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Benefits of mobile point-to-point safety cameras in rural South Australia

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TITLE

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ABSTRACT

The link between vehicle travel speeds and the likelihood of crashes and crash severity are well established. Speed enforcement in rural areas can be difficult due to the expanse of the road network and the limited resources available. Average speed enforcement has proven effective for improving compliance and safety along routes where it is used. Where fixed P2P enforcement is limited to the roads on which it is used, the advent of mobile average speed enforcement technology has the potential to provide more substantial and sustained enforcement activity across the rural road network. The effects of mobile P2P can be expected to be similar to fixed P2P provided they are deployed in a similar fashion (i.e., enforce all lanes and directions of travel, include signage advising drivers), although the magnitude can be expected to be lower due to lower enforcement times. Surveys of automated speed enforcement device manufacturers identified the mobile speed and P2P capabilities currently available. Four options for undertaking mobile P2P were developed based on the survey which were used to identify the potential resources needed to undertake this type of enforcement. Discussions with representatives from DIT and SAPOL identified the potential impact of introducing mobile P2P on current resources. The impact on police resources will vary depending on the method of deployment but in each instance are influenced by the type and number of devices, personnel, and back-end data processing and storage. while the capabilities exist, it is important to trial and evaluate the technology to ensure they are both feasible and effective methods of enforcement. The introduction of automated mobile P2P speed enforcement devices with the capability to address multiple problem behaviours has the potential to improve road safety in rural areas.

KEYWORDS

Mobile P2P, speed enforcement

Summary

The link between vehicle travel speeds and the likelihood of crashes and crash severity are well established. Enforcement, either by police or other automated methods (i.e., cameras) is one of the primary means to ensure drivers comply with established speed limits. Enforcement in rural areas can be difficult due to the expanse of the road network and the limited resources available. Average speed enforcement has demonstrated some success in improving compliance and safety along routes where it is used. The advent of mobile average speed systems that can be deployed across the rural road network has the potential to improve compliance and safety through more frequent and sustained enforcement activity virtually anywhere on the road network.

Mobile point-to-point (P2P) is a relatively new concept and there is little evidence available regarding the effects of this type of technology. In order to provide some idea of the potential benefits the effects of mobile P2P were inferred from evidence from fixed P2P and mobile spot speed enforcement. In general terms, mobile P2P can be expected to yield similar benefits to fixed P2P where they are deployed in a similar manner. That is, covering all available lanes and directions of travel and including signage at the commencement of, and intermittently throughout, the enforcement zone. While fixed P2P offers continuous enforcement, mobile enforcement does not. While time halos have been observed for mobile spot speed enforcement, it is not clear as to the extent this would be achieved for mobile P2P. As such, the magnitude of the effect of mobile P2P is likely to be lower than that observed for fixed P2P.

A survey of mobile speed enforcement technology manufacturers was undertaken to identify the availability of mobile P2P devices. Manufacturers included Acusensus, Redflex, Vitronic, Jenoptik, and Sensys Gatso. While all of the manufacturers of speed enforcement devices considered in this report have the potential to undertake fixed or semi-fixed P2P, only some report the capability to undertake mobile P2P and, of these, the capability is yet to be demonstrated in the field. A summary of the mobile speed and P2P enforcement capabilities offered by each is provided.

Based on the surveys of mobile speed enforcement technologies a number of options for undertaking mobile P2P were identified (assuming the capability exists) in order to determine the resources necessary to undertake enforcement. These options included the use of trailer-based systems, mobile vehicle-mounted or road-side devices, semi-fixed enforcement, and a combination of vehicle and trailer enforcement. Discussions with DIT and SAPOL identified the resourcing requirements necessary to undertake mobile P2P. The impact on existing resources will ultimately depend on the type and number of devices used, and the methods in which they will be deployed. Resourcing costs include:

- Personnel
- The type and number of devices
- Back-end data storage and processing.

Mobile P2P has the potential to enhance speed enforcement across the road network and particularly in rural locations where speed enforcement can be limited by the extent of the road network and the great distances that need to be policed. With advances and the increased capabilities of modern automated speed enforcement devices there is the potential to implement mobile enforcement systems that are capable of addressing key behaviours, such as speed, distraction, and seat belt use that are significant issues in rural areas. The mobile P2P concept is still in its infancy and while the capabilities exist, it is important to trial and evaluate the technology to ensure they are both feasible and effective methods of enforcement. The introduction of automated mobile P2P speed enforcement devices with the capability to address multiple problem behaviours has the potential to improve road safety in rural areas.

Contents

1 Introduction

The link between vehicle travel speeds and the likelihood of crashes and crash severity are well established (Aarts & van Schagen, 2006; Davis, Davuluri, & Pei, 2006; Doecke et al., 2018; Kloeden, McLean, & Glonek, 2002; Kloeden, Ponte, & Mclean, 2001; Nilsson, 2004; SWOV, 2012). Kloeden et al. (2001, 2002) estimated that on rural roads the risk of being involved in an injury crash approximately doubles with every 10 km/h above the average speed. Enforcement, either by police or other automated methods (i.e., cameras) is one of the primary means to ensure drivers comply with established speed limits. Enforcement in rural areas can be difficult due to the expanse of the road network and the limited resources available. Average speed enforcement (also called point-to-point or P2P) has demonstrated some success in improving compliance and safety along routes where it is used (see discussion below). The advent of mobile average speed systems that can be deployed across the rural road network has the potential to improve compliance and safety through more frequent and sustained enforcement activity. This report explores the safety benefits of mobile point-to-point systems, provides a summary of the mobile and P2P enforcement devices currently available, and identifies the resourcing requirements and the impact of introducing mobile P2P on police resources.

Mobile average speed enforcement is a relatively new concept and at the time of writing no evidence regarding either the use of such systems or evaluations of their effect was identified. Fixed point-to-point systems, however, have been in use for some time and there is a growing body of literature addressing the safety benefits of this type of enforcement. As the effects of mobile point-to-point are likely to be similar to fixed systems this review draws on the current state of knowledge regarding fixed point-to-point enforcement and considers the extent to which these effects might be expected for mobile systems.

2 The effects of fixed point-to-point enforcement

The goal of point-to-point enforcement is to control speeds along sections of road between two points. Knowing the distance between detection points at the beginning and end of the enforcement zone makes it possible to determine the average speed of vehicles between points. Drivers of vehicles found to exceed the speed limit, accounting for enforcement tolerance levels, can then be issued an infringement notice. An important characteristic of fixed point-to-point cameras is that they are in operation continually and typically enforce the speeds of vehicles travelling in all lanes and all directions.

Point-to-point cameras are relatively new in terms of traffic enforcement and while they have not been subjected to the same level of scientific scrutiny as other types of automated enforcement, there is a growing body of evidence regarding their effects on speeds and safety. The best evidence comes from studies that control for the effects of regression to the mean (RTM – a statistical phenomenon that describes a return to a "normal" state following high or low occurrences of an event in a series of data) and/or use control roads to control for the effects of confounding factors that may also contribute to the observed effects (e.g., general improvements in road safety, economic factors, weather, etc.). It is important to control for RTM when considering the effectiveness of speed cameras given the criteria for installation usually include crash history; sites with an unusually large number of crashes before the installation of a speed camera may be affected by RTM such that any observed reduction in crashes may have occurred even had a speed camera not been installed.

One of the few studies of P2P enforcement that considers the effects of RTM is a meta-analysis undertaken by Høye (2014). Høye identified four studies examining the effects of P2P, all of which followed a repeated-measures design and involved some method to control for general changes in crash numbers over time (e.g., comparison roads); two of the included studies controlled for RTM. The analysis found that P2P reduced all crashes by 30% (95%CI: 0.64 – 0.76) and those of greater severity (i.e., KSI) by 56% (95% CI: 0.34 – 0.58). This analysis also identified that 85th percentile speeds within enforcement zones reduced to below the speed limit and the proportion of speeding drivers was reduced to less than one per cent. The effects for P2P were greater than those found for fixed speed cameras, for which all crashes were reduced by about 20% (95% CI 0.72 – 0.90) and fatal crashes by 51% (95%CI 0.28 – 0.88). These findings were not likely to be influenced by RTM (Høye, 2014). This study provides the best estimate of the effect of P2P cameras currently available.

An important effect of any automated enforcement is the halo effect, or the area of effect in which the safety benefits may be observed. For spot speed cameras (fixed or mobile) the effect on speed are largely localised to the camera location, with stronger effects observed closer to the camera site (e.g., Christie et al., 2003; Gunarta & Kerr, 2005; Jones et al., 2009; Keall et al., 2002; Newstead & Cameron, 2013), although safety effects up to five kilometres past cameras have been observed (Thomas et al., 2008). Other research has also shown that drivers tend to slow down at camera sites but speed up again once past (De Pauw et al., 2014). One of the arguments behind the use of P2P enforcement is to achieve the effects on speeds and crashes over a larger section of roadway. While the effects reported above are generally observed within the average speed enforcement zone, a study examining P2P enforcement on a ring route around the city of Naples, Italy demonstrated that halos for P2P may be extend further than the enforcement zone (Montella et al., 2015). Montella et al (2015) observed a 32% reduction in total crashes within the enforcement zone, which covered about half of the ring route, but also observed a statistically significant reduction of 21% in total crashes on the part of the route without P2P, suggesting an extended halo effect (the unenforced section of the ring route was 22.3 km in length; the enforced section was 18.1 km). While these results were observed for a ring route, it is not clear whether this finding would apply to other types of roads. No other studies addressing distance halos for P2P enforcement were identified at the time of writing.

In addition to distance halos, automated enforcement may be subjected to time halos (i.e., the time period during which the effect may be observed). A few studies have examined this phenomenon. In a study of overt and covert spot-speed camera enforcement Wilmots et al., (2016) found that in the three weeks after speed enforcement activity speeds near enforcement sites increased but remained lower than speeds measured before enforcement activity. Wilmots et al. (2016) did not measure speeds beyond this time period. Gouda and El-Basyouny (2017) examined the time halo effect (in terms of the percentage of speed limit violations) of mobile enforcement on urban arterial and collector roads in Edmonton (Alberta, Canada). Across nine (seven arterial, two collector) sites in total they identified a halo effect of 4-7 days. The length of the effect was found to correlate with the number of times each site was used in the previous week and the total enforcement hours for that week; more visits and greater time of enforcement produced longer-lasting halo effects. For the P2P study in Naples, Italy, Montella et al. (2015) found that while the effect of P2P on total crashes appeared to be sustained over the three years post installation, it was more effective in the first year where a 32% reduction in crashes was observed with slight declines observed in the second (30%) and third (28%) years.

As with spot speed enforcement, the effects of P2P are likely due to driver awareness of the presence of the speed detection devices. In the case of P2P, extending the effects between two sites are likely due to drivers being aware that they are in a P2P enforcement zone and understanding that it detects infringements based on average speeds based on time taken to travel between the start and end points. In South Australia, P2P enforcement zones use roadside signs to inform drivers that they have entered a P2P zone and additional signs to remind drivers of this fact throughout the enforcement zone. Although research examining the contribution of signage to the effects of P2P were not identified, it is likely that driver awareness of the enforcement activity and how it works is necessary to achieve the desired behaviour in the enforcement zone (Soole et al., 2013).

2.1 Mobile point-to-point enforcement

A mobile P2P system is essentially a P2P system that is able to be deployed at a number of different sites. Presently there is no publicly available evidence regarding the use or efficacy of mobile P2P systems so outcomes must be inferred from what is known of fixed P2P and mobile spot speed enforcement while accounting for the operational differences between fixed and mobile systems. The key differences are that fixed systems provide continuous enforcement and are often accompanied by signage that indicates the commencement of the enforcement zone and signs to provide intermittent reminders. At present, mobile enforcement is predominantly used for spot speed enforcement, the effect of which are predominantly observed during enforcement periods, although halo effects during non-enforcement periods have been observed (e.g., Gouda & El-Basyouny, 2017). Mobile spot speed cameras are often sign-posted alerting drivers to their presence and indicating that the specific camera is only enforcing at that site at that time.

Broadly speaking, the effects of mobile P2P are expected to be similar to fixed P2P in terms of reductions in average speeds, the number of speeding vehicles, and crash numbers, however, there are a number of caveats to consider. First, to achieve these effects, mobile P2P would need to be deployed in a similar manner to fixed and include signage at the commencement of the enforcement zone and reminders throughout. Second, the magnitude of the effect of mobile P2P is likely to be smaller than fixed due to shorter duration of enforcement. Some have argued that the effects of mobile P2P are likely to be half that of fixed P2P assuming that the mobile variant enforces only one direction of travel (Clark et al., 2019). This would depend on the type of technology used and the manner in which it was deployed. Potential deployment options for mobile P2P systems are described in the next section.

While the effect of mobile P2P may be somewhat reduced compared to fixed P2P systems, the benefits of being able to undertake P2P enforcement in a number of areas are to be expected but are difficult to

quantify. The ability to relocate a mobile system would enable average speed enforcement to be undertaken in locations where fixed P2P cameras cannot be used due to lack of infrastructure (e.g., access to power and telecommunication network, etc.), or in locations where fixed P2P may not be feasible due to low traffic volumes or seasonal fluctuations in traffic. It would also be possible to deploy mobile P2P platforms based on local traffic intelligence, enabling enforcement at, for example, road works, or during significant events or periods (e.g., public holidays) that may produce increased traffic.

2.1.1 Types of mobile P2P

There are two common methods for deploying mobile P2P enforcement. The first consists of two vehicle-based speed cameras with ANPR capability (either mounted to/in a vehicle or set up at roadside, e.g., mounted on a tripod), one each up and down-stream, that are attended by a human operator while they are deployed for short periods (i.e., less than 24 hours). The second method involves trailer-based systems (see example in Figure 2.1) that can be left in place for longer periods of time. In Queensland, such trailers are fitted with extensive security measures to reduce the impact of vandalism, including a tracking system that monitors the camera's location, alarms, and they are also monitored remotely via CCTV. Camera trailers can be used in locations that are not safe for other, manned devices, and can be left in place for extended periods (e.g., weeks).

Figure 2.1
An autonomous speed camera trailer used in Queensland (source: abc.net.au)

As a side note, it has been suggested that using vehicles or trailers that are either identical or very similar to other mobile spot speed enforcement cameras may have wider benefits as road users would be uncertain as to whether a single camera they have passed is part of a P2P system (Clark et al., 2019). It has been suggested that this could broaden the halo effect of spot speed enforcement (Clark et al.) however, at the time of writing, no research regarding this effect was identified.

3 The state of current technology

There are, at present, several companies with existing mobile spot speed technology. Most claim to have the capability to undertake mobile P2P enforcement but, to the best of our knowledge, this has yet to be proven in field trials or other settings. These are described below.

3.1 Acusensus

A new-comer to the field, Acusensus are making a name for themselves primarily in the area of developing mobile cameras – *Heads Up* – that are able to detect distraction (i.e., mobile phone) offences. The *Heads Up* system is also capable of measuring vehicle speed via radar-based methods, or the use of ANPR over road sections (i.e., P2P). *Heads Up* is also able to detect seat-belt offences, and unregistered or priority listed vehicles (via ANPR). Additional capabilities possible with further development of the system could be used to monitor close-following, vehicles travelling the wrong way, and illegal overtaking. The system also has the potential to monitor compliance for specialised traffic lanes (e.g., high-occupancy lanes – additional cameras for back seat needed). The *Heads Up* system can be deployed in fixed or mobile configurations, with the recommended mobile deployment configuration utilising a specially designed trailer (see Figure 3.1), which can be left in place for extended periods (up to months at a time) depending on the power sources used (solar, battery, generator, or combination) and depending on the needs of clients. Multiple trailers would be required for P2P enforcement.

The use of the *Heads Up* system to detect mobile phone offending has been trialled by a number of Australian jurisdictions, including Victoria, while NSW introduced the cameras in December 2019 where, following a three-month introductory period (where drivers received a warning rather than penalty), full-time enforcement commenced in March 2020.

The capabilities of *Heads Up* in terms of the ability to detect a number of offences make this a versatile and attractive option for mobile P2P enforcement. The ability to undertake enforcement of multiple offences with one (or two as the case may be) cameras would be particularly advantageous in rural areas. However, it must be noted that, to our knowledge, P2P capabilities have not yet been developed for this system nor have they been fully tested.

Figure 3.1
Acusensus *Heads Up* system deployed in mobile trailer configuration (source: acusensus.com)

3.2 Vitronic

Vitronic provide P2P speed enforcement via the POLISCAN Seco platform that uses lidars for speed measurement and is able to be deployed in a mobile configuration when integrated with Vitronic's enforcement trailer (see Figure 3.2). The POLISCAN Seco system is able to monitor multiple vehicles in multiple lanes, is able to classify different vehicle classes, and can also be combined with ANPR applications. The trailer can be transported by a vehicle with a tow bar and may be able to be left in place for up to 10 days (trailer used for mobile spot speed enforcement can be left in place for up to 10 days, this time may differ for mobile P2P if the P2P configuration alters performance, e.g., power consumption). The trailer is protected by anti-vandalism through a fully sealed, bullet-proof shell, an alarm, and it can be completely lowered off of its wheels to prevent it from being towed away. For P2P enforcement two trailers would be necessary.

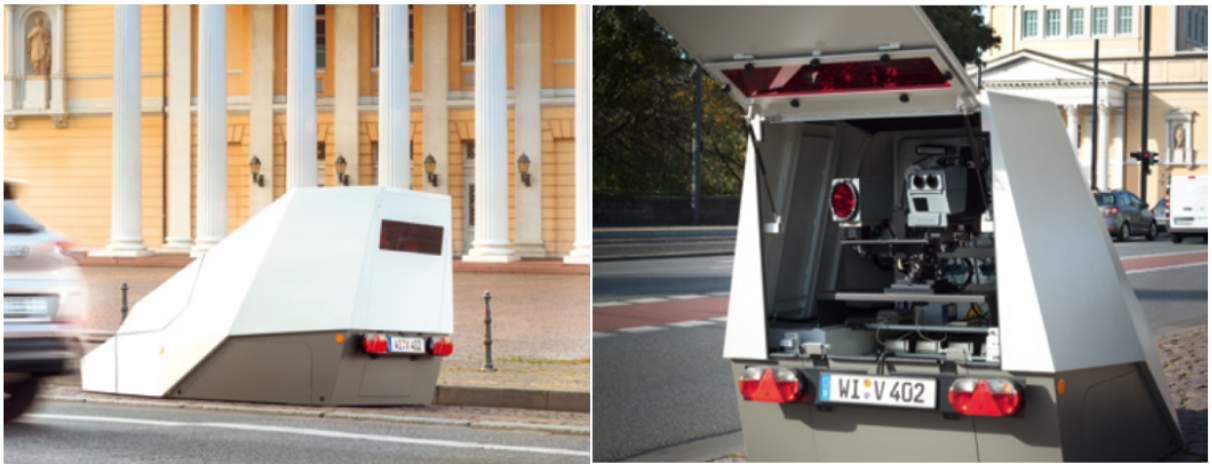

Figure 3.2
Vitronic enforcement trailer in situ and rear internal view (source: https://www.vitronic.com/en-us/traffic-technology/speed-enforcement)

3.3 Redflex

Redflex's systems are primarily radar-based. The Halo family of devices have been developed for point-to-point enforcement. The *Halo Edge* is a fixed-camera system that uses an AI system to identify a variety of details, including vehicles, pedestrians, and licence plates. The system is scalable such that the AI can be adapted to detect other offences, including distraction, seat belts, detection of types of vehicles (e.g., dangerous goods vehicles), and monitor special traffic lanes (e.g., bus lanes). The system also has ANPR capability, bringing associated enforcement capabilities (e.g., unregistered, unlicensed, hot list vehicles).

Other fixed P2P options include the *Halo* and *Halo Distributed* systems. These have the capabilities of devices used for this type of enforcement, including average and spot speed enforcement, ANPR related enforcement, and close following.

None of the P2P systems offered by Redflex are described as having mobile capabilities, but it is possible that they may develop such capability in the future.

3.4 Jenoptik

Jenoptic have a range of speed enforcement technologies utilising radar, laser, and induction loops to detect and measure the speed of vehicles. As with other manufacturers in this field they have a range of devices including fixed cameras, vehicle mounted (mobile and stationary), and average speed control.

Some of their systems (e.g., Traffistar models) can also be adapted to detect other offences, including red light, illegal turns, and illegal stopping (e.g., in pedestrian crossings). Jenoptik also have two systems for P2P enforcement – the Traffisection S450 modular system and the VectorP2P system. Of these the Vector P2P is described as having the ability to be used semi-stationary, although no further elaboration of this capability is provided.

The Vector P2P is able to detect speeds and vehicles across four lanes simultaneously and in both directions of travel. As Jenoptik speed enforcement cameras use both radar and laser sensors to measure speed, so it is likely the Vector P2P system uses these.

3.5 Sensys Gatso

While Sensys Gatso do not, at the time of this report, have a system designed specifically for mobile P2P enforcement they have a number of mobile speed enforcement systems and a fixed P2P system. Mobile speed enforcement options include in-vehicle, semi-fixed, and portable systems. The in-vehicle system is installed in vehicles and is capable of undertaking enforcement while driving and while parked. The semi-fixed system is intended for use at sites and locations where it is to be left unattended (e.g., road work sites). It can be set up by one person and operate for up to 10 days unattended on it's battery system, and is protected by vandalism and theft countermeasures. The portable system is tripod mounted and can be set up at the side of the road. The Sensys Gatso P2P system – *GATSO Section Control* – can be installed on existing infrastructure (e.g., gantries) and is capable of monitoring multiple lanes and is capable of measuring vehicle lengths to enforce speed limits for different types of vehicles.

4 Resources required to undertake mobile P2P enforcement

The introduction of mobile P2P enforcement will require the allocation of resources from SAPOL, which will be determined by the type and method of mobile P2P utilised. Several options for mobile P2P enforcement are described below.

Mobile enforcement via vehicle or roadside deployment

This type of enforcement would make use of systems mounted either to/in a vehicle or that are able to be deployed at the roadside (e.g., tripod mounted). In the case of vehicle-mounted systems two vehicles and human operators would be necessary. It may be possible to deploy as a combination vehicle-mounted and tripod-mounted, although both systems would require an attending operator, but this reduces the need for a second vehicle. The duration of this type of enforcement is limited by the need for human operators but also has the potential to be deployed at multiple locations during the day.

Trailer-only deployment

Trailer-only deployment would involve the use of two trailer-based systems at the beginning and end of the road section to be enforced. The duration of enforcement is dependent on the available power sources but could range from hours to weeks. The use of two trailers would require two tow vehicles and human operators for deployment.

Semi-fixed enforcement

The semi-fixed method of deployment would involve the installation of permanent infrastructure at enforcement locations (e.g., gantries or road-side poles) and the use of P2P systems that can be attached to these. Under this model, devices could be left in place for as long as practicable and then moved to other sites on the road network. Additional benefits of this method include the ability to meet legislative requirements for fixed P2P, allowing the use of gazetted sites. Installation and calibration may also be simplified due to the distance between end points being known. As the supporting infrastructure would remain in place there is the potential to deter speeding even when enforcement devices are not present. As the infrastructure would be fixed in place, it would also be possible to have warning signs in place, which may further enhance the efficacy of enforcement for these sites. Limitations of this approach are that enforcement sites may be limited to locations where existing infrastructure, particularly power sources and telecommunications, are readily available. This may exclude sections of the road network in more remote areas or increase the costs of installation to install power and telecommunications infrastructure.

Combination trailer and mobile

Another option for consideration is the use of trailer-based systems with a mobile device – vehicle or tripod mounted. Under this method one vehicle would be require to tow and deploy the trailer with the vehicle then moving to another location to act as the other bounding point to the enforced section. The duration of this method of enforcement would be limited by the need for human operators but potentially reduces the costs associated with using two trailers or two vehicles. It should be noted that while this method may be possible in theory confirmation with speed enforcement device manufacturers and trial of such systems would be required.

4.1 Enforcement resources

Discussions with Matthew Lohmeyer from the Department for Infrastructure and Transport (DIT) and Inspector Cindy Healey from SA Police (SAPOL) identified a number of considerations for resourcing associated with the deployment methods described above, including the costs of devices, the personnel necessary to undertake enforcement, maintenance, and the processing of data and distribution of traffic infringement notices. These costs are described below.

Personnel

This section is prepared on the assumption that mobile P2P is undertaken in addition to current levels of mobile spot speed enforcement. The increase in personnel will vary based on the deployment methods and OHSW practices. Assuming a minimum of one operator per device, a minimum of two operators are required where the deployment involves devices that are attended by an operator at all times, Where the trailer-plus-mobile deployment described above is used it may be possible to undertake the enforcement with a single operator.

An increase in the number of enforcement devices in use may require an increase in maintenance personnel to ensure maintenance schedules are maintained. At present, SAPOL undertake testing of fixed cameras every 28 days, which requires two personnel working on the same job. Increasing the maintenance cycle may reduce the impact of additional devices in the maintenance cycle. Increasing the number of devices and maintaining the current 28-day cycle may require additional personnel whereas increasing the maintenance cycle may be able to manage additional devices without the need for additional personnel.

In South Australia, mobile speed enforcement and camera maintenance are undertaken by unsworn officers.

The increase in offences detected and traffic infringement notices generated will likely require additional personnel to aid with the processing and management of these.

Enforcement devices

The nature of any form of P2P enforcement is such that a minimum of two devices are necessary. Considerations for resources will be determined by the deployment methods used and will include:

- The need for vehicles to deploy and/or undertake the enforcement;
- The number of trailers needed;
- The number of mobile devices needed;
- Semi-fixed devices require the installation and maintenance of roadside infrastructure.

For unattended enforcement devices (i.e., trailers) additional considerations include power sources, including solar, battery, generators, or a combination of each. Furthermore, while the trailer-based devices described above generally have security measures to reduce vandalism and tampering, there may be the added costs associated with monitoring CCTV security feeds, alarms, and also attending to any incidents.

Back-end resources

At present SAPOL handle all aspects of automated enforcement in terms of data storage and processing and the generation of traffic infringement notices. The introduction of mobile P2P can be expected to generate an increase in enforcements and thus an increase in the use of back-end resources in terms

of data storage and processing capabilities (the need for additional personnel was identified above). The number of additional infringements would be a product of the traffic volumes on the roads enforced and the duration of the enforcement. As unattended trailer-based enforcement may be in place longer than other types of enforcement involving human operators, it is possible that they will place a greater burden on back-end data processing and storage. It is also necessary to consider the need for additional resources/servers to securely store and handle the increase in enforcement data, including the buildings where these are located and the security and other associated aspects (e.g., maintenance, power consumption, climate control, etc.).

Further consideration should be given to the compatibility and requirements of mobile P2P systems with current systems. It is possible that current systems may need to be modified to accommodate mobile P2P, or an entirely new system may be necessary.

Other considerations

Another issue that may impact resources is the areas to be enforced. Rural South Australia is very large, including substantial distances between population centres. Deploying mobile P2P in remote areas may incur additional costs in terms of device down-time while they are moved to other locations.

5 Conclusion

Fixed P2P has demonstrable benefits in terms of managing the speed and improving the safety on sections of road where these types of enforcement are used. Similarly, mobile spot speed enforcement also has demonstrated benefits for the locations where they are deployed. While mobile P2P is yet to be used in any jurisdiction, it is likely to produce benefits similar to fixed P2P, although there are other factors, such as the presence of warning signs and the ability to enforce two directions of travel simultaneously, that make it difficult to accurately quantify the benefits.

While all of the manufacturers of speed enforcement devices considered in this report have the potential to undertake fixed or semi-fixed P2P, only some report the capability to undertake mobile P2P and, of these, the capability is yet to be demonstrated in the field. Western Australia are planning a trial of mobile P2P in September, 2021 (Hussey, 2021).

There are several methods of mobile P2P for consideration; the impact on resources will ultimately depend on the type and number of devices used, and the methods in which they will be deployed. Resourcing costs include:

- Personnel
- The type and number of devices
- Back-end data storage and processing.

Mobile P2P has the potential to enhance speed enforcement across the road network and particularly in rural locations where speed enforcement can be limited by the extent of the road network and the great distances that need to be policed. With advances and the increased capabilities of modern automated speed enforcement devices there is the potential to implement mobile enforcement systems that are capable of addressing key behaviours, such as speed, distraction, and seat belt use that are significant issues in rural areas. The mobile P2P concept is still in its infancy and while the capabilities exist, it is important to trial and evaluate the technology to ensure they are both feasible and effective methods of enforcement. The introduction of automated mobile P2P speed enforcement devices with the capability to address multiple problem behaviours has the potential to improve road safety in rural areas.

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References

Aarts, L., & van Schagen, I. (2006). Driving speed and the risk of crashes: A review. *Accident Analysis & Prevention, 38*, 215-214.

Clark, B., Budd, L., Thompson, L., Cameron, M., & Newstead, S. (2019). *Evaluation of the ACT road safety camera program* (Final Report). Clayton, Victoria: Monash University Accident Research Centre.

Davis, G.A., Davuluri, S., & Pei, J.P. (2006). A case control study of speed and crash risk, technical report 3: Speed as a risk factor in run-off road crashes (CTS 06-02C). Minneapolis: University of Minnesota Centre for Transportation Studies, Intelligent Transportation Systems Institute.

De Pauw, E., Dniels, S., Brijs, T., Hermans, E., & Wets, G. (2014). Behavioural effects of fixed speed cameras on motorways: Overall improved speed compliance or kangaroo jumps? *Accident Analysis and Prevention, 73,* 132-140.

Doecke, S. D., Kloeden, C. N., Dutschke, J. K., & Baldock, M. R. J. (2018). Safe Speed Limits for a Safe System: The Relationship Between Speed Limit and Fatal Crash Rate for Different Crash Types. *Traffic Injury Prevention, 19*(4), 404-408.

Gunarta, S. & Kerr, G. (2005). Speed impacts of mobile speed cameras in Christchurch. *Road and Transport Research, 14*(2), 16-27.

Gouda, M. & El-Basyouny, K. (2017). Investigating time halo effects of mobile photo enforcement on urban roads. *Transportation Research Record: Journal of the Transportation Research Board, 2660,* 39-47.

Høye, A. (2014). Speed cameras, section control, and kangaroo jumps – a meta-analysis. *Accident Analysis and Prevention, 73,* 200-208.

Hussey, T. (2021). WA set to trial Australia's first mobile average-speed police cameras to improve road safety. *ABC News.* Retrieved from https://www.abc.net.au/news/2021-02-03/wa-point-to-point-speed-cameras-road-safety/13112574

Jones, A. P., Haynes, R. M., Blincoe, K., & Sauerzapf, V. (2009). Driver responses to speed camera enforcement. In *Road Traffic: Safety, Modeling and Impacts* (pp. 403-416). Nova Science.

Keall, M.D., Povey, L.J., & Frith, W.J. (2002). Further results from a trial comparing a hidden speed camera programme with visible camera operation. *Accident Analysis and Prevention, 34,* 773-777.Kloeden, C. N., McLean, A. J., & Glonek, G. (2002). Reanalysis of travelling speed and the risk of crash involvement in Adelaide South Australia (CR207). Canberra: Australian Transport Safety Bureau.

Kloeden, C. N., Ponte, G., & McLean, A. (2001). Travelling speed and the risk of crash involvement on rural roads (CR204). Canberra: Australian Transport Safety Bureau.

Montella, A., Imbrrani, L.L., Mariano, V., & Mauriello, F. (2015). Effects on speed and safety of point-to-point speed enforcement systems: Evaluation on the urban motorway A-56 Tangenriate di Napoli. *Accident Analysis and Prevention, 25, 164-178.*

Newstead, S & Cameron, M. (2013). *Crash effects of the Queensland camera detected offence program.* Paper presented at the Australasian Road Safety Research, Policing and Education Conference, Brisbane, Queensland, 28-30 August.

Nilsson, G. (2004). Traffic safety dimensions and the Power Model to describe the effect of speed on safety. Doctoral Thesis, Lund Institute of Technology.

Soole, D., Fleiter, J.J., & Watson, B. (2013). *Point-to-point speed enforcement: recommendations for better practice*. Paper presented at the Australasian Road Safety Research, Policing and Education Conference, Brisbane, Queensland, 28-30 August.

SWOV. (2012). The relation between speed and crashes. Leidshendam: SWOV Institute for Road Safety.

Thomas, L.J., Srinivasan, R., Decina, L.E., & Staplin, L. (2008). Safety effects of automated speed enforcement programs: Critical review of international literature. *Transportation Research Record: Journal f the Transportation Research Board, 2078,* 117-126.

Wilmots, B., Hermans, E., Brijs, T., & Wets, G. (2016). Speed control with and without advanced warning sign on the field: An analysis of the effect on driving speed. *Safety Science, 85,* 23-32.