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SCIENTIFIC BASIS FOR THE STRATEGIC DIRECTIONS OF THE SAFETY CAMERA PROGRAM IN VICTORIA

Max Cameron
Amanda Delaney
Kathy Diamantopoulou
Bella Lough

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Authors:

Max Cameron [1]
Amanda Delaney
Kathy Diamantopoulou
Bella Lough

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Abstract:

The objective of this project was to provide a scientific base for the development of a safety camera strategy that will:

(1) maximise the road safety benefit of the safety camera program, and

(2) continue to build on the positive outcomes achieved by enforcement programs in Victoria over the last ten years.

A review of previous evaluation research concerning Victorian, interstate and international automated enforcement programs was conducted. The review concentrated on the way in which this research can inform the future use of new and existing safety camera technologies in Victoria. Strategic principles relating to the maximisation of available intelligence and technology were formulated. The deterrence mechanisms behind each of the enforcement programs are discussed and world's best practice is identified where possible.

The deterrence value of the Victorian safety camera program is assessed in relation to the principal road trauma problems addressed (speeding and red-light running), the number of serious casualty crashes targeted by each offence detection technology, information on likely effects on these crashes, the influence of the timing and severity of penalties, and the supporting role of mass media publicity. Community acceptance and support for the program is also discussed in detail. These elements of a traffic law enforcement program play a key role in determining the effectiveness of the program in achieving reductions in road trauma.

This report provides a valuable scientific base for developing a strategy for the future directions of the safety camera program, but the report is not that strategy. The limited information available about the effects of the new technologies, and recent changes to the mobile speed camera operations, precludes that step from a scientific point of view.

Key Words:

(IRRD except when marked*)

Speed, speed camera, traffic signals, red-light camera, enforcement, publicity

Monash University Accident Research Centre,
Building 70, Monash University, Victoria, 3800, Australia.
Telephone: +61 3 9905 4371, Fax: +61 3 9905 4363

[1] Author may be contacted by internet e-mail at max.cameron@general.monash.edu.au

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EXECUTIVE SUMMARY

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2) continue to build on the positive outcomes achieved by enforcement programs in Victoria over the last ten years.

A review of previous evaluation research concerning Victorian, interstate and international automated enforcement programs was conducted. The review concentrated on the way in which this research can inform the future use of new and existing safety camera technologies in Victoria. Strategic principles relating to the maximisation of available intelligence and technology were formulated. The deterrence mechanisms behind each of the enforcement programs are discussed and world's best practice is identified where possible.

The deterrence value of the Victorian safety camera program is assessed in relation to the principal road trauma problems addressed (speeding and red-light running), the number of serious casualty crashes targeted by each offence detection technology, information on likely effects on these crashes, the influence of the timing and severity of penalties, and the supporting role of mass media publicity. Community acceptance and support for the program is also discussed in detail. These elements of a traffic law enforcement program play a key role in determining the effectiveness of the program in achieving reductions in road trauma.

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From the point of view of the first specific objective, there is scope to expand the planned operations of the new technologies to a sufficient extent so that:

(a) a general effect of the technology is achieved across the road environment on which it is applied (i.e., all freeways and highways in the case of fixed and point-to-point speed cameras; all signalised intersections in the case of red-light and red-light/speed cameras)
(b) the marginal economic benefits of the road trauma savings achieved by the general effect are just greater than the marginal cost of each increase in the technology operation (i.e., the cost of each extra camera installation, and necessary offence processing capacity).

So far as the mobile speed camera program is concerned, it has been found that the increase in camera hours from 4000 to 6000 hours per month is likely to be economically worthwhile. The influence of the operational changes to make the enforcement more covert and unpredictable, and to reduce the speeding offence detection threshold, on the marginal economic benefits is unknown. However, it is expected that these latter changes have made the program more efficient. The general effect of the program on crashes across the broad road environment is expected to continue to operate.

Thus, from the point of view of the second specific objective of this project, it can be concluded that the current mobile speed camera program should continue. There may be a case for the program to be expanded further, with economic justification. However, a decision to reduce the mobile speed camera program, in order to provide resources to implement or expand other safety camera technologies, should be viewed with caution. This may result in an erosion in the overall positive benefits achieved by traffic enforcement programs in Victoria over the last ten years.

1 INTRODUCTION

The widespread use of safety cameras in Victoria, commencing in the late 1980s, marked the beginning of significant reductions in road trauma in this State. It also represented a shift away from traditional labour intensive methods of traffic law enforcement towards the use of semi-automated techniques. Scientific evaluations of these new techniques have demonstrated the positive contribution of automated enforcement technologies in reducing road trauma. Similarly, interstate and international research has evaluated the effects of similar enforcement operations in other states and countries. In considering the future directions of automated traffic law enforcement, the existing body of research may provide critical insights into the way in which existing and emerging technologies can be used to improve road safety outcomes in Victoria.

In view of the above, it is the objective of this project is to provide a scientific base for the development of a safety camera strategy that will maximise the road safety benefit and continue to build on the positive outcomes achieved by enforcement programs over the last ten years. In completing this task, a review of previous evaluation research concerning Victorian, interstate and international automated enforcement programs is conducted. This review concentrates on the way in which this research can inform the future use of new and existing safety camera technologies in Victoria. In particular, attention is given to the formulation of strategic principles relating to the maximisation of available intelligence and technology. In doing so, the deterrence mechanisms behind each of the enforcement programs are discussed and world's best practice is identified where possible.

The deterrence value of the Victorian safety camera program is assessed in relation to the principal road trauma problems addressed (speeding and red-light running), the number of serious casualty crashes targeted by each offence detection technology, information on likely effects on these crashes, the influence of the timing and severity of penalties, and the supporting role of mass media publicity. Community acceptance and support for the program is also discussed in detail. These elements of a traffic law enforcement program play a key role in determining the effectiveness of the program in achieving reductions in road trauma.

The remainder of this report is structured as follows. Section two provides necessary background information relating to the deterrence mechanisms that operate in traffic law enforcement operations and common features of such programs. An examination of existing and emerging technologies and their effectiveness is conducted in section three and strategic principles for their future use are developed. Section four focuses on the scheduling of enforcement operations. The deterrence value of the Victorian safety camera program is discussed in section five and section six summarises survey information about recent trends in community opinion about the program.

The conclusion emphasises that this report provides a scientific basis for developing a strategy for the future directions of the safety camera program, but the report is not that strategy. The limited information available about the effects of the new technologies, and recent changes to the mobile speed camera operations, precludes that step from a scientific point of view. However the report provides valuable information for policy-makers in the area.

2 BACKGROUND

2.1. DETERRENCE MECHANISMS

The primary objective of traffic law enforcement is to 'contribute to the safe operations of the road traffic system' in the context of the criminal justice system (Cameron & Sanderson, 1982). The two primary mechanisms through which automated enforcement achieves this objective are general and specific deterrence. The key reasoning behind these processes relies on utility theory as described by Ross (1981). In general, this assumes that road users will decide whether on not to commit a traffic offence based on a rational analysis of the benefits and risks associated with committing the offence. It is noted, that it is the *perceived* risks and benefits of committing the offence that determines the utility of the action. Therefore, where the perceived benefit of committing an offence outweighs the perceived disbenefit, an individual will elect to commit the offence. Similarly, where the perceived risks of committing an offence are greater than the perceived benefits, a rational individual will elect not to commit the offence.

Although both the general and specific deterrence mechanisms are based on an assumption of rational behaviour, there are considerable differences in the operation of the two mechanisms.

General deterrence is a process of influencing a potential traffic law offender, through his fear of detection and the consequences, to avoid offending (Cameron & Sanderson, 1982). Therefore, operations employing general deterrence mechanisms necessarily target all road users irrespective of whether they have previously offended. It follows that general deterrence programs have the potential to influence the behaviour of all road users.

There are thought to be three key elements that influence the effectiveness of a general deterrence program; the perceived risk of detection, the severity of punishment and the immediacy of punishment. The higher the perceived risk of detection the less likely a road user is to commit an offence. The actual risk of detection is less relevant given that it is most often unknown by the driver. Indeed, the perceived risk of detection may be higher than the actual risk. Nevertheless, over time the perceived risk of detection will be informed by the road user's own experience and that of their acquaintances (Shinar & McKnight, 1985). Therefore, some relationship between the perceived and actual risk of detection is expected, although the precise form of the relationship is unknown.

The severity of punishment is also relevant although it is it is not the primary mechanism of general deterrence. Past research has concluded that where the perceived risk of detection associated with an activity is low, severe punishment of the offence will have little impact (Ross, 1990). Similarly, two studies examining the effect of increases in penalties for speeding found no associated changes in driver behaviour (Arberg et al, 1989, and Andersson, 1989). It has therefore been suggested that it is the existence of a penalty rather than the size of the penalty that provides the general deterrence (Bjørnskau & Elvik, 1990).

Finally, the swiftness of punishment impacts on the effectiveness of enforcement operations relying on the general deterrence mechanism. Unfortunately, there is little conclusive research evidence detailing the optimal timing of punishment (Zaal, 1994). Nevertheless, reductions in casualty crashes were found in Victoria at a time when infringement notices resulting from automated enforcement operations took approximately two weeks to be received (Rogerson et al, 1994). This indicates that a two-week delay from detection to punishment does not entirely negate the deterrent effect of an enforcement program. The effect of this delay is however unknown.

In contrast to general deterrence, *specific deterrence* is a process of encouraging an apprehended offender, through his actual experience of detection and the consequences, to avoid re-offending (Cameron & Sanderson, 1982). Therefore, the potential impact of a specific deterrence program is more limited than that of a program relying on the general deterrence mechanism. Enforcement programs relying solely on the mechanism of specific deterrence have the potential to influence only those offenders who have previously been detected and punished for committing offences. It follows that the magnitude of the penalty, especially that applying if subsequent offences are committed, is of particular importance. The choice of penalty, whether it be a warning letter, a fine, demerit points on a licence or some combination of these, is likely to affect the recurrence of offending behaviour.

2.2. COMMON FEATURES OF ENFORCEMENT PROGRAMS

In order to achieve reductions in road trauma, speed enforcement programs may invoke one or both of the two deterrence mechanisms discussed above. The exact mechanism used will depend on the nature of the program and its operations. Therefore, it is necessary to understand the specific characteristics of an enforcement program in order to evaluate its effects.

Enforcement programs are generally classified as either overt or covert. It is the intention of overt operations to be highly visible to road users. In doing so, these types of operations are thought to increase the perceived risk of detection and thus alter the behaviour of road users immediately in time and space. On the other hand, covert operations are not intended to be seen by road users and road users should be unaware of the location and timing of such enforcement operations. Effective covert operations will create a perception that detection may occur at any location and at any time.

The effects of an enforcement program can either be either localised or general across a broader road network than the specific locations at which the enforcement operates. Overt operations are likely to have localised effects, but can also have general effects if the density of operations is sufficient. Enforcement programs relying on the general deterrence mechanism commonly have general effects, but the two “general” concepts are different. Programs based on the specific deterrence mechanism can have both general and localised effects on crashes.

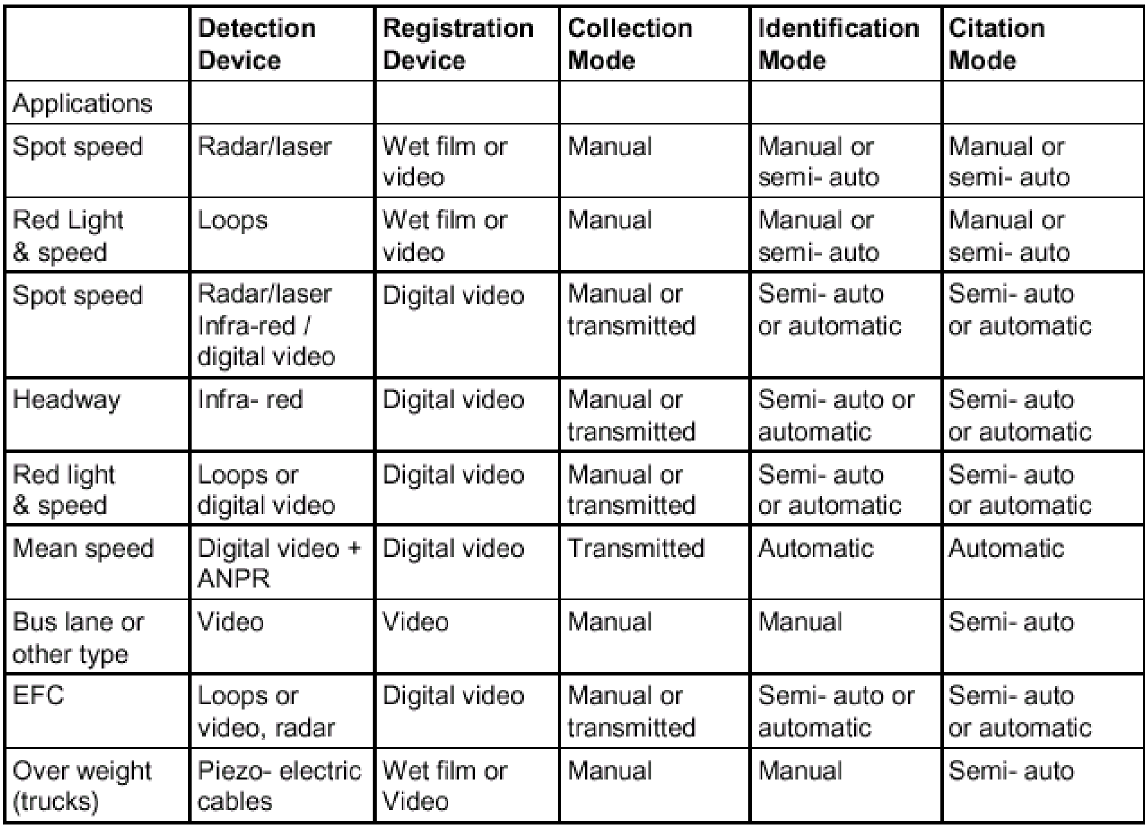
The type of enforcement program that can be implemented will be influenced by the type of technology available. In general, speed enforcement technology can be either fixed or mobile. Fixed devices, such as the safety cameras located in the Burnley and Domain tunnels in Victoria, are located permanently at one site. In contrast, technologies such as slant radar speed cameras, are portable and tend to operate at one site for only a short period of time. This technology, along with others that can be moved from site to site, is referred to as mobile technology.

In some circumstances, the location of safety cameras, whether fixed or mobile, may be chosen to affect a known problem of high crash risk or the risk of particularly severe crashes in a defined area. Such treatments are referred to as black spot treatments. Where the increased risk relates to a particular route or area the treatment can be spread across this black route or area. In general, black spot or black route programs are intended to have the greatest effect at the black spot site or along the black spot route and are rarely aimed at treating speed across the road network.

3 SAFETY CAMERA TECHNOLOGIES

As described above, a wide range of enforcement technologies are available for use in a variety of settings. Table 1 below summarises the characteristics of the available enforcement technologies and the purposes for which they can be used.

Table 1: Automatic enforcement modes, generic technologies, and areas of application (Zaidel & Makinen, 1999; from Heidstra et al 2000)



	Detection Device	Registration Device	Collection Mode	Identification Mode	Citation Mode
Applications					
Spot speed	Radar/laser	Wet film or video	Manual	Manual or semi- auto	Manual or semi- auto
Red Light & speed	Loops	Wet film or video	Manual	Manual or semi- auto	Manual or semi- auto
Spot speed	Radar/laser Infra-red / digital video	Digital video	Manual or transmitted	Semi- auto or automatic	Semi- auto or automatic
Headway	Infra- red	Digital video	Manual or transmitted	Semi- auto or automatic	Semi- auto or automatic
Red light & speed	Loops or digital video	Digital video	Manual or transmitted	Semi- auto or automatic	Semi- auto or automatic
Mean speed	Digital video + ANPR	Digital video	Transmitted	Automatic	Automatic
Bus lane or other type	Video	Video	Manual	Manual	Semi- auto
EFC	Loops or video, radar	Digital video	Manual or transmitted	Semi- auto or automatic	Semi- auto or automatic
Over weight (trucks)	Piezo- electric cables	Wet film or Video	Manual	Manual	Semi- auto

(ANPR = Automatic Number Plate Recognition)

The majority of the technologies in the above table are relevant to automated enforcement in Victoria. Therefore, the remainder of this section examines each of the relevant enforcement technologies in terms of their demonstrated effectiveness both in Victoria and elsewhere.

3.1. MOBILE SPEED CAMERAS

Slant radar speed cameras have been operating in Victoria since the initial trial period of this technology in 1985. Since that time, the speed camera program has undergone significant change and has expanded to its current form. There are currently 54 slant radar speed cameras used to achieve the target of 6,000 enforcement hours per month for the speed camera program.

The camera technology consists of two components; a slant radar and a camera control unit. The camera unit is capable of photographing 2 speeding vehicles per second and can monitor vehicles travelling towards or away from the camera. The radar unit can be mounted on a tripod on the roadside or less conspicuously within a vehicle. In general, these devices have been mounted inside unmarked police vehicles to reduce the visibility of operations. In addition, in 2001, flashless units were introduced to the speed camera program for use in clear weather conditions, thereby further reducing the ability of road users to detect the use of speed cameras.

The mobile cameras use conventional wet-film technology similar to that used in a standard 35mm camera. Current digital technology is not sufficiently developed to enable the introduction of mobile, digital safety cameras to the enforcement program. Trials of these devices conducted by LMT found that the resolution of the images produced by digital cameras is not sufficiently high to warrant their introduction. The clarity of images captured by the existing wet-film, slant radar cameras is superior to that of the images produced by current digital technology. Further, the processing of the images captured by digital cameras in not currently cost efficient. It is expected that over the next two to five years digital camera technology for use in a mobile setting will become available and produce images of sufficient quality to enable their use in an enforcement setting.

In considering the future operations of the Victorian speed camera program it is necessary to consider four key issues. The first of these is the effectiveness of the existing program in terms of its impact on the frequency of casualty crashes in Victoria. The following section highlights the key results of evaluations of the speed camera program as it operated up to the year 2000/01 in Victoria. International experience in the use of mobile speed cameras is also considered to assist in the development of strategic principles relating to future operations.

3.1.1. Effectiveness of Mobile, Car-mounted Speed Cameras

Evaluations of the Victorian Program

The initial trial of speed cameras in 1985 attempted to significantly increase the number of vehicles that could be detecting speeding per hour in comparison to traditional enforcement methods. This objective was to be achieved through the use of a small number of cameras operating at high crash frequency sites. The operations were highly visible and all camera sites were clearly identified with appropriate signage. The overt nature of the program was intended to invoke the general deterrence mechanism by raising the perceived risk of detection for speeding offences. Those offenders actually detected were also expected to be deterred by the penalties imposed as a result of the offence.

The results of an evaluation of the program's operation demonstrated that the effect of the speed camera trial was minimal. No statistically significant reductions in casualty crashes in the areas surrounding the camera sites were found. In addition, the effect on speed was limited to distances of approximately one to two kilometres from the camera sites (Portans, 1988). This suggests the following strategic principle.

Strategic Principle: The use of a small number of highly visible mobile speed cameras is likely to lead to small, localised casualty crash reductions only.

Covert operations of the expanded mobile camera program

The poor results of the initial speed camera trial led to a re-evaluation of the program and the introduction of the covert speed camera program detailed in section 3.1 in 1989. This program significantly increased the average number of infringement notices issued each month with a target of 4,000 enforcement hours per month being set. During 2001, this target was raised to 6,000 hours per month.

When evaluated from the period between December 1989 and December 1991 this program had a significant effect on casualty crash frequency and severity (Cameron et al., 1992). In particular, from December 1989 to March 1990, there was a statistically significant 15% reduction in low alcohol hour[1] casualty crashes on arterial roads. This coincided with low levels of both speed camera enforcement and speed related publicity. During the period April 1990 to June 1990, when the publicity campaign was launched but prior to extensive enforcement operations, low alcohol hour crashes were reduced by 34% on Melbourne arterial roads and 21% in country towns. Reductions in the severity of injuries sustained in these crashes were also found in Melbourne during this period.

Following the high levels of both publicity and enforcement experienced from July 1990, low alcohol hour casualty crashes were reduced on arterial roads in Melbourne, country towns and on rural highways by 32%, 23% and 14% respectively. The injury severity of these crashes was also found to have decreased, principally in Melbourne. The effect of the speed camera enforcement program on high alcohol hour crashes is less clear.

In addition to the estimation of casualty crash reductions, the impact of the mobile speed camera program on speeds was also examined (Rogerson et al., 1994). From November 1989 to March 1990 no significant change in mean speeds was found. However, the proportion of vehicles detected exceeding the speed limit by more than 15 km/h had decreased in 60 and 70 km/h speed zones during this period. In particular, in 60 km/h speed zones the proportion of vehicles exceeding the speed limit by more than 15 km/h had decreased from approximately 11% to 5.5%.

Localised effects

Further analysis of the period from July 1990 to December 1991 indicated that there is an additional effect of the mobile speed camera program which is localised in space to the immediate area surrounding the enforcement sites (Rogerson et al., 1994). During the two weeks following the receipt of TINs by offending motorists, a statistically significant 10% reduction in *high* alcohol hour casualty crashes was experienced on arterial roads within one kilometre of the camera site. However, there was no reliable evidence of crash reductions within one kilometre of the camera site during the week immediately following a speed camera enforcement session. Further, no localised reductions in low alcohol hour crashes or the severity of crashes were found during this period.

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[1] Low-alcohol hours are times of the week when alcohol related crashes are less likely to occur, whereas high-alcohol hours of the week are those periods when alcohol related crashes are more likely to occur.

The above results were updated in a more recent study examining the localised effects of the speed camera program during the period from July 1990 to December 1993 (Newstead et al. 1995). It was found that the speed camera program had no statistically significant additional effect on casualty crashes following enforcement operations or the receipt of TINs in rural towns. In contrast, statistically significant casualty crash reductions, in addition to the general effect, in metropolitan Melbourne were identified and linked to both camera operations and the receipt of TINs. The influence of TINs was evident during the three weeks following their receipt and was greatest on all roads during high alcohol hours. An 8.9% reduction in casualty crashes was experienced in high alcohol hours, on all roads, during the week following the receipt of TINs.

It is worth noting the differences in the results of the two studies detailed above. First, the estimated additional effect of the receipt of TINs is slightly less in the 1995 study; 6.2% compared to 8.4%. Second, the 1995 study identified additional crash reductions during the week immediately following the enforcement presence during both high and low alcohol hours. The earlier study found no such evidence of crash reductions following the enforcement presence. There are a number of possible explanations for these changes. The additional two years of data included in the 1995 analysis may be affected by changes in the behaviour of motorists during this period. Drivers may have become more aware of speed camera sites and adjusted their driving behaviour at these sites. In turn, this may have resulted in the reduced crash risk observed at the sites. However, further study would be required to examine this possibility.

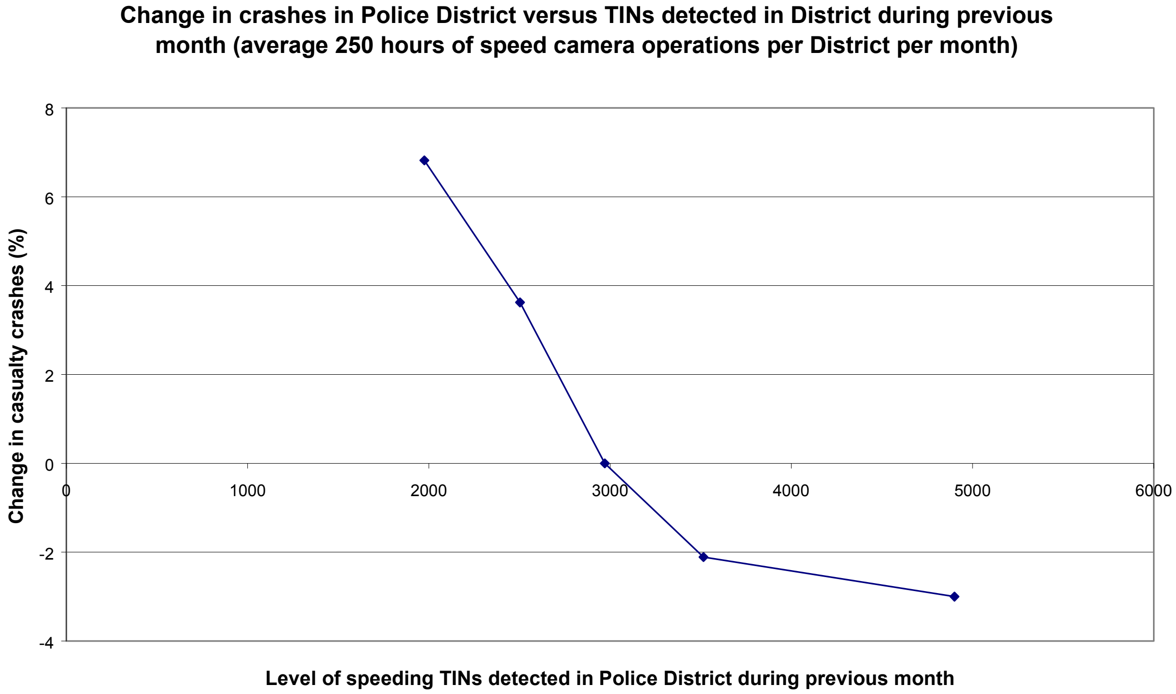
Mechanisms of effect

The mechanisms that drive reductions in casualty crashes have also been identified. Based on 1990-91 data, relationships between the monthly level of low alcohol hour casualty crashes and the inputs of the enforcement program have been established. Crash frequency was related to the number of speeding TINs issued (generally 2-3 weeks after the offence occurred) and the publicity levels in the same month. Also, crash severity was related to camera operating hours and the number of speeding TINs issued (Cameron et al. 1992). These results imply that actual detection of speeding drivers, as evidenced by the number of TINs issued, is a key driver of the frequency of casualty crashes. TINs issued as a result of speed camera operations were estimated to contribute reductions in serious casualty crashes of 8-9% during the 1990-1993 period (Newstead et al., 1995).

An update of the primary analysis using data from January 1994 to December 1996 produced some different results (Gelb et al., 2000). In particular reductions in casualty crash frequency were no longer attributable to TIN issuance. In addition, the number of hours of enforcement no longer had a positive effect on crash severity. Nevertheless, casualty crash severity was still affected by the number of TINs issued. This suggests that there has been a change over time in the mechanisms behind the speed camera enforcement program.

A more recent study has confirmed the key role of the number of speeding TINs detected having an influence on crashes in subsequent periods (Cameron et al., 2003a, b). During 1999, the Victoria Police varied the levels of speed camera activity substantially in four Melbourne police districts according to a systematic plan. Camera hours were increased or reduced by 50% or 100% in respective districts for a month at a time, during two separate months when speed-related publicity was present and during two months when it was absent. Monthly casualty crashes in the ten Melbourne police districts during 1996-2000 were analysed to test the effects of the enforcement, publicity and their interaction. Monthly levels of speeding offences detected by cameras varied substantially over time in all districts, but the most extreme variations occurred in the four districts as planned. Changes in crash frequency were found to be inversely associated with changes in the levels of speeding TINs detected in the same district during the previous month (Figure 1). The risk of fatal outcome of the casualty crashes was also reduced by more than 40% when the level of speeding TINs detected during the previous month was at relatively high levels (more than 30% greater than average).

Figure 1: Relationship between crashes and level of speeding TINs detected by speed cameras



Strategic Principles

From the above discussion the following conclusions and strategic principles related to the mobile speed camera program in Victoria can be suggested.

1. Significant reductions in low alcohol hour casualty crashes were experienced during the initial implementation phase of the new, covert speed camera program when publicity was high but actual enforcement levels were relatively low. This suggests that, *even with low enforcement levels, high profile media activity can establish and maintain a threat of detection in the short term.*

2. Following the full implementation of the mobile speed camera program (including supporting mass media publicity), statistically significant reductions in low alcohol hour casualty crashes were found across arterial roads in Melbourne and country towns and on rural highways. This demonstrates that, *the intense, covert use of speed cameras can lead to long term reductions in low alcohol hour casualty crashes across a number of road types when accompanied by high-profile publicity.*

3. Localised additional reductions in high alcohol hour casualty crashes were experienced during the two weeks following the receipt of TINs. This indicates that, *in addition to the general effect outlined above, the mobile speed camera program has a localised effect on high alcohol hour casualty crashes corresponding to the two-week period after the receipt of TINs. The exact duration of this effect is unknown.*

4. Later studies have identified additional casualty crash reductions within one kilometre of enforcement sites in the week following enforcement sessions. This demonstrates that *the localised effect of the mobile speed camera program is also linked to the enforcement presence although perhaps less strongly than to the receipt of TINS.*

5. From all the research relating crash and speed effects to the receipt of TINs emanating from camera-detected speeding offences, it can be concluded that *the principal mechanism through which the mobile speed camera program achieves its effects on crashes is specific deterrence, operating through the actual detection and punishment of offenders.*

Interstate and International Experience

To ensure that these principles are consistent with national and international experience of mobile speed cameras, it is useful to examine the results of evaluations of these technologies in British Columbia, Canada, New Zealand and Queensland, Australia.

British Columbia, Canada

The province of British Columbia implemented a province-wide speed camera program commencing in March 1996. The program made use of photo radar devices transported in and operated from unmarked vans. No signage was present at the speed camera sites and the radar unit was visible only after a vehicle had passed the van. Therefore, the camera program can be considered to have operated covertly. However, there was significant mass media publicity of the enforcement operation prior to and throughout its operation. Further, a survey of residents found that approximately 95% of residents were aware of the program prior to its commencement.

Operations were scheduled to operate primarily during daytime hours at sites with a history of high crash frequency or perceived speeding behaviour. Within the first year of operation the cameras achieved approximately 30,000 enforcement hours which resulted in 250,000 infringement notices being generated. The penalty for exceeding the posted speed limit ranged from $100-150, however, during the first five months of the program warning letters were issued and no fines imposed.

The program was found to have beneficial outcomes when evaluated with respect to a number of variables (Chen et al., 2001). First, it was found that the proportion of vehicles exceeding the speed limit at the camera sites dropped by 50% from May to December 1996. However, reductions of 75% were found for those vehicles exceeding the speed limit by more than 16 km/h. The single largest monthly reduction was experienced in August, when fines for exceeding the speed limit were introduced. Reductions in traffic speed were also identified at the control sites. Prior to the implementation of the program, an average of 69% of motorists exceeded the speed limit at these sites. Following the introduction of fines this had decreased to an average of 61% of motorists. The authors suggest that this is due to a generalised effect of the speed camera program.

The estimated program effect with respect to the frequency of daytime unsafe speed related crashes, indicates that the program led to a 25% reduction in these crashes after infringement notices were incorporated into the program. It is noted that these crashes are classified as crashes in which unsafe speed was identified as a contributing factor by the Police attending the crash scene. Daytime traffic collision injuries requiring transportation by ambulance also decreased by an estimated 11% during this period and fatalities resulting from daytime traffic collisions were estimated to have fallen by 17% as a result of the speed camera program.

Strategic Principles

The above results are generally consistent with those found in relation to the operation of the Victorian mobile speed camera program and confirm that covert operations can successfully reduce the frequency of casualty crashes. Although the analysis of the Canadian program does not examine the causal links between the speed cameras and improvements in road safety, when viewed in conjunction with the Victorian research it suggests the following conclusions and strategic principles.

1. The British Columbian program demonstrates that the use of covert, mobile speed camera operations is an effective means of reducing both vehicle speeds and casualty crashes. However, *the general deterrence effect of covert enforcement programs can be increased through high levels of public awareness brought about through media publicity*.

2. The imposition of monetary penalties will also increase the deterrence effect of enforcement programs. In particular, *the impact of an enforcement program on speeds will be greater when a monetary penalty is imposed when compared to warning letters only.*

New Zealand

The introduction of mobile speed cameras in New Zealand commenced in late 1993. The operation of the cameras was restricted to roads classified as ‘speed camera areas’ based on a record of speed related crashes. Entrances to these roads were clearly sign posted to ensure that motorists were aware of the potential presence of the speed cameras. Further, the majority of speed cameras were mounted on police cars and operators were prohibited from hiding the cameras. In urban areas, limited use was made of fixed position speed cameras mounted on poles, however, these were subject to the same signage requirements as the mobile camera operations. In total, 13 fixed and 31 mobile cameras have been operating in New Zealand since 1993. Prior to July 2000, the enforcement threshold was set at the 85th percentile speed for each site as determined by speed surveys of that site. Financial penalties (but no demerit points) were imposed where vehicles were detected travelling at or above the enforcement threshold. However, since 1 July 2000 a flat 10 km/h enforcement threshold has been in operation.

An evaluation of the effect of the speed camera program described above, found that fatal and serious crashes on roads with speed limits of 70 km/h or less were reduced by an estimated 13% during low alcohol times of day (Mara et al., 1996). In speed camera areas, the reduction in fatal and serious low alcohol hour crashes was 23.3%. Less substantial reductions in all injury crashes were experienced in speed camera areas on roads with speed limits of 100 km/h. No effect on crashes was identified on these roads when non-speed camera areas were included in the analysis.

Queensland, Australia

Mobile speed cameras were first introduced to Queensland in 1997 and a total of 15 camera units were in operation by June 1997. The camera program operates in an overt manner with marked vans stationed at the enforcement sites. Signs advising of the camera presence are also displayed when cameras are in operation. In addition, a public education program was conducted in late 1996 prior to the commencement of operations. The camera technology used in Queensland is the same as that currently being used in Victoria and discussed earlier in this report. The selection of speed camera sites is based on speed related crash history, however the scheduling of the operations is conducted randomly. The randomised allocation of resources between the approved camera sites is based on the Random Road Watch technique as detailed in section 4.2.

Preliminary results of the evaluation of the speed camera program indicate that the mobile speed camera program has reduced crash frequency by between 12 and 17 percent within a 6km radius of the camera sites. The greatest effects were found within a 2km radius of the camera sites. Further, there is some suggestion that the crash reduction increased over time particularly for higher severity crashes. No investigation as to the existence of a generalised effect of the camera program was conducted.

On the basis of the analysis of both the New Zealand and Queensland mobile speed camera programs, the following conclusion and strategic principle can be defined.

1. *The overt operation of speed cameras in sign-posted speed camera areas is likely to lead to localised effects on casualty crashes.* However, no general effect of an overt, mobile speed camera program has yet been identified.

3.1.2. Comparison of Overt and Covert Mobile Operations

The second key issue in relation to the operation of mobile speed cameras is the contrast between overt and covert operations. There has been little research directly comparing the impact of the mode of operation on the effectiveness of a mobile enforcement program. However, some evidence does exist and is discussed below.

New Zealand

As detailed above the operation of mobile speed cameras in New Zealand is conducted in a highly visible manner. However, from mid-1997 to mid-2000 a trial of the covert use of speed cameras was conducted in one of the four police regions in New Zealand on roads with speed limits of 100 km/h. This involved adding to existing signage an indication to motorists that hidden cameras may operate in the speed camera areas. In addition to the extra signage, there were high levels of newspaper and radio publicity relating to the trial prior to its commencement. It is also noted that in the first year of operation there was a 26% increase in the operational hours of speed cameras in the trial region. In the second year of operation, the number of operational hours decreased by 13% from the first year level. There were no changes in the operation of speed cameras during the trial period in other areas of New Zealand. In particular, on all roads in non-trial speed camera areas, speed camera operations remained overt. Further, on roads with speed limits of 70 km/h or less in the trial region, speed cameras were operated overtly.

An evaluation of the hidden camera trial in terms of vehicle speeds and reportable crashes demonstrated that during the first two years of the trial, improved road safety outcomes were experienced (Keall et al., 2002). First, average speed in the trial regions decreased by an estimated 1.3 km/h over the first two years of the trial. The speed below which 85 percent of vehicles travelled in the trial region fell by an estimated 4.3 km/h. In addition, reportable crashes in the trial region fell by 11% in comparison to reportable crashes in the control regions. Further, it was found that the number of casualties in the trial region fell by 19% in comparison to casualties in the control regions. The number of casualties per crash fell by 9% on open roads in the trial region compared to open roads in the control regions. It is noted that these results relate to reductions across the treated region and not only at camera sites. This indicates that the covert mobile operations were able to generalise the effect of the New Zealand program beyond the speed camera sites.

Despite the above results it is difficult to draw conclusions from this study on the relative effectiveness of overt and covert automated speed enforcement programs. During the trial period, enforcement levels in the trial region were higher than in the non-trial regions. Further, the number of penalties issued in relation to incidents in the trial areas increased four fold (Keall et al., 2002). Therefore, based on previously established relationships between speed enforcement and crashes (Cameron et al., 1995), it is not unexpected that improvements in road trauma would occur as the level of enforcement increases. Nevertheless, the authors point to three factors which they believe together support the conclusion that the introduction of covert speed cameras influenced the casualty crash reductions. First, the fall in the frequency of casualty crashes coincided with the introduction of the covert program. Second, mean and high percentile speeds fell significantly during the trial. Finally, the reduction in the number of casualties per crash also confirms that speeds fell during the trial period.

Victoria

To clarify the comparitive effect of covert and overt mobile speed enforcement operations, it is useful to examine some related Victorian research although it is noted that it does not relate directly to mobile speed cameras.

The effect of mobile (moving mode) radar speed detection devices on road trauma in rural Victoria has been examined in terms of the type of enforcement operation. That is, the effect of covert (unmarked car), overt (marked car) and mixed (marked and unmarked cars) mobile radar operations has been examined to identify any differences between the outcomes of different types of enforcement activity (Diamantopoulou and Cameron, 2001).

The analysis was conducted using crash data from July 1995 to June 1997 which was divided into two periods. These periods were July 1995 to June 1996 and July 1996 to

June 1997 and corresponded with the use of 48 and 73 mobile radar devices respectively. Analysis was also conducted on the two periods combined when up to 73 mobile radar device were in operation.

A net 20.7% reduction in casualty crashes occurring one to four days after a *covert* enforcement presence was identified during the period from July 1995 to June 1996. The presence of *overt* enforcement also had a positive effect on crashes occurring one to four days after enforcement however, the effect was less pronounced. During the period from July 1996 to June 1997, the largest reductions in casualty crashes occurred following mobile radar enforcement operations involving *both* marked and unmarked police cars. This effect was greatest on the day on which the enforcement activity took place (40.2% reduction).

The results of the combined period in which up to 73 mobile radar devices were in operation found that the most significant reductions in casualty crashes occurring one to four days after enforcement resulted from *covert* mobile radar enforcement. However, a mix of overt and covert enforcement was also found to be effective in reducing casualty crashes during this period.

It is noted that the crash reductions presented above are not statistically significant. Nevertheless the results are indicative of the likely relationships between overt, covert and mixed mobile radar enforcement and casualty crashes in rural Victoria.

In developing strategic principles in relation to the mode of operation of the mobile speed camera program, the limitations of the above research must be noted. First, the Victorian research concerns the operation of mobile radar operations and not mobile speed cameras. Second, the research relates to rural areas of Victoria only.

Despite these limitations the following conclusion and strategic principle is suggested on the basis of the New Zealand and Victorian research.

Strategic Principle: Covert operations increase uncertainty about the presence and location of the threat of detection, thus spreading the general deterrence effect over a broader area than overt operations. Visible symbols, such as signs warning of potential camera presence, and marked cars in parallel in the case of mobile radar, may help to remind drivers of the unseen threat of the covert operations, thus increasing general deterrence.

3.1.3. Intensity of Operation

The intensity of operation is relevant to the consideration of the mobile speed camera program. A cost benefit analysis of the Victorian mobile speed camera program as it operated up to 2000, has been conducted (Gelb et al., 2000). The study aimed to evaluate whether the existing speed camera operations involving approximately 4000 hours of operation per month was best practice. This was done using a marginal cost/benefit analysis in terms of both hours of operation and TIN issuance.

The economic analysis was limited to speed camera enforcement in Melbourne during low alcohol hours because most speed camera activities occur in Melbourne during these hours. In addition, crash data for low alcohol hours is less likely to include accidents associated with drink driving. Crash data from 1987 to 1998 was used along with data relating to the actual costs of running the speed camera program and the costs of casualty crashes to society in general. Further, the results presented below are drawn from the economic analysis based on TIN issuance. These results are likely to provide a better estimate than those based on hours of operation due to the greater variability of the TINs issued per month.

It was determined that, in order to reduce the social costs (camera operations plus casualty crash costs), the number of TINs issued per month should fall within the range of 37,000 to 66,000. This corresponds to a range of 3,592 to 6,408 enforcement hours per month and an optimal average investment per month of 5,146 enforcement hours. This would be expected to result in a reduction in monthly levels of low alcohol hour casualty crashes of 13%. Further, the marginal benefit cost ratio was determined to be 6.3. That is, by investing in an average of 5,146 operational hours per month the benefits obtained in reduced social costs per casualty crash would be 6.3 times the cost of investment.

These results are limited to benefits of speed camera enforcement under the program existing up to 1998. The results would change if any of the elements of the program such as camera technology or the operational principles underlying the timing and location of enforcement operations were to change. Any technological advance that would increase the number of speeders detected per hour of camera operation would increase the benefit/cost ratio of the program. Further, if it became possible to issue the same number of TINs with fewer hours of enforcement, the cost of the program would decrease and the benefit/cost ratio would necessarily increase. If such changes did occur, the estimates provided above could be viewed as the lower bounds of an economic assessment of a redesigned speed camera program.

During August 2001 to February 2002, the number of hours per month planned for speed cameras to operate was increased from 4,000 to 6,000 hours. There have been few other changes in mobile speed camera operations, apart from the use of cameras without flash assistance during daylight conditions, and reductions in speeding offence detection thresholds (both changes likely to increase, rather than decrease, the number of speeders detected per hour, at least in the short-term; see section 5.6.2). Research based on the increased speed camera hours in some Melbourne police districts during specific months in 1999 provides support for likely reductions in crashes following a 50% increase in camera hours (Cameron et al., 2003a, b; see Figure 1). The increased number of hours per month is consistent with the range of estimates for the optimal investment of camera hours per month, based on the economic analysis described above. This suggests the following strategic principle.

Strategic Principle: Covert speed camera operations are both effective in reducing road trauma and are highly cost beneficial. In addition, *the 50% increase in the level of speed camera activity during 2001/2002 is expected to further increase the economic benefit of the mobile speed camera program.*

3.1.4. Enforcement Thresholds

Finally, the issue of enforcement threshold is a relevant consideration to the future operation of the mobile speed camera program. An enforcement threshold is defined as the speed at or above which an infringement notice will be issued. In Victoria, this speed is not identical to the posted speed limit and has changed over time. The speed tolerance is the speed at which vehicles may travel without incurring a penalty. When the speed camera program was first introduced in Victoria, a speed tolerance of 10 percent of the speed limit plus 3 km/h was set. The Australian Design Rule (ADR) covering speedometers require that the indicated speed be within 10% of the actual speed. Further, the speed camera technology may have an error of up to 3 km/h. It is believed that the original speed tolerance was set in view of the variation in these devices. Therefore, in a 60 km/h speed zone, vehicles could travel up to the tolerance level of 69 km/h without receiving an infringement notice. In February 1993, 110 km/h speed limits were reintroduced for high quality freeways. To reduce the speed tolerance in these speed zones, a flat 10 km/h enforcement threshold was introduced on all roads. In March 2002, Victoria Police announced further staged reductions of speed enforcement thresholds. However, the details of these reductions have not been widely publicised.

It is noted that the travel speed alleged on traffic infringement notices is 3 km/h less than the speed detected by the camera device. Prior to 2000, both the detected and alleged speeds were recorded on infringement notices. Since at least January 2001 only the alleged speed has been documented on infringement notices.

As the reduction in the enforcement threshold is a recent occurrence, the effect of this action on casualty crashes or the speeds of vehicles has not yet been assessed. However, the effect of reducing enforcement thresholds has been evaluated in the Swedish context.

Swedish Experience

In 1987 reduced tolerance levels for speeding offences were implemented in the two Swedish cities of Halmstad and Jönköping. At the same time, increased penalties for speeding offences were introduced in July 1987 and a campaign aimed at reducing speeds was implemented. An evaluation study was conducted to determine the impact of these programs on speeds in the treatment areas (Andersson, 1990). The study used four distinct urban areas as control sites and measured speeds during 1986 and 1987.

Speeds in the treatment areas fell by approximately 0.8 to 1.2 km/h from 1986 to 1987. In contrast, in the control areas where the enforcement threshold did not change, there was a slight increase in speeds over this period. It is suggested by the authors of the study that the speed reduction was most likely due to the increased risk of detection caused by the lower enforcement thresholds rather than the increased penalties associated with speeding offences or the campaign targeted at reducing speeds. This conclusion is reached on the basis of surveys of drivers travelling through the treatment and control sites. One in three drivers reported driving slower than previously and the majority of motorists reported that this was due to the increased levels of police activity. Few drivers were aware of the new penalties and only ten percent of drivers who reported driving more slowly did so as a result of the campaign targeted at reducing speeds.

In view of this research the following conclusion and strategic principle is proposed.

Strategic Principle: Reductions in enforcement threshold will increase the actual risk of detection. *Providing the actual increase in the risk of detection translates into an increase in the perceived risk of detection, reductions in the enforcement threshold can lead to positive road safety outcomes.*

New Zealand Experience

This conclusion is further supported by the impact of a reduction in the enforcement threshold in New Zealand. Prior to July 2000, the enforcement threshold was determined by the 85th percentile speed for each stretch of road covered by speed cameras. Following the introduction of a flat 10km/h enforcement threshold applying across the road network in July 2000, the number of vehicles exceeding the speed limit at speed camera sites declined dramatically. Specifically, there was a 50% reduction in the proportion of vehicles detected exceeding the 10km/h tolerance at camera sites in the six weeks following the introduction of the reduced tolerance (Robinson, 2001). This reduction has been sustained over time. The translation of this reduction in offence rates into improvements in road trauma has not been evaluated. However, the proportion of drivers travelling at over 110km/h on rural roads (typically with 100km/h speed limits) fell from 24-26% during 1997-1999 to 20% in 2000, 15% in 2001 and 10% in 2002 (Land Transport Safety Authority, 2003). Whether this reduction in speeding was solely due to the reduced enforcement tolerance is unclear.

3.2. FIXED SPEED CAMERAS

In comparison to other forms of speed enforcement technology, fixed speed cameras are a relatively new method of automated speed enforcement in Victoria. The first fixed speed cameras used in Victoria were located on the Monash Freeway (CityLink) in the Domain tunnel and commenced operation in April 2000 when that tunnel was first opened for public use. Since that time, fixed speed cameras have also been installed in the Burnley tunnel and on the Monash Freeway some distance before the entrance to the Domain tunnel.

The operation of these fixed cameras is intended to be as covert as possible. However, over time, although the exact location of the cameras may remain unclear, the public have become aware of the existence of the cameras on the Monash Freeway particularly in the two tunnels. This has been achieved through extensive media comment on their presence. Nevertheless, there is no signage indicating the use of speed cameras at the sites and where necessary blanking plates are used to hide the cameras from view.

The fixed cameras operating in these positions are analog video cameras which are capable of operating continuously. Within each of the tunnels two pairs of camera banks are installed facing opposite directions to enable both the front and rear registrations plates to be captured. However, it is most common for only one pair of these camera banks to be in operation at one time. Each bank of cameras contains 2 cameras for each lane of traffic to be viewed. The first of these takes a wide view of the traffic and the second captures close up images of offending vehicles to enable registration details to be collected. Although the cameras operate continuously they retain images only when a speeding offence is detected. Once an offence has been detected the data is relayed for processing remotely and there is no need to access the site for this purpose. The images captured by the analog video camera must be converted to digital format to enable the processing of the offences.

In addition to the fixed camera installations described above, new banks of cameras have been installed along the Western Ring Road and are proposed for the Melbourne-Geelong Freeway. These roads are thought to have been selected on the basis of high proportions of speeding drivers and severe injury crashes. The cameras operate in a similar manner to the existing cameras, however the technology used differs. Digital cameras have been chosen for these routes following trials to ensure the viability of this technology.

3.2.1. Research on Effectiveness of Fixed Cameras in Victoria

The effectiveness of the fixed-position speed cameras was evaluated in terms of the impact on vehicle speeds in the tunnel (Diamantopoulou and Corben, 2001). Analysis of the effect on the enforcement was conducted with respect to each lane in the tunnel, the day of the week of travel and the hour of the day of travel.

The overall effect of the fixed-position speed cameras was to reduce the proportion of those drivers exceeding the speed limit and to reduce the average speed of vehicles in the tunnel. Average vehicle speeds fell from 75.05 km/h to 72.50 km/h. The proportion of drivers exceeding the 80 km/h speed limit fell by 66%. In addition, the proportion of drivers exceeding speeds of 90 and 110 km/h were also significantly reduced by 79% and 76% respectively.

A lane-by-lane analysis of the effects of the speed enforcement initiative suggests that the cameras were effective in reducing average vehicle speeds and the proportion of drivers exceeding speeds of 80, 90 and 110 km/h in all lanes of the tunnel. However, the effect was greater in the left lane than the right.

The day-by-day analysis also indicated that reductions in these measures of effect were experienced on both weekdays and weekends. In particular, average vehicle speeds were reduced by 2.9% during the week and 5.4% on weekends. Also, the proportion of drivers exceeding the speed limit was reduced by 65% during the week and 68% on weekends.

For the time of day analysis, it was found that the fixed-position speed cameras were effective in reducing both average vehicle speeds and the proportion of drivers exceeding speeds of 80, 90 and 110 km/h for most time periods on weekdays. The most significant reduction was experienced in the afternoon peak period. However, during the morning peak period no reductions in either average vehicle speeds or the proportion of vehicles exceeding 110 km/h were experienced. In addition, there was no reduction in the proportion of vehicles exceeding 110 km/h during the non-peak daytime period.

The cameras were also shown to be effective in reducing average vehicle speeds during all time periods on weekends. Reductions in the proportion of vehicles exceeding speeds of 80, 90 and 110 km/h were also generally found in all time periods.

3.2.2. International Experience

United Kingdom

Speed cameras were first introduced into the United Kingdom in 1992 and by 1994 there were thirty speed cameras in use. Since that time the number of speed cameras available for use has increased significantly. However, the exact number of fixed speed cameras currently in use is unclear. A 1996 study conducted by the Police Research Group (Hooke et al., 1996) indicated that in 10 out of the 43 Police forces in England and Wales there were 102 cameras in use which rotated through 475 speed camera sites. It is noted, however, that some of the 102 cameras were used as red-light rather than speed cameras and both fixed and mobile wet-film radar cameras are included. The number of cameras in use by the remaining Police forces is unknown.

Both fixed and mobile speed camera operations operate overtly in the UK. Indeed, new camera visibility rules were introduced in June 2002 to further increase the visibility of speed camera operations. These rules required that camera housing be yellow and visible from specified distances from the camera sites. There was a clear intention that drivers be aware of the location of the cameras. In March 2003, there was a High Court challenge to this requirement, on the grounds that the increased visibility reduced the ability of the cameras to have an effect on speeds beyond the camera sites because the element of unpredictability was reduced. This challenge was withdrawn in Court and the rules remain in place.

The minimum enforcement threshold for the UK speed camera program is 10% of the speed limit plus 2 mph (3 km/h), i.e. the camera can detect speeding at 35 mph (56.4 km/h) and above in the 30 mph (48 km/h) speed limit zones commonly used in urban areas. All speeding offences attract a fixed fine penalty, which is currently £60, and three demerit points (accumulation of 12 points in a three year period leads to licence loss, as in Victoria). There is a proposal to increase the fine for speeding offences 15 mph or greater in excess of the limit, but currently there is no escalation of the fine or points for higher levels of speeding, unlike the situation in Victoria (see section 5.13).

A cost benefit analysis of the speed camera program in ten police force areas conducted in 1996 (Hooke et al.) determined that accidents at the speed camera sites fell by 28% following the installation of the cameras. The speed of vehicles at camera sites also decreased by an estimated average of 4.2 mph (6.8 km/h) at each site. In financial terms the cost incurred in installing the cameras were returned five-fold after one year of operation. After five years, the speed cameras had generated a return 25 times the initial investment. The benefits were predominantly reductions in crash costs. Further, the fine revenue from the cameras in nine of the ten Police Force areas studied, was sufficient to cover the recurrent costs associated with the speed cameras. This demonstrated that the speed camera program operating in this form led to reductions in road trauma and was cost beneficial. It was noted, however, that the full benefits of speed cameras were not being achieved due to budgetary constraints. It was also noted that the fine revenue could cover the costs of an expansion in the program.

In response to a recommendation of the 1996 study concerning the constraints being placed on expanding the camera enforcement activity by the costs of cameras and their operation, the relevant authorities agreed to allow a two-year trial in eight areas of Great Britain in which the costs of camera enforcement and prosecution could be recovered from fine revenue. The trial commenced in April 2000 and as expected this resulted in increased enforcement in the trial areas. These areas were chosen to achieve a balance between geography, crash history and different enforcement strategies and technologies. In each area an operational partnership was formed to run the "safety camera scheme" comprising the police force for the area, the highway authorities and the courts. The term "safety cameras" is used as a generic term to include both speed and traffic light cameras used in the partnership areas, but the majority are speed cameras.

The impact of the increased funding for speed camera operations was examined in terms of both reductions in speed and casualty crashes during the trial. The results from the first year were so encouraging that the U.K. government took the decision to extend the system nationally before the pilot phase was completed (Gains et al., 2003).

The results from the first two years in the pilot areas allowed the effects of the fixed and mobile cameras to be compared (Gains et al., 2003). The fixed cameras being permanent could be expected to affect speeds and crashes at all times, but the mobile cameras may have an effect only at the time they are present and for a period thereafter. (However the study examined effects throughout the year at mobile camera locations; it is not known how frequently each mobile site was enforced.)

Over the full two years, average speed at camera sites fell by 10% or 3.7 mph (6 km/h). The decrease in average speed was slightly greater at fixed camera sites, but there was a much greater fall in the proportion of vehicles speeding at fixed camera sites (67%) than at mobile camera sites (37%). When excessive speeding was examined (exceeding the speed limit by more than 15 mph), the proportion of vehicles fell by 96% at fixed camera sites and by 55% at mobile camera sites.

Serious casualty reductions were also somewhat smaller over the full two years (35% reduction in fatal and serious injuries at camera sites), but the results showed that the reduction was greater at fixed camera sites (65%) than at mobile camera sites (28%), as could be expected given the relative magnitudes of the speed behaviour changes. The crash effects were similar in urban and rural areas, with pedestrians being particular beneficiaries of the program (56% reduction in fatal and serious injuries at camera sites). It should be noted that at mobile camera sites crash data for the whole two year period was used and not just those crashes occurring at a specified time after mobile camera activity at a site.

The effects of the overt cameras appeared to generalise across the whole of the trial areas, with the average number of fatal and serious injuries in each area being 4% below the long-term trend in serious road trauma in the rest of Great Britain. While the camera sites are located in speed-related “accident hot spots”, the density of their locations and/or their threat to speeding motorists appears to be sufficient to produce a general effect which extends beyond the camera sites.

The study also found that public support for the use of speed cameras was consistently high throughout the period, with 80% agreeing that “cameras are meant to encourage drivers to keep to the limits not punish them”. It also found that the system was successful in redirecting £20 million of fine revenue to local areas to fund the camera operations, and that there were benefits to society, in terms of the value of road casualties saved, of £112 million during the first two years of the program in the trial areas.

Sweden

Trials of fixed position speed cameras were conducted in Sweden from 1990-1992. Eight roads with speed limits of 90 km/h and eight roads with speed limits of 50 km/h were each fitted with two fixed position speed cameras. Signs advising drivers of the use of speed cameras were also used on these road sections.

The average speed of vehicles travelling on the treatment roads was reduced by approximately 2.3 km/h. The speed reduction at the camera sites themselves was estimated to be between 5 and 10 km/h. In addition to these reductions in speed, casualty crashes were estimated to have fallen by 5 percent and the number of casualties involved in collisions fell by an estimated 9 percent. However, it is noted that these results are not statistically significant.

3.2.3. Discussion

In the above three studies the evaluation of fixed speed camera technologies has been conducted primarily in terms of reductions in average speeds and casualty crashes. The UK study also conducted a comprehensive cost-benefit analysis of the program.

Prior to drawing conclusions based on the above research it is necessary to note the differences in the programs discussed. First, the operation of fixed speed cameras in Victoria remains semi-covert. In contrast, the existence of fixed position speed cameras in the UK and Sweden are heavily sign-posted. In addition, the road environment in which the different programs operated did vary somewhat. The use of fixed speed cameras in Victoria is currently restricted to use in tunnels and urban freeways (with rural freeways to be included soon). The UK and Swedish operations were not so restricted in their operation.

Despite these differences a number of conclusions and strategic principles can be proposed.

Strategic Principles

1. *The use of fixed speed cameras to address specific areas in which casualty crash frequency or excessive speed is high is a cost effective means of reducing both casualty crashes and average speeds around the camera sites.*

2. *The use of a high number of fixed speed cameras can result in casualty crash reductions across the road network.* That is, these reductions are not restricted to the camera sites themselves.

3. In general, fixed speed camera programs result in reductions in both average speeds and the proportion of vehicles exceeding the speed limit by more than 15km/h. *The effect of fixed speed cameras on 'high end' speeders is substantial.*

4. Fixed position speed cameras can operate effectively in a number of environments including tunnels and low and higher speed roads.

3.3. POINT-TO-POINT SPEED CAMERAS

Point-to-point speed measurement devices do not currently operate in Victoria. However, the Hume Highway has been identified as a potential route on which to use this technology. The technology uses a number of cameras mounted at staged intervals along a particular route. The cameras are able to measure the average speed between two points or the spot speed at an individual camera site. In order to measure the average speed between two points the cameras must be linked to one another and the time clocks on both machines must be synchronised. The average speed is then determined by dividing the distance travelled by the time taken to travel between the two points. The distance between two camera sites may vary from as low as 300 meters to up to tens of kilometres. An enforcement threshold may also be implemented to allow for acceptable variations in driver speed along the route. However, the speed limit and enforcement threshold set for these roads need to be considered in light of the accuracy of the available technology and the type of speed being measured. Potentially, however, a lower enforcement threshold could be considered for the average speed measured by this technology than the spot speeds measured by mobile and fixed speed cameras.

Although point-to-point speed camera technology has not yet been introduced for use on Australian roads, the equipment has been trialled in the Netherlands. The trial involved the installation of three cameras along a major motorway with high traffic volumes. Vehicles passing each of the camera sites were photographed and an electronic image processing device was used to match records of the same vehicle. The cameras were located 750 m and 2.25 km apart. If the average speed of vehicles between the camera sites (determined by the distance/time relationship) was in excess of the speed limit, infringement notices were issued. No study of the effectiveness of the Dutch trials in terms of speed or crash effects is currently available.

In the U.K., the first implementation of point-to-point camera technology, using digital imaging, was installed on Nottingham’s main link road from the M1 Motorway in July 2000, as part of the trial program of additional speed cameras in eight Police areas (see section 3.2.2). The evaluation of the trial found that fatal and serious injuries fell by 31% at camera sites in the Nottingham area, and that the results from the point-to-point camera site were not significantly different from the general effect (Gains et al., 2003). In a comparison with traditional wet-film spot-speed fixed cameras, Keenan (2002) found that reported casualty crashes at the Nottingham digital camera site fell from 33 during the year before installation to 21 during the year after, a reduction of 36%. In contrast, crashes at the spot-speed camera sites studied appeared to increase, but not statistically significantly so.

The Nottingham point-to-point camera system was manufactured by Speed Check Services (SPECS) and consisted of two digital cameras located approximately 0.5 km apart on a 40 mph (64 km/h) limit urban ring road. SPECS systems have been used at other locations in Great Britain, sometimes using more than two linked cameras, including other urban links and rural main road sites.. The SPECS web-site claims that, at the original Nottingham site, there was 5-6 mph (8-10 km/h) reduction in speeds, 40% reduction in serious injuries, and 30% reduction in slight casualties during the two years after installation.

Commenting on the relative merits of the new technology, Keenan (2002) noted that the spot-speed fixed cameras have a site-specific effect whereas the point-to-point camera system has a link-long influence on drivers and their speeds. The new technology achieves speed enforcement along a whole length of road by calculating a driver’s average speed over the link. The overt nature of the operations in the U.K. would result in drivers knowing this.

Keenan (2002) also noted from his study that “around the [spot-speed camera] sites a significant proportion of the drivers observed manipulated their behaviour in close vicinity to the installations, suddenly applying their brakes 50 metres before the camera and then promptly accelerating away from it. Most alarming was the fact that the accident statistics at some of the [spot-speed camera] sites had worsened since the camera installation”. While the crash data were probably too few for Keenan to claim that the situation had worsened, it is possible that any speed and crash reduction benefits at the overt fixed spot-speed camera sites were eroded by some drivers behaving in the way Keenan suggests. However, given the policy in the U.K. of making fixed camera sites conspicuous and the placing of advance camera warning signs a requirement of the scheme, there should be less likelihood of drivers being taken by surprise. This effect may be even less likely to be a significant consequence of the point-to-point camera systems.

However, the relative cost of the two types of fixed camera systems is a disadvantage. Keenan (2002) estimated that a typical spot-speed wet-film speed camera cost £45,000 to install, whereas the single point-to-point system in Nottingham cost £136,400 to install, a three times factor. The SPECS web-site estimated that a traditional camera costs about £40,000, whereas a pair of SPECS digital cameras costs £70,000 and requires at least another £100,000 for the computer network to support it.

3.4. RED-LIGHT CAMERAS

3.4.1. The Victorian Situation

Red light cameras were first introduced to Victoria in a six-month trial of the technology conducted in 1981. In August 1983, ten new red light cameras were purchased and commenced operations throughout Victoria. There are currently 35 red light cameras operating throughout metropolitan Melbourne and these cameras rotate through 132 red light camera sites. The red light cameras operate by taking two photographs of a vehicle as it passes over the detection loops imbedded in the road surface. The first captures the rear of the vehicle and will enable it to be identified. The second is used to determine whether the vehicle continued into the intersection after passing over the detection mechanism. It is noted that the camera only operates when a vehicle passes over the detection loop 0.9 or more seconds after the traffic lights have turned red.

Red-light camera sites are selected on the basis of the crash history at individual sites. Three or more ‘cross traffic type’ collisions must have occurred at an intersection over the preceding five years in order for a red-light camera to be installed at that intersection. The rotation of cameras through sites is determined on the basis of crash history, offence frequency, equipment and site availability, and operator knowledge of intersections. Further, the operation of the red light cameras is no longer entirely overt in nature. In the past, each red light camera sight was sign posted on all legs of the intersection regardless of whether a camera was in operation at the time. Such signage is no longer required.

3.4.2. Research on the effectiveness of red-light cameras

There has been only limited research conducted on the effectiveness of red-light cameras both in Victoria and internationally. Below the results of evaluations of the Victorian, U.K. and Californian red-light camera programs are presented.

Victoria, Australia

An evaluation of the effectiveness of the red-light camera program using crash data from 1981 to 1986 has been conducted examining the impact of the program on various crash types (South et al., 1988). During this time, 46 sites were in operation and cameras rotated between these sites. The results of this study indicate that the proportion of right-angle crashes occurring at treatment sites decreased by an estimated 32% over this period. (Right-angle crashes are defined as those crashes in which vehicles approaching from adjacent arms of an intersection collide at right angles.) No statistically significant reductions in other crash types were identified in this study. Although non-significant, the results suggests that rear-end collisions also decreased after the introduction of the red-light camera program. This surprising result is explained by the authors as a result of vehicles approaching treatment intersections at lower speeds than previously and thus reducing the likelihood of a crash. Overall, the number of casualties involved in collisions at the treatment sites decreased by an estimated 10.4%. Further, accident cost savings of 13.8% were estimated to have been generated by the red-light program.

United Kingdom

The use of red-light cameras in the UK in now widespread. In 1996, 254 red-light camera sites were in operation in10 of the 43 Police forces in England and Wales. A total of 102 cameras were available for use, however, these were distributed between both speed and red-light camera sites. The use of the red-light cameras were associated with an 18% reduction in casualty crashes at the camera sites (Hooke et al., 1996). The cost benefit analysis of this technology also produced positive results. Within a year of implementing the program the majority of sites had more than recovered the cost of the initial investment. Within five years the program had returned twelve times the initial investment.

California, USA

The red-light camera program introduced in July 1997 in Oxnard, California has also been the subject of an evaluation study (Retting et al., 1999). This program involved the installation of nine red-light cameras and numerous signs throughout the city warning motorists of automated enforcement at signalised intersections. The penalty for failing to obey the traffic signals was a financial penalty of $104 and one demerit point on the driver's licence. A one month warning period operated prior to full enforcement during which no penalties were issued.

The results of the study indicate that the proportion of vehicles offending at both camera and non-camera sites decreased by approximately 42% in the four months following the introduction of the program. The proportion of vehicles offending at control sites, located outside the city of Oxnard, did not change significantly during the evaluation period. This suggests that the effect of the speed camera program extended beyond the treatment sites to other nearby intersections in the city of Oxnard. The reductions in offence rates within Oxnard were associated with a 29% reduction in casualty crashes at signalised intersections. In addition, the frequency of rear-end collisions did not increase significantly. These results are consistent with those of the Victorian study, however, it is noted that this study is limited to the effects of the camera program in the four months following the implementation of the speed camera program. Therefore, no conclusions can be drawn from this study about the long term impact of the program on crashes associated with red-light running.

Strategic Principles

In considering the above evaluations, it is noted that the red-light camera programs discussed above, were conducted at a time when signage always accompanied the automated enforcement at signalised intersections. In Victoria such signage is no longer required and the use of red-light cameras has become more covert in nature. Therefore, the following conclusions must be read with this in mind.

1. *The overt use of red-light cameras can lead to statistically significant reductions in all crash types at treated intersections*. Some limited spill-over effect may also exist leading to reductions in casualty crashes at nearby intersections.

2. The use of red-light cameras does generate accident cost savings. In addition, *formal cost benefit analysis demonstrates that the overt use of red-light cameras is cost beneficial*.

3.5. RED-LIGHT/SPEED CAMERAS

As detailed previously, the use of speed and red-light cameras in Victoria has been wide spread over the past decade. However, during 2002, a trial of new red-light/speed camera technology commenced. Combined red-light/speed cameras are capable of operating simultaneously as both red-light and speed cameras. The devices are installed in fixed housings at signalised intersections and it is expected that they will be capable of rotation through a number of designated sites.

During the green and amber phases of traffic signals the cameras operate as fixed position speed cameras only. That is, they are able to assess the speed of vehicles passing through the intersection and capture images of those vehicles detected exceeding the speed limit. During the red-light phase, the cameras continue to operate as speed detection devices. However, in addition, they are able to capture vehicles entering the intersection against the red light. It therefore becomes possible to generate two infringement notices related to the same event in the case of vehicle entering the intersection against the signal at a speed in excess of the posted speed limit.

Trials of this technology are currently being conducted in Victoria using a mixture of wet-film and digital technology. The digital cameras are capable of operating without a flash and ensure that the operations are conducted as covertly as possible. However, it is believed that further refinements of the digital technology are required before the use of wet-film cameras can be eliminated.

As the use of combined red-light/speed cameras is only just commencing in Victoria, no evaluation of the effectiveness of these devices in reducing offence rates has been conducted. However, it is assumed that the mechanisms which drive the individual speed and red-light camera programs will also apply to the operation of the combined technology.

4 INTELLIGENCE BASED SCHEDULING OF SAFETY CAMERAS

4.1. THE VICTORIAN SITUATION

In Victoria, there are currently approximately 4,300 authorised speed camera sites. Of these approximately half are actively in use. The scheduling of mobile safety camera operations at these sites is of importance to the overall effectiveness of the program. To achieve the target of 6,000 enforcement hours per month across Victoria, the enforcement resources must be allocated across time and space.

The target number of enforcement hours to be conducted on each day of the week is determined centrally by the Traffic Intelligence Unit (TIU) of Victoria Police. The proportion of enforcement operations to be conducted on each day of the week corresponds to the proportion of casualty crashes occurring on that day over a one-year period ending three months prior to the planned enforcement operations. The time of day at which the enforcement is to take place is also determined by previous crash history at that time of day. The recommendations of the TIU are distributed to individual Traffic Management Units (TMUs) to enable them to schedule operations at individual locations in line with the recommendations.

At the TMU level no definitive guidelines exist to determine the placement of the speed cameras. However, the speed camera locations must be chosen from the pool of active sites. This pool of sites has developed over time and each of the active sites must meet the criteria set down in the Victoria Police Speed Camera Policy & Operations Manual. In brief, this requires that a site have a recent history of speed-related collisions or a written complaint concerning excessive speeds. Further, the physical characteristics of the site must be such as to enable efficient operation of the speed camera technology and minimise public complaints. It is noted that these guidelines apply only to the operation of mobile speed cameras. If the Senior Sergeant of a TMU believes that these criteria are met, the site can be submitted to the TIU for approval. In general, this process takes approximately six weeks and the site cannot become active until this process is completed.

In addition to contributing to the selection of new speed camera sites, Senior Sergeants or Sergeants of individual TMUs must schedule speed camera operations by the location and time of day. This must be completed in the context of the advice from the TIU regarding the intensity of operations on each day of the week. The general guidelines governing site selection are set out in the Victoria Police Speed Camera Policy & Operations Manual. This states that TMU Senior Sergeants and Sergeants ‘must still target high-risk behaviour, accident locations and subsequently allocate resources in such a manner as to ensure the maximum possible benefit in crash reduction whilst increasing the deterrent effect’. Nevertheless, it does not appear that more specific guidelines than these exist.

In general, it is believed that TMUs rely primarily on crash statistics to determine the geographic location of the speed cameras. In particular, it appears that sufficient data is available to provide each TMU with the locations in their area involving the highest number of crashes over the previous 12-month period. Further, some TMUs have implemented a system to provide feedback on the number of vehicles assessed and offences detected during each camera session. This information is then used to ensure that the maximum deterrent effect is achieved.

Once a proposed schedule of operation is complete, it is submitted to the Regional Traffic Inspector and subsequently the TIU on the 7th day of the month prior to the month to which the schedule applies. This allows sufficient time for the schedule to be forwarded to LMT who are responsible for the allocation of operators and vehicles to each camera session.

Using this method of resource allocation, the mobile speed camera program has achieved the positive results detailed in section 3.1.1. A general effect on serious crashes has apparently been achieved across the broader road network, although the camera locations and times have been chosen to reflect recent crash patterns and evidence of excessive speeds in time and space.

Zaidel (2002), in a comprehensive review of the impact of enforcement on crashes, has noted that most police traffic agencies plan their deployment according to a “black spot approach” and/or “black time approach”. Most experts advise the police to do this, as it appears consistent with good management principles. Zaidel notes that the approach is responsive to public concerns and can have, sometimes, immediate benefits at the specific locations. He suggests, however, that it is not necessarily a good guide for routine and sustained traffic enforcement aimed to raise compliance over the entire network, at all times.

4.2. ALTERNATIVE SCHEDULING METHODS

The major alternative to the method of scheduling mobile speed camera operations described previously, is the randomisation of the allocation of resources. This method is based primarily on the application of general deterrence theory. That is, this method aims to ensure that the perceived risk of detection amongst road users is high at all locations and times. In turn it is expected that any speed and casualty crash reduction will occur across the whole road network.

Queensland has successfully implemented this method of scheduling enforcement operations and the details and outcomes of the program are discussed below.

The Random Road Watch program (RRW) of traffic policing was introduced during December 1991 in the rural areas of the Southern Police Region of Queensland. Since that time the program has been extended and it now operates throughout the state. The program aims to allocate enforcement resources in a random way so as to maximise road safety benefits. In addition, the randomisation of the timing and location of visible road safety enforcement enables police to cover larger parts of the road network than would be the case with conventional policing and road users are less able to predict the location and timing of enforcement activities.

This approach is implemented by using the existing Police structure of regions and districts to select a number of road segments (approximately 40) that will be the subject of enforcement. These road segments are chosen to ensure that roads covering over 50 percent of all road crashes are included in the program. The next stage of implementation involves dividing each day into 2-hour segments for enforcement between 6 am and 12 midnight. No enforcement takes place between midnight and 6 am each day. A random selection of sites and times is then selected for enforcement activities. The number of hours per week required by each Division is tailored to match Police resources available within each Division. Actual enforcement is conducted conspicuously from marked Police vehicles.

The RRW program was evaluated in terms of the effect of its implementation on crash frequency over the period of December 1991 to July 1996 (Newstead et al., 1999).

The analysis indicated that for all non-metropolitan areas of Queensland the RRW program resulted in statistically significant crash reductions at all severity levels. The crash reductions increased as the severity level of the crash increased. Examining crash reductions for rural and urban areas separately produced some interesting results. In rural areas, there was a statistically significant 34% reduction in fatal crashes but reductions in other crash categories were not statistically significant. On the other hand, urban areas experienced crash reductions for all categories except fatal crashes. However, the failure to identify statistically significant reductions in fatal crashes may be due to insufficient data.

In addition to the variation between metropolitan and rural areas, the outputs and crash effects of the program differed across Police regions. The relationship between the outputs of the program, such as the number of hours of enforcement, and the crash effects of the program in each region was investigated with the aim of determining the mechanisms that drive the program. Significant variations in the offences detected per crash treated and enforcement hours per crash treated were identified across regions. Treated crashes are defined as crashes in the year prior to the introduction of RRW on routes and in time bands enforced by RRW. It was found that the crash coverage of the program, (i.e. the percentage of previous crashes in the region covered by the program) was positively related to both the total number of crashes saved and the percentage of crashes saved in the region. The analysis also indicated that total crashes saved and the percentage crash savings are positively related to offences detected and hours enforced, however, these associations were not statistically significant.

The effects of the program over time have also been analysed. The results show that the effect of the RRW program on all crash types except those involving fatalities has increased over time. The effect of the program on fatalities appears to be fairly consistent across the three years immediately following the implementation of the scheme.

It is noted that similar programs have been conducted in other jurisdictions and although the outcomes of these are not conclusive they indicate that reductions in crash frequency can be achieved by implementing randomly scheduled police enforcement.

Conclusions and Strategic Principles

1. Random scheduling of enforcement operations has successfully produced statistically significant crash reductions at all severity levels in non-metropolitan Queensland. The effect of the program in metropolitan areas has been more difficult to assess. Further, this effect has increased over time for all crash types (except those involving fatalities, for which the effect was approximately constant).

2. From point 1 above it is concluded that, *randomising the time and location of police road safety enforcement can have significant positive effects on the number of crashes reported and this effect has been shown to increase over time.*

3. The positive effect of the RRW program on crashes of various severities in both rural and urban areas indicates that, *such a program may be as effective in lower speed areas as on open highways*.

4. The statistically significant association between program coverage and crash effects indicates that in operational terms, wide spread but perhaps less intense, randomised enforcement will result in greater crash effects than more intense but less diverse coverage. That is, *the coverage of a randomised enforcement program is a key contributor to its effectiveness*.

5. *Analysis of similar programs in other jurisdictions suggests that the results experienced in Queensland could be reproduced elsewhere.*

5 DETERRENCE VALUE OF THE SAFETY CAMERA PROGRAM

To the extent that available information allows, the deterrence value of the Victorian safety camera program is assessed in the following sections by consideration of:

- the principal road trauma problems addressed by this enforcement (speeding and red-light running),
- the number of serious casualty crashes targeted by each offence detection technology,
- the likely effects on these crashes,
- the influence of the timing and severity of penalties, and
- the supporting role of mass media publicity.

The overall effect of the safety camera program is also discussed in relation to the objectives of achieving maximum road safety benefit and continuing to build on the positive outcomes achieved by enforcement programs in Victoria over the last ten years.

5.1. THE PROBLEM OF SPEEDING

The problem due to speed of vehicles on Victoria's roads can be categorised as follows:

- Increased crash risk due to inappropriate speed for the conditions (but not in excess of the regulated or sign-posted speed limit of the road zone)
- Increased crash risk due to illegal speed (risk dependent on the amount in excess)
- Increased risk of severe injury in crashes due to the kinetic energy of vehicles

It is not generally possible for police to focus enforcement resources on inappropriate speeds. However, safety cameras could be used to enforce speed limits which have been varied to lower levels due, for example, to weather conditions, the presence of numerous pedestrians, or high traffic densities. The principal responsibility for variable speed limit technology lies with VicRoads. When used, police can then focus on increased crash risk due to illegal speed, in much the same way as enforcement focuses on speeds above fixed speed limits.

5.1.1. Crash risk related to speed

The risk of crash involvement for vehicles travelling at free (unimpeded) speed has been calibrated for each speed level in urban and rural South Australia. The initial study estimated the relative risks of casualty crash involvement, relative to a speed of 60 km/h, in 60 km/h speed zones in urban Adelaide (Kloeden et al., 1997). The casualty crashes were those resulting in an injury severe enough to require ambulance transport, and were thus more severe than those crashes requiring a Police report because someone was injured to any degree. Five percent resulted in a fatality, 28% in hospital admission, and the remainder involved treatment at hospital. This well-known study found that the risk of a (relatively severe) casualty crash approximately doubled for each 5 km/h increase in free speed above 60 km/h, but found inconsistent estimates for the risk associated with free speeds below 60 km/h.

A recent re-analysis of this study has fitted smooth risk relationships to the data, resulting in more reliable risk estimates, especially at the lower speeds (Kloeden et al., 2002). The relationship fitted to the absolute speeds in urban 60 km/h speed zones is shown in Table 2. The relationship of the same type fitted to the difference from average speeds (which was 58.8 km/h overall in 60 km/h zones) produced similar results.

Table 2: Relative risk of involvement in casualty crash, related to free travelling speed in urban areas (60 km/h zones only) and rural areas (speed zones of 80 km/h and above). Source: Kloeden et al (2001, 2002)

URBAN AREAS		RURAL AREAS	
Speed in 60 km/h speed zone (average speed = 58.8 km/h)	**Relative risk of casualty crash involvement[1]**	Difference in speed from average speed in rural speed zone	**Relative risk of casualty crash involvement[2]**
45	0.27	n.a.	n.a.
50	0.39	-10	0.54
55	0.60	-5	0.72
60	**1**	**0**	**1**
65	1.82	5	1.45
70	3.57	10	2.20
75	7.63	15	3.49
80	17.66	20	5.77
85	44.36	25	9.96
90	120.82	30	17.94

[1] Crash resulting in an injury severe enough to require ambulance transport

[2] Crash resulting in someone being treated at hospital or killed

The second study calibrated the risk relationship for vehicles travelling at free speed in rural speed zones of 80 km/h or greater (Kloeden et al., 2001). The majority of the crashes (52%) occurred in 100 km/h zones, with 25% occurring in 110 km/h zones and 21% in 80 km/h zones. Because a variety of speed zones were covered in this study, the risk estimates were calculated for the difference in speed from the average speed in the speed zone. (It could be expected that the average speed is about the same as the speed zone limit in each environment.) The crashes considered were those in which someone was treated at hospital or killed, and thus were more severe than those crashes requiring a

Police report because someone was injured to any degree. Twenty-three percent resulted in a fatality, 46% in hospital admission, and the remainder involved treatment at hospital. The relative risks of involvement in these (relatively severe) casualty crashes are also shown in Table 2. The study did not provide an estimate of the risk for vehicles travelling 15 km/h slower than average.

Table 2 indicates that the risk of casualty crash involvement rises more rapidly for speeds in excess of the speed limit in urban areas than it does in rural areas. However the probability of the crash resulting in death or hospital admission (serious injury) is likely to be greater in rural areas because of the higher travelling speeds and hence impact speeds. The relationship of injury severity in crashes to travelling speed has not been fully covered by the risk estimates in Table 2 and will be covered in the following section.

5.1.2. Injury severity in crashes

A MUARC study has matched the crashed vehicles in the initial South Australian urban study (Kloeden et al., 1997) with Police accident reports on the same crashes (Diamantopoulou et al., 2002). This has allowed examination of the injury severity of persons occupying or hit by the vehicle whose free travelling speed before crashing was estimated. The injury severity of these casualties generally increased with the travelling speed, as expected (Figure 2).

The injury severity distribution in Figure 2 was used to adjust the urban casualty crash risks from Table 2 to estimate the risks of a serious casualty crash (ie. a crash resulting in fatality or hospital admission) given in Table 3. The risks were estimated for vehicle speeds in illegal speed categories related to the levels at which monetary and demerit point penalties change in Victoria, the previous speed offence threshold level (10 km/h in excess), and a lower level (5 km/h in excess) considered to be the tolerance level likely to be most acceptable by the community on urban roads (see Section 6.4).

There were too few fatal crashes (8) to reliably estimate fatal crash risk, and too few cases to provide reliable estimates of injury severity for speeds in the 61-65, 66-70 and 71-75 km/h ranges separately. The injury severity in crashes involving vehicles travelling in each illegal speed category is shown in the third column of Table 3 and the relative injury severity in the fourth column. The serious casualty crash risk (relative to that at 60 km/h) is the product of the casualty crash risk (second column: ex Table 2) and the relative injury severity.

Figure 2: Injury severity related to travel speed before impact

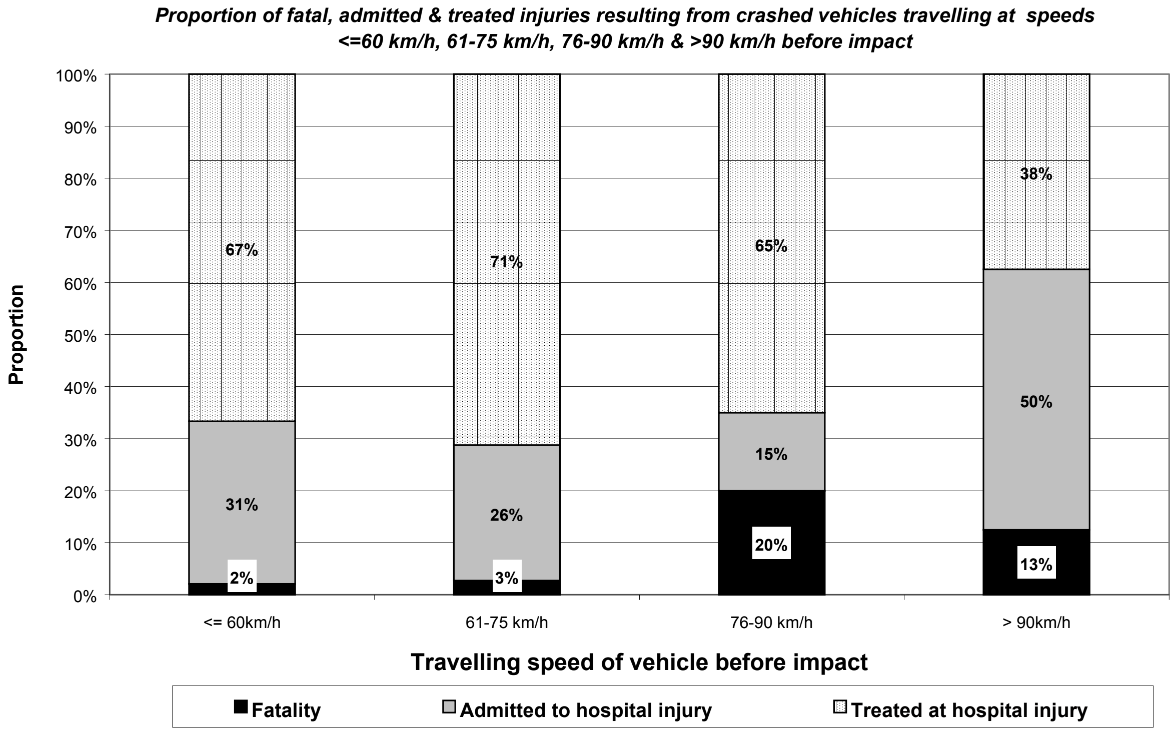


Table 3: Estimation of the risk of involvement in a serious casualty crash, related to speed categories in excess of the 60 km/h limit in urban areas

Free travelling speed in excess of 60 km/h limit (km/h)	Casualty crash risk (relative*)	Injury severity (% resulting in fatality or hospital admission)	Injury severity in casualty crash (relative**)	**Serious casualty crash risk (relative*)**
1 – 5 km/h	<= 1.82	28.8	1.0	**<= 1.82**
6 – 10 km/h	1.82 – 3.57		1.0	**1.82 – 3.57**
11 – 15 km/h	3.57 – 7.63		1.0	**3.57 – 7.63**
16 – 30 km/h	7.63 – 120.8	35.0	1.22	**9.31 – 147.4**
Over 30 km/h above limit	> 120.8	62.5	2.17	**> 262.1**

* Relative to travelling at 60 km/h (in urban area).

** Relative to injury severity (proportion resulting in fatality or hospital admission) at 61-75 km/h

This analysis shows that there are substantially increased risks of a serious casualty crash associated with travelling speeds more than 15 km/h above the limit in urban areas, especially for speeds more than 30 km/h above the limit. The extent of crashes resulting from drivers travelling at these speeds, and hence the potential for safety cameras to produce reductions in serious casualty crashes in urban areas, will be examined in the next section.

An analysis has not been conducted of the injury severity resulting from casualty crashes in rural areas, related to travelling speed. Hence it is not yet possible to adjust the rural casualty crash risks in Table 2 to estimate the serious casualty crash risk associated with various illegal speeds. However, given that the rural relative risks already relate to the probability of severe casualty crash involving hospital treatment (69% resulting in death or hospital admission), to a large extent the rural risks in Table 2 can be considered to represent the risks of a serious casualty crash related to speed.

5.1.3. Potential reductions in crashes at various illegal speeds

Based on the risks of casualty crash involvement in 60 km/h speed zones given in Table 2, Kloeden et al (2002) estimated that there would be a 44.3% reduction in free speed casualty crashes if all vehicles complied with the 60 km/h limit. A fundamental assumption was that the drivers who formerly travelled at the illegal speeds would have the reduction in risk related to their speed reduction, ie. their former risk was not related to other driver characteristics.

The percentage reduction in each illegal speed category is shown in Table 4. When the casualty crash reductions were adjusted by the relative injury severity related to speed, the contribution to serious casualty crash reductions from the higher illegal speeds is much greater. If speeds in excess of 15 km/h above the 60 km/h limit could be reduced to the limit, Table 4 indicates that there would be a 28.9% reduction in serious casualty crashes. In contrast, reducing speeds 6-15 km/h in excess to the limit would produce a 19.4% reduction in serious casualty crashes. It is not expected that safety cameras could reduce serious casualty crashes associated with speeds within 5 km/h of the limit (the likely acceptable tolerance on urban roads).

Table 4: Expected percentage reduction in free speed crashes if drivers in each speed category complied with the 60 km/h limit

Free travelling speed in excess of 60 km/h limit (km/h)	Reduction in casualty crashes	Relative injury severity in the casualty crashes	**Reduction in serious casualty crashes**
1 - 5 km/h	6.8 %	1.0	**6.8 %**
6 – 10 km/h	11.2 %	1.0	**11.2 %**
11 – 15 km/h	8.2 %	1.0	**8.2 %**
16 – 30 km/h	12.9 %	1.22	**15.7 %**
Over 30 km/h above limit	6.1 %	2.17	**13.2 %**

The crash reductions estimated in Table 4 relate to the situation in urban Adelaide during 1995-1996 when Kloeden et al's (1997, 2002) data was collected. Speed observations collected from their sample of non-crash involved vehicles showed that 42.1% exceeded the 60 km/h limit, 3.0% exceeded 70 km/h, and 0.5% exceeded 80 km/h There were too few to estimate the proportion exceeding 90 km/h. Recent speed observations in 60 km/h speed zones in Melbourne during May 2000 to October 2001 showed that 40.4% exceeded the limit, 8.1% exceeded 70 km/h, 1.0% exceeded 80 km/h, and 0.18% exceeded 90 km/h. Thus the crash reductions expected from Table 4 if drivers complied with the limit are expected to be somewhat greater in urban Victoria than in South Australia.

The substantial potential crash reductions from drivers travelling at excessive speeds, in contrast with their relatively small proportions on the road in 60 km/h zones, is illustrative of the very high risks associated with these speeds, especially the risk of a serious casualty crash (Table 3).

Kloeden et al (2001) in their analysis of rural crash risks related to speed did not provide such a detailed analysis of the expected crash reductions if drivers complied with the rural speed limits. However, they did estimate an overall 23.8% reduction in free speed casualty crashes if all drivers complied, based on the same assumptions as their urban study. It should be noted that their rural casualty crashes were relatively severe, so this estimate could be expected to be comparable with expected reductions in serious casualty crashes in 60 km/h zones shown in Table 4. Thus it can be seen that there is greater potential percentage reduction in serious casualty crashes from a focus of safety cameras on urban speeding than rural speeding.

5.1.4. Casualty crash risk (by severity) related to average speeds

Nilsson (1984) developed relationships of the following form linking changes in mean or median speeds with the number of crashes:

$$\mathbf{n_A = (v_A/v_B)^p * n_B}$$

where $\mathbf{n_A}$ = number of crashes after the speed change

$\mathbf{n_B}$ = number of crashes before the speed change

$\mathbf{v_A}$ = mean or median speed after

$\mathbf{v_B}$ = mean or median speed before

$\mathbf{p}$ = exponent depending on the injury severity of the crashes:

- $\mathbf{p}$ = 4 for fatal crashes
- $\mathbf{p}$ = 3 for serious injury crashes
- $\mathbf{p}$ = 2 for minor injury crashes

These relationships were based on research linking changes in median speeds (free speeds measured in traffic surveys) with changes in crash frequencies at various injury severities, as a result of a large number of changes in speed limits on Swedish rural roads. It has been claimed that these relationships have been found for speed limit changes in urban areas (Nilsson 1992), but it is difficult to find studies which confirm this.

Other studies in urban Australia have shown contradictory results. An evaluation of the 50 km/h urban speed limits in New South Wales showed substantial reductions in crash risk (22% decrease in casualty crashes) but only about 1 km/h reduction in mean speed (RTA, 2000). In contrast, there were large (at least 70%) reductions in the proportions of drivers exceeding 70 and 80 km/h, respectively, in the former 60 km/h speed zones, suggesting that this behaviour change was the major source of the crash reductions. The interim evaluation of the 50 km/h general urban speed limit in Victoria has found a 12% reduction in casualty crashes (Hoareau, Newstead and Cameron, 2002), but only about 1 km/h reduction in mean speeds on relevant streets compared with speed changes on comparable 60 km/h streets (Ratio Consultants, 2001). An analysis has not yet been conducted of changes in excessive speeding on 50 km/h streets.

More relevant to safety camera strategy is the finding that the escalation of the use of mobile, car-mounted speed cameras in Victoria during 1990 was accompanied by little change in average speeds in 60 km/h zones but substantial reductions in the proportions of drivers exceeding 75 and 90 km/h, respectively (Rogerson et al., 1994). The evaluation showed reductions in daytime casualty crashes on arterial roads of more than 30% in Melbourne and more than 20% in rural towns associated with the speed camera program from April 1990 (Cameron et al., 1992).

Nilsson's (1984) relationships do not suggest as strong a relationship between casualty crashes and speed as Kloeden et al's (1997, 2001, 2002) findings linking casualty crash risk with free speed (Table 2). The relative risk at 90 km/h in 60 km/h zones (about 1.5 times average speed) is approximately equivalent to the 12th power of the speed ratio. Similarly, the relative risk at 130 km/h in 100 km/h zones (about 1.3 times average speed) is equivalent to the 11th power of the speed ratio. Thus Nilsson's relationships would severely under-estimate the casualty crash risk at high free travelling speeds (2nd power) if they were to be incorrectly applied in this way. Even his relationships for serious injury crashes (3rd power) or fatal crashes (4th power) would under-estimate the risk.

In addition, it is not clear how Nilsson's relationships assist safety camera or other speed enforcement strategies, since they connect casualty crashes with average speeds not illegal speeds. Speed enforcement has a principal focus on illegal speeds and, by deterring such speeds, it probably leads to a reduction in average speed. Other speed management tools (such as reduced speed limits, physical speed limiting devices, and speed discouragement communications, eg. the Victorian "Wipe off 5" campaign) are likely to be more directly effective in reducing average speeds. General reductions in speed, as measured by the average speed, would reduce the kinetic energy in any crashes which occur (perhaps for reasons unrelated to illegal speeding) and hence could be expected to reduce serious casualty crashes. However, the reduction in serious casualty crashes from a decrease in average speeds is unlikely to be as great as the potential reduction if safety cameras focused on the excessive speeds with high relative risks identified in Table 3.

5.2. THE PROBLEM OF RED-LIGHT RUNNING

While it seems obvious that red-light running is associated with a higher risk of involvement in a severe crash compared with driving through a signalised intersection with a green (or even amber) light, it has not been possible to find studies which confirm an elevated risk. This contrasts with the research confirming the increased risk of casualty crash involvement associated with levels of illegal speeding behaviour.

Two North American studies have reported a higher level of injury severity associated with red-light running crashes compared with reported crashes in general. Retting et al's (1995) study of police-reported crashes in four US cities indicated that occupant injuries occurred in 45% of red-light running crashes, compared with 30% for other crash types. Chen et al (2001) found that among police-reported collisions in British Columbia, about 54% of red-light running related collisions resulted in injuries or fatalities compared with 34% otherwise.

It is likely that crashes at signalised intersections are more frequently side impact collisions involving at least one vehicle travelling at relatively high speed, compared with crashes in other road environments. Signalised intersections may also be associated with vehicles accelerating or braking rapidly to avoid running the red light, thus leading to relatively high numbers of speed-related and rear-end crashes at signalised intersections in comparison to other crash locations. Thus it could be expected that signalised intersections in Victoria are associated with relatively severe casualty crashes for a range of reasons in addition to red-light running crashes. However, as will be seen from the data in Sections 5.3 and 5.4, this was not the case during 2000/01.

5.3. TARGET CRASHES FOR SPEED CAMERAS

The number of crashes which could be targeted by speed cameras of each type (mobile, fixed or point-to-point cameras) were estimated from crashes on each road type within each speed zone in Melbourne (as defined by the statistical division) and the rest of Victoria during 2000/01 (Table 5). This period was the most recent year for which full information on reported casualty crashes is available. The type of road was defined from the suffix of the road name (missing in 1.3% of cases), in the absence of a code representing the road hierarchy level. Similar information for fatal and serious casualty crashes, together with percentages of totals, is in Appendix A.

Table 5: Number of casualty crashes on roads in Melbourne and rest of Victoria during July 2000-June 2001, by road type and speed zone

Speed Zone	**MELBOURNE (statistical division)**				
	Freeway	**Highway**	**Road**	**Street**	**All roads**
≤ 50 km/h	2	10	169	584	765
60 km/h	125	1082	3794	3013	8014
70 km/h	42	473	684	82	1281
80 km/h	94	955	574	43	1666
90 km/h	19	36	35	1	91
100 km/h	438	159	354	14	965
110 km/h	15	3			18
Other	4	23	40	27	94
All zones	739	2741	5650	3764	12894
Speed Zone	**REST OF VICTORIA**				
	Freeway	**Highway**	**Road**	**Street**	**All roads**
≤ 50 km/h		11	43	187	241
60 km/h	3	379	583	698	1663
70 km/h	1	112	41	11	165
80 km/h	16	155	146	20	337
90 km/h	1	31	8	4	44
100 km/h	32	520	1272	79	1903
110 km/h	128	28	2		158
Other		5	28	8	41
All zones	181	1241	2123	1007	4552
				Victoria total	**17466**

The road environment in which each type of speed camera was considered most suitable to operate and in which it has been shown or is expected to be most effective is outlined below. This has allowed the minimum number of annual casualty crashes which could be targeted by the camera technology to be defined. However it is possible that the target could be somewhat larger in each case. Other, non-automatic forms of speed enforcement are also included for completeness and to confirm that all essential elements of the road system are covered.

Mobile, covert, car-mounted speed cameras have been shown to be most effective in urban areas. They are most suitable to operate on streets and roads where parked cars are not unusual and the presence of the camera-car does not betray its purpose. Clear identification of the vehicle from the image requires that the road not be heavily trafficked and at most 2-3 lanes wide in each direction. Streets and roads with speed limits up to 80 km/h in Melbourne and rural Victoria were considered the most suitable targets. Speed zones of 60 and 70 km/h on rural highways, probably in towns, were also considered suitable. Together these road environments covered 11,163 casualty crashes during 2000/01. This represented 63.9% of all casualty crashes although these roads covered only 58.0% of serious casualty crashes.

The fixed, (semi-covert) speed cameras being operated or considered for Victoria are focused on very highly trafficked freeways where it would not be feasible to park a mobile speed camera car and the high traffic volume warrants a fixed installation. Roads described as freeways in Melbourne and rural Victoria, with speed limits from 80 to 110 km/h, were considered to be suitable targets. The crashes on freeways when lower speed limits operated (see Table 5) were considered to be temporary aberrations associated with roadworks and hence not a suitable for long-term, fixed camera installation. On this basis, the target road environments for fixed cameras covered 743 casualty crashes during 2000/01. This target covered 4.3% of casualty crashes or 4.1% of serious casualty crashes.

Point-to-point speed cameras were considered most suitable for heavily trafficked roads with limited access/egress opportunities on which most traffic is making more than a local trip (ie. likely to pass through at least two monitoring points to allow average speed to be calculated). Freeways and highways with speed limits of 100 or 110 km/h in Melbourne and rural Victoria were considered likely to attract this type of traffic. These road environments covered 1,323 casualty crashes during 2000/01. They covered 7.6% of casualty crashes, but 9.9% of serious casualty crashes.

Mobile (moving mode) radar speed detection devices are generally operated on light- to moderately-trafficked, rural, two-lane, undivided roads with speed limits of 80 to 100 km/h. Such roads can be unsuitable for covert, car-mounted speed cameras because parked cars are unusual. A mobile speed camera car could be parked and used in such circumstances if the intention is to have a semi-overt presence, however the deterrence effect may not be as broad as normal covert operations in urban areas. Mobile radar operations were considered most suitable in these road environments. The target roads selected were roads with speed limits of 90 or 100 km/h, and highways with speed limits of 80 or 90 km/h, in rural Victoria and the Melbourne statistical division (which covers some non-urban areas). These roads covered 2,846 casualty crashes during 2000/01. This target covered 16.3% of casualty crashes, but 20.9% of serious casualty crashes.

Hand-held laser speed detection devices are most suitable for operation on wide and/or heavily trafficked urban major roads where parking is unusual or is banned, thus making the road unsuitable for the use of car-mounted speed cameras. Roads described as highways with 60 or 70 km/h speed limits in Melbourne were considered suitable for this type of speed enforcement. These highways covered 1,555 casualty crashes during 2000/01. They covered 8.9% of casualty crashes and 8.3% of serious casualty crashes.

A few road environments with casualty crashes in Table 5 were not considered to be obvious targets for any of the speed enforcement operations discussed. Some of these crashes appeared to be aberrant, in that the road type appeared inconsistent with the speed zone recorded, and some appeared to be associated with (probably temporary) lower speed limits. In total, these represented 429 casualty crashes (2.5% of the total). The number and percentage of crashes considered to be the (minimum) targets for each form of speed enforcement is shown in Table 6. Note that the target crashes for fixed and point-to-point cameras overlap on freeways.

Table 6: Target annual crashes for speed camera and non-automatic speed enforcement operations (based on 2000/01 reported crashes in each road environment, from Table 5)

Type of speed enforcement	**Casualty crashes**		**Serious casualty crashes**	
	No.	% of total	No.	% of total
Mobile, covert, car-mounted speed cameras in urban areas	11163	63.9 %	3163	58.0 %
Fixed, semi-covert speed cameras on freeways	743	4.3 %	221	4.1 %
Point-to-point speed cameras on freeways and highways	1323	7.6 %	540	9.9 %
Mobile (moving mode) radar devices on rural, undivided roads	2846	16.3 %	1137	20.9 %
Laser speed detectors on urban major roads	1555	8.9 %	450	8.3 %

5.4. TARGET CRASHES FOR RED-LIGHT CAMERAS (AND RED-LIGHT/SPEED CAMERAS)

The crashes which could be targeted by red-light cameras are a sub-set of those occurring at signalised intersections in Victoria (Table 7). A substantial proportion of the serious casualty crashes at signalised intersections involve a vehicle running a red light. Some of the remaining serious casualty crashes involve a vehicle travelling at excessive speed and hence could be targeted by the speed camera mode of the combined red-light/speed cameras.

Signalised intersections occur in relatively low speed zones in Melbourne and the rest of Victoria, with very few crashes in speed zones above 80 km/h. During 2000/01, 15.5% of all reported casualty crashes occurred at signalised intersections, with 13.8% occuring in Melbourne. However, only 12.3% of serious casualty crashes occurred at signalised intersections, with 11.0% occurring in Melbourne.

Table 7: Target annual crashes for red-light cameras (and red-light/speed cameras) at signalised intersections, and percentage of all reported crashes during 2000/01

Region	Speed Zone	Casualty crashes		Serious casualty crashes	
		No.	% of total	No.	% of total
Melbourrne (statistical division)	≤ 60 km/h	1668	9.5 %	401	7.4 %
	70 km/h	318	1.8 %	89	1.6 %
	≥ 80 km/h	439	2.5 %	107	2.0 %
	Other	13		2	
Rest of Victoria	≤ 60 km/h	180	1.0 %	45	0.8 %
	70 km/h	37	0.2 %	10	0.2 %
	≥ 80 km/h	45	0.3 %	16	0.3 %
	Other	1			

In general, the crashes at signalised intersections were less severe during 2000/01 than other road environments. Only 24.8% of the casualty crashes at signalised intersections resulted in death or hospital admission compared with 31.2% of all reported casualty crashes. This difference is not explained by signalised intersections being located in lower speed zones than the road sections where other crashes occurred.

The potential for safety cameras located at signalised intersections to have a substantial impact on serious casualty crashes is limited by the 12.3% share of such crashes which signalised intersections represent (Table 7). The 670 serious casualty crashes which occurred at signalised intersections during 2000/01 can be compared with the target crashes identified for the other safety camera technologies, shown in Table 6. Some of these crashes could also be the target for mobile speed cameras in urban areas (though in practice these speed cameras cannot directly deter red-light running at signalised intersections).

5.5. TARGET BEHAVIOURS FOR SPEED CAMERAS

Recent speed surveys of 60 km/h speed zones in metropolitan Melbourne covering the 18 month period from May 2000 to October 2001 have been analysed to determine the speeding behaviour of drivers in this environment. The analysis demonstrates that the majority of vehicles travelling in excess of the speed limit travel between 1 and 10 km/h above the limit (32.3% of all drivers surveyed). Approximately 7.1 percent of drivers were found to exceed the speed limit by between 11 and 20 km/h and only 1 percent exceeded the speed limit by more than 20 km/h (Table 8). Speed survey data was not available for regional areas of Victoria nor for other speed zones.

Table 8: Proportion of vehicles exceeding the speed limit in 60 km/h zones in Melbourne, by level of speeding in excess of the limit , May 2000 to October 2001

Free travelling speed in excess of 60 km/h limit (km/h)	% of vehicles observed
1-10	32.3
11-20	7.1
21-30	0.9
>=31	0.18

The speeding behaviour of drivers in a broader range of speed zones is indicated by the offence rates of drivers passing speed cameras operating in each zone during January to April 2002 (Table 9). The data cover a period when the offence threshold was generally 10 km/h in excess of the limit, so the offence rates measure the proportion of drivers travelling at that speed at speed camera sites. It can be seen that the offence rate in 60 km/h zones (3.02%) was substantially lower than the proportion observed travelling at least 11 km/h above the limit in the speed surveys (8.1%). The difference may be explained by speed reductions at speed camera sites because the camera operations are not completely covert, or by more general speed reductions associated with the increase in speed camera hours commencing August 2001 (see Section 5.6.2).

Table 9: Offence rates detected by mobile and fixed speed cameras in Victoria, January to April 2002. Fixed cameras located in the CityLink tunnels and Monash Freeway approach covered 80 km/h zones (occasionally 40 and 60 km/h limits in tunnels)

Speed Zone	Vehicles detected offending speed limit*	Vehicles assessed for speed	Percentage detected offending speed limit
40	245	7,601	3.22%
50	45,441	460,658	9.86%
60	207,595	6,880,448	3.02%
70	29,516	1,332,129	2.22%
80	69,277	9,207,239	0.75%
90	3,852	115,091	3.35%
100	19,180	1,058,406	1.81%
110	3,687	283,730	1.30%
Total	**378,793**	**19,345,302**	**1.96%**

* Offence detection threshold of 10 km/h in excess of the speed limit applied in most speed zones during this period. Reduced thresholds were announced in March 2002, but their progressive implementation was not widespread at this stage.

5.6. EFFECTS OF MOBILE COVERT SPEED CAMERAS

5.6.1. Program to 2000/01

Considerable information is available about the effects of the program of mobile, covert, car-mounted speed cameras operated in Victoria from July 1990 to July 2001 (after which the target number of hours was increased progressively from 4000 hours per month to a new level of 6000 hours by mid-2002). An integral part of the program has been the support provided by TAC speed-related mass media publicity, which is considered to magnify the deterrence effect of the speed camera enforcement.

The evaluation of the general effect of the program in 1990/91 found that it reduced low alcohol hour casualty crashes on arterial roads in Melbourne, country towns and on rural highways by 32%, 23% and 14%, respectively. The severity of casualty crashes in Melbourne was also reduced. However, when the non-arterial roads in Melbourne were also considered, the overall effect of the program in Melbourne was 21% casualty crash reduction. Other evaluation studies showed localised effects in addition to the general effect, and that the program also reduced high alcohol hour casualty crashes.

Time series modelling of serious casualty crash variations by month has provided some indication of the separate effects of the camera enforcement (represented by variations in the speeding TINs) and the supporting publicity. During 1991-1996, speed camera TINs were associated with about 15% annual reduction in serious casualty crashes in Melbourne and about 11% reduction across Victoria (Newstead, Cameron and Narayan, 1998). Speeding-related publicity was associated with 6-7% reduction per year. Assuming these effects applied throughout the period the speed cameras were operated at 4000 hours per month, the number of serious casualty crashes during 2000/01 in road environments considered as targets for the mobile cameras (Table 6) would have been about 11% greater (ie. an additional 391 crashes) without the cameras. Also, the speeding-related publicity may have made a smaller contribution.

5.6.2. Program from 2001/02

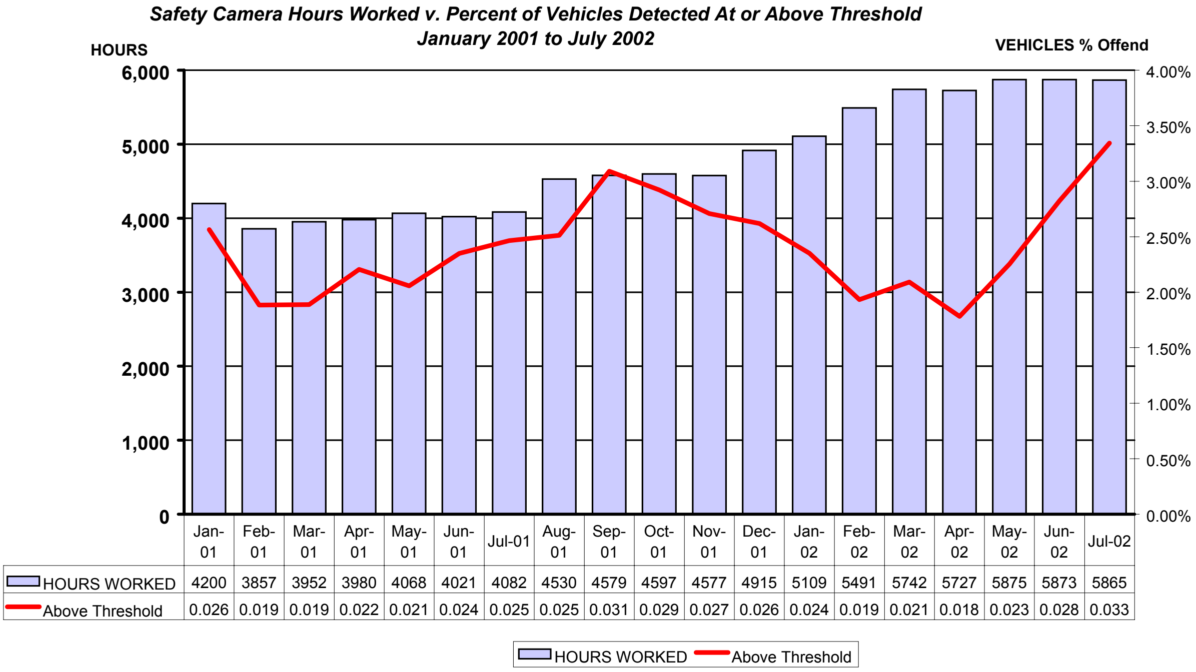
During 2001/02, the following changes have been made to the mobile camera operations:

- progressive increase in camera operating hours (from 4000 to 6000 target hours per month)
- introduction of "flashless" camera operations during daytime, use of a variety of unmarked cars, and use of new locations and times of day, all aimed at making the enforcement more covert and unpredictable to speeding drivers
- reduction in the speeding offence detection threshold from 10 km/h in excess of the speed limit in each speed zone, to an unspecified amount, in progressive stages from March 2002

The escalation in actual monthly camera operating hours is shown in Figure 3. The percentage of vehicles passing camera sites who were detected exceeding the enforcement threshold changed to a decreasing trend from October 2001, two months after the increased hours commenced. The trend changed direction again from April 2002, associated with the progressive introduction of lower tolerances. An initial increase in the percentage detected offending is expected in the short term before drivers assimilate the new tolerance levels.

None of the operational changes made during 2001/02 have yet been evaluated to measure their impacts on speeding and road trauma. However, an increase in camera hours, and the resulting increase in speeding TINs, is likely to have produced additional crash reductions because of previous findings suggesting that the principal mechanism through which the program achieves it effects is specific deterrence achieved through issuing TINs in large numbers. An economic analysis showed that an increase in camera operations up to about 6000 hours per month is cost-beneficial. On the basis that the escalated camera hours are likely to deter excessive speeders (those exceeding urban speed limits by more than 15 km/h) in the same way as the pre-2001/02 program, reductions in serious casualty crashes of up to 29% in urban areas could be achieved (Table 4). In practice, the effect is likely to be less than one-half of the overall 11% reduction achieved by the pre-2001/02 program, since the hours have increased by 50% of the previous level and diminishing returns probably apply.

Figure 3: Increased speed camera hours and effect of lower tolerances in 2001/02



	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	Oct-01	Nov-01	Dec-01	Jan-02	Feb-02	Mar-02	Apr-02	May-02	Jun-02	Jul-02
HOURS WORKED	4200	3857	3952	3980	4068	4021	4082	4530	4579	4597	4577	4915	5109	5491	5742	5727	5875	5873	5865
Above Threshold	0.026	0.019	0.019	0.022	0.021	0.024	0.025	0.025	0.031	0.029	0.027	0.026	0.024	0.019	0.021	0.018	0.023	0.028	0.033

Operational changes to make speed cameras more covert and less predictable are also likely to produce additional crash reductions. The Victoria Police trials of camera cars operating without flash units (thus making them less conspicuous) showed that both the detection rate and the number of speeding TINs issued increased by more than 50%. The New Zealand trial of operating their (normally overt) speed cameras covertly showed at least a temporary increase in detection rate and an additional reduction in casualty crashes compared with the normal program. A decrease in the predictability of camera presence is consistent with general deterrence principles and is likely to spread the general effect of the program in time and space. Thus these operational changes should enhance the effect achieved through the increase in camera operating hours. The combined effect may be greater than one-half of the 11% reduction in serious casualty crashes achieved by the pre-2001/02 program.

A reduction in the speeding offence detection threshold is expected to deter at least those drivers who travel between the old and new thresholds. While the previous threshold was well known, the new one is not. Community surveys have found that in 60 km/h speed zones a speed of up to 65 km/h is considered “tolerable” (Mitchell-Taverner, 2000), so this has been taken as the maximum tolerated speed. A reduction of up to 11% of serious casualty crashes in urban areas could be achieved if all drivers travelling 6-10 km/h above the speed limit could be deterred (Table 4). Swedish experience has indicated that speed reductions can be achieved by a reduction in the speeding threshold alone. In New Zealand, there was a 50% reduction in the proportion of drivers exceeding the (new) threshold when it was reduced. This suggests that a reduced threshold could prevent up to one-half of the crashes associated with drivers travelling 6-10 km/h above urban speed limits, ie. 5.5% reduction in serious casualty crashes. The possible effect of the reduced tolerance on rural speeds and crashes could be similar, based on New Zealand findings that the proportion of drivers exceeding 110 km/h on rural roads was more than halved during the years following their reduction in the tolerance.

The introduction of new automatic speed enforcement technologies, for use in ways and locations which were previously unsuited to mobile, car-mounted cameras, may also serve to increase the general effect of the mobile speed camera program. The ways in which these new technologies can add effect are discussed in the following sections.

5.7. EFFECTS OF FIXED SPEED CAMERAS

Fixed speed cameras have been shown to reduce vehicle speeds, at least at the camera sites, in the U.K. (where they are operated extensively), Sweden, and the CityLink tunnels. In the U.K. and Sweden the cameras are very overt. In the CityLink tunnels, while their exact location is not apparent, their presence in the tunnel is well known and reinforced by signage. While it is intended that the new fixed cameras to be installed on freeways in Victoria will be covert and unsigned, in practice their locations will soon become known and publicised by media attention. Thus the fixed cameras could be described as only "semi-covert" and it could be expected that the overseas findings regarding their effects will apply in Victoria.

Reductions in average speeds at camera sites, of the order of 5-10 km/h, have been observed in the U.K. and Sweden. There were also substantial reductions in the proportion of vehicles exceeding the speed limit. In the U.K. there were 28-35% reductions in casualty crashes at camera sites (and up to 65% reductions in deaths and serious injuries at fixed camera sites), however in Sweden the casualty crash reductions at camera sites were only 5% and not statistically reliable.

A feature of the U.K. fixed camera program was an apparent general effect on crashes which extended beyond the camera sites, at least in the short term. In the entire Police Force Areas where the recent expansion in camera operations has occurred, there was a 4% reduction in deaths and serious injuries during the first two years It is understood that the density of fixed cameras is relatively high, but the extent of this has not yet been published. Publicity is associated with the operation of cameras in the U.K. and this may be expected to contribute to the area-wide reduction in casualties. However, the density of fixed cameras being considered for Victoria in the short-term is unlikely to be sufficient to produce the general effect apparently achieved in the U.K. because the Victorian density is unlikely to exceed the necessary threshold.

In summary, the fixed, semi-covert speed cameras planned for operation on Victoria's freeways are likely to reduce average and excessive speeds, and casualty crashes and their injury severity, in the vicinity of the camera sites. With the limited number of fixed cameras being considered, they are unlikely to produce more than a small reduction in the total number of serious casualty crashes considered to be the target for this safety camera technology (Table 6).

5.8. EFFECTS OF POINT-TO-POINT SPEED CAMERAS

Relatively few evaluations of point-to-point speed cameras could be found in the available published literature, but studies of one installation in Nottingham did suggest they could achieve at least 30% reduction in deaths and serious injuries on road sections covered by the camera system. The principal effect of this technology is likely to derive from the ability to measure the average speed over a whole road segment, and perhaps set a lower offence detection threshold for the average speed compared with the threshold appropriate for spot speeds. A secondary effect may come from the real or perceived enforcement of spot speeds at the beginning and end of the segment. In other words, the same localised effect on speeds and crashes experienced with the operation of semi-covert fixed speed cameras discussed in the previous section can be expected. It is not known whether the point-to-point cameras will be operated covertly or overtly, but it is expected that the camera locations will be publicised and become "semi-covert" in the short term.

On those freeway and highway segments where point-to-point speed cameras are installed, it could be expected that all drivers with average speed above the speed limit will be deterred from that behaviour, to some extent. It has been suggested that the offence detection threshold could be set at 1 km/h above the limit because such a threshold for average speed is likely to be more acceptable to the community than the same threshold applied to spot speeds. Kloeden et al (2001) estimated that in rural speed zones there would be a 23.8% reduction in free speed (severe) casualty crashes if all drivers complied with the speed limit. In practice, the achievable effect on the route segments where point-to-point cameras are installed is not likely to be as large as this maximum potential effect.

The ability of point-to-point cameras to affect a substantial proportion of the target crashes identified in Table 6 is dependent on the availability of suitable traffic routes (free-running traffic on freeways and highways with limited access/egress opportunities and few speed zone changes), the number of camera system installations, the spacing of cameras, and the current extent of illegal speeding on those routes. Suitable routes are likely to be speed zoned with 100 or 110 km/h limits, and Table 9 shows that there were relatively low offence rates in these zones compared with lower speed zones (at a time when the speed offence detection threshold was 10 km/h in excess of the limit). However the proportion of vehicles travelling within 10 km/h of the 100 and 110 km/h limits on freeways and highways is not known. These vehicles would be candidates for a reduction in their speeds, and consequent road trauma, using point-to-point camera technology.

5.9. EFFECTS OF RED-LIGHT CAMERAS

Evaluations of red-light camera programs have generally found overall reductions in casualty crashes (or their injury severity) at camera sites and sometimes broader effects extending to signalised intersections not covered by cameras. While increases in rear-end crashes have sometimes been found to accompany the decreases in cross-traffic crashes, the overall effect is a reduction in serious casualty crashes.

The estimated effects at red-light camera sites range for 10% reduction (Melbourne) to 18% reduction (U.K.) in total casualty crashes. Neither of these studies examined the possibility of a general effect extending to signalised intersections other than those treated with a camera installation (ie. a camera housing and flash unit on at least one approach leg, but not necessarily a camera present in the housing at all times).

The general effect at all signalised intersections in one US city (Oxnard, California) was an estimated 29% reduction in casualty crashes during the first four months after the red-light camera program commenced. The long-term duration of this general effect is unknown. The intensity of coverage of signalised intersections by cameras was about 9% (11 of 125). The minimum level of coverage necessary to produce a general effect is also unknown. The proportion of approximately 2000 signalised intersections in Melbourne currently covered by 132 camera installations is 6.6%, of which at most 35 (1.8%) have a camera operating at the site at any one time.

The limited number of red-light camera installations in Melbourne could be expected to produce 10% reduction in casualty crashes at the intersections where they are installed, but the possibility of a broader effect is unclear. A general effect extending beyond the camera sites may require a greater proportion of signalised intersections to be obviously covered by cameras, and a greater proportion of those sites to have cameras continuously operating, than the current program.

5.10. EFFECTS OF RED-LIGHT/SPEED CAMERAS

No crash-based or behavioural evaluations of the combined red-light/speed cameras could be found in the available published literature. However it seemed reasonable that their effects could be predicted, to some degree, if each red-light/speed camera was treated as a red-light camera and a fixed speed camera.

Thus the effects could be a 10% reduction in casualty crashes at each camera site, principally due to the deterrence of red-light running, and up to 35% reduction in the remaining 90% of crashes at the site due to a reduction in speeding. Thus the total effect could be up to a 42% reduction in casualty crashes at the signalised intersections where the red-light/speed cameras are installed.

These cameras would also add to the number of (stand-alone) red-light camera installations and may assist to create a general effect on red-light running crashes at the broader population of signalised intersections. The total number of actual cameras operating in red-light mode may need to exceed about 9% of Melbourne's signalised intersections (ie. 180) for this effect to be achieved.

The red-light/speed cameras would also add to the total number of fixed speed cameras operating in Victoria, albeit only at signalised intersections mainly in 60, 70 and 80 km/h speed zones. This would be a very different environment to that being considered for installation of fixed cameras on freeways in Victoria. However it would add to the overall density of fixed speed cameras and may assist in contributing towards the general effect apparently achieved by fixed speed cameras in the U.K., but there is an absence of information about the necessary density to create such an effect.

5.11. OVERALL EFFECT OF THE SAFETY CAMERA PROGRAM

In theory it should be possible to consider each of the safety camera technologies described previously, define the annual number of target crashes in road environments in which the technology is applied, apply the percentage reduction in crashes achievable by the technology, and calculate the total number of crashes which could be saved per year.

These savings could then be aggregated to estimate the overall effect of safety camera operations.

In practice this is not possible, to any reliable degree, because of the absence of good estimates of the likely effects on casualty crashes in Victoria related to the new technologies and, to some extent, the existing technologies. The likely effects of the fixed speed cameras are somewhat known in the vicinity of camera sites, but their general effect is unknown. The likely effects of point-to-point cameras are also unknown. The effect of the red-light mode of the red-light/speed cameras is predictable, at camera sites, but the effect of the speed camera mode is predictable only to the same extent as that of fixed speed cameras (though the environment in which each is applied is very different). A general effect of each of these technologies can be expected if the density of their application is above a threshold, but the threshold density is uncertain (and unlikely to be achieved in Victoria in the short term).

The effects on crash outcomes of the current program of mobile speed cameras, as operated since 2001/02, are also unknown (except to say that the effects are likely to be greater than the program operated up to 2000/01). A program of scientific evaluation of the increased camera hours, the operational changes to make the enforcement more covert and unpredictable, and the reduced speeding offence detection threshold, is currently being carried out by MUARC but no results are available at this time.

Only the localised effects of red-light cameras are known to any reliable extent, but it should be noted that the evaluations (in Victoria and elsewhere) were conducted when signage accompanied the camera installations; this is no longer generally the case in Victoria. The existence of a general effect of Victoria's red-light cameras is unknown, and the threshold density at which this might be achieved is uncertain.

The objective of this project was to provide a scientific base for the development of a safety camera strategy which will:

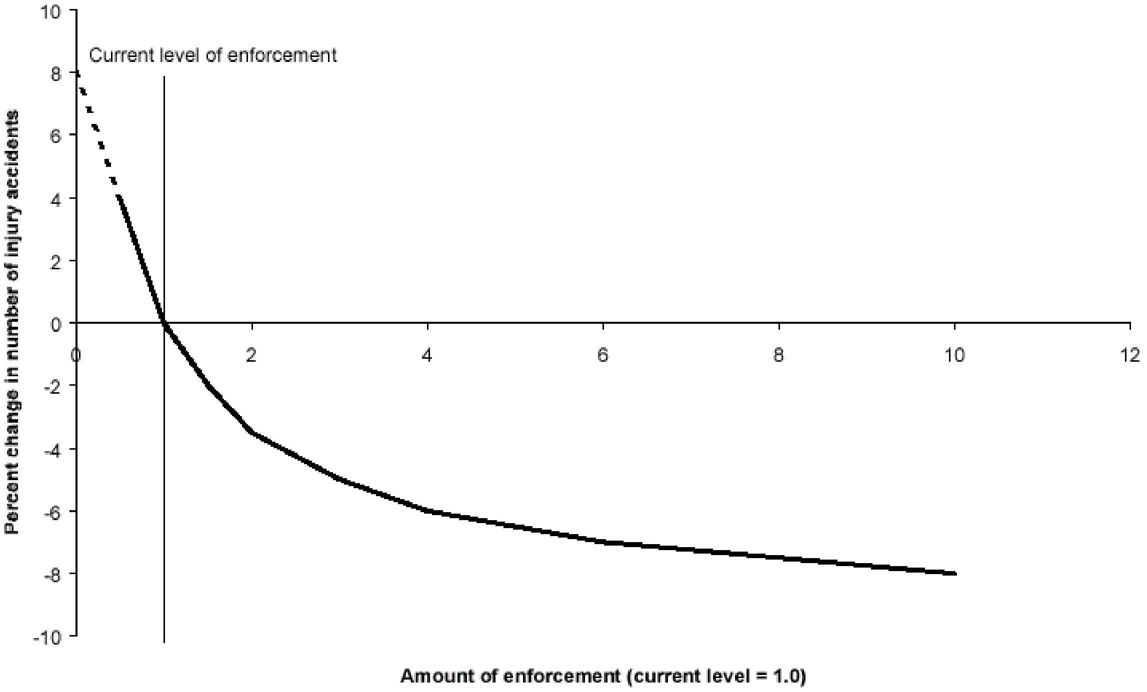
(1) have maximum road safety benefit, and
(2) continue to build on the positive outcomes achieved by enforcement programs over the last ten years.

From the point of view of the first specific objective, there is scope to expand the planned operations of all technologies, except the mobile speed camera program, to a sufficient extent so that:

(a) a general effect of the technology is achieved across the road environment on which it is applied (ie. all freeways and highways in the case of fixed and point-to-point speed cameras; all signalised intersections in the case of red-light and red-light/speed cameras)
(b) the marginal economic benefits of the road trauma savings achieved by the general effect are just greater than the marginal cost of each increase in the technology operation (ie. the cost of each extra camera installation, and necessary offence processing capacity).

Elvik (2001), in a comprehensive review of a large number of studies of the effects of varied levels of traffic enforcement on casualty crashes, concluded that the relationship is of the form shown in Figure 4. Some forms of enforcement have more powerful effects than others, but in every case the relationship with crash reductions is not linear. Because of this, there is a level of enforcement activity where the additional saving in crashes may not be worth the additional cost of extra enforcement.

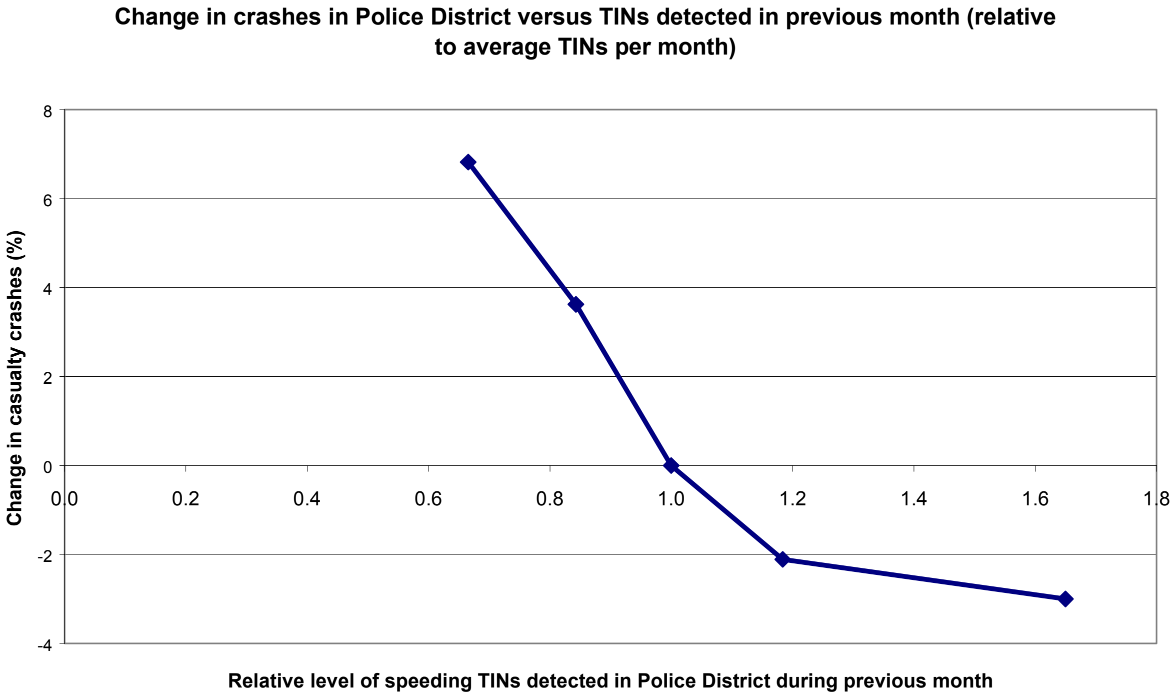
Figure 4: General relationship between traffic enforcement and crashes identified by Elvik (2001)



A relationship of this type was calibrated for the Victorian speed camera program, as it operated up to 1998, relating casualty crash reductions with monthly camera hours and speeding TINs issued for detected offences (see Section 3.1.3). The nature of the relationship was confirmed in more recent research linking changes in casualty crashes with the level of speeding TINs detected by speed cameras during the previous month in the same police district during 1996-2000 (Figure 5).

In the initial research, it was found that the increase in camera hours from 4000 to 6000 hours per month is likely to be economically worthwhile. The influence of the operational changes during 2001/02 to make the enforcement more covert and unpredictable, and to reduce the speeding offence detection threshold, on the marginal economic benefits is unknown. However, it is expected that these latter changes have made the program more efficient (ie. a greater level of crash reductions are being achieved, but a relatively small increase in operating costs, mainly in the offence processing function). The general effect of the program on crashes across the broad road environment, in addition to the times and locations in which the cameras operate, is expected to continue to operate.

Figure 5: Relationship between crashes and level of speeding TINs detected by speed cameras (Cameron et al., 2003a, b)



Thus, from the point of view of the second specific objective of this project, it can be concluded that the current mobile speed camera program should continue. There may be a case for the program to be expanded further, with economic justification. However, a decision to reduce the mobile speed camera program, in order to provide resources to implement or expand other safety camera technologies, should be viewed with caution. This may result in an erosion in the overall positive benefits achieved by traffic enforcement programs in Victoria over the last 10 years.

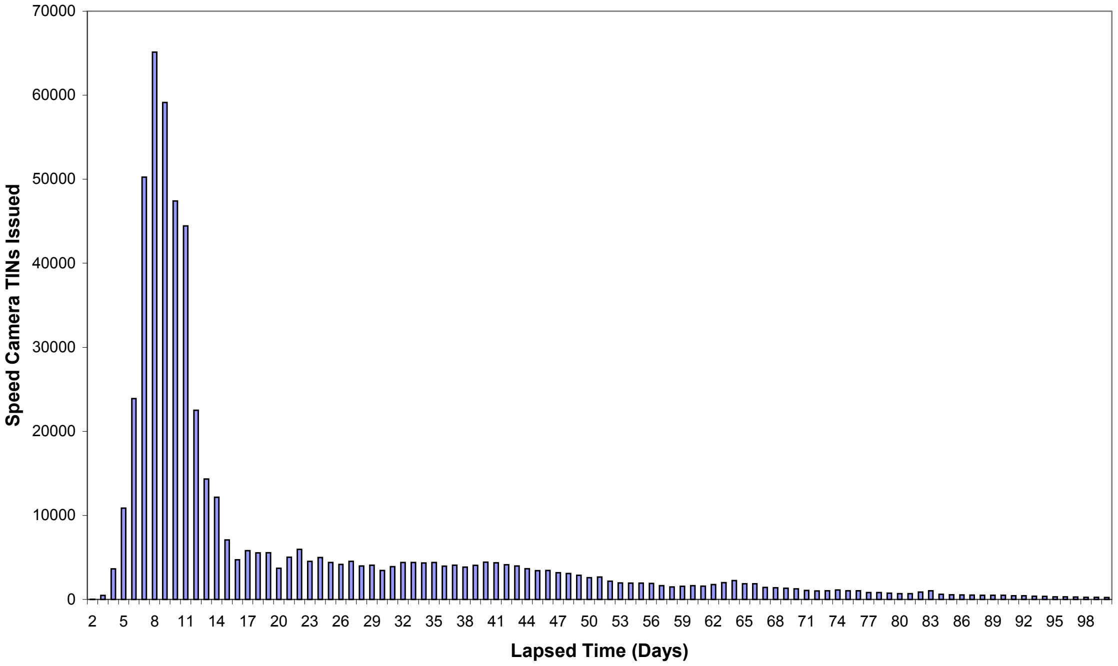
5.12. SWIFTNESS OF PENALTIES FROM SAFETY CAMERAS

The review of deterrence mechanisms outlined in Section 2.1 identified that the real and perceived risks of being detected committing a traffic offence are the principal factors affecting the effectiveness of traffic law enforcement programs, including those based on camera surveillance of offences. The swiftness of application of penalties, and the severity of penalty, are important but secondary factors.

The swiftness of penalties arising from the detection of offences by cameras is an issue for this type of traffic enforcement that does not arise to the same extent with operations involving manual interception of traffic offenders. This is because when offenders are intercepted they become immediately aware that a penalty is likely and can associate it with the very recent offence. The awareness of a penalty for an offence detected by camera surveillance in Victoria generally becomes apparent to offenders when a traffic infringement notice (TIN) is received by mail.

In 1999, after LMT became responsible for processing safety camera offence images, about 60% of TINs from speed cameras were issued within 7 to 14 days from the date of the offence (Figure 6). Most of the remainder were issued (or re-issued to nominated drivers identified by vehicle owners) within 12 weeks of the offence. A very small proportion were issued later.

Figure 6: Lapsed Time between Speed Camera TIN Creation Date and Offence Date, for TINs issued during 1999 (excluding lapsed times > 100 days)



Studies of the effects of the speed camera program during the early 1990's, when TINs were issued about two weeks after the offence, found apparent deterrent effects resulting in additional reductions in casualty crashes around the camera site (at the time the offence was detected) during the weeks immediately following the receipt of TINs emanating from the camera session, 80% of which were despatched on the same date (Rogerson et al 1994). This suggests that the current speed at which safety camera images are processed and TINs are issued is sufficiently swift for the deterrent effect of penalties associated with cameras detections to be maintained.

5.13. SEVERITY OF PENALTIES FROM SAFETY CAMERAS

The penalties for speeding and red light offences are the same no matter if the offence is detected by camera surveillance technology or manual enforcement methods (though the automatic methods detect much larger numbers of offences in each case). However, the need for the vehicle owner to identify the driver at the time of offence, so that demerit points can be assigned (and licences suspended), has led to the need for an offence of failing to identify the driver in the case of corporately owned vehicles, where the owner is not an individual (Table 10). In this case, the specific vehicle is de-registered for a period as well as a fine applied. In December 2002, the thresholds for higher speeding offences were reduced (Table 11).

Table 10: Penalties for offences detected by safety cameras (and other traffic enforcement methods, where applicable) up to 15 December 2002

Offence	Fine	Demerit Points*	Licence Suspension
Speed in excess of speed limit by:			
1 – 15 km/h	$ 125	1	
16 – 29 km/h	$ 200	3	
30 – 39 km/h	$ 265	4	1 month
40 – 44 km/h	$ 365	4	4 months
45 – 49 km/h	$ 365	6	4 months
50 km/h or more	$ 430	6	6 months
Failing to stop at a red light	$ 200	3	
Failing to nominate a driver of a corporate owned vehicle	$ 600		3 months (vehicle registration suspended)

* 12 points accumulated during any three year period leads to 3 months licence suspension or, at the driver's discretion, the option to remain demerit point free for the next year, but failing that a 6 months licence suspension

Table 11: Penalties for offences detected by safety cameras (and other traffic enforcement methods, where applicable) since 15 December 2002

Offence	Fine	Demerit Points*	Licence Suspension
Speed in excess of speed limit by:			
1 – 9 km/h	$ 125	1	
10 – 24 km/h	$ 200	3	
25 – 34 km/h	$ 265	4	1 month
35 – 44 km/h	$ 360	6	6 months
45 km/h or more	$ 430	8	12 months
Failing to stop at a red light	$ 200	3	
Failing to nominate a driver of a corporate owned vehicle	$ 600		3 months (vehicle registration suspended)

* 12 points accumulated during any three year period leads to 3 months licence suspension or, at the driver's discretion, the option to remain demerit point free for the next year, but failing that a 6 months licence suspension

The magnitudes of the penalties associated with speeding offences increase with the alleged speed in excess of the limit, as could be considered appropriate given the findings on the relative risk of a serious casualty crash related to speeding (Table 3). Relative to the risk at 60 km/h, the risk associated with speeding 6-15 km/h above the limit was estimated to be 1.8 to 7.6 times, whereas the relative risk when travelling 16-30 km/h in excess was 9.3 to 147 times, a 5 to19 times increase compared with 6-15 km/h above the limit. With the old penalties, the 60% increase in monetary fine and tripling of the demerit points was consistent with the direction of increase in risk when offences in these two categories are compared, but did not fully reflect the magnitude of the increase in risk. The new penalties also do not.

The relative risk associated with speeding more than 30 km/h above the limit was estimated to be at least 262 times the risk at 60 km/h, and at least 34 times the risk associated with travelling 6-15 km/h in excess (Table 3). The old penalties for speeding offences at this level (four categories), compared with those for speeding up to 15 km/h in excess, represented 2-3 times the fine, 4-6 times the demerit points, and 1-6 months licence loss (compared with no licence suspension). Depending on the perception of the severity of licence loss, it seems that the magnitude of the penalties associated with speeding more than 30 km/h above the limit did not fully reflect the increase in risk of a serious casualty crash. The new penalties more closely reflect the risk associated with excessive speeding (now defined as more than 25 km/h above the limit).

The magnitude of penalties for serious traffic offences is obviously relevant to the specific deterrence associated with safety camera programs, since this mechanism aims to persuade offenders not to re-offend through their actual experience of being detected and punished. In addition, it has been argued that the magnitudes of the penalties should reflect the risk of societal harm associated with the offensive behaviour. Against this argument is the possibility that offences may not be detected and penalties applied so rigorously if the community (and enforcement/judicial agencies in particular) perceive the penalties to be too high and inconsistent with their subjective understanding of the increase in risk. In such circumstances it is possible for enforcement/judicial systems (such as the safety camera program) to fall into disrepute and fail to operate in the way they are intended. There is the possibility that an increase in the penalties for speeding offences to reflect serious casualty crash risk, if it runs ahead of community understanding and acceptance, may precipitate this outcome.

5.14. EFFECT OF MASS MEDIA PUBLICITY SUPPORTING SAFETY CAMERAS

Enforcement programs aimed at deterring critical traffic offences (such as speeding and red-light running) are thought to have their effects magnified by mass media publicity emphasising the risks of detection, whether it be by automatic or manual surveillance methods. While this seems a reasonable expectation in the case of each safety camera technology, the scientific evidence supporting the existence of such an effect is not strong.

The evaluation of the initial introduction of the mobile speed camera program considered a period from April to June 1990, when mass media publicity had launched the new program but the extensive increase in camera operations had not commenced. Reductions in low alcohol hour casualty crashes of 34% on Melbourne arterial roads and 21% in rural towns were found during this period (Cameron et al., 1992). These effects were similar in magnitude to those found from July 1990 when the camera activity rose substantially and the Traffic Camera Office commenced processing large numbers of detected offenders. Thus the mass media publicity was able to magnify the effects of a relatively low level of camera activity during April to June 1990, albeit for only a few months.

Many other MUARC studies have associated levels of TAC speed-related advertising with reductions in casualty crashes and/or serious casualty crashes (eg. Cameron et al., 1992, 1993; Newstead et al., 1995, 1998). However, none of these studies were able to adequately test whether there was an interaction between the speed-related advertising and the speed camera program that produced a synergistic effect. During 1999, the Victoria Police increased the speed camera operations in two Police Districts for a month at a time, during two selected months when TAC speed-related advertising was present and two months when it was absent. The intention of this systematic plan was to allow MUARC to examine the interacting effect of the enforcement and publicity on crashes. MUARC's analysis ultimately considered the monthly variations throughout 1996-2000 of the speed camera activity, measured by the number of speeding TINs detected in each District, and of awareness of the TAC anti-speeding advertising, in total and for the emotive-style and enforcement-related advertising separately (Cameron et al., 2003a).

With respect to the influence of the speed-related advertising on the frequency and severity of crashes, the study concluded that:

1. There was no evidence of an interaction in the effects of the enforcement and the publicity on casualty crash frequency.
2. High levels of awareness of TAC speed-related publicity with emotive styles produced casualty crash reductions in Melbourne during the months in which it occurred.
3. There was no evidence of an effect of the emotive-style speed-related publicity on the injury severity outcome of the casualty crashes.
4. There was no evidence that awareness of the speed-related publicity with enforcement styles contributed to casualty crash reductions during 1996-2000.
5. There was an interaction effect on fatal casualty crash outcome when there were very high levels of speeding TINs detected in the previous month and high levels of awareness of enforcement-style speed-related publicity. The reduction in risk of fatal outcome was greater than expected from effects estimated when the enforcement and publicity operated alone at these levels.
6. Drivers' perception of the risk of detection, when speeding, was increased by high levels of awareness of the speed-related publicity, compared with the perception when the awareness was at medium levels.

The study also found an association between the level of speeding TINs detected by speed cameras in each Police District during the previous month and reductions in casualty crashes in the same District (see section 3.1.1 and Figures 1 and 5). There was also a substantial reduction in the risk of fatal outcome of the crashes when the level of speeding TINs detected during the previous month was at very high levels (Cameron et al., 2003a, b).

However, further regarding the interaction between speed enforcement and publicity, a MUARC study of the effects of mobile (moving mode) radar speed detection devices has found evidence of a synergistic effect on crash frequency with TAC speed-related advertising, particularly with an advertisement portraying the mobile radar enforcement in operation (Diamantopoulou, Cameron and Shtifelman, 1998). The effects of this enforcement activity on rural Victorian highways occurred on casualty crashes 1-4 days later, and was a stronger effect when awareness of the TAC advertising was at high levels compared with low levels.

Together, the research suggests that mass media publicity can play a valuable role in supporting safety camera operations. In such situations, the publicity may magnify the perceived risk of detection and add to the deterrent effect achieved by the camera operations. The role of publicity with an emotive style portraying the traumatic consequences of speeding (and perhaps red-light running) is also apparent. Such publicity may play a different kind of supporting role by persuading the community to be more receptive to increased camera surveillance rather than directly affecting perceptions of enforcement presence. The recent research also suggests that emotive-style speed-related publicity can have a direct effect on casualty crash risk, independent of any role in support of speed enforcement.

The media also play a role through public announcements of speed camera locations at the time of operation. This may appear counter-productive to the covert tactic of the mobile camera program. To the extent that the announcements do not give the specific location of the camera at the time of operation, they play a useful role in supporting TAC's paid media advertising. Announcements of specific mobile camera locations should be discouraged in order to avoid drivers developing an impression that they can predict locations and control their speed at only these sites rather than at all times. This issue will warrant greater attention when an expanded program of fixed cameras (speed cameras, point-to-point cameras and red-light/speed cameras) commences if the intention is to achieve more than localised effects. A strategy to deal with media identification of their locations will need to be developed.

6 COMMUNITY ACCEPTANCE AND SUPPORT

In Victoria, a number of organisations have surveyed community opinion regarding speed enforcement activities. Organisations such as MUARC, ATSB, TAC, Victorian Department of Justice, and RACV have all undertaken surveys of varying sample size (in Victoria) with varying questions. In October 1999, MUARC conducted a survey on a random sample of 1000 licensed drivers in metropolitan Melbourne. ATSB conducted Wave 13 of the Community Attitudes Survey in March 2000, with a sample of 250 Victorians. Surveys for TAC were conducted by Sweeney Market Research between October 2000 and July 2002. Sample size was approximately 600 at most time points, targeting licensed drivers in Victoria. In May 2002, Millward Brown conducted a survey of 2500 Victorians on behalf of the Department of Justice. RACV conducted a recent survey of 500 RACV members in May/June 2002. This section will review the findings and trends indicated by these surveys.

In this review, recent trends in community opinion will be considered, with particular focus on periods of changed levels of enforcement. Specific changes in enforcement occurred in August 2001, when the hours of speed camera use began to increase (progressively from 4000 to 6000 hours per month), and in March 2002 when it was announced that the speed offence threshold was reduced from 10 km/h above the limit to an undefined level (with the implication of zero tolerance).

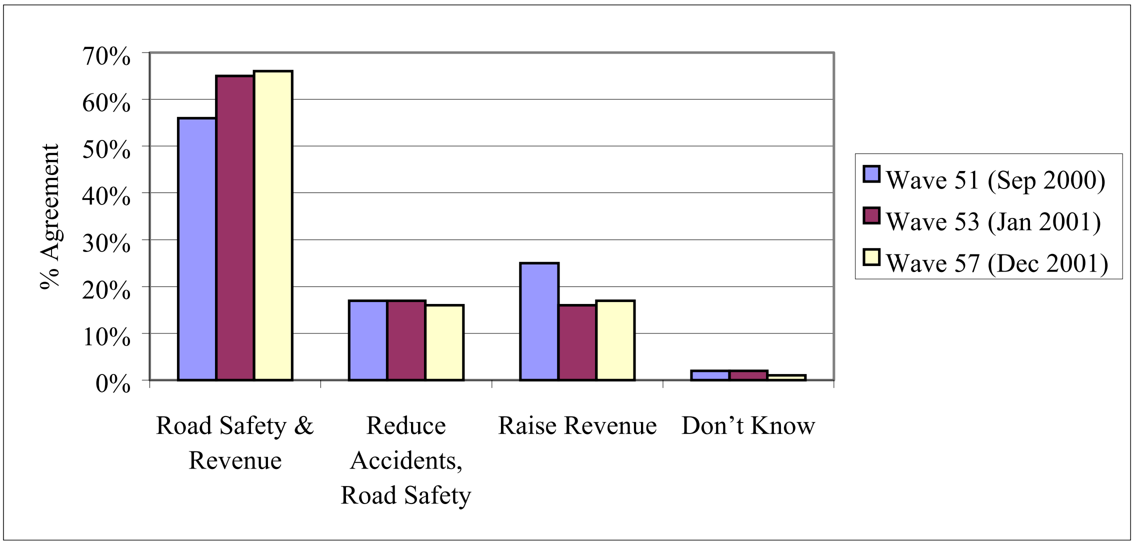
6.1. SPEED ENFORCEMENT - REVENUE RAISING

Surveys of community opinion have investigated public perceptions of speed enforcement. Specifically, questions have been asked about perception of enforcement as a revenue raising exercise as opposed to a road safety exercise. A survey conducted by MUARC in 1999 found that 87% of respondents agreed with the statement "Enforcing the speed limit with speed cameras helps lower the road toll". This finding differs from that of Mitchell-Taverner (2000). In Wave 13 of the Community Attitudes Survey (CAS), 53% of respondents agreed with the statement "Fines for speeding are mainly intended to raise revenue". Males were more likely to agree than females, as were beer drinkers, those who had been booked for speeding in the last 2 years, and drink-drivers.

Sweeney also investigated the perception of speed camera use. Participants were asked to speculate on the motivation underlying the widespread use of speed cameras in September 2000, January 2001, and December 2001 (see Figure 7). Over time, an increasing proportion of respondents believed that speed camera use was "to both improve road safety and raise revenue", increasing from 56% in September 2000 up to 66% in December 2001. However, the percentage that believed speed camera use was "to reduce accidents and improve road safety" declined very slightly from 17% to 16%. There has also been an overall decline in the number who believed speed cameras operate "to raise revenue". In September 2000, 25% supported this position before dropping to 16% (in January 2001), then climbing slightly in December 2001 to 17%. This belief was more common among young males (aged 21-29). Rural drivers were less likely to support the revenue raising option. Those sceptical of speed camera operations cited speed camera location, or the amounts being collected in fines, as rationale for their position.

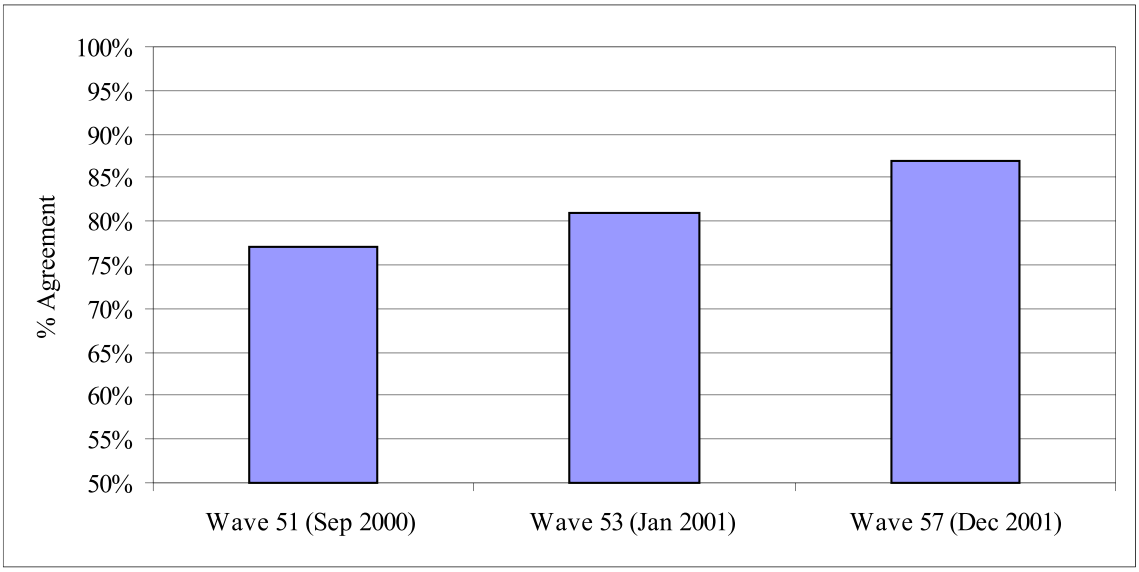
While findings from MUARC and Mitchell-Taverner may initially appear mutually exclusive, there are further issues for consideration. In both cases, respondents were given one statement and asked to express agreement or disagreement. In the survey by Sweeney, where respondents were given a range of options, it is evident that recent community opinion was evenly balanced between the perceptions of altruistic and self-serving motivations regarding the use of speed cameras. During the time frames of enforcement change, there has been little change in community opinion as outlined thus far.

Figure 7: Community perceptions - the use of speed cameras (Sweeney)



Sweeney further investigated the extent of speed camera use, asking drivers if they would support greater speed camera use if the extra revenue raised was put into road safety programs. Support increased from 77% of drivers in September 2000 to 87% support in December 2001 (see Figure 8). Metropolitan drivers showed a greater increase in support than rural drivers. Females were also more likely to be supportive than males. Opposing reasons predominantly revolved around scepticism that fines would be used for the stated purpose, that there were already enough cameras, or that such action would not improve road safety.

Figure 8: Support for greater speed camera use (Sweeney)



The RACV survey of members (RACV, 2002) also showed strong support (89%) for the return of speeding fine revenues into road safety programs, compared to support for general revenue (4%) or no preference (7%). Thus, community opinion is showing increasing support for speed camera use if revenue is directed into road safety programs. The increase in support has occurred through times of increased enforcement, suggesting that a large proportion of the public believe there is currently a link between speed camera revenue and road safety. This result is also consistent with the previous finding (Sweeney) that speed cameras operate to "improve road safety and raise revenue".

In 2002, Millward Brown investigated support for enforcement in different locations for both breaking the speed limit and running red lights. Respondents were supportive of enforcement on freeways and highways (71%), residential streets (80%) and red lights (89%). Respondents were also invited to provide "things you'd like to say to the enforcement authorities" regarding "On-the-Spot" Fines. The most common suggestion (8% of respondents) was to have circumstances taken into consideration. Five percent of respondents suggested that fixed cameras were just used for raising revenue, and 3% of drivers disagreed with the location of cameras - for example, rather than at the bottom of the hill, they should be put "where it is dangerous".

In summary, public opinion on whether speed cameras operate to raise revenue is divided. Depending on the phrasing of the questions, the public expressed support for a range of suggestions that are not incompatible. The results suggest support for both the concept that cameras are used to raise revenue, and that cameras are used to improve road safety. In isolation, these issues can appear to gain much stronger support. For example, Mitchell-Taverner (2000) reported that 53% of respondents agree speeding fines are for raising revenue, as opposed to Sweeney's report that only 17% of respondents support the "raising revenue" option. It seems evident that the belief in raising revenue needs to be considered in light of the fairly predominant suggestion that speed cameras both raise revenue and contribute to road safety. Furthermore, while there is support for the notion that revenue can be directed towards road safety, there is still scepticism within the community in regard to the likelihood of this happening.

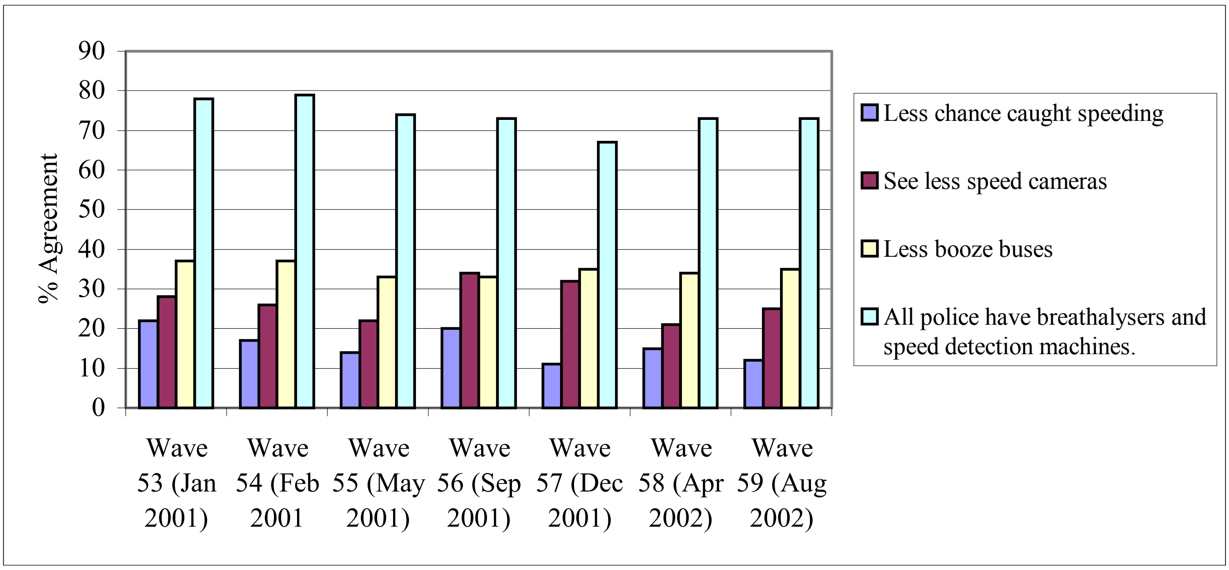
6.2. SPEED ENFORCEMENT OVER TIME

In 1999, MUARC found that 49% of respondents had not observed as many speed cameras as they used to, reflecting divided opinion on speed camera activity levels. Correspondingly Mitchell-Taverner (2000) reported that 55% of respondents believed that the amount of speed enforcement had increased in the last 2 years, compared to 27% who believed it had stayed the same, and 9% who said it had decreased (CAS 13). Drivers over 60 years showed the least awareness of any change in speed enforcement.

In a recent RACV survey (RACV, 2002), members were asked about their awareness of recent new speed management measures. Awareness of the increased level of speed camera use was relatively low, with only 22% spontaneously recalling this and a further 30% on prompting.

Sweeney investigated perceived police activity (see Figure 9). From January 2001 to August 2002, the number of respondents perceiving **less** chance of being caught speeding fluctuated, and actually rose (September 2001) just after the initial increase in speed camera hours, before dropping again at the end of 2001. Similarly, the percentage of respondents seeing **less** speed cameras followed a similar pattern, peaking in September and December 2001 before dropping in 2002. The proportion of drivers agreeing that all police are now equipped with breathalysers and speed detection machines dropped slightly over time, but maintained a high level (73%) of support.

Figure 9: Speed enforcement activity (Sweeney)



These results suggest that there is a lag in public awareness, with changes in community opinion appearing some months after changes in enforcement. Furthermore, the change in speed camera enforcement has been a steady increase over time commencing in August 2001, which would not necessarily be reflected in community opinion in a linear fashion, partially due to the influence of other variables that are not under consideration here.

6.3. ATTITUDES TO SPEED ENFORCEMENT

In 1999, MUARC investigated public perception of speed camera visibility. More than half the respondents agreed with the statement that speed cameras were easy to see (59%), yet conversely, 56% of respondents agreed that they rarely saw speed cameras. Furthermore, most respondents agreed that speed cameras were usually well hidden (71%). Only 8% of respondents had never seen a speed camera. Most respondents agreed that speed cameras were often used from different types of cars. Few respondents (16%) agreed that speed cameras would slow drivers down more effectively if they were in full view, while 84% of respondents agreed that speed cameras would catch more people if they were completely hidden. These responses highlight the community awareness regarding the strategic issue of visibility.

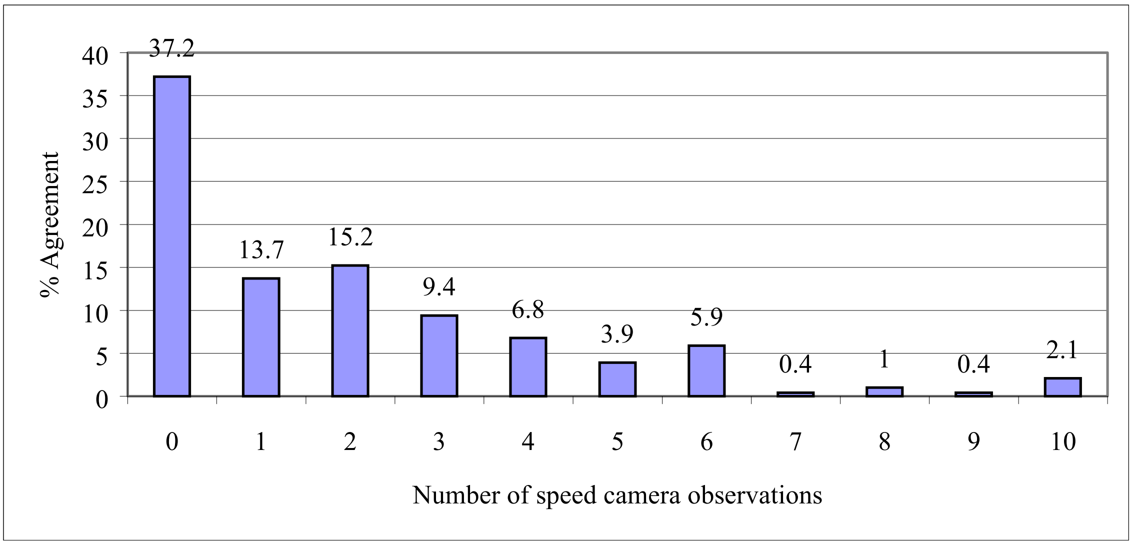
Just under half the sample agreed (45%) that it was easy to avoid being caught by a speed camera. Furthermore, approximately one third of respondents thought there wasn't much chance of being caught. However, most respondents (84%) disagreed with the statement "even if a speed camera catches you, you can still avoid being fined". Most respondents (76%) had not been caught speeding by a speed camera within the last 2 years. The majority of the remainder had been caught once (17%), or twice (5%).

Millward Brown (2002) asked drivers who had been fined how they had previously rated their chances of getting caught for speeding at less than 10 km/h, and at more than 10 km/h over the speed limit. In both categories, over a third of drivers had previously perceived their risk of being caught as very low. Over half the drivers agreed that the penalties for speeding (in either speed bracket) were fair. Slightly more drivers (37%) disagreed with penalties for speeding up to 10 km/h over the limit, compared to penalties speeding more than 10 km/h over the limit (31%).

In 1999, MUARC investigated public perception of speed camera predictability. Nearly two-thirds of respondents believed that speed cameras always operate at the same locations (59%) and only 40% agreed that enforcement only happens during the day. Most respondents (72%) agreed that "It's hard to predict where there are speed cameras", but also knew of some speed camera locations (84%). Respondents reported how many times they had seen a speed camera in the last 4 weeks, with 37% not observing any speed cameras. Observations (maximum of 10) in a 4-week period are presented in Figure 10. There were also reported observations as high as 28 speed cameras seen in 4 weeks. The majority (61%) of respondents stated they would not let other drivers know when they saw a speed camera.

Similarly, CAS13 (Mitchell-Taverner, 2000) investigated how easy it was for respondents to pick the locations where speed cameras or radars were likely to be operating. The majority (58%) thought it was easy to pick the spots. Most respondents also received warnings (by word of mouth, radio or other drivers etc) quite often (38%), sometimes (20%), or occasionally (30%). Only a small proportion (10%) of respondents had never received any warning.

Figure 10: Frequency of speed camera observations in a 4-week period (MUARC)

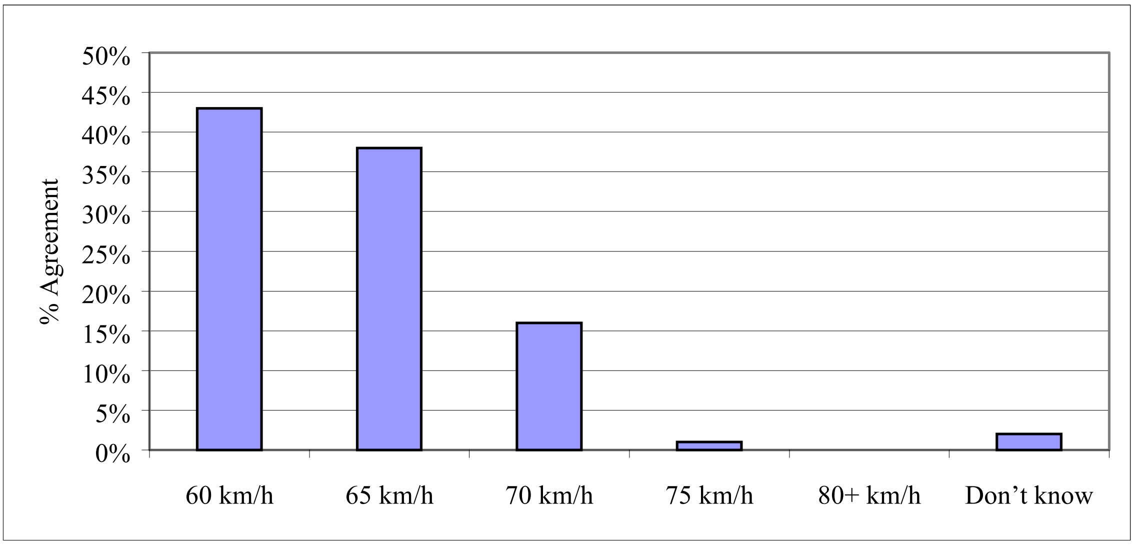


In summary, the issue of speed camera visibility is rife with contradiction, with drivers supporting both hidden and visible cameras, and reporting that cameras are easy to see yet they have not seen many. This suggests an underlying assumption of low-level speed camera use, and also highlights the need for further investigation of these issues since changes in speed enforcement.

6.4. TOLERANCE OF SPEEDING & SPEED LIMITS

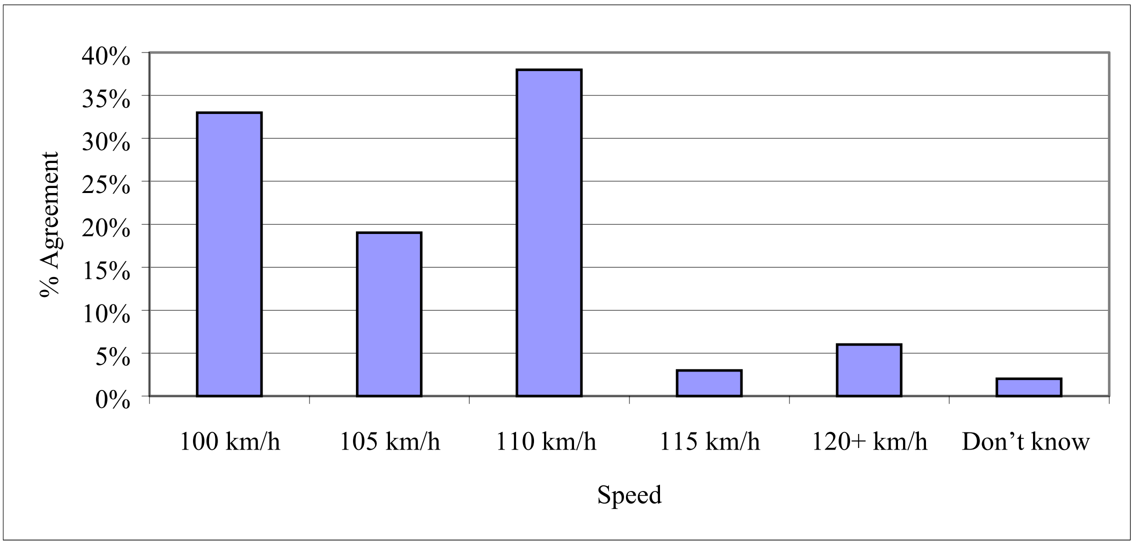
CAS 13 (Mitchell-Taverner, 2000) reported that 30% of respondents believed it was acceptable to exceed the speed limit if driving safely. Males were more likely to agree than females. Most drivers (49%) occasionally drove at 10 km/h or more over the speed limit, with 5% always or nearly always driving at 10 km/h over the limit. Males continued to be more likely than females to speed. Age was also a consistent predictor of how frequently drivers exceeded the speed limit. Tolerance of speed in a 60 km/h speed zone was also investigated (see Figure 11). Nearly half the respondents supported zero tolerance (48%), and most of the remainder (38%) supported a tolerance of 65 km/h. Once again, males were more tolerant of higher speeds than females. The over 60 age group were also much less tolerant of speeds over 60 km/h than the younger age groups.

Figure 11: Suggested tolerance of speed in a 60 km/h speed zone



Similarly, tolerance of speed in a 100 km/h speed zone was investigated (see Figure 12). Interestingly, support peaked at 38% for travelling 110 km/h, followed closely by support for zero tolerance from 33% of drivers. Significantly more females (40%) than males (25%) agreed with zero tolerance. Similarly, tolerance was increasingly strict with older drivers.

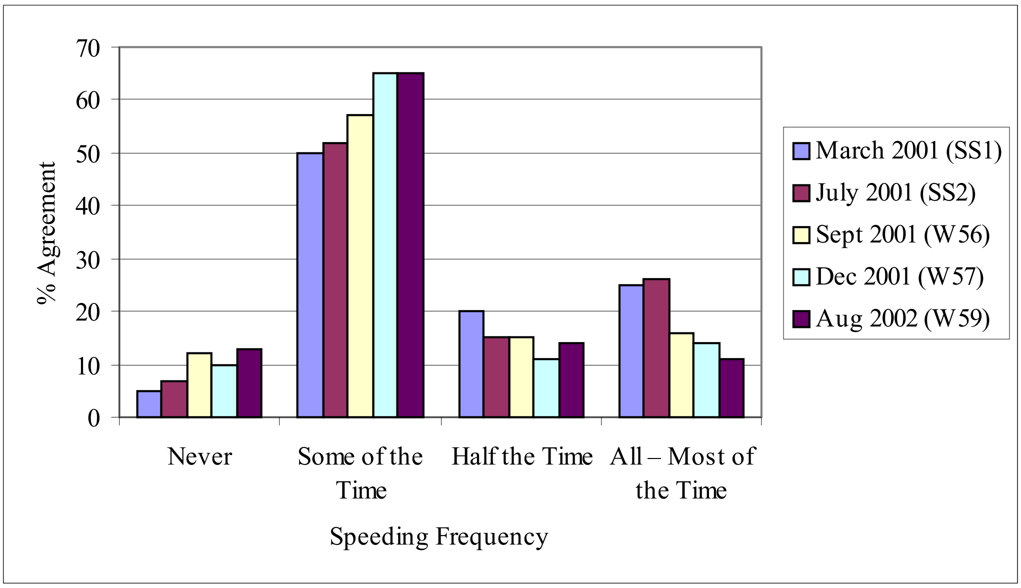
Figure 12: Suggested tolerance of speed in a 100 km/h speed zone



CAS 13 also investigated attitude to speed related issues. Over the last 4 years, an increasing number of respondents agreed that an increase of 10 km/h in driving speed significantly increased the likelihood of an accident. Similarly, most respondents thought an accident at 70 km/h would be much more severe than at 60 km/h (92%). Furthermore, nearly all respondents thought that speed limits were generally set at reasonable levels (90%). Thus, community opinion again seems divided between what could thought of as socially correct, as opposed to actual individual driving behaviour.

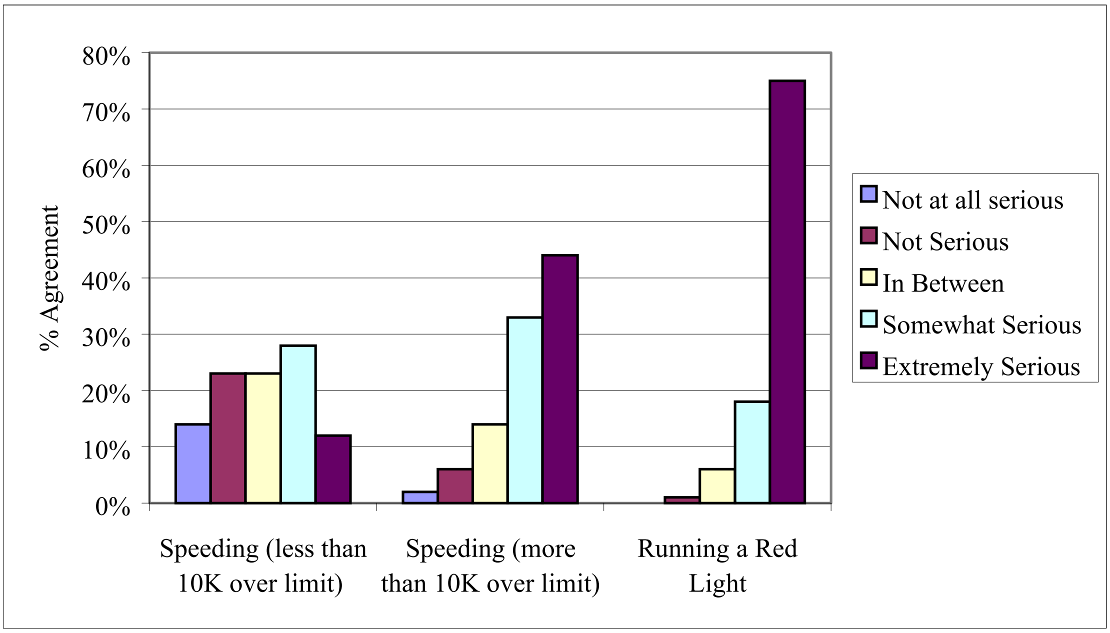
Sweeney also investigated self-reported frequency of speeding (see Figure 13). Approximately 90% of the drivers reported exceeding the speed limit at least some of the time. The proportion of drivers who reported speeding either half or most of the time has declined, with a corresponding increase in those speeding some of the time. In particular, the greatest reduction in drivers speeding all/most of the time occurred during the initial period of increased speed camera hours (between July and September 2001) and the reduction continued as the hours increased in late 2001 and early 2002. However, there was very little change (between December 2001 and August 2002) to reflect the March 2002 announcement of reduced speeding tolerance.

Figure 13: Frequency of speeding



Millward Brown asked drivers to rate perceived severity of a range of offences, including speeding (less than 10 km/h) over the limit, speeding (more than 10 km/h) over the limit, and running a red light (see Figure 14). Forty percent of respondents perceived a violation less 10 km/h over the limit as serious, compared to 77% of respondents for a violation over 10 km/h. Running a red light was considered a serious offence by 93% of respondents.

Figure 14: Perceived severity of offences



RACV members (RACV, 2002) also indicated strong support (69%) for police concentration on enforcement against excessive speeding (20 km/h or more over the limit). In comparison, the option of widespread enforcement "including drivers travelling a few km over the speed limit" gained little support (4%). The notion of police concentrating on "both" (options above) gained more support (26%).

In summary, age and gender continue to be consistent predictors of speeding tolerance. Tolerance in different speed zones varied greatly, with support in a 60 km/h zone decreasing with every 5 km/h above the posted speed, whereas the support in a 100 km/h zone was highest for a tolerance of 10 km/h above the posted speed. Conversely, public opinion also supported statements about increased risk at speeds increased by 10km/h. This contradiction appears to represent the conflict between social correctness and actual driving behaviour. The community in general also displayed greater support for enforcement against excessive speeding rather than speeding only a few kilometres above the limit. Self-reported speeding behaviour appeared to have reduced through the same time period as the increased speed camera hours. Reduced tolerance of speeding appeared to have little impact up to August 2002; however, further investigation may show a delayed effect.

6.5. SUMMARY OF COMMUNITY OPINION

In conclusion, recent community opinion supports the use of speed cameras to both raise revenue and improve road safety. There appears to be opportunity for further promotion regarding revenue use for road safety purposes. Awareness of speed enforcement did not appear to directly reflect changes in enforcement, yet some changes in awareness were evident later, suggesting a delayed impact. This would be useful to investigate further. Public perception of speeding tolerance indicated stated views regarding safety that were not consistent with self reported speeding behaviour. Support for enforcement was much stronger for that focused on excessive speeding. However, there was also a reduction in self-reported speeding behaviour concurrently with increased speed camera hours. Given the recent and ongoing changes in speeding enforcement, these issues require further investigation on an ongoing basis to detect changes over time.

7 CONCLUSION

This report has provided a valuable scientific base for developing a strategy for the future directions of the safety camera program, but the report is not that strategy. The limited information available about the effects of the new technologies, and recent changes to the mobile speed camera operations, precludes that step from a scientific point of view.

The objective of this project was to provide a scientific base for a safety camera program which will:

(1) have maximum road safety benefit, and
(2) continue to build on the positive outcomes achieved by enforcement programs over the last ten years.

From the point of view of the first specific objective, there is scope to expand the planned operations of all technologies, except the mobile speed camera program, to a sufficient extent so that:

(a) a general effect of the technology is achieved across the road environment on which it is applied (ie. all freeways and highways in the case of fixed and point-to-point speed cameras; all signalised intersections in the case of red-light and red-light/speed cameras)
(b) the marginal economic benefits of the road trauma savings achieved by the general effect are just greater than the marginal cost of each increase in the technology operation (ie. the cost of each extra camera installation, and necessary offence processing capacity).

So far as the mobile speed camera program is concerned, it has been found that the increase in camera hours from 4000 to 6000 hours per month is likely to be economically worthwhile. The influence of the operational changes to make the enforcement more covert and unpredictable, and to reduce the speeding offence detection threshold, on the marginal economic benefits is unknown. However, it is expected that these latter changes have made the program more efficient. The general effect of the program on crashes across the broad road environment is expected to continue to operate.

Thus, from the point of view of the second specific objective of this project, it can be concluded that the current mobile speed camera program should continue. There may be a case for the program to be expanded further, with economic justification. However, a decision to reduce the mobile speed camera program, in order to provide resources to implement or expand other safety camera technologies, should be viewed with caution. This may result in an erosion in the overall positive benefits achieved by traffic enforcement programs in Victoria over the last 10 years.

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Appendix A

TARGET CRASHES FOR SPEED CAMERAS

Table B. Number and Percentage of CASUALTY Crashes during July 2001-June 2002 by REGION, ROAD TYPE and SPEED ZONE

Speed Zone	**MELBOURNE**				
	Freeway	**Highway**	**Road**	**Street**	**All roads**
≤ 50 km/h	2 *0.01%*	10 *0.06%*	169 *0.97%*	**584** ***3.35%***	765 *4.38%*
60 km/h	125 *0.72%*	1082 *6.20%*	**3794** ***21.75%***	**3013** ***17.27%***	8014 *45.94%*
70 km/h	42 *0.24%*	473 *2.71%*	**684** ***3.92%***	82 *0.47%*	1281 *7.34%*
80 km/h	94 *0.54%*	**955** ***5.47%***	574 *3.29%*	43 *0.25%*	1666 *9.55%*
90 km/h	19 *0.11%*	**36** ***0.21%***	**35** ***0.20%***	1 *0.01%*	91 *0.52%*
100 km/h	438 *2.51%*	159 *0.91%*	**354** ***2.03%***	14 *0.08%*	965 *5.53%*
110 km/h	**15** ***0.09%***	3 *0.02%*			18 *0.10%*
other	4 *0.02%*	23 *0.13%*	40 *0.23%*	27 *0.15%*	94 *0.54%*
All speed zones	739 *4.24%*	2741 *15.71%*	5650 *32.39%*	3764 *21.58%*	12894 *73.91%*
Speed Zone	**REST OF VICTORIA**				
	Freeway	**Highway**	**Road**	**Street**	**All roads**
≤ 50 km/h		11 *0.06%*	43 *0.25%*	**187** ***1.07%***	241 *1.38%*
60 km/h	3 *0.02%*	379 *2.17%*	**583** ***3.34%***	**698** ***4.00%***	1663 *9.53%*
70 km/h	1 *0.01%*	**112** ***0.64%***	41 *0.24%*	11 *0.06%*	165 *0.95%*
80 km/h	16 *0.09%*	**155** ***0.89%***	**146** ***0.84%***	20 *0.11%*	337 *1.93%*
90 km/h	1 *0.01%*	**31** ***0.18%***	8 *0.05%*	4 *0.02%*	44 *0.25%*
100 km/h	32 *0.18%*	520 *2.98%*	**1272** ***7.29%***	79 *0.45%*	1903 *10.91%*
110 km/h	**128** ***0.73%***	28 *0.16%*	2 *0.01%*		158 *0.91%*
other		5 *0.03%*	28 *0.16%*	8 *0.05%*	41 *0.24%*
All speed zones	181 *1.04%*	1241 *7.11%*	2123 *12.17%*	1007 *5.77%*	4552 *26.09%*
				Victoria total	17466

Table C. Number and Percentage of SERIOUS CASUALTY Crashes during July 2001-June 2002 by REGION, ROAD TYPE and SPEED ZONE

Speed Zone	**MELBOURNE**				
	Freeway	**Highway**	**Road**	**Street**	**All roads**
≤ 50 km/h		1 *0.02%*	47 *0.86%*	**179** ***3.28%***	227 *4.17%*
60 km/h	25 *0.46%*	285 *5.23%*	**1031** ***18.92%***	**855** ***15.69%***	2196 *40.29%*
70 km/h	8 *0.15%*	**165** ***3.03%***	**199** ***3.65%***	30 *0.55%*	402 *7.38%*
80 km/h	23 *0.42%*	**252** ***4.62%***	162 *2.97%*	7 *0.13%*	444 *8.15%*
90 km/h	8 *0.15%*	**18** ***0.33%***	13 *0.24%*	1 *0.02%*	40 *0.73%*
100 km/h	**105** ***1.93%***	66 *1.21%*	**161** ***2.95%***	5 *0.09%*	337 *6.18%*
110 km/h	**9** ***0.17%***	1 *0.02%*			10 *0.18%*
other	0 *0.00%*	4 *0.07%*	8 *0.15%*	8 *0.15%*	20 *0.37%*
All speed zones	178 *3.27%*	792 *14.53%*	1621 *29.74%*	1085 *19.91%*	3676 *67.45%*
Speed Zone	**REST OF VICTORIA**				
	Freeway	**Highway**	**Road**	**Street**	**All roads**
≤ 50 km/h		4 *0.07%*	20 *0.37%*	**54** ***0.99%***	78 *1.43%*
60 km/h		113 *2.07%*	**159** ***2.92%***	**185** ***3.39%***	457 *8.39%*
70 km/h	1 *0.02%*	**35** ***0.64%***	14 *0.26%*	4 *0.07%*	54 *0.99%*
80 km/h	4 *0.07%*	**58** ***1.06%***	**62** ***1.14%***	7 *0.13%*	131 *2.40%*
90 km/h	1 *0.02%*	**15** ***0.28%***	4 *0.07%*	4 *0.07%*	24 *0.44%*
100 km/h	11 *0.20%*	277 *5.08%*	**616** ***11.30%***	36 *0.66%*	940 *17.25%*
110 km/h	**60** ***1.10%***	11 *0.20%*	1 *0.02%*		72 *1.32%*
other			15 *0.28%*	3 *0.06%*	18 *0.33%*
All speed zones	77 *1.41%*	513 *9.41%*	891 *16.35%*	293 *5.38%*	1774 *32.55%*
				Victoria total	5450

Table D. **Number and Percentage of FATAL Crashes during July 2001-June 2002 by REGION, ROAD TYPE and SPEED ZONE**

Speed Zone	**MELBOURNE** **Freeway**	**Highway**	**Road**	**Street**	**All roads**
≤ 50 km/h				1 *0.26%*	1 *0.26%*
60 km/h		8 *2.09%*	47 *12.27%*	36 *9.40%*	91 *23.76%*
70 km/h		17 *4.44%*	11 *2.87%*	6 *1.57%*	34 *8.88%*
80 km/h	1 *0.26%*	15 *3.92%*	15 *3.92%*	1 *0.26%*	32 *8.36%*
90 km/h	1 *0.26%*	5 *1.31%*	1 *0.26%*		7 *1.83%*
100 km/h	9 *2.35%*	9 *2.35%*	22 *5.74%*	2 *0.52%*	42 *10.97%*
110 km/h	2 *0.52%*				2 *0.52%*
other			1 *0.26%*		1 *0.26%*
All speed zones	13 *3.39%*	54 *14.10%*	97 *25.33%*	46 *12.01%*	210 *54.83%*
Speed Zone	**REST OF VICTORIA** **Freeway**	**Highway**	**Road**	**Street**	**All roads**
≤ 50 km/h				1 *0.26%*	1 *0.26%*
60 km/h		8 *2.09%*	12 *3.13%*	6 *1.57%*	26 *6.79%*
70 km/h		3 *0.78%*		1 *0.26%*	4 *1.04%*
80 km/h		6 *1.57%*	5 *1.31%*		11 *2.87%*
90 km/h		5 *1.31%*			5 *1.31%*
100 km/h	2 *0.52%*	42 *10.97%*	67 *17.49%*	5 *1.31%*	116 *30.29%*
110 km/h	9 *2.35%*				9 *2.35%*
other			1 *0.26%*		1 *0.26%*
All speed zones	11 *2.87%*	64 *16.71%*	85 *22.19%*	13 *3.39%*	173 *45.17%*
				Victoria total	383