Reducing Speeds – Accelerating Change

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Abstract

Increasingly, Australian jurisdictions are incorporating "Safe System" principles into the development of their long-term strategic planning. A primary consideration of the "Safe System" is the critical role of speed and its influence upon the incidence and severity of crashes. International research overwhelmingly points to this influence and yet significant numbers within our communities, through the prism of the media, question its veracity, at least in terms of their own decisions regarding speed choice.

This paper examines the challenge of bridging the gap between current speed management practices and those that are consistent with the "Safe System" approach. Specifically, the complementary roles of research and development, new technologies, promotion and education and demonstration projects are explored as key influencers of change. Profitable areas for complementary research and promotion include the relationship between speed choices and environmental impact, fuel economy and travel times. Intelligent speed assist (ISA) technologies hold out great promise in improving levels of speed limit compliance while projects that demonstrate the benefits of change in real-world settings provide impetus for broadly applied policy change.

The paper concludes that, while the optimum pathway is by no means certain, there are some promising directions that can act as stepping stones to help jurisdictions close the gap between the current situation and the desired speed management practices.

Keywords

Speed, "Safe System", Safety, Speed Limits

Introduction

Increasingly, Australian jurisdictions are incorporating "Safe System" principles into the development of their long-term strategic planning. A primary consideration of the "Safe System" is the critical role of speed and its influence upon the incidence and severity of crashes. International research overwhelmingly points to this influence and yet significant numbers within our communities, through the prism of the media, question its veracity, at least in terms of their own decisions regarding speed choice.

How then is the gap to be bridged between current practice and the recommended speed management practices, including speed zone settings, as advocated by "Safe System" thinking?

After briefly reviewing the impact of speed on safety and the principles underpinning a "Safe System", the paper turns to the current context within which speed zoning is viewed and judged, and goes on to recommend a series of actions that can act as important stepping stones between the present and the vision.

Relationship between speed and safety

The road-transport system is, fundamentally, a real-world illustration of the basic laws of nature governing the movement of objects, be they vehicles or humans, relative to the physical environment. How these objects interact is, ultimately, a matter of physics varied in time and space according to human intervention, which is particularly difficult to predict or control.

Safe outcomes are largely determined by the ability of individual road users to moderate kinetic energy, which is the physical energy gained by an object (here, a vehicle) as a result of its motion. Kinetic energy is a function of both the mass of an object and, more importantly, its speed at any instant in time. Unlike mass, which is linearly related to kinetic energy, speed has a squared (i.e. 2^{nd} power) relationship with kinetic energy. This squared relationship between kinetic energy and travel speed, shown in Figure 1, helps to explain why speed plays such a crucial role in safety, especially when unexpected events arise during any given journey.

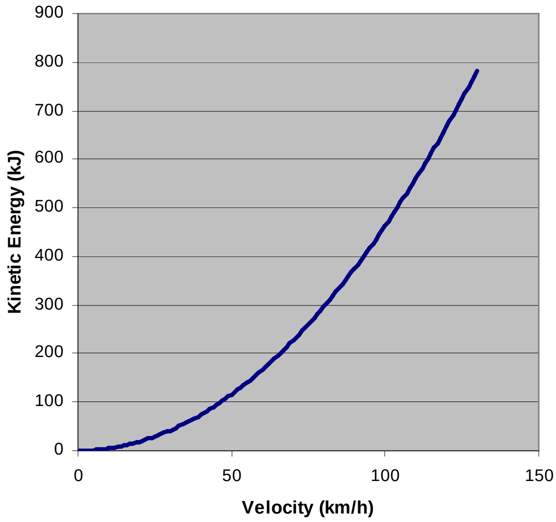


Figure 1: Kinetic Energy as a Function of Travel Speed for a 1200 kg vehicle

A safe road-transport system depends on the successful separation of sources of kinetic energy (crash avoidance) and, where this cannot be achieved, the controlled dissipation of kinetic energy to avoid exceeding human biomechanical limits (injury prevention or mitigation). Given the inherent limitations of human performance within the road-transport system, the "Safe System" seeks to create roads and roadsides that are tolerant of human error and reasonable levels of impairment. This is achieved by ensuring that sources of kinetic energy remain separated or, in worst cases, can be managed within the limits of human tolerance to serious injury.

Many studies of the role of speed illustrate the opportunities for reduced road trauma through improved management of travel speeds. Higher travel speeds increase crash risk for individuals

(Kloeden, McLean, Moore & Ponte (1997) and Kloeden, McLean and Glonek (2002)), at least in part because of the disproportionate increase in stopping distances required at higher speeds to avoid a collision. In general, higher travel speeds also lead to higher impact speeds in the event of a crash and, therefore, higher injury risk to the individual. The overall effects at a road-transport system level are reflected in the work of Nilsson (1984), who found that the probability of injury and the severity of injuries that occur in a crash increase, not linearly, but exponentially with mean speeds in the system - by a factor of about four for fatalities, three for serious injuries and two for casualties. The conclusions of Nilsson (1984) were later affirmed by Elvik, Christensen and Amundsen (2004). Thus even small increases in travel or impact speed may result in a great increase in the forces experienced by vehicle occupants and other road users.

In their investigation of tow-away crashes over a seven-year period, Bowie and Walz (1994) found that the risk of a moderate or more serious injury was less than five percent when impact speed was less than 16 km/h and increased to more than 50 percent when impact speed exceeded 48 km/h. Other research shows that, for car occupants in crashes with an impact speed of 80 km/h, the likelihood of death is about 20 times that at an impact speed of 30 km/h (European Transport Safety Council, 1995).

The relationship between vehicle speed and crash severity is critical for pedestrians. The risk of injury or death can occur at relatively slow impact speeds. At vehicle impact speeds of under 30 km/h the probability of pedestrian death is approximately 5 to 10 percent. However, the probability of death at impact speeds greater than 40 km/h increases rapidly with almost certain death at impact speeds over 55-60 km/h (Ashton & Mackay, 1979; Anderson, McLean, Farmer, Lee & Brooks, 1997).

Clearly, driver and rider speed choice and speed management have roles of fundamental importance in assuring road-transport system safety and, ultimately, in the achievement of Australasia's "Safe System".

Managing speed in accordance with "Safe System" principles

There is a growing body of evidence which relates impact speeds to the risk of death or severe injury to crash-involved humans. This concept is well illustrated in the following series of curves (Figure 2) that defines the relationships between the risk of a fatality as a function of impact speed for three major crash types; vehicle-pedestrian, vehicle-vehicle, side-impact and vehicle-vehicle head-on (The Swedish Association of Local Authorities, 1999**)**.

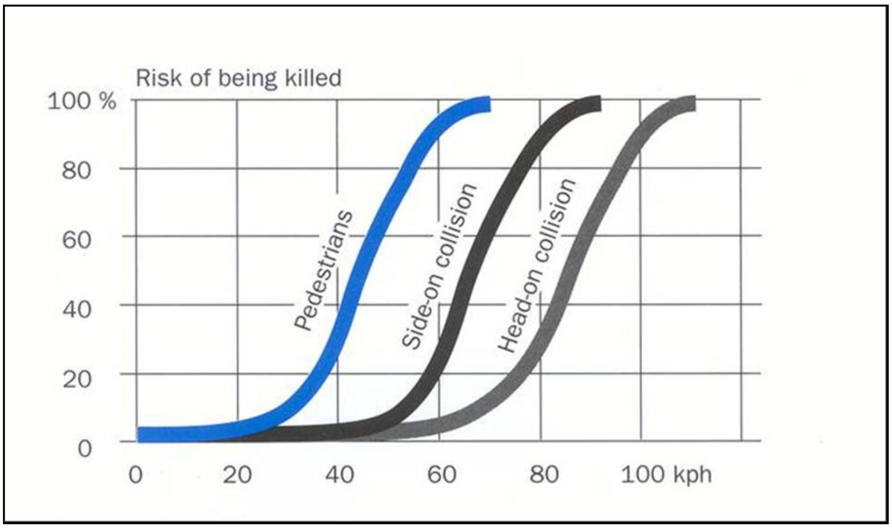


Figure 2: Relationships between the risk of a fatality as a function of impact speed for each of three major crash types; vehicle-pedestrian, vehicle-vehicle side-impact, and vehicle-vehicle head-on (The Swedish Association of Local Authorities, 1999**).**

While the precise relationships for the latter two crash types are less well defined than for pedestrians, it is generally understood that each curve is of the same basic form (i.e. similar gradient and shape) and that the major difference between crash types is the impact speed at which the risk of death begins to rise steeply.

That is, the marked change in gradient found for pedestrians at around 30-35 km/h is well-established through in-depth studies of pedestrian fatal crashes (Anderson et al., 1997). While comparable studies have not been reported for the side-impact and head-on impact crash types, expert opinion, based on real-world crash experience, reveals a consensus view that the corresponding critical impact speeds are around 50 km/h and 70 km/h for side-impacts and head-on impacts respectively (SWOV Institute for Road Safety Research, 2006). Other common crash types for which experientially-based maximum tolerable impact speeds have been defined include frontal-impact between vehicle and pole/tree (~50 km/h); side-impact between vehicle and pole/tree (~30 km/h); and impact with cyclist/motorcyclist (~30 km/h).

Given that a substantial proportion of fatal pedestrian crashes occur without braking (i.e., approximately 50%, Mclean, et al., 1994) and that a similar proportion may result for other major crash types, these maximum tolerable impact speeds for each major crash type help to explain why current speed limits can give rise to travel speeds that are well beyond “Safe System” levels. Table 1 focuses on the large gap that exists between safe impact speeds - determined to a large extent by travel speeds - and the profile of speed limits applicable for each of four major categories of severe trauma. While the serious casualty data shown are for Victoria for the period 2003-2007, they are expected to be similar in profile in other Australian jurisdictions.

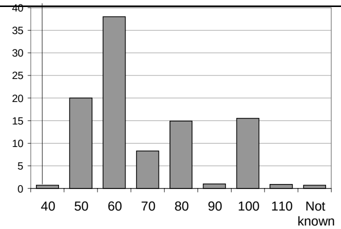
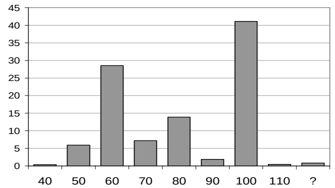
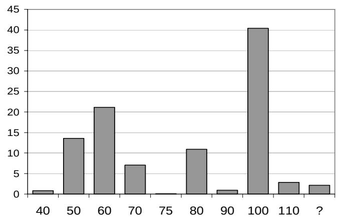
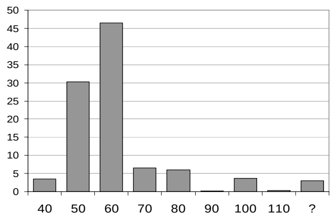
Crash Type	Estimate of Maximum Tolerable Impact Speeds (km/h)	Proportion of Serious Casualties by Speed Zone	Speed Limit Range Where Severe Trauma Most Common (km/h)	Proposed 'Towards "Safe System"' Speed Limit (km/h)	Higher Speed Limits Permissible if:
Side-impact (vehicle-vehicle) 	50		50-100	50	▪ roundabouts/other "Safe System" intersection designs provided. However, occupants of vehicles leaving driveways would still be vulnerable.
Head-on (vehicle-vehicle) 	70		60-100	70	▪ forgiving mid-barriers separate opposing directions.
Run-off-road (vehicle-pole/tree) 	30-50		50-100	50-70	▪ forgiving side barriers erected beside hazardous roadsides, or ▪ roadsides hazard-free (current clear zone standards should be reviewed against "Safe System" principles)
Vulnerable Road User (vehicle-pedestrian/cyclist) 	30		50-60	30-40	▪ effective separation provided for pedestrians and cyclists.

Table 1: Relationships between Current and "Safe System" Speed Limits for Urban and Rural Roads in Victoria

The “Safe System” acknowledges that human error (deliberate or otherwise) is inevitable within the road-transport system. To make the system more forgiving of these common human failings, it is necessary to modify infrastructure to absorb kinetic energy without resulting in severe injury, or to reduce impact speeds to be below levels tolerable to humans. To achieve this, there is a case for speed limits - a major determinant of speed choice - being revised downwards to prevent severe outcomes for the predictable crash types that characterise Australia’s road-transport system where infrastructure solutions are not practicable or cost-beneficial.

Speed zone settings – current Australian context

Development of the network of roads and streets in much of the “new world” including Australia has had the luxury of space to allocate generously to vehicular transport with wide thoroughfares and the segregation of pedestrians on footpaths beside the road. Unlike Europe where much of the transport network has developed organically within densely housed villages and towns with space limited and shared environments at times a necessity, the evolution of the transport network in urban Australia has very much placed the private motor vehicle at its centre.

Clearly, the transport network has been developed with the aim of getting people to their destinations in a convenient, timely and safe manner; safety (or lack of it) is a by-product and historically not the reason for investing in transport. From a community perspective, therefore, it is understandable then that questions are asked about the impact on the efficiency of the transport system when reductions in speed limits are raised. If we are asked to slow down, then surely we will arrive at our destinations appreciably later than planned?

While trip delays are most likely at the centre of many people’s concerns, “emotion” no doubt also plays a role for some in their choice of travel speed. – but this can hardly be used as a reason to sensibly argue for retaining current speed limit settings. It does represent a challenge, nevertheless, in building compliance with current limits and approving of new reduced limits. Even more so if emotion-based speed choices are linked to driving the modern car – the mobile equivalent of luxuriating in a comfortable chair in your lounge room that is capable of taking you from a stationary position to a multiple of the top speed limit within seconds!

But how does the community perceive the relationship between travel speed and safety? In-house consumer surveys conducted by the TAC suggest that increasingly drivers perceive 5 to 10 km/h over the speed limit as speeding. Nevertheless, the idea that small changes in travel speeds can lead to significant changes in trauma outcomes is one that appears to run counter to common sense. While the notion of increased impact speed leads to greater crash severity seems widely accepted, the relationship between small changes in travel speed and appreciable changes to the risk of being involved in a casualty crash is a concept less readily embraced!

It is understandable, then, that there are significant inertial forces at work to retain speed management regimes as they are. But incremental progress to improve safety has been achieved; steps have been taken to reduce speed limits in selective settings - outside schools during arrival and departure times, along selected heavily trafficked ribbon shopping centres and within local area precincts. Encouragingly, the gulf between the present speed management regime and the

"Safe System" scenario is beginning to narrow but the challenge to further bridge the gap remains substantial.

Before turning to those initiatives that can help us achieve safe speeds, it is instructive to first consider the process of change and what factors may be influential in achieving success.

On achieving change

Much significant change in road safety happens incrementally. Prime examples include the replacement of older, less safe cars with newer, safer ones and retro-fitting safety-based treatments to the road network. Progress for the former is tied to the average age of vehicles on our roads which hovers around 1ten years, while progress in the latter is constrained by the costs of road-based treatments and with the pace that they can be implemented. Both programs, however, play a crucial role in ultimately developing a "Safe System".

There are other models of change also – policy reforms that can change the landscape in a relatively short time, usually involving new legislation and support enforcement supplemented with public education activity. A prime early example of this model was the introduction of compulsory seatbelt wearing in Victoria in December 1970. The antecedent activities are instructive to consider as is the aftermath. Volvo first introduced the three-point seatbelt in the 1959 Volvo PV544 and then set in train a project to collect and compare injury outcomes for occupants in crashes wearing and not wearing seatbelts (Milne, 1985). The Snowy Mountains Authority (SMA) conducted the first trial in Australia of this measure within its company fleet. The results of these and similar studies were encouraging and, importantly, provided telling ammunition for those who advocated for the introduction of compulsory seatbelt wearing in Victoria. Once the new law was introduced, the protracted ground-breaking work was largely over with other Australian jurisdictions following suit in relatively quick succession. Trialling the intervention in a real-world setting helped to both demonstrate its safety value but also to reassure the community of its appropriateness – an important stepping stone that lead ultimately to introduction of the new law.

Similar stories can be told in relation to other key safety initiatives including the introduction of a bicycle helmet law and mandatory fitment of Electronic Stability Control in new passenger vehicles in Victoria. Progress in all these instances seems characterised by hard-fought incremental and localised gains, sometimes over a prolonged period, followed by a period of accelerated change that can include policy development and its introduction. It is as if a "critical mass" has been reached, a "tipping point" beyond which gains start to come rapidly.
And yet it would be simplistic to ascribe change to the conduct of demonstrations alone. Influential advocates are needed, as is community education developed from evidence-based research to allay fears and to present in a factual, persuasive manner how the community stands to gain from the change and how any potential down-sides are to be managed.

It is against this background that a number of recommendations are made that can help bridge the gap between current practice and speed management practices that reflect "Safe System" thinking.

Next steps

This paper does not advocate for ‘across the board’ reductions in speed limits. Importantly, there are many opportunities to retain existing speed limits where the quality of the road infrastructure performs to “Safe System” standards (as exemplified in Table 1, right-hand column). Increases in speed limits may even be possible where high quality infrastructure is in place or will be provided.

But there is little doubt, where infrastructure solutions are unavailable or not cost-beneficial, that reductions in speed limits to reflect “Safe System” thinking will lead to significant trauma savings. There is no definitive pathway that will inevitably lead to “Safe System” speed limit settings within a prescribed time period. There are steps, however, that we can take that will help to bring that reality closer and provide a climate that is conducive to such change occurring. Some suggested measures categorised under the broad headings of “Research and Development”, “Demonstration” and “Public Education and Persuasion” are described briefly below.

Research and Development

A key component in effecting change is to build the evidence-based foundations upon which business cases can be developed, the benefits of change made explicit and the educational content can be formed to allay community concerns, build allegiances and sway decision-makers. Research activities include:

- Continue to evaluate under Australian conditions changes in speed limits and travel speeds upon safety outcomes; consolidate the outcomes of parallel research from overseas

- Establish the influence of speed limit settings and speed choice upon travel times and vehicle operating costs , especially in built-up areas in light of the need to maintain the viability of the transport system while encouraging the adoption of safe speeds

- Establish partnerships with aligned agencies in order to assess the impact of speeds and speed limits upon the environment, modal choice and community health and well-being

- Track community knowledge and intentions that relate to speed choice, speed limit settings, travel times, vehicle operating costs and environmental impact

Demonstration

Demonstration projects can draw upon research results to show new safety approaches at work in real-world settings without the need to secure broad-based popular support and legislative change. They provide a “test bed” in which the impact of new approaches can be experienced, their benefits made apparent and their shortcomings addressed. In short, well-conducted demonstration projects founded on strong scientific evidence provide a powerful means of promoting broader application of the initiative and ultimately, the formulation of new policy.

Some examples of valuable pilot programs are now described.

- Demonstrate on a route and area-wide basis the impact of “Safe System” speed limit settings on travel speeds, the environment, tourism, retail trade and community acceptability

- Demonstrate the deployment of Intelligent Speed Assist (ISA) technology within key market segments - recidivist speeders, company fleets, road-based public transport and the broad community

- Encourage “top speed limiting” adjustments to a sample of company vehicle fleets under an Occupational Health and Safety umbrella to show a duty of care to employees by flagging the extreme risk associated with excessive speeds on our road networks

- Establish a pilot program within one or more transport companies in which the impact of reduced open-road travel speeds (for example, 10 km/h below the posted limit) upon travel time, fuel costs, maintenance and insurance costs, the environment and safety are measured with a view to developing a new business model for company operations. The impact of lower speed limits on the costs of road maintenance and rehabilitation, especially as they relate to the more severe levels of pavement damage caused by heavy vehicles, should also be explored.

Public education and persuasion

It is contended that, ultimately, success in bridging the gap between the current speed zoning policy and “Safe System” settings will hinge critically on communications. The outcomes of research programs and demonstration projects, some of which are described above, will help provide the “raw material” for crafting communications specific to the differing target markets, be they decision-makers, road safety professionals, stake-holders or the general community.

Key themes that will need emphasis as supporting evidence becomes available include:

- “Safe System” thinking and the primacy of personal health and well-being over other societal benefits

- The relationship between impact speed and the risk of death or serious injury for various crash configurations and what this means for setting safe speed limits

- The relationship between reduced speed limits, travel speeds and travel times, especially in built-up areas where evidence to date suggests increases in trip durations are either minimal or surprisingly small

- Engagement with the business sector to better define the relationship between the aggregation of small trip time savings (by maintaining rather than reducing current speed limits) accrued by many individuals in work-related travel and company productivity

- The impact of reduced speeds on the environment, neighbourhood amenity and modal choice
- The impact of reduced speeds on fuel economy and personal savings

- The outcomes of demonstration projects with particular emphasis on community reaction to the change and its impact on their lives and their willingness to accept such change.

It is important to note that it is not necessary to reduce speed limits across the network to "Safe System" levels to achieve highly valued reductions in deaths and serious injuries. With a shift *towards* "Safe System" travel speeds through progressive reductions in speed limits, there will be fewer crashes and, of those that happen, a greater proportion will happen within the biomechanical tolerances of humans. Of particular significance is the outcome that fewer crashes will occur at impact speeds *beyond* the crashworthiness limits of modern vehicles with good safety features. Significant safety gains can be delivered on the journey to "Safe System" solutions.

Conclusion

While some recent location-specific changes in speed limit settings have been very encouraging, the gap in Australia between current speed limit regimes and "Safe System" requirements remains significant. But history would suggest that effective change can occur increasingly rapidly, once the groundwork has been laid and a climate conducive to change established.

The authors contend that there are some valuable pieces of work, both current and future, that can help lay that groundwork for change. Specifically, the inter-dependent roles of research and development, real-world demonstrations and promotion and advocacy will be critical in garnering support for changes to speed limits. In particular, emphasis needs to be placed on how changes to the speed management regime not only improve community safety but contribute positively towards society's goals of tackling traffic congestion, climate change and other environmental concerns, improving population health, achieving more efficient and responsible energy use, enhancing urban character and supporting public transport.

The challenge then is to draw from current and new research evidence to promote and demonstrate in a compelling way the societal benefits that will flow from the application of "Safe System" thinking to speed management policy. In the interim, progressive reductions to selected speed limits where warranted will deliver significant trauma savings.

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