Methods for reducing speeds on urban arterial roads

Turner[a], B., Makwasha, T[a]., Pratt[a], K.,& Beecroft, A[a].

[a]ARRB Group Ltd

Abstract

Road crashes on urban arterial roads are a key contributor to deaths and serious injury. Core to the Safe System approach is management of vehicle speeds to ensure that those crashes that do occur happen at survivable impact speeds. There is little information on how to manage speeds on urban arterial roads, particularly in situations where there is a mix of road user types (particularly pedestrians). Austroads has commenced research to identify solutions for managing speeds in this environment. Initial results are presented indicating the effectiveness (speed reduction and crash reduction where this information is available) of mainly infrastructure–based solutions for managing speeds.

Introduction

A substantial proportion of road crashes occur on urban arterial roads, including those that lead to fatalities and serious injuries. A recent analysis by Bradshaw et al. (in press) shows that between 2006 and 2010, 38% of fatal and serious casualties in Australia occurred on roads with 60 or 70 km/h speed limits, which are generally the urban arterial network[1]. This is in comparison to 23% for roads with a speed limit of 50 km/h and below; 12% for 80 km/h roads (which may be either urban arterial or rural); and 28 % for roads with a speed limit of 90 km/h or above (the majority of which are rural).

Vulnerable road users are at particular risk on these roads. For example, Anderson (2008) identified that in Adelaide almost all pedestrian fatalities occurred on urban arterials, specifically arterial roads with a 60 km/h speed limit.

Information on the contribution of speed to this urban arterial problem is surprisingly scarce. Previous research has identified that speed has a significant role in contributing to overall death and serious injury outcomes. Worldwide, it is suggested that speed contributes to around one-third of all fatal crashes (OECD 2006). In an Australian study on urban speed, Kloeden et al. (1997) assessed the influence of speed on risk using a case-control study that compared safety of casualty crash involved drivers with vehicles at the same location and at similar times who were not involved in a crash. The study identified that the risk increased exponentially as speeds increased above 60 km/h, doubling with each additional 5 km/h increase in travelling speed.

A direct causal link between speed and crash risk has been firmly established. In a presentation to the Royal Statistical Society, Elvik (2004) concluded that there is a causal relationship between speed and road safety based on a number of arguments, including that:

“There is a very strong statistical relationship between speed and road safety. It is difficult to think of any other risk factor that has a more powerful impact on crashes or injuries than speed.

The statistical relationship between speed and road safety is very consistent. When speed goes down, the number of crashes or injured road users also goes down in 95% of the cases. When speed goes up, the number of crashes or injured road users goes up in 71% of the cases.

[1] These speed limits are a proxy for urban arterial roads, as generally information does not exist from crash data on road class. This figure is likely to underestimate the number of crashes, as urban arterials can also include 80 km/h and even 40 and 50 km/h in some instances

The causal direction between speed and road safety is clear. Most of the evidence reviewed in this report comes from before-and-after studies, in which there can be no doubt about the fact that the cause comes before the effect in time". (p.4).

From research on the topic of speed, it is clear that excessive speed is a substantial problem, and that for any given road, an increase in speed is likely to result in reductions in safety through a higher incidence of crashes and an increase in their severity.

Several studies have distinguished between low-end and high-end speeding (i.e. those who are speeding by only a small margin versus those who are exceeding the speed limit by a greater margin). Kloeden et al. (2002) analysed data from a sample in Adelaide and concluded that the risks were greater for low-end speeding (defined in this study as 61 to 75 km/h in a 60 km/h speed environment). This is because a large number of people exceed the speed limit by only a small amount, and although the risk for any individual driver is not as great as for high-end speeding, in aggregate, this group contributes a greater proportion of risk (estimated to be 60%).

A study by Arem et al. (2010) using data from New South Wales lends weight to the results from Kloeden et al. This study found that the greatest risks (in aggregate) were those for low end speeding (defined in this study as exceeding the speed limit by up to 10 km/h), with this group contributing to 43% of fatal crash risk and 38% of casualty crash risk. The next highest contribution came from those who were exceeding the speed limit by between 11 and 20 km/h, with 31% of fatal risk and 35% of casualty risk.

The results from Adelaide have been updated and refined in a study by Doecke et al. (2011). This study identified the likely casualty reduction from a 1 km/h reduction in speed for different road types. This study found that for urban roads posted with either 60 km/h or 80 km/h speed limits (likely to be urban arterials), more than half of the total reduction in casualty crashes would be expected to come from motorists who were between 1 and 5 km/h above the speed limit. The study concluded that reductions in speeds on any roads would be expected to improve safety, but that reductions in low-level speeding (motorists travelling between 1 and 5 km/h above the speed limit) on lower speed roads would be expected to provide the greatest safety benefits.

Given the likely impact of speed on the urban arterial safety problem, Austroads has commissioned research to identify solutions for managing speeds on urban arterial roads. The main focus is on infrastructure-based solutions, but coverage is also provided of non-engineering responses.

The definition of an urban arterial road was set fairly broadly for this project, and includes higher volume roads, some of which may actually be designated as collector roads. The current speed limits for arterial roads are typically 60–70 km/h, but may also sometimes include 80 km/h roads. Urban freeways were excluded from the review.

Urban arterials comprise a wide variety of road environments. In some instances they are multi-lane with the primary intention of moving large volumes of motorised vehicles quickly. In other circumstances they carry a variety of transport modes, including cars, trucks, delivery vehicles, motorcycles, bicycles, and pedestrians. Shopping strips represent one specific road environment where there are often high numbers of motorised and non-motorised vehicles mixing with pedestrians. It is also notable that the mix of vehicles and use of such roads may differ by time of day and day of week.

The term 'speed' in this study is used interchangeably with 'speeding'. This relates to situations where road users are either travelling above the speed limit, or where they are travelling at or below the speed limit, but too fast for the conditions. This may be due to both intentional and unintentional actions by motorists.

The project spans a three-year period. Key tasks include:

- literature reviews assessing the scale of the urban arterial speed problem and possible speed based solutions
- contact with key international agencies and individuals to determine measures currently in use or under development to manage speeds on urban arterial roads
- data analysis of crashes on urban arterial roads, highlighting situations where speed has been identified as a specific crash contributor
- site investigations at a sample of locations where high severity crashes have occurred on urban arterials in order to determine ways that speed may have contributed to crash outcomes, as well as potential ways that speed may be reduced at such locations
- workshops across Australia and New Zealand to discuss potential treatments, and issues with using such treatments
- trials on promising treatments where there are currently gaps in knowledge on effectiveness
- provision of guidance on good practice in managing urban arterial speeds.

This current paper presents findings to date relating to effective infrastructure treatments, based primarily on the literature review task.

Method

There is a large amount of research on the topic of speed. As an example, a search of the ARRB library database (the Australian Transport Index, or ATRI) on the term 'speed' produced almost 10,000 references. Therefore only an overview of the research has generally been provided. Where required, in depth reviews will be undertaken in future years.

Much of the key research on speed has been captured in a number of significant studies over the last decade or so. The literature review drew on these studies, as well as other work on specific topics where required. Therefore, the review is not considered a systematic, or even a comprehensive review of the literature on urban arterial speed management. Rather, it is a selective review intended to cover speed treatments.

Given that this is an Austroads technical research project, the main objective was to identify literature on engineering-based treatments, but in order to provide completeness on the topic of speed management, other non-engineering treatments have been highlighted. Only limited coverage has been made on this latter issue.

In order to identify relevant research, a literature review was conducted using the resources of ARRB Group's MG Lay Library, the leading land transport library in Australia. ATRI was used in identifying literature, as was TRID, an integrated database that combines the records from the US Transportation Research Board's Transportation Research Information Services (TRIS) Database and the OECD's International Transport Research Documentation (ITRD) Database. This information was supplemented with searches using Google Scholar. Contact was also made with national and international experts involved in research on this topic. Information on current or recent research was sought. Lastly, workshops were held around Australia and New Zealand involving practitioners and researchers. Part of the role of these workshops was to identify and fill gaps in knowledge.

Results: Effective speed treatments

A number of potential treatments were identified that might be used to effectively manage speeds on urban arterial roads. These treatments have either been used in this environment type (either in Australia, New Zealand, or overseas), or show potential for use. Over 30 infrastructure treatments were reviewed, and information on the likely benefit (in terms of speed or crash reduction) was obtained where this was available. Information was also gathered on non-engineering treatments.

At this stage of the project recommendations are not provided on which treatments should be used, as there is a need for further research regarding the practicality of some of these treatments. This task forms part of the Austroads research, and will be based on further literature review and workshops. The following section provides information on engineering-based speed treatments. Although most of the treatments identified through the review are listed, details are only provided for some of these.

Engineering-based treatments

This section provides information on the engineering-based treatments that have been identified. Some of the key intersection treatments are presented first, followed by treatments that can be used on a route for specifically for midblocks. Of particular interest is information on the speed and crash reduction potential of these treatments. In some cases there is substantial information on these factors, while for many there is not. Gaps in knowledge will be addressed in future years of this project.

A variety of intersection treatments were identified that can be used to reduce speed and improve safety at these key locations.

Roundabouts

Roundabouts are effective as they reduce the number of conflict points; the angle of impact when collisions do occur; and speed on approach and through the roundabout. This means that when collisions do occur, the severity outcomes are reduced. Hyden and Varhelyi (2000) found that roundabouts reduced vehicles speeds considerably at intersections and on links between roundabouts. In the before period of their study, mean speeds ranged from 20 km/h to 54 km/h. Four years after the roundabout construction, mean speeds ranged from 27–36 km/h, with 85th percentile speeds only marginally higher at 31–41 km/h.

Roundabouts are especially effective at reducing fatal and serious injury crashes, and also have a net benefit in terms of minor crashes. There are a large number of studies that identify safety improvement, although there are fewer that concentrate specifically on urban roads. Table 1 summarises the results from four urban studies on this issue.

Table 1. Summary of crash reduction at roundabouts

Study	Region	Reduction (causality crashes)	Reduction (fatal crashes)
Elvik (2002)	Non-USA	30–50%	50–70%
Retting et al. (2001)	USA	76%	90%
Austroads (2010a)	Mostly Australia	55% (all crashes)	
BITRE (2012)	Australia	71%	79%

It is clear that roundabouts produce significant reductions in crashes, particularly for those of higher severity.

Concerns have been raised in a number of studies about the safety of pedestrians at roundabouts. However, several studies have addressed this issue and it appears that roundabouts, in general, do have the potential for improving pedestrian safety with reduction of up to 75% in pedestrian casualties (Brilon et al. in Retting, Ferguson & McCartt 2003; Schoon & van Minnen in Retting, Ferguson & McCartt 2003; Midson 2009). However, roundabouts have a mixed record in relation to the safety of cyclists. Research in Sweden found that single-lane roundabouts have comparable safety records to other intersection types, while multi-lane roundabouts have an injury crash rate for cyclists more than double the predicted rate for other intersections (Bruede & Larsson 2000). Recent efforts have attempted to address this issue of cyclist safety, for example through a reduction in speed (e.g. Campbell et al. 2006; Asmus et al. 2012).

The Austroads project is also reviewing the benefits of signalised roundabouts, turbo roundabouts (which typically operate by reducing lane changes within the roundabout) and mini roundabouts. All of these designs appear to have benefits in terms of speed reduction and safety improvement.

Raised intersections

Raised intersections (also known as platform intersections, raised junctions or plateaus) are a speed management and safety device generally used on local roads, although there are some examples on arterials, particularly through activity centres. The entire intersection acts as a type of extended speed hump, with the aim of reducing speed. The height of the intersection is often equal to that of the surrounding pavement, which can facilitate pedestrian crossing movement. Raised intersections can be painted or paved in a manner such that they serve to raise driver awareness of the intersection.

Much of the research on raised intersections comes from the Netherlands. For example, Van der Dussen (2002) studied the relative effectiveness of a variety of infrastructure measures, including raised plateaus. There were 82 intersections studied, of which 10 were treated with raised plateaus. The intersections were in urban areas but with relatively modest vehicle flows of 3000–6000 per day. By weighting various crash types and comparing them to before the introduction of the treatment, the study concluded that raised plateaus reduced the number of crashes by 70%, comparing favourably with roundabouts and traffic signals which produced crash reductions of 57% and 46% respectively. Raised plateaus were especially effective at reducing the severity of crashes, with injury crashes reduced by 80%.

Optimising sight distance

Intuitively, a greater sight distance on the approach to an intersection should give the driver more information on the road environment and reduce the likelihood of a crash. While it is still necessary to maintain a degree of minimum sight distance, some evidence suggests that partially restricted sight distance may force drivers to slow down in advance of an intersection in case they need to stop. Several trials have been conducted with screens or vegetation restricting the sight distance on approach to an intersection.

In a comprehensive study in the UK, York et al. (2007) found significant speed reduction associated with reducing lines of sight at urban intersections. They found a strong relationship between mean and 85th percentile speeds and forward visibility. Cutting the sight distance from 120 m to 20 m resulted in a speed reduction of 11 mph (18 km/h) at intersections. The research results are presented in the UK Manual for Streets (Department for Transport 2007a). To date, no examples of this treatment have been identified in Australia or New Zealand for urban intersections. However, supporting evidence can be found in the work of Turner et al. (2009) who found that for roundabouts, crashes increased with increased visibility of vehicles approaching from the right, largely due to the correlation between greater visibility and higher speeds.

Signalised intersection treatments

Several traffic signal based options are also being assessed, including ‘rest on red’ or ‘dwell on red’ signals. This involves including an additional phase so that a red traffic signal is displayed to all vehicle and pedestrian directions. This treatment has typically been applied on roads where there are likely to be high volumes of alcohol-affected pedestrians, and is only activated late at night and into the early morning. The overall aim of rest-on-red signals is to reduce vehicle speeds and bring down the proportion of vehicles travelling at a speed that threatens severe pedestrian injury.

Lennè et al. (2007) installed a dwell-on-red treatment at an intersection in Ballarat, Victoria, on a section of road that reported a high number of pedestrian casualty crashes during high alcohol hours. The treatment was associated with mean speed reductions of 3.9 km/h at the 30 m detector point and 11.0 km/h at the stop line detector. Archer et al. (2008) trialled a similar treatment at an intersection in metropolitan Melbourne and also found significant reductions in average speed.

A study was undertaken in the United Kingdom as a part of the Mixed Priority Route Demonstration Project (Department for Transport 2008a) that included rest-on-red signals for pedestrians and vehicles on a major thoroughfare with a high concentration of pedestrians. The project included a number of other treatments, with the whole package of treatments resulting in a reduction of 60% in casualty crashes. Mean and 85th percentile vehicle speeds also showed a significant reduction along the route.

Other intersection treatments

Other treatments with speed reducing potential at intersections currently being reviewed include:

- Narrowing / deflection
- Gateways (sideroad) (gateways are described further below in regards to midblock treatments)
- Other traffic signal treatments including signals that turn red if motorists are speeding; and use of ‘green wave’, where a series of traffic signals are coordinated with potential to influence vehicle speeds
- Vehicle activated signs
- Speed limit change at intersections
- Perceptual countermeasures
- Transverse rumblestrips.

Each of these treatments appear to have some speed reduction benefit, although in some cases this is quite limited.

A number of midblock treatments were identified that produced substantial reductions in speed.

Vertical deflection

Vertical deflection treatments can be used to control speed, with various forms of speed humps available for different road types. There is relatively limited data on the effectiveness of speed humps or tables on urban arterial roads, with most studies focussing on local and collector roads.

There are, however, some studies on high volume roads with speed limits of 50 km/h or less such as those passing through activity centres.

Hawley et al. (1993) analysed the speed reduction associated with installations of platforms in Australia. Across the seven study sites, the initial average 85th percentile speed between platforms was 66.1 km/h. After the platforms were installed, the speed dropped to 48.9 km/h, a 26% reduction.

The UK Mixed Priority Routes Demonstration Project included speed humps or tables in several of their study sites. These sites were located in areas with high traffic volumes but relatively low speeds due to the mixed-use nature of the area. Across the four sites that included either a speed table or speed hump, there were casualty reductions ranging from 0–41%. Mean speeds were reduced by between 5 and 19% and 85th percentile speeds by between 5 and 17% (Gordon 2011).

Raised pedestrian crossings, typically termed wombat crossings in Australia, have a similar profile and speed reduction effect as flat top speed humps but they differ in that they give priority to pedestrians rather than motorists. A series of wombat crossings were trialled in NSW from 1991 to 1992. At the five study sites, the 85th percentile speed was 34–43% lower at the device after the installation of wombat crossings, as compared to a 10–12% reduction at the control sites (RTA 1992 in Hawley et al. 1993).

Elvik and Vaa (2009) outlined the crash reduction potential of several types of traffic control for pedestrians. They reported that installing a raised crosswalk instead of an ordinary marked crosswalk decreased pedestrian-related injury crashes by 42%, and in cases with no existing crosswalk the reduction in all injury crashes was 65%.

Vaa (2006) also provided figures for the crash reduction associated with raised pedestrian crossings. There was a statistically significant reduction in all injury crashes of 39%, although when broken down into pedestrian injury crashes and vehicle injury crashes, the reductions were 49% and 33% respectively (although these figures were not statistically significant).

Speed limits

Speed limits are a widely applied speed management method. According to Archer et al. (2008), the primary role of speed limits is to improve safety and reduce risks by influencing driver speed choice.

Elvik et al. (2004) conducted a meta-analysis of speed limit changes in order to identify the actual change in speed and crashes. The findings show that it is rare for the mean speed to change by the same amount as the speed limit, although it almost always moves in the same direction. On average, the change in speed is around 25% of the change in speed limit. Therefore, a 10 km/h reduction in speed limit could be expected to bring about a 2.5 km/h reduction in mean speed. Given the link between speed reduction and positive safety outcomes, especially for higher severity crashes, it is likely that reduction in speed limits that bring about subsequent changes in speed will have a positive safety benefit. It should be noted that the influence of speed limit change on safety is often a complex issue. The eventual change in speed is dependent on a number of factors, and not just the posted speed limit. Therefore, changes in speed limit may need to be supported with other measures.

Variable speed limits (VSL) are dynamic road signs displaying variable statutory speed limits depending on prevailing traffic, weather and road conditions. Austroads (2009a) provided a detailed review on the implementation of VSL across Australia and New Zealand, showing a wide variety of uses for this treatment. Several states across Australia are trialling VSL systems on urban arterial roads in high pedestrian activity centres (Scully et al. 2008; Main Roads Western Australia 2013; Austroads 2009b). The aim of the trials is to improve pedestrian safety during peak pedestrian activity periods.

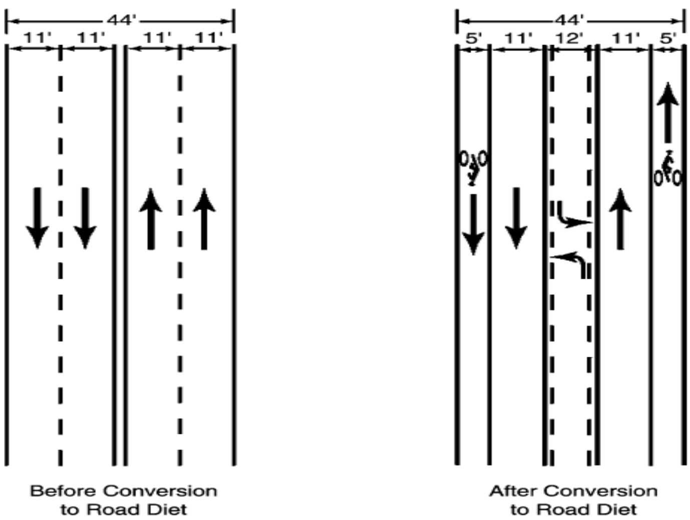
A wide-scale international and domestic practice literature review on the application of VSL was undertaken by Han et al. (2008). The study outlined the application, effectiveness and operation of different VSL signs in Australia, New Zealand and internationally. The applications included school zones, shopping precincts, tunnels, bridges, motorways/highways/freeways and roadworks.

Scully et al. (2008) assessed the implementation of VSL treatments at 18 strip shopping centres across metropolitan Melbourne. The aim of the study was to evaluate the effectiveness of VSL in terms of overall crash reductions and reductions in crashes involving pedestrians. The study included control sites from the same local government areas as the treated sites. The data indicated reductions of 8% in all casualty crashes and 17% in casualty crashes involving pedestrians. Overall crash impacts ranged from an increase of 4.5% to a 19% reduction while crashes involving pedestrians ranged from an increase of 8% to a 36% reduction. The reductions in all crashes and pedestrian-related crashes were not statistically significant.

Road diets

Several methods of managing speeds through road narrowing were identified. Perhaps most effective on urban arterial roads was the use of 'road diets'. This treatment involves converting a four-lane road (two each way) into a road with only one lane in each direction, and a two-way left turn lane (TWLTL, two-way *right* turn lane in Australia/NZ) in the centre. A road diet can also provide enough space to install a bicycle lane or on-street parking. An example is provided in Figure 1.

Figure 1. Conversion to Road Diet (Source: Saak 2007)



Stout et al. (2006) analysed the effect of 15 road diet projects in the United Sates. They found an overall 25% reduction in crash frequency per mile and a 19% reduction in crash rate. Injury crashes were 34% lower, and crashes involving at-risk groups (25 and under and 65 and older) were proportionately lower. It was noted that there was a significant reduction in crash types related to rear-end and left-turning crashes.

Another study of multiple road diets in the United States found a more modest but statistically significant 6% crash reduction in the after period compared to the after period at control sites. Also, there was no difference in crash types and severities between the treatment and control sites (Huang et al. 2002).

There is also evidence of speed reduction from the use of this treatment. An evaluation of a version of a road diet in New Zealand revealed that there were reduced speeds after the project was completed, although precise data on changes in mean and 85th percentile speed were not provided. Before the road diet, 21.1% of vehicles exceeded 60 km/h. After completion, this rate dropped to 5.1%. The rate of crashes dropped from approximately 8 to 7 per year (Rosales 2006).

Gateway treatments

Gateway treatments provide a clear transition point between high and lower speed environments. They are generally used to mark a change from a rural environment, to an area which is more built up or urban. Makwasha & Turner (2013) reported on an analysis of gateways in New Zealand. The study indicated a 26% reduction in overall crashes, with higher reductions (35% reduction in casualty crashes, and a 41% reduction in serious injury crashes) at locations where pinch points were used to restrict lane width.

Other midblock treatments

Other treatments currently being reviewed for use on urban arterial road midblocks include:

- Other forms of road narrowing, including reduced lane width, pedestrian refuge islands, median treatments
- Deflection
- Vehicle activated signs
- Repeater signs
- Variable message signs
- Painted speed limit markings/slow markings
- Road surface and tactile treatments
- Transverse rumble strips
- Shared spaces/naked roads.

Many of these treatments have shown positive but modest reductions in speed and safety improvement.

Engineering-based treatments are also being investigated for use in other environments, and particularly at roadworks and school zones. Details of these treatments will be provided in the final Austroads report.

Non-engineering treatments

Although the main focus of this study is on engineering-based treatments, information is also being sought on non-engineering treatments. This includes discussion on the effectiveness of enforcement (fixed and mobile cameras, point-to-point, combined speed and red light cameras); in-vehicle solutions; education, training and publicity; and penalties. Examples are provided below on the effectiveness of point-to-point speed cameras, and in-vehicle technology.

Point to point cameras work by capturing images of vehicles as they pass two points a known distance apart. The timestamps of the images can then be checked to calculate the average speed of the vehicle between the two points. Number plate recognition technology (ANPR) is used to identify vehicles. The two cameras can be anywhere from a few hundred metres to many kilometres apart. There is also potential for the point-to-point camera technology to be used for other purposes, such as driving infringements, travel time estimations and criminal investigations (Austroads 2012).

There is sometimes a reluctance to consider point to point cameras in urban areas due to the presence of multiple entry and exit points on urban arterials, making it more difficult to accurately track vehicles along a length of road. A Transport for London study (personal communication with Transport for London, June 2012) on the A13 arterial in London, a notorious high crash route, overcame this by installing 87 cameras along a 12 mile, (19 km) three-lane arterial. The cameras cover every entry and exit point along the route and are connected wirelessly, ensuring that any motorist with a calculated average speed above the limit can be prosecuted regardless of their journey within the enforcement area. The large number of cameras and the associated technology and maintenance come at a higher cost than a simple two-point system.

Similar systems involving multiple cameras have been in operation for some years in Italy and the Netherlands on the motorway system, ensuring that vehicle access and egress do not reduce the overall effectiveness of the system (Austroads 2012).

Austroads (2012) notes that a new style of ‘mobile’ point-to-point camera is being trialled in the Flevoland province of the Netherlands. Camera technology is mounted aboard police vans and distance information is automatically calculated with the use of GPS.

Intelligent speed adaptation (ISA) refers to advanced technology which assists drivers in adhering to the posted speed limits. The most widely applied ISA system uses the global position system (GPS) or satellite navigation technology to compare the local speed limits to the vehicle’s travelling speeds, alerting the driver (visual or audible alert) if they exceed the speed limit. ISA is now included in the Euro NCAP Safety Assist Assessment Protocol (Euro NCAP 2012).

ISA interface types include:

- advisory systems – audio or visual information about the prevailing speed limits
- supportive systems – provide information on prevailing speed limits and also warn the driver when the speed limit has been exceeded
- limiting systems – interact with the vehicle, e.g. active accelerator where there is resistance on the accelerator pedal when the driver attempts to exceed the speed limit.

The trials and implementation of ISA have shown positive safety and behavioural effects with reductions in mean, 85th percentile and median speeds as well as reductions in speed variations. Of the three types of ISA, mandatory systems appear to have the highest impact on speeds while advisory and informative had a lesser effect. Whichever type of ISA is deployed, accurate and current maps and speed limit data are needed. Map accuracy issues impacted on the trial in Western Australia to assess driver attitudes to advisory ISA systems (Crackel 2009). User acceptability, on the other hand, was higher for advisory systems.

Along with ISA, a number of other in-vehicle technologies have been developed, some of which assist in better managing vehicle speeds. Over recent years, a number of car manufacturers have been fitting their vehicles with various crash avoidance and speed management technologies. New technologies are developed every year.

Forward collision avoidance systems provide alerts to the driver if sensors detect that the vehicle travelling faster than the vehicle in front and getting too close. Advance systems also include autonomous braking to slow vehicles, and severity reducing features such as tightening seatbelts or adjusting head restraints.

Adaptive cruise control means that the car automatically slows and speeds up depending on the distance to the vehicle in front. Should the vehicle need to slow down considerably, the system will either disengage or continue to slow the vehicle to a complete stop.

A number of in-vehicle safety systems utilise GPS technology through devices in the vehicle or with smartphones. This includes curve speed warnings, which involves matching vehicle location and speed to digital maps. If the calculations determine that the speed is unsafe for an approaching curve then a warning is issued to the driver. The same GPS technology can be applied to warn drivers of upcoming black spots, school zones, traffic incidents, roadworks and the location of speed and red-light cameras. These features are also being integrated into some ISA systems.

There are a number of other in-vehicle safety features that do not have a direct impact on vehicle speeds but may help to reduce the number or severity of crashes. These include lane departure warnings, adaptive headlights, side view assist, electronic stability control, emergency brake assist, anti-lock brakes and more (Insurance Institute for Highway Safety 2013). Other in-vehicle warning systems including Cooperative Intelligent Transport Systems (C-ITS) are also being reviewed by this Austroads study.

Summary and next steps

Speed is a significant contributor to fatal and serious crash outcomes on urban arterial roads. This Austroads project has identified a number of treatments that can be used to effectively manage speeds on these roads. Effective treatments at intersections include roundabouts, raised platforms and better management of sight distance. Other treatments are also available that are likely to provide more modest reductions in speed. For midblock locations treatments include speed tables, road diets, effective speed limits and gateways. Again, other treatments are available that also provide speed reduction and safety benefits. It is likely that combinations of treatments will have the greatest impact on safety. This may include combinations of different engineering solutions, as well as combination of engineering treatments along with non-engineering based solutions (e.g. enforcement and education). Suitability of these treatments will depend on the road environment, with many of the treatments identified more suited to high activity centres.

This Austroads project continues, with current efforts aimed at filling gaps in knowledge, particularly regarding the effectiveness of treatments either in crash or speed reduction. Workshops are now complete, and the information obtained from these will be used to identify issues relating to implementation for each of the treatments identified. This will include considerations such as cost, design, construction, operation, maintenance, and acceptance by users (including public transport and emergency services). Data is currently being collected on several promising treatment types (road diets and vertical deflection, including raised platforms and crossings) and will be used to provide guidance on possible use of these treatments. The final output for this project is provision of a good practice compendium on speed related treatments for use of urban arterial roads. This document will be used to complement existing Austroads guidance, including speed related treatments for rural roads (Austroads 2014) and for local roads (Austroads 2008).

References

Anderson, R 2008, Pedestrian collisions in South Australia, report CASR039, Centre for Automotive Safety Research, Adelaide, SA.

Archer, J, Fotheringham, N, Symmons, M & Corben, B 2008, The impact of lowered speed limits in urban and metropolitan areas, report 276, Monash University Accident Research Centre, Clayton, Vic.

Arem, G, Walker, E, Murdoch, C, Graham, A, Fernandes, R & Job, R 2010, 'Is a focus on low level speeding justified? Objective determination of the relative contributions of low and high level speeding to the road toll', Australasian road safety research policing and education conference, 2010, Canberra, ACT, Conference Logistics, Kingston, ACT, 11 pp.

Asmus, D, Campbell, D & Dunn, R 2012, Evaluation of the C-roundabout: an improved multi-lane roundabout design for cyclists, research report 510, NZ Transport Agency, Wellington, New Zealand.

Austroads 2008, Guide to traffic management: part 8: local area traffic management, AGTM8/08, Austroads, Sydney, NSW.

Austroads 2009a, Best practice for variable speed limits: literature review, AP-R342/09, Austroads, Sydney, NSW.

Austroads 2009b, Best practice for variable speed limits: user perception and comprehensive study, AP-R343/09, Austroads, Sydney, NSW.

Austroads 2010a, Road safety engineering risk assessment: part 6: crash reduction factors, AP-T151/10, Austroads, Sydney, NSW.

Austroads 2010b, Guide to road design: part 3: geometric design, 2nd edn, AGRD03/10, Austroads, Sydney, NSW.

Austroads 2012, Point-to-point speed enforcement, AP-R415/12, Austroads, Sydney, NSW.

Austroads 2014, Methods for reducing speeds on rural roads: compendium of good practice, AP-R449/14, Austroads, Sydney, NSW.

Austroads, in press, Road Fatalities and Serious Injuries in Australia and New Zealand 2001–2010, Austroads, Sydney, NSW.

Bruede, U & Larsson, J 2000, What roundabout design provides the highest possible safety?, Nordic Road and Transport Research, vol. 12, no. 2, pp. 17-21.

Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2012, Evaluation of the national black spot program: volume 1, report no. 126, BITRE, Canberra, ACT.

Campbell, D, Jurisich, I & Dunn, R 2006, Improved multi-lane roundabout designs for cyclists, research report no. 287, Land Transport New Zealand, Wellington, NZ.

Crackel, L 2009, 'Intelligent speed assist in Western Australia: where have we been and where are we going?', Intelligent speed adaptation conference, 2009, Sydney, New South Wales, Roads and Traffic Authority, Sydney, NSW, 2 pp.

Department for Transport 2007a, Manual for streets, DfT, London, UK.

Department for Transport 2008, 'Prince of Wales Road, Norwich, mixed priority route demonstration project: final report', DfT, London, UK.

Doecke, S, Kloeden, C & McLean, A 2011, Casualty crash reductions from reducing various levels of speeding, report CASR076, Centre for Automotive Safety Research, Adelaide, SA.

Elvik, R 2002, ‘Effects on road safety of converting intersections to roundabouts: a review of evidence from non-US studies’, Transportation Research Record, no. 1847, pp. 1-10.

Elvik, R 2004, ‘Speed, speed cameras and road safety evaluation research: presentation to the Royal Statistical Society’, Institute of Transport Economics, Oslo, Norway.

Euro NCAP 2012, Euro NCAP rating review: report from the ratings group, Euro NCAP, Brussels, Belgium.

Gordon, G 2011, Mixed priority routes: results update and cost review, Department for Transport, London, UK.

Han, C, Pyta, V & Lennie, S 2008, ‘A review of variable speed limits initiatives and reported results’, Australian Institute of Traffic Planning and Management (AITPM) national conference, 2008, Perth, Western Australia, AITPM, Blackwood, SA, pp. 103-21.

Hawley, L, Henson, C, Hulse, A & Brindle, R 1993, Towards traffic calming: a practitioners’ manual of implemented local area traffic management and blackspot devices, report no. CR 126, Federal Office of Road Safety, Canberra, ACT.

Haworth, N, Ungers, B, Vulcan, P & Corben, B 2001, Evaluation of a 50 km/h default urban speed limit for Australia, National Road Transport Commission, Melbourne, Vic.

Hoareau, E & Newstead, SV 2004, An evaluation of the default 50 km/h speed limits in Western Australia, report no. 230, Monash University Accident Research Centre, Clayton, Vic.

Hoareau, E, Newstead, S & Cameron, M 2006, An evaluation of the default 50 km/h speed limit in Victoria, report no. 261, Monash University Accident Research Centre, Clayton, Vic.

Huang, HF, Stewart, JR & Zegeer, CV 2002, ‘Evaluation of lane reduction "road diet" measures on crashes and injuries’, Transportation Research Record, no. 1784, pp. 80-90.

Hyden, C & Varhelyi, A 2000, ‘The effects on safety, time consumption and environment of large scale use of roundabouts in an urban area: a case study’, Accident Analysis & Prevention, vol. 32, no. 1, pp. 11-23.

Insurance Institute for Highway Safety 2013, Q&A: crash avoidance technologies, webpage, , Insurance Institute for Highway Safety, Arlington, VA, USA, viewed 20/02/2013, <http://www.iihs.org/research/qanda/crash_avoidance.aspx>.

Jiang, R, Chung, E & Lee, J 2011, ‘Variable speed limits: conceptual design for Queensland practice’, Australasian transport research forum (ATRF), 34th, 2011, Adelaide, South Australia, University of South Australia, Adelaide, SA, 11 pp.

Kloeden, CN, McLean, AJ & Glonek, G 2002, Reanalysis of travelling speed and the risk of crash involvement in Adelaide South Australia, CR 207, Australian Transport Safety Bureau, Canberra, ACT.

Kloeden, C, McLean, A, Moore , V & Ponte, G 1997, Travelling speed and the risk of crash involvement: volume 1: findings, CR 172, Federal Office of Road Safety, Canberra, ACT.

Kloeden, C, Woolley, J & McLean, J 2007, ‘A follow up evaluation of the 50km/h default urban speed limit in South Australia’, Road safety research, policing and education conference, 2007, Melbourne, Victoria, The Meeting Planners, Collingwood, Victoria.

Main Roads Western Australia 2013, Beaufort Street: variable speed zone trial, webpage, MRWA, Perth, WA, viewed August 2013, <https://www.mainroads.wa.gov.au/BUILDINGROADS/PROJECTS/URBANPROJECTS/Pages/Beaufort.aspx>.

Makwasha, T & Turner, B, 2013, Evaluating the use of rural-urban gateway treatments in New Zealand, Proceedings of the 2013 Australasian Road Safety Research, Policing & Education Conference, Brisbane, Australia.

Midson, K 2009, 'Traffic control measures to improve pedestrian safety in shopping strips', Public Works Engineering, April/May, pp. 40-6.

OECD 2006, Speed Management, Organisation for Economic Co-operation and Development, Paris, France.

Retting, RA, Ferguson, SA & McCartt, AT 2003, 'A review of evidence-based traffic engineering measures designed to reduce pedestrian-motor vehicle crashes', American Journal of Public Health, vol. 93, no. 9, pp. 1456–63.

Retting, R, Persaud, BN, Gardner, PE & Lord, D 2001, 'Crash and injury reduction following installation of roundabouts in the United States', American Journal of Public Health, vol. 91, no. 4, pp. 628-31.

Roads and Traffic Authority 2000, 50 km/h urban speed limit evaluation: summary report, RTA, Sydney, NSW.

Rosales, J 2006, Road diet handbook: setting trends for livable streets, monograph no. 20, Parsons Brinckerhoff, New York, NY, USA.

Scully, J, Newstead, S & Corben, B 2008, Evaluation of the crash effects of strip shopping centre treatments in Victoria, Monash University Accident Research Centre, Clayton, Vic.

Stout, TB, Pawlovitch, MD, Souleyrette, RR & Carriquiry, A 2006, 'Safety impacts of "road diets" in Iowa', ITE Journal, vol. 76, no. 12, 5 pp.

Turner, SA, Roozenburg, AP & Smith, AW 2009, Roundabout crash prediction models, report 386, NZ Transport Agency, Wellington, New Zealand.

Van der Dussen, P 2002, 'Verhoogde plateaus effectief en goedkoop bij terugdringen aantal ongevallen', [in Dutch Raised plateaus effective and cheap in reducing number of crashes], Wegen, vol. 76, no. 8, pp. 18-20.

Walsh, D & Smith, M 1999, 'Effective speed management: the next step forward: saving lives by decreasing speeds in local streets', Road safety research, policing, education conference, 2nd, 1999, Canberra, ACT, Australian Transport Safety Bureau, Canberra, ACT, pp. 685-94.

York, I, Bradbury, A, Reid, S, Ewings, T & Paradise, R 2007 The manual for streets: evidence and research, report no. 661, Transport Research Laboratory, Crowthorne, UK.