



Austroads


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**Methods for Reducing
Speeds on Rural Roads**
Compendium of Good Practice

Methods for Reducing Speeds on Rural Roads – Compendium of Good Practice

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Keywords
Speed, rural, countermeasures, treatments, curves, intersections, railway crossing, transition zone.

Abstract
This compendium presents information on speed as a contributor to rural road crashes. It provides information on treatments that can be used to address speed, either at key locations (curves, intersections or the approach to towns) or for routes in general. The main focus is on road-engineering-based treatments, but information is also provided on other approaches that may be used (e.g. enforcement and in-vehicle devices).

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- promote improved practice and capability by road agencies.
- promote consistency in road and road agency operations.

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- Australian Local Government Association
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The success of Austroads is derived from the collaboration of member organisations and others in the road industry. It aims to be the Australasian leader in providing high quality information, advice and fostering research in the road transport sector.

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This report has been prepared for Austroads as part of its work to promote improved Australian and New Zealand transport outcomes by providing expert technical input on road and road transport issues.

Individual road agencies will determine their response to this report following consideration of their legislative or administrative arrangements, available funding, as well as local circumstances and priorities.

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Summary

Speed is a significant contributor to deaths and serious injuries on rural roads in both Australia and New Zealand. In 2008, a four-year research program commenced on the topic of speed reduction in rural areas. The key objective of this research was to provide information to Austroads members on effective techniques to reduce speed and speed-related crashes in rural areas, particularly those involving engineering-based solutions. The research included a literature review and international review of expert opinion; the development of a strategy for future research to address gaps in knowledge; data analysis; site visits; consultation with industry; rural speed workshops; trials of new treatments; and development of guidance.

This report is the final output for this program and is designed to be a compendium of good practice to inform practitioners of the extent of the speed issue in rural areas and to provide guidance on effective actions that can be taken to reduce the incidence and severity of crashes on rural roads.

A key finding is that speed contributes to around 28% of all fatal rural crashes in Australia, and 31% in New Zealand.

In general, there has been an overall increase in awareness of speed as a contributing factor to crashes amongst the general driving population, and speeds on both urban and rural roads have generally been decreasing over time. However, speeds in rural areas have declined to a lesser extent than in other environments.

Detailed information is provided on almost 30 road engineering treatments that may be used to reduce speeds at key locations on rural roads. Information is presented on the speed and crash reduction effectiveness of commonly used treatments. These include advance warning signs, chevron alignment markers, and advisory speed signs at curves; advance warning signs and roundabouts at intersections; and advance warning signs and buffer zones on the approach to towns.

Emerging treatments have been identified, although less reliable information is available on their effectiveness. New and promising treatments include vehicle-activated signs and route-based curve treatments at curves; speed management and vehicle-activated signs at rural intersections; and rural gateway/threshold treatments on the entry to small towns.

Other treatments require further investigation, but show some promise. These include in-vehicle speed warning systems for curves (and potentially other locations on rural roads); removing 'excess' sight distance at intersections, and methods to highlight the presence of intersections; and road narrowing combined with reduced speed limits.

Limited information is also provided on non-engineering measures (e.g. enforcement).

In the short term, speed reductions are likely to result in incremental improvements in safety. It is anticipated that in the longer term, Safe System objectives can be met through appropriate speed management used in combination with other system elements (safer roads, road users and vehicles).

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1. Introduction

1.1 Background

Speed has been identified as a major factor in the occurrence and severity of road crashes (e.g. OECD 2006; Armour & Cinquegrana 1990; Haworth & Rechnitzer 1993). Research to date has identified that speed is recorded as a significant contributor to death and serious injuries on rural roads in both Australia and New Zealand.

In 2008, a four-year research program commenced on the topic of speed reduction in rural areas. The key objective of this research was to provide information to Austroads members on effective techniques to reduce speed and speed-related crashes in rural areas. In order to achieve this objective, the project has identified and reviewed existing approaches to speed management as well as trialling innovative approaches. These have been assessed in light of the Safe System approach, and particularly with a view to harm minimisation utilising speed management principles.

Definitions of 'rural' vary across different jurisdictions and in the overseas literature. This research has generally examined speeds on those parts of the network that are currently signposted as greater or equal to 80 km/h and that are outside of major cities. This is typically considered as 'open road' in many jurisdictions. It also includes the interface with lower speed parts of the network (e.g. entering a rural town, but not speeds through the town itself). In some cases, the definition of rural may differ to this, and where possible, the definition that has been used by the respective jurisdiction is given.

Similarly, definitions of 'speed' and 'speeding' also vary. In this context, speeding relates to any road user who is travelling above the posted speed limit, or who is driving at a speed that is dangerous for the conditions (whether that be above or below the posted speed limit). These are often two quite different driving behaviours that occur in different road environments. For example, travelling above the speed limit is more likely to occur on long straight roads, while travelling too fast for the conditions may occur on any type of road, but more typically in environments where the geometry is constrained. The ways to address each type of behaviour can also differ.

The four-year research program included a literature review and international review of expert opinion; the development of a strategy for future research to address gaps in knowledge; data analysis; site visits; consultation with industry; rural speed workshops; trials of new treatments; and development of guidance.

Although there are a range of different measures available to address the issue of speeding in rural areas, the focus of this Austroads technical research project has been on engineering-based speed treatments to achieve reductions in operating speeds in rural areas. Non-engineering-based speed treatments are outside the scope of this project. However, for completeness on the topic of speed management, some non-engineering treatments have been briefly covered.

1.2 Intent of the Report

The research program has been based on local and international experience, with the inclusion of research, trials and analysis to provide robust information. This report is the final output for this program and is designed to be a compendium of good practice to inform practitioners of the extent of the speed issue in rural areas and to provide guidance on effective actions that can be taken to reduce the incidence and severity of crashes on rural roads, particularly through road engineering treatments.

1.3 Structure of the Report

The report is comprised of five sections, as follows:

- Section 1 (this section) presents the background to the Austroads project and outlines the scope and intent of the report.
- Section 2 presents a literature review and crash analysis to address the issue of speed as a contributor to rural crashes. This is complemented by information from surveys of public attitudes to speed, in addition to speed monitoring data.
- Section 3 identifies the engineering-based treatments for reducing rural speeds. Detailed information on each of these treatments is provided in Appendix A.
- Section 4 identifies some non-engineering treatments. Although outside the scope of this project, these treatments have been briefly covered for completeness.
- Section 5 provides the concluding comments, including the key findings and limitations of the research, as well as identification of areas for future study in the area of rural speed management.
- Details are provided in Appendix A on engineering-based treatments for reducing rural speeds.

2. Speed as a Contributor to Rural Crashes

2.1 Literature Review

A literature review was conducted to help determine the scale of the rural speed problem in Australia and New Zealand. This review commenced in 2008, and was updated at the start of 2012. Literature following this date is not included in this report. This compendium brings together some of the main issues identified.

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 work on other specific topics where required. Therefore, this review is not considered a systematic, or even a comprehensive review of the literature on rural speed management. Rather, it is a selective review intended to outline some key rural speed-related road safety issues, namely, the Safe System approach to road safety and how this relates to the rural speed problem, the extent of the rural speed problem, and how drivers select an appropriate speed.

2.1.1 Speed within the Safe System Context

In recent years, there has been a move to a new basis for road safety in Australia and New Zealand. Based primarily on the Swedish Vision Zero and the Dutch Sustainable Safety approaches, the Safe System approach has been formally adopted by Austroads, and forms a key component of the Australian National Road Safety Strategy (Australian Transport Council 2011) and New Zealand's Safer Journeys Strategy (Ministry of Transport 2010).

The Safe System approach accepts that humans will make errors and take risks and, as such, crashes will continue to occur. In addition, humans are physically vulnerable, and are only able to withstand limited change in kinetic energy (e.g. during the rapid deceleration associated with a crash) before injury or death occurs. Therefore, infrastructure that takes account of these errors is required so that road users are able to avoid serious injury or death in the event of a crash. The Safe System aims to manage vehicles, road and roadside infrastructure, and speeds in order to minimise death and serious injury as a consequence of a road crash.

A report by Fildes et al. (2005) summarised the biomechanical tolerances of humans for different crash types. Table 2.1 presents the findings from that work, showing the survivable impact speeds for various crash types.

Table 2.1: Biomechanical tolerances

Crash type	Tolerance
Car/pedestrian	20–30 km/h
Car/motorcyclist	20–30 km/h
Car/tree or pole	30–40 km/h
Car/car (side impact)	50 km/h
Car/car (head-on)	70 km/h

Source: Fildes et al. (2005).

This report suggested that human tolerances need to be considered in the setting of speed limits so that in the event of a crash, the chances of road users being killed or seriously injured are minimised.

Of significant interest for this project on rural speeds are those tolerances relating to car versus tree or pole crashes, which are a major risk factor in rural run-off-road crashes; car versus car side impacts, which are of relevance to intersection crashes; and car versus car, which are of relevance to head-on crashes. These are three of the major crash types on rural roads.

In the Netherlands, these tolerances have been used as the basis to derive safe speeds for different road environment types, as shown in Table 2.2.

Table 2.2: Speed limits based on tolerances

Type of road	Safe speed (km/h)
Roads with possible conflicts between cars and unprotected road users	30
Locations where impacts with fixed roadside objects are possible	40
Intersections with possible lateral conflicts between cars	50
Roads with possible head-on conflicts between cars	70
Roads where head-on and side conflicts with other road users are impossible	≥ 70

Source: Adapted from Austroads (2009a).

There is a strong relationship between the management of safe speeds and the provision of appropriate infrastructure when trying to achieve Safe System outcomes. In situations where adequate infrastructure exists (e.g. separation of road users and roadside protection), it is possible to have higher speeds. However, in order to achieve Safe System outcomes without the provision of such infrastructure, the only alternative is to provide lower speed environments. Ultimately, speeds that match human tolerances are required. However, it can be expected that it will take some time before such speed limits are widely used (or alternatively, adequate infrastructure put in place to facilitate higher speeds). Until then, incremental improvements to safety can be made by reducing speeds by even small amounts (as demonstrated in Section 2.1.2).

This compendium does not provide advice on speed limit setting within a Safe System context. Further guidance on this issue is available in Austroads (2008a, 2008b, 2010a) and is the subject of further Austroads research on this topic. Instead, this compendium provides information on ways to reduce speeds to Safe System levels, or if that is not possible, to a lesser extent, thereby producing incremental improvements in safety.

2.1.2 The Rural Speed Problem

It is not the intention of this report to review all previous material relating to rural speed and safety in detail. This topic has been well covered in previous literature, and a clear relationship between speed and safety has been established (e.g. Elvik et al. 2004; GRSP 2008; OECD 2006).

Speed is often cited as being one of the leading causes of crashes in rural areas. Worldwide, it is suggested that speed contributes to around one-third of all fatal crashes (OECD 2006). Armour and Cinquegrana (1990) reported that speed is the probable or possible cause of a quarter of rural serious crashes in Australia that involved single vehicles, while Haworth and Rechnitzer (1993) reported that around 20% of fatal crashes in rural areas involved excessive speed. The figures are similar in New Zealand, with over 30% of fatal and 22% of injury crashes in rural areas occurring where ‘travelling too fast for the conditions’ was a factor (NZ Crash Analysis System database, average for the period 2003 to 2007). It is often suggested that such figures are an underestimation of the true extent of the rural crash problem (e.g. Kloeden et al. 2001; Patterson et al. 2000).

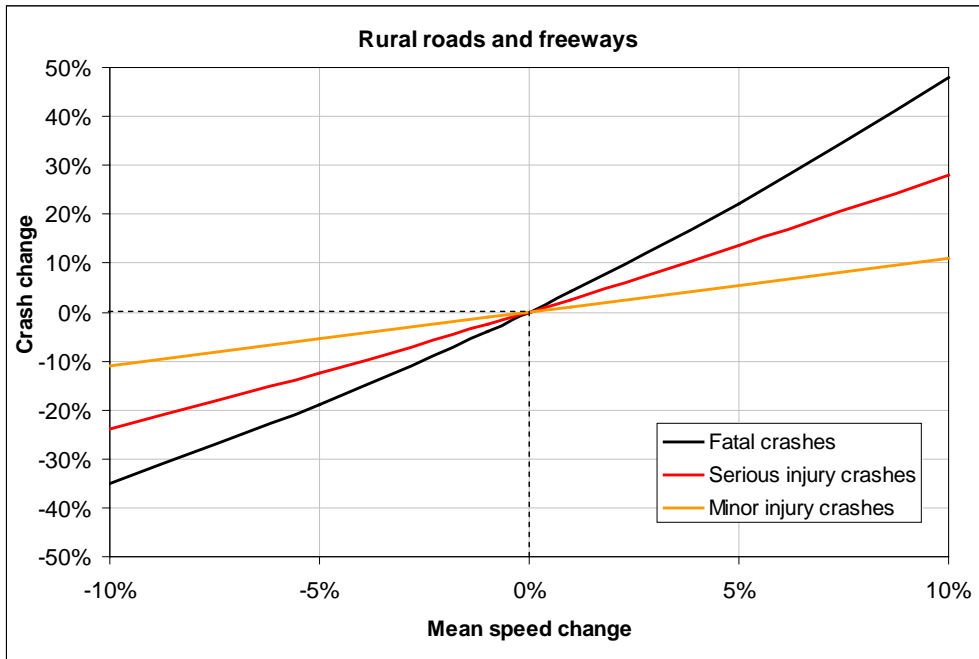
In an Australian study on rural speed, Kloeden et al. (2001) identified that the risk of involvement in a casualty crash more than doubles when travelling 10 km/h above the average speed of non-crash involved vehicles, and that it is nearly six times as great when travelling 20 km/h above that average speed.

Overseas, Elvik (2009) conducted an analysis of 115 separate speed studies across a number of countries. The study included 526 estimates of a change in the casualty rate in response to a change in speed. A meta-analysis was conducted on this combined data, and the results provide strong support for the Power Model for speed. This shows that even small reductions in mean speed can result in substantial decreases in fatal and injury crashes.

The 2009 revision of the Power Model indicates that the expected crash savings from mean speed reductions would be slightly lower on rural roads and freeways than previously estimated by Elvik et al. (2004). This was confirmed recently by Cameron and Elvik (2010).

Figure 2.1 provides a graphical representation of the relationship for rural roads.

Figure 2.1: Mean speed changes versus expected crash changes for rural roads and freeways



Source: Based on Elvik (2009).

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 accidents or injuries than speed.

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

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 excess speed is a substantial problem in rural areas (as it is in urban areas), 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.

2.1.3 How Drivers Select their Speed

In order to discuss appropriate methods relating to speed reduction, it is important to understand how motorists select a speed that they think is appropriate. This section provides a summary from the extensive research that exists on the ways that drivers select their current driving speed, including research from Australia, New Zealand and other countries.

One difficulty associated with research on road design elements (or characteristics) and speed is that a 'cross-sectional' methodology is often adopted. That is, speeds on roads with different characteristics are compared to assess the effect of a single road characteristic (for instance, lane width). However, it is very unlikely that the roads compared will be exactly the same in all respects, apart from this single factor. Often roads will differ on a number of different characteristics (e.g. lane width, shoulder width, distance to roadside objects, etc.). It is therefore very difficult to isolate the effect of single characteristics on speed. A more robust approach is to conduct a 'before-and-after' analysis, where a single characteristic is changed, and speeds are measured before and after this change. Unfortunately, such research relating to road design elements and speed is rare; therefore, the results provided here need to be treated with some caution.

Australian and New Zealand research

The research evidence is relatively consistent in terms of identifying factors that contribute to speed choice by motorists. Cairney (1986) conducted a trial that involved presenting different road scenes to subjects who were asked to estimate the speed limit, what a safe operating speed might be, and the speed they thought most traffic would be travelling at for each environment. The road configuration (whether two or four lanes, and whether there was a narrow or wide median) and the land use (recreational, industrial, commercial or residential) were assessed. The study identified that estimates of speeds are quite sensitive to differences in the environment. Two-lane roads and commercial land use produced the lowest estimates of safe speed, while roads with wide medians and with recreational land use produced the highest estimates.

As part of a study to develop an expert system for the setting of speed limits, Jarvis and Hoban (1988) conducted a study that included the assessment of important factors in selecting speed limits. This involved an assessment by an expert panel, and collection of data from 64 sites with varying road characteristics. The study suggested that abutting development and road cross-section are the major determinants that should be included in speed zoning decisions.

Fildes et al. (1991) identified that motorists typically knew the prevailing speed limit on sections of road they were driving, but tended to drive at speeds at which they felt were appropriate.

Fildes and Lee (1993) reported that the road surface (including the width of the road and the number of lanes) has the greatest influence on drivers' choice of speed, while the level of roadside development has an important but lesser influence. Other road or environment factors of interest include time of day, curve radius and length, shoulder width, intersections or driveways, average traffic speed, delineation, weather, grade, traffic volumes, parked vehicles, pedestrians, and sight distance. This study also highlighted the role of behavioural determinants of speed choice, including trip purpose and distance, driving experience, and possibly the number of passengers.

Harrison et al. (1998) identified road-based factors such as land use or population density, roadside development, road category and lane width, horizontal and vertical curves, and traffic density. Also highlighted were issues such as trip purpose and motivation, internal values relating to legal behaviour, attitudes towards road safety, social factors (including presence of passengers and age of drivers), the perceived speed of other drivers, and perceptions regarding enforcement. Based on these factors, a speed choice model was developed.

Fleiter and Watson (2005) identified four types of factors that influence a driver's choice of speed. These were legal, social, person-related, and situational factors. Legal factors include a range of enforcement issues. Social influences can include pressure from family, friends, passengers, the media, and others on the road. Person-related factors include crash history of the driver, age, gender, attitudes and values, and personality factors such as sensation seeking behaviour. Situational factors include issues relating to the current driving experience, including purpose of the trip, keeping up with the traffic flow, and running late.

Elliott (2001) used similar categories to other authors and suggested four main determinants of driver speed: the driving environment (which includes the physical road design and signage), enforcement, behaviour of other drivers, and societal norms and values.

Oxley and Corben (2002) reviewed existing literature to determine factors that influence choice of speed. The factors identified included driver/rider factors, vehicle factors, enforcement, education/publicity/promotion, and road factors. The driver/rider factors of interest included prior history of driving at high speed without crash involvement, the reward or excitement of driving at speed, personal characteristics (including age, sex, driving experience, risk behaviour), trip motivations, level of blood alcohol or other drug impairment, ownership of the vehicle, and presence of passengers.

Oxley and Corben (2002) also identified that:

- motorists are mostly aware of their speeding behaviour, and that speeding is often a conscious decision
- motorists are likely to overestimate the speed of others, and as they want to drive at a similar speed, it leads to speeding behaviour
- speeding is contagious
- speeding is not regarded as a dangerous activity
- motorists tend to overestimate what is a safe speed
- the perception of an appropriate or safe speed is important as this affects speed choice (this requires a knowledge of risks, both to oneself and to others)
- posted speed limits are seen as advisory, and at the lower end of a continuum of acceptable speeds. The higher end of this continuum is the speed that drivers perceive will be tolerated by the police.

Vehicle factors include the performance and handling of the vehicle, the maximum achievable speed, the power-to-weight ratio, and crashworthiness.

Enforcement factors include the perceived risk of detection. It was suggested that enforcement needed to be based on widespread, highly visible and constant police presence. This needs to be supported by mass media campaigns.

The road factors identified by Oxley and Corben (2002) were speed limits (which they felt to be the most important factor), curvature, grade, length of grade, number of lanes, surface conditions, sight distance, lateral clearance, number of intersections, built-up areas near the roadway, advisory and warning signs, traffic density and composition, speed of traffic, and presence of road lighting.

In a New Zealand review of the literature, Patterson et al. (2000) suggested that drivers select a speed based on what they judge as being 'safe'. This study identified issues that influence speed, including the level of roadside development, road width, road geometry, sight distance, and road smoothness. Traffic factors were also identified as having an influence, and include traffic volume, the number of intersections, parked vehicles, and the presence of pedestrians. The time of day and weather were both also found to influence driver speed, although there is a close link between time of day and traffic volumes resulting in higher speeds at night.

Charlton and Baas (2006) conducted a review on road design elements and speed as part of a review to identify ways to maintain speed reductions on an area-wide basis. In summarising literature on this topic, they suggested the values shown in Table 2.3 for speed reduction (or increase) based on changes to road elements. These values are based on a number of studies, some of which apply to rural roads, while others are from research on urban arterials. Information on local roads was also presented in the study by Charlton and Baas, but has not been replicated here.

As discussed, it is important to note that it is often difficult to isolate the effect of individual design elements on speed from such studies, as typically roads vary on two or more of these elements. For example, higher quality roads will be wider, have road markings, and be comparatively free from roadside hazards. However, the information presented above is useful as it serves as a guide to speed based on various design elements.

In recognition of this ‘covariance’ issue, Thoresen (1999) conducted a study that sought to isolate the effect of width alone on speed. This study assessed a 1000 km primary inter-regional two-lane highway that had seal widths ranging from about 6 m to 12 m. The study used a series of paired observations which allowed direct comparison of road sections based primarily on seal width. A regression analysis yielded a statistically significant coefficient that indicated that with each additional metre of seal width, speeds increased by around 0.75 km/h.

Overseas research

A UK review by Silcock et al. (2000) suggested that selection of speed is based on the following factors:

- self-image as a driver
- the vehicle
- the road environment
- cultural factors
- presence of passengers
- perceived risk of detection and prosecution.

Table 2.3: Road elements and their impact on speed

Road element	Mean speed (km/h)	85 th percentile speed (km/h)
Carriageway width		
6.0 m	80	Unknown
8.0 m	90-100	Unknown
Number of lanes – urban arterial		
4	50	51
2	45	46
1	40	Unknown
Delineation		
Marked centreline	Unknown	72
No centreline	Unknown	51
Marked edge line	Unknown	77
No edge line	Unknown	64
Medians		
No median	55	61
Raised median	59	68
2-way turn lane	Unknown	71
Deflecting median	50	Unknown
Median width		
0	Unknown	69
3 m	Unknown	87
6 m	Unknown	97
Access density		
< 29 per km	Unknown	74
< 29 per km	Unknown	83
On-street parking		
Parking	Unknown	51
No parking	Unknown	77

Road element	Mean speed (km/h)	85 th percentile speed (km/h)
Roadside hazards 3 m from road edge		
Clear	Unknown	80
Yielding objects	Unknown	72
Yielding and rigid	Unknown	61
Isolated rigid (arterial)	Unknown	68
Continuous rigid (arterial)	Unknown	76

Source: Adapted from Charlton and Baas (2006).

Of most interest in this study are those elements that relate to the road environment. Silcock et al. (2000) suggested that the physical dimensions and layout of the road, prevailing traffic conditions, and the perception as to whether the road was urban or rural in its characteristics, were important determinants of driver speed. Based on video footage of drivers in differing road environments, they found that in lower speed environments (30–40 mph, or 48–64 km/h), the speed limit was most often exceeded in situations where roads were wide and straight, where there was good sight distance, and where there was little frontage activity. The report also identified the need to inform motorists of the reason for speed limits if these are not clear (e.g. by providing supplementary plates on speed limit signs). Note this approach is not permitted under current rules, although separate signs can be used.

Elliott et al. (2003) identified a number of features that can be used to influence speed. They suggested a number of behavioural approaches to reducing speed, including:

- increasing cognitive workload (i.e. the complexity of the driving task)
- reducing the perceived benefit of speeding (e.g. by using designs that increase physical discomfort or stress when speeding)
- enhancing the perceived risk of a crash
- increasing the perceived level of enforcement
- increasing retinal streaming (placing elements in a driver's peripheral vision to increase the perception of speed)
- improving driver knowledge of current speed limits (through appropriate road features)
- better knowledge of own travelling speed.

A number of road design features were also identified as influencing speed, including:

- roadside development (or 'filled roadside space', which includes trees and undergrowth, buildings, statues and monuments, and pedestrians)
- carriageway width
- presence of a median
- parked cars
- road surface roughness
- presence of road signs (including speed camera signs and warning signs)
- road markings (including transverse and longitudinal markings, cycle lanes, and bus lanes)
- frequency of road junctions
- gateways (transition points between rural and urban environments)
- shared space (including the Dutch 'woonerf' and UK 'Home Zone' concepts¹).

¹ A woonerf is a type of shared space where pedestrians and cyclists have priority over motorised traffic. Slower speeds are achieved through traffic calming and other forms of speed management. Home Zones are a similar initiative used in the United Kingdom.

The review by Elliott et al. (2003) also identified that combinations of treatments are likely to be more effective than individual treatments.

A review by Varhelyi (1996) identified various factors that influence a driver's speed behaviour, categorising these as speed raising or speed lowering. Amongst the road and traffic environment characteristics thought to increase speeds were: the design speed; the road standard (when good) including lane width, number of lanes and roughness; visual guidance (speeds increase when delineation is good); and downhill gradient. Elements thought to reduce speeds were: speed limits (thought to be the most important element in reducing speeds), bad road and weather conditions, and increased traffic volumes.

Varhelyi (1996) also identified previous literature that put values on some of these road elements. For instance, research by Nilsson (1989, cited in Varhelyi 1996), suggested that for every 1 m increase in the paved width of a road, speeds increased by 0.4 km/h. Evidence from Yagar and Aerde (1983) is cited suggesting that for every per cent reduction in gradient, there is about a 2 km/h increase in speed. For roughness, a study by Anund (1992) is cited, suggesting that there is a 3 km/h reduction in speed with each additional IRI (International Roughness Index) increase of 1 mm/m.

In a major review conducted as part of the European MASTER project, Martens et al. (1997) assessed the effect of design elements on speed, providing information on a number of relevant factors. In some cases, the effects of these elements were quantified. They cited a study by Van der Hoeven (1987) that identified a mean speed of 80 km/h for a pavement width of 6 m, while with a width of 8 m, speeds increased to 90–100 km/h. They also cited a study that indicated a minimal reduction in speed from a reduction in lateral clearance (the space that is visually available on either side of the footpath) from 30 m to 15 m (only 3%), while a decrease to 7.5 m resulted in a speed reduction of 16% (Van der Heijden 1978). They identified a further study that indicated a speed reduction of 13% when objects are placed directly alongside the road compared with 1 m from the edge of the road (Knoflachner & Gatterer 1981).

Martens et al. (1997) identified information that indicated that roughness had a quantifiable impact on speeds. They cited a study by Slangen (1983) that indicated a 14–23% reduction in speeds for roads with a rough surface. Similarly, they cited a study by Cooper et al. (1980) which found that with improvements to the road surface following resurfacing, speeds increased by up to 2.6 km/h. Te Velde (1985, cited in Martens et al. 1997) reported that a rough road that followed a smooth section of road reduced speeds by 5%.

Other road design elements were identified by Martens et al. (1997) but were not quantified, including roadside obstacles (the closer to the side of the road, the slower the speed, but typically only if the pavement width was less than 6 m), road curvature (where reductions in speed are partly influenced by reduced visibility along the road), and gradient (again, possibly due to reduced visibility).

Based partly on information regarding drivers' choice of speeds, the Netherlands has developed the concept of a 'self-explaining road' (e.g. Schermers 1999; Wegman & Aarts 2006; Theeuwes & Godthelp 1992). This key element of their 'sustainable safety' approach suggests a need to make clear to motorists what is expected of them in terms of their driving behaviour based on the design of the road. In the speed context, the ultimate self-explaining road is one that does not require speed limit signs to inform motorists as to the required safe speed.

In order to recognise the current road function and to predict road elements, the following three features are required (World Bank 2005):

- clear designing, marking and signing
- recognisable road categories
- a limit to the number of design elements for each road category and making them uniform.

Limiting the number of road classes and making these distinct (e.g. through markings, signs, and road or roadside elements specific to the type of road) is a key feature in recognition of the current road class, including ensuring that road users are aware of the speed limit on that road. Adoption of a self-explaining road approach typically involves assigning roads to a newly developed set of road categories, and then implementing changes in order to make these categories discrete but uniform.

Charlton and Baas (2006) suggested that the uniform road categories and their features should act to clearly indicate to motorists the type of road that they are on, but should also act implicitly (or subconsciously) to control the behaviour of motorists. In terms of speed management, they suggest these features could include the use of median and edge line treatments, access controls, road markings, pavement surfaces, and roadside furniture.

Although self-explaining road concepts have been around for a number of decades now, there has been a relatively limited application of the approach. Stelling-Konczak et al. (2011) suggest that providing adequate infrastructure to match the relevant road class is one of the key problems with implementing self-explaining roads in the Netherlands.

There is obviously still a great deal of work to be completed in identifying elements that help define different road types. Once this work is complete, there is also the substantial task of ensuring that the required infrastructure is in place for each type of road. Work on this topic is yet to commence in Australia, and initial attempts in New Zealand appear to be limited to the urban setting.

Summary

A number of studies report that drivers select their current speed based on what they feel is 'safe' for the current conditions. More specific research describes a variety of factors that have been found to influence a motorist's selection of driving speed. Factors include behavioural issues such as self-image, influence of passengers, perception of enforcement, trip purpose, attitudes to safety including crash history, and comparison with other drivers. Factors relating to traffic were also found to be important, including volumes of other vehicles and pedestrians, speed of other vehicles, and the presence of parked vehicles (this may be related to available road width).

Of more interest to this study are the factors that relate to the road environment. Research on this topic is fairly consistent and includes the road layout (including lane and shoulder width), roadside development, hazards and activity, presence of a median, number of access points, horizontal alignment, sight distance, and road smoothness. It also appears that these factors have greater influence in combination than as individual features.

It may be possible to manipulate a number of these factors in order to produce a reduction in speed. However, in some cases this manipulation would be costly or even lead to an increased level of risk (e.g. through the introduction of roadside hazards). Careful consideration of each issue is required to determine which factors might be cost-effective and safe options to effect a change in speed.

Also of merit would be the provision of increased information to motorists about the risks associated with different road factors and environments. Given current speed selection by motorists, it is likely that there is a poor understanding of risks related to some road factors (e.g. roadside hazards). Improved knowledge about these risks might assist in increasing public acceptability for lower limits in some environments.

2.2 Crash Data Analysis

To identify the key factors associated with speed-related crashes in rural areas in Australia and New Zealand, an analysis of road authority crash data was undertaken. The methodology adopted and the findings from the crash data analysis are outlined in the following subsections.

2.2.1 Data Analysis Methodology

The data for speed-related crashes in rural locations in New Zealand and some Australian jurisdictions (which, for the purposes of comparison was analysed alongside data for all crashes in rural areas) was disaggregated by variables to reflect the following: temporal characteristics (e.g. time of day), site characteristics (e.g. speed limit), crash characteristics (e.g. vehicle manoeuvre type), environmental conditions (e.g. light conditions), and road user characteristics (e.g. controller age and vehicle type).

No Victorian or ACT data was analysed, as the VicRoads crash database does not include causation factor information (including speed), while the ACT has a predominately urban transport environment. Crash data for New South Wales, Western Australia, South Australia, Tasmania, Northern Territory and New Zealand for the period from 1 January 2003 to 31 December 2007 was used. For Queensland, the most recent data available was for the period 1 January 2002 to 31 December 2006. Although these reporting periods do not reflect the most current period, the data is considered relevant to reflect current conditions.

It is important to note that in most cases, the contributing factors to crashes are determined subjectively. In some cases, speed may be identified as a contributing factor due to the nature of the crash, rather than through knowledge of what actually occurred. This may have biased some or all of the results presented in this section, so all results need to be treated with caution. In addition, in some cases speed may not have been recognised as a contributing factor, again creating bias in these results.

A speed-related crash was deemed to be any crash where one of the causal factors attributed to the crash or to any unit in the crash was speed. To be included in the analysis as rural crashes, crashes must have:

- occurred in a rural area (see Table 2.4 for the definitions of ‘rural’ that were employed for each jurisdiction)
- occurred within an area with a posted speed limit greater than or equal to 80 km/h (to further filter out crashes that probably did not occur within a rural environment).

Table 2.4: Definitions of a rural area

Jurisdiction	Variable	Values allowed	Values excluded
New South Wales	Urbanisation	Country urban areas, Country non-urban areas, Country unknown	Sydney metro, Newcastle metro, Wollongong metro
Queensland	LGA	All LGAs not within the Brisbane or Moreton Statistical Divisions	LGAs located within the Brisbane or Moreton Statistical Divisions
Western Australia	Region	Gasgoyne, Goldfields, Great Southern, Kimberley, Mid West, Pilbara, South West, Wheatbelt North, Wheatbelt South	Metropolitan
South Australia	Statistical area code	Country	Adelaide, metropolitan
Tasmania	Land use	Rural	Metropolitan – industrial, residential and commercial
Northern Territory	Urban/Rural	Rural	Urban
New Zealand	Urban/Rural	Rural – open roads	Urban

It is acknowledged that there are problems inherent in this method of defining ‘rural’ crashes. For example, some crashes that occurred within 80 km/h zones in rural towns (built-up areas) would have been included in the analyses. However, the bulk of crashes that occurred in built-up areas should have been successfully filtered from the results presented.

Only casualty crashes (any injury level) were of interest for the present purpose. ‘Property damage only’ crashes were not included because not all jurisdictions record such crashes. In addition, the under-reporting of ‘property damage only’ crashes is likely to be more problematic in rural and remote areas due to reduced access to police services.

Analyses of crash data were conducted using SPSS (Statistical Package for the Social Sciences) Version 16.02. The findings of the analyses are outlined in the following sections.

2.2.2 Rural Speed and ‘Not-speed’ Crashes

By severity

From 2003 to 2007, the total number of fatal rural crashes recorded in the six sample Australian jurisdictions where speed was recorded as a contributory factor was 756, while the total number of fatal rural crashes was 2686. As discussed in Section 2.2.1, Victoria does not record contributory factors with their crash data, while the ACT is predominantly urban, so this result excludes crashes from these jurisdictions.

For jurisdictions in Australia where speed contribution was recorded, speed was reported to contribute to 28% of all fatal rural crashes and 20% of all rural injury crashes. The proportion that speed contributed to fatal crashes in each Australian jurisdiction varied from about 5% to 40% (Table 2.5). This difference could in part be due to real differences in driver behaviour and/or road environment in each jurisdiction, but will most likely be due to differences in the reporting of speed-related crashes. In New Zealand, speed was reported as contributing to 31% of fatal crashes, and 22% of injury crashes.

Table 2.5: All crashes for Australian jurisdictions and New Zealand between 2003 and 2007

Jurisdiction	Speed		Not speed		% speed	
	Fatal	Injury	Fatal	Injury	Fatal	Injury
New South Wales	456	6 054	653	9 727	41%	38%
Queensland	81	506	503	9 197	14%	5%
Western Australia	114	263	253	3 038	31%	8%
South Australia	16	76	298	4 652	5%	2%
Tasmania	71	884	97	2 944	42%	23%
Northern Territory	18	163	126	2 307	13%	7%
Total Australia	756	7 946	1 930	31 866	28%	20%
New Zealand	412	4 932	913	16 796	31%	22%

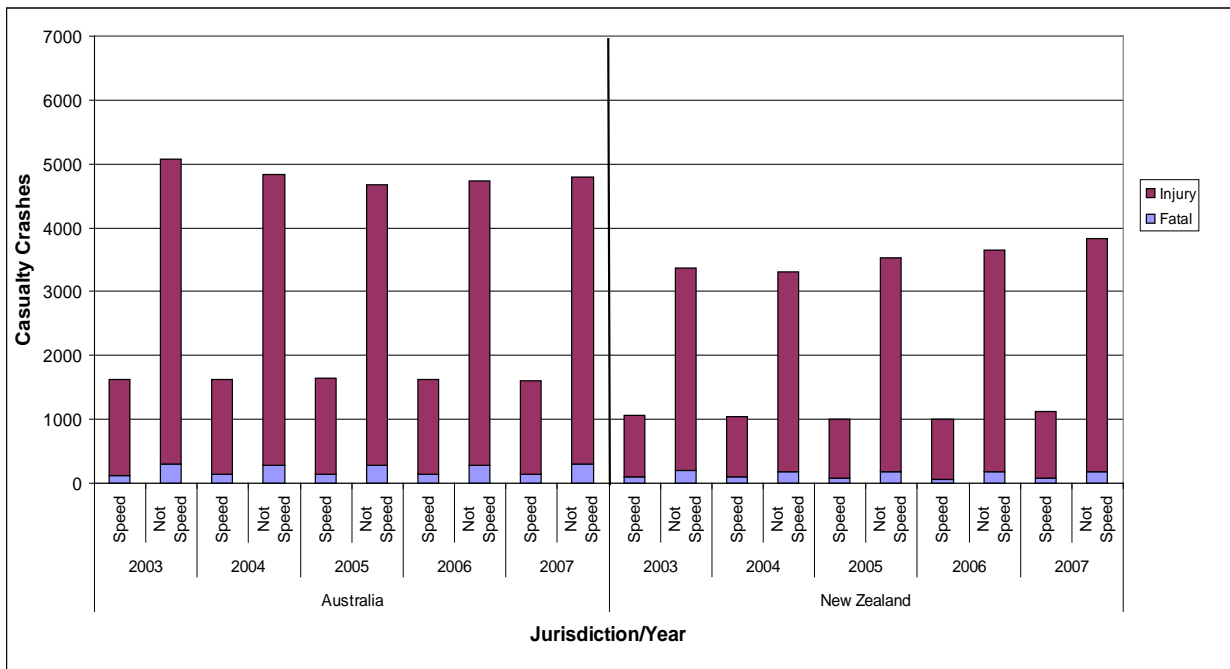
The data for Queensland actually covers the period from 2002 to 2006. As noted earlier, this analysis does not include data for Victoria or ACT. Although no data was available for either of these jurisdictions on speed-related crashes, the total numbers of fatal and injury rural crashes that occurred in these jurisdictions during this timeframe were 776 fatal crashes and 13 661 injury crashes. Applying the average proportion of speed-related crashes for the other jurisdictions to these figures provides an estimate of speed-related crashes across all of Australia. It is estimated that there were 973 fatal speed-related crashes on rural roads between 2003 and 2007. This equates to almost 200 fatal crashes per year. For injury crashes, there was an estimated total of 10 678 speed-related crashes on rural roads between 2003 and 2007, which equates to 2136 injury crashes per year.

By year

Figure 2.2 shows that the number of speed-related casualty crashes has been relatively stable in Australia between 2003 and 2007, whereas New Zealand has shown a slight upward trend for this period. These results demonstrate that speed is still a significant contributor to crashes and must be addressed accordingly.

Note: this analysis excludes data from Queensland, Victoria and ACT.

Figure 2.2: Annual rural speed and non-speed crashes in Australia and New Zealand



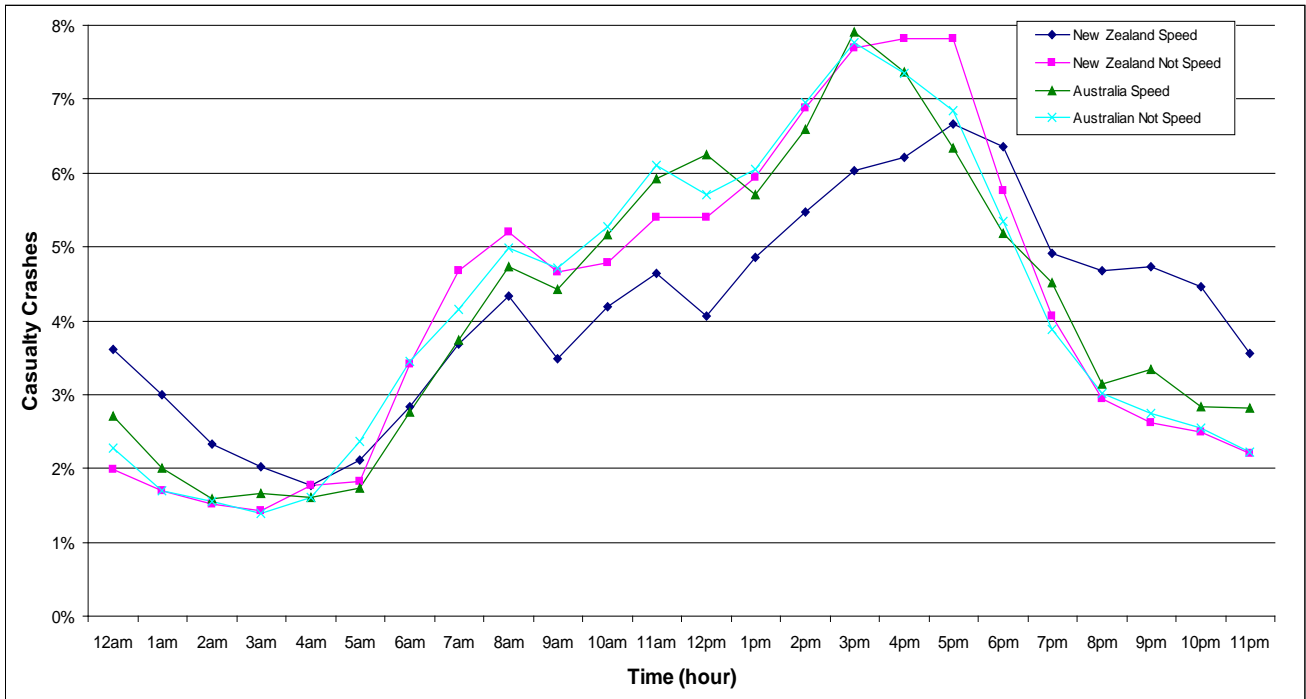
By time of day

Figure 2.3 shows the casualty crash trend for Australia and New Zealand by time of day.

Both Australia and New Zealand experience a similar casualty crash pattern, with the highest proportion of rural speed and rural non-speed crashes occurring around the evening ‘peak’ (3 pm and 5 pm). For both countries, speed-related crashes appear to be over-represented in the evening and the early morning (6 pm to 3 am) compared to other crash types, with this pattern most pronounced in New Zealand. An analysis of fatal crashes was also conducted (not shown here) and demonstrated that the over-representation of speed in the evening and early morning was even more pronounced.

Note: this analysis excludes data from Victoria and ACT.

Figure 2.3: Proportion of rural speed casualty crashes and non-speed crashes by time of day



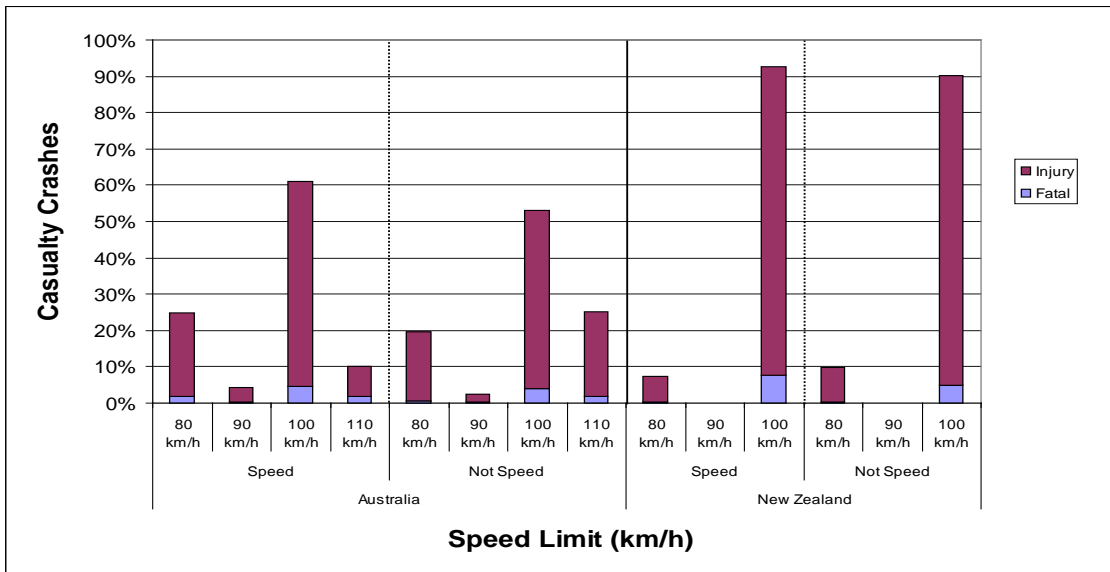
By speed limit

Figure 2.4 shows that the majority of both speed and non-speed casualty crashes occur in 100 km/h zones. In Australia, there is a higher proportion of crashes on both 80 km/h and 100 km/h roads when speed is involved, while the proportion on 110 km/h roads is lower. However, a check of the fatal crash data revealed that the chances of a crash resulting in a fatality were far greater on 110 km/h roads if speed was involved (18% for 110 km/h, 7% for 80 km/h, 9% for 90 km/h, and 8% for 100 km/h). For speed-related crashes, the chances of a fatal outcome were greater for most speed limits in both Australia and New Zealand.

In New Zealand, a slightly higher proportion of speed-related crashes occur on 100 km/h roads when speed is involved compared to when it is not. There is currently only one short section of road in New Zealand that has a 90 km/h speed limit, and this was only recently installed. This would have influenced the finding that there were no crashes for this speed limit type during the study period.

Note: this analysis excludes data from Victoria and ACT.

Figure 2.4: Proportion of rural speed crashes and non-speed crashes by speed limit²

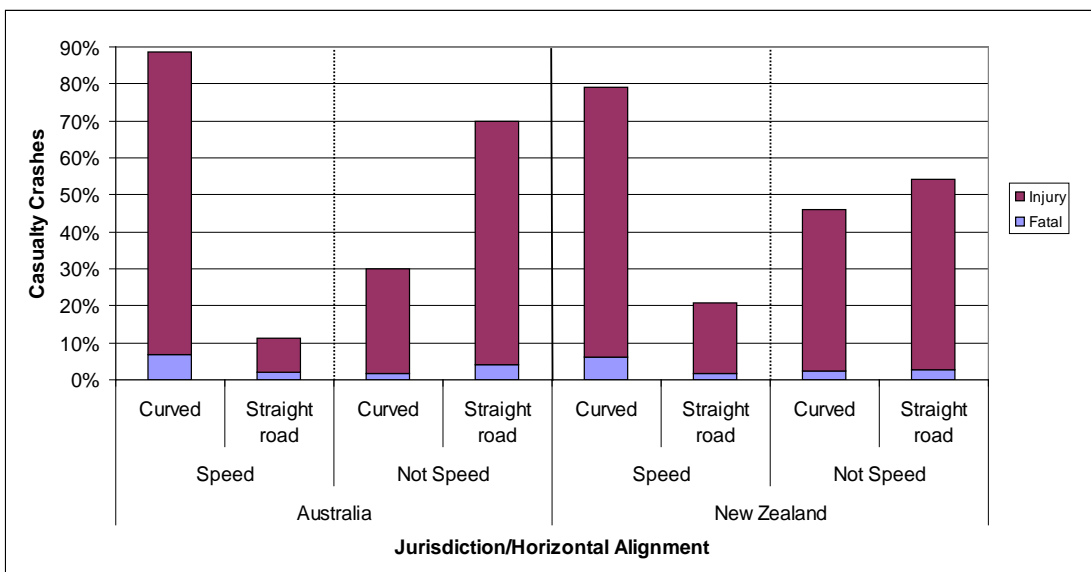


By horizontal alignment

Figure 2.5 shows that the vast majority of speed-related crashes occur on curved roads, and this pattern appears in both the Australian data (around 90%) and the New Zealand data (almost 80%). In both cases, a far higher proportion of crashes occur at curves for crashes where speed has been recorded as a factor whereas other factors are of more relevance on straight sections of road.

Note: this analysis excludes data from Victoria and ACT.

Figure 2.5: Proportion of rural speed and non-speed crashes in Australia and New Zealand by horizontal alignment



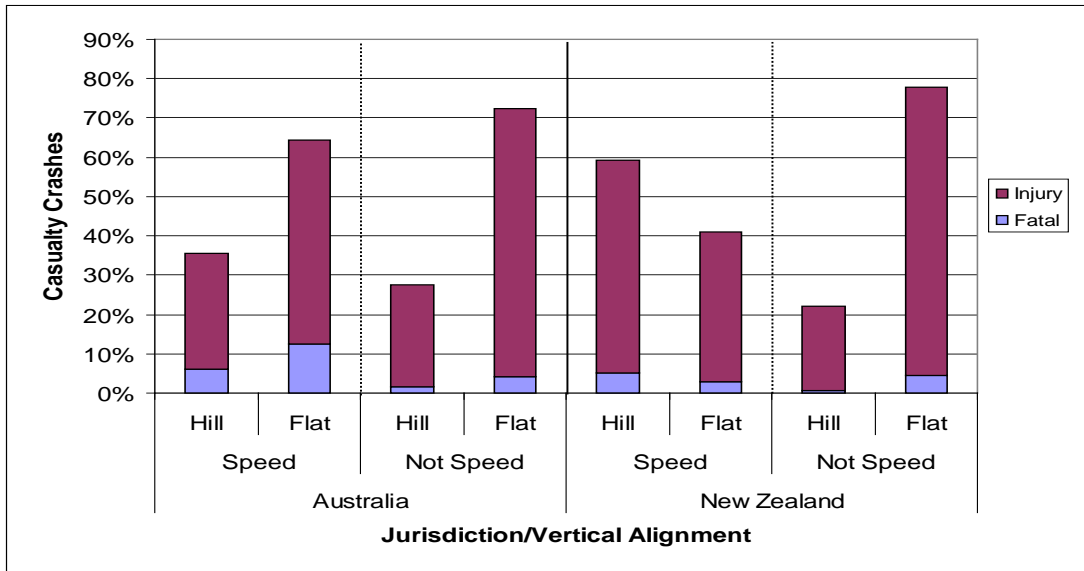
² In the Northern Territory, a value of '0' for speed limit in a non-urban region represents a derestricted zone (essentially, an area with no speed limit). Crashes in derestricted zones have been included and are represented under the 110 km/h category.

By vertical alignment

Figure 2.6 shows that the majority of speed and non-speed crashes occur on flat or level road sections in Australia. However, in New Zealand, the majority of rural speed-related crashes occur on hilly road sections, while the majority of rural non-speed crashes occur on flat road sections. For both countries, a higher proportion of speed crashes occur on hilly roads compared to non-speed crashes on hilly roads.

Note: this analysis excludes data from Victoria and ACT.

Figure 2.6: Proportion of rural speed and non-speed crashes in Australia and New Zealand by vertical alignment



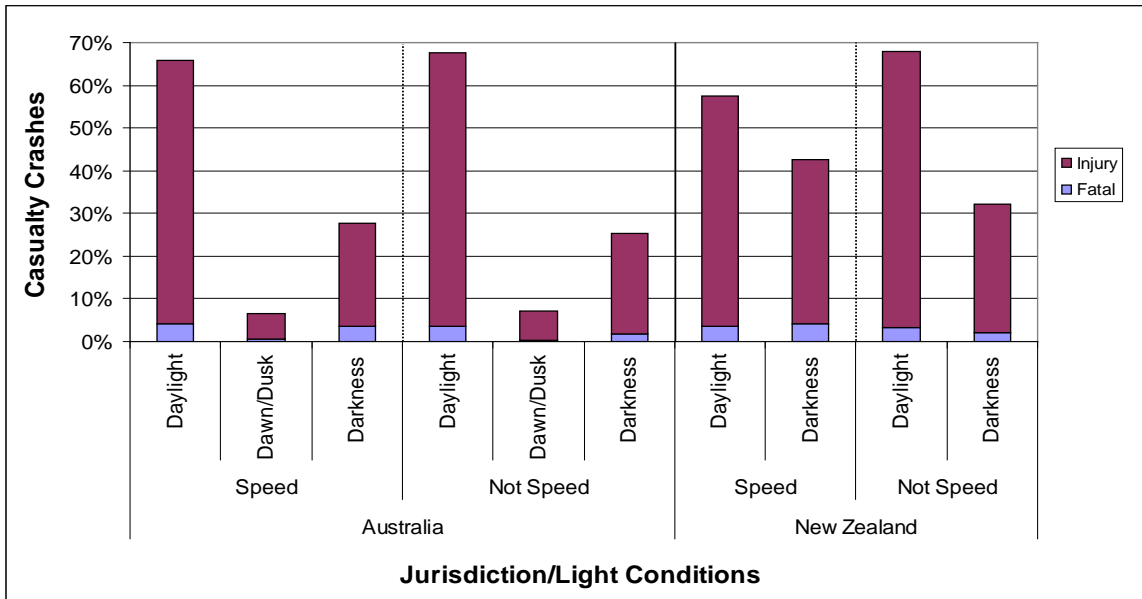
By light conditions

The Australian data in Figure 2.7 indicates that the proportion of casualty crashes occurring in daylight conditions is similar for both speed and non-speed crashes. For both the Australian and New Zealand data, a higher proportion of crashes occur during daylight conditions. However, a separate analysis of the fatal crash data (not shown in the figure) showed that the proportion of fatal crashes occurring due to speed in daylight is 50%, while the proportion of fatal crashes where speed is not involved is 58%.

In New Zealand, a higher proportion of speed-related crashes occur in darkness (43%) than for non-speed crashes (around 32%).

Note: this analysis excludes data from Victoria and ACT.

Figure 2.7: Proportion of rural speed and non-speed crashes in Australia and New Zealand by light conditions

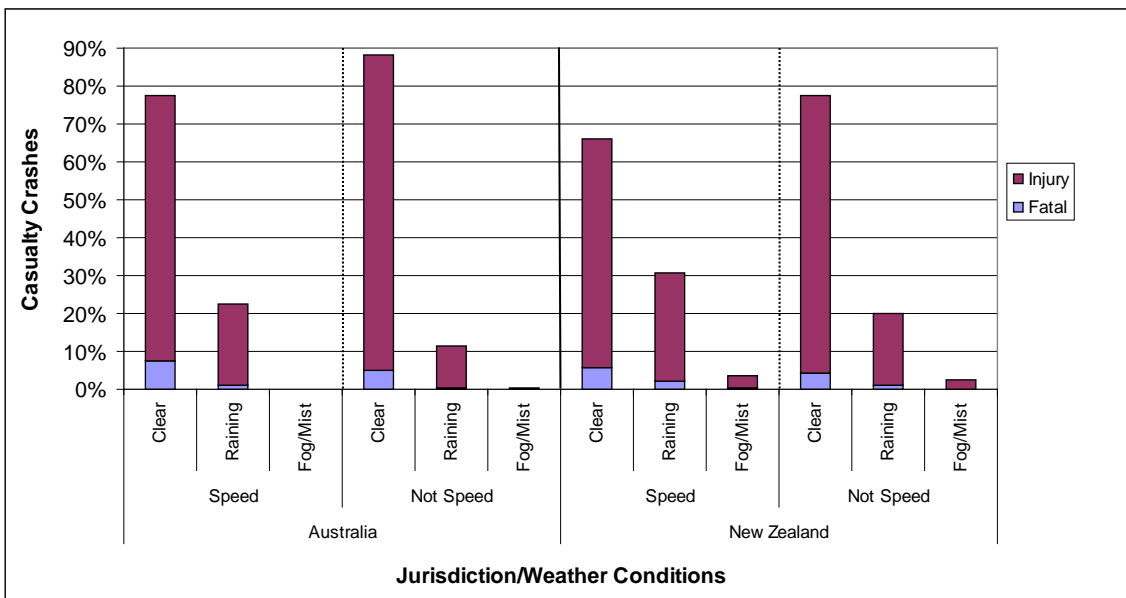


By weather conditions

Figure 2.8 shows that the majority of rural speed casualty crashes occur during clear weather in both Australia and New Zealand. However, speed-related crashes appear to be over-represented during rain in both countries.

Note: this analysis excludes data from Victoria and ACT.

Figure 2.8: Proportion of rural speed and non-speed crashes in Australia and New Zealand by weather conditions

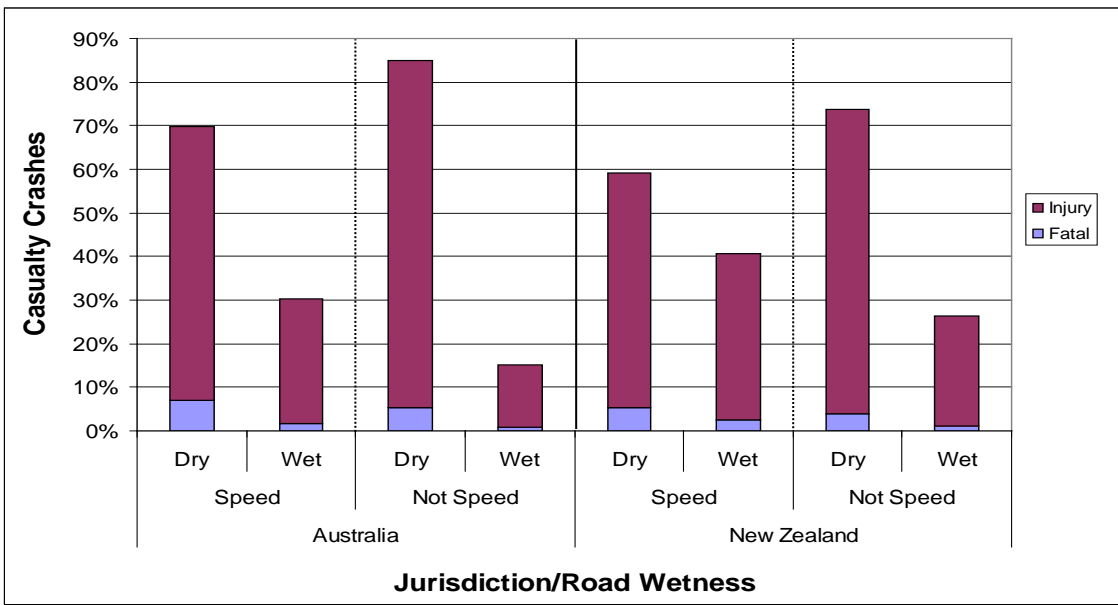


By road wetness

Similar proportions to those seen for the weather condition analysis are evident in Figure 2.9. This shows that although the vast majority of casualty crashes occur when the road is dry, speed-related crashes appear to be over-represented while the road is wet.

Note: this analysis excludes data from Victoria and ACT.

Figure 2.9: Proportion of rural speed and non-speed crashes in Australia and New Zealand by road wetness

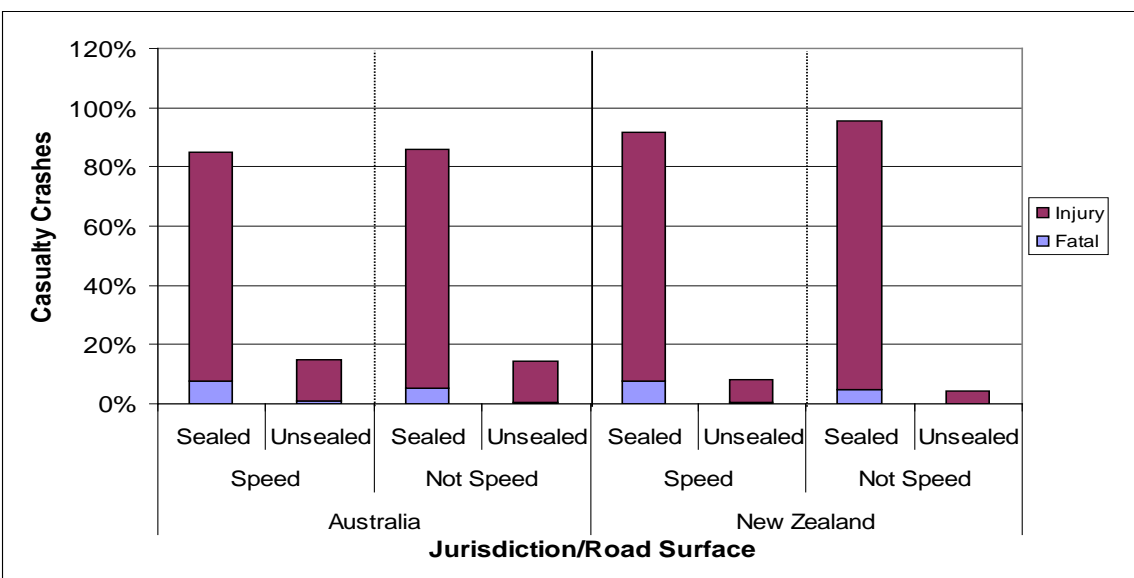


By road surface

Figure 2.10 indicates that the vast majority of crashes occur on the sealed road network, and a similar proportion of speed and non-speed-related casualty crashes occur on sealed roads.

Note: this analysis excludes data from Victoria and ACT.

Figure 2.10: Proportion of rural speed and non-speed crashes in Australia and New Zealand by road surface



By crash type

Figure 2.11 shows the proportion of speed and non-speed crashes in Australia. ‘Off path on curve’ casualty crashes contribute to 78% of speed-related crashes, a proportion that is well over-represented when compared to non-speed-related crashes (only 20% of non-speed crashes).

A separate analysis of fatal speed-related crashes (not shown in the figure) revealed that the most common crash type was also ‘off path on curve’ (63% of fatal speed-related crashes), followed by ‘off path on straight’ (15%) and ‘vehicles from opposing directions’ (14%). For non-speed crashes, the most common crash types were ‘off path on straight’ (31%), ‘vehicles from opposing directions’ (28%), and ‘off path on curve’ (14%).

Note: this analysis excludes data from Victoria, ACT and South Australia (South Australia does not have a crash coding system that can be reconciled with the movement codes used in other jurisdictions).

Figure 2.11: Proportion of rural speed and non-speed crashes in Australia by crash type

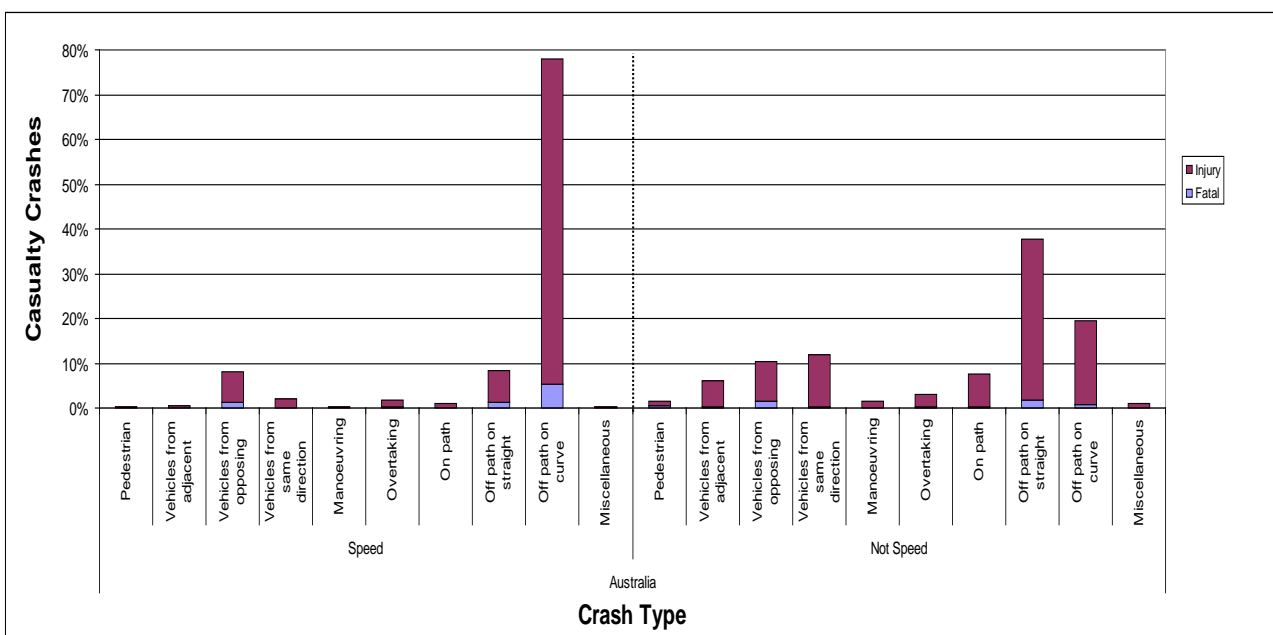
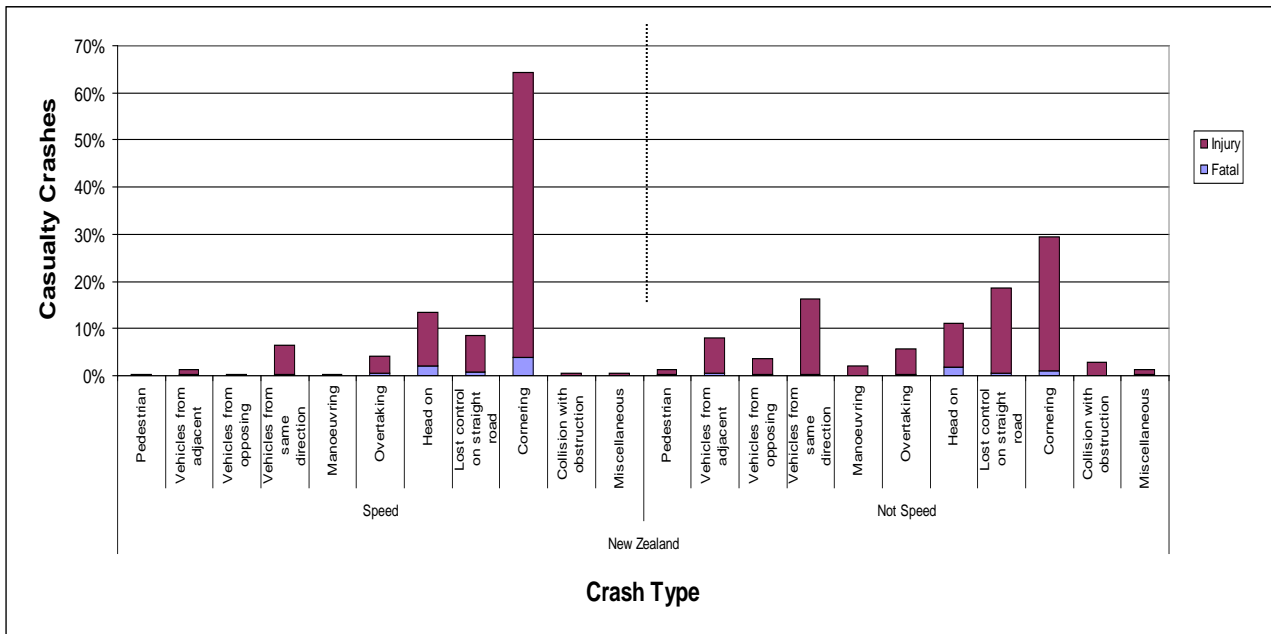


Figure 2.12 illustrates that ‘cornering’ was the most common crash type in New Zealand, and this was highly over-represented for speed-related crashes. The next most common crash types for speed-related crashes were ‘head on’ and ‘lost control on straight road’.

A separate analysis of the fatal crash data showed that 50% of fatal speed-related crashes occurred while ‘cornering’, 26% from ‘head on’ crashes, and 9% from ‘lost control on straight’ crashes. For non-speed crashes, the most common crash type was ‘head on’ (35%), followed by ‘cornering’ (19%) and ‘lost control on straight’ (12%).

Figure 2.12: Proportion of rural speed and non-speed crashes in New Zealand by crash type



Since there is a significant number of speed-related casualty crashes occurring when cornering, further analysis using New Zealand data was undertaken to examine whether these crashes occurred due to a loss of control while cornering to the right or to the left. The results showed that 57% occur due to 'lost control turning right' and 43% due to 'lost control turning left' (Table 2.6).

Table 2.6: Cornering analysis using movement codes for New Zealand

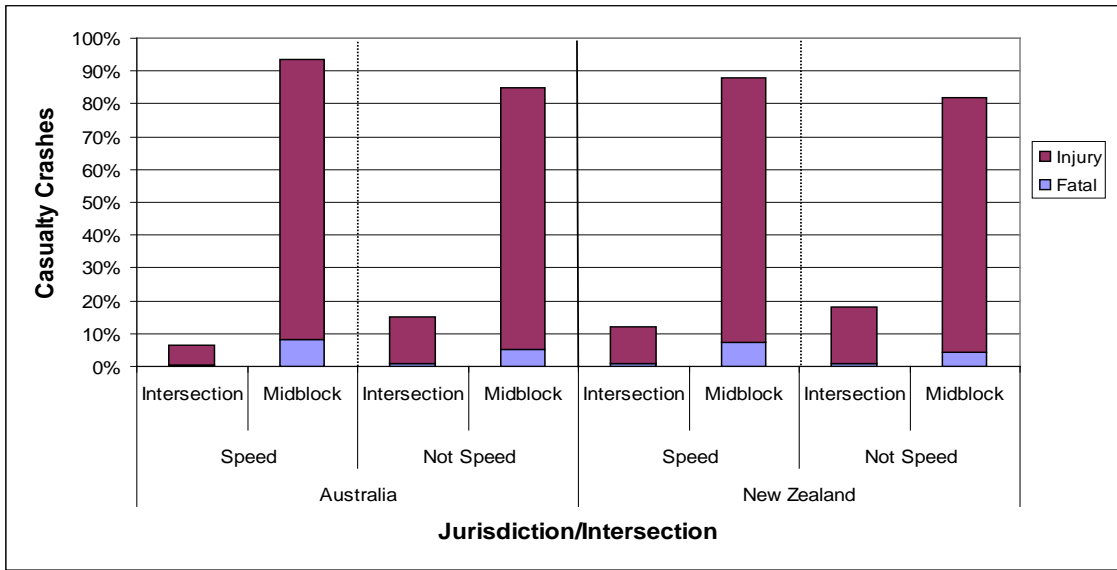
	Lost control turning right	Lost control turning left
Fatal	110	94
Injury	1746	1332
Total	1856	1426

By intersection/midblock

In both Australia and New Zealand, the majority of rural speed-related casualty crashes occur at midblock road sections (Figure 2.13). For non-speed crashes, the majority also occur at midblock road sections. A slightly higher proportion occurs at midblock locations when speed has been identified as a factor. A lower percentage of speed and non-speed crashes occur at intersections, and it appears that speed at intersections is under-represented.

Note: this analysis excludes data from Victoria and ACT.

Figure 2.13: Proportion of rural speed and non-speed crashes in Australia and New Zealand by intersection or midblock



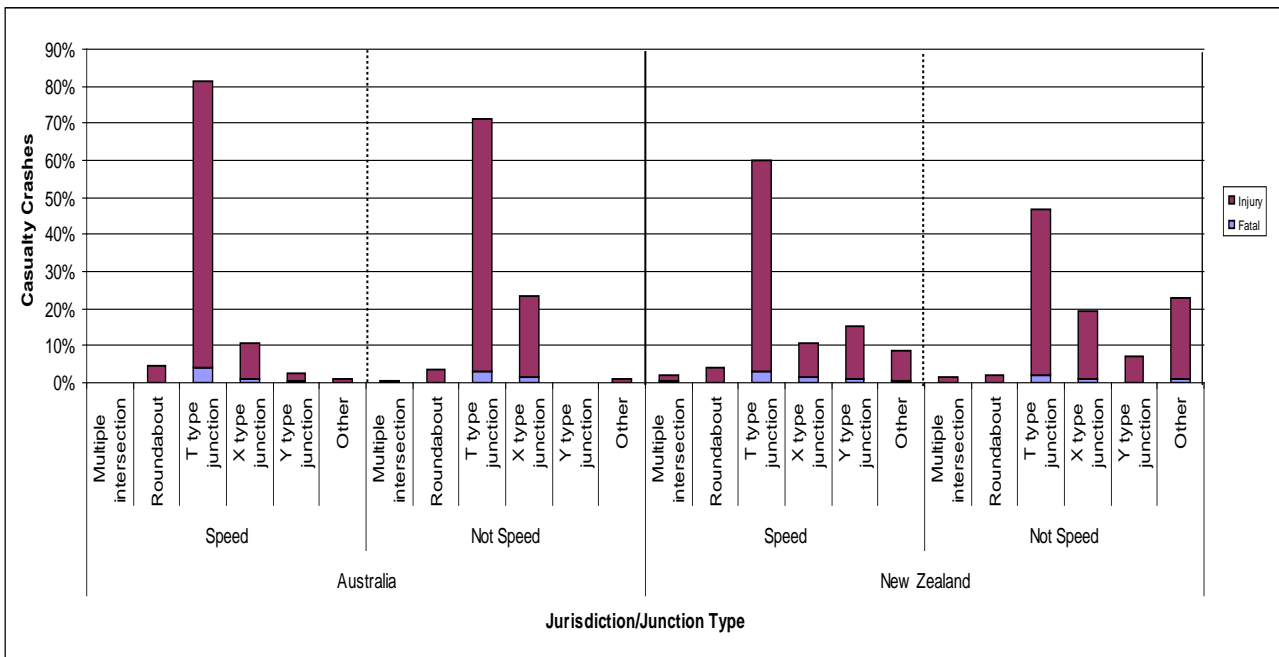
By junction type

Figure 2.14 shows that most rural casualty crashes at intersections occur at T-intersections in both Australia and New Zealand. This is true for both speed and non-speed crashes. It appears that a higher proportion of intersection crashes occur at T-intersections for speed-related crashes in both countries.

In New Zealand, casualty crashes at Y-intersections also appear to be over-represented for speed-related crashes.

Note: this analysis excludes data from Victoria and ACT.

Figure 2.14: Proportion of rural speed and non-speed crashes in Australia and New Zealand by junction type

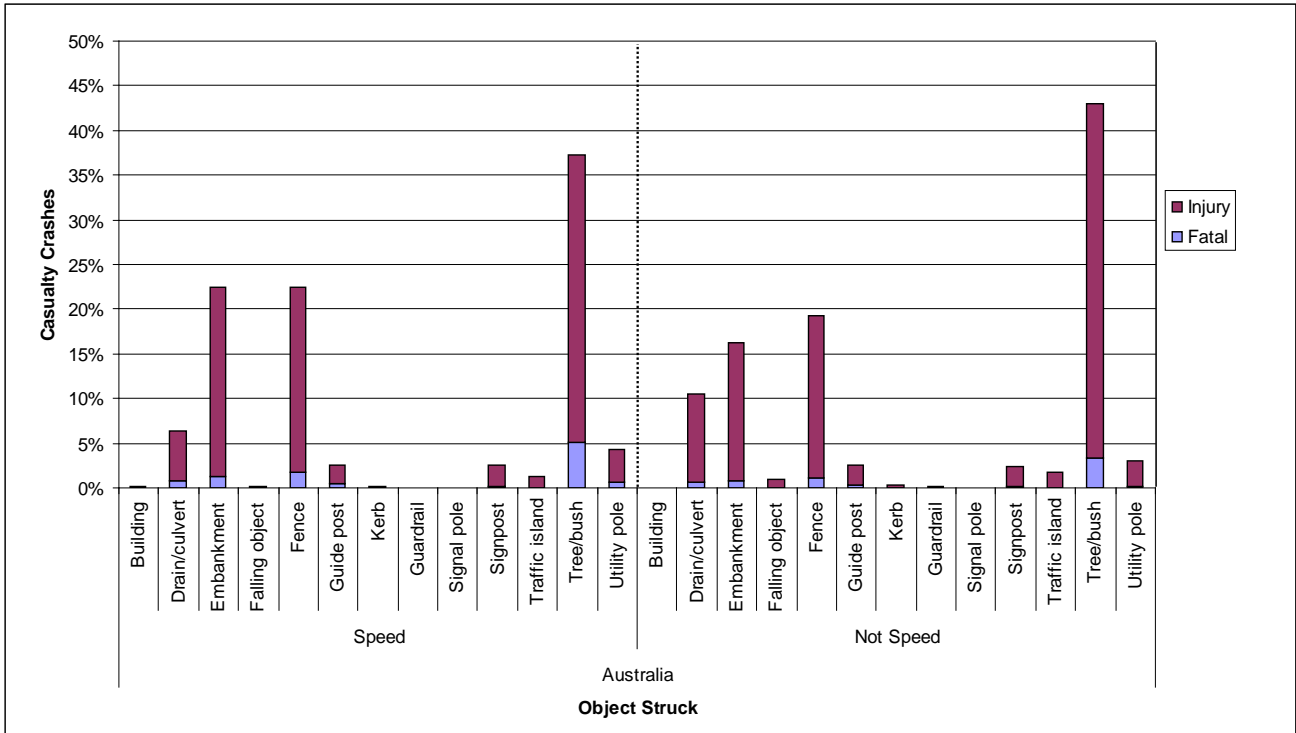


By object struck

Figure 2.15 shows that a tree/bush is the most likely object to be struck in both speed and non-speed crashes in Australia. Embankments and fences also appear to be over-represented when speed is involved.

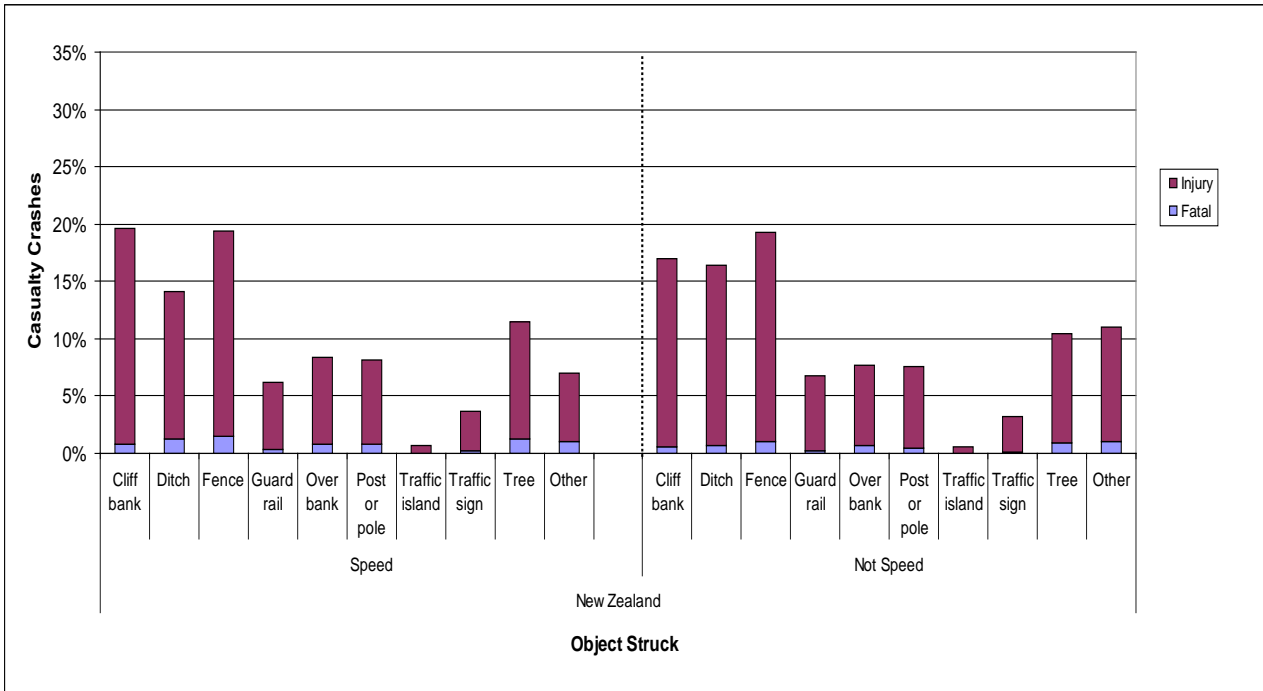
Note: this analysis is missing data from Victoria and ACT.

Figure 2.15: Proportion of rural speed and non-speed crashes in Australia by object struck



In New Zealand, the objects most likely to be struck in speed-related crashes are a cliff or bank (20%), ditch (14%), and fence (19%). The findings are similar for non-speed crashes (Figure 2.16).

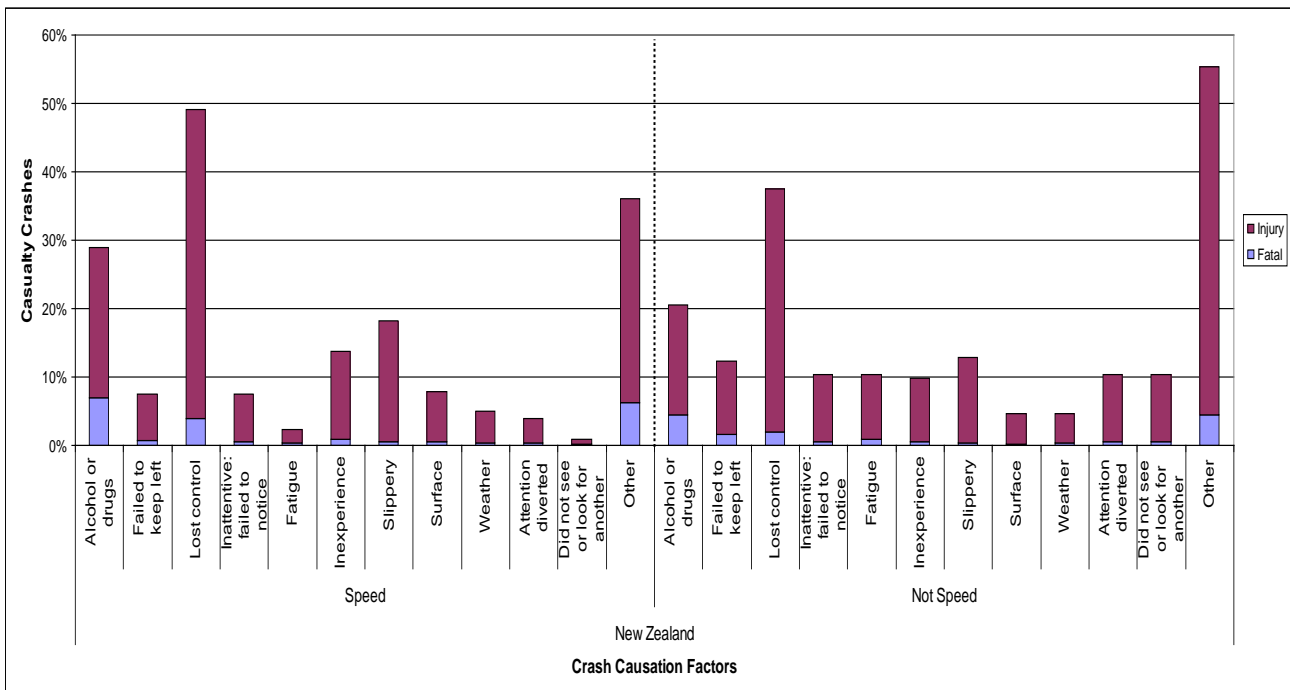
Figure 2.16: Proportion of rural speed and non-speed crashes in New Zealand by object struck



By crash causation factors

Figure 2.17 shows some of the most common causation factors (besides speed) listed in the New Zealand crash data. For speed, the most common causation factors were lost control, alcohol or drugs, slippery road and inexperience. All of these factors were over-represented when compared to non-speed crashes. Almost a quarter (24%) of the alcohol or drugs crashes resulted in a fatality when speed was involved.

Figure 2.17: Proportion of rural speed and non-speed crashes in New Zealand by crash causation factors



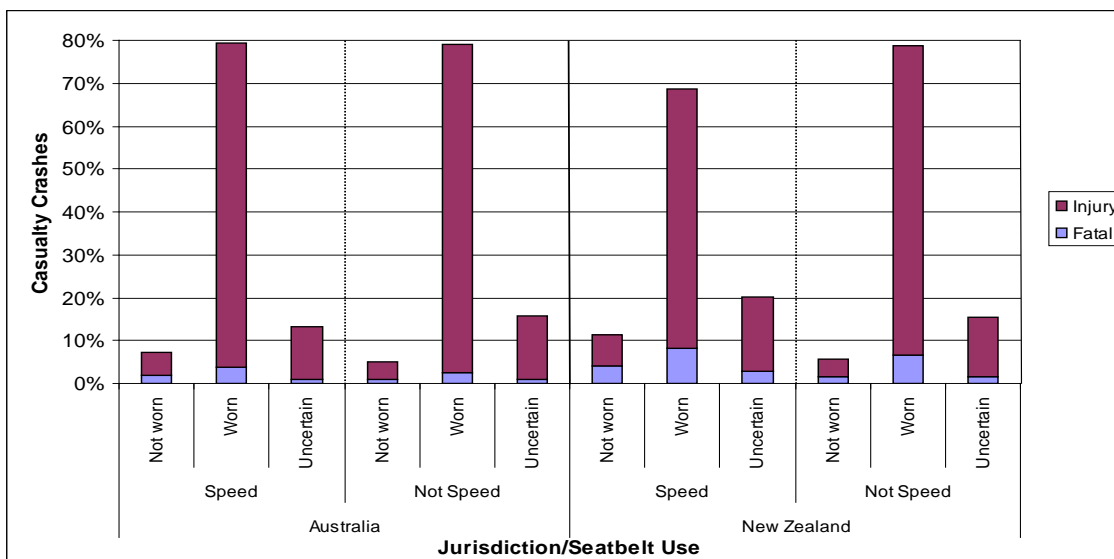
By seatbelt use

Figure 2.18 indicates that seatbelt usage in crashes is reasonably high in both Australia and New Zealand. While seatbelt usage is very similar in speed and non-speed crashes in Australia, in New Zealand, the proportion of seatbelts worn in speed crashes is less than the proportion of seatbelts worn in non-speed crashes.

In a separate examination of the fatal crash data (not shown in the figure) it was identified that for speed crashes in Australia (where seatbelt usage was known), seatbelts were not worn in 35% of crashes. This compares with 28% for non-speed crashes. This situation is even more pronounced in New Zealand, where for speed crashes, seatbelts were not worn in 33% of fatal crashes (where this was known), while for non-speed crashes, seatbelts were not worn in 19% of crashes.

Note: this analysis excludes data from Victoria and ACT.

Figure 2.18: Proportion of rural speed and non-speed crashes in Australia and New Zealand by seatbelt use



By driver age

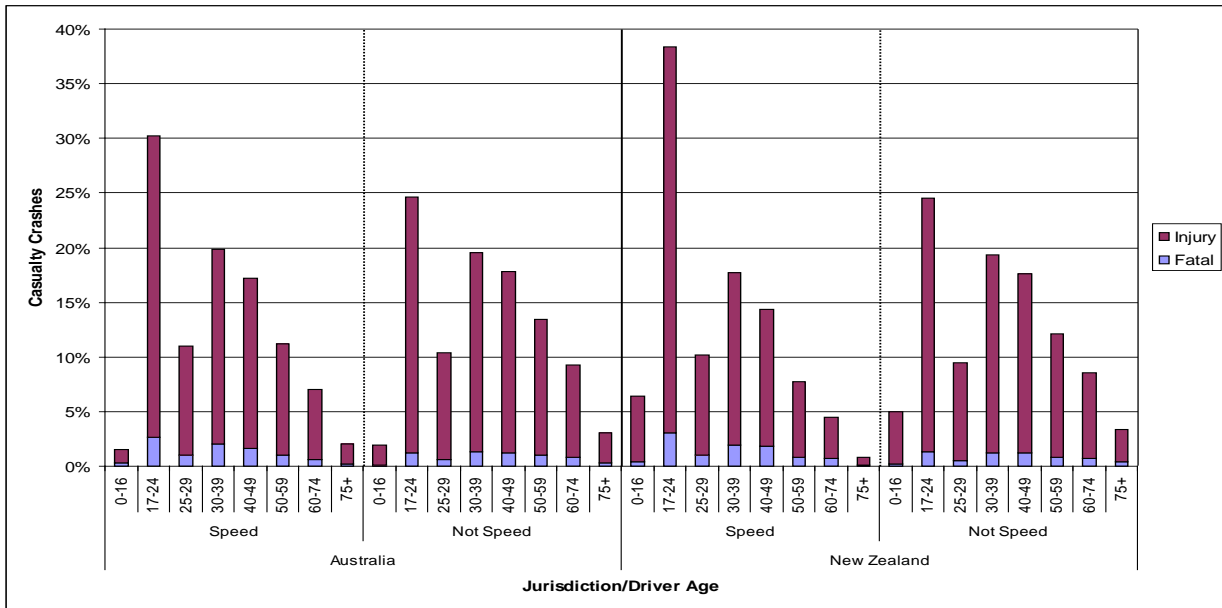
Figure 2.19 indicates that the highest numbers of casualty crashes occur within the 17–24 age group in both Australia and New Zealand for both speed and non-speed crashes. This age group is over-represented when compared with non-speed crashes.

In Australia, 28% of fatal speed crashes and 21% of fatal non-speed crashes occur within the 17–24 age group.

In New Zealand, 31% of fatal speed crashes and 24% of fatal non-speed crashes occur within the 17–24 age group.

Note: this analysis excludes data from Victoria and ACT. Some states were only able to provide data in age categories, and not for each year. Therefore, to include this data, the information shown here uses these same age categories.

Figure 2.19: Proportion of rural speed and non-speed crashes in Australia and New Zealand by driver age



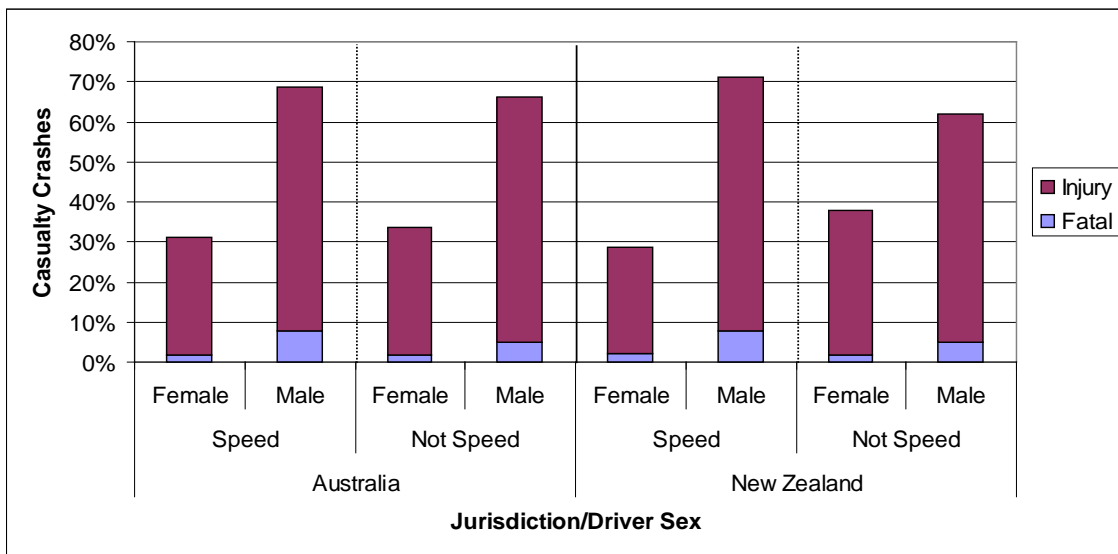
By driver sex

Figure 2.20 shows that the majority of speed and non-speed crashes involve male drivers in both Australia and New Zealand. In Australia, male drivers appear to be slightly over-represented for speed-related crashes, while in New Zealand, this tendency is more pronounced.

In Australia, the proportion of fatal speed crashes involving male drivers is 81% and for fatal non-speed crashes it is 77%. In New Zealand, the proportion of fatal speed crashes involving male drivers is 79%, and for fatal non-speed crashes it is 76%.

Note: this analysis excludes data from Victoria and ACT.

Figure 2.20: Proportion of rural speed and non-speed crashes in Australia and New Zealand by driver sex

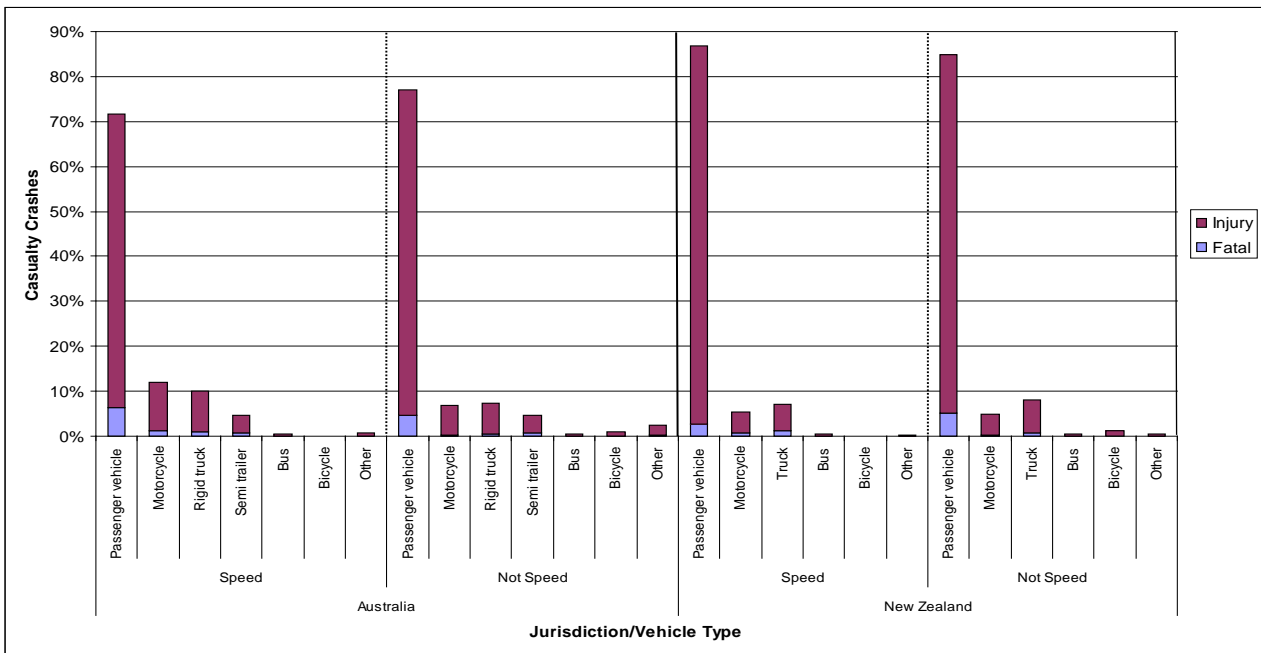


By vehicle type

Figure 2.21 indicates that the vast majority of casualty crashes involve passenger vehicles in both Australia and New Zealand. In Australia, motorcycles appear to be slightly over-represented in speed-related crashes, as do rigid trucks. A separate examination of the fatal crash data supported this, with 12% of fatal speed crashes involving a motorcyclist, compared to 5% for non-speed crashes. While the casualty data for New Zealand shows no such disparity, examination of the fatal data shows a similar trend. Motorcyclists were involved in 17% of New Zealand’s speed-related crashes and 5% of non-speed crashes. A similar over-representation was also seen for fatal truck crashes in New Zealand (25% for speed, 12% for non-speed).

Note: this analysis excludes data from Victoria and ACT.

Figure 2.21: Proportion of rural speed and non-speed crashes in Australia and New Zealand by vehicle type



2.2.3 Summary

Speed is recorded as a significant contributor to death and serious injuries on rural roads in both Australia and New Zealand. Around 28% of all fatal crashes in Australia, and 31% in New Zealand are recorded as being attributed to speed.

In addition, speed contributes to 20% of rural injuries in Australia, and 22% in New Zealand. The number of crashes and fatalities due to speed has remained relatively steady over the five-year period from 2003 to 2007.

It is found that a higher proportion of speed-related crashes occur:

- at night or in the early morning
- on curved roads
- at midblocks (as opposed to intersections)
- on hilly roads
- on wet roads.

Also, a higher proportion of speed-related crashes involve:

- not wearing a seatbelt
- alcohol or drugs
- motorists aged 17–24 years
- motorcycles.

2.3 Surveys of Attitudes to Speeds

2.3.1 Australian Attitude Surveys

Regular Australian national attitude surveys are undertaken by the Department of Infrastructure and Transport. These surveys are generally conducted every year and contain valuable information on public perceptions and attitudes to speed. Ad hoc surveys have also been undertaken in various states (e.g. in Queensland by Fleiter & Watson 2005) and overseas (e.g. in the UK by Quimby & Drake 1989), but are not reviewed here.

In 2008, the national survey included a total of 1592 interviews with those aged 15 years and over (Pennay 2008). A disproportionate stratified sampling methodology was utilised to ensure adequate coverage of the population by age, sex, state/territory, and capital city.

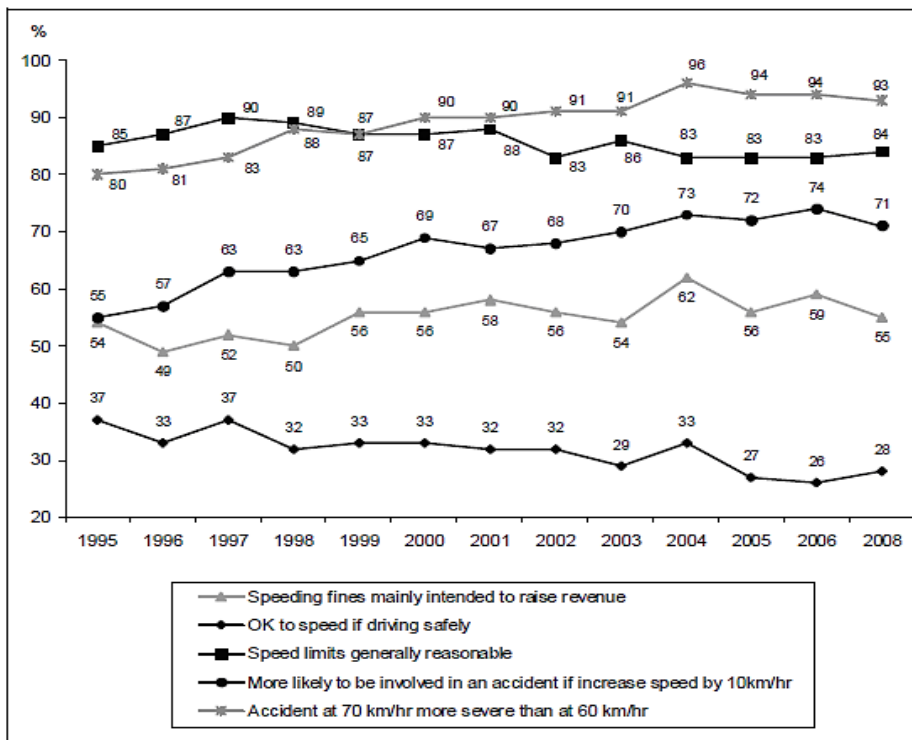
The survey found that:

- 39% identified speed as the factor that most often leads to road crashes, followed by 14% due to inattention/lack of concentration, 11% due to drink driving, and 7% due to driver fatigue
- 26% believed that it is okay to exceed the speed limit if driving safely
- 71% believed that if the driving speed increased by 10 km/h, the driver was significantly more likely to be involved in a crash
- there has been an increase over the past decade in community awareness of the link between speeding and road crashes
- 55% believed that speeding fines are mainly intended to raise revenue
- 84% felt that speed limits are generally set at reasonable levels
- 38% believed that people should be immediately booked if they exceed the speed limit by any margin in an urban 60 km/h zone
- 34% believed that driving over 100 km/h on rural roads is acceptable
- 46% supported an increase in the amount of speed limit enforcement.

Figure 2.22 shows the trends in national attitudes towards speeding between 1995 and 2008. The trends show:

- a decrease in the percentage of respondents who believe that it is okay to exceed the speed limit if driving safely, from 37% in 1995 to 28% in 2008
- the belief that speeding fines are mainly intended to raise revenue has stayed relatively stable, from 54% in 1995 to 55% in 2008 (although there was a peak in 2004 at 62%)
- a big increase in community perception that if driving speed increased by 10 km/h, the driver was significantly more likely to be involved in a car accident, from 55% in 1995 to 71% in 2008
- an increase in awareness that a crash at 70 km/h is more severe than at 60 km/h, from 80% in 1995 to 93% in 2008
- the belief that speed limits are generally set at reasonable levels has remained relatively stable with 85% in 1995 and 84% in 2008.

Figure 2.22: General attitudes towards speeding, 1995 to 2008



Source: Pennay (2008).

An on-line survey conducted across Victoria, South Australia, Western Australia and Tasmania by Lahaussé et al. (2010) found that just over half of the respondents (51%) believed that the current speed limit on rural roads (100 km/h) was too high, while 88% thought that the speed limit on unsealed roads (also 100 km/h) was currently too high.

2.3.2 New Zealand Attitude Surveys

Attitude surveys on road safety issues have been conducted in New Zealand since 1974 on a periodic basis, and on an annual basis since 1994. One of the main focuses of the surveys is on attitudes to speed. The most recent survey was conducted in 2010. Comparisons drawn between this and previous surveys (dating back to 1995) have found the following:

- There is a steady downward trend in those who think that there is not much chance of a crash if careful when speeding (in 1995, around 25% of respondents believed this statement, compared to 16% in 2010).
- Overall, 76% of respondents believed that enforcing speed limits will help lower the road toll (this figure has remained steady over the 15 year survey period).
- There is an increased awareness of enforcement with regard to speeding.
- When asked specifically about the rural (open road) speed limit of 100 km/h, 78% of respondents wanted it kept as it was; 18% wanted an increase, down from 25% in 1995.

2.3.3 Summary

In general, the results of surveys of attitudes to speed both in Australia and New Zealand have demonstrated an overall increase in awareness of speed as a contributing factor to rural crashes. This has been reflected by a significant increase in public perception that if driving speeds increased by 10 km/h then the likelihood of being involved in a crash also increased and the lower percentage of drivers who are likely to drive 10 km/h over the speed limit and a decrease in the percentage who believed that driving at speeds in excess of the speed limit was acceptable if driving safely.

2.4 Speed Monitoring Data

Speed monitoring surveys are designed to monitor changes in vehicle speeds and provide an insight into speed and driver behaviour. The data collected enables practitioners to design and implement behaviour modifying policies and also measure the effectiveness of existing programs. For this task, speed data was collected from each jurisdiction where this was available (all jurisdictions except for ACT and NT). Speeds on both rural and urban roads were collected. Urban speeds were thought to be of interest when comparing changes over time (e.g. to determine whether speeds are falling faster on rural or urban roads).

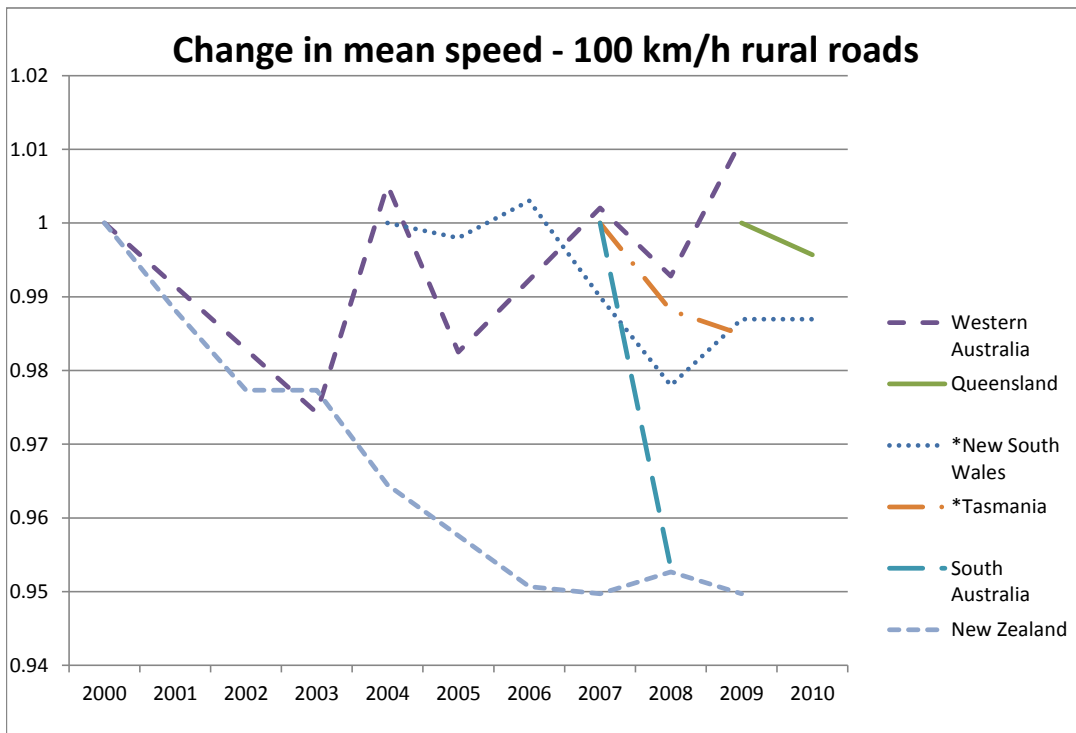
Changes in mean speeds were observed for different road environments and speed zones across Australia’s and New Zealand’s road networks over time. It should be noted that it is not possible to directly compare the mean and 85th percentile speeds across jurisdictions, particularly given the different collection methods used, the differences in traffic conditions, and the differences in road types from where the data was obtained. However, the changes in speeds over time are of interest, from the point at which the data was first collected.

Speed monitoring data across Australian jurisdictions and New Zealand were reviewed for 100 km/h rural roads. The main findings from this analysis found that for most jurisdictions there appears to have been a reduction in mean speeds, although in two cases (Queensland and South Australia), there is only two years of data available. The exception to this is in Western Australia, where mean speeds fluctuated around the baseline figure in 2000, but have increased in the most recent year. It was also found that New Zealand showed strong reductions in mean speeds between 2000 and 2006, but not much has changed since that time.

A comparison of the data between urban roads and rural roads seems to indicate that (with the exception of New Zealand) speeds have not reduced on rural roads as much as they have in other environments.

Figure 2.23 presents the mean speeds on 100 km/h rural roads that have been normalised to the first year in which the data was available. All mean speeds were below the posted speed limit, except for New Zealand where the mean speed in 2000 was above the speed limit before falling in 2001.

Figure 2.23: 100 km/h rural road mean speeds (normalised to the first year of available data)



*Data grouped by speed zone and not environment.

Overall, speeds on both urban and rural roads have generally been decreasing over time. In almost all cases, the mean speed is below the posted speed limit in the most recent year in which data has been collected. However, it is noted that speeds in rural areas appear to have declined to a lesser extent than for other environments. Also, the 85th percentile speeds still remain above the posted speed limits in almost all cases (not shown), although in recent years they have come close to the posted limits in a number of cases.

It is outside the scope of this study to explore why speeds have decreased to such an extent in some types of speed zones in some jurisdictions, while in others there has been little change, or even an increase.

The data presented here is a useful starting point for monitoring speed behaviour in different jurisdictions, and will be of value when measuring progress against speed-related strategies. The data in some jurisdictions was limited in terms of the number of years for which information was available. In addition, some jurisdictions do not collect this data in a format that allows comparisons, or they do not collect this data at all. It is suggested that jurisdictions that currently collect this data, continue this practice, and that other jurisdictions that do not collect this data, begin to do so.

In order to collect this speed data, a variety of different speed data collection devices have been used over the years and new technologies are also emerging. Guidance for the collection of speed data in Australia is presented in the Austroads *Guide to Traffic Management Part 3* (Austroads 2009b). The document describes three types of speed surveys of interest in traffic engineering. Spot speed surveys provide information on vehicle speeds at a specific point on the road, and are the most widely used survey for safety purposes. However, 'journey' or 'space speed' surveys can also be undertaken to determine the effective speed of a vehicle between two points. A third survey type is used to determine 'running speed', or the average speed determined by the distance travelled divided by the time the vehicle is in motion.

3. Engineering-based Treatments for Reducing Rural Speeds

A large number of road safety engineering measures are available that serve to reduce operating speeds on rural roads. These vary by cost and effectiveness (in terms of speed and crash reduction). Table 3.1 to Table 3.5 provide a summary of the engineering treatments identified as part of this research, while further details for each treatment are provided in Appendix A. Detailed information is provided on treatments that can be used at rural curves, intersections, railway level crossings, approaching towns and on routes. Limited information is also provided on speed reduction at work zones.

Information on these treatments is based on the literature review and analysis undertaken as part of this study. This work was completed in 2012, and so information following this time is not included in this report.

The tables provide information on the typical reductions, either in terms of speed or crashes from each of these treatments. Unless otherwise stated, the reductions in speeds are for mean speed, while the reductions in crashes are for casualty crashes. Both are a suggested maximum, although in some cases there are instances where higher speed reductions may have been identified. The reliability of these values is currently not high in some cases. However, this project has improved this reliability via input from trials and reviews, and presents much of the current extent of knowledge on this subject.

A summary of how frequently treatments are used in Australia and New Zealand is also provided for each treatment type in Table 3.1 to Table 3.5. The categories of usage are: 'well established' (the treatment has been used in Australia and/or New Zealand for some time); 'emerging treatment' (has been used, but not widely); 'shows promise' (used on a trial basis only); and untested (not yet used here, although trials may have commenced).

Local guidelines and standards may apply to the use of these treatments, and in some cases special permission for the use of a treatment may be required. It is suggested that practitioners consult with the relevant road authority when selecting treatments, particularly those that are not included as 'well established' in terms of usage. In addition, the legal implications of installing treatments need to be considered. Further advice on this topic can be found in Austroads Guide to Road Safety Audit (2009c; see Chapter 3 on Legal Issues).

It is important to note that some of the most successful approaches to managing speeds involve combinations of treatments, and this should be considered by practitioners when selecting appropriate treatments. Non-engineering treatments (outlined in Section 4) should also be considered.

3.1 Rural Curves

As identified in Section 2.2, a high proportion of speed-related crashes occur at curves. High speeds at rural curves can result in motorists losing control of their vehicles. Outcomes can include running off the side of the road (either to the left or right), and crossing the opposing lane of traffic and striking a vehicle head-on. Both crash types can have serious consequences. Typical speed-related treatments involve alerting motorists to the presence and severity of curves. Therefore the treatments will produce advantages over and above the reduction in vehicle speed.

Table 3.1: Summary of engineering treatments at curves

Rural curves					Appendix reference
Treatment type	Brief description	Crash reduction	Speed reduction	Usage	
Advance warning signs	Used in advance of curves to raise attention level and slow motorists.	25%	Unknown	Well established	Appendix A.1.1
Chevron alignment markers (CAMs)	Used to indicate presence and severity of curves.	30%	3.5 km/h	Well established	Appendix A.1.2
Speed advisory signs	Sometimes used to help indicate the comfortable travelling speed (and hence the severity) of a curve.	40%	Unknown	Well established	Appendix A.1.3
Vehicle activated signs	Once triggered by approaching speed exceeding threshold speed limit, sign displays the hazard.	35%	6 km/h	Emerging treatment	Appendix A.1.4
Other delineation devices	Includes guide posts, linemarking, pavement markers, etc. to provide additional guidance for safe roadway negotiation.	5–20%	May increase	Well established	Appendix A.1.5
Transverse rumble strips	Audio-tactile treatments applied transversely or across the driving lane to warn of approaching curves.	Unknown	5 km/h	Shows promise	Appendix A.1.6
Perceptual countermeasures	Changing the motorists' perception of the environment to improve safety, e.g. creating an illusion that a curve is tighter than it is in reality.	Unknown	10 km/h	Shows promise	Appendix A.1.7
Route-based curve treatments	Consistent application of curve treatment(s) along a route.	Unknown	Unknown	Untested	Appendix A.1.8
Slow markings	Road markings in advance of a curve to indicate the need to slow down.	Unknown	5%	Untested	Appendix A.1.9

3.2 Rural Intersections

Under a Safe System approach, reduced operating speeds are of paramount importance at intersections given the potential for side impacts that result in death or serious injury. As indicated in Section 2.1.1, a speed of 50 km/h or less is required in order to minimise the chance of death or serious injury in a side-impact crash. Well-designed roundabouts are able to achieve these sorts of speeds, while the other treatments indicated here provide incremental safety improvements. As with curve treatments, many treatments identified for use as speed-reducing measures for intersections have the added benefit of alerting motorists to the presence of the intersection. This increased awareness means that the treatment will provide added benefits over and above the reduction in speed.

Table 3.2: Summary of engineering treatments at intersections

Rural intersections					Appendix reference
Treatment type	Brief description	Crash reduction	Speed reduction	Usage	
Advance warning signs	Used in advance of intersections to raise attention level and slow down motorists.	30%	Unknown	Well established	Appendix A.2.1
Vehicle activated signs	Once triggered by approaching speed exceeding threshold speed limit, sign displays the hazard.	70%	5 km/h	Emerging treatment	Appendix A.2.2
Roundabouts	Can reduce speeds and number of conflict points.	70%	4 km/h	Well established	Appendix A.2.3
Perceptual countermeasures	Changing the motorists' perception of the environment to improve safety, e.g. markings to make the lane appear narrower.	60%	8 km/h	Shows promise	Appendix A.2.4
Transverse rumble strips	Audio-tactile treatments applied transversely or across the driving lane to warn of intersections.	20%	5 km/h	Shows promise	Appendix A.2.5
Reductions in sight distance	Reducing 'excess' sight visibility at the intersection so that drivers do not anticipate gaps in traffic too far in advance.	40%	18 km/h	Untested	Appendix A.2.6
Speed limits	Reduced speed limits on approach and through intersections.	Unknown	Unknown	Shows promise	Appendix A.2.7
Variable speed limits (VSL)	Speed limits that activate when vehicles approach the intersection from a side road.	Unknown	17 km/h	Untested	Appendix A.2.8
Lane narrowing	Narrowed lanes through use of a wide median, or widened road shoulder.	30%	5 km/h	Shows promise	Appendix A.2.9
Increasing the prominence of the intersection	Markings to make the intersection more prominent.	Unknown	10 km/h	Untested	Appendix A.2.10

3.3 Railway Level Crossings

Crashes at railway crossings, although not frequent, are the most severe in terms of fatalities, personal injuries, and property damage. Some of the rural railway crossing treatments available are aimed at reducing speed on the approach to the crossing.

Table 3.3: Summary of engineering treatments at level crossings

Railway level crossings					Appendix reference
Treatment type	Brief description	Crash reduction	Speed reduction	Usage	
Transverse rumble strips	Audio-tactile treatments applied transversely (across the traffic lane) in advance of rail level crossings.	Unknown	5 km/h	Shows promise	Appendix A.3.1
Speed limits	Regulatory speed limit signs to reduce speeds at railway level crossings.	Unknown	10 km/h	Shows promise	Appendix A.3.2

3.4 Approaching Towns

When approaching towns, it is important to indicate to motorists the change in environment, as risks typically increase when entering built-up areas. This is due to the increase in traffic (with associated vehicle movements) and vulnerable road users. A number of measures have been used to alert motorists to this changed environment.

Table 3.4: Summary of engineering treatments approaching towns

Approaching towns/transition zones					Appendix reference
Treatment type	Brief description	Crash reduction	Speed reduction	Usage	
Advance warning	Signage warning of a lower speed environment ahead.	Minimal	Minimal	Well established	Appendix A.4.1
Buffer zones	A short length of speed zone used to provide a stepped change between adjacent sections of road that have different speed limits.	Minimal	Minimal	Well established	Appendix A.4.2
Count-down signs	Count-down signs in advance of towns displaying a decreasing number of diagonal marks until a new speed limit comes into force.	Minimal	Minimal	Untested	Appendix A.4.3
Rural thresholds/gateway treatments	Use of signs with other techniques to create a rural threshold or gateway between high and low speed environments.	35%	25 km/h	Well established (NZ only)	Appendix A.4.4
Vehicle activated traffic signals	Signs are triggered by approaching vehicles that exceed a threshold speed.	Unknown	Unknown	Untested	Appendix A.4.5

3.5 On Routes

Rural speed limits in Australia and New Zealand are generally higher than the safest countries in the world (e.g. Austroads 2008a; Cameron 2003; Fildes et al. 2005). It is very likely that there would be large safety benefits from reductions in speeds on routes, particularly where the infrastructure does not support current speeds. To achieve Safe System outcomes on rural roads, speeds of 70 km/h or less are required where roads are undivided. This is the speed above which the chance of survival in a head-on crash decreases dramatically. However, incremental improvements in safety are also likely to be obtained with even minor reductions in rural speeds.

Table 3.5: Summary of engineering treatments on routes

On routes/rural routes and mid-block					Appendix reference
Treatment type	Brief description	Crash reduction	Speed reduction	Usage	
Speed limits	Setting an appropriate rural speed limit.	Unknown	4 km/h	Emerging treatment	Appendix A.5.1
Road narrowing	Road narrowing to reduce speeds, using physical or perceptual measures, or a combination of both.	Unknown	5 km/h	Shows promise	Appendix A.5.2
Weather activated speed limit signs	Use of dynamic message signs to inform drivers of adverse weather conditions (e.g. fog, wind, snow) and static signs to inform of changes in speeds when these conditions are present.	Unknown	5 km/h	Shows promise	Appendix A.5.3er

3.6 At Work Sites

The identification of engineering treatments at work sites (roadworks) did not form a core part of this project. However, during the project, limited information was obtained on various treatments that can be applied at rural work sites. This section identifies some of the main treatments that are available, and provides some information on the effectiveness of such treatments in terms of speed reduction. Given the limited extent of the review on this topic, more detailed information is not provided in the appendix.

When considering appropriate measures at work sites, the relevant standards (particularly AS 1742.3-2009, Standards Australia 2009) as well as local guidance should be consulted.

Regulatory speed limit signs are typically used at work sites, along with appropriate warning signage. Compliance with lower speed limits can be low, especially in rural areas. Several studies have identified ways in which to increase vehicle compliance with work zone speed limits.

Wang et al. (2003) suggest the use of enhance warning signs (e.g. fluorescent backing board and innovative message) and vehicle activated signs (VAS) which alert motorists that they are exceeding the speed limit. The VAS appeared to be quite effective, reducing speeds by around 10 km/h.

Rumblestrips on the approach to work zones have been used in several trials (Fontaine & Carlson 2001; Maze et al. 2000). Speed reduction from temporary rumblestrips appeared to produce modest speed reductions (around 3 km/h), but concerns were raised regarding the installation time and cost.

The effect of 'flaggers' (personnel placed in advance of work zones who indicate the need to slow down or stop, using either flags or hand-held signs) appears to produce substantial speed reductions. Reductions of around 20 km/h were identified by Benekohal and Kastel (1991), with greater benefit identified when flaggers had been appropriately trained.

Reduced lane width, through use of cones or barrier devices also appears to lead to substantial speed reductions. Speed reductions of 16 km/h were identified by Chitturi and Benekohal (2005) for 10 foot (3 m) lanes, while Allpress and Leland (2010) identified reductions of between 8–10 km/h (the higher figure was obtained when uneven spacing was used).

Enforcement is also an effective way to manage speeds at work zones. Point-to-point speed enforcement has been shown to be particularly effective (Collins 2007 reported compliance of over 99%). Further information on enforcement, including point-to-point can be found in Section 4.1.1.

4. Non-engineering Treatments

The focus of this project is on the reduction of operating speeds in rural areas using engineering-based treatments. However, for completeness, the following section covers some non-engineering treatments that are either currently in use or that have shown potential for use in reducing speed and speed-related crashes.

4.1 Enforcement and Penalties

4.1.1 Treatment of Rural Speed through Enforcement

There are various types of enforcement employed to reduce operating speeds in rural areas. A summary of some of these enforcement technologies is listed below. However, it is important to note that in order for speed enforcement to be most effective, it needs to be combined with an adequate education and publicity campaign (see Section 4.2).

Fixed speed cameras

The use of fixed speed cameras is widespread in Australia and New Zealand, and their effectiveness has been evaluated both in Australia and internationally. Studies conducted in Australia by Diamantopoulou and Corben (2002) and ARRB Group (2005) have shown that fixed speed camera use has resulted in reductions in mean vehicle speeds by approximately 2.5–6 km/h, whereas the proportion of drivers exceeding the speed limit has reduced by 66–80%. Likewise, casualty crashes at treated sites have reduced by 20%, while fatal crashes have reduced by 90%.

A UK study of fixed cameras by PA Consulting (2005) identified similar high casualty reductions. For rural operations, deaths and serious injuries reduced by over 60%, while all injury severities reduced by a third.

Mobile speed cameras

Mobile speed cameras (typically vehicle-based or roadside) have also been used extensively, and various evaluations regarding their effectiveness have been conducted. A study by Tay (2000) of 24 mobile speed camera sites in New Zealand found that serious crashes reduced by a third, while crash severities reduced by nearly 10%. International studies have shown reductions in injury and serious injury crashes of 20–60% (Christie 2003; Goldenbeld & van Schagen 2005).

Perhaps the most dramatic example demonstrating the success of speed cameras is in France, where studies have shown that between 2001 and 2007 fatal crashes reduced by 43%, with 75% of this reduction attributed to the introduction of speed cameras (personal communication, Phil Allan unpublished trip report from the Austroads Young Professionals Tour, 14–26 September 2008).

Speed cameras can be used either overtly or covertly. A study in New Zealand by Keall et al. (2002) assessed the differences in the effectiveness of the two types of cameras. The results of this study indicated that covert camera use in rural areas can be more effective over overt camera use.

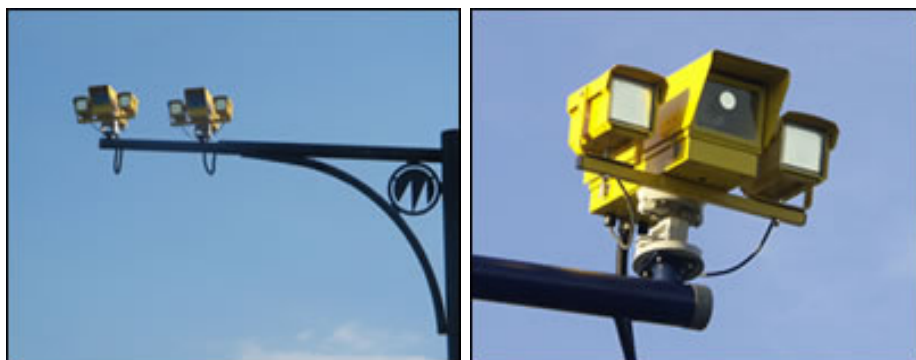
Point-to-point speed camera system

An average speed or 'point-to-point' speed enforcement system uses pairs of cameras that cover a length of road. Each pair of video cameras continuously capture images of vehicles as they pass through. Thus, the average speed of the vehicle is able to be calculated since the travel distance between the two cameras is known. If this calculated average speed exceeds the speed limit, then a speeding offence is recorded, along with the registration number of the vehicle.

Point-to-point cameras are more effective in reducing the speed of vehicles than the use of spot cameras (fixed or temporary) because the system creates a control zone that may stretch for several kilometres, rather than influence a certain spot along the road. Therefore, vehicles travelling along a length of road controlled by a point-to-point speed camera system are less likely to have stop/start behaviour, and are more likely to drive at the appropriate speed limit along the entire length of the road.

The system has been used for a number of years in the UK (Figure 4.1), and more recently in Australia. Evidence from the UK shows that the system is highly effective in reducing speeds over sections of the road network. Cameron (2008) provided a review of point-to-point camera technology, including results of two UK-based evaluations. A study by Keenan (2002) is cited that found a 36% reduction in casualty crashes at a site in Nottingham, England, while a study by Gains et al. (2003) is cited that reported a 31% reduction (not statistically significant) in serious injuries at the same location. A similar evaluation in Strathclyde, Scotland is also reported by Cameron (2008). This indicated a 20% reduction in reported injury crashes; a one-third drop in fatal and serious crashes; and a more than halving of road deaths at the trial location (although not statistically significant).

Figure 4.1: Point-to-point speed camera system, UK



Source: Speed Cameras UK web site.

Cameron (2008) reported similar results from Austria, where a point-to-point system was installed in a 2.3 km urban tunnel. Speeds initially fell by 10–15 km/h, and then settled at about 5 km/h below the speed limit. Injury crashes reduced by one-third, while fatal and serious crashes almost halved (Stefan 2006, cited in Cameron 2008).

Cameron (2008) also provided details of a vehicle-based mobile point-to-point camera system, although no information was available on the effectiveness of this system.

Recently the use of point-to-point cameras has extended to networks of cameras (rather than two locations on the same road), with this approach being trialled in London and Northern Ireland. This approach greatly increases the potential area covered.

The point-to-point speed camera system is not an entirely new concept. An earlier variant of this system was introduced in Australia in 1995 in the form of Safe-T-Cam, which is used to monitor heavy vehicle compliance, including compliance with speed (Austroads 2008c). In NSW, a system of 24 camera sites is used in conjunction with other heavy vehicle testing stations, and together forms a network that covers most of the state. Austroads (2008c) also reported that this system has been adopted in South Australia.

Courtesy speed checks

Although not strictly an enforcement device, courtesy speed checks (sometimes referred to as a speed observation sign or speed trailers) are commonly used to indicate to motorists whether they are travelling at an appropriate speed. These typically work by collecting the current speed of a vehicle (using radar or similar technology), and then displaying this information to motorists. The current speed limit is usually displayed providing information to motorists about whether they are travelling within the speed limit. In some cases, messages or symbols are displayed to reinforce positive behaviour and to discourage speeding.

A review by Mabbott and Cairney (2002) indicated that the use of these devices seems to have a positive effect on speed reductions (around 3.5–8 km/h), as well as general acceptance by the driving public. A study by Wall et al. (2001) assessed these devices on rural roads in NSW, and indicated reductions in speed of around 14%, while compliance with the speed limit increased from around 50% to almost 90%.

4.1.2 Speed Enforcement Tolerance

Mitchell-Taverner et al. (2003) conducted a telephone survey on speeding and enforcement. The survey included a sample of 2543 people aged over 15 years who were residing in New South Wales, Victoria, South Australia, Queensland and Western Australia. Some key findings with respect to speed enforcement and enforcement tolerance were:

- 33% of drivers admitted to exceeding the posted speed limit by 10 km/h or more in both urban 60 km/h zones and rural 100 km/h zones
- 75% believed that speed limits are enforced with some degree of tolerance
- 50% believed that the enforcement tolerance in a 60 km/h zone is at least 5 km/h
- 40% believed that the enforcement tolerance in a 100 km/h zone is at least 10 km/h
- 29% favoured a zero tolerance on urban roads, and 24% favoured a zero tolerance on rural roads
- the community generally believed that enforcement intensities should either stay the same or increase
- 42% supported an increase in speed limit enforcement.

It was also found that 25% of drivers under the age of 60 years believed it was allowable to drive above 65 km/h in a 60 km/h zone without being booked by police. Similarly, 38% of drivers aged between 15 to 59 years believed that it was permissible to drive at 110 km/h or more in a 100 km/h zone.

However, it is interesting to note that respondents from Victoria perceived the lowest enforcement tolerances compared with respondents from any other state. The survey showed that 67% of Victorians believed that the maximum allowed speed in an urban 60 km/h zone was less than 65 km/h, compared with 33% of respondents from the other states; 60% thought that the maximum speed allowed in a rural 100 km/h zone was 105 km/h or lower, compared to 42% of respondents from the other states. These differences in enforcement attitudes in Victoria were most likely influenced by a highly publicised announcement in Victoria during March 2002 stating that Victorian speed camera and police booking tolerances were being reduced to 3 km/h.

The OECD (2006, citing the Auditor General's Office Victoria 2006) stated that since the introduction of tougher enforcement tolerances in Victoria, there had been a 43% reduction in fatalities in metropolitan Melbourne from 2001 to 2003 across all road user categories. However, in order for enforcement tolerances to be more effective, new legislation and regulations need to be established. The need for increased infrastructure safety programs, higher speeding penalties, and immediate licence suspension³ if a vehicle is detected travelling 25 km/h or more over the speed limit are also necessary measures to help intensify enforcement efforts.

Between 2000 and 2002, both the Victorian Transport Accident Commission (TAC) and Royal Automobile Club of Victoria (RACV) conducted surveys on the community acceptance of speed enforcement activities (both reported in Cameron et al. 2003). The results from these surveys indicated that the greatest reduction in driver speeding occurred during the initial enforcement and that, in general, there was a lack of awareness of new speed management measures. The RACV survey also showed strong support for police to concentrate on enforcement of excessive speeding, that is, 20 km/h or more above the speed limit. In addition, these surveys indicated that there is a link between community perception of speed camera revenue and road safety. It appears that when the enforcement tolerance is lowered, the community is more aware of complying with the speed limit; at the same time, a proportion of the community believes that the lower enforcement tolerance is connected to revenue raising. It was also found that public perception of the speeding tolerance was much more positive when it was focused on excessive speeding.

³ Due to high levels of camera enforcement, immediate suspension can be extremely complex to implement.

Both Sweden and New Zealand have used a reduced enforcement tolerance to lower speed. The Swedish road authorities implemented reduced tolerance levels in 1987 in the cities of Halmstead and Jönköping (Cameron et al. 2003). At the time of implementation, increased penalties for speeding were also introduced, as were mass publicity campaigns. It was found that speeds in the treatment areas fell by 0.8 to 1.2 km/h between 1986 and 1987. The speed reduction was believed to be caused by the increased risk of detection due to the lower speed thresholds rather than the increase in speeding penalties or the publicity campaigns; 33% of drivers reported driving slower after the implementation of the enforcement tolerance and reported that this change in driver behaviour was due to the increased police activity. Only 10% of drivers reported driving slower as a result of the publicity campaigns.

New Zealand enforced a flat 10 km/h enforcement threshold across all roads in July 2000 (Cameron et al. 2003). This resulted in a substantial decline in the amount of vehicles exceeding the speed limit at speed camera sites. There was a 50% reduction in the proportion of vehicles detected exceeding the 10 km/h tolerance at camera sites in the first six weeks following the introduction of the speed tolerance. The proportion of drivers travelling over 110 km/h on rural roads fell from levels of 24–26% during 1997–99, to 20% in 2000, 15% in 2001 and 10% in 2002 (Land Transport Safety Authority 2003, cited in Cameron et al. 2003). This indicates that the introduction of a smaller speed enforcement tolerance can reduce vehicle speeds.

4.1.3 Penalties

While the effect of speed enforcement has been studied extensively over a number of years, the effect of penalties with regard to speed management has been studied to a lesser extent.

The use of penalties to maintain appropriate speed has long been a contentious issue. The range of penalties for speeding includes fines, demerit points, loss of licence, and impounding of vehicles.

Speeding may be seen by the public as being an acceptable form of breaking the law. The public perception of the use of penalties to address speeding varies from appropriate and supporting the fines system, to the opposing view of the penalties being revenue raising and not affecting the safety of road users. Penalties should be used as a form of behaviour modification and give drivers an opportunity to change their behaviour.

Job et al. (2001) stated that penalties can be effective under the following conditions:

- the perceived probability of detection is high
- the penalty is known
- the penalty is a sufficient deterrent but not seen as unreasonable
- the alternative behaviours are known and viable.

Job et al. (2001) also stated that for penalties to be more effective, drivers should know of the offence and the penalty as soon as possible. Kasetner et al. (1967) and Jones (1997), cited in Job et al. (2001), noted that an effective measure many jurisdictions employ to change behaviour is to send a warning letter to drivers who are in danger of losing their licence due to a bad record.

Austrroads (2001) cited a Victorian study by Haque (1993) which showed that there was a longer period of time between a second and third offence attracting demerit points than there was between a first and second offence, suggesting that demerit points and fines can reduce the likelihood of drivers re-offending. However, contrary to this, Hatfield and Job (2006) found that those who had been caught speeding previously, reported being more likely to speed than those who had not been caught previously, while those who had reported being in a speed-related crash did not differ in the likelihood of continuing to speed.

Hatfield and Job (2006) also found that the possibility of losing demerit points and the possibility of being fined, both contributed significantly to the decision of whether or not to speed. Approximately 64% of drivers surveyed stated that demerit points were a consideration, while 68% stated that fines were a consideration. Further, Ferrara and Missios (2001) determined that a demerit point penalty system is important, as a high-probability, fine-only system may not be as effective as a low-probability, fine and demerit system. Ferrara and Missios (2001) determined that speed cameras were effective in reducing traffic fatalities, injuries and collisions where demerit points were applied to speeding offences.

Fleiter et al. (2007) studied driver perceptions of speeding. They determined that regular speeders hold a more casual approach to enforcement, and were more often willing to continue driving while suspended. In order to remove these drivers from the road, vehicle impoundment was suggested as a potential measure. Studies on the impoundment of vehicles under 'hoon laws' in Victoria and Queensland were performed by Perry and McGillian (2008) and Folkman (2005), respectively. Low offence repeat rates under the hoon laws in these states suggested that this law was having a positive effect on driving behaviour.

4.2 Education, Training and Publicity

Numerous attempts have been made to reduce vehicle speeds through the use of education and publicity campaigns, and driver education. Typically, education and publicity approaches are used in association with enforcement-based measures, and to some extent, changes to the road environment. Indeed, research generally indicates that campaigns conducted in isolation have a limited effect (e.g. ERSO 2007; Huguenin 2008). However, it is also clear that such measures are important to the success of enforcement. The OECD report on speed management (OECD 2006) suggested that targeted education and information for the public and policy-makers is an important part of an effective speed management strategy. ERSO (2007) suggests that publicity can be used to explain the goals of campaigns and raise awareness of the problems being addressed. Education and publicity campaigns are an important component of a comprehensive speed reduction program in rural areas because speeding is common and is often seen as socially acceptable. Delaney et al. (2004) provide a useful source of information on conducting successful road safety campaigns.

Road safety training is also sometimes used in attempts to reduce driver speeds, including for recidivist drivers. Courses can include group-based discussions, delivery of educational material, individual sessions, and more recently, computer-based assessments. Austroads (2008d) reviewed a number of courses aimed at recidivist speeders. This study included a review of the UK Speed Awareness Scheme which has been widely evaluated. The results from that course showed that the majority of attendees intended to drive more slowly in future (although as the review highlights, an intention does not always translate into behaviour). Re-offending rates also tended to be lower for those attending courses, although the review noted that there may be a self-selecting bias in evaluations of this type (e.g. those most motivated to attend such courses are most likely to change their behaviour). Further controlled trials are required before firm conclusions can be drawn about the effectiveness of such training.

4.3 Intelligent Transport Systems

New technologies may play an important role in reducing speed-related crashes in the future. Intelligent transport systems (ITS) are a broad range of communications-based information, control, and electronics technologies integrated into the transportation system infrastructure, and in vehicles, to help monitor and manage traffic flow, reduce congestion, provide alternative routes to travellers, enhance productivity, and save lives, time and money (Austroads 2010b).

4.3.1 In-vehicle Technology

Generally, in-vehicle ITS technology works by combining knowledge about the road ahead (based on maps that include geometric alignment information that is stored within the vehicle) and knowledge about the current speed of a vehicle in order to determine whether the current speed is appropriate for the conditions.

Intelligent Speed Assist (also known as Intelligent Speed Adaptation or ISA) refers to an in-vehicle technology that helps drivers maintain the correct speed by providing warnings or intervening in the control of the vehicle. Crackel and Toster (2007) classified three versions of ISA:

- **Advisory ISA** – systems that remind drivers of the prevailing speed limit and exert no control over the vehicle
- **Supportive ISA** – systems that provide some degree of vehicle-initiated limiting of speed, but which allow the driver to override the system
- **Limiting ISA** – systems that include vehicle-initiated speed limiting that cannot be overridden (usually accompanied by an emergency failure function).

International developments

Crackel and Toster (2007) noted that ISA has been evaluated over the last 15 years mainly through small-scale trials monitoring driver attitudes and experience with various formats. These field trials report safety benefits associated with speed reductions, improved vehicle following distance on lower speed roads, less abrupt braking and variation in speeds, as well as smoother approach speeds.

The first large-scale field trial of ISA was conducted from 1999 to 2002 by the Swedish National Road Administration (SRA) (Biding & Lind 2002) and investigated advisory and supportive ISA. In the advisory system, the driver received a warning signal (audio and visual) when the legal speed limit was exceeded. In the supportive system, an 'active accelerator' applied a counter pressure when the driver reached the legal speed limit.

The report concluded that for advisory and supportive ISA:

- it is reasonable to believe that there was a general road safety improvement derived from ISA
- there would be 20% fewer road injuries in urban areas if all vehicles were equipped with ISA
- the average speed on stretches of road fell during the trial
- there was little difference between the two types of systems
- the ISA vehicles were driven more homogeneously and with less spread of speed
- driver awareness of the presence of pedestrians increased
- entry speeds into intersections (at the beginning of the braking process) fell
- travel times in urban areas remained unchanged despite lower driving speeds in specific areas.

Crackel and Toster (2007) concluded that international ISA trials indicated that genuine vehicle speed reductions were possible and user acceptability was good, especially for advisory ISA systems. Crackel and Toster (2007) cautioned that technical difficulties may, however, result in loss of confidence in the system. Other negative effects include risk compensation behaviour (where drivers compensate by driving faster on roads without ISA coverage), diminished attention when the system is not active, and overconfidence (in relying completely on the speed limit indicated by the system without observing real-time traffic circumstances) (Morsink et al. 2007).

There is little specific mention of the use of ISA in rural areas in the literature. The only trial identified was a simulator study in the United Kingdom outlined by Carsten et al. (2008). The study was designed to quantify how the presence of mandatory or voluntary ISA systems might affect drivers' overtaking decisions on rural roads. Drivers became less inclined to initiate an overtaking manoeuvre or carry on with ill-timed overtaking when the mandatory ISA was enacted. However, the quality of the manoeuvres undertaken was compromised. In the case of the voluntary ISA system, there was no difference in the number of attempted and successful overtakes when the ISA was either active or inactive. Drivers seemed to routinely disable the voluntary ISA when making an overtaking manoeuvre.

ISA may have less effect on rural roads with speed limits greater than 100 km/h. This is due to the fact that the problem often lies in motorists driving too fast for the road conditions but still within the speed limit. A new variant on ISA is a system that alerts motorists if they are driving too fast for the road conditions; for example, a curve warning system (CWS) to alert motorists if they are driving too fast for a specific curve.

Bousquet and Peck (2006) suggested the possibility of introducing an in-vehicle railway level crossing warning device. This would rely on properly equipped intelligent infrastructure and continuous wireless communication. The in-vehicle warning would enable drivers to detect when they are approaching a railway level crossing and advise them to slow down accordingly.

Australian developments

The first Australian ISA trial was conducted as part of the TAC SafeCar Project (Mitsopoulos et al. 2004). Fifteen vehicles in Melbourne were equipped with an advisory ISA system (visual and auditory signals), which became a supportive ISA system (upward accelerator pressure) if the warning signals were ignored for more than two seconds. The vehicles were equipped with a following distance warning (FDW) system (aimed at preventing tailgating), a seatbelt reminder, a reverse collision warning system (aimed to prevent collisions while driving backwards), and daytime running lights. A control group consisted of eight drivers, with control vehicles not equipped with ISA or FDW. All 23 drivers travelled at least 16 500 km. The ISA system reduced the mean, maximum and 85th percentile speeds, as well as speed variability in all speed zones. The use of ISA plus FDW tended to have better results than when ISA was used in isolation. The use of ISA plus FDW or ISA alone reduced the percentage of time driven above the speed limit, while not increasing travel times. FDW alone did not significantly affect speed.

Crackel and Toster (2007) noted that the interest in and use of ISA in certain sectors was gaining momentum in Australia, with a small number of private companies making supportive or intervening ISA available to truck fleets operating on certain routes or in industrial sites. An advisory ISA product is available for general drivers in New South Wales. The state is embarking on an extensive speed limit database project to support its network management, which will also facilitate widespread adoption of ISA in the future.

Crackel and Toster (2007) noted that in Western Australia the Road Safety Council was undertaking a project to demonstrate the utility of advisory ISA. However, it was not intended to include data logging of vehicles to determine the extent and nature of speed reductions. Rather, the focus was to be on qualitatively assessing the ISA architecture, from the in-vehicle experience of drivers, to the speed limit data creation, maintenance and update experience of road agencies. Crackel (2009) provides an interim update on the trial, and during phase 1 it was found that drivers were generally positive about the technology.

Wall et al. (2008) outlined an Australian trial which was launched in the Illawarra region of New South Wales using 100 private fleet vehicles. This trial involved an ISA system which accesses a 'live' database, where speed limit changes can be entered on the database. Speed limit information is hence always up-to-date. This may potentially allow for interfacing with dynamic speed limits, so that in-car advice matches the information given by roadside signs to take account of weather or traffic conditions.

In 2009–10 the then Roads and Transport Authority (RTA) in New South Wales conducted another large-scale study of the effects of advisory ISA units. The trial included a mixture of non-government fleet vehicles and private vehicles. The test area was also the Illawarra region which includes both urban and rural roads. The study found that 89% of 106 vehicles broke the speed limit less often with the ISA installed than before it was installed and 86% of 101 vehicles then spent more time above the speed limit following the removal of ISA compared to when it was installed (NSW Centre for Road Safety 2010). This shows that the effects of the ISA are not permanent and the ISA must be installed and working to have an effect on the driver's speed. However, drivers did generally not return to as high a level of non-compliance after the trial as before the installation of the ISA.

As well as quantitative data, drivers were interviewed to assess their attitudes to the ISA. Drivers 25 and under were more likely to admit to turning off the ISA during the trial. This was reflected in the speed data which showed that drivers 25 and under were less likely to reduce the time they spent speeding than those over 25 (77% of drivers and 93% of drivers respectively). Elvik's Power Model was used to estimate the reduction in fatal and serious injuries based on the mean speed reduction that occurred during the trial. It was estimated that the use of ISA would result in an 8.4% reduction in fatalities and a 5.9% reduction in injuries in the test area. There was no analysis conducted to determine the effectiveness of the ISA on rural roads specifically.

However, the potential effectiveness of ISA in rural areas is not clear, and may differ to that in urban areas. This is because a single rural default speed limit applies to the vast majority of rural roads, and there are fewer changes in the speed limit. ISA would alert motorists when they are exceeding the speed limit, but in its present format does not alert motorists to other risks that may require a reduction in speed (for example, a severe bend in the road). It would be of benefit to examine a variant of ISA that included other risk-based information, including advisory speeds.

A review was conducted on the emerging use of in-vehicle curve warning systems (CWS). CWS warns drivers that they are approaching curves too fast, issuing warnings based on knowledge of where the vehicle is on the road (through GPS) and information on the road alignment ahead (through on-board maps). The review identified that there appears to be potential for reducing speed-related crashes from this technology. For example, Hatakenaka et al. (2008) identified reductions in driver speeds as a result of a CWS system. Similar trials have now commenced in Australia to test such a system under local conditions.

Whichever type of ISA is deployed, accurate and current maps and speed limit data are needed. Map accuracy issues impacted on the trial in WA to assess driver's attitudes to advisory ISA systems (Crackel 2009). It was suggested that acceptance of ISA can be increased with improved map accuracy, presumably through less driver frustration by having more accurate data.

4.3.2 Vehicle-to-vehicle Technology

The concept of vehicle-to-vehicle (V2V) ITS is relatively new, with a number of organisations conducting trials or planning to conduct trials in the next few years. Work to date has been largely theoretical, with much of the work funded by vehicle manufacturers. The following information is based on published literature on this topic and information available from the Internet. It is likely to date very quickly as this is a rapidly evolving area.

V2V ITS refers to data communications between individual vehicles in a traffic stream. V2V is able to forewarn the driver of dangers on the road. Once an emergency occurs and a vehicle brakes suddenly, it sends a message to the other vehicles travelling on that same section of road. With this warning message, the drivers of the other vehicles are alerted, and would have more reaction time to reduce their speed and avoid the possible collision.

One way in which V2V communication could reduce crashes is by providing drivers with early warning of emergency situations. Yang et al. (2004) claimed that 60% of roadway collisions could be avoided if the operator of the vehicle was provided with some kind of warning at least one-half second prior to a collision. It was suggested that drivers' vision may be limited during emergency situations (e.g. by other vehicles), resulting in delayed responses.

Sensors in the vehicle detect abnormal driving activity, such as deceleration exceeding a certain threshold, change of direction, major mechanical failure, or any other abnormal vehicle behaviour that is occurring. Once the abnormal vehicle behaviour is detected, a message will be sent out to surrounding vehicles via the V2V communication system and drivers will be alerted to possible dangers on the road. The message is displayed to the driver via a visual display next to the steering column (Figure 4.2). An auditory alert may accompany this message.

Figure 4.2: Vehicle-to-vehicle ITS system



Source: Yang et al. (2004).

V2V equipped vehicles are not yet available to the general public, either in Australia or internationally. However, trials in both the United States and Europe have commenced, with most of the research being undertaken by private car manufacturers.

Shuldiner (2007) stated that 12 V2V communication prototype vehicles have been released for testing, eight in the United States and four in Europe. It was expected to take a further five to seven years to release the V2V communication technology to the public.

Further, the United States Department of Transport (USDOT) has developed a draft plan for the investigation of V2V ITS safety (Research and Innovative Technology Administration 2012). This plan will provide direction for further research conducted on ITS communication and will analyse engineering prototypes that address ITS technologies, such as emergency brake light warning, forward collision warning, intersection movement assist, blind spot and lane change warning, do not pass warning, and loss of control warning. This research investigation commenced in March 2009, and is intended to be completed by 2013.

4.3.3 Vehicle-to-infrastructure Technology

Other vehicle ITS systems have emerged as a result of V2V communication research, including vehicle-to-infrastructure (V2I) technology. V2I is currently being trialled by General Motors and is expected to cost between US\$3 billion to US\$10 billion for the United States government to implement if the trials are proven successful. Extensive work is also being undertaken in Europe (e.g. the Cooperative Vehicle Infrastructure Systems or CVIS program and the Safe Mobility program). There is also extensive development in Japan.

5. Conclusions

The objective of this compendium is to highlight the significance of speed in crashes on rural roads, and provide information on treatments that can be used to reduce speeds where required. In order to deliver Safe System outcomes on rural roads, there is a requirement to either improve the quality of road infrastructure in order to support current speeds, or to reduce speeds to a level where death or serious injury is minimised. Where this is not possible in the short to medium term, incremental safety improvements can be made through more moderate reductions in speed and/or through less substantial infrastructure improvements.

This document has provided information on well-proven speed treatments for specific rural road environments. Information is also provided on any implementation issues that have been identified through practice or trials, the reviewed literature, and consultation workshops.

There are also a number of emerging treatments that have been identified. Less is known about the speed or crash reduction benefits of these treatments, but it is likely that with further experience in implementing these treatments, this knowledge will improve over time.

The information provided in this document was produced based on literature review, consultation and analysis. This work was completed in 2012, and information following this period has not been included.

Key conclusions from the project are as follows:

- Information is now known on the extent of the rural speed problem in Australia and New Zealand (around 30% of all fatal crashes on rural roads), including the road environments and types of drivers most at risk.
- Speeds have generally been reducing on rural roads, but not to the same extent as on urban roads.
- Public attitudes have changed over time, with more people understanding the link between higher speed and crash risks. In addition, there has been a decrease in the number of drivers who believe that driving at speeds in excess of the speed limit was acceptable if driving safely.
- Information is now known on the speed and crash reduction effectiveness of commonly used treatments. These include:
 - advance warning signs, chevron alignment markers, and speed advisory signs at curves
 - advance warning signs and roundabouts at intersections
 - advance warning signs and buffer zones on the approach to towns.
- Emerging treatments have been identified, and in several cases data has been collected to determine the effectiveness of these treatments. New and promising treatments include:
 - vehicle activated signs and route-based treatments at curves
 - speed management and vehicle activated signs at rural intersections
 - rural gateway/threshold treatments on the entry to small towns in rural areas.
- Other treatments require further investigation, but show some promise including:
 - in-vehicle speed warning systems for curves (and potentially other locations on rural roads)
 - removing ‘excess’ sight distance at intersections, and methods to highlight the presence of intersections
 - road narrowing combined with reduced speed limits on rural roads.

As with all research programs, further questions have been raised through some of these findings. Further research is required on the above promising treatments. Further research is also required on the effect of speed limit change, both at intersections and on routes, including the means of determining the lower limit.

Finally, opportunities should be sought to disseminate these key findings within jurisdictions and to road safety practitioners.

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Appendix A Treatments

A.1 Rural Curves

A.1.1 Advance Curve Warning Signs – Curves



Source: <http://www.engtoolkit.com.au/>.

Description

Sign placed on the approach to a curve to alert drivers to a change in the horizontal alignment of the road. Often an advisory speed sign is also installed underneath (see Appendix A.1.3). The signs alert drivers to the presence and alignment of the curve (e.g. left curve, right curve, reverse curve etc.) giving additional information to safely negotiate the curve.

Aside from the standard warning sign, a number of different sign configurations have been employed to raise awareness at particularly problematic locations. Measures include the use of larger than standard sized signs, brightly coloured backing boards, and flashing lights.

Benefits

Speed reduction: Unknown.

Crash reduction: 25% reduction in casualty crashes (i.e. all crash types, and all fatalities and injuries).

Other:

- reduced risk of run-off-road crashes
- reduced risk of head-on crashes.

Implementation issues

Careful consideration is needed as to the correct placement of the signs, including the distance from the curve, ensuring the visibility and conspicuity of the sign, taking into account operating speed and road layout.

Signs present a hazard to errant vehicles and consideration should be given to using flexible posts.

Overuse of the signs can lead to driver complacency, thus reducing their effectiveness, so should only be used where the curve is unexpected, where the operating speed is a good deal less than the regulatory speed limit (e.g. 10 km/h is used in a number of jurisdictions), or there are other risk factors.

A route-based approach should be taken to the installation of curve warning signs.

Where applicable, the sign needs to show additional hazards, such as intersections on the curve.

Cost

Low

Treatment life

5–10 years

Key references

Austrroads & ARRB Group Ltd 2010, 'Treatment type: curves: curve warning signs', Austrroads road safety engineering toolkit, Austrroads & ARRB Group Ltd, Vermont South, Vic, viewed 02 April 2012, <<http://www.engtoolkit.com.au>>.

Elvik, R, Høye, A, Vaa, T & Sørensen, M 2009, The handbook of road safety measures, 2nd edn, Emerald Publishing Group, Bingley, UK.

Donald, D 1997, Be warned! A review of curve warning signs and curve advisory speeds, research report ARR 304, ARRB Transport Research Ltd, Vermont South, Vic.

A.1.2 Chevron Alignment Markers – Curves



Source: ARRB Group.



Source: ARRB Group.

Description

Chevron alignment markers (CAMs) are individual or grouped chevron signs, placed on the outside of a curve to help indicate the presence and severity of the curve. This assists the driver in positioning the vehicle to negotiate the curve safely. As the driver traverses the curve, the delineation device also provides a continuous feature for positive guidance. This treatment tends to affect driver speeds on a horizontal curve, which is particularly important because excessive speed is a significant factor in crashes at horizontal curves.

Benefits

Speed reduction: 2 km/h and 3.5 km/h for chevrons with fully retro-reflective posts.

Crash reduction: 30% reduction in casualty crashes.

Other:

- improved delineation at curves
- advance driver cues of a curve ahead
- an indication of the curvature (the tighter the curve, the closer the spacing).

Implementation issues

Need to be positioned carefully so that drivers will have at least two in view at all times, until the curve has straightened out to a point where they are not required.

Potential hazard to errant vehicles. Design of posts to minimise damage and injury is an important consideration when selecting this treatment.

The misuse or overuse of these signs could potentially reduce their effectiveness in critical road sections.

Cost

Low

Treatment life

5–10 years

Key references

ARRB Group 2005, 'Evaluation of the fixed digital speed camera program in NSW', contract report no. RC2416, ARRB Group, Vermont South, Vic.

Austrroads & ARRB Group Ltd 2010, 'Treatment type: curve widening: chevron alignment markers', *Austrroads road safety engineering toolkit*, Austrroads & ARRB Group Ltd, Vermont South, Vic, viewed 02 April 2012, <<http://www.engtoolkit.com.au>>.

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Re, J, Hawkins, H & Chrysler, S. 2010, 'Assessing benefits of chevrons with full retroreflective signposts on rural horizontal curves', *Transportation Research Record*, no. 2149, pp. 30–6.

Turner, B 2007, 'Crash reduction estimates for road safety treatments', *Road Safety Risk Reporter*, no 6, ARRB Group, Vermont South, Vic.

A.1.3 Advisory Speed Signs – Curves



Source: <http://www.engtoolkit.com.au/>.



Source: ARRB Group.

Description

Advisory speed signs are plates, usually attached under a curve warning sign, which display the appropriate speed to be able to negotiate the curve comfortably. The treatment also indicates the severity of the curve, with a lower speed indicating a more severe curve. Reducing speeds on the road sections preceding horizontal curves is particularly important because excessive speed is a significant factor in crashes at curves.

Benefits

Speed reduction: Unknown.

Crash reduction: 40% reduction in casualty crashes.

Other:

- provide advance warning of approaching curve
- indicate the severity of the curve
- low installation cost
- convey a simple clear meaning to the motorist.

Implementation issues

Signs must be used in a consistent and credible manner to ensure compliance by motorists. If drivers think the speed is too low they may drive at a higher speed than they would have done without the sign present.

Advisory speed signs are not recommended on unsealed roads due to rapidly changing conditions.

The signs should be placed so they can be seen in time for the driver to brake before the curve.

Care must be taken not to place the signs where they can be seen at the same time as a mandatory speed limit sign.

Signs present a hazard to errant vehicles and consideration should be given to using flexible posts.

Cost

Low

Treatment life

5–10 years

Key references

Austrroads & ARRB Group Ltd 2010, 'Treatment type: linemarking & delineation: advisory speed signs', *Austrroads road safety engineering toolkit*, Austrroads & ARRB Group Ltd, Vermont South, Vic, viewed 02 April 2012, <<http://www.engtoolkit.com.au>>.

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- Land Transport Safety Authority 1998, *Traffic standards and guidelines 1996/97 survey: advisory speed signs*, Land Transport Safety Authority, Wellington, NZ.

A.1.4 Vehicle-activated Signs – Curves



Source: Warwickshire County Council.

Description

The electronic signs are only activated by the presence of a vehicle, and in some cases only if the vehicle is travelling above a threshold speed limit. Once triggered, the sign displays the hazard, and may include a message to slow down. This alerts the driver to the presence of the curve with the aim being that they reduce their speed to negotiate the curve safely.

Benefits

Speed reduction: 2–6 km/h.

Crash reduction: 35% in injury crashes.

Other:

- additional guidance to alert motorists to hazards
- provide information on the direction of the curve.

Implementation issues

Vandalism has been noted as an issue, especially in isolated rural locations.

Overuse of the treatment may reduce their novelty value, and therefore their effectiveness.

The line of sight from the sign to the vehicle should be clear so that the radar works effectively, and the sign is clearly visible.

There may be power supply issues in rural areas, although solar powered devices are now available.

As the sign presents a hazard to errant vehicles, it should be frangible.

Cost

Medium

Treatment life

5–10 years

Key references

Austrroads & ARRB Group Ltd 2010, 'Treatment type: miscellaneous: vehicle activated signs', *Austrroads road safety engineering toolkit*, Austrroads & ARRB Group Ltd, Vermont South, Vic, viewed 02 April 2012, <<http://www.engtoolkit.com.au>>.

Burbridge, A, Eveleigh, M & Van Eysden, P 2010, 'Queensland experiences with vehicle activated signs', *Australasian road safety research policing education conference, 2010, Canberra*, Conference Logistics, Kingston, ACT, 12 pp.

Gardener, R & Kortegast, P 2010, *Trial of vehicle activated electronic signs for improved driver awareness at known crash sites in Tasman and Marlborough districts*, technical note, New Zealand Transport Agency, Wellington, NZ.

Winnett, MA & Wheeler, AH 2002, *Vehicle-activated signs - a large scale evaluation*, report 548, TRL Ltd, Crowthorne, UK.

A.1.5 Other Delineation Devices – Curves



Guide posts and linemarking. Source: ARRB Group.

Description

Alternative delineation devices to chevron alignment markers are available. These are:

- guide posts
- linemarking
- pavement markers.

They provide additional guidance to the driver to improve safe negotiation, but may also have some effect on motorists' speed.

Benefits

Speed reduction: Unclear – some studies show an increase in speed.

Crash reduction:

- guide posts: 5%
- edgeline marking: 10%
- centreline marking: 20%
- pavement markers: 5%.

Other:

- clearer delineation
- improved path definition
- alert driver to presence of curve.

Implementation issues

Road markings have been shown to increase speeds in some rural settings. There are maintenance costs associated with these treatments.

Cost

Low

Treatment life

1–5 years

Key references

Austrroads & ARRB Group Ltd 2010, 'Treatment type: linemarking & delineation: guide posts', *Austrroads Road Safety Engineering Toolkit*, viewed 02 April 2012, Austrroads & ARRB Group Ltd, <<http://www.engtoolkit.com.au>>.

Austrroads & ARRB Group Ltd 2010, 'Treatment type: linemarking & delineation: edge lines', *Austrroads Road Safety Engineering Toolkit*, Austrroads & ARRB Group Ltd, Vermont South, Vic, viewed 02 April 2012, <<http://www.engtoolkit.com.au>>.

Burdett, B & Nicholson, A 2010. 'Speed management on rural roads: the effect of pavement markings', *IPENZ transportation group conference, 2010, Christchurch*, Institution of Professional Engineers New Zealand, Wellington, New Zealand.

Elvik, R, Høye, A, Vaa, T & Sørensen, M 2009, *The handbook of road safety measures*, 2nd edn, Emerald Publishing Group, Bingley, UK.

A.1.6 Transverse Rumble Strips – Curves



Source: ARRB Group.

Description

Rumble strips are lines or sections of profiled road markings placed across the carriageway so as to cause noise and vibration in the vehicle to alert the driver to the presence of a hazard. They have been used to a limited extent in advance of rural curves.

Benefits

Speed reduction: 5 km/h.

Crash reduction: Unknown.

Other: Increased awareness of curve.

Implementation issues

Rumble strips are noisy and should not be used near residential areas. However, if driven over at higher speeds the noise and vibratory effects are less severe.

Need to be placed so that the driver has enough time to slow down before the curve. Excessive braking on the curve would be dangerous.

There are maintenance issues with such markings.

There may be issues with skid resistance (particularly for motorcyclists) when using these markings.

Cost

Low

Treatment life

1–5 years

Key references

Charman, S, Grayson, G, Helman, S, Kennedy, J, de Smidt, O, Lawton, B, Nossek, G, Wiesauer, L, Fördös, A, Pelikan, V, Skládany, P, Pokorný, P, Matejka, M & Tucka, P 2010, *Speed adaptation control by self-explaining roads: deliverable nr 1: self-explaining roads literature review and treatment information*, Road ERA net, European Commission.

Hore-Lacy, W 2008, 'Rumble strip effectiveness at rural intersections and railway level crossings', contract report VC73896-1, ARRB Group, Vermont South, Vic.

McGee, HW & Hanscom, FR 2006, *Low-cost treatments for horizontal curve safety*, FHWA-SA-07-002, Federal Highway Administration (FHWA), Washington, DC, USA.

A.1.7 Perceptual Countermeasures – Curves



Source: Macaulay et al. (2004).

Description

Perceptual countermeasures are treatments which are used to alter the drivers' perception of their speed, or of the road environment (e.g. making the road appear to narrow, or to make a curve appear more severe). By altering the drivers' perception it is hoped that the driver will slow down to match the perceived conditions rather than the actual ones.

Perceptual countermeasures at curves include altering the spacing and height of guide posts on the outside edge of the curve to make the curve appear more severe, or by using road markings to give the impression that lanes are narrower, or that the curve is more severe.

Benefits

Speed reduction: 5–10 km/h.

Crash reduction: Unknown.

Other: Improved lane positioning.

Implementation issues

The results in terms of speed reduction have been mixed for this treatment. Some studies have shown decreases in speed of up to 10 km/h, although speed reductions of 5 km/h are more typical. Other studies have found no benefit.

There may be maintenance issues with this type of treatment.

Caution should be used when placing markings on the road surface, as these may decrease surface friction.

Cost

Low to medium

Treatment life

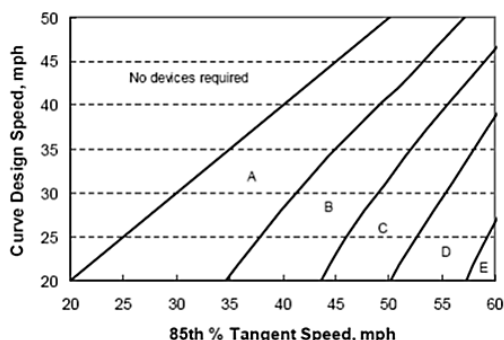
1–5 years

Key references

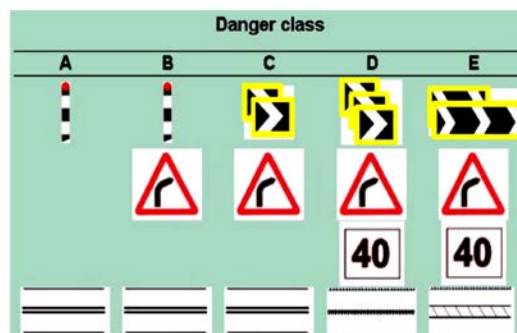
Charman, S, Grayson, G, Helman, S, Kennedy, J, de Smidt, O, Lawton, B, Nossek, G, Wiesauer, L, Fördös, A, Pelikan, V, Skládány, P, Pokorný, P, Matejka, M & Tucka, P 2010, *Speed adaptation control by self-explaining roads: deliverable nr 1: self-explaining roads literature review and treatment information*, Road ERA net, European Commission.

Macaulay, J, Gunatillake, T, Tziotis, M, Fildes, B, Corben, B & Newstead, S 2004, *On-road evaluation of perceptual countermeasures*, report CR 219, Australian Transport Safety Bureau, Canberra, ACT.

A.1.8 Route-based Curve Treatments – Curves



Source: Bonneson, Pratt, Miles and Carlson (2007).



Source: TRL and Department for International Development (2001).

Description

Route-based treatments are a method of ensuring consistency of signing of curves along a section of road. Each curve is classified based on risk factors, such as design speed, tangent speed, sight distances etc. Once the risk of the curve has been identified, signs and markings for that curve are installed according to this risk category. The higher the risk category the more treatments are installed. These include advance curve warning signs, guide posts, chevron markers and profiled road markings.

Benefits

Speed reduction: Unknown.

Crash reduction: Unknown.

Other:

- alert driver to presence of curves based on risk
- consistent with the self-explaining roads concept.

Implementation issues

Must be consistent to avoid confusion and maintain driver confidence and compliance.

An assessment process is required to determine risk category.

Cost

Low to medium

Treatment life

Up to 10 years

Key references

Bonneson, J, Pratt, M, Miles, J & Carlson, P 2007, *Horizontal curve signing handbook*, research report 0-5439-P1, Texas Transportation Institute, Austin, Texas, USA.

Cardoso, J 2005, 'Safety assessment for design and redesign of horizontal curves', *International symposium on highway geometric design, 3rd, 2005, Chicago*, Transportation Research Board (TRB), Washington, DC, 20 pp.

Helman, S, Kennedy, J & Gallagher, A 2010, *Bend treatments on the A377 between Cowley and Bishops Tawnton: final report*, PPR494, TRL Ltd, Crowthorne, UK.

Herrstedt, L & Griebe, P 2001, 'Safer signing and marking of horizontal curves on rural roads', *Traffic Engineering and Control*, vol. 42, no. 3, pp. 82-7.

TRL & Department for International Development 2001, *Horizontal curves*, highway design note 2/01, TRL Ltd, Crowthorne, UK.

A.1.9 Slow Markings – Curves



Source: Hallmark, Hawkins and Knickerbocker (2013).

Description

The word SLOW is painted on the road on the approach to a curve, giving drivers additional advance warning of the hazard, and a clear indication of what they are required to do.

Benefits

Speed reduction: 5%.

Crash reduction: Unknown.

Implementation issues

There is very limited research on this topic.

Road markings can be hard to read in certain conditions.

Skid resistance may be decreased when using road markings.

Cost

Low

Treatment life

5–10 years

Key references

Charman, S, Grayson, G, Helman, S, Kennedy, J, de Smidt, O, Lawton, B, Nossek, G, Wiesauer, L, Fördös, A, Pelikan, V, Skláráný, P, Pokorný, P, Matejka, M & Tucka, P 2010, *Speed adaptation control by self-explaining roads: deliverable nr 1: self-explaining roads literature review and treatment information*, Road ERA net, European Commission.

Hallmark, S, Hawkins, N & Knickerbocker, S 2013, *Speed management toolbox for rural communities*, Iowa Highway Research Board, Ames, Iowa, USA.

A.2 Rural Intersections

A.2.1 Advance Warning Signs – Intersections



Source: ARRB Group.

Description

Warning signs are often used in advance of intersections to alert motorists to the possibility of an increased level of risk. It is expected that such signs will raise the attention level of motorists, and it is also possible that motorists will slow to a safer speed in some circumstances. Aside from the standard warning signs, a number of different sign configurations have been employed to raise awareness at particularly problematic locations. Measures include the use of larger than standard sized signs, brightly coloured backing boards, and flashing lights.

Benefits

Speed reduction: Unknown, but it is known that presence of an intersection tends to lower speeds, so there is likely to be some reduction.

Crash reduction: 30%.

Other: Alert motorists to presence of intersection.

Implementation issues

Signs present a hazard to errant vehicles and consideration should be given to using flexible posts.

Different sign configurations (e.g. larger than standard signs) could be considered at particularly problematic locations.

Cost

Low

Treatment life

5–10 years

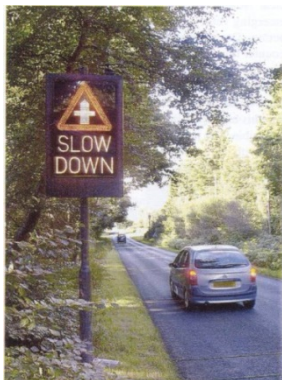
Key references

Agent, KR, Stamatidis, N & Jones, S 1996, *Development of accident reduction factors*, research report KTC-96-13, Kentucky Transportation Centre, University of Kentucky, Lexington, KY.

Austrroads & ARRB Group Ltd 2010, 'Treatment type: warning signs', *Austrroads Road Safety Engineering Toolkit*, Austrroads & ARRB Group Ltd, Vermont South, Vic, viewed 02 April 2012, <<http://www.engtoolkit.com.au>>.

Radalj, T 2003, 'Traffic safety effects of advanced warning flashing lights at intersections on high-speed roads, Perth Metropolitan Area', *Road safety research, policing and education conference, 2003, Sydney*, Roads and Traffic Authority (RTA), Sydney, NSW, vol. 2, pp. 518-26.

A.2.2 Vehicle-activated Signs – Intersections



Source: Winnett and Wheeler (2002).

Description

The electronic signs are only activated by the presence of a vehicle, and in some cases only if the vehicle is travelling above a threshold speed limit. Once triggered, the sign displays the hazard, and may include a message to slow down. This alerts the driver to the presence of the intersection with the aim being that they increase their alertness and reduce their speed to negotiate the intersection safely.

Benefits

Speed reduction: 5 km/h.

Crash reduction: 70%.

Other:

- alert motorists to presence of intersection
- provide more prominent warning
- may be set to only alert motorists who are exceeding a threshold speed
- may be set to operate in certain conditions only (e.g. time of day).

Implementation issues

Vandalism has been identified as a potential issue, especially in remote rural areas.

There may be power supply issues in rural areas, although solar powered devices are now available.

As the sign presents a hazard to errant vehicles, it should be frangible.

Cost

Medium

Treatment life

5–10 years

Key references

Austrroads & ARRB Group Ltd 2010, 'Treatment type: miscellaneous: vehicle activated signs' *Austrroads Road Safety Engineering Toolkit*, Austrroads & ARRB Group Ltd, Vermont South, Vic, viewed 02 April 2012, <<http://www.engtoolkit.com.au>>.

Burbridge, A, Eveleigh, M & Van Eysden, P 2010, 'Queensland experiences with vehicle activated signs', *Australasian road safety research policing education conference, 2010, Canberra*, Conference Logistics, Kingston, ACT, 12 pp.

Gardener, R & Kortegast, P 2010, *Trial of vehicle activated electronic signs for improved driver awareness at known crash sites in Tasman and Marlborough districts*, technical note, New Zealand Transport Agency, Wellington, NZ.

Winnett, MA & Wheeler, AH 2002, *Vehicle-activated signs - a large scale evaluation*, report 548, TRL Ltd, Crowthorne, UK.

A.2.3 Roundabouts – Intersections



Source: ARRB Group.



Source: ARRB Group.

Description

Roundabouts are circular central islands, around which traffic circulates in a clockwise direction, which are used at intersections. Entry to the roundabout is controlled by way of signs and markings, with all entering traffic required to give way to traffic on the circulating roadway. However, in certain circumstances roundabouts are signalised, either partly or wholly and either at peak times only or all the time.

Benefits

Speed reduction: 4 km/h (30 m in advance of intersection).

Crash reduction: 70%.

Other:

- fewer conflict points and improved angles of conflict in comparison with conventional intersections
- more time for drivers to react to potential dangers
- priority is simple and consistent on all approaches (give way to circulating traffic)
- since most road users travel at similar speeds through roundabouts, crash severity can be reduced compared to some traditionally controlled intersections
- the visibility of the intersection is increased
- can improve traffic flow.

Implementation issues

Good design (including deflection) is required to reduce vehicle speeds on the approach to the roundabout. Additional signs may also be used to provide advance warning.

If traffic flows are unequal on approaches, additional features may be needed.

Can increase the risk of bicycle crashes.

Need to be able to accommodate the turning circle of emergency services vehicles and large goods vehicles.

Provision for pedestrians is needed, although this may be less of an issue on most rural roads.

A larger area of land is needed than for a traditional intersection.

Cost

High

Treatment life

20 years+

Key references

Austrroads & ARRB Group Ltd 2010, 'Treatment type: intersections: roundabouts', *Austrroads road safety engineering toolkit*, Austrroads & ARRB Group Ltd, Vermont South, Vic, viewed 02 April 2012, <<http://www.engtoolkit.com.au>>.

Austrroads 2011, *Guide to road design: part 4B: roundabouts*, AGRD04B/11, Austrroads, Sydney, NSW.

Austrroads 2011, *Safe intersection approach treatments and safer speeds through intersections: phase 2*, AP-R385/11, Austrroads, Sydney, NSW.

Isebrands, H 2011, 'Quantifying safety and speed data for rural roundabouts with high-speed approaches: chapter 6: approach speed effects at rural high-speed intersections: roundabouts vs. two-way stop control', PhD thesis, Iowa State University.

A.2.4 Perceptual Countermeasures – Intersections



Source: Macaulay et al. (2004).



Source: DETR (2001).

Description

The treatments are used to alter a driver's perception of the environment. Can be used to make drivers think they are going faster than they are, or that the road narrows. Both of these cause the driver to slow on approach to the intersection. In addition, the treatments are likely to raise awareness of the presence of the intersection. This type of treatment is quite common in the UK, particularly on the approach to roundabouts.

Benefits

Speed reduction:

- 4 km/h from perceptual narrowing
- up to 8 km/h from markings that give the appearance of travelling faster on the approach to an intersection.

Crash reduction: 60% on approach to roundabouts.

Other: Increased awareness of intersection.

Implementation issues

Overuse of the treatments can lead to them losing their effect and drivers not responding to the same extent.

Careful consideration on placement of the treatment needs to be undertaken to ensure that drivers have enough time to brake safely before the intersection after encountering the treatment.

Additional line marking may have a negative effect on skid resistance, particularly for motorcyclists.

Cost

Low

Treatment life

1–5 years

Key references

Department of the Environment, Transport and the Regions 2001, *Road safety good practice guide*, DETR, London, UK.

Hallmark, S, Hawkins, N & Smadi, O 2010, *Evaluation of dynamic speed feedback signs on curves: a national demonstration project: interim report*, Federal Highway Administration (FHWA), Washington, DC, USA.

Macaulay, J, Gunatillake, T, Tziotis, M, Fildes, B, Corben, B & Newstead, S 2004, *On-road evaluation of perceptual countermeasures*, report CR 219, Australian Transport Safety Bureau, Canberra, ACT.

Martindale, A & Ulrich, C 2010, *Effectiveness of transverse road markings on reducing vehicle speeds*, research report 423, New Zealand Transport Agency, Wellington, NZ.

A.2.5 Transverse Rumble Strips – Intersections



Source: Hore-Lacy (2008).



Source: ARRB Group.

Description

Rumble strips are lines or sections of profiled road markings placed across the carriageway so as to cause noise and vibration in the vehicle to alert the driver to the presence of a hazard. They can be placed equidistantly or spaced at decreasing intervals to shorten the time between vibrations.

Benefits

Speed reduction: 5 km/h (200 m in advance of the intersection).

Crash reduction:

- 20% fatal and injury crashes
- 30% fatal and serious injury crashes.

Other:

- increased awareness of the intersection
- more time to react to other vehicles on the intersection.

Implementation issues

Rumble strips are noisy and should not be used near residential areas. However, if driven over at higher speeds the noise and vibratory effects are less severe.

Need to be placed so that the driver has enough time to slow down before the intersection and stop if necessary.

Signs are also required to indicate the reason(s) to slow down.

The profile for the rumble strips needs to be suitable so as not to present a hazard to motorcyclists.

Cost

Low

Treatment life

1–5 years

Key references

Hore-Lacy, W 2008, 'Rumble strip effectiveness at rural intersections and railway level crossings', contract report VC73896-1, ARRB Group, Vermont South, Vic.

Srinivasan, R, Baek, J & Council, F 2010, 'Safety evaluation of transverse rumble strips on approaches to stop-controlled intersections in rural areas', *Journal of Transportation Safety and Security*, vol. 2, no.3, pp. 261-78.

Thompson, TD, Burris, MW & Carlson, PJ. 2006, 'Speed changes due to transverse rumble strips on approaches to high-speed stop-controlled intersections', *Transportation Research Record*, no.1973, pp. 1-9.

A.2.6 Reduction in Sight Distance – Intersections



Source: Charlton (2003).



Source: Leicestershire County Council (2012).

Description

Use of screens or hedges to reduce the view available of traffic approaching the intersection from other directions. This prevents drivers from taking risks by anticipating gaps that might not still be present when the traffic approaches the intersection. It also forces them to slow down in case they need to stop at the intersection. Note that minimum sight distance is still required at these locations. This treatment is relatively untested in Australia or New Zealand and so detailed assessment should be undertaken at any potential sites before this treatment is used. Following installation, close monitoring should also be undertaken.

Benefits

Speed reduction: Up to 18 km/h.

Crash reduction: 40%.

Implementation issues

Screens need to be placed carefully so that adequate sight distances are maintained close to the intersection so that drivers can see oncoming traffic.

Additional signs may be needed to warn drivers of the presence of the intersection.

Erection of a screen presents an additional hazard and should be flexible or shielded.

This treatment shows potential, but has not been widely trialled in Australia or New Zealand. The treatment should therefore be only be used after a detailed site assessment, and following installation the site should be carefully monitored.

Cost

Low

Treatment life

5–10 years

Key references

Charlton, S 2003, 'Restricting intersection visibility to reduce approach speeds', *Accident Analysis and Prevention*, vol. 35, no. 5, pp. 817-23.

Charman, S, Grayson, G, Helman, S, Kennedy, J, de Smidt, O, Lawton, B, Nossek, G, Wiesauer, L, Fördös, A, Pelikan, V, Skládány, P, Pokorný, P, Matejka, M & Tucka, P 2010, *Speed adaptation control by self-explaining roads: deliverable nr 1: self-explaining roads literature review and treatment information*, Road ERA net, European Commission.

Leicestershire County Council, 2010, *Road safety in Leicestershire 2010*, Leicestershire County Council, Leicester, UK, viewed 21 December 2011, <http://www.leics.gov.uk/road_safety_report_web.pdf>.

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

A.2.7 Reduction in Speed Limits – Intersections



Source: Austroads (2011).



Source: Austroads (2011).

Description

Lowering of the mandatory speed limit on the approach to the intersection.

This is typically used in combination with other treatments (for example, enhance signing) and is rarely used as a sole method of speed reduction. No evidence was identified indicating a reduction in speed or crashes from reductions in speed limits alone; however, when used in combination with other treatments it appears that this treatment has promise.

Benefits

Speed reduction: Unknown.

Crash reduction: Unknown.

Implementation issues

Enforcement is needed to ensure compliance.

Cost

Low

Treatment life

5–10 years

Key references

Austroads 2011, *Safe intersection approach treatments and safer speeds through intersections: phase 2*, AP-R385/11, Austroads, Sydney, NSW.

A.2.8 Variable Speed Limits – Intersections



Source: Swedish Road Administration (2006).

Description

Use of variable message signs to signal changes in the speed limit, when traffic volumes or environmental conditions make it necessary. These can be mandatory or advisory speed limits. Some systems respond when vehicles approach the intersection from a side road.

Benefits

Speed reduction: Dependent on limits; 17 km/h when reduced from 90 km/h to 70 km/h.

Crash reduction: Unknown.

Other: Improved traffic flow.

Implementation issues

The post presents a hazard to errant vehicles and flexible posts should be used where possible.

A power supply is needed, which is particularly an issue in remote rural areas, although solar powered signs are now available.

Enforcement is needed to ensure compliance.

Cost

Low to medium

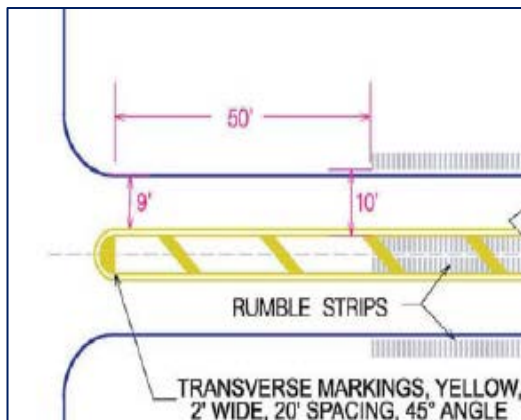
Treatment life

5–10 years

Key references

Swedish Road Administration 2006, *Variable speed limits: evaluation at intersections*, Vagverket, Borlange, Sweden, viewed 7 August 2012, <http://publikationswebbutik.vv.se/upload/3140/88884_E_Evaluation_at_intersections.pdf>.

A.2.9 Lane Narrowing – Intersections



Source: Gross et al. (2009).

Description

Use of solid or painted median, possibly incorporating profiled edge lines, to create narrower lanes on the approach to an intersection. This encourages motorists to slow down to safely navigate through the narrower section. Also see Appendix A.2.4 on perceptual countermeasures, which may also act to produce a perceived narrowing of lanes on approach to intersections.

Benefits

Speed reduction: 5 km/h.

Crash reduction:

- 30% all crashes
- 20% fatal and injury crashes.

Implementation issues

Need to ensure consistency in application in local areas to avoid driver confusion.

Lanes need to be wide enough for emergency vehicles and other larger trucks to navigate.

Cost

Low to medium (dependent on method used)

Treatment life

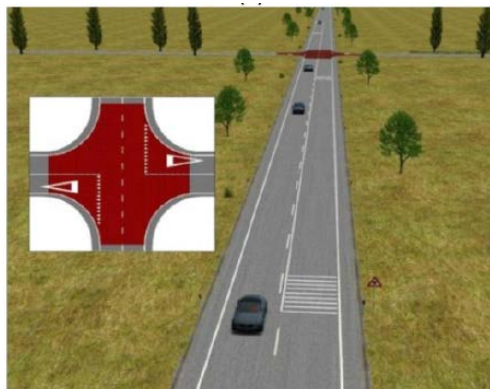
5–10 years

Key references

Austrroads & ARRB Group Ltd 2010, 'Treatment type: intersections: splitter islands', *Austrroads road safety engineering toolkit*, Austrroads & ARRB Group Ltd, Vermont South, Vic, viewed 02 April 2012, <<http://www.engtoolkit.com.au>>.

Gross, F, Jagannathan, R & Hughes, W 2009, 'Two low-cost safety concepts for two-way, stop-controlled intersections in rural areas', *Transportation Research Record*, no. 2092, pp. 11–8.

A.2.10 Increasing the Prominence of the Intersection – Intersections



Source: Montella et al. (2011).

Description

Increasing the visibility of an intersection by painting the road surface, or using coloured pavement. The theory behind the treatment is that people do slow for an intersection, so if they become aware of it earlier they will slow earlier and so reach a lower speed upon reaching the intersection itself. So far the treatment has only been tested in a simulator and not in an on-road environment.

Benefits

Speed reduction: 10 km/h (based on simulation).

Crash reduction: Unknown.

Other: Increases awareness of the intersection.

Implementation issues

As this is an untested treatment care would need to be taken when first implementing, and careful monitoring should be undertaken.

Care should be taken so that the treatment does not have a negative effect on skid resistance, as this would present an additional risk, particularly for motorcyclists.

It is important that the priority remain clear to motorists through appropriate linemarking and signage.

There may be maintenance issues associated with this treatment.

Cost

Low

Treatment life

1–5 years

Key references

Montella, A, Aria, M, D'Ambrosio, A, Galante, F, Mauriello, F & Perneti, M 2011, 'Simulator evaluation of drivers' speed, deceleration and lateral position at rural intersections in relation to different perceptual cues', *Accident Analysis and Prevention*, vol. 43, no. 6, pp. 2072-84.

A.3 Level Crossing Treatments

A.3.1 Rumble Strips – Railway Level Crossing



Source: ARRB Group.



Source: ARRB Group.

Description

Rumble strips are lines or sections of profiled road markings placed across the carriageway so as to cause noise and vibration in the vehicle to alert the driver to the presence of a hazard. This treatment can be used in advance of curves (see Appendix A.1.6) or intersections (also see Appendix A.2.5), including at rail level crossings.

Benefits

Speed reduction: 5 km/h.

Crash reduction: Unknown.

Other: Increase awareness of the hazard.

Implementation issues

Signs need to be installed to inform motorists of the reason(s) to slow down.

This treatment can be noisy – though this is less of an issue with railway lines in rural areas.

The profile used needs to be suitable so as to not present a hazard to motorcyclists.

A small number of drivers were filmed driving around the rumble strips and onto the wrong side of the road during one trial.

Cost

Low

Treatment life

1–5 years

Key references

Hore-Lacy, W 2008, 'Rumble strip effectiveness at rural intersections and railway level crossings', contract report VC73896-1, ARRB Group, Vermont South, Vic.

Radalj, T & Kidd, B 2005, 'A trial with rumble strips as a means of alerting drivers to hazards at approaches to passively protected railway level crossings on high speed Western Australian rural roads', *Australasian road safety research policing education conference, 2005, Wellington, New Zealand*, Ministry of Transport, Wellington, NZ, 11 pp.

A.3.2 Speed Signage – Railway Level Crossing



Source: Brian Kidd, Main Roads Western Australia.

Description

Use of mandatory speed limit reductions on the approach to level crossings. These are instigated through the use of static speed limit signs. This approach has been trialled overseas and more recently in Australia.

Benefits

Speed reduction: 7–12 km/h.

Crash reduction: Unknown.

Other: Increases awareness of the presence of the level crossing.

Implementation issues

Requires enforcement to have full effect, which is problematic in very remote locations.

Cost

Low

Treatment life

5–10 years

Key references

Radalj, T & Sultana, S 2012, 'Evaluation of reduced speed limits at railway level crossings on 110 km/h rural roads', Main Roads Western Australia, Perth, WA.

Peltola, H & Pajunen, K 2006, 'Improving safety of level crossings by reducing road vehicle speeds', International level crossing safety and trespass prevention symposium, 9th, 2006, Montreal, Canada.

A.4 Transition Zones

A.4.1 Advance Warning – Transition Zones



Source: Donald (1994).

Description

An advisory sign (e.g. '60 ahead') used in advance of a speed limit change to alert motorists of this impending change. A review of this treatment (from a 100 km/h to a 60 km/h zone) identified that the treatment was not effective at slowing speeds to 60 km/h at the speed transition point, but was more effective than the 60 km/h sign alone.

Benefits

Speed reduction: Minor.

Crash reduction: Unknown.

Implementation issues

Should be considered instead of buffer zones, as this treatment is as effective, but does not have the same enforcement implications.

Cost

Low

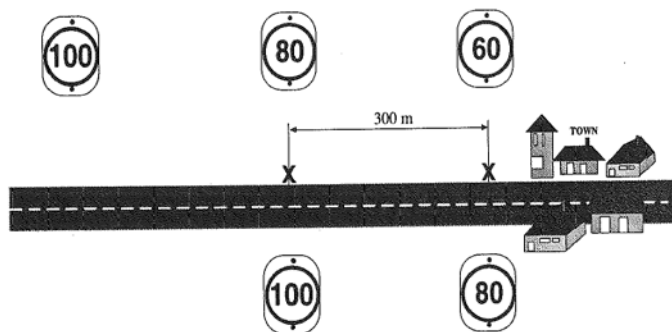
Treatment life

5–10 years

Key references

Donald, D 1994, 'Reducing speed: the relative effectiveness of a variety of sign types', *Australian Road Research Board conference, 17th, 1994, Gold Coast*, ARRB, Vermont South, Vic, vol. 17, no. 5, pp. 31-48.

A.4.2 Buffer Zones – Transition Zones



Source: Donald (1994).

Description

A staged reduction in the speed limit, usually used on the approach to a village or other built-up area. For example, a drop in speed limit for 100 km/h to 80 km/h then shortly after 60 km/h.

Implemented through use of static speed limit signs.

Benefits

Speed reduction: Minor.

Crash reduction: Unknown.

Implementation issues

Enforcement is needed to ensure compliance which is problematic over a small area.

This treatment is no more effective than using advance warning signs (which do not require enforcement).

Cost

Low

Treatment life

5–10 years

Key references

Donald, D 1994, 'Reducing speed: the relative effectiveness of a variety of sign types', *Australian Road Research Board conference, 17th, 1994, Gold Coast*, ARRB, Vermont South, Vic, vol. 17, no. 5, pp. 31-48.

A.4.3 Count-down Signs – Transition Zones



Source: Leicestershire County Council (2008).

Description

A series of static signs with decreasing number of diagonal marks until a new speed limit comes into force. They are similar to those used on the approach to motorway exit slip roads in the UK.

Benefits

Speed reduction: No significant change.

Crash reduction: Unknown.

Other: Increase awareness of the change in conditions ahead.

Implementation issues

The post presents a hazard to errant vehicles, and flexible posts should be used where possible.

May cause confusion as to when the speed limit changes.

Cost

Low

Treatment life

5–10 years

Key references

Barker, J & Helliard-Symons, RD 1997, *Count-down signs and roundel markings trials*, Transport Research Laboratory, report no. 201, Crowthorne, UK.

Department for Transport 2004, *Village speed limits*, traffic advisory leaflet 1/04, DfT, London, UK.

Forbes, G 2011, *Speed reduction techniques for rural high-to-low speed transitions*, NCHRP SHP 412, Transportation Research Board, Washington, DC, USA.

Leicestershire County Council 2008, viewed 23 October 2008.

http://www.leicestershire.gov.uk/index/highways/road_improvements/integrated_transport_home/road_safety_gallery/gallery_part_2.htm.

A.4.4 Rural Thresholds – Transition Zones



Source: ARRB Group.



Source: Land Transport Safety Authority (2002).

Description

Using a combination of treatments to slow traffic down and to create a visual difference on entering a village or other built-up area. There is usually a combination of signs (either static or active), road markings and road narrowing. Threshold treatments work significantly better when a pinch point (some form of perceived or actual road narrowing) is used.

Benefits

Speed reduction: Up to 25 km/h.

Crash reduction:

- 25% overall reduction (fatal and injury)
- 35% overall if pinch point used
- 40% reduction in fatal and serious injury when a pinch point is used.

Other: Raised awareness of a change in road environment.

Implementation issues

The treatment needs to be located at the point where development commences to be most effective.

The treatments may need to be backed up by changes in the environment (e.g. use of painted medians) after the threshold to maintain the speed reductions.

May introduce hazards for errant vehicles.

Care should be taken so that the treatment does not have a negative effect on skid resistance, as this would present an additional risk, particularly for motorcyclists.

There may be maintenance issues associated with this treatment.

Cost

Low to medium (depending on treatments used)

Treatment life

5–20 years (depending on treatments used)

Key references

Berger, W & Linauer, M 1999, *Speed reduction at city limits by using raised traffic islands*, Institute for Transport Studies, Universitaet fuer Bodenkultur, Vienna, Austria.

Charlton SG & Baas PH 2006, *Speed change management for New Zealand roads*, report no. 300, Land Transport New Zealand, Wellington, NZ.

- Forbes, G 2011, *Speed reduction techniques for rural high-to-low speed transitions*, NCHRP SHP 412, Transportation Research Board, Washington, DC, USA.
- Galante, F, Mauriello, F, Montella, A, Perneti, M, Aria, M & D'Ambrosio A 2010, 'Traffic calming along rural highways crossing small urban communities: driving simulator experiment', *Accident Analysis and Prevention*, vol. 42, no. 6, pp. 1585-94.
- Land Transport Safety Authority 2002, *Guidelines for urban-rural speed thresholds*, RTS 15, Land Transport Safety Authority, Wellington, NZ.
- Steinbrecher, J 1992, 'Restructuring of town entrances on roads classified as major', *Road Safety in Europe Conference, 1992, Berlin, Germany*, VTI rapport 380A, part 4, Swedish Road and Traffic Research Institute, Linköping, Sweden, pp. 17-31.
- Wheeler, A, Taylor, M & Payne, A 1993, *The effectiveness of village 'gateways' in Devon and Gloucestershire*, project report no. 35, Transport Research Laboratory, Crowthorne, UK.

A.4.5 Vehicle-activated Traffic Signals – Transition Zones



Source: ARRB Group.

Description

Vehicle-activated traffic signals are used on the approach to some small towns in Portugal and Spain on the secondary interurban road network. If motorists exceed the speed limit on approach to the town, the signals turn to red, thereby delaying motorists. It is reported that authorities are 'happy' with the use of this device, but that there are no evaluations as to their effectiveness.

Benefits

Speed reduction: Unknown.

Crash reduction: Unknown.

Implementation issues

If used at isolated locations (e.g. away from intersections or pedestrian crossing points), their credibility might be questioned.

Cost

Medium

Treatment life

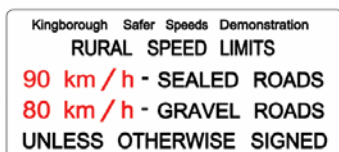
5–10 years

Key references

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

A.5 Rural Routes and Midblocks

A.5.1 Speed Limits – Rural Routes and Midblock



Source: Langford (2009).

Description

Lower speed limits in rural areas have historically been set in locations where there are increases in roadside development. Recently, trials in Australia and New Zealand have set lower speeds based on risk, including roads with adverse horizontal alignment. There have been mixed results for this treatment.

Benefits

Speed reduction: 0–4 km/h (individual sites vary to a much greater extent).

Crash reduction: Unknown.

Other: Raised awareness of a change in road environment.

Implementation issues

Compliance levels often decrease.

Public consultation and education is typically required.

Higher benefits are possible when coupled with road narrowing.

Cost

Low

Treatment life

5–10 years

Key references

Edgar, N & Tripathi, S 2011, 'Queensland's experience with speed limit reductions on 'Black Links'' *Australasian road safety research, policing and education conference, 2011, Perth, WA*, Insurance Commission of Western Australia, Perth, WA, 10 pp.

Langford, J 2009, *Kingborough Safer Speeds Demonstration (KiSS): twelve-month evaluation report*, Department of Infrastructure, Energy and Resources, Hobart, Tas, viewed 29 July 2010, http://www.transport.tas.gov.au/__data/assets/pdf_file/0020/50375/Twelve-Month_Report_KiSS_Demonstration.pdf

Long, A & Hutchinson, T 2009, *Evaluation of the Adelaide Hills speed limit change from 100km/h to 80km/h*, report CASR056, Centre for Automotive Safety Research, University of Adelaide, SA.

A.5.2 Road Narrowing – Rural Routes and Midblock



Source: Herrstedt (2006).



Source: Schermers (1999).

Description

Either physical narrowing of the road by using extended kerbs or raised medians, or narrowing by use of road markings and wide, painted medians. In some overseas cases a low-volume two-lane road is converted to a one-lane road, by removing the centre line and providing broken edge lines.

Benefits

Speed reduction: Up to 5 km/h.

Crash reduction: Unknown.

Other: Reduction in vehicles drifting from the lane, resulting in reductions in head-on and run-off-road crashes.

Implementation issues

Perceptual measures (including painted medians) have the advantage that they typically do not introduce a roadside hazard, whereas physical measures can.

In several cases this treatment has been installed but not evaluated so outcomes may be unreliable.

Higher benefits are possible when coupled with lower speed limits.

Cost

Low to medium (depending on extent)

Treatment life

5–10 years

Key references

Beca 2011, 'Wide centreline trial: interim report', produced for New Zealand Transport Agency, Wellington, NZ.

Connell, D 2011, 'Newell highway line-marking trial', *Australasian road safety research, policing and education conference, 2011*, Perth, Insurance Commission of Western Australia, Perth, WA.

Department for Transport 2011, *Taking on the rural road safety challenge: report annex 3*, DfT, London, UK.

Herrstedt, L 2006, 'Self-explaining and forgiving roads: speed management in rural areas', *ARRB conference, 22nd, 2006, Canberra*, ARRB Group Ltd, Vermont South, Vic, 14 pp.

Richter, T & Zierke, B 2009, 'Safe design of rural roads by normalized road characteristics', *European Transport conference, 2009, Noordwijkerhout, The Netherlands*, Association for European Transport (AET), London, UK.

Schermers, G 1999, *Sustainable safety: a preventative road safety strategy for the future*, Transport Research Centre, Ministry of Public Works and Water Management, The Hague, Netherlands.

Whittaker, A 2012, 'The safety benefit of continuous narrow painted median strips: continuous narrowing painted median trial: preliminary findings', Transport and Main Roads, Brisbane, Qld.

A.5.3 Weather-activated Signs – Rural Routes and Midblock



Source: Graham Brisbane.



Source: Brisbane (2003).

Description

Weather-activated signs include variable speed limit signs and dynamic message signs to inform the driver of the adverse weather conditions. They also include static signs, warning motorists of potentially adverse conditions, or changes in speed limit when adverse weather conditions are present. The adverse weather conditions include fog, rain, wind, snow and ice.

Benefits

Speed reduction: Up to 15 km/h.

Crash reduction: Unknown.

Other:

- less variance in speed
- greater spacing between vehicles.

Implementation issues

A power supply or solar panels are required which may increase costs in more remote areas.

Vandalism may be an issue, especially in isolated rural locations.

As the sign presents a hazard to errant vehicles, it should be frangible.

Cost

Low to medium (depending on extent)

Treatment life

5–10 years

Key references

Austrroads 2010, *Reviewing ITS technologies and road safety opportunities*, AP-T157/10, Austrroads, Sydney, NSW.

Brisbane, G 2003, 'Signs of change in wet weather conditions', *Road safety research, policing and education conference, 2003, Sydney*, Roads and Traffic Authority, Sydney, NSW, vol. 2, pp. 72-80.

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*, AITPM, Blackwood, SA, pp. 103-21.

Rama, P 1999, 'Effects of weather-controlled variable speed limits and warning signs on driver behaviour', *Transportation Research Record*, no. 1689, pp. 53-9.



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