MONASH University
Accident Research Centre

CAN SAFETY WARNING SYSTEM (SWS) SIGNALS RECEIVED BY USERS OF RADAR DETECTORS IMPROVE ROAD SAFETY?

Miranda Cornelissen
Christina M. Rudin-Brown

1 November 2010

MONASH UNIVERSITY ACCIDENT RESEARCH CENTRE
REPORT DOCUMENTATION PAGE

Report No.	Date	ISBN	ISSN	Pages
	1 November 2010			24

Title and sub-title:
Can safety warning system (SWS) signals received by users of radar detectors benefit road safety?

Author(s):
Miranda Cornelissen, Christina M. Rudin-Brown

Sponsoring Organisation(s): Western Australia Office of Road Safety (ORS) on behalf of the Road Safety Council of Western Australia.

Abstract:

The relationship between speed, crash risk, and crash severity is well-documented. In-vehicle radar detectors are small, specialised radio receivers tuned to the frequency range used by police radar guns that make it possible for drivers to detect police radar efforts and to alter their travel speed to avoid penalties for speeding infractions.

The Western Australian Office of Road Safety on behalf of the Road Safety Council contracted the Curtin-Monash Accident Research Centre (C-MARC) to conduct an independent review of the literature pertaining to Safety Warning System (SWS) signals and radar detectors, and to comment on the state-wide road safety implications of banning the ability of vehicles equipped with radar detectors to receive signals from SWS transmitters. The aims of the literature review were to investigate the road safety impacts of 1) radar detector use by drivers, 2) SWS signals transmitted from road works' sites, emergency vehicles, and black spot locations being received by users of radar detectors, and 3) SWS signals transmitted from tractors using drone radar being received by users of radar detectors.

The relevant survey, observational (on-road), and crash (insurance) data research in the area of radar detector use and SWS signals was reviewed. Collectively, the literature indicates that, because radar detectors are used predominantly by an already high-risk group of drivers, their application as receivers of SWS and drone radar signals is unlikely to result in overall benefits to road safety. Such a system would only be of benefit to *temporarily* and *locally* reduce the speed of those target vehicles equipped with radar detectors, which are already likely to be exceeding the speed limit (possibly because of the presence of an active radar detector in the first place).

Key Words:
Road safety, speed choice, drone radar, crash risk

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

www.monash.edu.au/muarc

Preface

Team Leader:

- Dr Michael G. Lenné

Research Team:

- Mr Brett Hughes (Project manager)
- Dr Christina M. Rudin-Brown
- Ms Miranda Cornelissen

Contributorship Statement:

MC researched and wrote the report.

CMR-B provided guidance and direction regarding the selection of material and the writing for the report, and edited the report.

BH provided project management support.

Ethics Statement

Ethics approval was not required for this project.

Contents

1 INTRODUCTION

The relationship between speed and crash risk well-documented (1999; Davis, 2006; C. Kloeden, & McLean, J. , 1998; C. N. Kloeden, & McLean, A. J., 2001; Liu, 1997; TRB, 1998; Vorko-Jovic, 2006). Driving at high speeds reduces the available time margin for a driver to recognise and respond to hazards in the road environment and makes lateral control of the vehicle more difficult (Davis, 2006; Liu, 1997). In turn, crash severity is also highly affected by impact speed (OECD, 2006).

In-vehicle radar detectors are small, specialised radio receivers tuned to the frequency range used by police radar guns [www.iihs.org]. Radar detectors make it possible for drivers to detect police radar efforts and to alter their travel speed to avoid penalties for speeding infractions (Teed, Lund, & Knoblauch, 1993).

Radar detectors are illegal in many jurisdictions around the world, including most European countries, Canadian provinces and territories, and American states. In Australia, the use of in-vehicle radar detectors is prohibited in all states, except Western Australia. In keeping with Australian Road Rule 225 ('Using radar detectors and similar devices'), the government of Western Australia is drafting proposed amendments that will ban the fitment and use of radar detectors by drivers. There is opposition, however, from certain driver lobby groups that argue against the proposed ban and contend that radar detectors offer safety benefits by allowing drivers to be more aware of their speed and to slow down. More specifically, the primary benefit advanced by these lobby groups is the ability of some radar detector devices to detect warning signals emitted by Safety Warning Systems (SWS) and drone radar. SWS are pre-programmed devices that emit radar signals that can be received by radar detectors up to one km away. 'Smart' detectors can, in turn, provide an audible and/or visual warning to a driver regarding a potential road safety hazard (Crackel, 2010; ORS, 2010). According to the Australia Drivers' Rights Association (ADRA), as of 1 June 2010, there were approximately 170 SWS transmitter locations in WA.

1.1 PROJECT AIMS

The Western Australian Office of Road Safety on behalf of the Road Safety Council has contracted the Curtin-Monash Accident Research Centre (C-MARC) to conduct an independent review of the literature pertaining to SWS and radar detectors and to comment on the state-wide road safety implications of banning the ability of vehicle equipped with radar detectors to receive signals from SWS transmitters. The present report represents the final deliverable for this work.

The aims of the literature review were to investigate the road safety impacts of 1) radar detector use by drivers, 2) SWS signals transmitted from road works' sites, emergency vehicles, and black spot locations being received by users of radar detectors, and 3) SWS signals transmitted from tractors using drone radar being received by users of radar detectors.

2 LITERATURE REVIEW

2.1 BACKGROUND

Research has indicated that the presence of in-vehicle radar detectors contributes to drivers' non-compliance with highway speed limits. In a random sampled survey in the United States, 58% of radar detector users said they drove faster than they would without a radar detector; and 75% of the users said that the apparatus saved them from at least one speeding ticket (Opinion Research Cooperation (1988) in Teed et al., 1993).

Besides those that only detect police radar emissions, there are also so-called 'smart' radar detectors that can also detect SWS messages. When activated, SWSs emit pre-programmed messages that can warn a driver through the use of either an audible tone or a visual (on-screen) message. There are currently 64 standard messages[1] which can warn drivers, amongst other things, of accidents, lane closings, severe weather conditions, road construction, and the presence of emergency vehicles. It is asserted that other radar detectors, which are not SWS-compatible, can nevertheless detect SWS signals; however, they generally produce only a simple audible tone and do not display standard SWS messages (Scaduto, 1996).

One of the benefits of SWSs is that they can be used immediately within existing infrastructure; this makes them inexpensive and practical to implement. Furthermore, it is possible to use SWS technology in a safety warning-only receiver system capacity that displays highway safety and information messages *only*, while not being able to detect and alert a motorist to the presence of police radar (Greneker, 1997).

The question remains as to whether the proposed benefits of SWS signals on road safety are, in fact, accurate. Are radar detectors really a means of improving safety on our roads? The relevant research evidence in the area of radar detector use and SWS signals from survey, observational (on-road), and crash (insurance) data studies was reviewed, and is presented below.

2.2 SURVEYS OF RADAR DETECTOR OWNERS / USERS

Three surveys of radar detector users were found to be prominent in the discussion concerning banning of these detectors. Probably the most referred-to study in the debate is a study by Yankelovich, Clancy, and Schulman (Yankelovich, 1987). Unfortunately, the original, complete report is not publicly available; therefore, only highlights and abstracts as described by other sources are presented here. The ostensible purpose of the survey was to determine whether there was a significant difference in the accident rate per miles driven of users *vs.* non-users of radar detectors. The researchers selected two samples of participants for a telephone survey: one consisted of 1000 randomly drawn American drivers, and the second consisted of 1000 recent purchasers of radar detectors (although

[1] It has been argued that 64 potential message varieties may be excessive, and could result in the 'danger of crying wolf'. If a radar detector produces a warning once every few minutes, it is possible that drivers' attention could decrease and their annoyance could increase, which would result in the increased likelihood of a device being turned off (Scaduto, 1996).

only 805 reported having and using a radar detector at the time of the survey). Radar detector users were found to report driving, on average, twice the mileage of non-users. The authors conclude that radar detector users are at least as safe as non-users because they drive more miles between collisions (233,933 miles for users *vs.* 174,554 miles for non-users). A limitation of the survey, however, is that the two samples were not balanced across any other, possibly contributory, factors. This makes it difficult to conclude whether the difference in mileage driven is due to radar detector use or because of other reasons.

Users of radar detectors believe that they are safer drivers when using their radar detectors than when not using them (Safety Warning System, 2001). A survey of radar detector users undertaken by the Australian Drivers' Rights Association (ADRA) revealed that 75% of drivers interviewed believed that they were safer drivers with their detector. Unfortunately, the original ADRA survey data (2000) is not publically available; therefore, it is not possible to systematically review the survey methodology used. Three hundred radar detector owners in Australia were randomly selected for the survey that was conducted by telephone, fax and email. Only the first 200 responses were analysed. Non-users of radar detectors were not included. Users reported driving between 12,500 – 25,000 miles (20,000 – 40,000 kms) annually. Ninety-three percent of respondents were male and 37 percent aged between 26 and 35 years old.

When asked about their driving behaviours when using radar detectors, 41 percent of the sample reported not slowing their average speed after fitting a radar detector. Those who reported that they drove faster than the posted speed limit reported that they only did so in rural areas and that they stayed with the flow of traffic. Almost 70 percent of respondents said they were more aware of enforcement while using a radar detector, and 86 percent reported being more aware of their speed, speed limits (71%) and driving conditions (82%). Two-thirds of the respondents reported that the use of radar detectors helped them combat fatigue. Interestingly, four percent of respondents reported having been involved in an accident since they purchased their radar detector, and 45 percent reported that they had received one or more speeding tickets.

Radar users and non-users appear to differ on a number of driving-related and demographic characteristics. A telephone-based survey of over one thousand radar detector users and non-users, conducted for the Drivers' Technology Association in the UK, was designed to gain insight into drivers' behaviour and attitudes towards in-vehicle radar detectors (Leaman & Down, 2001). Results showed that users and non-users differ in characteristics including annual mileage driven, employment status, and type of vehicle model owned. In general, users of radar detectors were found to drive almost twice the annual mileage of non-users. Further, compared to non-users, a larger proportion of users were employed full-time, had higher incomes, and were more likely to driver a high performance vehicle (e.g. Audi, Volkswagen, BMW, Mercedes or Jaguar), which, in turn, were also more likely to be equipped with other in-vehicle technological features (Leaman & Down, 2001).

According to Leaman & Down (2001), users of radar detectors reported travelling 50 percent further between collisions than did non-users. It is not known, however, where this additional driving took place (e.g., motorways, city driving) or if the driving patterns of both groups were similar; therefore, this statistic should be interpreted with caution. Regarding attitudes reported in the survey, 50 percent of users agreed that they were not always aware of speed limit, as compared to only 43 percent of the non-users who agreed with this statement. Interestingly, 75 percent of users reported that they were more aware of the speed limit since purchasing a radar detector.

Results from this study were suggestive of radar detector users interviewed being were more cynical than non-users regarding the general purpose of speed cameras. Despite this attitude, however, they also felt that purchasing a radar detector had had a positive effect on their driving behaviour, and argued that they were more conscious about keeping to the speed limit, were more aware of the speed limit in general, and had become safer drivers since purchasing their radar detector.

Based on the results of these three surveys, it is difficult to draw conclusions regarding whether radar detector users are safer drivers than non-users. First, survey data are subjective, self-reported results, and therefore only reflect the opinions of users and non-users about how safe they think they are, and do not provide objective data regarding whether they are, in fact, or not. Second, the radar detector user group has different characteristics than the non-user group, which indicates that the samples are not equal. This diminishes the reliability of the data and precludes reliable conclusions from being drawn. Third, two of the three studies were reported only by third party sources, of which many are lobbying against the ban for radar detectors, and therefore detailed review of the results is not possible. Finally, it is impossible to make conclusions from the Australian ADRA study (Safety Warning System, 2001), as the survey sample did not include non-users.

Survey results are highly suggestive of radar detector users being a specific group of the general population, consisting of males, who drive greater distances than the average driver, have higher-powered vehicles fitted that are more likely to be equipped with in-vehicle technology, are employed full-time, and receive a higher-than-average salary.

Radar detector users report that they are more aware of speed limits and their speed than non-users. The data suggests, however, that non-users are naturally more aware of their own speed than users, as users only appear to gain this awareness after the purchase of their radar detector. Whether the awareness of speed results in changes in driving behaviour is questionable; only 41 percent of users report having slowed their average speed since beginning to use a radar detector and, despite having one, many (45 %) report continuing to receive speeding tickets. The lack of objective performance data associated with the above surveys prevents reliable conclusions from being drawn regarding the safety of users *vs.* non users. Observational (on-road) studies should provide more objective evidence of any differences between user *vs.* non-user groups.

2.3 OBSERVATIONAL STUDIES

Potentially, experimental and/or observational studies can provide objective evidence regarding the effect of radar detectors, and whether there are safety benefits associated with the use of these devices. Observational studies typically use a variety of methods to measure the speed of vehicles and whether they are equipped with radar detectors. For example, to measure the speed of passing traffic, typically non-detectable speed measuring devices (e.g. in-pavement loop detectors or retuned radars) are used to determine the normal mean traffic speeds. Following this first measure, regular police radar emissions, which can be received by radar detectors, are then activated. The resulting speed change (if effected) is then measured using the non-detectable speed measuring devices. Vehicles that change their speed by a certain threshold after the regular radar has been used are then presumed to be equipped with a radar detector. Studies may also use the observation of brake light activation following the discharge of regular radar to determine whether vehicles are fitted with a radar detector. Finally, radar-detector-detectors have been used by some researchers to provide a more reliable measure of radar detector usage (Freedman, Williams, Teed, & Lund, 1990).

2.3.1 Effects of SWS signals on vehicle speeds

SWS signals have been found to result in speed reductions in vehicles equipped with radar detectors.

The effect of SWS signals was evaluated in a study by Oliveira, Geisheimer, Greneker & Leonard (2002). In this research, software was used to control the measurement system and process the generated data stream. This methodology is beyond the scope of this report and therefore only the preliminary results reported by the researchers on the effectiveness of the SWS system itself will be discussed. The study took place in a work zone in the United States. Speed was measured under three conditions: no transmitter activity, a drone radar signal, or SWS messages. Speeds were measured at three stations: road tube station, data collection vehicle station, and radar station. A radar-detector-detector was used to determine whether passing vehicles were equipped with radar detectors. Results showed no significant changes in speed, probably due to the low level of use of radar detectors in the traffic stream. When data of individual vehicles were analyzed, however, the majority of the vehicles with radar detectors were found to slow down, and to do so more when exposed to a SWS message than with a drone radar signal or no signal at all.

Studies in the US in which multiple devices were evaluated, including a SWS, revealed mixed results, but perhaps mainly due to measurement issues. Reports from Iowa (Kamyab, Maze, Gent, & Poole, 2000) showed no significant change in measured vehicle speed. Speed was measured in a work zone involving a left lane closure with a crossover leading into two way traffic. Data was collected two days prior to, and two days following, the installation of the SWS. None of the speed measures showed a significant difference. According to Robinson et al., (Robinson, McGowen, Habets, & Strong, 2002) the lack of an effect might have been due to the small number of vehicles equipped with radar detectors in the traffic stream. In Kansas, however, researchers (Meyer, 2000) also installed a SWS on a crossover point in a work zone. There they measured speed prior to reaching the crossover and half way through the crossover bend. The data of the prior measurements were not usable, but measurements taken in the curve were, and they showed a significant decrease in speed after installing the SWS.

Although there are indications that SWS might be more beneficial than the use of radar drones in reducing speeds of radar detector-equipped vehicles, this cannot be concluded based on the above studies. This is especially true since users of older detectors will receive the same signal in their vehicle regardless of whether the transmitter is an SWS or drone radar. The use of drone radars will be discussed next.

2.3.2 Effects of drone or police radar on vehicle speeds

Drone radar simulates the presence of law enforcement by transmitting signals using the same radar frequency; therefore, activating radar detectors in passing vehicles. Results from observational studies examining the ability of drone radar to reduce vehicle speed are generally inconclusive. The different results are reported below.

Streff, Kostvniuk and Christoff (1995) determined that the effectiveness of drone radars in reducing speed (with and without police patrol car presence) on a freeway (speed limit of 65 mph or 105 km/h) and in a construction zone (speed limit of 55 mph or 90 km/h).

Measurement conditions varied. The radar drones were either on or off; police patrols were present or not; and speed was measured at three locations (upstream, at, and downstream of the drone radar). Different speed measures were used. Presence of radar detectors was measured using radar-detector-detectors. Results from the freeway and the work zones appeared to be consistent. Approximately five percent of the traffic stream was equipped with a radar detector. The results show that the actual difference in means of speed were small (between 1 and 1.5 mph), but statistically significant. However, differences between measurements in the opposite directions showed that other factors influenced the speed of passing traffic. Surprisingly, the additional presence of police patrols did not cause practical reductions in the speed of the vehicles, which is contrary to findings of other studies (see next paragraph). Further, the speed reducing effect of drone radar was consistently found for commercial vehicles, which are generally more likely than other vehicle types to be equipped with radar detectors.

Work zones. Observational studies find that vehicles equipped with radar detectors were generally speeding more before the radar detectors were turned on (Eckenrode, Sarasua, III, Ogle, & Chowdhury, 2007). Further, research by Ullman (1991) has found that desirable effects probably won't be observed by using SWS by itself, but rather in combination with warning signs for example.

A study that found an effect of drone radar is reported by Turochy (1997). The effectiveness of unmanned radar was investigated for its effectiveness as a speed control technique in freeway working zones. On-site data were collected in several work zones. Speed measurements were conducted upstream as well as near the unmanned radars. The results showed significant reductions in mean speed and the percent of traffic that was exceeding the speed limit. Interestingly, unmanned radar was most effective when police presence was expected by drivers. This has been confirmed by Benekohal (1993), who, despite not obtaining consistent results, showed that speed reductions were not as effective when drivers knew the radar was a drone than when they did not.

Another study with considerable results is a recent study by Eckenrode and colleagues (Eckenrode et al., 2007). The effect of drone radars in different type of work zones was investigated under different conditions, to determine when the drone radar was most effective. In one condition, the drone radar was activated, while in the other, it was turned off. Speed was measured at three stations: 1) at a station before the drone signal range, but within work zone signage, with an undetectable radar, 2) inside the drone signal range and within work zone signage, 3) at a station after the drone signal range, with a minimally detectable radar gun (some cars might have detected it, but it should be minimal). In order to detect whether vehicles were using radar detectors, a radar-detector-detector was used. Results revealed a 3 km/h decrease in mean speed of all highway vehicles, and a 10 km/h decrease in those vehicles that were equipped with radar detectors. The reductions were minimal, though, in terms of mean speed, and in terms of the percentage of vehicles that were found to be exceeding the speed limit. Only short term effects were found. Of particular interest, when the drone radar was turned off, there were major differences between the vehicle groups. Radar detector-equipped vehicles were travelling much faster than non-detector-equipped vehicles, which is the opposite of what happened when the drone radar was turned on. The researchers therefore conclude that, due to the ease of installation and low costs involved, radar detector use might be effective to reduce speeds in certain radar-equipped vehicles.

Several studies have found interaction effects concerning vehicles equipped with radar detectors *vs.* those that are not. Ullman (1991) found different effects for those vehicles observed to be exceeding the speed limit, and for trucks. Speed measurements were collected upstream from, and in, a work zone, and speed changes within the work zone as well as vehicle conflicts were recorded. Results showed that radar signals had only a small effect on the average speed within the work zone. The greatest effect, however, was demonstrated by those who where approaching the work zone with a speed greater than 105 km/h (the speed limit), and by trucks. This coincides with the observation that those target vehicles (speeding and commercial vehicles) are generally more likely to be equipped with a radar detector than other vehicles. Interestingly, these researchers also looked at vehicle conflicts during their study and found that crashes due to severe braking may increase in the presence of radar signals.

As part of a larger research project, Carlson, Fontaine and Hawkins (2000) tested the effect of drone radar on speed reduction in a work zone and found an interaction with the use of other devices. Speed reductions as a result of the drone radar were marginal (≅ 3.2 km/h) and were not statistically significant. Radar drones were also tested alongside other devices, like warning signs. Together with advisory signs of the temporary speed limit, speed of cars was reduced significantly (≅4.8 km/h) and it reduced the number of vehicles exceeding the maximum speed limit. These researchers note that, in previous research, it has been noted that commuters and truck drivers who drive the road regularly become suspicious if no obvious enforcement is in place.

The effectiveness of drone radars appears to depend on several factors. On the basis of a literature review, Eckenrode et al. (2007) concluded that this effectiveness depends on three factors: the number of radar detectors in the traffic stream, the frequency used (as some bands have more false alarms than others), and whether drivers are actually deceived that there is police presence. Furthermore, based on previous research, the presence of drone radars decreases the speed of vehicles. However, it is also suggested that, with advancements in the sophistication of radar detector technology, drone radars are becoming less effective. As well, only a limited number of studies have been conducted in the United States since 1995, the year in which radar detectors became illegal, and thus the amount of radar detectors in the traffic stream has since became fewer (Eckendrode, 2007).

Blackspots/high accident zones. A study by Pigman et al., (1989) took place in a high accident zone in Kentucky. Safety measures put in place were the installation of unmanned radars as well as the diversion of trucks onto a bypass route. Speed-related data were collected over time and a survey on radar detector use was undertaken. Differences in mean speed after installation of the unmanned radars were small; however, the individual speed of vehicles with radar detectors decreased significantly, while those of vehicles that were not equipped with radar detectors was not affected.

Long term effects. Teed, Lund & Knoblauch (1993) have argued that, although research has found that speed is reduced when police radars are activated, direct empirical evidence regarding the duration of speed reduction is lacking. They therefore conducted two separate studies to determine the duration of speed reductions caused by radar detector exposure. In a first study, they measured the speed of ambient traffic using an inductance loop. Speed measurements were made in five different conditions: a) no police radar present, b) police radar at inductance loop, c) police radar one mile before the loop, d) police radar 2 miles before the loop, and e) police radar 5 miles before the loop. Results showed that when speed was measured directly after exposure to the police radar, the vehicles exceeding the speed limit by 10 mph decreased from 42 to 28 percent. Measurements taken one mile after police radar activation showed that 38 percent of vehicles were travelling more than 10 mph above the speed limit again. By two or five miles after exposure to the police radar, 40 percent of vehicles were exceeding the speed limit by more than 10 mph.

In a second study, only speeding vehicles were included. Speed of a vehicle was measured at five different locations. First, a non-detectable speed measurement device was used. If this device indicated that a vehicle was speeding, a detectable radar was then directed towards the vehicle, and speed was re-measured (1, 3 and 4 miles after activation of the detectable radar) and potential lane changes and brake light activation were observed. Results revealed that, of those vehicles speeding (more than 10 mph above the speed limit, which was 65 mph on this particular stretch of road), 39 percent reduced their speed by at least five mph after activation of the detectable radar. In total, 44 percent of the vehicles reduced their speeds by at least five mph or activated their brake lights (without receiving obvious traffic obstructions), which suggests that 44 percent of the speeding vehicles passing the study zone were using active radar detectors (Teed et al., 1993).

Speed measurements also revealed that speed prior to detectable radar activation was, on average, higher for those assumed to be using radar detectors than for those assumed not to be using radar detectors. After activation of the detectable radar, the vehicles assumed to use radar detectors slowed down by more than 10 mph, while other vehicles only slowed down by 1 mph, on average. The speed of the vehicles with assumed radar detectors was equivalent to the other speeding vehicles again four miles after radar activation; however, it did not return to the speed level recorded before activation within those four miles. The authors therefore conclude that radar detectors do not induce long-term compliance with speed limits, and view the results as supporting their contention that the motivation for buying a radar detector is to avoid speeding-related infractions.

To conclude, radar detector users generally seem to drive faster than non users. Upon detecting radar signals, however, users decrease their speed more so than non-users. Whether this has an effect on the flow of the general traffic stream remains to be determined. Furthermore, the speed reduction is greatest directly after exposure to a detectable radar. By approximately three to five kilometres after the exposure, effects are largely nonexistent.

The effectiveness of radar transmission on speed reduction depends on whether police presence is expected, although results are not consistent. It also depends on the percentage of radar detector users in the traffic stream, frequency used, the number of false alarms on that frequency, and other factors such as road infrastructure, signage etc. that can decrease or increase the traffic speed.

The research does provide some general findings that seem to be consistent over the studies. Methods used, however, differ among the studies. The speed measurement techniques differ, as well as the determination of presence of radar detectors (from visual inspection, to change in speed and braking lights, to use of radar-detector-detectors). Therefore, individual differences in results cannot be compared; a 5 mph reduction in speed in one study does not necessarily equal a 5 mph reduction in another. Reduction in speed can be due to methodological differences, or environmental differences, including factors influencing the average speed like road infrastructure, signs, surrounding traffic etcetera. Furthermore, legal issues influence studies as, in 1995, radar detectors were made illegal in most states of the United States (Eckenrode et al., 2007), where most studies have been conducted to-date. Further, the use of drone radars was contrary to policy in the United States prior to 1991 (Streff et al., 1995).

2.4 ANALYSIS OF CRASH DATA OF RADAR USERS *VS.* NON-USERS

Based on the research, there is no conclusive evidence regarding whether higher speeds are an expected outcome resulting from the protection offered by radar detectors, or whether those who own (and use) such devices would be faster drivers than others regardless of radar detector use status. Furthermore, radar detector manufacturers and lobby groups claim that those who use detectors are actually better drivers and have fewer accidents per km driven than those drivers who do not use radar detectors (e.g., see Section 2.2). However, such claims are difficult to evaluate without more solid data concerning the safety impact of radar detectors (Cooper, 1992).

Cooper, Zuo and Pinili (1992) attempted to provide an objective answer to the question of whether radar detector users are less safe than non-users. These researchers used records of an insurer (Insurance Cooperation of British Columbia; ICBC) to sample participants. Radar detector users were identified by identifying claims and policies in which radar detectors were listed. The researchers acknowledged that the group of users that took out the extra insurance probably was not representative of the general population, and this was confirmed as this group were more likely to be younger, male, owners of expensive cars, and they were more likely to drive either to/from work or as part of their work than the general population. As a consequence, the researchers controlled the sample for exposure.

Because of the non-representativeness of the sample, conclusions based on the results can only be extended to the subgroup of male drivers between ages of 21 and 42 who drive for business purposes or to/from work, typically in medium- or higher-priced vehicles. For that group, and controlled for exposure, radar detector ownership was associated with significantly higher rates of collision claims per year in general as well as for those where the driver was at-fault or for those occurring on weekends with only a single vehicle involved. The radar detector users in this subgroup were also convicted of speeding more often than were non-users.

Based on these results, and the attempt to control for as many factors as possible, the researchers concluded that radar detector users in the subgroup under study were less safe than non-users. However, they did not imply a cause-and-effect relationship between owning a radar detector and driving less safe. Rather, they concluded that ownership of a radar detector may be indicative of a predisposition toward more risky driving behaviour in the first place (Cooper et al., 1992). This is contradictory to the results of the surveys (Section 2.2); however, the surveys compared non-representative samples and, therefore, the comparisons were skewed. Still, based on one study it cannot be determined conclusively whether radar detector users are safer drivers than non-users; however, results of this study are suggestive that this may be the case.

3 DISCUSSION

The main question guiding this report was: "Will radar detectors and, specifically, those that can receive SWS messages, increase safety on our roads?" This is a very broad and complex question; however, we will try to answer it based on the literature reviewed above.

Radar detector use seems to be restricted to a particular subgroup of the population: young men, with good jobs and high performing cars, who drive long distances. Furthermore, the use of radar detectors seems to be more prevalent in trucks. Claims regarding the effects of radar detector use can therefore only be made regarding this subgroup of drivers. This subgroup generally seems to speed more often than the general population, which may be due either because they feel protected by the radar detector, or because they are more predisposed to speeding in the first place—cause and effect cannot be determined by the studies above.

When radar emissions are received by a vehicle equipped with a radar detector, drivers of those vehicles appear to reduce their speed more than non-users (as non-users do not detect the signal of the radar detector), and will then show slower speeds than non-users. After a few miles, though, the effect seems to diminish and the users are either back to their previous speed or to the speed of the traffic flow locally.

Even though there is a lack of research on SWS messages specifically, the one study reported above (Oliveira et al., 2002) suggests that individual users show slower speeds when exposed to SWS messages compared to radar signals. It must be noted though, that not all radar detectors are able to receive SWS messages and will instead broadcast a generic warning.

Based on the above, the transmission of radar or SWS messages seems be associated with reduced average speeds for the high-risk driver subgroup described above. These speed reductions appear to last only for a short distance within a local area. The effect is only temporary; it will not result in reduced average speeds of the entire traffic stream, and vehicle collisions due to the braking of those drivers responding to the radar signal have been reported (Ullman, 1991).

Whether the use of radar detectors makes drivers safer is difficult to determine. The research presented seems to be inconsistent. Surveys report that people feel they are safer drivers when using a radar detector. Also, survey responses indicate that radar detector users drive more km's in between collisions than non-users. However, samples are non-representative and, therefore, user and non-user groups are not comparable. Furthermore, the surveys are based on self-reported data, which is recognised as being limited methodologically (Rudin-Brown, Jenkins, Whitehead, & Burns, 2009).

In a crash data evaluation study that controlled for exposure within its sample, radar detector users were actually found to be less safe than non-users; however, relying on safety statistics for proving whether radar detectors in use make the roads safer may be problematic. There are likely to be more factors influencing the road toll than the use of radar detectors alone, and therefore conclusions about the safety consequences of radar detectors cannot be drawn based on statistics comparing states and countries on road toll for example.

Whether these results should encourage or discourage the use of radar detectors should be subject to more in-depth research. For example, controlled or driving simulator experiments could be used to investigate the effect of radar detector use on a wider group of the general population and under different circumstances. This would overcome some of the limitations within the current literature described above, for example, the non-representative of samples.

Also, the question remains as to whether the benefits of speed reduction locally due to the use of radar detectors outweigh the costs of speed increases in areas that are not under radar transmission by those same drivers. That is a question that is impossible to be answered based on the reviewed research.

Unfortunately, scientific studies on the use of drone radar beacons on tractors were not identified by the literature review. Therefore, no conclusions can be made about the road safety effects of the use of drone radar transmission on tractors.

Finally, the effects of prolonged exposure to radar warning transmissions by radar detector users are not known. Research suggests that, if vehicles are exposed to drone radars without obvious enforcement for long periods, they will be less likely to decrease their speed; however, there is, at present, no objective research available to confirm this contention.

4 CONCLUSIONS

The literature review identified a number of survey, observational, and crash data studies that have been undertaken in the area of radar detectors, owner characteristics, and driver speed choice. Relevant findings include:

1. In-vehicle radar detectors are associated with non-compliance of highway speed limits;

2. Drivers of vehicles equipped with radar detectors tend to be predominantly young, employed males, who own expensive, high-performance vehicles;

3. Compared to others, drivers of vehicles equipped with radar detectors tend to drive greater distances and be involved in more collisions (make more insurance claims);

4. Collectively, results from observational studies indicate that the presence of SWS or drone radar signals results in small (3 to 10 km/h) but significant reductions in the speed of radar detector-equipped vehicles in their vicinity;

5. The speed reduction effects of radar detectors is limited to vehicles that are equipped with an active device;

6. The speed reduction effects of radar detectors are limited to a small area (approximately 3 km) around the location of a SWS / drone radar;

7. Some research has found an increase in crashes in areas surrounding drone radar emissions. This may be due to increases in speed variability between those vehicles equipped with radar detectors *vs.* those that are not;

8. There are currently a limited number (≅170) of SWS transmitters in use in WA.

To conclude, because radar detectors are used predominantly by an already high-risk group of drivers, and because of the relatively small number of SWS transmitter locations in WA, the application of radar detectors as receivers of SWS and drone radar signals is unlikely to result in overall benefits to road safety. Such a system would only be of benefit to *temporarily* and *locally* reduce the speed of those target vehicles equipped with radar detectors, which are already likely to be exceeding the speed limit (possibly due to the pre-existing presence of an active radar detector).

5 REFERENCES

Aljanahi, A. A. M., Rhodes, A. H., & Metcalfe, A. V. . (1999). Speed, speed limits and road traffic accidents under free flow conditions. *Accident Analysis & Prevention, 31*(1), 161-168.

Benekohal, R. F. (1993). Temporal speed reduction effects of drone radar in work zones. *Transportation Research Record, 1409*, 32 - 41.

Carlson, P. J., Fontaine, M. D., & Jr., H. G. H. (2000). *Evaluation of traffic control devices for rural high-speed maintenance work zones* (No. FHWA/TX-00/1879-1). College Station: Texas Transportation Institute

Cooper, P. J. (1992). Speed safety and radar detectors. *ITE journal, 62*(10), 17-20.

Cooper, P. J., Zuo, Y., & Pinili, M. (1992). Are radar detector users less safe than nonusers? *Accident Analysis and Prevention, 24*(4), 329 - 338.

Crackel, L. (2010). *Request for quotion: Literature review on the road safety benefits of safety warning signals being received by users of radar detectors.* Perth: Office of Road Safety.

Davis, G. A., Davuluri, S., & Pei, J. P. (2006). Speed as a Risk Factor in Serious Run-off-Road Crashes: Bayesian Case-Control Analysis with Case Speed Uncertainty. *Journal of Transportation and Statistics, 9*(1), 17-28.

Eckenrode, R. T., Sarasua, W. A., III, J. H. M., Ogle, J. H., & Chowdhury, M. (2007). *Revisiting the use of drone radar to reduce speed in work zones: South Carolina's experience.* Paper presented at the TRB 2007 Annual meeting, Washington D.C.

Freedman, M., Williams, A. F., Teed, N., & Lund, A. K. (1990). *Radar detector use and speeds in Maryland and Virginia*. Arlington: Insurance Institute for Highway Safety.

Greneker, E. F. (1997). *The safety warning system: An in-vehicle signing system using an existing infrastructure of 10 to 20 million vehicular receivers.* Paper presented at the Merging the transportation and communications revolutions. Seventh Annual Meeting and Exposition, Washington D.C.

Kamyab, A., Maze, T. H., Gent, S., & Poole, C. (2000). *Evaluation of speed reduction techniques at work zones.* Paper presented at the Mid-Continent Transportation Symposium Ames, Iowa.

Kloeden, C., & McLean, J. . (1998). How traveling speed relates to the risk of crash involvement. *ITE Journal, 68*(9), 16-17.

Kloeden, C. N., & McLean, A. J. (2001). *Rural speed and crash risk* Paper presented at the Road Safety Research, Policing and Education conference, Melbourne.

Leaman, J., & Down, J. (2001). Radar Detector Survey. London: MORI.

Liu, G. X., & Popoff, A. (1997). Provincial-wide travel speed and traffic safety study in Saskatchewan. *Transportation Research Record, 1595*(8-13).

Meyer, E. (2000). *Midwest smart work zone deployment initiative: Kansas' results.* Paper presented at the Mid-continent transportation symposium Ames, Iowa.

OECD. (2006). *Speed Management Summary Document*: European Conference of Ministers of Transport/OECD Joint Transport Research Centre

Oliveira, M. G. S. d., Geisheimer, J., Greneker, E. F., & Leonard, J. D. (2002). *A methodology for assessing the impact of radar transmissions on a work zone.* Paper presented at the TRB 2002 Annual meeting, Washington, D.C.

ORS (2010). *Request for quote: Literature review on the road safety benefits of safety warning signals being received by users of radar detectors.* Perth: Office of Road Safety.

Pigman, J. G., Agent, K. R., Deacon, J. A., & Kryscio, R. J. (1989). Evaluation of unmanned radar installations. *Transportation Research Record, 1244*, 7 - 16.

Robinson, M., McGowen, P., Habets, A., & Strong, C. (2002). *SAfety applications of ITS in rural areas* (No. DTFH61-98-C-00073). McLean, Va: Science Applications International Corporation

Rudin-Brown, C. M., Jenkins, R. W., Whitehead, T., & Burns, P. C. (2009). Could ESC change the way we drive? *Traffic Injury Prevention, 10*(4), 340-347.

Safety Warning System. (2001). Speed, radar detectors and safety: New Australian survey validates concept behind SWS [Electronic Version]. *SWS Monitor*, 1-2,

Scaduto, T. (1996). Driving intelligence: now radar detectors can alert you to road hazards, approaching emergency vehicles and a lot more than just speed traps. *Popular mechanics*(October), 66-68.

Streff, F. M., Kostyniuk, L. P., & Christoff, C. (1995). *Effects of drone radar and police enforcement on travel speeds: Test on a 65 mph freeway and 55 mph construction zone* (No. UMTRI-95-22). Ann Arober: The University of Michigan, Transportation Research Institute

Teed, N., Lund, A. K., & Knoblauch, R. (1993). The duration of speed reductions attributable to radar detectors. *Accident Analysis and Prevention, 25*(2), 131 - 137.

TRB (1998). *Managing speed: review of current practice for setting and enforcing speed limits*: Transportation Research Board

Turochy, R. E. (1997). *A study of the effectiveness of unmanned radar as a speed control technique in freeway work zones.* Virginia Polytechnic Institute and State University, Blacksburg.

Ullman, G. L. (1991). Effect of radar transmissions on traffic operations at highway work zones. *Transportation Research Record, 1304*.

Vorko-Jovic, A., Kern, J., & Biloglav, Z. (2006). Risk Factors in Urban Road Traffic Accidents. *Journal of Safety Research, 37*(1), 93-98.

Yankelovich. (1987). Yankelovich Clancy Schulman Radar Detector Survey Highlights. Retrieved 20-10-2010, from http://www.stoptheban.org/reports/yankelovich.pdf

6 APPENDIX

Summary of survey studies

Reference	Method	Results
Leaman & Down (2001)	Telephone survey of users *vs.* non-users of radar detectors	• Users appear to travel 50% further between collisions than non-users • Half of users agree that they are not always aware of speed limit; 43% of non-users not always aware. ¾ of users say they are more aware of speed limit since purchasing detector. • Users cynical about purpose of speed cameras • Despite attitude towards speed limits, users feel that purchasing detector has had positive effect on driving behaviour, more conscious about keeping to speed limit, more aware in general, report having become safer drivers
Yankelovich et al., 1987 (as reported by others, mainly 'stop the ban' groups)	Survey of 1000 random people (users and non users of radar detector)	• Radar detection users report driving almost twice the distance of non-users. • Radar detector users report driving longer distances between collisions than non-users • Radar detection device users are more likely than non users to report wearing seatbelts.
ADRA (reported in Safety Warning System, 2001)	Mail, email, telephone survey of 300 randomly-selected radar detector owners (only first 200 responses were analysed)	• Just over half said the average speed did not change • 41 % said they drove slower • If speeding, in rural areas they report doing so "according to flow of traffic" • Almost 70% said they were more aware of enforcement since purchasing detector. • 86% said more aware of speed; 71% more aware of speed limits, 82% paid closer attention to driving conditions. • 2/3 said detector helped combat fatigue, ¾ believed they were safer drivers. • 45% reported that they had received speeding tickets while using the detector.

Summary of observational studies

Reference	Method	Results
Teed (1993)	Objectively measured the duration of speed reductions due to radar detectors exposure	• Authors conclude that radar detectors do not induce long-term compliance with speed limits and that it provides strong evidence that detectors are primarily used to elude police detection of excessive speed. No evidence was found that radar detectors are used as speed monitoring devices (as claimed by Smith, 1988; Lee, 1988)
Eckenrode, Sarasua, Mattox, Ogle, & Chowdhury (2007)	Investigation of drone radar device in multiple types of work zones under day and night conditions to determine the potential successful scenarios for deployment	• 2 mph decrease in mean speed of all high way vehicles, and 6 mph decrease with those equipped with radar detectors. • Drone radar caused minor reductions in the mean speed, the 85th percentile speed, and percentage of vehicles exceeding the speed limit in overall traffic stream. Vehicles equipped with radar detectors exhibited larger reductions in main speed (sample size insufficient for statistical test). • The research only tested the short term impact. • In the condition drone radar OFF there were major differences between the two groups. Radar detector users were travelling much faster than non detector users. • Ease of installation and low cost of instalment, could be effective, depending on number of radar detectors in traffic stream.
Oliveira et al., 2002	In work zones, detected presence of vehicles equipped with radar detectors, stimulate them with police radar and a SWS and then observe their response	• No significant changes in speed, probably due to low level of use of radar transmissions (1%). Those with detectors mainly changed their speed and did so more than to drone or no transmission scenarios.
Robinson, McGowen, Habets & Strong, 2002	Observational evaluation of the effectiveness of SWS deployed in Iowa and Kansas (US)	• Iowa: No statistically significant differences found in speeds when transmitter was in place. A slight increase in number of vehicles observing speed limit. Could be due to small number of vehicles equipped with radar detectors. • Kansas: Small reductions in mean and 85th percentile speeds in the crossover bend for passenger cars at night and for cars and trucks during the day. Statistically significant results related to percent of drivers exceeding speed limit. • Conclusion: system cannot be recommended on basis of speed reduction alone. However, they note

		that the device may have the potential to improve work zone safety by alerting drivers that unusual roadway conditions/hazards require attention.
Robinson et al., 2002	Evaluated the effectiveness of drone radars in work zones	• No consistent pattern in changes in the mean and 85th percentile speeds. Concluded that the use of a radar drone system does not seem to be effective in reducing work zone speeds.

Reference	**Method**	**Results**
Turochy (1997)	Studied effectiveness of unmanned radar as a speed control technique in freeway working zones Motorists on Interstate highway.	• Significant reductions in mean speed and in percent of traffic exceeding the speed limit, minor reductions in speed variance and eighty-fifth percentile speed. Unmanned radar was found to be particularly effective when police presence was expected
Teed (1993)	Measure the duration of speed reductions due to radar detectors exposure	• Study 1: when speeds were measured immediately after exposure to the radar, the percentage of vehicles exceeding the speed limit dropped by more than 10 mph. Effect was short-lived. Speeds had largely recovered 2 miles later. The largest reduction of speed was in tractor-trailers.
Pigman, Agent, Deacon & Kryscio (1989)	Evaluation of unmanned radars on interstate highway	• Unmanned radar was an effective means of reducing the number of vehicles travelling at excessive speeds. The speeds of vehicles with radar detectors decreased significantly as a result, whereas the speed of vehicles without detectors was not affected.

Summary of crash data evaluation study

Cooper, Zuo & Pinili (1992)	Data on accidents and claims of radar detector users *vs.* non-users	• Radar detector users are less safe than non-users. Cannot imply cause and effect, but rather ownership of a detector may be indicative of a predisposition toward more risky driving behaviour on the part of those who avail themselves of the devices perceived protection