1. **Purpose of this Fact Sheet**

The main purposes of this paper are:

- to describe types of speed cameras and their operational modes;
- to outline how speed cameras deter speeding;
- to summarise the measured effects of speed cameras on road trauma;
- to resent relationships between the intensity of enforcement and crash outcomes; and
- to outline a speed enforcement strategy for Western Australia featuring speed cameras.

2. **Types of speed camera operations**

There are a number of variables that influence the method and outcome of speed camera operations. In particular, speed cameras may operate overtly or covertly, be fixed or mobile, measure spot-speeds at a specific location or average speed over a road section, and may treat “black spot” locations or address problem behaviour across the entire road network. A brief explanation of the principles surrounding these modes of operation follows.

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

- In general, speed camera technology is either fixed or mobile. Fixed devices are located permanently at one site. In contrast mobile technologies are portable and tend to operate at one site for only a relatively short period of time.

- Traditionally, speed cameras and other manual speed enforcement methods have measured instantaneous speeds of vehicles passing a spot on the road (spot-speed). Recent technological developments, using Automatic Number Plate Recognition (ANPR) imaging, have allowed the average speed of a vehicle travelling from one point to another on a road to be measured (point-to-point cameras). An average speed greater than the speed limit between the two points is evidence of a speeding offence. This differs substantially from a spot-speed offence.

- In some circumstances, the location of speed cameras, whether fixed or mobile, may be chosen to affect a known problem of high crash risk or the risk of particularly severe crashes in a defined area. Such treatments are referred to as black spot treatments. Where the
increased risk relates to a particular route or area, the treatment can be spread across this black route or area. In general, black spot or black route operations are intended to have the greatest effect at the black spot site or along the black route. In contrast, other forms of speed camera operations aim to influence speeding across major parts of the road network, using techniques outlined below.

Decisions regarding overt or covert, mobile or fixed, spot-speed or average speed, and black spot or network-wide operations may be dependent on a number of factors and this is reflected in the variety of enforcement programs operating in different jurisdictions. Some common factors that likely influence the nature and extent of speed camera operations are the level of resources available (e.g. equipment, staff, and offence processing capacity), the road type to be enforced, the prevalence of speeding behaviour prior to enforcement, and public attitudes towards the use of automated or semi-automated speed enforcement technologies.

3. How speed cameras deter speeding

The two primary mechanisms through which speed camera enforcement may effect positive behaviour change are general deterrence and specific deterrence. The key reasoning behind these processes relies on utility theory as described by Ross (1981). Road users will decide whether or not to commit a traffic offence based on a rational analysis of the benefits and risks associated with committing the offence. Note that it is the perceived risks and benefits of committing the offence that determines the utility of the action. The perceptions of the certainty, swiftness and severity of punishment (in that order of importance) are generally accepted as the key elements of deterrence theory applied to traffic law enforcement and adjudication (Nichols & Ross, 1990).

General deterrence is a process of influencing a potential traffic law offender, through his fear of detection and the consequences, to avoid offending (Cameron & Sanderson, 1982). Therefore, operations employing general deterrence mechanisms necessarily target all road users irrespective of whether they have previously offended. It follows that general deterrence programs have the potential to influence the behaviour of all road users. Homel (1988) has established this as the key mechanism in the deterrence of drink-driving using random breath testing.

In contrast, specific deterrence is a process of encouraging an apprehended offender, through his actual experience of detection and the consequences, to avoid re-offending (Cameron & Sanderson, 1982). Therefore, the potential impact of a specific deterrence program may be more limited than that of programs relying on the general deterrence mechanism, unless the program is operated intensely. Enforcement programs relying solely on the mechanism of specific deterrence have the potential to immediately influence only those offenders who have previously been detected and punished for committing offences. (Other, potential offenders may be influenced by word-of-mouth communication with apprehended offenders.) It follows that the magnitude of the penalty, especially that applying if subsequent offences are committed, is of greater importance to specific deterrence programs than those relying on the general deterrence mechanism.

A general effect on speeding by a speed camera program, in contrast with a local effect, can be achieved through the mechanism of general deterrence or specific deterrence. General effects across a road network need not be produced only through general deterrence.

The threat inherent in a speed camera program influences its acceptability to the community and to the decision-makers. Some decision-makers perceive that the threat from some forms of speed camera enforcement would be too high and unacceptable. This attitude has resulted in some jurisdictions being reluctant to specifically deter speeders on a large scale and instead aiming to generally deter speeders only at identified problem locations.
4. Effects of speed cameras on road trauma

A large number of scientific evaluations of the effects on road trauma by speed cameras in various Australian States, New Zealand and Europe (particularly Great Britain) have been conducted and are summarised in Cameron and Delaney (2006). The effects vary by the mode of camera operations and indicate reductions in crashes at various levels of injury severity, depending on the study criteria used. Some modes of camera operations apparently achieve only local effects, some also weaker general effects, and some achieve strong general effects across the road system in which they operate. The covert operations generally achieve effects on the severity of casualty crashes, especially fatal and more serious crashes, as well as effects on crashes generally (Table 1).

Table 1. Measured effects of speed cameras on crashes and crash injury severity (percentage reductions in road trauma shown as negative values), Australasia and Great Britain.

<table>
<thead>
<tr>
<th>Type of speed camera site and operation:</th>
<th>Overt Camera Operations</th>
<th>Covert Camera Operations</th>
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<tbody>
<tr>
<td><strong>Effects On crashes:</strong></td>
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<tr>
<td><strong>Jurisdictions operating automatic cameras in this way</strong></td>
<td>Fixed installations, conspicuous signage</td>
<td>Randomly scheduled mobile operations at fixed sites</td>
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<tr>
<td>Fatal crashes</td>
<td>Great Britain New Zealand N.S.W.</td>
<td>Queensland (3000 hours per month, 2002)</td>
</tr>
<tr>
<td>Serious casualty crashes</td>
<td>Local effect [NSW]: -90%</td>
<td>Doubling of camera hours (2003) - Additional general effect: -9%</td>
</tr>
<tr>
<td>Serious casualty crashes</td>
<td>Local effect [GB]: -53%</td>
<td></td>
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<tr>
<td>Casualty crashes</td>
<td>Local effect [NSW]: -23%</td>
<td>Local effect [NZ]: -23% General effect: -13%</td>
</tr>
<tr>
<td>Casualty crashes</td>
<td>Local effect [GB]: -26%</td>
<td>Local effect: -35%. General effect: -26%</td>
</tr>
<tr>
<td>Casualties per casualty crash</td>
<td></td>
<td>Additional general effect: -9%</td>
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<tr>
<td>Serious casualties per crash</td>
<td></td>
<td>General effect: -21%</td>
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</tbody>
</table>
**Fact Sheet No. 5 Safety Benefits of Speed Cameras**

<table>
<thead>
<tr>
<th>Fatalities per crash</th>
<th>Material damage crashes</th>
<th>(Melbourne)</th>
<th>Additional general effect: - 51% *</th>
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<tbody>
<tr>
<td><strong>Local effect:</strong></td>
<td></td>
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<tr>
<td>- 20%</td>
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<tr>
<td><strong>General effect:</strong></td>
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<tr>
<td>≈ - 10%</td>
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* Added general effect of covert mobile operations in Victoria was principally due to the increased hours in 2001/02

Point-to-point camera systems measuring average speeds over road sections have not been included in the above table because of limited experience with them and very few evaluation studies. A system of 15 linked cameras on a 46 km section of highway in Strathclyde, Scotland was associated with a 29% reduction in serious casualty crashes and a 16% reduction in slight injury crashes during the first three years (A77 Safety Group, 2008). The point-to-point camera system covering speeds through a heavily-trafficked urban tunnel in Austria was associated with 33% reduction in injury crashes (including fatal), 49% reduction in fatal and serious injuries, and 32% reduction in slight injuries. These average speed cameras have a general effect across the whole of the road environment that they cover, in contrast with the limited local effect of fixed spot-speed cameras.

5. **Relationships between enforcement intensity and crash outcomes**

As well as the mode of operation, the effect of speed cameras is related to the intensity of operation in the road environment covered, and hence to drivers’ perceptions of the risk of detection when speeding. The intensity is measured by dimensions such as the number of fixed cameras, the monthly operating hours of mobile cameras, or the number of speeding tickets issued following detection of speeding offences by the different types of camera technology.

On the basis of a review of a large number of studies, Elvik (2001) derived a general relationship between speed enforcement intensity and casualty crash reductions. It was concluded that, even for the most effective forms of enforcement, 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. Effects beyond that level are uncertain.

**Covert mobile speed cameras**

Evaluations of the covert mobile speed camera program operating in Victoria provide the data from which the relationship between enforcement levels using this technology and crash outcomes was derived (Cameron, Newstead, Diamantopoulou & Oxley, 2003a,b). During 1999, Victoria Police varied the levels of speed camera activity substantially in four Melbourne Police districts according to a systematic plan. Analysis of the associated changes in casualty crash frequency revealed that crash frequency was inversely associated with changes in the levels of speeding TINs (Traffic Infringement Notices) issued following detection in the same district during the previous month. A similar relationship was found for the risk of fatal outcome in a casualty crash. The relationships are displayed in Figures 1 and 2 together with 95% confidence limits on the estimates.
Figure 1 shows the relative relationship between casualty crash risk and the level of speeding TINs issued in the prior month, relative to the average level of TINs issued, which was about 3,000 TINs per month from speeding offences detected in each Police District during 1999. Figure 2 shows the relationship between the risk of fatal outcome of the casualty crashes and the level of speeding TINs issued, again expressed in relative terms. As you can see, as TINs issued increase, the relative risk in both figures decreases.

**Overt mobile speed cameras with randomised scheduling**

Studies have been conducted on the crash reduction effects of the Queensland program as it has grown from 852 hours per month in 1997 to about 6,000 hours per month during 2003-2006 (Newstead and Cameron, 2003; Newstead, 2004, 2005, 2006). The crash reductions have generally been limited to an area within two kilometres of the camera sites. The strongest effects have been on casualty crashes, with no differential effect on crashes of different severity (fatal, hospital admission, or medical treatment crashes). As the program grew, the two kilometre areas around camera sites covered a greater proportion of the total casualty crashes in Queensland, rising from about 50% to 83% over the evaluation period. Thus the localised crash reductions around camera sites can be interpreted as a general effect on crashes, even if assuming that the program has no effect beyond the two kilometre areas (a conservative assumption). The relationship between the increased monthly hours and the general casualty crash reductions can be seen in Figure 3.
Figure 4 shows the estimated reductions in fatal crashes associated with the level of monthly hours operated each year. It should be noted that the individual annual estimated reductions are not as reliable as the reductions in all casualty crashes shown in Figure 3 and that no individual reduction is statistically significant. Nevertheless, the estimates do suggest a relationship between fatal crash reductions and camera hours of the same type as that in Figure 3. However, there is no evidence that the magnitude of the reduction achieved by the Queensland program on fatal crashes is any greater than that achieved on casualty crashes in general.

6. **A strategy for speed enforcement in Western Australia**

The information in Table 1 and illustrated in Figures 1-4 was used to define a package of speed enforcement options suited to the Western Australian road environment which together would produce at least 25% reduction in fatal crashes, somewhat smaller reductions in less-serious crashes, and would have maximum benefits from savings in crash costs compared with the investment (Table 2). As well as speed camera systems of appropriate type, the options considered included hand-held laser speed detectors and moving-mode mobile radar units, both of which require manual interceptions of detected speeding offenders. These interception methods were considered because of doubts about the cost-effectiveness of speed cameras operated on Western Australia’s lightly-trafficked rural local roads and urban residential streets.

### Table 2. Recommended speed enforcement programs

<table>
<thead>
<tr>
<th>Speed Enforcement Program</th>
<th>Speed Enforcement Hours per month</th>
<th>Speeding Tickets Issued per month (short-term)</th>
<th>Crash savings per month</th>
<th>Benefit Cost Ratio</th>
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<tbody>
<tr>
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<tr>
<td>URBAN ROADS (Perth)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Covert mobile speed cameras on urban highways</td>
<td>9,000</td>
<td>90,000</td>
<td>1.11</td>
<td>3.0</td>
</tr>
<tr>
<td>Laser speed detectors at black spot sites on urban local roads</td>
<td>1,025</td>
<td>3,410</td>
<td>0.11</td>
<td>2.4</td>
</tr>
<tr>
<td>Overt fixed spot-speed cameras on Perth freeways</td>
<td>Intermittent at 24 sites</td>
<td>10,000</td>
<td>0.04</td>
<td>0.7</td>
</tr>
<tr>
<td><strong>Total for urban roads</strong></td>
<td><strong>103,410</strong></td>
<td><strong>1.3</strong></td>
<td><strong>6.1</strong></td>
<td><strong>17.0</strong></td>
</tr>
<tr>
<td>RURAL ROADS (Rest of WA)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overt mobile speed cameras randomly scheduled on rural highways</td>
<td>3,000</td>
<td>10,000</td>
<td>1.13</td>
<td>6.4</td>
</tr>
<tr>
<td>Mobile radar units on rural local roads</td>
<td>15,000</td>
<td>11,250</td>
<td>0.62</td>
<td>4.9</td>
</tr>
<tr>
<td><strong>Total for rural roads</strong></td>
<td><strong>21,250</strong></td>
<td><strong>1.7</strong></td>
<td><strong>11.4</strong></td>
<td><strong>12.7</strong></td>
</tr>
<tr>
<td><strong>Total program for all WA roads</strong></td>
<td><strong>124,660</strong></td>
<td><strong>3.0</strong></td>
<td><strong>17.5</strong></td>
<td><strong>29.7</strong></td>
</tr>
<tr>
<td><strong>Percentage reduction in WA crashes</strong></td>
<td></td>
<td></td>
<td><strong>26.0%</strong></td>
<td><strong>12.3%</strong></td>
</tr>
</tbody>
</table>
Alternatives to the operation of covert mobile cameras on Perth’s urban highways were also considered in the analysis (Cameron and Delaney, 2006; Cameron, 2008). The options of operating the mobile cameras overtly (with randomised scheduling), or a mixture of overt and covert operations, were found to have similar crash reduction benefits but not as strong an effect on fatal crashes as covert operations (Cameron, 2008).

Another alternative considered was the installation of point-to-point speed cameras on Perth freeways, instead of fixed spot-speed cameras, and also on links on the urban and rural highway system suitable for their application. The analysis found that point-to-point cameras were potentially more effective and would have greater economic justification than the speed camera options in Table 2 for some parts of the Western Australian road system (e.g. Perth freeways).

7. Summary and conclusions

Speed cameras can be operated overtly or covertly, at fixed locations or mobile, measure spot-speeds or average speed on a road section, and can be directed at black spot locations or aim to reduce speeding network-wide. All forms of operation have been shown to reduce casualty crashes, at least locally around operating sites, but some operational forms have general effects across substantial parts of the road network that they cover. The operations producing general effects raise the perceived risk of detection when speeding anywhere within broad areas. These operations are characterised by intensive covert operation or randomised scheduling of overt mobile speed cameras. Point-to-point speed cameras measuring average speed along a road section offer the potential for a strong general effect over at least the road environments that they cover.

The acceptability of different forms of speed camera operation in a jurisdiction is related to the effectiveness and efficiency of the threat of being detected when speeding by each operational type. The decision to implement a speed camera system is a socio-political one reflecting the value society places on reducing road trauma, belief in the evidence that the camera system will achieve this, acceptance that the threat of detection when speeding is reasonable, and being prepared to forgo some of the perceived benefits of speeding.

A package of speed enforcement programs has been defined for the Western Australian road environment that recognised its relatively unique characteristics of vast size and light traffic density, except in Perth. A suitable speed enforcement method has been defined for each part of the Western Australia road system and the road trauma reductions and economic benefits calculated if operated at each level. The speed enforcement package, if fully implemented, is estimated to produce 26% reduction in fatal crashes, 12% reduction crashes resulting in hospital admission, and 9% reduction in medically-treated injury crashes. These effects correspond to a reduction of 36 fatal, 210 hospital admission and 357 medically-treated injury crashes per annum. This represents a saving of at least $186 million in social costs per annum, with a benefit-cost ratio of at least 10 to 1.

Alternatives to the speed camera options included in the package exist, such as operating the mobile speed cameras in Perth overtly (with randomised scheduling), or mixed overt and covert, instead of solely covert mobile operations, but the effect on fatal crashes would not be as great. The inclusion of point-to-point speed cameras in the package, replacing the fixed cameras on Perth freeways and other camera options on parts of urban and rural highways, where economically warranted, could make the package more cost-beneficial and effective.
8. References


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