

## Evaluation of Safety Treatments at Roadwork Zones

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### Abstract

A major 3-year research project to improve safety at roadworks has recently been completed by the Centre for Accident Research and Road Safety – Queensland (CARRS-Q) and industry partners. This project involved developing strategies to mitigate roadwork hazards including speeding. This paper presents three on-road evaluation studies on the effectiveness of some current and new safety treatments: use of pilot vehicles, variable message signage (VMS), police enforcement with and without VMS, and remote-controlled traffic control devices. The speed reduction potential of pilot vehicles was evaluated at a highway site. Results showed that pilot vehicles reduced average speeds within the work area, but not at a downstream location. Combinations of VMS and police enforcement were evaluated at a motorway site and results showed that police enforcement accompanied with VMS had greater effects on reducing speeds than either of these treatments alone. Three new remote-controlled traffic control devices—red and amber lights, red light and amber arrow, and a robotic stop/slow sign—were evaluated at a highway site. Results showed that the red light and amber arrow option produced consistent effects on the speeds at the approach to traffic controls and at a location inside the work area. This paper presents the first rigorous evaluations of these roadwork safety treatments in Queensland.

### Introduction

Excessive speeds at roadwork zones pose significant risks to roadworkers and motorists (Allpress & Leland Jr, 2010; Debnath, Blackman, & Haworth, 2015; Garber & Zhao, 2002). A recent study of driver speeds in three Queensland roadwork zones (Debnath, Blackman, & Haworth, 2014) reported that drivers violate the posted speed limits at all stages of roadworks (advance warning area, taper area, work area, and termination area), often with high margins over the posted limits. For example, almost all drivers (77-98%) drove over posted speed limits when approaching a roadwork zone, while many (19-45%) drove at 20 Km/h or more over the posted limits. The high rate of speeding is known to be associated with roadwork crashes. Speeding was cited as a contributing factor in 42% of work zone crashes in Texas (Brewer, Pesti, & Schneider, 2006), 7% of fatal crashes in Georgia (Daniel, Dixon, & Jared, 2000), and 25% and 16% of fatal and injury crashes respectively in Kansas (Bai & Li, 2011).

The dangers caused by excessive speeds in roadwork zones motivated this study to evaluate potential safety treatments for reducing driver speeds at roadworks. This research was a part of a recently completed major research project on improving the safety at roadworks hosted at the Centre for Accident Research and Road Safety – Queensland (CARRS-Q). The findings obtained from three studies evaluating the effectiveness of speed control treatments at roadwork zones are presented in this paper.

### Method

To three on-road evaluation studies involved evaluating the speed reduction potentials of pilot vehicles, variable message signage (VMS), police enforcement with and without VMS,

and remote-controlled traffic control devices. The evaluation methodologies for each study are discussed in the subsequent paragraphs.

Effectiveness of pilot vehicles was evaluated in a long-term rural two-lane highway roadwork zone (Bruce Highway) where one lane was closed for roadworks and the other lane was alternating two-way traffic, controlled by manual stop/slow method. A pilot vehicle was used to guide the traffic on the open lane on three days in a five day study period (i.e., there was no pilot vehicle on the other two days). Driver speeds were measured at two locations: (1) within the work area where the pilot vehicle was operating and (2) at a location after the work area (not covered by the pilot vehicle) to examine downstream effects. A detailed description of the data collection plan and the data analysis method is available in Debnath et al. (2014).

Effects of VMS with and without (overt) police enforcement were studied in a long-term motorway work zone (Pacific Motorway, near Gold Coast). A VMS was placed ahead of the work area which displayed messages ‘Roadwork speed limits are enforced’, ‘Speed cameras operate in roadworks’, ‘Slow down for road worker safety’, and ‘Slow down, road workers on site’. Police enforced the 60 km/h posted speed limit using a speed camera on three days (5 hours each day). Among these three enforcement days, the VMS was active on two days. This study design produced three combinations of police enforcement and VMS: (1) only VMS was active, (2) police enforcement without VMS, and (3) police enforcement with VMS. These combinations allowed examining both the individual and combined effects of VMS and police enforcement on driver speeds. Reductions in mean speeds and proportions of vehicles speeding at various margins (5 km/h, and 20 km/h over the limit) were computed.

Three new remote-controlled traffic control devices—amber and red lights (A-R), amber arrow and red light (AA-R), and a robotic stop/slow sign (RS)—were evaluated at a rural highway roadwork zone (Moonie Highway, southern QLD). Out of the two lanes of the highway, one was closed for roadworks. The other lane served alternating traffic from both directions using manual stop/slow methods. The new traffic control devices were remotely controlled and therefore it was possible to reduce the exposure of human traffic controllers (HTC) to traffic by allowing them to be positioned away from road. Traditional traffic control devices including HTC and Green-Amber-Red traffic lights (G-A-R) were also used to provide baseline reference for evaluating the effectiveness of the new TC options. Effectiveness was assessed using three measures: compliance with stop condition, speeds ahead and after the traffic controls, and driver understanding of the traffic control devices. Speeds were measured using pneumatic tubes at three points: (1) 50m after the first speed reduction sign, (2) 30m ahead of traffic controls, and (3) 70m after traffic controls. A roadside survey was conducted at the other end of the site among the drivers who stopped at the front of the traffic queue. Drivers were asked questions regarding their understanding of the different traffic control devices and their preferences, if any.

## **Results**

### ***Evaluation of pilot vehicle operation***

The mean speed of all vehicles under a posted speed limit of 40 km/h was 5.9 km/h lower (dropped from 52.0 to 46.1 km/h) when a pilot vehicle was in operation. The size of the reduction did not differ significantly by type of vehicle. Despite these reductions, the mean speed of all vehicles remained 6.1 km/h above the posted limit under pilot vehicle operation.

Under pilot vehicle operation, the proportion of speeding vehicles fell by 12.5%. Almost all vehicles (97.8%) violated the posted limit in the absence of the pilot vehicle, whereas 85.3% did so when it was present. The largest reduction in prevalence of speeding was seen for medium vehicles (15.0%), followed by heavy (12.8%) and light vehicles (12.1%). The effect of the pilot vehicle in reducing speeding vehicles was greater (32.7%) in the case of travelling at least 5 km/h above the posted limit. Similar patterns of reductions were seen for the three types of vehicles. Despite these reductions, 55.7% vehicles (again with a smaller share of medium vehicles than the other types of vehicles) still travelled at least 5 km/h above the limit. The greatest reduction occurred in the proportion of vehicles travelling at least 10 km/h over the limit (38.1%) with a greater reduction for medium vehicles (40.4%) than the light (37.9%) and heavy vehicles (37.8%). Results indicated that the pilot vehicle has greater effects in reducing speeds of the vehicles following it closely in a traffic stream (i.e., smaller gaps between vehicles) than those which are far behind the traffic stream and have larger gaps from their preceding vehicles.

While the pilot vehicle reduced driver speeds considerably, the pilot vehicle itself was found exceeding the posted limit on 34% of its trips, and exceeded the limit by 5 km/h or more on 7.4% of the trips. No significant effects of the pilot vehicle on the downstream speeds were observed.

### ***Evaluation of VMS and police enforcement***

Both the separate and combined use of police enforcement and VMS resulted in reductions in the mean speeds. Police enforcement alone led to a 1.1 km/h mean speed reduction, whereas VMS alone showed a 2.8 km/h reduction. However, a greater reduction was found (4.2 km/h) when police enforcement was accompanied by VMS.

A similar trend was observed for the reductions in the proportions of speeding vehicles achieved by the three treatment options. About 27% fewer vehicles violated the posted speed limit when both VMS and police enforcement were present. On the other hand, police enforcement and VMS separately showed reduction of 4% and 20% respectively. About 27% reduction was observed in the percent of vehicles travelling at least 5 km/h over the speed limit when both VMS and police enforcement were present. About 4% and 14% reductions were observed for police only and VMS only conditions, respectively. In the case of speeding by a larger margin (10 km/h over the limit), the trend remained similar to the above findings. About 15% reduction was observed in the percent of vehicles travelling at least 10 km/h over the speed limit when both treatments were present. Police enforcement alone produced a 3% reduction, whereas VMS alone produced 7% reduction. The reductions in the percent of vehicles speeding by at least 20 km/h were not meaningful as only about 0.5-2.5% vehicles were speeding by 20 km/h when no treatments were present.

Overall, it appears that while both VMS and police enforcement effectively reduce driver speeds and rates of speeding at different margins over the speed limit, the greatest effects were obtained when both treatments were present together. A possible explanation for this finding is that drivers might become more aware of the risk of getting a fine for speeding by reading the VMS messages and then seeing a police car parked on the side of the road.

### ***Evaluation of remote-controlled traffic control devices***

Results showed 100% compliance rates with the direction to stop for all traffic control devices, except for the RS which had 4 vehicles fail to stop in 6.7 hour observation period.

The mean speeds ahead of the traffic control location were higher for all traffic control devices (G-A-R: 4.8 Km/h, A-R: 7.3 Km/h, AA-R: 5.0 Km/h, and RS: 6.0 Km/h) than the HTC. The highest speeds were found for A-R. Under this condition drivers may have increased their speed anticipating an imminent change from solid Amber to Red. This does not seem to have occurred under AA-R where mean speed was similar to G-A-R.

At a location inside the work area, mean speeds were similar for HTC, G-A-R and AA-R (less than 1 km/h difference). Speeds for A-R and RS were lower than for HTC (4.4 and 2.6 Km/h, respectively). The relatively low speed for A-R likely reflects a greater speed reduction after approaching (and passing) the TC location at relatively high speed.

While most drivers understood ‘when to stop’ and ‘when to go’ for G-A-R and RS devices, the A-R and AA-R devices caused some confusion. While about 93% and 94% drivers understood when to stop for the A-R and AA-R devices respectively, the corresponding values for when to go were rather low (33% and 24% respectively). Asked what they would do upon seeing an amber (A-R) light, 10 of 69 drivers were unsure of its meaning (‘caution’/‘go’), while another 9 said they would call the fault line to report a fault. Similarly, 16 of 69 drivers were unsure what to do upon seeing an amber arrow (AA-R).

Drivers’ preferred option for knowing ‘when to stop’ was the G-A-R condition (66.9%), followed by RS (27.7%), A-R (3.6%) and AA-R (1.5%), while 6.9% had no preference (includes multiple responses). The best option for knowing ‘when to go’ was clearly G-A-R (82.9%), followed by RS (23.3%), AA-R (4.7%) and A-R (3.1%). These values suggest that drivers like to see on road what they are familiar with. The driver survey indicates that driver education campaigns may be necessary before widespread implementation of the new traffic control devices.

## **Conclusions**

Findings from three on-road evaluation studies of roadwork safety treatments showed promising results. A pilot vehicle effectively reduced driver speeds and proportions of speeding vehicles within the work area, but did not bring the mean speeds down to posted speed limit and did not show significant effects on the speeds at a location downstream of the work area. Police enforcement and VMS were found to reduce driver speeds, but greater reductions were achieved with these treatments used in combination. The new remote controlled traffic control devices showed promising results in reducing driver speeds before and after the traffic control location, but the roadside driver survey revealed that the two-aspect traffic lights (amber light and amber arrows) caused confusions among some drivers. These devices, however, were successful in reducing the exposure of the human traffic controllers by allowing them to stand away from the road.

## **Acknowledgements**

The authors are grateful to Australian Research Council, GHD Pty Ltd, Leighton Contractors, and QLD Department of Transport and Main Roads for funding the research project titled “Integrating Technological and Organisational Approaches to Enhance the Safety of Roadworkers” (Grant No. LP100200038). The authors would also like to acknowledge the support of the Australian Workers Union. The comments expressed in this paper are those of the authors and do not necessarily represent the policies of these organizations.

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