Guide to Road Safety Part 3
Safe Speed

Austroads

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Abstract

The *Guide to Road Safety Part 3: Safe Speed* provides an overview of speed limits and their application as a speed management tool. The use of appropriate speed limits forms an integral part of a safe road system. They are a speed management tool used to improve road safety, while maintaining the efficiency of the road network.

Within the context of a safe road system, speed limits need to reflect the varying types of road users, the road environment, types of vehicles driven and the safety, amenity and economic needs of the community.

The general philosophy adopted when setting speed limits is that when they are being assessed they take into consideration a comprehensive range of factors. These factors include the safety record of the road, the road's operating performance, the road and roadside infrastructure, geometry and roadside development.

This Guide is intended for road authorities to use when considering a speed limit change or preparing a speed management policy. The guide will also be useful to road safety practitioners who are investigating speed limit changes as part of a solution to a road safety problem. Speed management is so fundamental to the Safe System approach that this Guide should be read in conjunction with all other parts of the *Guide to Road Safety*.

Keywords

harm minimisation, safe road system, speed, speed limits, speed management, speed zones, road safety

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About Austroads

Austroads is the peak organisation of Australasian road transport and traffic agencies.

Austroads' purpose is to support our member organisations to deliver an improved Australasian road transport network. To succeed in this task, we undertake leading-edge road and transport research which underpins our input to policy development and published guidance on the design, construction and management of the road network and its associated infrastructure.

Austroads provides a collective approach that delivers value for money, encourages shared knowledge and drives consistency for road users.

Austroads is governed by a Board consisting of senior executive representatives from each of its eleven member organisations:

- Transport for NSW
- Department of Transport Victoria
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- Main Roads Western Australia
- Department for Infrastructure and Transport South Australia
- Department of State Growth Tasmania
- Department of Infrastructure, Planning and Logistics Northern Territory
- Transport Canberra and City Services Directorate, Australian Capital Territory
- Department of Infrastructure, Transport, Regional Development and Communications
- Australian Local Government Association
- New Zealand Transport Agency.

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1. Introduction

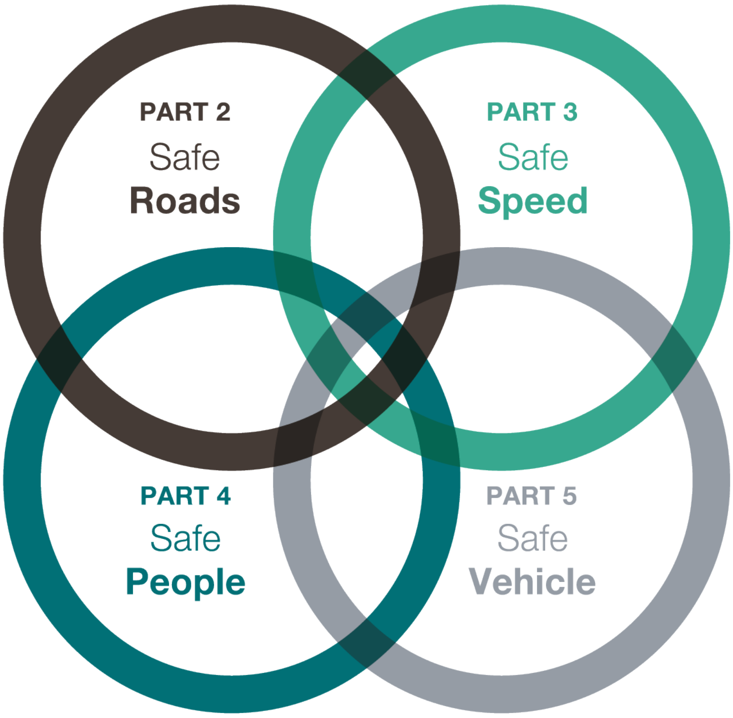
This *Guide to Road Safety* has been structured to reflect the Safe System which has been adopted by Australia and New Zealand as part of their overall road safety strategy. The Guide consists of the parts as documented in Table 1.1

Table 1.1: Parts of the Guide to Road Safety

Part	Title	Content
Part 1	Introduction and the Safe System	An overview of the *Guide to Road Safety* and the Safe System philosophy.
Part 2	Safe Roads	Guidance on safe road design.
Part 3	**Safe Speed**	**Guidance on the application of safe speeds.**
Part 4	Safe People	Information on safe people and communities.
Part 5	Safe Vehicles	Information on safe vehicles and vehicle safety features.
Part 6	Managing Road Safety Audits	Guidance on the procurement, management and conduct of road safety audits.
Part 6A	Road Safety Auditing	Guides practitioners through the practical implementation of road safety audits. (Part 6 and 6A will be consolidated)
Part 7	Road Safety Strategy and Management	Guidance on road safety strategies and road safety management.

The four pillars of the Safe System are reflected in this Guide through the aforementioned structure and also through the contents of the Guide. It is noted that each pillar does not stand on its own but, rather, interlinks with other pillars to form the Safe System (Figure 1.1). As such, readers of this Guide are encouraged to refer to multiple pillars when reading this Guide, even though this AGRS Part focusses on Safe Speed (Figure 1.2).

Figure 1.1: AGRS Part 2 to Part 5 interlink with each other



1.1 Purpose of the Guide

The *Guide to Road Safety*, in association with other key Austroads publications, will provide road safety practitioners with the knowledge and techniques to enable the application of Safe System principles.

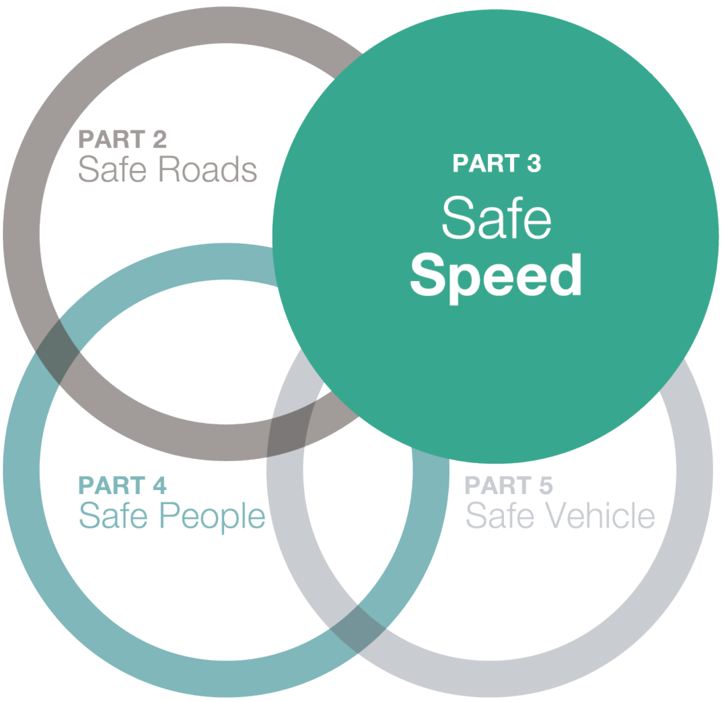
The purpose of this part of the guide is to provide an overview of speed management and the application of methods to manage speed, including speed limits, enforcement, infrastructure countermeasures and vehicle features.

What we know:

- Speed management is at the core of a forgiving road transport system.
- Impact speed is a primary determinant of injury outcome.
- Travelling speed also influences vehicle controllability and crash likelihood.
- The risk of loss of control and injury increases with travelling speed.
- In a 60 km/h speed limit zone, the risk of involvement in a casualty crash doubles with each 5 km/h increase in travelling speed above 60 km/h.
- Reducing rural speeds by 5 km/h is likely to reduce rural casualty crashes by about 30%.
- Reducing urban speeds by 5 km/h is likely to reduce urban casualty crashes by 26%.
- Reducing urban speed limits would lead to major reductions in pedestrian and cyclist injury.
- Speeds limits have usually been regarded as a trade-off between desired mobility function and other competing demands including safety.
- The understanding of the relationship between speed and injury outcomes will continue to be refined over time.
- The speed threshold for serious injury is around 20 km/h .

- Aspirational impact speeds aligned to Safe System performance are:
  - 30 km/h where pedestrians and cyclists interact with traffic
  - 50 km/h where cars may collide at right angles at intersections
  - 70 km/h where cars can collide head-on.
- The effect of reducing speed limits on travel times is commonly over-estimated.
- Road users can be poor at assessing risk on the road especially in relation to speed so infrastructure elements to support road user behaviours are required.
- Any way in which planning, road design and traffic management can guarantee safe speeds at facilities will be highly beneficial (e.g. raised pedestrian crossings) and aligned with harm minimisation principles.
- Small changes in speed can have large benefits so any reductions are better than nothing at all.
- Speed management has the potential to deliver the highest injury reductions at the lowest cost when compared to other safety interventions; however this can only be regarded as a primary treatment if reductions are achieved down to survivable levels.
- Road function and speed management are inextricably linked; the best features of self-explaining road design are likely to maximise the ability to achieve harm minimisation outcomes in the context of "Movement and Place" considerations.
- Safe Speed is only one of the four pillars of the Safe System and overlaps with the other three pillars of the Safe System (Figure 1.2). (Austroads 2018)

Figure 1.2: AGRS Part 3: Safe Speed



1.2 Why is Speed Management Important?

Speed management is a key factor in the safe and efficient operation of the road network. Speed limits need to reflect varying road user types, road environments, vehicle types and community needs such as safety, amenity and economics. Speed management is much more than just legal speed limits and signs.

The travel or operating speed of vehicles has a number of effects relating to vehicle emissions, traffic flow, user costs and safety. Reduced travel speeds can help reduce harmful emissions, enhance traffic flow, decrease user costs and improve safety.

Speed limit management is about meeting an acceptable compromise across a wide range of objectives and a diverse group of road users and communities. Safe and efficient travel contributes to a healthy and prosperous society.

Effective speed management needs appropriate infrastructure, accompanied by education and enforcement to maximise compliance and appropriate travel speeds. It is important that drivers and riders are aware of the speed limits that apply on the roads that they use. It is also important that the community understands why speed limits apply, the reasoning behind any changes to speed limits and benefits of travelling at safe speeds. It is critical that police enforce all speed limits.

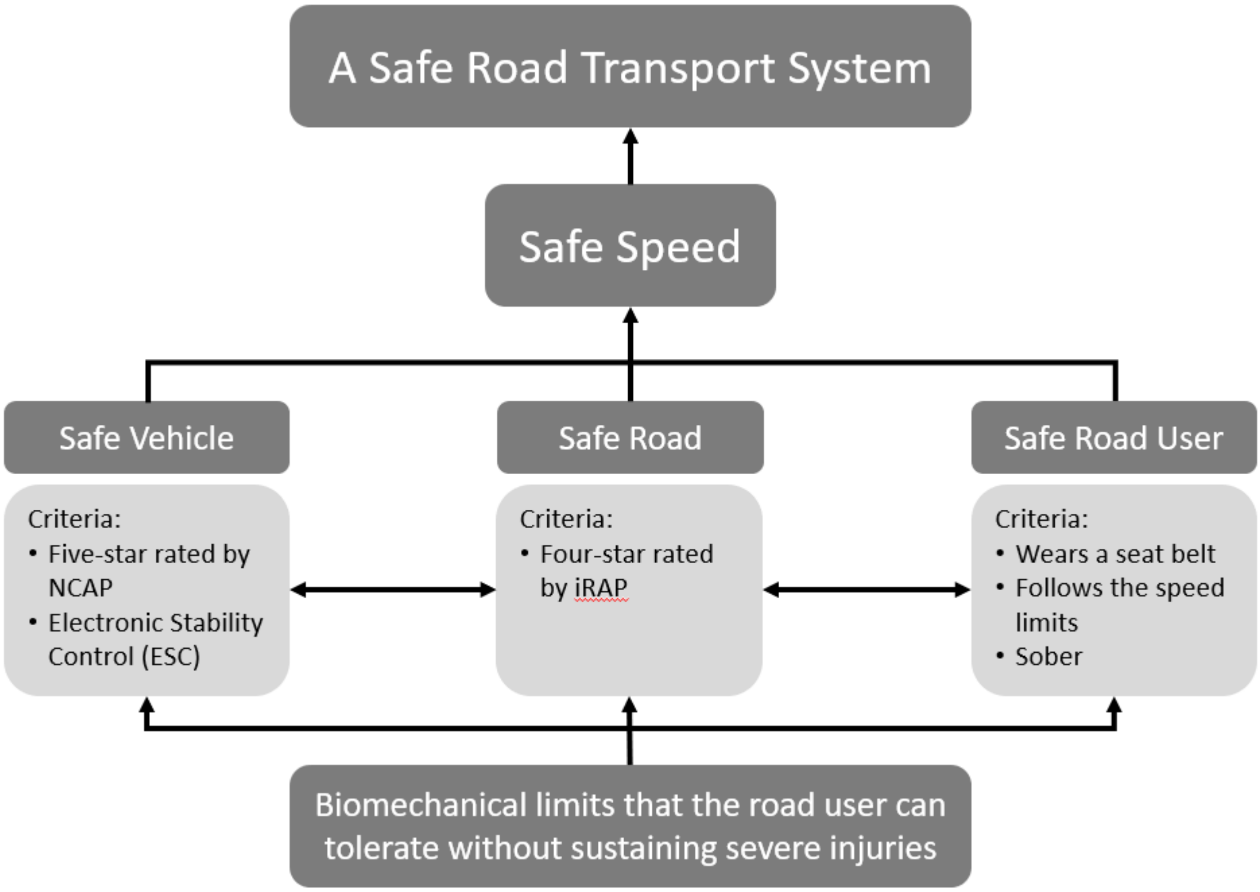
1.3 Speed and the Safe System

The appropriate management of speed is an integral part of the Safe System approach to road safety.

An explanation of the Safe System approach can be found in the *Guide to Road Safety Part 1: Introduction and the Safe System* (Austroads 2021a).

Some jurisdictions around the world graphically depict the importance of speed within a Safe System by showing speed as the regulating element of the system (Stigson, Krafft & Tingvall 2008). Figure 1.3 below is an example of that representation from Sweden.

Figure 1.3: Speed represented as the regulating element of a Safe System



Source: Adaped from Stigson, Krafft and Tingvall (2008)

2. Speed and Harm

Speed is at the core of a forgiving road transport system. While many can relate to the physics of stopping associated with travelling speed, the intricate and non-linear relationship with crash energy and consequent injury is more difficult to appreciate.

Figure 2.1: Effect of a small travelling speed change on injury

The effect of a small travelling speed change on injury outcome

A small change in travel speed

↓

A relatively large change in stopping distance

↓

A much larger change in impact speed

↓

A still larger change in impact energy

↓

A very large change in probability of death and serious injury

In this context, all aspects associated with speed are important. Even small reductions in travelling speed can have large effects on injury outcomes and the creation of an inherently safe road system is largely dependent on the kinetic energy in the system. The transition towards the Safe System will be dependent not only on the adoption of speed limits compatible with harm minimisation but also the integration of solutions that guarantee safe interaction speeds where conflict occurs or where lane departure is possible (e.g. with driver assist technologies). From a road infrastructure perspective, this means the greater use of design features to ensure that survivable interaction speeds are actually being achieved.

This Section looks at the relationships between impact speed and trauma and how speeds influence crash likelihood and severity.

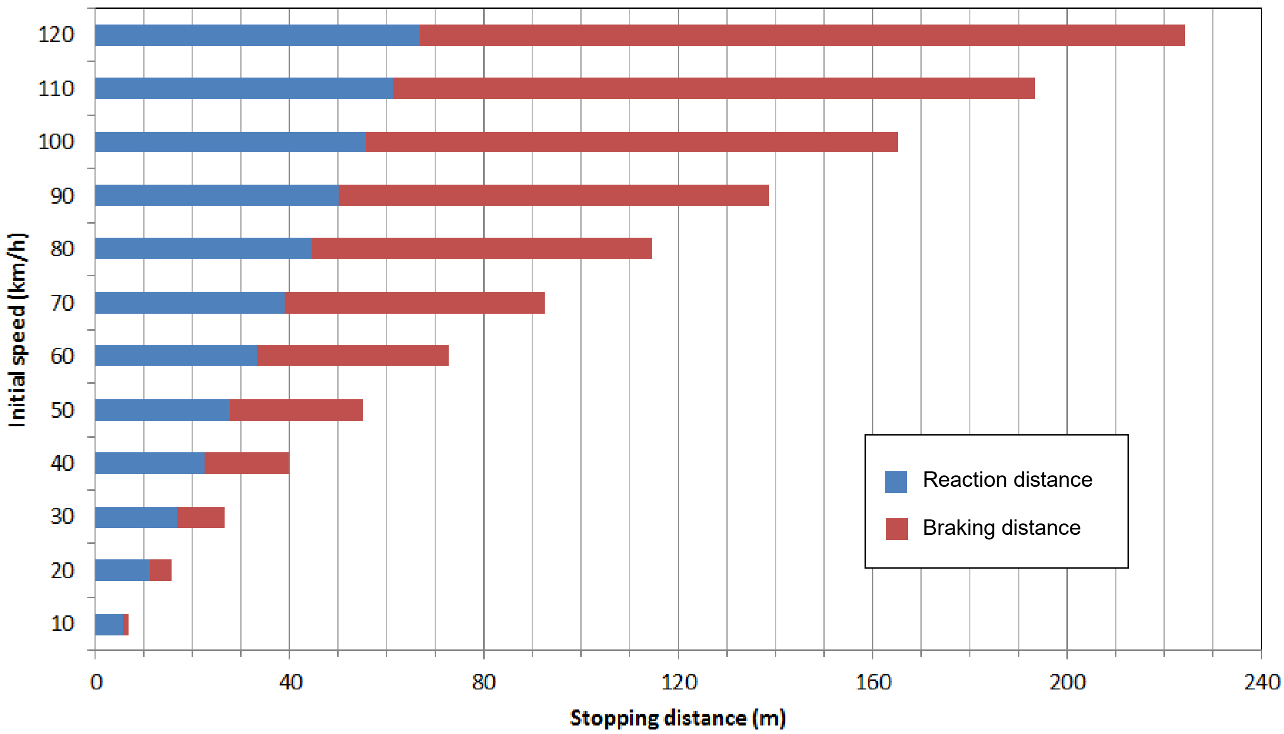
2.1 The Association Between Impact Speed and Injury

A number of studies have shown the relationship between speed, crash likelihood and severity, with increases in speed increasing both the likelihood of a casualty crash occurring and the severity of injury to the crash participants (Jurewicz et al. 2015a). It should be noted that research in this area is ongoing and while the specific definitions of tolerable risk and the shapes of curves may change, current indications are that impact speeds below around 20 to 30 km/h are necessary to prevent severe injury from occurring. As occupant and vulnerable road user protection improves amongst the vehicle fleet, the relationships are likely to change over time; however, the needs of the most vulnerable (the elderly and children) will need to be understood and considered as the aspirational governing design consideration.

2.1.1 Stopping distance

A fundamental aspect of safe road design is the provision of adequate sight distances where conflict between road users can occur or where there might be an object lying on the road. In Figure 2.2, assumptions are made that drivers and riders can recognise a safety critical situation and respond to the situation in a timely manner (usually a 1.5 to 2.5 second reaction time). If braking, the distance required to bring a vehicle to rest to avoid a collision is reliant on the reaction time, travelling speed of the vehicle and the condition of the pavement surface. As shown in Figure 2.2, higher speeds result in proportionately longer stopping distances.

Figure 2.2: Stopping distance as a function of reaction time and braking on a wet sealed pavement surface*

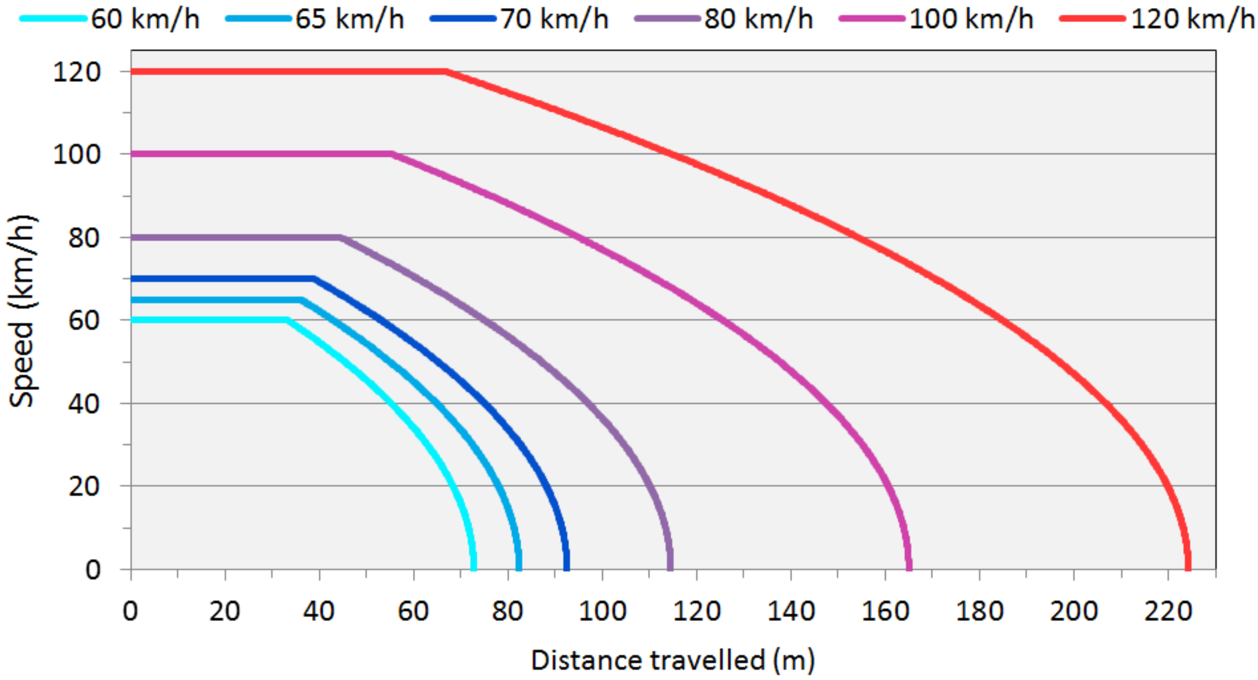


*Note: * Combined distance travelled by a vehicle during the time it takes for a driver to react (blue segment) and then brake (red segment) at different initial travelling speeds. A reaction time of 2.0 seconds and a friction factor of 0.36 are assumed constant. Situation represents a 90th percentile value and a wet sealed pavement.*

The first component of stopping, reaction time, is the time it takes for a driver to see the conflict and react to it by initialising braking. During this time, no braking is actually performed and the vehicle's speed does not change noticeably. The distance covered during the reaction time is linearly proportional to the initial travel speed. The second component of stopping is braking. This is the time from when the driver initializes braking to the time the vehicle stops. Braking distance is proportional to the square of the initial travel speed.

While an increase in travel speed of 5 or 10 km/h may not seem substantial, it has a considerable effect on stopping distance. Figure 2.3 shows how speed decreases under typical braking conditions on a wet sealed pavement. Very little speed is actually lost in the early stages of braking and most speed is lost in the final stages of braking once a considerable amount of distance has been covered. Therefore any late reaction and braking is likely to be biased towards higher impact speeds.

Figure 2.3: Speed versus distance travelled for vehicles travelling at different initial speeds before braking on a wet sealed pavement surface*



*Note: * A reaction time of 2.0 seconds and a friction factor of 0.36 are assumed constant.*

While the various sight distance considerations form an essential foundation of road design, from a Safe System perspective allowance is still required for the scenario that a driver or rider does not react in time and impact forces are still beyond the threshold of serious injury.

2.1.2 Energy transfer

Kinetic energy is the energy associated with the movement of an object and is determined by a combination of speed and mass such that:

$$E_k = \frac{1}{2} m\, v^2 \qquad (1)$$

where

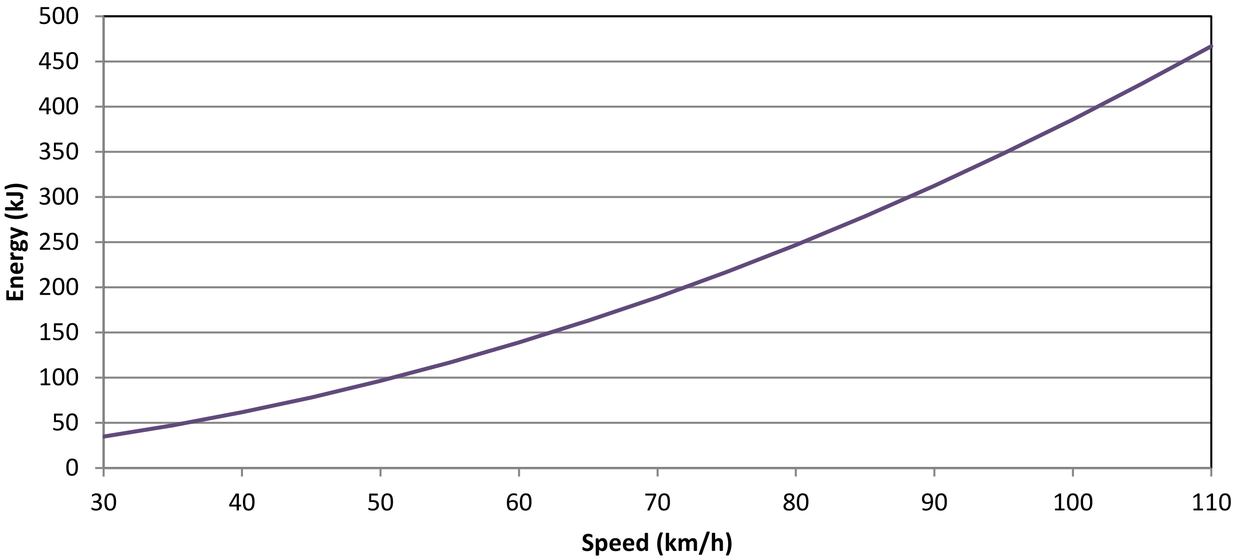
E_k = Kinetic energy (Joules)

m = Mass (kg)

v = Velocity (m/s)

A 1000 kg vehicle travelling at 60 km/h will have 139 Kilojoules (kJ) of kinetic energy. The same vehicle travelling at 80 and 100 km/h will have 247 and 386 kJ of kinetic energy respectively. A plot of the relationship between speed and kinetic energy is shown in Figure 2.4. As a comparison, in terms of potential energy, this is the equivalent to the same car falling 14 m, 25 m and 40 m respectively.

Figure 2.4: The relationship between speed and kinetic energy (assuming constant mass)



The squared relationship with speed means that there is a proportionately higher increase in energy as speed increases. Doubling the speed will result in four times the kinetic energy and tripling the speed will result in nine times the kinetic energy. It is therefore apparent that small changes in speed can have large effects on crash energy.

Figure 2.5 demonstrates this in the context of frontal deformation between identical vehicles striking an object at 60 km/h and 100 km/h. Assuming equal mass, the faster vehicle at 100 km/h has 3.4 times more kinetic energy than the slower vehicle at 60 km/h and the deformation outcomes are apparent. Note that the collision scenario represents a full frontal collision where the load is distributed across the full front of the vehicle. Such a collision with a tree or an offset with another vehicle would be much more severe.

Kinetic energy has a linear relationship with mass and a doubling of mass doubles the kinetic energy. Therefore an eight ton truck will have eight times the kinetic energy of a one ton car for the same collision.

> *"In road injury epidemiology, kinetic energy is the pathogen",*
> *LS Robertson – Epidemiologist.*

In reality, the exchange of energy in collisions between vehicles, objects and people is more complicated and there can be many determinants of specific injury such as vehicle orientation in car to car crashes. However, managing energy in the road transport system is a key to managing injury outcomes. Outside of vehicle design, speed management and safety barriers provide a key way to manage kinetic energy. With unprotected road users, safe speeds remain the most practical way for addressing safety. Due to their mass, the consequences of crashes involving heavy vehicles are difficult to mitigate if speed is not adjusted.

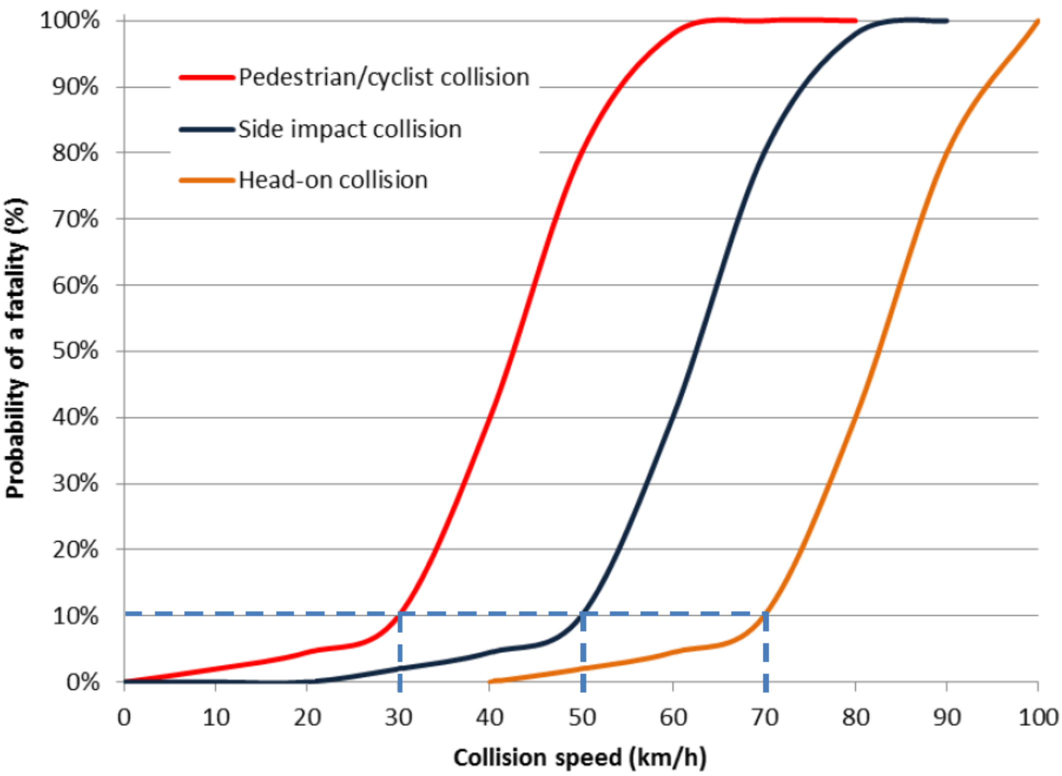
Figure 2.5: Difference in deformation striking a solid object at 60 km/h and 100 km/h

Source: Transport for NSW – CrashLab

2.1.3 Safe System speeds

The Wramborg curves (Wramborg 2005) have been adopted internationally to illustrate "survivable" thresholds against impact speeds as shown in Figure 2.6. A 10% threshold for fatal outcomes was used as the basis for establishing a Safe System performance threshold. There is nothing to say that a threshold less than 10% would be inappropriate, however given the initial illustrative purpose of the curves, the 10% appears to have been universally adopted.

Figure 2.6: Relationships between a motorised vehicle collision speed and probability of a fatality for different crash configurations



Source: Jurewicz et al. (2015a) and based on Wramborg (2005)

Often referred to as the Safe System speeds, the following aspirational operating speeds are as follows (OECD / ECMT 2006):

- **30 km/h** where there is the possibility of a collision between a vulnerable road user and a passenger vehicle or where there is the possibility of a side impact with a fixed object such as a tree or pole
- **50 km/h** where there is the possibility of a right angle collision between passenger vehicles
- **70 km/h** where there is the possibility of a head on collision between passenger vehicles
- **≥100 km/h** where there is no possibility of side or frontal impact between vehicles or impacts with vulnerable road user impacts.

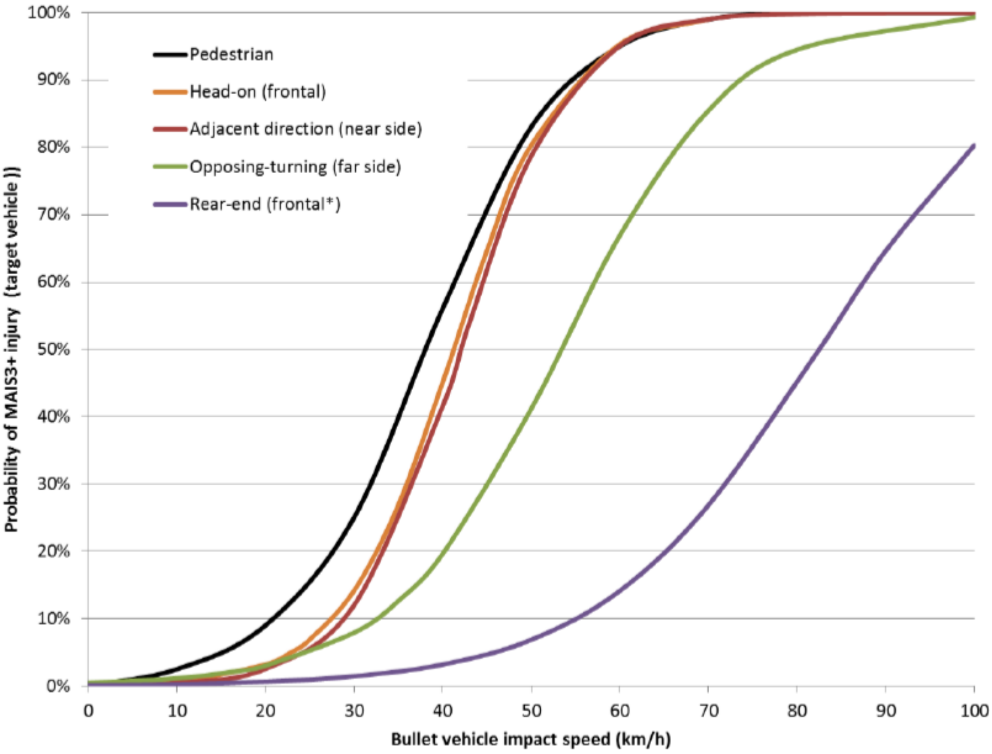
Note that at present there is only limited evidence on cyclist and motorcyclist injury thresholds and an assumption is often made that their injury potential is the same as the pedestrian curve.

The curves only represent passenger car interactions and do not account for young and elderly people and heavy vehicles. The curves are also limited in that they only provide the probability of fatality and not serious injury and there is little published evidence demonstrating the origins of the curves. Despite this, the Wramborg curves have become the aspirational criteria for Safe System speeds and have achieved practical application in The Netherlands and Sweden.

2.1.4 Further insights on speed and injury severity

There is strong evidence that indicates that the part of the vehicle struck will tend to determine the injury outcomes for the occupants. A number of studies have presented relationships between the change in velocity during a crash for a given vehicle and MAIS 3+ (a measure of traumatic injury). Figure 2.7 shows curves derived by Jurewicz et al. (2015a) based on pedestrian crash models by Davis (2001) and vehicle crash models by Bahouth et al. (2014). The bullet vehicle referred to in Figure 2.7 is the vehicle that impacts another vehicle, person or object.

Figure 2.7: Relationships between bullet vehicle impact speed and probability of a MAIS 3+ injury to a target vehicle occupant for different crash configurations



Source: Jurewicz et al. (2015a)

The modelling shows that when considering (serious) injury in addition to fatality risk, the speed thresholds communicated by Wramborg decrease. For example, the equivalent speeds to those shown previously become 20 km/h for pedestrians, 30 km/h for side impact (near side) and also 30 km/h for a head on collision.

These relationships provide a good indication of the changing nature of injury severity with increasing speeds. They are, however, limited to certain road user cohorts (e.g. adult front seat occupants) and further work is required to provide more generalized relationships that consider the effects of collisions for all road users of all ages.

These relationships are also generally only indicative of situations where mass inequality does not play a role. Mass inequality will play a large role in the severity of collisions between vehicles of substantially different masses. This is most clearly seen with vehicle/pedestrian collisions but is also relevant to collisions where heavy vehicles are involved.

3. Speed Behaviour on Roads

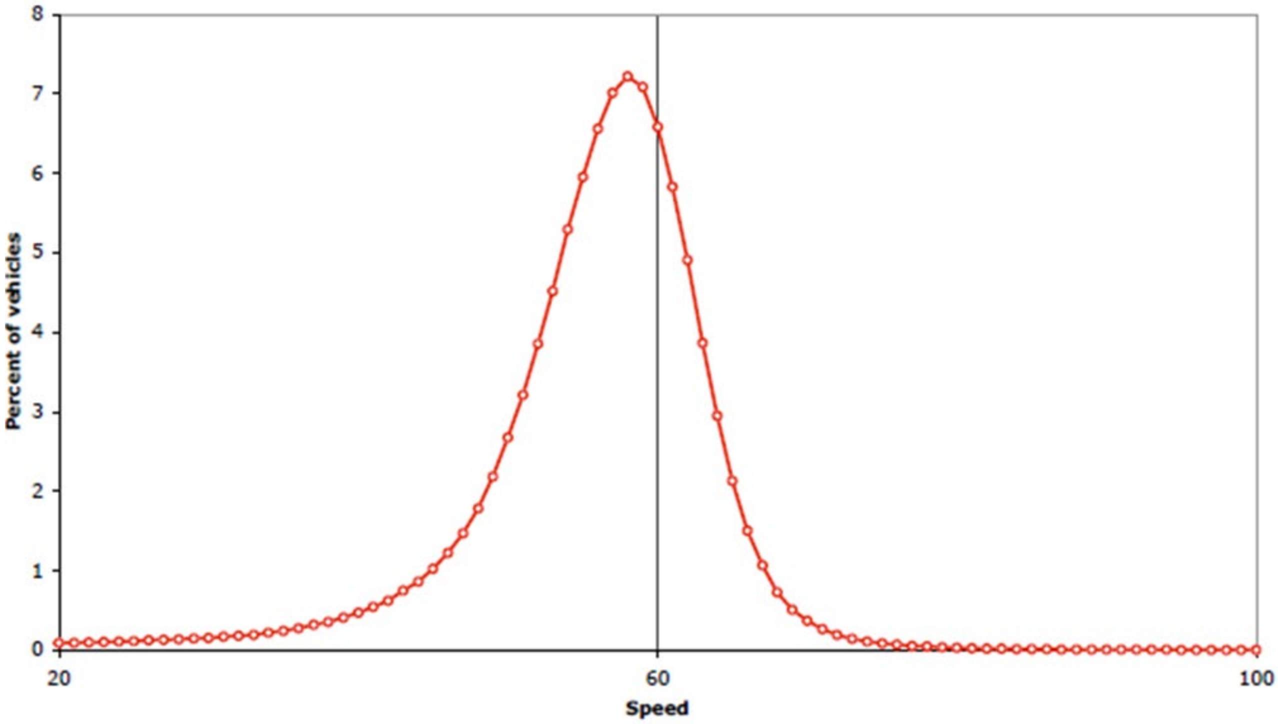
When considering the safety and mobility implications of speed it is important to recognise that a posted speed limit does not mean that all road users will be travelling at that speed. Multiple factors will influence travel speeds besides the speed limit, including road and traffic conditions, environmental conditions (such as weather and landscape) and driver perceptions and behaviours.

3.1 Range of Speeds on the Road Network

In most situations vehicle speeds on the road network tend to follow a normal distribution with the bulk of vehicles slightly above or slightly below the speed limit (see Figure 3.1). It is usual that mean speeds are a few kilometres per hour below the posted speed limit and there is a tail of a few vehicles travelling at very high speeds and vehicles at very low speeds. It therefore follows that the same situation will exist on the approaches to intersections or on mid-block sections of road. Although the planning, design and management of the road network is based on certain operating speeds, historically less was done from the engineering side to guarantee that speeds of interaction were actually safe.

In this context, road users are expected to make critical decisions at intersections or when overtaking, and perceive and compensate for the range of speeds usually encountered on the network. Some of the best speed management treatments provide very clear guidance on the appropriate speed, guarantee safe speeds of interaction and also narrow down the variation in speeds encountered.

Figure 3.1: Example of a typical speed distribution for an arterial road



Source: CASR

3.2 Complications in Perceiving Speed Risk

Speed limits were initially adopted with little understanding of safety in relation to crash incidence, vehicle occupant protection and vulnerable road users. A range of limits were historically fixed according to an adopted hierarchy and roads were generally designed to maintain these operating speeds with less consideration given to the benefits of adopting lower speed limits as a means of achieving lower operating speeds on the basis of safety or infrastructure cost. These practices have resulted in a legacy that is taking considerable effort to change, mainly because the population has been living with “high” speed limits not aligned with injury reduction for many decades. Given that many in the population have personal experience travelling at a high speed, it has been difficult to communicate in a credible manner the scientific evidence that population risk can be lowered through speed management.

One of the reasons why the communication on speed limits may appear contradictory is shown in Figure 3.2. Portrayed are six different road environments each with different traffic conditions and safety features. It is evident to road users that risk on the road is not managed in a consistent manner across the network as each of the six road environments has a 100 km/h speed limit. In fact, on this basis a counter argument could be made that because the speed limit is the same in each environment, speed is actually not regarded as a critical variable. Much of the Dutch approach, based on credible speed limits, seeks to address this type of inconsistency.

Drivers and riders become habituated to risk as they repeatedly perform tasks within the road system with little or no ill-consequence over a lifetime. The fact is there is very little feedback in relation to risk when using the road system. Given that the individual risk of crashing is small, a doubling of this small risk is also likely to go un-noticed. Often people build up a perception over a lifetime of driving or riding that travelling above the speed limit has very little or no negative safety consequence.

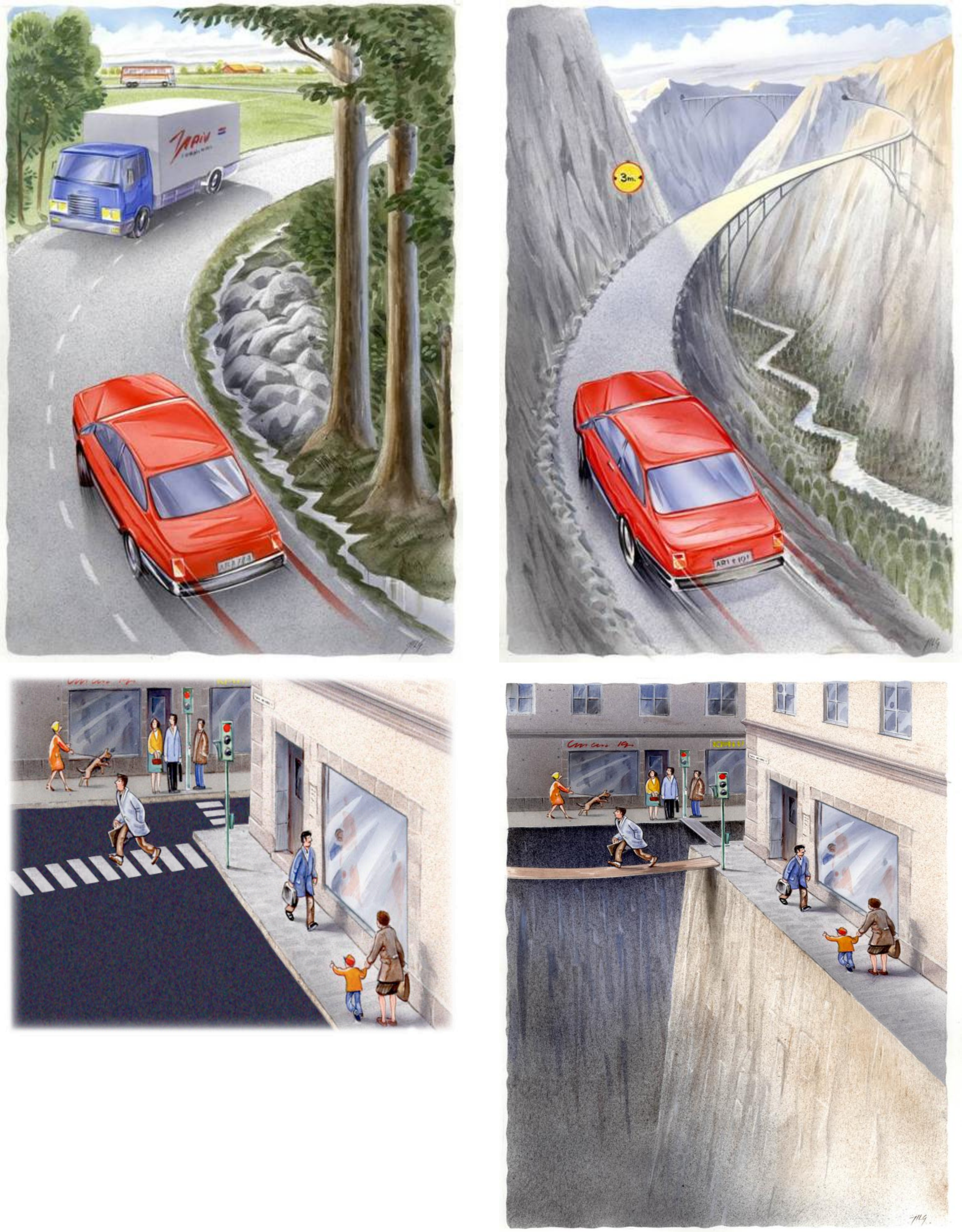
Figure 3.2: Six different road environments all with a 100 km/h speed limit

By contrast, people are generally aware of the risk associated with heights (i.e. potential energy) as the risk is reinforced over a lifetime of feedback. It is appreciated that trips and falls even at ground level have the ability to cause severe and sometimes permanent injury. It is therefore unacceptable to think that a reliance be placed on training and education to prevent people from falling off unprotected balconies. Instead a forgiving environment that is error tolerant is created where balconies are lined with barriers that prevent people from falling off even if they are young, old, distracted or impaired. Extending this analogy a little further, there is no specific cost-benefit analysis for individual balconies that takes account of height of the balcony, wind exposure, width of the balcony, age and experience of people potentially using it, nor the opinions of people in the neighbourhood as to whether it should be protected or not. There is an expectation that designers will provide buildings with balcony protection from falls regardless of circumstance.

Taking this perspective into account, Figure 3.3 shows how a road network appears in terms of the kinetic energy converted to potential energy. If road users were to perceive the energy in the road transport system as potential energy, it is likely that behaviours would be very different. When considering the driver in the car approaching the bridge with no guardrails, a universal response would be to slow down in the interests of self-preservation to maintain control of the vehicle so it did not fall off the bridge. This provides a stark contrast to the comfort people feel when passing other vehicles only divided by a painted centreline or trees close to the edge of the road.

These factors combined with “optimism bias” makes it difficult for individuals to mitigate their behaviour in relation to speed without any supporting measures. Despite these challenges, speed management continues to be one of the most effective ways a transition towards a Safe System can be achieved. Although much focus has been placed on better aligning speed limits with injury reduction, there is significant opportunity to further support road users through road design features at points of elevated risk in the network.

Figure 3.3: Perceived and actual risk in terms of energy transfer



Source: Claes Tingvall, Swedish Road Administration

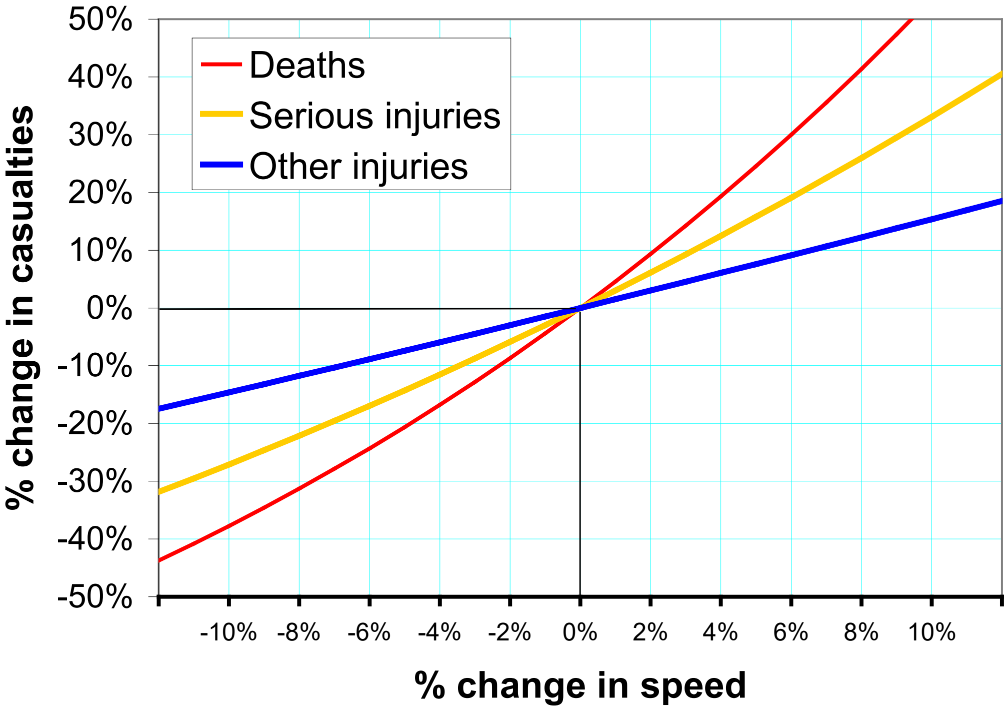
4. The Case for Safer Speeds

There exists a large body of evidence associating lower speeds with reductions in injury crashes and injury severity. The following sections outline the most commonly referenced studies and the basis to their established relationships.

4.1 Nilsson's power model

A number of studies have modelled the change in crash and casualty numbers with a change in average speed. The power models presented by Nilsson (2004) describe the relationships between average speed, the number of injury or fatal crashes and the number of injuries or fatalities. These relationships are shown graphically in Figure 4.1.

Figure 4.1: Relationship speed changes and changes in casualty rates



Source: Elvik, Christensen and Amundsen (2004)

These models were validated against a number of speed limit changes in Sweden during 1967 to 1972. The initial speed limits were mainly 90 km/h and included one of 130 km/h. Changes in speed limits were a 20 km/h decrease, no change (control) or 20 km/h increase in speed limit.

While Nilsson's power models are generally accepted as accurate for speed limit changes on high speed rural roads, their relevance to urban roads and within lower speed environments has been questioned by Cameron and Elvik (2008; 2010) and Elvik (2013). In a re-evaluation, Elvik (2013) constructed a model with a crash modification factor that was better at estimating the change in the number of injury crashes but worked less well for estimating the change in the number of fatal crashes. It was concluded that the power model provides a good estimate of the change in serious injuries and fatality numbers associated with traffic speed changes on rural highways. However, it is limited in its applicability to urban roads, where it substantially overestimates the change in crashes for a particular change in traffic speed (Cameron & Elvik 2010).

Elvik, Christensen and Amundsen (2004) conducted a meta-analysis of research on the relationship between travel speeds and casualty rates. The analysis included 98 separate studies which provided a total of 460 estimates of the relationship between changes in the mean speed of traffic on a road and changes in the casualty rate. Data from 20 countries were included. Studies conducted between 1966 and 2004 were included; about half the estimates came from studies conducted after 1990. The estimates were based on both rural and urban roads, and covered a speed range from about 25 km/h to about 120 km/h.

This meta-analysis provided strong support for the ‘power model’ originally proposed by Nilsson (1981; 2004). The model parameters estimated by Elvik, Christensen and Amundsen (2004) differ slightly from those in the original power model, but they are close, and show a similar pattern: a small percentage change in travel speeds typically results in a similar percentage change in property damage crashes, but a larger percentage change in casualties – particularly severe casualties. For small speed changes, the percentage change in deaths is typically about four times the percentage change in speed.

Table 4.1 and Figure 4.1 summarise these results. The power model exponents estimated from the meta-analysis were: fatalities: 4.5, fatal crashes: 3.6, people seriously injured: 3.0, serious injury crashes 2.4, people with minor injuries 1.5, other injury crashes 1.2, property damage crashes 1.0 and total people injured (severity unspecified) 2.7.

Table 4.1: Relationship speed changes and changes in casualty rates

Change in:	Change in mean speed					
	Speed reduction			Speed increase		
	-10%	-5%	-1%	+1%	+5%	+10%
Deaths	-38%	-21%	-4%	+5%	+25%	+54%
Serious injuries	-27%	-14%	-3%	+3%	+16%	+33%
Other injuries	-15%	-7%	-1%	+2%	+8%	+15%
Property damage crashes	-10%	-5%	-1%	+1%	+5%	+10%

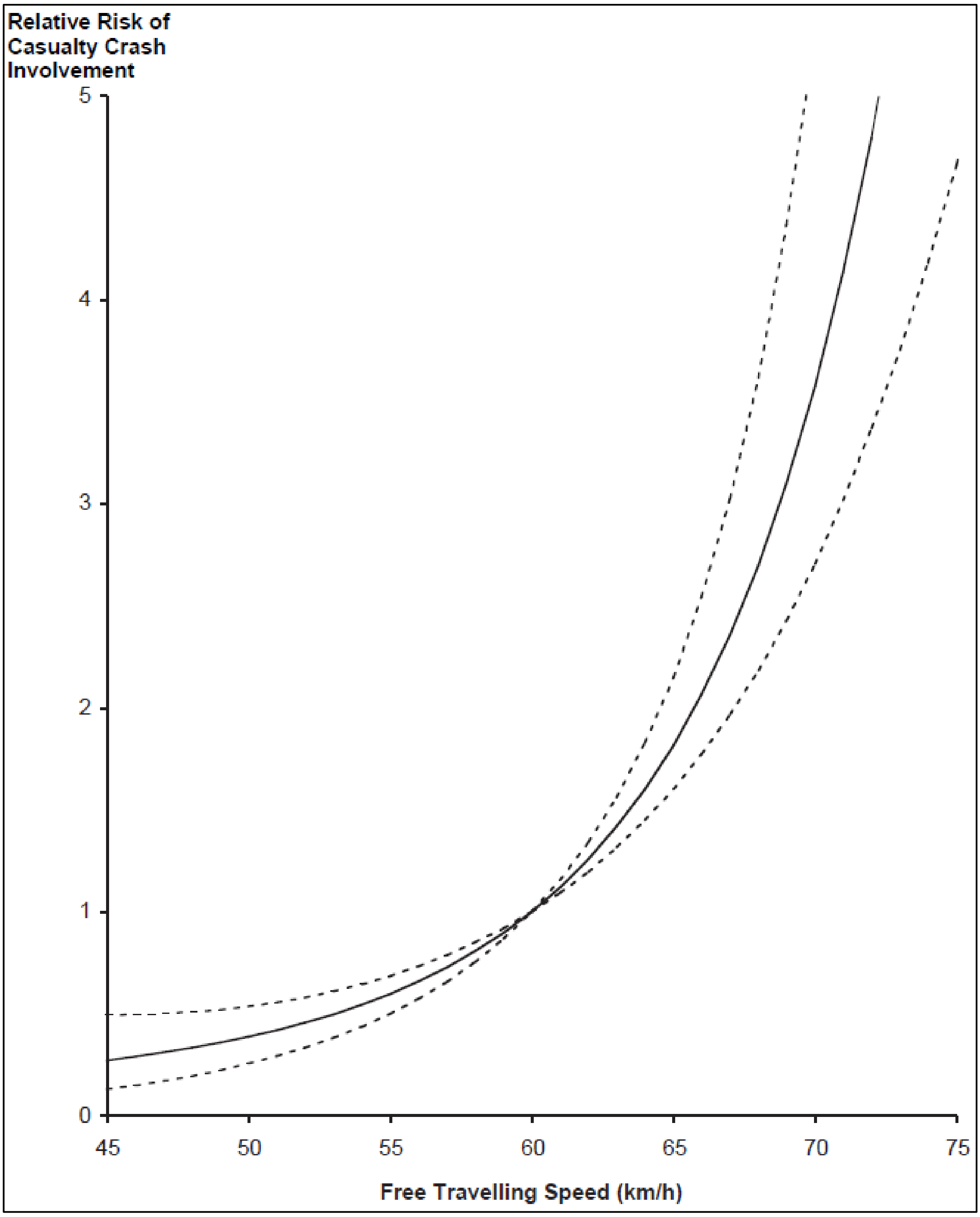
Note: severity categories are mutually exclusive (for example, serious injuries exclude deaths).

Source: Elvik, Christensen and Amundsen (2004)

4.2 Kloeden Curves

Kloeden, McLean and Glonek (2002) used in-depth crash investigations as part of a case control study in Adelaide to describe the relationship between a change in travel speed and the relative risk of being involved in a casualty crash. The first of their results relates the risk of being involved in a casualty crash relative to travelling at 60 km/h in a 60 km/h speed limit zone in urban areas (Figure 4.2). Confidence intervals are shown as dashed lines on the graph.

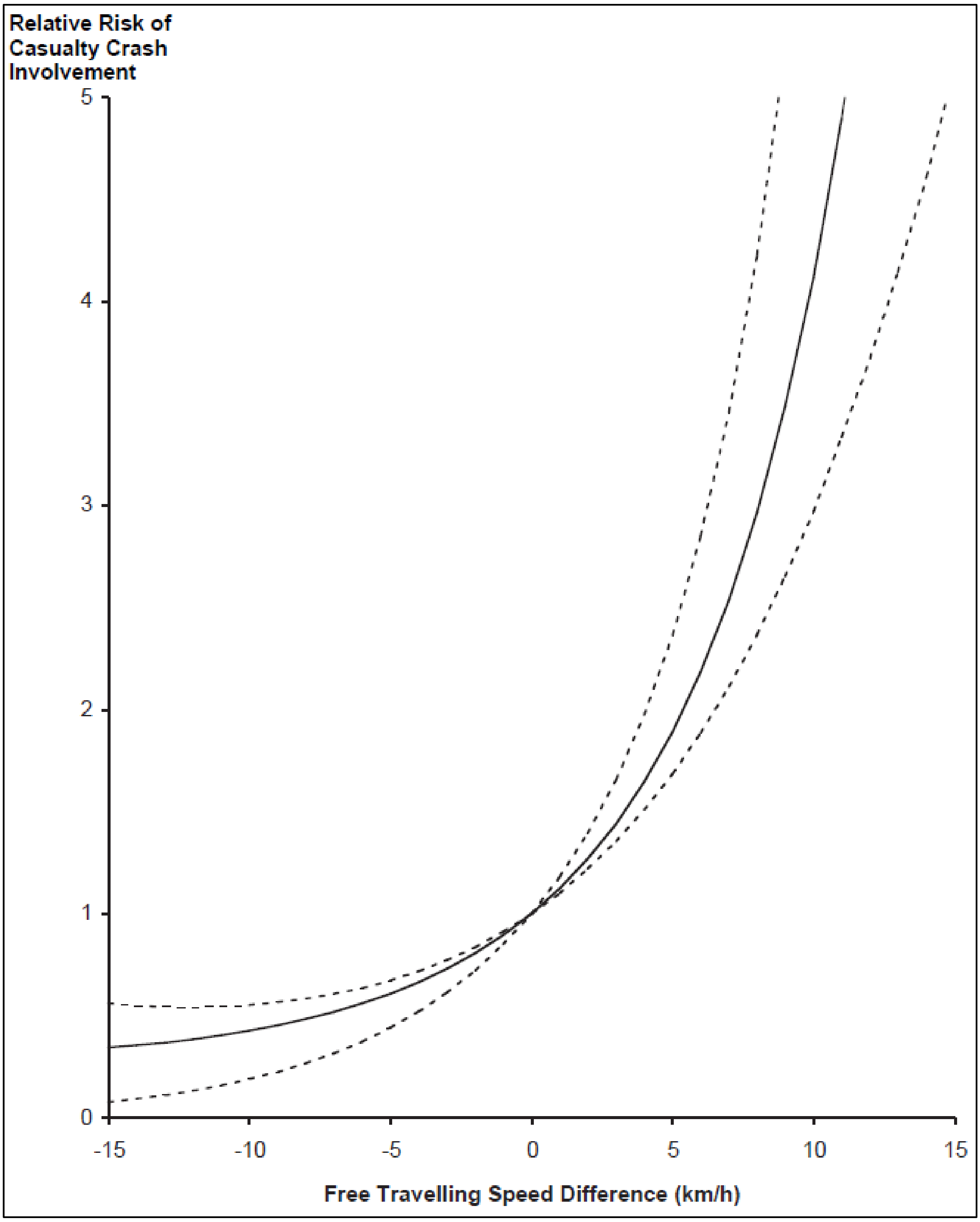
Figure 4.2: Risk of being involved in a casualty crash relative to travelling at 60 km/h in a 60 km/h speed limit zone



Source: Kloeden, McLean and Glonek (2002)

A second study derived a relationship for rural roads in South Australia. This was considered in terms of average speed because the roads studied had varying speed limits ranging from 80 to 110 km/h. Figure 4.3 shows the risk of being involved in a rural casualty crash relative to travelling at the average control speed for a given crash site.

Figure 4.3: Risk of being involved in a casualty crash relative to the average control speed for a given crash site



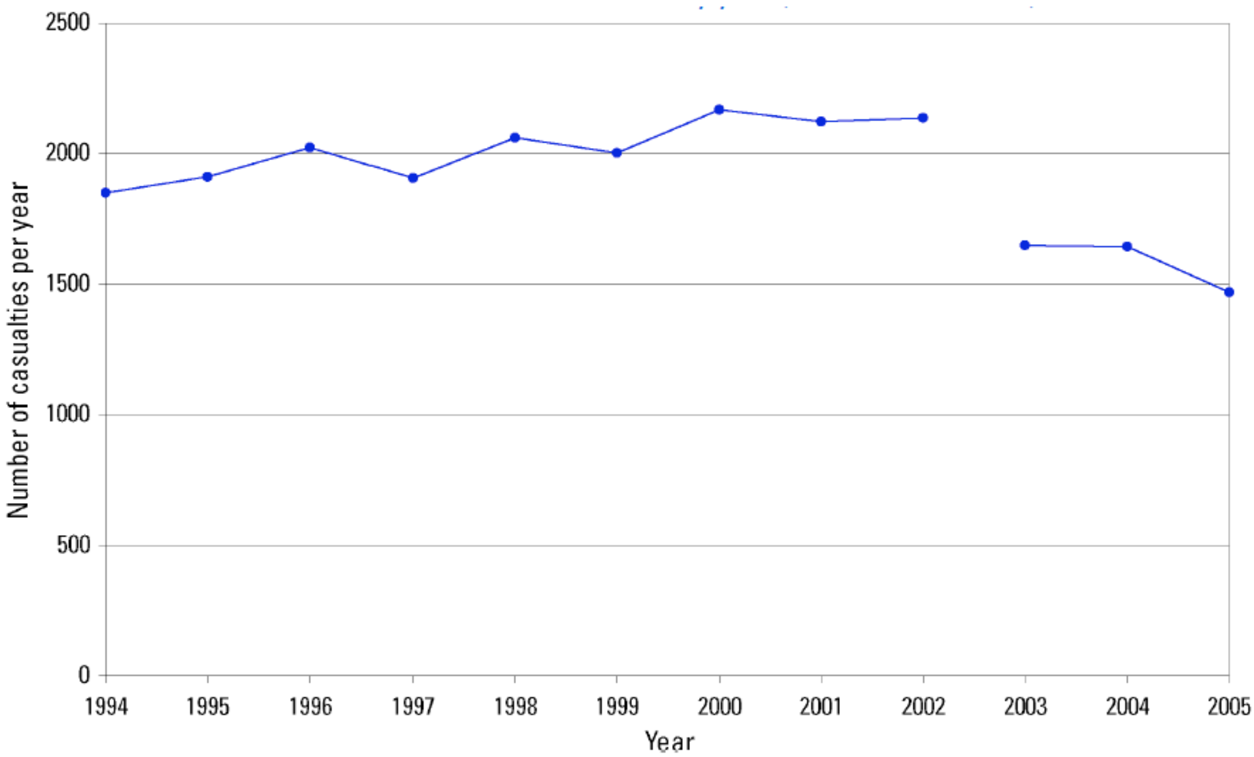
Source: Kloeden, McLean and Glonek (2002)

The work of Kloeden, McLean and Glonek (2002) has led to an understanding that for every 5 km/h increase in travelling speed, the risk of being involved in a casualty crash doubles.

4.3 Evidence from Speed Limit Reductions

Studies by Kloeden, Woolley and McLean (2006; 2007) reported on the effect of a change in the South Australian default urban speed limit from 60 km/h to 50 km/h in March 2003. The results of this study suggested a statistically significant reduction in the number of injuries, injury crashes and fatal crashes associated with the reduction in speed limit. The overall reduction in the number of casualty crashes was found to be 23.4% with an overall reduction in the number of casualties of 25.9%. While crashes along control roads (i.e. those where the speed limit did not change) also reduced after the speed limit reduction came into effect, a substantial step-change in the number of crashes on those roads affected by the change in speed limit could be seen (Figure 4.4). The actual reductions in mean free travel speed associated with the speed limit change were found to be 2.19 km/h (from 51.76 km/h to 49.58 km/h) one year after the change in speed limit, and 3.62 km/h (51.76 km/h to 48.14 km/h) three years after the change in speed limit. These findings not only show a reduction in casualty crashes, they suggest that the number of people being injured in each casualty crash also reduced as there was a greater reduction of casualties compared to casualty crashes.

Figure 4.4: Casualties per year on affected roads before and after the introduction of a 50 km/h urban speed limit (formally 60 km/h) in South Australia

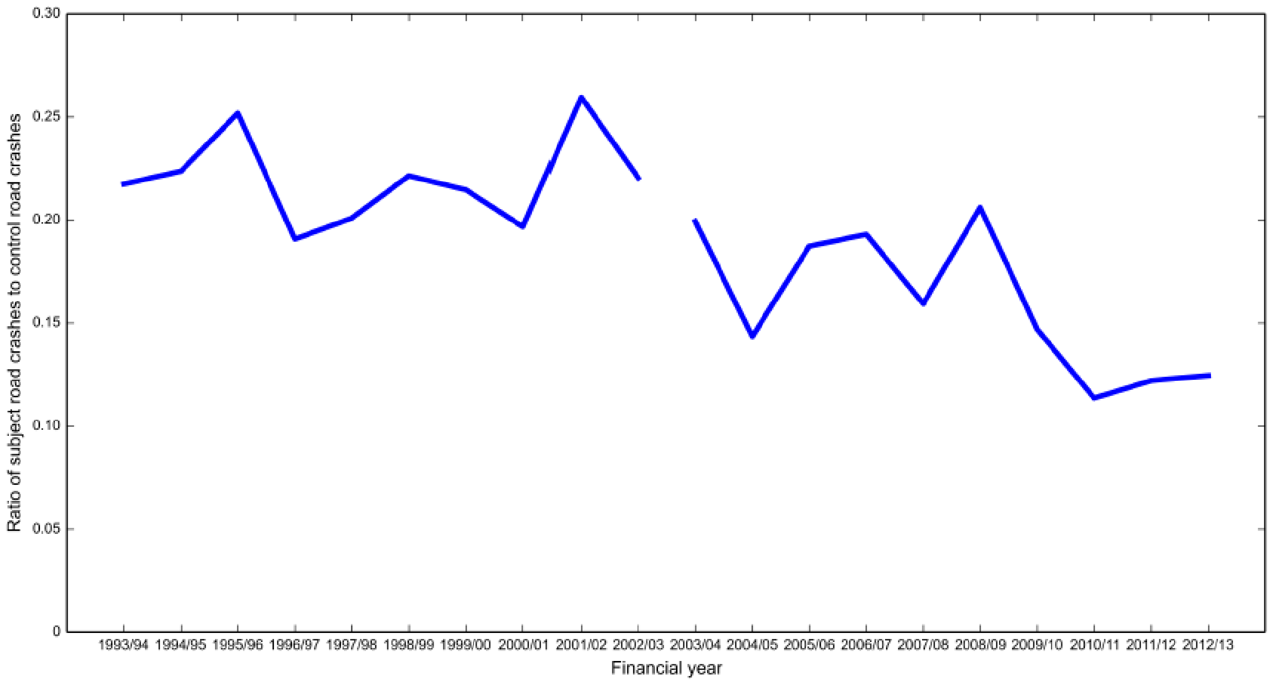


Source: Kloeden, Woolley and McLean (2006; 2007)

Another study (Mackenzie, Kloeden & Hutchinson 2015) reported on the effect of a change in speed limit of 110 km/h to 100 km/h along 1,100 km of rural roads in South Australia which occurred in July 2003. The results of this study suggested statistically significant reductions in the numbers of casualties and casualty crashes of 25.56% and 27.40%, respectively. These figures represented reductions beyond those found for the control roads (rural roads where the speed limit of 110 km/h did not change), suggesting that the change in speed limit alone had a real and substantial effect of reducing the number of casualties and casualty crashes (Figure 4.5). An initial reduction in mean travel speed of 1.9 km/h was found (Long et al. 2006), with continuing reductions in mean and 85th percentile speeds in the preceding 10 years after the change in speed limit (Mackenzie, Kloeden & Hutchinson 2015).

The examples presented here are replicated in multiple jurisdictions all over the world as shown in Table 4.2 and Table 4.3. The association between speed and crashes is arguably one of the most robust relationships established in road safety. The encouraging fact is that even small reductions can result in considerable safety benefits and such benefits continue to accrue over time.

Figure 4.5: Ratio of subject road crashes (roads affected by the introduction of a 100 km/h speed limit, formally 110 km/h) to control crashes in South Australia



Source: Mackenzie, Kloeden and Hutchinson (2015)

Table 4.2: Synthesis of trauma reductions from speed limit changes (international literature)

Jurisdiction	Extent	Observations	Reference
United States	55 mph (89 km/h) national speed limit on interstate and primary and secondary state controlled highways (latterly 65-75 mph (105-121 km/h) introduced in 1974 and repealed in full in 1995	• 18% reduction in fatalities • 5-9% reduction in injuries • No reduction in non-casualty crashes (after introduction) • 17% increase in fatalities on interstate highways (after repeal)	Kamerud (1983) Farmer, Retting and Lund (1999)
Israel	100 km/h speed limit on 115 km of interurban highways (formerly 90 km/h) introduced in 1993	• 2.5 additional fatalities per month	Friedman, Barach and Richter (2007)
Belgium	70 km/h speed limit along 116 km of Flemish roads (formerly 90 km/h) introduced in 2001	• 33% reduction in severe (fatal and serious injury) crashes	De Pauw et al. (2014)
Iowa, United States	70 mph (113 km/h) speed limit along interstate highways (formerly 65 mph or 105 km/h) introduced in 2005	• 25% increase in all casualty and non-casualty crashes • 52% reduction in night-time fatal crashes	Souleyrette and Cook (2010)

Table 4.3: Synthesis of trauma reductions from speed limit changes (Australian literature)

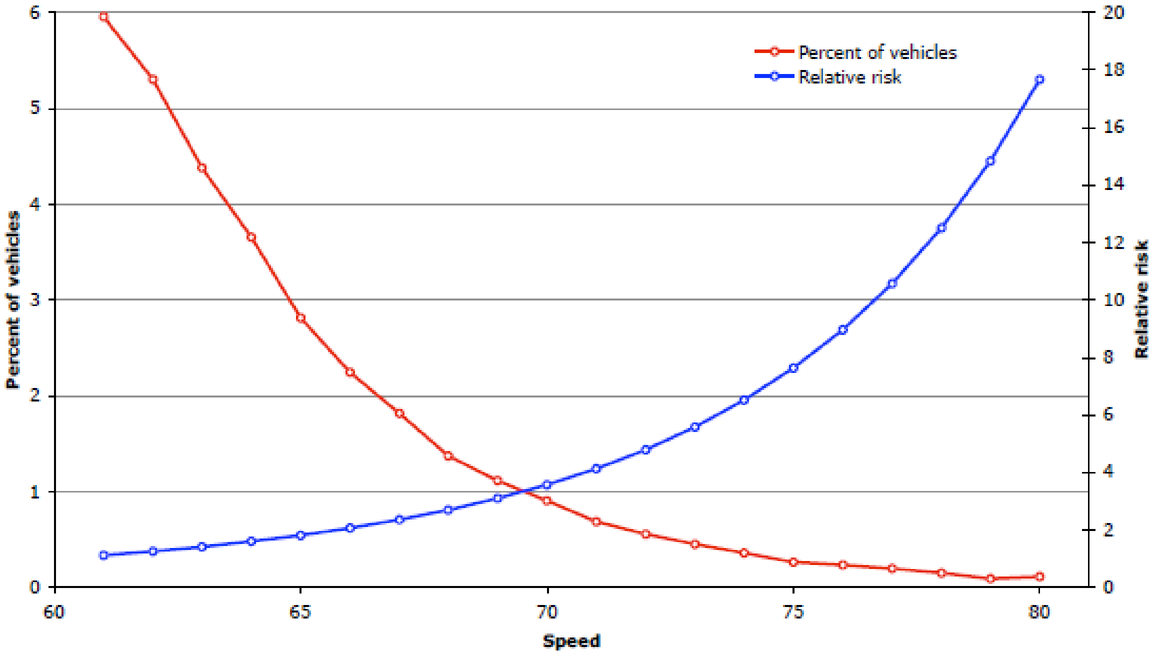
Jurisdiction	Extent	Observations	Reference
Victoria	50 km/h default speed limit in built-up areas (formerly 60 km/h), introduced 22 January 2001	• 21% reduction in fatal crashes • 3% reduction in serious injury crashes • 12% reduction in all casualty crashes • 41% reduction in fatal and serious injury crashes involving pedestrians	Hoareau, Newstead and Cameron (2006)
South-east Queensland	50 km/h default speed limit in built-up areas (formerly 60 km/h), introduced March 1999	• 88% reduction in fatal crashes • 20% reduction in serious injury crashes • 23% reduction in all casualty crashes • 2.2 km/h reduction in mean speed	Hoareau et al. (2002)
Western Australia (metropolitan Perth area)	50 km/h default speed limit in built-up areas (formerly 60 km/h), introduced December 2001	• 25% reduction in fatal crashes • 4% reduction in serious injury crashes • 21% reduction in all casualty crashes • 51% reduction in all crashes involving pedestrians	Hoareau and Newstead (2004)
Victoria	110 km/h speed limit on rural and outer Melbourne freeways (formerly 100 km/h), introduced June 1987, with 100 km/h speed limit reintroduced September 1989	• 21% increase in fatal and serious injury crashes (100 to 110 km/h) • 25% increase in all casualty crashes (100 to 110 km/h) • 18% reduction in fatal and serious injury crashes (110 to 100 km/h) • 19% reduction in all casualty crashes (110 to 100 km/h)	Sliogeris (1992)
South Australia	100 km/h speed limit along 1,100 km of rural roads (formerly 110 km/h), introduced July 2003	• 29% reduction in fatal crashes • 28% reduction in admitted to hospital severity crashes • 27% reduction in all casualty crashes	Mackenzie, Kloeden and Hutchinson (2015)
South Australia	50 km/h default speed limit in urban areas (formerly 60 km/h), introduced 1 March 2003	• 37% reduction in fatal crashes • 20% reduction in admitted to hospital severity crashes • 23% reduction in all casualty crashes • 3.7 km/h reduction in mean speed	Kloeden et al. (2006)

4.4 The Case for Addressing Low Level Speeding

The previous studies point to a common conclusion: increasing speed increases the relative risk of being involved in a casualty crash. A positive relationship between increased speeds and increased crash severity has also been shown (Kloeden, McLean & Glonek 2002; Elvik 2013). The studies suggest reducing any level of speeding will decrease casualty crashes. Due to the non-linear relationship between speed and relative risk, reducing a driver's speed from 75 to 74 km/h has a greater effect on personal risk (i.e. the effect on that individual) than reducing his or her speed from 65 to 64 km/h. However, the substantially larger population of low level speeders (such as those travelling at 65 km/h in a 60 km/h speed limit zone) means that reducing their speed will have a greater collective effect (i.e. an effect over the entire population) than reducing the speeds of the smaller number of drivers involved in higher level speeding (such as those travelling at 75 km/h in the same speed limit zone).

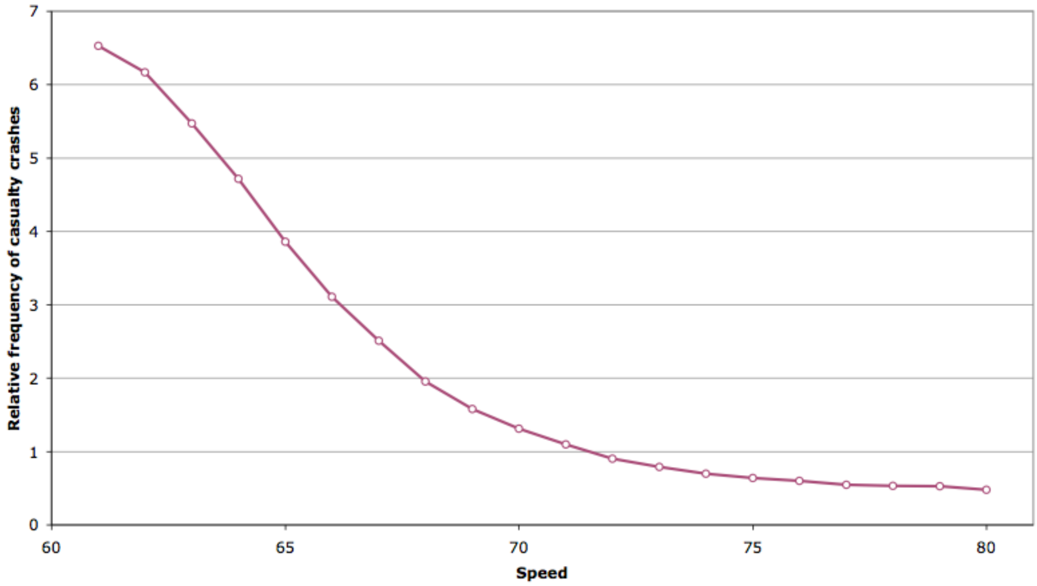
This relationship is demonstrated in a study by Doecke, Kloeden and McLean (2011) which showed the relationship between different levels of speeding, reducing the speed of these drivers and the associated potential reduction in casualty crashes. This is presented in Figure 4.6, which shows the relationship between the proportion of drivers travelling at different speeds over the speed limit and the relative risk of being involved in a casualty crash at different speeds. The results suggest that the greatest potential for reducing casualty crashes comes from reducing the speeds of low level speeders (Figure 4.7). In some cases, more than 50% of casualty crash reductions can come from reducing the speeds of only those drivers travelling at between 1 to 5 km/h above the speed limit.

Figure 4.6: Relative proportion of vehicles measured at speeds between 1 and 20 km/h over the speed limit in an urban 60 km/h speed limit zone and the relative risk of involvement in a casualty crash



Source: Doecke, Kloeden and McLean (2011)

Figure 4.7: Relative frequency of casualty crashes of vehicles measured at speeds between 1 and 20 km/h over the speed limit in an urban 60 km/h speed limit zone



Source: Doecke, Kloeden and McLean (2011)

Low level speeding (e.g. up to 5 km/h above the speed limit) is often perceived by the wider community as being inconsequential. The reality of low level speeding is very different. While South Australian data has been used to demonstrate this fact, the findings have also been replicated in other States.

4.5 Travel Time and Productivity

A common point of resistance to lower operating speeds in the road network usually relates to arguments associated with lost productivity and increased travel times.

The productivity argument is likely to provide an ongoing dilemma for road authorities. Core issues revolve around how fair and meaningful comparisons can be made between safety and productivity objectives. For example, many argue that the impact of incrementally adding up a five second delay for thousands of vehicles at an intersection cannot be meaningfully compared to equivalent safety benefits at the individual level. Additionally, delay is often calculated from the perspective of motor vehicles and the impact on pedestrians is frequently not considered.

Austroads (2010b) has presented a review of literature on the effect of reduced speed limits on network operations. It was concluded that reduced speed limits would have the largest effect on travel time along roads with minimal congestion and number of intersections. It was also concluded that, for arterial roads within urban environments, reduced speed limits would have no appreciable effect during times of congestion.

The travel time argument is often raised by the community because of a perception that lower speed limits will dramatically increase travel times and hence fatigue, especially in rural areas. Evidence to date suggests that where speed limits are lowered, net road injury reduces and there appears to be no compensating effect of fatigue crashes. The proportional increase in travel time will generally be less than the decrease in speed limit. There are a number of reasons for this:

- the actual reduction in average travel speed is less than the reduction in speed limit
- vehicles are unlikely to travel at free speeds for 100% of a journey
- other sources of influence on a vehicle's speed can include townships, intersections, curves, grade changes and interactions with other traffic.

Dutschke and Woolley (2010) studied the effects on travel times from the change in speed limit from 110 km/h to 100 km/h along a number of rural highways in South Australia. The study found that increases in travel times were proportionally less than the decreases in speed limit. The 10% decrease in speed limit increased travel times by 2% to 8 % for higher density traffic (6000 vehicles per day) and 4% to 10% for lower density traffic (1000 vehicles per day). In relative terms, this means that a journey that took 60 minutes at 110 km/h would take between 61 and 66 minutes at 100 km/h.

Kamerud (1983) presented a study into the effects of the 1974 implementation of a 55 mph (89 km/h) national maximum speed limit (NMSL) across the United States. This law saw the speed limit along interstate highways and many state controlled highways reduce from 65 to 55 mph (105 to 89 km/h) and, in many cases, from 70 to 55 mph (113 to 89 km/h). These represented speed limit reductions of between 18% and 27%. It was reported that, along interstate highways, passenger vehicle travel times increased from 15.30 hours per 1000 miles in 1973 to 17.50 hours per 1000 miles in 1974/75. This represented an increase in travel time of 14%. The increase in travel time for trucks was found to be only 6%. The increase in travel time along state controlled highways was much less, with passenger vehicles taking between 3% and 7% longer than before implementation of the NMSL.

5. Ways to Manage Speed

There are different ways to manage speeds on roads and they are usually inter-related and apply concurrently. Once a road is built and in use, drivers and riders will adopt a travel speed which is managed by a road authority either actively through interventions (such as speed enforcement) or passively by allowing users to make their own choice of travel speed (for example, based on the type of road environment). Therefore, in practice, a road authority will always, to some degree, influence travel speeds whether they do so actively or passively. Methods to manage speed include:

- roads and roadside infrastructure – such as speed calming treatments
- speed limits and speed enforcement
- people – such as influencing people's attitudes and behaviours regarding risk and safety
- vehicles – such as speed limiter devices, adaptive cruise control.

5.1 Roads and Roadside Infrastructure

The link between the road and roadside environment and travel speed is well known. In recent years, this concept has been clarified and expanded in the concept of a 'self-explaining' road (e.g. Schermers 1999; Theeuwes & Godthelp 1995; Wegman, Aarts & Bax 2006). Application of the concept of self-explaining roads seeks to provide road features and characteristics that encourage speed choices consistent with the safe speed for the function and design of a road. The ultimate self-explaining road is one for which the road elements inform motorists as to the required safe speed. In order to recognise the current road function and to predict road elements, the following features are required (World Bank 2005):

- clear design, marking and signing
- recognisable road categories
- design elements for each road category that are uniform.

Many of the features (or alterations) to the road and roadside environment that can influence travel speed are discussed in depth in the *Guide to Road Safety Part 2: Safe Roads* (Austroads 2021b)

5.2 Speed Limits and Speed Enforcement

There is potential for obtaining community support for road function and consequently infrastructure that manages safe speeds in the context of "movement and place." When speed limits are supported in this context, there is a potential for greater compliance, safety improvement and community acceptance.

In some communities there is also growing acceptance for lower speed limits, particularly at locations where there is higher risk. This has started at schools, has migrated to shopping strips and now is gaining acceptance for lower quality rural roads. Such support has been demonstrated, for example, with the adoption of 80 km/h on rural roads in the Mornington Peninsula in Victoria (Pyta, Pratt & Bradbrook 2014) and the adoption of 20 mph zones amongst local authorities in the United Kingdom.

Travelling speed reductions and consequent reductions in road trauma can be achieved virtually instantaneously when a speed limit is changed. This contrasts with a reliance on safe infrastructure treatments that can take considerable time to plan, design and implement. This relationship between speed and road trauma is being increasingly considered by road authorities; Austroads (2010a) provides advice on speed limit setting based around the Safe System principles of harm minimisation and with consideration of road function, road infrastructure and driver selection of speeds.

Speed limit reductions remain one of the single most cost-effective countermeasures available to practitioners for reducing death and serious injury on the road system. Doecke, Kloeden and McLean (2011) performed an exercise in South Australia to compare the cost of implementing infrastructure changes to the State's rural road network in order to achieve the equivalent safety gains from a 10 km/h speed limit reduction. As can be seen in Table 5.1, multiple millions and sometimes billions of dollars of infrastructure expenditure would be necessary to achieve the equivalent reductions that a speed limit change could achieve. Many existing infrastructure treatments are unable to deliver the equivalent 20% reduction expected with a 10 km/h reduction in speed limit on 100 km/h roads. For those treatments that can match the 20% reduction, approximately eight billion dollars in expenditure would be required on the 110 km/h state road network. This compares with an assumed cost of less than a million dollars to lower the speed limit and change signage accordingly on the State's road network.

Table 5.1: Cost of obtaining reductions on State controlled roads in South Australia with infrastructure changes or speed limits:

Speed limit	Treatment option	Serious casualty crash reduction	Cost of treatment ($M)	Cost of 20% serious casualty crash reduction ($M)
100 km/h	10 km/h speed limit reduction	20%	<1	<1
	Shoulder sealing	14%	104	NA
	Roadside barriers	18%	526	NA
	Median barriers	14%	2,142	NA
	Clear zones	9%	545	NA
110 km/h	10 km/h speed limit reduction	20%	<1	<1
	Shoulder sealing	25%	427	338
	Roadside barriers	35%	2,404	1,367
	Median barriers	26%	9,540	7,235
	Clear zones	18%	2,428	NA

Source: Doecke, Kloeden and McLean (2011)

The outcomes of the exercise challenge the notion that road authorities can continue to build and retrofit high quality roads to safely maintain high speed limits. Appropriate speed management is essential in any transition towards Safe System performance. It is also important to note that unless speeds are reduced to survivable levels in the event of a crash, (most effective with the support of engineering treatments), a speed limit reduction can only be considered a supporting treatment and not a primary Safe System solution in its own right.

The following guidance in Table 5.2 briefly summarises design philosophies towards specific road user types and situations in the context of the South Australian "Link and Place" approach (Government of South Australia 2012).

Table 5.2: Design philosophies aimed towards specific road user and road user interaction types

Road user/ interaction type	Design philosophy
Cars	• Establish appropriate speed environment, in accordance with street's strategic role • Good connections from 'slow' local networks of 30 km/h and below to faster arterial networks • Preference for passive speed control measures • Use urban design techniques for speed control: minimising carriageway width, limiting visual length of street sections, varying surface materials at intersections and crossings, etc.
Cycling	• Cyclists considered and incorporated into all streets, as priority street users • Preference for sharing street space in low speed environments • On busier streets: segregated continuous lanes and safe crossing points • Cycle paths should be direct, continuous, smooth and barrier-free • Good connections to important destinations and end-of-trip facilities • The optimum position for locating a cycle lane is between the pedestrian footway and any car parking spaces
Walking	• Pedestrians should be prioritised in most street environments, with facilities such as footways of 1.5 m and wider, crossing facilities at appropriate locations and waiting times at signals not exceeding much beyond 60 seconds, climate protection, seating at frequent intervals, good levels of lighting, etc • Pedestrian needs should be considered for all street types • Streets should be designed on a 'human/pedestrian scale', responding to the needs of pedestrians • Streets should offer good connections of small grain • Streets should encourage staying activities and interaction for a diverse range of users • Street environments should be adaptable and flexible
Shared Streets	• An alternative approach to street design suitable for streets with 'design' speeds below 25 km/h • 'Shared streets' integrate street functions by removing barriers separating users • It calls for a different design approach, avoiding conventional signage, traffic islands and markings, etc. • Local expression within the street space should be enhanced and encouraged

Sections 6, 7 and 8 of this document expand on speed limits and their application.

The Austroads research report on Driver Attitude to Speed Enforcement (Austroads 2013) found that safety concerns influence drivers' choice of speed, but those concerns are primarily considered in certain circumstances; for example, when driving through areas with high pedestrian activity, when driving conditions are poor, and when driving at speeds so high as to feel unsafe. In discussion groups, drivers indicated that the fear of being caught was usually the most salient negative consequence of speeding, and was therefore the most prominent consideration in choosing driving speed. Although 92% of survey respondents agreed with the statement 'if I regularly speed, there's a good chance I'll be caught sooner or later', 24% agreed with the statement 'I drive faster than the speed limit when I know it's unlikely I'll get caught'. Similarly, Ipsos Social Research Institute (2009) found in NSW that 29% of participants agreed that they tended to drive faster than the speed limit when they believed it was unlikely they would be caught.

The influence of enforcement on travel speed is discussed in depth in the *Guide to Road Safety Part 4: Safe People* (Austroads 2021c)

5.3 People

Ultimately, the success of any speed management measure (be it in the road environment, the vehicle or through legislation) is with the impact on travel speed within the driving or riding task. In most cases this is dictated by the human's choice of travel speed. There are a variety of factors that influence a driver's choice of travel speed in relation to the posted speed limit. These include:

5.3.1 Personal factors

The key personal factors that have been found to be associated with speeding behaviour include age and gender, with speeding more prevalent among males and younger drivers (Harrison et al. 1998; Williams, Kyrychenko & Retting 2006). In addition, speeding has been reported as being more prevalent among individuals with crash and infringement histories (Watson et al. 2015), a greater propensity for sensation-seeking and risk taking behaviours (Stradling et al. 2003) and more positive attitudes toward speeding behaviour (De Pelsmacker & Janssens 2007; Austroads 2013). Of relevance is the consideration that young males also tend to score higher on these latter measures. Since this demographic group also represents a high risk road user group, they should be a particular target group for future interventions.

5.3.2 Legal factors

The key legal factors that have been found to influence driving speeds are related to concepts from deterrence theory and include perceptions of risk of detection and punishment, as well as the perceived certainty, swiftness and severity of punishment, and the perceived ability to avoid punishment (Cedersund & Forward 2007; Stafford & Warr 1993). Specifically, it is argued that speeding behaviour is more likely when individuals perceive the risk of detection and punishment to be low and that experiences of punishment avoidance (i.e. speeding and not getting detected or penalised) are a strong reinforcing factor which leads to continued speeding behaviour (Fleiter, Watson & Lennon 2013).

5.3.3 Situational factors

Key situational factors associated with a greater propensity to speed include time pressures (Stradling et al. 2003), perceptions that posted speed limits are too low (Austroads 2005), opportunities to speed (Richard et al. 2012), and when driving for work-related purposes (Glendon 2007).

5.3.4 Social factors

Finally, key social factors found to be associated with increased speeding behaviour include having a greater number of significant others (e.g., family, peers) who hold favourable attitudes toward speeding or engage in the behaviour more frequently (Fleiter et al. 2006) as well as the influence of passengers in a vehicle. The evidence regarding the role of passengers is somewhat mixed with family members and siblings likely to serve a protective function for some drivers (Walker et al. 2009), whereas same age peers may increase risk. Importantly, the potential for other people to model un/safe driving behaviours, including speeding, is an area worthy of consideration when attempting to change community attitudes, particularly in light of the extensive input parents have in providing instruction and supervision to learner drivers via graduated driver licensing programs in Australia and New Zealand (Bates, Watson & King 2009; Beck et al. 2003; Begg & Stephenson 2003).

5.3.5 Implementation intentions and pledges to counter speeding

Implementation intentions represent a way to assist people to change their behaviour based on the concept of predetermining a plan to implement when a particular situation arises in order to attain a certain goal (goal intention). In relation to speeding, an example of a goal intention may be ‘I intend to comply with all posted speed limits’. Beyond this goal, it is argued that a volitional phase is also needed in order for people to be able to translate this goal into action. This is where implementation intentions are used.

Pledges have also been used in a speeding context. Delhomme, Kreel and Ragot (2008b) recruited 624 driving offenders to examine the effectiveness that a public commitment had on speeding behaviour. Participants were assigned to one of three groups: the experimental group involved making a public commitment to comply with the speed limit each time that they drove a vehicle over the next six months, the comparison group, and the control group. Of the 271 participants allocated to the experimental group, 53% committed to comply with the speed limit for each driving trip over the following six months. Findings revealed that the committed group were more likely to comply with the speed limit (49%) 5.5 months after marking the pledge compared to the control group (20%), comparison group (29%), and non-committed group (9%). In a follow-up study, Delhomme, Grenier and Kreel (2008a) reported that the use of an action sheet where drivers had to report the actions that they had planned to implement to keep their safe driving commitments were more likely to comply with the speed limit at the 5.5 month follow-up (53%), compared to those drivers who undertook the pledge but did not complete an action sheet (41%).

5.3.6 People's attitudes towards speeding

When analysing people's attitudes to speed and speeding, a noteworthy paradoxical phenomenon that is apparent from examining community reactions to speed management initiatives is the concept of agreeing with the use of speed control initiatives where one lives, and/or where one's children go to school (i.e., 'in my community to protect me and those important to me'), but at the same time, disagreeing with speed control in other areas (e.g., reduced speed limits on roads used for commuting, even if these roads are where other people's children attend school or where other people live). This phenomenon has been described in a range of ways, including as an example of 'the JIMBY effect - Just In My Back Yard' (Tapp 2015), and as 'YIMBY – Yes In My Back Yard' (Fleiter 2013), where agreement with speed management measures are viewed as acceptable within one's own community, but generally not supported elsewhere. These phrases are variations of the more well-known phrase, 'NIMBY – Not In My Back Yard', and are of relevance to the current project in that they represent contradictory beliefs about where speed management measures, and therefore, speeding, may be deemed appropriate by the community.

Garnering support and compliance from the community for speed limits can be achieved by:

- Awareness – making people aware of the specific speed limit on the sections of road that they use, and of the broad principles of speed zoning.
- Understanding – why speed limits apply and the relationship to risk and safety.
- Support – try to build support (or at least acceptance) for speed limit setting principles and the Safe System approach.
- Communicating and engaging – with people on a policy and project level, via campaigns, education and training (e.g. GLS).

5.3.7 What does the community think about speed risks and speed management?

Community attitude surveys show growing public understanding of speed risks, and majority support for strict approaches to speed management.

For example, the ATSB's national survey of community attitudes to road safety (Pennay 2006) shows that:

- Agreement with the statement 'If you increase your driving speed by 10 km/h you are significantly more likely to be involved in a car accident' has increased from 55% in 1995 to 74% in 2006.
- An overwhelming majority (94%) of people surveyed in 2006 agreed that 'an accident at 70 km/h will be a lot more severe than an accident at 60 km/h'. (Compared to 80% in 1995).
- In 1995, 1 in 4 people (26%) believed motorists should not be booked for driving at 70 km/h in a 60 km/h zone; by 2006, only 1 in 10 (10%) still held this view.
- Half the people surveyed in 2006 (49%) believed that drivers should be booked for travelling at 65 km/h in a 60 km/h zone.
- In 2006 most people believed that the amount of speed enforcement activity should be either maintained (44%) or increased (44%); only 11% favoured a decrease.

6. Types of Speed Limit

Under the Australian and New Zealand road rules a driver must not drive at a speed over the speed-limit applying to the length of road where the driver is driving. Speed limits apply when regulatory speed limit signposting is provided. Sign posted speed limits should reflect particular road attributes such as the role and function of the road, type of road users, abutting land and access, road geometry, roadside hazards and crash risk.

Road users understand that there must be a range of speed limits depending on the road and traffic situation. Across Australia and New Zealand a number of common types of speed limits apply as outlined below.

6.1 Default Speed Limits

As a means of implementing speed limits, when there is no speed limit sign, the default legal speed limits apply. There are two general 'default' (unsigned) speed limits in Australia and New Zealand, one that applies within the urban or 'built-up' area, and the other that is applicable within a 'rural' open-road environment. Generally, the default limit in urban areas is 50 km/h and in rural areas 100 km/h[1].

6.2 Signed Speed Limits

Speed limits also apply when regulatory speed limit sign posting is provided. There are a variety of applications of signed speed limits as follows:

- Shared road space speed limits. This includes car parks and pedestrian malls and the speed limit is typically 10 km/h but can vary from 4 or 5 km/h up to 20 km/h. In shared zones, pedestrians have priority over vehicles. The road layout/infrastructure should be such as to limit the travel speed of vehicles.
- Linear speed limits. In this situation a speed limit is applied along a road and any change in the nature of the road such as moving into a residential area, would be indicated with a different speed limit sign. Speed limits can vary from 110 km/h in the rural areas to 50 km/h in built up areas. Speed limits such as 60, 70 km/h, 80 km/h and 90 km/h are applied depending on traffic volumes, roadside development and the nature of the road (e.g. is it divided, is the alignment simple etc).
- Area-wide residential or commercial speed limits. In some situations, a speed limit, generally 40 km/h, is applied to a broad zone such as a residential area or shopping/business district. All enter and exit roads need to be signed to give legal effect.
- Time based speed limits. These are applied in various situations including adjacent to schools, in work zones, shopping precincts, during seasonal holiday activities, special events and if there are marked changes in the season (e.g. snow and ice are present in winter) and for congestion management. Speed limits generally vary from 25 km/h to 40 km/h.
- Variable speed limits. In some cases, the normal speed limit may need to be lowered (electronically or manually) for a variety of reasons including:
  - To reflect changes in traffic flow conditions.
  - To cater for adverse weather conditions (e.g. high crosswinds on an elevated structure, fog, etc.).

[1] Exceptions:
- Western Australia rural default 110km/h
- Northern Territory urban default 60km/h
- Northern Territory rural default 110km/h
- Tasmania unsealed roads default 80km/h

  - As an incident management tool (i.e. a lower speed limit may be applied when an incident, such as a vehicle breakdown or road crash has occurred).
  - Where periodic activity such as the opening and closing of a heavy vehicle inspection station may warrant a reduction in general traffic speed past the site when heavy vehicles are entering/leaving.
- Heavy vehicle speed limits. While regulations stipulate that the maximum speed limit for heavy vehicles (i.e. trucks and buses) is 100 km/h (or 90 km/h in New Zealand) and, in parts of Australia, 90 km/h for road trains, there are some circumstances where there may be the need for a reduced speed limit to apply. This may be due to:
  - steep down grades
  - substandard horizontal alignment.
- Reduced speed limits for trucks and buses on sections of road with steep down grades or substandard horizontal alignment may be considered where:
  - there is an over representation of trucks/buses in crashes
  - the speed of descent exceeds safe values for steep grades
  - heavy vehicles experience difficulties negotiating the road alignment.

Reduced speed limits for trucks and buses on roads should, however, be applied with caution as creating a large speed limit differential with other road users may increase the risk of crashes. Where a lower speed limit is applied, treatments to provide safe passing opportunities (e.g. passing lanes, and truck and bus turn-out bays) should be considered for other road users.

In some cases lower speed limits can apply to certain licence holders. For example, in some parts of Australia, a lower limit applies to a novice driver such as a learner or provisional licence holder.

7. How Do You Choose the Speed Limit?

Each Austroads jurisdictions has their own prescribed speed limit review/setting process and procedure which present the on-ground requirements for speed limit setting.

In general, when setting speed limits, a range of factors need to be considered, within the context of the Safe System.

7.1 Crash Risk

The most important consideration in the assessment or review of a speed zone should be the determination of the crash risk on that road. The most common way to determine the crash risk is the crash history, however risk can be determined in a variety of other ways, as crash history is heavily influenced by the volume of road users using that road.

The crash history can be viewed in two ways: the risk faced by individuals, which is measured by the casualty crash rate per 100 million vehicle kilometres, and the collective risk, which is measured by the casualty crash rate per kilometre of road.

Collective risk represents the total risk along a length of road, as opposed to the risk faced by each individual driver. For example, a link might experience a relatively low number of crashes. Other things being equal, this low number of crashes would equate to a relatively low collective risk. However, if this link also carried very low traffic volumes, then the few motorists that use the link might actually face a relatively high personal risk. Conversely, if that link carried a high traffic volume, then the risk to each individual motorist would be low.

Using collective risk as a basis for setting speed limits can create anomalies. Roads with higher traffic volumes tend to be built to higher standards, but these roads can still have higher collective risk statistics than lower standard roads with low traffic volumes. Therefore, a strong emphasis on collective risk in setting limits can lead to relatively safe roads attracting lower limits than relatively unsafe roads.

A focus on individual risk is likely to provide a more consistent relationship between speed limits and characteristics of the road and road environment, giving a hierarchy of limits that makes more sense to most road users.

Lowering limits on roads with high collective risk can bring safety benefits, but these are the roads where safety-focused road improvements are likely to be most cost-effective.

Enforcement is usually limited on low volume roads, and this limits the extent to which reduced speed limits alone can reduce individual risk on these roads.

7.2 Current Operating Performance

The physical and operating environment of a road section is a major influencing factor on risk. Driver speed behaviour is also influenced by the road user activity and visual cues associated with differing road locations. Speed zone assessments or reviews of a road need to take these factors into account. The road environment factors which have a marked influence on risk include roadside hazards, uncontrolled intersections and other access points (such as driveways) and opportunities for collisions between motor vehicles and pedestrians and cyclists.

The function of a road is one consideration in the determination of the most appropriate speed limit that should apply. The assessment should also recognise that roads may have more than one function and that there is a need to identify the primary function of the length of road under review. The issues that need to be considered include whether the road:

- is a major traffic route (i.e. a road whose primary function is to move traffic between regions or centres – these roads are typically primary arterials or secondary/sub-arterial roads)
- is a freeway or motorway (i.e. a high standard divided road whose primary function is to carry high volumes of traffic)
- is a local collector (i.e. a non-arterial road that distributes traffic from local roads onto the arterial road network)
- has a significant number of activities that generate a large number of pedestrians
- forms part of a residential precinct (i.e. a network of local roads bounded by collector and arterial roads) or local traffic area (i.e. a network of local and collector roads bounded by arterial roads)
- is a shared zone road (i.e. an area or length of road that is shared by vehicles and pedestrians).

Road authorities seek to achieve a good match between road function and road design: as far as possible, major traffic routes are designed to reduce collision risks, so that higher vehicle speeds can be sustained without unacceptable risk. However, this is not always possible in practice. Where a road does not meet the safety standards appropriate to its function, the speed limit should reflect the road as it is, not the road as it ought to be.

A traditional consideration in assessing or reviewing speed limits is the determination of the 85^{th} percentile speed of the road.

The use of 85^{th} percentile speed has been discontinued by many road authorities as a key factor in speed limit setting and is not supported by the Safe System approach to road safety. Should it be found that the travel speed is markedly higher than the assessed speed limit then it may be necessary to consider establishing engineering measures designed to constrain vehicle speeds. Targeted speed enforcement (including automatic enforcement, where appropriate) may also be considered as a means by which vehicle speeds may be reduced.

Other major factors considered during speed zone assessments and reviews include:

- the presence of pedestrian and cyclist facilities (controlled and uncontrolled)
- the volume and composition of traffic (i.e. heavy and over dimensional vehicles, cyclists and pedestrians)
- traffic patterns or the presence of any special activities (e.g. schools and school crossings, frequent regular bus stops, extensive periods of large numbers of pedestrians/cyclists, etc.), that may have an impact on traffic flow and speed
- the level of distraction from the surrounding environment (remarkable views, unexpected wildlife, etc.).

7.3 Road and Roadside Infrastructure, Geometry and Roadside Development

The geometric features of a road strongly influence the speed at which motorists travel. When assessing or reviewing a speed zone the following geometric features are considered:

- alignment of the road (i.e. whether it is straight or curved, and if it is flat or steep)
  Short sections of a road with an adverse alignment should be treated with advisory warning signs.
- road cross-section – characteristics can include:
  - whether the road is divided or undivided
  - where divided, the width of the median

- whether there is provision for protected right turn movement
- number of lanes and their widths
- presence of bus lanes/bicycle lanes
- the presence of edgelines, and whether there are sealed (i.e. minimum 0.6 m width) or unsealed shoulders
- the offset to roadside features.

A key factor that influences vehicle speeds relates to the level of activity generated by the abutting roadside properties. When assessing or reviewing speed zones the following factors need to be considered:

- whether there is restricted access on one or both sides of the road. This may result from the presence of service roads, parkland, rail-line, river, beach, etc.
- whether the development on each side of the road is similar or vastly different
- the number of at-grade intersections (controlled and uncontrolled)
- the frequency and set back of driveways
- the nature and level of the roadside environment (i.e. residential, commercial/shopping or industrial).

A speed zone is generally not applied as a means of addressing isolated roadside hazards (e.g. unprotected bridge end, tree or pole, intersection, etc.), or ‘black spot’ site (i.e. high crash locations). The more appropriate course of action is to undertake appropriate remedial work to ameliorate the problem. The corrective work may include improvements such as the installation of suitable advance warning signs and the installation of safety barriers. The treatment of hazardous road locations will be expected to be undertaken as part of a road safety program at either the local, State or Federal government level.

A lower speed zone may, however, be applied where there are a series of hazards that prevail along an extended length of road.

The speed limit on adjacent road sections requires consideration when conducting a speed zone assessment. Many motorists object to frequent speed zone changes over a short distance. A short section of a lower limit can be appropriate (e.g. within a shopping precinct or around a school) but if a number of such locations are fairly close together, consideration should be given to extending the reduced speed zone to a longer stretch of road.

Most jurisdictions have identified that lower speed limits are required on much of their road network to better align with Safe System principles. As a transition measure, there is growing support for a process of identifying roads with existing lower travel speeds and starting with these for speed limit reductions (as they are seen by some of the community as ‘credible’ and will still achieve significant cash risk reductions).

7.4 Unsealed Roads

While the default rural speed limit on unsealed roads may be the same as for sealed roads (with the exception of Tasmania), consideration could be given to lower speed limits where there is direct roadside development, the road has a poor crash history or poor alignment.

Factors that should be considered when investigating the appropriateness of applying a lower speed limit on unsealed roads include:

- function of the road (e.g. arterial, collector road, local road, etc.)
- type and volume of traffic using the road
- alignment of the road
- climatic variation the road is likely to experience

- crash history of the road
- Likelihood of compliance/enforcement
- amenity of the driving environment such as dust.

Speed limits based on the 85th percentile speed – not a recommended approach

The 85th percentile speed is the speed at or below which 85% of motorists travel under free flow conditions. Some existing guidelines specify that it is one of a number of factors that should be considered when setting a speed limit. However, setting the speed limit based on unconstrained speed choices is unlikely to deliver an optimum balance between costs and benefits, either for individual drivers, or the community as a whole. (For further discussion, see Appendix A.)

8. Safe Speed for Regional and Remote Areas

There are clear differences between regional and remote roads, and urban roads. First the default speed limit on regional and remote roads is 100km/h in all states and territories other than WA and the NT where it is 110 km/h. In urban areas the default speed limit is 50 km/h but can range from 25km/h to 90km/h. Irrespective of whether drivers follow the law or exceed the speed limit, higher travel speeds increase both the likelihood that a crash will occur and the severity of injuries in crashes. An analysis of speed related crashes in regional and remote Australia for the period 2003-2007 suggested that speed contributed to around 28% of fatal crashes and 20% of injury, although there was considerable variation by jurisdiction, probably as a result of reporting practices (Austroads 2014). Fatal injuries were greatest when the speed limit was 110 km/h. Factors increasing the risk of a speed related crash in regional and remote areas included the road being curved, the road being flat and not hilly, wet road conditions, and occurring mid-block. Speed-related crashes at intersections were most likely to occur at T-junctions. Speed is a major contributor to “off-path on curve” casualty crashes, which form 78% of speed-related casualty crashes (versus 20% of non-speed crashes) and 63% of fatal speed-related crashes (versus 14% of non-speed related crashes) (Austroads 2014). Males, young drivers (17-24 years old), motorcyclists, and rigid truck drivers are also over-represented in regional and remote speed-related crashes (Austroads 2014).

The effects of higher travelling speeds in regional and remote areas are exacerbated by other factors, particularly the characteristics of the driving environment. Many regional and remote roads are undivided, of poor quality, and there is a higher share of unsealed roads in regional and remote areas. Furthermore, roadsides can be more hazardous due to lack of, or narrow or unsealed shoulders, limited or no clear zones, and other features such as embankments, culverts, and trees at the side of the road. Road geometry may also be more challenging due to poor curve alignment and changing gradient. For these reasons, many roads in regional and remote areas would be better suited to a lower speed limit. In addition to the nature of regional and remote roads, there is also a greater likelihood of encountering livestock and wildlife, and heavy vehicles, including mining vehicles, agricultural vehicles, and road trains (National Rural Health Alliance 2015). Undivided regional and remote roads are known to have higher fatal crash rates than other road types (Austroads 2020).

Vehicles can also moderate the relationship between travel speed and crash outcome. Compared to vehicles in metropolitan areas, vehicles in rural and remote areas are generally older, less well maintained, and have fewer safety features such as electronic stability control. As such, vehicles in regional and remote areas are less crashworthy and less able to ameliorate the consequences of high-speed crashes.

Enforcement plays an important part in speed management in general but faces a number of challenges in regional and remote areas, including low traffic volumes and limited resources. Police in regional and remote areas are also responsible for general duties and may have limited time to dedicate to traffic enforcement. Also, due to geography, large road networks with low traffic volume, and personnel limitations, police presence may not be economically justifiable. Other factors that impact on enforcement include size of regional and remote communities, which means that information about the location of speed enforcement spreads quickly via word-of-mouth, and some police officers may be reluctant to enforce unpopular road rules for fear of being ostracised from the community in which they live. Nevertheless, lower speed limits on regional and remote road will not get compliance unless there is significantly increased enforcement.

8.1 Speed Limits

As described in Section 4, the association between higher vehicle speed, increased crash rates and injury severity is well established (Aarts et al. 2009; Nilsson 2004). Nilsson (2004) modelled the relationship between speed and crash risk and showed that a 5% increase in mean speed leads to around a 10% increase in all injury crashes and a 20% increase in fatal crashes. Kloeden, Ponte and McLean (2001) showed that there is a greater than exponential increase in the risk of a casualty crash for vehicles travelling above the mean traffic speed on regional and remote roads in South Australia with a speed limit of 80km/h or more.

Within the Safe System approach, it is acknowledged that humans will continue to make mistakes and that road infrastructure and vehicles should be designed to minimise the effect of a crash. Similarly, speeds should be set such that they minimise the effect of a crash, given the prevailing road infrastructure. Research studying the biomechanical tolerance of humans in crashes suggests speed limits should ideally be set within these tolerance limits. For poor quality undivided roads, the target speed limit should be around 70 km/h, as currently used in Sweden (Austroads 2005). A more recent model proposes an alternate relationship between speed and fatality or serious injury (Jurewicz et al. 2015b). Based on this model critical impact speeds were estimated at which 10% of people aged 15-55 years may be seriously injured. This model indicated ideal speed limits should be even lower than those proposed by Austroads (2005).

The most obvious method of managing speed is by setting appropriate speed limits. However, when speed limits were initially introduced there was little knowledge of the relationship between speed, crash risk, vehicle safety and vulnerable road users (Austroads 2018). Over time the population has become accustomed to driving at high speeds and undoing this practice requires long term, ongoing strategies.

In many cases, the current road infrastructure does not support the speed limit on regional and remote roads in Australia. A speed of 70 km/h or less is currently recommended on the basis of Safe System principles to improve the chance of survival in the case of a head-on crash. Given that many such roads currently have a 100 km/h speed limit, a reduction to 70 km/h is unlikely to gain solid community support and thus smaller reductions in speed may need to be used to bring about incremental improvements. This may be done in conjunction with infrastructure upgrades as discussed in the Safe Roads section.

The choice between lowering the speed limit or improving infrastructure is strongly influenced by budget. Victorian data suggest that infrastructure solutions are cost-effective on roads with high traffic volumes (>4000 vehicles per day) whereas speed limit solutions may be more cost-effective on low traffic volume roads (<2000 vehicles per day) (Australian Transport Council 2011).

Trials of lower speed limits in regional and remote areas have generally demonstrated reductions in casualty crashes. For example, speed reductions on roads in South Australia and New South Wales from 110 km/h to 100 km/h were associated with reductions in casualty crashes of just over 25% (Mackenzie, Kloeden & Hutchinson 2015; Bhatnagar et al. 2010). Similar results have been found internationally where increasing speed limits has been shown to increase the number of crashes (De Pauw et al. 2014; Jaarsma et al. 2011; Farmer, Retting & Lund 1999; Souleyrette & Cook 2010). In 2014, Tasmania implemented a reduction in the default limit on unsealed roads from 100 to 80 km/h. The effects of this change have not yet been evaluated.

8.2 Engineering Treatments

In addition to speed limits, alternative speed countermeasures include engineering treatments and enforcement related options. Engineering based countermeasures aim to alert the driver to potential hazards so that they reduce their speed sufficiently before encountering the hazard. Potential hazards include curves, intersections, approaches to towns, railway level crossings and work sites (Austroads 2014).

Countermeasures that may alert drivers to these hazards include:

- advance warning signs
- chevron alignment markers
- speed advisory signs/speed limits/variable speed limits
- vehicle activated signs, including speed limit signs
- transverse rumble strips
- perceptual countermeasures
- slow markings
- lane narrowing

- adequate sight and stopping distance (for railway level crossings)
- Specifically for worksites:
- workers holding slow-down and stop signs
- use of cones or barrier devices to reduce lane width.

Countermeasures for risky curves have been associated with a reduction in crashes of up to 40% and for hazardous intersections a reduction in crashes of up to 70% (Austroads 2014).

When entering a town, advance warning signs advising that the speed limit is about to change, buffer zones where there is a staged reduction in the speed limit and count-down signs to the new speed limit have been shown to be minimally effective in reducing speeds and crashes (Austroads 2014; Turner 2009). Rural thresholds are designed to provide a gateway between high and low speed environments using a combination of signs and road markings and have been trialled in New Zealand. They are most effective when they include road narrowing and have been shown to reduce fatal and serious injury crashes by up to 40% (Charlton & Baas 2006).

8.3 Enforcing Safe Speeds

Enforcing vehicle speeds to the posted limit contributes to uniform travel speeds and reduces the risk of a serious injury collision across the network. Excess speeding by drivers in regional and remote areas entails considerable risks, largely because of the typically higher speed limits in these areas to begin with, and the significant risk of injury associated with higher speed collisions in these locations. Unsurprisingly, speeding has been identified as a significant contributor to fatal crashes in rural Australia (Siskind et al. 2011). However, enforcing safe speeds in non-urban areas can be problematic. Certain policing and enforcement strategies that are successful in major cities are often unsuccessful or considered unsuitable for use in regional and remote areas. For instance, the effectiveness of speed cameras and random breath testing (e.g., through booze buses) is reportedly diminished outside major cities, which can be due to their high visibility and/or the influence of drivers alerting others of operation locations via word-of-mouth (Rural and Regional Affairs and Transport References Committee 2016). Therefore, there is a need for unique deterrent measures in regional and remote areas, given the enforcement and speed monitoring challenges.

A recommended countermeasure to target speeding is that of average speed enforcement through point-to-point speed cameras in regional and remote areas. Average speed enforcement has a positive influence on vehicle speeds and has been shown to reduce the mean and 85th percentile speeds by up to a third (Soole, Watson & Fleiter 2013). Mobile speed cameras are another example of automated speed enforcement that can be adapted to the regional and remote environment. The benefits of mobile speed camera operations have most recently been demonstrated by Newstead et al. (2014) in a review of Western Australia's program. In regional WA, there was an estimated reduction of 18% and 13% in fatal crashes within 500 and 1000 metres of the camera site for every 100 speed camera sessions undertaken per month. Fixed speed cameras and combined speed and red light cameras have also been shown to be effective in reducing casualty and property damage crashes, though they are most frequently used in urban and urbanised regional settings. Speed enforcement programs should ideally be conducted in tandem with education and publicity campaigns in rural areas where speeding is common and seen as socially acceptable (Austroads 2014).

8.4 Vehicle Countermeasures - ISA

Advanced driver assist systems (ADAS) are vehicle technologies that assist drivers with the driving task. Of these discussed in the *Guide to Road Safety Part 5: Safe Vehicles* (Austroads 2021d), intelligent speed assist, or ISA, is most likely to have the greatest effect on vehicle speed. This technology and speed related telematics are also likely to be employed in workplace vehicles to manage drivers' speeds.

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Appendix A Meaning of the 85th Percentile Speed

One of the oldest criteria for setting speed limits is the 85th percentile speed (the speed at or below which 85% of motorists travel under free flow conditions – when their speed choice is not constrained by vehicles in front of them).

The view that limits should be set at or close to the 85th percentile speed dates back to the early 1940s in the USA (Transportation Research Board 1998). Three main arguments were put forward at the time, and have been repeated over the years (Transportation Research Board 1998):

- **The collective wisdom argument:** that 85th percentile speeds provide an objective basis for determining 'maximum safe speeds'.
  - The theory was that most drivers are capable of making good judgements about 'safe' driving speeds and will in fact choose to drive at 'safe' speeds.
  - From this perspective, the only function of speed management is to limit the speeds of the small minority of drivers who are incompetent or irresponsible.
- **The speed dispersion argument:** that speed limits near the 85th percentile will minimise the variance of the speed distribution – thus minimising opportunities for vehicle conflict and therefore also minimising the number of crashes.
  - An important element of this argument is the proposition that setting speed limits lower than the 85th percentile will lead to greater speed dispersion, and that this will offset any benefits of lower speeds and may actually increase crash rates.
- **The enforcement practicality argument:** that 85th percentile limits have 'appeal' from an enforcement perspective and represent a reasonable and realistic benchmark for enforcement.
  - A modern variant of this argument is that enforcing speed limits below the 85th percentile 'requires a level of enforcement intensity and expense that has proven difficult to sustain [in the USA]' (Transportation Research Board 1998).

The political appeal of 85th percentile speed limits is clear: this criterion produces limits that are, by design, acceptable to the great majority of drivers. If the limits are enforced with a fairly broad tolerance, and not very intensively, not many drivers will be penalised, or even inconvenienced. The behavioural impact will be minimal, but authorities will be able to claim that compliance is generally good.

However, the traditional arguments for 85th percentile speed limits assert that such limits are not merely expedient: they actually produce the best attainable safety outcomes. The first argument predicts that speed limits below the 85th percentile will not improve safety (since only drivers who are already 'safe' will be affected, and reducing their speeds will not make them safer). The second argument predicts that lower limits may actually increase crashes and casualties. The third predicts that attempts to reduce speeds by lowering limits will fail because enforcement is too difficult.

When the 85th percentile criterion was first adopted, there was relatively little direct scientific evidence about the consequences of different travel speeds, or even the extent to which changing limits would affect travel speeds.

There is now ample evidence that setting and enforcing lower speed limits is feasible, sustainable, and produces safety benefits (see reviews and research cited in Sections 2, 3 and 4 of this report).

In Australia this was recognised in the early 1980s and the use of the 85th percentile speed has been largely discontinued by many road authorities as a key factor in speed limit setting.

It is true that benefits from speed limit reductions may be very limited if enforcement and public education efforts are minimal. It is also true that actual speed reductions have typically been less than the nominal reduction in speed limit. However, substantial benefits have been observed even when enforcement was not very rigorous and initial speed compliance was poor (by contemporary Australian standards).

For example, the National Maximum Speed Limit of 55 mph (89 km/h) that was introduced in the United States in 1973 as a fuel-saving measure was well below previous 85th percentile speeds on most rural roads. It was actually below prevailing median speeds on rural interstate and rural primary roads, and well below typical design speeds of the rural Interstate system. After the limit was imposed, a majority of drivers exceeded it. But mean speeds, 85th percentile speeds and speed variance were reduced on all three major rural road classes (interstate highways, rural primaries and rural secondaries). There was a substantial reduction in the number of deaths, and the death rate per distance travelled (Transportation Research Board 1998; Evans 2004).

Apart from the direct evidence that safety can be improved by setting limits below 85th percentile speeds, there have been other critiques of the arguments for 85th percentile speeds.

A.1 Driver Selection of Safe (or Optimum) Speeds

Speeds selected by the majority of drivers are not safe in any absolute sense. At current 50th or 70th percentile free speeds on most roads, the risk of a serious crash is small, but not zero. Lower speeds would reduce that risk.

There are even grounds to doubt that most drivers will select speeds that represent a good balance between the advantages and disadvantages of different speeds.

Drivers may not consider all the relevant costs and benefits when they make their speed choices.

The main benefits of higher speeds (reduced actual or perceived travel times, competition, enjoyment) accrue to the driver; some potential negative consequences are borne by others (environmental impacts, loss of amenity, injuries to others, crash costs covered by insurance).

Drivers' subjective assessments of risk, and the relationship between speed and risk, are likely to be inaccurate

Personal experience is a poor guide to understanding the links between travel speed and risk for the following reasons:

- Although serious crashes happen every day, they are rare in the experience of individual drivers.
- The personal experience of most drivers convinces them that the speeds at which they usually drive are 'safe'.[2]
- Many people find the objective data on speed risks surprising and counter-intuitive.[3]

For these reasons, limits based on drivers' unconstrained speed choices are unlikely to deliver an optimum balance between costs and benefits for the community as a whole, or even individual drivers.

[2] The effect of travel speed on risk shows up clearly in aggregate data based on very large numbers of drivers, but when individual drivers take decisions that increase their risk, most will not experience a crash. If they do crash, they are unlikely to carry out detailed calculations to work out how the outcome might have changed if their speed had been slightly lower.

It follows that when the authorities responsible for the regulation of road traffic engage in speed management, that is, in policies and measures to influence drivers' choice of speed, they are usually seeking to reduce speeds. Speed regulation can also be seen as persuading vehicle users to forego some of the perceived advantages to them of higher speeds, in order to reduce some of the less well-perceived disadvantages to themselves and many disadvantages to others (VTT Communities and Infrastructure 1999).

A.2 Speed Dispersion

Research conducted in the 1960s (Transportation Research Board 1998) appeared to show that vehicles travelling at speeds that were close to average had the lowest crash risk, while both slower vehicles and faster vehicles were more at risk of crashing. This was interpreted as providing support for the speed dispersion argument, but there are a number of caveats to this interpretation:

There were a number of methodological flaws in these studies which may have inflated risk estimates for lower speed vehicles (see Kloeden et al. 1997; Kloeden, Ponte & McLean 2001; Transportation Research Board 1998).

The crashes studied were mainly low severity property damage crashes. Hence the risk curves would not have reflected the effects of speed on crash severity and injury/fatality risk. Moreover, Evans (2004) has noted that the types of crash that might be affected by speed dispersion (such as rear end and side-swipe crashes) form a very small proportion of high-severity crashes; the bulk of fatal crashes are events where speed dispersion is a most unlikely factor: single vehicle crashes, non-overtaking head-on crashes and intersection crashes on rural roads; side impacts, frontal crashes and pedestrian crashes on urban roads.

More recent, better designed case control studies based on casualty crashes (Koeden et al. 1997, 2001, 2002) did not find an inverted-U risk function: the results show a rapid monotonic increase in risk as speed increases.

Many correlational studies have found a relationship between aggregate measures of speed dispersion and aggregate crash rates, but when the study design controls for other variables the relationship can vanish (Taylor, Baruya & Kennedy 2002).

The question of whether speed dispersion is a significant causal factor in serious crashes remains controversial. Even if it is a factor, the available evidence does not indicate that raising speed limits in the hope of reducing speed variance will improve safety. As Evans (2004) and Baruya (1997) have noted, the more logical solution, with much stronger research backing, is to reduce limits and use enforcement backed by public education to reduce the speeds of the fastest vehicles. This will reduce speed variance, mean speeds, and crash risk.

Austroads' **Guide to Road Safety Part 3: Safe Speed** provides an overview of speed limits and their application as a speed management tool. The use of appropriate speed limits forms an integral part of a safe road system. They are a speed management tool used to improve road safety, while maintaining the efficiency of the road network.

Guide to Road Safety Part 3

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