# Low Range Speeding and the Potential Benefits of Intelligent Speed Assistance

Michael Paine

Vehicle Design & Research Pty Ltd

email: mpaine@tpg.com.au

**Abstract**

More than half of fatalities to seat-belt-wearing drivers in frontal crashes occur at impact speeds below 55km/h. Pedestrians and other vulnerable road users are at risk at much lower speeds. The impact speed depends on the timing and degree of braking, if any, that occurs before the crash. The resulting impact speed is highly dependent on the initial travel speed. Small increases in travel speed can disproportionately increase impact speeds and small increases in impact speed can greatly increase the risk of serious injury or fatality. This double whammy effect is not appreciated by many motorists, who routinely travel several km/h over the speed limit.

It is shown that low-range speeding, up to 10km/h over the speed limit, makes up a large proportion of preventable road trauma. It is difficult for enforcement methods alone to have an effect on this minor speeding. An added problem is that even motorists who want to obey the speed limits (to keep their life, licence or livelihood) have difficulty doing so in modern cars on modern roads.

This is where Intelligent Speed Assistance (ISA) can help. The system has a simple function, backed up by clever technology. It knows the location and speed of the vehicle and, from an on-board database of speed limits, it can alert the driver to speeding

**Keywords**

Speeding, ISA, Speed limiter, Enforcement

## Introduction

Most motorists do not appreciate the extra risks involved in travelling just a few km/h over the speed limit. Most think that the risk of a casualty crash is doubled if you are travelling at least 25km/h over the speed limit [1]. Research has found that that, in urban areas, the risk of a casualty crash is doubled for each 5km/h over the limit. So travelling at 70km/h in a 60km/h zone quadruples the risk of a crash in which someone is hospitalised. As a result, it is estimated that about 12% of casualties could be prevented if the large group of motorists who routinely travel at up to 10km/h over the limit were encouraged to obey the speed limits [2 , 3]. Savings in fatal crashes would likely be greater, as analysed below.

The reasons for the extra risk, and the potential savings, are examined further in this paper. It can be demonstrated that "low range" speeding makes up a substantial proportion of preventable road trauma. It is difficult for enforcement methods alone to have an effect on low-range speeding. An added problem is that even motorists who want to obey the speed limits (to keep their life, licence or livelihood) have difficulty doing so in modern cars on urban roads.

## Speed and injury risk

Common misunderstandings amongst motorists are:

- that exceeding the speed limit by a "minor" amount is not a safety problem
- that most road fatalities 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 most cases include an estimated Delta-V (change in velocity, which is a relative measure that is not necessarily the same as the impact speed).

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 [4].

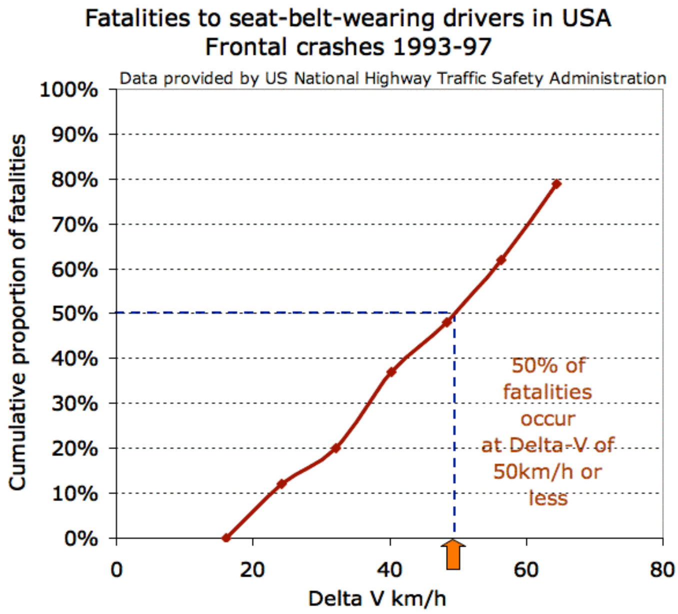


**Figure 1.** Delta V distribution from US fatalities (drivers wearing seat belts)

In 2005 NHTSA [5] published a notice of rulemaking on a proposed standard for tyre pressure monitoring systems. The notice included an analysis of the risk of injury or fatality in frontal crashes. Figure 2 shows the results of that analysis.

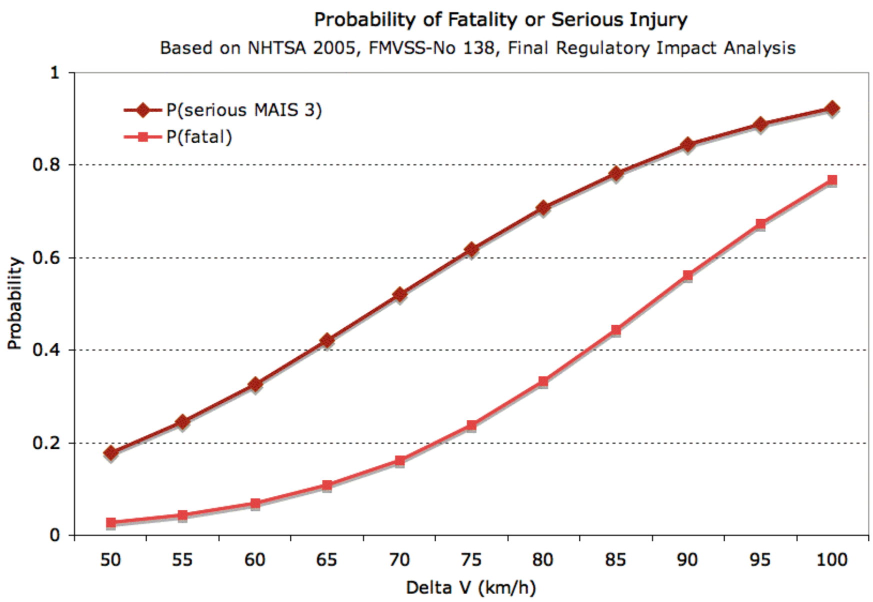


**Figure 2**. Delta V and risk of injury or fatality for drivers

Note that the probability of a fatality rises in an exponential manner in the range 50 to 80km/h. This helps to explain why the risk of a fatality is highly sensitive to travel speed.

***Adelaide Study***

An analysis of travel speeds and involvement in casualty crashes was undertaken in metropolitan Adelaide in 1997. The data were subsequently reanalysed [2]. This confirmed an earlier finding that risk approximately doubled for each 5km/h above the prevailing speed limit of 60km/h (Figure 3).

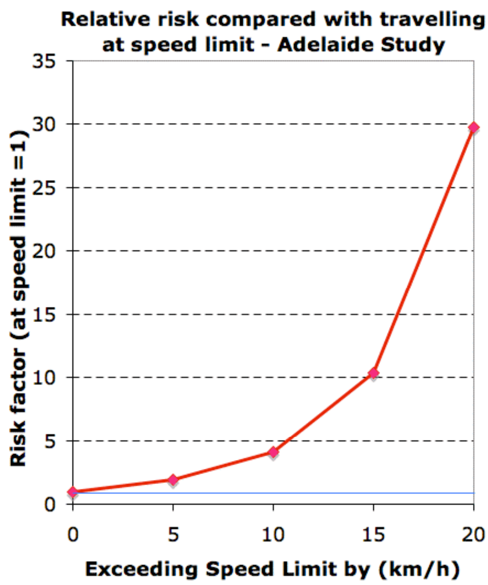


**Figure 3**. Risk of casualty crash doubles with each 5km/h above the speed limit of 60km/h

***Effects of changes to average travel speeds and speed limits***

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.

These findings are similar to:

- Nilsson [6] who, in 1993, found that a 3% reduction in mean traffic speeds produces a 12% reduction in fatal accidents,
- a 2006 European study which found that 15% of injury accidents would be saved if mean traffic speeds reduced by 5km/h [7]
- US studies of the effects of speed limit changes "Higher travel speeds on rural interstates reportedly are responsible for about a 35% increase in death rates." [8]
- Woolley [9] 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.

***The physics of car crashes***

There is a scientific reason for the extra risk associated with minor speeding. A typical crash sequence involves detection of a hazard, reacting to the hazard by applying the brakes and braking to reduce speed to avoid a collision (or reduce the speed of impact). Although they are all familiar with the distance involved in braking once the foot hits the pedal, many drivers do not appreciate the distances travelled before a hazard is detected, a decision is made to apply the brakes and the foot actually depresses the pedal - the so-called reaction time. Modern distractions such as mobile phones and navigation devices tend to add to reaction time problems.

The probability of a serious injury or fatality for drivers from real-world crashes, as illustrated in Figure 2, can be applied to hypothetical scenarios to show the extra risk from low-range speeding.

In the following example a non-alert reaction time of 2 seconds is followed by heavy braking. It is assumed that the initial distance to the hazard (when it first becomes visible, but not necessarily detected by the driver) is 50m.

If the initial speed of the vehicle is 50km/h or less then no collision occurs. If the speed is 60km/h then the impact speed is 38km/h. An initial speed of 70km/h results in an impact speed of 59km/h. The impact speed rapidly climbs until it matches the initial speed at 100km/h (green line in Figure 4).

Based on NHTSA [4] the probability of a serious injury at a Delta-V of 38km/h is 7.6%. The probability of a fatality is 0.9% at this speed. These are the typical risks associated with an initial speed of 60km/h *in this scenario*. Using this as a baseline risk (=1), Figure 4 illustrates the relative risk associated with higher travel speeds.

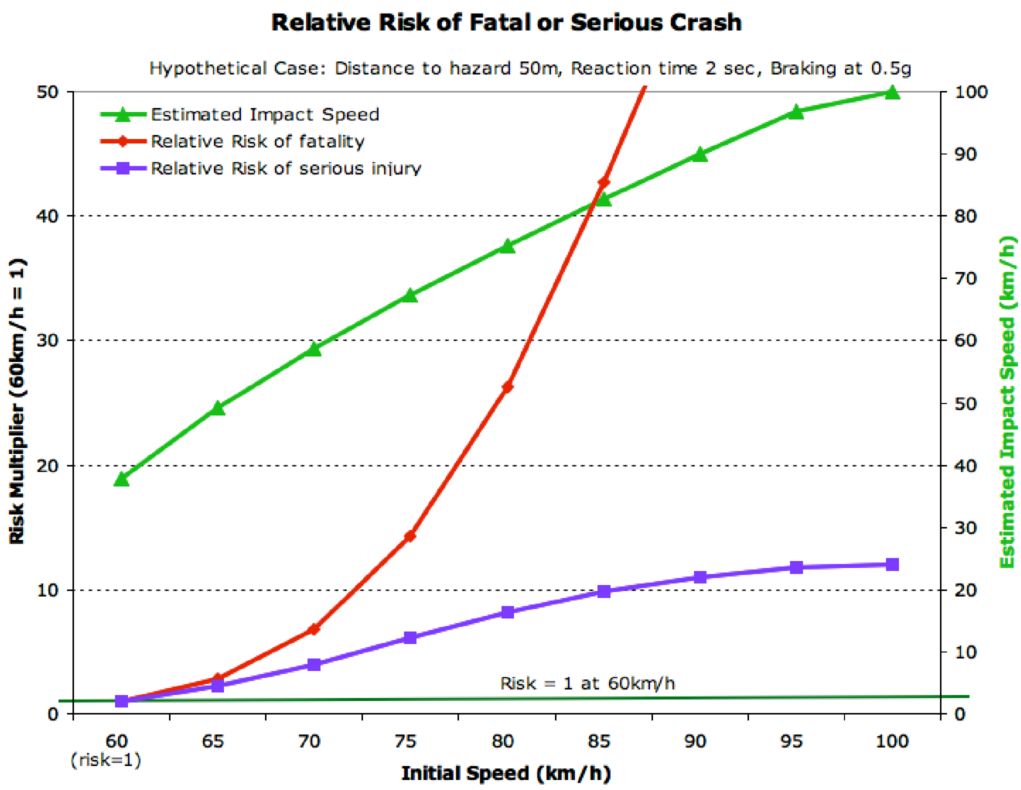


**Figure 4**. Relative risk of travel speeds in excess of 60km/h

Subject to this being just one scenario out of many, this analysis indicates that the relative risk of a fatality (red line) rises much more quickly than that of a serious injury (purple line) in the range 65 to 80km/h. This is a result of a "double whammy" - firstly the impact speed rises sharply in this range and, secondly, the risk of a fatality (Figure 2) rises sharply in the resulting range of impact speeds.

The relative risk for casualty crashes from this analysis is similar to that derived from the Adelaide study (Figure 3), with about 4 times the risk when travelling at 10km/h over the limit.

This tentative analysis suggests that eliminating low-range speeding can have a much greater influence on fatal crashes than serious injury crashes.

### *Potential savings from reductions in speeding*

The relative risk derived from the Adelaide Study ([2] & Figure 3) can be used to derive an estimate of the potential savings arising from discouraging speeding. Firstly an estimate is made of the proportion of motorists travelling in excess of the speed limit. For this analysis it is assumed that with a 60km/h speed limit the travel speed has a normal distribution with a mean of 61km/h and the standard deviation is 8km/h [10]. This is the blue curve in Figure 5. This proportion is multiplied by the relative risk (red curve) to obtain the contribution of each group to overall casualty crashes. The potential savings are calculated by assuming that the relative risk of each group is reduced to 1, that is, the same risk as non-speeding motorists. For example, travelling at 10km/h over the limit has a relative risk of 3.7. If this risk is reduced to 1 (e.g. by obeying the speed limit) then the saving is (3.7-1)/3.7 = 73%.

The green curve of Figure 5 shows the savings, for each speeding group, resulting from this analysis.

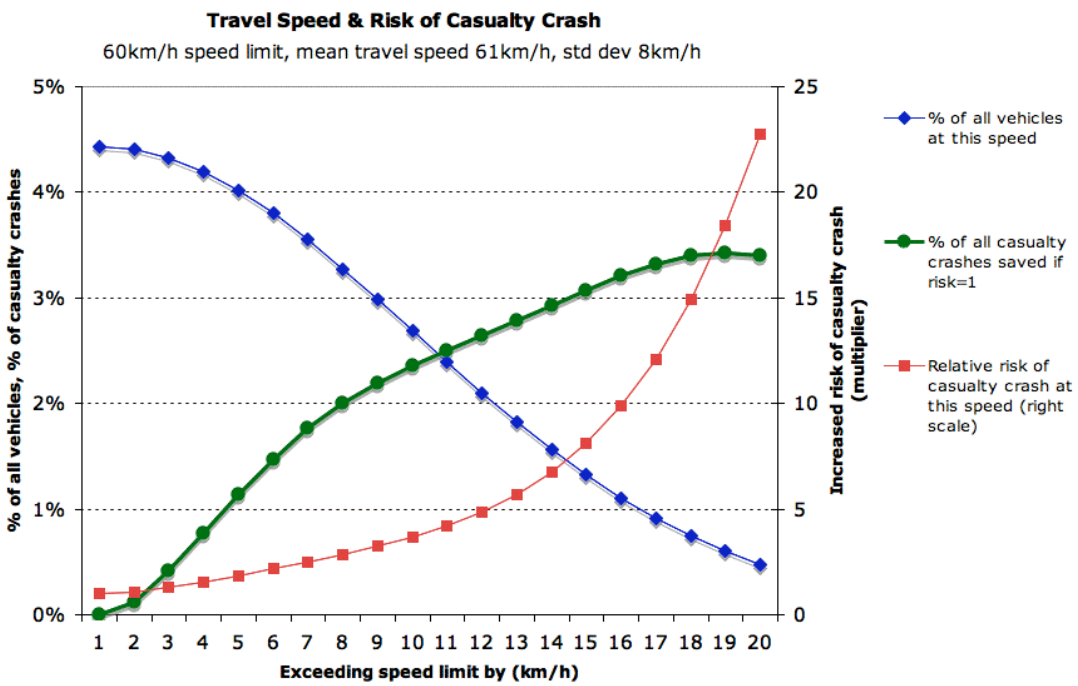


**Figure 5**. Potential savings in casualty crashes resulting from reduced speeding

It should be noted that the green curve in Figure 5 is not cumulative. The estimated cumulative savings by speeding group are:

- 2% of casualty crashes for speeding up to 5km/h over the limit
- *12% of casualty crashes for speeding up to 10km/h over the limit* (ie 10% for the speeding range 6 to 10km/h over the limit)
- 26% of casualty crashes for speeding up to 15km/h over the limit

This analysis supports the findings of previous studies that there are substantial savings in casualty crashes to be gained from discouraging "low range" speeding [2, 6, 7, 8, 9]. The analysis summarised in Figure 4 indicates that savings in fatal crashes are likely to be greater than those for casualty crashes shown in Figure 5.

According to the above scenario about three-quarters of casualty crashes that involve a vehicle that is travelling at 10km/h over the speed limit would not have resulted in serious injury if the relevant vehicle had not been speeding. Clearly, in this scenario, speeding is a contributing factor to the severity of the crash, even though it might not be identified or reported as the "cause" of the crash. Indeed, for every casualty/fatal crash the sequence of questions can be asked:

a) whether an involved vehicle had been exceeding the speed limit just prior to the impact (estimates range from one third to half of all crashes [7])

b) whether the impact speed would have been reduced if that vehicle had obeyed the speed limit (likely in most cases)

c) whether the injury outcomes would have been less severe due to the reduced impact speed (highly likely, based on Figure 2)

This suggests that crashes statistics which attempt to identify speeding as a cause of a crash (or even those described as "speeding related") may be substantially underestimating the contribution of speeding to road trauma.

**Discouraging speeding**

The primary means of discouraging speeding in Australia is through enforcement, including the use of speed cameras. It is generally accepted that a tolerance applies to current enforcement techniques. Indeed, for legal certainty, it is inevitable that a tolerance is applied to the enforcement of speed limits.

It is speculated that this tends to reinforce the attitude, reported by Hatfield and Job [1], that low-range speeding (10km/h under the speed limit) is "safe". Many motorists therefore travel at the same speed as other traffic and, in doing so, travel in excess of the speed limit.

Modern cars do an excellent job of isolating the driver from the road environment and, as a result, they can give the impression that minor speeding is acceptable and does not increase risk of a serious crash. Some vehicle marketing techniques reinforce this illusion [7]. However, as Figure 2 illustrates, the reality is that even a 50km/h crash is a violent event, with a 1 in 5 chance of serious injury.

It seems unlikely that traditional enforcement methods will ever successfully address low-range speeding. In order to gain the road safety benefits (i.e. a potential 12% saving in casualty crashes) from encouraging low-range speeders to obey the speed limits some other strategies are required. The most promising is Intelligent Speed Assistance (ISA) [7].

### *ISA Technologies*

Most ISA systems use Global Positioning Satellite (GPS) technology in a similar manner to satellite navigation (sat-nav) devices. Via GPS the system knows the location and speed of the vehicle and, from an on-board database of speed limits, it can alert the driver to speeding (Passive ISA) or take other action such as reducing engine power to prevent speeding (Active ISA).

Australia is leading the world with ISA technology [11]. An initial reaction from some researchers has been that there could be negative outcomes, such as driving at the speed limit rather than to the conditions, but numerous ISA trials around the word have shown these concerns are unsubstantiated [12].

Some critics have expressed concern that ISA "takes control away from the driver". This is also unsubstantiated because ISA systems are either advisory or they have provision for over-ride by the driver in the event that the set speed is temporarily inappropriate (for example, when joining a motorway). In any case, cruise control has been in use on vehicles for many decades and, in effect, cruise control forces the vehicle to travel at a *minimum* speed unless there is driver intervention. Indeed, active ISA can replace cruise control as a way of maintaining an appropriate speed on the open road.

### SpeedAlert passive ISA

The Australian SpeedAlert product is a passive ISA that is available for GPS-equipped mobile phones and some portable satellite-navigation devices. SpeedAlert has a database of the speed limits of most roads in Australia. Using GPS it works out the speed limit of the current section of road and also the current vehicle speed. The circle shown in Figure 6 is filled with red colour if the vehicle is speeding and the unit beeps if the speed limit is exceeded by more than 5km/h. The system also knows when 40km/h school zones are in operation and speaks an alert "school zone" during these times. Pedestrian crossings and railway crossings are also in the database.


**Figure 6**. SpeedAlert running on a portable satellite navigation device

The device can be run exclusively in SpeedAlert mode where only the speed limit and current vehicle speed are displayed (Figure 6). This avoids the distraction of a navigation map and makes it highly suitable for novice drivers. A dynamic speedometer function was recently added to the display (right illustration of Figure 6). Kumar et al. [13] found this type of display results in safer driver behaviour.

The author has purchased and evaluated SpeedAlert devices and used them in Sydney, Brisbane, Melbourne, Canberra, Adelaide and Perth since mid 2006. He has driven more 30,000km with ISA.

**Speedshield active ISA**

The Australian Speedshield product is an active ISA system. It was developed for industrial applications but is now available for road vehicles and is being used in several ISA pilot programs throughout Australia. It can be retrofitted to vehicles that have drive-by-wire throttle systems.


**Figure 7**. Speedshield display unit

***Estimates of crash savings***

The following table sets out estimates of the potential savings in serious road crashes in Australia through the widespread implementation of various speed limitation devices [14]. The estimate of relevant serious crashes for ISA (20%) is a conservative estimate and the analysis presented in this paper suggests that the actual value may be double this. The estimates of effectiveness for passive and active ISA are also considered to be conservative and result in lower estimated savings than those predicted in Europe [3]. This is on the assumption that ISA will be voluntary.

**Table 1.** Estimates of casualty crash savings in Australia through speed control technology

| Device | % of all serious crashes potentially influenced (relevant crashes) | % of relevant crashes that are saved by device (effectiveness) | % of all serious crashes saved by device |
|---|---|---|---|
| Top-speed limiting | 1% (exceeding 120kmh) | 100% | 1% |
| Speed alarm/limiter manually set by the driver | 20% | 5% (low due to the task of setting the device) | 1% |
| Passive ISA | 20% | 25% | 5% |
| Active ISA | 20% | 50% | 10% |

ISA does not require 100% implementation in order to realise these benefits. It has been estimated that 20% fleet penetration would result in a noticeable reduction in average traffic speeds (where they are currently above the speed limit) and a consequent reduction in casualty crashes [7]. Paine [10] noted that traffic congestion would be largely unaffected by ISA because traffic usually moves at much less than the speed limit through congestion points. Indeed, a reduction in casualty crashes would reduce the major traffic disruptions associated with these crashes.

Another advantage of ISA, compared with many other new technologies, is that it can be easily retrofitted to existing vehicles. This can greatly reduce the time for widespread uptake of the technology.

Passive and active ISA rank highly in a recent analysis of a wide range of vehicle safety technologies to identify priorities for government support [15]. For several reasons ISA ranked higher than Electronic Stability Control (ESC), which has received much attention in recent years.

## CONCLUSIONS

There is widespread misunderstanding of the risks of low-range speeding and the contribution of such speeding to road trauma. A vehicle travelling at 10km/h over the speed limit has four times the risk of being involved in a casualty crash, compared with a vehicle travelling at the speed limit. The reasons for this can be demonstrated through basic physics theory.

Substantial road safety benefits would result from encouraging all drivers to obey the speed limits. About 12% of casualty crashes could been avoided if vehicles travelling at up to 10km/h over the speed limit slow down to the speed limit. This group is difficult to target through conventional enforcement methods.

ISA would assist drivers keep to the speed limits and the technology is ready for widespread implementation [16]. A key to the success of ISA is that drivers must understand the benefits of obeying speed limits and the limitations of ISA. The numerous trials have shown that, once they try it out, most drivers find ISA acceptable, useful and unobtrusive.

ISA does not usually fit in with the marketing image of motor cars and it seems unlikely that ISA will become popular through market forces alone. 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 (e.g. notification of changes to speed limits)

b) being the first major customers for commercial ISA systems

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

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

Australia could be a world leader in the implementation of this technology, which is likely to become an essential component of the Safe Systems approach to road safety within the next decade.

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