

INTELLIGENT TRANSPORT SYSTEMS AND SAFER VEHICLES

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1. A BRIEF STATEMENT OF THE ISSUE

Safer vehicles represent a key component of Austroads' Safe System approach to road safety. This paper aims to describe the main Intelligent Transport Systems (ITS) developments, either already in the marketplace or anticipated, which will contribute to a safer light vehicle fleet in Australasia.

2. INTRODUCTION

The term Intelligent Transport Systems refers to the application of electronic, computer and information and communication technologies to vehicles and roadways to enhance safety, reduce congestion, enhance mobility, minimize environmental impact, increase energy efficiency and promote economic productivity^{1, 2}.

The actual safety benefits of these technologies are largely unknown, given that the systems have not been deployed in traffic for long enough in large enough numbers for crash numbers to be a reliable indicator of a change in safety³. Nevertheless, it is predicted that the safety benefits deriving from them will be great. The OECD² for example estimates that, if fully deployed in OECD countries, they have the potential:

- to save up to 47,000 lives per year
- to reduce road crash injuries and fatalities by around 40 percent, with resulting per annum savings of \$US 194 billion
- to save more than \$US 73 billion per year from reduced fatalities alone.

It is generally accepted that the most promising avenue for future gains in vehicle safety is the continuing development of ITS. Despite some barriers to implementation of these technologies, the majority of OECD countries appear to support the deployment of those with high safety potential². Three broad categories of ITS can be discerned^{2, 4}.

Vehicle-based ITS safety technologies consist of sensors on the vehicle (e.g. radar, Global Positioning System) that collect traffic data, on-board units (OBUs) that receive and process this data, and display units that issue messages and warnings to the driver within the vehicle. Following Distance Warning systems, for example, utilise forward looking radar to determine if the host vehicle is following a vehicle ahead too closely and warn the driver if this is so.

Infrastructure-based ITS technologies consist of roadside sensors that collect traffic data which is processed on site, or remotely, and transmitted to the driver via roadside equipment such as a Variable message Sign (VMS). The advantage of these systems over vehicle-based systems is that traffic information and warnings derived from them are available to all drivers. In addition, they are able to collect traffic data that cannot be collected by vehicle-based systems, such as the presence of fog on the road ahead.

Cooperative-based ITS technologies derive traffic information from the road infrastructure, from other vehicles, from remote service providers or from all of these sources, and transmit this to the driver via VMS or via displays within the vehicle. Infrastructure-based ITS technologies, for example, can be used to detect a vehicle approaching an intersection and send a warning to other vehicles approaching the intersection of the presence of the first vehicle. Alternatively, vehicle-based ITS technologies in one vehicle can be used to warn another vehicle equipped with ITS technologies of its presence on the approach to an intersection, without any support from infrastructure-based systems.

This paper focuses on vehicle-based and cooperative technologies, either currently available or close to market release, that have potential to enhance the safety of light vehicles.

3. REVIEW OF ITS VEHICLE SAFETY TECHNOLOGIES

3.1 Overview of technologies

Most OECD countries, including Australia, suffer from similar road safety problems. In particular, these include run-off-road, intersection and head-on crashes.² Alcohol, speed, fatigue and seatbelt usage patterns commonly play a role across these crash scenarios², and driver distraction is emerging as another major causal factor. There is a common expectation among OECD countries that four types of technology – collision avoidance, driver status and performance, speed control, and automated enforcement – offer the greatest potential for reducing the incidence and severity of vehicle crashes.²

The table in the Appendix summarizes the main ITS vehicle safety technologies that have entered the world market or are close to commercial maturity. In Europe, these are usually referred to as Advanced Driver Assistance Systems (ADAS). Several of them address directly the crash scenarios described above.

Whilst these technologies are listed individually, integrated systems are being developed that combine several applications into one. The US Department of Transport, for example, is currently funding the development and evaluation of an integrated crash warning system for forward collisions, run-off-road and lane-change crashes, which together account for 48 percent of crashes in the US.⁵

The focus in The Attachment is on vehicle-based ITS technologies, as most of these do not rely on communication with road infrastructure and are more readily deployed. Infrastructure-based systems with high safety potential, however, do exist and include animal detection systems, speed feedback indicators and weather/road/traffic information display systems².

Commercial vehicles (trucks and, to a lesser extent, buses) have paved the way for wider scale deployment of ITS safety technologies in the light vehicle fleet. Several countries are testing, evaluating and implementing various ITS safety technologies in commercial vehicles. These include²: speed limiters; digital tachographs; collision avoidance systems; adaptive cruise control; driver drowsiness warning systems; rollover stability and control; lane tracking systems; electronic brakes for stability and improved stopping; fatigue detection and warning systems; and in-vehicle recorders to record driving data. Vehicle and cargo tracking systems, also in wide use on heavy vehicles, also enhance logistic operations and security.

3.2 Estimated Safety Benefits

As noted above, the actual safety benefits of ITS vehicle safety technologies are largely unknown, given that most systems have been deployed for very little time in traffic, if at all. Consequently, estimates of the benefits of ITS vehicle safety technologies are generally derived from three sources²: empirical results from field trials; estimates made by researchers involved in field trials; and results from analysis and simulation.

The table in The Attachment contains some scattered data on the estimated safety benefits associated with individual technologies, where known. These were derived from various sources (see ^{1,2,3,5,8,15,17}). PIARC (2000; cited in ²) provides rare information on estimated benefit/cost ratios for selected ITS technologies, as follows:

- Incident detection – 1.7 to 3.8
- Speed control – 2.9
- Lane control – 2.7
- Intersection control – 34.0
- Emergency vehicle priority – 4.8
- Speed enforcement – 4.1.

One of the few attempts in Australia to estimate the potential crash savings to be derived from the deployment of vehicle ITS safety technologies⁶ looked at technologies which met the following criteria:

- the systems had to be commercially available in Australia, or likely to be so within five years
- the systems had to be judged (on best available evidence) capable of reducing the incidence and severity of crash types in which drivers are either over-involved or are involved in large numbers (based on Victorian casualty crash patterns)
- the systems were not at the time being assessed by other research studies in Australia.

Technologies meeting these criteria, the relevant crash scenarios they address, their estimated impact on crashes and the estimated savings associated with the crash reductions (based on Victorian crash data) are shown in Table 1. It can be seen that, of those systems examined, the Alcohol Interlock, Electronic Licence and Intelligent Speed Adaptation would result in the greatest savings and are likely to be the cheapest technologies to install and maintain. A separate attempt has been made to quantify the crash costs and savings associated with the deployment of Intelligent Speed Adaptation in both light and heavy vehicles in Australia (see ⁷).

Table 1. Summary of ITS technologies, affected crash types and estimated impact

System Type	Functional Description	Casualty crash scenarios	Estimated impact on appropriate crash types
Intelligent Speed Adaptation	Limiting: Limits speed according to posted local speed limits. Alerting: Warns when driver has exceeded speed above a certain threshold (usually the posted limit).	Single-vehicle, head-on, same-direction rear-end, intersection and pedestrian crashes. 20% of above likely to be potentially affected.	10.8% reduction (saving \$155 million per annum)
Forward Collision Warning	Warns of an imminent collision with lead vehicle.	All rear-end crashes likely to be potentially affected.	7.0% reduction (saving \$40 million per annum)
Lane Departure Warning	Warns when vehicle leaves the designated lane.	Rural single-vehicle off-path and rural multi-vehicle sideswipe crashes. 50% of above likely to be potentially affected.	5.2% reduction (saving \$17 million per annum)
Fatigue Monitoring System	Detects impairment due to fatigue and warns driver.	Single-vehicle crashes. 50% of above to be potentially affected.	4.3% reduction (saving \$64 million per annum)
Alcohol Sniffer/ Interlock	Prevents/discourages drink driving.	All crashes where BAC exceeds 0.05 likely to be potentially affected.	96.4% reduction (saving \$263 million per annum)
Mayday System	Manually or automatically notifies emergency and roadside services of GPS-derived vehicle location in the event of a crash.	All crash types likely to be potentially affected.	no reduction in crashes (but estimated to save \$21 million in crash costs)
Electronic Driver's Licence	Prevents unlicensed driving and driving outside conditions of driver's licence.	All crashes involving unlicensed drivers, drivers outside of licensing conditions, likely to be potentially affected.	97.6% reduction (saving \$134 million)

In the absence of further research, it is difficult to know which ITS technologies in Table 1 and The Attachment will yield the greatest safety benefits in specific jurisdictions within Australasia. A recent policy paper published by the European Transport Safety Council⁸ highlights the importance of three vehicle ITS safety technologies in reducing the road toll in Europe: alcohol interlock/sniffer systems; seat belt reminders and Intelligent Speed Adaptation. The following are the technologies that, in the opinion of the present authors, are likely to yield the greatest safety benefits across the board in Australasia:

- electronic stability control
- seat belt reminders
- alcohol interlock and Sniffer systems
- collision warning systems (especially for intersection and forward collisions)
- combined active and passive safety systems
- brake assist/forward crash mitigation
- intelligent speed adaptation
- electronic driver's licence
- driver drowsiness warning

- lane departure warning
- following distance warning
- automatic crash notification
- location specific alerting and warning
- pedestrian detection and warning
- event data recorders.

The estimates in Table 1 are hypothetical. They rely on critical assumptions about what crash type(s) the systems will address, how effective the systems will be in changing driver behaviour and safety and at what level the systems will penetrate the market. Several human factors have potential to undermine the potential effectiveness of these systems⁹:

- the Human-Machine Interface (HMI) - poorly designed systems may distract, confuse and overload drivers, thus inducing errors
- negative behavioural adaptation – drivers may compensate for increased automation by engaging in other activities like talking on mobile phones; Alternatively, they may respond in unintended ways, such as adopting shorter headways when driving vehicles with ABS brakes
- awareness of system limitations – if the limitations of the system are not understood, drivers may expect the system to, for example, alert them to situations it is not capable of detecting
- system operation – driver education and training are critical in ensuring the appropriate and safe use of new cockpit technologies
- over-reliance – over-reliance on a Forward Collision warning system, for example, might encourage drivers to scan less, or not at all, for vehicles in front of them, assuming the system will always do this for them. But what if the system fails?
- automation – driver's danger avoidance skills, derived from driving manual vehicles, may be degraded as vehicles become more automated. This is a problem when going from a manual to a highly automated vehicle
- driver acceptance – if ITS technologies with great safety potential are not perceived by users to be effective, usable, cost effective, useful, and socially acceptable, there will be no demand for them.

In summary, it is not yet possible to reach definitive conclusions from mass crash data about the full range of ITS outcomes, including any unforeseen results.

3.3 Vehicle Purchase Policy

The current array of possible active and passive safety features to consider when purchasing a safe vehicle, as promoted by the Monash University Accident Research Centre in its fleet safety policy¹⁰, has already been discussed in detail in another Handbook paper¹¹. While this policy is not universally accepted, it contains a comprehensive range of features to enhance vehicle safety and has been modified for use by other fleets in Australia.

4. POLITICAL, SOCIAL AND OTHER ISSUES

Traditionally we have relied upon government regulation to ensure that proven safety features are fitted to all new vehicles at time of manufacture because manufacturers are, understandably, reluctant to add cost that might put them at a competitive disadvantage, particularly in the international marketplace. As the industry has increasingly globalized so has the design rule process become increasingly harmonized internationally, with the net effect of increasing the inertia that already existed in implementing new safety technologies in Australia. Vehicle safety regulation lags behind the appearance of proven safety technologies by many years.

Manufacturers and researchers continue to develop new safety features. The most promising are frequently included as options that purchasers may specify at additional cost or are included only in “top of the range” vehicles as part of an integrated “luxury” package. This severely limits the penetration of safety innovations through the on-road vehicle fleet.

While regulation will remain important, other mechanisms are needed to shorten the time between the development of new safety technologies and their widespread appearance in the vehicle fleet.

The most effective mechanism is the creation of consumer demand for safety features. Several nations, and regional groups such as the EU, have evolved safety star rating systems for new vehicles which are showing signs of creating consumer demand. A similar effort is being made to develop safety ratings for used vehicles from the analysis of mass data by make and model, controlling for crash type and for driver characteristics. Facilitating a consumer market for safety features is one of the most important actions governments can take. The most obvious step is for governments to use their considerable power as bulk purchasers of new vehicles to include unregulated safety features in their purchase specifications.

There are, however, other actions that can be taken by governments^{1, 2, 5}:

- identify and prioritize intractable road safety problems that are most amenable to ITS intervention and stimulate industry to develop ITS that address those problems (rather than, as at present, to identify existing or emerging technologies and search for crash problems that they might solve)
- conversely, identify existing and emerging systems with high safety potential that exist or are emerging and determine if they are more cost effective than other countermeasures in addressing intractable road safety problems
- encourage and fund targeted research on specific safety technologies, particularly those with high estimated benefit-cost ratios
- establish the effectiveness of ITS technologies through the collection and evaluation of crash data, field operational testing and macroscopic risk-utility analysis
- demonstrate to consumers that systems with high safety potential work and that there are no unintended or adverse consequences associated with their use
- leverage previous research and development, here and overseas, in facilitating the deployment of candidate systems
- facilitate the development and dissemination of system architectures and standards for the design, deployment and evaluation of future technologies
- provide infrastructure support for emerging cooperative and infrastructure-based systems
- introduce and support fiscal incentives to stimulate system demand, such as tax incentives, reductions in insurance premiums, reduced road user charges and access to parts of the road network at reduced cost

- provide an effective legal and regulatory framework to support system deployment and remove regulatory barriers
- initiate and support cross-industry activities, such as the European “e-Safety” forum and its working groups, to harmonize system development and deployment
- ensure that new systems entering the market, both Original Equipment from Manufacturer and aftermarket products, do not distract or otherwise compromise driver safety in unintended ways
- promote an industry-wide approach to the development of standard tests and methods for evaluating new ITS safety technologies.

In Australia there is currently no national strategy and action plan to guide the design, development, evaluation and deployment of vehicle ITS safety technologies. Such strategies have been developed in Europe (the “e-Safety Initiative”) and in North America (the “Intelligent Vehicle Initiative”). The Federal Department of Transport and Regional Services (DOTARS) is currently pursuing, in conjunction with jurisdictions, the development of a National ITS strategy that would include reference to vehicle safety technologies.

In the promotion of ITS technologies however, it is critical to ensure that these options are underpinned by an appropriately designed human-machine interface, which will determine both their acceptance and their safety benefits. For example inappropriately designed technologies can lead either to overload (where the driver is required to handle more than he/she can), underload (where the driver is no longer involved in the main tasks of driving) or distraction (where attention is diverted from the main components of the driving task at critical times).

5. CONCLUSIONS

The substantial developments in vehicle crash avoidance and crashworthiness features over the past three decades have been given added impetus by the possibilities offered by ITS. While vehicle manufacturers have been keen to invest in new safety features, economic considerations combined with a lag in mandatory regulations have severely restricted the spread of these features through the vehicle fleet. There is a need for governments in particular to lead a consumer demand for vehicles with the latest safety features.

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ATTACHMENT

ITS Technologies with Potential to Enhance Vehicle Safety

Application	Safety Benefits	Stage of development
1. Applications that can prevent/reduce crash occurrence		
Electronic Stability Control (ESC)	Compares the driver's intended direction in steering and braking inputs, to the vehicle's response, via lateral acceleration, rotation (yaw) and individual wheel speeds. Brakes individual front or rear wheels and/or reduces excess engine power as needed to help correct under steer (ploughing) or over steer (fishtailing). In a 2004 US study ¹⁴ , vehicles with ESC had a 41% reduction in both single-vehicle crashes and single-vehicle injury crashes, translating into an overall crash reduction of 7% and injury crash reduction of 9%.	Introduced to market in 1995. Now widely available on mass market in Australia; standard in some high end vehicle models and optional for many lower end models.
Intelligent Speed Adaptation (ISA) – Warning and Limiting	Warns driver when posted speed limit exceeded, or limits vehicle to speed limit. Both warning and limiting system types have potential to reduce fatal and non-fatal crashes. Swedish data suggests a 10 to 32% reduction in fatal crashes for warning systems, depending on road type. Victorian data from the TAC SafeCar project ¹⁵ suggests up to 8% reduction in fatal crashes. Higher fatality reduction benefits (between 37 and 59% are estimated for speed <i>limiting</i> systems) are possible, with even higher benefits for systems responsive to speed limit changes and prevailing traffic/weather conditions.	Advanced prototype warning and limiting systems trialled in Europe. Warning systems trialled in Australia. ISA trials soon to be conducted in Canada, Japan and US. Prototype limiting systems being developed in Australia. A commercial ISA warning system, integrated into a portable satellite navigation system, has been developed by Navigon. It became available in Europe in May 2005.
Following Distance Warning (FDW) (also called Safe Gap Advisory)	Warns driver when following a vehicle ahead too closely. Shown to increase headways in Israeli and Australian studies. Israeli studies found 25% and 90% reductions in percentage time spent at time headways of 0.8 and 1 second, respectively. Australian study found large significant reduction in time spent at time headways below 1.1 seconds.	Commercial systems available in some Japanese cars and recently evaluated in Victorian TAC SafeCar study.

Application	Safety Benefits	Stage of development
1. Applications that can prevent/reduce crash occurrence		
Forward Collision Warning	Warns driver of imminent forward collisions with vehicles in front. US studies suggest systems would be effective in 42% of rear-end crashes where lead vehicle is decelerating, and 75% of crashes where lead vehicle is stationary. Overall, a 51% reduction in injury crashes is predicted. Canadian transport company found 34% reduction in at-fault crashes in first year after installation of collision warning system with forward and blind spot sensors. Infrastructure-based systems are being developed to warn drivers entering curves of oncoming vehicles. Japanese study found 46% reduction in such crashes.	Commercial systems available on trucks since mid 1990s and on cars in Japan since 1998. Collision “mitigation” systems, which automatically apply some braking if driver does not respond to warnings, introduced in Japan in 2003.
Lane Departure Warning	Warns driver in advance if about to drive off the road. Dutch study estimates 10% reduction in heavy vehicle injury crashes if fitted to all trucks ²² . US study estimates system will be effective in 24% of crashes.	Commercially available in trucks in Europe since 2000, and since then in the US. Entered automobile markets in Europe and US in 2004, and earlier in Japan.
Lane Keeping Assistance	Uses machine vision technology to detect the lane in which the host vehicle is travelling and steering actuation to add torque to the steering wheel to minimize the number of minute steering adjustments required on long trips. May reduce fatigue. Predicted but unknown benefits.	Commercially available in Japan since 2001.
Rollover Countermeasures Systems	Prevent rollovers by heavy trucks by warning the driver when a rollover is close to imminent. Some systems can automatically slow the vehicle to prevent rollover. Predicted but unknown benefits.	Commercially available for heavy vehicles.
Rear Impact Collision Warning	Warns driver if vehicle behind is about to collide with rear of own vehicle. System can activate hazard lights to warn following driver. Potential safety benefits unknown.	Prototypes being developed in US.
Side Object Warning.	Assists driver in changing lanes by detecting vehicles behind and in the blind spot, left and right. Potential to reduce lane change crashes by 37%.	Commercially available for trucks since early 1990s. Also commercially available for light vehicles.

Lane Change Support	Assists driver in changing lanes by detecting vehicles behind which are far upstream in adjacent lanes.	Prototype systems have been developed.
Driver Drowsiness Warning	Warns drivers, well in advance, that it is inevitable they will fall asleep at the wheel. Benefits predicted but unknown. Difficulty is knowing how drivers will respond to warnings that tell them they are about to fall asleep at the wheel.	Many systems commercially available (e.g. Australian Optalert system, produced by Sleep Diagnostics Pty Ltd). Optalert system currently being evaluated by MUARC.

Application	Safety Benefits	Stage of development
1. Applications that can prevent/reduce crash occurrence		
Driver Distraction Warning	Monitors drivers' eyes off the road time and issues warning if eyes off the road for longer than some pre-defined time. Potential safety benefits predicted but unknown.	Advanced prototype system developed in Australia by Seeing Machines Pty Ltd.
Curve Speed Warning	A form of Lane Departure Warning that warns driver if travel speed is excessive on the approaches to curves. US study found significant reduction in truck speeds on downgrades greater than 5%.	Prototype systems have been built and are being evaluated in the US, Europe and Japan.
Reverse Collision Warning (RCW)	Warns driver when reversing if crash with rear object is inevitable. Reverse parking aids poor at detecting irregular shaped and fast moving rearward objects such as pedestrians. Safety benefits unknown.	Commercially available as reverse parking aids for encroachment crashes. Prototypes being developed for crossing path crashes (e.g. when backing out of driveway into cross traffic).
Smart Restraint Systems	System recognizes that a collision is imminent or just occurring, and pre-activates passive restraint systems for optimal operation. Estimated to reduce serious injuries by up to 20%.	Commercially available, here and overseas.
Pedestrian Detection and Avoidance	Utilises vehicle sensors to detect pedestrians ahead, or receive warnings from pedestrian-mounted sensors (e.g. in shoes) or road infrastructure. Animal detection systems have also been developed, which rely on roadside sensors and variable message signs to warn drivers. Predicted but unknown benefits.	Honda introduced night vision system incorporating pedestrian detection in Japan in 2004. Animal detection systems deployed in Europe and North America.
Vision Enhancement	Enables driver to see objects in the dark or in low visibility conditions, through special display. Predicted but unknown benefits.	Night vision systems commercially available since mid 1990s. A night vision system that also incorporates pedestrian detection entered Japanese market in 2004.
Adaptive Front Lighting	Optimally illuminates areas ahead and to side of vehicle path to enhance night visibility. Advanced systems have swivelling head lamps which aim into curves to enhance visibility. Predicted but unknown benefits.	Advanced systems commercially available in Japan, and in Europe since 2003.

Vehicle Diagnostics	Vehicle warns driver if safety-critical systems failing or likely to fail (e.g. low tyre pressure). Predicted but unknown benefits.	Commercially available here and overseas.
Adaptive Cruise Control	More of a comfort than a safety feature. An extension of normal cruise control which automatically slows vehicle down and adopts a safe following distance when a vehicle ahead is travelling more slowly than the chosen cruise speed. OECD paper estimates 1.4% reduction in injury crashes and 0.7% reduction in fatal crashes.	Entered market in 1995 in Japan, in 1998 in Europe and in 2000 in US. Recently available in Australia. So-called "low speed ACC" systems were introduced in Japan in 2004, enabling system to operate in slow, congested, traffic.

Application	Safety Benefits	Stage of development
1. Applications that can prevent/reduce crash occurrence		
Cooperative Vehicle-Highway Systems	Vehicles communicate in real time with each other, with remote service provider and/or with the road infrastructure e.g. sensors on road detect dangerous traffic conditions ahead and convey these to drivers via in-car warnings and/or variable message signs. Cooperative systems can provide warnings for high-risk situations that cannot easily be detected by on-board vehicle sensors e.g. collisions with forward obstacles, overshooting on curves, crossing collisions at intersections, right-turn crashes, pedestrian crashes, lane departures on wet or icy roads. Predicted but unknown safety benefits.	Some cooperative systems being trialled at selected sites in Japan.
Electronic Mirrors	Provide image of other road users travelling around vehicle where external vision is limited or there are blind spots. Predicted but unknown safety benefits.	Prototypes available in US and Japan.
Intersection Collision Warning	Warns driver when on imminent collision course with another vehicle, through vehicle-to-vehicle or road-to-vehicle communication. Initial systems can provide warnings to drivers on Variable Message Signs. Predicted but unknown benefits. Awaiting outcome of Japanese trials. US study predicts 50% reduction in intersection crashes.	Mature systems involving road-to-car communication being trialled in selected sites in Japan. Prototype systems being developed in the US and Europe.
Driver-to-driver communication.	Drivers can communicate with each other with direct voice or other communication link. Predicted but unknown benefits.	Prototype systems being trialled in Japan and Europe.
Brake Assist/Forward Crash Mitigation	Brake Assist optimizes braking performance when vehicle senses imminent collision and/or when driver applies emergency braking. FCM automatically initiates hard braking when a crash is imminent. Predicted but unknown benefits.	Brake Assist commercially available in Japan, Europe and US. FCM introduced in Japan in 2003.
Active Noise Reduction	Acoustically cancels out excessive road noise in vehicle, with potential to reduce fatigue. Predicted but unknown benefits.	Commercially available in US.
Automatic Cockpit Configuration	Driver can use car key or other device to automatically configure mirrors, seat position etc to suit own driving requirements. Predicted but unknown benefits.	Commercially available, here and overseas.

2. Applications that reduce crash trauma		
Automatic Crash Notification	System automatically dials an ambulance and provides GPS coordinates and data about type of crash. Has potential to prevent up to 11% of road fatalities by rendering faster emergency assistance. US study found reductions in average notification time of around 2 minutes. Average notification time for ACN-equipped vehicles was less than 1 minute.	Commercially available, here and overseas.

Application	Safety Benefits	Stage of development
2. Applications that reduce crash trauma		
Seat-Belt Reminder	Warns driver if any occupant is unbelted. Swedish study demonstrated 17% increase in wearing rates with system that fulfilled the EuroNCAP specification. ¹⁶ US study showed 5% increase in wearing rates, and estimated 1.7% reduction in all fatalities. Victorian TAC SafeCar study showed significant reductions in distance travelled unbelted (by 96%), time to belt up (by 77%), and percentage of unbelted trips (by 48%). Another MUARC study predicted cost-benefit ratios of between 0.7 to 1 and 5.1 to 1, depending on system design.	Commercially available on many vehicles in Australia, mainly for driver and front passenger seats. Of all vehicles tested by EuroNCAP since 2003, 72% have seat belt reminders. ¹⁶
Intelligent Speed Adaptation	Reduces mean and peak speeds, and hence reduces impact trauma.	See above.
Combined Active and Passive Systems (CAPS)	Radar and other sensors on vehicle detect that a crash is inevitable and trigger advanced activation of passive safety systems to optimally protect occupants e.g. via seatbelt pre-tensioning and pre-firing of airbags.	Many systems commercially available.
Event Data Recorders	Record data immediately prior to, and during, a crash. Data can inform the crash reconstruction process and benefit researchers, crash investigators and manufacturers. May change driver behaviour through drivers knowing their driving performance is monitored. One study found a 72% reduction in crash risk for EDR-equipped fleet buses, with smaller reductions for medium and heavy fleet trucks. No known benefits for private vehicles at this stage.	Commercially available, in Australia and overseas. Data ownership, privacy and confidentiality are possible obstacles to widespread use.

2. Applications that prevent/reduce exposure to crash risk		
Electronic driver's licence	Prevents unlicensed/unauthorized drivers from starting car. Predicted benefits high but unknown.	Prototype systems available. Commercial systems for fleet vehicles available in Europe.
Route Navigation Systems	Gives driver turn-by-turn instructions (visual and/or auditory) on how to reach a destination. Several studies show reduced cognitive workload compared to using paper map for navigation. There is potential for system to both reduce unnecessary travel (e.g. when lost) and increase it (when using it to navigate to new destinations). US study estimates up to 4% reduction in crash risk.	Many systems commercially available overseas, and in Australia.

Application	Safety Benefits	Stage of development
2. Applications that reduce crash trauma		
Alcohol Sniffers and Interlocks	Sniffer systems passively detect presence of alcohol after engine started. Breath test is required if alcohol detected and, if pre-determined BAC threshold is exceeded, engine stops within certain period. Interlock systems prevent vehicle from being started if driver is inebriated at or above some threshold BAC. For interlocks, Canadian and US studies have shown 40 to 95% reductions in rate of drink driving repeat offences. Canadian study found 60% reduction casualty crash rate when interlock fitted, and for 6 months after.	Both systems commercially available. Sniffer systems not yet available in Australia. A Swedish vehicle manufacturer has built an alcohol detector into a vehicle ignition key. Drivers must blow into the key before starting the car. ²⁰
Location Specific Alerting and Warning	System warns driver, usually through route navigation system, of locations to be avoided or negotiated with caution (e.g. crash scenes, black ice, fog etc). Predicted benefits, depending on type of danger, but unknown.	Variable messages signs used in Australia to convey some of this information. In-car warnings available overseas.