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Evaluation of the ACT Road Safety Camera Program

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Evaluation of the ACT Road Safety Camera Program

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Abstract:
Like most jurisdictions, the road safety camera program forms a key element of the ACTs road safety strategy aimed at reducing road trauma through enforcing speed and red light compliance. This report presents the results of an evaluation of the ACT Road Safety Speed Camera Program up to the end of 2017. Analysis assesses the impact of the ACT's mobile road safety camera program, point-to-point, and fixed single point mid-block speed cameras on reducing crashes and speed. It also presents the results of a survey to identify any changes in community attitudes towards speeding and enforcement by road safety cameras since the ACT Road Safety Camera Strategy was released in May 2015.

Evaluation results showed that each type of road safety camera considered was associated with crash savings. Both the fixed spot mid-block speed cameras and the Hindmarsh Drive point-to-point camera system showed an average reduction in all reported crashes of 25%, translating to savings of 69 reported crashes annually and saving $1.3M annually in crash costs to the ACT community. On average, post implementation, the ACT mobile speed camera program was associated with a 19.7% reduction in crash risk. Estimated crash reductions have increased in the most recent year of evaluation in response to increased hours of mobile speed camera deployment, with a 22% crash reduction estimated for the most recent completed year considered in the analysis. This reduction translated to an estimated saving of over 3000 reported crashes, corresponded to savings in economic costs to the ACT community of over $60M.

A survey of community attitudes to speeding and speed enforcement completed by 2,241 respondents showed a general lack of awareness of the recent increases in mobile camera enforcement in the ACT, although the majority of respondents felt that the current level of speed enforcement should be maintained (not increased nor decreased). Respondents were generally aware of the point-to-point camera in operation in the ACT and most could identify its specific location. The majority of respondents reported typically driving within the speed limit, or exceeding the limit very occasionally and that compared to 2 years ago their chances of speeding were either the same or less likely. An increased percentage of respondents acknowledged the relationship between speeding and crash risk although most supported police patrols for speed enforcement instead of cameras and did not support increased penalties for speeding.

Based on the results of the crash outcome evaluation, a strategic model was constructed to estimate the potential road safety and economic benefits of further expansion of the ACT Road Safety Camera Program. Application of the model showed potential for significant additional road safety benefits through further expansion of the program, with expansion of the number of deployment hours of mobile speed cameras representing the most cost effective expansion option.

Key Words:
Speed camera, evaluation, statistics, road safety, crash, survey, point-to-point, mobile speed camera.

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Contributor Statement

Belinda Clark	Project management, survey design and administration, ethics approval, report preparation.
Laurie Budd	Analysis of Speed Survey, mobile camera operations and crash data, report preparation.
Luke Thompson	Data analysis and reporting for Community Survey
Stuart Newstead	Proposal submission, evaluation design, statistical analysis, report preparation
Max Cameron	Strategic analysis, report preparation

Ethics Statement

Ethics approval was granted by Monash University Human Research Ethics Committee, Project Number 11124

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Introduction

Most jurisdictions around Australia have, as a key part of their road safety strategy, a program of camera based automated traffic enforcement (ATE). Types of cameras used include fixed elements such as spot speed cameras, point-to-point (P2P) speed enforcement, intersection speed and red light cameras, and mobile elements which are primarily mobile speed cameras but also include automatic number plate recognition for a range of traffic and non-traffic enforcement. There is some variation between jurisdictions regarding the deployment of fixed elements, such as the overt or covert nature of operations through the use, or absence, of associated signage warning motorists of the camera presence.

In 2014, a Performance Audit into Speed Cameras in the ACT was undertaken through the ACT Auditor-General's Office. One of the recommendations from this audit was to develop a road safety camera strategy for the ACT. The resultant strategy was launched in May 2015. The ACT Road Safety Camera Strategy sets out the objectives for each of the camera types used in the ACT's Road Safety Camera Program.

The stated goals of the strategy are to:

- deliver an improved strategic management framework for the camera program;
- improve the community's understanding of the purpose and the role of the camera program in supporting improved road safety outcomes for the Territory; and,
- provide clear objectives and measurable targets for assessing the impact and contribution of the cameras to road safety in the Territory (ACT Government, 2014).

Outlined in the strategy is a commitment to undertake three-yearly evaluations of the whole road safety camera program. Prior to this commitment the last evaluation undertaken was in 2014 (TARS, 2014). That evaluation identified a 6-8% reduction in mean percentile speeds. This coincided with a 25-30% reduction in serious injury crashes on roads with mobile speed cameras, in the first few years after their introduction in 1999. A drop in serious injury crashes at red-light camera intersections was also reported. The fixed mid-block cameras were not evaluated due to data limitations, nor were the point-to-point (P2P) cameras as they had only recently been installed. ACT resident attitudes to speeding and speed cameras, obtained from data collected through the Community Attitudes to Road Safety Surveys, previously gathered by the Department of Transport and Regional Services (1995 – 2011), was also analysed.

This current evaluation of the ACT Road Safety Speed Camera Program was contracted to the Monash University Accident Research Centre (MUARC) by the Justice and Community Services Directorate (JACs). The overall aim of the evaluation is to assess the impact of the ACT's mobile road safety camera program and point-to-point camera on reducing crashes and speed, and to identify any changes in community attitudes towards speeding and road safety camera enforcement, since the ACT Road Safety Camera Strategy was released in May 2015. This report outlines the methodology developed and applied to conduct the evaluation, the results and the research outcomes and recommendations.

Community Attitudes Survey

Attitudes to speeding and speed cameras

To review changes in ACT residents' attitudes to speeding over time, an Enhanced ACT Community Attitudes to Speed Survey (MUARC, 2018) was developed and administered to residents of the ACT. This updated survey design included the speed related questions from the Community Attitudes to Road Safety Survey analysed in the TARS evaluation (2014), including two additional years of survey responses (2013 & 2018), as well as a couple of questions obtained from the ACT administered Road Safety Awareness Survey (Micromex, 2013). This survey design supported the comparison of data over time and extended the sampling timeframe by 7 years to reflect contemporary ACT attitudes. Survey questions were modified slightly to suit an online administration format, making it applicable for future evaluations.

The Enhanced ACT Community Attitudes to Speed Survey was launched on the 18th January 2018 and was available up to and including the 30th March 2018. The anonymous online survey could be completed via computer, laptop, tablet or smart phone. A total of 2,241 ACT residents completed the entire survey with the predominant response demographic being males aged between 25 to 64 years, with a full car licence (68%). Data was analysed within the context of the current survey and then comparisons were made with results from previous years.

Speed enforcement activity

There were mixed views about the level of speed enforcement occurring in the ACT over the last 2 years, with 38% of residents reporting that the level of speed enforcement had increased and 35% reporting that it had stayed the same. The 18-24-year old respondents, motorcycle riders, and those who had been booked in the last 2 years were the most likely to perceive that the level of speed enforcement had increased over the last 2 years. The majority of participants were satisfied with the current level of speed enforcement; however, those reporting that enforcement had increased during this time also thought that this level of enforcement and penalties should be decreased. While all types of speed enforcement were viewed as effective, police patrols were viewed as the most effective (82%). Although there is only one P2P camera currently operating within the ACT, the majority of residents knew its specific location and perceive P2P cameras as an effective deterrent against speeding.

Driving speeds and penalties

Residents self-reported their 'typical' driving speeds and speeding fines, with the majority of the 2,241 respondents reporting travelling over the speed limit 'very occasionally' (43%). Of the 16% who reported driving 10 km/h or more over the speed limit frequently (always, nearly always, or often) 31% were 18-24 years old, 44% learner motorcyclists, and 36% of provisional motorcyclists. When asked to compare their current driving speeds with those of two years prior 67% reported the 'same' likelihood (neither more likely nor less likely) of speeding and 29% claimed to be less likely to speed now.

A total 14% of the residents had been booked within the last two years (5% within the last 6 months). Of those detected in the last two years 73% had been detected once, 18% twice and 8% three or more times. The majority of detections resulted from mobile speed camera vans (69%), followed by Police patrols (68%).

To ascertain attitudes regarding speed tolerance, residents were asked to identify speeds they thought were acceptable to travel at (within 60km/h & 100km/h speed zones) and the travel speeds they thought would result in a speeding offence within these zones. Within a 60km/h speed zone, the majority of residents (85%) thought that it was acceptable to travel over the speed limit with the mean acceptable excess being 5km/h over (65km/h). Of concern was that the youngest road users (18-24yrs) and the most inexperienced motorcycle rider groups (learner and provisional) represented the lowest percentage of those reporting a 'No tolerance' to speeding attitude. The majority of residents (82%) were of the belief they would not receive a speeding fine if detected travelling up to 5 km/h over the speed limit.

Similarly, for travel in a 100km/h speed zone, the majority of residents (87%) thought that it was acceptable to travel over the speed limit with the mean acceptable excess being 7km/h over (107km/h). Drivers 75+ years were the most likely to support a zero tolerance approach. The majority of residents (82%) were of the belief they would not receive a speeding fine if detected travelling within 5 km/h over the speed limit.

Similar speed tolerances were reported in previous surveys (1999-2013), what differs however are the reported 'No tolerance' percentages regarding 'acceptable' speeds in both the 60 and 100 km/h zones. These percentages are the lowest ever reported and it is the first time they have been below the actual permitted 'No tolerance' responses (receive a speeding offence). These responses appear to indicate an increase in community sentiment that drivers should be permitted to travel over the speed limit without recording a speeding offence, however only up to the 5 km/h tolerance in the 60 and 7 km/h in 100 km/h zones. This may be in response to the reported increased perception (compared to the 2013 results) that actual speed enforcement within these zones has adopted a zero tolerance and reflect a reaction that low-level speeding should be overlooked.

Speeding and crash risk

Attitudes to speeding crash risk were reported on a 5-point Likert type scale. The greatest percentage of residents (42%) 'agreed strongly' that driver behaviour would improve through increasing the number of police on the roads. Compared to 2013 responses, more residents acknowledged the relationship between speeding and crash risk (21% & 52% respectively). To the contrary, there was an increase in the number of those who disagreed that speed limit enforcement helps lower the road toll. While a similar number of residents reported that increasing the number of police on the road would improve driver behaviour, a higher percentage thought that the risk of being caught speeding was low (41%) compared to 2013 (26%), and that increasing penalties would not improve driver behaviour (59% in 2018 compared to 28% in 2013).

Access Canberra speed related resources

In this Enhanced ACT Community Attitudes to Speed Survey (MUARC, 2018) a series of questions were included to gauge residents' knowledge regarding the Access Canberra website. The responses showed that approximately a third of residents (33%) were aware of their ability to nominate a speed camera location through the Access Canberra website, with 9% having done so. Just over half of the residents (51%) were aware that speed camera locations and infringement data is published on the website, 18% of had visited the open data section on the site.

Impact of the Program on Crashes, Crash Costs and Travel Speeds

Effects of the program on crashes and crash costs

Assessment of the impact of the ACT Road Safety Camera Program on reported crashes and their cost to the community is the most critical element of the evaluation for establishing the road safety benefits of the program. Evaluation of the effects of both fixed spot mid-block speed cameras and the Hindmarsh Drive point-to-point camera system showed an average reduction in all reported crashes of 25% associated with installation and operation of the fixed speed cameras. Analysis results showed that the crash savings associated with point to point speed cameras are statistically the same as those associated with fixed spot mid-block speed cameras. The primary difference between the two camera types is the geographical area able to be enforced by the cameras. Point to point cameras are able to enforce longer lengths of road than fixed spot cameras which have a geographical range of influence within only 1km from the camera site. The fixed mid-block speed camera program in the ACT was estimated to be associated with savings of 69 reported crashes annually, 13 of which were associated with the Hindmarsh Drive point to point system. This translates to a saving of $1.3M annually in crash costs to the ACT community with $262K coming from the Hindmarsh Drive site.

The mobile speed camera program in the ACT is arguable the most important element of the ACT traffic camera program given that interrogation of the data found that over 80% of crashes in the ACT occurred within 0.5 km of a site used at one or more times for mobile speed camera enforcement. Estimates of average post program implementation crash effects associated with the mobile speed camera program were similar for non-injury crashes and injury crashes. On average, post implementation, the ACT mobile speed camera program was associated with a 19.7% reduction in casualty crash risk. Effectiveness estimates have varied greatly over time. In the early years after program implementation (up to September 2009), casualty crash reduction estimates associated with the program varied between 24% and 43% and were highly statistically significant. Over the period October 2009 to September 2014, estimates of associated program effects were much smaller, with estimated casualty crash reductions being less than 10% and generally not statistically significant. From October 2014 onwards, estimated associated casualty crash reductions have increased greatly to 22% in the most recent completed year considered in the analysis. Indications are that crash reductions from October 2017 onwards have been even greater, although the last analysis is only based on 4 months of data. In the most recent full year of the program analysed, the mobile speed camera program was associated with an estimated saving of over 3000 reported crashes, this corresponded to economic savings costs to the ACT community of over $60M. Both these figures reflect the much higher crash coverage of the mobile camera program compared to the fixed non-intersection camera program. Estimates of mobile speed camera program crash effects by district and year correlated strongly with the hours of mobile camera operation.

Effects of the program on travel speeds

Analysis of ACT speed monitoring data estimated statistically significant reductions in both mean speeds, and 85th percentile speeds on average over the post implementation period of the ACT Road Safety Camera Program, and particularly the mobile speed camera program. Average reductions in mean speeds of 4.6km/h and in 85th percentile speed of 4.9km/h were estimated. Whilst these estimates accorded with the average crash reductions over the post program implementation period, the patterns in estimated speed reductions over the post implementation period did not generally correlate with the time based variation in crash reduction estimates due to the survey ending well before the crash analysis period and the mean and 85% percentile speeds being too coarse a measure of speed behaviour to reflect the likely impacts of the camera program.

Strategic Advice on Future Program Expansion

Strategic analysis of the potential benefits of further expansion of the ACT Road Safety Camera Program showed potential for cost effective expansion of the program to produce further road trauma savings. For example, the benefit-cost ratio (BCR) and annual crash savings for 25 percentage increases in enforcement (camera units, sites, sections or MSC hours) were considered. The highest BCRs in rank order from a nominal 25% increase in enforcement were estimated for:

- Mobile speed camera hours (BCR 4.12 from 9 casualty crashes and 141 non-injury crashes saved per year)
- Fixed spot-speed cameras at mid-blocks on arterial roads (BCR 2.63 from 0.9 casualty crashes and 24 non-injury crashes saved per year)
- One additional fixed P2P camera system at a high-ranked long section of an arterial road (BCR 1.14 from 0.8 casualty crashes and 10 non-injury crashes saved per year)
- Speed/red-light cameras at signalised intersections (BCR 0.92 from 1.1 casualty crashes and unknown number of non-injury crashes saved per year)

The BCR and crash savings were also estimated for a new ATE type not yet used in the ACT, namely:

- Mobile P2P camera pairs operated regularly at two high-ranked long sections on arterial roads (BCR 2.39 from 0.6 casualty crashes and 7 non-injury crashes saved per year)

The method of strategic analysis allows the BCR and crash savings to be estimated for other percentage increases in each ATE type. In each case, the estimated BCR could be an under-estimate because the available crash data did not allow specific estimates of the savings in fatal and serious injury crashes. Savings in these serious crash types would represent higher savings in social costs of crashes than those estimated for savings in casualty crashes in general.

1 INTRDUCTION

1.1 Background

Most jurisdictions around Australia have, as a key part of their road safety strategy, a program of camera based automated traffic enforcement (ATE). Whilst such programs primarily enforce speed limits, intersection cameras also include enforcement of red light compliance. There is significant variation in the mix of enforcement types between jurisdictions as well as the mode of operation of each enforcement, based on the Deterrence Theory philosophy adopted. Types of cameras in use include fixed elements such as spot speed cameras, point-to-point speed enforcement, intersection speed and red light cameras, and mobile elements which are primarily mobile speed cameras but also include automatic number plate recognition (ANPR) for a range of traffic and non-traffic enforcement. There is some variation between jurisdictions regarding the deployment of fixed elements, such as the overt or covert nature of operations through the use, or absence, of associated signage warning motorists of the camera presence. However, the largest jurisdictional variation occurs in the deployment of mobile speed cameras. For example, Victoria uses mobile speed cameras covertly to create a perception amongst motorists of 'anywhere and anytime' and to encourage speed compliance generally. Its system detects a large number of drivers speeding, using a mechanism of specific deterrence, being supported by a large back office infringement processing capacity. In contrast, Queensland specifically targets areas of high crash population covering a high proportion of the total crash problem and uses mobile cameras in a predominantly overt way. To create the same perception of anywhere and anytime, Queensland schedules camera operations in a highly randomised way. A similar approach is used in New South Wales whilst Western Australia uses an approach that sits somewhere in between.

1.1.1 The ACT Road Safety Camera Program

In 2014, a Performance Audit into Speed Cameras in the ACT was undertaken through the ACT Auditor-General's Office. One of the recommendations from this audit was to develop a road safety camera strategy for the ACT, which was launched in May 2015. The ACT Road Safety Camera Strategy sets out the objectives for each of the camera types used in the ACT's Road Safety Camera Program. The stated goals of the strategy are: to deliver an improved strategic management framework for the camera program; to improve the community's understanding of the purpose and the role of the camera program in supporting improved road safety outcomes for the Territory; and, to provide clear objectives and measurable targets for assessing the impact and contribution of the cameras to road safety in the Territory (ACT Government, 2014).

Similar to other jurisdictions, the ACT Road Safety Camera Program comprises a number of different elements. At the centre of the program is a mobile speed camera program, which has been operational since October 1999. Fixed cameras were introduced soon after in 2000 and comprised intersection speed and red light cameras, with fixed spot speed cameras introduced in 2007. In 2012, two point-to-point camera systems were activated on Hindmarsh Drive (between Yamba Drive and Dalrymple Street) and Athllon Drive (between Beasley Street and Drakeford Drive). The Athllon Drive system was decommissioned in October 2016 due to concerns about the appropriateness of its location. Additional locations for point-to-point camera systems in the ACT have been investigated, yet no additional systems have become operational.

The focus of this study was to evaluate the road safety impacts of two specific camera types. The first is the mobile speed camera program in the ACT, which is currently approved for operation at over 1,000 sites in the ACT. The overall objective of the mobile camera program is to create the perception of "anywhere, anytime" speed enforcement in the ACT to encourage compliance with the speed limits generally by motorists. Sites for operation are chosen on a range of technical and health and safety criteria including: being at least 200 metres from a change of speed limit (not applicable for school zone, work sites or other reduced speed limit areas); being clear of merging lanes, changes of road alignment and/or road width, and any other changes to traffic conditions on either side of the location; and, not cause any obstruction, line-of-sight issues or interruption to traffic flow on either side of the location.

The second camera type of focus is the point-to-point system in operation on Hindmarsh Drive between Yamba Drive and Dalrymple Street. The expectation is that the system will not only improve safety but also has the potential to lead to reduced congestion, improved traffic flow, and lower carbon emissions resulting from less speed variation.

Signage warning of the presence of the camera system is used in conjunction with the point-to-point system. Legislation requires that signs be displayed 100 metres before each detection point and at the midpoint of the shortest practicable route between the detection points (see https://www.accesscanberra.act.gov.au/app/answers/detail/a_id/3010/~/act-road-safety-camera-program).

1.1.2 Evaluation

As outlined in the ACT Road Safety Camera Strategy (2015), the ACT Government has made a commitment to undertake three-yearly evaluations of the whole road safety camera program. The last evaluation was undertaken in 2014 by the University of New South Wales, Traffic and Road Safety (TARS) research centre based on crash data from the years 1995 to 2011. That evaluation identified that the mean percentile speeds on roads with mobile cameras reduced by six per cent to eight per cent in the first few years after their introduction in 1999, coinciding with a 25 per cent to 30 per cent reduction in serious injury crashes on roads where the cameras were being used. Also reported was a drop in serious injury crashes at red-light camera intersections. At that time, the fixed mid-block cameras could not be evaluated due to data limitations and the point-to-point cameras were not evaluated as they had only recently been installed at the time of the 2014 evaluation. In addition, the evaluation also examined effects of infringing at camera sites, and community attitudes to speeding and the camera program, based on ACT data obtained through the national Community Attitudes to Road Safety Survey up to and including the 2011 survey. Analysis of community attitudes was based on a set of speed related survey questions found to be common to each of the surveys conducted historically.

1.2 Aims

The overall aim of this research is to assess the impact of the ACT's mobile road safety camera program and point-to-point camera on reducing crashes and speed, and to identify any changes in community attitudes towards speeding and road safety camera enforcement since the ACT Road Safety Camera Strategy was released in May 2015

As outlined in the project brief the specific aims of the research are to:

1. Assess the effectiveness of the mobile camera program using the high-level evaluation criteria set out in the camera strategy. This assessment is to include an examination of compliance rates including any reduction in the number of vehicles exceeding the speed limit at mobile camera locations and an analysis of crash data to identify any reduction in crashes that can be attributed to the mobile cameras.
2. Assess the effectiveness of the point-to-point camera system on Hindmarsh Drive using the high-level evaluation criteria set out in the camera strategy. This includes an examination compliance rates including any reduction in speeding within the enforcement area and an analysis of crash data to identify any reduction in crashes resulting from the installation of the camera.
3. Review any changes in community attitudes towards speeding and road safety cameras, particularly following the implementation of a range of measures delivered as part of the ACT Road Safety Camera Strategy.
4. Provide advice regarding any improvements that could be made to the strategic management, operation, and makeup of the ACT Road Safety Camera Program.

1.3 Report outline

This report outlines the evaluation methodology developed and applied to assess the impact of the ACT's mobile road safety camera program and point-to-point camera on reducing vehicle speed and crashes, within the ACT. It details the available data sources and the method by which they were processed and matched to support the most robust evaluation design option. Data analysis and results of the estimation of the road safety benefits of the ACT Road Safety Camera Program are presented. The report also documents the development and implantation of an online survey exploring community attitudes towards speeding and road safety camera enforcement within the ACT. Implications of the results and strengths and limitations of the evaluation are discussed and conclusions from the evaluation presented.

2 COMMUITY ATTITUDES SURVEY

2.1 Background

The aim of this stage of the project was to review any changes in ACT resident community attitudes towards speeding and road safety cameras, particularly following the implementation of a range of measures delivered as part of the ACT Road Safety Camera Strategy (released May 2015).

In their Evaluation of the ACT Road Safety Camera Program, TARS (2014) explored community attitudes towards speeding and the road safety camera program within the ACT. Their exploration was based on a review of ACT resident responses to the national Community Attitudes to Road Safety Surveys, conducted through the Department of Infrastructure and Regional Development (DIRD). Although these nationally based surveys have been conducted regularly since 1986 (annually, no surveys were conducted 2007, ’10, ’12 or ’14), the TARS review focussed on ACT resident responses commencing from 1995, as then was when a standard series of survey questions relating to speeding was introduced. They then compared these survey responses over 15 surveys conducted over a 17-year period 1995 - 2011 (TARS, 2014).

These community attitudes surveys were conducted over landline telephone with residents over 15 years of age, following a mail out survey introductory letter. There were approximately 100 ACT respondents for each survey during 1995 to 1998 and a minimum of 150 per survey from 1999 onwards. The speed related survey questions from the Community Attitudes to Road Safety Surveys that were reviewed in the TARS (2014) evaluation are provided in Appendix A.1.

2.2 Current survey design

To review changes in community attitudes to speeding over time, a decision was made to compare current attitudes to the results of the previous Community Attitudes to Road Safety Surveys (1995-2011) used in the TARS (2014) evaluation data and include the latest 2013 survey data into the analysis. In addition, MUARC administered a 2018 survey to residents of the ACT, which included the speed related questions analysed in the TARS evaluation, as well as some additional questions added to enhance the survey’s relevance to the current ACT context. This updated survey design supports the direct comparison of data from the 2014 evaluation with data obtained from two additional years of survey responses (2013 & 2018), extending the sampling timeframe 7 years (previously 2011) and reflecting contemporary attitudes.

A Road Safety Awareness Survey was developed and conducted in conjunction with JACs (2012) and Micromex Research (2013), to review community attitudes within the ACT to various road safety issues, one of which was speeding. The 2013 survey was administered to a sample of 1,000 ACT residents, aged 18 years and over, who had resided in the ACT for six months or longer. The residents were sampled from the White Pages telephone directory using a computer based random selection process and weighted by age to reflect the ABS 2011 Census data (Micromex Research, 2013). Two tables of questions from that survey were included in this current MUARC survey (see Appendix A.2). These questions were included because they inquired about additional community attitude information that was not covered in the Community Attitudes to Road Safety Survey questions.

The final Enhanced ACT Community Attitudes to Speed Survey (MUARC, 2018) is provided in A3. The survey questions were slightly modified to suit an online administration format. A previous survey question inquiring about attitudes to lowering the speed limit on local streets and minor roads, not arterial roads or highways, to 50km/h, was updated to enquire about lowering the speed limit to 40km/h. In addition, as outlined in the MUARC project proposal, a further ten questions were devised enquiring about experiences using the ACT Road Safety Camera Program webpage available on the Access Canberra website (https://www.accesscanberra.act.gov.au/app/answers/detail/a_id/3010). These questions ask about information provided on this website relating specifically to the changes in the ACT Road Safety Camera Program since 2013 and the following themes:

- knowledge and use of the ACT Road Safety Camera Program website, including the function for the public to nominate a location for a mobile speed camera;
- knowledge and use of the published infringement data and camera locations on the ACT Government open data website;
- perceptions of the mobile safety camera program to identify if residents are aware of its expansion.

The draft survey was piloted amongst Monash University Accident Research Centre staff and students, and staff from JACs.

The finalised survey was reviewed and approved through the Monash University Human Research Ethics Committee. The survey was hosted online through the Qualtrics online survey software platform under Monash University's licence with this company. The anonymous survey could be completed via computer, laptop, tablet or smart phone.

To maximise response rates, participant recruitment was undertaken across multiple sources, co-ordinated through MUARC and the ACT Government. Access Canberra hosted advertising for the survey and its link on their: website homepage, service centre TV screens, in-queue phone message system. Flyers advertising the survey were distributed with electronic vehicle registration notices.

The Enhanced ACT Community Attitudes to Speed Survey was launched on the 18th January 2018 with a media release from the ACT Government Minister for Justice, Consumer Affairs and Road Safety, Mr Shane Rattenbury. The survey was available online up to and including the 30th March. 2018.

2.3 ACT Community Attitudes to Speed Survey - Results

This section summarises the results of the Enhanced ACT Community Attitudes to Speed Surveyconducted by MUARC in 2018. These results are contrasted against pre-existing community attitude data gathered by the Department of Transport and Regional Services (1995 – 2011), utilised by TARS in their 2014 evaluation and in addition, the results of their 2013 survey have been included.

2.3.1 Sample demographics Enhanced ACT Community Attitudes to Speed Survey

There was a total of 2,473 responses to the online Enhanced ACT Community Attitudes to Speed Survey (MUARC, 2018). Of these 2,473 responses, 2,241 completed the entire survey. As exhibited in Figure 1 the predominant response demographic was males between the ages of 25 to 64. It is of note that there were more than two male respondents to every female respondent across all recorded age categories.

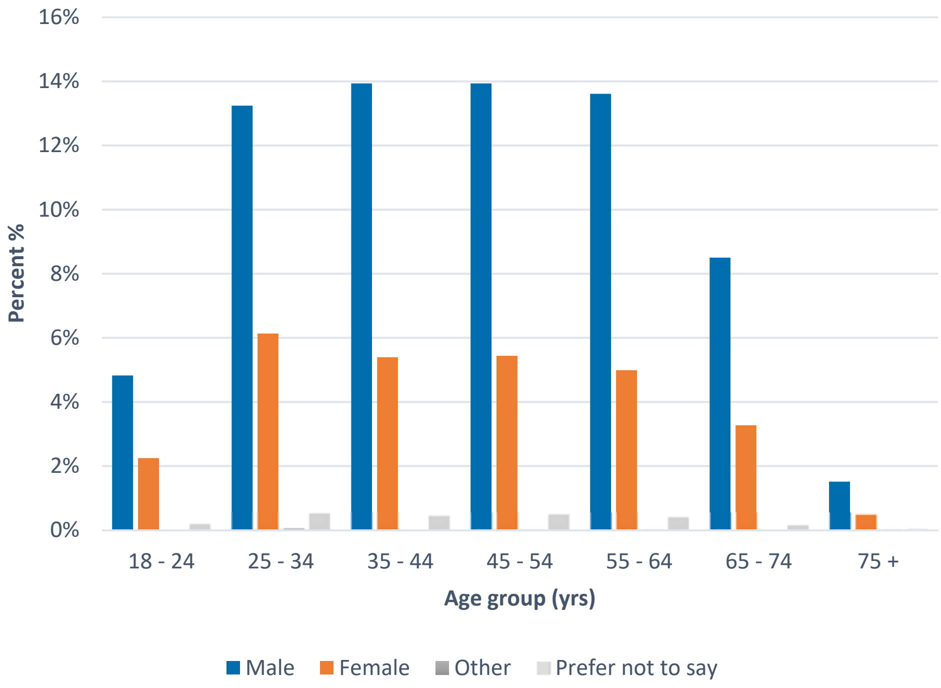


Figure 1 Distribution of resident age groups by gender, 2018.

As shown in Figure 2 the majority of respondents possess a full car licence (68%), with 18% possessing a full motorcycle licence. The majority of participants possessed only one type of licence (71%), two licence types (23%), three or more licence types (6%), see Figure 3.

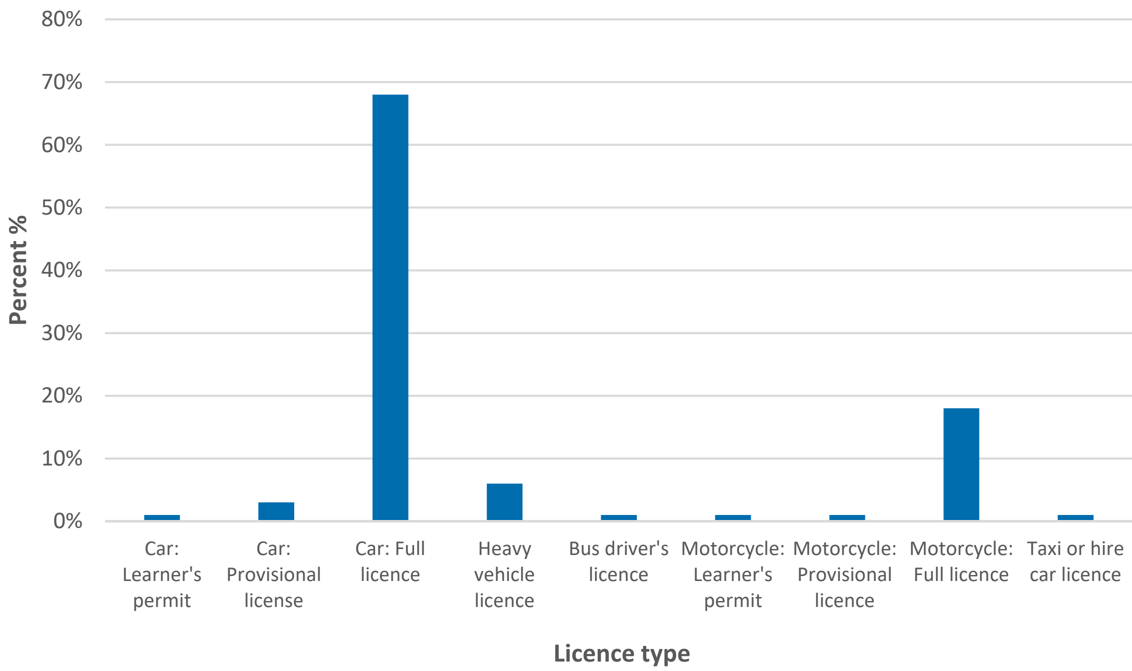


Figure 2 Residents' licence type (%), 2018.

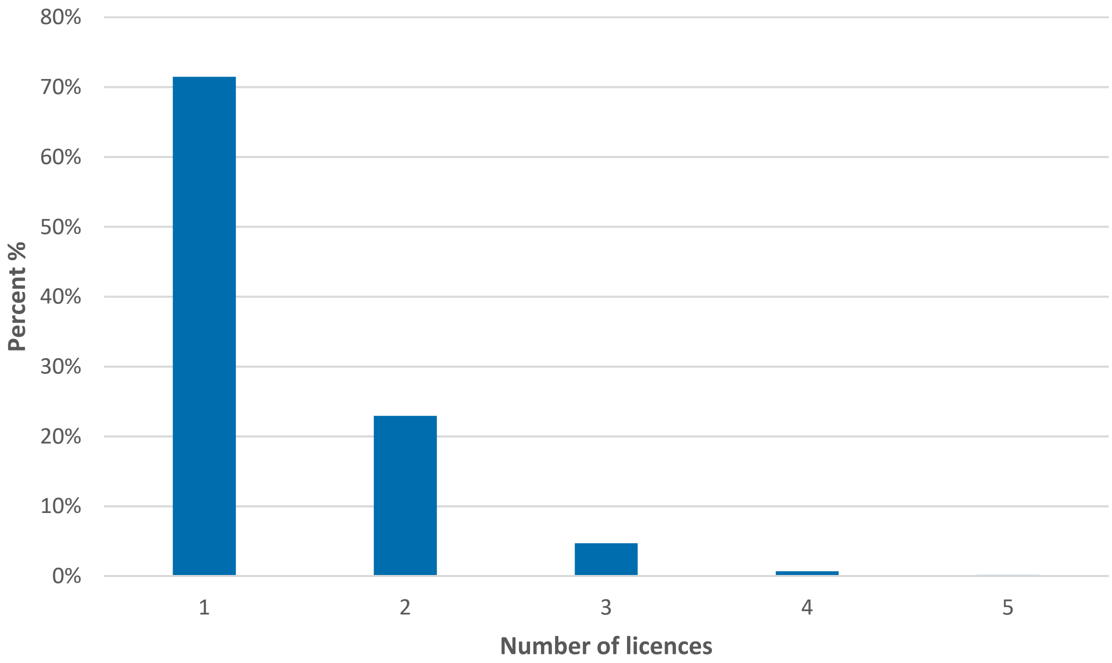


Figure 3 Number of licence types held by individual residents (%), 2018.

2.3.2 Speed limit enforcement activity

There were mixed views about the level of speed enforcement occurring in the ACT over the last 2 years, with 38% of residents reporting that the level of speed enforcement had increased and 35% reporting that it had stayed the same. Only 10% of residents thought that there had been a decrease (see Table-1). The 18-24-year old respondents reported the highest percentage (48%) of those who perceived an increase, and most residents who reported an increase (87%) thought that it was mobile camera enforcement that had increased. The majority of those who had been booked in the last 6 months (53%) and two years (53%) also perceived that speed enforcement had increased. Within the various licence type groups, learner motorcycle riders (57%) and probationary car drivers (47%) were most likely to report that speed enforcement activity had increased.

Table -1 Perceptions about the level of speed enforcement over the past 2 years, in the ACT.

Characteristics		Level of speed enforcement over the last 2 years in the ACT				
		Increased %	Same %	Decreased %	Don't know %	Net difference (a) %
Total		38	35	10	17	28
Gender	Male	38	36	12	14#	26
	Female	37	32	9	22#	28
	Other/prefer not to say	37	26	9	28#	28
Age group (years)	18-24	48#	31	6#	15	42#
	25-34	38	35	10	17	28
	35-44	33	41#	11	15	22#
	45-54	33#	37	13	17	20#
	55-64	42	30#	12	16	30
	65-74	38	36	8	18	30
	75+	37	23	15	25	22
Booked for speeding	Last 6 months	53#	29	6	12	47#
	Last 2 years	53#	28#	7#	12#	46#
What type of enforcement has increased?	Mobile speed camera vans	87				
	Fixed speed cameras	8				
	Point-to-point cameras	3				
	Don't know	2				
Licence type	Learner car	36	21	14	29	22
	Provisional car	47	31	6	16	41#
	Full car	37	35	11	17	26
	Learner motorcycle	57	29	5	9	52
	Provisional motorcycle	39	31	4	26	35
	Full motorcycle	37	35	12	16	25
	Heavy vehicle	38	36	13	13	25
	Bus driver	37	39	15	9	22
	Taxi/hire car	34	38	14	14	20
What type of enforcement has increased?	Mobile speed camera vans	87				
	Fixed speed cameras	8				
	Point-to-point cameras	3				
	Don't know	2				
Do you think the amount of speed enforcement should be …	Increased	20#	37	22#	21#	-2#
	Stay the same	40	38#	6#	16	34#
	Decreased	57#	26#	6#	11#	51#
Do think speeding penalties should be	More severe	18#	37	24#	21#	-6#
	Stay the same	36	39	9	16	27
	Less severe	57#	27#	5#	11#	52#

(a) Nett difference = % reporting increase minus % reporting decrease
# Denotes statistically significant at the 95% confidence interval
Table design based on tables presented in DIRD report (2014)

Community attitudes regarding the amount of speed enforcement conducted, dating back to 1995 are shown in Figure 4. In previous years, a large majority of residents thought that speed limit enforcement activity by Police and speed cameras had increased over the prior two years, however in 2018 a growing percentage of residents thought that this enforcement level had stayed the same (35%), with 38% thinking it has increased. There was more than a three-fold increase in the percentage of residents who thought that speed limit enforcement had decreased (17%) compared to the last two surveys (5% & 4%).

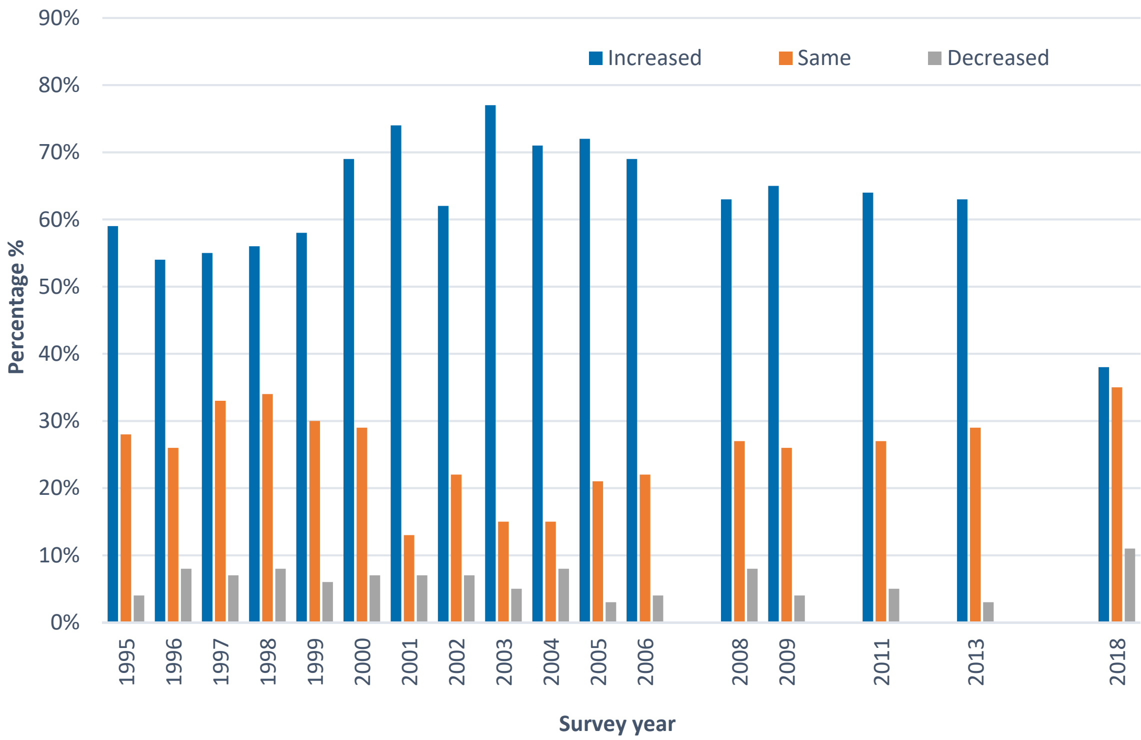


Figure 4 Community perception regarding the amount of speed limit enforcement over the past two years.

Interestingly, even though as shown in Figure 4 an increasing percentage of ACT residents thought that speed limit enforcement had decreased, as is evident in Figure 5 they also appear content with a lower level of speed enforcement. When asked if the amount of speed enforcement activity by Police and speed cameras should be changed, compared to responses from previous years, the 2018 results reported the lowest percentage of residents indicating that speed enforcement should be increased (31%), with more residents (44%) suggesting that the level of speed enforcement should 'stay the same'. However, as shown in Table-1, the majority of residents who already perceived that there had been an increase in speed enforcement, thought that the level of enforcement should be decreased (57%) and similarly that the associated penalties should be less severe (57%).

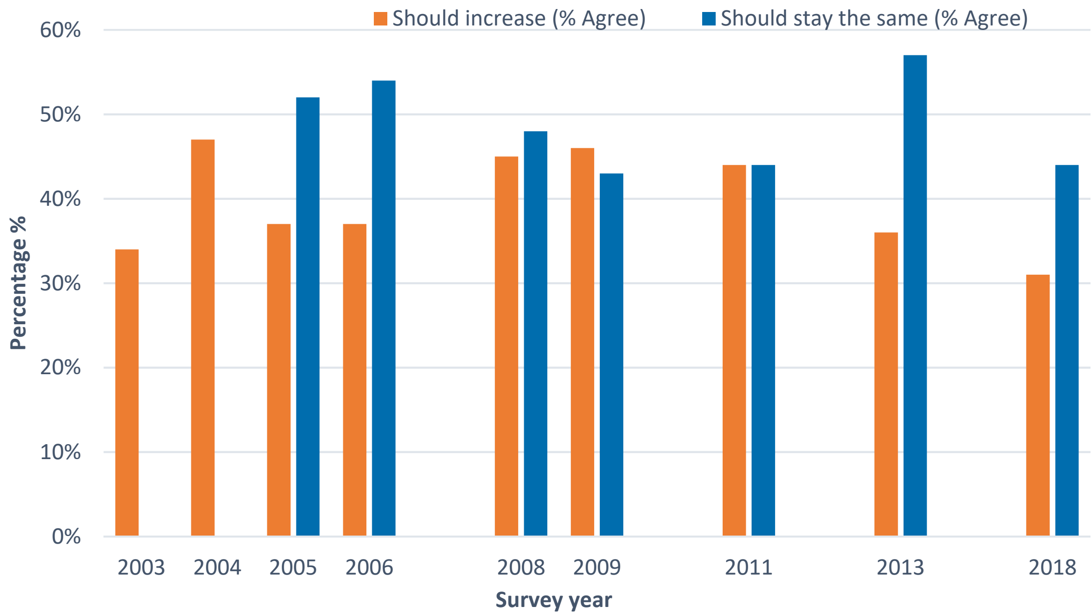


Figure 5 Speed limit enforcement activity by police and speed cameras, do you think this should increase or stay the same?

2.3.3 Speed limit enforcement effectiveness

The following section reports on residents' attitudes regarding the effectiveness of the various speed limit enforcement mechanisms (police patrol, mobile, fixed & Point-to-Point). As shown in Figure 6, ACT residents appear to view all types of speed limit enforcement as somewhat effective, with Police patrol-based speed enforcement viewed as the most effective (82%).

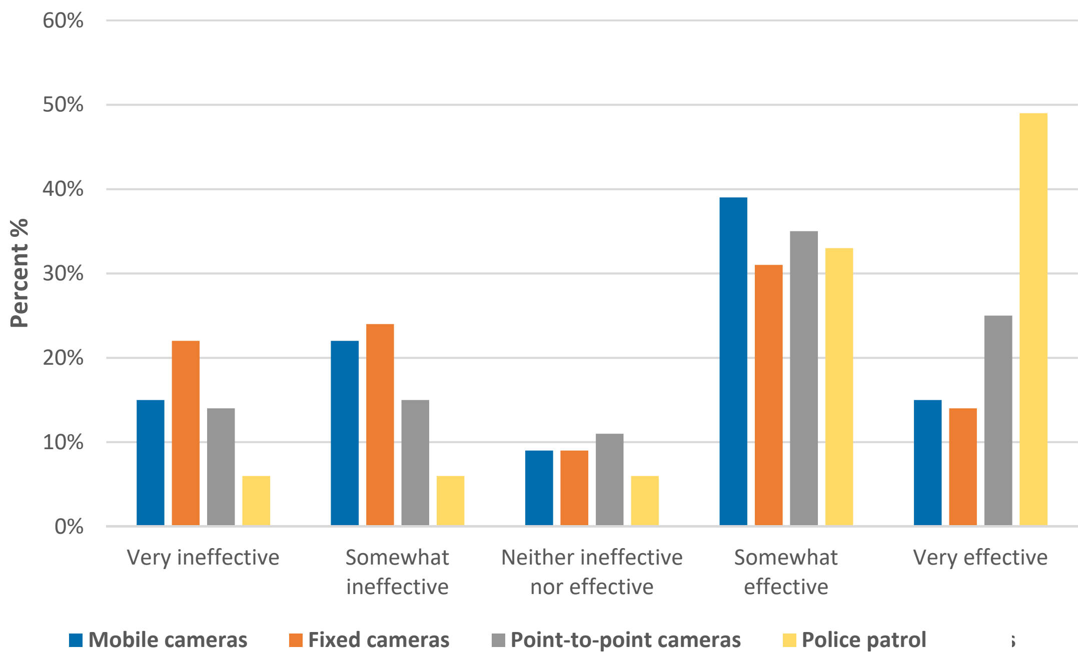


Figure 6 Perceived effectiveness of speed enforcement methods %, 2018.

Point-to-Point speed cameras

Participants were asked specifically about the use of Point-to-Point cameras within the ACT, with 80% of participants reporting that they were aware this type of speed detection was used, 14% did not know if it was used, and 6% believed that it was not used in the ACT. The vast majority of those who were aware of the use of the Point-to-Point cameras could also identify its specific operation location, within Canberra.

Table -2 outlines the approval ratings toward the use of Point-to-Point speed cameras in the ACT in relation to gender, age group, and licence type.

Table -2 Residents approval rating for the use of Point-to-Point camera speed enforcement, in the ACT.

Characteristics		Approval of point-to-point cameras					
		Approve Strongly %	Somewhat approve %	Neither approve nor disapprove %	Somewhat disapprove %	Disapprove strongly %	Don't know %
Total		20	22	12	14	31	1
Gender	Male	19	20	12	15	34#	0
	Female	24#	29#	13	13	20#	2#
	Other/prefer not to say	11	5	14	9	56#	5
Age group (years)	18-24	20	28	10	19	23	1
	25-34	18	18#	10	14	38#	1
	35-44	19	19	12	15	35	1
	45-54	21	22	13	13	31	1
	55-64	18	22	15	14	30	0
	65-74	27#	31#	12	12	18#	0
	75+	41#	20	2	10	25	2
Licence type	Learner car	40	20	10	10	20	0
	Provisional car	33#	24	6	24#	13#	0
	Full car	23#	24	12	13	27#	1
	Learner motorcycle	0	11	11	22	56#	0
	Provisional motorcycle	9	9	23	14	46	0
	Full motorcycle	15#	19	11	15	40#	0
	Heavy vehicle	14	25	16	13	32	0
	Bus driver	40	20	20	10	10	0
	Taxi/car hire	5	14	0	5	71#	5

n=2,233
# Denotes statistically significant at the 95% confidence interval
Table design based on tables presented in DIRD report (2014)

As shown in Figure 7 a similar percentage of participants approve (strongly & somewhat) with the use of point-to-point speed camera detection, as those who disapprove (strongly & somewhat), 42 and 45% respectively.

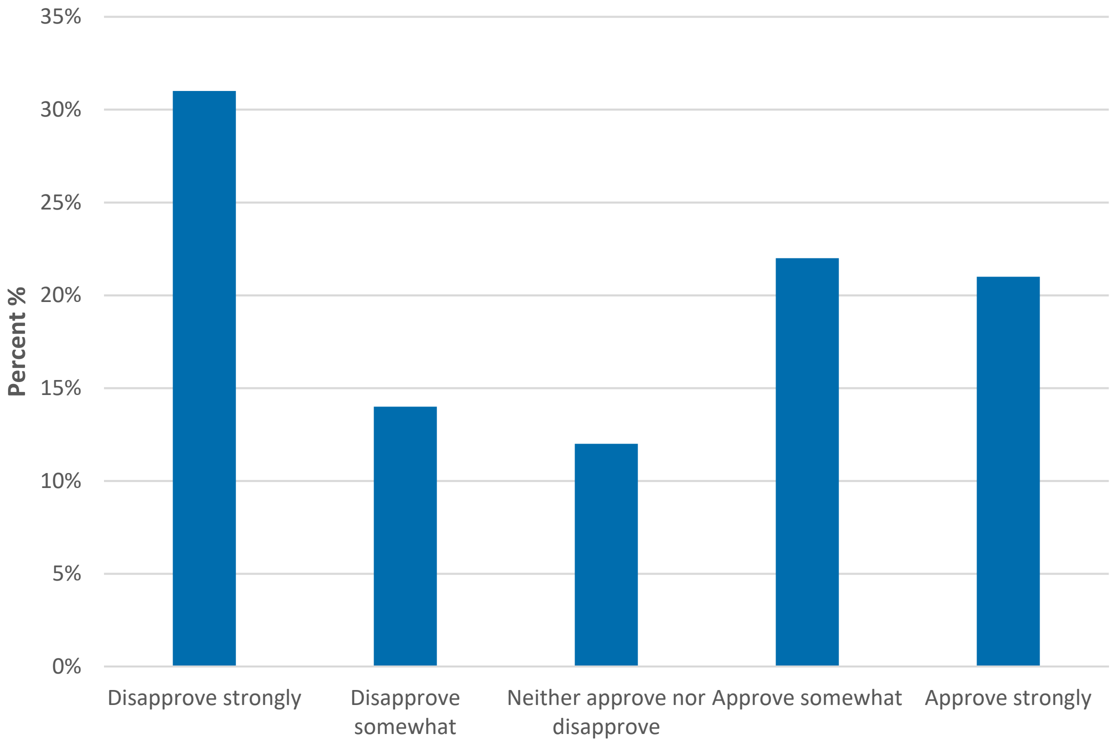


Figure 7 Responses to: How do you feel about the use of Point-to-Point camera enforcement on ACT main roads?

2.3.4 Self-reported driving speeds and fines

The following section reports on resident responses to questions about their common driving speeds and any self-reported speeding behaviours and/or speeding fines. Residents were asked to report if they had been booked for speeding within the last two years and the last six months, the results are presented in Table -3. A total 14% of the residents had been booked within the last two years and 5% of these were within the last six months. Of those detected in the last two years 73% had been detected once, 18% twice and 8% 3 or more times.

The associated detection methods are outlined in Figure 8. As shown, the majority of detections resulted from mobile speed camera vans (69%), followed by Police patrols (68%). Comparison of the actual detection methods presented in Figure 8 with previous results regarding perceived effectiveness of detection methods (Figure 6) indicate that, although Point-to-Point cameras have the lowest detection rate (3%), because there is only one of these operating in the ACT, residents still perceive Point-to-Point cameras as an effective deterrent against speeding.

Table -3 Booked for speeding in the last 2 years and last 6 months.

Characteristics		Booked for speeding	
		Last 2 years %	Last 6 months %
Total		14	5
Gender	Male	17	6
	Female	14	4
	Other/prefer not to say	12	-
Age group (years)	18-24	25#	10#
	25-34	16	5
	35-44	13	6
	45-54	15	4
	55-64	12	3
	65-74	8#	4
	75+	8	2
Detection method	Mobile speed camera	35	34
	Red light camera (intersection)	9	7
	Fixed (mid-block) camera	20	23
	Point-to-Point	2	2
	Police patrol	34	34
Licence type	Learner car	8	8
	Provisional car	16	8
	Full car	14	5
	Learner motorcycle	19	10
	Provisional motorcycle	17	13
	Full motorcycle	15	5
	Heavy vehicle	16	2
	Bus driver	12	3
	Taxi/car hire	10	5
Current likelihood of speeding, compared to 2 years ago	More likely	19	13
	The same likelihood	13	4
	Less likely	15	5

n=2,241
# Denotes statistically significant at the 95% confidence interval
Table design based on tables presented in DIRD report (2014)

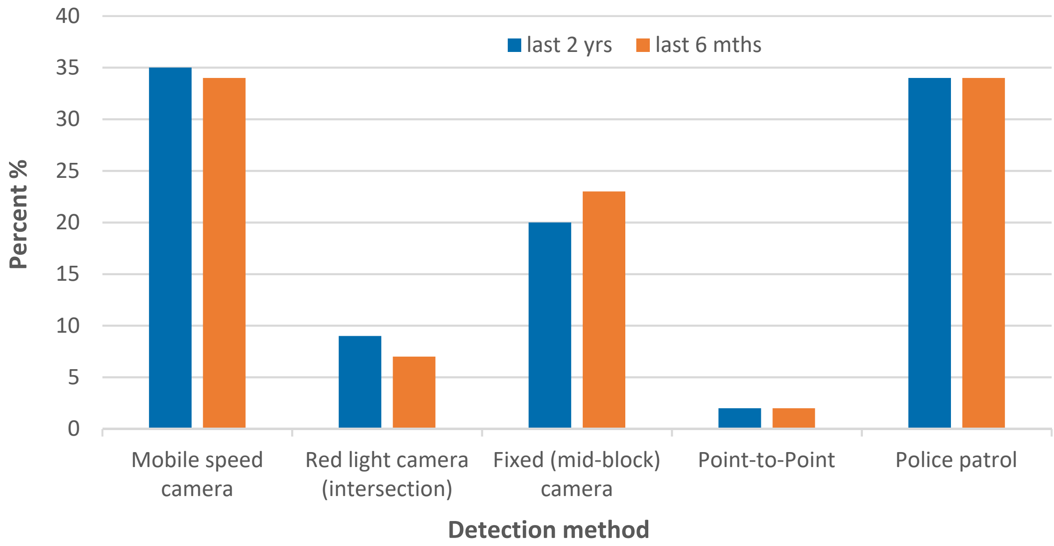


Figure 8 Detection method for respondents booked within the last 6 months and last 2 years (%), 2018 responses.

Respondents were asked about how often (what % of the time) they currently drive at 10km/h or more over the speed limit, the results from drivers who reported frequently (Always, Nearly always or Often) driving in this manner are presented in Table -4. Of the 2,241 respondents, 16% reported driving 10 km/h or more over the speed limit frequently (Always, Nearly always, or Often). With 31% of the 18-24 years old, 44% of learner motorcyclists and 36% of provisional motorcyclists reporting this regular speeding behaviour.

Table -4 Self-reported driving at 10km/h or > over the speed limit, % (Always, Nearly always, Often).

Characteristics		Reported driving at 10km/h over the speed limit Always, Nearly always, Often %
Total		16
Gender	Male	17
	Female	12#
	Other/prefer not to say	4
Age group (years)	18-24	31#
	25-34	22#
	35-44	18
	45-54	16
	55-64	11#
	65-74	5#
	75+	8
Licence type	Learner car	10
	Provisional car	17
	Full car	14#
	Learner motorcycle	44
	Provisional motorcycle	36
	Full motorcycle	20#
	Heavy vehicle	13
	Bus driver	10
	Taxi/car hire	10

n=2,241
# Denotes statistically significant at the 95% confidence interval
Table design based on tables presented in DIRD report (2014)

Figure 9 shows results from the total respondents (n=2,241), which more optimistically reports that 20% of the residents claim they ‘Never’ travel 10 km/h or move over the speed limit and another 43% report this occurring ‘Very occasionally”.

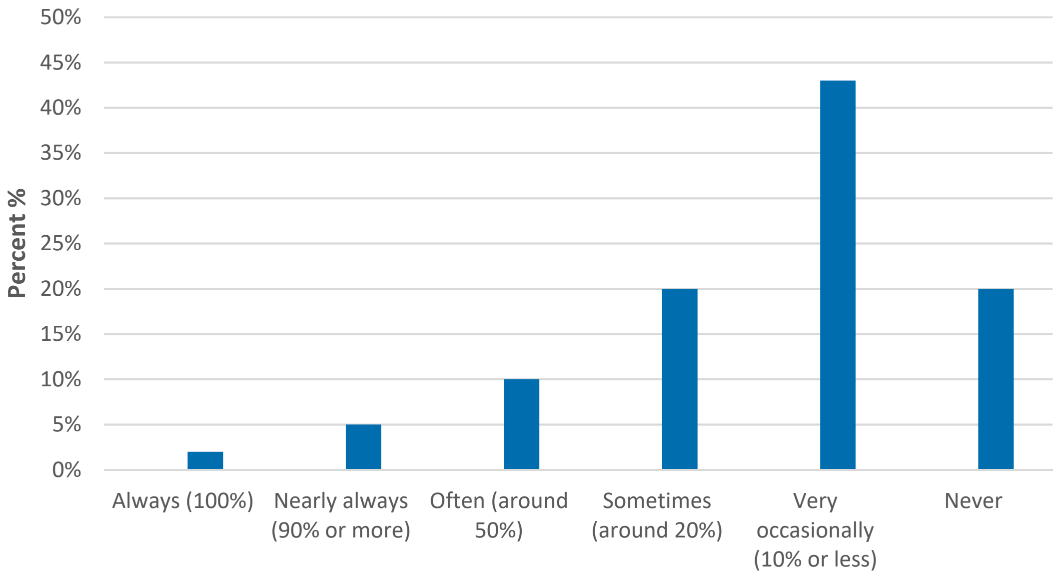


Figure 9 How often (% of the time) do you drive 10km/h or > over the speed limit? (All response categories).

Figure 10 shows resident responses to a question asking about their current likelihood of driving over the speed limit compared to their driving behaviour two years prior. Only 4% reported that they were 'More likely' to drive over the speed limit now compared to two years ago. The majority of residents reported that their likelihood of speeding was the 'Same' (67%) or that they were now 'Less likely' to speed (29%), compared to two years ago (see Figure 10).

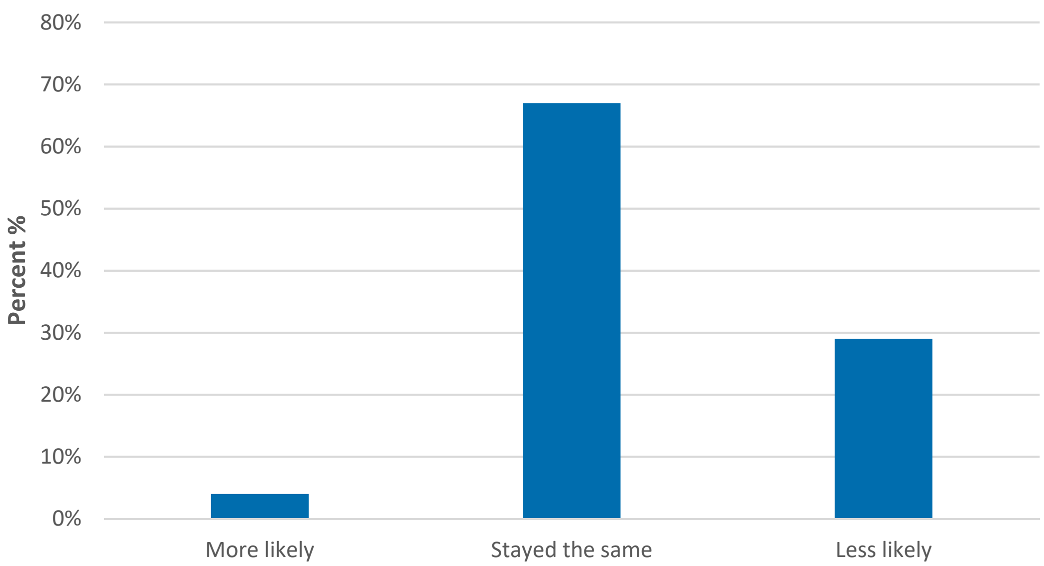


Figure 10 Likelihood of driving over the speed limit %, compared to two years prior.

2.3.5 Speed tolerances

The Community Attitudes to Road Safety Surveys, conducted between 1995 and 2001 included a question about zero speed tolerance. From 2002 to this current 2018 survey, a standard set of questions regarding attitudes toward speed tolerances have been included. These questions are designed to ascertain the level of tolerance (travel speeds over the posted speed limit, considered as acceptable) within both the 60 and 100km/h speed zones. The participants were asked what speed they think ACT drivers are actually permitted to travel at before they would receive an official speeding infringement; they are then asked what speed above each limit they think should be considered acceptable before being classified as a speeding offence.

The majority of residents think that it is acceptable to travel over the posted speed limit (85%), in a 60km/h zone, with the median acceptable speed (without receiving a fine) being 65km/h (5km/h over the limit. Figure 11 shows the resident responses (%) regarding acceptable speeds over the limit from zero tolerance to 10+ km/h. There was no significant variation in responses in relation to gender. Of concern is that the youngest road users (18-24 yrs.) and the most inexperienced motorcycle rider groups (learner and provisional motorcycle) reported the lowest responses (%) regarding 'No tolerance' to speeding (see Table -5).

The most common speed that residents think you can travel in a 60km/h, before attracting a speeding offence, was also 65 km/r (5km/h over the speed limit), with only 18% believing that a 'No tolerance' approach was enforced. Males, 18-44 and 75+ age groups, and provisional motorcycle riders were slightly more likely to believe that some speed enforcement tolerance was practised. Figure 11 shows the resident responses (%) from zero tolerance to 10+ km/h over the speed limit.

Table -5 Accepted and tolerated speeds.

60 km/h zone		What speeds are acceptable to drive at and what speeds are tolerated before you get fined, in a 60km/h zone?			
Characteristics		Should be acceptable		Actually permitted	
		Median km/h	No tolerance %	Median km/h	No tolerance %
Total		66	15	65	18
Gender	Male	66	14	65	17
	Female	65	18	64	21
	Other/prefer not to say	66	16	65	26
Age group (years)	18-24	66	5#	66	14
	25-34	66	11#	65	18
	35-44	66	13	65	18
	45-54	66	15	66	16
	55-64	66	19	65	19
	65-74	64	26#	64	26#
	75+	64	27	64	15
Licence type	Learner car	64	10	63	31
	Provisional car	66	15	65	23
	Full car	66	15	65	18
	Learner motorcycle	67	5	65	25
	Provisional motorcycle	66	9	66	13
	Full motorcycle	66	11#	65	17
	Heavy vehicle	66	15	66	17
	Bus driver	66	15	64	27
	Taxi/car hire	66	11	65	28

n= 2,355
# Denotes statistically significant at the 95% confidence interval
Table design based on tables presented in DIRD report (2014)

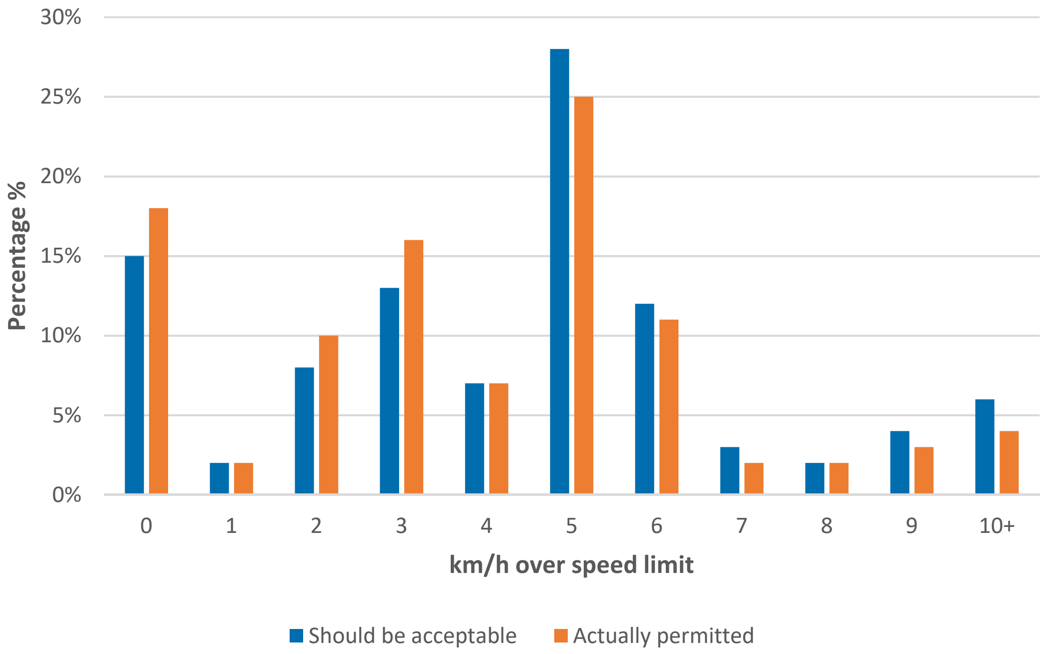


Figure 11 km/h over the speed limit that should be acceptable and is actually permitted in 60km/h speed zones.

The most common speed that residents think should be acceptable (without recording an offence), within a 100 km/h zone, was 107km/h (7km/h over the limit). However, 87% of residents thought that there should be some degree of tolerance toward speeding in a 100km/h zone. Figure 12 shows the resident responses (%) from zero tolerance to 15+ km/h over the speed limit. Similar to the responses for the 60km/h zone, there was no significant variation in responses in relation to gender, the youngest road users (18-24 yrs.) and motorcycle rider groups (learner and full motorcycle) reported the lowest responses (%) regarding 'No tolerance' to speeding (see Table-6). Drivers 75+ years were the most likely to support a zero tolerance approach.

The most common speed that residents though you could travel at in a 100km/h zone, before attracting a speeding offence, was 105 km/h (5km/h over the speed limit), with only 15% believing that a 'No tolerance' approach was enforced. Males, 18-44-year old participants, and motorcycle riders (learner, provisional & full licence) were slightly more likely to believe that some degree of speed enforcement tolerance was practised. Figure 12 shows the resident responses (%) from zero tolerance to 15+ km/h over the speed limit.

Table -6 Accepted and tolerated speeds.

100 k/m zone		What speeds are acceptable to drive at and what speeds are tolerated before you get fined, 100km/h zone?			
Characteristics		Should be acceptable		Actually permitted	
		Median km/h	No tolerance %	Median km/h	No tolerance %
Total		107	13	105	15
Gender	Male	107	12	106	14
	Female	106	16	106	18
	Other/prefer not to say	107	13	106	23
Age group (years)	18-24	108	5#	106	13
	25-34	107	11	106	15
	35-44	109	11	107	14
	45-54	106	12	106	14
	55-64	106	17	106	17
	65-74	106	18#	106	17
	75+	106	23#	106	15
Licence type	Learner car	104	39	104	39
	Provisional car	109	10	106	21
	Full car	106	13	106	15
	Learner motorcycle	111	7	106	12
	Provisional motorcycle	111	11	110	13
	Full motorcycle	109	9#	106	13
	Heavy vehicle	106	13	106	17
	Bus driver	106	16	106	34
	Taxi/car hire	101	19	106	17

n=2,335
# Denotes statistically significant at the 95% confidence interval
Table design based on tables presented in DIRD report (2014)

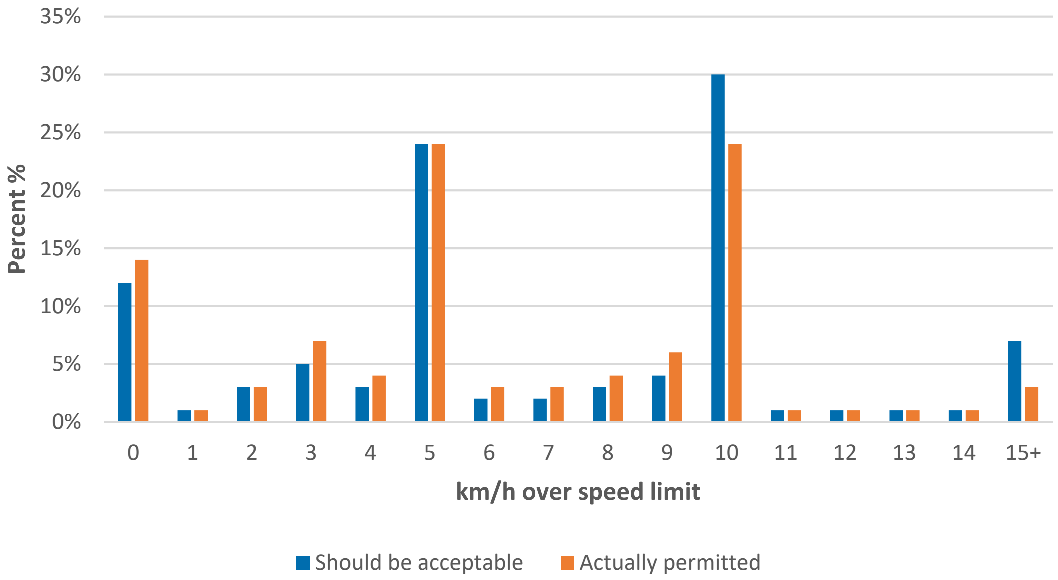


Figure 12 km/h over the speed limit that should be acceptable and is actually permitted in 100km/h speed zones.

Table -7 and Table -8 present the speed tolerance responses for 60 and 100 km/h speed zones, respectively, from 1999 to 2018 (full comparison data available from 2003). In the 2018 survey, the median perceived speed values (acceptable & permitted) are consistent with values from past surveys and indicate no change in community opinion. What does differ however, are the 'No tolerance' percentages, in regards to acceptable speeds in both the 60 and 100 km/h zones. These percentages are the lowest ever reported.

Table -7 Perceptions of 'acceptable' and 'actual' speed tolerances within 60km/h zones.

	Should be acceptable		Actually permitted	
Year	Median (km/h)	No tolerance (%)	Median (km/h)	No tolerance (%)
1995		34		
1996		42		
1997		49		
1998		49		
1999 Mobile		49		
2000 Red light		38		
2001		44		
2002		51	65	15
2003	64	33	65	10
2004	65	28	65	13
2005	64	33	64	12
2006	64	32	64	15
2007 Fixed				
2008	64	36	65	21
2009	65	34	64	22
2011	64	31	64	20
2012 P2P				
2013	64	33	65	11
2018	66	15	65	18

Table -8 Perceptions of 'acceptable' and 'actual' speed tolerances within 100km/h zones.

	Should be acceptable		Actually permitted	
Year	Median (km/h)	No tolerance (%)	Median (km/h)	No tolerance (%)
1995		27		
1996		23		
1997		36		
1998		28		
1999 *Mobile		25		
2000 *Red light		26		
2001		26		
2002		35	109	10
2003	107	22	109	6
2004	110	23	109	8
2005	109	20	109	7
2006	107	18	107	5
2007				
2008 *Fixed	106	28	108	14
2009	110	23	108	15
2011	106	25	106	21
2012 *P2P				
2013	108	19	108	10
2018	107	13	105	15

* Denotes year of introduction of various speed camera technology

2.3.6 Community attitudes towards speeding and crashes

Residents were asked to report their level of agreement on a 5-point Likert type scale, to a selection of speed related statements. Responses that reflected Agreement (strongly or somewhat) with these statements are provided in Table -9.

In previous analyses of The Community Attitudes to Road Safety Surveys, a variable has been created titled 'Total Cautious/Conservative attitude to speeding and speed limit enforcement'. "This variable has been created by identifying the proportion of the population, and each sub-group, that agree speed limits are reasonably set, that you are more likely to be involved in an accident if you increase your speed by 10km/h, and that an accident at 70km/h would be more severe that one at 60km/h; and that disagree that speeding fines are mainly intended to raise revenue and it is okay to speed as long as you are driving safely" Petroulias, 2011, p.47). In total of the residents who agreed (strongly or somewhat) with the speed enforcement statements, only 3% were identified as having a 'Total Cautious/Conservative attitude to speeding and speed limit enforcement'. With females, 65-74-year old participants, and provisional car drivers scoring higher on this attribute. Notably, low scores on this attribute were reported by learners (car and motorcycle, provisional motorcycle riders and taxi drivers).

Table -9 Residents in agreement with speed enforcement.

Characteristics		Agreement (strongly/somewhat) with speed related issues: If I am careful, even when driving over the speed limit, my chances of having a crash are low %	The risk of being caught speeding is low %	Enforcing the speed limit helps to lower the road toll %	Increasing penalties for speeding would improve driver behaviour %	Increasing the number of police officers on the road would improve driver behaviour %	Total Cautious / conservative attitude to speeding / speed limit enforcement %
Total		52	41	51	29	76	3
Gender	Male	58#	43#	46#	26#	76	2#
	Female	38#	36#	65#	36#	79	6#
	Other/prefer not to say	54	23#	32#	14#	63#	2
Age group (years)	18-24	66#	34	53	31	63#	1
	25-34	55	39	43#	26	66#	3
	35-44	52	41	49	26	75#	3
	45-54	51	41	51	29	84#	3
	55-64	52	38	48	28	78	4
	65-74	44#	46#	65#	36#	84#	3
	75+	51	47	69#	49#	80	10
Booked for speeding	Last 6 months	70#	31#	38#	22	59#	3
	Last 2 years	67#	31#	40#	22#	69#	3
Licence type	Learner car	30	60	60	50	90	0
	Provisional car	57	27#	62	41#	60#	6
	Full car	46#	41	57#	32#	77	4#
	Learner motorcycle	78#	28	17#	6#	50#	0
	Provisional motorcycle	73	46	41	18	73	0
	Full motorcycle	66#	40	36#	20#	78	1#
	Heavy vehicle	45	40	41	30	80	6
	Bus driver	60	40	70	30	100	10
	Taxi/hire car	62	33	24#	29	81	0

n=2,241
# Denotes statistically significant at the 95% confidence interval
Table design based on tables presented in DIRD report (2014)

The full range of responses, from 'Agree strongly' through to 'Disagree strongly' are presented in Figure 13. The greatest percentage of residents (42%) agreed strongly that driver behaviour would improve through increasing the number of police on the roads. With the greatest percentage (58%) disagreeing strongly or somewhat that driver behaviour would improve if speeding penalties were increased.

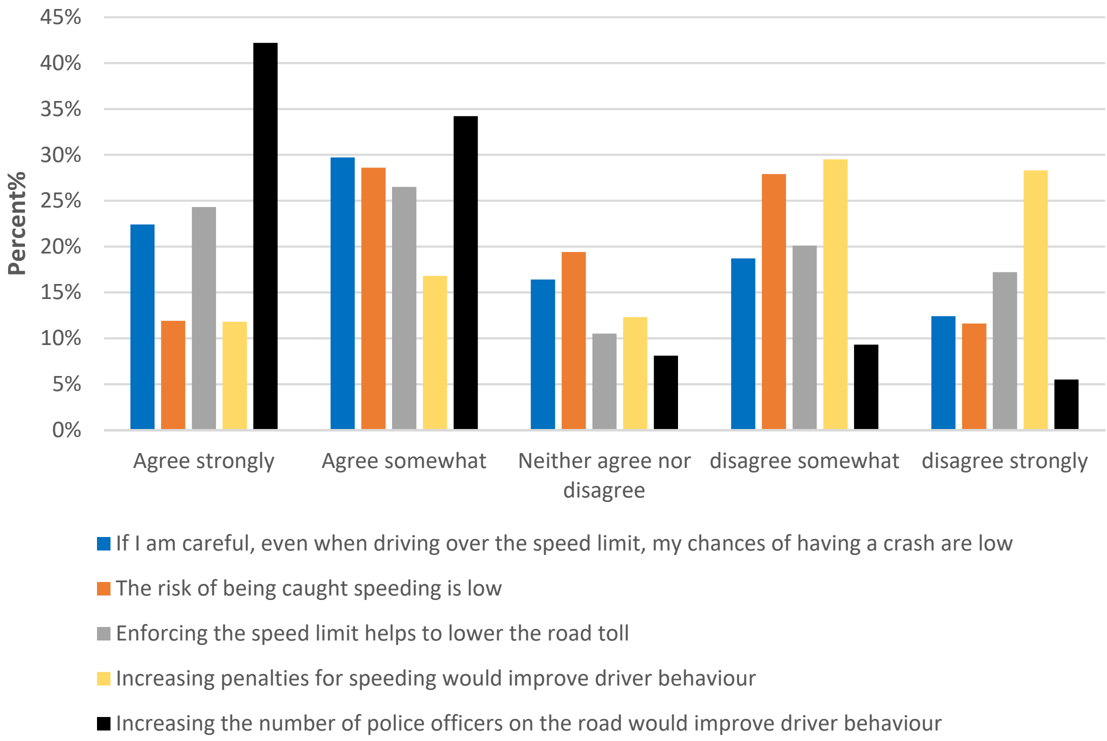


Figure 13 Level of agreement with speed related statements, 2018

Figures 14 to 18 compare the 2018 survey results for these statements with those obtained in the 2013 DTRD survey. As shown in Figure 14, in 2018 more residents acknowledged (agree somewhat or strongly) the relationship between speeding and crash risk (52%) compared to the 2013 survey results (21%) however, to the contrary, there was an increase in the number of drivers who disagreed that speed limit enforcement helps lower the road toll (Figure 16). While a similar number of residents in 2018 thought that increasing the number of police on the road would improve driver behaviour, a higher percentage thought that the risk of being caught speeding was low (41% compared to 26% in 2013, Figure 15), and that increasing penalties would not improve driver behaviour (59% compared to 28% in 2013, Figure 17).

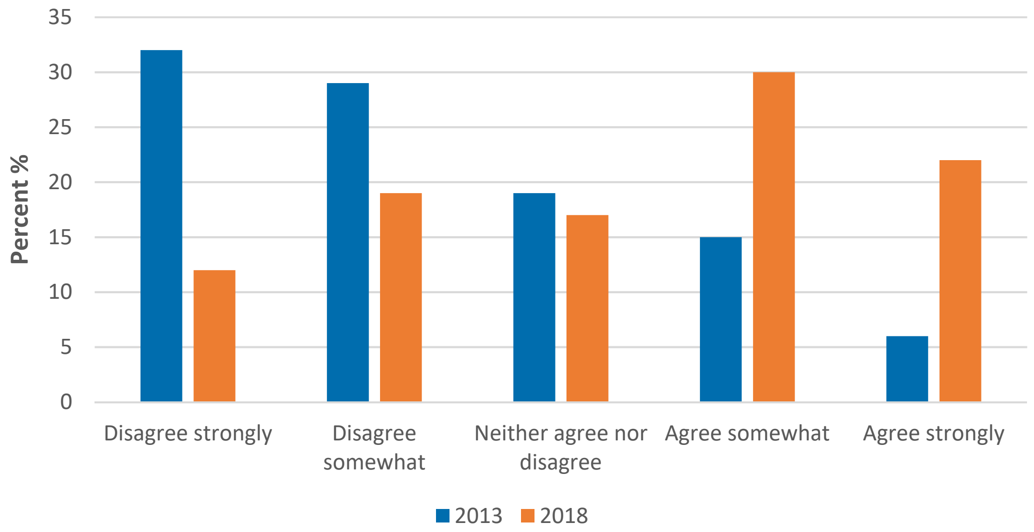


Figure 14 If I am careful, even when driving over the speed limit, my chances of having a crash are low (% agreement) 2013 and 2018.

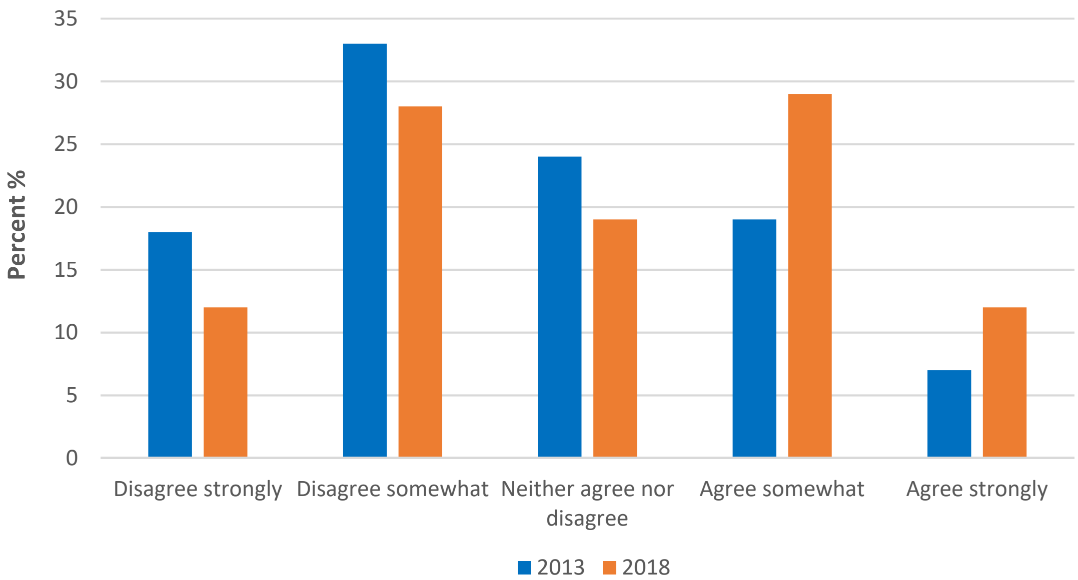


Figure 15 The risk of being caught speeding is low (% agreement) 2013 and 2018.

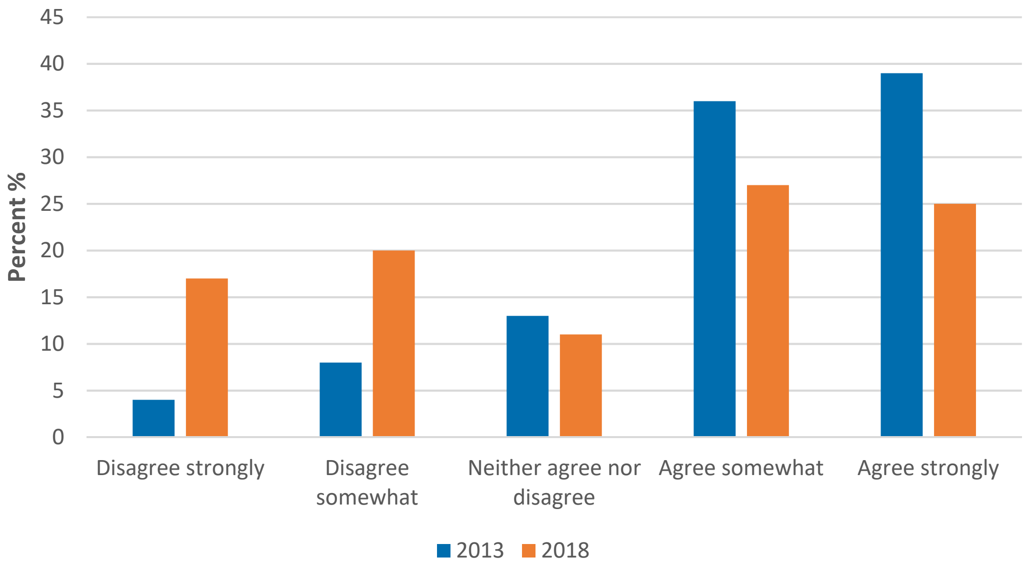


Figure 16 Enforcing the speed limit helps to lower the road toll (% agreement), 2013 and 2018.

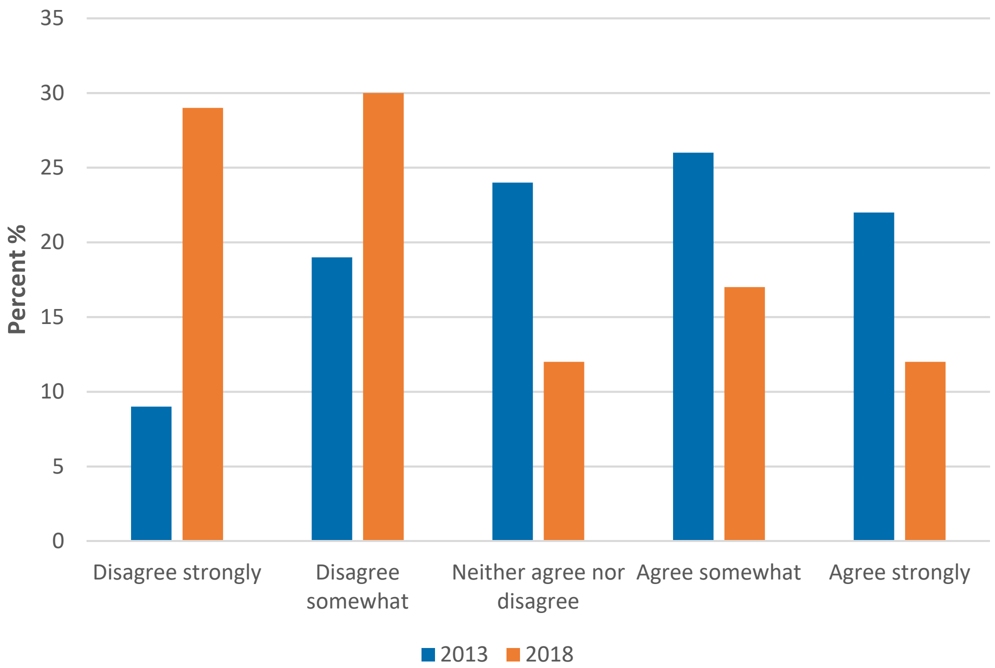


Figure 17 Increasing penalties for speeding would improve driver behaviour (% agreement), 2013 and 2018.

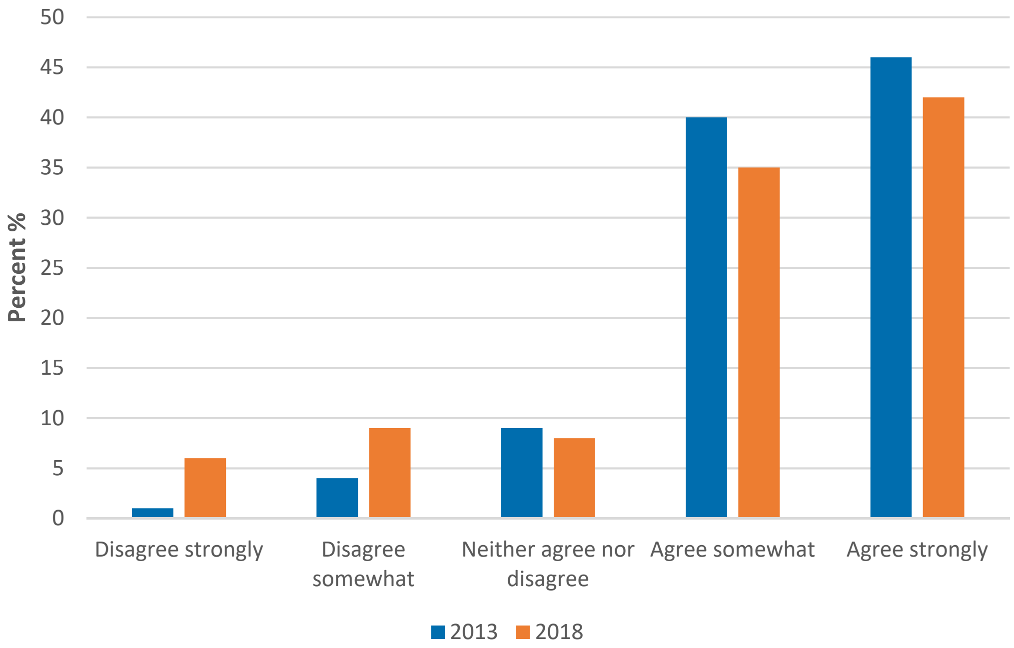


Figure 18 Increasing the number of police officers on the road would improve driver behaviour, 2013 & 2018.

Residents were then asked to report their level of agreement on a 5-point Likert type scale, to a selection of speed safety related attitudes. Responses that reflected Agreement (strongly or somewhat) with these statements are provided in Table -10. Similar to Table -9 a 'Total Cautious/conservative attitude to speeding and speed related safety' variable was calculated.

In total only 11% of the residents were identified as having a 'Total Cautious/Conservative attitude to speed and related safety'. With females, 65-74-year old respondents, and provisional car drivers scoring higher on this attribute. Notably, low scores on this attribute were reported from motorcycle riders and taxi drivers.

Table -10 Resident attitudes toward speed safety behaviour %, 2018

Characteristics		Agreement (strongly/somewhat) with speed related issues: Speeding fines mainly intended to raise revenue %	OK to speed if driving safely %	Speed limits generally responsible %	More likely to be involved in accident if increase speed by 10km/h %	Accident at 70km/h more severe than 60km/h %	Total Cautious / conservative attitude to speeding and speed related safety
Total		61	35	50	44	80	11
Gender	Male	64#	40#	46#	41#	79	9
	Female	53#	22#	63#	55#	84#	15#
	Other/prefer not to say	77#	39	32#	35#	63#	0#
Age group (years)	18-24	61	44#	55	51	70#	8
	25-34	62	43#	47	42	75#	10
	35-44	63	36	48	39#	80	10
	45-54	59	33	53	44	81	13
	55-64	68#	33	45#	40#	82	8
	65-74	52#	23#	58#	60#	90#	15#
	75+	51	28	55	57	84	8
Booked for speeding	Last 6 months	77#	62#	41	31#	73	5#
	Last 2 years	74#	55#	42#	32#	72#	7#
Licence type	Learner car	60	10	60	90	100	10
	Provisional car	54	29	62	61#	75	14
	Full car	58#	30#	55#	49#	83#	13#
	Learner motorcycle	68	72#	39	28	72	0
	Provisional motorcycle	68	64#	32	18#	73	0
	Full motorcycle	71#	48#	38#	32#	76#	7#
	Heavy vehicle	67	28	42	44	75	7
	Bus driver	80	0	70	30	80	10
	Taxi/hire car	86#	38	19#	33	48#	5

n=2,241
# Denotes statistically significant at the 95% confidence interval
Table design based on tables presented in DIRD report (2014)

The full range of responses, from ‘Agree strongly’ through to ‘Disagree strongly’ are presented in Figure 19. The greatest percentage of residents (42%) Agreed somewhat that an accident involving a vehicle travelling at 70km/h would be more a lot more severe than for one travelling at 60km/h. Overall residents tended to agree with the statements, with the highest percentage of disagreement (somewhat) related to the statement ‘Speed limits are generally set at reasonable rates at only 28% and again 40% of residents were in agreement (somewhat) with that statement.

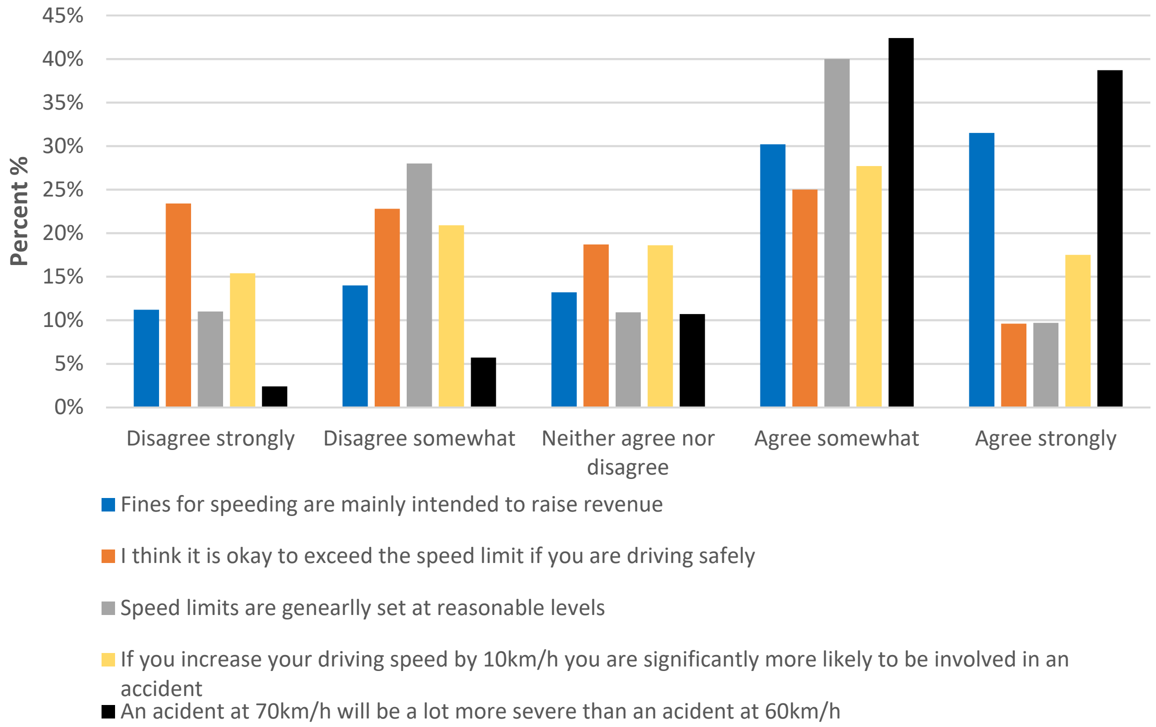


Figure 19 Level of agreement with speed safety related attitudes, 2018

2.3.7 Community awareness of Access Canberra resources

As mentioned, a series of questions were included into the Enhanced ACT Community Attitudes to Speed Survey to gauge residents' knowledge regarding the Access Canberra website. The responses to these questions are summarised in Figure 20. Approximately a third of residents (33%) were aware of their ability to nominate a speed camera location through the Access Canberra website, with 9% having done so. Just over half of the residents (51%) were aware that speed camera locations and infringement data are published on the website, 18% of had visited the open data section on the site.

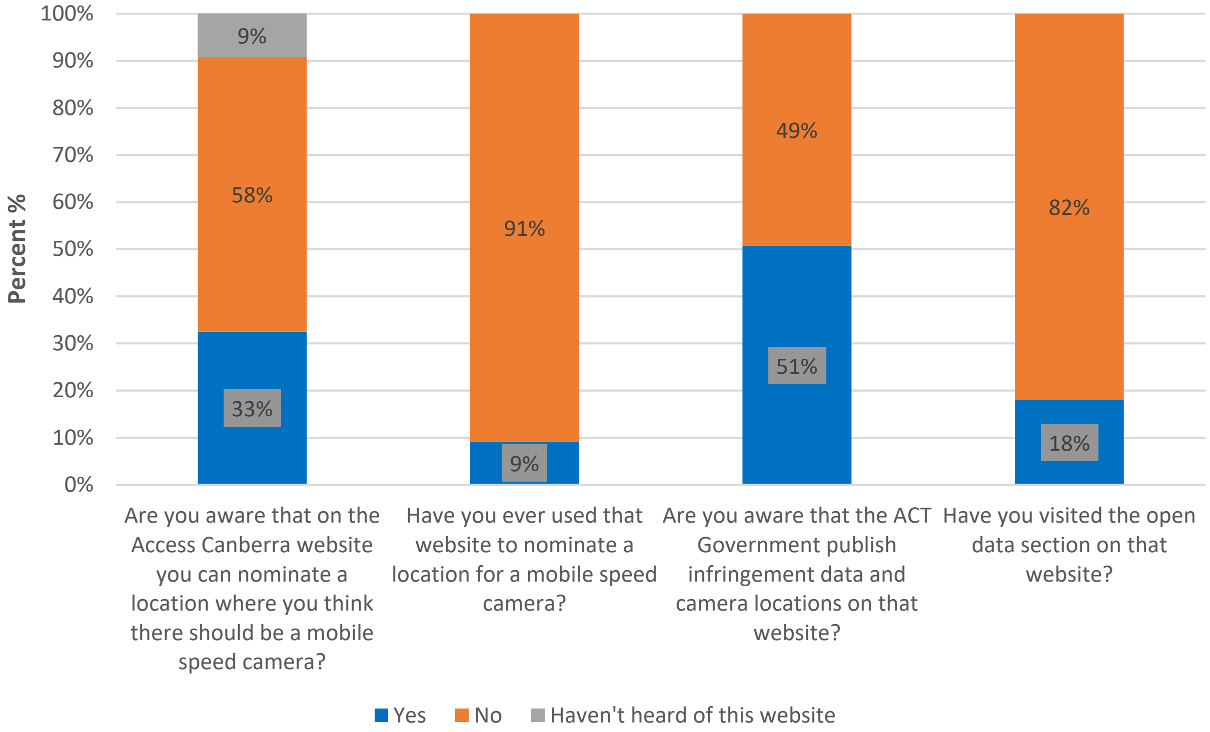


Figure 20 Responses to questions relating to information on and capabilities of the Access Canberra website.

3 DATA: SPEED SURVEY AND CRASH OUTCOMES ANALYSIS

3.1 Speed survey data

Speed survey data were provided by ACT Government (Territory and Municipal Services Directorate) for the traffic surveys carried out by 'Trans Traffic Survey' from January 1997 to November 2016. Each survey was carried out over seven continuous 24-hour days using Automatic Traffic Counter (ATC) technology, consisting of pairs of tubes laid across the traffic lanes). An average of 280 different streets per year were surveyed over the period provided. Raw data were provided for surveys undertaken during 2015 and 2016 aggregated over each hour of measurement and included: vehicle count, average speed, 85th percentile speed, modal speed, minimum speed, maximum speed and standard deviation. The raw data files also included banded speed distribution of daily aggregates, all of which revealed normal distributions. Only annual averages of weekday aggregated, site specific, survey data were provided for the years prior to 2015. For consistency, the analysis dataset for all surveyed years was created from the annual summaries provided in the form of MS Word tables for the period (1997 to 2016).

Each of these summary tables of data presented, by direction of travel and unique survey location, the mean weekday speed, the eighty-fifth percentile weekday speed and the mean weekday traffic volume over the seven-day survey period. Only survey locations considered as not being in school zones were included in the annual summary tables. Interrogation of this data revealed that more than half of these streets surveyed were only surveyed 1 to 3 times during the entire 20-year period.

3.2 Camera operations and infringement data

The monthly count and value of issued infringements by camera location, penalty and client type for the period July 2010 for November 2017 were downloaded from the data ACT web site (https://www.data.act.gov.au/Transport/Traffic-camera-offences-and-fines/2sx9-4wg7).

The Justice and Community Safety Directorate of the ACT, Transport Canberra and City Services Directorate and Access Canberra provided speed camera locations and operational details. The mobile camera operations data were provided as annual summaries in the form of Excel spreadsheets for the period 2010 to 2017, to enable matching of the hours of operation and the volume of vehicles checked, to the infringement download. For each operation, the supplied data provided the mobile camera location, date, hours of operation, count of checked vehicles, average vehicle speed, highest vehicle speed and count of potential infringements. Counts of vehicles checked and vehicles over the threshold were not collected for fixed camera operations.

Locations and dates of operations were provided for the 31 fixed speed cameras of the ACT: 14 Red light and speed cameras (including two decommissioned), 13 fixed speed cameras, two point-to-point and fixed spot speed cameras and two decommissioned point-to-point cameras. GPS co-ordinates were also provided for 1,139 unique locations of mobile camera operations.

Figure 21 displays the locations of the fixed speed cameras and mobile speed camera operations of the period evaluated within this analysis.

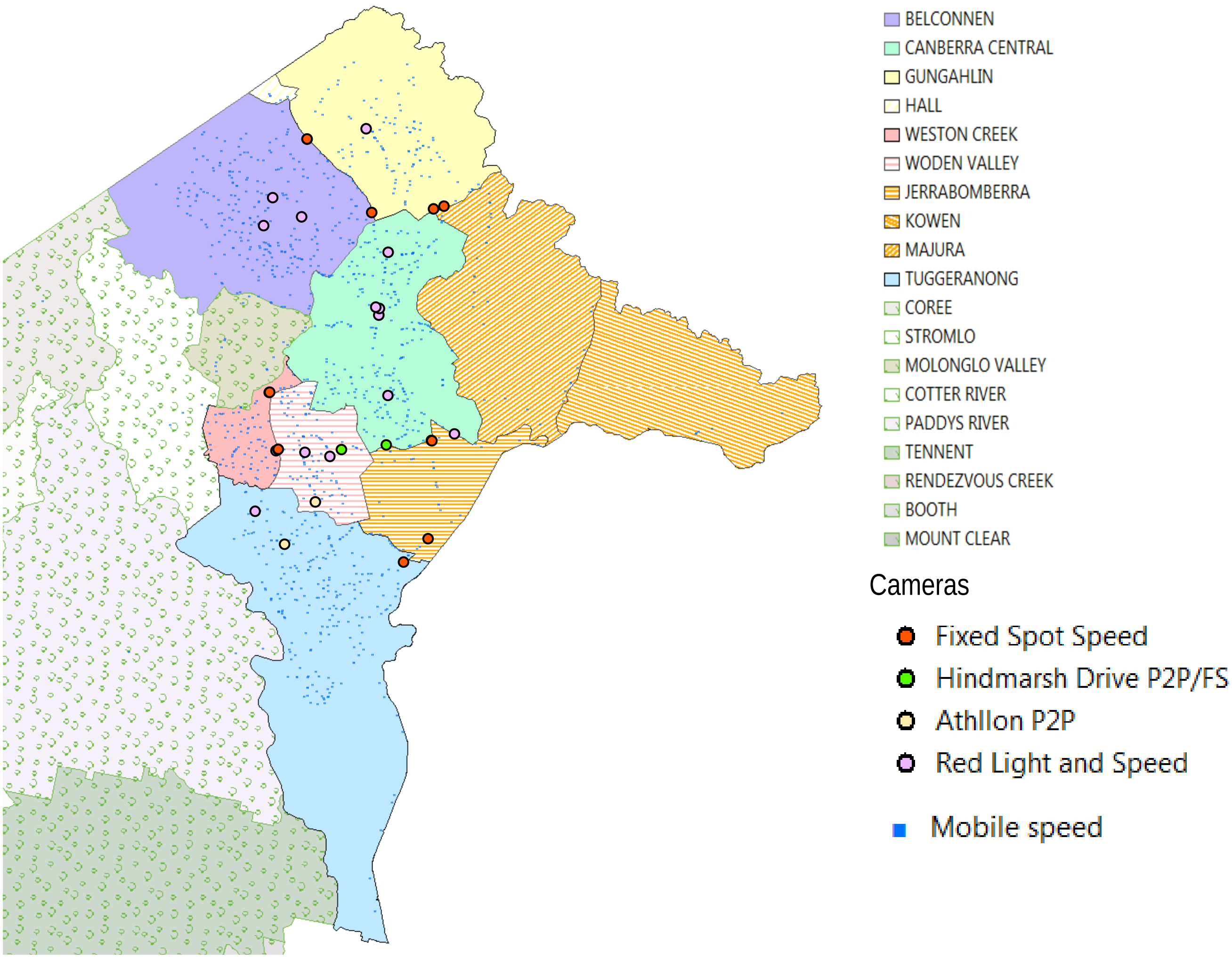


Figure 21 Location of fixed cameras and mobile speed camera operations within the districts of Canberra.

3.3 Crash data

Crash data from January 1, 1994 to January 20, 2018, provided by the Justice and Community Safety Directorate of the ACT included variables that described the crash date, time, location (street, mid-block identifier and intersection identifier), crash type, crash conditions, road geometry, traffic controls, direction of travel, severity, number of vehicles and vehicle occupants. The crash severity had three levels: property damage only, injury crash and fatal crash. The severity of an injury crash was not provided and in particular, whether the injury resulted in hospital admission.

In addition, the data contained the GPS location of a crash given in the projected datum grid, 'AGD 1966 ACT Standard Grid', which allowed for a spatial join with the GIS shape files of speed zones and camera locations (also supplied by the Community Safety Directorate of the ACT), and of ACT districts and road centrelines (with road hierarchy) downloaded from ACTmapi viewer (http://www.actmapi.act.gov.au/). Of the 194,310 crashes, 3 825 crashes (2%) were not provided with geolocation co-ordinates; these crashes with missing co-ordinates were excluded from the analyses since they could not be associated with speed camera locations. The geolocation data for each crash was located either at the exact mid-point of a mid-block crash or at the mid-point of an intersection, rather than for the actual crash location.

No red light and speed camera was operational prior to 2000 and no other fixed speed camera was operational prior to 2007. This meant that regression to the mean effects within the crash analysis were able to be minimised through the use of a long before-camera installation period; the before fixed/point-to-point camera operations period held greater than 12 years of crash data and the before mobile camera operations period held more than eight years of crash data.

3.4 Crash costs

The unit injury crash costs for fatal, non-fatal injury and non-injury crashes have been sourced from the Bureau of Infrastructure, Transport and Regional Economics' (BITRE) report which described a methodology to estimate the costs due to road crashes in Australia (Bureau of Infrastructure Transport and Regional Economics [BITRE] 2009). This report took a hybrid human capital approach to estimating the magnitude of different components of the costs of injury from road crashes. The alternative to the human capital approach, the willingness to pay approach, includes the cost of pain and suffering and reduced quality of life whilst it estimates the maximum amount of money a person is willing to pay to reduce risks to his or her safety.

Both the willingness to pay and the human capital approaches have their deficiencies. BITRE (2009) gives a detailed description of the disadvantages and advantages of both approaches. BITRE (2009) recognised that as willingness to pay includes elements that the human capital approach does not include in its estimates of cost, the former approach usually gives higher values of the cost of injury than the human capital approach. A hybrid approach is used by BITRE (2009) and includes the following measures:

- a notational age dependant value for the quality of life that would be lost by the unknown individual in the event of their premature death;
- an allowance for pain, grief and suffering that the family and relatives of the deceased suffer;
- costs to employers for the disruption caused; the cost of a premature funeral and
- the costs of prosecuting culpable drivers.

Despite all the quality of life inclusions in the hybrid approach BITRE (2009) estimates the full 'willingness to pay' costs at 52% higher than their hybrid approach.

The evaluation uses the 2006 values estimated by BITRE (2009), further updated with the Australian Bureau of Statistics consumer price index to a 2017 value (Australian Bureau of Statistics 2017). Since the reported BITRE estimated costs are categorised into four crash types (fatalities, hospitalisation without fatality (serious), non-hospitalised injuries (minor) and property damage only), and ACT categorises crashes into only three types (fatality, injury and property damage only), the cost of injury crashes was estimated. The proportion of non-fatal injury crashes involving hospitalisation was found to be 0.262 for NSW crash data from 2005 to 2014. This proportion was used to weight the non-hospitalised and hospitalised injury crash costs to produce an average cost of injury crashes.

In summary, the BITRE 2006 ACT reported crash costs of: $2 693 284 for a fatal crash, $264 677 for a serious injury crash, $14 667 for a minor injury crash and $10,433 for a property damage only crash. These translated to the 2017 Australian dollar values of: $3 486 341 for a fatal crash, $106 501 for an injury crash and $13 505 for a property damage only crash.

4 METHODS: SPEED SURVEY AND CRASH OUTCOMES ANALYSIS

4.1 Design for the statistical evaluations

The statistical analyses of crashes, mean surveyed speeds and mean 85th percentile surveyed speeds for this evaluation of road safety cameras in the ACT were based on the framework developed for a similar Queensland speed camera analysis performed by MUARC in 2014 and 2016 (Newstead and Cameron 2012). The report documenting the development of the evaluation framework provided evidence for the methodology through literature review and established practices. In addition, it thoroughly discussed the design strengths and weaknesses, and may be referred to for further details. The efficacy of the methodology has been established through the production of scientifically robust estimates of the crash effects of the Queensland safety camera program.

To estimate impacts of the ACT Road Safety Camera Program on both observed speeds and crashes, a quasi-experimental analysis design was considered. This design compares changes in crash counts or mean speeds from a period before the speed camera treatment to a period after the treatment implementation was assessed against parallel changes at defined comparison areas where the cameras were not placed but were similar in other respects. For the analysis of speed data, the available sites allowed the utilisation of the quasi-experimental design. Evaluation of the crash effects of the fixed camera program (fixed spot and point to point) was also able to use this design. Due to the extensive coverage of the crash population by the mobile speed camera program in most areas, suitable comparison sites were not available to use in the quasi-experiment. This will be further described below. Instead, analysis of the mobile speed camera program crash effects used a before after comparison controlling for the effects of changes in travel exposure over time on observed crash numbers at camera sites.

For the crash count evaluation of fixed spot and point-to-point speed cameras, the treatments being considered were highly localised geographically in their impact on crashes. Accordingly, the crash counts in the before and after periods were too small to facilitate a time series-based analysis. Instead, the statistical analysis was performed on aggregated data in the form of total crash counts in each of the before and after periods (see Appendix A7). For the mobile camera analyses, sufficient crash data was available to facilitate a yearly based time series analysis of crash effects associated with the program. From this data, crash effects of the mobile speed camera program in each year after the implementation of the program were estimated allowing comparisons with annual mobile speed camera operational measures to inform the strategic analysis undertaken in the final stage of the study.

Regression analysis was used to estimate the effects of the cameras on crash counts. The outcome measure for the regression is a relative risk estimate which measures the risk of crash occurrence within the camera's hypothesised halo of influence in the period after the camera's activation compared to changes in crashes in the comparison area over the same period. Use of the comparison area in the analysis design means that the estimated relative risk is adjusted for the effects of non-camera related factors leading to changes in crash risk as represented at the comparison site. Relative risks of less than one indicate a crash reduction associated with camera operation. A net percentage crash reduction associated with the camera can be obtained by subtracting the relative risk from 1 and multiplying by 100%. Relative risk estimates are also produced from the before-after analysis design used to estimate mobile camera crash effects. Instead of representing changes in crash risk at camera sites using a comparison site, changes in travel exposure were used to represent changes in crash risk over time not related to the cameras.

Regression analysis models were applied to crashes by severity level with the following levels considered: property damage only (i.e. non-injury), casualty (i.e. all crashes excluding non-injury), non-fatal injury, fatal and all crashes in aggregate. It should be noted that the estimated crash savings associated with the aggregate categories of all severity and casualty crashes were determined from the respective regression model crash reduction estimates and not from the summation of the savings associated with fatal, injury and non-injury crashes. This provides a more robust statistical assessment of camera effects on the aggregate crash groupings. Because of the nature of the source of crash costs, the monetary value of the crash savings of all severity and casualty crashes was determined by the summation of the monetary values of the crash savings associated with fatal, injury and non-injury crashes.

Crash count data were stratified for analysis in order to match cases and comparisons by location and broad speed zone in the quasi-experiment as well as to enable crash effects associated with the camera program to be estimated within strata of interest.

For the fixed spot/point-to-point analysis, stratification was based on the road on which the cameras were sited: Barton Highway, Monaro Highway, Federal Highway, Tuggeranong Parkway and Hindmarsh Drive. The roads where the fixed spot speed cameras were located were all either highways or major arterials and therefore likely to have similar patterns of traffic flow and similar speed zones along each length within a two or three-kilometre proximity of the camera. Comparison sites were chosen from these areas on the same roads as the cameras were installed as is described further below.

For the mobile camera crash data analysis, analysis was stratified based on districts. These strata were subsequently labelled as metropolitan or rural. Districts were: (i) Canberra Central, (ii) Woden Valley and Weston Creek, (iii) Gungahlin and Hall, (iv) Majura, Kowen and Jerrabomberra, (v) Belconnen, (vi) Tuggeranong and (viii) all the remaining rural south and western districts.

The statistical analysis of speed survey data evaluated the relationship between the speed camera program and the mean differences from the speed limit (or threshold), of the mean weekday speed or the mean 85th percentile weekday speed. The data was first summarised by traffic volume weighted averages within groups defined by case/comparison and 'before/after intervention' status, street, year and speed limit. The weighting of averages was performed to minimise bias and prevent under estimation of confidence intervals due to repeated measures. Analysing summary data in this way allowed each street to be represented only once per year of analysis[1]. The summary structure also permitted the statistical analysis of speed survey data to be stratified by the grouping variables such as calendar year, speed limit and suburb or district. The final version of the regression model used only the same broad speed zones as the mobile crash data analysis as stratification groups. Districts were not used because the cases and controls often were not both included in a single district. The regression model for the speed survey analysis estimated the absolute speed reduction (in km/hr) associated with the introduction of the mobile speed camera program. The speed survey, like the crash-based evaluations of mobile speed cameras, was analysed using a time series structure based on yearly intervals.

4.1.1 Statistical methods for evaluation of fixed spot and point-to-point speed cameras using crash data

To outline the basic statistical analysis methodology, first the case of a single treatment site assessed against aggregated data across the chosen control areas is considered. The crash data for a particular treatment (or case) site and control (or comparison) site in a simultaneous before and after comparison can be summarised in a 2x2 contingency table, shown in Table -11. The before and after treatment crash counts are taken over the entire before and after treatment periods defined in the study. Often the before and after crash periods are of different duration, however this has no bearing on the analysis method since the length of period is intrinsically adjusted through the use of the comparison group.

Table -11: Contingency table representation of crash counts in the quasi-experiment.

	Before treatment crash count	After treatment crash count
Control group	n_{00}	n_{01}
Treatment group	n_{10}	n_{11}

The assessment of the treatment effect in the quasi-experiment is made by comparing changes in the crash frequency at the treatment site from before to after the treatment, with parallel changes in crash frequency at the control site, over the same time period. If there is no treatment effect the ratio of crashes after treatment to before treatment, at the treated site, will be the same as the ratio at the control site (within chance variation). A treatment producing an effect at the treatment site will result in different after to before crash ratios between treatment and control sites. In terms of the contingency table representation of crashes in Table -11, the treatment crash effect is reflected in an interactive effect on cell counts between the rows and columns of the table.

[1] The 'within street' measurement error for the surveys conducted on a particular street for the year was already not measureable since only weekday mean data were provided and not individual speed measurements.

To assess this interactive effect a regression model framework was used to test for the statistical significance of an interactive effect in the contingency table. The model for crash count analyses is defined as:

$$\ln(n_{tb}) = \alpha + \beta_t + \gamma_b + \delta_{tb} + \varepsilon_{tb} \qquad \text{(Equation 1)}$$

where:

t is the index for treatment or control group (0=control, 1=treatment)

b is the index for before or after treatment

(0=before treatment, 1=after treatment)

α, β, γ, δ are parameters of the model

ε is a random error term

n_{tb} is the observed crash count

The structure of the linear form of parameters in the above model can be thought of as including the base effects and first order interaction of two categorical variables, each with two levels. Parameterisation of the two level categorical variables in the model is most convenient for an interpretation using a simple contrast scheme where the design matrix elements are represented only as a combination of zeros and ones. Because the model includes an intercept, one level of each of the categorical variables must be aliased through setting the associated parameter to zero. The choice of the aliased parameter in the model is critical for ease of interpretation of the remaining parameters. It turns out to be most convenient to alias the parameters corresponding to the zero levels of the before and after treatment indicator, which is the before level, and the treatment-control indicator, which is the control indicator. Correspondingly, three out of the four interaction parameters, where either the before-after or treatment-control indicators are at their zero level, are also aliased. Symbolically, this is:

$$\beta_0 = \gamma_0 = 0 \quad and$$
$$\delta_{00} = \delta_{01} = \delta_{10} = 0$$

Parameter β_1 then represents the difference in the number of crashes between the treatment and control groups in the before treatment period and parameter γ_1 represents the change in crash frequency in the control group from before to after treatment. Most importantly, parameter δ_{11} represents the differential crash change in the treatment group from before to after the treatment compared to the control group as shown in Table -12. In other words, parameter δ_{11} is a direct measure of the crash effect of the treatment being assessed. It is straightforward to show that the ratio of after to before treatment crashes at the treatment site, relative to the control site, is simply the exponent of parameter δ_{11}. This leads to the estimated percentage crash reduction at the treatment site attributable to the treatment, after parallel adjustment for changes in the control series crashes, being given as:

$$\Delta = (1 - \exp(\delta_{11})) \times 100\% \qquad \text{(Equation 2)}$$

Table -12: Expected values contingency table representation of crash counts in the quasi-experiment.

	Before treatment crash count	After treatment crash count
Control group	$\exp(\alpha)$	$\exp(\alpha + \gamma_1)$
Treatment group	$\exp(\alpha + \beta_1)$	$\exp(\alpha + \beta_1 + \gamma_1 + \delta_{11})$

A log link function is chosen for the regression model as is assumes the countermeasure acts on crash frequency in a multiplicative rather than an additive way. The assumption of multiplicative effects within the model can be sustained because a road safety countermeasure will generally reduce the frequency of accidents by a certain proportion and not by a certain number. The multiplicative structure also ensures that the crash counts predicted from the regression model are non-negative, a clearly desirable property for models of crash counts.

A test of the statistical significance of the estimated treatment effect can be made using the parameter estimate for δ_{11} and its standard error, SE(δ_{11}). The generic null hypothesis being tested is that the treatment had no effect on observed crash frequency after implementation relative to the control. This is tested against the two-sided alternative hypothesis that the treatment resulted in some change in observed crashes. Existing evidence of speed camera effectiveness suggests that it could be expected that each camera system would reduce, but not increase, crashes to some degree and, because of this, it would be appropriate to test against a one sided alternative hypothesis in each case in order to maximise statistical power. However, drivers may react to visible camera equipment by speeding up after slowing very temporarily in response to a perceived short-distance threat, and hence increasing crashes or their severity on road sections adjacent to areas around the camera sites. Because of this unintended possibility, it is considered that two sided alternative hypotheses are appropriate in most circumstances in this study.

In relation to the parameter δ_{11}, the null and alternative hypotheses can be phrased in the following way:

$$H_o : \delta_{11} = 0$$
$$H_1 : \delta_{11} \neq 0$$

Having both the parameter estimate and its standard error, calculation of the Type I error probability for acceptance or rejection of the null hypothesis can be made using a standard normal quantity, Z, defined as:

$$Z = \frac{\delta_{11}}{SE(\delta_{11})} \quad \text{(Equation 3)}$$

The significance probability for assessment of the null hypothesis is calculated by comparing Z to the standard normal distribution in the usual way. Similarly, (1-k)100% confidence limits can be calculated for the treatment effect parameter δ_{11}, from the following:

$$\delta_{11} \pm Z_{k/2} SE(\delta_{11}) \quad \text{(Equation 4)}$$

Here Z_k is the kth percentile of the standard normal distribution. The confidence limit for the parameter estimate can be transformed into a confidence limit for the estimated percentage crash reduction by applying Equation 4 to each bound of the parameter confidence limit.

A final important consideration in specifying the analysis regression model is the error structure, which is assumed for the crash count data. The most commonly assumed error structure is a Poisson distribution (Nicholson 1985, Nicholson 1986) although when data are aggregated across a number of sites, which might be the case when control data is taken across a range of eligible sites, other distributions arise. The most common of these is the negative binomial distribution which accounts for over or under dispersion of the data as well as cases where there is a surplus of zero crash counts (Hilbe 2007). The general strategy in choosing the most appropriate analysis error structure was to either start with the negative binomial error structure and assess the relationship between the estimated mean and variance parameters, or to start with the Poisson distribution and examine for evidence of over dispersion. Goodness of fit statistics such as the Akaike Information Criteria (AIC) were used to inform the choice (Wood 2002). Newstead & Cameron (2012) proposed testing the use of negative binomial error distributions in the statistical analysis of the Queensland speed camera program crash count data. Ultimately Poisson distributions were found to adequately represent the variability in the data reflecting the low crash counts when camera crash data were disaggregated by stratifying levels such as district, speed zones, regions, year, treatment group and crash severity. Testing proved over-dispersion to be significant and Pearson deviance was used to correct for the over-dispersion in all crash count regression models where negative binomial regression models were not possible.

Presentation of the analysis model above has considered estimating the treatment crash effect at groups of sites defined by stratifying variables. The above model is readily extended to simultaneously estimate the effect of L treatments from L treatment and control pairs with before and after treatment data. In this analysis of fixed spot and point-to-point speed cameras, the strata were defined by the street in which the cameras were located.

For L treatment and control pairs, the before and after crash count data may be summarised in a 2x2xL contingency table as shown in Table -13.

Table -13: Contingency table representation of crash counts from L groups of treatment and control pairs pairs.

Stratifying	Control Group		Treatment Group	
Level	Before	After	Before	After
1	n_{111}	n_{112}	n_{121}	n_{122}
2	n_{211}	n_{212}	n_{221}	n_{222}
.	.	.	.	.
.	.	.	.	.
L	n_{L11}	n_{L22}	n_{L21}	n_{L22}

The regression model for analysis of the treatment crash effects at the L levels in Table -13 is an extension of that described by Equation 1. Equation 5 gives the extended model and is essentially Equation 1 with each term interacted with a stratifying indicator variable.

$$\ln(n_{stb}) = \alpha + \lambda_s + \beta_{st} + \gamma_{sb} + \delta_{stb} + \varepsilon_{stb} \qquad \text{(Equation 5)}$$

The definition of terms in Equation 5 is the same as for Equation 1 with the addition of the following.

S is the indicator for the stratifying levels (1, 2,…, L)

λ_s are model parameters indicating differences in the number of crashes between stratifying levels.

Appropriate aliasing of indicator variable levels in the extended model is again critical for obtaining the direct estimate of the crash effects of the treatment at each stratifying level. The following parameters are aliased in the model to achieve this

$$\beta_{s0} = \gamma_{s0} = 0 \ \forall s \ \ and$$
$$\delta_{s00} = \delta_{s01} = \delta_{s10} = 0 \ \ \forall s$$

Which of the λ_s are aliased is not important.

Aliasing in this way leaves the parameters δ_{s11} as direct estimates of the treatment effect at each stratifying level. The percentage crash reduction at stratifying level s is given by Equation 6, being analogous to Equation 2 for the single treatment case.

$$\Delta_s = (1 - \exp(\delta_{s11})) \times 100\% \qquad \text{(Equation 6)}$$

Tests of the statistical significance of each treatment effect parameter and their corresponding confidence limits follow through appropriate modifications to Equations 3 and 4.

One of the advantages of using a single model to estimate treatment effects across a number of stratifying levels is that the model of Equation 5 can be modified subtly to provide an average treatment effect across all L levels being assessed. The modifications to the model involve a modification to Equation 5 replacing the L 3-way interaction terms δ_{s11} with a single global 2-way interaction term as indicated in Equation 7.

$$\ln(n_{stb}) = \alpha + \lambda_s + \beta_{st} + \gamma_{sb} + \delta_{tb} + \varepsilon_{stb} \qquad \text{(Equation 7)}$$

Aliasing is as before except with all but δ_{11} of the δ parameters aliased. The non-aliased parameter δ_{11} represents the average net treatment crash effect across the L stratifying levels. Calculation of the overall percentage treatment crash reduction, significance probabilities, and confidence limits are as before based on the overall treatment effect parameter, δ_{11} in Equation 7, and its estimated standard error.

There are specific benefits to using the formulation of Equation 7 rather than aggregating data across all of the treatment and control sites to produce an overall effect estimate. Firstly, it avoids the potential for the occurrence of Simpson's paradox which can occur when data are aggregated across a confounding variable (Simpson 1951, Jarrett 1997). If the treatment effect is confounded with a stratifying level then aggregation of the data across levels may lead to a biased overall treatment effect estimate.

4.1.2 Statistical methods for evaluation of mobile speed cameras using crash data

A time series analyses was carried out for the mobile speed camera program to estimate crash effects of the program in each year after implementation. To achieve this, crash counts were stratified into yearlong periods with October 1, 1999 defining the start of the mobile speed camera program (after treatment period) and all year long periods beginning October 1 and finishing September 30 of the following year. The exception was the first and last period, which were shorter. The first period ran from January 1 1994 to September 30 1999 and the last period ran from October 1 2017 to January 20, 2018. Both these periods were converted to expected annualised counts by inflating each by the number of months under a full year represented.

As noted, the evaluation design for the mobile speed camera program does not include a comparison are due to the mobile camera program having such high coverage of the ACT geographically in the areas which it is implemented that suitable comparison sites were not available. Instead, a controlled before to after mobile camera program implementation design was used with adjustment for changes in annual travel growth in the ACT as a measure of the change in broad crash frequency across the territory. Data were prepared in annual time series of crash counts for analysis within each region of the ACT. The regression model fitted to the data is described by Equation 8.

$$\ln(n_{rp}) = \ln(T_p) + \alpha + \lambda_r + \beta_{rp} + \varepsilon_{rp} \quad \text{(Equation 8)}$$

In Equation 8:

r	is the indicator of ACT region (Canberra Central, Belconnen etc.)
p	= 0 if year was before the introduction of the speed camera program
	= 1 if year was in the first year after the introduction of the speed of speed camera program
	= 2 if year was in the second year after the introduction of the speed camera program.
α, β, λ	are parameters of the model
ε	is a random error term

Estimates of post implementation crash risks in each year are derived as relative risks directly from the model by setting the before implementation values of p as the reference category in the model and then using the transformation of Equation 6 to estimate the associated crash reductions for each year. Modifications to the analysis model were made to estimate effects within speed zone (≤ 60 km/hr or >60 km/hr), general metropolitan or rural location and for the program overall post mobile camera program implementation. Separate models were fitted to each crash severity level considered.

4.1.3 Evaluation of mobile speed cameras using speed survey data

A quasi-experimental before-after case-control experimental design was used with general linear regression modelling of the mean differences between the mean weekday speed (or the mean 85th percentile speed) and the speed limit (or threshold) of the street surveyed. This model estimated the absolute speed reduction (in km/hr) associated with the introduction of the mobile speed camera program. General linear modelling was chosen because mean speed was observed to have a normal distribution.

The model took the form:

$$y_{sitb} = \alpha + \lambda_s + \beta_{st} + \gamma_{si} + \delta_{tb} + \varepsilon_{sti} \qquad \text{(Equation 10)}$$

Variations of the form, allowed the fifth term to be:

•δ_{tb} (Intervention x Case) for the whole program average effect

•δ_{tp} (Intervention x Case x Year) for the effect by calendar year, and

•δ_{stp} (Intervention x Case x Year x Strata) for the effect by calendar year and stratum.

y was the mean difference in speeds as described in the paragraph above: either the mean difference between the mean speed and the speed limit (or threshold), or the mean difference between the mean 85th percentile speed and the speed limit (or threshold).

s,t,b,p and i are as defined in sections 4.1.1 and 4.1.2, with one difference in that data limitations required that standard calendar years from January to December were used for *i*.

The fifth term directly provided the estimate of the speed reduction in km/hr associated with the mobile speed camera operations. Variations in the model permitted the estimation of the overall average reduction, the average reduction by calendar year and the average reduction by year and broad speed limit group. The stratification used in this design was only based on broad speed limit group (under 80 km/hr & ≥ 80km/hr), which essentially stratified by speed tolerances[2]. Further stratification separated the data so much so that complete sets of 'before/after and case/comparison' averages were not available for the many levels produced. Furthermore, using mean speeds centralised by the speed limit or threshold allowed surveys from all speed zones to be pooled without the need for stratification by speed zone.

4.1.4 Analysis of the relationship between mobile camera operations and estimated crash reductions

In order to inform the strategic analysis described in Section 6 of this report, the relationship between mobile speed camera operations and associated crash reductions needed to be established. A number of measures of mobiles speed camera operations data were available including hours of operation, number of session delivered, number of vehicles passing the camera, number of vehicles detected exceeding the speed threshold and number of infringements issued. Vehicles exceeding the speed limit and infringements issued are partly a measure of program effectiveness so were not considered appropriate for the analysis. Number of vehicles passing the camera is also not a pure measure of operational output. This left number of sessions conducted and hours of operation as the measures of pure operational output for inclusion in the model. Both were highly correlated so the number of operational hours was chosen for inclusion in the model since it was invariant to changes in session length over time.

The form of the analysis model used to estimate the relationship between mobile speed camera program crash effects and program operation output was a double log elasticity model traditionally used in econometric analysis. The form is given in Equation 9:

$$\ln(RR_{rp}) = \alpha + \beta \ln(H_{rp}) + \varepsilon_{rp} \qquad \text{(Equation 9)}$$

In Equation 9:

r	is the indicator of ACT region (Canberra Central, Belconnen etc.)
p	is the year after the introduction of the speed of speed camera program
α, β	are parameters of the model
ε	is a random error term

[2] Most of the over 80 km/hr survey zones were 100 km/hr zones. Tolerances were 8 km/hr for all zones except 100 km/hr zones, (which were 11 km/hr).

β is the elasticity measure relating operation output to crash outcomes and represents the percentage change in the outcome measure for each percentage change in the program output measure. Regression models were estimated for each crash severity level separately. Analysis was based on estimated program crash effects by year for the program from 2010 onwards, the period for which mobile camera operations and infringement data were available for this evaluation.

4.2 Excluded crash data

Crashes were excluded from statistical analysis if they were

- without GPS location data;
- within 50 metres of a red light speed camera site;
- between, and 500 metres beyond (on the same street), the point-to-point cameras on Athllon Drive;
- crashes at commuter cycle-ways, construction sites, driveways, parking areas, recreational areas, private property and other off-road locations.

Analyses of red light cameras and the analysis of the Athllon Drive point-to-point cameras were not within the scope of this evaluation.

4.3 Case and comparison selection

To implement the evaluation framework for both fixed and mobile speed cameras, it was necessary to define areas of hypothesised influence for each camera type in which the '*case*' data is selected for analysis. In addition, for the fixed camera evaluation it was also necessary to define areas similar to the camera sites where cameras were not places from which 'comparisons' data is selected for analysis. The way cases and comparisons where used were defined for each of the three statistical analysis datasets follows.

4.3.1 Fixed spot and point-to-point speed camera crash data

Fixed spot speed cameras were located on five roads: Barton Highway, Monaro Highway, Federal Highway, Tuggeranong Parkway and Hindmarsh Drive. Point-to-point cameras were also located on Hindmarsh Drive at the same site as the fixed spot speed cameras.

Crashes located on all of these roads, except Hindmarsh Drive, within one kilometre of a camera site, were defined as case crashes. On Hindmarsh drive, cases were all crashes occurring between the point-to-point cameras, and all those extending 500m in either direction away from the enclosed section. The size of these hypothesized zones of influence have been established in literature[3].

Except those crashes on Hindmarsh Drive, those crashes more than one and up to two kilometres from a fixed camera site, on the same road as the camera, and not already defined as a 'case' were considered as the 'comparison' crashes. On Hindmarsh Drive, crashes greater than 0.5 km east of the eastern point-to-point camera, extending to the Monaro Highway (0.5 km to 2 km from the eastern camera), and crashes greater than 0.5km west of the western point-to-point camera and those a further 2km down Hindmarsh Drive were considered as the 'comparison' crashes.

It was thought sufficient for comparison crashes to be on the same roads and within a reasonably close distance; no further matching by speed zone nor by road dividedness nor district was attempted. Both speed and dividedness were considered too unreliable to use in this matching: speed zone data was only available for a fixed point in time, from spatial maps, and road dividedness data contained a considerable amount of missing data. Matching by district was also not attempted. Neighbouring districts of comparison crashes were considered sufficiently similar to those of the cameras because of their proximity and their being located on the same road.

[3] The validity of the size of the chosen zones of influence is discussed at length in Newstead & Cameron, 2012. The 1km zone for fixed spot speed cameras was used in the Queensland speed camera evaluations.

4.3.2 Mobile speed cameras crash data

Case crashes were defined as those that fell on sites within 0.5 km of the sites where mobile camera operations had taken place. In addition to this requirement, the crash had to have not been considered a case crash for the fixed spot and point-to-point camera analysis. Over 80% of ACT crashes occurred within 0.5 km of a mobile speed camera operation site. Figure 22 graphically displays the location of case crashes used in the evaluation of the mobile speed camera program.

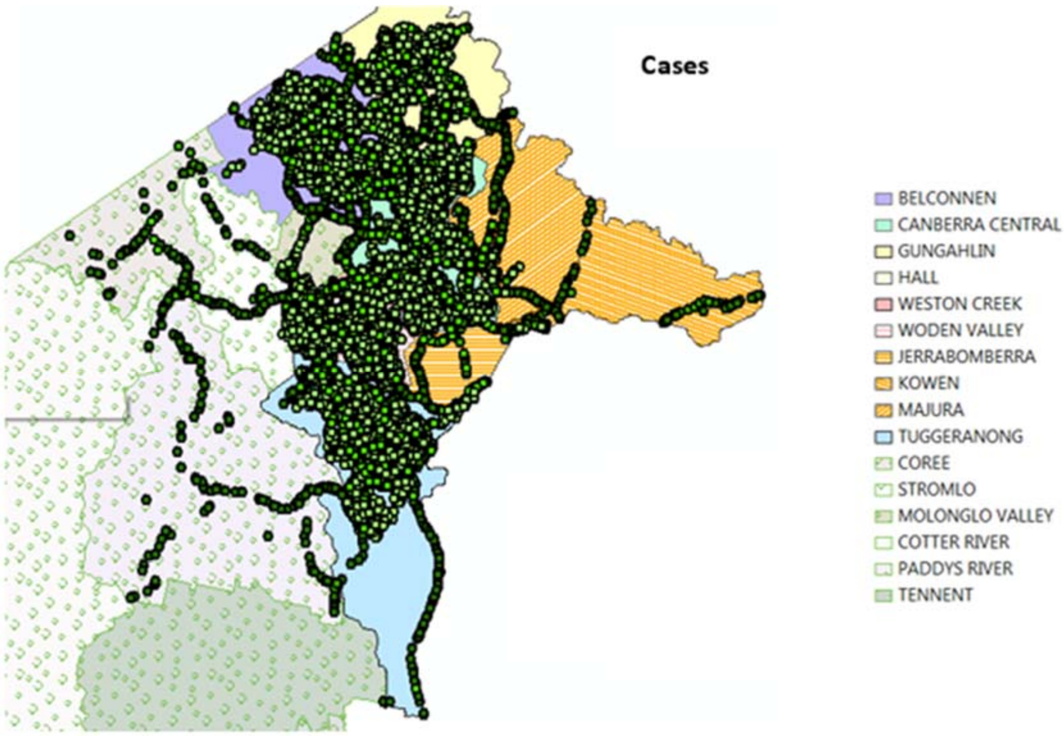


Figure 22 Location of case crashes associated with the analysis of mobile speed camera operations, by district.

4.3.3 Mobile speed cameras speed survey data

Case sites were speed survey sites in which mobile camera operations had taken place and comparison sites were survey sites where mobile speed camera operations had not taken place.

To support consistency between this current evaluation, and the previous evaluation, the same 95 streets (48 case & 47 control) used in the previous evaluation (TARS Research, 2014) were used in this analysis dataset. These 95 streets (see Appendix A5), originally selected with the aim of maximising pre-intervention data, were chosen as streets:

- used in the 1997 speed surveys;
- on which a mobile speed camera had (cases) or had not (controls) been introduced, between 1999 and 2012;
- had been included in a speed survey for a minimum of five years (up until 2012).

4.4 Before and after treatment period selection

4.4.1 Evaluation of fixed spot and point-to-point speed cameras

A crash could be defined as in the 'before' camera operations period if it fell between the earliest crash date in the data (January 1, 1994) and the date in which the nearest camera was installed. If an installation date was unavailable, the date for the start of operations could be substituted. Cases and controls were grouped by the roads on which the fixed spot cameras were sited, for each set of cases and controls defined by cameras on a single road (Barton Highway, Monaro Highway, Federal Highway, Tuggeranong Parkway and Hindmarsh Drive). Consequently, the earliest date of installation (or operation) for the camera group was used to mark the end of the 'before' camera operations period for the entire group on the same road.

Similarly, for each set of cases and controls, defined by cameras on a single road (Barton Highway, Monaro Highway, Federal Highway, Tuggeranong Parkway and Hindmarsh Drive), the latest date of installation (or operation) for the camera group was used to mark the start of the 'during speed camera operations' period for the entire group. The last date of available data (January 20, 2018) marked the end of this period.

The earliest installation or operation date for a fixed spot or point-to-point camera was July 13, 2007. This means that there was more than twelve years of before operations data, which provides a suitable period for minimising regression-to-the-mean (RTM) effects.

4.4.2 Evaluation of mobile speed cameras

Mobile camera operations commenced in October 1999; speed surveys which commenced prior to October 1999 and crashes which commenced prior to October 1999 were assigned a '*before*' status, and later speed surveys and crashes were allocated the status of '*during mobile camera operations*'.

The 2014 analyses of speed survey data used two intervention periods, with the second intervention marking a decline in mobile speed camera operations. The use of two intervention periods was deemed unnecessary in this analysis because a longer period of mobile speed camera operations was being examined, and because this study design used stratification by calendar year to account for annual mobile speed camera program differences.

The 33-month pre-intervention period for the analysis of speed survey data, was judged sufficient to control for regression-to-the-mean (RTM) effects expected from the choice of mobile camera speed programs in higher risk locations. Almost five years of pre-intervention crash data was available to provide adequate control of RTM effects for the crash-based analyses.

4.5 Speed survey data graphs and aggregates

A qualitative analysis of speed survey data was also performed using graphical representations of mean monthly summaries of case and comparison data. The difference between the mean weekday speed and the speed limit, and the difference between the 85th percentile weekday speed and the speed limit, were first calculated for each case and comparison survey (by street, direction of travel and survey start date). In addition, the difference between the mean weekday speed and the speed threshold and the difference between the 85th percentile weekday speed and the speed threshold were calculated for each case and comparison survey (by street, direction of travel and survey start date). The mean weekday traffic volume was used to weight monthly averages of these differences. Plots of the weighted mean differences by month, case/comparison and speed limit are presented for 100, 80, 60 and 50 km/hr speed zones. Very few data points were available for 90, 70 and 40 km/hr speed zones, so these were not presented.

4.6 Analyses of camera operations and infringement data

The mobile camera operations data were aggregated[4] for each month and merged with the monthly issued infringement download. Rates per hour of operation and per vehicle checked were calculated and graphed. In addition, the rate of infringements per vehicle detected above the enforcement threshold was calculated as a measure of the efficiency of mobile speed camera processing.

In addition, to provide a comparative reference for the mobile speed camera crash evaluation by program year (and district[5]), hours of operations data and number of operations per district were aggregated for each year of the mobile speed camera program. Furthermore, the annual estimated crash reductions associated with the mobile speed camera were plotted against the rate of infringements per vehicle detected above the enforcement threshold, the annual hours of operation and the annual number of operations[6]. It was not possible to determine speed zone and metropolitan and rural regions from the data provided, so comparisons with the mobile speed camera crash analysis by speed zone and metropolitan/rural status was not possible.

4.7 Proposed analyses that could not be performed

The association of the mobile speed camera program with the severity of an injury crash was not evaluated because injury crashes were not categorised into minor and serious levels. Speed survey distributions were only made available for 2015 and 2016 surveys. Thus only 2015 and 2016 speed survey distributions could be converted into relative crash risk estimates and risk weighted speed distributions, based on Nilsson's power models for mean speeds (Nilsson, 2004; Nilsson, 1981) and Kloeden et al's (Kloeden et al, 2001; Kloeden et al, 2002) crash risk functions. This also had the follow-on effect of limiting to 2015 and 2016 the identification of crashes attributable to low, medium and high speeding ranges, based on attributable risk methods (Cameron, 2015)for urban and rural speed distributions. So annual changes over time within the program period and comparisons with the before program period were not possible using this technique.

4.8 Software

The statistical package IBM SPSS (version 24, 2016) was used to manage data. Data was then analysed statistically in SAS version 9.4 for Windows (SAS Institute Inc., Cary, NC, USA).

ESRI ARCMap 10.4 for Desktop (version 10.4.0.5524) was used to map camera locations, crashes, districts and speed zones, so that the distances of crashes from cameras, districts and speed zones could be joined with the crash data.

[4] Before data were aggregated, cases with missing or 0 values for the count of vehicles checked, as well as seven cases with missing infringement count values, were excluded. Also, to ensure the best estimate of operation hours, imputations based on operation hours at the same time of day and location were used to replace the calculated operating hours for a small percentage of cases with odd or missing start/finish times.
[5] Districts were determined from the suburbs provided.
[6] The number of operations and the hours of operations were found to be highly correlated, so the graphical presentations of the crash reductions against the number of operations were not included in the report.

5 RESULTS

5.1 Fixed speed cameras

5.1.1 Percentage crash savings

The quasi-experimental study design described in Section 4.1 and statistical analysis methods described in Section 4.1.1 were applied to the crash data at camera and comparison sites to estimate the crash effects associated with the installation and activation of both the fixed spot mid-block located speed cameras and the Hindmarsh Drive point to point camera system. Estimated percentage crash reductions for each spot speed camera and the point-to-point system are shown in Table 14. Point estimates of percentage crash savings associated with each camera sites as well as on average across all sites are given by crash severity grouping along with 95% confidence limits and the statistical significance values for each estimate. Casualty crashes are fatality and injury crashes combined whilst all crashes are all reported crashes including casualty and non-injury crashes combined. The outcome measure given in Table 14 is the Relative Risk, which measures the change in crash risk form before to after installation of the camera adjusted for changes in crash risk over the same time at comparison sites. As noted, the comparison sites measure the impact of factors other than the speed camera on crash risk at camera sites. Relative risks can be converted into percentage crash savings by subtracting the relative risk from 1 and multiplying by 100 (Equation 6). Relative risks less than one (giving positive percentage crash savings) indicate a crash risk reduction associated with camera installation. Conversely, a relative risk greater than one (giving a negative percentage crash saving) indicate a crash risk increase associated with camera installation.

Results in Table 14 indicate an average 25% reduction across all camera sites in all reported crashes associated with fixed speed camera installation. Analysis indicated a slightly higher reduction in non-injury crashes compared to casualty crashes although the significant overall of the 95% confidence limits on the estimates indicates the difference are not statistically significant. Analysis of casualty crashes lacked statistical power due to the small number of casualty crashes local to the camera sites with only the estimate for the Monaro Highway achieving statistical significance. However, results from the all crash analyses are highly statistically significant confirming the association between camera placement and crash reductions. Differences in crash effects estimated between camera sites are also not statistically significantly different based on the confidence limit overlap meaning that the average estimated effects across all camera sites gives the most robust estimate of crash effects associated with the cameras available from the study. Importantly, relative risk estimates for the Hindmarsh Drive point-to-point camera system were not statistically significantly different to the spot speed cameras showing that value of the combined analysis in deriving and estimate of overall crash effects associated with the point-to-point camera system.

Table -14 Estimated crash effects associated with fixed spot mid-block speed cameras and the point to point camera system in the ACT

Crash Severity	Relative Risk	(95% CI)		p-value
Non-injury Crashes				
All Cameras	0.73	(0.67,	0.80)	<.0001
Barton Highway	0.65	(0.55,	0.78)	<.0001
Monaro Highway	0.79	(0.66,	0.95)	0.01
Federal Highway	0.39	(0.29,	0.51)	<.0001
Tuggeranong Parkway	0.84	(0.68,	1.04)	0.11
Hindmarsh Drive	0.87	(0.74,	1.03)	0.10
Casualty Crashes				
All Cameras	0.89	(0.66,	1.20)	0.45
Barton Highway	0.62	(0.33,	1.14)	0.12
Monaro Highway	0.53	(0.28,	0.99)	0.04
Federal Highway	0.73	(0.24,	2.18)	0.57
Tuggeranong Parkway	1.74	(0.84,	3.57)	0.13
Hindmarsh Drive	1.36	(0.76,	2.43)	0.31
Non-Fatal Injury Crashes				
All Cameras	0.92	(0.68,	1.25)	0.59
Barton Highway	0.65	(0.35,	1.20)	0.16
Monaro Highway	0.54	(0.29,	1.02)	0.06
Federal Highway	0.78	(0.26,	2.35)	0.66
Tuggeranong Parkway	1.74	(0.84,	3.61)	0.14
Hindmarsh Drive	1.41	(0.78,	2.54)	0.25
All Crashes				
All Cameras	0.75	(0.69,	0.81)	<.0001
Barton Highway	0.65	(0.55,	0.77)	<.0001
Monaro Highway	0.76	(0.63,	0.90)	<.0001
Federal Highway	0.42	(0.32,	0.56)	<.0001
Tuggeranong Parkway	0.89	(0.73,	1.09)	0.27
Hindmarsh Drive	0.91	(0.78,	1.07)	0.27

5.1.2 Absolute crash savings and economic worth

Using the annual average crash population at camera sites in post camera installation and activation period along with the estimated relative risks from Table 14, annual absolute crash savings across the fixed speed camera were calculated and are given in Table 15. Given the lack of statistical significance in crash effects estimates between camera sites in Table 14, average crash effects across all cameras have been used. Furthermore, for consistency, total crash savings in Table 15 have been calculated as the sum of casualty and non-injury crashes rather than using the all reported crash estimates, although the results are similar for the two different methods. Using the BITRE-derived community crash cost estimates described in Section 3.4, the absolute annual savings in community crash costs associated with each camera and overall were estimated and presented in Table 15. Using the 95% confidence limits from the crash effect relative risk estimates in Table 15, corresponding 95% confidence limits on absolute crash savings and community crash cost savings have been estimated and included in Table 15.

Table 15 shows and overall saving in crash costs to the community associated with the ACT fixed mid-block speed camera system of just over $1.3M per annum. The estimated cost savings were generated from estimated annual savings of 2 casualty crashes and 66 non-injury crashes across all sites.

Table -15 Annual crash rate post camera installation, estimated absolute annual crash savings and estimated annual community crash cost savings (A$2017) associated with ACT fixed mid-block speed cameras.

	Crashes*	Annual Crash Savings	Lower 95% CI	Upper 95% CI	Annual Crash Cost Savings ($1,000s)	Lower 95% CI	Upper 95% CI
Non-injury Crashes							
All Roads	180	66	46	88	$893	$621	$1,188
Barton Highway	26	10	7	13	$129	$95	$176
Monaro Highway	53	19	13	26	$263	$176	$351
Federal Highway	13	5	3	6	$65	$41	$81
Tuggeranong Parkway	53	19	13	26	$263	$176	$351
Hindmarsh Drive	35	13	9	17	$174	$122	$230
Casualty Crashes							
All Roads	19	2	-3	10	$420	-$533	$1,776
Barton Highway	3	0.4	-0.5	1.6	$66	-$90	$277
Monaro Highway	4	0.5	-0.7	2.1	$88	-$120	$370
Federal Highway	3	0.4	-0.5	1.6	$66	-$90	$277
Tuggeranong Parkway	5	0.6	-0.8	2.6	$110	-$150	$462
Hindmarsh Drive	4	0.5	-0.7	2.1	$88	-$120	$370
All crashes							
All Roads	194	69	43	98	$1,313	$88	$2,964
Barton Highway	28	10	6	15	$195	$5	$453
Monaro Highway	57	20	12	28	$351	$56	$721
Federal Highway	16	5	2	8	$131	-$49	$358
Tuggeranong Parkway	57	20	12	29	$373	$26	$813
Hindmarsh Drive	39	13	8	19	$262	$2	$600

*Average annual crash rate at camera sites in the post implementation period.

5.2 Mobile speed cameras

5.2.1 Percentage crash savings

Methods described in Section 4.1.2 were applied to estimate the crash effects associated with operation of the mobile speed camera program in the ACT. A key input to the analysis is estimates of total vehicle travel in the ACT, which is included in the model to control for changes in travel exposure over time, in the absence of a suitable comparison area. Estimates of total vehicle travel in the ACT for use in the analysis have been derived from the Australian Bureau of Statistics Survey of Motor Vehicle Usage (SMVU) (ABS, 2016). The SMVU is conducted periodically providing estimates of total vehicle travel in each state and territory in Australia. Estimates for the ACT were extracted from each available survey and were interpolated between surveys to produce the series shown in Figure 23. The data presented have been converted to annual averages for the 12-month periods corresponding to the 12-month periods after implementation of the ACT mobile camera program for which the crash data have been analysed.

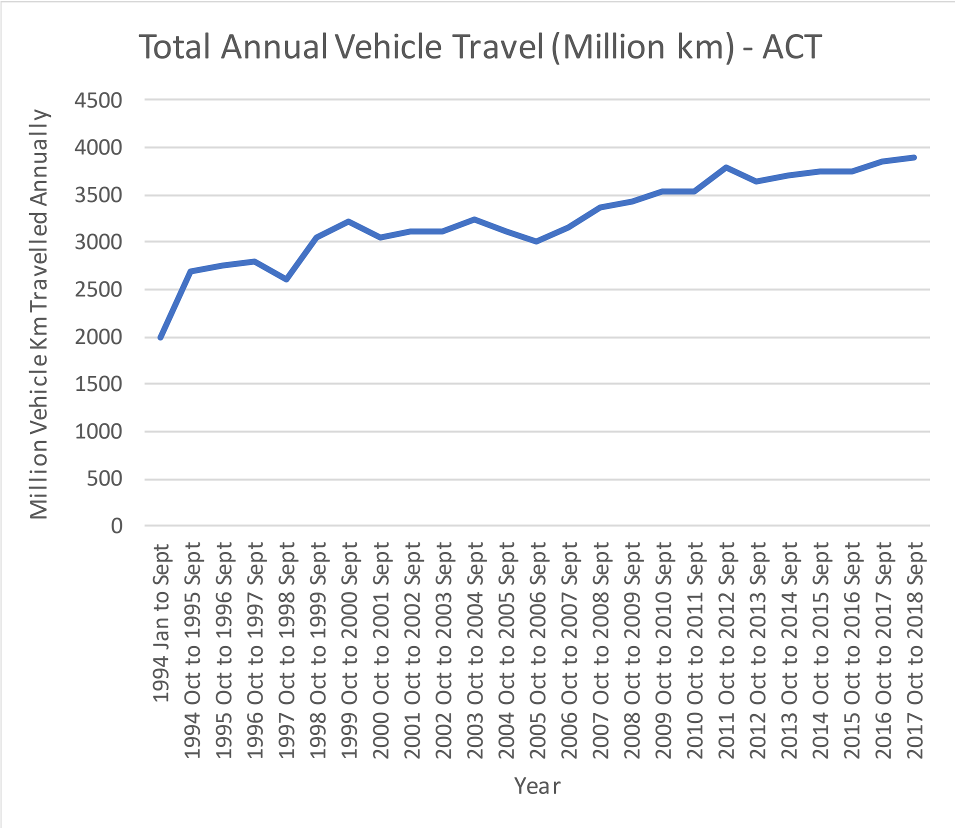


Figure 23 Estimated annual total vehicle travel in the ACT (from ABS Survey of motor vehicle usage)

Estimates of travel from the SVMU were not available for each region of the ACT separately so the growth in travel shown in Figure 23 is assumed to apply equally to all regions. The only exception is for Gunghalin which the 2016 census data analysis show has been growing faster than the remainder of the ACT. Census 2016 data shows the, while the ACT's population grew by 11.2 per cent in five years, Gungahlin was Australia's second-fastest growing region, with 71,000 residents, up from 47,000 in 2011. Is expected that the observed large population growth in Gunghalin will have resulted in higher than average travel growth in that district compared to the ACT overall. As noted, specific travel exposure estimates for Gunghalin are not available. Due to the likely bias in mobile speed camera crash effects estimated using the overall ACT travel estimates, specific crash effect estimates Gunghalin have not been estimated. Estimates of mobile speed camera effectiveness for ACT overall were not impacted by this problem.

Table 16 shows the relative risk estimates for non-injury crashes for the ACT speed camera program both overall and within district. Like the fixed camera analysis in the previous section, the relative risk estimates reflects the risk of crash involvement in areas within 500m of a mobile speed camera site after implementation of the mobile speed camera program compared to prior to the program not being implemented. Estimates are corrected for changes in travel exposure in the ACT over time. Estimates are provided as an average crash effect associated with the mobile speed camera program in the full period post implementation for the ACT as a whole and by district (except for Gunghalin and Hall for the reasons explained) as well as by 12 month period after implementation of the program for the ACT as a whole. As well as the relative risk estimate, the table gives the statistical significance of each estimate along with the 95% statistical confidence limits on each estimate. Percentage crash savings can be derived from the relative risk estimates by subtracting the relative risk from 1 and multiplying by 100%. For example, the relative risk estimate for the ACT as a whole over the entire camera post-implementation period is 0.765, which corresponds to a 23.5% crash reduction.

Table -16 Relative crash risks for non-injury crashes associated with the ACT mobile speed camera program overall, by district and by year after program implementation

Year or District	Statistical Significance.	Relative Risk	95% Confidence Interval for RR	
			Lower	Upper
All Districts – Average All Years				
All Districts	<0.001	.765	.756	.774
By District – Average All Years				
Canberra Central	<0.001	.707	.693	.721
Woden Valley & Weston Creek	<0.001	.718	.694	.742
Majura, Kowen & Jerrabomberra	.353	1.041	.956	1.133
Belconnen	<0.001	.758	.739	.779
Tuggeranong	<0.001	.720	.699	.741
Rural Southern & Western	<0.001	.737	.674	.807
All Districts - By Year				
1999 Oct to 2000 Sept	<0.001	.909	.885	.934
2000 Oct to 2001 Sept	<0.001	.952	.926	.978
2001 Oct to 2002 Sept	<0.001	.936	.911	.962
2002 Oct to 2003 Sept	<0.001	.893	.869	.918
2003 Oct to 2004 Sept	<0.001	.811	.788	.834
2004 Oct to 2005 Sept	<0.001	.747	.725	.770
2005 Oct to 2006 Sept	<0.001	.789	.766	.813
2006 Oct to 2007 Sept	<0.001	.872	.848	.897
2007 Oct to 2008 Sept	<0.001	.785	.763	.807
2008 Oct to 2009 Sept	<0.001	.747	.726	.768
2009 Oct to 2010 Sept	<0.001	.678	.658	.698
2010 Oct to 2011 Sept	<0.001	.797	.775	.819
2011 Oct to 2012 Sept	<0.001	.705	.686	.725
2012 Oct to 2013 Sept	<0.001	.712	.692	.733
2013 Oct to 2014 Sept	<0.001	.676	.656	.695
2014 Oct to 2015 Sept	<0.001	.666	.647	.685
2015 Oct to 2016 Sept	<0.001	.674	.655	.694
2016 Oct to 2017 Sept	<0.001	.646	.628	.665
2017 Oct to 2018 Jan	<0.001	.492	.466	.520

Figure 24 plots the annual non-injury crash effects associated with the ACT mobile speed camera program for the ACT as a whole with 95% confidence limits. It also shows the line of no estimated effect in red and the average crash effect across the whole post implementation period in grey along with its 95% confidence limits. Figure 24 shows clearly that the crash effects associated with the ACT mobile speed camera program over time have not been constant varying about the average effect with estimated reductions of between 4.8% and 50.8%. Table 16 shows variation between ACT districts in the estimated non-injury crash effects associated with the ACT mobile camera program for those districts that have been considered. Estimated effects varied from no statistically significant average reduction in Majura, Kowen & Jerrabomberra to a 29.3% average reduction in non-injury crashes in Canberra Central. Non-injury crash effects by district over time are also shown in Figure 25 in the same format as the overall analysis in Figure 24. Figure 25 further confirms the difference in average non-injury crash effects by district; it also shows that the patterns in effects over time vary by district. Section 5.2.3 of this report explores the relationship between the variance in estimated crash effects, both between district and over time, and the variance in the delivery of speed camera enforcement between district and over time.

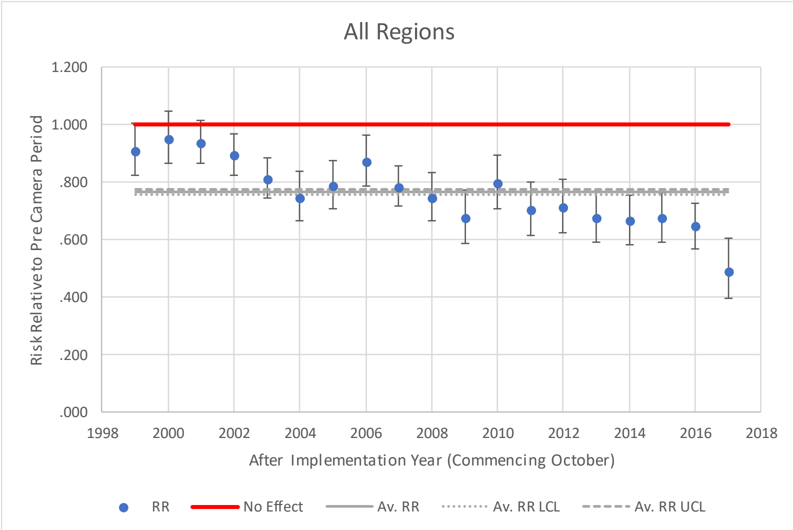
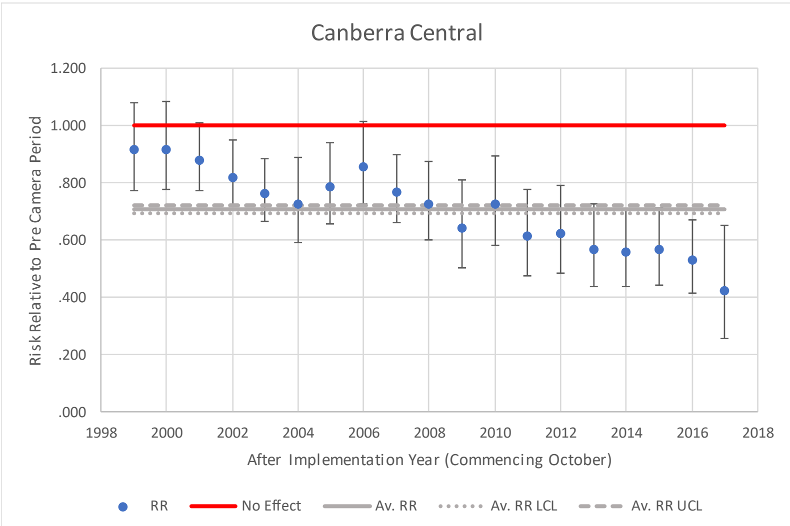
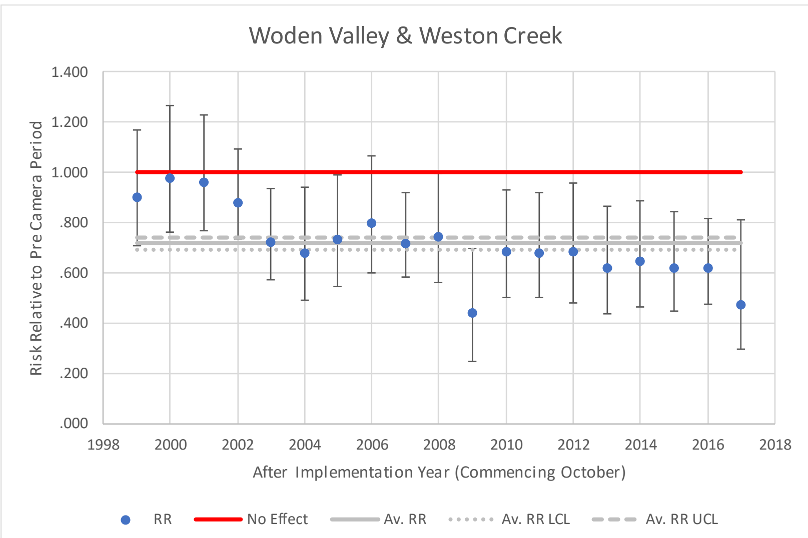
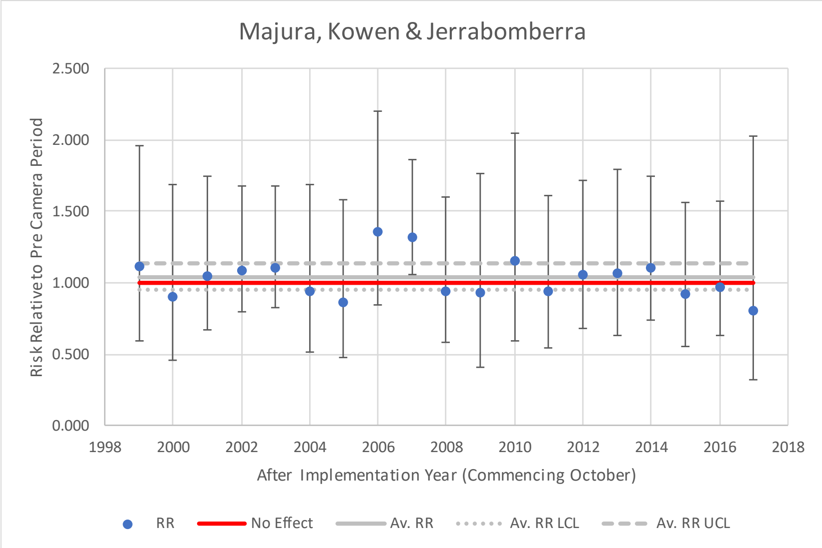
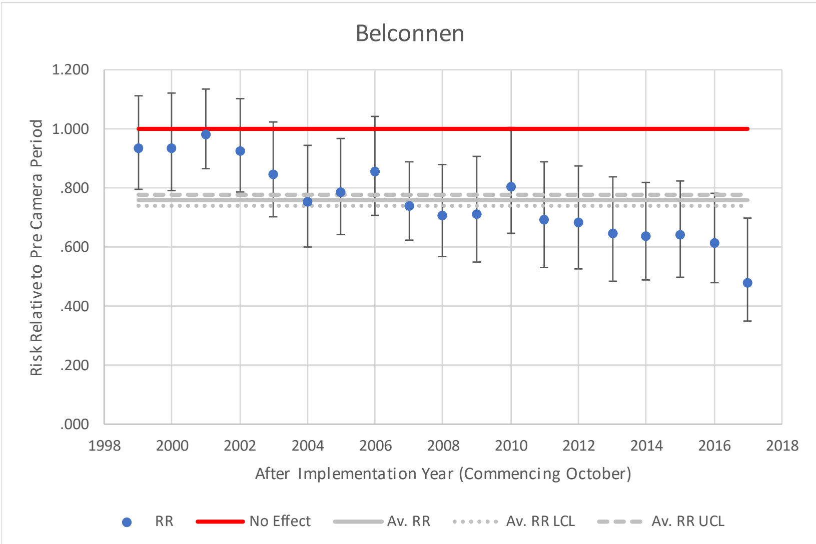


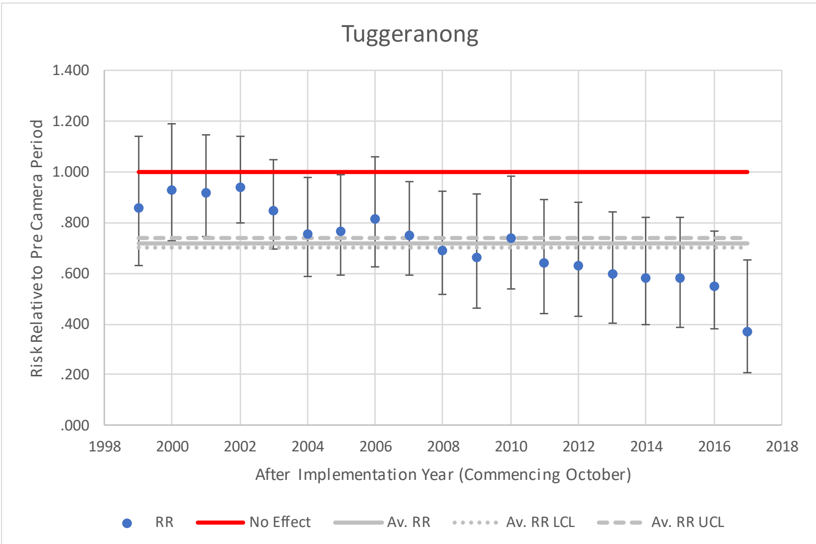
Figure 24 Relative risk of non-injury crashes within 500m of an ACT mobile speed camera site on average over all years and in each individual year after program implementation compared to before program implementation






Majura, Kowen & Jerrabomberra
Risk Relative to Pre Camera Period
2.500
2.000
1.500
1.000
0.500
0.000
1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018
After Implementation Year (Commencing October)
RR
No Effect
Av. RR
Av. RR LCL
Av. RR UCL


Belconnen
Risk Relative to Pre Camera Period
1.200
1.000
.800
.600
.400
.200
.000
1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018
After Implementation Year (Commencing October)
RR
No Effect
Av. RR
Av. RR LCL
Av. RR UCL


Tuggeranong
Risk Relative to Pre Camera Period
1.400
1.200
1.000
.800
.600
.400
.200
.000
1998 2000 2002 2004 2006 2008 2010 2012 2014 2016 2018
After Implementation Year (Commencing October)
RR
No Effect
Av. RR
Av. RR LCL
Av. RR UCL

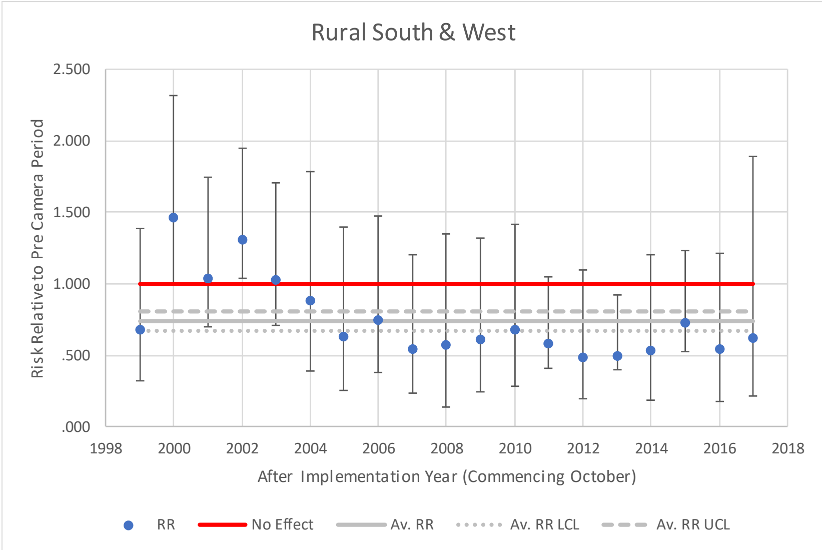


Figure 25 Relative risk of non-injury crashes within 500m of an ACT mobile speed camera site on average over all years and in each individual year after program implementation compared to before program implementation with each ACT region

Table 17 gives analysis results analogous to Table 16 but for casualty crashes instead of non-injury crashes. Presentation and interpretation of the information in Table 17 is the same as for Table 16. Results in Table 17 show that the ACT mobile speed camera program has been associated with an average 19.7% reduction in casualty crashes in areas within 500m of a mobile speed camera site since program implementation. Like the non-injury crash analysis, the analysis results for casualty crashes in Table 17 also show significant variation in associated crash effects between district and over time. Estimated average crash reductions varied from no statistically significant effects in Majura, Kowen & Jerrabomberra to a 32.9% reduction in Rural Southern and Western. Figure 26 plots the estimated crash effects for the ACT as a whole by year after program implementation. Like the non-injury crash analysis, it shows significant variation program effectiveness over time. Up to September 2009, the program was associated with significant casualty crash reductions of between 20% and 40%. From October 2009 to September 2016, estimated crash effects were small and not statistically significant. Over the last full year period studied, a statistically significant 22% crash reduction was estimated. The crash effect estimated from October 2017 is even greater but is based only on 4 months of data.

Figure 27 shows the annual estimated casualty effects associated with the mobile speed camera program by ACT district along with the average effects across the whole post implementation period. Like the non-injury crash analysis, the patterns in annual effects by district vary greatly between districts. Again, variation in crash effects over time and between districts has been capitalised upon to identify the relationship between the level of mobile speed camera enforcement and measured crash effects in Section 5.2.3.

Table -17 Relative crash risks for casualty crashes associated with the ACT mobile speed camera program overall, by district and by year after program implementation

Year or District	Statistical Significance.	Relative Risk	95% Confidence Interval for RR	
			Lower	Upper
All Districts – Average All Years				
All Districts	<0.001	.803	*.766*	*.841*
By District – Average All Years				
Canberra Central	<0.001	.773	*.715*	*.835*
Woden Valley & Weston Creek	<0.001	.703	*.620*	*.796*
Gungahlin & Hall	<0.001	2.691	*2.002*	*3.617*
Majura, Kowen & Jerrabomberra	.715	.953	*.738*	*1.232*
Belconnen	<0.001	.728	*.662*	*.800*
Tuggeranong	.001	.825	*.738*	*.923*
Rural Southern & Western	.005	.661	*.494*	*.883*
All Districts - By Year				
1999 Oct to 2000 Sept	.006	.863	*.777*	*.959*
2000 Oct to 2001 Sept	.002	.841	*.754*	*.937*
2001 Oct to 2002 Sept	<0.001	.602	*.531*	*.682*
2002 Oct to 2003 Sept	<0.001	.555	*.488*	*.631*
2003 Oct to 2004 Sept	<0.001	.556	*.489*	*.631*
2004 Oct to 2005 Sept	<0.001	.773	*.691*	*.865*
2005 Oct to 2006 Sept	<0.001	.720	*.640*	*.809*
2006 Oct to 2007 Sept	<0.001	.822	*.738*	*.915*
2007 Oct to 2008 Sept	<0.001	.574	*.508*	*.649*
2008 Oct to 2009 Sept	<0.001	.761	*.684*	*.848*
2009 Oct to 2010 Sept	.404	.960	*.871*	*1.057*
2010 Oct to 2011 Sept	.808	.988	*.898*	*1.087*
2011 Oct to 2012 Sept	.831	.990	*.902*	*1.086*
2012 Oct to 2013 Sept	.862	.992	*.903*	*1.090*
2013 Oct to 2014 Sept	.130	.929	*.844*	*1.022*
2014 Oct to 2015 Sept	.005	.870	*.789*	*.960*
2015 Oct to 2016 Sept	.003	.860	*.779*	*.949*
2016 Oct to 2017 Sept	<0.001	.781	*.706*	*.865*
2017 Oct to 2018 Jan	<0.001	.511	*.418*	*.626*

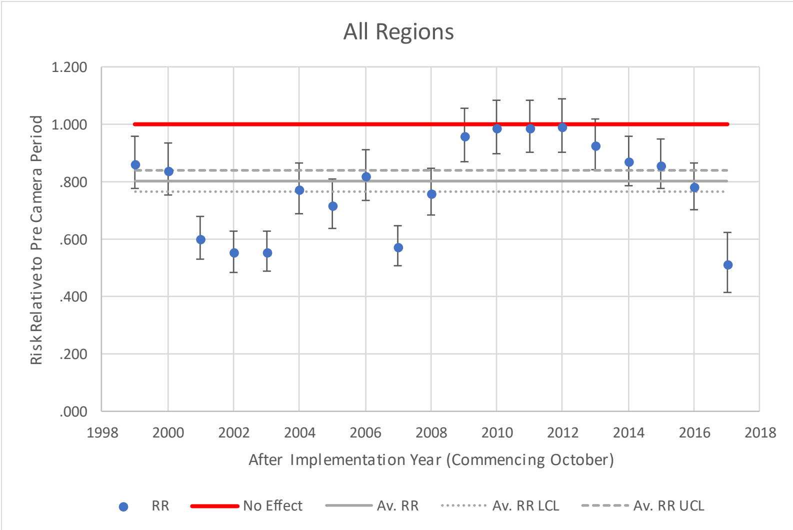
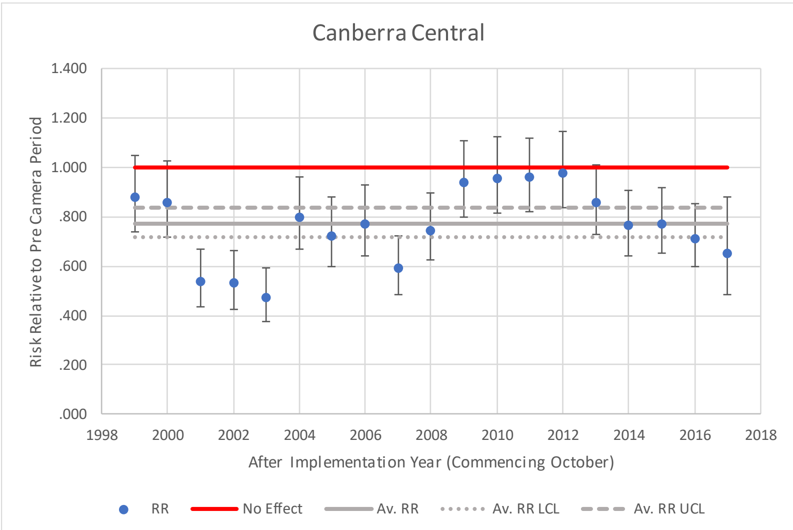
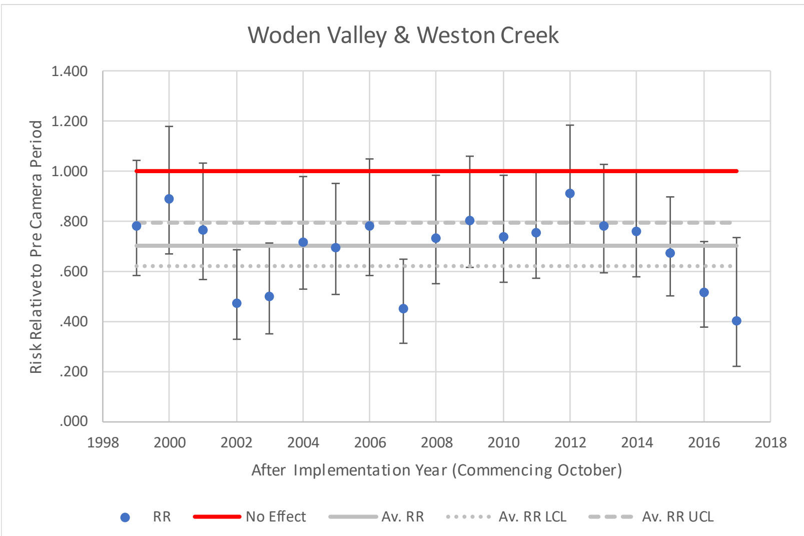
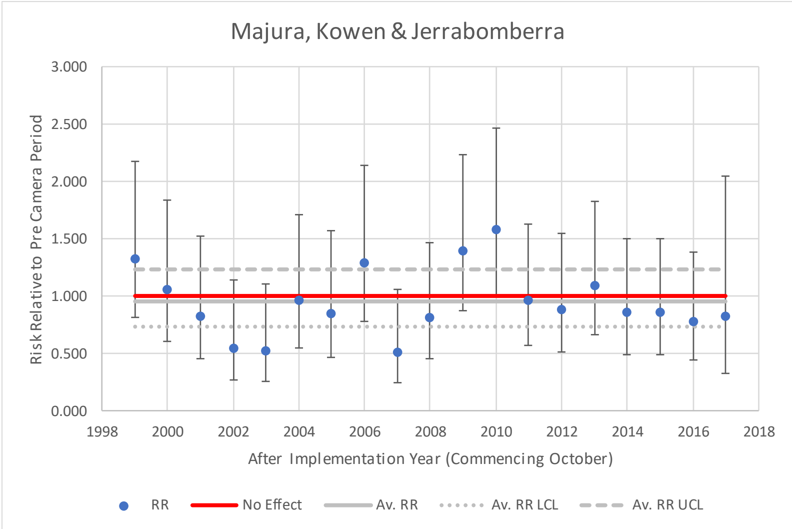
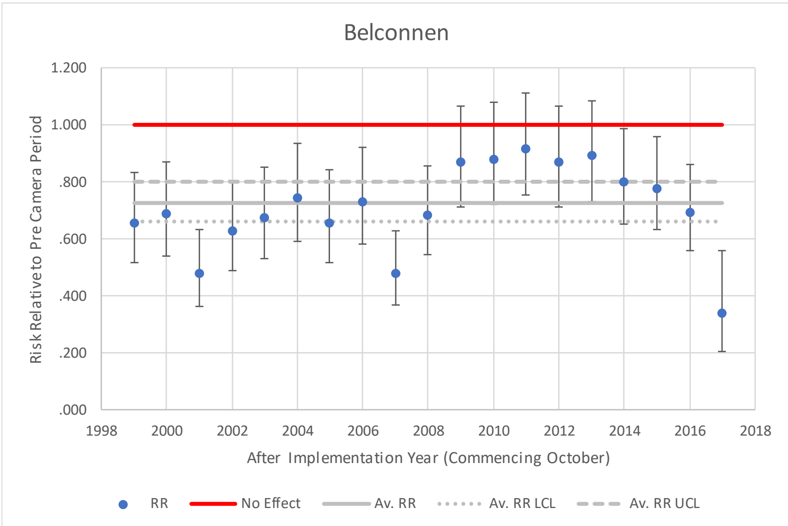


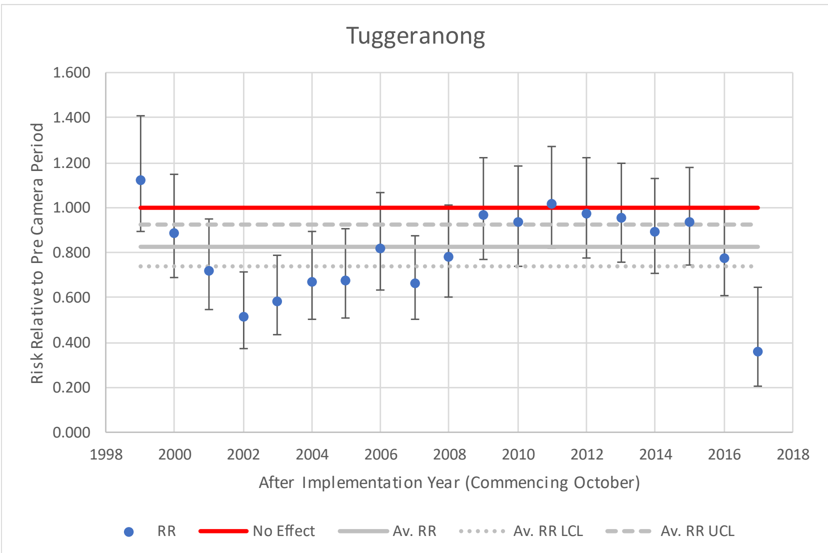
Figure 26 Relative risk of casualty crashes within 500m of an ACT mobile speed camera site on average over all years and in each individual year after program implementation compared to before program implementation






Majura, Kowen & Jerrabomberra
Risk Relative to Pre Camera Period
After Implementation Year (Commencing October)
RR
No Effect
Av. RR
Av. RR LCL
Av. RR UCL


Belconnen
Risk Relative to Pre Camera Period
After Implementation Year (Commencing October)
RR
No Effect
Av. RR
Av. RR LCL
Av. RR UCL


Tuggeranong
Risk Relative to Pre Camera Period
After Implementation Year (Commencing October)
RR
No Effect
Av. RR
Av. RR LCL
Av. RR UCL

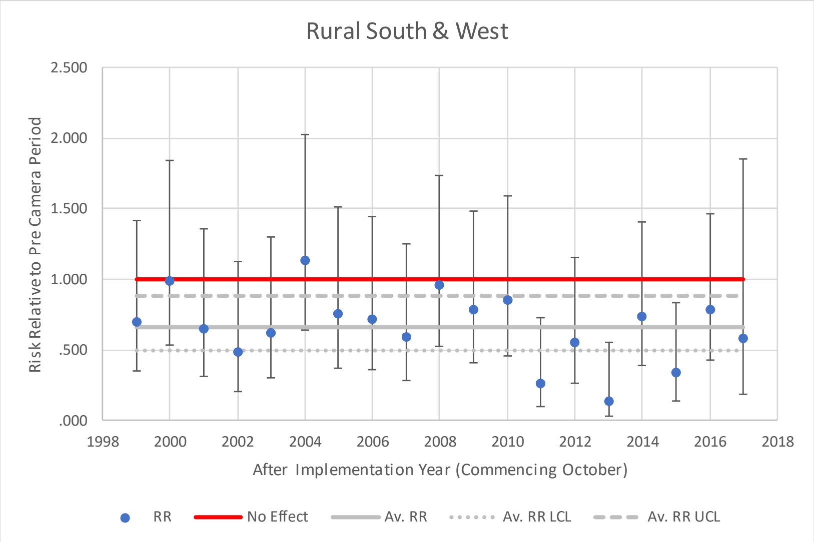


Figure 27 Relative risk of casualty crashes within 500m of an ACT mobile speed camera site on average over all years and in each individual year after program implementation compared to before program implementation by ACT Region

5.2.2 Absolute crash savings and economic worth

Estimates of percentage crash savings associated with the ACT mobile speed camera program were translated into estimated absolute crash savings using the crash population covered by the program along with the estimated relative crash risks associated with the program in each year after program implementation. Analysis was conducted at the territory wide level using the relative risk estimates for non-injury crashes and casualty crashes given in Tables 16 and 17 respectively. The observed crash numbers each year were divided by the relative risk estimates in the corresponding year to derive the expected crash population had the camera program not been in operation. The difference between observed and expected crash counts was the estimated crash saving attributable to the mobile camera program.

Table 18 gives the observed annual crash counts in the ACT within 500m of a mobile speed camera site used up to the end of January 2018. Crash counts are tabulated by crash severity with casualty (fatal + injury) and all reported crash (casualty + non-injury) counts also reported. Table 19 shows the estimated crash savings associated with the mobile speed camera program derived through combining the data in Table 18 with the relative risk estimates in Tables 16 and 17. Since relative risk estimates are only available for non-injury and casualty crashes, crash savings estimates presented in Table 19 are limited to these two crash severity groupings. Based on the 95% confidence limits on the relative risk estimates, 95% confidence limits have also been assigned to the estimated absolute crash savings in Table 19.

Table -18 Observed annual crashes within 500m of a mobile speed camera site in the ACT by crash severity

Year	Observed Crashes				
	All Reported	Non-injury	Injury	Casualty	Fatal
1999 Oct to 2000 Sept	6718	6307	400	411	11
2000 Oct to 2001 Sept	6610	6232	366	378	12
2001 Oct to 2002 Sept	6526	6250	272	276	4
2002 Oct to 2003 Sept	6235	5980	249	255	6
2003 Oct to 2004 Sept	5898	5633	259	265	6
2004 Oct to 2005 Sept	5336	4982	336	354	18
2005 Oct to 2006 Sept	5431	5111	308	320	12
2006 Oct to 2007 Sept	6305	5922	372	383	11
2007 Oct to 2008 Sept	5977	5691	270	286	16
2008 Oct to 2009 Sept	5885	5500	379	385	6
2009 Oct to 2010 Sept	5656	5155	487	501	14
2010 Oct to 2011 Sept	6564	6049	512	515	3
2011 Oct to 2012 Sept	6290	5737	547	553	6
2012 Oct to 2013 Sept	6098	5566	526	532	6
2013 Oct to 2014 Sept	5892	5384	502	508	6
2014 Oct to 2015 Sept	5830	5350	471	480	9
2015 Oct to 2016 Sept	5903	5428	469	475	6
2016 Oct to 2017 Sept	5781	5338	439	443	4
2017 Oct to 2018 Jan	1472	1374	98	98	0

Table -19 Estimated crash savings associated with the ACT mobile speed camera program by crash severity

Year	Non-Injury	Upper 95% CL	Lower 95% CL	Casualty	Upper 95% CL	Lower 95% CL
1999 Oct to 2000 Sept	629	*817*	*445*	65	*118*	*18*
2000 Oct to 2001 Sept	317	*496*	*142*	72	*123*	*25*
2001 Oct to 2002 Sept	428	*610*	*250*	182	*243*	*129*
2002 Oct to 2003 Sept	715	*901*	*534*	205	*268*	*149*
2003 Oct to 2004 Sept	1315	*1514*	*1122*	212	*277*	*155*
2004 Oct to 2005 Sept	1687	*1888*	*1492*	104	*158*	*55*
2005 Oct to 2006 Sept	1365	*1558*	*1177*	125	*180*	*76*
2006 Oct to 2007 Sept	867	*1057*	*683*	83	*136*	*35*
2007 Oct to 2008 Sept	1563	*1769*	*1362*	212	*277*	*154*
2008 Oct to 2009 Sept	1865	*2078*	*1659*	121	*178*	*69*
2009 Oct to 2010 Sept	2449	*2675*	*2229*	21	*74*	*-27*
2010 Oct to 2011 Sept	1542	*1752*	*1337*	6	*58*	*-41*
2011 Oct to 2012 Sept	2400	*2630*	*2175*	6	*60*	*-44*
2012 Oct to 2013 Sept	2248	*2473*	*2030*	4	*57*	*-44*
2013 Oct to 2014 Sept	2585	*2817*	*2359*	39	*94*	*-11*
2014 Oct to 2015 Sept	2688	*2923*	*2459*	72	*129*	*20*
2015 Oct to 2016 Sept	2621	*2854*	*2393*	78	*135*	*26*
2016 Oct to 2017 Sept	2923	*3165*	*2688*	124	*185*	*69*
2017 Oct to 2018 Jan	1417	*1572*	*1270*	94	*137*	*59*

Using the estimates of average community costs of road crashes derived by BITRE and reported in Section 3.4, the crash savings estimates given in Table 19 have been converted into community cost savings estimates. The resulting estimates are shown in Table 20. Based on the 95% confidence limits for the non-injury and casualty crash savings in Table 19, 95% confidence limits on the overall crash cost savings have also been assigned in Table 20. Results in Table 20 show that in the most recent complete year of data after implementation of the mobile speed camera program in the ACT (October 2016 to September 2017) crash savings associated with the program had an estimated social cost value of $61.5M. Over the lifetime of the program, annual social cost savings have varied from around $17M in the early year of the program to the $61M estimate for the most recent full year.

Table-20 Estimated community crash cost savings associated with the ACT mobile speed camera program by year after program implementation

Year	Non-Injury	Casualty	Total	Upper 95% CL	Lower 95% CL
1999 Oct to 2000 Sept	$8,489,120	$11,567,3298	$20,056,449	*$31,949,350*	*$9,160,772*
2000 Oct to 2001 Sept	$4,279,031	$12,712,622	$16,991,653	*$28,573,337*	*$6,417,502*
2001 Oct to 2002 Sept	$5,776,929	$32,397,261	$38,174,190	*$51,453,209*	*$26,228,826*
2002 Oct to 2003 Sept	$9,655,411	$36,335,962	$45,991,373	*$59,770,179*	*$33,645,969*
2003 Oct to 2004 Sept	$17,765,589	$37,650,993	$55,416,581	*$69,572,173*	*$42,704,100*
2004 Oct to 2005 Sept	$22,785,203	$18,441,342	$41,226,545	*$53,557,447*	*$29,991,750*
2005 Oct to 2006 Sept	$18,431,576	$22,121,617	$40,553,193	*$52,943,376*	*$29,316,857*
2006 Oct to 2007 Sept	$11,715,425	$14,758,386	$26,473,811	*$38,480,284*	*$15,503,850*
2007 Oct to 2008 Sept	$21,102,637	$37,641,297	$58,743,934	*$73,081,674*	*$45,817,620*
2008 Oct to 2009 Sept	$25,190,948	$21,423,052	$46,614,001	*$59,705,407*	*$34,647,278*
2009 Oct to 2010 Sept	$33,071,001	$3,731,377	$36,802,379	*$49,241,957*	*$25,314,173*
2010 Oct to 2011 Sept	$20,823,432	$1,088,114	$21,911,546	*$34,014,258*	*$10,727,985*
2011 Oct to 2012 Sept	$32,407,175	$993,237	$33,400,412	*$46,146,724*	*$21,592,208*
2012 Oct to 2013 Sept	$30,364,060	$793,386	$31,157,446	*$43,592,101*	*$19,652,071*
2013 Oct to 2014 Sept	$34,911,156	$6,941,199	$41,852,355	*$54,770,224*	*$29,917,868*
2014 Oct to 2015 Sept	$36,298,852	$12,751,594	$49,050,446	*$62,333,946*	*$36,802,596*
2015 Oct to 2016 Sept	$35,390,545	$13,770,454	$49,160,999	*$62,488,508*	*$36,877,682*
2016 Oct to 2017 Sept	$39,478,625	$22,046,120	$61,524,745	*$75,553,199*	*$48,628,344*
2017 Oct to 2018 Jan	$19,136,520	$16,622,472	$35,758,992	*$45,467,337*	*$27,554,505*

5.2.3 Association between camera outputs and estimated crash savings

The final stage of analysis for the mobile speed camera program undertaken was to relate variations in the level of speed camera operational output over time and by district to the estimated crash reductions associated with the ACT mobile speed camera program in the corresponding strata. This analysis had two purposes. First, relating measures of road safety program outputs to outcomes provides stronger evidence of the causal effect of the program than demonstrated through simply establishing an association between program implementation and outcomes for the mobile speed camera program in the previous section. Second, establishing an association between mobile camera operational outputs and estimated crash effects provides the basis for consideration of the mobile speed camera program in the strategic analysis presented in Section 6.

A number of potential measures of output from the ACT mobile speed camera program could be derived from the data provided by the ACT Government including the number of camera sessions undertaken, the number of hours of camera enforcement undertaken and the number of infringements issued from detection of speeding motorists. Each of these could be summarized per time period and by district. Each of these measures is plotted by year of operation for the ACT as a whole in Figure 28 for the available operations data from January 2010 onwards. Data have been summarized in years post camera program implementation to match the analysis years used in the crash analysis above. The first year presented in the figure has been annualized based on the 9 months of data available. Number of infringements issued from the cameras was not considered to be a pure measure of operational output since it will reflect both the time of use of the camera as well as the speed compliance of the passing vehicles. For this reason this measure was not considered in the analysis. As evident from Figure 28, there was a high degree of correlation between the number of mobile camera sessions delivered and the hours of camera deployment meaning it was not possible to consider both in the analysis. Because the hours of operation was able to accommodate potential historical and future changes in session time lengths, it was decided to use this as the primary measure of program output. Figure 29 plots the annual hours of mobile speed camera operation by ACT district over the available data period. It shows general decline in the number of hours of mobile speed camera enforcement delivered over the period January 2010 to September 2013 after which there has been strong growth in enforcement hours in all regions, albeit with some variation in the pattern and level of growth between regions.

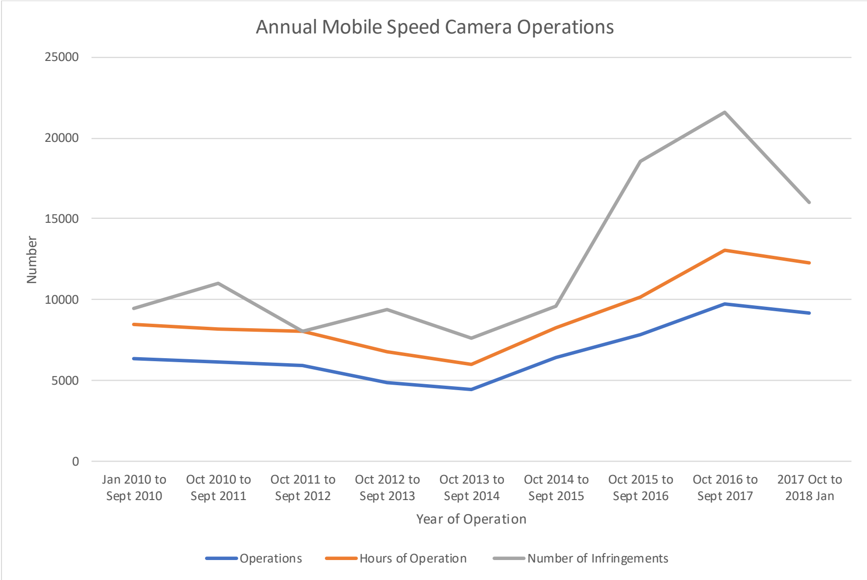


Figure 28 Annual number of operations, hours of operation and number of infringements issued from the mobile speed camera program in the ACT

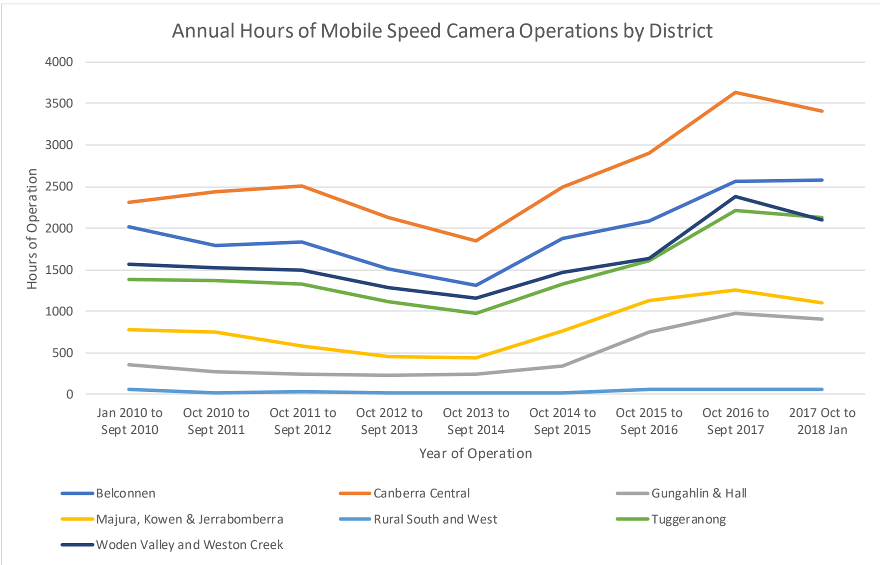


Figure 29 Annual hours of operation of the mobile speed camera program in the ACT by region

Using the methods outlined in Section 4.1.4, a regression equation was estimated relating the estimated relative risk of a crash associated with the ACT mobile speed camera program by district and year as a function of the hours of mobile speed camera operation in the corresponding year and district. Separate regression analyses were conducted for non-injury crashes and for casualty crashes. In order to ensure a robust analysis, only those districts from the ACT were included in the analysis where the estimated crash effects of the program were reasonably accurate as reflected by the confidence limit widths in Figures 25 and 27. The following districts were included in the analysis: Canberra Central, Belconnen, Tuggeranong, and Woden Valley and Weston Creek.

Results of the regression analysis showed a statistically significant relationship between the estimated relative crash risks associated with the mobile speed camera program by district and year and the corresponding hours of mobile speed camera enforcement for both non-injury crashes ($p<0.001$) and casualty crashes ($p=0.003$). The estimated relationship between increase in hours of annual mobile speed camera enforcement and the relative risk of crash involvement derived from the regression equations for non-injury and casualty crashes is shown in Figure 30. Figure 30 shows a slightly stronger association for non-injury crashes compared to casualty crashes although the curves are not different within the bounds of statistical confidence. Predicted crash reductions associated with increasing camera annual hours of camera operation per district can be taken straight from Figure 30. For example, an increase in camera hours of 1500 annually per district is estimated to result in a 40% reduction (relative risk of 0.6) in casualty crash frequency in areas within 500m of a mobile speed camera site. This increase would represent an average doubling of the current speed camera hours delivered annually in the ACT.

The relationships shown in Figure 20 have been used in the strategic analysis detailed in Section 6.

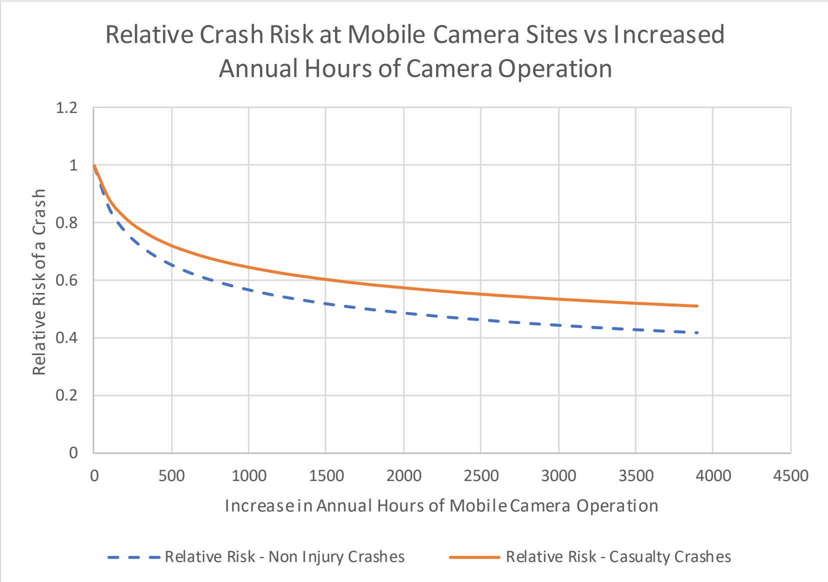


Figure 30 Relationship between increasing mobile speed camera annual hours of operation and change in relative crash risk associated with the ACT mobile speed camera program by crash severity

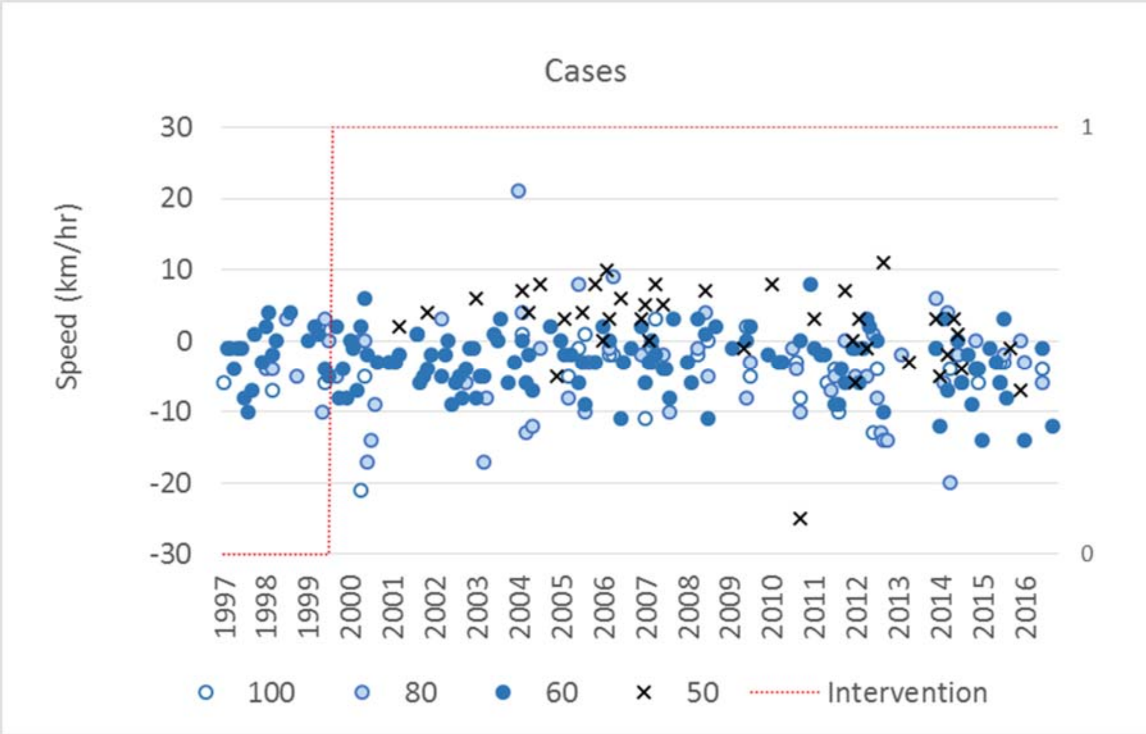
5.3 Speed Survey Analysis

The set of speed survey data chosen for analysis (according to the methodology outlined in section 4.1) were graphically presented in a similar manner to the previous ACT speed program analysis. Figure 31 presents the monthly differences in observed mean speeds from speed *limits* across all of the streets surveyed by speed zone and case/comparison status. Figure 32 presents the monthly differences in 85th percentile speeds from speed *limits* across all of the streets surveyed by speed zone and case/comparison status. Figure 33 and Figure 34 depict the same as Figure 31 and Figure 32 but the differences here is to the speed enforcement *threshold* rather than the speed *limit*. The current speed enforcement threshold 8km/h over the speed limit in speed zones 90km/hr or less, and 11km/hr over the speed limit in 100km/hr speed zones. The tolerance has been in place since the mobile camera program began in 1999.

The initial interrogation of the speed survey data found the following:

- 50 km/hr speed zones had the average speeds in excess of the speed limit by the greatest amount (Figure 31). However, there were no surveys in 50 km/hr speed zones amongst the 95 locations chosen for analysis available for the period prior to the ACT mobile speed camera program implementation, so their presence acts as a potential source of bias, potentially reducing the measured benefit of the mobile speed camera (MSC) program.
- The average excess speed (over the limit), for the entire observed period, was greater in the case streets than in the comparison streets (Figure 31).
- The 85th percentile speeds for the cases appear to be decreasing over time; more so than the mean speeds (Figure 32) and the means speeds of the cases appear to be decreasing over time more than the comparisons suggesting an impact of the mobile camera program in reducing speeds.
- Very few of the monthly average survey speeds were greater than threshold values (Figure 33). This was true for both cases and controls.
- Very few of the monthly average 85^{th} percentile comparison survey speeds were greater than threshold values (Figure 34).

Figure 31 has been repeated in Appendix Figure A6 with the addition of the quantity of single direction traffic surveys per month plotted on the secondary axis.



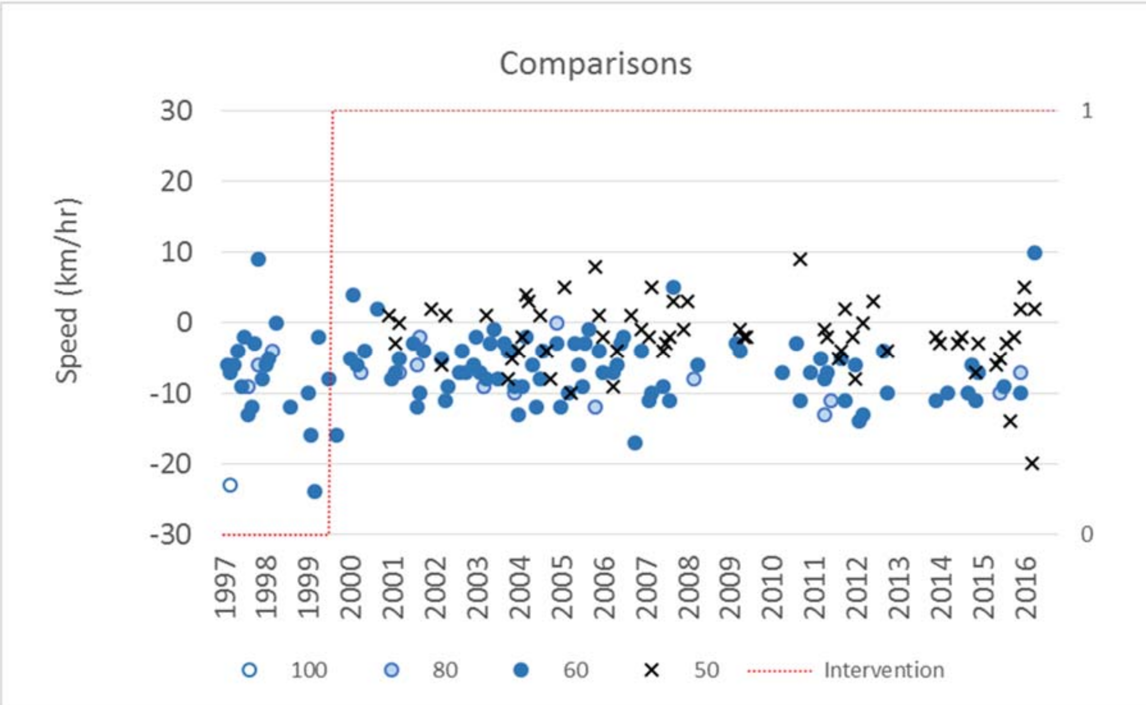
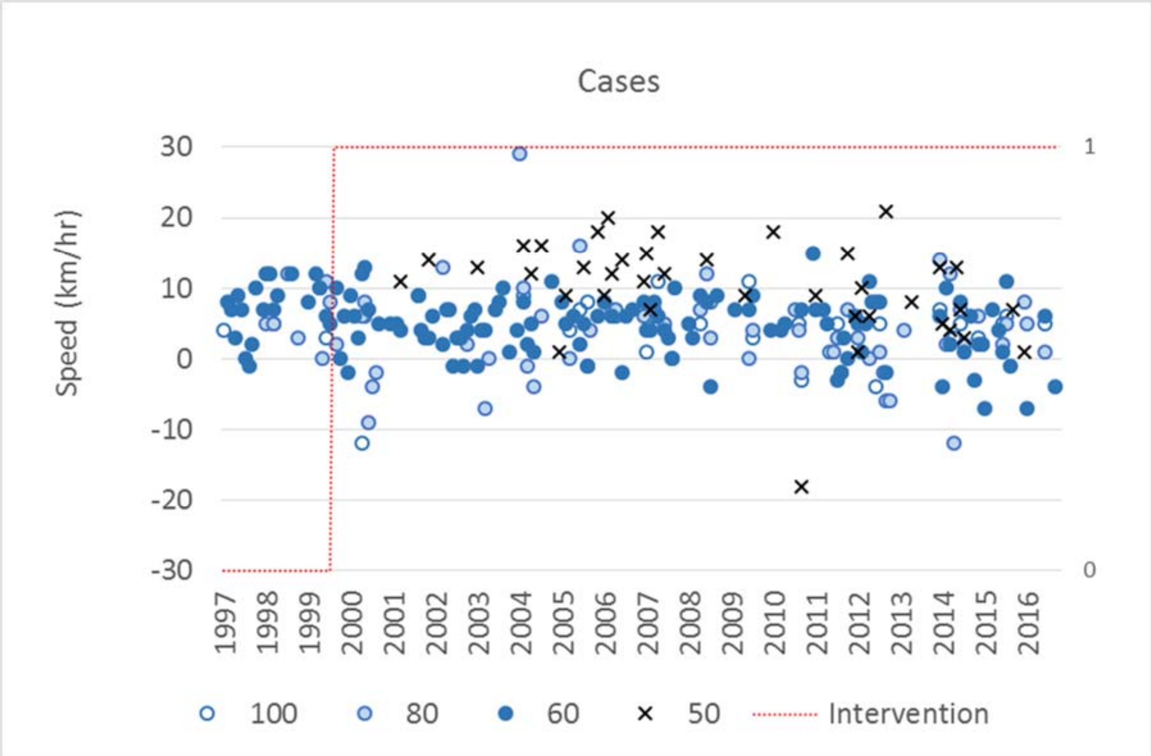


*Figure 31 a & b Mean difference between <u>mean speed</u> and **speed limit** for cases and comparisons by speed limit.*



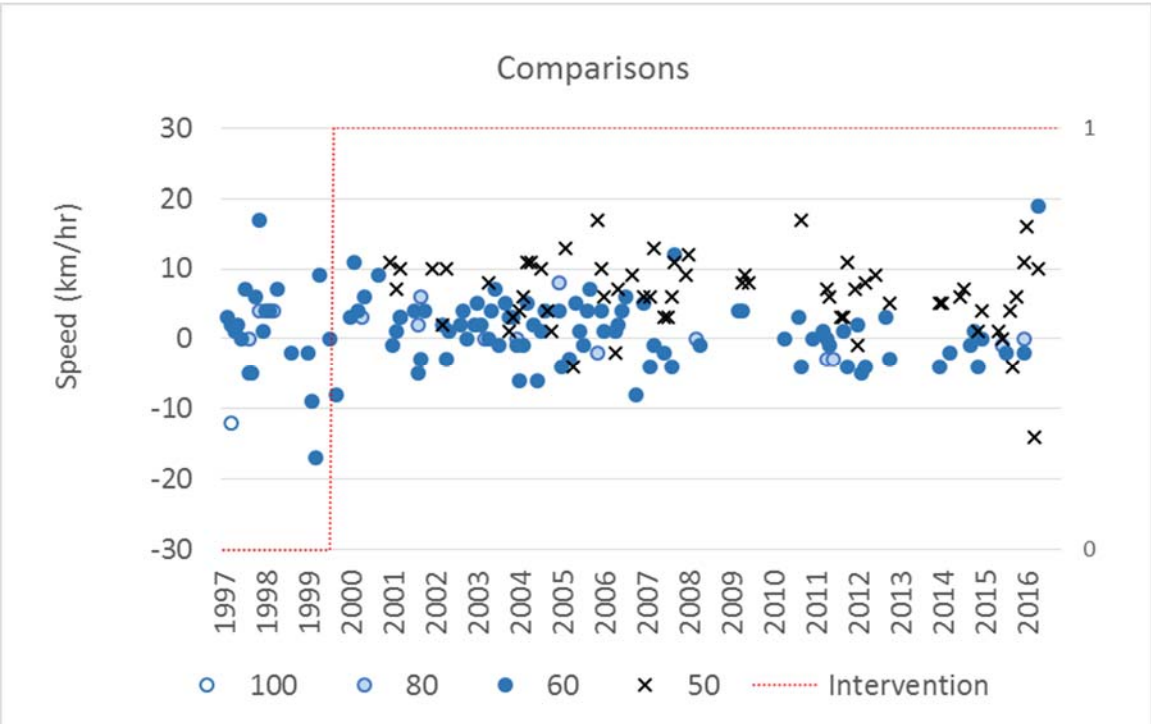
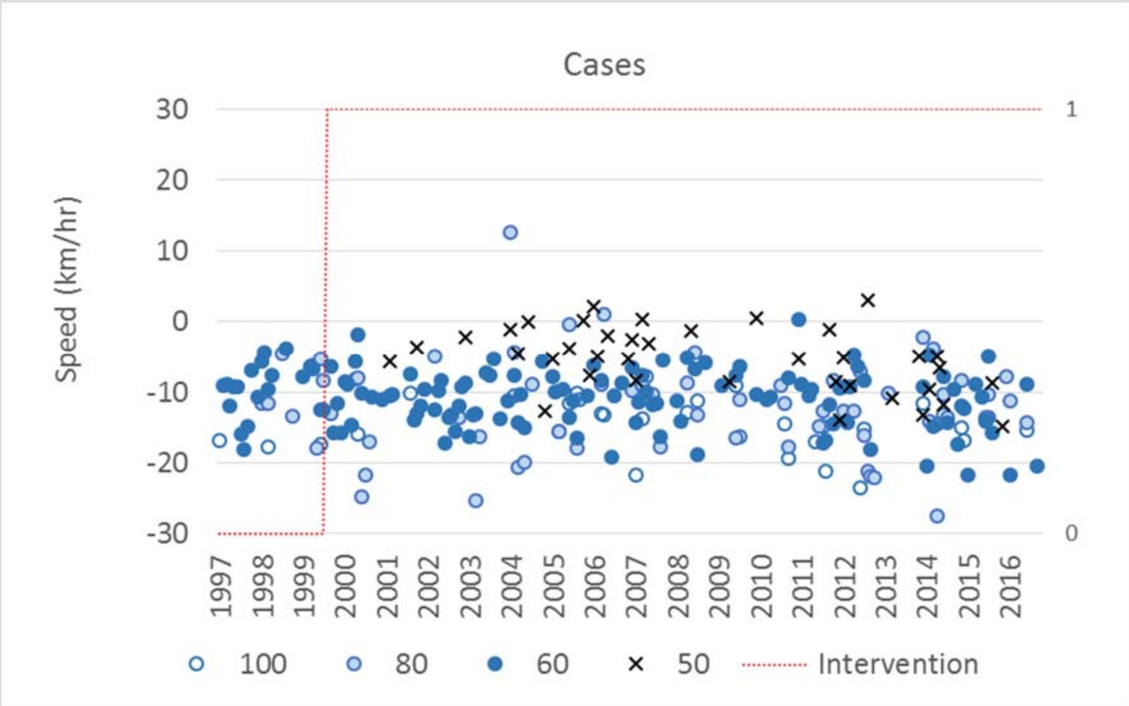


*Figure 32 a & b Mean difference between <u>mean 85th percentile speed</u> and **speed limit** for cases and comparisons by speed limit.*



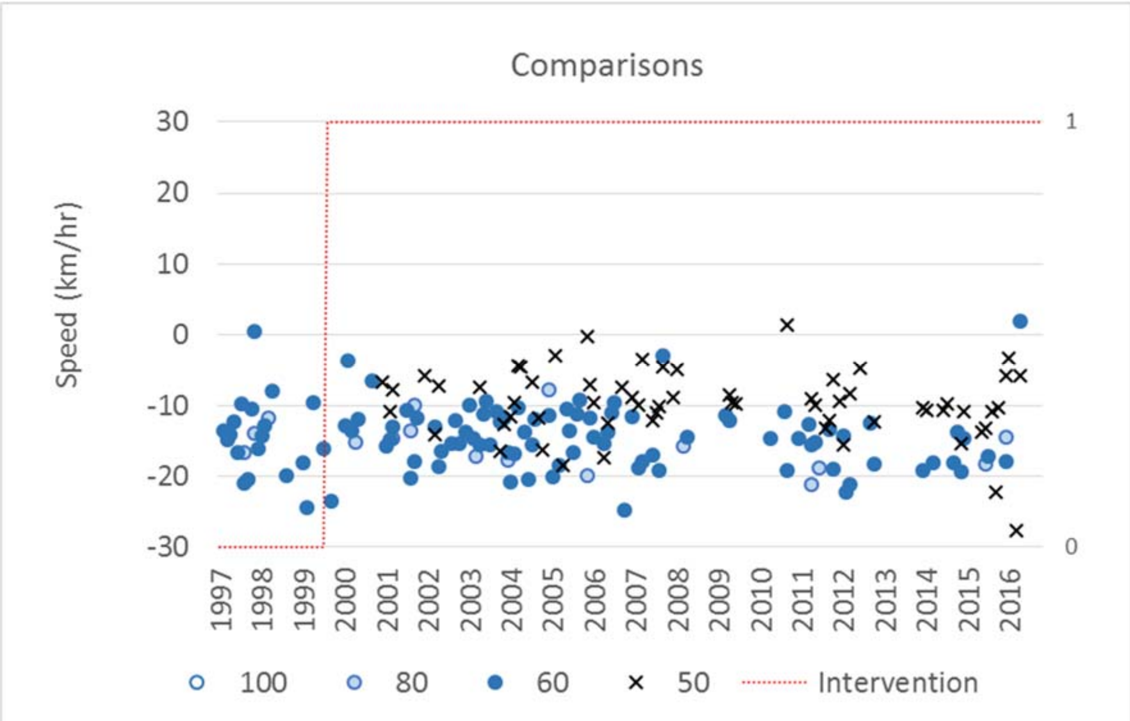
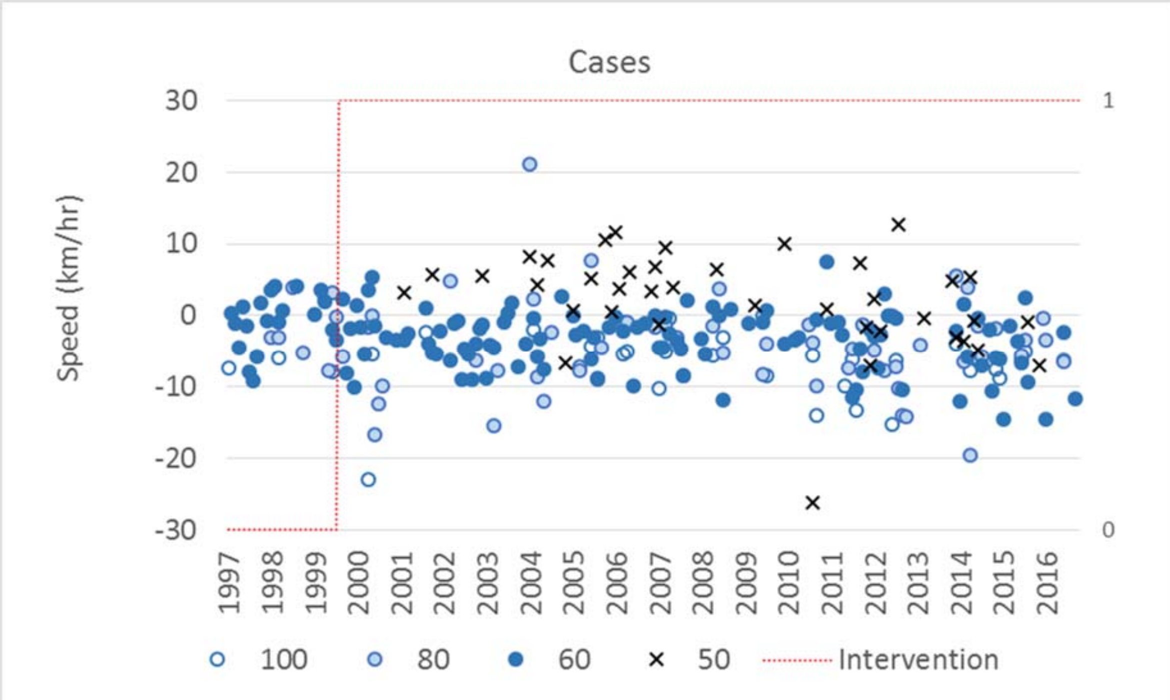


*Figure 33 a & b Mean difference between <u>mean speed</u> and **speed threshold** for cases and comparisons by speed limit.*



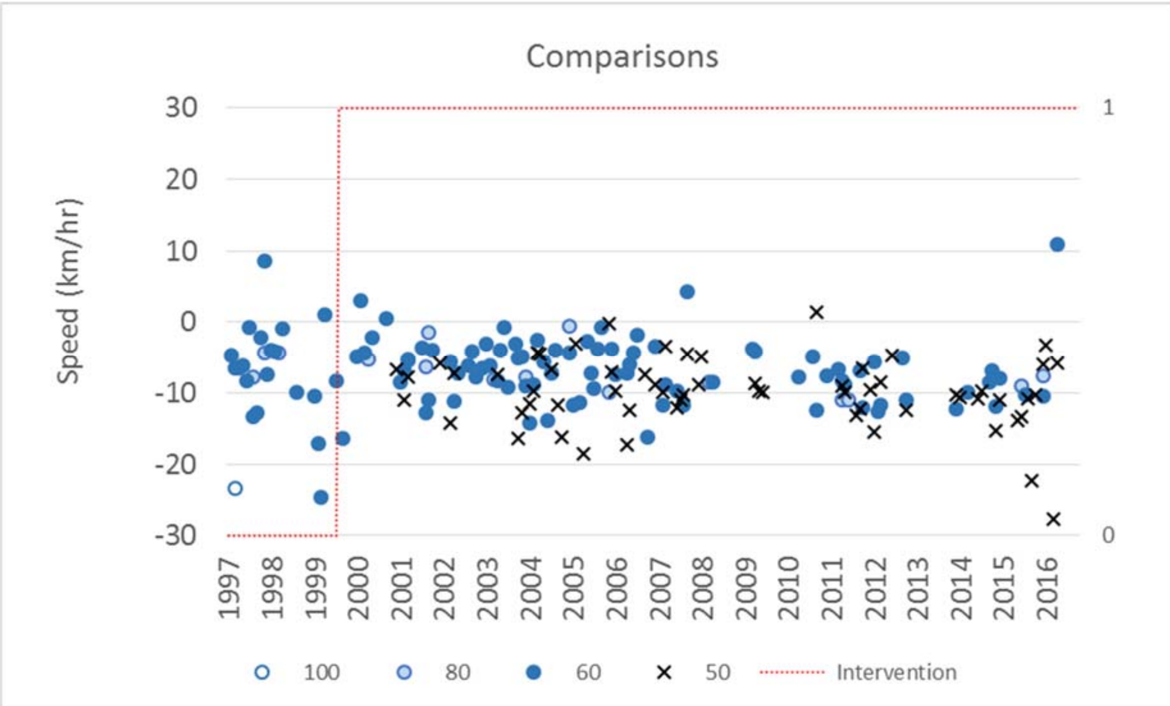


*Figure 34a & b Mean difference between <u>mean 85th percentile speed</u> and **speed threshold** for cases and comparisons by speed limit.*

Figure 35 and Figure 36 depict the results of the analysis of net speed changes at case (mobile speed camera) sites relative to control sites. Results are shown for both the mean and 85th percentile speed measures and for speeds relative to the speed limit and the enforcement threshold. In both figures estimates are provided by calendar year (orange circles), the linear trend in the annual estimates (orange dotted line) and averaged over all of the years post mobile speed camera program implementation (yellow dotted line). Estimates presented from the analysis are the speed changes estimated to be associated with the mobile speed camera program.

The average whole program effects (yellow dotted line) associated with the mobile speed program when referenced against the speed limit or against the speed thresholds were similar and can be summarised as:

- 4.6 (95% confidence interval: 2.2 to 7.0, p=0.0002) km/hr reduction in mean speed;
- 4.9 (95% confidence interval: 2.4 to 7.4, p=0.0001) km/hr reduction in mean 85th percentile speed.

The referencing to the speed limit or enforcement threshold made little difference to the net average change estimates.

In addition to the speed reduction associated with the mobile speed camera program, Figure 35 also presents the annual net mean speed differences (mean and 85th percentile) so that trends in the post-intervention speed impacts of the mobile speed camera program may be broadly observed. To examine this trend in more detail, a linear regression line of best fit (orange dotted line) for the mean and 85th percentile speed difference regression results from 2000 to 2015, shows a slight trend to a decreasing net impact of the mobile speed camera program on mean and 85th percentile speeds over the years 2000 to 2015. The regression line shows that the mobile camera effect on net mean speed at camera sites was declining at a rate of 0.08 km/hr per year and 0.05km/hr per year for 85th percentile speeds (again regardless of whether the speed limit or enforcement threshold speed was used as the reference). Unfortunately, speed survey data for the years 2016 to 2018 where significant reductions in relative crash risk at mobile camera sites was estimated in the previous section were not available for analysis in this study.

Annual speed reduction estimates associated with the mobile speed camera are tabled in Appendix A.7, as are Figure 54 and Figure 55, which depict the annual regression results by broad speed, zone over the years of the mobile speed camera program. Effects by speed zone were not significantly different from the whole program effects.

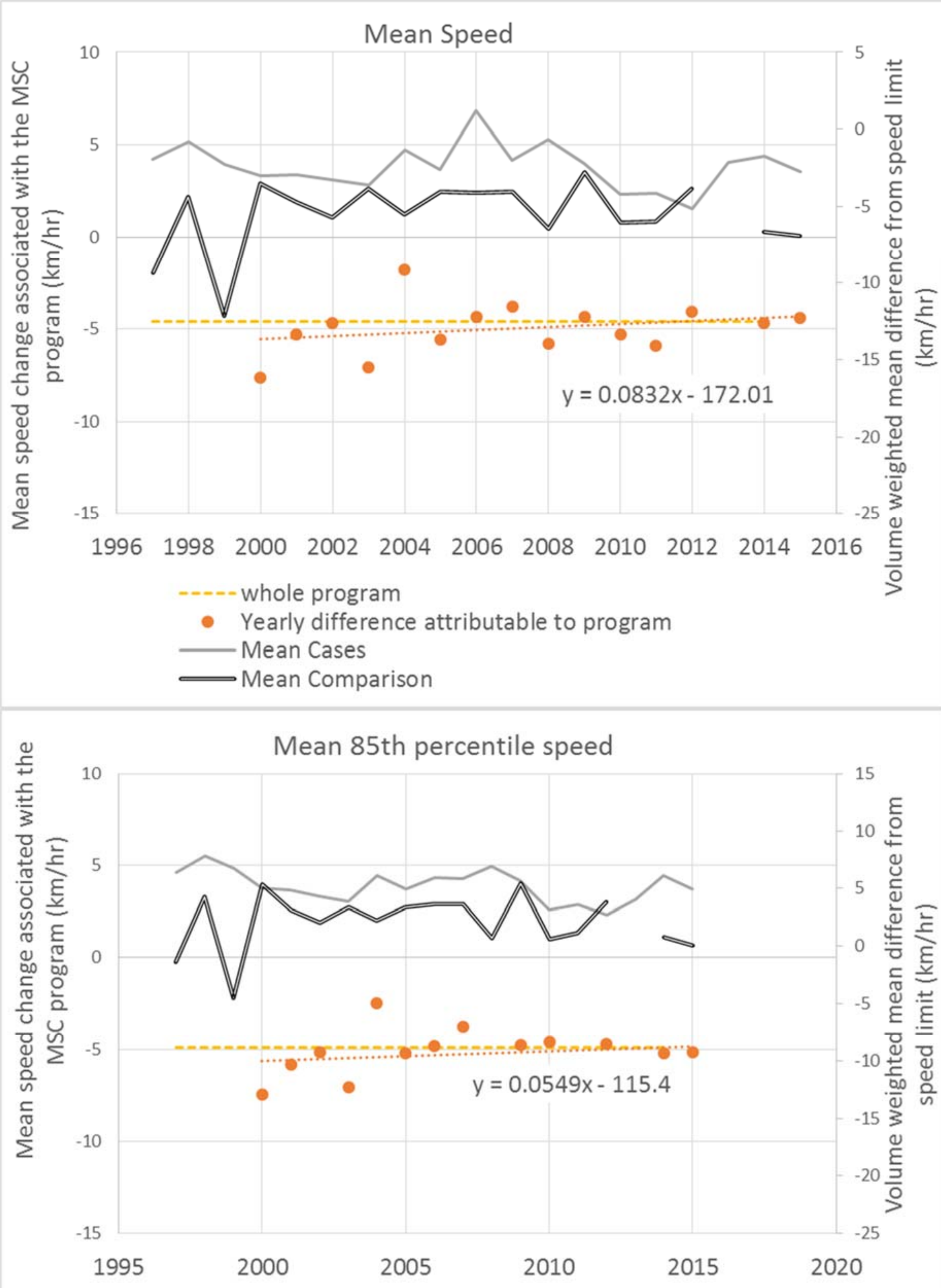


*Figure 35 a & b Mean annual difference from the speed limit (solid lines), and Mean speed change (**referenced to speed limit**) associated with the MSC program for each calendar year (circles) and for all years (whole program, dashed line), for mean speed and for mean 85th percentile speed.*

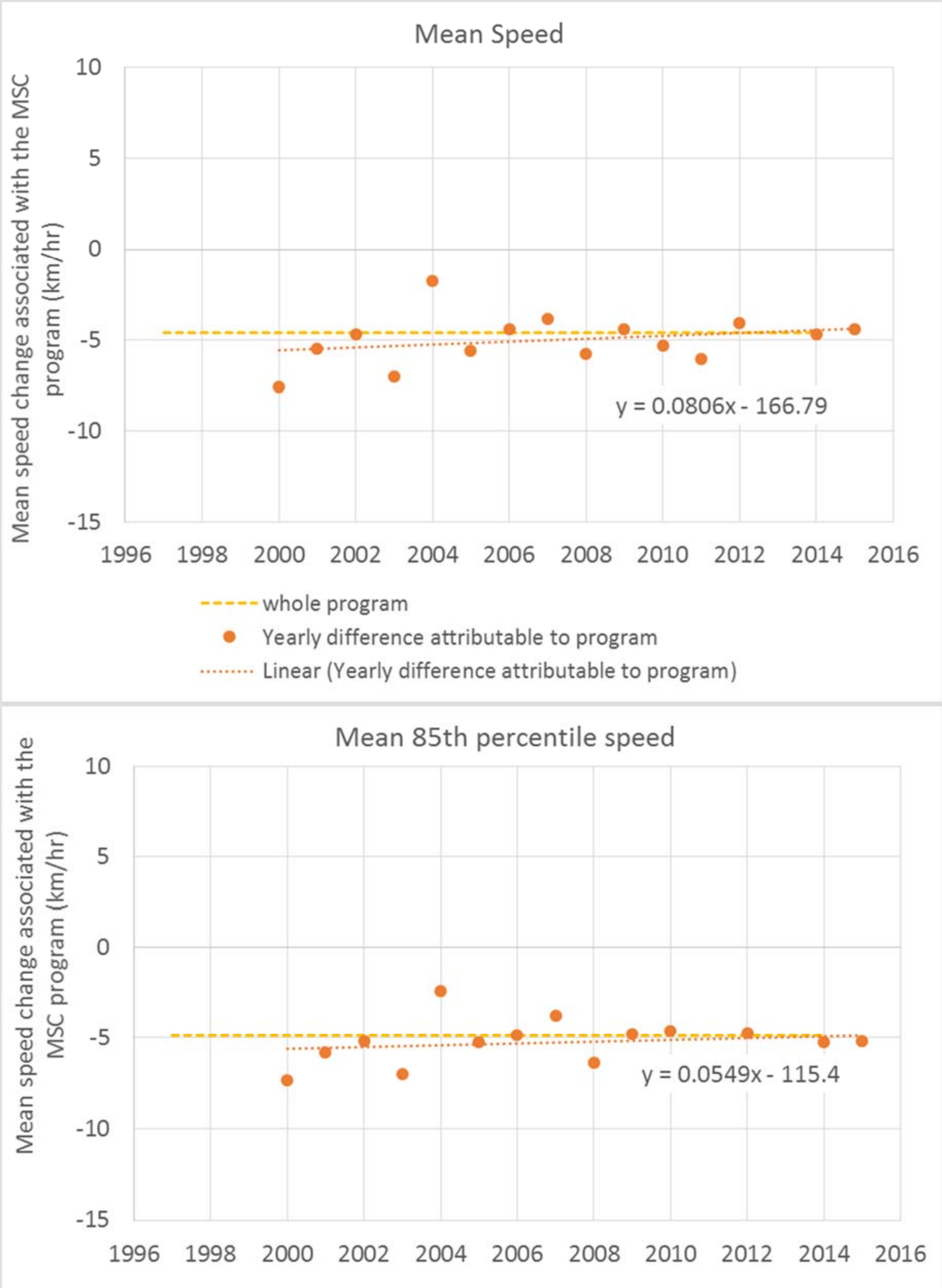


*Figure 36 a & b Mean speed change (**referenced to threshold**) associated with the MSC program for each calendar year (circles) and for all years (whole program, dashed line), for mean speed and for mean 85th percentile speed.*

5.4 Camera operations and infringements analysis

The rate of vehicles with potential (those exceeding the enforcement threshold) and actually issued infringements per vehicles checked are show in Figure 37. The rate of infringements issued per hour of operation (Figure 38) for the period of July 2010 to July 2017 is also given. Potential infringements were calculated from operations data infringement counts and were representative of the rate of vehicles exceeding the set enforcement threshold during mobile speed camera operations. Issued Infringements refer only to speed related offences that were issued to the detected offender.

The drop in rates at the start of 2012 is consistent with the drop observed in the previous 2014 evaluation.

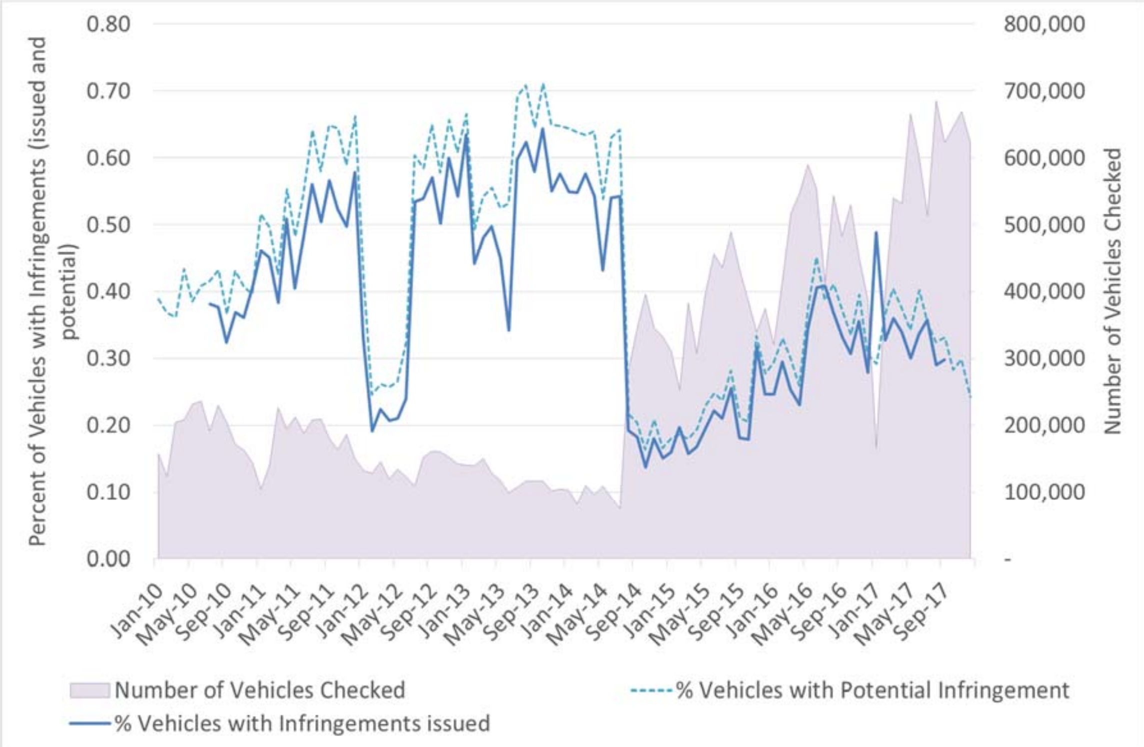


Figure 37 Average monthly infringement rates per vehicle checked for mobile camera operations.

Mid 2014, marked not only the start of a trend for increased operation hours (Figure 38) but also a dramatic doubling in the number of vehicles being checked per hour of operation (Figure 39). Figure 37 clearly shows that the increased checking rate per hour corresponded with drop in infringement rates per vehicle checked. Overall the number of offenders per month more than doubled from June 2014 to June 2016 (Figure 39) with similar increases in the hours of operations and infringement rates per operation (Figure 39) but with these increases occurring more gradually over time.

Figure 40 demonstrates that trends in infringement revenue raised per hour of operation matched the trends observed for hours of mobile camera operation.

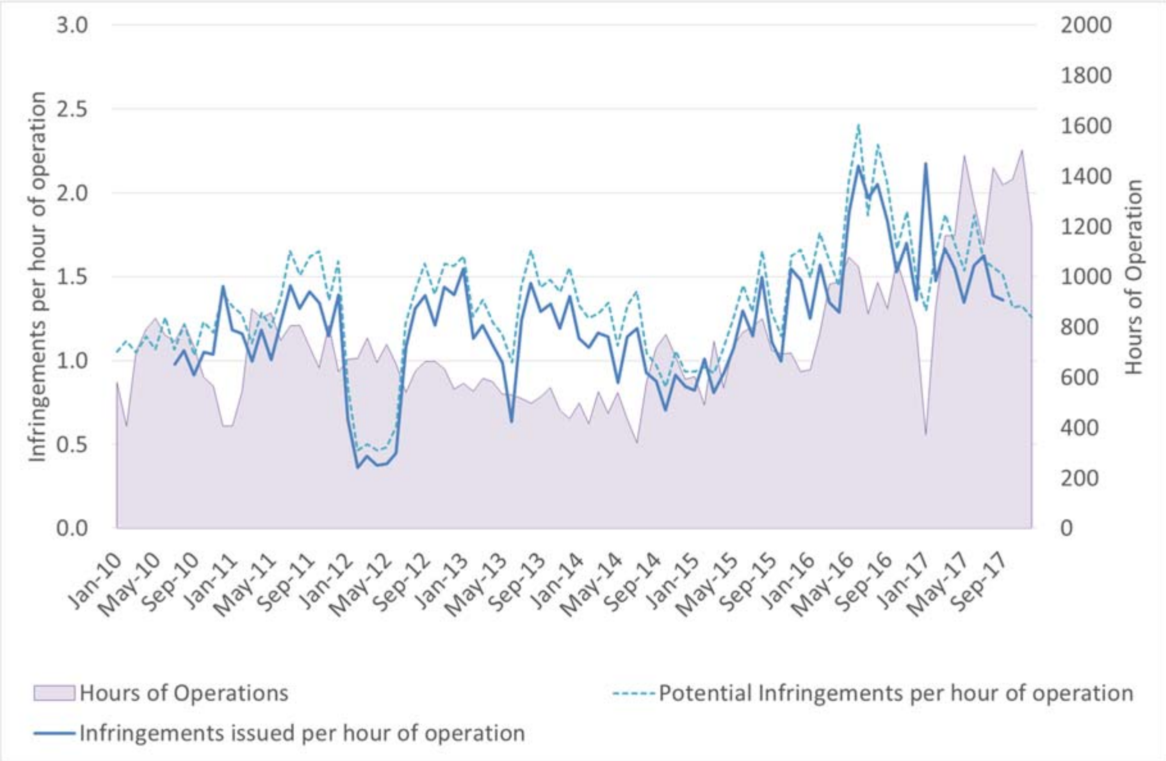


Figure 38 Average monthly infringement rates per hour of mobile camera operations.

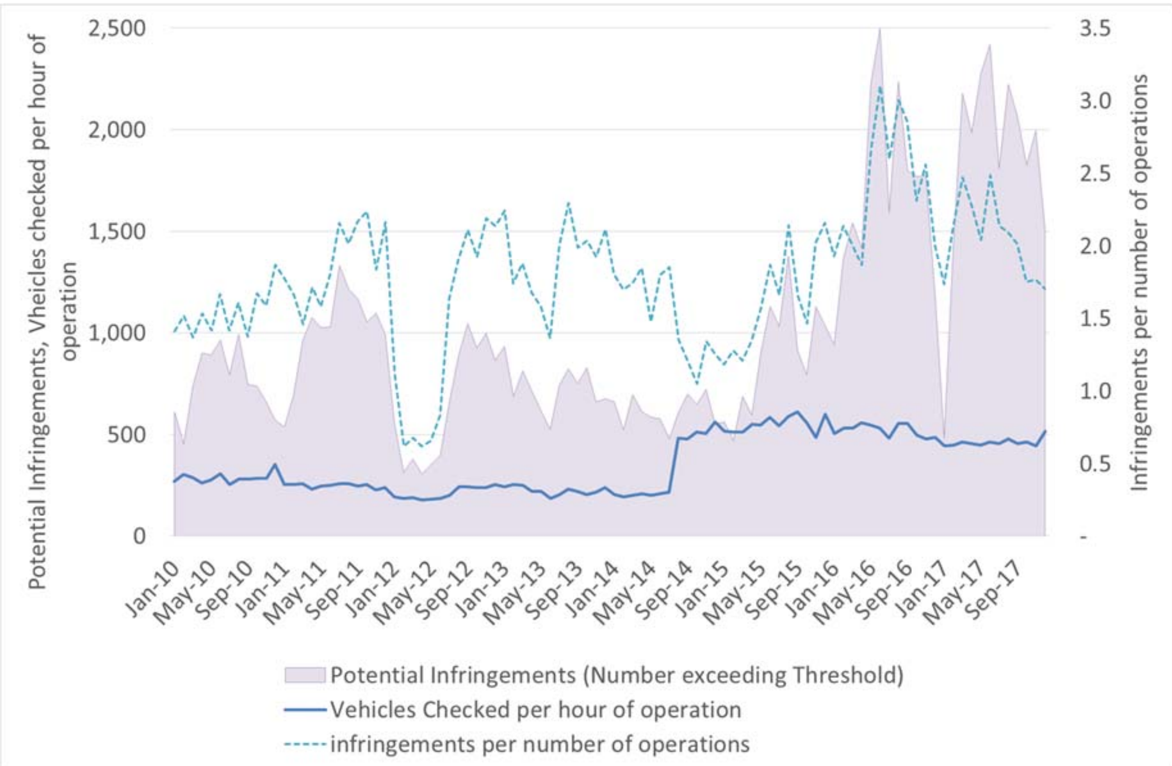


Figure 39 Monthly counts of vehicles checked per hour of mobile camera operations and Monthly potential infringement counts.

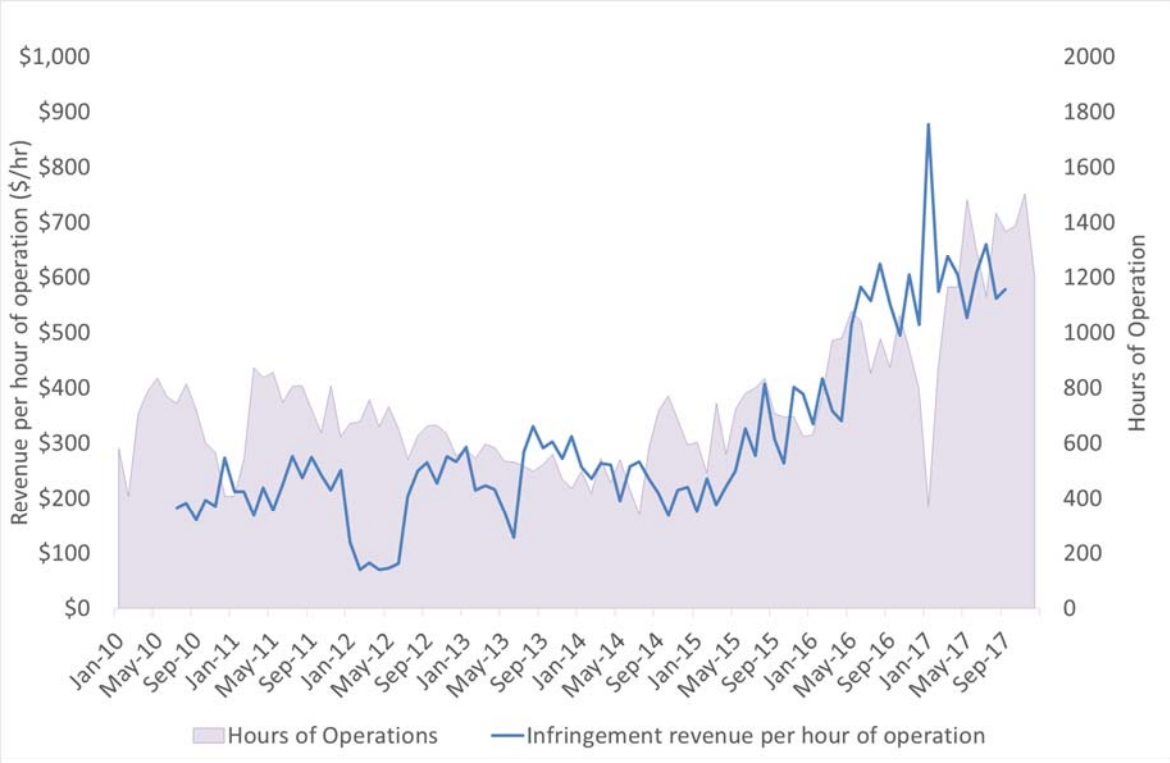


Figure 40 Monthly (issued) infringement revenue per hours of mobile camera operations and Monthly potential infringement counts.

Infringements issued over July 2010 to September 2017 by offence and camera were analysed. The proportions of offences remained stable over the periods that they were issued for all camera types except red-light speed cameras, where the proportion of offences for proceeding through a red light more than doubled and the proportion speeding by up to 15 km/hr decreased by about 30% (Figure 41). This increase in red light offences coincided with the introduction of RT3 radar technology in existing red light speed cameras.

Over March 2012 to September 2017, a period when the Hindmarsh Drive point-to-point cameras were operational, almost 80% of issued infringements arose from fixed cameras: 38% red light speed cameras, 5% point-to-point cameras and 35% from other fixed speed cameras. Twenty-one percent of infringements were issued from mobile speed cameras (Figure 42).

Over July 2010 to September 2017, 91% of infringements arose from exceeding the speed limits (82% by 15 km/hr or less in non-school zones) and 9% arose from red-light offences (Figure 43). Offence type proportions by camera type are depicted in Figure 44.

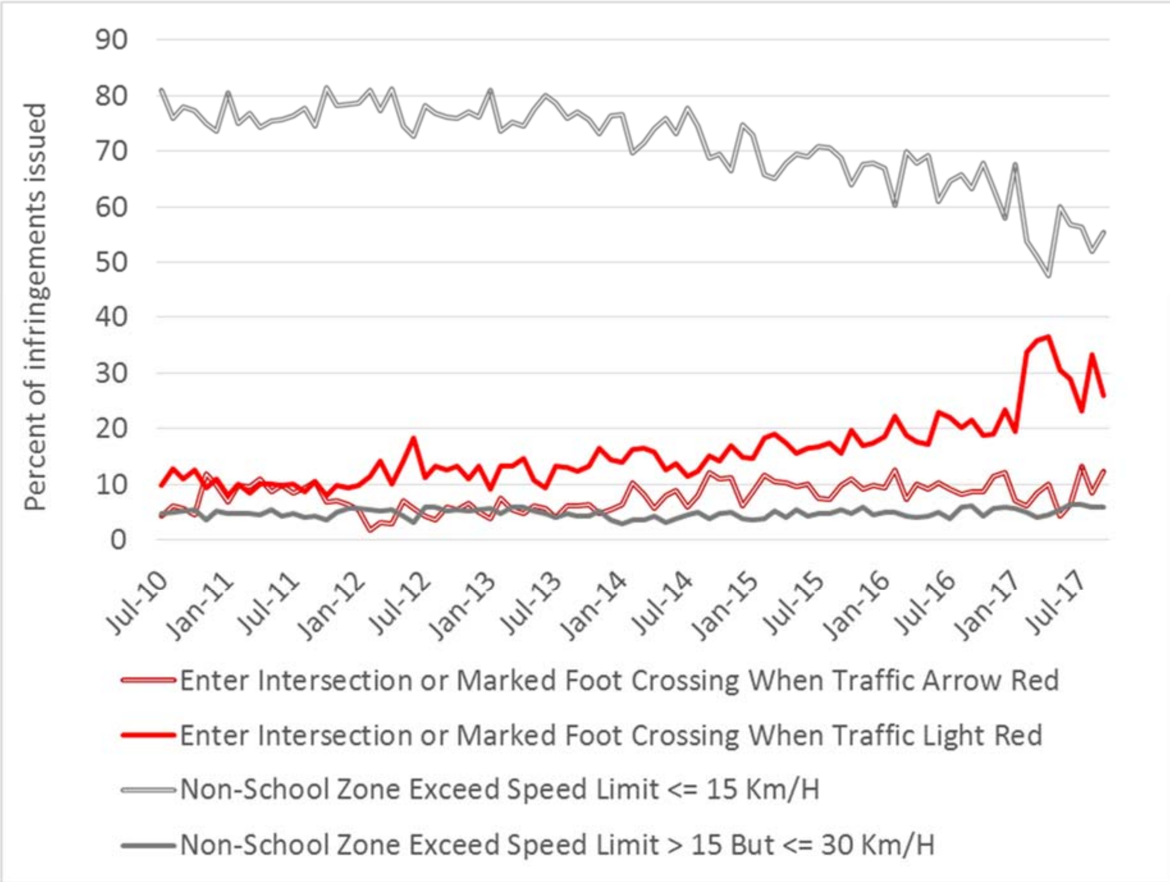


Figure 41 Percent of infringements issued from Red light-speed cameras by offence type and month.

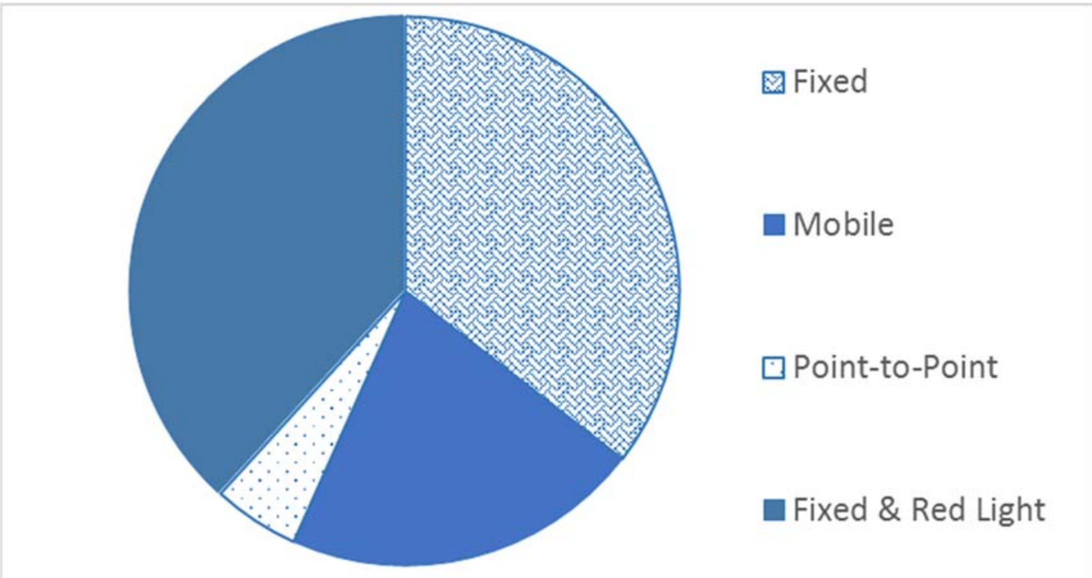


Figure 42 Proportion of infringements issued from road safety cameras from March 2012 to September 2017.

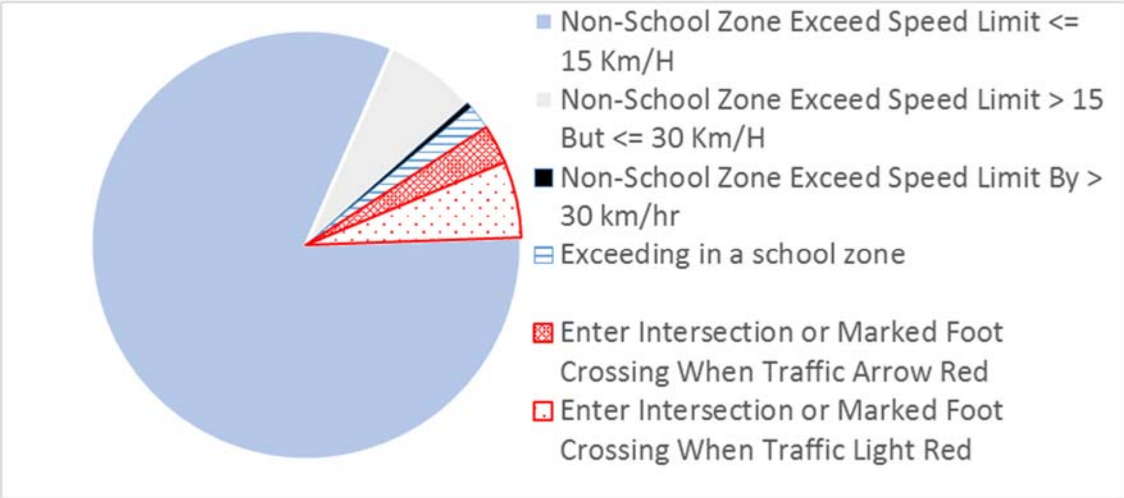


Figure 43 Proportion of infringements issued from road safety by offence type from July 2010 to September 2017.

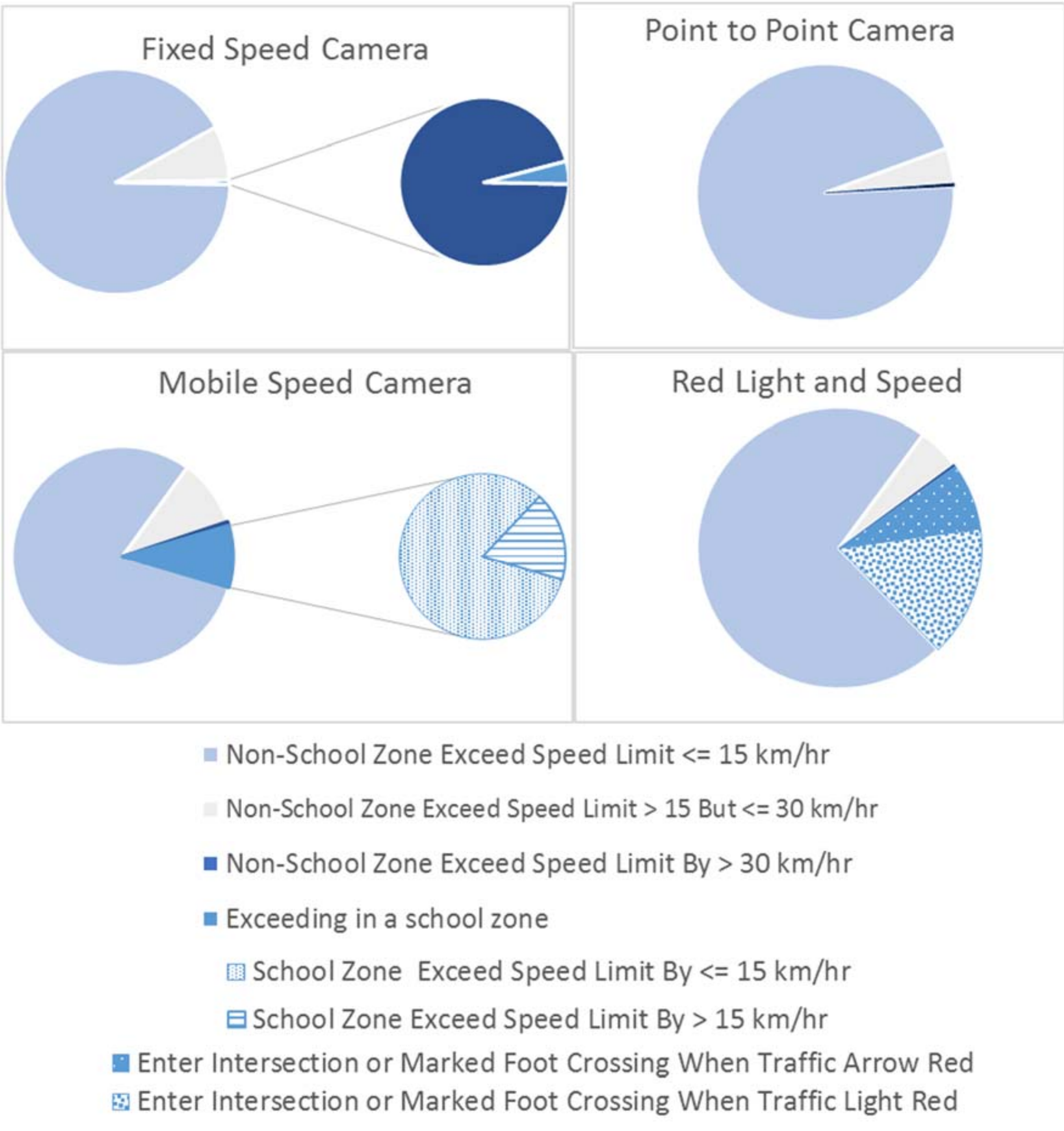


Figure 44 Proportion of infringements issued from road safety by offence and camera type from July 2010 to September 2017.

6 STRATEGIC ANALYSIS

The development of the strategic model for expansion of the ACT Road Safety Camera Program was based on the Traffic Enforcement Resource Allocation Model (TERAM) developed by Cameron, Newstead and Diamantopoulou (2016). This model covered all forms of traffic enforcement in Victoria for which there are reliable relationships between the enforcement operations and reductions in road trauma. The automated traffic enforcement (ATE) methods in TERAM were subsequently applied in Queensland (Cameron, Newstead and Budd 2017) and Western Australia (Cameron and Newstead 2018). Each enforcement type was considered for its applicability to appropriate parts of the road system ("black" spots, "black" sections, signalised intersections, and roads of each type generally). The essence of construction of the TERAM model for ATE elements is as follows:

- The relationship between output from each ATE enforcement element and expected crash outcomes is determined either from local research if available or meta-analysis of existing research from other jurisdictions if local research evidence is not available.
  - For fixed camera elements, the geographical scope of influence of the camera on crashes is determined from evaluation research along with the expected percentage reduction in crashes expected upon placement of the camera at the site. Potential crash savings at a site for potential enforcement are then estimated by applying the percentage crash reduction effect to the pool of crashes within the geographical scope of influence of the camera.
  - For mobile cameras, the geographical zone of influence of the camera is established from evaluation research along with the relationship between mobile camera program inputs and outputs (e.g. hours of enforcement, vehicles checked, infringements issued, etc.) and expected crash reductions. Like the fixed cameras, crash savings are estimated based on the crash coverage by the camera locations and the level at which increased camera inputs will be set.
- The ACT-wide crash population is partitioned according to potential areas where cameras might be operated. A scenario for additional fixed camera placement or increased hours of enforcement for mobile cameras is proposed and overlaid on the state-wide crash partition to estimate the crash savings estimated to be achieved under the scenario.
- Economic analysis is carried out by applying unit costs to the crash savings estimates to estimate economic savings. Costs of program expansion are estimated based on information on the cost of camera installations, operation and infringement processing.

6.1 Camera-based options for each road environment in ACT

The strategic analysis for expansion of ATE in ACT considered the following camera-based operations and road environments:

1. Fixed spot-speed cameras (FSC) on midblocks between intersections
2. Fixed P2P average-speed cameras on relatively long midblocks
3. Fixed speed/red-light (SRL) cameras at signalised intersections
4. Mobile speed cameras (MSC) at all approved midblock sites in ACT collectively
5. Mobile P2P cameras regularly operated at the terminals of pre-defined long midblocks

The three fixed camera methods (1-3) are focused on "black" spots or sections of appropriate roads where a relatively high number of serious crashes is likely to occur in the absence of effective enforcement to deter speeding. These "black" spots/sections are usually determined initially by ranking all candidate spots/sections by their individual frequency of serious crashes during an historical period (five or more years). "Black" signalised intersections chosen for installation of SRL cameras are selected in a similar way. A program of camera enforcement that selects the highest rank sites will have a higher potential for crash reductions than at lower ranked sites (Schluter et al., 1998). It will be focused on sites with higher crash rates than average for the road type. The diminishing potential for crash reductions associated with expansion of camera enforcement programs will be outlined in Section 6.2.

6.2 Crash effects of fixed camera systems

The crash reduction achieved by each type of fixed camera is related to the number of camera systems added to the road environment as well as to the limited distance-halo or road coverage of each system. The estimated crash effects (percentage reduction by crash type) of each fixed camera system are summarised in Table 21 based on results in Table 14. It includes a definitive evaluation of 77 speed/red-light cameras in Victoria (Budd et al 2011), but which covered effects only on casualty crashes. These estimated crash effects were used in the strategic analysis here.

Table-211 Estimated crash effects of fixed speed camera systems in ACT

Enforcement type	Casualty crashes (fatal and injury)	PDO crashes	All reported crashes
Fixed spot-speed camera	-11%	-27%	-15%
Fixed P2P system	-11%	-13%	-9%
Speed/Red-Light camera	-26%	NK	NK

6.2.1 Ranking of fixed camera sites by their crash history

As part of its Road Safety Strategy 2016-2020, the ACT government commissioned a review of the siting of each of ACT's fixed speed camera technologies (midblock fixed spot-speed cameras, speed/red-light cameras at signalised intersections, and P2P speed camera systems) (Small, Dutschke and Kloeden 2015). They obtained data on all crashes in the ACT during 2004-2013 (ten year), of which 76 were fatal and 2240 were injury crashes. The remainder involved property damage only (PDO).

Small et al (2015) considered a range of crash ranking criteria for selecting the priority of installing appropriate fixed camera types at midblocks or signalised intersections based on their crash history. They favoured a weighted sum of five times the casualty crashes (fatal and injury) plus the number of PDO crashes at each location in the ACT. For midblocks, they divided the weighted crashes by the midblock length.

6.2.2 Midblocks for fixed spot-speed cameras (FSC)

Small et al (2015) ranked 1239 midblocks on arterial roads by their weighted crashes per kilometer. The top 20 midblocks ranked in this way were relatively short (1.14 km). In some cases, their relatively high ranking was due to their short length rather than to high numbers of crashes, especially the more-important fatal and injury crashes.

The data presented by Small et al (2015) allowed arterial midblocks to be also ranked by their weighted crashes without considering the midblock length. The average length of the top ranking midblocks was 2.36 km and these midblocks covered more crashes than those ranked by weighted crashes per kilometer. In addition, the distance-halo effect of fixed spot-speed cameras has been found to extend up to one kilometer from the camera site, i.e. a two kilometer section centered on the camera. For these two reasons, the strategic analysis of midblocks with highest ranking for consideration of fixed spot-speed cameras was based on ranking by their weighted crash count.

Figure 45 shows the effect of expanding the selected set of top ranked midblocks. The average number of casualty crashes per midblock falls as the maximum rank increases. The first selected midblock had 24 casualty crashes over ten years, but if 25 top ranked midblocks were selected, the average casualty crashes per midblock would be only 11.8 over the ten years. Figure 46 shows the similar fall in average PDO crashes in the top ranked midblocks. This illustrates the diminishing potential for crash savings from the crash effects in Table 21. Cameron, Newstead and Budd (2017) and Cameron and Newstead (2018) have found similar diminishing potential in different road environments ranked by their crash history and have calibrated "crash ranking selection factors" to take this into account in strategic analysis of expanding camera programs.

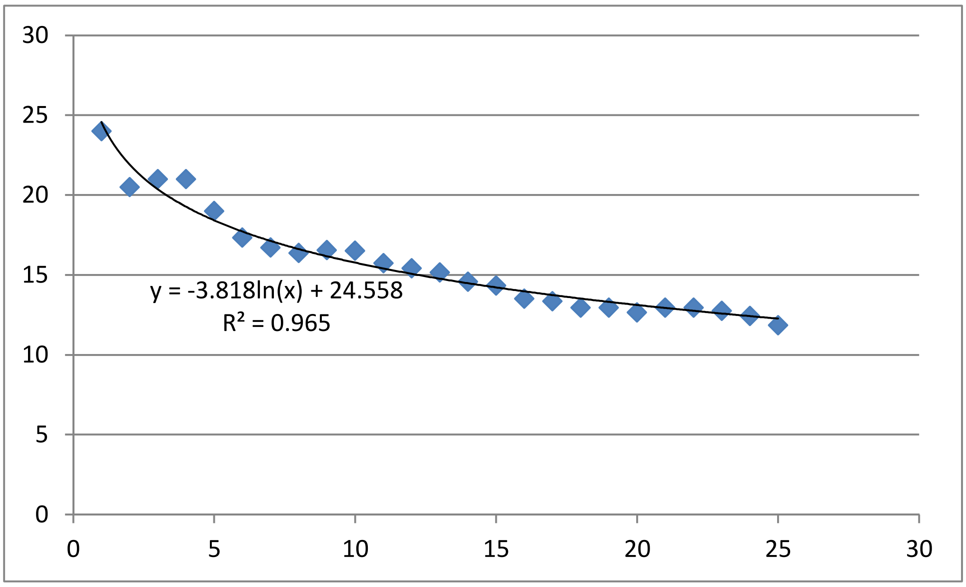


Figure 45 Cumulative average casualty crashes over 10 years on arterial midblocks, by maximum rank of top sites ranked by weighted crash history

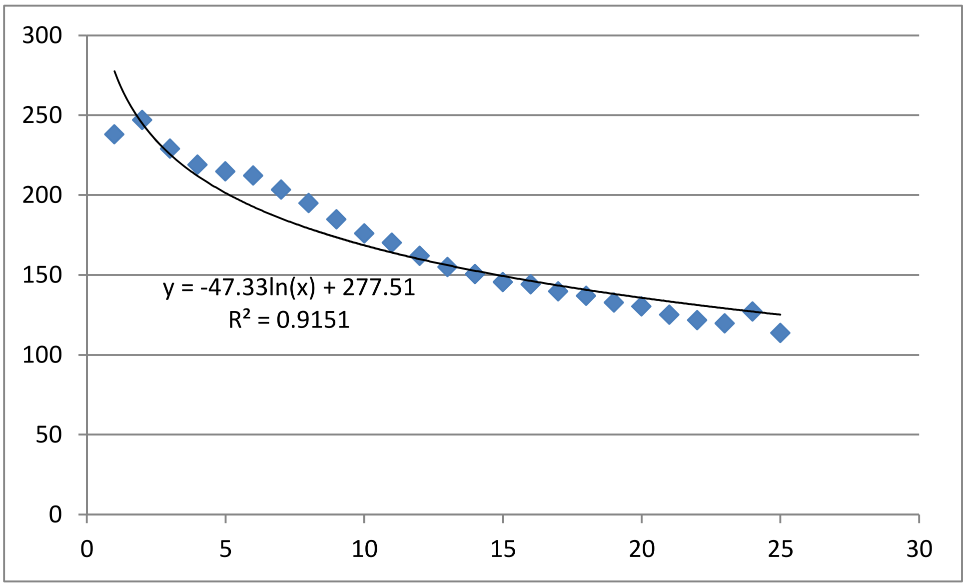


Figure 46 Cumulative average PDO crashes over 10 years on arterial midblocks, by maximum rank of top sites ranked by weighted crash history

6.2.3 Midblocks for P2P camera systems

Many midblocks ranked highly by Small et al (2015) have the same road name. Four midblocks were parts of the eight sections of Tuggeranong Parkway considered suitable for P2P camera enforcement by Small et al (2015), and two sections of Parkes Way were similarly considered.

The highest ranked midblocks were sorted by road name and the crash histories on those with the same name were pooled. The pooled and unpooled midblocks were then ranked by their weighted crashes. Not surprisingly, the pooled midblocks on Tuggeranong Parkway and Parkes Way were the highest ranks, but another twelve midblock sections were also included in the top ranks. Figures 47 and 48 show the average crash rates per midblock section considered suitable for P2P camera enforcement. The average length of the top ranked midblock sections was 5.22 km.

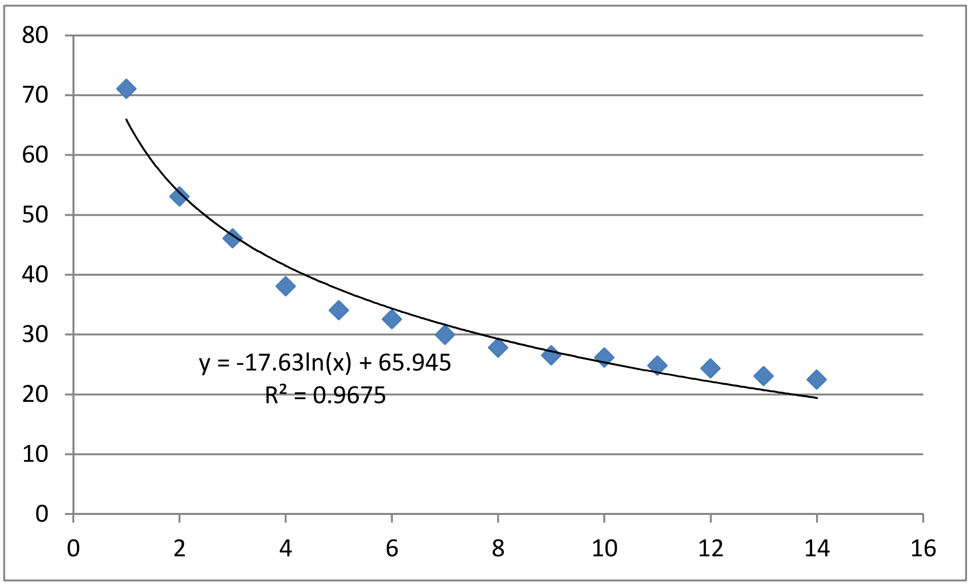


Figure 47: Cumulative average casualty crashes over 10 years on arterial midblock sections suitable for P2P cameras, by maximum rank of top sites ranked by weighted crash history

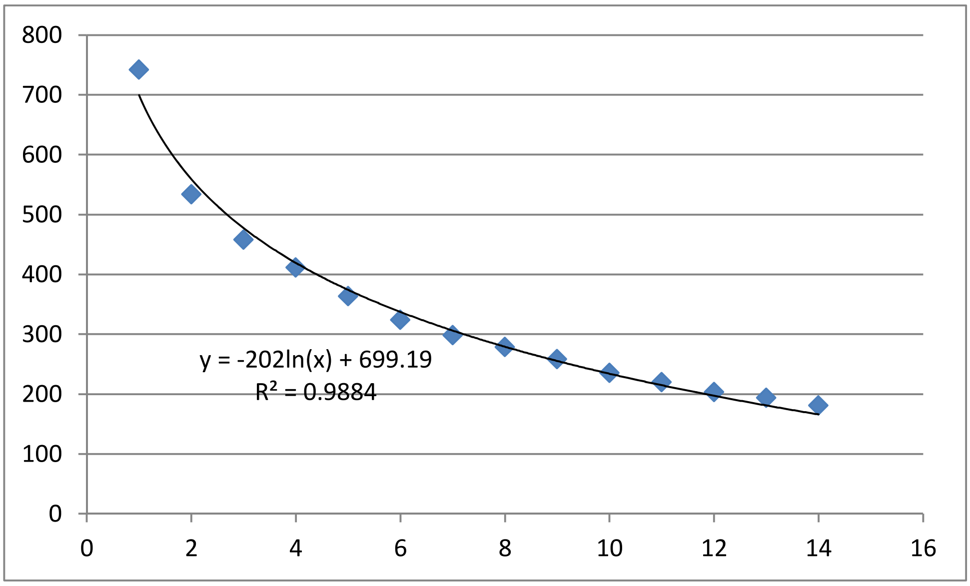


Figure 48: Cumulative average PDO crashes over 10 years on arterial midblock sections suitable for P2P cameras, by maximum rank of top sites ranked by weighted crash history

6.2.4 Signalised intersections for SRL cameras

Small et al. (2015) ranked the signalised intersections by their weighted crashes over ten years. Seven of the top 20 ranked intersections already have SRL cameras installed, so only the remaining 13 were considered in the strategic analysis of potential expansion of SRL cameras. Figure 49 shows the average casualty crash rate per signalised intersection without SRL by the maximum rank to select suitable locations. This does not decrease much as the potential set of intersections considered for SRL cameras increases. This may reflect the criteria used previously to select intersections for installation of traffic signals. In contrast, the average PDO crash rate falls consistently as the ranked set of signalised intersections increases (Figure 50).

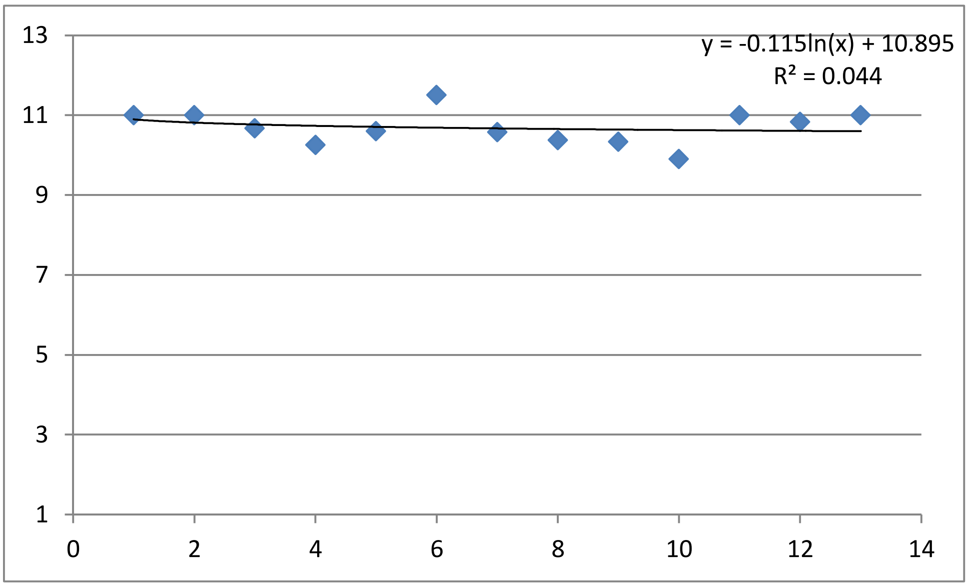


Figure 49: Cumulative average casualty crashes over 10 years at signalised intersections without SRL, by maximum rank of top sites ranked by weighted crash history

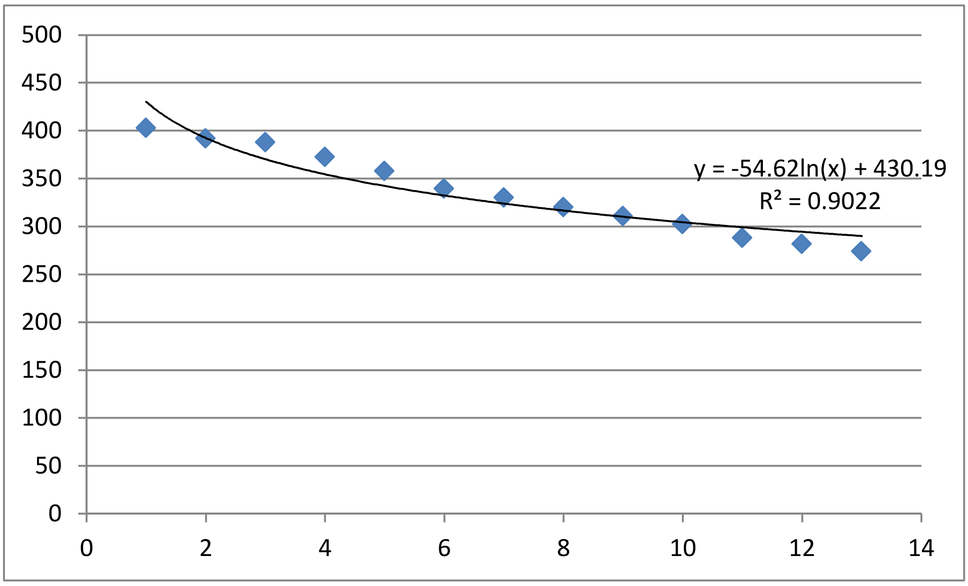


Figure 50: Cumulative average PDO crashes over 10 years at signalised intersections without SRL, by maximum rank of top sites ranked by weighted crash history

6.3 Crash effects of mobile camera systems

6.3.1 Mobile speed cameras (MSC)

After reviewing a large number of studies of the effects of varied levels of traffic enforcement on casualty crashes, Elvik (2001) concluded that the relationship is of the form shown in Figure 51. Even for the most effective forms of enforcement, the relationship with crash reductions is not linear. Diminishing returns apply as the level of enforcement increases. However, within the range of increases observed in the studies (up to 10-12 fold), it appears that at least some crash reductions occur for each increase in enforcement effort.

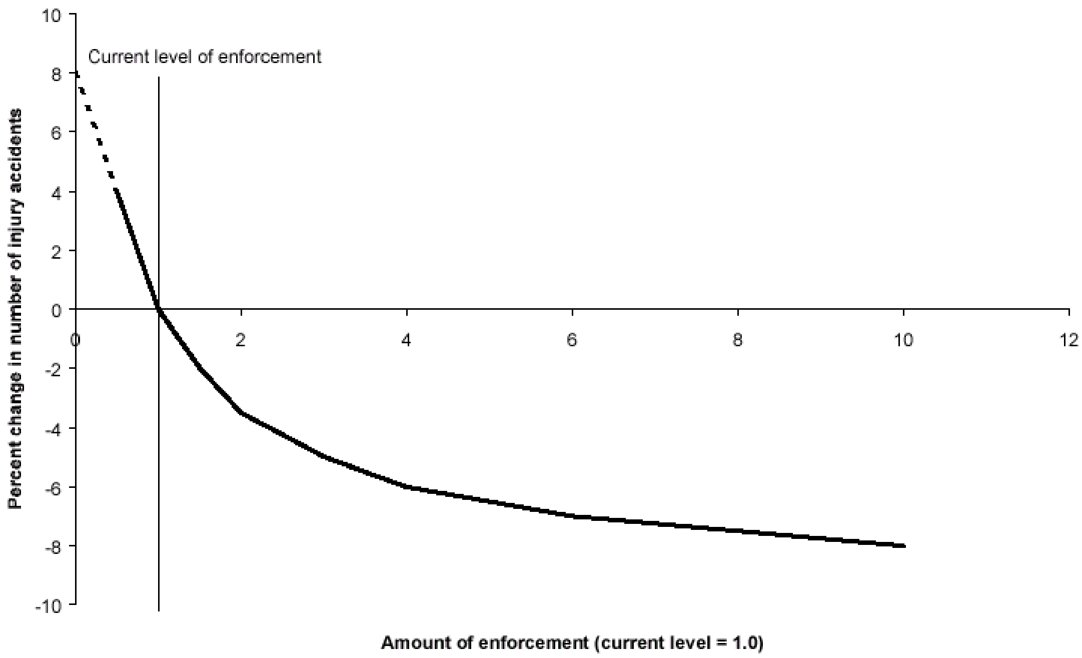


Figure 51: General relationship between traffic enforcement and crashes (Elvik 2001)

Elvik (2001) proposed a number of potential functional forms for the relationship shown in Figure 51. The most suitable is the power function:

$$Y = A \cdot X^{B}$$

where Y is the relative risk of casualty crashes, X is the level of enforcement, and A and B are parameters related to the shape and level of the relationship. B is negative, i.e., a given increase in enforcement from its current level leads to a lower level of crashes. The magnitude of B depends on the strength of the relationship between the specific type of enforcement and crashes. B is often referred to as the “elasticity”, i.e., the percentage change (reduction) in crashes for 1% increase in enforcement.

The elasticity analysis (section 5.2.3) following evaluation of the crash effects of the ACT MSC program showed strong relationships between the total operational hours and reductions in casualty and PDO crashes within 0.5 km of the sites where the speed camera had been used. These relationships are shown in Figure 52. The estimated elasticities for casualty and PDO crashes were -0.183 and -0.237, respectively. In the strategic analysis, these elasticities were used to estimate the corresponding crash reductions of each type with increases in MSC hours.

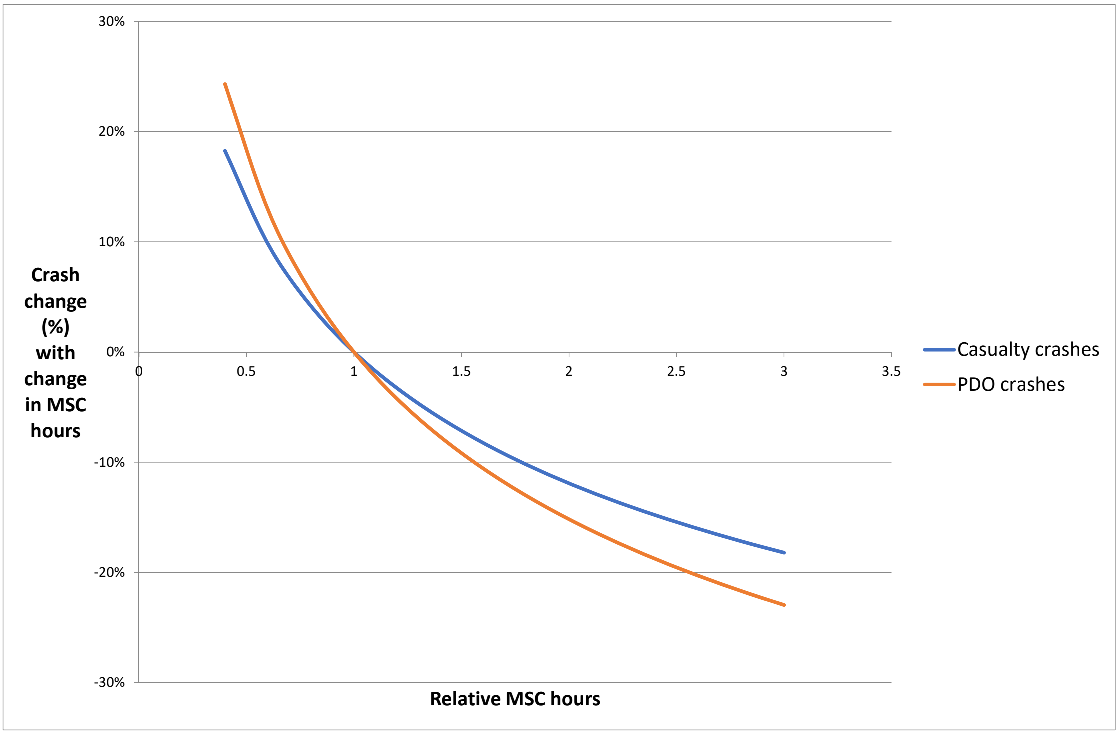


Figure 52: Percentage change in crashes associated with relative levels of MSC operating hours in the ACT

The estimated reductions in crashes associated with MSC operations were evaluated within 0.5 km of MSC sites. Crashes within this range represented 82.7% of all casualty crashes in the ACT and 83.8% of all PDO crashes. Effects on crashes beyond this range are possible but unknown.

In the strategic analysis, the percentage reductions in casualty and PDO crashes for a given level of MSC hours (Figure 52) were applied to the proportion of all crashes of each type covered within 0.5 km of MSC operations.

6.3.2 Mobile point-to-point (P2P) cameras

Mobile P2P (average-speed) camera units are a new technology that makes use of two vehicle units parked at the terminals of a carefully-surveyed road length ("black" section) to measure the average speed in the same way as fixed P2P camera systems. Ideally, the vehicles should be identical to those used for spot-speed MSC operations, thus creating uncertainty about whether the other MSCs could be mobile P2P cameras and thereby extending their crash effects beyond the "black" section, perhaps weakly. Based on analysis of MSC operations in Queensland, it is expected that each one-way "black" section will need to be visited on average for 34.5 hours per year, as visited by the spot-speed MSCs in rural Queensland (ten sessions averaging 3.45 hours), to produce a long-term time-halo effect along each "black" section in a similar way as the effect produced by a fixed P2P system operating continuously (see Table 21).

Current technology for mobile P2P camera units measures average speed in only one direction. The crash effects of fixed P2P camera systems relate to bi-directional systems (two paired cameras at each terminal, measuring average speeds in each direction on the same road length). Hence, the crash effects of each uni-directional mobile P2P camera pair was estimated to be one-half of the crash effect of the fixed P2P camera systems shown in Table 21.

The selection of locations for mobile P2P camera operations should follow the same approach as that used for fixed P2P cameras, ranking the arterial midblocks by their weighted crashes (pooled across midblocks on the same road, where appropriate). The relatively low cost of mobile P2P operations, notwithstanding a minimum of 34.5 operational hours per year, may make mobile P2P more cost-beneficial than fixed P2P cameras (and provide greater flexibility in the operations).

6.4 Base level of crashes during 2014-2017

As the basis of the strategic analysis, the annual number of crashes on each part of the ACT road system was estimated from the average during 2014-2017 of each crash type (Table 22). An average over four years was taken to provide a more reliable annual estimate than the single year 2017, especially the numbers of fatal and injury crashes. Casualty crashes are the sum of these.

Table-222 Average level of crashes each year during 2014-2017 on the ACT road system

	Fatal crashes	Injury crashes	Casualty crashes	PDO crashes	Total crashes
Midblocks	7.3	264.5	271.8	3254.3	3526.0
Intersections	2.5	348.8	351.3	3898.8	4250.0
Signalised intersections	0.5	113.8	114.3	1681.0	1795.3

6.5 Base level of enforcement during 2017

As the basis for specific percentage increases in each type of ATE, the levels of operation during 2017 were obtained (Table 23). Units of ATE were either numbers of cameras or sites, or road sections for P2P enforcement (fixed or mobile). The hours operated and infringements detected during 2017 were also obtained.

For the strategic analysis, the base level of crashes and the level of enforcement during 2017 were considered to be in equilibrium. The effects of increased enforcement were estimated from the crash reductions shown in Table 21 and Figure 52 applied to the base crashes considered covered by each type of ATE.

Table-233 ATE units, hours operated and infringements detected in ACT during 2017

Target environments and ATE enforcement type	Units – cameras, sites or P2P sections	Hours operated	Infringements
Midblocks			
Fixed spot-speed camera	13	113,880	18,903
Fixed P2P camera system	1	8,760	2,997
Mobile speed camera (MSC)	6	14,373	22,008
Mobile P2P camera pair	0	NA	NA
Signalised Intersections			
Speed/Red-Light camera	14	122,640	15,595

6.6 Effects of 25% increase in enforcement

A spreadsheet was developed to examine the crash effects of percentage increases in enforcement, which were not necessarily the same for each ATE type. Table 23 shows the increased enforcement for a nominal 25% increase in each type. The increase in the current fixed P2P camera system was rounded up to one additional system. The 25% increase in MSC hours could be achieved by additional hours per camera or by additional cameras, so the increased number of MSC units is unknown.

Two long midblock sections covered regularly by a pair of mobile P2P units (as outlined in section 6.3.2) are also included for illustrative purposes although none currently operate in the ACT.

The coverage of crashes at fixed locations is based on the ranking of potential sites by their crash history (section 6.2) and the number of selected sites shown in the second column of Table 24. The annual average crash numbers per site at the top ranked sites are illustrated in:

- Figures 45-46 for arterial midblocks suitable for fixed spot-speed cameras
- Figures 47-48 for relatively long arterial midblocks suitable for P2P camera systems
- Figures 49-50 for signalised intersections suitable for speed/red-light cameras.

The data behind these figures was used to estimate the crashes covered per site shown in the last two columns of Table 24, based on the number of additional sites in the second column. If the number of additional sites is increased, Figures 45-50 show that the crashes covered per site would decrease, i.e. there is less potential for crash reductions per site although the sites increase.

The percentage of crashes within 0.5 km of MSC sites was considered to be the percentage of all midblock crashes of each type covered by MSCs. The density of MSC sites on the ACT road system is already high (Figure 22), so the proportion of midblock crashes covered is unlikely to increase substantially if additional sites are added. The analysis here was based on the crash effects of increased operational hours at essentially the same base number of sites.

Table-244 Nominal 25% increase in ATE (unit numbers rounded up), crash coverage per site/section, and percentage of total crashes on midblocks covered by MSC. Two mobile P2P camera pairs included (in red) for illustrative purposes.

Target environments and ATE enforcement type	**Units – cameras, sites or P2P sections**	**Hours operated (p.a.)**	**Estimated infringe-ments (p.a.)**	**Crashes covered p.a. per site or section [% of total crashes by MSCs]**	
				Casualty	**PDO**
Midblocks					
Fixed spot-speed camera	4	35,040	5,816	2.1	21.9
Fixed P2P camera system	1	8,760	2,997	7.1	74.2
Mobile speed camera (MSC)	NK*	3,593	5,502	82.7%	83.8%
Mobile P2P camera pair	2	69	24	5.3	53.4
Signalised Intersections					
Speed/Red-Light camera	4	35,040	4,456	1.0	37.3

* Increased hours could be achieved by greater use of existing MSCs and/or increased number of MSC units

The estimated crashes saved by the increase in each type of ATE as indicated in Table 24 is shown in Table 25, together with the estimated total saving in crash costs per year. Unit crash costs were based on BITRE (2009), updated to 2017 using the CPI, and were $106,501 per casualty crash and $13,505 per PDO crash. The percentage reductions in casualty crashes and crash costs are based on the estimated savings compared with annual total crashes (Table 22) in each road environment considered to be the target for the specific ATE type.

Table-255 Crashes and crash costs saved per year by nominal 25% increase in ATE (as shown in Table 24)

Target environments and ATE enforcement type	Casualty crashes saved per year	PDO crashes saved per year	**Total crash cost saving ($m p.a.)**	Percent reduction in target casualty crashes	Percent reduction in target crash costs
Midblocks					
Fixed spot-speed camera	0.9	23.7	0.418	0.34%	0.57%
Fixed P2P camera system	0.8	9.6	0.213	0.29%	0.29%
Mobile speed camera (MSC)	9.0	140.5	2.855	3.31%	3.92%
Mobile P2P camera pair	0.6	6.9	0.156	0.21%	0.21%
Signalised Intersections					
Speed/Red-Light camera	1.1	0.0	0.114	0.93%	0.33%
TOTAL SAVINGS	**12.3**	**180.7**	**3.755**	3.20%	3.48%

6.7 Benefit and cost analysis of increases in enforcement

The annual savings in crash costs due to the nominal 25% increase in ATE are compared with the estimated annual costs of the increased enforcement in Table 26. Capital costs of fixed camera equipment have been amortised over their useful life to provide an annual cost. Offence detection costs per mobile camera hour (spot-speed and P2P) were based on estimates for TERAM (Cameron et al 2016), updated to 2017 using the CPI. Offence processing costs per camera-detected offence were also based on TERAM and updated to 2017.

Table 26 indicates that the increase of four SRL cameras has gone beyond the point of a sound investment because the additional costs exceed the benefits from the crash savings (BCR less than one).

Table 27 shows the BCRs if each ATE type was increased by 50%, 75% and 100% and indicates the increased fixed cameras, P2P sections and MSC hours used in the analysis.

Table 27 indicates that an increase of more than one (i.e. two or more) fixed P2P camera systems on long arterial midblocks would not be a sound investment because the BCR is less than one for all further increases. However, further increases in defined arterial midblocks enforced regularly by mobile P2P camera pairs would be cost-beneficial for up to at least eight road sections if the expected crash effects of these operations were to be realised.

Further increases in fixed spot-speed cameras and especially MSC hours would be cost-beneficial, perhaps beyond the 100% increases analysed in Table 27.

Table-266 Benefits and costs of nominal 25% increase in ATE (as shown in Table 24)

Target environments and ATE enforcement type	**Total crash cost saving ($m p.a.)**	Capital cost (amortised) ($m p.a.)	Offence detection ($m p.a.)	Offence processing ($m p.a.)	**Total extra cost ($m p.a.)**	**Benefit cost ratio (BCR)**
Midblocks						
Fixed spot-speed camera	0.418	0.104		0.055	0.159	**2.63**
Fixed P2P camera system	0.213	0.158		0.028	0.187	**1.14**
Mobile speed camera	2.855		0.586	0.107	0.693	**4.12**
Mobile P2P camera pair	0.156	0.040	0.025	0.0002	0.065	**2.39**
Signalised Intersections						
Speed/Red-Light camera	0.114	0.082		0.042	0.12	**0.92**
TOTAL SAVINGS & COSTS	**3.755**	**0.385**	**0.611**	**0.232**	**1.228**	**3.06**

Table-277 Benefit-costs of further increases in ATE in the ACT

Target environments and ATE enforcement type	**Nominal 50% increase in each type of ATE**		**Nominal 75% increase in each type of ATE**		**Nominal 100% increase in each type**	
	Units or %	**BCR**	Units or %	**BCR**	Units or %	**BCR**
Midblocks						
Fixed spot-speed camera	7	**2.35**	10	**2.10**	13	**1.87**
Fixed P2P camera system	2	**0.83**	3	**0.72**	4	**0.63**
MSC hours per year	50%	**3.67**	75%	**3.32**	100%	**3.04**
Mobile P2P camera pair	4	**1.79**	6	**1.46**	8	**1.25**
Signalised Intersections						
Speed/Red-Light camera	7	**0.94**	11	**0.98**	14	**0.95**
TOTAL SAVINGS & COSTS		**2.72**		**2.45**		**2.24**

6.8 Limitations of the strategic analysis

The results in Tables 26-27 can be compared with the BCRs for each ATE type estimated in TERAM (Victoria), SCRAM (Queensland) and WATERAM (Western Australia), especially for operations on urban roads in those States. In nearly every case for increases ranging from 25% to 100%, the BCRs are higher, sometimes doubled, compared with the ACT estimates.

This difference may be due to the analysis in each State being based on crash bases in which disaggregation of casualty crashes by their severity is available (e.g. fatal, hospital admission and other medical treatment) and the known reductions in more severe injury crashes due to some ATE types could be applied in the strategy analysis model. Fortunately, there are few fatal crashes in the ACT (about eight per year), but their relatively low frequency compared with other jurisdictions did prevent fatal crashes from being separately modelled. Non-fatal injury crashes are not categorised by their injury severity in the ACT crash data, so this also meant that crashes resulting in hospitalisation and other medical treatment could not be separately modelled.

The result of these data constraints in the ACT has meant that the high unit costs of a fatal crash ($3,486,341) and severe injury crash ($342,613), both based on BITRE (2009) updated to 2017, are not reflected in the strategic analysis here in the cases of the ATE types that are known to achieve greater percentage reductions in fatal and/or severe injury crashes than injury crashes on average. These ATE types include all those analysed here except SRL cameras at signalised intersections. Thus, the BCRs given in Tables 26 and 27 could be under-estimates of the true BCRs.

7 DISCUSSION

The ACT Road Safety Camera Strategy (launched May 2015) sets out the objectives for each of the camera types used in the ACT's Road Safety Camera Program. The stated goals of the strategy are: to deliver an improved strategic management framework for the camera program; "to improve the community's understanding of the purpose and the role of the camera program in supporting improved road safety outcomes for the Territory; and, to provide clear objectives and measurable targets for assessing the impact and contribution of the cameras to road safety in the Territory" (ACT Government, 2014).

The overall aim of this study was to assess the impact of the ACT's mobile road safety camera program and fixed non-intersection speed camera program, including the point-to-point camera system, on reducing crashes and speed, and to identify any changes in community attitudes towards speeding and road safety camera enforcement. To achieve this aim several research methodologies were employed. Community attitudes ware assessed via the administration of a community survey focused on attitudes to speeding and ACT speed legislation and camera activities. Impact of the ACT Road Safety Camera Program on crashes and speeds was assessed through the analysis of ACT speed camera operations data and police reported crash data. A final section of the study drew on results of the crash analysis and speed camera operations analysis, to providing strategic advice on the potential road safety benefits on future expansion of the ACT Road Safety Camera Program.

7.1 Community attitudes to speeding and speed cameras in the ACT

7.1.1 Survey design

While it was important to ascertain current community attitudes to speed limits, camera enforcement and penalties within the ACT, the importance of comparing these attitudes over time provide a more informative context through which to interpret current attitudes and developing trends. To achieve this, an Enhanced ACT Community Attitudes to Speed Survey was developed (MUARC, 2019). To support long term comparison and trend identification, this survey was based on previous surveys administered nationally (including in the ACT) and locally within the ACT. The Community Attitudes to Road Safety Survey is a national survey, administered yearly from 1995 to 2013 (not administered in 2007, 2010 & 2012) through the Department of Transport and Regional Services. Several survey questions contained in this survey and considered relevant to the ACT were included in the current survey and data pertaining to the speed related questions and ACT resident responses from previous years was included in the analysis. Previous research into the ACT speed camera program conducted by TARS (2104) had also used this data from the years (1995-2011), thus further supporting comparison of findings over time. A few extra questions contained in previous ACT resident based speed surveys administered by the ACT Justice and Community Services Directorate (2012) and Micromex Research (2013) were added, as were questions inquiring about residents' knowledge of the Access Canberra Road Safety Camera website, and ACT speed camera locations, and updates to reflect changes to speed limit zones such as the 40km/h school zones, that have occurred since the most recent 2013 attitudes survey. The final survey was designed to suit self-report, anonymous, online format.

7.1.2 Survey results

The online, anonymous survey was publicly accessible from the 18th January 2018 until the 30th March 2018 (approx. 10 weeks). A total of 2,241 ACT residents completed the entire survey, with more than two male respondents to every female respondent across all recorded age categories. Most residents only held one type of licence, most commonly a full car licence.

Attitudes to speeding and speed cameras

When asked about the level of speed enforcement undertaken in the ACT during the last 2 years there were split views, with 38% perceiving that the level of enforcement had remained the same and 35% considering that it had increased, understandably those who had been booked within the last 2 years were more likely to perceive an increase. This increase was overwhelmingly attributed to detection through mobile speed camera vans. It is worth noting that this is the first time, since the 1995 survey, that the majority of residents did not perceived that speed enforcement had increased. To the contrary, there was more than a three-fold increase in the percentage of residents who thought that speed limit enforcement had decreased compared to the last two surveys and who were content with this decrease. More than half of those who perceived an increase also reported that the level of speed enforcement and associated penalties should be decreased. However, the majority of residents felt that the current level of speed enforcement should be maintained (not increased nor decreased). ACT residents were aware of the single P2P camera in operation in the ACT and most could identify its specific location but police patrols were judged as the most effective detection method.

Figure 40 in Section 5.4 shows that the hours of mobile speed camera enforcement have more than doubled over the period from September 17 to current even though only 35% of survey respondents perceived this change. Furthermore, the majority of respondents did not believe the level of enforcement had changed, the first time this had occurred since 1995. These results suggest that people are generally not critically aware of speed enforcement and particularly mobile speed enforcement until they are fined by the system, after which they perceive an increase in enforcement. Figure 39 shows that the rate of infringing per hour of mobile speed camera enforcement has decreased in recent times. This is possibly a response to greater compliance with speeds at speed camera sites following an increase in the hours of mobile enforcement. Such a response pattern would lead to the reported perception of decreased enforcement. Overall, the results show public perception of the level of speed enforcement is often divorced from the reality of trends in operation, with perceptions driven by both real enforcement levels as well as the likelihood of interacting with the enforcement system through receipt of a penalty.

Attitudes to driving speeds and limits

In relation to their personal speeding behaviour, the majority of residents reported 'typically' driving within the speed limit, or exceeding the limit 'very occasionally' and that compared to 2 years ago their chances of speeding were the 'same' (neither more nor less likely) or less likely. In relation to speeding detections, 14% of the residents admitted to having been booked within the last two years with 73% detected once, 18% twice and 8% three or more times. The majority of these detections had resulted from mobile speed camera vans, followed by Police patrols. In contrast, analysis of infringements from road safety cameras in Figure 42 shows the majority came from fixed cameras, including fixed intersection cameras and the point-to-point system. Of concern is that the majority of those who reported regular speeding behaviour (driving 10 km/h or more over the speed limit always, nearly always, or often) were novice drivers/riders (18-24 years old, learner motorcyclists, or provisional motorcyclists).

Resident attitudes toward current speed limits in both the 60km/h and 100km/h zones were explored from two perspectives, first residents responded to questions about the travel speeds they think should be allowed (acceptable) within these speed zones and then what speed tolerances they think are actually permitted within these zones before resulting in an official speeding offence. Most residents thought that it was acceptable to travel over the posted speed limit in both speed zones. The majority identified that travelling up to 5km/h over the limit in a 60km/h zone and 7km/h in 100 km/h zone was acceptable. They also reported that these speed excesses are actually permitted, as reflected in the stated enforcement tolerances, and would not result in a speeding offence. Of concern is that novice drivers (18-24 yrs. old, & learner motorcycle riders) were the least likely to report a zero tolerance to speeding in either speed zones. Those aged 75 years and over were most likely to report a zero tolerance to speeding. These attitudes towards speed zone tolerances (acceptable & actually permitted) are similar to those reported in previous survey years and indicate no change in community opinion. What does differ however, are the 'No tolerance' percentages, in regards to acceptable speeds in both the 60 and 100 km/h zones. These percentages are the lowest ever reported and it is the first time they have been below the actual permitted 'No tolerance' responses. These responses appear to indicate an increase in community sentiment that drivers should be permitted to travel over the speed limit without recording a speeding offence, however only up to the 5 km/h tolerance in the 60 and 7 km/h in 100 km/h zones. This may be in response to the reported increased perception (compared to the 2013 results) that actual speed enforcement within these zones adopts a zero tolerance and reflect an attitude that low-level speeding should be overlooked.

Attitudes toward speeding and crash risk

The residents' attitudes toward speeding and its relationship with crash involvement were gauged through their response to a number of speeding, safety and crash related statements. Similar to previous years' surveys, the majority of ACT residents strongly agreed that increasing the number of police patrols on the road would result in improved driver behaviour. However compared to 2013 results, a higher percentage thought that the risk of being caught speeding was low, and that increasing penalties would not improve driver behaviour. More favourably, a greater percentage of residents acknowledged the relationship between speeding and crash risk (21% & 52%

respectively) however to the contrary; there was an increase in the number of those who disagreed that speed limit enforcement helps lower the road toll.

Access Canberra speed related resources

In this Enhanced ACT Community Attitudes to Speed Survey (MUARC, 2018) a series of questions were included to gauge residents' knowledge regarding the Access Canberra website. These responses showed that approximately a third of residents were aware of their ability to nominate a speed camera location through the Access Canberra website, with some (9%) having done so. Just over half of the residents were aware that speed camera locations and infringement data is published on the website, 18% of whom had visited the open data section on the site.

While the results of the current survey proved informative the ability to compare changes in residents attitudes over time has offered the opportunity to view changes in social attitudes and trends as well as provide an indication of community responses to changes in speed camera technology, limit setting, and legislation that may have occurred in the timeframe since the previous survey, and indicate the timeframe associated with how long it takes to achieve public adoption/support of introduced speed related countermeasures.

Enhancements to survey delivery and exposure

Previous community attitudes surveys have been administered through telephone interviews, this methodology presents several limitations such as high costs, and sample bias related to the limited population who still possess a home phone line. With the rapidly increasing adoption of mobile phones, there has been a sharp decline in the number of households with a landline and demographic biases (e.g. by age bracket) are associated with household who still have an active home phone line. Online survey administration is now a favourable choice as a low cost administration option, which supports accessing large samples, and as a more successful medium to access younger participants who can be difficult to access through landline and paper-based survey methods. The adaptation of this current survey to an easy to administer and complete online format should support its ongoing future application. For future survey administration, the questions should be reviewed to accommodate any changes in speed zones and legislation. However, it is important that any changes to the questions and their specific wording are kept to a minimum to support valid comparison of responses over time, with previous surveys. The host platform facilitated the ability to complete the survey using multiple devices such as smart phone, tablet, and computer, and allowed participants the ability to pause and complete the survey at a later convenient time. Survey responses were entered directly into a database, which saved on the costs and errors associated with manual data entry, and data from completed surveys could be downloaded in a format ready for analysis.

In addition to the more representative sample associated with accessing a broader sample of ACT residents, and the ease of completing the predominantly multiple choice response questions, the successful response rate can also be attributed to the active promotion of the survey by the ACT Government. The survey and its corresponding link was promoted on a 'tile' on the Access Canberra homepage, as well as on the televisions screens within Access Canberra Service Centres, and as an audio message through their in-queue phone message waiting system for the 10 week duration that the survey was available. The ACT Minister for Justice, Consumer Affairs and Road Safety, Mr Shane Ratenbury announced the launch of the survey through a media release. The collaboration between the MUARC research team and JACs in launching and advertising the survey reduced the overall costs of the research and resulted in an increased sample size, thus increasing the validity of the survey results.

7.2 Impact of the Program on Crashes, Crash Costs and Travel Speeds

7.2.1 Effects of the program on crashes and crash costs

Assessment of the impact of the ACT Road Safety Camera Program on reported crashes and their cost to the community is the most critical element of the evaluation for establishing the road safety benefits of the program. The previous evaluation of the program (Transport and Road Safety (TARS) Research, 2014) was able to consider crash data up to 2012. Whilst the previous evaluation was able to identify initial road safety benefits of the ACT mobile speed camera program, benefits of the program towards the end of the available data period were unclear, warranting further investigation. The current evaluation has been able to add a further five more years of crash data to assess the road safety benefits of the safety camera program over the years 2013-2017, a period over which mobile speed camera operations have changed significantly. Additional crash data history has also allowed a more definitive evaluation of the non-intersection fixed road safety camera program to be undertaken.

Evaluation has estimated the crash benefits of fixed non-intersection speed cameras in the ACT across the 4 different roads on which spot speed cameras are installed as well as for the point to point camera system in operation on Hindmarsh Drive. Evaluation of the crash effects of fixed camera systems is always challenging due to the limited number of crashes observed at individual camera sites. Indeed, results of this evaluation were somewhat inconclusive for individual camera sites as well as when the analysis was stratified by crash severity due to the wide statistical confidence limits in the estimates. Assessment of camera effects across all report crashes was reasonably robust, showing an average reduction in all reported crashes of 25% associated with installation and operation of the fixed speed cameras. Although there was some variation in the point estimates of camera crash effects between individual sites, analysis also showed there was no statistically significant difference in crash effects between camera sites, including the point to point camera site. This justified the approach of analysing the point to point system in conjunction with other fixed mid-block speed cameras to obtain a robust estimate of effectiveness.

Analysis results show, as they have in other jurisdictions such as Victoria, that the crash savings associated with point to point speed cameras are statistically the same as those associated with fixed spot mid-block speed cameras. The primary difference between the two camera types is the geographical area able to be enforced by the cameras. Point to point cameras are able to enforce longer lengths of road than fixed spot cameras which have a geographical range of influence within only 1km from the camera site. The ACT point to point camera system covers a road length of around 4km which is greater than would be covered by a single point camera. The ACT application of the point to point system is somewhat unique in that most other jurisdictions use point to point on high speed rural roads and not in a largely urban area such as the ACT site.

Despite the ACT point to point camera covering a longer road length than a spot speed camera, the total reported crash coverage on Hindmarsh drive is less than that covered by the spot speed cameras on both the Monaro Hwy and the Tuggeranong Parkway. Consequently the absolute crash savings from the point to point system are less than those associated with the other 2 roads (Table 15). Regardless, the fixed mid-block speed camera program in the ACT was estimated to be associated with savings of 69 reported crashes annually, 13 of which were associated with the Hindmarsh Drive point to point system. This translates to a saving of $1.3M annually in crash costs to the ACT community with $262K coming from the Hindmarsh Drive site.

Although the current analysis has provided sufficient evidence to support the road safety benefits of the Hindmarsh Drive point to point camera system, further evaluation of the point to point system is warranted once additional crash history is available. Further analysis will potentially allow more robust analysis of road safety benefits at individual sites as well as the opportunity to assess and differential crash effects by crash severity.

The mobile speed camera program in the ACT is arguable the most important element of the ACT traffic camera program given that interrogation of the data found that over 80% of crashes in the ACT occurred within 0.5 km of a site used at one or more times for mobile speed camera enforcement. Estimates of average post program implementation crash effects associated with the mobile speed camera program were similar for non-injury crashes and injury crashes so discussion will focus largely on the impacts of the program on injury crashes which are more important from a strategic road safety point of view in the ACT.

High coverage of the crash population by the mobile speed camera program led to some difficulties in establishing a viable evaluation design, primarily due to the lack of comparable geographical areas that were uninfluenced by the mobile camera program which could be used to control from the influence of non-camera based factors on observed crash counts. Instead, a simple before to after evaluation design was used controlling for changes in travel exposure. As acknowledge, this design excluded the analysis of the ACT districts Gunghalin and Hall which have experienced population growth, and likely corresponding travel growth, well above the ACT average. Despite these limitations, the analysis design used was the next most robust available and was considered adequate to provide accurate measures of program crash effects. The efficacy of the design was demonstrated by the strong association between measured crash effects and mobile speed camera program hours of operation established in Section 5.2.3 which demonstrates that the associations measured in the crash effects analysis are likely not spurious.

On average post implementation, the ACT mobile speed camera program was associated with a 19.7% reduction in casualty crash risk (Table 17). Effectiveness estimates have varied greatly over time. In the early years after program implementation up to September 2009, casualty crash reduction estimates associated with the program varied between 24% and 43% and were highly statistically significant. Over the period October 2009 to September 2014, estimates of associated program effects were much smaller, estimated casualty crash reductions being less than 10%

and generally not statistically significant. Measured program crash effects over this time period are highly concordant with those form the previous evaluation (TARS, 2014). From October 2014 onwards, estimated associated casualty crash reductions have increased greatly to 22% in the most recent completed year considered in the analysis. Indications are that crash reductions from October 2017 onwards have been even greater although the last analysis period covers only 4 months of data.

Analysis also indicated significant variation in mobile speed camera program crash effects between ACT districts. Analysis presented in Section 5.2.3 shows there is a high correlation between measured crash effects both over time and across districts and the number of hours of mobile speed camera deployment per year. Figure 28 shows that over the period October 2011 to September 2014 there was a notable decline in the annual hours of mobile speed camera deployment in most divisions being particularly strong in the higher travel exposure regions on the ACT (Canberra Central, Belconnen and Tuggeranong). This corresponded to the time when estimated crash reductions were smallest. Since then, annual hours of mobile speed camera deployment have grown consistently in most regions with estimated crash reductions associated with the program increasing accordingly.

As noted, the ACT mobile speed camera program is a key component camera based traffic enforcement in the ACT. This is demonstrated clearly by the estimated crash savings and corresponding economic savings associated with the mobile speed camera program. As shown in Table 19, in the most recent full year of the program analysed, the mobile speed camera program was associated with and estimated saving of over 3000 reported crashes, compared to 69 for the fixed non-intersection camera program. This corresponded to savings in economic costs to the ACT community of over $60M compared to $1.3m for the fixed non-intersection camera program. Both these figures reflect the much higher crash coverage of the mobile camera program compared to the fixed non-intersection camera program.

Analysis of speed camera operations data in Section 5.4 gives some further insight into the causal relationship between camera operations and crash effects measured beyond the association measured in the crash analysis. Key amongst these is the measured association between hours of mobile speed camera operation and measured crash effects. Figure 38 also shows that corresponding to the increase in mobile camera hours of operation was an increase in the detection rate of speeding drivers per hour of operation up to around mid-September 2016 where the infringement rate then decreased. This is suggestive of a change in population speeding behaviour in response to the increased mobile camera deployment hours, with behaviour change lagging the operation change due to it taking time for a critical mass of speeding drivers to be detected to have an impact on both speed behaviour and crash outcomes.

Figure 37 suggests there was some operation change in mobile camera use in mid-2014 with the number of vehicles checked rising sharply and the infringement rates per checked vehicle decreasing sharply. The reason for this change and the actual operation change that occurred is not clear. Furthermore, the change did not correspond to an observed change in the measured crash effects at this time with the crash effects primarily driven by the total hours of mobile camera use and not any other operation changes resulting in the trends of Figure 37.

Another interesting pointer to the mechanism of effectiveness of the mobile speed camera program comes from the analysis of infringements. Despite the mobile camera program accounting for the largest share of crash reductions associated with the broader camera program, it only accounts for just over one third of infringements issued from the broader program. This suggest that specific deterrence is not the primary mechanism of effectiveness for the mobile camera program. Instead visual deterrence by overt camera operations supported by use of the cameras at a large number of sites perhaps with random deployment of operations seem to be the likely driver of measured road safety outcomes associated with the mobile speed cameras. This is similar to the mechanism of effectiveness measured for mobile speed cameras in Western Australia (research yet to be published) and to some degree Queensland (Newstead and Cameron, 2012)

7.2.2 Effects of the program on travel speeds

Analysis of ACT speed monitoring data estimated statistically significant reductions in both mean speeds, and 85th percentile speeds on average over the post implementation period of the ACT Road Safety Camera Program, and particularly the mobile speed camera program. Average reductions in mean speeds of 4.6km/h (95% CI: 2.2 to 7.0 km/h, p=0.0002) and in 85th percentile speed of 4.9km/h (95% CI: 2.4 to 7.4 km/h, p=0.0001) were estimated. Whilst these estimates accorded with the average crash reductions over the post program implementation period, the patterns in estimated speed reductions over the post implementation period did not generally correlate with the time based variation in crash reduction estimates. There are number of possible reasons for this.

Analysis of the speed survey data was hampered by only covering 3 additional years after the previous evaluation up to 2015. As demonstrated in the crash analysis and the analysis of infringements, significant changes in the crash effects of the mobile speed camera program and the corresponding impact on infringement rates were only seen from mid-2016, after the last available speed survey. Furthermore, the speed survey results only reported mean and 85th percentile speeds. Given that most people in the ACT report being largely compliant with speeds and mean and 85th percentile speeds measured were generally below the speed limit, it is possible that the speed camera program has its greatest impact on speeds above the 85th percentile that are not reported from the survey. Whilst people travelling at these speeds might only be a small percentage of traffic, they represent a high percentage of the aggregate crash risk in the traffic stream. Future analysis of ACT speed survey data would be more informative if it provided analysis the full distribution of traffic speeds and not simply mean and 85th percentile speeds. Distributions could then be risk weighted using appropriate travel speed and risk curves to better correlate with the crash reductions estimates to which they are being compared. Without this refinement, the current estimates of impacts of the ACT speed camera program on travel speeds offer only limited information.

7.3 Strategic Advice on Future Program Expansion

Strategic analysis conducted in the last stage of the study drew upon results from the crash analysis based evaluation phase to identify the potential road safety and economic benefits of further expansion of the Road Safety Camera Program in the ACT. Specifically, strategic analysis incorporated the crash evaluation results derived for the fixed spot midblock, point-to-point and mobile speed cameras. Effectiveness of intersection speed and red light cameras was taken from evaluation of Victorian installations (Budd et al, 2011) whilst potential benefits for mobile point to point cameras were taken from similar strategic analysis in Queensland (Cameron et al, 2017) and Western Australia (Cameron and Newstead, 2018). The overarching objective of the strategy analysis is to provide objective evidence on likely crash saving and economic benefits that could be realised by applying the known benefits of each available camera type to the existing crash population in the ACT. As noted in describing the strategic analysis, potential expansion of the program could involve a number of activities. These include: the installation of additional fixed cameras, both spot speed and point to point; additional hours of mobile speed camera enforcement noting that increases in the number of sites for enforcement is unlikely given the current high coverage of the program; and introduction of mobile point to point cameras. The last of these is the most speculative given mobile point-to-point cameras are technically feasible but have not yet seen operational use in any Australian jurisdiction.

The strategic analysis of increases in each ATE type provided estimates of the benefit-cost ratio (BCR) and annual crash savings for given percentage increases in enforcement (camera units, sites, sections or MSC hours). The highest BCRs in rank order from a nominal 25% increase in enforcement were estimated for:

- Mobile speed camera hours (BCR 4.12 from 9 casualty crashes and 141 non-injury crashes saved per year)
- Fixed spot-speed cameras at mid-blocks on arterial roads (BCR 2.63 from 0.9 casualty crashes and 24 non-injury crashes saved per year)
- One additional fixed P2P camera system at a high-ranked long section of an arterial road (BCR 1.14 from 0.8 casualty crashes and 10 non-injury crashes saved per year)
- Speed/red-light cameras at signalised intersections (BCR 0.92 from 1.1 casualty crashes and unknown number of non-injury crashes saved per year)

The BCR and crash savings were also estimated for a new ATE type not yet used in the ACT, namely:

- Mobile P2P camera pairs operated regularly at two high-ranked long sections on arterial roads (BCR 2.39 from 0.6 casualty crashes and 7 non-injury crashes saved per year)

The method of strategic analysis allows the BCR and crash savings to be estimated for other numerical and percentage increases in each ATE type. Results have been presented for nominal 50%, 75% and 100% increases. In each case, the estimated BCR could be an under-estimate because the available crash data did not allow specific estimates of the savings in fatal and serious injury crashes. Savings in these serious crash types would represent higher savings in social costs of crashes than those estimated for savings in casualty crashes in general.

The strategic analysis was based on the methods developed for increases in each ATE type in TERAM (Victoria), SCRAM (Queensland) and WATERAM (Western Australia), especially for operations on urban roads. The results in Tables 26-27 can be compared with the BCRs for each ATE type estimated in those States. In nearly every case, for increases ranging from 25% to 100%, the BCRs are higher, sometimes doubled, compared with the ACT estimates.

This difference may be due to the analysis in each State being based on crash bases in which disaggregation of casualty crashes by their severity is available (e.g. fatal, hospital admission and other medical treatment) and the known reductions in more severe injury crashes due to some ATE types could be applied in the strategy analysis model. Fortunately, there are few fatal crashes in the ACT (about eight per year), but their relatively low frequency compared with other jurisdictions did prevent fatal crashes from being separately modelled. Non-fatal injury crashes are not categorised by their injury severity in the ACT crash data, so this also meant that crashes resulting in hospitalisation and other medical treatment could not be separately modelled.

The result of these data constraints in the ACT has meant that the high unit costs of a fatal crash ($3,486,341) and severe injury crash ($342,613), both based on BITRE (2009) updated to 2017, are not reflected in the strategic analysis here. This is particularly problematic for the ATE types that are known to achieve greater percentage reductions in fatal and/or severe injury crashes than injury crashes on average. These ATE types include all those analysed here except SRL cameras at signalised intersections. Thus, the BCRs given in Tables 26 and 27 could be under-estimates of the true BCRs. Furthermore, achieving the benefits predicted in the strategic modelling are based on a number of assumptions. First, it is assumed that the established relationship between hours of mobile camera deployment and crash reductions continue to hold, which is considered likely. Next, it assumes that the crash reduction effects of intersection speed and red light cameras in the ACT is the same as in other jurisdictions, which is also considered likely. In addition, it assumes that the estimated benefits of mobile point-to-point cameras are correct, which is likely to be the case based on experience with fixed point-to-point cameras but remains un-validated due to the lack of real world operation experience with such cameras. Finally, it assumes that selection of additional sites for fixed camera enforcement is based strictly on the identified hierarchy of merit dictated by current crash frequency. This may not always be that case due to political and community imperatives as well as operational difficulties that sometimes occur in placing and operating fixed cameras at certain sites.

In summary, the strategic analysis provides objective information on the significant potential for additional road trauma savings through further expansion of the Road Safety Camera Program in the ACT. Further increases in mobile camera deployment hours is the specific expansion offering the greatest potential for road trauma savings with the greatest economic worth.

8 CONCLUSION

Like most jurisdictions, the Road Safety Camera Program forms a key element of the ACTs Road Safety Strategy aimed at reducing road trauma through enforcing speed and red light compliance. In line with the goals of the ACT Road Safety Camera Strategy, this study has evaluated the impact of the ACT Road Safety Camera Program on improving road safety outcomes in the ACT and provided measurement of community perception and understanding of the program as well as their attitude to speed enforcement and compliance. Specifically the study has assessed the impact of the ACT's mobile road safety camera program and point-to-point camera on reducing crashes and speed, and identified changes in community attitudes towards speeding and road safety camera enforcement, since the ACT Road Safety Camera Strategy was released in May 2015.

A survey of community attitudes to speeding and speed enforcement was completed by 2,241 respondents and showed the following trends:

- 38% of respondents perceiving that the level of enforcement in the ACT had remained the same and 35% considering that it had increased through use of mobile speed camera vans. For the first time since the 1995 survey, a majority of residents did not perceived that speed enforcement had increased with a three-fold increase in the percentage of residents who thought that speed limit enforcement had decreased compared to the last two surveys and who were content with this decrease.

- The majority of respondents felt that the current level of speed enforcement should be maintained (not increased nor decreased).

- Respondents were aware of the single P2P camera in operation in the ACT and most could identify its specific location but police patrols were judged as the most effective detection method.

- The majority of respondents reported 'typically' driving within the speed limit, or exceeding the limit 'very occasionally' and that compared to 2 years ago their chances of speeding were the 'same' (neither more nor less likely) or less likely.

- Similar to previous years' surveys, the majority of respondents strongly agreed that increasing the number of police patrols on the road would result in improved driver behaviour. However compared to 2013 results, a higher percentage thought that the risk of being caught speeding was low, and that increasing penalties would not improve driver behaviour. More favourably, a greater percentage of respondents acknowledged the relationship between speeding and crash risk.

- Approximately a third of respondents were aware of their ability to nominate a speed camera location through the Access Canberra website, with some (9%) having done so. Just over half of the respondents were aware that speed camera locations and infringement data is published on the website, 18% of whom had visited the open data section on the site.

Assessment of the impact of the ACT Road Safety Camera Program on reported crashes and their cost to the community is the most critical element of the evaluation for establishing the road safety benefits of the program. Evaluation of the effects of both fixed spot mid-block speed cameras and the Hindmarsh Drive point-to-point camera system showed an average reduction in all reported crashes of 25% associated with installation and operation of the fixed speed cameras. Analysis results show that the crash savings associated with point to point speed cameras are statistically the same as those associated with fixed spot mid-block speed cameras. The primary difference between the two camera types is the geographical area able to be enforced by the cameras. Point to point cameras are able to enforce longer lengths of road than fixed spot cameras which have a geographical range of influence within only 1km from the camera site. The fixed mid-block speed camera program in the ACT was estimated to be associated with savings of 69 reported crashes annually, 13 of which were associated with the Hindmarsh Drive point to point system. This translates to a saving of $1.3M annually in crash costs to the ACT community with $262K coming from the Hindmarsh Drive site.

The mobile speed camera program in the ACT is arguable the most important element of the ACT traffic camera program, given that interrogation of the data found that over 80% of crashes in the ACT occurred within 0.5 km of a site used at one or more times for mobile speed camera enforcement. Estimates of average post program implementation crash effects associated with the mobile speed camera program were similar for non-injury crashes and injury crashes. On average post implementation, the ACT mobile speed camera program was associated with a 19.7% reduction in casualty crash risk. Effectiveness estimates have varied greatly over time. In the early years after program implementation up to September 2009, casualty crash reduction estimates associated with the program varied between 24% and 43% and were highly statistically significant. Over the period October 2009 to September 2014, estimates of associated program effects were much smaller, estimated casualty crash reductions being less than 10% and generally not statistically significant. From October 2014 onwards, estimated associated casualty crash reductions have increased greatly to 22% in the most recent completed year considered in the analysis. Indications are that crash reductions from October 2017 onwards have been even greater although the last analysis period covers only 4 months of data. In the most recent full year of the program analysed, the mobile speed camera program was associated with an estimated saving of over 3000 reported crashes, corresponding to savings in economic costs to the ACT community of over $60M. Both these figures reflect the much higher crash coverage of the mobile camera program compared to the fixed non-intersection camera program. Estimates of mobile speed camera program crash effects by district and year correlated strongly with the hours of mobile camera operation.

Analysis of ACT speed monitoring data estimated statistically significant reductions in both mean speeds, and 85th percentile speeds on average, over the post implementation period of the ACT Road Safety Camera Program, and particularly the mobile speed camera program. Average reductions in mean speeds of 4.6km/h and in 85th percentile speed of 4.9km/h were estimated. Whilst these estimates accorded with the average crash reductions over the post program implementation period, the patterns in estimated speed reductions over the post implementation period did not generally correlate with the time based variation in crash reduction estimates, due to the survey ending well before the crash analysis period and the mean and 85% percentile speeds being too coarse a measure of speed behaviour to reflect the likely impacts of the camera program.

Strategic analysis of the potential benefits of further expansion of the ACT Road Safety Camera Program showed potential for cost effective expansion of the program to produce further road trauma savings. For example, the benefit-cost ratio (BCR) and annual crash savings for 25 percentage increases in enforcement (camera units, sites, sections or MSC hours) were considered. The highest BCRs in rank order from a nominal 25% increase in enforcement were estimated for:

- Mobile speed camera hours (BCR 4.12 from 9 casualty crashes and 141 non-injury crashes saved per year)
- Fixed spot-speed cameras at mid-blocks on arterial roads (BCR 2.63 from 0.9 casualty crashes and 24 non-injury crashes saved per year)
- One additional fixed P2P camera system at a high-ranked long section of an arterial road (BCR 1.14 from 0.8 casualty crashes and 10 non-injury crashes saved per year)
- Speed/red-light cameras at signalised intersections (BCR 0.92 from 1.1 casualty crashes and unknown number of non-injury crashes saved per year)

The BCR and crash savings were also estimated for a new ATE type not yet used in the ACT, namely:

- Mobile P2P camera pairs operated regularly at two high-ranked long sections on arterial roads (BCR 2.39 from 0.6 casualty crashes and 7 non-injury crashes saved per year)

Further options for expansion of the program were considered which also showed even larger cost effective trauma reductions could be achieved through greater expansion.

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10 APPENDICES

A.1 Community attitudes to road safety speed related questions included in TARS (2014) evaluation

1. In the last two years, in your opinion, has the amount of speed limit enforcement carried out by police and speed cameras increased, stayed the same, or decreased?"

2. Have you personally been booked for speeding in the last two years?" And, if so "Have you personally been booked for speeding in the last six months?"

3. Thinking about 60km/h speed zones in urban areas:
   a) How fast should people be allowed to drive without being booked for speeding? (i.e. the 'acceptable' speed tolerance)
   b) How far over the speed limit are people generally allowed to drive without being booked for speeding?" (perceived 'actual' speed tolerance)"

4. Thinking about 100km/h speed zones in rural areas,
   a) How fast should people be allowed to drive without being booked for speeding?" (i.e. the 'acceptable' speed tolerance)
   b) How far over the speed limit are people generally allowed to drive without being booked for speeding?" (perceived 'actual' speed tolerance)"

5. Respondents were asked to consider five statements on speed issues and express their level of agreement or disagreement:
   1. Fines for speeding are mainly intended to raise revenue
   2. I think it is okay to exceed the speed limit if you are driving safely
   3. Speed limits are generally set at reasonable levels
   4. If you increase your driving speed by 10km/h you are significantly more likely to be involved in a car accident
   5. An accident at 70km/h will be a lot more severe than an accident at 60km/h

6. Do you think the amount of speed limit enforcement activity by police and speed cameras should be increased, stay the same, or decreased?"

7. Do you think the penalties for exceeding the speed limits should be more severe, or should they be less severe, or should they stay the same as they are now?"

8. Some road safety authorities believe that the speed limit in residential areas should be lowered from 60km/h to 50 or 40km/h. This would only apply to local streets and minor roads, not arterial roads or highways", they were then asked: "how would you feel about a decision to lower the speed limit in residential areas to 50km/h?"

9. In the last 2 years has your driving speed generally increased, stayed the same, or decreased?"

A.2 Speed related questions, Micromex survey 2013

1. **How strongly do you agree or disagree with the following statements: Please rate on the scale of 1 to 5, where 1 is strongly disagree and 5 is strongly agree.**

	Strongly disagree	2	3	4	5 Strongly agree
If I am careful. even when driving over the speed limit, · my chances of having a crash are low	O	O	O	O	O
The risk of being caught speeding is small	O	O	O	O	O
Enforcing the speed limit helps to lower the road toll	O	O	O	O	O
Increasing penalties for speeding would improve driver behaviour	O	O	O	O	O
Increasing the number of police officers on the road would improve driver behaviour	O	O	O	O	O

2. **How would you rate the effectiveness of the following methods of speed enforcement? The scale is 1 to 5, where 1 is not at all effective and *5* is very effective.**

	Not at all effective	2	3	4	5 Very effective
Speed camera vans	O	O	O	O	O
Fixed speed cameras	O	O	O	O	O
Point-to-point cameras (covering a length of road)	O	O	O	O	O
Police presence to cover a length of road	O	O	O	O	O

A.3 Enhanced ACT Community Attitudes to Speed Survey, MUARC 2018

1. Age group (years)

18 - 24

25 - 34

35 - 44

45 - 54

55 - 64

65 - 74

75 +

2. What licence(s) do you currently hold? (tick as many as appropriate)

Car: Learner's permit

Car: Provisional license or p/plate

Car: Full licence

Heavy vehicle licence

Bus driver's licence

Motorcycle: Learner's permit

Motorcycle: Provisional licence or P/plate

Motorcycle: Full licence

Taxi or hire car licence

I do not currently hold a licence

Other (please specify) ____________________________________

3. Gender

Male

Female

Other

Prefer not to say

4. Regarding the amount of speed limit enforcement activity by police and speed cameras, do you think this should be ....

Increased

Stay the same

Decreased

Don't know

5. Do you think the penalties for exceeding the speed limits should ....

Be less severe

Stay the same as they are now

Be more severe

Don't know

6. *Thinking about <u>60km/h</u> speed zones in <u>urban</u> (built up) areas* How fast do you think people <u>are generally allowed</u> to drive <u>without</u> being booked for speeding?

No more than 60 km/h (zero km over speed limit)

61 km/h (1 km over)

62 km/h (2 kms over)

63 km/h (3 kms over)

64 km/h (4 kms over)

65 km/h (5 kms over)

66 km/h (6 kms over)

67 km/h (7 kms over)

68 km/h (8 kms over)

69 km/h (9 kms over)

70+ km/h (10+ kms over)

Other (please specify) ________________________________

Don't know / cannot say

7. *Thinking about <u>60km/h</u> speed zones in <u>urban</u> areas* How fast do you think people <u>should be allowed</u> to drive <u>without</u> being booked for speeding?

No more than 60 km/h (zero km over speed limit) (1)

61 km/h (1 km over)

62 km/h (2 kms over)

63 km/h (3 kms over)

64 km/h (4 kms over)

65 km/h (5 kms over)

66 km/h (6 kms over)

67 km/h (7 kms over)

68 km/h (8 kms over)

69 km/h (9 kms over)

70+ km/h (10+ kms over)

Other (please specify) ________________________________

Don't know / cannot say

8. *Thinking about <u>100km/h</u> speed zones in <u>rural</u>* (country) *areas*
How fast do you think people <u>are generally allowed</u> to drive <u>without</u> being booked for speeding?

No more than 100 km/h (zero kms over)

101 km/h (1 km over)

102 km/h (2 kms over)

103 km/h (3 kms over)

104 km/h (4 kms over)

105 km/h (5 kms over)

106 km/h (6 kms over)

107 km/h (7 kms over)

108 km/h (8 kms over)

109 km/h (9 kms over)

110 km/h (10 kms over)

111 km/h (11 kms over)

112 km/h (12 kms over)

113 km/h (13 kms over)

114 km/h (14 kms over)

115+ km/h (15+ kms over)

Other (please specify) ____

Don't know / cannot say

9. *Thinking about <u>100km/h</u> speed zones in <u>rural</u> areas*
How fast do you think people <u>should be allowed</u> to drive <u>without</u> being booked for speeding?

No more than 100 km/h (zero kms over) (1)

101 km/h (1 km over)

102 km/h (2 kms over)

103 km/h (3 kms over)

104 km/h (4 kms over)

105 km/h (5 kms over)

106 km/h (6 kms over)

107 km/h (7 kms over)

108 km/h (8 kms over)

109 km/h (9 kms over)

110 km/h (10 kms over)

111 km/h (11 kms over)

112 km/h (12 kms over)

113 km/h (13 kms over)

114 km/h (14 kms over)

115+ km/h (15+ kms over)

Other (please specify) ______________________________________

Don't know / cannot say

10. Do you think that a *50km/h* speed limit in a *residential area* is .....

Too low

About right

Too high

Don't know

11. Do you think that the speed limits *below* *60km/h* should be set on .....

More streets

It's about right as it is now

Fewer streets

Don't know

12. Over the last few years the speed limit on some streets with high levels of pedestrian activity, such as shopping centres, has been reduced to 40 km/h.
Do you agree or disagree with these high activity *40 km/h* areas around areas such as shopping centres?

Agree strongly

Agree

Neither agree nor disagree

Disagree

Disagree strongly

Don't know

13. Do you agree or disagree with these high activity *40 km/h* areas around school zones?

Agree strongly

Agree

Neither agree nor disagree

Disagree

Disagree strongly

Don't know

14. Some road safety authorities believe that the speed limit in *residential* areas should be lowered from *50km/h* to *40km/h*. This would *only apply* to *local streets* and *minor roads*, not main roads or highways. How would you feel about a decision to *lower* the speed limit in *residential* areas to *40km/h*?

Approve strongly

Approve

Neither approve nor disapprove

Disapprove

Disapprove strongly

Don't know

15. Please consider the following 5 statements about speed issues and indicate your level of agreement or disagreement with each statement:

	Agree strongly	Agree somewhat	Neither agree nor disagree	Disagree somewhat	Disagree strongly	Don't know
If I am careful, even when driving over the speed limit, my chances of having a crash are low						
The risk of being caught speeding is low						
Enforcing the speed limit helps to lower the road toll						
Increasing penalties for speeding would improve driver behaviour						
Increasing the number of police officers on the road would improve driver behaviour						

16. Please consider the following 5 statements about speed issues and indicate your level of agreement or disagreement with each statement:

	Agree strongly	Agree somewhat	Neither agree nor disagree	Disagree somewhat	Disagree strongly	Don't know
Fines for speeding are mainly intended to raise revenue						
I think it is okay to exceed the speed limit if you are driving safely						
Speed limits are generally set at reasonable levels						
If you increase your driving speed by 10 km/h you are significantly more likely to be involved in an accident						
An accident at 70 km/h will be a lot more severe than an accident at 60 km/h						

17. How often (% of time) do you drive at *10km/h or more* over the speed limit?

Always (100%)

Nearly always (90% or more)

Often (around 50%)

Sometimes (around 20%)

Very occasionally (10% or less)

Never

Do not want to answer

18. Compared to your driving 2 years ago, how likely are you to drive over the speed limit?

More likely

Stayed the same

Less likely

Haven't driven in the last 2 years

Was not driving 2 years ago

19. Have you personally been booked for speeding during the last *2 years*?

Yes

No (skip to Q.22)

Can't recall (skip to Q.22)

20. If yes, how many times?

1

2

3

4

5+

Can't recall

Prefer not to answer

21. How were you detected?

Red light speed camera (intersection based)

Mobile camera van

Fixed mid-block camera (not at an intersection)

Point-to-point camera

Police patrol

Other (please specify) ____________________

Don't know / can't recall

22. Have you personally been booked for speeding in the *last six months*?

Yes

No (skip to Q. 24)

Can't recall (skip to Q. 24)

23. If yes, how were you detected? (tick as many as appropriate)

Red light speed camera (intersection based)

Mobile camera van

Fixed mid-block camera (not at an intersection)

Point-to-point camera

Police patrol

Other (please specify) ________________________________

Don't know / can't recall

24. Instead of checking a vehicle's speed at a single time and location (such as a red light/speed camera does), *point-to-point cameras* measure the vehicle's average speed over a distance of several kilometres.
How do you feel about the use of point-to-point camera enforcement on ACT main roads?

Approve strongly

Approve somewhat

Neither approve nor disapprove

Disapprove somewhat

Disapprove strongly

Don't know

25. Do you know if point-to-point speed cameras are currently used in the ACT?

Yes, they are used in the ACT

No, they are not used in the ACT (skip to Q. 27)

Don't know (skip to Q. 27)

26. If yes, what location (s) are these found? (give road names)

Location ____

Location ____

Location ____

Can't recall location

Don't know location

27. In the *last 2 years,* in your opinion, has the amount of speed limit enforcement carried out *by police* and through *speed cameras* .....

Increased

Stayed the same (skip to Q.29)

Decreased (skip to Q.29)

Don't know (skip to Q.29)

28. What type of speed enforcement do you feel has increased?

Mobile speed camera vans

Fixed speed cameras

Point-to-point cameras

Don't know

29. How would you rate the effectiveness of the following methods of speed enforcement?

	Very **in**effective	Somewhat **in**effective	Neither **in**effective nor effective	Somewhat effective	Very effective	Don't know
Mobile speed camera vans						
Fixed speed cameras						
Point-to-point cameras (covering a length of road)						
Police presence to cover a length of road						

30. Are you aware that on the *Access Canberra website* you can nominate a location where you think there should be a mobile speed camera?

Yes

No (skip to Q.32)

Haven't heard of this website (skip to Q.32)

31. Have you ever used that website to nominate a location for a mobile speed camera?

Yes

No

32. Are you aware that the ACT Government publish infringement data and camera locations on that website?

Yes

No (skip to Q.34)

33. Have you visited the open data section on that website?

Yes

No

34. Do you have any further comments about road safety cameras and speed limits within the ACT?

____

____

____

____

____

MONASH University

ACCIDENT RESEARCH CENTRE

A.4 Results of Community Attitude Survey, MUARC 2018

Age Group by Gender cross tabulation percentages

Age Group	Male	Female	Other	Prefer not to say
18 - 24	4.8%	2.2%	0.0%	0.2%
25 - 34	13.2%	6.1%	0.1%	0.5%
35 - 44	13.9%	5.4%	0.0%	0.4%
45 - 54	13.9%	5.4%	0.0%	0.5%
55 - 64	13.6%	5.0%	0.0%	0.4%
65 - 74	8.5%	3.3%	0.0%	0.2%
75 +	1.5%	0.5%	0.0%	0.0%

What licence(s) do you currently hold? (tick as many as appropriate)

Car: Learner's permit	Car: Provisional license	Car: Full licence	Heavy vehicle licence	Bus driver's licence	Motorcycle: Learner's permit	Motorcycle: Provisional licence	Motorcycle: Full licence	Taxi or hire car licence	I do not currently hold a licence	Other licence
1%	4%	97%	9%	2%	1%	1%	26%	1%	0%	1%

In the last 2 years, in your opinion, has the amount of speed limit enforcement carried out by police and through speed cameras .....

	Increased %	Same %	Decreased %	Don't know %
1995	59	28	4	9
1996	54	26	8	13
1997	55	33	7	5
1998	56	34	8	2
1999	58	30	6	5
2000	69	29	7	4
2001	74	13	7	5
2002	62	22	7	8
2003	77	15	5	3
2004	71	15	8	7
2005	72	21	3	3
2006	69	22	4	5
2008	63	27	8	2
2009	65	26	4	6
2011	64	27	5	4
2013	63	29	3	5
2018	38	35	11	17

Regarding the amount of speed limit enforcement activity by police and speed cameras, do you think this should...

Year	Should increase (% Agree)	Should stay the same (% Agree)
2003	34	
2004	47	
2005	37	52
2006	37	54
2008	45	48
2009	46	43
2011	44	44
2013	36	57
2018	31	44

What type of enforcement do you feel has increased?

Type	%
Mobile speed camera vans	87%
Fixed speed cameras	8%
Point-to-point cameras	3%
Don't know	2%

How would you rate the effectiveness of the following methods of speed enforcement?

	Fixed Speed cameras	Police presence to cover a length of road	Point-to-point cameras	Mobile speed camera vans
Very ineffective	22%	13%	13%	15%
Somewhat ineffective	23%	14%	13%	21%
Neither ineffective nor effective	8%	10%	10%	8%
Somewhat effective	31%	32%	32%	39%
Very effective	14%	23%	23%	15%
Don't know	2%	8%	8%	2%

Have you personally been booked for speeding in the in the last two years? Last six months?

	Red light speed camera (intersection based)	Mobile camera van	Fixed mid-block camera (not at an intersection)	Point-to-point camera	Police patrol	Other (please specify)	Don't know / can't recall
Last 6 Months	4%	31%	21%	3%	34%	4%	3%
Last 2 Years	9%	33%	19%	2%	32%	3%	3%

How do you feel about the use of point-to-point camera enforcement on ACT main roads?

Response	%
Disapprove strongly	31%
Disapprove somewhat	14%
Neither approve nor disapprove	12%
Approve somewhat	22%
Approve strongly	20%
Don't know	9%

Thinking about 60km/h speed zones in urban (build up) areas. How fast do you think people are generally allowed to drive without being booked for speeding? How fast do you think people should be allowed to drive without being booked for speeding?

	Should be acceptable		Actually permitted	
Year	Median (km/h)	No tolerance (%)	Median (km/h)	No tolerance (%)
1995		34		
1996		42		
1997		49		
1998		49		
1999 Mobile		49		
2000 Red light		38		
2001		44		
2002		51	65	15
2003	64	33	65	10
2004	65	28	65	13
2005	64	33	64	12
2006	64	32	64	15
2007 Fixed				
2008	64	36	65	21
2009	65	34	64	22
2011	64	31	64	20
2012 P2P				
2013	64	33	65	11
2018	66	15	65	18

Thinking about 100km/h speed zones in rural (country) areas. How fast do you think people are generally allowed to drive without being booked for speeding? How fast do you think people should be allowed to drive without being booked for speeding?

	Should be acceptable		Actually permitted	
Year	Median (km/h)	No tolerance (%)	Median (km/h)	No tolerance (%)
1995		27		
1996		23		
1997		36		
1998		28		
1999 Mobile		25		
2000 Red light		26		
2001		26		
2002		35	109	10
2003	107	22	109	6
2004	110	23	109	8
2005	109	20	109	7
2006	107	18	107	5
2007				
2008 Fixed	106	28	108	14
2009	110	23	108	15
2011	106	25	106	21
2012 P2p				
2013	108	19	108	10
2018	107	13	105	15

Please consider the following statements about speed issues and indicate your level of agreement or disagreement with each statement:

	The risk of being caught speeding is low	If I am careful, even when driving over the speed limit, my chances of having a crash are low	I think it is okay to exceed the speed limit if you are driving safely	Speed limits are generally set at reasonable levels
Disagree strongly	11%	12%	23%	11%
Disagree somewhat	28%	19%	23%	28%
Neither agree nor disagree	19%	16%	19%	11%
Agree somewhat	29%	30%	25%	40%
Agree strongly	12%	22%	10%	10%
Don't know	1%	0%	0%	0%

Compared to your driving two years ago, how likely are you to drive over the speed limit?

Response	%
More likely	4%
Stayed the same	66%
Less likely	28%
Haven't driven in the last 2 years	0%
Was not driving 2 years ago	1%

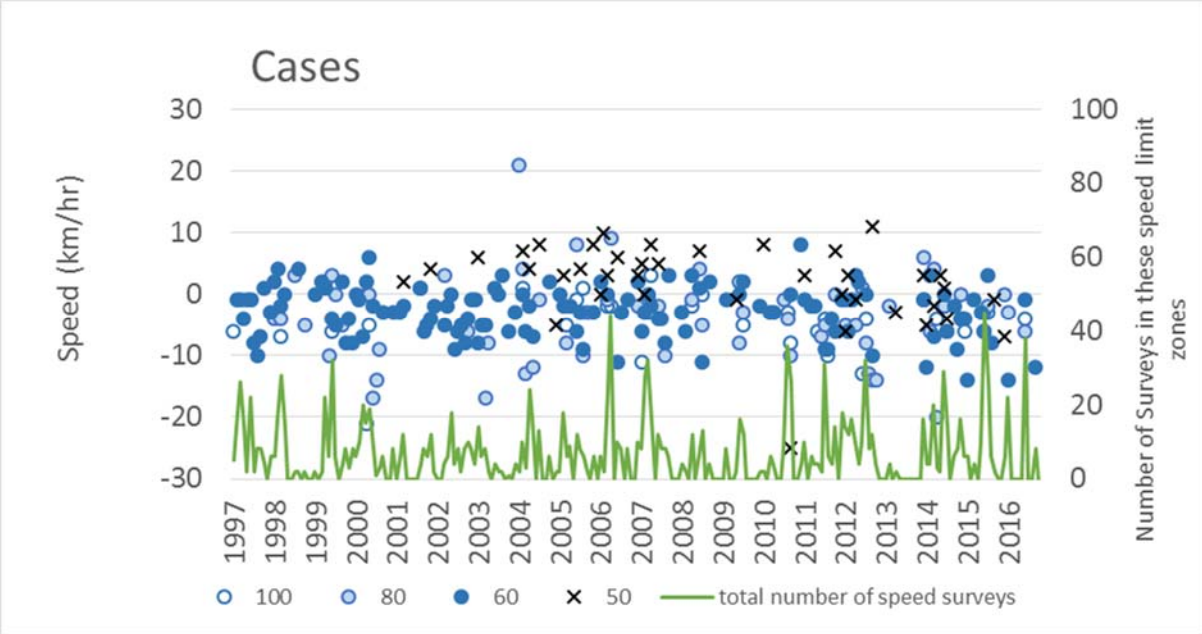
Access Canberra related questions:

	Are you aware that on the Access Canberra website you can nominate a location where you think there should be a mobile speed camera?	Have you ever used that website to nominate a location for a mobile speed camera?	Are you aware that the ACT Government publish infringement data and camera locations on that website?	Have you visited the open data section on that website?
Yes	33%	9%	51%	18%
No	58%	91%	49%	82%
Haven't heard of this website	9%			

A.5 Case and control streets used in the 2014 evaluation of speed surveys

CASES	CONTROLS
Anthill St	A'Beckett St
Athllon Drv	Archibald St
Barry Drv	Ballumbir St
Barton Hwy	Boldrewood St
Bateman St	Brigalow St
Beasley St	Canopus Cr
Belconnen Way	Chrisholm St
Canberra Ave	Condamine St
Carruthers St	Cowper St
Chuculba Cr	Culgoa Cct
Clift Cr	Dalrymple St
Clive steele Ave	Davenport St
Darwinia Ter	De Burgh St
David St	Emu Bank
Drakeford Drv	Fincham Cr
Dryandra St	Flemington Rd
Ellerston Ave	Forbes St
Federal Hwy	Foveaux St
Florey Drv	Goodwin St
Gilmore St	Grey St
Ginninderra Drv	Hawdon St
Gladstone St	Hopetoun St
Goyder St	Knox St
Groom St	Krefft St
Gungahlin Drv	Langdon Ave
Heyson St	Mackennal St
Hindmarsh Dr	Macpherson St
Kent St	McCaughey St
Kitchener St	McCulloch St
La perouse St	Melba St
Lady Denman Drv	Miller St
Launceston St	Moore St
Learmonth Drv	Mortimer Lewis
Livingston Ave	Murranji St
Macgregor St	Palmer St
Melrose Drv	Paul Coe Cr
Monaro Hwy	Ratcliffe Cr
Namatjira Drv	Scrivener St
Northbourne Ave	Spalding St
Novar St	Vanisttart Cr
Officer Cr	Verbrugghen St
Petterd St	Victoria St
Phillip Ave	Watson St
Ross smith Cr	Wattle St
Theodore St	William Slim Dr
Tillyard Drv	Windeyer St
Tuggeranong Pkwy	Wisdom St
Williamson St	

A.6 Mean difference of mean speed and speed limit for cases and comparisons by speed limit



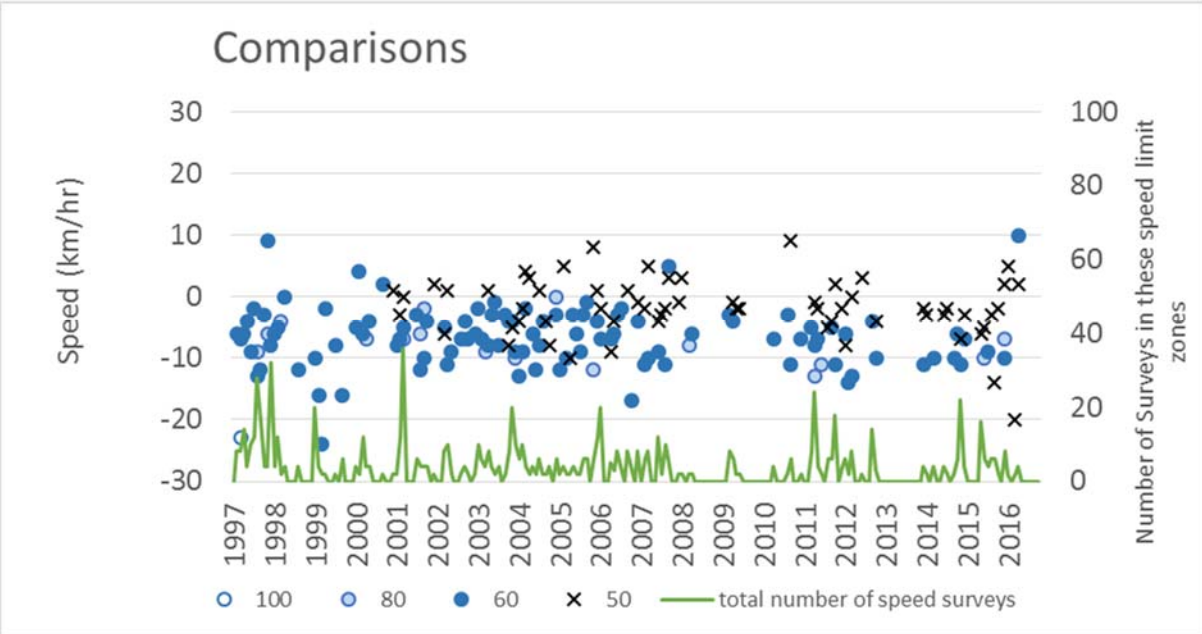


*Figure 53 a & b Mean difference of <u>mean speed</u> and **speed limit** for cases and comparisons by speed limit and the number of surveys within these speed limits.*

A.7 Speed survey analysis

Table 288 Mean speed change (referenced to speed limit) associated with the MSC Program for each calendar year for mean speed and for mean 85th percentile speed.

	Mean speed				Mean 85th percentile			
	Estimate	95% Confidence Limits		p-value	Estimate	95% Confidence Limits		p-value
Year								
1999	3.6	(-1.5	, 8.7)	0.17	4.4	(-1.0	, 9.7)	0.11
2000	-7.6	(-12.7	, -2.6)	0.003	-7.4	(-12.7	, -2.2)	0.01
2001	-5.3	(-9.6	, -1.0)	0.02	-5.8	(-10.3	, -1.4)	0.01
2002	-4.7	(-9.5	, 0.1)	0.06	-5.1	(-10.1	, -0.1)	0.04
2003	-7.1	(-11.6	, -2.6)	0.002	-7.1	(-11.8	, -2.4)	0.003
2004	-1.8	(-5.7	, 2.2)	0.38	-2.5	(-6.6	, 1.7)	0.24
2005	-5.6	(-10.4	, -0.8)	0.02	-5.2	(-10.3	, -0.2)	0.04
2006	-4.3	(-8.4	, -0.3)	0.04	-4.8	(-9.0	, -0.6)	0.03
2007	-3.8	(-8.1	, 0.5)	0.08	-3.7	(-8.2	, 0.7)	0.10
2008	-5.8	(-12.8	, 1.3)	0.11	-6.4	(-13.7	, 1.0)	0.09
2009	-4.4	(-12.2	, 3.5)	0.28	-4.8	(-13.0	, 3.5)	0.26
2010	-5.3	(-11.6	, 1.0)	0.10	-4.6	(-11.2	, 2.0)	0.17
2011	-5.9	(-9.9	, -1.9)	0.004	-6.5	(-10.7	, -2.3)	0.002
2012	-4.1	(-8.3	, 0.2)	0.06	-4.7	(-9.1	, -0.3)	0.03
2013								
2014	-4.7	(-9.8	, 0.4)	0.07	-5.2	(-10.6	, 0.1)	0.05
2015	-4.4	(-8.6	, -0.1)	0.04	-5.2	(-9.6	, -0.7)	0.02
2016	-11.6	(-18.3	, -5.0)	0.001	-12.1	(-19.0	, -5.2)	0.001

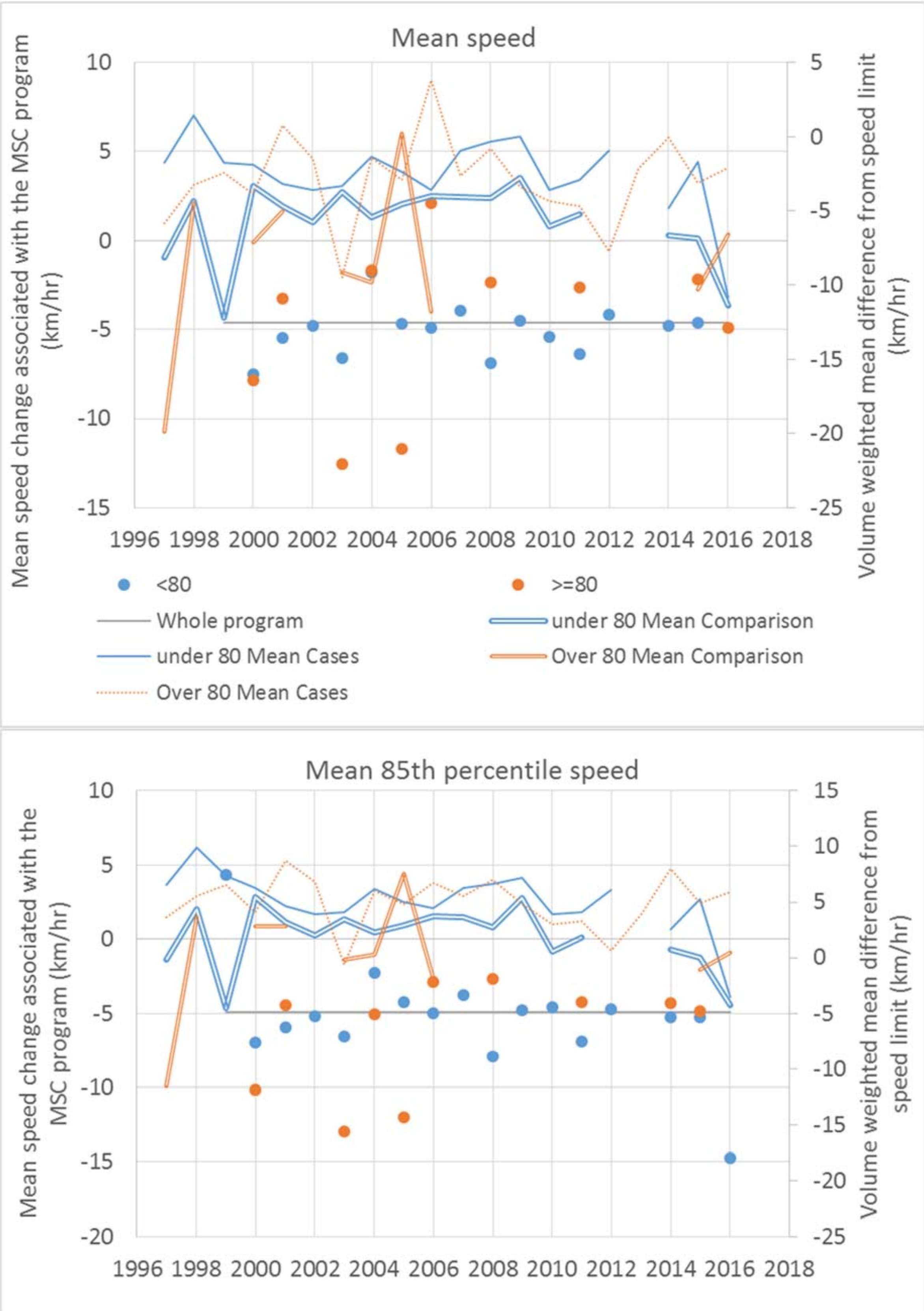


*Figure 54 Mean annual difference from the speed limit (coloured lines), and Mean speed change (**referenced to speed limit**) associated with the MSC program for each calendar year (circles) and for all years (whole program, thick grey line), for mean speed and for mean 85th percentile speed by broad speed zone.*

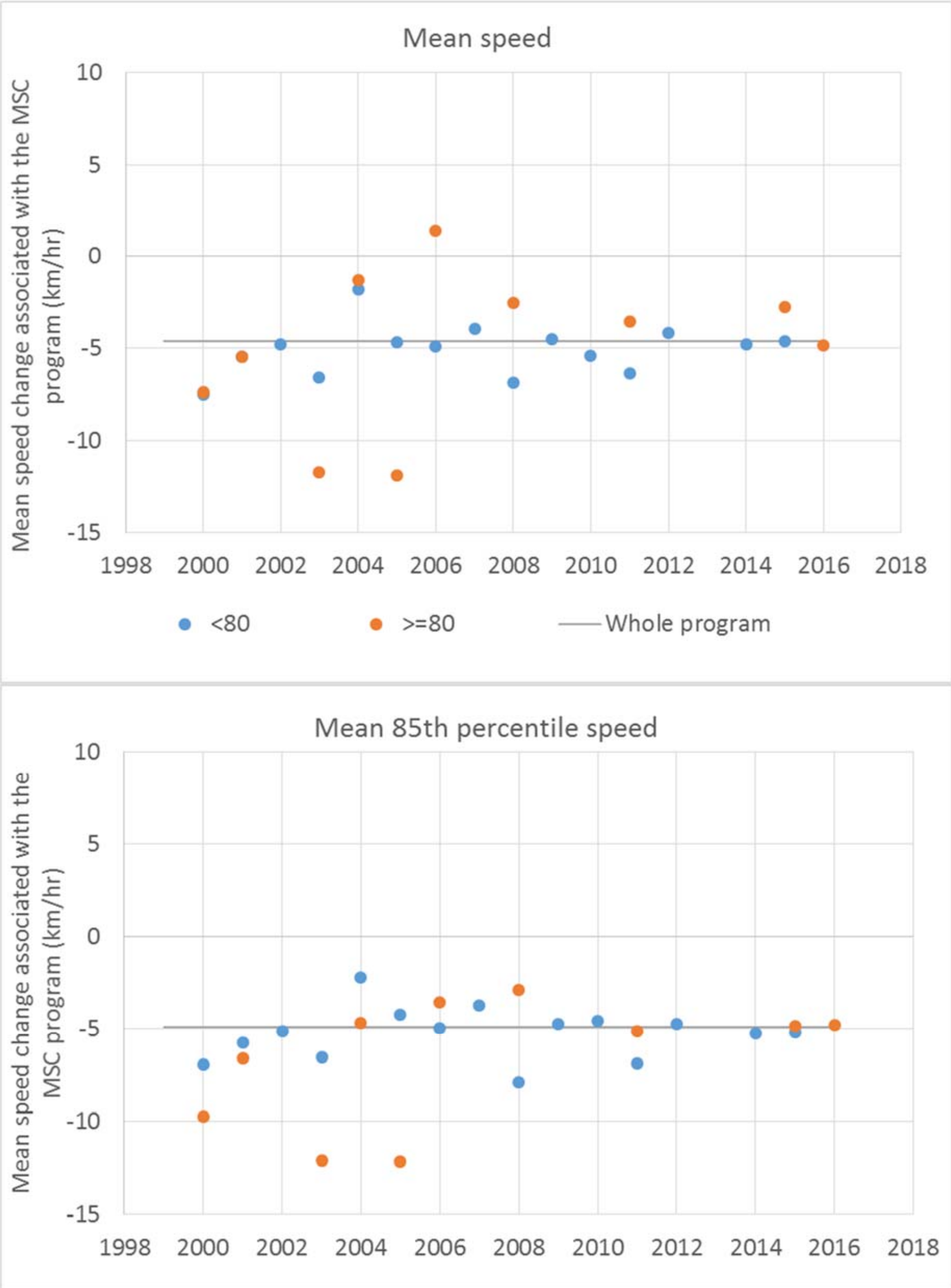


*Figure 55 Mean speed change (**referenced to threshold**) associated with the MSC program for each calendar year (circles) and for all years (whole program, grey line), for mean speed and for mean 85th percentile speed by broad speed zone.*

Table -299 Mean speed change (referenced to speed threshold) associated with the MSC program for each calendar year for mean speed and for mean 85th percentile speed.

	Mean speed			Mean 85th percentile		
Year	Estimate	95% Confidence Limits	p-value	Estimate	95% Confidence Limits	p-value
1999	3.5	(-1.6 , 8.7)	0.18	4.3	(-1.0 , 9.7)	0.11
2000	-7.6	(-12.6 , -2.5)	0.004	-7.4	(-12.6 , -2.1)	0.01
2001	-5.5	(-9.8 , -1.2)	0.01	-5.8	(-10.3 , -1.3)	0.01
2002	-4.7	(-9.5 , 0.1)	0.06	-5.2	(-10.2 , -0.1)	0.04
2003	-7.0	(-11.6 , -2.5)	0.002	-7.0	(-11.7 , -2.3)	0.004
2004	-1.7	(-5.7 , 2.2)	0.39	-2.4	(-6.6 , 1.7)	0.25
2005	-5.6	(-10.4 , -0.8)	0.02	-5.3	(-10.3 , -0.2)	0.04
2006	-4.4	(-8.5 , -0.3)	0.03	-4.9	(-9.1 , -0.6)	0.02
2007	-3.8	(-8.1 , 0.5)	0.08	-3.8	(-8.3 , 0.7)	0.10
2008	-5.8	(-12.9 , 1.3)	0.11	-6.4	(-13.8 , 1.0)	0.09
2009	-4.4	(-12.3 , 3.5)	0.28	-4.8	(-13.1 , 3.5)	0.25
2010	-5.3	(-11.7 , 1.1)	0.10	-4.6	(-11.2 , 2.0)	0.17
2011	-6.0	(-10.1 , -2.0)	0.004	-6.6	(-10.9 , -2.4)	0.002
2012	-4.1	(-8.3 , 0.2)	0.06	-4.7	(-9.2 , -0.3)	0.03
2013						
2014	-4.7	(-9.8 , 0.4)	0.07	-5.3	(-10.6 , 0.1)	0.05
2015	-4.4	(-8.7 , -0.1)	0.04	-5.2	(-9.7 , -0.7)	0.02
2016	-11.6	(-18.2 , -4.9)	0.001	-12.0	(-19.0 , -5.1)	0.001

Table -30 Mean speed change (referenced to speed limit) associated with the MSC program in speed zones under 80 km/hr for each calendar year for mean speed and for mean 85th percentile speed.

	Mean speed			Mean 85th percentile		
Year	Estimate	95% Confidence Limits	p-value	Estimate	95% Confidence Limits	p-value
1999	3.5	(-1.7 , 8.6)	0.19	4.3	(-1.0 , 9.7)	0.11
2000	-7.5	(-13.0 , -2.1)	0.007	-7.0	(-12.6 , -1.3)	0.02
2001	-5.5	(-10.0 , -1.0)	0.02	-5.9	(-10.6 , -1.3)	0.01
2002	-4.8	(-9.6 , 0.1)	0.05	-5.2	(-10.2 , -0.1)	0.05
2003	-6.6	(-11.3 , -1.9)	0.006	-6.5	(-11.5 , -1.6)	0.009
2004	-1.8	(-5.9 , 2.3)	0.39	-2.3	(-6.6 , 2.1)	0.31
2005	-4.7	(-9.8 , 0.5)	0.08	-4.3	(-9.6 , 1.1)	0.12
2006	-4.9	(-9.1 , -0.7)	0.02	-5.0	(-9.4 , -0.5)	0.03
2007	-3.9	(-8.3 , 0.4)	0.08	-3.8	(-8.3 , 0.8)	0.10
2008	-6.9	(-15.2 , 1.5)	0.11	-7.9	(-16.6 , 0.8)	0.07
2009	-4.5	(-12.4 , 3.4)	0.27	-4.8	(-13.1 , 3.5)	0.26
2010	-5.4	(-11.8 , 1.0)	0.10	-4.6	(-11.3 , 2.1)	0.18
2011	-6.4	(-10.7 , -2.0)	0.004	-6.9	(-11.4 , -2.4)	0.003
2012	-4.2	(-8.4 , 0.1)	0.05	-4.7	(-9.2 , -0.3)	0.04
2014	-4.8	(-9.9 , 0.3)	0.07	-5.3	(-10.6 , 0.1)	0.05
2015	-4.6	(-9.1 , -0.1)	0.04	-5.2	(-9.9 , -0.5)	0.03
2016	-13.8	(-21.5 , -6.1)	0.0004	-14.7	(-22.7 , -6.8)	0.0003

Table -31 Mean speed change (referenced to speed limit) associated with the MSC program in speed zones over 80 km/hr for each calendar year for mean speed and for mean 85th percentile speed.

	Mean speed			Mean 85th percentile		
Year	Estimate	95% Confidence Limits	p-value	Estimate	95% Confidence Limits	p-value
2000	-7.8	(-21.8 , 6.1)	0.3	-10.2	(-24.7 , 4.3)	0.2
2001	-3.3	(-18.1 , 11.6)	0.7	-4.4	(-19.9 , 11.1)	0.6
2003	-12.5	(-28.1 , 3.0)	0.1	-12.9	(-29.2 , 3.3)	0.1
2004	-1.7	(-15.7 , 12.4)	0.8	-5.1	(-19.7 , 9.6)	0.5
2005	-11.7	(-25.8 , 2.4)	0.1	-12.0	(-26.7 , 2.8)	0.1
2006	2.1	(-12.0 , 16.2)	0.8	-2.9	(-17.6 , 11.9)	0.7
2008	-2.3	(-16.5 , 11.8)	0.7	-2.7	(-17.4 , 12.0)	0.7
2011	-2.6	(-14.1 , 8.8)	0.7	-4.2	(-16.2 , 7.8)	0.5
2015	-2.2	(-16.1 , 11.7)	0.8	-4.3	(-18.8 , 10.1)	0.6
2016	-4.9	(-18.9 , 9.0)	0.5	-4.9	(-19.4 , 9.7)	0.5

Table -32 Mean speed change (referenced to speed threshold) associated with the MSC program in speed zones under 80 km/hr for each calendar year for mean speed and for mean 85th percentile speed.

Year	Estimate	95% Confidence Limits	p-value	Estimate	95% Confidence Limits	p-value
1999	3.5	(-1.7 , 8.6)	0.19	4.3	(-1.1 , 9.7)	0.12
2000	-7.5	(-13.0 , -2.0)	0.007	-7.0	(-12.7 , -1.3)	0.02
2001	-5.5	(-10.0 , -1.0)	0.02	-5.8	(-10.5 , -1.1)	0.02
2002	-4.8	(-9.7 , 0.1)	0.05	-5.2	(-10.2 , -0.1)	0.05
2003	-6.6	(-11.4 , -1.9)	0.006	-6.5	(-11.5 , -1.6)	0.010
2004	-1.8	(-6.0 , 2.4)	0.40	-2.3	(-6.6 , 2.1)	0.31
2005	-4.7	(-9.8 , 0.5)	0.08	-4.3	(-9.7 , 1.1)	0.12
2006	-4.9	(-9.2 , -0.6)	0.02	-5.0	(-9.4 , -0.5)	0.03
2007	-3.9	(-8.3 , 0.5)	0.08	-3.8	(-8.3 , 0.8)	0.11
2008	-6.9	(-15.2 , 1.5)	0.11	-7.9	(-16.6 , 0.8)	0.08
2009	-4.5	(-12.5 , 3.5)	0.27	-4.8	(-13.1 , 3.5)	0.26
2010	-5.4	(-11.8 , 1.0)	0.10	-4.6	(-11.3 , 2.1)	0.18
2011	-6.4	(-10.7 , -2.0)	0.004	-6.9	(-11.4 , -2.4)	0.003
2012	-4.2	(-8.5 , 0.1)	0.06	-4.7	(-9.2 , -0.3)	0.04
2014	-4.8	(-10.0 , 0.4)	0.07	-5.3	(-10.7 , 0.1)	0.06
2015	-4.6	(-9.1 , -0.1)	0.05	-5.2	(-10.0 , -0.5)	0.03
2016	-13.8	(-21.5 , -6.1)	0.0005	-14.7	(-22.8 , -6.7)	0.0003

Table -33 Mean speed change (referenced to speed threshold) associated with the MSC program in speed zones over 80 km/hr for each calendar year for mean speed and for mean 85th percentile speed.

	Mean speed			Mean 85th percentile		
Year	Estimate	95% Confidence Limits	p-value	Estimate	95% Confidence Limits	p-value
2000	-7.4	(-21.4 , 6.6)	0.3	-9.8	(-24.4 , 4.9)	0.2
2001	-5.5	(-20.4 , 9.5)	0.5	-6.6	(-22.2 , 9.0)	0.4
2003	-11.7	(-27.4 , 4.0)	0.1	-12.1	(-28.5 , 4.2)	0.1
2004	-1.3	(-15.4 , 12.8)	0.9	-4.7	(-19.4 , 10.0)	0.5
2005	-11.9	(-26.1 , 2.4)	0.1	-12.2	(-27.0 , 2.7)	0.1
2006	1.4	(-12.8 , 15.7)	0.8	-3.6	(-18.4 , 11.2)	0.6
2008	-2.5	(-16.8 , 11.7)	0.7	-2.9	(-17.7 , 11.9)	0.7
2011	-3.6	(-15.1 , 8.0)	0.5	-5.1	(-17.2 , 6.9)	0.4
2015	-2.7	(-16.7 , 11.2)	0.7	-4.9	(-18.8 , 10.1)	0.6
2016	-4.9	(-18.9 , 9.2)	0.5	-4.8	(-19.4 , 9.7)	0.5

Table -34 Fixed speed camera crash data

	Before		During	
	Treatment	Control	Treatment	Control
No-injury Crashes				
Barton Highway	418	1,291	269	1,272
Monaro Highway	880	426	501	306
Federal Highway	233	182	126	255
Tuggeranong Parkway	397	239	493	352
Hindmarsh Drive	850	3,464	217	1,016
All Roads	2,778	5,602	1,606	3,201
Casualty Crashes				
Barton Highway	46	48	29	49
Monaro Highway	50	29	41	45
Federal Highway	15	7	25	16
Tuggeranong Parkway	25	27	45	28
Hindmarsh Drive	47	111	27	47
All Roads	183	222	167	185
Fatal Crashes				
Barton Highway	2	1	0	1
Monaro Highway	2	1	0	1
Federal Highway	1	0	0	0
Tuggeranong Parkway	1	1	0	0
Hindmarsh Drive	2	3	0	1
All Roads	8	6	0	3
All crashes				
Barton Highway	464	1,339	298	1,321
Monaro Highway	930	455	542	351
Federal Highway	248	189	151	271
Tuggeranong Parkway	422	266	538	380
Hindmarsh Drive	897	3,575	244	1,063
All Roads	2,961	5,824	1,773	3,386

A.8 Mobile speed camera crash data

Table -35 Crash Counts by period, treatment group and road name for the fixed spot and point-to-point analysis.

	Treatment				Control			
Program Year	Metro <=60km/hr	Metro >60km/hr	Rural <=60 km/hr	Rural >60km /hr	Metro <=60 km/hr	Metro >60 km/hr	Rural <=60 km/hr	Rural > 60 km/hr
Before program	26091	9100	80	1232	4642	556	123	567
1	4784	1779	14	141	813	141	21	70
2	4604	1740	15	251	834	146	21	63
3	4465	1813	14	234	788	147	22	83
4	4140	1817	17	261	715	153	15	80
5	3952	1723	6	217	668	168	8	58
6	3546	1630	20	140	544	165	7	75
7	3715	1647	9	57	547	155	11	37
8	4153	1888	23	148	665	213	6	80
9	3931	1655	29	195	653	208	13	74
10	3950	1686	26	211	658	208	17	48
11	3683	1716	18	199	594	216	26	68
12	4258	2010	22	181	684	257	31	81
13	3979	1967	22	191	647	287	31	86
14	3862	1819	34	213	613	261	46	111
15	3579	1811	43	268	580	241	41	100
16	3570	1800	46	260	649	309	31	118
17	3740	1794	54	305	630	305	20	95
18	3763	1685	52	281	655	290	20	86
19	935	442	12	83	202	82	4	20

A.9 Logistic regression covariates odds ratios for severity analysis

Table -36 Odds of an injury crash associated with covariates relative to their reference levels.

Covariate	Odds Ratio Estimate	95% Confidence Limits		p-value
Un-signalised intersection	1.77	1.63	1.92	<.0001
Intersection	1.58	1.44	1.73	<.0001
Unknown if intersection	0.87	0.80	0.95	0.001
Divided road	0.78	0.73	0.84	<.0001
Unknown if divided road	0.49	0.44	0.53	<.0001
Majura, Kowen & Jerrabomberra	1.08	0.97	1.20	0.17
Woden Valley and Weston Creek	1.11	1.03	1.18	0.003
Belconnen	1.07	1.01	1.13	0.02
Tuggeranong	1.07	1.01	1.14	0.03
Gungahlin & Hall	0.98	0.90	1.07	0.6638
Rural South and West	1.14	0.99	1.31	0.07
Access Road	1.05	0.93	1.19	0.43
Collector Road	1.35	1.27	1.44	<.0001
Local Road	1.08	1.01	1.16	0.03
National or State Highway	1.46	1.25	1.70	<.0001
Sub-arterial Road	1.31	1.23	1.39	<.0001
Loose, oily, icy, snowy, muddy, or wet surface	0.99	0.88	1.11	0.87
Dark or semi-darkness	2.70	2.57	2.83	<.0001
Fog, rain, dust, snow, smoke or other	0.83	0.74	0.94	0.004
October 2015 and beyond	1.35	1.14	1.60	0.0006

Reference levels are listed in section **Error! Reference source not found.**.

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