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Cost benefit analysis of Intelligent Speed Adaptation

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ABSTRACT

This report examines the potential costs and benefits of Intelligent Speed Adaptation (ISA) in Australia. Analysis was conducted to determine the benefits of advisory, supportive and limiting ISA. This analysis suggested advisory ISA would reduce injury crashes by 7.7% and save $1,226 million per year. These figures were 15.1% and $2,240 million for supportive ISA and 26.4% and $3,725 million for limiting ISA. A cost benefit analysis was conducted considering different implementation scenarios including: all vehicles, new vehicles, fleet vehicles, market driven, heavy vehicles, young drivers and navaid devices. The cost benefit analysis was heavily influenced by the unit price of the ISA devices causing the cost benefit ratios (BCRs) to vary from as low as 0.29 to 4.03 over a 20 year timeframe. The "all vehicles" and "new vehicles" scenarios produced the greatest BCRs although it was thought that, taking into account the elevated risk of young drivers, a combination of implementing ISA on young driver's vehicles and new vehicles may be the most cost effective implementation scenario. Limiting ISA generally produced the highest BCRs therefore this level of ISA should be implemented wherever possible.

KEYWORDS

Intelligent speed adaptation (ISA), Cost benefit analysis

Summary

This report examines the potential costs and benefits of Intelligent Speed Adaptation (ISA) in Australia. Quantitative results from ISA trials reported in the literature were reviewed and the benefits of ISA in terms of reducing the quantities such as mean speed, 85th percentile speed and reduction in speeding identified. The literature also revealed a high variability in these benefits from trial to trial.

An analysis of speeding crashes was conducted using mass crash data collected by the six Australian states from 2004 to 2008. This analysis was hampered by inadequate identification of speed as a factor in this data set and inconsistencies between states. Despite these shortcomings, segregation of this data allowed some general conclusions to be drawn. Speed related crashes occurred in metropolitan and rural areas therefore ISA should be operational in both areas. Curves were over represented suggesting ISA incorporating curve speeds should be considered. Young drivers and motorcyclists were also over represented highlighting the need to ensure these groups of road users benefit from ISA.

A more detailed analysis was conducted to determine the benefits of advisory, supportive and limiting ISA. This analysis suggested advisory ISA would reduce injury crashes by 7.7% and save $1,226 million per year. These figures were 15.1% and $2,240 million for supportive ISA and 26.4% and $3,725 million for limiting ISA.

The costs associated with mapping and the cost of the ISA devices available were investigated. Mapping the Australian states was estimated to cost $15.6 million with a further $2.4 million per year required for updating. Only two states have completed maps with another state currently undertaking the process. Dedicated ISA devices that are currently available in Australia cost between $800 and $1,800 for a single unit although this could reduce to as little as $200 in two years if a high volume order were placed. A navaid that has advisory ISA functionality is also available. This costs just under $30 for a year subscription.

A cost benefit analysis was conducted considering different implementation scenarios including: all vehicles, new vehicles, fleet vehicles, market driven, heavy vehicles, young drivers and navaid devices. The cost benefit analysis was heavily influenced by the unit price of the ISA devices causing the cost benefit ratios (BCRs) to vary from as low as 0.29 to 4.03 over a 20 year timeframe. Payback periods were also calculated to give an indication of economic benefit independent of a set timeframe and break even price was calculated to give an indication of economic benefit independent of a set unit price. Payback periods ranged from 3 to over 100 years and break even prices from $341 to $2,164 per unit. The “all vehicles” and “new vehicles” scenarios produced the greatest BCRs although it was thought that, taking into account the elevated risk of young drivers, a combination of implementing ISA on young driver’s vehicles and new vehicles may be the most cost effective implementation scenario. The navaid scenario suggested that even if these devices are only infrequently used and less effective than dedicated devices they may still prove a cost effective option. Limiting ISA generally produced the highest BCRs therefore this level of ISA should be implemented wherever possible.

Contents

1 Introduction

The problem of travelling above the posted speed limit, commonly referred to as speeding, has been well documented in the literature, as has the potential of Intelligent Speed Adaptation (ISA) to reduce the problem. ISA devices can be divided into three categories: advisory, supportive and limiting. Advisory devices communicate to the driver that they are travelling above the speed limit by using audio and visual signals. The audio signal can be a simple beep or a statement delivered such as “you are driving above the speed limit”. The driver is not obliged to slow to the speed limit but some advisory devices encourage this by using more annoying audio signals the longer the speed limit is exceeded or the greater the amount the limit is exceeded by. Supportive devices prevent the vehicle breaking the speed limit by various methods such as ‘hardening’ the accelerator pedal, cutting fuel supply, electronically manipulating the throttle, applying the brakes or a combination of these methods. Supportive devices allow this control to be overridden. A limiting device works in the same way as a supportive device except that the driver cannot override it.

The broad aims of this project were to:

- Review results of ISA trials reported in the literature, particularly the changes on speed behaviour achieved
- Determine the prevalence of crashes in which speeding was a factor in Australia
- Determine the possible benefits of ISA in Australia
- Determine the potential costs of implementing ISA in Australia
- Comment on the progress in Australia towards implementation
- Conduct a cost-benefit analysis considering different implementation scenarios

2 Literature review

The various aspects of ISA have been well researched. Summaries of much of the research have been provided by Carsten (2004) Jamson et al. (2006) and Regan et al. 2003. The research can be divided into three categories; research which focuses on the change in speed behaviour produced by ISA, research which focuses on user reaction to and acceptance of ISA, and research which focuses on policy, planning and overcoming hurdles to implementation. Some publications span more than one of these categories. The purpose of this literature review is to update the summaries conducted previously and to highlight the results of the trials that have focused on the quantitative change in speed behaviour produced by ISA. In some instances large-scale trials with refined methodology were conducted after an early small-scale trial; when this occurred only the more recent trial has been included in the review.

Unfortunately trials differ in the way that they present the change in speed behaviour. The value that is most typically quoted is change in mean speed where mean speed is defined as the average of the speed measurements in the given study. Some studies also quote the change in the time spent above the speed limit or 85th percentile speed (the speed which was not exceeded for 85 percent of the speed measurements) as these give an indication of the reduction in speeds at the high end of the distribution. A few studies show the change in the speed distribution at a given speed limit. Such distributions provide a more complete picture of the effect of the ISA system.

The following sections include tables summarising the trials reviewed. Note that the number of vehicles listed in each table refers to the number of vehicles that operated successfully for the whole trial. A number of trials had technical problems that caused vehicles to be removed from the substantive results of the trial. Also note that the study year represents the year the study was conducted, not the year of publication of the report on the trial.

2.1 Advisory ISA trials

Publications that report the change in speed behaviour in trials using an advisory ISA system include Adell et al. (2008), Driscoll et al. (2007), Lahrmann et al. (2001), Päätalo et al. (2001), Taylor (2006) and Biding and Lind (2002). The results of these trials are summarised in Table 2.1.

Table 2.1
Advisory ISA trials

1st Author	Location	Study Year	Light Vehicles	Heavy Vehicles	Speed zones (km/h)	Mean speed change (km/h)	85th% speed change (km/h)	Speeding Reduction
Adell	Debrecen, Hungary	2003	20	none	50	-0.7	-1.8	-
Adell	Mataro, Spain	2003	20	none	30-120	-1.9 to -2.8	-0.4 to -5	-
Lahrmann	Aalborg, Denmark	2001	20	none	undefined	-5 to -6	-	-
Päätalo	Finland	2001	24	none	40-80	-2.8	-	39%
Taylor	Ottawa, Canada	2006	20	none	40-100	-	-	13-22%
Biding	Borlänge, Sweden	2001	400	none	30-110	-0.6 to -3.4	-	10-77%
Driscoll	France	2001	20	none	undefined	-0.8	-	-

Table 2.1 shows that the field trials using an advisory ISA system resulted in the reductions of mean speed between 0.6 km/h and 6 km/h. Small reductions typically occurred in low speed zones (30 km/h zones) and larger reductions in the high speed zones (110 km/h zones).

The results reported in Lahrmann et al. (2001) should be viewed with caution. It is not clear from the report if the reported reduction in mean speed is actually mean speed or if it is the reduction in the mean of speeds over the posted speed limit. The Danish study also employed a 5 km/h tolerance before an auditory warning was sounded, unlike the rest of the advisory trials that gave no tolerance to exceeding the speed limit. If these results are considered separately the mean speed reduction is between 0.6 km/h and 3.4 km/h for an advisory ISA as occurred in the Borlänge trial in Sweden, the largest ISA trial reviewed. The reduction in the 85th percentile speed was only reported in two trials and ranged from 0.4 km/h to 5 km/h (Adell et al. 2008). Two trials reported the percentage reduction in speeding. The reduction in speeding was highly variable, but unsurprisingly the smallest reduction was found on low speed roads (30 km/h speed limit) while the largest reduction was on high speed roads (110 km/h speed limit).

Three trials have been conducted that combined incentives with an advisory ISA system. The earlier trial in Denmark (Agerholm et al. 2008) used company cars and involved employees in a competition for a prize from the company's management. This prize was given to the driver with the least amount of speeding 'points' per 1,000km driven. Drivers could also access a web page to see their performance relative to their colleagues. The added incentives in this trial may have contributed to the increased effectiveness of ISA, a postulation that is supported by a reported increase in speeding when drivers did not use their identification key (Agerholm et al. 2008). The 'Pay as you speed' project, also conducted in Denmark, provided a 30% discount on the drivers insurance premium that was reduced if speeding 'points' were accumulated. Both Danish trials allowed the speed limit to be exceeded by up to 5 km/h before speeding 'points' were accumulated. Hultkrantz and Linberg (2003) followed on from the Borlänge trial and paid drivers the equivalent of approximately AUD 40 or AUD 80 per month and reduced this by up to AUD 0.31 per minute spent speeding (2010 exchange rate not adjusted for inflation). The results of these trials are shown in Table 2.2.

Table 2.2
Advisory ISA trials that include incentives

1st Author	Location	Study Year	Light Vehicles	Heavy Vehicles	Speed zones	Mean speed change	85th% speed change	Speeding Reduction
Hultkrantz	Borlänge, Sweden	2002	90	none	30-110	-	-	46- 67%
Lahrmann	Denmark	2008	153	unknown	50-130	-3.6	~-3.5 to -8.5	~77%*
Agerholm	Denmark	2007	26	none	50-130	0.8 to -6.2	-	60-75%*

* Percentage reduction in speeding by more than 5 km/h

The results shown in Table 2.2 appear to indicate that the use of incentives with an advisory system has the potential to enhance the effectiveness of advisory ISA although the amount of variance in both sets of results does cast a shadow of uncertainty. The large variance reported in Agerholm et al. (2008) may be due to limited data at high speed limits (110 and 130 km/h) that produce the increase in mean speed shown. The trend in this trial was to produce higher mean speed reductions at lower speeds and lower reductions (or increases) at higher speeds. This is the opposite of that found in the Borlänge study (without incentives). It should also be noted that the speeding reduction quoted in the Danish trials is the percentage reduction in speeding by more than 5 km/h.

2.2 Supportive and Limiting ISA trials

Publications that report the change in speed behaviour in trials using a supportive ISA system include Adell et al. (2008), Lai et al. (2007), Driscoll et al. (2007), Regan et al. (2005), Taylor (2006), Várhelyi and Mäkinen (2001), Várhelyi et al. (2004) and Vlassenroot et al. (2007). The results reported in these publications are shown in Table 2.3

Table 2.3
Supportive ISA trials

1st Author	Location	Study Year	Light Vehicles	Heavy Vehicles	Speed zones	Mean speed change	85th% speed change	Speeding Reduction
Vlassenroot	Ghent, Belgium	2002	34	3 buses	30-90	+0.7 to -1.1	-0.4 to -2.5	7-72%
Adell	Debrecen, Hungary	2003	20	none	50	-1.1	-3.2	-
Adell	Mataro, Spain	2003	20	none	30-120	-2.5 to -3.9	-2.2 to -7.2	-
Regan	Melbourne, Australia	2003	15	none	60-100	-1.4	up to -2.7	57%*
Várhelyi	Netherlands, Spain and Sweden	1997	64-68	none	30-120	+2.4 to -16.1	-	-
Várhelyi	Lund, Sweden	2001	206	none	30-70	-3.7	-1.4 to -7.6	20-53%
Taylor	Ottawa, Canada	2006	10	unknown	40-100	-	-	2-19%
Lai	United Kingdom	2003	79	1 truck	32-113	-0.4 to –3.1	-0.6 to -4.3	2-22%
Driscoll	France	2001	20	unknown	UK	-1.4 to -2	-	-

* Percentage reduction in speeding by more than 10 km/h

There is a large amount of variance in mean speed reductions observed in the supportive ISA trials. The study in the Netherlands, Spain and Sweden conducted by Várhelyi and Mäkinen found changes in mean speed ranging from a 16.1 km/h decrease to a 2.4 km/h increase. These large variations can be explained by differences in pre-ISA mean travel speeds. The 16.1 km/h reduction was achieved when the pre-ISA mean speed was 14.8 km/h over the speed limit, whereas the pre-ISA mean speed was 12.7 km/h below the speed limit when the 2.4 km/h increase was observed. It was observed that despite the mean speed increase momentary high speeds were effectively eliminated (Várhelyi and Mäkinen, 2001). In the other studies the mean speed was reduced by between 0.7 and 3.7 km/h. The 85th percentile speeds were found to be reduced by between 0.4 to 7.6 km/h.

The 85th percentile speed reductions have a greater range than the corresponding mean speed reductions: the high value being around twice as great in most cases while the low value is about the same. This suggests that ISA, and in particular supportive ISA, can have greater effect on the high end of the speed distribution. Once again large variations in the percentage reduction in speeding were observed. The study in Belgium by Vlassenroot et al. carried out in 2002 produced the greatest range of reductions, between 7 and 72%, although reductions as low as 2% were observed in the Canadian and United Kingdom studies. In the Belgium supportive trial the lowest reduction was observed on low speed roads (30 km/h speed limit) and the highest reduction on high speed roads (90 km/h speed limit), similar to the trend in the Swedish advisory trial mentioned earlier. It should also be noted that the 57% reduction reported in the trial in Melbourne is for speeding by over 10 km/h (Regan et al. 2003). Again it is difficult to compare these outcomes with those of advisory ISA trials due to the variance in result. The results published in Adell et al. (2008) as well as Driscoll et al. (2007) do allow comparison between the two levels of ISA. When comparing only these studies it appears that supportive ISA has a greater effect at reducing both mean and 85th percentile speed than advisory ISA.

Two publications report the results of limiting trials, Päätalo et al. (2001) and Besseling and van Boxtel (2001 cited by Oei and Polak, 2002), the results of which are shown in Table 2.4. These limiting ISA trials found mean speed reductions of between 3 and 8.3 km/h. Speeding was reduced by 74% in the Finnish trial. This appears to be a higher reduction in mean speed than the majority of advisory or supportive ISA trials although the lower speed ranges may have had an effect on this (the 8.3 km/h reduction found in the Netherlands was on a 30 km/h speed limit road).

Table 2.4
Limiting ISA trials

1st Author	Location	Study Year	Light Vehicles	Heavy Vehicles	Speed zones	Mean speed change	85th% speed change	Speeding Reduction
Besseling	Tilburg, Netherlands	2000	20	1 bus	30-50	-3 to -8.3	-	-
Päätalo	Finland	2001	24	none	40-80	-3.4	-	74%

2.3 Australian ISA trials

Two trials of ISA have been completed in Australia, one is currently in progress and a further trial is about to start. The two completed trials were the SafeCar project in Victoria and the Western Australian demonstration project. The Victorian SafeCar project equipped 15 Ford Falcons with an ISA, a following distance warning and a seatbelt reminder device (Regan et al. 2005). The ISA system was supportive and warned the driver if they travelled over the speed limit by more than 2 km/h and exerted an upwards pressure on the accelerator pedal. The effects of ISA were isolated and are presented above in Table 2.3. The mean speed reduction appears to sit in the middle of all the supportive trial results while the 85th percentile speed is at the low end of the trial results. Regan et al. suggest that this may be due to a speed enforcement campaign that was conducted during the trial that caused state wide reductions in mean speed. The Western Australian demonstration project was designed to create demand within the general community for ISA, demonstrate that reliable ISA is technically possible (even on a large geographical scale) and to develop systems in government necessary to implement ISA (Crackel and Toster, 2007). All speed limits in Western Australia were mapped and 35 advisory ISA devices were installed in vehicles. Further work is planned including placing transmitters that will automatically update the ISA device’s maps (Crackel, 2009). Both these trials used a version of Speedshield’s ISA devices, described in further detail in Section 5.2.

A trial of advisory ISA is currently underway in New South Wales, in the Illawarra region. In mid 2009 it was announced that the trial planned to fit over 100 vehicles (a mixture of fleet and privately owned) with Speed Alert’s second generation ISA device which allows live updating of maps using a general packet radio service, sometimes referred to as a mobile modem. The overall aims of the trial are; to research the potential road safety benefits of advisory ISA in New South Wales, measure economic effects such as reduced fuel consumption, travel times and installing ISA, and assess user acceptance (Wall et al. 2009).

A Victorian trial of advisory ISA devices for recidivist speed offenders was announced in January 2010 (Pallas, 2010). This trial will use a Speed Alert advisory device to alert the driver to the speed limit and log changes in speed behaviour. The results will be compared to the behaviour of another group of recidivist speeders that will undergo an educational program.

2.4 Trials in progress

The authors are aware of three trials outside of Australia that are currently in progress, in London, Lancashire and Winnipeg. The London trial will fit supportive ISA devices to 20 Transport for London (TfL) vehicles, a London bus and potentially a taxi (TfL, 2009). The speed limit map of London produced for the project has been made available for public download onto a compatible navaid device. TfL announced this project in May 2009 and stated that it was to run for six months but no report has been forthcoming to date. The Lancashire trial is much larger, aiming to fit 550 advisory devices (second generation Speed Alert device) to vehicles of volunteers (Lancashire County Council, 2009). Young drivers are being particularly targeted for recruitment into the study. The trial is set to commence in March 2010 and run for nine months with results expected in the first half of 2011. The third trial in progress is being conducted in Winnipeg, Canada. Little information is known about the Winnipeg trial except that it started during 2009 and the results were expected to be released around March 2010 (although no results were available at the time this report was written).

2.5 Costs

Very few trials have reported the costs of the ISA system used in the trial. This is understandable given that most devices used could be described as prototypes and so the costs are not reflective of the cost of commercial devices. Because the ISA-UK project included a cost benefit analysis, Tate and Carsten (2008) attempted to estimate the costs of the in-vehicle devices. This was done assuming some level of sharing of the technology required for ISA with other vehicle equipment and the economies of scale associated with mass production. The cost of installation when retro-fitting was also taken into account as was the decrease in costs over time. Their estimate can be seen below in Table 2.5. Given that only a small reduction in cost over time was applied they believe their estimate to be conservative.

Table 2.5
Estimated cost of supportive and limiting ISA device in GBP (Tate and Carsten, 2008)

Vehicles	Fitment	ISA Category	2010	2020	2030 onwards
Light Vehicles	New	Advisory	220	110	110
		Voluntary/Mandatory	820	560	560
	Retrofit	Advisory	350	240	240
		Voluntary/Mandatory	1,150	890	790
Heavy Vehicles	New	Advisory	220	110	110
		Voluntary/Mandatory	1220	860	860
	Retrofit	Advisory	350	240	240
		Voluntary/Mandatory	2,250	1,590	1,490

3 Potential Safety Benefits of ISA in Australia

To determine the potential safety benefits of ISA in Australia two separate analyses were conducted. The first analysis used routinely collected crash data to determine the prevalence of speeding crashes in Australia. This analysis should be treated with caution due to the probable underreporting of speed involvement in the crash data, as discussed further in section 3.1. This analysis is useful in identifying trends in speeding crashes rather than providing a reliable measure of the benefits of ISA. The second analysis (Section 3.2) was conducted by applying risk curves for travel speed to derived speed distributions with and without ISA. This analysis examined the risk reduction in all crashes rather than just crashes which had been identified in routine data collection as involving speed. The authors believe this second analysis to be a more thorough and accurate method in determining the benefits of ISA in Australia.

3.1 Speeding crashes analysis

3.1.1 Speeding crash identification methods and issues

Determining the precise prevalence of speeding in crashes in Australia is a difficult task as the methods by which it is determined differ from state to state. Routinely collected crash data is commonly relied upon for this task. This data typically relies on a police officer listing one apparent error or crash factor. The options that are available for the police officer to select include ‘excessive speed’ or ‘exceeding the speed limit’. Drivers can not be expected to readily admit to police that they were speeding at the time of the crash so crashes will only be classified with an apparent error of ‘excessive speed’ or ‘exceeding the speed limit’ when there are reliable witnesses or if it is clearly indicated by vehicle damage or tyre marks. Therefore basic crash data will provide an underestimate of speeding in crashes and probably include only cases of very high speeding rather than speeding in general.

Fatal crashes are usually investigated by specially trained police more thoroughly than less severe crashes however speeding is still unlikely to be listed as the sole apparent error unless it is clearly excessive and considered to be more important than other factors. Tasmania allows a second crash factor to be recorded. This might allow speed to be recorded as a factor more reliably. Both Tasmania and Queensland provide a distinction between excessive speed and exceeding the speed limit. Both categories were deemed to involve excessive speed for the purposes of this study. Western Australia requires police that attend a crash to state if speed was a factor. Because this is independent of other variables such as main error it may promote the police attending to consider if speed was a factor in more cases. For this analysis only the subset of crashes in Western Australia that police attended were used. Victoria only determines if speed was a factor in fatal crashes, based on the initial police assessment.

New South Wales post process their routine police data to determine if speed was a factor as described below.

> *“A motor vehicle is assessed as having been speeding if it satisfies the conditions described below:*
>
> *(a) The vehicle’s controller (driver or rider) was charged with a speeding offence; or the vehicle was described by police as travelling at excessive speed; or the stated speed of the vehicle was in excess of the speed limit.*

(b) The vehicle was performing a manoeuvre characteristic of excessive speed, that is: while on a curve the vehicle jack-knifed, skidded, slid or the controller lost control; or the vehicle ran off the road while negotiating a bend or turning a corner and the controller was not distracted by something or disadvantaged by drowsiness or sudden illness and was not swerving to avoid another vehicle, animal or object and the vehicle did not suffer equipment failure" (New South Wales Centre for Road Safety, 2008).

South Australia adopted this method to determine the prevalence of excessive speed in fatal crashes to improve the reliability of the data. For example using the 'main error' field of the routinely collected crash data in South Australia only 7.6% of fatal crashes, were attributed to excessive speed, numbers which are well below the percentages found in other states.

3.1.2 Injury severity classification

Different states have different categories for crash injury severity and New South Wales do not distinguish between serious and minor injuries. To arrive at an estimate of serious and minor injuries for New South Wales the ratio of serious to minor injuries reported in the Bureau of Infrastructure, Transport, Regional Economics' (BITRE) (formally known as the Bureau for Transport Economics) report on road crashes costs in Australia (BITRE, 2009) was used. For the purpose of this analysis a serious crash included; serious crashes from Tasmania, hospital crashes from Western Australia and hospitalisation crashes from Queensland. Minor crashes included; minor and first aid crashes from Tasmania, medical crashes from Western Australia and medical treatment and minor injury crashes from Queensland.

3.1.3 Crashes involving excessive speed in Australian states

Table 3.1 shows the percentage and total number of crashes that were reported as involving excessive speed between 2004 and 2008 in each state of Australia (note that data from Queensland state is for mid 2003 to mid 2008 due to data issues). It is clear that excessive speed is a significant factor in Australian crashes although the prevalence can vary considerably from state to state. The variance of the prevalence of crashes involving excessive speed between states and injury severities may simply be a product of the different methods that are employed to determine speed involvement or it may represent a real difference between states. For example, the prevalence of speed as a factor in Tasmanian injury crashes is particularly high when compared to the other states. This may be partly due to the police being allowed to list multiple crash factors or it may be a product of other factors unique to the small island state. New South Wales has a greater proportion of property damage only (PDO) crashes due to excessive speed. There are two possible reasons for this. It may be because New South Wales only record tow away PDO crashes which are likely to be more severe crashes than the $3000 damage limit, or no limit, imposed in some other states. It may also be a result of the New South Wales methodology for determining an excessive speed crash. A clear trend that is consistent across the states that record excessive speed as a factor at all injury severities is that fatal crashes are at least twice as likely to involve excessive speed that non-fatal crashes. While this is credible (excessive speed would lead to increased risk of fatal injury) the effect may be inflated by better determination of excessive speed in fatal crashes due to specially trained police attending. In other words it may be that in non-fatal crashes excessive speed is under-reported to a greater degree than in fatal crashes.

Table 3.1
Percentage of crashes involving excessive speed in Australian states by injury severity and average number of crashes by injury severity and state per year (2004-2008)

Injury Severity	TAS	SA	NSW	WA	VIC	QLD	Total Number
PDO	13.2%	-	17.3%	2.4%	-	6.4%	6,297
Minor	20.8%	-	15.9%	3.3%	-	3.9%	3,583
Serious	30.7%	-	15.9%	13.2%	-	6.8%	1,101
Fatal	66.1%	39.6%	37.2%	33.2%	30.9%	22.0%	450
Total Number	1,014	44	7,664	1,291	93	1,325	11,431

3.1.4 Crashes involving excessive speed by location

Table 3.2 shows the injury crashes (minor, serious and fatal) reported as being due to excessive speed segregated by location; metropolitan or rural. Tasmanian data could not be segregated in this way. It should be noted that in Queensland all areas outside greater Brisbane have been included in rural. This includes provincial cities such as Mt Isa and the Gold Coast. The rural/metropolitan split appears to vary around 50-50 with South Australia, New South Wales and Queensland having more excessive speed crashes in rural areas than metropolitan and Western Australia and Victoria having more in metropolitan areas than rural. Western Australia has a particularly large proportion of excessive speed crashes occurring in metropolitan areas. A possible reason for this may be that Western Australia require police attendance at a crash to determine if speed was a factor and police are less likely to attend rural crashes. This data suggests that ISA could produce benefits in both rural and metropolitan areas.

Table 3.2
Percentage of injury crashes involving excessive speed in Australian states by location (2004-2008)

Location	TAS	SA*	NSW	WA	VIC*	QLD
Metropolitan	-	42.5%	40.7%	68.1%	54.1%	42.0%
Rural	-	57.5%	59.3%	31.9%	45.9%	58.0%

*Fatal crashes only

3.1.5 Crashes involving excessive speed by road alignment

Table 3.3 shows crashes reported as being due to excessive speed segregated by road alignment. Queensland and Tasmanian data could not be segregated in this way. Several observations were made from this data:

- In South Australia road alignment is coded under the variable 'road feature', 23% of which were coded as 'bridge, culvert or causeway' that could not be placed in either the curve or straight category and hence were treated as unknown and excluded from the segregation.
- All states but New South Wales had at least 59% of these crashes occurring on a straight section of road.
- New South Wales crashes are heavily biased towards curves, most likely a result of the method of post processing data to determine if excessive speed was a factor. This may point to an overestimation of excessive speed crashes caused by their method or an underestimation in other state's methods.
- South Australia uses the same method as New South Wales for fatal crashes but has almost exactly the opposite split between curves and straights.

- South Australia's data may have been affected by the data that had to be treated as unknown as described earlier although even if these crashes all occurred on bends the split would only reduce to around 60-40 in favour of straights.

- This may suggest that whatever causes the drastic differences in New South Wales data in terms of road alignment only occurs in non-fatal crashes.

Taking this into account it is probable that curves are over represented in excessive speed crashes in all states as it is unlikely that they make up a quarter of the road network. For this reason it would be worthwhile to consider advisory speeds for curves in ISA as well as speed limits. Heavy vehicles may especially benefit from the inclusion of curve speeds in ISA.

Table 3.3
Percentage of injury crashes involving excessive speed in Australian states by road alignment (2004-2008)

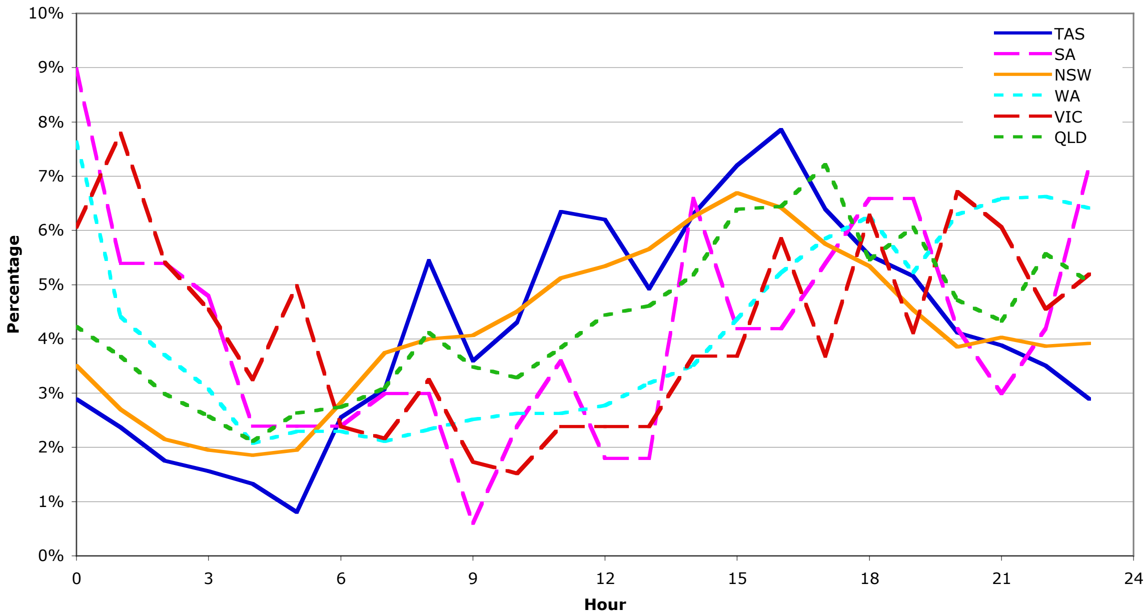
Road Alignment	TAS	SA*	NSW	WA	VIC*	QLD
Straight	-	76.6%	24.0%	59.0%	67.9%	-
Curve	-	23.4%	76.0%	41.0%	32.1%	-

*Fatal crashes only

3.1.6 Crashes involving excessive speed by hour of day

Figure 3.1 shows the percentage of excessive speed injury crashes by hour of day. It should be noted that South Australian and Victorian data only represents fatal crashes, which results in more variability in the results than the other states. While a reasonable amount of noise is present in the data it can be seen that crashes are at their lowest level around hour four and five before rising steadily throughout the day until around hour 15. From hour 15 until hour zero the crashes remain at around their maximum level before decreasing from hour one to hour four. Data on hours of operation of speed cameras in South Australia in 2008 revealed that very little enforcement of this type is done between hours 20 and hour six (Wundersitz and Doecke, in press). This highlights the strength of ISA over traditional enforcement as a deterrent. ISA can operate at any hour of the day while enforcement is often limited by the resources available.

Figure 3.1
Percentage of injury crashes involving excessive speed in Australian states by hour of day (2004-2008)



3.1.7 Crashes involving excessive speed by age group

Table 3.4 shows the excessive speed injury crashes segregated by the age group of the driver deemed to be driving at excessive speed (if more than one driver in a multi-vehicle crash was deemed to be driving at excessive speed the first driver's age was used). Western Australian and Victorian data could not be segregated in this way. Currently 13.8% of licensed drivers in South Australia and 14.6% in Queensland are less than 25 years old, therefore young drivers are more prevalent in crashes involving excessive speed than could be expected given their prevalence among licensed drivers. While it may be that some of this over representation of young drivers is due to reporting bias it is unlikely that this is the sole cause. Given that young drivers are widely reported to be over represented in all crash types it seems reasonable to assume that the majority of over representation is caused by age of the driver. Queensland had a much higher proportion of young drivers crashing due to excessive speed than the other states. No explanation can be found for this difference.

Table 3.4
Percentage of injury crashes involving excessive speed in Australian states by age group of driver deemed to be driving at excessive speed (2004-2008)

Age Group	TAS	SA*	NSW	WA	VIC	QLD
16-24	39.6%	37.1%	39.8%	-	-	67.4%
25-50	46.7%	52.1%	43.2%	-	-	29.7%
51+	13.7%	10.8%	17.1%	-	-	2.9%

*Fatal crashes only

3.1.8 Crashes involving excessive speed by vehicle type

Table 3.5 shows the excessive speed injury crashes segregated by type of vehicle deemed to be travelling at excessive speed (if both vehicles were deemed to be travelling at excessive speed the first vehicle's type was used). The Western Australian data could not be segregated in this way. According to the Australian Bureau of Statistics (ABS) heavy vehicles represent about 3.7% of the total fleet in Australia (ABS, 2009a). If this prevalence is similar across all states only New South Wales has a substantial over representation of heavy vehicles in excessive speed crashes. This may be a result of their method for determining excessive speed that may bias the results towards 'excessive speed for the condition' rather than 'exceeding the speed limit'. For example, heavy vehicles may be more prone to crash on a bend due to entering the bend at too high a speed considering their mass and centre of gravity while not travelling at a speed that is above the speed limit. Motorcycles accounted for 4% of all registered vehicles in Australia in 2009 (ABS, 2009a). Given the proportion of excessive speed crashes where a motorcycle was deemed to be travelling at excessive speed motorcycles are highly over represented in these crashes. Some of the over representation may be due to reporting bias or motorcyclists vulnerability to injury but, as with young drivers, these factors are unlikely to be the sole cause of the over representation. Very limited research into ISA on motorcycles has been conducted to date although it has been shown to be technically possible with all levels of ISA (Carsten et al. 2008). The figures shown in Table 3.5 suggest that motorcycles should not be excluded from any deployment of ISA.

Table 3.5
Percentage of injury crashes involving excessive speed in Australian states by vehicle type deemed to be travelling at excessive speed (2004-2008)

Vehicle Type	TAS	SA*	NSW	WA	VIC*	QLD
Heavy	4.5%	2.4%	12.7%	-	5.0%	3.8%
Light	82.7%	79.6%	70.1%	-	79.7%	82.1%
Motorcycle	12.8%	18.0%	17.2%	-	15.3%	14.1%

*Fatal crashes only

3.1.9 Economic benefits of reducing speeding crashes with ISA

Crashes were monetised according to costs estimated by BITRE (2009). To estimate the total costs of crashes in Australia, BITRE (2009) adopt a "bottom-up" approach where details of costs associated with individual crashes are totalled. The total costs of all crashes at each severity level are then averaged. It should, however, be understood that BITRE estimate that the number of crashes in Australia far exceeds the number of crashes recorded by state transport authorities. Therefore, when applying the average costs of crashes to reductions in police reported crashes, some adjustment is required to maintain consistency with the BITRE estimate of the costs of crashes in Australia.

In essence, calculations need to account for under-reporting and the non-processing of crash reports. A comprehensive treatment of this issue is given by BITRE (2009). They used data from multiple sources, and examined crash ratios across jurisdictions to impute the numbers of crashes not appearing in official statistics at each level of severity. In summary, they found that there is effectively no under-reporting of fatal crashes, but at each subsequent level of severity, a greater proportion of crashes tends to be "missing" from crash databases maintained by state transport authorities.

One method of accounting for missing crashes in the present report would have been to impute the numbers of missing crashes using the methods applied by BITRE. Instead, the approach that has been adopted is to apply a factor to monetised crash reduction estimates to account for the estimated savings associated with the reduction in crashes that are not recorded.

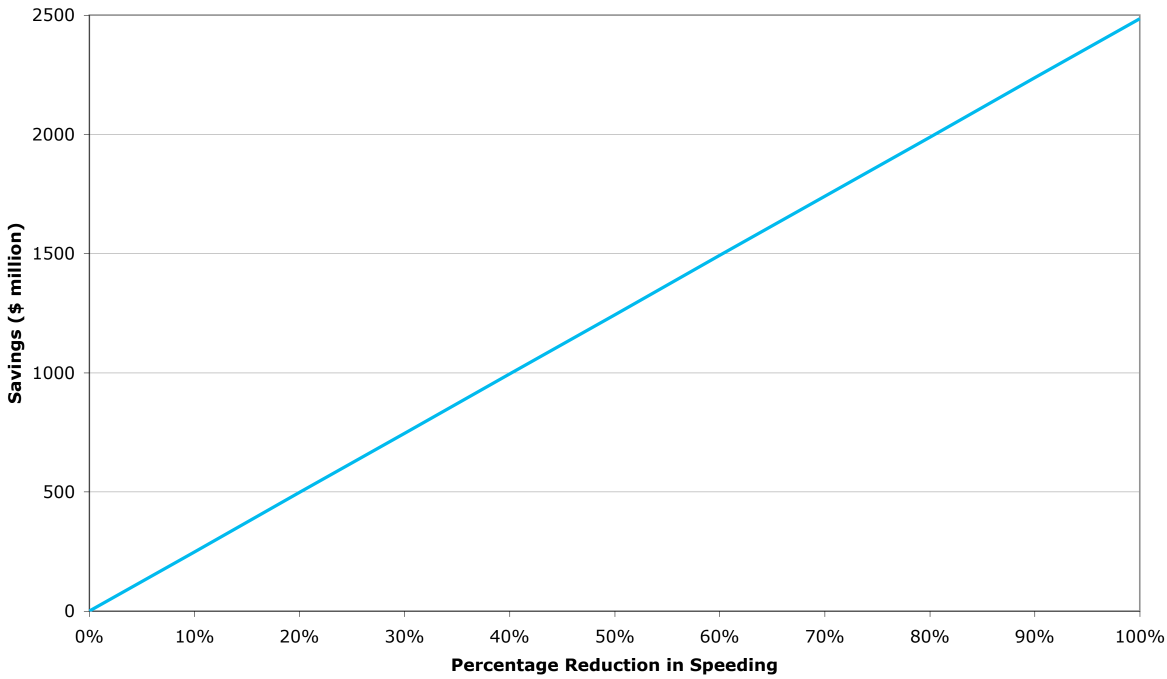
Table 3.6 shows the difference between the police reported crash numbers and the BITRE imputed crash numbers (T Risbey 2010, pers. comm., 2 June) the cost per crash as calculated in the BITRE report (2009), and the factors that were applied to these costs to take account of under-reporting. The average costs of crashes were expressed in 2009 dollars using the consumer price index (ABS, 2010).

Table 3.6
Cost of crashes in the Australian states by severity

Severity	BITRE crashes 2006	Police reported crashes, 2006	BITRE crash costs ($, 2009)	Under-reporting factor
PDO	428,305	60,608	10,810	7.1
Minor	181,390	45,136	16,014	4.0
Serious	24,575	16,673	288,972	1.5
Fatal	1,402	1,400	2,899,297	1.0

By multiplying the number of crashes where excessive speed was reported as a factor for different injury severities found in Table 3.1 with the cost of a crash of the respective injury severity and the under-reporting factor, shown in Table 3.6, it is possible to calculate, in monetary terms, the benefits of reducing or eliminating these crashes. Figure 3.2 shows the relationship between the percentage reduction in excessive speed crashes and the calculated monetary savings.

Figure 3.2
Monetary savings per year by percentage reduction in speeding crashes



From Figure 3.2 it can be estimated that almost $2.5 billion could be saved every year if all excessive speed was eliminated as might be expected with a properly functioning limiting ISA system on every vehicle. If the reductions in speeding reported in the literature (10 to 77% for advisory and 2 to 72% for supportive) are applied to Figure 3.2 savings of anywhere between $249 million and $1.91 billion per year can be expected for an advisory system and $50 million and $1.79 billion per year for a supportive system. The large ranges in these estimates are a product of the highly varied results reported in the literature, discussed in Section 2. The limitations in this analysis are that it relies upon data which is known to be unreliable and the variable effects of ISA reported in the literature. For these reasons the more thorough analysis outlined in Section 3.2 was undertaken.

3.2 Speed Risk Analysis

3.2.1 Travel speed and crash risk

There is a large body of research on the effect of travel speed on crash risk and the overwhelming conclusion has been that when travel speed increases the risk of having a crash or being injured in a crash increases (Elvik et al., 2004). This conclusion is not only supported by many studies using empirical data but by the laws of physics and a basic understanding of the limitations of the human body. For these reasons it was deemed desirable to understand the effect ISA would have on the distributions of speeds in Australia and then apply crash risk curves to the speed distributions with and without ISA. This method was utilised in Tate and Carsten's implementation scenarios report on the ISA-UK project in 2008.

One of the widely recognised studies on the relationship between travel speed and crash risk was conducted in Australia by Kloeden et al. in 1997 and was further developed in Kloeden et al. 2001 and Kloeden et al. 2002. The equations for risk relative to travel speed (for 50 and 60 km/h roads) and mean speed (for 80 km/h and above roads) presented in these reports were used in this analysis for three reasons; they are widely accepted in the road safety community, they have been applied to determining the benefits of ISA previously (Tate and Carsten, 2008) and they are based on Australian conditions. It should be noted that these studies considered injury crashes and so they cannot necessarily be applied to PDO crashes, although it is likely that the introduction of ISA would produce some reduction in PDO crashes. In this sense the analysis is conservative. It should also be noted that Kloeden et al.'s work used free travel speed whilst in this study a combination of free and non-free travel speeds are used in the analysis. A vehicle is said to have a free travel speed if it has at least a four second headway gap to the preceding vehicle and is therefore not influenced by the preceding vehicle's speed (Kloeden and Woolley, 2009).

3.2.2 The influence of ISA on travelling speed

The ISA-UK project (Tate and Carsten, 2008) measured changes to speed distributions, which can be expressed as changes to the percentages of vehicle numbers in 2 km/h speed bands. To determine the effect that the differing levels of ISA would have on the Australian speeds, equivalent changes were applied to Australian speed distributions on 50, 60, 80, 100 and 110 km/h roads. The results from the ISA-UK project were used, as this is a robust and recent trial of ISA that contained sufficient data necessary for this analysis. As the speed limits in the United Kingdom are given in miles per hour, the effect of ISA was applied to Australian data relative to the speed limit rather than directly applying the change to the corresponding speed band. For example, if the number of vehicles travelling 10 to 12 km/h over the speed limit in 40 mph speed zones was found to reduce by 50% with limiting ISA in the ISA-UK project, the same reduction was applied to the number of vehicles measured travelling 10 to 12 km/h over the speed limit in 60 km/h zones. The resulting speed distributions were normalised by expressing them as a percentage of the total number of speed measurements.

The Australian speed data comes from 171 sites in South Australia and Queensland and is based on over 5.3 million individual speed measurements taken in 2008 and 2009. The available data from Queensland did not contain any 110 km/h zones so only South Australian data could be used for this speed zone. More detail on the speed measurement sites can be found in Kloeden, 2009 and Kloeden and Woolley, 2009. The speed measurements have been combined with equal weight given to every measurement, hence the sites that have a greater volume of traffic passing the speed measuring equipment have more effect on the distribution. It should be noted that the speed distributions in the

ISA-UK project related to the ISA equipped vehicles' travel speeds over the length of their journeys during the study while the speed distributions from Australia represent vehicle speeds measured at discrete locations.

3.2.3 50 and 60 km/h zones

Figure 3.3 shows the risk curve applied to 50 and 60 km/h zones. It was decided to cap the risk curve above 80km/h as in Tate and Carsten (2008) to minimise the impact of small, potentially variable, amounts of high level speeding. If the risk curve had been capped at a higher speed the analysis would have shown a greater impact of ISA hence this approach is conservative.

Figure 3.3
Risk curve applied to speed distributions for 50 and 60 km/h roads

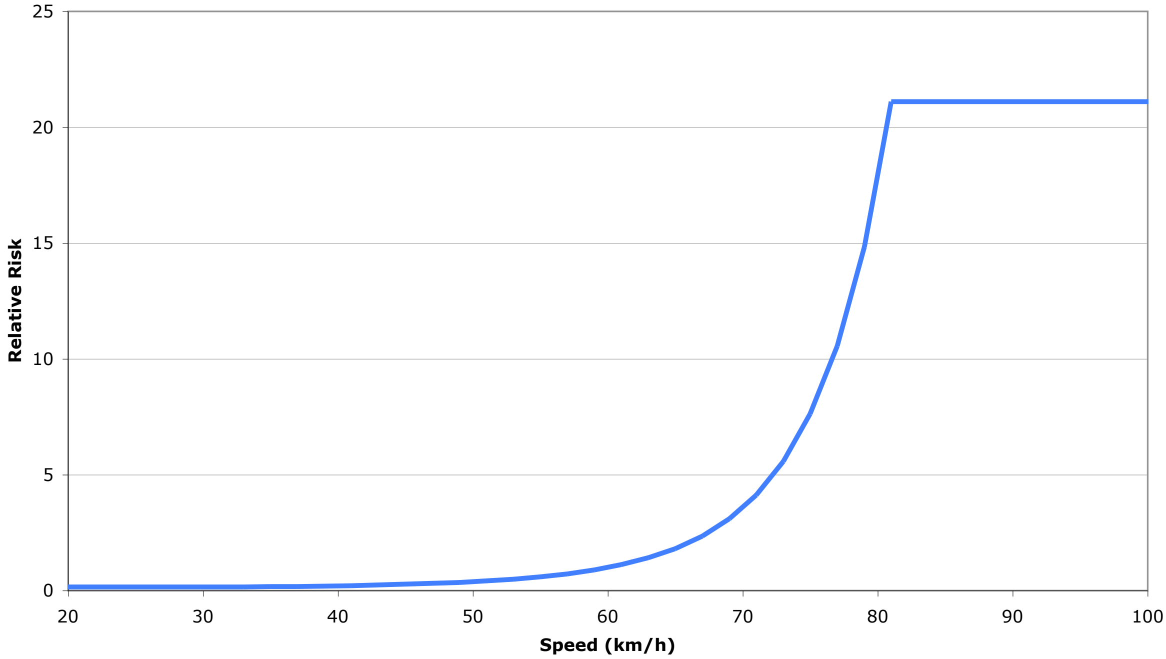


Figure 3.4 shows the results of the analysis described in Section 3.2.2 for 50 km/h zones. It can be seen that supportive and limiting ISA would change the shape of the speed distribution, shifting those that were speeding by more than a few km/h back to just above the speed limit. Advisory ISA also changed the shape of the distribution although the change appears slight relative to supportive and limiting ISA.

Figure 3.4
Speed distributions with and without ISA for 50 km/h zones

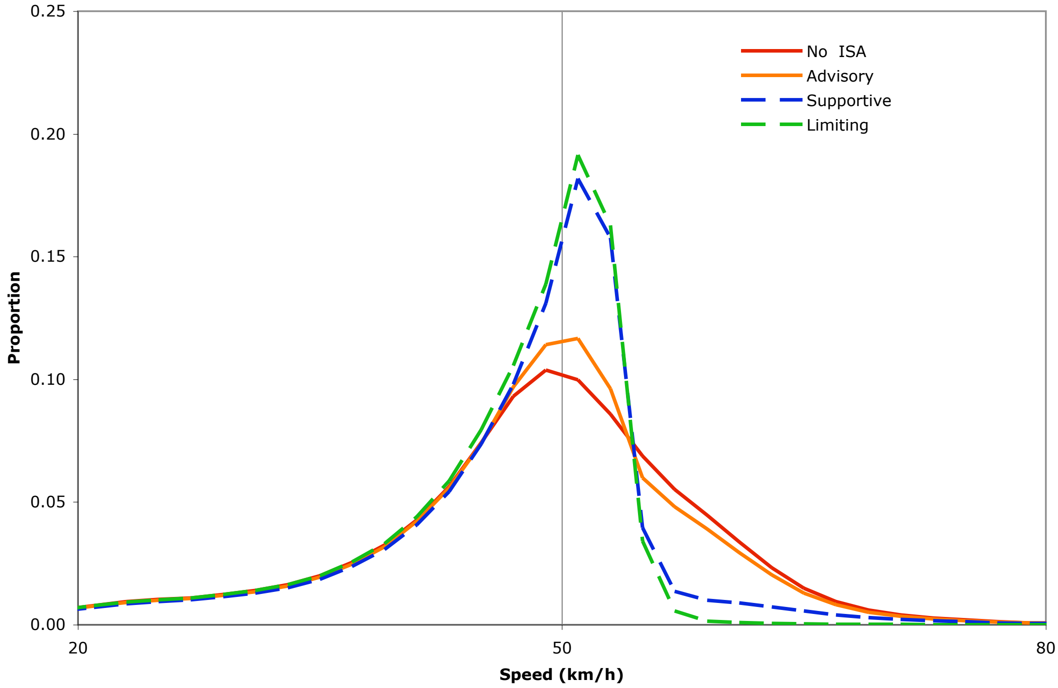
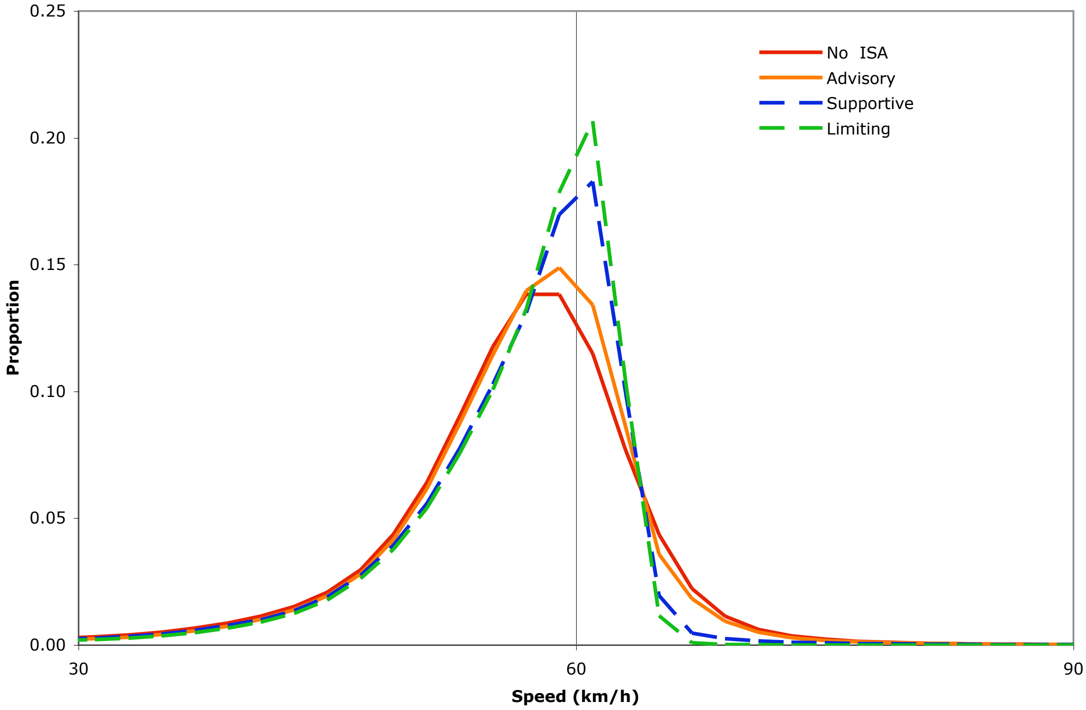


Figure 3.5 shows the results of the analysis described in Section 3.2.2 for 60 km/h zones. The effects of ISA appear less pronounced than in the 50 km/h zones. This is due to the 'No ISA' speed distribution being centred further below the speed limit than in 50 km/h zones distribution.

Figure 3.5
Speed distributions with and without ISA for 60 km/h zones



3.2.4 80 km/h zones

The risk curve for 80km/h zones is shown in Figure 3.6. The curve was based on the mean speed of the speed distribution without ISA, 75.5 km/h. The risk was capped at 30km/h above the mean speed (or as close as possible given 2 km/h bands were used), as in Tate and Carsten (2008), to minimise the impact of small, potentially quite variable, amounts of high level speeding. A point of differentiation between the work of Tate and Carsten (2008) and this analysis is that the risk curve was not recalculated using the mean speed of the ISA effected profiles, as was done in Tate and Carsten (2008). This would produce the same total risk if the distribution shifted by any amount but retained the same shape. The authors believe the absolute speed relative to the original mean speed is what is important, not the speed relative to any new mean speed.

Figure 3.6
Risk curve applied to speed distributions for 80 km/h roads

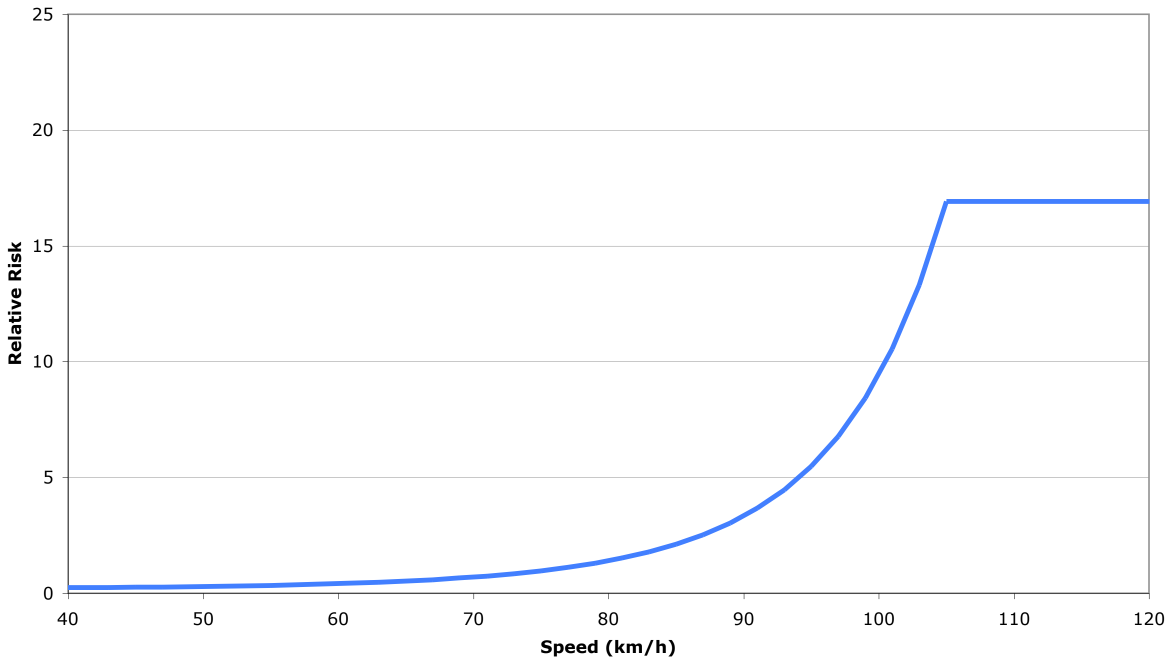
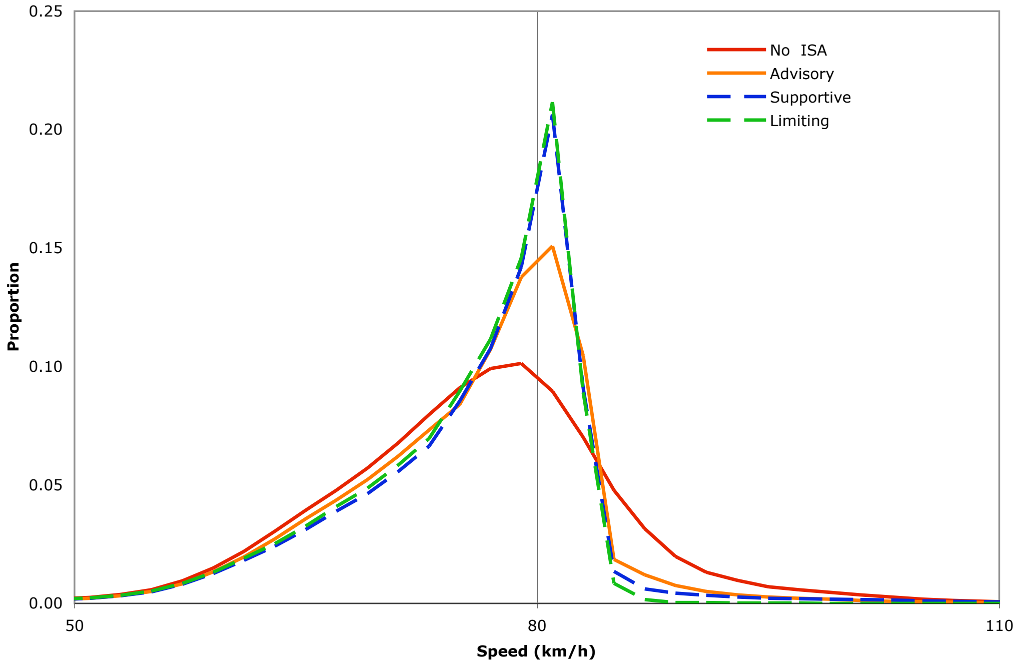


Figure 3.7 shows the results of the analysis described in Section 3.2.2 for 80 km/h zones. Advisory ISA appears to be more effective in 80 km/h zones than other speed zones. Supportive and limiting ISA produce very similar distributions.

Figure 3.7
Speed distributions with and without ISA for 80 km/h zones



3.2.5 100 km/h zones

The risk curve for 100km/h zones is shown in Figure 3.8. The curve was based on the mean speed of the speed distribution without ISA (96.3 km/h).

Figure 3.8
Risk curve applied to speed distributions for 100 km/h roads

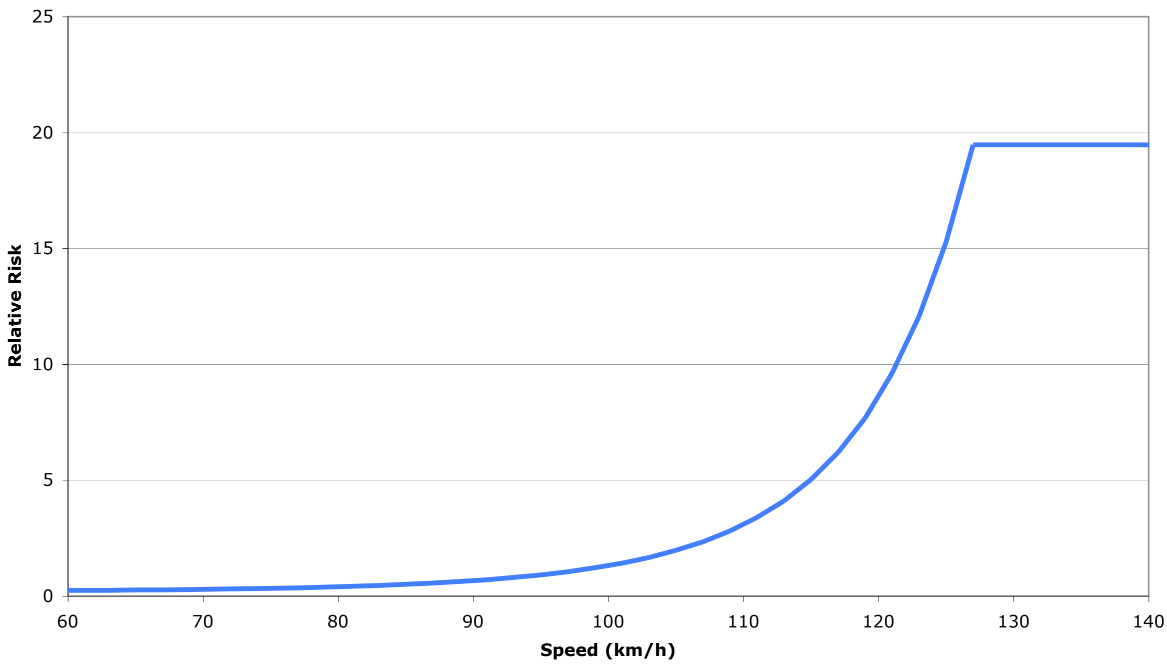
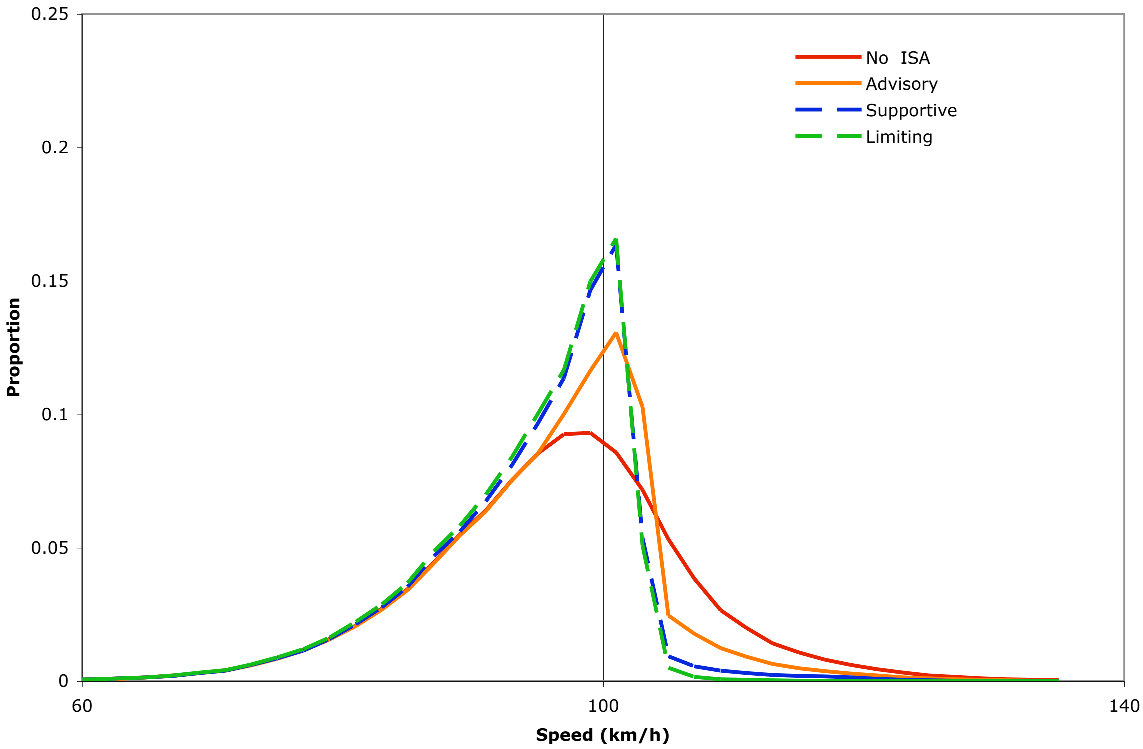


Figure 3.9 shows the results of the analysis described in Section 3.2.2 for 100 km/h zones. Once again supportive and limiting ISA produce very similar distributions. Advisory ISA does not appear to be as effective in 100 km/h zones as in 80 km/h zones although it has a more pronounced effect on the distribution than in 50 and 60 km/h zones.

Figure 3.9
Speed distributions with and without ISA for 100 km/h zones



3.2.6 110 km/h zones

The risk curve for 110 km/h zones is shown in Figure 3.10. It was based on the mean speed of the speed distribution without ISA (102.9 km/h).

Figure 3.10
Risk curve applied to speed distributions for 110 km/h roads.

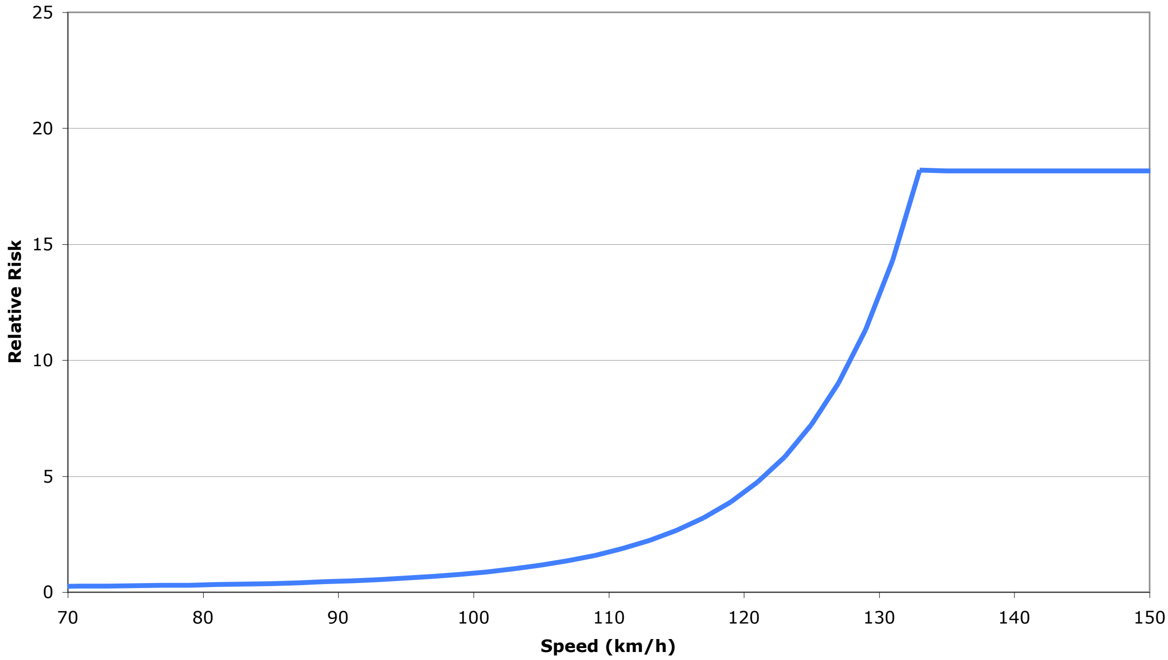
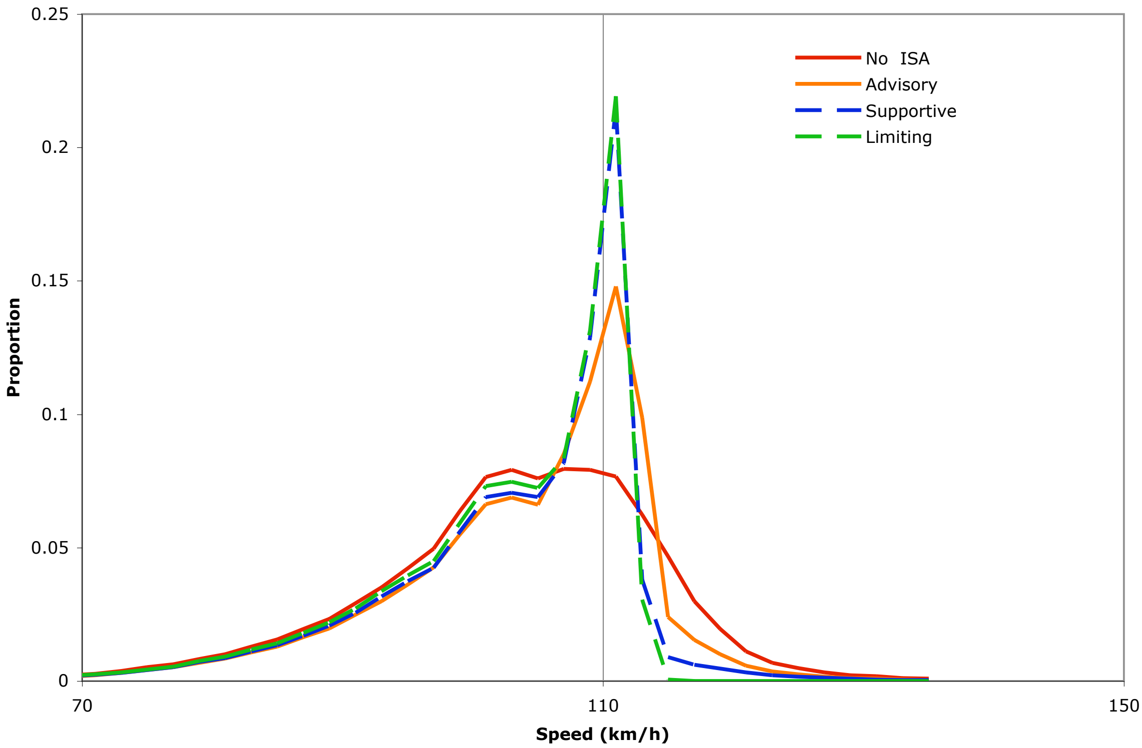


Figure 3.11 shows the results of the analysis described in Section 3.2.2 for 110 km/h zones. It is clear from the speed distribution with no ISA that there are distinct differences in the measurement sites that result in double peak in the distribution. The peak just over the speed limit produced by limiting and supportive ISA was greater than at the lower speed limits.

Figure 3.11
Speed distributions with and without ISA for 110 km/h zones



3.2.7 Risk reduction and savings

After the distributions with and without ISA were determined (for example Figure 3.10) the proportion in each 2km/h band was multiplied by the risk at the average speed for that band (for example Figure 3.9). The results for each speed band were then summed to produce a total injury crash risk. The percentage reduction in the injury crash risk was then determined for the particular level of ISA. Table 3.7 shows the percentage injury crash risk reduction at different speed limits relative to the level of ISA implemented. Of interest is the difference between supportive and limiting ISA given the similar distributions. This highlights the risk reduction produced by ensuring that it is impossible to speed by more than a few km/h. Advisory ISA appears most effective in 80 and 100 km/h zones while supportive and limiting ISA excelled in 50 and 100 km/h zones. Generally limiting ISA was the most effective at reducing crash risk, followed by supportive ISA with advisory ISA being the least effective. 80 km/h zones provided the exception to this rule as advisory ISA was found to be more effective than supportive ISA, albeit marginally so.

Table 3.7
Percentage injury crash risk reduction by level of ISA and speed zone

Speed Limit (km/h)	Advisory	Supportive	Limiting
50	6.5%	19.6%	42.4%
60	2.1%	9.4%	15.8%
80	14.4%	12.3%	23.3%
100	17.3%	28.8%	35.9%
110	4.6%	12.4%	21.7%

Table 3.8 shows the percentage and number of all crashes of differing injury severities occurring in each speed zone between 2004 and 2008 in the Australian states, as well as the average number of crashes per year. It should be noted that for the purposes of this analysis 70 km/h and 90 km/h zones were treated as 80 km/h zones and speed zones less than 50 km/h were excluded. These figures were multiplied by the risk reductions shown in Table 3.7 to determine the overall risk reductions that are shown in Table 3.9. This reveals that advisory ISA would reduce all crashes by 7.7%, supportive ISA by 15.1% and limiting ISA by 26.4%. Supportive ISA is almost twice as effective at reducing crashes as advisory ISA and limiting ISA is almost three and a half times more effective. It should be noted that this percentage is applicable to all crashes, not simply to the speeding crashes presented in Section 3.1.

Table 3.8
Percentage of injury crashes by injury severity and speed zone
and average number of crashes by injury severity per year (2004 - 2008)

Speed Limit	Fatal		Serious		Minor	
	Number	Percentage	Number	Percentage	Number	Percentage
050	160	11.9%	3,259	20.1%	11,174	24.4%
060	273	20.3%	6,129	37.8%	19,273	42.2%
080	308	22.9%	3,371	20.8%	8,974	19.6%
100	474	35.2%	2,845	17.5%	5,324	11.6%
110	130	9.7%	629	3.9%	965	2.1%
Total	1,345	100.0%	16,233	100.0%	45,710	100.0%

Table 3.9
Crash risk reduction by level of ISA and injury severity and monetary savings per year by level of ISA

	Advisory	Supportive	Limiting
Fatal	11.0%	18.4%	28.3%
Serious	8.3%	15.6%	26.5%
Minor	7.4%	14.8%	26.3%
Total	7.7%	15.1%	26.4%
Savings per year ($M)	1,226	2,240	3,725

By multiplying the risk reductions in Table 3.9 by the number of crashes of differing severities shown in Table 3.8, and the cost per crash and under-reporting factor shown in Table 3.6, the overall crash savings per year were calculated. The results are also shown in Table 3.9. This reveals that full implementation of advisory ISA could be expected to save about $1.2 billion per year while about $2.2 billion could be saved per year with supportive ISA and about $3.7 billion could be saved per year with limiting ISA.

3.3 Discussion of analyses results

The analyses produced different results. Due to the high degree of uncertainty in the speeding crash analysis for advisory and supportive ISA (due to varied speeding reductions reported in the literature) only the limiting ISA results will be compared between the two analyses. The monetary saving found in the speeding crashes analysis for limiting ISA (Figure 3.1) is 33% smaller than that found in the speed risk analysis (Table 3.9). This can be explained by the comparison shown in Table 3.10. It can be seen that while the crash, and hence monetary, savings are greater for the speeding crashes analysis for fatal crashes, at lesser severities the speed risk analysis produces much larger crash savings. This may support the assertion in Section 3.1 that the speeding crash data under reports speeding crashes when the crash is not fatal. The large monetary discrepancy between the two analyses is mostly due to the large discrepancy between serious crash savings and the high cost of such crashes.

Table 3.10
Crash and monetary savings by analysis method and injury severity per year

Injury Severity	Speeding crashes analysis		Speed risk analysis	
	Crash savings	Monetary Savings ($M)	Crash savings	Monetary Savings ($M)
Fatal	450	1,300	381	1,101
Serious	1,101	474	4,302	1,850
Minor	3,583	231	12,021	774
PDO	6,297	481	NA	NA

Overall the authors have more confidence in the speed risk analysis for the following reasons.

- It does not rely on police reports to determine the role of speed, a task that is difficult, especially at modest levels of speeding.
- It uses actual vehicle speeds.
- It allows for increased risk at increased travel speed.
- It investigates the effect of the change in the whole travel speed distribution due to ISA.
- It does not rely simply on percentage reduction in speeding to determine the benefit, a figure that varied considerably in the literature.

For these reasons it was decided that the monetary savings determined by the speed risk analysis would be used in the implementation scenarios described in Section 5.

It should be noted that limitations still exist with the speed risk analysis. The speed risk analysis uses the effects of ISA reported in the ISA-UK report (Tate and Carsten, 2008). This was applied to Australian speed data to attempt to frame the effects of ISA within an Australian context. This allows for the variation in the benefit of ISA relative to the extent of the speeding problem in the geographical area in which it was applied, an effect that was noted from the literature, but it does not allow for variation between the drivers response to ISA measured in the ISA-UK study and Australian drivers. The Australian ISA trial (Regan et al. 2005) produced changes in mean speed and 85th percentile speed within the ranges reported in the ISA-UK study. This gives some confidence that Australian and English drivers do not differ notably in the way in which they react to ISA.

4 Technology and Costs

4.1 Speed limit mapping

4.1.1 Current progress

One of the major requirements of an effective ISA system is the accurate digital mapping of speed zones in a format that can be used with a GPS to determine the speed limit at a precise location on the road network. The responsibility for mapping speed zones has traditionally fallen to the government transport authorities although commercial companies have also undertaken such work. To date the progress of speed limit mapping varies considerably between the states. Main Roads Western Australia and Vicroads have completed the mapping of speed zones on all public roads although some accuracy issues still exist in Western Australia, and are currently being rectified.

The New South Wales Roads and Traffic Authority (RTA) have mapped 30% (RTA, 2009) of their network and are in the process of implementing a system to maintain the accuracy of their database. This process has taken two and a half years to date. Other states such as Tasmania, South Australia and Queensland have no digital speed zone maps produced by their respective road transport authorities at this point in time although the Department of Infrastructure Energy and Resources in Tasmania plans to have completed such a map by the end of 2010. It should be noted that the creation of the speed zone map is probably easier when only a single organisation, such as the state transport authority, has the authority to set and change speed limits (such as Western Australia). In some states this responsibility is shared between the transport authority and many local governments (such as Queensland).

A commercial enterprise known as Speed Alert has also undertaken its own mapping of speed limits in Australia. Speed Alert began the mapping process in 2006. Currently coverage includes all roads in the capital cities and surrounding suburbs, other major towns and many of the major interconnecting highways. The company estimates that they cover 70-80% of the population and that the maps are at least 95% accurate (on a zone, not kilometre, basis). Speed Alert's maps are predominately updated by customers reporting an incorrect speed zone, which is then reviewed at the site by an employee. These updates are made available to customers monthly. Speed Alert anticipates that in the future access to road authority data will assist in increasing the coverage and accuracy of their maps.

4.1.2 Costs of mapping

VicRoads has spent $700,000 on completing its map although a further $1.9 million was spent on the project as a whole. Most of this $1.9 million was spent on developing a system to update and maintain the map. Between $350,000 and $400,000 per year has been budgeted to keep the database up to date (C Jones 2010, pers. comm., 21 Jan). The New South Wales RTA has spent $800,000 mapping its southern region, one of its six regions (V Cuenca 2010, pers. comm., 19 Jan). Given that this does not include Sydney it could be estimated that the total cost of mapping New South Wales would be between five and six million dollars. Tasmania has set aside $350,000 to complete its map (D Davis 2010, pers. comm., 19 Jan). Main Roads Western Australia completed the mapping as part of its normal tasks and hence did not ascribe a cost to a specific project (L Crackel 2010, pers. comm., 21 Jan). The commercial mapping that has been undertaken cost around $1.8 million with a further $100,000 to $160,000 spent each year updating it (G Germanos 2010, pers. comm., 1 Feb). If Victoria is used as the average state then a total of $15.6 million may be spent completing speed limit maps in all six states. A further $2.4 million may be spent every year keeping the maps up to date.

4.2 In vehicle devices

The Australian market for ISA devices is in its infancy and there are currently only two companies that produce ISA devices; Speed Alert and Speedshield. The Speed Alert's ISA devices currently only come in advisory format while Speedshield's devices are capable of advisory, supportive and limiting ISA. While the Speed Alert devices use the custom commercially developed speed limit maps mentioned in section 4.1 the Speedshield devices rely on speed limit maps provided by government departments. For all devices it should be noted that the price would not differ between light and heavy vehicles. The information contained in this section was obtained by personal communication with George Germanos from Speed Alert and Jason Ko from Speedshield on the 1st of February, 2010.

Installation costs are not discussed in this section or included in the economic analyses in Section 5. This is because they are largely unknown and may vary considerably given the exact nature of the installation, device and vehicle. For example, installations of prototype devices may be as expensive as the device itself while a device installed on a vehicle during manufacture would add only very small expense to the manufacture of vehicles. Navaid devices can be installed at no cost.

4.2.1 Advisory devices

Advisory ISA integrated into Navaid devices and GPS equipped mobile phones

Speed Alert currently markets several versions of advisory ISA devices. The first generation Speed Alert advisory ISA is integrated into a navaid device and can only be updated by downloading updated maps from the internet. The cost of the navaid device can range between $160 and $260 with the ISA software costing $9.90 for a single update or $29.90 for a yearly subscription. Given that the navaid device must be switched on separately from the vehicle there is no way to ensure that this device is operated when the vehicle is driven. An application for GPS equipped mobile phones is currently being tested that uses the same live system as the second generation Speed Alert device discussed below. This is expected to start at $10 per month but would reduce to $1 month if usage expanded to one million. Once again there is no way to ensure that this device is actually operating when the vehicle is in use.

Dedicated advisory ISA devices

The second generation device from Speed Alert is sold as a stand alone device. It downloads the current speed limit zone as the vehicle is driven and hence is always up to date. It also has the capacity to log the vehicle speeds remotely, which could have enforcement or incentive applications. If this device was to be bought as a single retail unit it would cost $800 but this cost could be expected to reduce to $500 if 50,000 units per year were purchased and to $400 if one million units were purchased. The technology for this second generation device is also expected to reduce in cost by 30% by 2011 and by 50% by 2012.

The Speedshield advisory ISA device is a standalone device that can supplement the GPS signal with dead reckoning to ensure the device works when the GPS signal is low or lost. It can also theoretically supplement speed limit map data with information from portable transmitters placed at temporary speed limit locations such as work zones or car accidents. The current cost of this device as a single retail unit is $1200 but this is expected to reduce significantly for larger orders, maybe to as low as $300.

4.2.2 Supportive and Limiting devices

Currently only Speedshield offer a supportive or limiting ISA device. This device taps into the throttle signal in a drive by wire vehicle and electronically prevents it from exceeding the speed limit. For this reason the device requires the vehicle to be equipped with a drive-by-wire system. Currently this device would retail at $1800 for a single unit but this cost could be expected to reduce to $650 if 50,000 units per year were purchased and $520 if one million units were purchased. Speedshield can also offer the power and acceleration limiting device by itself. If this could be integrated with a factory fitted navaid device a single device would cost $800 but this would reduce to $350 if 50,000 units a year were ordered and may reduce to as low as $175 if a mass order of over one million units was placed. As with Speedshield's advisory device it can theoretically supplement speed limit map data with information from portable transmitters placed at temporary speed limit locations such as work zones or car accidents.

5 Implementation scenarios

The economic analysis of several implementation scenarios is presented in this section. Three particular economic indicators have been calculated; the benefit-cost ratio (BCR), the payback period and the break even price. The BCR and break even price have been calculated over 20 years. Because ongoing cost and benefits would be incurred for the foreseeable future under all these scenarios the time frame used is not indicative of the expected life of the technology but rather addresses the questions 'what would the return on investment be after 20 years?' with the BCR and 'what would the cost of the technology need to be to achieve no net gain or loss after 20 years?' with the break even price. The payback period was calculated to give an indication of the time it might take to break even. If the payback period was found to be greater than 100 years it was deemed not applicable (NA).

Discount rates that are applied to economic analyses are designed to reflect the return on investment that could be gained elsewhere. This has the effect of devaluing future benefits (and costs as well if the net benefit at that point in time is negative). Discount rates that are applied to transportation economics vary from 3% to 10% (Tate and Carsten, 2008: COWI, 2006: Litman, 2009: Cairney et al. in press). It can also be argued that discounting the benefits of crash reductions is incorrect as attributing less value to future crash reductions is unfair to the future population. Taking this into account three different discount rates were used in the analysis; 0%, 4% and 8%.

In all scenarios except the one considering heavy vehicles all types of vehicles are included in the analysis. The underlying assumption is that ISA can be applied to all types of vehicles and will have the same effect for all these vehicles. This may not be the case for motorcycles; as discussed earlier motorcycles appear to be overly represented in excessive speed crashes and it may be technically more challenging to implement ISA for them.

The analyses that follow do not allow for ISA vehicles affecting other vehicles. It may be the case that when a certain level of penetration of ISA into the fleet occurs those vehicles that are not equipped with ISA will be affected by the ISA equipped vehicles. In this sense the analyses are conservative.

Only the cost of the devices themselves and the mapping are included in the economic analysis. Costs associated with installation, enforcement of any implementation (such as ensuring devices are not being tampered with), lost speeding infringement revenue and increased travel times have not been included. Conversely only the benefits associated with crash reductions have been included. The benefits of reduced fuel consumption, reduced emissions and the potential for smoother traffic flow have not been included.

It is assumed for the purpose of these analyses that the ISA device operates whenever the vehicle is turned on. The exception to this is the Navaid scenario. Such an assumption would be unreasonable for such devices.

5.1 All vehicles

The ABS's Motor Vehicle Census reports that on the 31st of March 2009 there were 15,298,693 vehicles in the Australian states (ABS, 2009a). If the current advisory ISA device from Speed Alert that has live updates was installed on all current vehicles at a cost of $400 per vehicle the initial cost would be $6,135 million (including mapping costs). To install this on new vehicles would cost around $400 million per year although the technology is expected to reduce in cost by 30% in a year and by 50% in two years, meaning that in 2011 it may only cost $280 million and in 2012 and thereafter it may only cost $200 million. New vehicle sales have fluctuated around the one million per year mark between 2005 and 2009 hence this is the number of new vehicle sales that were used in this analysis. On going costs of $2.4 million for mapping updates have also been included in the ongoing costs. The benefit over one year is expected to be $1,226 million.

If the Speedshield advisory device is used at a cost of $300 per unit the initial cost would be $4,605 million and the ongoing costs would equal $302 million per year.

If the Speedshield supportive and limiting device was installed on all vehicles it would cost around $520 per vehicle giving a total cost of $7,971 million with an ongoing cost of $522.4 million per year. The benefit over one year is expected to be $2,240 million for supportive ISA and $3,725 million for limiting ISA.

It should be noted that since the Speedshield supportive and limiting device can only be installed on vehicles that utilise drive-by-wire it could not be installed on many vehicles manufactured before 2005. By examining the current distribution of vehicle ages (ABS, 2009a) a market penetration curve was produced for vehicles manufactured in 2005 and after. This curve is shown in Figure 5.1. The prevalence of post 2004 vehicles was then multiplied by the benefits and costs for that year to produce the results shown in Table 5.1. This reduced the initial cost of supportive and limiting ISA to $2,148 million as just under 27% of the current fleet were manufactured after 2004.

Figure 5.1
Market penetration of vehicles manufactured after 2004

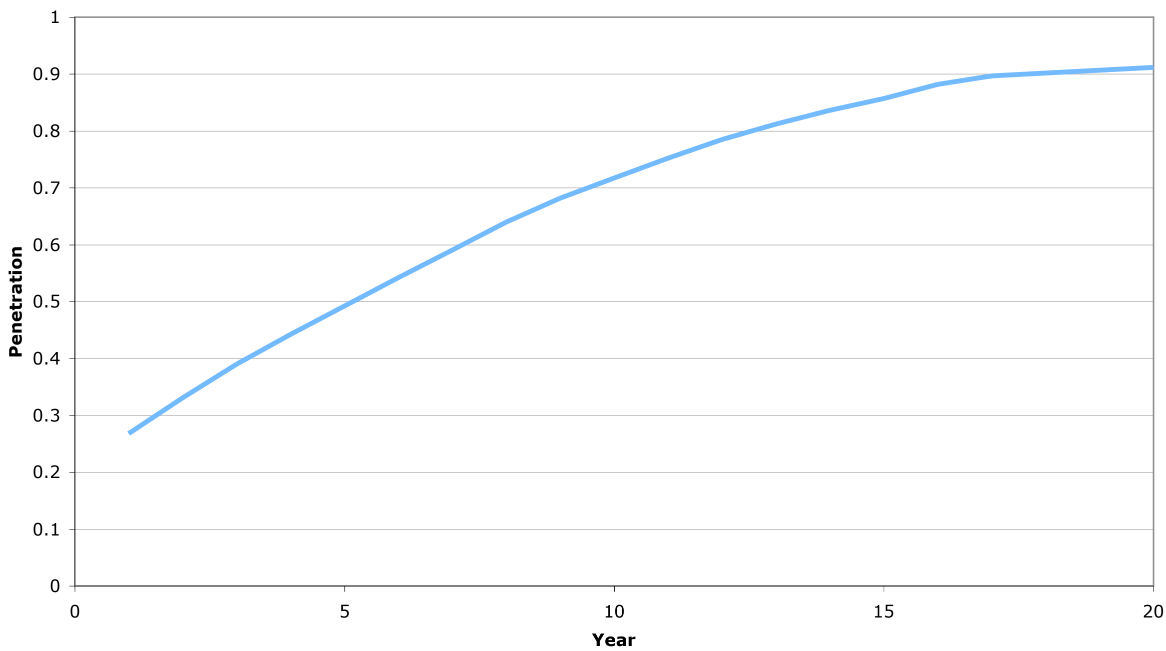


Table 5.1 shows limiting ISA would produce the greatest return on investment. All BCRs are above one. The payback periods range from around three years for limiting ISA up to around seven years for other forms of ISA. The break even prices over 20 years reflect the differing levels of benefit produced by the different levels of ISA. Over $1,500 could be spent on a limiting system before the return would begin to be negative while less than $500 needs to be spent on an advisory ISA device to ensure negative returns are not produced.

Table 5.1
Economic analysis results if ISA was implemented on all vehicles

ISA device	BCR			Payback Period (years)			Break Even Price ($AU)		
	0%	4%	8%	0%	4%	8%	0%	4%	8%
Advisory – Speed Alert	2.89	2.36	1.92	3.7	4.0	4.3	691	596	511
Advisory – Speedshield	2.29	1.89	1.58	6.1	6.7	7.5	691	596	511
Supportive – Speedshield	2.42	2.09	1.79	5.7	6.2	6.9	1,264	1,092	935
Limiting – Speedshield	4.03	3.48	2.98	3.0	3.2	3.5	2,104	1,818	1,556

Table 5.2 shows the percentage reduction in crashes at different injury severities if all vehicles were fitted with ISA over the 20 year duration of the scenario. Limiting ISA could reduce injury crashes by more than a quarter, supportive ISA by over 15% and advisory ISA by almost 8%. Advisory, supportive and limiting ISA all have increased effectiveness in reducing crashes of higher injury severities.

Table 5.2
Percentage reduction in injury crashes if ISA was implemented on all vehicles by level of ISA and injury severity over 20 years

Injury Severity	Advisory	Supportive	Limiting
Fatal	11.0%	18.4%	28.3%
Serious	8.3%	15.6%	26.5%
Minor	7.4%	14.8%	26.3%
Total	7.7%	15.1%	26.4%

5.2 New vehicles

New vehicle sales have fluctuated around the one million per year mark between 2005 and 2009 hence this is the number of new vehicle sales that are used in this analysis. The cost per unit used in this analysis are the cost quoted for an order of one million, as used in the 'all vehicles' scenario.

In order to examine the benefits of the installation of ISA in all new vehicles the penetration of new vehicles into the total fleet was calculated using the current distribution of vehicle ages provided in the data that accompanied the ABS's motor vehicle census report in 2009. A graph of this is shown in Figure 5.2. The fleet penetration factor can then be multiplied by the expected benefit if all vehicles were equipped with ISA.

Figure 5.2
Market penetration of vehicles manufactured after 2009

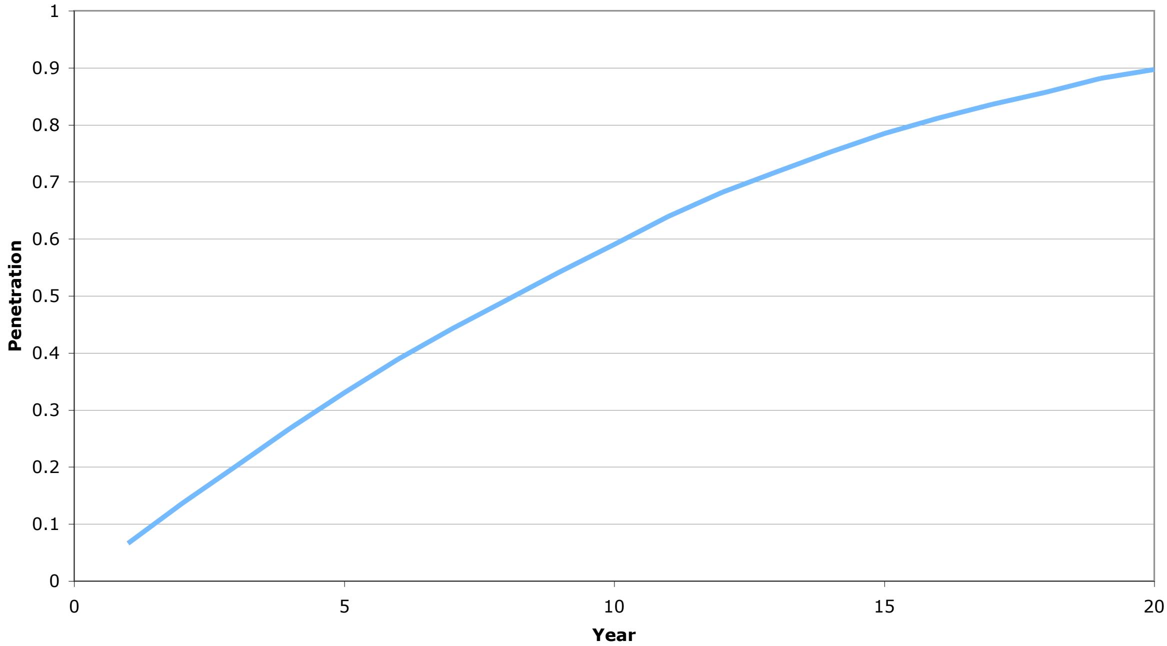


Table 5.3 shows the results of the economic analysis for the introduction of ISA on all new vehicles. As with the 'all vehicles' scenario, limiting ISA produces the greatest return on investment although it is more closely followed by the Speed Alert version of advisory ISA. This is explained by the rapid reduction in cost of this device as discussed in Section 4.2.1.

Table 5.3
Economic analysis results if ISA was implemented on new vehicles

ISA device	BCR			Payback Period (years)			Break Even Price ($AU)		
	0%	4%	8%	0%	4%	8%	0%	4%	8%
Advisory – Speed Alert	3.35	2.98	2.63	4.5	4.6	4.8	691	620	553
Advisory – Speedshield	2.29	2.05	1.83	6.6	6.9	7.3	691	620	553
Supportive – Speedshield	2.42	2.17	1.94	6.1	6.4	6.7	1,265	1,135	1,014
Limiting – Speedshield	4.03	3.62	3.23	3.2	3.3	3.4	2,104	1,891	1,688

Table 5.4 shows the percentage reduction in crashes at different injury severities if new vehicles were fitted with ISA over the 20 year duration of the scenario. Limiting ISA could reduce injury crashes almost 15%, supportive ISA by 8.5% and by 4.4% for advisory ISA.

Table 5.4
Percentage reduction in injury crashes if ISA was implemented on new vehicles by level of ISA and injury severity over 20 years

Injury Severity	Advisory	Supportive	Limiting
Fatal	6.2%	10.4%	16.0%
Serious	4.7%	8.8%	15.0%
Minor	4.2%	8.4%	14.9%
Total	4.4%	8.5%	14.9%

5.3 Organisation fleet vehicles

Vehicles that are used by organisations (companies, governments and other non-private use) are often referred to as fleet vehicles. The term 'the fleet' is also used to describe all vehicles in a state or country. This section refers to both these groups and therefore the terminology 'organisation fleet' and 'overall fleet' will be used to avoid confusion.

An Austroads report into organisation fleet safety (MUARC, 2008) estimated that on average 15.5% of vehicles in the overall fleet are organisation fleet vehicles. This percentage was derived from vehicle usage codes in New South Wales between 2000 and 2004. Over that period the percentage trended down from 17% to 14.6%. A snapshot taken of the overall South Australian fleet in the first quarter of 2010 revealed that 13.4% of vehicles in South Australia are registered to organisations rather than personal clients or joint clients.

Based on the above information a current organisation fleet prevalence of 14% Australia wide was assumed for the analysis. This value allowed the initial cost of fitting fleet vehicles to be calculated. In order to calculate the ongoing benefits of ISA it was necessary to know how the percentage of the overall fleet that originated as an organisation fleet vehicle. A sample of the current overall South Australian fleet revealed that 54% of vehicles were originally sold to an organisation fleet buyer. To examine the penetration of ISA equipped vehicles into the overall fleet if organisation fleet vehicles were equipped with ISA Figure 5.2 was modified to reflect organisation fleet vehicles only. The result can be seen in Figure 5.3. The organisation fleet penetration factor can then be multiplied by the expected benefit if all vehicles were equipped with ISA. The costs of ISA devices for organisation fleets is assumed to be equal to the retail cost as fleets are unlikely to be of the order of 50,000 vehicles (largest in South Australia was just under 9,000 in late 2008 while only 6 of 474 fleets over 50 vehicles were over 1,000 vehicles).

Figure 5.3
Market penetration of vehicles sold to organisation fleet buyers

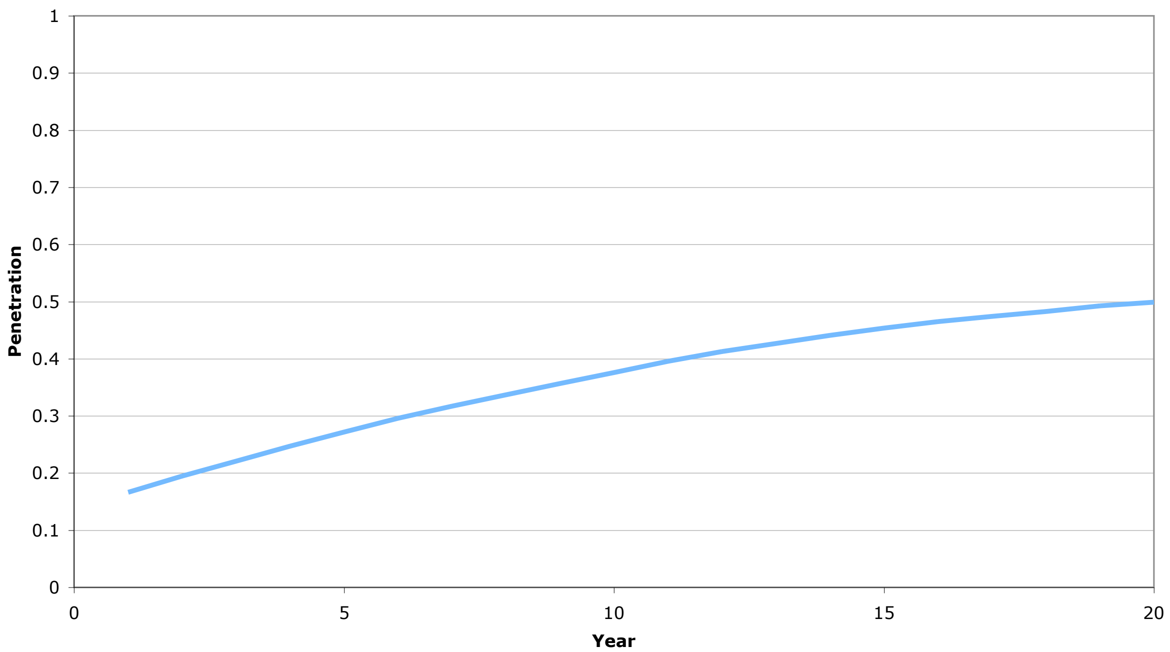


Table 5.5 shows that the BCRs for organization fleet vehicles can be either above or below one, depending on the type of ISA device used. This is due to the higher cost of ISA when small orders are made. The Speed Alert advisory ISA produces the best BCR in this scenario due to the reduction in price over time, as discussed in Section 4.2.1.

Table 5.5
Economic analysis results if ISA was implemented on organisation fleet vehicles

ISA device	BCR			Payback Period (years)			Break Even Price ($AU)		
	0%	4%	8%	0%	4%	8%	0%	4%	8%
Advisory – Speed Alert	1.45	1.20	0.98	12.1	14.9	21.0	689	598	515
Advisory – Speedshield	0.58	0.50	0.43	NA	NA	NA	689	598	515
Supportive – Speedshield	0.70	0.61	0.53	53.4	NA	NA	1,263	1,097	945
Limiting – Speedshield	1.17	1.02	0.88	15.3	19.3	34.4	2,104	1,828	1,576

Table 5.6 shows the percentage reduction in crashes at different injury severities if fleet vehicles were fitted with ISA over the 20 year duration of the scenario. Limiting ISA could reduce injury crashes by almost 10%, by 5.5% for supportive ISA and by almost 3% for advisory ISA.

Table 5.6
Percentage reduction in injury crashes if ISA was implemented
on organisation fleet vehicles by level of ISA and injury severity over 20 years

Injury Severity	Advisory	Supportive	Limiting
Fatal	4.0%	6.7%	10.4%
Serious	3.0%	5.7%	9.7%
Minor	2.7%	5.4%	9.6%
Total	2.8%	5.5%	9.7%

5.4 Market driven

The total fleet penetration of new technologies such as ISA that would be achieved if the market were left to itself is difficult to predict, especially given that ISA has had a mixed reaction from consumers who have been involved with trials. Sweden has historically led the way in ISA research and promotion but even there only about 5,000 vehicles have been fitted with ISA to date. In Australia, very weak versions of ISA such as the first generation Speed Alert addition to navaid devices has only sold about 10,000 units in 12 months, which represents about 1.3% of total aftermarket navaid sales. Even the 30% discount on insurance premiums offered in the 'Pay as you speed' trial conducted by Lahrmann (in press) was found to be insufficient to ensure market driven implementation of ISA.

Some attempts have been made in the past to estimate the fleet penetration of ISA over time (Tate and Carsten, 2008) but these appear overly optimistic in light of the current situation. Government promotion, without regulation, of ISA could increase the market penetration but once again there is a high degree of uncertainty. It is also known that user acceptance of ISA decreases as the strength of ISA increases (Biding and Lind, 2002: Adell et al. 2008: Päätalo et al. 2001). Taking all of this into account it was decided to simply assume that the penetration of ISA would begin at 0% and advisory ISA would increase by 0.5%, supportive by 0.4% and limiting by 0.3% every year. To derive the sales of ISA devices that would be required every year to achieve this, the values from Figure 5.2 that show the vehicle year penetration were divided by the assumed penetration profile shown in Figure 5.4 to gain the fraction of new vehicle sales that would include ISA. Given that ISA is able to be retro-fitted it is optimistic to assume they will be fitted to new vehicles that will have a longer life span than older vehicles.

Figure 5.4
Market penetration of ISA vehicles if implementation was purely market driven

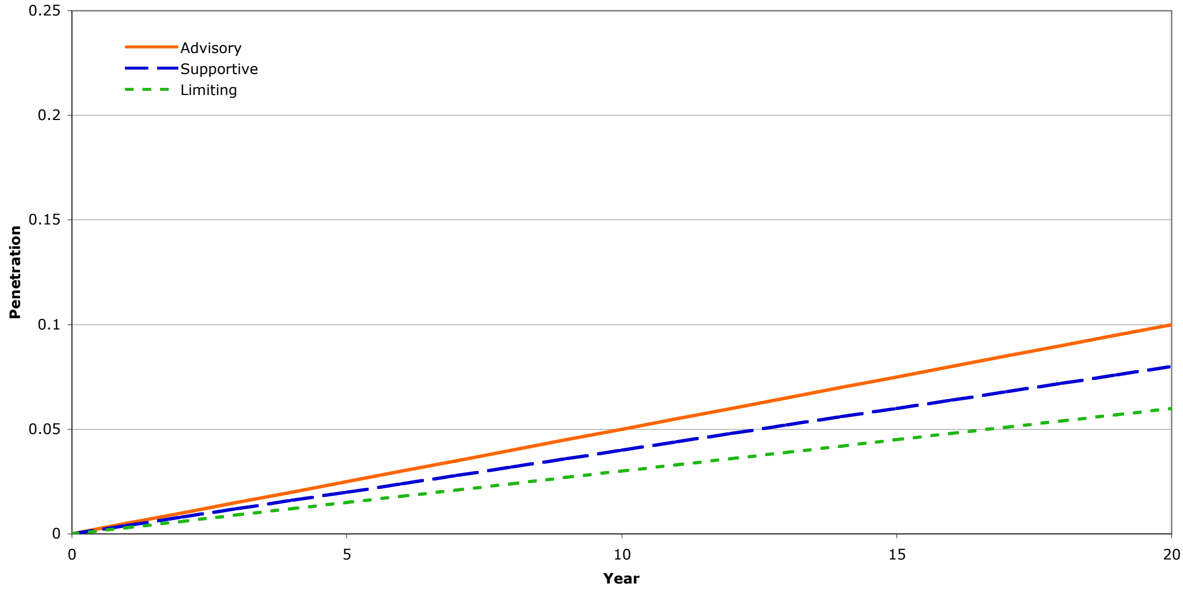


Table 5.7 shows the results of the economic analysis for a market driven approach. It can be seen that only the cheaper advisory system and limiting ISA result in a BCR above one. The other ISA devices all return a BCR of less than one. This is due to the cost of the devices when sold individually being greater than the break even price.

Table 5.7
Economic analysis results if ISA implementation was purely market driven

ISA device	BCR			Payback Period (years)			Break Even Price ($AU)		
	0%	4%	8%	0%	4%	8%	0%	4%	8%
Advisory – Speed Alert	1.57	1.38	1.20	11.7	13.0	15.0	672	592	513
Advisory – Speedshield	0.58	0.52	0.46	NA	NA	NA	672	592	513
Supportive – Speedshield	0.72	0.65	0.58	39.0	79.4	NA	1,279	1,138	1,002
Limiting – Speedshield	1.20	1.08	0.96	15.6	17.8	21.9	2,164	1,942	1,719

Table 5.8 shows the percentage reduction in crashes at different injury severities if it were left to the market to determine which vehicles are fitted with ISA over the 20 year duration of the scenario. Limiting ISA could reduce injury crashes by 3.3%, supportive ISA by 2.5% and 1.6% for advisory ISA. The low market penetration would result in relatively low crash reductions.

Table 5.8
Percentage reduction in injury crashes if ISA implementation was purely market driven by level of ISA and injury severity over 20 years

Injury Severity	Advisory	Supportive	Limiting
Fatal	2.3%	3.1%	3.6%
Serious	1.7%	2.6%	3.3%
Minor	1.6%	2.5%	3.3%
Total	1.6%	2.5%	3.3%

5.5 Heavy vehicles

Currently heavy vehicles (trucks and buses over 3,500 kg) make up about 3.7% of the total Australian fleet and sales represent a similar percentage (ABS, 2009a: FCAI, 2010). For this analysis it was assumed that the ongoing prevalence of heavy vehicles will remain static at 3.7%. The current penetration of drive-by-wire heavy vehicles is not known, hence it was assumed that all heavy vehicles could be fitted with supportive and limiting ISA for the purpose of the analysis. In this sense the analysis indicates the result if supportive and limiting ISA were available on all heavy vehicles at the price discussed earlier for the supportive and limiting device. As with fleet vehicles and the market driven scenario the retail costs of the ISA devices was used. Table 5.9 shows the results of the economic analysis. The increased cost of ISA devices purchased at retail price resulted in BCRs that are marginal at best. What has not been allowed for in this analysis is the increased costs of heavy vehicle crashes or any reduced benefit due to heavy vehicles already having top speed limiters fitted.

Table 5.9
Economic analysis results if ISA was implemented on heavy vehicles

ISA device	BCR			Payback Period (years)			Break Even Price ($AU)		
	0%	4%	8%	0%	4%	8%	0%	4%	8%
Advisory – Speed Alert	1.11	0.87	0.69	16.8	28.5	NA	646	532	437
Advisory – Speedshield	0.56	0.46	0.39	NA	NA	NA	646	532	437
Supportive – Speedshield	0.69	0.57	0.48	74.5	NA	NA	1,221	1,009	833
Limiting – Speedshield	1.14	0.95	0.79	15.0	23.4	NA	2,062	1,707	1,415

Table 5.10 shows the percentage reduction in crashes at different injury severities if heavy vehicles were fitted with ISA over the 20 year duration of the scenario. Limiting ISA could reduce injury crashes by 1%, supportive ISA by 0.6% and 0.3% for advisory ISA. These percentages are low because of the low percentage of heavy vehicles (3.7%) in the total fleet.

Table 5.10
Percentage reduction in injury crashes if ISA was implemented on heavy vehicles by level of ISA and injury severity over 20 years

Injury Severity	Advisory	Supportive	Limiting
Fatal	0.4%	0.7%	1.0%
Serious	0.3%	0.6%	1.0%
Minor	0.3%	0.5%	1.0%
Total	0.3%	0.6%	1.0%

5.6 Young drivers

Because ISA can be retrofitted to vehicles it can be targeted at a particular demographic of drivers, such as young drivers. A snapshot taken in the first quarter of 2010 revealed that the proportion of driver's license holders that were less than 25 year old was 13.8% in South Australia and 14.6% in Queensland. Data from the ABS shows that of people Australia wide 16.7% of people aged 16 to 80 are aged 16 to 24 while in South Australia this figure was 16.1% and in Queensland it was 16.9% (ABS, 2009b). By applying the difference in the ABS statistics between all of Australia, Queensland and South Australia to the licensing data obtained from Queensland and South Australia, 14.4% was determined to be the proportion of licensed drivers that are young drivers in Australia. It is then assumed that each young driver owns one vehicle and that the vehicle will be scrapped when the owner reaches 25 years of age hence the penetration into the fleet remains at 14.4%. Not all young drivers own their own vehicles hence the assumption of one vehicle per licensed young driver may be an over estimate. Given that young drivers tend to drive older vehicles the assumption that the vehicle would be scrapped when the driver reached 25 years of age did not seem an unreasonable assumption. This results in a shorter life span of vehicles in this scenario than in other scenarios.

In South Australia 78% of the people aged 16 to 24 are licensed drivers. This percentage was then multiplied by the number of 15 year olds in the Australian states to determine the number of ongoing fitments of ISA that would be required. This resulted in 281,630 vehicles being fitted each year to maintain 14.4% penetration. This results in twice the scrappage rate of the 'all vehicles' scenario, which used 1,000,000 vehicles per year to maintain 100% fleet penetration. As mentioned previously the Speedshield supportive and limiting device can not be fitted to cars without drive-by-wire, typically pre 2005 vehicles. Given that in South Australia the average age of a young driver's vehicle is 13.7 years it is likely that only a minority of young drivers drive post 2004 vehicles. For this reason the supportive and limiting ISA results should be viewed as using a theoretical device that can be fitted to all young drivers' vehicles that costs the same as the Speedshield device.

Table 5.11 shows the results of the economic analysis. Because of the greater scrappage rate of the vehicles used in the analysis the results are generally poor over the 20 year period. What has not been taken into account in this analysis is the greatly increased crash risk associated with younger drivers as discussed in Section 3. If this were allowed for, it is possible that the BCRs could be greater than one.

Table 5.11
Economic analysis results if ISA was implemented on young drivers vehicles

ISA device	BCR			Payback Period (years)			Break Even Price ($AU)		
	0%	4%	8%	0%	4%	8%	0%	4%	8%
Advisory – Speed Alert	0.86	0.71	0.59	29.7	NA	NA	442	390	341
Advisory – Speedshield	0.37	0.33	0.29	NA	NA	NA	442	390	341
Supportive – Speedshield	0.46	0.40	0.35	NA	NA	NA	815	719	630
Limiting – Speedshield	0.76	0.67	0.59	NA	NA	NA	1,362	1,201	1,052

Table 5.12 shows the percentage reduction in crashes at different injury severities if young drivers vehicles were fitted with ISA over the 20 year duration of the scenario. Limiting ISA could reduce injury crashes by 3.8%, supportive ISA by 2.2% and 1.1% for advisory ISA. As mentioned previously this does not allow for the greatly increased crash risk associated with younger drivers. If the over representation of young drivers found in Section 3 was applied to the percentage reductions shown in

Table 5.12 they would increase to between 3% and 5.1% for advisory ISA, between 5.9% and 10.2% for supportive ISA and between 10.2% and 17.6% for limiting ISA.

Table 5.12
Percentage reduction in injury crashes if ISA
was implemented on young drivers vehicles over 20 years

Injury Severity	Advisory	Supportive	Limiting
Fatal	1.6%	2.7%	4.1%
Serious	1.2%	2.2%	3.8%
Minor	1.1%	2.1%	3.8%
Total	1.1%	2.2%	3.8%

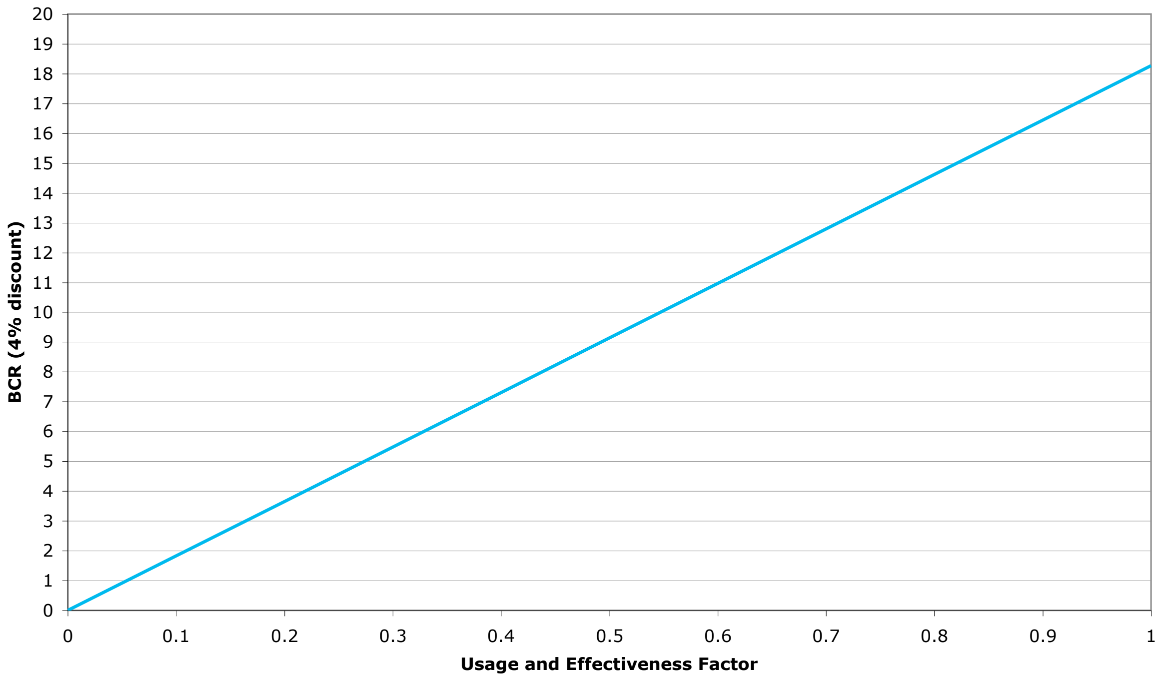
5.7 Navaid devices

The popularity of navaid devices has been noted as an opportunity to easily introduce advisory ISA to the vehicle market (Healy and Truong, 2009). As discussed in Section 4.2.1 navaids that can incorporate an advisory ISA function are commercially available.

Calculating the cost effectiveness of such devices is confounded by two main issues. The first of these is the actual amount of usage the advisory ISA function would get given that it does not automatically activate with the vehicle and can be deactivated when the navaid is on. The second unknown is the effectiveness of such an advisory ISA system given that elements of the system can be user adjusted, such as tolerance before an auditory warning is sounded. There is likely to be interaction between these two, for example if the user cannot set the tolerance to their desired level they may be more likely to not use the ISA function of the navaid device.

To be able to present some insight into the possible cost effectiveness of navaid devices, and to provide some comparison with a dedicated ISA device scenario, the graph shown in Figure 5.5 was produced. This graph shows the relationship between the BCR and a ‘usage and effectiveness factor’, which is the product of these unknown quantities, if all vehicles in the Australian states were equipped with an advisory ISA capable navaid device. The middle discount rate of 4% was utilised for this application. The subscription cost for a year of updates for Speed Alerts navaid version was used as the yearly cost per vehicle ($29.90). The cost of the navaid device was not included in the scenario calculations.

Figure 5.5
The relationship between BCR and the usage and effectiveness factor if all vehicles were fitted with an ISA capable Navaid device



This graph reveals that to obtain a BCR greater than one the usage and effectiveness factor must be greater than 0.055. To get the same BCR as implementing Speed Alert's dedicated advisory ISA device on all vehicles shown in Table 5.1, using the same discount rate of 4% (2.36), the usage and effectiveness factor would need to be 0.13. Such a usage and effectiveness factor would result if the navaid advisory ISA device was 50% as effective as a dedicated advisory ISA device and was used for 26% of the total distance driven (0.5 x 0.26 = 0.13).

5.8 Discussion of scenarios

All vehicles and drivers/riders have been treated equally in the scenarios. Care should therefore be taken when examining the economic factors, such as BCR, for scenarios that target groups that may have a differing risk of crash (or cost of crash) from the norm. The young driver and heavy vehicle scenarios are most effected by this limitation.

In comparing these scenarios it should be taken into account that different costs were applied to different scenarios, which had a large effect on the BCRs and the pay back periods. These prices were based on estimates given by the companies that produce the devices when asked about potential price reductions for large purchases. While the price reductions quoted were due to buying power, economies of scale may produce similar price reductions.

A limitation of the costs determined in the economic analysis is that installation costs were not included. While this may change the BCR results this does not effect the break even price. The break even price can therefore reflect the cost of the device and the installation costs per unit that would produce a BCR of one.

Given that the actual price of devices may differ and installation costs were not included it is important to consider the break even price. The best break even prices were achieved using the market driven scenario. Given that it is likely that a higher price per unit would be paid under the market driven scenario than the much more extensive new vehicles or all vehicles scenarios the BCR may provide a better comparison in this case. The BCR of the market driven scenario is well below that of the larger scale scenarios. The market driven scenario may also suffer from a negative self selection bias, meaning drivers that are less likely to speed are the drivers that are more likely to purchase an ISA device. This is supported by the work of Jamson (2005) who found that drivers who confessed to enjoying speeding were less likely to have an advisory system activated.

If the greatest injury crash reduction over the twenty year period is desired, the 'all vehicles' scenario presents the best option although the authors acknowledge that this would be practically impossible to achieve. The BCRs of the all vehicles and new vehicles scenario are similar although the new vehicles scenario is less sensitive to the discount rate as no initial costs are incurred.

In the scenarios which use the lowest quoted cost for the devices (all vehicles and new vehicles) the limiting system produced the greatest BCR while in the scenarios that used the most expensive cost per device the cheaper advisory and the limiting devices produced the highest BCR, albeit often only marginally above one.

It has been determined previously that while young drivers are over represented in crashes they tend to be the last to benefit from new vehicle based safety technology as they drive older vehicles than the rest of the population (Anderson et al. 2009). ISA presents the opportunity to reverse this trend as it can be retro-fitted to older vehicles. The cost-benefit analysis revealed that this would produce BCRs less than one although the greatly increased crash risk of this age group was not taken into account. If this is taken into account the BCRs may be above one and it could present a cost effective option. It is the authors' belief that, considering the data presented in this report, the combination of installing the strongest possible ISA device in young driver's vehicles as well as all new vehicles may be the most cost effective (and crash reduction effective) implementation scenario, although modelling this scenario accurately is outside the scope of this report. This approach may also be more publicly, and therefore politically, acceptable than implementing ISA on all vehicles. It must also be considered if this would only apply to a vehicle owned by the young driver or to any vehicle that may be driven by the young driver.

Another approach that may be possible to promote is the organisation fleet vehicles scenario although this would only provide limited penetration. The new vehicles, organisation fleet vehicles and market driven scenarios may produce a vehicle market which allows an individual to choose if they would like to drive an ISA equipped vehicle or not. This would potentially result in drivers that desire to speed simply not selecting an ISA equipped vehicle to purchase. Consequently this would force such drivers to purchase older vehicles that are less crashworthy, although this may not apply to the market driven scenario if vehicles of all ages are retro-fitted with ISA.

The navaid scenario suggests that even if these devices are only infrequently used and less effective than dedicated devices they may still prove a cost effective option. More information is required on the use of such devices before this can be known with any degree of certainty. It should be noted that even if they are cost effective the crash reductions they produce may be much smaller than a dedicated advisory system.

6 Key Points

The literature shows positive results from all levels of ISA although the magnitudes of the benefits differ greatly.

This is most likely explained by the logic that ISA will be more effective in situations with greater speeding problems, therefore if it is trialled in an area where speeding is a large problem it will show a large effect while if it is trialled in an area where speeding is a minor problem it will have a small effect.

Determining the prevalence of speeding crashes in Australia is difficult due to unreliability in the mass crash data with respect to determining the presence of speed as a factor in a crash, however certain insights can be gained by segregating this data. These insights include:

- Speeding crashes are evenly split between metropolitan and rural areas hence ISA should operate in both areas.
- Curves are probably over represented in speeding crashes therefore consideration should be given to including maximum curve speeds as well as speed limits in an ISA speed map.
- Speeding crashes are spread throughout the day although more occur between 3pm and 1am than at other times. This highlights the advantage that ISA has (by operating at all times) as opposed to other deterrents that are limited by resource availability.
- Young drivers/riders and motorcyclists are over represented in speeding crashes therefore consideration should be given to ensuring these groups are given priority in the introduction of ISA.

A more detailed analysis was conducted that applied Kloeden's risk curves to speed distributions with and without ISA to determine the reduction in crash risk that would be achieved by implementing different levels of ISA. This analysis revealed that:

- If advisory ISA was fitted to all vehicles it would reduce injury crashes by 7.7% and save $1,226 million per year
- If supportive ISA was fitted to all vehicles it would reduce injury crashes by 15.1% and save $2,240 million per year
- If limiting ISA was fitted to all vehicles it would reduce injury crashes by 26.4% and save $3,725 million per year

State representatives were contacted to discuss the current progress of their speed limit mapping and the cost associated with producing and maintaining the map. Of the six states, two have completed a state-wide map while another has mapped about a third of the state. The remaining three states have not begun mapping. Victoria could provide the most complete picture of costs having spent $700,000 on completing its map and about $1.9 million on developing a system to maintain the map. They estimated that around $400,000 may be spent every year to keep the map up to date (C Jones 2010, pers. comm., 21 Jan). Applying these costs to all states the initial mapping cost for all states would be $15.6 million and the ongoing cost would be $2.4 million per year.

Industry representatives were contacted to discuss the current ISA devices available and the costs of their devices considering three different sales volumes, a single unit, 50,000 units per year and one million or more units. They were also asked how they would expect the technology to change in cost over time. Two advisory devices and one supportive and limiting device were available. The supportive and limiting device could not be installed in most vehicles manufactured before 2005. They estimated that:

- For advisory device A, a single unit costs $800, 50,000 units cost $500 per unit and one million units cost $400 per unit with expected reductions of 30% in 2011 and 50% in 2012 from current prices.
- For advisory device B a single unit costs $1200, large orders could bring the price as low as $300. No expected reductions in price with time were quoted.
- For the supportive and limiting device a single unit costs $1800, 50,000 units cost $650 per unit and one million units cost $520 per unit. No expected reductions in price with time were quoted due to the uncertainty in such a prediction.
- A subscription for advisory ISA functionality on a navaid device costs $29.90 per year.

A cost-benefit analysis was conducted using several implementation scenarios. The scenarios were all vehicle, new vehicles, fleet vehicles, market driven, heavy vehicles, young drivers and navaid devices. The economic indicators that were calculated were BCR, pay back period and break even price. Installation costs were not included in the calculation of these economic indicators. The results revealed that:

- The BCR and pay back period were heavily influenced by the unit price.
- Break even price provides a useful economic measure that is not effected by uncertainty in unit and installation costs.
- BCRs range from 0.29 to 4.03 over 20 years for ISA implementation.
- Payback periods range from 3 to over 100 years for ISA implementation.
- Break even prices range from $341 to $2,164 per unit for ISA implementation, the highest price always for limiting ISA, the lowest always for advisory ISA.
- The BCR was greatest for the all vehicles and new vehicles implementation scenarios.
- Even if navaid ISA devices are only infrequently used and are less effective than dedicated ISA devices they may still prove a cost effective option.
- If the elevated risk of young drivers could be taken into account implementation of ISA on young drivers vehicles may present a cost effective option.
- Limiting ISA generally produced the greatest BCR for a given scenario.
- Installing the strongest possible ISA device in young driver’s vehicle’s and in new vehicles may represent the most cost effective implementation method.
- Care should be taken when deciding on an ISA implementation path that a vehicle market is not produced where older, less safe, vehicles are made more attractive to drivers who are most likely to be responsible for a speeding crash, such as young drivers.

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References

Agerholm N, Waagepetersen R, Tradisauskas N, Lahrmann H (2008) 'Intelligent speed adaptation in company vehicles' in Proceedings of IEEE Intelligent Vehicles Symposium, Eindhoven, The Netherlands, 4-6 June 2008.

Anderson RWG, Doecke S, Searson D (2009). Vehicle age-related crashworthiness of the South Australian passenger fleet. CASR062. Adelaide: Centre for Automotive Safety Research.

ABS (2009a). Motor vehicle census. 9309.0. Canberra: Australian Bureau of Statistics

ABS (2009b). Population by Age and Sex, Australian States and Territories, Jun 2009. 3201.0. Canberra: Australian Bureau of Statistics

ABS (2010). Consumer Price Index, Australia, Dec 2009. 6401.0. Canberra: Australian Bureau of Statistics

Adell E, Várhelyi A, Hjälmdahl M (2008), 'Auditory and haptic systems for in-car speed management: a comparative real life study', Transportation research part f, 11, pp. 445-458.

Biding T, Lind G (2002). Intelligent speed adaptation: results of large-scale trials in Borlänge, Lidköping, Lund and Umeå during the period 1999-2002. 2002:89 E. Borlänge: Vägverket – Swedish National Road Administration

BITRE (2009). Cost of road crashes in Australia 2006. BITRE118, Canberra: Bureau of Infrastructure, Transport and Regional Economics.

Cairney P, Imberger K, Walsh K, Styles T (in press) Reviewing ITS technologies and road safety opportunities. Australian Road Research Board for Austroads.

Carsten O (2004) 'ISA - from fields trials to reality', PACTS conference Targets 2010: No Room for Complacency, London, 10 February 2004.

Carsten O, Fowkes M, Lai F, Chorlton K, Jamson S, Tate F, Simpkin B (2008). ISA – UK: final report. Leeds: Institute for Transport Studies, University of Leeds and MIRA Ltd

COWI (2006) Cost benefit assessment and prioritisation of vehicle safety technologies. European Commission Directorate General Energy and Transport.

Crackel L (2009), 'Intelligent speed assist in Western Australia – where have we been and where are we going?' in Proceedings of the Intelligent Speed Adaptation Conference, Sydney, Australia, 10 November 2009.

Crackel L, Toster N (2007), 'Intelligent speed adaptation – Western Australia's demonstration project' in Proceedings of Australasian Road Safety Research, Policing and Education Conference, Melbourne, Australia, 12-14 November 2007.

Driscoll R, Page Y, Lassarre, Ehrlich J (2007) 'LAVIA – an evaluation of the potential safety benefits of the French intelligent speed adaptation project' in Proceedings of the 51st AAAM Conference, Melbourne, Australia, 15-17 October 2007.

Elvik R, Christensen P, Amundsen A (2004) Speed and road accidents. Oslo: The institute for Transport Economics

FCAI (2010) New vehicles market, viewed 3 March 2010, <http://www.fcai.com.au/sales/new-vehicle-market>

Healy D, Truong J (2009) 'Intelligent speed assist (ISA) technology and navaid systems – seizing the moment' in Proceedings of the Intelligent Speed Adaptation Conference, Sydney, Australia, 10 November 2009.

Hultkrantz L, Lindberg G (2003) 'Intelligent economic speed adaptation' 10th International Conference on Travel behaviour Research, Lucerne, Switzerland, 10-15 August 2003.

Jamson S (2006), ‘Would those who need ISA, use it? Investigating the relationship between drivers’ speed choice and their use of a voluntary ISA system’ Transportation research part f, 9, pp. 195-206

Jamson S, Carsten O, Chorlton K, Fowkes M (2006) Intelligent speed adaptation literature review and scoping study. Leeds: Institute for Transport Studies, University of Leeds and MIRA Ltd

Kloeden CN (2009) Vehicle speeds on Queensland roads – May 2009, Adelaide: Centre for Automotive Safety Research.

Kloeden CN, McLean AJ, Glonek G (2002) Reanalysis of travelling speed and the risk of crash involvement in Adelaide South Australia, CR 207, Adelaide: Road Accident Research Unit for Canberra: Australian Transport Safety Bureau

Kloeden CN, McLean AJ, Moore VM, Ponte G (1997) Travelling speed and the risk of crash involvement, CR172, Canberra: Federal Office of Road Safety, Transport and Communications.

Kloeden CN, Ponte G, McLean AJ (2001) Travelling speed and the risk of crash involvement on rural roads, CR 204, Adelaide: Road Accident Research Unit for Canberra: Australian Transport Safety Bureau

Kloeden CN, Woolley JW (2009) Vehicle speeds in South Australia 2007, CASR051, Adelaide: Centre for Automotive Safety Research.

Lahrmann H, Agerholm N, Tradisauskas N, Berthelsen, K Harms, L (in press) ‘Pay as you speed, ISA with incentive for not speeding, results and interpretation of data’, Accident analysis and prevention.

Lahrmann H, Madsen JR and Boroch T (2001) ‘Intelligent speed adaptation — development of a GPS based ISA-system and field trial of the system with 24 drivers’ in Proceedings of the Eighth World Congress on Intelligent Transport Systems, Sydney, Australia, 30 September–4 October.

Lai F, Chorlton K, Carsten O (2007) ISA – UK: Overall field trial results. Leeds: Institute for Transport Studies, University of Leeds and MIRA Ltd

Litman TA (2009), Transportation cost and benefit analysis, techniques, estimates and implications, viewed 1 March 2010, <http://www.vtpi.org/tca/tca01.pdf>

Lancashire County Council 2009, ISA trial on the move, Lancashire County Council, Lancaster, 11 September.

MUARC (2008) Safer Vehicle Purchases: Developing cost-effectiveness estimates for fleet managers and others – Part A: Crash profiles and risk estimates, AP–R324/08, Monash University Accident Research Centre for Sydney: Austroads.

New South Wales Centre for Road Safety. (2008) Road traffic crashes in New South Wales 2007. Sydney: New South Wales Centre for Road Safety, Road Traffic Authority.

Oei HL, Polak PH (2002), ‘Intelligent speed adaptation (ISA) and road safety’ International association of traffic and safety sciences research, 26(2), pp 45-51.

Päätalo M, Peltola H, Kallio M (2001). ‘Intelligent speed adaptation-effects on driving behaviour’ in Proceedings of Traffic Safety on Three Continents Conference, Moscow, Russia, 19-21 September 2001.

Pallas T (Minister for Roads and Ports) 2010, Trial of new technology to slow down speeding drivers, Vicroads, Melbourne, 13 January.

Regan RA, Young K, Haworth N (2003) A review of literature and trials of intelligent speed adaptation devices for light and heavy vehicles. Monash University Accident Research Centre for Sydney: Austroads.

Regan M, Young K, Tomasevic N, Mitsopoulos E, Tierney P, Healy D, Connelly K, Tingvall C (2005) ‘Final results of a long-term evaluation of intelligent speed adaptation, following distance warning and seatbelt reminder systems: system and interactive effects’ in Proceedings of 12th World Congress on ITS, San Francisco, United States of America, 6-10 November 2005.

RTA (2009) Annual report. Sydney: Roads and Traffic Authority.

Tate F, Carsten O (2008). ISA – UK: implementation scenarios. Leeds: Institute for Transport Studies, University of Leeds and MIRA Ltd

Taylor GW (2006). Speed choice and modelling of the impacts of speed on safety and the environment, Ontario: G.W. Taylor Consulting

Transport for London (TfL) 2009, TfL announces trial of intelligent speed adaptation, TfL, London, 11 May

Várhelyi A, Hjälmdahl M, Hydén C, Draskóczy M (2004), 'Effects of an active accelerator pedal on driver behaviour and traffic safety after long-term use in urban areas', Accident analysis and prevention, 36, pp. 729-737.

Várhelyi A, Mäkinen T (2001), ' The effects of in-car speed limiters: field studies', Transportation Research Part C, 9, pp. 191-211.

Vlassenroot S, Broekx S, De Mol J, Int Panis L, Brijs T, Wets G (2007), 'Driving with intelligent speed adaptation: final results of the Belgian ISA-trial', Transportation Research Record Part A, 41, pp. 267-279.

Wall JP, Job SRF, Boland P, Cuenca V, Creef K, Beck J, and Saffron D (2009) 'The New South Wales intelligent speed adaptation trial' in Proceedings of the Intelligent Speed Adaptation Conference, Sydney, Australia, 10 November 2009.

Wundersitz LN, Doecke S, Baldock M (in press). Annual performance indicators of enforced driver behaviours in South Australia, 2008. CASR Report Series CASR058. Adelaide: Centre for Automotive Safety Research.