Maximising positive driver behaviour change and minimising driver distraction in the deployment of Cooperative Intelligent Transport Systems

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Abstract

Cooperative Intelligent Transport Systems (CITS) are emerging technology solutions with huge potential to improve road safety. CITS use Dedicated Short Range Communications to send and receive data between vehicles and infrastructure. The Cooperative Intelligent Transport Initiative is the establishment of an integrated testbed in the Illawarra region of New South Wales to facilitate the testing, measuring and assessing of CITS. Up to 60 heavy vehicles and a range of roadside infrastructure have been fitted with CITS. Participating drivers receive visual and auditory messages on an in-vehicle display. Messages include collision avoidance warning between equipped vehicles and alerts when exceeding the heavy vehicle speed limit or approaching red traffic signals.

A key focus in planning the testbed has been to maximise positive changes to driver behaviour while minimising the potential for the technology to distract from the driving task. To do this, the proposed warnings and information messages were assessed for clarity, consistency, and impact on driver workload against Human Machine Interface (HMI) design guidelines prepared for this project. The HMI design was subsequently revised based on this assessment. Other mechanisms to minimise driver distraction included a comprehensive driver induction package and customisation of the placement of the in-vehicle display screens for different cabins.

This paper will discuss the CITS initiative and the process used to optimise the HMI. By considering the impacts on driver behaviour and driver distraction now, road safety practitioners will be well-placed in the future to oversee the deployment of CITS in a manner that maximises its potential benefits.

Introduction

Cooperative Intelligent Transport Systems (CITS) use Dedicated Short Range Communications (DSRC) to transmit information between vehicles and between vehicles and infrastructure. This information can lead to important, concise messages being given to drivers - for example, to alert drivers of a potential collision or weather or congestion alerts. CITS increases the quality and reliability of information available to drivers about their immediate environment, other vehicles and road users by providing information that may not be directly visible. Some anticipated benefits include improved road safety, increased network capacity, reduced congestion and lower vehicle operating costs.

Researchers in the United States estimate that CITS has the potential to positively impact on 80% of crashes involving an unimpaired driver (Harding et. al. 2014). In the United States policy makers have announced an intention to implement a regulation that will require the technology to be installed on all new light vehicles. (National Highway Traffic Safety Administration, 2014). Research and testing of CITS in an Australian environment will allow researchers to examine some of the potential local impacts and learn more about the deployment of CITS.

Transport for NSW has established Australia's first CITS testbed in the Illawarra region of NSW, known as the Cooperative Intelligent Transport Initiative (CITI). The testbed provides an environment that allows testing, research and development of CITS in an Australian environment. This is the world's first CITS testbed dedicated to heavy vehicles. The testbed includes:

- 60 heavy vehicles equipped with CITS, including in-vehicle display of safety alerts
- 3 traffic signals equipped with CITS, broadcasting signal phase information to equipped vehicles
- 1 portable roadside unit broadcasting speed limit information to equipped vehicles
- 2 portable roadside units receiving and collecting data from equipped vehicles.

The CITS technology installed in the 60 heavy vehicles allows them to communicate with other equipped vehicles and with CITS-equipped infrastructure. Each heavy vehicle is fitted with a DSRC Radio and DSRC antennas, GPS and a 7-inch in-vehicle audiovisual display. In the first phase of the testbed, drivers will receive the following messages: forward collision warning, intersection collision warning, heavy braking ahead alert, red signal phase alert and truck speed limit information. Over time, more alerts will be added.

Method

Prior to proceeding with the installation of 60 CITI devices in heavy vehicles, Transport for NSW commissioned the Monash University Accident Research Centre (MUARC) to undertake a project to understand the potential impacts on driver behaviour and safety of providing visual and auditory warnings on an in-vehicle display.

First, a targeted review was conducted of previous research that has examined the safety impacts of in-vehicle driver assistance and warning systems that are similar in nature to the CITI device. Second, a set of Human Machine Interface (HMI) design guidelines were developed to minimise the unintended negative effects on driver behaviour of the CITI device. Finally, an assessment of the proposed CITI messages against the HMI design guidelines was conducted and changes were made to the HMI based on this assessment.

Other mechanisms to maximise driver safety included a comprehensive driver induction package and customisation of the placement of the in-vehicle display screens for different cabins.

HMI Design Guidelines

The review of the literature (Young & Lenné, 2013a) identified four main ways in which the use of in-vehicle warning systems may negatively impact on driver behaviour and safety. These are:

1) drivers adopting risky driving styles and behaviour

   What motivates drivers to engage in riskier behaviours when driving with in-vehicle warning systems is not clear, but may be because drivers are seeking to maintain a preferred target level of risk (Peltzman, 1975; Wilde, 1994) or because drivers are trying to improve their mobility or compensate for factors such as lost time due to the lower speeds brought about by some support systems.

2) over-reliance on the system

3) increased or decreased driver workload

   The introduction of in-vehicle warning systems can reduce the attentional demands on the driver as the system takes over a proportion of the workload (e.g. monitoring of following distance). This reduction can result in driver underload (Young & Stanton, 2007). When a driver’s mental workload is reduced enough it can lead to a reduction in situation awareness or boredom. This may lead to an inability to cope with a sudden increase in task demand, as can occur during a system failure or a safety-critical event that the system is not designed to handle (Ward, 2000; Young & Stanton, 2007).

4) driver distraction.

Many of the negative safety impacts of in-vehicle warning systems identified in the review can be overcome with good HMI design or appropriate training. HMI design guidelines for in-vehicle warning systems were developed. These aimed to ensure the CITI device met best practice design principles and that the use of the CITI device while driving led to minimal distraction and changes in workload. The focus of the guidelines was on the visual and auditory presentation of warnings and information to drivers. The guidelines comprise five sections: general design principles; visual display; auditory display; multiple warning design and scheduling; and portable device placement. The guidelines primarily consist of high-level, principle based guidance that is applicable to a range of visual and auditory driver warning systems.

There is the potential in the future for the vehicle to respond automatically rather than issue a warning to the driver. For example, by automatically applying the brakes when the CITS technology determines that a collision is imminent. This has not been explored in the CITI project at this stage. As the technology for automated vehicles matures, the need to provide warnings so that drivers can respond will lessen, and the vehicle’s systems will automatically take action. It is expected that this will reduce negative impacts on driver behaviour from in-vehicle warning systems.

Assessment of the CITI Device HMI

The guidelines were used to determine if the initial design of the CITI device as customised by Transport for NSW met best practice design principles in relation to usability and safety (Young & Lenné, 2013b). For each alert, an assessment was made as to whether it conformed to each relevant HMI guideline. Overall, many of the alerts individually conformed to the HMI guidelines. Some changes were made to the image, auditory tone or spoken message of some alerts, to distinguish different alerts from each other and to aid fast recognition of the meaning of each warning.

Driver Training

The literature review which was conducted to assess the safety impacts of in-vehicle warning systems found that issues such as system overreliance and some risky driving behaviours such as experimenting with the system can be overcome with training. The training must inform drivers how the system operates and what it is capable of doing and not doing and of what aspects of the driving task drivers will still need to be in control.

Transport for NSW prepared and delivered a comprehensive training package to induct drivers and familiarise them with the system. The training included a presentation that gave an introduction to CITI, the equipment being installed in vehicles and expectations of drivers. Most importantly, drivers were shown each message that the CITI device may generate. Animations were produced that effectively depict each scenario where an alert may be triggered, show what the alert looks and sounds like, and described what action a driver may need to take. The training package also included a fact sheet and user guide.

Placement of in-vehicle display

A 7-inch tablet was installed into each heavy vehicle and placement of the display was carefully considered. The size, shape and layout of each heavy vehicle's interior cabin, dashboard and windscreen differed greatly from vehicle to vehicle depending on the make and model. In addition to the constraints of the interior, many vehicles had existing equipment including dispatch systems, communication radios, and other devices. For each installation the drivers, fleet manager and installers were consulted as to where the best position may be. The placement of the screen in each vehicle was customised to suit the vehicle and the drivers of that vehicle. Improved safety and increased driver acceptance was achieved by consulting with the relevant stakeholders to identify their requirements and any usability issues. The HMI guidelines were also taken into consideration so that the CITI device was mounted securely to the vehicle, did not obstruct the driver's forward field of view or access to vehicle's controls and was placed as close as practicable to the driver's normal line of sight.

Conclusion

The Cooperative Intelligent Transport Initiative is establishing Australia's first CITS testbed to further explore the benefits of CITS and learn about the deployment of this technology. 60 heavy vehicles are being fitted with CITS and receive safety messages through an in-vehicle display. A review of the literature shows that in-vehicle warning systems can have both positive and negative effects on driving behaviour. In order to maximise positive driver behaviour changes and minimise any negative impacts, HMI design guidelines for in-vehicle warnings were developed based on best practice. The HMI of the CITI device was assessed against these guidelines and changes were made to the visual and auditory message of some alerts. Appropriate HMI design will become more critical in the future, as more CITS are introduced into new vehicles. The HMI design guidelines developed for CITI can be applied to all in-vehicle warning systems to assist in maximising the potential positive road safety benefits of this new technology.

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