Road Safety Benefits of Intelligent Speed Adaptation for Australia

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John P Wall
Ph 02 42212477
Email: john_wall@rta.nsw.gov.au
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Kim Creef[2;] John P Wall[1]; Peter Boland[1]; Vanessa Vecovski[1]; Margaret Prendergast[1;]; Jacqueline Stow[1]; Ralston Fernandes[1]; Janine Beck[3]; Sam Doecke[4]; Jeremy Woolley[4]

[1] NSW Centre for Road Safety, Roads and Traffic Authority of New South Wales,
[2] Stomp Services Pty Ltd, [3]Kutikina Trust; [4]Centre for Automotive Safety Research

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Abstract
Intelligent Speed Adaptation (ISA) refers to in-vehicle technology systems which assist drivers to keep to or below the speed limit. In 2009-2010 the NSW Centre for Road Safety conducted the NSW ISA Trial which was the largest road safety technology trial ever conducted in Australia. Over 110 light vehicles from private and company fleets were fitted with an Advisory ISA device and a speed data recorder. Over 7.6 million vehicle speed data records were collected and analysed to measure changes in drivers' speed compliance. The Advisory ISA system reduced speeding in 89 per cent of trial vehicles. The median probability of speeding was also reduced by almost 30 per cent. Initial modelling suggested that if all vehicles in NSW were equipped with the Advisory ISA system trialled, road deaths would be reduced by 8.4 per cent and the number of people injured would be reduced by 5.9 per cent.

Results of the trial demonstrated that Advisory ISA technology has the potential to realise substantial road safety benefits by increasing compliance with speed limits.

This paper presents further findings of the trial and additional crash reduction benefits and community savings attributed to this technology. The analysis includes the impact of Advisory ISA at various vehicle penetration levels within Australia as well as the estimated reductions in the number of serious injury and fatality crashes in future years.

Background
Speeding is recognised as a significant road safety issue both in Australia and internationally. In NSW, approximately 40 per cent of all fatal crashes have speed as a contributing factor. On average, approximately 200 people die each year in NSW as a result of being involved in a speed related crash (RTA 2011). International research has found a clear relationship between changes in average traffic speed and crash outcomes (ATC 2011). Furthermore, the research suggests that even small reductions in speed will yield substantial safety benefits. The Nilsson power model shows that the number of fatal crashes will increase in proportion to the fourth power of an increase in

mean vehicle travel speed. According to the model, a five per cent increase in speed leads to around a 15 per cent increase in serious injury crashes and a 22 per cent increase in fatal crashes (Nilsson 2004).

There has been extensive international research to indicate that ISA technology is an effective tool to reduce speeding and therefore realise substantial road safety benefits.

The NSW Centre for Road Safety (NSWCRS) has recently completed the NSW Intelligent Speed Adaptation Trial. The trial was, at the time, the largest trial of ISA ever conducted outside of Sweden, with 104 vehicles participating for the duration of the trial, and the largest road safety technology trial ever conducted in Australia.

What is ISA?

ISA refers to in-vehicle technology systems which assist drivers to keep to or below the speed limit. By using global positioning system (GPS) technology and on-board maps which are linked to a speed zone database, the ISA system 'knows' where the vehicle is and what the speed limit is for that road at all times. There are three different types of ISA systems; Advisory, Supportive and Limiting. The Advisory system warns the driver via an audible alarm and or visual feedback when the legal speed limit has been exceeded. Supportive and Limiting ISA systems can also limit the vehicle's speed by interacting with the throttle or braking systems.

International ISA research

ISA technology has been well researched internationally, although ISA trials have differed widely between jurisdictions in terms of their objectives, methodologies and presentation of change in speed behaviour.

Europe has trialled ISA technology over the past decade. Eleven European countries conducted ISA trials, including; Austria, Belgium, Denmark, Finland, France, Hungary, The Netherlands, Norway, Spain, Sweden and the United Kingdom (ETSC, 2006). The largest trial conducted to date was in Lund, Sweden in 2001, which involved over 200 vehicles fitted with a Supportive ISA system. The Lund trial showed a reduction in speeding of 20 to 53 per cent and potential crash reductions of up to 32 per cent of fatal crashes and up to 25 per cent of injury crashes (Hjalmdahl et al 2002).

Estimates for crash reductions are generally lower for Advisory ISA systems than for the Supportive and Limiting ISA systems. Carsten and Tate (2005) suggest that the mandatory use of a Limiting ISA system could bring about a reduction of serious crashes of up to 50 per cent, while the voluntary use of an Advisory ISA system could result in a crash reduction of up to 10 per cent across the road network.

Australian ISA research

Four ISA trials have been completed in Australia, and a further trial has recently begun.

The TAC Safecar project was the first on-road trial of ISA technology in Australia. It was conducted in 2006 by the Monash University Accident Research Centre (MUARC) in

partnership with the Transport Accident Commission (TAC) and Ford Australia (Regan et al., 2006). Fifteen 'SafeCars' were fitted with a range of Intelligent Transport Systems (ITS) technologies, including Supportive ISA. Regan et al (2006) concluded that the ISA system reduced mean speeds up to 1.4 km/h and reduced the amount of time drivers spent travelling 10 km/h or more above the speed limit by up to 65 per cent. Modelling conducted as part of the SafeCar project also concluded that the ISA system trialled could bring about a reduction in fatal crashes of up to 8 per cent and injury crashes of up to 6 per cent (Regan et al 2006)

The intention of the Western Australian (WA) ISA demonstration project was to create demand within the general community for ISA technology, to demonstrate that reliable ISA is technically possible (even on a large geographical scale) and to develop systems in government necessary to implement ISA systems (Crackel and Toster, 2007). Trial participants revealed a very favourable response to the technology, despite some occasional minor technical problems being experienced by some drivers.

The Transport Accident Commission (TAC) in collaboration with the Victorian Transport Association (VTA), and with the cooperation of three heavy vehicle transport companies, conducted a small scale ISA trial in an attempt to assess the relative merits of ISA on driver speed choice, ISA acceptability and fuel consumption. Phase One analysis indicated that the drivers found the ISA technology helpful in preventing them from speeding and the divergence of opinion with driver acceptability and speed violations suggested the relationship between ISA effectiveness and user acceptability required further investigation (Truong, *personal communication*, 08/09/2010).

A Victorian trial with recidivist speed offenders was announced in January 2010 (Pallas, 2010). Drivers were divided into two groups; one group was alerted of the speed limit via Advisory ISA and the other group underwent a speed awareness educational program. The trial has continued through 2011.

Benefits of ISA

A recent MUARC review (Young et al 2009), concluded that ISA technology will have a range of benefits for Australia, including the opportunity to save running costs, fuel, carbon emissions and improve traffic flow. The most significant benefit being the reduction in the incidence and severity of speeding related crashes.

Recent research conducted by The Centre for Automotive Safety Research (CASR) for the Queensland Department of Transport and Main Roads analysed speeding crashes using mass crash data collected by the Australian states and territories from 2004 to 2008. This study suggested that the use of ISA technology across the national road network could result in reduced injury crashes of between 7.7 per cent for Advisory ISA and 26.4 per cent for Limiting ISA. The research suggests that full implementation of Advisory ISA could save $1,226 million per year across Australia. These figures increase to $2,240 million per year for Supportive ISA and $3,725 million per year for Limiting ISA (Doecke and Woolley, 2011).

Possible barriers to the introduction of ISA as identified by other trials

One of the most significant challenges to deploying ISA technology in Australia, or anywhere in the world, is ensuring that the infrastructure required to support ISA is developed, implemented and maintained. ISA is unlikely to achieve widespread support until it can provide reliable and accurate advice on speed limits in all circumstances and throughout all states and territories. Driver acceptance and usability is another significant challenge for even the most technically advanced ISA system.

Young et al (2009) concluded that the long-term benefits of deploying ISA technology in Australia will far outweigh the costs and challenges of its development and implementation.

The New South Wales ISA Trial

The overall aim of the NSW ISA Trial was to investigate the effectiveness of Advisory ISA devices in improving speed limit compliance by NSW drivers. The trial area was located 45 km south of Sydney within the Illawarra region of NSW, and included three local government areas (Wollongong City, Shellharbour City and Kiama Municipality). The total length of the road network in this area was approximately 2,500 km. Over 4,000 speed signs were located allowing 932 speed zones and 452 curve Advisory signs to be mapped. The area has a wide variety of speed zones including 40 km/h high pedestrian, 40 km/h school zones, 50 km/h and 60 km/h urban areas, 80 km/h winding rural roads and 100 km/h freeways.

The trial began with 114 participating vehicles, of which 104 participated for the full duration of the Trial. Trial participants included a combination of drivers from nine non-government Illawarra businesses and general population private drivers.

The Advisory ISA device selected for the trial was one of the few personal navigation devices currently available with an open software platform that enabled the deployment of customised two-way telematic applications. This two way communication capability enabled the ISA device to be connected to a centralised computer server that allowed automatic speed zone changes to be sent to the device continuously.

To measure the baseline speed compliance of drivers before the ISA device was installed in their vehicle, a separate GPS based speed and location data recorder was fitted to all vehicles at least one month before the ISA device was installed. The data recorder remained in the vehicle until the end of the trial. It logged the speed and location of each vehicle every ten seconds, producing a total of 7.5 million speed records. The data recorder was used to measure speed behaviour of drivers, before, during and after the ISA device was operating in the vehicle. Speed data analysis used vehicle ‘free speeds’, defined as the speed of a vehicle when it travelled at least 75% of the speed limit, 2.5 million speed measurements were recorded at speeds above 75% of the speed limit.

The NSW ISA Trial demonstrated that Advisory ISA technology had a positive impact on reducing the amount of time drivers spent speeding, as well as reducing the level and

duration of speeding amongst the majority of participating drivers. Key findings of the trial included:

- When the ISA device was active in vehicles, 89 per cent of drivers reduced the amount of time they spent exceeding the speed limit.
- When the ISA device was active in vehicles, the probability of speeding was reduced by almost one third.
- The ISA technology was equally effective at reducing speeding amongst all driver demographics, including 'repeat speeders' and 'deliberate speeders', with the exception of younger drivers aged 25 years or less.
- The Advisory ISA devices were generally well received by trial participants. Many drivers reported that the ISA device was particularly useful in preventing "accidental" speeding and ensuring drivers were always aware of the speed limit.

Estimation of casualty benefits associated with the NSW ISA Trial

Nilsson's power model was used to calculate the casualty benefits from changes in mean speeds that occurred during the NSW ISA Trial. By employing Elvik's (2009) power estimate for fatalities (3.87) and injuries (2.67) to the reduction in mean speed observed during the trial from 69.4 km/h in the 'before ISA' period to 67.9 km/h in the 'during ISA' period (0.9775), it was estimated there would be approximately 8.4 per cent reduction in fatalities and 5.9 per cent reduction in injuries if all vehicles in NSW had an Advisory ISA device fitted. NSW could therefore expect to save more than 35 lives per year and reduce the number of injured road users by more than 1455. This would equate to an annual saving of more than $370 million[1,2] in the cost of NSW road trauma. For the purpose of this analysis an assumption was made that drivers participating in the NSW Trial were representative of all drivers in NSW, and that implementation of ISA in all vehicles would result in comparable and complete levels of driver compliance.

Nilsson's power model is not the only method that can be used to estimate casualty reductions from mean travel speed changes, although it provides a more conservative estimate of change. Analysis from the NSW ISA Trial demonstrated that Advisory ISA technology has the potential to save a significant number of lives, injuries and associated costs. On a larger scale, the potential benefits of ISA should all vehicles in Australia be fitted with an Advisory ISA device would be even more considerable.

To further quantify the benefits of Advisory ISA, the NSWCRS engaged CASR in 2011 to conduct further analysis of the NSW ISA trial results, with the overall intention of evaluating the road safety benefits of ISA for Australia (Doecke et al, 2011).

The CASR analysis of the NSW ISA trial results had the following aims:

- To estimate the reduction in serious and fatal crashes due to Advisory ISA in Australia, and to do so at different penetration levels.

1 Using the willingness to pay method based on September 2009 values.

2 The willingness-to-pay approach estimates the value of life in terms of the amounts that individuals are prepared to pay to reduce risks to their lives (this is the value to the individual before the fact). This approach uses people's preferences (either stated or revealed) to ascertain the value they place on reducing risk to life, and reflects the value of intangible elements such as quality of life and joy of living. This approach is now used by the NSW Roads & Traffic Authority for calculating the benefits and costs of safety related projects.

- To determine if the effect of Advisory ISA is sensitive to the amount of time the driver is exposed to the Advisory ISA device.
- To predict the number of serious and fatal crashes that could be saved by Advisory ISA in future years.

The methods and results from CASR's analysis of the NSW ISA trial results are presented in the following sections of this paper, with further detail regarding the complete project found in Doecke et al. (2011).

Methods

Reduction in crashes due to Advisory ISA in Australia

ISA results in a reduction in the vehicle's travelling speed which then reduces the risk of that vehicle being involved in a crash. To calculate the change in risk from the 'before ISA' period and the 'during ISA' period, measurements were weighted by speed to produce distance-based measurements. The percentage of distance spent at each speed was calculated for the 'before ISA' period and 'during ISA' period by speed zone.

The reduction in crash risk was calculated by applying Kloeden's risk curves for travel speed to the speed distributions found in the trial. Kloeden's risk curves are widely recognised in the road safety community and are based on Australian crashes (Kloeden 2002). The reduction in crash risk due to ISA was then estimated in terms of the difference in the in total crash risk produced by these speed profiles.

Initial modelling by CRS researchers used changes in mean speeds during the NSW ISA trial to calculate the potential casualty reductions of advisory ISA. These potential casualty reductions were significant, but given ISA changes the shape of the distribution of speed, by using a risk curve applied to the distribution of speed rather than the power model applied to mean speed the entire change can be captured.

Sensitivity of Advisory ISA effect to time

To determine if the effect of Advisory ISA differed during the time that the ISA device was activated in vehicles, the data in the 'during ISA' period was grouped by week. Two measures of the sensitivity of ISA to time were used; changes in mean speed and changes in percentage of distance travelled over the speed limit. The percentage of distance travelled over the speed limit was examined in three ways; percentage of distance travelled speeding by 5 km/h or less, percentage of distance spent speeding by more than 5 km/h and up to 10 km/h, and speeding by more than 10 km/h. The change in both mean speed and percentage of distance travelled over the speed limit over the 12 week 'during ISA' period was determined by calculating the slope of a fitted linear trend line for each vehicle.

Projected reduction of crashes due to Advisory ISA in Australia in future years

The potential projected reduction in crashes attributable to all vehicles having Advisory ISA in future years was determined by multiplying the predicted number of fatal and injury crashes in Australia in 2015, 2020 and 2030 by the percentage reduction in crashes determined earlier. The predicted number of fatal and injury crashes in Australia

in 2015, 2020 and 2030 was calculated by fitting an exponential trend line to previous years data and therefore determining the percentage change in crashes each year.

Results

Reduction in crashes due to Advisory ISA in Australia

The greatest reduction in casualty crash risk from the use of Advisory ISA was found in 70 km/h speed zones (25.4 per cent reduction) followed by 110 km/h speed zones (23.6 per cent reduction) and 60 km/h speed zones (21.9 per cent reduction).

Table 1: Percentage reduction in casualty crash risk in Australia produced by Advisory ISA, by speed zone

Speed Limit (km/h)	Crash risk reduction (%)
40	12.1
50	16.6
60	21.9
70	25.4
80	11.7
90	13.7
100	18.8
110	23.6

The casualty crash risk reductions were multiplied by the average number of serious and fatal crashes per year from 2004 to 2008 to determine the annual crash reductions that could be achieved if all vehicles in Australia had an Advisory ISA device fitted. It is estimated that 3,300 serious crashes and 265 fatal crashes could be saved per year.

Table 2: Serious casualty crash reductions per year produced by Advisory ISA in Australian states

Speed Limit (km/h)	State								Total
	ACT[3]	NSW[4]	NT	QLD	SA	TAS	VIC	WA	
40	-	3.6	1.2	9.0	1.0	0.3	11.7	1.6	28.3
50	-	121.3	4.5	108.9	39.3	6.6	163.5	100.2	544.3
60	-	179.9	21.9	514.1	72.9	10.7	431.6	131.4	1362.4
70	-	53.6	6.9	82.2	5.3	2.2	130.1	86.9	367.2
80	-	21.0	7.8	59.5	12.2	3.7	85.8	23.4	213.3
90	-	5.1	0.7	5.4	1.0	0.0	6.1	9.4	27.6
100	-	45.3	7.2	186.2	30.4	20.3	219.8	33.2	542.4
110	-	14.8	5.6	22.1	37.2	3.4	14.2	57.2	154.4
Total	70	444.5	55.7	987.4	199.2	47.2	1062.8	443.2	3310.0
% Reduction	19.3	19.2	18.7	19.6	19.3	18.6	19.1	19.7	19.2

[3] The ACT does not record speed zones for crashes. The percentage reductions found in other states and territories were applied to the ACT data

[4] NSW crash data reported by police does not differentiate between serious and minor injuries. An estimate was made using the ratio of serious to minor injuries reported in the Bureau of Infrastructure, Transport, Regional Economics report on road crashes in Australia, 2009

Table 3: Fatal crash reductions per year produced by Advisory ISA in Australian states

Speed Limit (km/h)	State								Total
	ACT	NSW	NT	QLD	SA	TAS	VIC	WA	
40	-	0.4	0.1	0.4	0.0	0.0	0.3	0.1	1.3
50	-	11.4	0.3	3.9	1.5	0.5	3.8	5.4	26.8
60	-	16.9	1.5	18.0	5.8	1.1	12.6	5.2	61.2
70	-	7.4	0.6	3.5	0.7	0.4	5.5	4.4	22.5
80	-	7.1	0.8	5.1	1.6	0.6	5.0	2.2	22.4
90	-	2.1	0.0	0.4	0.4	0.1	0.8	1.5	5.1
100	-	26.4	1.3	23.4	6.1	3.8	25.6	3.8	90.5
110	-	7.0	1.8	2.3	5.2	1.8	2.3	12.1	32.5
Total	2.9	78.8	6.5	56.8	21.4	8.4	55.9	34.6	265.3
% Reduction	18.9	18.5	19.1	18.8	19.5	19.1	18.7	19.8	18.9

The estimated crash reductions by penetration level in Table 4 assume a linear relationship between ISA penetration and crash reduction. A 'critical mass' may exist at which the benefits of ISA accrue rapidly for the entire vehicle network. Searson et al, 2011 have researched this topic on behalf of the NSWCRS and results will be available in the latter half of 2011.

Table 4: Serious and fatal crash reductions per year produced by Advisory ISA in Australia, by penetration level

Penetration of ISA (%)	Serious Injury Crashes			Fatal Crashes			Total saving ($M)
	Number	%	Savings ($M)	Number	%	Savings ($M)	
20	662	3.9	290.2	53.1	3.8	158.5	448.7
40	1324	7.7	580.4	106.1	7.6	317.1	897.4
60	1986	11.6	870.5	159.2	11.3	475.6	1346.1
80	2648	15.5	1160.7	212.2	15.1	634.1	1794.8
100	3310	19.3	1450.9	265.3	18.9	792.6	2243.5

Sensitivity of Advisory ISA effect to time

The 'during ISA' period of the trial was tested to explore whether the effect of Advisory ISA was sensitive to the length of time the driver had been exposed to the ISA device. Changes in mean speed and changes in percentage of distance travelled over the speed limit were examined. The existence of any sensitivity of the effect of ISA to time was tested for the sample of drivers as a whole and also by driver characteristics such as age, gender and licence type. No evidence was found that the effect of Advisory ISA was sensitive to the length of time the device was installed in drivers' vehicles.

Projected crash reductions

To project crash reductions in 2015, 2020 and 2030 an estimation of the change in crashes over time was required. The current trend in fatal crashes was determined to be a 3.3 per cent reduction per year and serious crashes 1.6 per cent increase per year.

Table 5: Serious and fatal crash savings if all vehicles were equipped with Advisory ISA in future years

Year	Saved serious crashes	Saved fatal crashes
2015	3872.8	219.3
2020	4190.0	203.8
2030	4904.5	175.9

Conclusions and discussion

ISA technology has been well researched internationally and increasingly in Australia, studies demonstrating ISA has the ability to significantly reduce speeding. The NSW ISA Trial has demonstrated that Advisory ISA technology has the potential to deliver considerable road safety benefits by reducing the level and duration of speeding.

CASR's modelling for the NSW ISA Trial determined that if all Australian vehicles were fitted with an ISA device then a reduction of 19.3 per cent of serious crashes and 18.9 per cent of fatal crashes could be achieved (Doecke et al, 2011). This represents a reduction of over 3,300 serious crashes and 265 fatal crashes per year.

Projecting this modelling into future years, it can be estimated that if all Australian vehicles were fitted with an Advisory ISA device, then approximately 3873 serious crashes and 219 fatal crashes could be avoided in 2015. The estimated serious crash reductions increase to 4190 crashes in 2020 and 4905 crashes in Australia in 2030. This modelling assumes that crash rates will continue to change at the same rate as per the past four or five years.

All Australian states and territories are at different stages of researching and promoting ISA technology. In NSW the RTA are currently working on a number of projects to enable wide scale deployment of ISA across the State. The RTA will be the first government fleet in Australia to install customised Advisory ISA devices into its entire shared vehicle fleet by 2011-2012. The RTA is also in the process of developing a smartphone Advisory ISA application for major mobile platforms which will be made freely available to all NSW drivers. The ISA Connect project has also been established, which will develop an Australasian speed zone data and exchange system. This national project is being lead by the RTA.

Modelling of the NSW ISA Trial results has demonstrated that Advisory ISA has the potential to make a significant difference to the NSW and Australian road toll. The broader adoption of ISA initiatives at a national level will provide greater uniformity and enable the realisation of substantial road safety benefits for all Australian drivers.

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