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IN-VEHICLE INTELLIGENT SPEED ADVISORY SYSTEMS

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ABSTRACT

We review research findings on intelligent speed adaptation (ISA) and evaluate a self-contained, on-board speed advisory system that alerts drivers when the prevailing speed limit is exceeded (passive ISA).

Recent developments in technology, including improvements to GPS and other navigation aids, mean that ISA has become a commercial reality rather than an experimental novelty. Passive and active ISA systems are now on sale in Australia.

Extensive trials of ISA throughout the world have demonstrated the potential for significant accident savings as well as other community benefits. There is a compelling case for governments to actively support ISA implementation.

INTRODUCTION

Excessive or inappropriate speed is a significant factor in serious road accidents. Road safety authorities around the world devote considerable resources to addressing the speeding problem - particularly compliance with speed limits. One countermeasure that is gaining increasing attention is the use in-vehicle technology to assist drivers keep to speed limits or even prevent the vehicle from exceeding speed limits on all roads at all times. This is known as Intelligent Speed Adaptation (ISA).

Recent developments have meant that the reliability, accuracy and effectiveness of in-vehicle technologies has gone beyond the experimental stage and they are becoming commercially available.

Numerous trials of ISA for more than a decade have demonstrated that it is effective in reducing the risk and severity of accidents and has other societal benefits such as reduced emissions and fewer major traffic disruptions resulting from road accidents.

This paper examines the role of speeding in road accidents, the reasons for speeding, ISA technology, trials and limitations of ISA, potential benefits and implementation issues.

CONTRIBUTION OF SPEEDING TO ACCIDENTS

Speed Related Crashes

The New South Wales Roads and Traffic Authority (RTA) defines a "speeding-related accident" as one where:

- The driver was charged with a speeding offence (normally exceeding the speed limit) or
- The Police report stated that the vehicle was speeding or
- The vehicle movement indicated inappropriate speed (not necessarily in excess of the speed limit). For example loss of control or skidding while negotiating a curve when there were no other factors to explain the incident.

Using this definition, the RTA estimates that about 40% of fatal road accidents in New South Wales are speed-related.

It can be seen that there are two aspects to speeding:

- "Excessive speed" where at least one vehicle was exceeding the speed limit and
- "Inappropriate speed" where a vehicle was obeying the speed limit but was travelling too fast for the road conditions.

Reports of road accident statistics do not always distinguish between these categories of speeding but it is expected that most reported cases involve excessive speed. Subject to this caution, Table 1 sets out speed-related crash statistics from several countries.

Table 1

Speed-related crashes

Region/Country	% of crashes where speeding was a factor
New South Wales, Australia (RTA 2005)	38% of fatals 17% of all crashes
United Kingdom (THINK)	29% of fatals 12% of all casualties
USA (NHTSA)	33% of fatals
New Zealand (ACC)	42% of fatals
Europe (ECMT)	33% of fatals in some countries

Speed and injury risk

Common misunderstandings amongst motorists (and perhaps some road safety organisations) are:

- that exceeding the speed limit by a "minor" amount is not a safety problem
- that most road fatalities occur at high speeds and involve vehicles travelling at grossly excessive speeds.

Although it is the case that a high speed crash is much more likely to result in a fatality, there are many more crashes which occur at relatively low speeds and, as a consequence, the majority of fatalities occur at these low speeds.

In the USA a sample of fatal crashes is investigated in detail and in most cases a delta V (the effective speed of impact) is estimated. Between 1993 and 1997 more that half of the deaths to seat-belt wearing drivers involved in frontal crashes occurred at a delta-V of 50km/h or less (NHTSA personal communication).

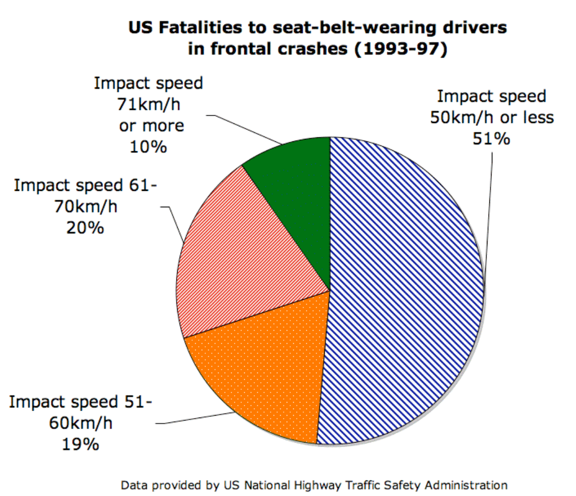

Figure 1. Delta V distribution from US fatalities

Despite improvements to crashworthiness, the proportions for recent vehicles are likely to be similar - the median speed may have increased a few km/h. A 1997 video "Physics of Car Crashes" by the NSW RTA dramatically illustrates the energy involved in a 50km/h collision (Figure 2) and this type of message should be included in road safety campaigns .

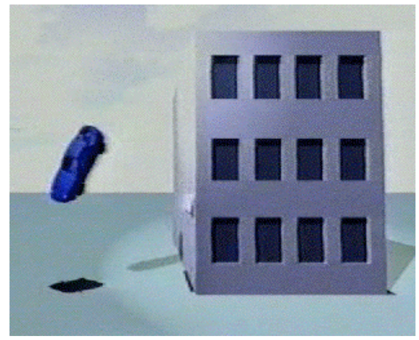

Figure 2. Frame from a video illustrating the energy in a 50km/h crash.

Side impacts offer less opportunity for protection of occupants and the median delta-V for fatal injuries is likely to be less than 50km/h. For example, the Australasian New Car Assessment Program (ANCAP) conducted a series of 29km/h side impact pole tests for SUVs with and without head-protecting side airbags (Coxon 2005). HICs of between 5900 and 9000 were recorded for all vehicles without airbags - indicating a very high risk of fatal head injury in this highly intrusive type of crash. Vehicles with airbags generally had HICs associated a low risk of head injury. However, the degree of intrusion (Figure 3) and the injury measurements for other body regions indicate that serious injury would likely occur at slightly higher impact speeds.

Figure 3. Pole impact test at 29km/h (ANCAP)

Crash risk - An analysis of travel speeds and involvement in casualty crashes was undertaken in metropolitan Adelaide in 1997. The data were recently reanalysed (Kloeden 2002). This confirmed an earlier finding that risk approximately doubled for each 5km/h above the prevailing speed limit of 60km/h.

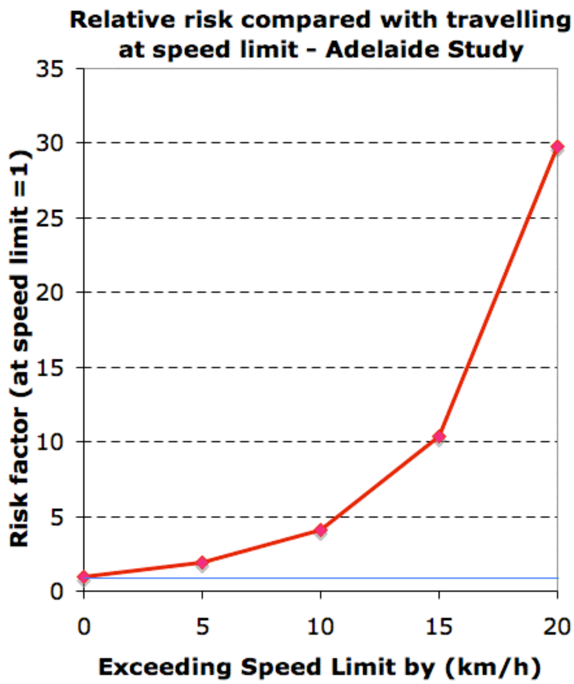

Figure 4. Risk of casualty crash doubles with each 5km/h above the speed limit

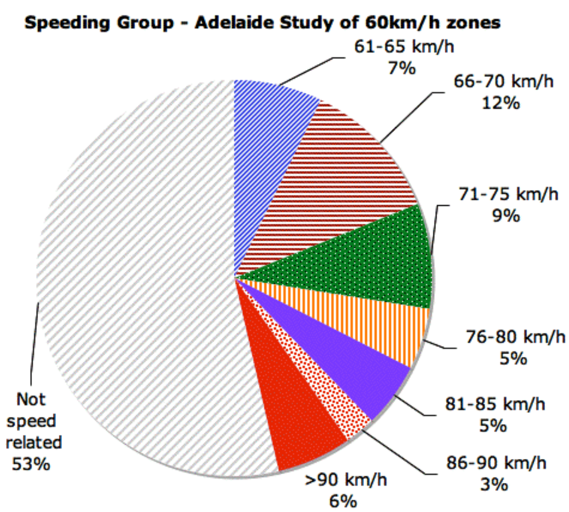

Figure 5. Contribution of speeding groups to casualty crashes.

The same Adelaide study analysed the contribution of each speeding group to the overall speeding problem. As with the case of the US impact speeds, it was found that a large proportion of casualty crashes involved "minor" speeding. It was estimated that 19% of all crashes would have be eliminated if vehicles travelling at between 1 and 10km/h over the speed limit had obeyed the speed limit (Figure 5). This represents 42% of all speeding related crashes and shows that "minor" speeding should be addressed in road safety strategies.

Changing average travel speeds - The Adelaide study estimated the overall crash savings through measures which reduce traffic speeds. It was found that 100% compliance with speed limits would eliminate 21% of all metropolitan casualty crashes and that reducing mean travel speeds by just 2km/h would eliminate 11% of these crashes.

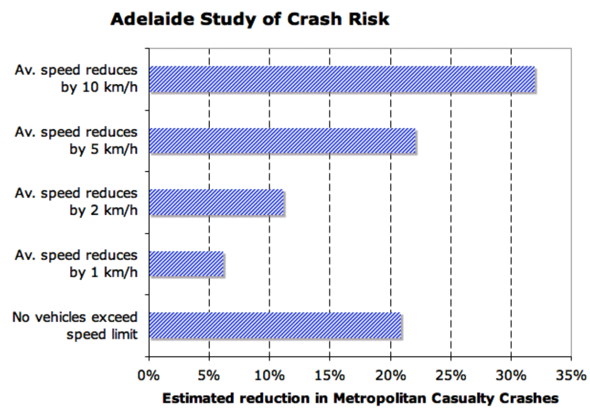

Figure 6. Effect of reducing mean traffic speeds

These findings are similar Nilsson (1993), who found that a 3% reduction in mean traffic speeds produces a 12% reduction in fatal accidents, a European study which found that 15% of injury accidents would be saved if mean traffic speeds reduced by 5km/h (ETSC 2005) and US studies of the effects of speed limit changes (IIHS 2002).

Woolley (2005) describes the results of an analysis of the effects of reducing speed limits of most residential streets in Australia from 60km/h to 50km/h. In New South Wales reportable crashes on residential streets dropped by 25%, with pedestrians and cyclists benefiting most. In Queensland a limited analysis revealed an 18% drop in fatalities. Victoria reported a 59% drop in fatalities and a 12% drop in injury crashes. South Australia found a 20% drop in casualty crashes.

It can be shown that the steep increase in serious crash risk for travel speeds above the speed limit (or the optimum safe speed, in the case of the Australian experience) is due to a "double whammy" effect. On average the impact speed will be higher and, at this higher speed, the probability of serious injury is greater (Paine 1998, Kloeden 2002, OECD 2006). This matches the real-world outcomes illustrated in Figure 4.

WHY DO DRIVERS SPEED?

Some of the common reasons that drivers give for intentionally exceeding the speed limit are that they are in a hurry, that they need to speed up to overtake, that they get a thrill from speeding (Harsha & Hedlund 2007) or that their vehicle/driving ability is better than most other drivers. Some claim that they will slow the traffic or inconvenience other drivers if they drive at the limit. Others report being intimidated into speeding by following drivers such as tailgators.

In a Victorian study associated with the TAC Safe Car (fitted with a prototype speed alert system) 87% of drivers reported that excessive speeding had been inadvertent. (Regan et al 2005). This may be an over-estimate for the general motoring population but it does suggest that in-vehicle measures to assist drivers obey speed limits could be quite effective.

Hatfield and Job (2006) report on the attitudes of New South Wales motorists to speeding. A factor is that motorists under-estimate the negative consequences of speeding. For example, participants were asked at how many km/h above the speed limit would the crash risk double (the correct answer is 5 to 10km/h). The average response was 25km/h for urban roads and 30km/h for rural roads. Also of concern, 42% of respondents felt that modern cars made speeding safer. 55% of participants supported some form of speed governing device on cars but 24% opposed this countermeasure..

Mitchell-Taverner & others (2003) found that 14% of surveyed New South Wales motorists normally exceeded the speed limit by at least 5km/h. However, there was a substantial difference across age groups, with 23% of those below the age of 25, 18% of 25-30 year olds,13% of 40-59 year olds and 3% of over 60s.

In order to assess the effectiveness of various types of speed control devices it is useful to identify the different groups of speeding motorists. Paine (1996) made an estimate based on limited data:

Table 2.
Estimated proportion of speeding drivers and contribution to speed-related crashes

Category of speeding driver	Est. %
Recidivist - Grossly excessive speeds. Risk taker. May be alcohol affected	3% drivers 10% crashes
Intentional - Feels "safe" at 10-15km/h over the speed limit. Thinks that risk of booking is low	30% drivers 35% crashes
Inadvertent - Drives a powerful/smooth car which is too easy to drive at over the speed limit or misses speed sign or forgets current speed zoning	35% drivers 30% crashes
Reluctant - Under pressure, drives at the speed of the traffic stream, which is exceeding speed limit. Does not want to impede traffic. Intimidated by tailgators.	30% drivers 25% crashes

Based on this estimate, about two thirds of drivers ("inadvertent" and "reluctant") would be assisted by an advisory system that informed them when they exceeded the speed limit. "Reluctant" speeders would be further assisted if following drivers knew that an ISA system was in operation. The Leeds trial had a sign for this purpose (Figure 7).

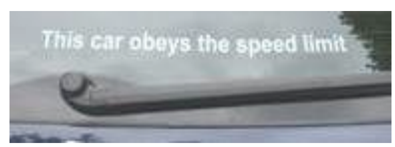

Figure 7. Sticker for Leeds trial

About one third of motorists would need a stronger countermeasure, such as a system that prevented the vehicle from exceeding the speed limit. Although somewhat speculative, these ratios are broadly in agreement with support for speed governors reported by Hatfield and Job.

INTELLIGENT SPEED ADAPTATION

In essence ISA systems constantly monitor the local speed limit and the vehicle speed and take action when the vehicle is found to be exceeding the speed limit. This action can be advisory or "passive", where the driver is warned, or "active" where there is some degree of automated control of vehicle speed. To achieve this ISA systems need to know when the vehicle has entered a new speed zone and when variable speed zones are in force (e.g. school zones). Additional ISA features might be the ability to detect temporary speed zones (such as at accident scenes or near roadworks) and knowledge of advisory speeds such as sharp curves and stop signs (in effect, a stop sign signifies a speed limit of zero).

Types of ISA

Passive systems allow the driver to make a choice on what action should be taken. These can range from a simple audio or visual warning (a flashing light or a beep) to a more sophisticated human-machine interface Some ISA trials have used haptic feedback, where the accelerator pedal became stiffer or vibrated when the vehicle exceeded the speed limit. An alternative is to turn off convenience items such as the radio or air-conditioner when speed limits are exceeded for prolonged periods (Paine 1996).

Active systems reduce (or limit) the vehicle's speed automatically, without intervention from the driver. Methods used to achieve this include throttle control, brake application, engine management system manipulation, fuel limiting or a combination of these. Headley (2005) notes that Adaptive Cruise Control (ACC) can be programmed to "maintain the vehicle speed to that posted" and discusses sign recognition as a way of determining speed limits.

Most of the active ISA systems that have been trialled have an override system so that the driver can disable the ISA if necessary. The provision of such disabling features need not be a concern provided that the times when the system is disabled are logged for monitoring purposes.

One "non-intelligent" form of ISA is top-speed-limiting, where the vehicle is rendered incapable of travelling for prolonged periods in excess of a set top speed. This is simple to achieve with most modern engine management systems - indeed most already have a top speed setting set to unrealistically high values such as 250km/h. Top-speed-limiting based on regional speed limits (e.g. 110km/h plus, say 10km/h in Australia) would be simple to introduce and would be an effective deterrent to vehicle theft and joy-riding.

In Australia top speed limiters set at 100km/h are required on all heavy vehicle built since 1991. However it is evident that there is widespread tampering with these systems (Paine - unpublished report for NSW RTA 2000).

Speed and Location Technology

To function, the ISA system needs to know the location of the vehicle, accurate to a few metres. This location information must be linked to a detailed digital map (or its equivalent) containing information such as local speed limits, and the location of known variable speed zones (e.g. schools). Advanced ISA has the capacity for real time updating to include information on areas where speed limits should be reduced due to weather conditions (rain, snow, ice, fog) or around accident scenes and roadworks.

There are three main types of technology currently available for determining location (and, in turn local speed limits). Some of these also determine the speed of the vehicle independent of the vehicle's own speedometer (which can be out by as much as 10%). These technologies are:

- GPS
- Radio Beacons
- Dead Reckoning

Global Positioning System (GPS) - GPS is based on a network of satellites that constantly transmit radio signals. GPS radio receivers pick up these transmissions and, by comparing the signals from several satellites, are able to pinpoint the receiver's location, usually to within a few meters (for advanced receivers).

There are currently 24 satellites making up the GPS network and their orbits are configured so that a minimum of five satellites are generally available at any one time for terrestrial users. In theory four satellites is the minimum number of satellites required to determine a precise three dimensional position (latitude, longitude and altitude).

Despite its popularity, GPS is subject to a number of fundamental problems related to the accuracy of the determined position. The receiver still gets the signal from the satellites, but due to satellites ephemeris uncertainties, propagation errors, timing errors, multiple signal propagation paths (eg reflected signals) and receiver noise, the position given is not always accurate (Kao 1991). Usually these inaccuracies are insignificant for car navigation purposes but sometimes they can be up to hundreds of metres. Furthermore, because GPS relies upon a signal transmitted from a satellite in orbit it does not function when the receiver is underground or in a tunnel and the signal can become weak if tall buildings, trees or heavy clouds come between the receiver and the satellites.

Current improvements being made to the GPS satellite network and receivers will help to increase GPS reliability and accuracy but are unlikely to overcome some of the fundamental shortcomings of GPS.

Radio beacons - Roadside radio beacons work by transmitting data to a receiver in the car. The beacons constantly transmit data, which the car mounted receiver picks up as it passes each beacon. This data could include local speed limits, school zones, variable speed limits or traffic warnings (roadworks, weather, etc).

Beacons could be placed near (or on) speed limit signs or other roadside furniture or in the road itself. Mobile beacons could be deployed (that would override fixed beacons or GPS) for use around accident scenes, during poor weather or during special events.

A problem with beacon technology is that the vehicle needs to be in the proximity of a beacon in order to determine the speed limit. There would need to be some redundancy in the system to allow for broken beacons and transmission errors. Also, to work properly, every intersection where the roads had different speed limits would need a set of beacons (eg side roads joining arterial roads).

Dead reckoning - Dead reckoning (DR) uses a mechanical system linked to the vehicle's driving assembly, to predict the path taken by the vehicle. By measuring items such as the rotation of the road wheels and the angle of the steering wheel a reasonably accurate estimation of the vehicle's speed and location can be made. More accurate systems rely on specialised sensors (accelerometers, flux gate compass, gyroscope). However, dead reckoning requires the vehicle to begin at a known, fixed point near the start of the journey. Inaccuracies result from a variety of sources, including changes to tyre diameter as the tyres warm up. Errors gradually accumulate and become unworkable unless there is periodic correction with a new reference point. For this reason dead-reckoning needs to work in conjunction with another system, such as GPS. Some top-end GPS based navigation systems use dead reckoning as a backup system in case GPS signal is lost (such as in tunnels).

Map matching - Once the vehicle location has been determined, the accuracy can be checked by digital map matching. Under this scheme, the assumed location is compared with known roads (such as those available from a navigation map) and the system snaps to the most likely location on a known road. A check is also made against the last known position to determine if the new location is physically reasonable.

The most accurate ISA systems possible today use a combination of GPS, dead reckoning and map matching (Basnayake 2004, Calafell 2000, Kao 1991)

Optical recognition systems - So far optical recognition technology has been focussed on recognising speed signs only, however other roadside objects, such as the reflective 'cats eyes' that divide lanes could possibly be used. This system requires the vehicle to pass a speed sign (or similar indicator) for data. As the system recognises a sign the speed limit data is obtained and compared to the vehicle's speed. The system would use the speed limit from the last sign passed until it recognises a speed sign with a different limit.

As with beacons, if speed signs are not present or are obscured the system does not function. This is a particular problem when exiting a side road onto a main road (the vehicle may not pass speed sign for some distance). The accuracy, reliability and effectiveness of optical recognition technology remains unproven in ISA and it appears that the other technologies are more suitable.

EVALUATIONS OF ISA

The table in the Appendix summarises ISA trials conducted in several countries. There have been at least 25 trials conducted in a total of 14 countries, with the notable exception of the USA.

Carsten's review (2004) indicates that, on the whole, these trials have exceeded the organisations expectations. However, Carsten notes that some trials have missed an opportunity for collecting pertinent data.

Accuracy and Reliability of ISA

A warning resulting from an incorrect speed limit would be a nuisance for an advisory system. The same errors in an active system could have serious road safety disadvantages, depending on the level of control of the system and the ability of the driver to over-ride the system. A typical example of a safety hazard would be a car travelling at 110km/h on a motorway where the ISA system unexpectedly reduces the vehicle speed to 50km/h, due to a GPS or mapping error. It is therefore important that sources of possible errors be identified and minimised.

The overall system comprises three major components (Figure 8):

- DRIVER/VEHICLE
- ISA SYSTEM
- SPEED LIMIT DATABASE

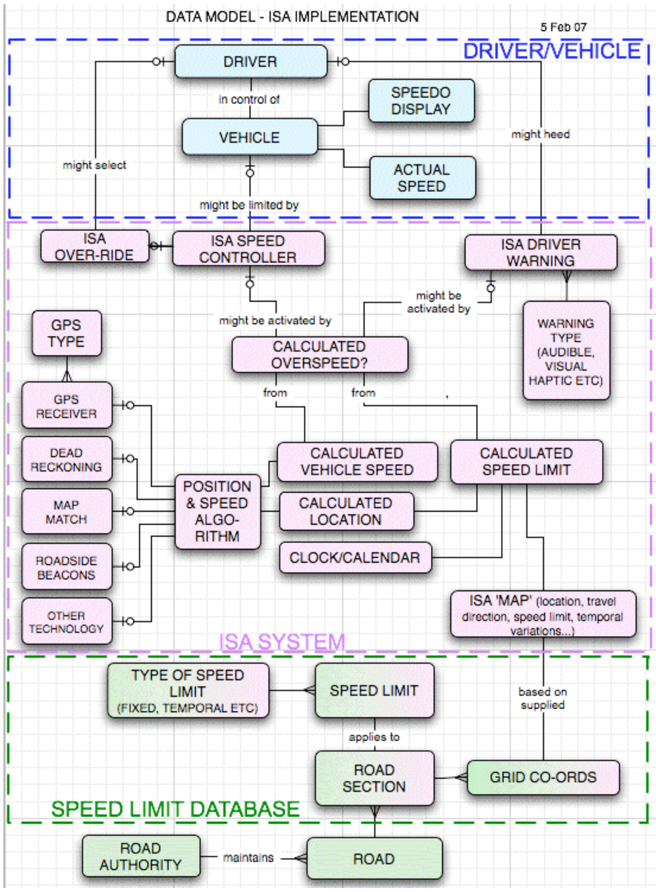

Figure 8. Data model of ISA

The ISA system includes any components that determine the vehicle's position or velocity, and compares it with a map of speed limits to determine whether the vehicle is speeding. For passive systems it also includes the way in which the driver is warned of excess speed (flashing lights, sounds, voice prompts, etc). For active systems it includes the controls that are used to automatically prevent speeding.

The speed limit database contains all information related to any digital map or other information system that is used to determine local speed limits, some of which may be temporal (such as school zones).

The list below shows the potential faults for each of the three main areas of ISA

Driver/vehicle

- The driver may ignore, misunderstand or not notice a speed warning
- The driver may perform an unintended action in reaction to a speed warning (e.g. become distracted)
- For active systems, the driver might over-ride the system, or might not be aware that it is not operative (over-ridden by a previous driver).

ISA System

- The speed warning may be a false alarm (e.g. wrong speed limit or incorrect vehicle speed)
- The speed warning may fail to activate when the vehicle is actually speeding,
- The vehicle speed or position may be inaccurate or inoperative (GPS 'drop out', beacon failure)
- Time or date incorrect (time dependant variable speed zones affected)
- System may be out of operational range (e.g. no beacon close enough or boundaries of digital map reached)
- With active ISA, the speed controlling mechanism fails to activate or sets to the wrong speed
- The override, if any, might not work
- Failsafe operation might not work with an active system (driver loses throttle control)

Speed Limit Database

- Variable speed limits are not included
- Timing information for time dependent variable limits is incorrect (e.g. holidays)
- A speed limit changes but the digital map is not updated
- Road path (alignment) changes but the digital map is not updated
- Wrong speed limit is assigned
- Coordinates of map are incorrect/inaccurate
- Road is not mapped

ISA ON SALE IN AUSTRALIA

SpeedAlert

In mid-2006 a Sydney company, Smart Car Technologies, began commercial sales of a GPS-based speed limit advisory system.

SpeedAlert is a software package that is designed to work with compatible PDAs and programmable mobile phones. SpeedAlert works with GPS to pinpoint the position of the car. Using a pre-recorded database of speed limits, the software is able to recognise the current speed zone the car is travelling in. Using GPS, SpeedAlert is also able to accurately calculate the speed of the vehicle and so is able to warn the driver, using audible and/or visual alerts, if the car exceeds the speed limit at any time. No connection to the vehicle's speedometer system or other components is required.

The system is designed to be highly portable and can be easily transferred between vehicles. Installation involves an optional cradle to hold the PDA, a power cable to a cigarette lighter socket and a bluetooth GPS receiver placed on the dash. The software is also designed to work with PDAs and mobile phones that have built-in GPS reception. Costs range from US$90 for software and a 12 month update subscription to about US$500 for a PDA with built-in GPS receiver and the SpeedAlert software and update service. Updates are downloaded over the Internet and are typically several megabytes.

Speed zone information - SpeedAlert uses a patented layered mapping system. The first layer is a polygon defining the default speed limit for a region. The next layer comprises strips/tracks for all roads that do not have the default speed limit. The top (priority) layer has polygons defining school zones and similar safety-related areas. Once the program has established communication with the GPS receiver it analyses the speed zone database and prominently displays the current speed limit as large black numerals inside a red circle (Figure 9). The current vehicle speed is displayed in smaller numerals below the speed limit.

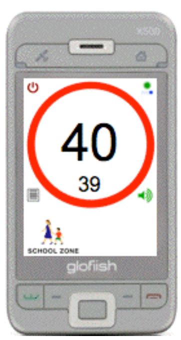

Figure 9. SpeedAlert display

If the speed limit is exceeded the numerals turn to red. Depending on user settings (2 or 5km/h over the limit), an audible beep is activated. The beeps continue until the vehicle speed is decreased. There are two levels of beeping - one beep per second or two beeps per second - depending on the amount by which the speed limit is exceeded.

The driver can choose to mute the beep, but the mute facility is over-ridden in the vicinity of a school zones or fixed speed cameras.

At the time of the evaluation the system was not able to display variable or temporary speed limit information, such as on some freeways and in the vicinity of roadworks. However it did alert drivers when travelling along a road with variable speed limits.

The database has school zone information. When the vehicle is approaching a school zone the unit announces this by voice and a logo appears in the lower left of the screen. Once the school zone is reached the unit displays the appropriate speed limit information, depending on the time of day and day of week.

Irrespective of the time of day, the voice alert always activates in school zones and always beeps if the current speed limit is exceeded by more than 1km/h. This is in recognition that children might be crossing the road outside the designated school zone hours.

The system also gives a voice alert when approaching railway crossings, fixed speed cameras, red light cameras and bus lane cameras.

On-road trials - The authors have used SpeedAlert for many road trips within the Sydney metropolitan region. Some refinements to the user interface and some updates to the maps were implemented during this period. Key points from the evaluation are set out below.

The user interface was found to be simple to use and intuitive. Once the program loads and is communicating with the GPS unit there is no need for driver intervention - it simply displays the current speed limit and vehicle speed and will beep if the speed limit is exceeded. Importantly, there is no need to look at the screen at all while driving, unless there is uncertainty about the current speed limit. In any case, this likely to be a less distracting task than scanning the roadside for the occasional speed limit sign.

Knowing the speed limit, the driver monitors and adjusts the vehicle speed in the normal way. If the unit starts to beep then it means that either the speed has crept up over the speed limit or the speed zoning has changed. In either case the driver reduces speed until the beeping stops. There is no need to look at or touch the PDA during this sequence. For the evaluation the tolerance for audible warning was set at 2km/h and it was found to be easy to travel at or below the speed limit without an undue number of audible alarms.

For most of the time the system worked well. However occasionally it reverted to the default 50km/h speed limit while travelling on arterial roads. The system apparently decided that the vehicle had left the arterial road and was in a 50km/h zone. This was mostly resolved by fine-tuning the digital map to better define some portions of the arterial roads. Algorithms to better detect and deal with remaining situations (such as spurious GPS positions) are under development.

From a "warm" start the GPS receiver usually takes between 30 seconds to a minute to establish location. This means that the first few hundred metres of a journey are not covered. After this period the system was found to be very reliable and accurate.

One of the authors has travelled approximately 6000km with SpeedAlert in operation and has noted instances when the system appeared to be unreliable. In a typical journey of 50km through suburban Sydney it is estimated that the system would lose the signal or display an inaccurate reading for no more than about 30 seconds. This equates to about 99% accuracy, which is considered acceptable for a passive system. Occasionally, however, the GPS receiver was unable to obtain a reliable signal and several kilometres were travelled with the system out of action. Also, as expected, the system did not operate in tunnels and took several seconds to reacquire the signal on exiting the tunnel.

Most of the evaluation was conducted using an i-mate PDA-N device with built-in GPS receiver (SiRF starIII).

It is often difficult to obtain good GPS reception in city streets with tall buildings. However, with Sydney city traffic there is little opportunity to drive at anywhere near the posted speed limits most of the time so this is not seen as a serious obstacle to use of the system. Nevertheless, it is important that drivers using this type of advisory system are made aware of its limitations and do not become complacent about monitoring their speed.

Speed limit database - At the time of this evaluation the mapping database covered the Sydney metropolitan area. Mapping is underway for the remainder of Australia.

In order to prepare a complete and accurate database, Smart Car Technologies has developed an efficient but labour-intensive method of mapping the roads of interest. A two-person team drives along roads that might contain non-default speed limits. Speed zone changes, the road geometry and other features are recorded using a GPS-equipped laptop computer. Multiple trips are used to improve accuracy.

It is understood that most of the trials of ISA have involved similar mapping exercises due to the lack of good speed limit information from road authorities.

There is evidently a need for pooling of resources and greater co-operation from road authorities to create and maintain the necessary speed limit databases for widespread implementation of ISA (ETSC 2006).

Speedshield

Melbourne company, Automotion Control Systems (ACS), has developed an active speed control system which has been in operation in industrial locations such as warehouses since 2003. The system is in widespread use on forklifts and similar vehicles by a number of major Australian companies.

The company further developed this system for use in cars and commercial vehicles. In 2006 ACS was awarded a contract to conduct ISA demonstration projects with the Transport Accident Commission of Victoria and with the Office of Road Safety and Main Roads WA of Western Australia. A total of 100 units will soon be in operation in these two Australian states. One aim is to generate public demand for ISA. ACS is also currently running an on-road trial with trucks in Victoria.

Speedshield uses a combination of GPS and dead-reckoning to establish vehicle location and local speed limits. Radio beacons and wireless communication are used to provide speed zone database updates. The system accommodates temporary speed control e.g. roadworks, accidents etc. by use of bollards fitted with roadside transceivers and time based limits such as school zones.

Figure 10. Speedshield display and controls

Figure 10 shows the display used in the demonstration project. The device provides alerts for current speed zone, speed zone changes and over speed. Full vehicle speed control operates when optionally selected.

A control module is installed between the accelerator pedal and the engine and mirrors the driver's throttle movement until the speed limit is reached, at which stage the module will hold or reduce the throttle signal. An optional over-ride is available where the driver briefly pushes the accelerator pedal to the floor.

Other features of particular interest to fleet operators are driver identification (only authorised people can drive the vehicle), crash data logging, vehicle operation reports and despatch management.

The current installed cost of the basic Speedshield system is about US$2000. With large-scale production this should reduce to a cost that is comparable to in-car navigation systems.

BENEFITS OF ISA

Road accident savings

Carsten (2001, 2004 and 2005) provides a review of various trials and estimates of the effectiveness of ISA. He considers three levels of control: advisory, voluntary (active but driver can disable) and mandatory (active all the time) and three types of speed limit: fixed, variable and dynamic (adjusting to current road conditions). Table 3 sets out "best estimates" of injury and fatal accident reductions.

Table 3.
Estimates of ISA savings by crash type

System Type	Speed Limit Type	Injury	Fatal
Advisory	Fixed	10%	18%
	Variable	10%	19%
	Dynamic	13%	24%
Voluntary	Fixed	10%	19%
	Variable	11%	20%
	Dynamic	18%	32%
Mandatory	Fixed	20%	37%
	Variable	22%	39%
	Dynamic	36%	59%

For comparison, based on logged data from a trial of a passive ISA system working with fixed speed limits, Regan (2006) estimated that the system could reduce fatal accidents by 8% and serious injury crashes by 6% but noted that these were likely to be under-estimates

From Table 3, estimates of savings for mandatory ISA are about twice that for advisory ISA. This broadly agrees with the proportions provided in Table 2, on the assumption that advisory ISA will generally only be of benefit for inadvertent or reluctant speeders.

Mandatory ISA and, to a lesser extent, voluntary ISA would also cover "intentional" speeders. Although, in theory, "recidivist" drivers would also be covered by mandatory systems, experience with heavy vehicle top-speed limiters in Australia suggests that extra monitoring functions would need to be in place to discourage tampering. This is quite feasible with ISA - many of the ISA trials have collected data for later analysis.

Environmental benefits

Most ISA trials have reported reductions in fuel consumption. Carsten (2005) describes the modelling of ISA on various types of roads. Fuel consumption savings were: 8% for urban roads, 3% for rural roads and 1% for motorways. Results of emissions modelling were mixed and so no environmental benefits were assumed. Regan (2006) reported no significant fuel consumption reductions for an ISA trial in Melbourne. However, it should be noted that with widespread adoption of ISA, vehicle manufacturers are more likely optimise drive system performance to suit typical driving conditions, rather than the marketed top speed capability of the vehicle. This should ultimately result in reduced emissions. There are also noise and amenity benefits (OECD 2006)

Travel times and other issues

Regan (2006) reports that ISA did not increase travel times during the extensive trial in Melbourne, Australia. Many other trials have reported little or no increase in travel times.

Based on modelling, Carsten (2000) estimated a maximum overall increase in travel time of 2.5%. However, this does not appear to take account of a reduction in major traffic disruption resulting from crashes avoided by widespread implementation of ISA.

Paine (1996) noted that urban network capacity is generally constrained by locations where the traffic is moving at much lower speeds than the statutory speed limit therefore ISA is unlikely to have adverse effects on road network efficiency. Speeding in urban areas is essentially a form of queue-jumping and there is no net advantage to the community from this practice. ISA trials have supported this conclusion (OECD 2006).

Paine also evaluated the effects of ISA on overtaking practices. It was noted that travelling at excessive speed to complete an overtaking manoeuvre is a highly risky practice (the time saved through overtaking is likely to be offset by an equivalent decrease in life expectancy) but, if it is deemed necessary to allow temporary ISA over-ride in these circumstances, then a time-limit of about 20 seconds would be appropriate. However, in planning an overtaking manoeuvre the driver must take a range of factors into consideration and the potential speed of overtaking is one of these factors. Plowden & Hillman (1984) point out that the main effect of a speed limiter is that "the driver of a high-performance vehicle would no longer perform certain manoeuvres which he now regards as safe".

GOVERNMENT SUPPORT FOR ISA

A 2006 OECD/ECMT report on speed management supports the introduction of ISA and recommends that governments develop digital speed limit databases.

In a 2006 report, the European Transport Safety Council states:

- ISA technologies do work, are robust and reliable. They are technically simple, much simpler than other automatic devices such as collision avoidance systems
- Delivering and maintaining the relevant map data for ISA is not a problem, provided that legislation is there to ensure action is undertaken in a harmonised way.
- The substantial accident reductions to be gained from ISA outweigh its costs, particularly if ISA fitment was required by law. Doing nothing or achieving speed reduction by other means will turn out more expensive in the end than implementing ISA technology.
- Liability is a "red herring": industry has already implemented other support systems (advanced cruise control, etc.) that intervene in vehicle control to assist the driver without being concerned about liability.
- There is no single vehicle technology remaining to be implemented - neither on the market nor in development - that offers the same safety potential as ISA.
- Speed management is a government task and the European governments will realise important economic benefits for their citizens if they decide to encourage and eventually require them to install ISA in their cars. EU countries should therefore wait no longer for industry to act but set the scene themselves. They should as a first step promote the industry's efforts by supporting additional research and standardisation, by introducing tax cuts as incentives to install ISA and becoming first customers of ISA technology. As a second step, they should require ISA by law.

In 2003 the New South Wales Parliament Staysafe Committee commenced an enquiry "Speed and motor vehicles: Vehicle-based measures to monitor, manage and control speed". A report is due to be released during 2007 (Faulks 2007). Late in 2006 the Committee agreed to the following recommendations relating to ISA:

- that there be a regulatory requirement for top speed limiting of all new vehicles and a review of speedometer scales
- that trials be conducted of ISA in New South Wales, including a special trial for novice drivers.
- that the Roads and Traffic Authority provides and supports digital mapping, speed zone databases and other information associated with ISA.
- that consideration be given to incentives for ISA.

These recommendations reflect the difficulties that ISA faces without active support from government. In particular, there is a need for governments to assist with the hurdle of preparing digital maps of speed limits so that ISA systems can be used throughout the nation.

In addition it would be helpful if government organisations (and large corporations) embraced ISA technology by making it a requirement for fleet vehicles. Clear, co-ordinated messages to drivers about the safety consequences of exceeding the speed limit are also needed.

CONCLUSIONS

Recent developments in technology, including improvements to GPS and other navigation aids, mean that ISA has become a commercial reality rather than an experimental novelty. Passive and active ISA systems are now on sale in Australia but are limited by the geographical extent of speed limit mapping.

Extensive trials of ISA throughout the world have demonstrated the potential for significant accident savings as well as other community benefits.

There is a compelling case for governments to actively support ISA implementation through:

a) assistance with the mapping of speed limits and the maintenance of databases

b) being the first major customers for commercial ISA systems

c) inclusion of ISA in fleet vehicle purchasing policies and occupational health and safety guidelines

d) promoting the benefits and functionality of ISA

e) introducing financial incentives such as tax concessions

f) educating motorists that most fatalities occur at surprisingly low impact speeds and that just a few km/h over the speed limit greatly increases the risk of a serious injury crash.

g) introducing subsidised ISA rental/purchase schemes for novice drivers

REFERENCES

Basnayake C, Mezentsev O, Lachapelle G and Cannon M (2004) "A Portable Vehicular Navigation System Using High Sensitivity GPS Augmented with Inertial Sensors and Map-Matching", SAE Paper 2004-01-0748.

Biding T (2002) "Intelligent Speed Adaptation", Swedish National Road Administration.

Calafell J, Foyer P and Porooshasp K (2000) "Navigation Systems in Europe: Past , Present and Future", SAE Paper 2000-01-1298.

Carsten O (2000) "External Vehicle Speed Control - Executive Summary of Projects Results", University of Leeds, July 2000.

Carsten O (2001) "ISA: the Best Collision Avoidance System?", *Proceedings of 17th Conference on the Enhanced Safety of Vehicles*, Netherlands. http://tinyurl.com/26cfod

Carsten O (2004) "ISA - From Fields Trials to Reality", PACTS conference *Targets 2010: No Room for Complacency*, London, 10 February , 2004.

Carsten O and Tate F (2005) "Intelligent Speed Adaptation: Accident Savings and Cost-Benefit Analysis", *Accident Analysis and Prevention* 37, pp.407-416 2005.

Coxon C, Paine M and Haley J (2005) "Side Impacts and Improved Occupant Protection", *Proceedings of 19th Conference on the Enhanced Safety of Vehicles*, Washington. http://tinyurl.com/2m4otn

ETSC (2005) "Motor Vehicle Speed in the EU", European Transport Safety Council, No.6, September 2005.

ETSC (2006) "Intelligent Speed Assistance - Myths and Reality: ETSC Position on ISA", European Transport Safety Council, May 2006

Faulks I (2007) "How fast am I going now? What is the speed limit? Vehicle-based measures to enable drivers to better monitor, manage and control speed: An examination of possible road safety countermeasures", Safety and Policy Analysis International, Sydney, NSW (pending)

Harsha B and Hedlund J (2007) "Changing America's culture of speed on the roads", AAA Foundation. http://tinyurl.com/38mktm

Hatfield J and Job S (2006) "Beliefs and Attitudes about Speeding and its Countermeasures", Australian Transport Safety Bureau, Report B2001/0342, May 2006.

IIHS (2002) "Faster Travel and the Price We Pay", Status Report Vol.38 No. 10, Nov 2003. Arlington.

Kao W (1991) "Integration of GPS and Dead-Reckoning Navigation Systems", SAE Paper 912808.

Mitchell-Taverner P, Zipparo L and Goldsworthy J (2003) "Survey on Speeding and Enforcement", Australian Transport Safety Bureau, Report CR 214a, October 2003.

Kloeden C, McClean A,and Glonek G (2002) "Reanalysis of Travelling Speed and Risk of Crash Involvement in Adelaide, South Australia", Australian Transport Safety Bureau Report CR 207, April 2002.

NHTSA (2005) "Analysis of Speeding-Related Fatal Motor Vehicle Traffic Crashes", Report DOT HS 809 839, August 2005. http://tinyurl.com/36mm7c

Nilsson G (1993) 'Relationship between speed and safety: calculation method', *The Speed Review: Appendix of Speed Workshop Papers*, Federal Office of Road Safety, Report CR127A, Department of Transport and Communications, Canberra.

OECD/ECMT (2006) "Speed Management", Joint OECD/ECMT Transport Research Centre, October 2006. http://tinyurl.com/2xxuow

Page J (2005) "A Final Technical Report on the Belgium ISA Trial", Belgian Institute for Road Safety.

Paine M (1996) "Speed Control Devices for Cars", report prepared for NSW Roads and Traffic Authority, May 1996. http://tinyurl.com/2vutwc

Paine M (1998) "Why Consider Speed Control Devices for Vehicles?", *Developments in Safer Motor Vehicles Conference*, NSW Parliament, March 1998. http://tinyurl.com/2ucfnm

Peltola H, Tapio J and Rajamaki R (2004) "Recording ISA in Finland", Via Nordica.

Plowden S and Hillman M (1984) "Danger on the Road: The Needless Scourge". Policy Studies Institute. London.

Regan M, Triggs T, Young K, Tomasevic N, Mitsopoulos E, Stephan K and Tingvall C (2006) "On-road Evaluation of ISA, Following Distance Warning and Seat Belt Reminder Systems: Final Results of the TAC Safecar Project", Monash University Accident Research Centre, September 2006.

RTA (2005) "Road Traffic Crashes in New South Wales 2004", Roads and Traffic Authority.

Wolley J (2005) "Recent Advantages of Lower Speed Limits in Australia", *Journal of the Eastern Asia Society for Transportation Studies*, Vol. 6, pp. 3562 - 3573, 2005. http://tinyurl.com/2jtzaq

Appendix - Summary of ISA Trials

Country	Region	Year	Participants	Type of ISA
Sweden	Lund	1992	75	Active
Sweden	Almqvist & Towliat	1993	16	Active + Passive
Sweden	Ezlov	1996	92	Passive
Sweden	Borlange	1999	400	Passive
	Umea		4000	Passive
	Lund		290	Active
	Lidkoping		280	Active (150) + Passive (130)
Netherlands	Tilburg	1999	20	Active
Sweden, Spain & Netherlands	-	1997	20-24 per country	Active
Hungary	Debrecen	2003	20	Active + Passive
Spain	Mataro	2003	19	Active + Passive
UK	Leeds	1997	24	Active
UK	Leeds	2003	80	Active
Denmark	Aalborg	2000	24	Passive
Finland	-	2001	24	Passive
France	Several locations	2001	100	Active + Passive
Belgium	Ghent	2002	20	Active
Belgium	Ghent (DIVOTE)	2002	100	Passive
Austria	RONCALLI project	2004	-	Passive
Norway	Karmoy	2004	50	Passive
Australia	Melbourne	2003	23	Active/Passive
Canada	Ottawa	2005-6	10 + 10	Passive "Otto Mate" + "Imita"
Canada (pending)	Ottawa	2007	50	Passive "Belonitor"
Australia	Sydney	2006	20+	Passive "SpeedAlert"
Australia	Melbourne	2006-7	3 + 50 in 2007	Active/Passive "Speedshield"
Australia	Western Australia	2006-7	3 + 50 in 2007	Active/Passive "Speedshield"

This list is based on published reports. There are likely to be other trials that do not appear in this table.