CURTIN - MONASH ACCIDENT RESEARCH CENTRE

# C-MARC

FACT SHEET NO. 9

# IN-VEHICLE INTELLIGENT TRANSPORT SYSTEMS

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## 1. Purpose of this Fact Sheet

The purposes of this paper are:

- to define in-vehicle Intelligent Transport Systems (ITS) and discuss their history and purpose;
- identify existing and emerging in-vehicle ITS applications;
- review the safety benefits and risks associated with the use of in-vehicle ITS; and
- discuss issues surrounding the wide-scale implementation of in-vehicle ITS.

This fact sheet has been restricted to issues pertaining to in-vehicle ITS applications and, in particular, those focused in improving safety, rather than those addressing wider transport efficiency, mobility and environmental issues.

## 2. What is ITS?

Intelligent Transport Systems (ITS) is an umbrella term for a range of advanced computer control, communication, information, sensor and electronics technology applied to transport. ITS technologies have been developed to address a range of transportation problems, including enhancing safety, improving travel efficiency and mobility, and environmental conservation and sustainability. [1]

Although the potential for ITS to improve traffic mobility and efficiency and reduce the environmental impact of the transport system is large, the greatest impact that in-vehicle ITS may be in the improvement of transport safety. In particular, a sub-set of in-vehicle ITS called Advanced Driver Assistance Systems (ADAS) is predicted to substantially reduce the incidence and severity of road crashes. ADAS use advanced information, communication and sensor technology to support the driver in performing the driving task. This support can range from simple information presentation (for example, visual over-speed warning), through to full intervention (for example, taking control of the driving task).

ITS have existed in some form since the 1930's, beginning with the introduction of electric traffic signals in 1928. Since then, ITS have evolved into the advanced, intelligent systems of today through three main phases: preparation (1930-1980), feasibility testing (1980-1995) and product development (1995-present [1,2].

The development of ITS is currently being driven by a number of factors.[3] First, road authorities and transport operators recognise that ITS offer the potential to alleviate many transport problems, including safety and congestion. This is evidenced by the inclusion of certain ITS systems as a key component of a number of road safety strategies, such as Swedish Vision Zero[4] initiative and the Western Australian *Towards Zero Road Safety Strategy*[5]. For example, as part of a Safe Systems approach, the Towards Zero Strategy recommends implementing a range of well-researched ITS to support drivers in adhering to safe driving practices. These include Intelligent Speed Adaptation, alcohol interlocks, seat belt reminders/interlocks, adaptive braking, following distance, lane departure and fatigue warning systems; all which have high estimated crash reduction benefits (see Table 1). Second, vehicle manufacturers and suppliers are recognising ITS as an important part of vehicle innovation that may offer a competitive market advantage. Finally, as the capabilities of information and communication technology increase outside the transport domain, there is a consequential push by consumers to have such technology available inside the vehicle.

## 3. What Types of ITS Exist?

ITS can be classified in a number of different, but interconnected ways. These classifications are usually based on:

- the location of the system - *autonomous vehicle-based*, where all instrumentation is contained on board the vehicle; *autonomous infrastructure-based*, where sensors embedded in the road environment collect and provide information about traffic conditions; or *cooperative*, involving communication between vehicles and/or between vehicles and the road infrastructure;
- the aspects of the driving task or transport system that is being supported - improved traffic safety, eased traffic congestion and increased travel efficiency, or improved productivity;
- the transport domain to which the system is applied – private vehicle fleets, public transport and commercial vehicle fleets; and
- the level of system intervention – ranging from the provision of information and warnings, to physical intervention (e.g. automatic braking) and full automation where the system controls all aspect of the driving task.

Table 1 displays a selection of commonly available and emerging in-vehicle ITS applications that are aimed primarily at improving road safety. The purpose and availability of each system are presented, as is their estimated safety benefits. The ITS in Table 1 have been categorised according to the aspect of the driving task that they primarily address, although these categories are not mutually exclusive.

## Table 1 Current and emerging ITS systems aimed primarily at improving safety

| Category | System | Description | Availability* | Estimated effectiveness |
|---|---|---|---|---|
| Support Safe Vehicle Control | Following Distance Warning (FDW) | Detects and warns driver when they are travelling too close to vehicle ahead | B | Up to 57% reduction in rear-impact crashes, and up to 47% reduction in costs |
| | Adaptive Cruise Control (ACC) | Maintains longitudinal control (speed and headway) of vehicle at set threshold | B | Up to 50% reduction in serious injury and fatal rear-impact crashes |
| | Lane Departure Warning (LDW) | Recognises lane markings and issues warning when driver leaves lane without indicating | B | Up to 50% reduction in fatal and serious injury side-swipe, head-on and run-off-road collisions 60% reduction in the occurrence of side-swipe crashes |
| | Assisted parking Systems (APS) | Warns of objects in close proximity or provides steering assistance when parking | B | No effectiveness estimates available |
| Offence Prevention | Intelligent Speed Adaptation (ISA) | Warns driver or limits speed when vehicle speed has exceeded set threshold | C (advisory)<br>D (supportive & limiting) | Reductions of between 14% (fixed advisory ISA) to 48% (dynamic, mandatory limiting ISA) in fatal and serious injury crashes |
| | Seatbelt Reminder (SBR) or Interlock | Warns the driver or prevents vehicle motion if one or more occupants are unrestrained | A | Up to 50% reduction in fatalities and serious injuries for non-wearers<br>Savings of $335 million (AU) in injury costs to the Australian community |
| | Electronic Driver's Licence | Prevents unlicensed driving and driving outside conditions of the licence | D | Potential effectiveness acknowledged to be high, but actual data unavailable |
| Detection/ Prevention of Hazards | Collision Avoidance/Warning System (CAS) | Warns or intervenes if an imminent collision with a vehicle ahead is detected | B | Reductions of up to 80% in rear-end crashes have been cited by several authors |
| | Intersection Collision Avoidance System | Detects and warns driver if there is a potential risk of a collision at upcoming intersection | D | 50% reduction in intersection crashes |
| | Blind Spot Detection (BSD) | Provides information on presence of objects or road users in area not visible to driver | B/C | 10% reduction in run-off road fatalities by one estimate |
| | Vision Enhancement | Capture and present the road scene with greater contrast in situations | B | 17.5% reduction in crashes occurring |

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| | System | with reduced visibility (e.g. fog, night) | | in low visibility<br>Up to 15% reduction in pedestrian and 8% in bicyclist fatalities |
| | Pedestrian Detection System | Detects small, slow moving soft objects with critical path projection and warns driver | B | 48% of pedestrian crashes avoided with use of system + auto braking according to PC model |
| | Reverse Collision Warning (RCW) | Warns reversing driver if collision with a rear object is imminent | A | Up to 81% reduction in backing collisions |
| Detecting Reduced Fitness to Drive | Alcohol Interlock | Prevents vehicle ignition if BAC above pre-set threshold | C (usually via re-licensing program) | Up to 60% reduction in alcohol-related crashes<br>40-95% reduction in incidence of repeat drink driving offences |
| | Fatigue Warning System/Drowsiness Detection | Detects impairment due to fatigue and issues alert to driver | B | Up to 20% reduction in injury-related crashes |

* Availability – A = Standard on many vehicles; B = Available in some high-end vehicles; C = Optional/post-sale feature; D = At development/prototype stage.

Note: The availability and effectiveness estimates make use of information contained in the reviews by Bayly et al.[9] and Cairney et al.[10], as well as from an independent literature and internet searches.

## 4. Safety Benefits of ITS

The true safety benefits of many in-vehicle ITS applications are unknown given that most systems have not been available in the vehicle market long enough, or available on a wide enough scale to establish their overall impact. Thus, many of the estimates are based on modelling conducted as part of Field Operational Tests and simulation studies.

A range of studies have sought to estimate the potential of ITS to enhance safety. McKeever[6], for example, estimated that 26 percent of fatal and 30 percent of injury crashes in the United States could be prevented with the system-wide deployment of autonomous and cooperative ITS systems. Another report by the OECD[7] predicted that full deployment of ITS in OECD countries could result in the prevention of up to 47,000 fatalities each year, which equates to a societal cost saving of US $73 billion. More recently, the eIMPACT project estimated that the introduction of 12 selected intelligent driver support systems at 100% penetration rates would reduce road fatalities in Europe by up to 16.6%.[8]

The expected safety benefits of individual ITS applications vary substantially depending on a range of factors, including the level of system control, the aspect(s) of driving or driver behaviour that they address, and the type of road environment wherein they are predominantly used. Current crash reduction estimates for a range of common and emerging ITS have been included in Table 1.

## 5. Potential Safety Risks of ITS

While the introduction of ITS into the vehicle is expected to have many positive safety benefits, it can also lead drivers to change their behaviour in ways not intended by the system designers or implementers. Identified unintended negative side-effects of ITS include:

- ***Risky and Compensatory Behaviour.*** ITS can change drivers' perception of the risk associated with driving, leading them to engage in 'risky' driving behaviour if their *perceived* level of risk is lower than their *preferred* level of risk. Drivers may also engage in risky driving to compensate for reduced mobility (e.g. slower speeds).
- ***Over-reliance.*** Drivers may assign too much responsibility for certain driving tasks to the system, and may even delegate responsibility for tasks that the system was not designed to address. Over-reliance on ITS can create problems when the system is no longer active, such as when driving a non-ITS equipped car, or if the system fails and the driver needs to regain control.
- ***Attention overload***. ITS may lead to driver overload if they require drivers to attend to too much information for long periods of time.
- ***Diminished attention or driver underload.*** ITS can also lead drivers to become underloaded. Automating part of the driving task can lead drivers to 'zone out' and pay less attention to some or all aspects of the driving task.
- ***Distraction.*** ITS can become a distraction if they take drivers' attention away from safety critical events in the roadway or delay (or prevent altogether) drivers from taking evasive action. ITS may also lead drivers to engage more frequently in distracting activities, because the systems free up the driver's attention making it available for other tasks.

## 6. Challenges to ITS Implementation

The majority of OECD countries support the deployment of in-vehicle ITS applications, particularly those with high estimated safety potential. However, there are a number of challenges that need to be resolved before ITS can be successfully implemented:

- ***Improving acceptance.*** The full benefits of ITS will not be realised without the adoption and proper use of these technologies by the wider population. Improving driver and community acceptance of ITS is a major challenge that needs to be addressed as part of any implementation strategy.
- ***Building supporting infrastructure.*** One of the greatest challenges to ITS deployment is the development and implementation of the infrastructure needed to maintain the systems, and the associated costs.
- ***Ensuring technical reliability.*** The possibility of system malfunctions is a real concern for the public and ITS stakeholders. Manufacturers want to be certain of a system's reliability before introducing it in their vehicles, and the public want assurance that the system operates correctly and reliably.
- ***Coordination, cooperation and interoperability.*** The successful implementation of ADAS requires a coordinated effort by many stakeholders. ITS implementation needs to be coordinated and integrated to provide a common platform for the provision of services, communication and information. This needs to be achieved at a national level and across jurisdictions or countries where cross-border travel is common (e.g. Europe).

- ***Legal and privacy concerns.*** ITS raise a number of legal, privacy and security issues that need to be addressed if their deployment is to be successful. Who is liable in the event of a system failure or crash? Will systems be capable of recording driving data? If so, who owns the data? Who can access it and for what purposes? Such privacy, data ownership, data access and liability issues are difficult to resolve, particularly across jurisdictions who may have different legislation.

The benefits of ITS can be maximised and the risks minimised by following a comprehensive systems development and implementation program, such as outlined in the Systems Engineering Guidebook for ITS (see: http://www.fhwa.dot.gov/cadiv/segb/).

## 7. Summary and Conclusions

The development of in-vehicle ITS applications is in full force in most developed countries around the world and there are high expectations regarding their associated safety benefits. In the absence of real-world crash data, no definitive conclusions can be drawn about the true crash reduction effects of in-vehicle ITS; however, simulator, on-road and modelling studies suggest that their safety impact will be substantial. For the implementation of ITS to be successful and their full safety and other benefits to be realised, a continuous, coordinated effort is required from many stakeholders including governments, road safety agencies, system designers and suppliers, vehicle manufacturers and the driving public.

## 8. Useful ITS Links

- ITS Australia http://www.its-australia.com.au/main
- Ertico ITS Europe http://www.ertico.com/
- ITS America http://www.itsa.org/
- US Dept of Transportation Research and Innovative Technology Administration (RITA) http://www.its.dot.gov/
- California Partners for Advanced Transit and Highways (PATH) http://www-path.eecs.berkeley.edu/
- Transport Canada http://www.tc.gc.ca/eng/innovation/its-menu.htm

## 9. References

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[2]Masaki, I. (1998). Machine-Vision Systems for Intelligent Transportation Systems. *IEEE Intelligent Systems and Their Applications*, *13*(6), 24-31.

[3]van Arem, B. (2007). *Cooperative vehicle-infrastructure systems: An intelligent way forward?* (Report 2007-D-R0158/B). Delft, The Netherlands: TNO Mobility & Logistics.

[4]Vision Zero. See: http://www.visionzeroinitiative.com/

[5]Western Australian Office of Road Safety Towards Zero Strategy. See: http://www.ors.wa.gov.au/StrategiesRoadSafety/Pages/NewStrategy2008-2020.aspx

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