USED CAR SAFETY RATINGS RESEARCH PROGRAM
ROAD SAFETY POLICY PAPER

POTENTIAL OF CURRENT VEHICLE TECHNOLOGIES TO IMPROVE SAFETY IN THE AUSTRALIAN AND NEW ZEALAND VEHICLE FLEETS
Potential of current vehicle technologies to improve safety in the Australian and New Zealand vehicle fleets

Introduction

Over the last 40 years there have been various improvements in vehicle technology and construction that have led to significant improvements in vehicle secondary safety (the ability of the vehicle to protect its occupants in the event of a crash, commonly referred to as crashworthiness). These improvements have been spurred by both legislative requirements, such as the Australian Design Rules (ADRs), administered federally in Australia under the Motor Vehicle Standards Act 1989, and, more recently, by market forces guided by crash testing of new vehicles and ratings of crashworthiness of used vehicles (Newstead et al, 2000). Figure 1, from Newstead et al (2000), shows the estimated trend in vehicle crashworthiness by year of manufacture for the Australian fleet along with the dates when ADRs relating to vehicle passive safety and major consumer focused vehicle safety initiatives were introduced. Improvement in crashworthiness is also notable over this period in the New Zealand fleet (Keall et al, 2007).

Figure 1: Estimated vehicle crashworthiness by year of manufacture for the Australian passenger fleet together with the years\(^ 1\) of introduction of key ADRs and dissemination of consumer vehicle safety ratings

\(^1\) Indicated on the graph are the following: in 1969, ADRs 4, 5A (seatbelt assembly and anchorage); in 1971, 2, 3, 8, 10A (seat design, door retention, glazing, steering column collapsibility); in 1972, 11, 14, 22 (sun visors, rear vision mirrors, head restraints); in 1973, 10B, 21 (steering column, energy absorbing instrument panel); in 1974, 4A (seatbelt buckle); in 1975 4B, 5B, 22A (seatbelt retraction and locking, seatbelt anchorage, head
There have also been improvements in vehicle design leading to better primary safety (the ability of the vehicle to avoid crashes). Intelligent Transport Systems (ITS) have become more and more widespread in passenger vehicles, starting initially with antilock brake systems (ABS), which became a commonly available ITS in the 1990s. Some ITS systems provide information (e.g., navigation) and warning signals via nomadic devices (mobile phones, navigators, personal digital assistants, etc.). Cooperative systems that function by communicating with other vehicles or between vehicles and the infrastructure are currently cutting-edge technology (Kulmala, 2010). There are also monitoring systems that can be used to modify the driving behaviour of recidivist drink-drivers (alcohol interlocks) or of teenage drivers (systems such as teen driver support systems (TDSS)). Older drivers can theoretically be helped by systems that compensate for deteriorating sensory or cognitive ability that comes with ageing (Fildes, 2008).

Despite the theoretical effectiveness of many of these systems, safety improvements can be undermined or cancelled out altogether by user behaviour adaptation. Drivers can trade off the safety improvements by increasing speed or devoting less attention to driving. Information overload can occur where warning messages and information inspire a panicked or distracted response. Therefore on-road evaluations are required wherever possible to support the safety claims of the manufacturers. These are not always feasible when the technology is relatively rare to the extent that data from vehicles equipped with this technology are too scarce for meaningful on-road studies.

This paper describes briefly the technology available to potentially improve primary and secondary vehicle safety both for drivers generally and for particular target groups of drivers. Systems with the greatest potential safety benefits for Australia and New Zealand are identified and policy options for increasing uptake of effective systems – and thereby increasing the safety of the broader vehicle fleet – are also discussed. Although there are technologies that are particularly applicable to heavy vehicles and motorcycles, discussion is restricted to ITS that improve safety for light passenger vehicles or unprotected road users into which they may crash.

**Technology types**

This section briefly describes the technologies available, grouped according to their function into six groups: (1) systems that only provide a warning or information; (2) Systems that provide a warning and then potentially intervene in the control of the vehicle; (3) systems that intervene in the control of the vehicle; (4) systems that prevent high risk behaviours; (5) systems to protect pedestrians and cyclists; and (6) post-crash systems. Although systems are described below individually, different systems can be integrated in such a way that there is a coordinated crash-avoidance response, and such integration may yield still greater safety benefits (Cairney et al, 2010).

1. **Systems that provide information or warning only**

   - **Lane departure warning.** The system assists drivers in maintaining the vehicle within a given lane by warning drivers when the car is in danger of leaving the lane unintentionally. Some restraints); in 1976, 4C (seatbelts); in 1977, 29 (door strength); in 1995, 69 (frontal impact protection); also, first crashworthiness ratings produced in 1992 and NCAP ratings in 1993.
lane departure systems actively resist the movement of a vehicle out of its lane. This technology can potentially prevent single-vehicle, head-on, and sideswipe crashes in situations where the driver inadvertently allows the vehicle to drift out of the lane.

- **Side view assist systems** use sensors to monitor areas to the side of a vehicle and alert the driver of the presence of objects in the side blind spots. This technology has the potential to prevent certain crashes involving two vehicles travelling in the same direction when one of the vehicles changes lanes.

- **Tyre pressure monitoring systems** automatically assess tyre pressure and provide warnings when they are underinflated.

2. Systems that provide a warning and then potentially intervene in the control of the vehicle

- **Fatigue detection.** The system monitors the driver’s reactions that may be most indicative of fatigue and drowsiness, including tracking, distraction and inattention, and provides warning signals. Emergency braking can be triggered if there is no reaction from the driver to the warning signals. Lane departure warning systems (see above) also address a symptom of fatigued driving. Fatigue monitoring technology is in a relatively early stage of development, and many attempts to develop effective systems have been unsuccessful. Systems that require the wearing of special glasses may have a low level of acceptability to drivers. Less intrusive systems monitor deviance from normal steering wheel reversal rate, lane deviation and headway maintenance, which can indicate impairment of driver performance due to fatigue.

- **Collision warning systems.** Sensors like infrared, radar, laser, ultrasonic and cameras provide information to microprocessors to calculate when collision risk is high. A warning system then alerts the driver in advance and potentially activates a pre-crash system or crash avoidance system. A pre-crash system activates passive safety systems (e.g., restraint systems, head rests, seat position, systems for protecting pedestrians and cyclists). A related system, the pre-emptive brake assist system (PBAS), combines aspects of the collision warning system with brake assist systems. It detects potential imminent collisions, warns the driver and then activates systems including BAS (see below). If the driver does not respond, braking can be initiated automatically. Most current collision warning systems are intended to prevent front-to-rear crashes in traffic although pedestrian detection and avoidance systems are also on the cusp of more widespread introduction.

- **Intelligent speed adaptation (ISA).** The driver is alerted by audible, visible or tactile (haptic) warnings when the speed limit is exceeded. The speed limit data is either received from maps pre-loaded into the system and referenced via GPS location devices, for which reliable positioning information is necessary, or from transponders at the roadside. Other versions of ISA devices (including curve speed prediction, traffic sign recognition, speed advice, road status, and intersection support) guide the driver to maintain a safe speed in relation to the road conditions (curves, intersections, congestion etc) and environment.

3. Systems that intervene in the control of the vehicle without initiation by the driver
• **Electronic stability control (ESC)** manages the lateral control of the vehicle when traction is lost by applying braking to each wheel individually.

• **Brake assist systems (BAS).** The system manages the braking of the vehicle once emergency braking is detected so that the vehicle comes to a stop in as short a distance as can be managed. Emergency braking is an unaccustomed behaviour for most drivers and it is assumed that most drivers may therefore be too tentative when applying the brakes. Some drivers may also be surprised by the invocation of the ABS system and as a consequence prematurely release pressure from the brake pedal. BAS technology therefore takes over when braking is unusually abrupt (presumed to be emergency braking) and makes full use of the vehicle’s braking capacity. Some versions of BAS detect rapid lift-off of the accelerator pedal, presumed to be a precursor of emergency braking, and then reduce the gap between brake pad and disc rotor to prime the brake system for instantaneous use. Pre-emptive brake assist systems (PBAS), combine aspects of the collision warning system with brake assist systems (see above) and can automatically apply the brakes when an imminent collision with another vehicle, person or object is detected by the sensor system.

• **Adaptive cruise control (ACC).** This system maintains a driver-defined distance from the preceding vehicle while driving at speeds generally above 30 km/h. If the vehicle slows suddenly, the system warns the driver to take control.

• **Adaptive headlights** focus illumination in the direction that the vehicle is steering and improve night visibility on curves. These systems can also adapt the distance of beam penetration depending on the presence and proximity of preceding or oncoming traffic.

4. **Systems that prevent high-risk behaviours or promote safe behaviours**

• **Seat belt reminder (SBR) systems** detect whether a seat is occupied and whether the seat belt is fastened or not. A visible/audible warning is activated when an occupied seat has an unfastened belt. **Seat belt interlocks** inhibit vehicle use via an ignition interlock when an occupied seat has an unfastened belt.

• **Alcohol ignition interlocks** requires breath samples of the driver and prevents ignition when the driver has a BAC over a given level. Once the vehicle is in motion, the system also checks BAC levels periodically.

• **Teen driver support systems (TDSS)** provide feedback and monitoring of driver behaviour to support the learning of safer behaviours by young drivers. Feedback to the driver can include warnings about speeding, hard braking, cornering at excessive speed, and ignoring stop signs. TDSS can also monitor seat belt use, and graduated driver licensing scheme provisions such as the presence of passengers and driving during curfews.

• **Smart licence car key** has electronic information about the classes of vehicles a particular driver is permitted to drive, and any restrictions which apply. The licence has to be swiped through a card reader before starting the vehicle. Alternatively, a driver specific key is used which communicates to the car the specific performance levels and features of the vehicle that will be available to that driver. Potentially such technology can be used to enforce
aspects of graduated driver licensing schemes and, if widely employed, prevent unlicensed driving.

5. Systems to protect pedestrians and cyclists

- **Active bonnet lift systems (ABLS)** work by raising the bonnet of a vehicle to provide space to absorb the impact energy particularly of the pedestrian’s or cyclist’s head. The system is triggered by a sudden force on the front bumper.

- **Collision warning systems.** As mentioned above, some versions of these systems can detect pedestrians and cyclists and provide warnings or automatic braking to reduce impact speed or avoid a collision.

6. Post-crash systems

- **Accident data recorders** collect downloadable data on vehicle speed and acceleration as well as driver use of steering and brakes immediately preceding and during a crash. The data can be used for research purposes or to provide evidence for driver prosecution.

- **Emergency crash assistance systems** detect severe collisions and send GPS location data to an emergency response centre. The emergency response system attempts to make voice contact with the vehicle occupants and dispatches help to the presumed crash location if no contact is made or if help is requested. These systems would be of benefit particularly in remote areas of Australia and New Zealand, where a proportion of vehicle occupants currently fatally injured would survive if medical treatment were available more quickly. A barrier to these systems’ effective use may be the lack of adequate network mobile phone coverage in rural areas.

**Behaviour in response to technology**

There are various behavioural responses to vehicle technologies, which can vary from driver to driver. These can range from safety-enhancing behavioural responses, a total absence of response, to responses that harm safety or at least cancel out some of the safety benefits of the technology. Such responses can be expected to vary according to whether the technology is passive or active and whether the driver can cope with extra cognitive demand, such as is potentially produced by warning devices or systems that provide information. As noted by Fildes (2008): “... for effective use, some technologies rely on optimal interactions with the driver that may or may not happen in various driving situations.”

With passive systems that require no driver action, there is less potential for some of the behavioural responses listed above. Nevertheless, when drivers are aware of a safety device, it is not unusual for at least some of the safety benefits to be sacrificed by the driver electing to travel at higher speeds or taking less care and attention to the driving task, a phenomenon sometimes termed ‘risk compensation’ (Haight, 1986). Such compensation has been observed in the case of adaptive headlights, which provide better illumination when driving around corners at night, but may encourage higher speeds when cornering as a result (Braitman et al, 2010).
Of course, it is expected that most crash avoidance systems will influence driver behaviour positively, leading to increased following distances, appropriate use of indicators and maintenance of lanes (LeBlanc et al, 2006). Vehicle manufacturers are continually developing and refining ITS to determine the best way to warn drivers of impending collisions and assist in correcting errors. However, the effectiveness of crash avoidance systems can only really be established from real-world data as drivers in the test environment never behave naturalistically (Jermakian, in press 2010).

A final class of behavioural response occurs when the system is used in an unintended fashion. One example of potentially unintended uses of technology occurs with Adaptive Cruise Control (ACC) systems (Jagtman et al, 2006). ACC is designed to be used only in higher speed limit areas where the roads are relatively straight and uncongested. Thus there are many situations where the technology can be used where it was not designed to be used, leading to compromised safety (ibid).

Warning systems have particular issues with acceptability. Drivers may misunderstand the alerts and perceived or actual false alarms may lead drivers to ignore warnings or disable the system (Jermakian, in press 2010). Despite these potential problems, there is evidence that most drivers do not disable such systems (Braitman et al, 2010).

Assessing the on-road effectiveness of a particular ITS, which – in contrast to laboratory studies – accounts for behavioural responses, is not straightforward. The technology must be widely used before enough data become available, and even then, there are often difficulties in identifying which vehicles had the ITS installed when designing the study. Also, when a vehicle is fitted with two or more types of ITS, it is difficult to assess the overall benefit in terms of risk reduction as the technologies may address similar aspects of crash risk: for example, both ISA and ESC are both predicted to reduce the risk of single vehicle crashes (MUARC, 2008). To date, ESC by far the best evaluated technology, helped by its evident effectiveness (Erke, 2008; Farmer, 2004; Farmer, 2006; Lie et al, 2006; Scully and Newstead, 2008).

**Acceptability of ITS**

Unless supported by legislation, particular classes of ITS are not going to be adopted by the driving public, and hence will not be supported by vehicle manufacturers, unless the benefits of the system clearly outweigh any perceived negatives. Benefits will usually be defined in terms of safety improvements, although protection from potential prosecution could also be seen as a benefit. Negatives potentially include extra purchase or maintenance costs and annoyance caused by unwanted or misdirected warning messages or the imposition of slower travelling speeds than desired. A recent Australian study has found reasonably high acceptance of ITS, although some systems have the potential to reduce enjoyment of driving and generate frustration at lower than desired travelling speeds (Young and Regan, 2007). There are also likely problems with implementing the technologies that rely on GPS relating to digital maps that may be inaccurate, out-of-date, or non-existent (ibid).

Vehicle manufacturers are motivated primarily to increase sales when designing vehicles. Therefore, technology will be developed and installed if there is seen to be an existing or potential future
demand for the technology, or manufacturers are forced to employ the technology via regulation (e.g., Australian Design Rules). As pointed out by O’Neill (2009), crash testing has resulted in much greater investment by the motor vehicle manufacturing industry to produce well-performing vehicles in these tests, assisted by growing consumer interest. However, both NCAP/ANCAP and the Used Car Safety Ratings focus on occupant protection in the event of a crash; there are no tests currently undertaken in consumer information programs for crash avoidance. Hence there is no incentive via crash test ratings to improve and develop primary safety systems. The only response to this area has been to give credit arbitrarily for a technology, such as is the case with ESC in ANCAP, a process that is planned to be extended in the future to other crash avoidance technologies under the new ANCAP Road-map. It is planned that ANCAP ratings will be used to encourage the fitment of safety features encompassing pedestrian safety, seat belt reminders, daytime running lights and emergency brake assist, for example.

Older drivers

The benefits of ITS particularly to older drivers has not been well studied. Supposed safety benefits have the potential to be either enhanced or substantially diminished for older drivers, who tend to be functionally limited physically and/or cognitively. Older people become more limited in their ability to multitask, thus additional cognitive load associated with having to respond to vehicle technologies may lead to unintended responses, which need to be properly assessed (Fildes, 2008). Fildes also warns that technology development often results in interfaces that favour younger users, creating barriers for older users, although older people can successfully learn to operate new technology when given training (ibid). Effective restraint systems, including frontal, thorax and side curtain airbags, are particularly important for older people because of their frailty and resultant greater tendency to be injured when subjected to the forces of a crash (Keall and Frith, 2004). Emergency crash assistance systems also have particular benefits for older people who are physically less robust, as these systems can reduce time between the occurrence of the crash and subsequent medical attention.

Although in-vehicle information systems (IVIS) may not be seen as having a safety role and therefore have not been discussed previously in this paper, for older drivers such technology can reduce short-term mental workload. The drivers can be fed appropriate useful information for navigation etc, and may therefore be less distracted from the driving task (Brookhuis and Carsten). The interface needs to be appropriate for older users in order to reduce cognitive demands as mentioned above (Fildes, 2008).

Shaheen and Niemeier (2001) identified five main areas of older driver impairments that can be assisted by appropriate vehicle design: (1) vision, (2) hearing, (3) cognitive response time, (4) cognitive attention and memory, and (5) physical strength. Older drivers commonly have difficulty with neck mobility: such technologies as rear proximity warning systems and lane departure warning systems as being particularly appropriate for this physical limitation. Visual limitations can be partially addressed by infrared video systems for improving night vision (ibid). Declining perceptual,

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cognitive, and physical performance can be helped by GPS route guidance, collision warning systems; the effects of medication dosage misjudgements can be identified by fatigue detection systems. The use of ITS by other vehicles can also benefit older drivers. Daytime running lights used by other vehicles can reduce the occurrence of crashes where the older driver fails to see the other vehicle. Likewise, widespread use of intelligent speed adaptation can be of particular benefit to older drivers as vehicles will move more predictably and regularly, placing lower demands on cognition.

**Learner drivers**

Young drivers are a high risk group because of their inexperience and tendency to take risks (Williams, 2006). When accompanied by an experienced adult as a supervisor, their crash risk has been shown to be reduced considerably (Masten and Foss, in press 2010). An obvious role of ITS to benefit young drivers safety is as a virtual supervisor, which monitors and provides feedback on the driving task. Systems including Teen Driver Support System (TDSS) have event data recorders that capture vehicle speeds, engine data and details of when the vehicle is used (Guttman and Gesser-Edelsburg). There are issues about the use and acceptability of the technology that may limit its general adoption as it is inevitably seen as a “big brother” device and an extension of parental authority (Young et al, 2004). As alcohol use and non-use of seatbelts are major issues with young drivers, other effective ITS for teenagers would include alcohol interlocks and seatbelt interlocks (Brovold et al, 2007). Smart licence car keys can be used to enforce aspects of graduated driver licensing schemes and, if widely employed, prevent unlicensed driving.

**Reducing drink-driving recidivism**

Alcohol interlock systems link a small breath-testing device to the vehicle ignition system in such a way that the vehicle cannot be started unless a breath sample is provided with zero or low levels of alcohol. Many systems also require a breath sample periodically while the vehicle is being used. Alcohol interlocks are effective, but somewhat inconvenient to the driver (Beirness and Marques, 2004) and are unlikely to be acceptable to motorists in general.

Alcohol interlocks are in use in many countries and are being trialled in a number of Australian states to reduce drink-driving recidivism. In Victoria an alcohol interlock program is now in place: those drivers charged with a repeat drink-driving offence within a ten-year period must have an alcohol interlock fitted to their vehicle for between 6 months and 3 years (Young and Regan, 2007).

**Protecting vulnerable road users**

Pedestrians hit by vehicles have a very high fatality and serious injury rate, so there are considerable potential safety gains from ITS or vehicle design that mitigate the severity of such impacts (Oh et al, 2008). Technologies to protect pedestrians include the active hood lift system and improvements to the design of the front of vehicles to cushion any impacts, particularly those to a pedestrian’s or cyclist’s head. The collision warning system, particularly newer systems incorporating camera based pedestrian detection technology, is a primary safety technology designed to avoid the impact with
the cyclist or pedestrian, or at least to alert the driver to braking or other avoidance manoeuvres that may reduce impact speeds.

**Effectiveness of technologies**

Many of the technologies are too new to be properly assessed by on-road evaluations. Therefore, most commentators have attempted to prioritise the various technologies according to expert opinion of potential effectiveness in the driving situations to which the ITS applies, multiplied by the proportion of crashes or casualties that are relevant. History has shown that estimates of potential effectiveness derived through expert opinion are often highly inaccurate (for example, the inflated predicted safety benefits of ABS brakes) meaning cost benefit rankings derived on this basis may be challenged. The ideal rankings are based on robust evaluation outcomes although, as noted above, these can only be obtained once the technology has been in reasonably wide usage for some time.

Table 1 summarises the results of four evaluations performed on the bases of potential benefits for various crash environments. Cost-effectiveness has been calculated from benefit-cost ratios where the benefits are the monetised value of injuries prevented (including a value for pain and suffering) and the costs are for the provision of the technology. These benefits vary according to the jurisdiction. The European Commission used social cost of injuries prevented as €1 million per fatal injury, €143,100 per hospitalised injury and €23,100 per minor injury (European Commission, 2006)\(^3\). The Australian studies (Anderson et al, 2010; Cairney et al, 2010) used costs of $2,176,000 for a fatal crash and $502,000 for a serious injury crash based on a modified human capital approach to estimate the statistical value of deaths and injuries. New Zealand values used in road safety, which are based on willingness to pay estimates, are higher for fatal crashes at $NZ 4,163,200, but lower for serious injury crashes at $NZ 417,900 per crash (Ministry of Transport, 2010)\(^4\). Although Cairney et al (2010) concluded that for most of the ITS considered in their report, the costs of the technologies greatly outweighed their benefits (with the exception of seatbelt reminder systems, which were considered highly cost-beneficial), some of the marginal technologies could have been considered cost-beneficial if the NZ social cost estimates had been used.

A further limitation of the cost-benefit estimates is that these will not always be seen as valid from the consumer’s point-of-view. For example, accident data recorders were regarded as cost-beneficial by the European Commission (2006) seen from a societal perspective. But it would take a very creative car salesman to convince a customer to spend extra funds on this technology that provides information to researchers and gathers evidence that can later be used against the driver in the event of prosecution for unsafe driving behaviour.

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\(^3\) These equate approximately to AU$1.52 million per fatal injury, AU$220,000 per hospitalised injury and AU$35,000 per minor injury using May 2011 exchange rates.

\(^4\) These equate approximately to AU$3.1 million for fatal crashes and AU$300,000 for serious injury crashes using May 2011 exchange rates.
Table 1: Safety benefits of some ITS as rated by studies. Percentages shown refer to reductions in casualties or crashes: F=Fatal, S=Serious, M=Minor.

<table>
<thead>
<tr>
<th>Country</th>
<th>Europe</th>
<th>US</th>
<th>Australia (NSW)</th>
<th>Australia and NZ*</th>
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<tbody>
<tr>
<td>Electronic stability control (ESC)</td>
<td>Very cost-effective</td>
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<tr>
<td>Intelligent speed adaptation (ISA)</td>
<td>Very cost-effective</td>
<td></td>
<td>Cost-effective if optimistic</td>
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<tr>
<td>Alcohol ignition interlocks</td>
<td>Very cost-effective</td>
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<td>15% F</td>
<td></td>
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<tr>
<td>Event or accident data recorders</td>
<td>Very cost-effective</td>
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<tr>
<td>Forward collision avoidance*</td>
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<td>16% FSM all crashes; 9% just higher speed roads</td>
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<tr>
<td>Daytime running lights</td>
<td>Cost-effective</td>
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<tr>
<td>Lane departure warning</td>
<td>Cost-effective</td>
<td>23% F, 5% M&amp;S</td>
<td>8% F **</td>
<td>Cost-effective if optimistic. 15%-50% F&amp;S</td>
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<tr>
<td>Side view assist</td>
<td></td>
<td>1% F, 3% M&amp;S</td>
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<tr>
<td>Collision warning system</td>
<td>Cost-effective &lt;€1,200</td>
<td>3% F, 9% M&amp;S</td>
<td>12%-20% F, 10%-22% S</td>
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<tr>
<td>Fatigue detectors</td>
<td>Cost-effective &lt;€710</td>
<td></td>
<td>10% F</td>
<td>5%-50% F&amp;S **</td>
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<td>Brake assist systems (BAS)</td>
<td>Cost-effective &lt;€460</td>
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<td>Marginally cost-effective if optimistic 3%-12% F&amp;S</td>
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<tr>
<td>Country</td>
<td>Europe</td>
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<td>Australia (NSW)</td>
<td>Australia and NZ†</td>
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<tr>
<td>Improved vehicle compatibility</td>
<td>Cost-effective &lt;€285</td>
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<tr>
<td>Adaptive cruise control (ACC)</td>
<td>Unlikely cost-effective</td>
<td></td>
<td></td>
<td>15%-50% F&amp;S</td>
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<tr>
<td>Tyre pressure monitors</td>
<td>Unlikely cost-effective</td>
<td></td>
<td></td>
<td>0.08% F&amp;S</td>
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<tr>
<td>Dedicated pedestrian detection – daylight and night-time</td>
<td>7% F</td>
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<tr>
<td>Seatbelt interlocks</td>
<td>6% F ***</td>
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<tr>
<td>Seatbelt reminders</td>
<td>5% F</td>
<td></td>
<td></td>
<td>Most cost-effective 30%-50% F&amp;S</td>
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<tr>
<td>Adaptive headlights</td>
<td>8% F, 4% M&amp;S</td>
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*This is three technologies evaluated together, including emergency brake assist (EBA), collision warning and intervention, and adaptive cruise control (ACC).

** Includes lane change warning systems

***Identified as most cost-effective by Anderson et al.

* Benefits are “optimistic” at the higher end of the range of possible safety benefits assumed

** As additional fatigue management is required in addition to the system, the costs were considered too difficult to determine

The studies shown in Table 1 indicate that there is a lot of variability in the estimated potential safety benefits of the technologies. Seatbelt reminders were singled out by Cairney et al (2010) as being clearly cost-beneficial and seatbelt interlocks were estimated as the most cost-beneficial by Anderson et al (2010) if universally adopted, even though their estimated safety benefits were far lower. There was some agreement that lane departure warning systems should be effective, with Jermakian (in press 2010), the European Commission (2006) and Cairney et al (2010) rating them highly, although Anderson et al (2010) estimated they would produce only an 8% fatality reduction. Intelligent speed adaptation was considered very cost-effective by the European Commission (2006) and marginally cost-effective by Cairney et al (2010).
**Encouraging uptake**

Realistically, ITS will arrive in the Australian and NZ fleets via new vehicles rather than via the retrofitting of older vehicles. This is a relatively slow process, taking over 20 years to cover the whole vehicle fleet, even after 100% fitment to new vehicles has been achieved, since only a small proportion of the on-road fleet is new at any point in time. The process will be even slower in New Zealand unless the proportion of older used cars imported into that fleet is reduced (Keall et al, 2007).

Approaching 50% of the Australian passenger vehicle fleet are current fleet vehicles (government and non-government) or are second-hand vehicles that were originally fleet vehicles (Anderson et al, 2010). This provides a useful mechanism for encouraging effective ITS to penetrate more quickly into the national fleet if the fleet managers and purchasers could be encouraged or required to buy vehicles with these technologies. Greater volumes of particular ITS being manufactured will lead to greater efficiencies in production and lower unit costs, encouraging further uptake (ibid). When purchasing vehicles, fleet managers may have a bias towards selecting vehicles with primary safety features rather than those that reduce injury severity as most fleet crashes only involve property damage, which are therefore the main concern of the fleet managers (Haworth, 2002). Encouraging uptake of technologies in fleet vehicles can also provide a potential basis for on-road evaluation of new technologies before they are mandated for all new vehicles. Some classes of ITS (particularly those that use interlocks, data recorders or speed limiting) can be introduced into the fleet much more easily via fleet and commercial vehicles. This is because the fleet managers can purchase the technologies as a means to modify certain unsafe driving practices amongst its employees. For example, the Swedish Road Administration has mandated alcohol interlocks in the Swedish commercial vehicle fleet (Eksler and Janitzek, 2010, cited in Anderson et al, 2010). Private buyers will be less motivated to seek such technologies to monitor or enforce changes to their own driving behaviours.

As noted by Cairney et al. (2010), technology changes rapidly, so Australasian regulatory effort should focus on standards related to the performance of the technology rather than product-based standards or technical checklists. A range of policy options needs to be employed, including rating systems for ITS performance, the development of legislation, guidance for fleet purchases and effective communication of the desirability of particular technologies (ibid).

**Recommendations**

There are a number of recommendations that can be made based on this survey of Australian and international literature on ITS.

- Apart from electronic stability control, with its well-established safety benefits, there is a lot of variability in the estimated potential safety benefits of the other technologies. Seatbelt reminders and seatbelt interlocks have been singled out by Australian studies as having worthwhile safety benefits compared to their costs. There is some agreement in the literature that lane departure warning systems and intelligent speed adaptation are also likely to be cost-effective. These technologies should be the focus of potential policies to encourage their uptake supported by on-road evaluation efforts.
For learner drivers, smart car licenses may be an effective measure for ensuring that graduated driver licensing conditions are met. However, creating the administrative, legislative and technological infrastructure to support this measure is a challenge that requires further investigation.

For older drivers, a group that is growing proportionately in the Western World, more effective occupant protection combined with technologies that lower the cognitive load of the driving task are likely to be effective in increasing safety.

As much as 50% of the Australian passenger vehicle fleet are originally fleet vehicles – this is an important avenue for policy to influence the types of ITS introduced into the fleet:

- Greater volumes of particular ITS being manufactured will lead to greater efficiencies in production and lower unit costs, encouraging further uptake.
- Less “popular” ITS such as interlocks, data recorders, and speed limiting devices are much more easily introduced into the fleet via fleet and commercial vehicles

The benefits of ITS need to be communicated to all sectors (government, fleet managers, the public). However, evaluation of the benefits needs to precede the dissemination of such information. It is likely that at least some of the apparent safety benefits of a given ITS will fail to materialise because of driver behavioural adaptations.

Rating systems for ITS need to be developed, based on the performance of the technology. This may necessitate an independent testing regime.

Regulation should be used to support the adoption of effective ITS, where feasible. This is likely to be one of the few mechanisms whereby the uptake of ITS designed to protect other road users can be increased.

References


