Centre for
Automotive Safety Research

Evaluation of South Australian red light and speed cameras

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CASR REPORT SERIES
CASR011
February 2009

THE UNIVERSITY OF ADELAIDE AUSTRALIA

Report documentation

REPORT NO.	DATE	PAGES	ISBN	ISSN
CASR011	February 2009	44	978 1 920947 10 1	1449-2237

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AVAILABLE FROM

Centre for Automotive Safety Research
http://casr.adelaide.edu.au/reports

ABSTRACT

This study examined the number and types of crashes at locations in Adelaide where red light cameras have been installed. While some indications are that the cameras installed in 1988 did reduce the incidence of some types of road crashes, the cameras installed in 2001 appear to have had no effect on crash numbers. It is suggested that inadequate driver knowledge of the 2001 camera locations may be the primary reason for this. Initial results from combined red light and speed cameras were examined and their potential benefit considered. Note that this report was substantially completed in 2003 before the use of dual purpose red light and speed cameras for speed enforcement was started. Literature later than 2003 has also not been considered.

KEYWORDS

Red light camera, Speed camera, Signalised intersection, Accident rate, Literature review, Data analysis

Summary

This study examined the number and types of crashes at locations in Adelaide where red light cameras have been installed.

While some indications are that the cameras installed in 1988 did reduce the incidence of some types of road crashes, the cameras installed in 2001 appear to have had no effect on crash numbers.

It is suggested that inadequate driver knowledge of the 2001 camera locations may be the primary reason for this and it is suggested that installing warning signs on the far side traffic signal poles may improve red light camera effects.

By using clearly indicated combined red light and speed cameras at intersections it would be expected that speeds would be reduced through the intersections and possibly some distance away from the intersections. Given the apparent strong association between travelling speed and casualty crash risk such cameras could be expected to reduce the number of casualty crashes more than red light cameras alone.

Note that this report was substantially completed in 2003 before the use of dual purpose red light and speed cameras for speed enforcement was started. Literature later than 2003 has also not been considered.

Contents

1 Introduction

Red light cameras are installed at signalised intersections in order to photograph vehicles that enter an intersection after the traffic signal has changed to red. Traffic expiation notices are then sent to the registered owner of the vehicle. Signs before the intersection indicate that red light cameras are in operation. The aim of the cameras is to deter red light running and hence reduce the number of crashes at covered intersections.

South Australia first introduced 6 red light cameras in 1998 that were rotated among 15 sites. Subsequent evaluations suggested that that the cameras were effective in reducing crashes and, in particular, casualty crashes at the locations where they were used.

In 2001, a further 12 red light cameras were introduced to cover 24 additional signalised intersections. These cameras also had the ability to measure and record the speeds of vehicles passing through the intersection although this ability was not used for enforcement purposes until 15 December 2003.

The main purpose of this Report is to re-evaluate the effect of the original 1998 red light camera sites on crash numbers and to conduct an initial evaluation of the effect of the 2001 red light cameras sites on crash numbers. Red light running offence data will also be examined.

The secondary purpose of this report is to examine some pre-enforcement speed data collected by the newer cameras in order to gain some understanding of the likely effects of enforcing speeds with these cameras. Actual evaluation of the dual purpose ability of red light and speed enforcement that commenced on 15 December 2003 will not be conducted in this Report.

2 Literature review

Several studies have claimed to show that red light cameras and speed cameras reduce the incidence of red light running and speeding, respectively. However, little is known about the effect of devices used to measure both of these behaviours simultaneously (these cameras are known as "dual cameras"). By inference, dual cameras may further reduce casualty crashes at signalised intersections as speed is currently not measured at such locations. However, there is little direct evidence for this: dual cameras have only recently been operational in Canberra and as such only one investigation has begun to empirically test their effectiveness.

2.1 Methodological limitations within the red light camera literature

Before considering the evidence for the effectiveness of red light cameras, some consideration of the limitations of much of the evidence presented in the literature is required. There is considerable variability in the quality of the results and of the methodologies used to study the effectiveness of red light cameras. Nevertheless, positive results have been found in several investigations.

Red light cameras are often installed at an intersection, chosen for its poor crash history. This presents an immediate methodological problem in that ensuing crash reductions at the site might not necessarily be a result of the presence of the red light camera, but of a phenomenon known as "regression to the mean" (Galton, 1886). For example, if crash frequencies at a particular location are at one end of an extreme, it is natural for the crash rate to decrease or increase (regress) towards the mean crash rates over time, even in the absence of any intervention (McGee & Eccles, 2003). McGee & Eccles (2003) found that in studies of red light camera effectiveness, the effects of regression to the mean have been poorly accounted for.

A further common methodological problem encountered in studies of red light camera effectiveness is the halo effect. The halo effect occurs when the effects of an intervention spill over to groups (or, in this case, locations) to which the intervention is not applied. Specifically, the effect of red light cameras has been shown to produce crash reductions in surrounding signalised intersections that are not equipped with red light cameras, and these reductions are comparable to the intersection where the camera was installed (Retting & Kyrychenko, 2002). Halo effects are especially evident when red light camera enforcement is well advertised (e.g. media campaigns, or camera warning signs posted at the sites), producing a general awareness. However, there is not a consensus about the importance of this effect: while Retting and Kyrychenko (2002) found that the reductions in red light running at 11 intersections post-installation of red light cameras, generalised to 114 surrounding signalised intersections that were not equipped with red light cameras, in another study, Hillier, Ronczka and Schnerring (1993) found no evidence of a halo effect at control intersections. Hence, it is informative to observe the crash frequencies in the area at large rather than solely at red light camera intersections and intersections in close proximity, to ensure that any changes in crash frequencies as a result of red light camera usage are placed in context.

2.2 Effectiveness of red light cameras in deterring red light running

There is an accumulation of evidence that red light running is a significant cause of road crashes (McGee & Eccles, 2003; Retting, Ferguson & Hakkert, 2003) and that red light cameras can deter red light running (Retting & Kyrychenko, 2002). In the year 2001 in South Australia, failure to obey a red traffic signal was cited as the cause of 610 crashes, causing 259 casualties (defined as people whose injuries required hospitalisation and/or caused their demise) (Transport SA, 2001).

Red light running may be defined as a behaviour in which a vehicle enters a signalised intersection after the onset of a red traffic signal, but excludes vehicles that are already within the intersection after the onset of the red traffic signal. Red light cameras automatically photograph vehicles involved in red light running. This evidence is used to penalise offenders, with the aim of deterring such behaviour and reducing the number of crashes at signalised intersections (Zaal, 1994). Hillier et al. (1993) reported that the advent of red light cameras increased the frequency of rear-end crashes due to the tendency of drivers to stop suddenly on a yellow light. However, the severity of the resulting damage (both injury and property) is often more extreme in the side impact collisions that occur as a result of red light running than in the rear-end collisions that might increase as a result of the use of red light cameras. Thus, if red light cameras reduce the frequency of severe side impact crashes they may be deemed to be an effective road safety countermeasure.

MacLean (1985) reported that red light cameras deter red light runners and, therefore, reduce potential crashes in two ways: by 'specific deterrence' and 'general deterrence'. Specific deterrence occurs when drivers previously detected by red light cameras (and issued with traffic infringement notices) are consequently deterred from engaging in future red light running. General deterrence occurs when drivers are reluctant to run red lights due to the perception that they 'will' be caught by red light cameras. In Adelaide, the original wet film red light cameras were rotated between signalised intersections with some camera housings being empty at any given time, unbeknown to road users, in an endeavour to deter a wider population from red light running. This practice has been shown to reduce red light running behaviour and associated crashes as the presence of camera housings and warning signs enhance a general awareness of red light running enforcement within the community (Hillier et al., 1993). The newer digital cameras used in Adelaide are permanently located at their selected sites.

2.3 Investigating the prevalence of red light running

Woolley & Taylor (1998) conducted an investigation into the prevalence of red light running at 12 signalised intersections in the Adelaide Central Business District and metropolitan area of Adelaide, South Australia. A red light camera housing was installed at two of the observed intersections. Each intersection was observed for a total of 8 hours, over a 6-week period (four sessions of two hours duration at each intersection, with the time and day of the sessions randomly selected). A total of 1,668 red light running violations were observed out of 298,049 vehicles that travelled through the 12 intersections. On average red light running occurred 17 times per hour. However, the frequency of red light running varied between the sites: in one two hour session, the frequency of red light running varied from one vehicle at one intersection to 110 vehicles at another intersection. Moreover, when controlling for the traffic flow at each site, the two intersections with red light camera housings recorded the third and fourth lowest frequency of red light running

Green (2000) recently investigated the prevalence of red light running in Melbourne, Victoria. Fifteen signalised intersections were videotaped for 220 hours over a one-month period. A total of 133,238 vehicles travelled through the signalised intersections and 522 red light running violations were recorded (an average of 2.4 instances per hour) which was a considerably lower frequency than found by Woolley and Taylor (1998) (17 instances per hour). Green did not report whether red light cameras were installed at any of the intersections, the presence of which may have confounded the results as red light cameras may have created a general or specific deterrence against red light running. Green estimated that between 10% and 30% of all crashes occurring at signalised intersections are consequences of red light running.

Red light running elevates the risk of serious crashes, and therefore evaluations of the methods used to reduce red light running are warranted. Retting et al. (1999) examined the effectiveness of the Californian Government's red light camera initiative. Red light running offences were observed at 9 red light camera intersections in Oxnard and five non-red light camera signalised intersections (three in Oxnard to analyse any halo effect and two outside Oxnard, in Santa Barbara, to control for the weather and seasonal variability in travelling).

Baseline measures were recorded (with the red light cameras at ground level so not visible to drivers) prior to the media campaign that ran for the initial 30 days of the program. During the warning period and combined media campaign, all red light runners received warnings regarding their offence. During the enforcement period, violations attracted automatic traffic infringement notices and the loss of one demerit point. Data were recorded again three to four months following the enforcement period. Retting et al. (1999) found evidence that, at both camera and non-camera (control) intersections in Oxnard, red light running rates were reduced by the same amount (40% and 50%, respectively - this difference was not statistically significant). The results suggest that a halo effect was present. No statistically significant reduction in red light running was evident at the two control intersections in Santa Barbara. Hence, the results supported the conclusion that red light cameras contributed to a reduction of red light running, although these results were not without limitations. Data were only analysed for the three to four months following the installation of the red light camera program. Therefore, the reduction in red light running may have been at least partly attributable to some confounding factor such as the novelty effect, which could have been overcome by observing the red light running rates over a longer period of time. The low number of control intersections also limited the investigation. There were only two intersections that attempted to control for confounding factors (non-red light camera intersections outside Oxnard) which did not even equate to the number of red light intersections under investigation (9), severely limiting the power and validity of the results.

2.4 Effectiveness of red light cameras in reducing crashes

Given the reasonable assumption that red light cameras do reduce red light running it is also reasonable to assume that crashes and injuries associated with red light running will also be reduced. While this might be true, they may also increase the number of rear-end crashes (Retting et al., 2003). Consider the type of rear-end crash that is the result of different intentions between a driver encountering a yellow light (choosing to stop) and those in vehicles following (choosing to enter the intersection). Red light cameras could conceivably increase this type of collision by causing drivers to react to a yellow light in a way that a following driver does not expect. However, Blakey (2003) asserts that increases in rear-end collisions post-installation of red light cameras would decline after “drivers become accustomed to the cameras” (p. 43).

Retting et al. (2003) reviewed the international literature and concluded that red light cameras lower the incidence of right-angle and right-turn crashes and associated injuries, while increasing the incidence of rear-end crashes but without increasing injuries associated with those crashes. However, the authors acknowledge that the majority of investigations had methodological limitations, such as an absence of adequate control and comparison groups and failure to control for regression to the mean and halo effects. Furthermore, there were substantial differences among the findings of the reviewed research, which partially reflected the methodological differences between the studies and the design flaws in each of the studies. The relevant investigations are discussed below.

The Office of Road Safety (1991) of the South Australian Department of Transport conducted one of the early studies on the effectiveness of red light cameras. The study analysed the effectiveness of red light cameras in reducing crashes at signalised intersections in metropolitan Adelaide for the 12 months from July 1988 to June 1989. Crash frequencies at 15 signalised intersections with red light camera housings (five cameras were rotated between them) were compared with all remaining signalised intersections within Metropolitan Adelaide. In order to enhance the deterrence effect, red light camera ‘warning signage’ was erected on all approaches to the red light camera intersections accompanied by a large-scale media campaign. There were four years of pre-camera installation crash data followed by one year of post-camera installation crash data. The results provided evidence that right-angle casualty and property damage crashes decreased substantially (57% and 32% reductions, respectively) without increasing casualties or property damage resulting from rear end crashes. If the intersections selected for red light camera installations had been chosen because of a poor crash record then the frequency of crashes may have regressed to the mean frequency without any intervention. Furthermore, several red light camera sites had geometrical alterations that may have biased the results. The presence of red light cameras appeared to have played an important role in the reduction of casualty crashes, however the extent to which the reduction may have been at least partially due to other factors is unknown.

Mann, Brown and Coxon (1994) investigated the same 15 red light cameras sites in metropolitan Adelaide studied by the Office of Road Safety in 1991, increasing the collection of crash data to five years pre-and-post red light camera installation (July 1983 to June 1993) whilst controlling for changes to intersection geometry. The number of sites studied was reduced to 13 as structural changes may have confounded the results at two sites. The sites were divided into eight with red light cameras, five with red light cameras that underwent changes to intersection geometry during the study, and 14 matched non-red light camera signalised intersections which underwent intersection improvements over the course of the study. Each red light camera site initially had warning signs installed on all approaches to the intersection although over time it was decided that only the monitored leg would have a warning sign maintained. Interestingly, none of the red light camera sites significantly outperformed the control sites. It is plausible that the intersection changes to the control sites over this period may have confounded the results, because the red light camera sites that were accompanied by intersection alterations had significant reductions in right-angle and right-turn crashes in comparison to the control sites. The authors suggested that the data might have been subject to regression to the mean as the crash rates at the red light camera sites had declined to a greater extent pre-camera installation than for the control sites. Furthermore, halo effects may have masked the crash reductions as the control intersections were within the same community as the red light camera sites. Mann et al. suggested that the analysis of a limited number of red light cameras may have deducted from the power of the statistical analyses in detecting a significant difference between the sites. After controlling for alterations to intersection geometry and analysing 10 years of data, a decrease in casualty crashes was evident at red light camera sites (54% right-angle and 38% right-turn) but this reduction was not statistically significant.

Andreassen (1995) analysed a greater number of red light cameras to determine the efficacy of red light cameras in reducing crashes at signalised intersections. Crash data that had been collected in Melbourne, Australia between 1979 and 1989 were analysed. All 41 red light camera intersections in metropolitan Melbourne were studied, using all remaining signalised intersections as comparison sites. The red light cameras had been installed in 1984, despite the fact that 75% of the intersections had low crash frequencies (average of two crashes per year) and were, therefore, not ideal for observing crash reductions. Intersections with low crash frequencies are not ideal sites for red light cameras as only minimal reductions are possible. Warning signs were erected at the red light camera intersections and publicity was widespread. The study used data covering five years pre-and-post-camera installation excluding data for 1984 (the year that the cameras were installed).

Despite the automated enforcement of red light running using the cameras, Andreassen (1995) found no substantial differences in crash reductions between red light camera and non-red light camera sites. In contrast, there was evidence that rear-end crashes had increased by a statistically significant 20% at red light camera intersections. A further analysis was conducted to determine if the camera approach (the direction of flow monitored by the camera) demonstrated different crash frequencies in comparison to the intersection crash rates as a whole, but there was no evidence of a camera approach effect. Unfortunately for the analysis, intersection changes were implemented at specific intersections (e.g., lane additions and green arrows) with no record of the dates of the changes. Therefore it was not possible to assess the effect of those changes on crash frequency at either the control or the camera sites. Another potential confounding factor was a speed-camera program that was simultaneously introduced in Melbourne. The methodological problems in this study limit the confidence in the finding that red light cameras are not effective in reducing crashes.

In contrast, a study by Hillier et al. (1993) in Metropolitan Sydney, New South Wales reported substantial reductions in crashes post-installation of red light cameras. A two-year pre-and-post red light camera installation analysis was undertaken for 16 red light camera sites and 16 non-red light camera control sites that were matched in terms of traffic volume, accident history and intersection design. Red light cameras were rotated between the housings at the camera sites, therefore, they were analysed in terms of the most and the least frequent use of red light cameras. A general media campaign was operational and all red light camera intersections had warning signs and camera housings, although it is not clear if the signs were on all approaches or solely the approach housing the red light camera. The results were varied, there was no effect of camera approach so all of the crashes occurring within the intersection were analysed together. Right-angle and right-turn crashes (target crashes) at the most frequently used camera sites decreased (48%) in comparison to an increase at control sites (2%), revealing that the frequent use of red light cameras was effective in reducing target crashes. However, rear end crashes did increase at these camera sites (62%) in comparison to the control sites (29%). For the least used camera sites there was a different pattern, target crashes decreased to a similar magnitude at both camera (49%) and control sites (52%). While rear end crashes increased at these camera sites (27%) but decreased at control sites (18%). All of these results were statistically significant. However, as acknowledged by the authors, the validity of the control sites for the least used camera sites became contaminated when changes were made to the sites during the study period (implementing right-turn arrows and altering signal phase length). Such changes may have accounted for the apparently superior performance of the control sites for the least used camera sites. Furthermore, halo effects were not evident at the control sites. Despite the limitations presented by the least used control group, the evidence indicated that red light cameras and other interventions in combination with the red light cameras were effective in reducing right-angle and right-turn crashes at signalised intersections.

Findings of the studies have increasingly shown that the most superior research designs tend to highlight the effectiveness of red light cameras in reducing right-angle and right-turn crashes, with variable increases in rear-end crashes. However, Retting and Kyrychenko (2002) conducted a methodologically sound analysis that found a positive effect of red light cameras in Oxnard, California in reducing crashes and associated injuries, without significant increases in rear-end crashes. The research design enabled Retting & Kyrychenko to control for regression to the mean and halo effects, which many other investigations have not entirely controlled for. This was a follow-up study to Retting et al.'s (1999) investigation on the prevalence of red light running (discussed previously).

In particular, Retting and Kyrychenko (2002) investigated all 125 signalised intersections in Oxnard, including 11 installed with red light cameras to determine reductions in crashes. Retting and Kyrychenko controlled for potential confounding variables that may have affected the results in Oxnard (eg., weather and economic situations), by incorporating data from three Californian cities. Each city had similar crash histories and was located more than 100 miles away from Oxnard so that the effects of the red light cameras in Oxnard would presumably not generalise to the control populations (without cameras). Crash data were obtained for 29 months pre-and-post camera installation, excluding the month prior to, and the initial month of, the red light camera enforcement to allow time for the community to become aware of the enforcement program. A major media publicity campaign aimed to increase the awareness of red light cameras and postcards detailing the enforcement were sent to all Oxnard residents. The researchers concluded that red light cameras in Oxnard contributed to a 7% reduction of all crashes and a 29% reduction in associated injuries. This result provided support for the phenomenon of halo effects, that is, the effect of the cameras generalised to all signalised intersections in Oxnard, thus reducing crashes at intersections without red light cameras. In further detail, right-angle crashes (which tend to equate to serious injury) reduced by 32% with injuries reducing by 68%. Importantly, no statistically significant increase was evident for rear-end crashes. The findings of this methodologically sound investigation provide strong support for the effectiveness of red light camera enforcement in reducing crash frequency.

In summary, red light cameras appear to be effective in reducing serious casualty crashes. Retting and Kyrychenko (2002) conducted a methodologically sound study that found a positive effect of red light cameras. Hillier et al. (1993), also found support for the effectiveness of red light cameras in reducing serious angle crashes (despite increases in rear end crashes) although this study has some methodological limitations. Andreassen (1995) was unable to find support for the effectiveness of red light cameras but this study also had numerous methodological problems.

2.5 Speed and its relationship to crash frequency and severity

As with red light running, there is also an accumulation of evidence that speeding (driving in excess of the legal speed limit) contributes to the causation and severity of motor vehicle crashes. Tziotis and Green (2001) reported that on average, from a number of investigations, 30% of fatal crashes in Australia were attributable to speed. Despite the fact that speeding holds such a great risk of injury and fatality, over 90% of drivers will drive faster than the posted speed limit in their lifetime (Zaal, 1994).

A study by Kloeden, et al (1997) provides an estimate of the risk of being involved in a casualty crash whilst speeding. A comparison was conducted between the estimated free travelling speeds of vehicles involved in casualty crashes and the speeds of vehicles not involved in casualty crashes (ie: control vehicles). The control vehicles were travelling on the same road at the same location and direction of travel as the vehicle involved in the crash and at the same time of day and week, under similar weather conditions. Kloeden et al. found that "above 60 km/h... there is a steady increase in risk of involvement in a casualty crash... the risk approximately doubles with each 5 km/h increase in travelling speed" (p. 38). Kloeden et al. concluded that many of the crashes could have been avoided had the vehicles been travelling at lower speeds. Speed cameras affect speeding by reprimanding such driving behaviour and can also have a deterrent effect on subsequent speeding tendencies. Fildes and Lee (1993) explained the effect that the presence of speed cameras can have on drivers. Distance halo effect refers to the distance in which drivers reduce their speed further away from the immediate vicinity of the speed camera sites. Whereas, time halo effect refers to the length of time (in days) that drivers continue to reduce their speed at locations where they have previously been reprimanded for speeding (Fildes & Lee, 1993). Obviously, it is beneficial for both the distance and the time halo effects to be operational as they contribute to increasing driver awareness and a generalisation of speed camera enforcement. Hence, it would appear plausible that increasing the visibility and the unpredictability of speed enforcement could maximise the potential benefits of the halo effects. For example, speed camera housings could be installed to alert drivers that speed enforcement may be operational but the speed cameras rotate between the locations to enhance unpredictability. Maintaining the aspect of unpredictability is important, as drivers may simply adjust their speed so that they engage in speeding only in the absence of the cameras. Ensuring that a broad selection of locations are installed with speed camera housings (not necessarily with actual speed cameras) should affect resulting speeding and, therefore, reduce associated crashes.

2.6 The effectiveness of speed cameras in reducing speeding and associated crashes

Ragnoy (2002) analysed the efficacy of speed cameras in reducing speeding in Norway, and concluded that speed cameras were successful in decreasing driving speeds. A one year pre-and-post speed camera installation design was used on three roads with matched traffic volumes. The three roads differed in length (8.4, 10.8 and 26.0 km) in the number of speed cameras (10, 10 and 4, respectively) and in speed zones (90, 80 and 70 km/h). Ragnoy collected speed measurements at all three sites for the one year before speed camera installation and the year following the installation and at two of the sites for the second year following speed camera installation. All data were compared to one year of pre-installation data. Speed reductions were observed on all three roads ranging from 4.18 km/h to 6.16 km/h.

If speed cameras are effective in reducing speeding it follows that the crashes associated with speeding should also decrease. Keall, Povey and Frith (2002) conducted an investigation to determine the efficacy of hidden (not visible to drivers) versus visible (situated on police vehicles) speed cameras in reducing crashes in New Zealand. Roads with a 100 km/h speed limit in the district of the Midland Police were designated as the intervention sites (16 speed camera sites) while all remaining roads with a speed limit over 100 km/h (41 sites) were used as matched control sites (with respect to road quality, traffic flow, safety campaigns as well as level of enforcement and average speeds prior to enforcement). Control sites were incorporated to account for speed reductions due to traffic conditions and other confounding variables (such as traffic flow and media campaigns). Over a two-year period the hidden cameras (although signs were posted to alerted drivers that speed cameras may have been present) resulted in an 11% reduction of crashes and a 19% reduction of casualty crashes in comparison to the control sites. Furthermore, the casualty rate and level of severity per crash was lower where hidden speed cameras were present strengthening the theory that driving speeds just prior to the collision had reduced.

Gains, Humble, Heydecker and Robertson (2003) analysed data obtained from a large pilot study that investigated the effectiveness of speed cameras in reducing casualty crashes in the United Kingdom. The study incorporated 599 camera sites (cameras varied between fixed speed cameras, mobile speed cameras and digital speed cameras) that were situated in eight areas over a two-year period. Historically, speed cameras were extensively used in four of the areas while the remaining four had a history of meagre speed camera use. Within each of the eight areas, cameras were placed at sites with the poorest record of speed related casualty crashes. Data were collected on the speed of the vehicles and the frequency of crashes and casualties. Gains et al. found evidence that speed cameras appeared to reduce fatalities and serious injuries by 35% with sites housing fixed cameras having the greatest impact (65% reduction in fatalities and serious injuries). They also reported that at the 599 camera sites the mean speed of vehicles reduced by an average of 3.7mph, with reductions in speed greater at fixed speed camera sites than at mobile speed camera sites.

As evident from the studies presented here, speed cameras can have a positive effect in reducing crashes and associated injuries, which appears to increase in effectiveness with additional speed cameras.

2.7 Combining automated red light cameras with speed cameras (dual cameras)

The potential value of combining red light cameras with speed cameras and, therefore, issuing double fines when individuals break both of the road rules can be appreciated when one considers the danger of speeding through signalised intersections. McLean, Offler and Sandow (1979) reporting on an in-depth study of 304 crashes occurring within Metropolitan Adelaide, Australia, noted that some of the crash involved vehicles that had been travelling on the through road when entering a signalised intersection were speeding. They described how such speeding was a contributing factor to vehicle involvement in crashes. This phenomenon was observed again in a later study (McLean, Lindsay and Kloeden, 2002). In that study, Accidents were investigated at the scene, with the speeds of vehicles being estimated using computer reconstruction techniques. The authors noted that, out of 148 crashes investigated in 60 km/h zones of the metropolitan area of Adelaide, 32 occurred at a signalised intersection and that in 13 of those, one of the vehicles involved was travelling at greater that 70 km/h.

When approaching the onset of yellow traffic lights drivers have to decide whether to stop or proceed through the signalised intersection on the yellow light. The decision is made in either the 'option zone' or the 'dilemma zone' (Allos & Al-Hadithi, 1992). In the option zone a driver can either safely enter the intersection at their pre-existing speed before the signal changes to red, or slow their vehicle and brake effortlessly to halt at the stop line. The dilemma zone reflects the driver's difficult decision making where both entering the intersection at the pre-existing speed and braking to halt at the stop line are dangerous options in terms of crash risk (Allos & Al-Hadithi, 1992). Hence, travelling speed plays an extreme role in the decision making process, such that at higher speeds the decision to stop or proceed through the intersection becomes difficult to make as the time frame in which to make this decision decreases substantially with increases in speed (Baguley, 1988). Another aspect that plays a role in the decision making process whilst in the dilemma zone is the distance of the vehicle from the signalised intersection on observing the yellow traffic signal (Allos & Al-Hadithi, 1992; Lum & Wong, 2003). For example, in combining the speed and location of the vehicle, those drivers that are reasonably close to the intersection may decide to speed up to beat the onset of the red light. Whereas, drivers further from the intersection and travelling at a slower speed may choose to stop their vehicle at the intersection (Lum & Wong, 2003). Thus, speed plays a significant role in deciding to drive through a signalised intersection or to stop on the yellow light.

Speeding through signalised intersections can hold grave implications for road users. Fakhry and Salaita (2002) found that on average 50% of red light running occurred whilst driving at, or faster than, the speed limit at signalised intersections with and without red light cameras. Sixteen per cent of speeding vehicles drove more than 10 mph above the speed limit when running the red light. Thus, red light cameras did not appear to impede such behaviours, however, if combined with speed cameras individuals may become more hesitant to receive two traffic infringements. Considering that the yellow phase has a predetermined interval time to account for the posted speed limit, exceeding this speed limit means that the yellow phase may not be adequate to allow for speeding vehicles. In locations with higher speed limits, longer yellow intervals are required to allow the traffic through the intersection safely (Retting, Chapline & Williams, 2002). The combination of speed and running red lights creates a potentially fatal combination: a conflict between a right-turning vehicle and a speeding through vehicle can be lethal.

Green (2000) and Kent et al. (1995) investigated the antecedents to red light running at signalised intersections in locations with high and low speed limits. Both investigations found evidence that drivers ran significantly more red lights when executing a right-turn relative to left and straight through movements. Right-turn crashes at signalised intersections tend to be associated with a greater severity of injuries than rear-end crashes. Moreover, both investigations found evidence that speed affected the frequency of red light running, in particular, that red lights were run when intersections were small and in low speed limit areas in comparison to larger intersections with higher speed limits.

Red light cameras in combination with fixed digital speed cameras (dual cameras) were installed in Canberra at three signalised intersections renowned for their problematic crash frequency in 2001. Brimson and Anderson (2002) conducted an investigation into the effectiveness of the dual cameras. A before and after camera installation design was utilised with three control intersections in close proximity to the signalised intersections housing the dual cameras. There were five years pre-installation data and one year post-installation data available at the time of publication The results indicated that rear-end crashes had significantly increased at the signalised intersections housed with dual cameras and decreased at the control intersections. Brimson and Anderson reported that the data on the frequency of right-angle and right-turn crashes were not conclusive for any of the sites because the control intersections had such a substantial decrease in crash frequency. Brimson and Anderson suggested that the decline in crash frequency at the control sites may be attributable to a generalised decrease in red light running and speeding through signalised intersections resulting from public awareness of the new system (a halo effect). Therefore, control sites should have been appropriately selected to account for this well-known phenomenon. Alternatively, Brimson and Anderson suggested that changes in crash data record keeping may have confounded the results. In summary, the crash data available for this study only spanned one year post-dual camera installation and therefore their efficacy remains unanswered.

2.8 Summary

Substantial evidence reveals the promising effects of red light cameras and speed cameras in reducing red light running and speeding, respectively. A reduction of red light running has similarly been shown to reduce right-angle and right-turn casualty crashes, with a variable effect on rear-end crashes.

One study analysed the effects on crashes of combined red light and speed cameras but failed to find any conclusive reductions in crashes or associated injuries.

3 Signalised intersection crashes in Adelaide over time

In order to place any observed changes of crash rates at red light camera intersections in context, it is necessary to have a more general reference measure of crashes. This allows other factors affecting reported crash rates to be taken into account (such as changes in traffic volumes, reporting thresholds and crash type classifications). Typically, this is done by matching one or more control intersections, where red light cameras are not installed, with each of the red light camera intersections. However, possible halo effects of the red light cameras on driver behaviour at nearby intersections and the low number of crashes at individual intersections leading to large random fluctuations in comparable crash numbers may substantially reduce the validity and precision of comparisons with crashes at these control sites.

For these reasons, it was decided to use crashes at all Adelaide signalised intersections as the reference measure for the red light camera intersections. Figure 3.1 shows the number and type of crashes of all severities (specifically crashes resulting in a casualty or with total property damage of $1,000 or more) reported to the police at Adelaide signalised intersections from 1983 to 2002. Figure 3.2 shows the corresponding numbers for casualty crashes.

One potential problem with this method is that over time we would expect more intersections to become signalised which could inflate the reference number of crashes. This was examined by comparing the total number of crashes occurring at the 24 sites at which red light cameras were installed in 2001 (see Section 5) with the number of crashes at all other Adelaide signalised intersections each year from 1983 to 2002. Changes in these two measures tracked each other very closely (both for all crashes and casualty crashes) which suggests that the effect of new signalised intersections is negligible and that this reference group is a reasonable one to use (see Figures 3.3 and 3.4).

Figure 3.1
Number and type of crashes of all severities reported to police at Adelaide signalised intersections 1983-2002

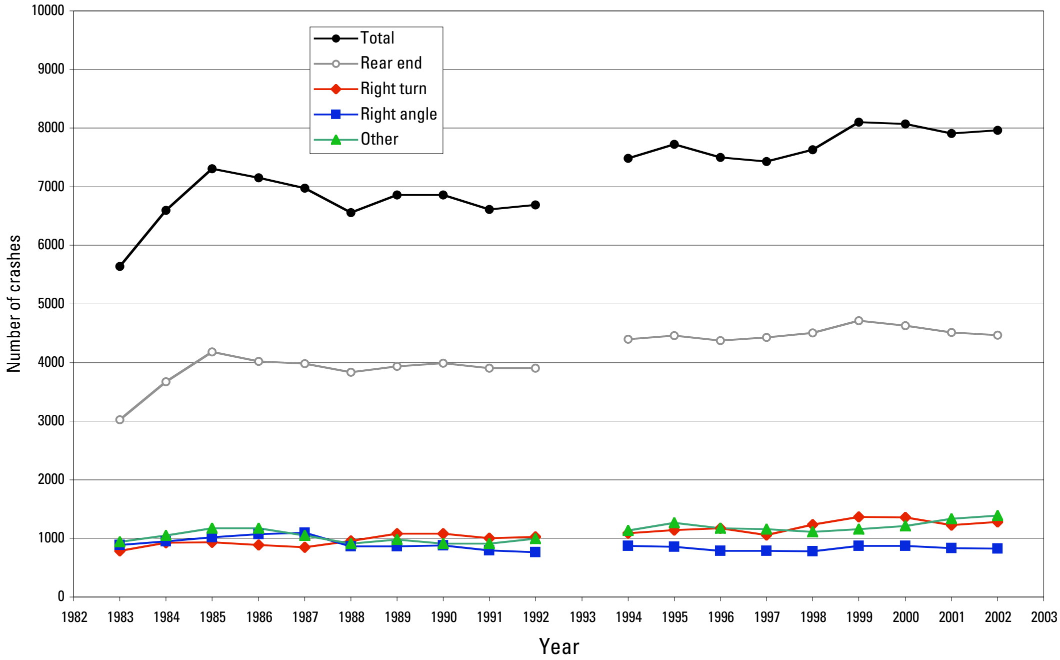


Figure 3.2
Number and type of casualty crashes reported to police at Adelaide signalised intersections 1983-2002

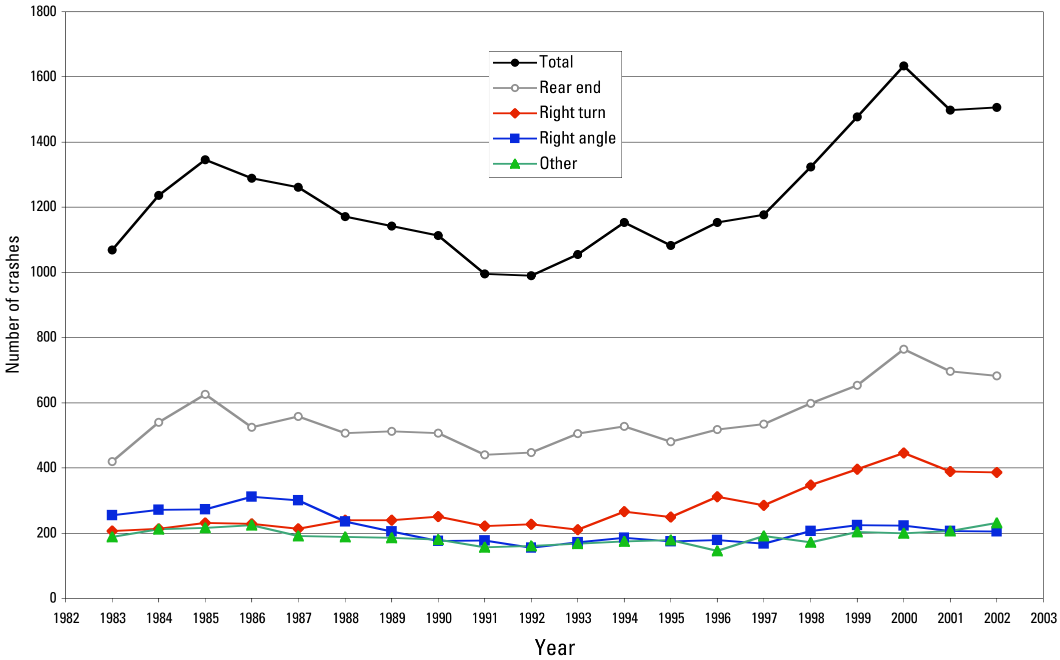


Figure 3.3
Number of crashes of all severities reported to police
at the 24 signalised intersections at which red light cameras were installed in 2001
compared to all other Adelaide signalised intersections 1983-2002

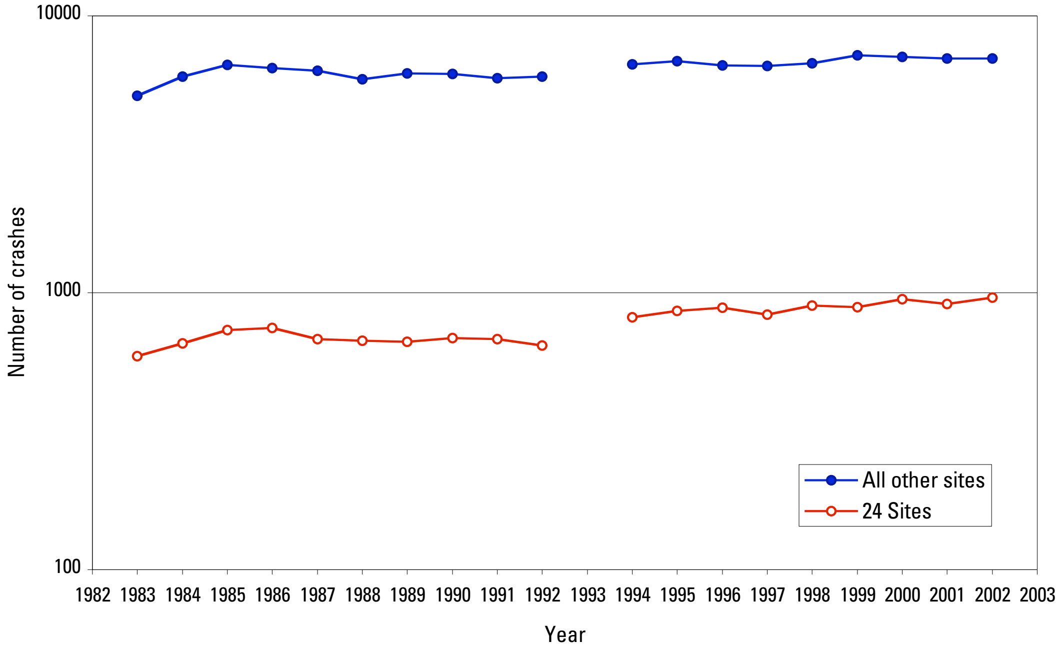
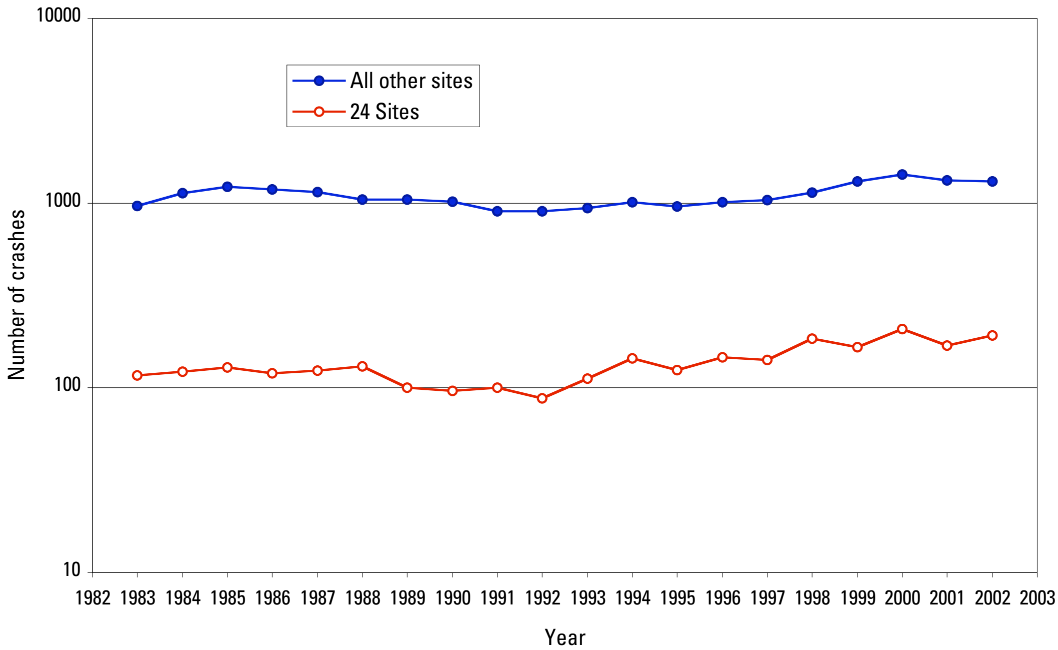


Figure 3.4
Number of casualty crashes reported to police
at the 24 signalised intersections at which red light cameras were installed in 2001
compared to all other Adelaide signalised intersections 1983-2002



4 Red light camera sites in 1988

In mid 1988, a total of 15 signalised intersections in the Adelaide metropolitan area were fitted with housings for red light cameras with 6 cameras being rotated between them. Two of these intersections were only used for a short period of time and five had other significant changes made to the intersection layout after the cameras were installed (see Table 4.1). This left 8 intersections available for the evaluation of the effect of the red light cameras on crash frequency. Each leg of the intersection had a sign in place indicating that a red light camera was in operation even though only one leg was covered by a camera.

Table 4.1
Red light camera intersection sites introduced in 1988

Site Number	Road 1	Road 2	Comment
1	Hutt Street	Pirie Street/Bartels Road	
2	Morphett Street	Franklin Street	
3	Fullarton Road	The Parade	
4	Melbourne Street	Mann Terrace	
5	Taunton Road	Hampstead Road	
6	Main North Road	Elizabeth Way	
7	West Lakes Boulevard	Frederick Road	
8	Port Road	South Road	
9	South Road	Richmond Road	Limited use
10	South Road	George Street, Thebarton	Limited use
11	Sudholz Road	North East Road	Other changes
12	Ascot Avenue	North East Road	Other changes
13	Goodwood Road	Springbank Road	Other changes
14	Diagonal Road	Oaklands Road	Other changes
15	Portrush Road	Payneham Road	Other changes

4.1 Analysis of crashes of all severities

Tables 4.2 to 4.6 show the observed number of crashes of all severities (specifically crashes resulting in a casualty or with total property damage of $1,000 or more), by total and by crash type, recorded at each of the 8 intersections where red light cameras were installed in 1988 during the 4 years before and the 4 years after installation. The expected number of crashes after the introduction was calculated after correcting the before crashes by changes in the same crash type at all other Adelaide signalised intersections. The difference column gives the difference between the number of observed crashes from the number of crashes which would be expected if the particular intersection behaved like all other Adelaide signalised intersections. A matched pair t-test was used to determine if there was a statistically significant change in crashes after the red light cameras were introduced (specifically it tests if the difference column is consistently positive or negative). A p-value of 0.05 or less indicates that any observed differences are unlikely to be due to random variation alone. The advantage of this method is that it treats each individual intersection with the same importance and so the results are not biased towards high crash rate intersections.

The number of crashes at all 8 sites combined in the 4 years before and the 4 years after the cameras were introduced were also compared with the corresponding numbers at all other Adelaide signalised intersections (the Control row). A Chi-squared test was used to determine if the total number of crashes at the red light camera sites had changed compared to all other Adelaide signalised intersections.

None of the results of the statistical tests on Tables 4.2 to 4.6 were significant (all had p-values greater than 0.05) indicating no statistically significant change in crash numbers.

Table 4.2
Crashes of all severities recorded at
intersections where red light cameras were installed in 1988
Expected crashes corrected for overall trends in
Adelaide signalised intersection crashes
Control crashes are crashes at all other Adelaide signalised intersections

Site Number	Observed crashes before the cameras 1984-1987	Observed crashes after the cameras 1989-1992	Expected crashes 1989-1992	Difference between observed and expected crashes 1989-1992
1	68	93	65	+28
2	44	29	42	-13
3	105	108	101	+7
4	42	29	40	-11
5	40	42	39	+3
6	44	44	42	+2
7	67	55	65	-10
8	226	208	218	-10
Total crashes	636	608	612	-4
Control crashes	27435	26419		

A matched pair t-test of observed vs expected crashes 1989-1992 has a p-value of 0.912

A Chi-squared test of total crashes vs control crashes has a p-value of 0.899

Table 4.3
Right turn crashes of all severities recorded at intersections where red light cameras were installed in 1988
Expected crashes corrected for overall trends in Adelaide signalised intersection right turn crashes
Control crashes are crashes at all other Adelaide signalised intersections

Site Number	Observed crashes before the cameras 1984-1987	Observed crashes after the cameras 1989-1992	Expected crashes 1989-1992	Difference between observed and expected crashes 1989-1992
1	6	19	7	+12
2	8	10	9	+1
3	26	45	30	+15
4	0	0	0	0
5	0	0	0	0
6	2	1	2	-1
7	20	25	23	+2
8	14	14	16	-2
Total crashes	76	114	88	+26
Control crashes	3524	4078		

A matched pair t-test of observed vs expected crashes 1989-1992 has a p-value of 0.198

A Chi-squared test of total crashes vs control crashes has a p-value of 0.083

Table 4.4
Right angle crashes of all severities recorded at intersections where red light cameras were installed in 1988
Expected crashes corrected for overall trends in Adelaide signalised intersection right angle crashes
Control crashes are crashes at all other Adelaide signalised intersections

Site Number	Observed crashes before the cameras 1984-1987	Observed crashes after the cameras 1989-1992	Expected crashes 1989-1992	Difference between observed and expected crashes 1989-1992
1	11	11	9	+2
2	16	5	13	-8
3	24	13	19	-6
4	16	10	13	-3
5	24	27	19	+8
6	7	5	6	-1
7	10	4	8	-4
8	25	13	20	-7
Total crashes	133	88	107	-19
Control crashes	4004	3212		

A matched pair t-test of observed vs expected crashes 1989-1992 has a p-value of 0.252

A Chi-squared test of total crashes vs control crashes has a p-value of 0.167

Table 4.5
Rear end crashes of all severities recorded at intersections where red light cameras were installed in 1988
Expected crashes corrected for overall trends in Adelaide signalised intersection rear end crashes
Control crashes are crashes at all other Adelaide signalised intersections

Site Number	Observed crashes before the cameras 1984-1987	Observed crashes after the cameras 1989-1992	Expected crashes 1989-1992	Difference between observed and expected crashes 1989-1992
1	40	57	40	+17
2	11	5	11	-6
3	35	35	35	+0
4	13	11	13	-2
5	10	10	10	+0
6	29	32	29	+3
7	29	23	29	-6
8	148	155	147	+8
Total crashes	315	328	312	+16
Control crashes	15556	15407		

A matched pair t-test of observed vs expected crashes 1989-1992 has a p-value of 0.490

A Chi-squared test of total crashes vs control crashes has a p-value of 0.530

Table 4.6
Other crash types of all severities recorded at intersections where red light cameras were installed in 1988
Expected crashes corrected for overall trends in Adelaide signalised intersection other crash types
Control crashes are crashes at all other Adelaide signalised intersections

Site Number	Observed crashes before the cameras 1984-1987	Observed crashes after the cameras 1989-1992	Expected crashes 1989-1992	Difference between observed and expected crashes 1989-1992
1	11	6	9	-3
2	9	9	8	+1
3	20	15	17	-2
4	13	8	11	-3
5	6	5	5	-0
6	6	6	5	+1
7	8	3	7	-4
8	39	26	33	-7
Total crashes	112	78	96	-18
Control crashes	4351	3722		

A matched pair t-test of observed vs expected crashes 1989-1992 has a p-value of 0.064

A Chi-squared test of total crashes vs control crashes has a p-value of 0.167

4.2 Analysis of casualty crashes

Tables 4.7 to 4.11 show the observed number of casualty crashes, by total and by crash type, recorded at each of the 8 intersections where red light cameras were installed in 1988 during the 4 years before and the 4 years after installation. The expected number of casualty crashes after the introduction was calculated after correcting the before crashes by changes in the same crash type at all other Adelaide signalised intersections. The difference column gives the difference between the number of observed casualty crashes from the number of casualty crashes which would be expected if the particular intersection behaved like all other Adelaide signalised intersections. A matched pair t-test was used to determine if there was a statistically significant change in casualty crashes after the red light cameras were introduced (specifically it tests if the difference column is consistently positive or negative). A p-value of 0.05 or less indicates that any observed differences are unlikely to be due to random variation alone. The advantage of this method is that it treats each individual intersection with the same importance and so the results are not biased towards high casualty crash rate intersections.

The number of casualty crashes at all 8 sites combined in the 4 years before and the 4 years after the cameras were introduced were also compared with the corresponding numbers at all other Adelaide signalised intersections (the Control row). A Chi-squared test was used to determine if the total number of crashes at the red light camera sites had changed compared to all other Adelaide signalised intersections.

The statistical tests on Tables 4.7 to 4.11 indicate a statistically significant decrease in "right angle" casualty crashes after the installation of the red light cameras and no evidence of any real effect for any other crash type. The reduction in total crashes appears to reflect the reduction in "right angle" casualty crashes although only the t-test was statistically significant. This suggests that the red light cameras had a significant effect on crashes with a more serious outcome.

Table 4.7
Casualty crashes recorded at
intersections where red light cameras were installed in 1988
Expected crashes corrected for overall trends in
Adelaide signalised intersection casualty crashes
Control crashes are casualty crashes at all other Adelaide signalised intersections

Site Number	Observed crashes before the cameras 1984-1987	Observed crashes after the cameras 1989-1992	Expected crashes 1989-1992	Difference between observed and expected crashes 1989-1992
1	17	12	14	-2
2	12	6	10	-4
3	20	16	17	-1
4	14	8	12	-4
5	16	6	13	-7
6	12	10	10	+0
7	14	11	12	-1
8	41	26	34	-8
Total crashes	146	95	121	-26
Control crashes	4996	4147		

A matched pair t-test of observed vs expected crashes 1989-1992 has a p-value of 0.019

A Chi-squared test of total crashes vs control crashes has a p-value of 0.068

Table 4.8
Right turn casualty crashes recorded at
intersections where red light cameras were installed in 1988
Expected crashes corrected for overall trends in
Adelaide signalised intersection right turn casualty crashes

Site Number	Observed crashes before the cameras 1984-1987	Observed crashes after the cameras 1989-1992	Expected crashes 1989-1992	Difference between observed and expected crashes 1989-1992
1	2	3	2	+1
2	1	2	1	+1
3	3	6	3	+3
4	0	0	0	0
5	0	0	0	0
6	2	0	2	-2
7	6	5	6	-1
8	4	1	4	-3
Total crashes	18	17	19	-2
Control crashes	869	921		

A matched pair t-test of observed vs expected crashes 1989-1992 has a p-value of 0.714

A Chi-squared test of total crashes vs control crashes has a p-value of 0.736

Table 4.9
Right angle casualty crashes recorded at
intersections where red light cameras were installed in 1988
Expected crashes corrected for overall trends in
Adelaide signalised intersection right angle casualty crashes

Site Number	Observed crashes before the cameras 1984-1987	Observed crashes after the cameras 1989-1992	Expected crashes 1989-1992	Difference between observed and expected crashes 1989-1992
1	7	3	4	-1
2	8	1	5	-4
3	9	2	6	-4
4	8	5	5	-0
5	12	6	8	-2
6	5	2	3	-1
7	5	2	3	-1
8	10	0	6	-6
Total crashes	64	21	41	-20
Control crashes	1092	692		

A matched pair t-test of observed vs expected crashes 1989-1992 has a p-value of 0.012

A Chi-squared test of total crashes vs control crashes has a p-value of 0.009

Table 4.10
Rear end casualty crashes recorded at
intersections where red light cameras were installed in 1988
Expected crashes corrected for overall trends in
Adelaide signalised intersection rear end casualty crashes

Site Number	Observed crashes before the cameras 1984-1987	Observed crashes after the cameras 1989-1992	Expected crashes 1989-1992	Difference between observed and expected crashes 1989-1992
1	6	5	5	-0
2	2	0	2	-2
3	3	4	3	+1
4	3	0	3	-3
5	2	0	2	-2
6	3	4	3	+1
7	2	3	2	+1
8	18	23	15	+8
Total crashes	39	39	33	+6
Control crashes	2215	1868		

A matched pair t-test of observed vs expected crashes 1989-1992 has a p-value of 0.529

A Chi-squared test of total crashes vs control crashes has a p-value of 0.456

Table 4.11
Other casualty crash types recorded at
intersections where red light cameras were installed in 1988
Expected crashes corrected for overall trends in
Adelaide signalised intersection other casualty crash types

Site Number	Observed crashes before the cameras 1984-1987	Observed crashes after the cameras 1989-1992	Expected crashes 1989-1992	Difference between observed and expected crashes 1989-1992
1	2	1	2	-1
2	1	3	1	+2
3	5	4	4	-0
4	3	3	2	+1
5	2	0	2	-2
6	2	4	2	+2
7	1	1	1	+0
8	9	2	7	-5
Total crashes	25	18	20	-2
Control crashes	820	666		

A matched pair t-test of observed vs expected crashes 1989-1992 has a p-value of 0.747

A Chi-squared test of total crashes vs control crashes has a p-value of 0.701

5 Red light camera sites in 2001

During 2001, 24 additional signalised intersections in the Adelaide metropolitan area were fitted with housings for red light cameras (Table 5.1). Only the leg of the intersection covered by the camera had a sign in place indicating that a red light camera was in operation. Note that due to the more recent installation of the cameras, fewer years of post implementation crash data were available for analysis (one year compared to four years for the 1988 camera sites).

Table 5.1
Red light camera intersection sites introduced in 2001

Site Number	Road 1	Road 2	Start date
1	Findon Road	Crittenden Road	20/04/2001
2	South Road	Daws Road	25/04/2001
3	North Terrace	Frome Road	07/05/2001
4	North Terrace	King William Street	07/05/2001
5	Beach Road	Dyson Road	07/05/2001
6	Prospect Road	Fitzroy Terrace	08/05/2001
7	Marion Road	Cross Road	08/05/2001
8	South Road	Torrens Road	08/05/2001
9	Marion Road	Sturt Road	09/05/2001
10	Brighton Road	Sturt Road	09/05/2001
11	Goodwood Road	Cross Road	09/05/2001
12	South Road	Manton Street	09/05/2001
13	Wakefield Street	Pulteney Street	26/05/2001
14	St Bernards Road	Montacute Road	04/06/2001
15	Golden Grove Road	Milne Road	06/06/2001
16	North East Road	Reservoir Road	12/06/2001
17	The Parade	Glynburn Road	25/06/2001
18	Lower North East Road	Gorge Road	28/06/2001
19	Main North Road	Regency Road	29/06/2001
20	The Grove Way	The Golden Way	06/07/2001
21	Salisbury Highway	Kings Road	17/07/2001
22	Anzac Highway	West Terrace	04/10/2001
23	Portrush Road	Magill Road	19/11/2001
24	Glynburn Road	Montacute Road	19/11/2001

5.1 Analysis of crashes of all severities

Tables 5.2 to 5.6 show the observed number of crashes of all severities (specifically crashes resulting in a casualty or with total property damage of $1,000 or more), by total and by crash type, recorded at each of the 24 intersections where red light cameras were installed in 2001 during the year before and the year after installation. The expected number of crashes after the introduction was calculated after correcting the before crashes by changes in the same crash type at all other Adelaide signalised intersections. The difference column gives the difference between the number of observed crashes from the number of crashes which would be expected if the particular intersection behaved like all other Adelaide signalised intersections. A matched pair t-test was used to determine if there was a statistically significant change in crashes after the red light cameras were introduced (specifically it tests if the difference column is consistently positive or negative). A p-value of 0.05 or less indicates that any observed differences are unlikely to be due to random variation alone. The advantage of this method is that it treats each individual intersection with the same importance and so the results are not biased towards high crash rate intersections.

The number of crashes at all 24 sites combined in the year before and the year after the cameras were introduced were also compared with the corresponding numbers at all other Adelaide signalised intersections (the Control row). A Chi-squared test was used to determine if the total number of crashes at the red light camera sites had changed compared to all other Adelaide signalised intersections.

None of the results of the statistical tests on Tables 5.2 to 5.6 were significant (all had p-values greater than 0.05) indicating no statistically significant change in crash numbers.

Statistical tests were also conducted comparing 4 years of crash data before the red light cameras with 1 year after. Again no statistically significant differences were found.

Table 5.2
Crashes of all severities recorded at
red light camera intersection sites introduced in 2001
Expected crashes corrected for overall trends in
Adelaide signalised intersection crashes

Site Number	Observed crashes before the cameras 2000	Observed crashes after the cameras 2002	Expected crashes 2002	Difference between observed and expected crashes 2002
1	13	23	13	+10
2	35	36	34	+2
3	49	52	48	+4
4	83	68	82	-14
5	30	39	30	+9
6	43	30	42	-12
7	51	49	50	-1
8	35	37	34	+3
9	86	76	85	-9
10	28	41	28	+13
11	57	73	56	+17
12	61	45	60	-15
13	17	12	17	-5
14	37	23	36	-13
15	6	13	6	+7
16	51	45	50	-5
17	19	25	19	+6
18	14	16	14	+2
19	43	57	42	+15
20	29	40	29	+11
21	46	50	45	+5
22	24	33	24	+9
23	49	40	48	-8
24	41	38	40	-2
Total crashes	947	961	932	+29
Control crashes	7122	7006		

A matched pair t-test of observed vs expected crashes 2002 has a p-value of 0.540

A Chi-squared test of total crashes vs control crashes has a p-value of 0.524

Table 5.3
Right turn crashes of all severities recorded at intersections where red light cameras were installed in 2001 Expected crashes corrected for overall trends in Adelaide signalised intersection right turn crashes

Site Number	Observed crashes before the cameras 2000	Observed crashes after the cameras 2002	Expected crashes 2002	Difference between observed and expected crashes 2002
1	4	5	4	+1
2	10	7	9	-2
3	16	14	15	-1
4	29	22	27	-5
5	16	13	15	-2
6	13	12	12	-0
7	12	12	11	+1
8	6	7	6	+1
9	30	17	28	-11
10	2	7	2	+5
11	6	9	6	+3
12	25	17	23	-6
13	4	4	4	+0
14	7	6	6	-0
15	2	6	2	+4
16	22	22	20	+2
17	8	11	7	+4
18	4	6	4	+2
19	17	22	16	+6
20	4	10	4	+6
21	5	11	5	+6
22	7	14	6	+8
23	10	13	9	+4
24	10	6	9	-3
Total crashes	269	273	249	+24
Control crashes	1087	1008		

A matched pair t-test of observed vs expected crashes 2002 has a p-value of 0.286

A Chi-squared test of total crashes vs control crashes has a p-value of 0.349

Table 5.4
Right angle crashes of all severities recorded at intersections where red light cameras were installed in 2001
Expected crashes corrected for overall trends in Adelaide signalised intersection right angle crashes

Site Number	Observed crashes before the cameras 2000	Observed crashes after the cameras 2002	Expected crashes 2002	Difference between observed and expected crashes 2002
1	3	6	3	+3
2	2	2	2	+0
3	5	4	5	-1
4	6	5	6	-1
5	2	6	2	+4
6	6	1	6	-5
7	8	1	8	-7
8	3	4	3	+1
9	6	4	6	-2
10	4	2	4	-2
11	11	9	11	-2
12	4	5	4	+1
13	2	5	2	+3
14	5	2	5	-3
15	1	1	1	+0
16	4	1	4	-3
17	3	2	3	-1
18	0	1	0	+1
19	1	1	1	+0
20	5	2	5	-3
21	10	3	10	-7
22	0	2	0	+2
23	8	4	8	-4
24	5	7	5	+2
Total crashes	104	80	101	-21
Control crashes	767	746		

A matched pair t-test of observed vs expected crashes 2002 has a p-value of 0.151

A Chi-squared test of total crashes vs control crashes has a p-value of 0.135

Table 5.5
Rear end crashes of all severities recorded at intersections where red light cameras were installed in 2001
Expected crashes corrected for overall trends in Adelaide signalised intersection rear end crashes

Site Number	Observed crashes before the cameras 2000	Observed crashes after the cameras 2002	Expected crashes 2002	Difference between observed and expected crashes 2002
1	4	11	4	+7
2	16	19	15	+4
3	18	29	17	+12
4	27	27	26	+1
5	10	20	10	+10
6	22	14	21	-7
7	29	27	28	-1
8	22	21	21	-0
9	42	45	40	+5
10	21	30	20	+10
11	33	41	32	+9
12	27	17	26	-9
13	9	3	9	-6
14	23	12	22	-10
15	3	5	3	+2
16	18	21	17	+4
17	5	9	5	+4
18	7	7	7	+0
19	20	29	19	+10
20	17	24	16	+8
21	26	26	25	+1
22	13	12	12	-0
23	25	19	24	-5
24	19	17	18	-1
Total crashes	456	485	436	+49
Control crashes	4172	3986		

A matched pair t-test of observed vs expected crashes 2002 has a p-value of 0.122

A Chi-squared test of total crashes vs control crashes has a p-value of 0.119

Table 5.6
Other crash types of all severities recorded at intersections where red light cameras were installed in 2001
Expected crashes corrected for overall trends in Adelaide signalised intersection other crash types

Site Number	Observed crashes before the cameras 2000	Observed crashes after the cameras 2002	Expected crashes 2002	Difference between observed and expected crashes 2002
1	2	1	2	-1
2	7	8	8	-0
3	10	5	12	-7
4	21	14	24	-10
5	2	0	2	-2
6	2	3	2	+1
7	2	9	2	+7
8	4	5	5	+0
9	8	10	9	+1
10	1	2	1	+1
11	7	14	8	+6
12	5	6	6	+0
13	2	0	2	-2
14	2	3	2	+1
15	0	1	0	+1
16	7	1	8	-7
17	3	3	3	-0
18	3	2	3	-1
19	5	5	6	-1
20	3	4	3	+1
21	5	10	6	+4
22	4	5	5	+0
23	6	4	7	-3
24	7	8	8	-0
Total crashes	118	123	136	-13
Control crashes	1096	1266		

A matched pair t-test of observed vs expected crashes 2002 has a p-value of 0.471

A Chi-squared test of total crashes vs control crashes has a p-value of 0.448

5.2 Analysis of casualty crashes

Tables 5.7 to 5.11 show the observed number of casualty crashes, by total and by crash type, recorded at each of the 24 intersections where red light cameras were installed in 2001 during the year before and the year after installation. The expected number of casualty crashes after the introduction was calculated after correcting the before casualty crashes by changes in the same casualty crash type at all other Adelaide signalised intersections. The difference column gives the difference between the number of observed casualty crashes from the number of casualty crashes which would be expected if the particular intersection behaved like all other Adelaide signalised intersections. A matched pair t-test was used to determine if there was a statistically significant change in casualty crashes after the red light cameras were introduced (specifically it tests if the difference column is consistently positive or negative). A p-value of 0.05 or less indicates that any observed differences are unlikely to be due to random variation alone. The advantage of this method is that it treats each individual intersection with the same importance and so the results are not biased towards high casualty crash rate intersections.

The number of casualty crashes at all 24 sites combined in the year before and the year after the cameras were introduced were also compared with the corresponding numbers at all other Adelaide signalised intersections (the Control row). A Chi-squared test was used to determine if the total number of casualty crashes at the red light camera sites had changed compared to all other Adelaide signalised intersections.

Apart from one, none of the statistical tests on Tables 5.7 to 5.11 were significant (all had p-values greater than 0.05). The exception was for “other crash types”. Although the t-test indicated no effect, the Chi-squared test indicated a statistically significant reduction in this crash type after the introduction of the red light cameras. This is likely an aberration due either to the large number of statistical tests conducted (which increase the likelihood of finding an errant statistically significant result) or due to some other change in a few intersections (sites 3 and 4 showed large reductions) unrelated to the red light cameras. Although not significant, there was an observed decrease in right angle crashes.

The following tests were also conducted: comparing 4 years of casualty crash data before the red light cameras with 1 year after; and comparing 4 years of casualty crash data before the red light cameras with 2 years after. Neither of these tests produced statistically significant results. The failure of the “other crash types” to appear as statistically significant under these conditions suggests that it may well have been an aberration.

Table 5.7
Casualty crashes recorded at
intersections where red light cameras were installed in 2001
Expected crashes corrected for overall trends in
Adelaide signalised intersection casualty crashes

Site Number	Observed crashes before the cameras 2000	Observed crashes after the cameras 2002	Expected crashes 2002	Difference between observed and expected crashes 2002
1	3	8	3	+5
2	7	6	6	-0
3	17	15	16	-1
4	20	12	18	-6
5	9	6	8	-2
6	7	7	6	+1
7	4	11	4	+7
8	11	9	10	-1
9	21	12	19	-7
10	3	7	3	+4
11	12	15	11	+4
12	12	10	11	-1
13	1	2	1	+1
14	6	4	6	-2
15	2	3	2	+1
16	13	11	12	-1
17	4	5	4	+1
18	5	2	5	-3
19	9	12	8	+4
20	9	10	8	+2
21	14	7	13	-6
22	2	3	2	+1
23	9	7	8	-1
24	8	8	7	+1
Total crashes	208	192	192	+0
Control crashes	1426	1314		

A matched pair t-test of observed vs expected crashes 2002 has a p-value of 0.985

A Chi-squared test of total crashes vs control crashes has a p-value of 0.987

Table 5.8
Right turn casualty crashes recorded at
intersections where red light cameras were installed in 2001
Expected crashes corrected for overall trends in
Adelaide signalised intersection right turn casualty crashes

Site Number	Observed crashes before the cameras 2000	Observed crashes after the cameras 2002	Expected crashes 2002	Difference between observed and expected crashes 2002
1	1	2	1	+1
2	2	1	2	-1
3	6	5	5	-0
4	8	6	7	-1
5	6	6	5	+1
6	1	3	1	+2
7	1	3	1	+2
8	3	2	3	-1
9	11	6	9	-3
10	1	2	1	+1
11	2	4	2	+2
12	7	4	6	-2
13	0	0	0	0
14	3	1	3	-2
15	1	1	1	+0
16	8	8	7	+1
17	2	4	2	+2
18	2	1	2	-1
19	6	8	5	+3
20	4	6	3	+3
21	1	3	1	+2
22	1	1	1	+0
23	3	3	3	+0
24	3	3	3	+0
Total crashes	83	83	70	+13
Control crashes	363	304		

A matched pair t-test of observed vs expected crashes 2002 has a p-value of 0.093

A Chi-squared test of total crashes vs control crashes has a p-value of 0.307

Table 5.9
Right angle casualty crashes recorded at
intersections where red light cameras were installed in 2001
Expected crashes corrected for overall trends in
Adelaide signalised intersection right angle casualty crashes

Site Number	Observed crashes before the cameras 2000	Observed crashes after the cameras 2002	Expected crashes 2002	Difference between observed and expected crashes 2002
1	1	0	1	-1
2	0	0	0	0
3	1	2	1	+1
4	1	3	1	+2
5	0	0	0	0
6	3	1	3	-2
7	1	0	1	-1
8	0	1	0	+1
9	2	1	2	-1
10	0	1	0	+1
11	3	3	3	+0
12	2	0	2	-2
13	1	1	1	+0
14	1	0	1	-1
15	0	0	0	0
16	2	0	2	-2
17	2	0	2	-2
18	0	0	0	0
19	0	0	0	0
20	2	0	2	-2
21	3	0	3	-3
22	0	2	0	+2
23	1	0	1	-1
24	2	1	2	-1
Total crashes	28	16	27	-11
Control crashes	195	189		

A matched pair t-test of observed vs expected crashes 2002 has a p-value of 0.093

A Chi-squared test of total crashes vs control crashes has a p-value of 0.106

Table 5.10
Rear end casualty crashes recorded at
intersections where red light cameras were installed in 2001
Expected crashes corrected for overall trends in
Adelaide signalised intersection rear end casualty crashes

Site Number	Observed crashes before the cameras 2000	Observed crashes after the cameras 2002	Expected crashes 2002	Difference between observed and expected crashes 2002
1	0	6	0	+6
2	3	5	3	+2
3	5	8	4	+4
4	5	2	4	-2
5	2	0	2	-2
6	3	3	3	+0
7	2	5	2	+3
8	7	6	6	-0
9	6	5	5	-0
10	2	4	2	+2
11	3	7	3	+4
12	2	3	2	+1
13	0	1	0	+1
14	2	3	2	+1
15	1	1	1	+0
16	2	2	2	+0
17	0	1	0	+1
18	2	0	2	-2
19	3	3	3	+0
20	2	4	2	+2
21	10	3	9	-6
22	1	0	1	-1
23	4	4	3	+1
24	3	2	3	-1
Total crashes	70	78	61	+17
Control crashes	695	605		

A matched pair t-test of observed vs expected crashes 2002 has a p-value of 0.163

A Chi-squared test of total crashes vs control crashes has a p-value of 0.155

Table 5.11
Other casualty crash types recorded at
intersections where red light cameras were installed in 2001
Expected crashes corrected for overall trends in
Adelaide signalised intersection other casualty crash types

Site Number	Observed crashes before the cameras 2000	Observed crashes after the cameras 2002	Expected crashes 2002	Difference between observed and expected crashes 2002
1	1	0	1	-1
2	2	0	2	-2
3	5	0	6	-6
4	6	1	7	-6
5	1	0	1	-1
6	0	0	0	0
7	0	3	0	+3
8	1	0	1	-1
9	2	0	2	-2
10	0	0	0	0
11	4	1	5	-4
12	1	3	1	+2
13	0	0	0	0
14	0	0	0	0
15	0	1	0	+1
16	1	1	1	-0
17	0	0	0	0
18	1	1	1	-0
19	0	1	0	+1
20	1	0	1	-1
21	0	1	0	+1
22	0	0	0	0
23	1	0	1	-1
24	0	2	0	+2
Total crashes	27	15	34	-19
Control crashes	173	216		

A matched pair t-test of observed vs expected crashes 2002 has a p-value of 0.111

A Chi-squared test of total crashes vs control crashes has a p-value of 0.014

6 Offence data

Some red light running offence data for the intersections was obtained. However, during this initial period of red light camera usage, cameras were moved between intersections, were sometimes taken offline for repair and no record could be found of when cameras were in operation at particular intersections. As a result, no meaningful analysis could be performed since offence data was not recorded when there was no operational camera at the site.

7 Speed cameras

Dual operation red light and speed cameras were brought in to operation in South Australia in December 2003. However, the current project was initiated before that time and so an evaluation of these camera sites is beyond the scope of this Report.

Some sample data was obtained from Transport SA on speeding through intersections at a number of sites prior to the dual operation cameras being officially introduced for enforcement purposes (Table 7.1).

Table 7.1
Number of drivers exceeding 70 km/h in a 24 hour period by phase of signal at various intersections in Adelaide

Location	Signal Phase			Total
	Green	Yellow	Red	
Marion Road and Sturt Road	267	80	11	358
Brighton Road and Sturt Road	62	5	2	69
Beach Road and Beach Road	50	12	1	63
Wakefield Street and Pulteney Street	55	-	-	55
Salisbury Highway and Kings Road	47	-	-	47
The Grove Way and The Golden Way	44	-	-	44
Anzac Highway and West Terrace	34	-	-	34
Total	559	97	14	670
Per cent	83.4	14.5	2.1	100.0

Two per cent of the speeding vehicles were going through a red light with the great majority going through a green light (83 per cent).

8 Discussion

This Section summarises and discusses the results of this Report.

8.1 Red light camera sites in 1988

Using crashes at all Adelaide signalised intersections as a control, the 1988 red light camera sites showed no statistically significant changes in overall crash numbers or for any particular crash type at the intersections after the introduction of the red light cameras.

However when comparing total casualty crash numbers with the number of casualty crashes expected at those sites, there was a statistically significant reduction for casualty crashes of all types (21 per cent) and in particular right angle casualty crashes (49 per cent) associated with the introduction of the red light cameras.

While it is possible that the observed reductions may be explainable by regression to the mean effects it is not clear that this is the case. The selected sites did not have particularly high crash numbers and it is known that crash numbers were only one of the factors considered in the selection of sites. Hence, it is unlikely that regression to the mean is a large factor.

One factor that is worth noting is that there was considerable publicity about the introduction of the cameras and because of this the selected sites were presumably well known to the public.

8.2 Red light camera sites in 2001

Using crashes at all Adelaide signalised intersections as a control, the 2001 red light camera sites showed no statistically significant changes in overall crash numbers or for any particular crash type at the intersections after the introduction of the red light cameras.

With one exception no statistically significant changes were observed in casualty crash numbers overall or of any particular casualty crash type at the intersections after the introduction of the red light cameras.

These findings were robust in that no meaningful effects were found using a number of different time periods and methods.

If these red light cameras did have an effect on crashes or casualty crashes, it was smaller than that which could be detected given the number of sites and the limit of one year post implementation crash data. Although it was not statistically significant a decrease in right angle crashes was observed for both overall and casualty crashes.

It is interesting to note that there was no associated publicity with the introduction of these cameras.

8.3 Knowledge of red light camera location

It was beyond the scope of this project to explore public knowledge of red light camera installations in a systematic way. However, a number of people were questioned informally about their knowledge of red light camera locations. Many expressed surprise that certain intersections that they regularly drove through did in fact have red light cameras in operation.

Given that the warning signs are generally placed well back from the intersection off to the side of the road this is not entirely surprising.

This lack of knowledge may be a partial explanation for the apparent lack of effectiveness of the 2001 red light cameras in reducing crashes. It may also explain why the 1988 red light cameras did appear to be effective in reducing at least right angle casualty crashes since their locations were well known to the public due to the associated publicity. However, given the lack of empirical evidence this must remain a conjecture.

It is interesting to note that the Federal Highway Administration National Highway Traffic Safety Administration (2005) states that "advance warning signs should be clearly visible" and that signs should also be erected "at photo-enforced intersections, typically on the far side traffic signal pole".

Such signs may well be worth considering as an extension to the current system.

8.4 Combining automated red light cameras with speed cameras

By using clearly indicated combined red light and speed cameras at intersections it would be expected that speeds would be reduced through the intersections and possibly some distance away from the intersections. Given the apparent strong association between travelling speed and casualty crash risk (Kloeden et al, 1997) such cameras could be expected to reduce the number of casualty crashes to a greater extent than red light cameras alone.

Note that dual purpose red light and speed cameras began operation in South Australia in December 2003 after the scope of this report was set.

Acknowledgments

This study was funded by the South Australian Department of Transport and Urban Planning (now the Department for Transport, Energy and Infrastructure - DTEI) through a Project Grant to the Centre for Automotive Safety Research. The DTEI Project Managers were Michael White and Tamra Fedojuk.

The Centre for Automotive Safety Research receives core funding from both DTEI and South Australia's Motor Accident Commission.

The views expressed in this report are those of the authors and do not necessarily represent those of the University of Adelaide or the sponsoring organisations.

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