Queensland Experiences with Vehicle Activated Signs

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Abstract

Vehicle activated signs (VAS) are widely used in the United Kingdom and a number of other European countries. A large scale evaluation study of VAS undertaken by the UK Transportation Research Laboratory identified significant speed reductions on the approaches to hazards and associated reductions in crashes where these signs were deployed.

While the signs are perceived to be expensive and have not to date been widely used in Australia, the potential to yield similar safety results from their application in Queensland has encouraged further investigation into the use of this technology as a road safety device. In particular there is scope to encourage better speed compliance on the approaches to intersections with poor safety performance, and in advance of hazardous curves.

In addition, there is appeal in their ability to be quickly deployed on the approaches to known problem locations as an interim treatment, prior to more significant works being designed and implemented.

This paper outlines the Queensland Department of Transport and Main Roads' experiences with the deployment of speed activated signs.

Keywords

Vehicle Activated Signs, Department of Transport and Main Roads, LED, Radar

Introduction

Queensland Department of Transport and Main Roads (TMR) is responsible for the planning, management and oversight of delivery of a safe, efficient and integrated transport system that supports sound economic, social and environmental outcomes in Queensland.

This includes the management, preservation, operation, and improvement of some 33,343 km of state controlled road throughout the state, carrying over 4.2M registered vehicles operated by over 3M licensed vehicle drivers [1].

The safety of Queenslanders is one of TMR's key priorities with a focus on reduction of the number of people injured in, among other things, road incidents. Part of a suite of strategies to address this is the Safer Roads Sooner (SRS) Program. The SRS Program is aimed specifically at reducing road trauma on Queensland roads by targeting road safety improvements at locations with a severe accident history. Funding, based on the highest priority, is allocated under the program to address known and potential accident sites.

Vehicle activated signs have potential to address TMR's stated priority to reduce the number of people injured in road incidents. Moreover, as the trial and evaluation of VAS on state controlled roads throughout Queensland is a Safer Roads Sooner funded initiative, the intended philosophy of this project is to establish a methodology to identify suitable sites with a high crash history and to apply funding based on priority.

Background – History of Speed Activated Signs

Vehicle activated signs are an active road safety device consisting of a radar and an LED message. The principle of sign operation is that the speed of an approaching vehicle is detected by the radar. If the detected speed exceeds a predetermined activation speed then the LEDs will be illuminated thus broadcasting a message to the driver of the approaching vehicle.

Vehicle activated signs have been in widespread use in the UK since 1990. In 2002 The Transport Research Laboratory on behalf of the Road Safety Division of the UK Department for Transport published 'TRL548', a large scale evaluation study of the VAS technology [2]. The study was conducted over a 3 year period on 60 VAS signs and provided the following strong independent endorsement of the technology:

- A 4 mph (~6.4 km/h) reduction of average speed in Speed Limit Zones.
- A 7 mph (~11.2 km/h) reduction of average speed in advance of specific road hazards.
- A 4 mph (~6.4 km/h) reduction of average speed in advance of Safety Camera Locations.
- A one-third reduction in crash frequency at sign sites recorded over a 3 year period after sign deployment.

Use of VAS as a road safety device continues to expand. Recent evaluations have taken place in Victoria and in New Zealand. The VicRoads trial [3] evaluated signs at seven locations and in summary concluded that four of the VAS sites appeared to be operating effectively, two sites appeared ineffective and one site was inconclusive. The New Zealand evaluation [4] summarised that as the signage had been operational for only a short period, further monitoring of the sites and data collection should be carried out to assess the effectiveness of this type of technology on driver behaviour and crash incidence.

Site Selection

Initially, eleven Queensland sites were selected for placement of 16 signs. These are listed in Table 1.

#	Road / Site	Direction	Configuration
1	Bruce Highway Shoulder	NB	100 km/h + SLOW DOWN
2	Bruce Highway Median	NB	100 km/h + SLOW DOWN
3	D'Aguilar Highway WB	WB	Reverse Curves + SLOW DOWN
4	D'Aguilar Highway EB	EB	Reverse Curves + SLOW DOWN
5	Mooloolaba WB	WB	60 km/h + SLOW DOWN
6	Mooloolaba EB	EB	60 km/h + SLOW DOWN
7	Tamborine-Oxenford WB	WB	Right Curve + SLOW DOWN
8	Tamborine-Oxenford EB	EB	Right Curve + SLOW DOWN
9	Nerang-Murwillimbah	SB	Right Curve + SLOW DOWN
10	Warrego Haigslea-Amberley	EB	100 km/h + SLOW DOWN
11	Warrego Blacksoil	EB	80 km/h + SLOW DOWN
12	Warrego Lowood-Minden WB	WB	80 km/h + SLOW DOWN
13	Warrego Lowood-Minden EB	EB	80 km/h + SLOW DOWN
14	Captain Cook Hwy Roundabout	SB	Roundabout Ahead + SLOW DOWN
15	Cairns Western Arterial Ramsay Drive	EB	Crossroads + SLOW DOWN
16	Cairns Western Arterial Ramsay Drive	WB	Crossroads + SLOW DOWN
17	Nambour Connection Rd	WB	70 km/h + SLOW DOWN
18	Yorkey's Knob		Roundabout ahead + SLOW DOWN

Table 1: VAS Trial Sites in Queensland, 2009-2010.

These sites were typically selected on the basis of known crash history, and where it was anticipated that a benefit (i.e., a reduction in speed and hence crash frequency) could be earned by deploying a VAS device. Two further sites were added, respectively at Nambour Connection Rd and at Yorkey's Knob.

As part of the evaluation process a methodology for identifying potential VAS sites is being developed. The intended general philosophy for site selection is represented in the flowchart included as Appendix A. The decision tree followed by the flowchart may be represented simply as follows:

- Is there a crash history? Yes.
- Is there a problem of inappropriate speed at the location? Yes.
- Are existing static devices in place? Yes.

If all three answers are 'Yes', then the site could be assessed as a suitable candidate for VAS.

The flowchart however is idealised in that it presumes the ready availability of speed census data at any given location. However as this Department does not currently collect and maintain such speed census data it has been necessary to develop a filter to act as a speed identifier for crash locations where speed would be likely to be a contributing factor.

DCA Code Group	DCA Codes	Description
Two Vehicle Crash		
1	100-109	Intersection, from adjacent approaches
2	201, 501	Head-on
3	202, 206	Opposing Vehicle, turning
4	301-303	Rear-end
5	305-307, 504	Lane change
6	308, 309	Parallel lanes, turning
7	207, 304	U-Turn
8	401, 406-408	Entering Roadway
9	503, 505, 506	Overtaking same direction
10	402, 404, 601, 602, 604, 608	Hit parked Vehicle
11	903	Hit Railway Train
Single Vehicle Crash		
12	001-009	Pedestrian
13	605	Permanent obstruction on carriageway
14	609, 905	Hit animal
15	502, 701, 702, 706, 707	Off carriageway on straight
16	703, 704, 708, 904	Off carriageway on straight hit object
17	705	Out of control on straight
18	801, 802	Off carriageway on curve
19	803, 804, 808	Off carriageway on curve hit object
20	805, 806, 807	Out of control on curve
21	000, 200, 300, 400, 500, 600, 700, 800, 900, 901, 906, 907, 403, 405, 606, 607, 610	Crashes which are unlikely to be attributed to any road environment factor, and which are therefore unlikely to be addressed by any road based remedial treatment. Crashes in this DCA code Group will not be used in crash rates or BCR calculations or reports.

Table 2: Table showing DCA Code Groups selected to represent speed related crashes. Selected Code Groups are highlighted in green.

Initially, crash data was filtered using "speed as a contributing factor". This however proved to be an unreliable search criterion. As such, the following DCA groups were selected to filter crash data:

- DCA Codes belonging to the following DCA Code Group: 1, 3, 8, & 15-20.

The expectation was that the removed DCA Code Groups (2, 4-7, 9-14 & 21) would be typically not emblematic of speed related crashes, and hence could be used as a filter to remove from the analysis crashes of that nature.

In addition, in order to filter out crashes caused by vehicles disobeying traffic signals or signs, the following filter has also been applied to the data:

- Exclude crashes where contributing factor is "Disobey Traffic Light/Sign".

The reasoning in the first instance was to remove signalised sites from the list of potential sites. Second it was an attempt to filter out sites where the entering traffic was established to be at fault rather than the through traffic being deemed to be travelling at excessive speed.

Additional filters may yet prove worthy of introduction to the analysis tool, for example, to remove multiple lane sites, or to remove sites with a traffic volume above which VAS appears to lose impact. At present though, the methodology as unsophisticated as it may appear, does provide a fair first pass to highlight sites for closer inspection and appraisal, with potential to prioritise based on crash history, potentially weighted to crash severity, and risk exposure (AADT).

Sign Design

A roadside traffic sign does not control the actions of a driver but aims to influence driver behaviour to precipitate a desired response. Traffic signs are generally not effective if they are unseen (hidden) or not capable of being understood in time for a driver to respond in a safe and efficient manner. This department holds that the same principles should apply to VAS. It is therefore important that a VAS design is consistent with the requirements for all roadside signs and should have the following characteristics:

Familiarity: Drivers will respond better to signs that are familiar to them. VAS can use established warning and regulatory diagrams from the Manual of Uniform Traffic Control Devices (MUTCD) which are automatically recognisable to the motorist. Therefore perception and understanding will be quicker and reaction times lower if signs are both MUTCD compliant and consistent in appearance with their static equivalents.

Provide positive information: The less ambiguity a sign presents, the less opportunity there is for a motorist to think of an alternative course of action. As such signs should be specific about how a driver should respond. Appending a "SLOW DOWN" message to a VAS gives the driver no doubt about the instruction being displayed and the expected course of action.

During this evaluation, the following sign faces have been used:

- Intersection + SLOW DOWN
- Left/Right Curve + SLOW DOWN
- Roundabout + SLOW DOWN
- Left/Right Reverse Curves + SLOW DOWN
- Speed Roundel (100 km/h / 80 km/h / 70 km/h) + SLOW DOWN

These are depicted as extracts from TMR's TC sign catalogue in Figure 1. It is noted that whilst a 100 km/h speed roundel is the only speed sign depicted, the trial has also deployed 70 km/h and 80 km/h signs as appropriate.

Figure 1: Extracts from TMR's TC Signs catalogue.

Sign Management

Management of the signs is via remote internet access. Each of the signs has been set up with a remote connection to a server so that the sign can be accessed via the internet. Examples of data screens are depicted in Figures 2 and 3. It can be seen in the depictions that collectable data includes traffic counts split up into speed bins. It should be stressed here that the signs are not a traffic counting device, but a road safety device, and data from the obtained signs should be evaluated as such.

From the outset, there has been an intention to actively manage signs installed under this trial in order to more effectively influence driver behaviour. The principle adopted at an early stage was to set up signs to activate and broadcast their message at the prevailing 85th percentile speed, i.e., to target the fastest 15% of drivers.

Typically (but not in every case) the sign set to covert mode (i.e., not activating) was used initially to establish the prevailing traffic speed distribution curve, from which an 85th percentile speed could be derived and then used to set the activation speed of the sign. Thereafter, speed data obtained from the sign itself would be used to manage the sign (i.e., to set the activation speed). It was expected that continued monitoring would show a subsequent reduction in 85th percentile speed, which would then be used to reset the new activation speed. It was anticipated that by iteration in this fashion, both the 85th percentile speed and the number of speed non-conformances could be reduced.

In reality, the above approach has been partly but not fully successful, with data from some signs deployed throughout the trial inaccessible due to compatibility issues between this department's server and one supplier's nominated proprietary server carrying the sign data. That said, in general, the signs have been monitored and managed although not always as closely as would have been desired at the start of the trial.

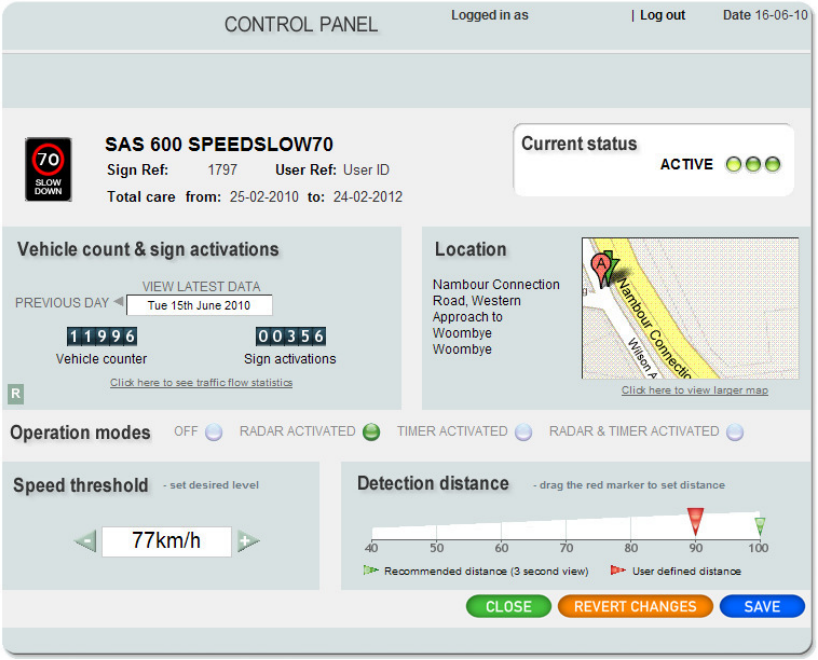

Figure 2: Screenshot from proprietary VAS management website.

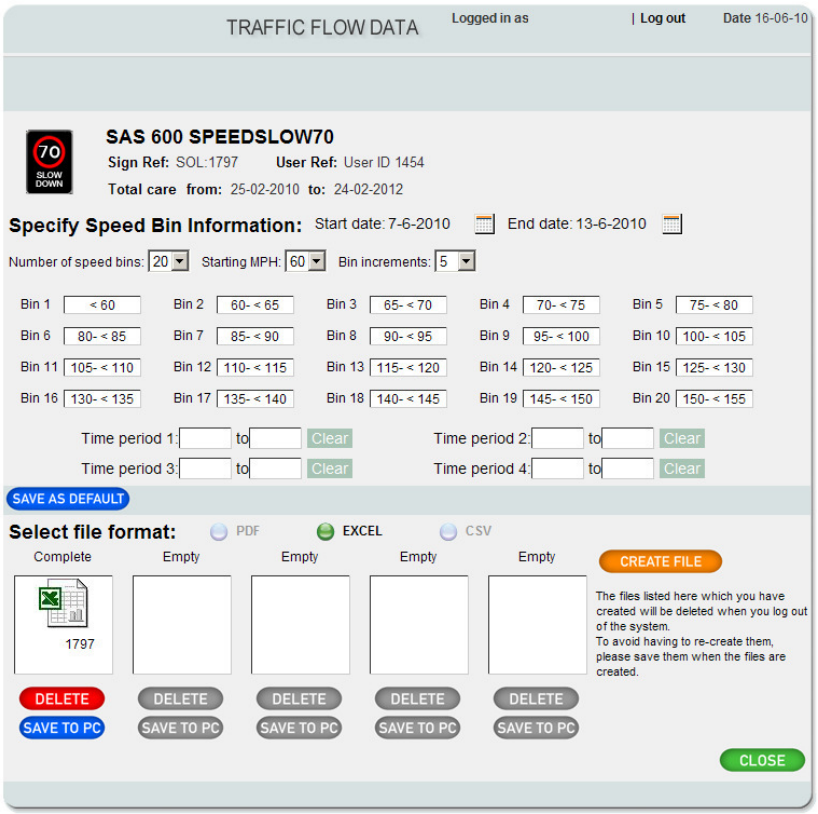

Figure 3: Screenshot from proprietary VAS management website.

Sign Evaluation

Ideally, speed data collecting tubes would have been deployed both upstream and downstream of each sign, prior to and after deployment of the sign.

Tube data was obtained upstream and downstream of the four Warrego Highway sign sites during September/October 2009, i.e., after sign deployment. The following is a synopsis of the analysis of the data:

- The signs have resulted in reductions in average speeds of 5-10 km/h. This is comprised of an initial average speed reduction of up to 5 km/h.
- The percentage of drivers travelling in excess of 9 km/h over the speed when approaching the signs has reduced significantly (on average by 10%-15%).
- Typically, in the order of 20% of vehicles approaching the sign are still travelling in excess of 9 km/h over the limit, but this percentage reduces further once the signs are activated. The secondary tube speed data (collected downstream from the signs) reveals that less than 2% of drivers travel in excess of 9 km/h over the speed limit downstream of the signs.

It was suggested and accepted that the reductions resulted from the drivers' prior experiences with the signs and observations of the signs being activated by vehicles ahead. Secondary tube speed data (collected downstream from the signs) indicated that there is a further average reduction (of up to 5 km/h) resulting from those vehicles which slow when they activate the sign.

Whilst this analysis was a good indicator of the sign performance, this same data gathering exercise has not been undertaken for the remaining signs.

As such, for each sign, the sign itself has been used as the primary evaluation tool. It is certainly arguable that this is an imperfect evaluation tool. In the first instance the hypothesis is that the signs have a three-tier effect:

(i) Motorists aware of the presence of the sign will modify their behaviour so as to not activate the message. This would need to be a learned response.
(ii) Motorists that do activate the sign subsequently slow down in response.
(iii) Motorists that do activate the sign but do not respond by slowing down still have a heightened awareness in advance of a hazard.

It is intuitive that the data recovered from the sign will be a strong indicator of effect (i) only. 'Before and after' tube/loop data from a location immediately downstream of the sign would be required to establish whether sign activation was generating a speed reduction (effect ii). And it is expected that longer term (say three-five year) crash data from the subject sites will be a key indicator of effect (iii) in terms of both frequency and severity.

It is suggested therefore that any effects discernible from the data captured by the sign itself are conservative in that the sign data only indicates drivers' responses to the sign as a result of a learned behaviour change. Further monitoring is required to quantitatively and qualitatively assess whether VAS consistently increases the magnitude by which drivers slow in response to the sign and reduces crash frequency and severity.

Example speed data obtained from a pair of signs is shown in Figure 4.

Mooloolaba Road is an undivided road within an urban environment. The VAS at this location were located respectively at the top and bottom of a steep winding hill with a "poor" crash history. Both signs were a "60 km/h + SLOW DOWN" combination configuration (see Figure 5). Of note the eastbound sign was damaged by an errant vehicle during the trial (in February 2010) and has yet to be replaced.

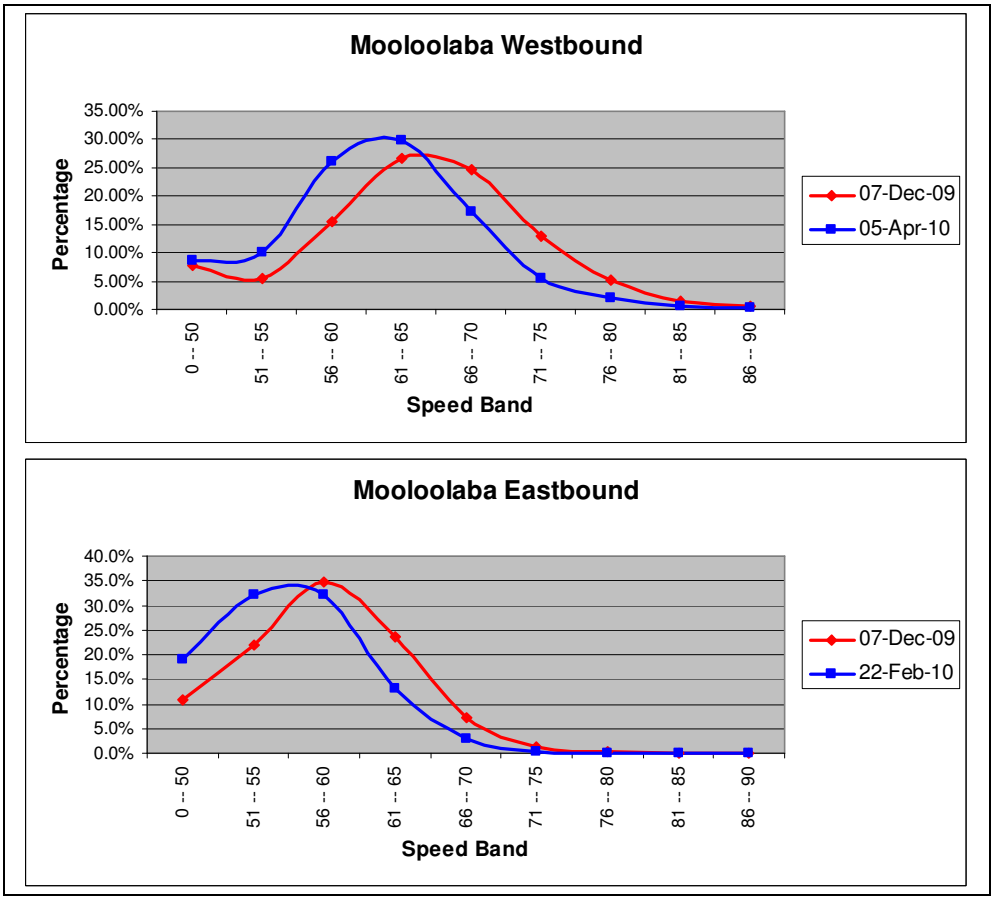

Figure 4: Speed distribution curves at VAS installations on Mooloolaba Road.

Figure 5: VAS #5 at Mooloolaba Road, WB.

Analysis of the data indicates that the 85th percentile speed has been reduced from 64 km/h to 61 km/h (3 km/h) eastbound and from 72 km/h to 68 km/h (4 km/h) westbound. It can further be shown that there was a substantial jump in the number of speed compliant vehicles. The westbound sign at this location for example shows an increase in the number of vehicles approaching the sign at or slower than 60 km/h from around 30% to around 45% (i.e., a 50% increase) in speed compliance. Similar results were obtained at other signs (see Figure 6).

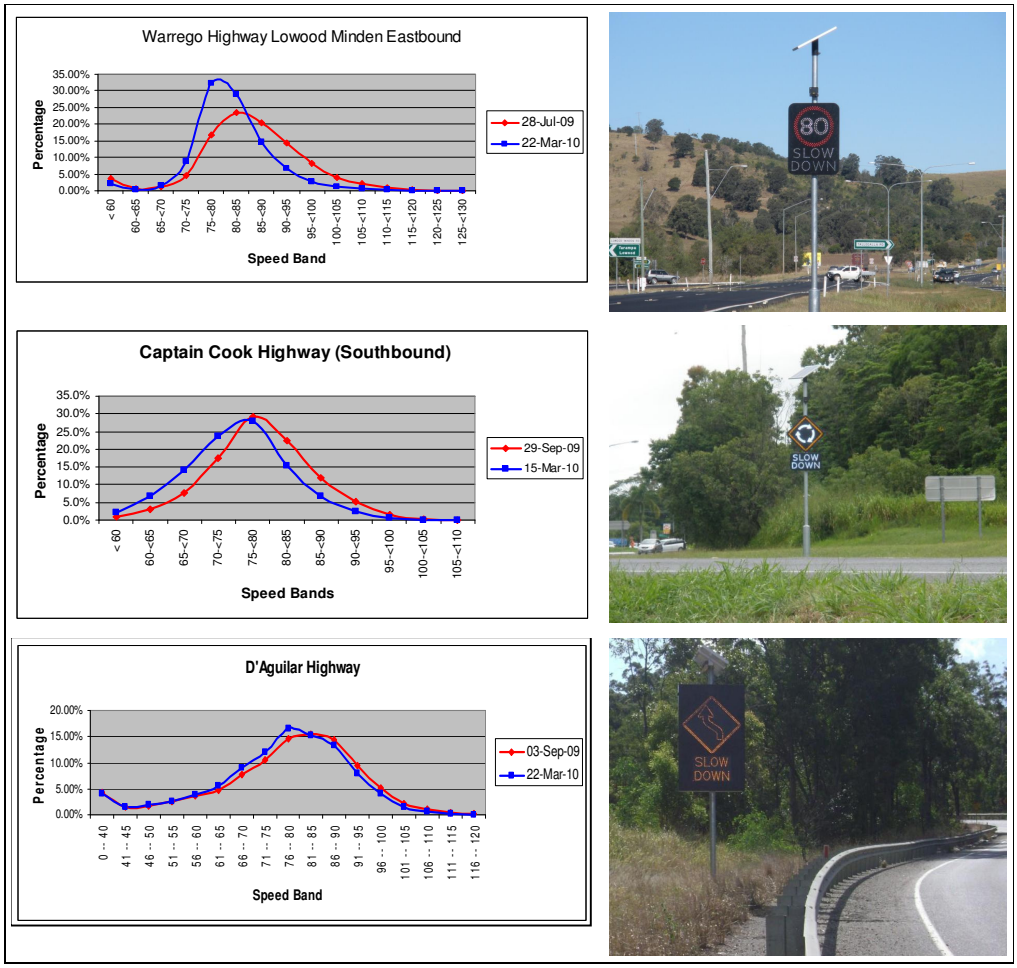

Figure 6: Speed distribution curves at various signs depicting fairly consistent downward trends in overall traffic speeds and numbers of speeding vehicles.

In summary then, the data obtained from each of the other signs generally shows similar trend shifts in speed distributions at each sign site, albeit of a different magnitude, with, in almost every case:

- A decrease in the 85th percentile speed.
- A decrease in mean/average speed.
- A decrease in the overall number of speeding vehicles.

It is intended that this is documented further in a more detailed evaluation.

Conclusions

Some of the vehicle activated signs installed under this trial have now been in place for close to one year.

Analysis of the data indicates that there is generally consistently a shift downwards in average speed, 85th percentile speed and frequency of speed non-compliance on approach to the sign site, all indicating a learned change in driver behaviour in response to the presence of the sign at a given location.

Tube data collected downstream of a small number of sites showed a further downward shift in speed downstream of the sign, thus suggesting that the activating signs do influence driver behaviour.

It was noted that the bulk of speed reductions occurred within a month after activation, but that this reduction remained stable within the following months – signs installed 12 months ago still show the same reduction as yielded shortly after activation.

The data indicates that the positive effects may be a function of traffic volume and that the best results (highest magnitude) appear to be yielded on lower (<10,000 AADT) roads.

Learnings

1. Practitioners should be cognisant of sign location. The approach to the sign should be straight and clear so that vehicles cannot "disappear" and fail to trigger the radar. See Figure 7.

2. The approach to the sign should be such that a vehicle "over-reacting" to the activation does not brake heavily on a curve. Of note two VAS signs (#6 Mooloolaba EB and #15 Cairns Western Arterial EB (See Figure 8)) have been knocked over by errant vehicles during the course of this trial (although in both cases activation of and reaction to the sign was not a contributory factor to the crash).

3. Signs with in-built radar require extra careful installation. A separate radar unit is a more manageable solution, as it can be aimed at the oncoming traffic without needing to rotate the whole sign face.

4. Road authorities should establish policy for management of the sign. During this trial at more than one site the 85th percentile speed dropped to or below the posted speed limit. In view of the fact that the activated messages "instruct" drivers to SLOW DOWN, it was determined that the activation speed should not drop below the posted or advisory speed (plus 2 km/h). Of note the New Zealand evaluation [4] reported on a sign triggered by dual activation speeds, with the SLOW DOWN message not triggered by the lower activation speed.

5. Practitioners and road authorities should be cautious when releasing or using the data. These signs are not traffic census devices but road safety devices. Data may be misused or politicised. Practitioners and road authorities should champion the view that the technology has tolerance limitations, and that the data derived from the signs should be used only to show trends in driver behaviour.

6. Practitioners should establish a policy for sign mounting. TMR is currently reviewing the current practice of mounting VAS on public domain slip-base footings or proprietary "forgiving" systems.

Figure 7: Learning #1 – Ensure sign is/can be located so that radar is directed at oncoming traffic. See also learnings #2 and #3.

Figure 8: Learning #4 – Can you instruct a speed compliant driver to SLOW DOWN? Note the mounting (learning #6).

Proposed Future Developments

Whilst the trial has developed into a Mass Action Plan and further signs are being deployed throughout the state, a number of related intelligent solutions are being investigated:

- Combination of VAS with a classifier for use at sites where heavy vehicles (rather than speeding vehicles) are the at risk vehicle. Solutions for "Truck tipping" and "Steep Descent" sites are currently being sought/developed.

- Likewise, combination of VAS with a classifier on motorcycle routes to specifically target motorcycles.

- Combination of VAS with a wet weather sensor is currently being developed for use on sites where crash history indicates high occurrence of wet weather crashes.

References

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Appendix A

Flow Chart – Site Selection Criteria for VAS