THE VICTORIAN INTELLIGENT SPEED ASSIST AND HEAVY VEHICLES TRIAL: ANALYSIS OF DEVICE ACCEPTABILITY AND INFLUENCE ON SPEED CHOICE

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ABSTRACT

The road safety benefits of Intelligent Speed Assist (ISA) have been demonstrated in passenger car trials. These benefits, however, have yet to be replicated in the heavy vehicle (trucking) industry. This small-scale trial conducted by the Transport Accident Commission (TAC) in collaboration with the Victorian Transport Association (VTA) with the cooperation of several heavy vehicle transport companies sought to assess the relative merits of ISA in terms of driver acceptability, speed choice, and fuel consumption.

The study was a pre-post design. Prior to the installation of the ISA device, a GPS device was fitted to six heavy vehicles and vehicle speed and trip characteristics were continuously recorded. An advisory ISA device was then installed for a period of four to six weeks. Seven drivers participated in the trial and completed a survey before and after the trial.

Prior to the study, six of the seven drivers stated they would find a device that would assist their speed choice to be useful, while four believed a device that would prevent them speeding would also be valuable. Following the trial, six drivers reported finding the system helpful in preventing them from speeding, rating it as 5 or above on the 10 point scale. Opinions were more divided in terms of the accuracy of the speed limit map, with two drivers rating it as very poor.

Analysis of speed data indicated mixed benefits of ISA with a reduction of up to 21% in the odds of travelling over the posted speed limit; however reductions were speed zone dependent. ISA was most effective in improving compliance at the higher speed zones (≥80km/h) and not at all for the mid-level speed zones. Analysis of the speed data indicated an increase in the mean speed in the mid-level speed zones but a reduction in the lower and higher speed zones.

Device acceptability appears to play some role in the effectiveness of advisory ISA systems, however the relationship is complex. Further work that explores the relationship between acceptability of ISA and compliance with the assigned speed limit is required.

INTRODUCTION

Speeding is recognised to be a leading contributor to the occurrence of crashes and their associated level of injury severity.[1-4] There is a considerable body of work that examines the factors associated with exceeding the speed limit, and these include personal characteristics (e.g., age, gender), trip purpose, perceived level of detection by police, as well as the perceived credibility of the assigned limits themselves.[5-9]

Compliance with posted speed limits is a critical facet of a safe transport system.[10] As noted by Jiménez and colleagues, and supported by a large number of research studies, the setting of speed limits – and associated compliance, leads to more appropriate driving speeds and less variability in travelling speeds, leading to a safer road environment. [11] Speed has been identified as a major factor in heavy vehicle crashes and there has been a push both in Australia and globally to address speeding behaviour – as well as a range of other behavioural, organisational and vehicle safety concerns as a means of improving heavy vehicle safety.

Heavy vehicle safety and crashes in Australia

In Australia, for the 12-month period ending June 2010, 258 people died as a result of 212 crashes that involved heavy trucks or buses. One-quarter of those killed were occupants of the truck/bus itself (60% single vehicle crash).[12] Truck-involved fatalities account for approximately one-fifth of those killed on Australian roads, despite representing approximately only 4% of registered vehicles in Australia.

This over-representation can be explained by increased vehicle mass and exposure. It has been reported that heavy vehicles account for 8% of the total kilometres travelled in Australia and on a per distance rate travel twice that of passenger vehicles.[13]

Given their high rates of exposure, transport drivers are unsurprisingly the most frequently involved group in work-related crashes in Australia. This was shown in a study of 13,124 drivers involved in crashes during the period 1997-2002 in New South Wales, Australia. In this study, nearly half of all fatalities resulting from work-related crashes were drivers of heavy vehicles and speeding was associated with 15% of crashes. [14]

An analysis of the Australian National Coronial Information System (NCIS) of heavy vehicle deaths in Victoria in the period 1997 to 2007 reported that speeding was associated with 36% of crashes where the driver of a heavy vehicle was killed. In this study all of the truck drivers that were killed were male, one-third involved the vehicle leaving the roadway and 17% of drivers were detected with an illicit drug in their system; seatbelts were worn by only 40% of the 61 drivers killed.[15]

The importance of the heavy vehicle industry to the economy – whether it be in the movement of goods or people, cannot be underestimated. This will increasingly be the case in the future given that road freight is predicted to double by 2020. With fuel costs expected to rise [16, 17], the role of speed management in assisting drivers and helping companies reduce crashes, contain costs and remain competitive is thus likely to play an increasingly important role in the operational plans of many transport operators. It is within this context that government regulation and road safety management plans are likely to be crucial.

Regulations and road safety management systems focussed on heavy vehicles

In recognition of the importance of the transport sector to the economy, governments have increasingly relied upon regulations that focus on improving safety in the sector. Bodies such as the USA Federal Motor Carrier Safety Administration (http://www.fmcsa.dot.gov/)[18], the National Transport Commission in Australia (http://www.ntc.gov.au/)[19] and the European Commission (http://ec.europa.eu/transport)[20] have regulations focussed on professional drivers that cover driver licensing, alcohol and fatigue control, the transportation of dangerous goods as well as vehicle dynamics. The explicit link between scheduling and the adherence to speed limits has been recognised through the introduction of regulations designed to control the expectations of transport operators and their clients with respect to delivery times.

In addition to regulations, road safety management plans are becoming increasingly common in the private sector. This has stemmed from a recognition of the significant loss of productivity associated with crashes and the resultant injuries.[10] Indeed, the Michelin Challenge Bibendum Road Safety Taskforce notes that much can be achieved in the reduction of work-related crashes though the '*collective mobilization of private companies'* though the adoption of innovative policies.[21]

The proposed ISO Standard for *Road-traffic Safety Management Systems – Requirements and Guidance for use (*ISO 39001)*[22],* currently under development (*http://www.iso.org),* falls under the ambit of occupational health and safety in the transport sector domain and is designed to promote effective road safety management. A key component of effective road safety management in the fleet context is speed control. In Australia this has been recognised by the Australian Transport Council who set a target of a 30% reduction in heavy vehicle associated crashes due to improved speed management.[13] New active safety system technologies, such as Intelligent Speed Assist devices (ISA), offer a potential way to assist the driver – and the fleet operator, in ensuring speed limit compliance.

A role for Intelligent Speed Assist (ISA) Systems in heavy vehicles

Advisory ISA systems are a driver support system that uses knowledge of the road network and GPS technology to improve compliance with the posted speed limit by delivering visual and / or auditory warnings to the driver. More interactive ISA systems actively discourage (via haptic feedback) or prevent the driver from exceeding the speed limit (i.e., intervening, over-rideable or not over-rideable). [23-26]

A number of studies have documented the benefits of ISA technology in 'reducing speed, speed variability and speed violations'.[23, 25, 27, 28] Devices that exercise a greater control over the driver are seen to be most beneficial, as opposed to simple advisory systems, however these controlling systems are less likely to be acceptable to drivers.[23, 26] Reductions in mean speed, the 85^{th} percentile speed and percentage of distance travelled over the speed limit have all been documented with the use of ISA.[25, 28] Using these observed reductions in speed, substantial reductions in the number of crashes and of individuals injured have been estimated.[29]

Despite these benefits, a number of negative effects have been observed with ISA. Two key issues are the acceptability of the system warnings [11] and driver adaptation or system over-reliance. [23, 25, 26, 30] System over-reliance is of concern as faster speeds on bends and in approaching intersections have been observed. In addition, young drivers and males appear to be less accepting of the ISA device and it is precisely this group that could benefit most from ISA given their heightened crash risk.[28]

While the beneficial effects of ISA have been demonstrated in passenger cars, no study had demonstrated the value of ISA in heavy vehicles at the time this study was planned. This was despite the findings of a comprehensive review undertaken in 2003 by Regan, Young and Haworth that concluded that ISA systems have the potential to deliver a range of benefits for the heavy vehicle industry, including improved speed control and improved fuel efficiency.[31]

This study set out to examine whether the potential benefits of ISA observed in passenger cars would translate to heavy vehicles.

The current study: a real-world trial of ISA in heavy vehicles in Victoria

The Transport Accident Commission (TAC) in collaboration with the Victorian Transport Association (VTA) and with the cooperation of three heavy vehicle transport companies conducted a small scale trial in an attempt to assess the relative merits of ISA in terms of speed choice, driver acceptability and fuel consumption.

A preliminary paper published elsewhere examined in detail the pre-and post-survey (qualitative) responses for all drivers in the trial and used on-road data for two drivers to examine the on-road effect of ISA. The preliminary analysis reported mixed findings with the level of benefit being speed zone dependent.[32]

This paper presents an examination of the effect ISA has on the change between the number of recorded occasions the driver exceeded the assigned speed limit in the baseline (pre-ISA period) period compared to the ISA trial period, overall and for each speed zone. Also of interest was the association between the perceived usefulness of the device and compliance with the speed limit.

METHOD

Participants

Seven drivers from three transport companies agreed to participate in the trial. The drivers provided informed consent to participate and each completed a questionnaire before and after the completion of the study.

Participating companies/vehicles were selected on the basis of the following criteria:

- they had significant Victorian-based long distance travel undertaken by a number of company vehicles;
- trucks in the study were of similar makes and models and operate repeat trips within Victoria, and
- the company is committed to providing data for evaluation purposes and to allow access to drivers for a briefing session and to complete pre-/post-questionnaires

Design of the trial

The trial was designed as a pre-post study of ISA. (Figure 1). Phase 1 collected baseline data using a GPS logger while Phase 2 was the ISA trial period. Hence the trial was a simple baseline vs. ISA trial of the effect of ISA in improving speed limit compliance.

Phase 1	Phase 2
Baseline speed assessment *('baseline')*	ISA trial period *('trial')*

Figure 1. Design of the ISA trial

Each Phase differed slightly in duration for each company and driver for operational reasons. In general, Phase 1 was approximately four weeks in length while Phase 2 was approximately 8 weeks duration.

The ISA device for use in the trial

The ISA technology deployed was advisory; that is, it did not limit the speed of the vehicle but simply provided the driver with auditory and visual warnings when the speed limit was exceeded. No data was collected by the advisory ISA device but rather it served purely to advise the driver of the speed limit at each particular moment in time. The ISA device was programmed to alarm when the driver exceeded the assigned speed limit by two km/h for a period of two seconds or more. The driver could override and switch the ISA device off if needed. No data was collected from the vehicle speedometer though the ISA device was calibrated to the speedometer.

Data sources

Data collected in the trial included a pre-post participation questionnaire, the logged trip data referred to as the GPS-Enhanced data and the Transport Operator Trip logs. Each is discussed below.

Survey data - A *pre-trial survey* was completed by each participating driver with the aim of capturing a range of attitudes to speeding and the likely benefits of 'smart' technology in aiding the driving process. Attitudinal data was collected using either a 5-point Likert scale (1: strongly disagree to 5: strongly agree) or via free text responses. Demographic information was also collected.

A *post-trial survey* was completed to obtain feedback concerning the usability and acceptability of the ISA device, as well as attitudes relating to road safety more generally. A number of attitudinal questions were repeated from the pre-trial survey, permitting a pre-post analysis to be undertaken.

GPS-Enhanced data – In Phase 1, the baseline period, a GPS data logger was installed into the truck to collect speed and associated trip data. Drivers were aware of the data logging capability of the GPS device however they could neither see nor interfere with the device.

The GPS device continually collected detailed information in 15 second cycles. For each cycle, speed (km/h) was captured as were GPS co-ordinates, time and date, distance covered (metres) and bearing / heading.

The GPS logged data was enhanced via linkage with the Victorian road network using Geographic Information System (GIS) software. Vehicle position was established using the longitude and latitude of each cycle. Of particular relevance was the assignment of the speed limit of the road for each recorded cycle. Allowance was given for school day periods associated school speed zones and shopping zones with variable speed signs. The linkage was conducted by the Roads Corporation, Victoria (VicRoads).

Transport Operator Trip Logs – At the conclusion of the trial, companies provided extensive trip logs for each of the trucks involved in the trial. This included the drivers of each trip, the date of vehicle use, destination, odometer readings, load mass, and fuel consumption or fuel refill amount and date. The time of day that the trip was undertaken and completed was not reported in the trip logs.

The trip logs were critical in determining which data cycles to analyse. While two drivers were the sole drivers of their vehicles for the duration of the trial, one truck was driven by five drivers, two of whom were in the study; one truck was driven by 10 drivers (one in trial) 1 truck was driven by 11 drivers (one in trial), while another truck was driven by 19 drivers. It was then necessary to link the driver log data to the GPS enhanced dataset to ensure that only those drivers that were enrolled in the trial (i.e., drivers of interest) were included in the analysis. Where multiple drivers drove the truck on a single day, data pertaining to that day was excluded from the analysis.

Data Analysis

A single database was constructed that linked the pre-/post-survey data, the trip log data and the GPS Enhanced dataset. This dataset formed the basis of the analysis reported here.

For the survey data, median values and the associated range among respondents were presented due to the ordinal nature of most of the items and the small sample size. Non-parametric statistics were used to examine pre-post survey responses where appropriate.[33]

The principal outcome of interest was the change in the number of cycles that the vehicle travelled over the posted speed limit following the installation of the ISA device compared to the baseline period. Analysis of the effect of ISA included time cycles 'where the vehicle was in motion and the speed limit of the road was known'. Hence, this excluded cycles: i.) where the vehicle was not in motion (including when stationary at lights or off-road), and / or ii.) where the assigned speed of the vehicle was unknown.

To examine the change, if any, in the number of timed cycles the vehicle exceeded the assigned speed limit, calculation of the percentage point difference in cycles over the speed limit was determined overall and for each speed zone.

A General Estimating Equation (GEE) logit model was used to assess the effectiveness of the ISA device [34-36]. The GEE logit model was considered the most appropriate model given the repeated measures nature of the data with speed captured in 15-second cycles and the fact that each subsequent 15-second cycle would be correlated with that immediately prior, with this correlation likely diminishing with every cycle; that is, for repeated observations taken through time, those observations taken more closely to one another in time are likely to be more highly correlated than those taken further apart - this is known as an *autocorrelation.* It is critical to specify the nature of the working correlation matrix in order to account for the within-subject correlations. Ideally we would specify an unstructured matrix as this states that the correlation between any two cycles is unknown and thus needs to be estimated. An alternative model uses an autoregressive matrix of the first order (AR(1)) which would be acceptable as the interval length is constant between any two observations although this is not always true. Due to computational limitations (i.e., processing power, number of observations), an exchangeable within-subject correlation matrix was used. The autocorrelation matrix used assumes that the correlation between any two responses on any one driver is the same

The base main effects model of the effect of ISA on vehicles travelling in excess of the posted speed limit was: speed zone (note: 80km/h + was used in the model due to the GEE failing to converge when all speed zones were included), day of week, and the post-ISA device rating of the usefulness of the device. The repeated measures term was the driver variable. The dependent variable was the vehicle travelling over the posted limit, expressed as a dichotomous outcome.

Analysis was performed in SAS V9.2 of the SAS System for Windows.[37] Statistical significance was set at $p \leq 0.05$.

Ethics approval

The trial was conducted by the Transport Accident Commission with the data analysis conducted with the approval of the Monash University Human Research Ethics Committee.

RESULTS

Driver characteristics

The characteristics of the drivers are presented in Table 1 below. All of the drivers were male, 4 were aged under 50 years of age, and driving experience ranged from 10 – 19 years (median: 19 years). None of the drivers had heard about ISA prior to the commencement of the trial.

Table 1. Characteristics of the drivers involved in the trial

Characteristics	Number	Percent
Male (%)	7	100
Age category		
30 – 39	2	28.5
40 – 49	2	28.5
50 – 59	2	28.5
60+	1	14.25
Fined for speeding prior 5 years	2	28.5
Heard of ISA before trial	None	None
Driving experience	10 – 45 years, median: 19	

Pre-trial views of speed assist devices and speed behaviour

Drivers were asked a series of questions as to whether they would find a 'smart' speed warning device useful and their awareness of the speed limit when driving (Table 2).

Despite none of the drivers having heard of ISA prior to the trial, 6 of the 7 agreed that they would find a device that told them whenever they exceeded the speed limit useful. These same 6 drivers agreed that they sometimes exceeded the speed limit without realising it, and of these four agreed that they would find a device that stopped them going over the speed limit useful; the other two drivers who agreed that a simple advisory device would be useful altered their view to neutral on the usefulness of a more controlling device after the trial had concluded.

Three of the seven drivers stated they were neutral to *always being aware of the speed limit,* two agreed, and one disagreed. In combination, these findings suggest these drivers might find value in an ISA device. On the other hand, one driver disagreed that any device – advisory or controlling, would be useful, was neutral to 'sometimes going over the limit without realising' and strongly agreed that he was always aware of the speed limit. These divergent views are important to consider in the subsequent findings presented below.

Table 2. Pre-trial views of the perceived usefulness of ISA and speeding behaviour

Rating item	Median †rating	Range†
A device that told me whenever I went over the limit would be useful	4 (agree)	2 - 5
A smart device that stopped me from going over the speed limit would be useful	4 (agree)	2-5
I go over the speed limit sometimes without realising it	4 (agree)	3-4
I am always aware of the speed limit	3 (neutral)	2-5

† Rating scale: 1 – strongly disagree; 2 – disagree; 3 – neither; 4 – agree; 5 – strongly agree

Post trial driver views of ISA captured by the survey

At the conclusion of the trial drivers were asked to rate ISA according to how useful it was, its road safety benefits, how helpful it was, and how accurate it was, using a 10 point scale (with 10 as the highest most positive rating). The responses were as follows:

- Five drivers reported finding the system useful and to have road safety benefits, rating it as 5 or above on a 10 point scale;
- Six drivers reported finding the system helpful in preventing them from speeding, rating it as 5 or above on the 10 point scale
- Four drivers rated the accuracy of the speed limit map as 6 or higher, while one driver gave a rating of 4 while two drivers gave the lowest possible rating of very poor (1)
- Four of the seven stated they needed to over-ride the system or turn it off at some point;
- Six of the seven stated that the default volume for the auditory warnings was acceptable, while one stated it was too loud, although six stated the volume should be controllable, and
- To the question of whether drivers looked at the speedometer less due to the presence of the ISA device, three agreed, two were neutral and two strongly disagreed; of the latter two, one rated the digital speed map as very poor while the other suggested a device to show the speed prior to exceeding the limit – notably, this driver also pointed to the issue of calibration of the device and the difference in reading against the truck speedometer.

Finally, the pre- and post surveys indicated that the drivers held very conservative views of speeding, universally disagreeing to questions such as, *I think it is ok to drive a little bit faster if you are a good driver* and *It is easy to avoid being caught speeding.*

Summary of recorded 15-second cycles

The GPS recorded vehicle movement and associated information every 15-seconds. Only cycles where the where the truck was moving were used in the analysis, and those periods where the truck was off-road and stationary or stopped in traffic were excluded. There were somewhat fewer cycles recorded in the baseline period than during the ISA trial period, with the total recorded moving time translating to 934.4 hours and 1082.7 hours of continuous driving respectively; in total, 2017 driving (moving) hours were recorded. The crude odds ratio for an ISA benefit was 0.82 (95th% CI: 0.81-0.83), which means that the crude (unadjusted) odds of travelling over the speed limit when ISA was active were 18% lower than during the baseline period.

Table 3. Overall data collected, including consideration of under/at vs. over limit (vehicle moving)

	Baseline	ISA
Time cycles captured	224,269	259,870
Under or at limit	192,999 (86.1%)	229,386 (88.3%)
Over limit	31,270 (13.9%)	30,484 (11.7%)

Effect of ISA on the speed profile

ISA has been shown previously to influence speed distributions differentially according to speed zone. Table 4 presents evidence for an increases in the overall mean speed and notable increases in the mean speed and median in the 50km/h zone, the 60 km/h and the 70 km/h speed zones.

In contrast, reductions in the mean speed can be observed in the 80 km/h, 100 km/h and 110 km/h speed zones. There was little difference in the median and the 85th percentile speeds travelled.

Table 4. Speed profile before and during ISA installation

Speed zone(s)	Baseline	ISA
	Mean speed; Median; 85^{th}%	
Omnibus† (all)	77.7; 92; 100	78.5; 92; 100
40 km/h	28.9; 29; 44	29.2; 29; 44
50 km/h†	27.9; 18; 53	31.9; 26; 55
60 km/h†	41.2; 45; 59	42.5; 47; 60
70 km/h†	46.9; 51; 68	48.7; 53; 70
80 km/h‡	65.1; 70; 82	63.8; 69; 81
90 km/k	78.4; 81; 99	79.4; 85; 99
100 km/h‡	92.3; 98; 101	91.9; 98; 100
110 km/h‡	97.4; 100; 101	95.1; 100; 100

† P ≤0.05, Higher ‡ P ≤0.05, Lower

Regression modelling of the effect of ISA

Using the recorded speed and the assigned speed limit to the road, we determined the number of cycles where the vehicle exceeded the posted speed limit. We can see an overall 2.23 percentage point reduction in the total number of 15-second cycles over-limit in the ISA trial period relative to the baseline period; this is derived by simple subtraction of the percent cycles over the limit in the ISA trial period (11.74%) from the baseline period (13.98%).

The GEE logit regression model was used to assess the influence of the ISA device on episodes of exceeding the speed limit. In short, after adjusting for correlated outcome data and controlling for speed zone, day of week and the post-ISA trial rated 'usefulness' of the device, the odds of the drivers exceeding the speed limit were reduced by 21% compared to the pre-trial period. This difference was statistically significant (OR: 0.79, 95^{th}% CI: 0.70 – 0.91, p=0.001).

As evident in Table 5, this positive benefit of ISA was not uniform across speed zones, with benefit observed in the 50km/h (OR: 0.86, 95^{th}% CI: 0.79 – 0.94, p=0.002) and the 80km/h and faster speed zones (OR: 0.73, 95^{th}% CI: 0.63 – 0.88, p=0.001). The 50km/h result appears anomalous given the higher percentage point increase in being over-limit and the negative OR that indicates a benefit; the OR result is a consequence of effect of the covariates and / or the effect of one driver being over-represented in this speed zone (as an aside, this is known as Simpsons Paradox). It remains the case that the adjusted OR is the appropriate value to interpret and is indicative of a significant benefit of the ISA system.

Table 5. Effect of ISA device overall and by speed zone on the number of recorded violations of the speed limit

Effect of ISA device	% point diff. in over-limit	Association with over-limit cycles OR	CI	P
Omnibus (all speed zones)	-2.23	0.79	0.70-0.91	0.001
40 km/h	-1.30	0.91	0.48-1.73	0.7
50 km/h	+4.74	0.86	0.79-0.94	0.002
60 km/h	+1.39	0.99	0.74-1.31	0.9
70 km/h	+3.87	1.01	0.74-1.37	0.9
80 km/h plus	-3.33	0.73	0.63-0.88	0.001

Post-trial attitudes to the usefulness of the ISA device

Of interest was the association between attitudinal responses to the acceptability and usefulness of the ISA device and travelling over the posted speed limit. This was modelled in the same GEE model as presented in Table 5. Table 6 shows that for driver responses as to the usefulness of the ISA device (rated on a 1, not at all to 10, extremely useful), there was little association overall. However it can be seen that for every 1-point increase in perceived usefulness of ISA there was a 17% lower odds of exceeding the speed limit in the 60 km/h and 70km/h zones. This finding could be a manifestation of drivers relying on the ISA system and hence there is no change in the vehicle over-limit episodes. This is supported by a higher mean speed in these zones in the ISA trial compared to baseline. It is possible the truck drivers take more immediate preventative action in these road contexts when the device alarms given the increased complexity of the environment. As the ISA device was calibrated to the speedometer and drivers rely on the device to monitor their speed, and consequently there was no difference in vehicle over-limit episodes between the two periods; this explains nicely why there is a relationship between perceived usefulness of ISA in these speed zones with respect to a reduced likelihood of exceeding the assigned limit.

Table 6. Association between rated ISA device usefulness and over-limit episodes

Effect of ISA device	Association with over-limit cycles		
(pre-post), overall and by speed zone	OR	CI	P
Omnibus (all speed zones)	0.96	0.41-1.29	0.3
40 km/h	1.20	0.93-1.54	0.2
50 km/h	1.12	0.84-1.50	0.8
60 km/h	0.83	0.75-0.92	≤0.001
70 km/h	0.83	0.75-0.92	≤0.001
80 km/h plus	0.73	0.41-1.29	0.3

DISCUSSION

Despite the small scale nature of this trial, which involved seven drivers from three trucking companies, the richness and volume of the data lead us to report four key findings with respect to the implementation of ISA.

First, the drivers who had previously not heard of ISA prior to the introduction of the trial and who reported uniformly conservative attitudes to speeding reported differential levels of acceptability and usefulness of the ISA device. This was despite the finding that most of the drivers agreed or strongly agreed prior to the trial that a device that informed them they were exceeding the speed limit would be useful, as would a device that prevented them from speeding.

Second, there was an increase in the mean travel speeds in the lower range speed zones and a reduction in the higher speed zones with the introduction of the ISA system. There have been previous reports of drivers 'driving to the ISA device' and our results appear to reaffirm this at least in the case of the lower speed zones.

Third, there was a statistically significant 21% reduction in the odds of exceeding the posted speed limits overall, though this effect was not uniform and was present in the lower end and was particularly pronounced in the high-end speed zones. ISA had little influence on the odds of exceeding the speed limit in the 60 km/h and 70km/h zones, though importantly the mean speed in these zones did increase significantly.

Fourth and finally, we explored the survey responses with respect the perceived usefulness of the ISA device. It was interesting that the relationship emerged in the 60km/h and 70km/h speed zone in the absence of an ISA effect and in the context of higher mean speeds. This provides further support for the notion that in these speed zones, which tend to have much greater complexity in the environment, that drivers rely on the ISA device, which when it alarms they react accordingly and slow down; hence there was no observable statistical benefit of the ISA device since the ISA device was calibrated to the speedometer. This could give drivers an opportunity to place greater emphasis on recognizing and responding to road hazards, and hence these results also explain the finding that the perceived usefulness of ISA was associated with the likelihood of exceeding the assigned speed limit.

That a beneficial effect of the ISA device was present in the higher speed zones is reassuring, particularly as it is these zones that there is more opportunity for 'free speed' driving uninfluenced by the presence of other drivers.

Analysis of the post-trial survey data reported previously bear relevance to the new findings report here. [32] The survey results reported previously found that despite most drivers regarding ISA as helpful in preventing them from speeding, the majority were not interested in being involved in future ISA trials. This pointed lack of enthusiasm might be a consequence of some of the practical issues and perceived limitations of the ISA device that became evident in the rollout of the trial. Three of the seven drivers reported needing to override the system during the trial while two drivers needed to turn the system off, principally due to inaccuracies in the speed limit map; one also expressed a profound dislike for the auditory warnings. Once the inaccuracies in the speed limit map became evident in the early phase of the trial, considerable effort – both financially and in person hours, was put into upgrading the speed map which was of benefit to the drivers who entered the trial at a later date. In addition to ensuring a 'perfect' speed zone map to the extent possible, modifications to the devices such as the inclusion of a volume control button and the redesign and customisation of auditory warnings could help build greater acceptance of the technology among heavy vehicle drivers.

Limitations and Lessons

In the analysis of the trial two key technical matters came to light, the first relating to the matching of the GPS co-ordinates to the exact location and hence speed zone, and the second concerns the statistical analysis methods utilised for this type of data.

The first issue is a technical concern that relates to the imperfect matching of the longitude and latitude co-ordinates of the road on which the vehicle was travelling with respect to assignment of the speed limit. This appears to be due to a lack of precision and ability to differentiate the speed zones at certain locations, for instances on bridges and service/slip roads. Our investigations do however indicate that i.) the error rate is low, and ii.) the error would be systematic and hence unbiased with respect the pre-post installation period of the ISA device. We are further benefited in this trial by the truck drivers in the study driving consistent routes, commencing each day at largely the same point of origin and driving a consistent pattern of destinations. Consequently we consider that our percentage difference of cycles and Odds Ratio values comparing baseline to the ISA trial period would not be biased by this problem.

The repeated measures nature of the data collected and the dichotomous outcome (i.e., vehicle over-limit) presented a considerable analytical challenge, particularly as the relatively new GEE logit model was used in this analysis. Despite having over 500,000 records, admittedly for only seven drivers, we were limited in the number of covariates that we could model, while the modelling of interactions proved extremely difficult. The inclusion of covariates in addition to the day of week and a single attitudinal measure of acceptability such as time of day, weather conditions, and additional demographic, route and vehicle characteristics would be ideal, however vast number of observations would be required and the associated computing power required would be immense.

Finally and as already noted, we report the difference in the percentage of cycles over the assigned speed limit. This is an important methodological consideration as the 15 second interval, while used to capture cycles over the assigned speed limit, is unlikely to represent a singular speed violation episode, particularly given the mass, and hence momentum of the truck. That is, it is most probable that a number of sequential 15-second cycles represent a singular speed violation episode. Future analysis will need to determine an appropriate algorithm in order to discriminate 'speeding' behaviour associated with throttle control from braking and gliding as a means of slowing down once an ISA speed alert has activated.

CONCLUSIONS

In summary, the TAC in collaboration with the Victorian Transport Association (VTA) and with the cooperation of several heavy vehicle companies conducted a small scale trial to assess the relative merits of ISA in terms of driver acceptability and speed choice. By the conclusion of the trial, there was a divergence of opinion with respect to driver acceptability of the device with some key issues emerging that require further investigation. In particular, further work is required on this dataset before a complete understanding of the relationship between acceptability and the effectiveness of ISA in mitigating speed among this group of drivers can be gained.

Overall, there was a significant 21% reduction in the likelihood of drivers exceeding the speed limit in the ISA trial period compared to the baseline period, and this effect was particularly strong in the higher speed zones. Despite a number of significant challenges both in the conduct of this research and the analysis of the collected data, the positive results encourage the initiation of larger-scale trials of active safety technology in the heavy vehicle industry. Further analysis is required to determine whether the differences in speed compliance result in fuel consumption benefits.

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NOTE

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