Safe System – Comparisons of this Approach in Australia

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Abstract: The concept of the safe system approach evolves from the *Vision Zero* and *Sustainable Safety* concepts that were introduced in the mid-1990s. In preparation for a truly *safe system* strategy for road safety in Australia, it is instructive to learn from the achievements and shortcomings of this type of approach. This paper examines the experience of *Safe System* approaches in Victoria, Western Australia and New South Wales thusfar. Each of these cases has interpreted the *Safe System* approach differently. The question is, do these differences in approach affect safety outcomes? In addition, do these cases provide evidence of the effectiveness of the *Safe System* approach? While *Safe System* principles have underpinned some road safety projects in Western Australia, Victoria and New South Wales it is difficult to definitively attribute overall road safety gains in these jurisdictions to the adoption of this principle. The primary levers of the *Safe System* approach are forgiving roads/roadsides, crashworthy vehicles and speed management to levels needed for sustaining human health. These aspects bring significant engineering and political challenges.

Keywords: Safe system, road safety, policy, outcomes

Background:

The *Safe System* approach to road safety was adopted in principle by Australian Road and Transport Ministers through the Australian Transport Council in 2004 [1]. This policy principle now underpins Australian road safety strategies in all jurisdictions in the country [2].

The *Safe System* thinking evolved from the visions that emerged in Sweden and The Netherlands in the mid-1990s and then later from Australia at the turn of the century in 1999 to 2002 [3, 4]. However, the application of this thinking relies on road authorities and others interpreting the principles and planning actions that are consistent with this thinking.

It is said that this approach represents a "paradigm shift" [5,6,7] in road safety approaches. The shift is from treating road injury factors as notionally equal with the underlying assumption that there will always be injury risks inherent in road travel, to conceptualising and pursuing the development and management of a road traffic transport system that is inherently safe for human users. The *Safe System* approach calls for road, vehicle, cyclists, pedestrians and management design parameters that acknowledge human fallibility and vulnerability, and places a biomechanical injury tolerance criterion and consideration of human fallibility, as the central governing principle underpinning any road safety policy decisions.

Under the former epidemiological (Haddon) approach [8] to road safety, discrete injury factors were systematically identified and countermeasures to these factors were implemented, often guided by benefit-cost analysis. For example, in the case of roads and single vehicle crashes through and beyond clear zones, it is still accepted by Australian road design engineers that around 15-20% of people will not recover from

an incident or crash with ensuing associated fatalities and injuries [9,10]. This is based on a US AASHTO 2006 Road Design Guidelines [11] where the US is one of the poorer performing developed countries in terms of road safety outcomes [7]. Moreover, this approach masked or smeared over detailed 'in-depth' analysis that highlighted design flaws, biomechanical human injury hazards and behavioural errors. While this epidemiological approach significantly helped mitigate fatalities and injuries in a broader road safety context, reducing fatality and injury numbers had become more difficult in recent years and thus required this paradigm shift. It was important to recognise that humans do make errors, to assess the consequences of those errors, and proposed countermeasures that reduced crash severity to survivable limits and/or eliminated or compensated for the human error [4,5,6,12,13,14].

A key principle of the *Safe System* approach is a shift of responsibility from an emphasis on road users being responsible for their behaviour on the road, to a greater responsibility for road system designers and managers to build safe guards into the system to prevent injury-causing crashes.

The bottom line in this new paradigm for road safety is the extent to which road injury and fatalities are reduced, or eliminated rather than trading off lives and injuries for the benefit of mobility and cost efficiency. An exploration of the achievements of the early efforts to adopt a *Safe System* approach can inform further evolution of this new paradigm. The States of New South Wales, Victoria and Western Australia were chosen for examination because information about the experience in these States was more readily available than for other States.

Methods:
An examination of the literature relating to *Safe System* and systems theory applied to road safety was undertaken to determine what distinguishes this approach from more traditional approaches to road safety. In addition, an analysis of the practical benefits and dis-benefits of both types of approaches was carried out.

The application of the more recent *Safe System* approaches in Victoria, Western Australia and New South Wales were also examined. Each of these cases has interpreted *Safe System* differently. A comparison of these cases provided some insights into the strengths and challenges of this new paradigm as it is applied and tested in Australian jurisdictions.

Introduction of Vision Zero Concepts in Australia
In November 1998, Tingvall, then working with the Monash University Accident Research Centre (MUARC), introduced his new paradigm for injury prevention, namely Vision Zero, at the Road Safety Research, Policing and Education conference in Wellington New Zealand [3].

However, prior to Tingvall's arrival, a number of researchers were already highlighting flaws and questioning the moral ethics of the road transport system. Job et al in 1989 noted that "*many fatalities occur not because of driver error but because of driver error combined with a negligent designed road system and a politically acceptable but technically substandard vehicle. Most of us would not condone a legal system which handed out the death penalty (or permanent disability) for "crimes" such as the*

misjudging of the camber of the road or driving when slightly drowsy, so we should not accept a politically determined traffic system which metes out such penalties" [12].

Murray, Grzebieta and Rechnitzer, along with Job et al and others in Australia, had also been researching and highlighting various flaws in vehicles and the road system [13,15,16,17,18,19,20] such as poor roof strength for rollover crashworthiness, inadequate near and far side impact occupant protection, geometric T-bone crash compatibility between heavy vehicles and cars, lack of adequate truck under-run barriers decapitating car occupants, poor frontal impact compatibility between trams and buses and pedestrians, spearing w-beam roadside barriers and roadside pole and tree impacts. These researchers had also highlighted on a number of occasions the inadequacy of the Australian Design Rules (ADR) in regards to vehicle crashworthiness. This helped precipitate the formation in 1993 of the Australian New Car Assessment (ANCAP)[1] program, which in turn inspired EuroNCAP and further expansion of consumer testing in the US through the Insurance Institute of Highway Safety (IIHS) and US National Highway Traffic Safety Administration (NHTSA).

Rechnitzer and Grzebieta then took up Tingvall's lead by presenting these various flaws in the road transport system at a "Aus Top Tec" Topical Technical Symposia run by the Society of Automotive Engineers Australia, in Melbourne, in Aug 1999 [5]. They supported a paradigm shift away from the economic 'cost-benefit' model, widely used throughout the western world where deaths and injuries are an acceptable cost of mobility that commonly resulted in the flaws outlined in their paper, to a 'crashworthy system' underpinned by Tingvall's more humanistic biomechanical model where "*any foreseeable accident should not be more severe than the tolerance of the human body in order not to receive an injury that causes long term health loss*".

Grzebieta and Rechnitzer then highlighted in their part 2 sequel paper '*Crashworthy Systems – a paradigm shift in road safety design*' in 2001 [6], and how the national road toll had stagnated over the past five years, as shown in Figure 1, and indeed was rising back up again to levels eight years prior and a paradigm shift in thinking was essential to reach any further gains. They further highlighted in another paper [21] the crash energy management and system compatibility with other road users: reduce the exchange of energy between impacting vehicles; manage the exchange of energy rather than attempt to dissipate the full kinetic energy of the vehicle(s)/road users involved; make interfaces compatible (stiffness and geometric) between interacting systems, be they structures, roadside objects, vehicles or humans; provide energy absorption to reduce forces and accelerations on vehicles, vehicle occupants and unprotected road users. They further stated that '*Road and vehicle systems must now be designed to tolerate human error. The systems must negate high-risk behaviour if we are to advance towards a zero road toll. Any uncontrollable errors that do occur must be benign in terms of injury and fatalities.*'

Fildes also highlighted the stall in terms fatality reductions and also advocated for a Vision Zero and systems approach to road safety in November 2001 [22]. Significant controversy between policy makers and engineers via a number of newspaper opinion articles by Grzebieta and Rechnitzer ensued at the time in early 2002 [23,24] as a consequence of a call for redesign of a safer road system and a Vision Zero approach.

[1] http://www.aaa.asn.au/directions/directions%201-03/ANCAP%20Review.htm

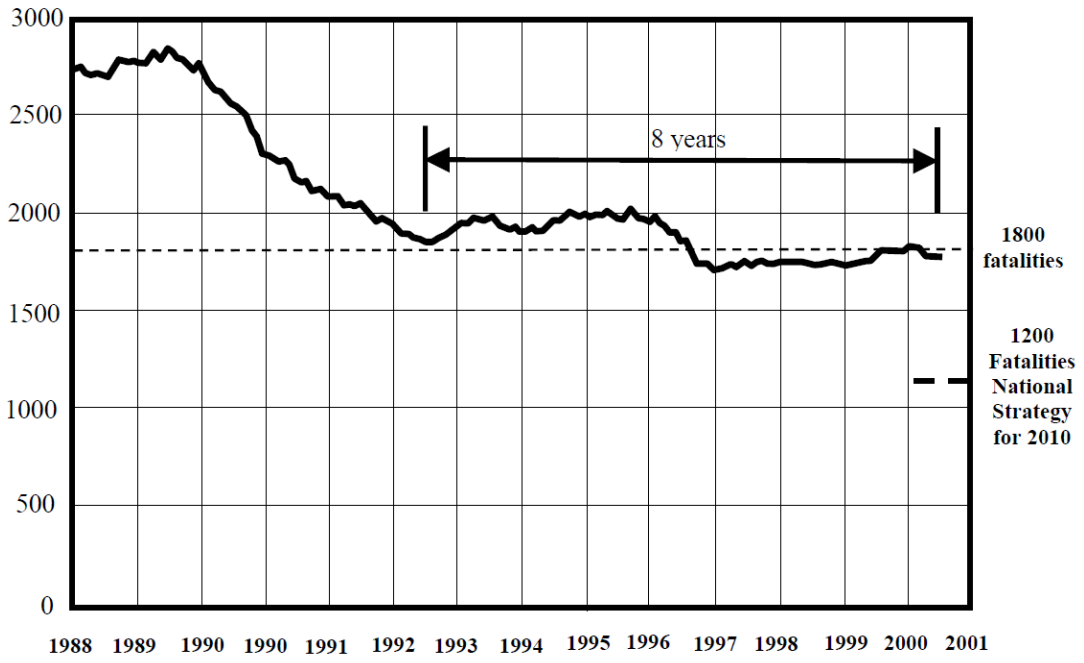

Figure 1 – Australian road deaths after Grzebieta and Rechnitzer, 2001 [6].

Design engineers were concerned about the cost and how realistic was achieving zero deaths on the roads. Australian road designers were underpinned by design guidelines that effectively permitted in the case of clear zones that around 15% to 20% of people who run-off-the-road will not recover from the incident and possibly crash and die or be seriously injured [9,10]. This was a trade off for reducing costs of road construction while maintaining mobility. In effect, this meant that the public policy position was more like *Vision 85%.* That is, the road design principles accepted that some people would necessarily die in road crashes.

Road safety debate on these principles continued, but in 2004 the Australian Transport Council adopted the principles of a *Safe System* to underpin Australian road safety. Put simply, this is a policy that does not accept that human road users will die or be seriously injured and that the design parameter of road systems would be human tolerance to crash forces resulting from dissipation of kinetic energy.

Safe System – Victoria's starting point

In September, 1999, Tingvall together with Haworth published a paper where they recommended that the State of Victoria adopt a Vision Zero approach to road safety [4], advising that the only way to radically reduce the road toll in Victoria was to drop the road travel speeds and gradually align speeds to the inherent safety of the system as a practical start. Long term maximum speed limits for differing types of road infrastructure were recommended, assuming best practice vehicle safety design and 100% restraint use is depicted in Figure 2. The Vision Zero philosophy demands that road conflict does not result in serious harm to the health of any road user. Reducing speed limits is one means of achieving reductions in serious harm if money is not available to engineer safety in the system. But given that reducing speed limits is a most contestable road safety issue for the Australian community, the full adoption of the Vision Zero approach was rejected by policy-makers.[2]

[2] Advised by Eric Howard, former General Manager, Road Safety at VicRoads.

Type of infrastructure and traffic	Possible travel speed
Locations with possible conflicts between pedestrians and cars	30
Intersections with possible side impacts between cars	50
Roads with possible frontal impacts between cars	70
Roads with no possibility of a side impact or frontal impact (only impact with infrastructure)	100+

Figure 2 – Possible long-term maximum travel speeds under Vision Zero (reproduced from Tingvall and Haworth [4])

Instead, a slightly less radical concept, the *Safe System* approach, emerged in the State of Victoria in 2004 and was later endorsed by the Australian Transport Council in their 2004-2005 Road Safety Strategy. This signalled an acceptance of the paradigm shift in road safety thinking, research and strategy. The *Safe System* approach is founded on Vision Zero principles, but requires that road users remain alert and compliant in order to ensure harm avoidance [25]. The *Safe System* model is provided in Figure 3. At the same time as this was occurring, a concerted effort was underway by other Monash University researchers (Ogden and Daly) who had moved to industry positions and were advocating star rating road systems after a return visit to Australia by Tingvall.[3] This spawned the birth of AusRAP as the sister program of EuroRAP, which safety rates road infrastructure.[4]

Under the *Safe System* approach, road and vehicle designers and managers are responsible for designing, producing and managing road travel infrastructure and equipment. Beyond this, road and transport authorities are responsible for putting in place rules and guidance to safe system use – and road users themselves are responsible for abiding by the rules and being alert to injury risks.

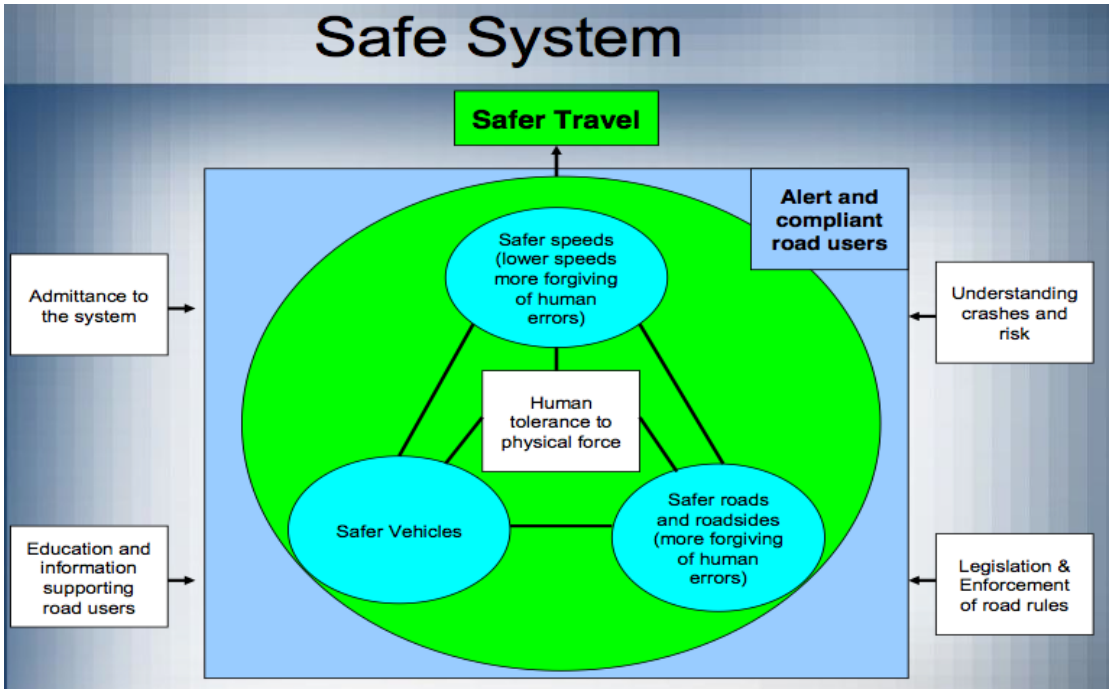

Figure 3 – The Safe System model reproduced from Howard, 2004 [25]

[3] http://www.acrs.org.au/srcfiles/December-04---Issue-5.pdf

[4] http://www.ausrap.org/ausrap/aboutus.htm

The *Safe System* philosophy recognises that people make mistakes, but it requires a proactive approach to reduce injury risks through road, vehicle, speed and behaviour management. Thus, collisions in the road environment due to human error should not exceed the human body tolerance to physical force. This new paradigm also accepted that humans make errors and that corrections need to be made to the system to reduce harm consequences of errors if the error could not be mitigated through corrective design or active or passive intervention. Between the years 2001 and 2004, the Victorian Government introduced a number of strong measures to reduce the risks of unsafe travel speeds. Other efforts at achieving road user compliance focused on initiatives to reduce alcohol and drug impaired driving.

Following the adoption of the *Safe System* principle a number of programs to enhance the safety of roads, roadsides and vehicles were also introduced with a boost in funding to address the biggest infrastructure contributions to road injury. In 2004, Victoria commenced a Safer Road Infrastructure Program, initially injecting $130 million for 113 projects designed to address the major crash type risks in the network. Another injection of $110 million for 252 projects was allocated in 2006, followed by a commitment of $650 million in 2007 for projects to be carried out over the next 10 years [26]. Victoria continued to reduce its fatalities and fatality rates until 2007 (Figure 4) and by the end of calendar year 2010 the fatality rate per 100,000 population was 5.2.

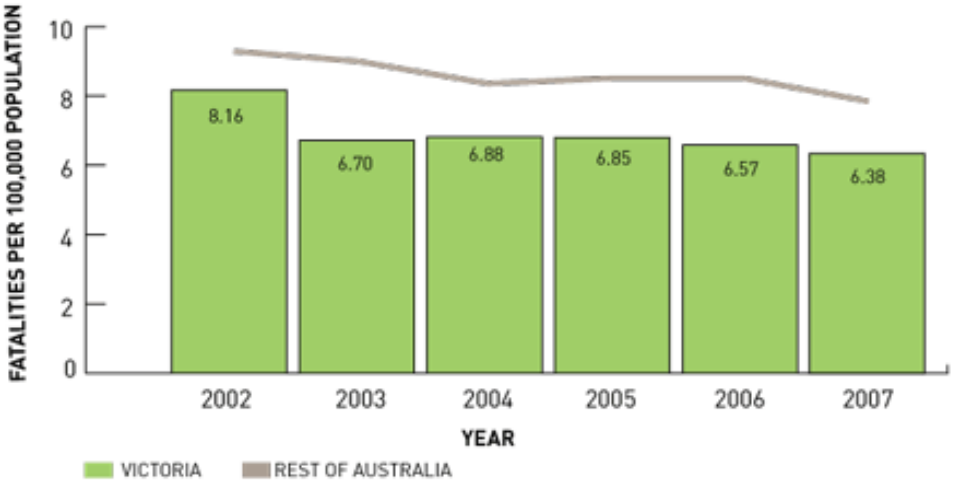

Figure 4– Victoria's fatality rate trend compared with the Australian average[5]

Victoria has made good strides in road safety, but the challenges continue. The challenges are largely not technical nor scientific challenges. They are mainly political and social challenges. The biggest challenge is to win public support for lower road travel speeds. However, the challenges include: addressing a *Safe System* for motorcyclists, aligning engineering guidelines with *Safe System* principles, raising awareness of the *Safe System* approach by key stakeholders, and considering the role of ITS, performance indicators and the use of route-based strategies [27].

Safe System – Western Australia's starting point

Another early adopter of the *Safe System* approach is Western Australia (WA). The

[5] http://www.arrivealive.vic.gov.au/about/victorias_road_safety_record/victorias_road_safety_record.html

Road Safety Strategic Plan for 2003-2007 was underpinned by the *Safe System* philosophy [28]. The aim was to create a safe road transport system that sought to prevent crashes as well as keep the amount of energy exchanged in crashes to within the limits that the human body can tolerate. Like in Victoria, the WA actions in the early years were concentrated on behaviour management, especially speed limit compliance. But unlike Victoria, there was little extra investment into improving road infrastructure safety at the same time. The expenditure on road infrastructure safety improvements was only $60.4 million in 2003 and $65.3 million in 2004. Currently in addition to safety aspects of general works, major projects and maintenance budgets there are two dedicated road safety treatment programs in WA:

1. The Safer Roads and Bridges Program (currently at $35m per annum); and
2. The Blackspot programs totalling approximately $31.5m per annum (made up of $6.485m National Blackspot program in WA, $20m state funds and $5m local government funds).

This initial blackspot injection of funding achieved a 2.8 benefit to cost ratio [29]. By comparison, Victoria invested $130 million in 2004 to target improvements based on ameliorating risks at the most prevalent injury crash type sites in this relatively small State. It was estimated that the benefit to cost ratio for this investment was 3.4 [30].

By 2005, it became clear that the road safety targets for 2007 would not be met and the WA Road Safety Council recognised that road safety is a *social issue*, that it would be necessary to *create a demand for safer travel*, and road safety responsibilities would need to be shared more actively by all agencies and road users [28].

The new focus was to be on stakeholder and community consultations. In developing the current Towards Zero Road Safety Strategy 2008-2020, an extensive consultation process was undertaken.[6]

The consultation and strategy development process produced 3 major strategic outcomes. One was the establishment of a Parliamentary Reference Group to bolster synergies between road safety stakeholders towards effective action. Secondly, the Office of Road Safety engaged Monash University's Accident Research Centre (MUARC) in collaboration with Curtin University to undertake an extensive review of road fatality and injury data (2005-2007) and advise on the priority injury crash types and locations and injury factors as well as on effective strategies. Thirdly, in an effort to encourage the broader corporate community to take action for road safety a Road Safety Partnership program was developed. This innovative initiative has been successful in attracting over $4.5 million of road safety resources and programs for an outlay of $600,000 by the Government. Initiatives of this program thus far include: privately funded road infrastructure upgrades, off-site parking for employees to travel by bus to work, voluntary night curfew for heavy vehicles, workplace road safety education, signage and line of sight improvements on key roads, and reduction of speed limits on local roads and sites [31].

[6] For more information on *Towards Zero* and the development processes go to http://www.ors.wa.gov.au/Towards-Zero.aspx

Fatal crashes in Western Australia between 2004 to 2009 rose by 5.6% but did fall by 2.6% from 190 to 185 between July, 2009 and July, 2010. Corben et al [32] explain that the failure to achieve predicted reductions in road trauma is likely to be due to delays in implementing the recommended strategies such as: less annual investment in infrastructure safety projects, delayed reductions of speed limits, delayed enhanced enforcement, and delays in vehicle safety initiatives, such as ESC, side/curtain airbags, active head restraints and intelligent speed adaptation.

Safe System – New South Wales starting point

The New South Wales (NSW) Government took a different approach to implementing a *Safe System* road safety strategy. Importantly, in 2006, the Government listed road safety as one of 10 top priorities to deliver to the NSW community and adopted the *Safe System* policy framework in 2007. In response to this, the Roads and Traffic Authority (RTA) released a document called "Mainstreaming Road Safety" and established the NSW Centre for Road Safety to guide road safety actions of those responsible within the RTA for delivery of various road authority services and to provide advice to other agencies. This mainstream approach integrated road safety responsibilities into all relevant jobs and sections of the organisation. The institutional challenge was to establish performance measures to focus each business area of the RTA on *Safe System* requisites.

The Major Infrastructure Directorate is the group in the RTA that plan and develop roads with an annual budget of $1.8 billion (2008/9). This group, in partnership with RTA's road safety experts must now carry out these tasks with *Safe System* objectives. The key road safety aims of the road development program are to:

- ensure that road safety benefits are a key consideration in the selection of projects in the RTA Road Development Program;
- support the NSW Centre for Road Safety to develop and implement a method to forecast road safety outcomes of projects and programs;
- implement a process to involve internal stakeholders at an early stage of project development and planning; and
- ensure specific road safety objectives are set for all major infrastructure projects.

By the end of 2008, a number of key management processes and systems were introduced to guide the work involved in road development. These included Road Safety Audits, Road Safety Impact Statements, Development Program Guidelines, Project OH&S Development Plans, Project Pack and Major Project Review Committees. These were all aimed at applying the *Safe System* approach to every stage of road development, incorporating team methods of involving road safety personnel in the processes involved in road development.

With respect to road maintenance and safety improvement, the NSW Centre for Road Safety has undertaken research and provided advice for "retro-fitting existing roads to optimise safety" [33]. RTA crash data for 1998-2003 indicated a consistently high level of run-off-road crashes on undivided roads with ≥90km/h speed limits on curves. Therefore the NSW Centre for Road Safety advised a range of remedial treatments including widening and sealing shoulders, profile edge-line marking, advisory curve speed warnings, curve alignment markers, removal of roadside hazards, and wire rope

fencing with priority given to curves of a 200-600 metre radius. Moreover, a range of improvements to dangerous straight roads included new types of shoulder treatments, larger clear zones, and wider and audio-tactile centre lines.

Examples of the RTA's road safety review process using a multi-disciplinary method and a *Safe System* approach are the review of the Pacific and Princes Highways [34] which were the tangible start of the *Safe System* approach in NSW. These reviews and the subsequent largely engineering works based on a *Safe System* approach to these highways resulted in dramatic reductions in annual fatalities (55 to 25 for the Pacific, and 24 to 4 for the Princes) and injuries [33]. These successes elevated the *Safe System* approach to formal adoption (as *Safe System Partnership*), and led to the commitment to further similar reviews (the Newell Highway review process is complete [35] and works are underway; reviews of the Great Western, Mid-Western, and Mitchell Highways are under way). In these reviews instead of only addressing the behavioural problem a more holistic remedial program is developed. The infrastructure change component of the program of engineering works involve mass action treatments as well as precise treatments at specific locations. Works include minor and major road junction upgrades, addressing horizontal curve deficiencies, clear zone treatments, and median wire rope barriers. The review of the Newell also resulted in an innovative wide centre-line design to better separate opposing streams of traffic yet allow overtaking where appropriate, which has trialled successfully [36].

A major plank of the Australian *Safe System* strategy is safer road travel speeds, alongside road infrastructure improvements. Therefore the NSW Centre for Road Safety undertook a review of RTA Speed Zoning Guidelines [37] to ensure that these guidelines reflected *Safe System* principles. The new NSW Speed Zoning Guidelines, Version 3 (2009)[7] reflect following features:

- *Less discretion*;
- *Clear definitions of contentious terms* - For example, defines - *regularly used driveways and private accesses, regularly used intersections, urban fringe*, etc;
- *Increased minimum lengths*;
- *Lengths of reduced alignment*;
- *Reflect risk to all road users*;
- *Enhance signage*; *Speed limit on unsealed roads*;
- *Non-use of 85th percentile speed in setting speed limits*;
- *Sensitive to Safe System approach*; and
- *The document is key to developing future speed management strategies*

Comparisons of Safe System Approaches in Victoria, Western Australia and New South Wales

Since the early 1990s NSW and Victoria, as the States with the largest sources of revenue, have led policies in practices in Australian road safety. Increasingly other Australian States have become active and sophisticated in researching, testing and implementing effective and innovative road safety actions.

[7] *NSW Speed Zoning Guidelines is a public document* for everyone to see the basis of setting speed limits in NSW, satisfying accountability, transparency and quality management requirements (http://www.rta.nsw.gov.au/roadsafety/downloads/nsw_szg_dl1.html).

Each of the three States examined have different physical and institutional characteristics that impact on road safety performance (Figure 6). Victoria and NSW have long established their road safety institutional arrangements and have been active in applying evidence based road safety actions. WA has more recently developed different structures that aim to secure a whole of government approach to road safety.

	Victoria	Western Australia	New South Wales
Characteristics of the problem	Sound infrastructure, still large incidence of run-off-road and speeding (urban and rural equally).	Poor infrastructure, occupant fatalities in high speed environments.	Biggest problem in urban-rural and rural areas, need for safer infrastructure and improve speed reductions.
Road safety management capacities	A national leader in road safety action and innovation. Well resourced, well served by research.	Is evolving its experience and is supported by experts in the Office of Road Safety and research.	A national leader in road safety action and innovation. Well resourced, well served by research.
Institutional arrangements	Three active and committed lead organisations – each with differing responsibilities. The Road Safety Branch at VicRoads has some interaction with infrastructure operatives but not as fully as in RTA, NSW.	Complex consultative arrangements without clear accountabilities for delivery. Office of Road Safety develops strategy, encourages action and provides advice.	Long established strong lead agency with good support from stakeholders, clear and strong accountabilities, now internal teams are problem-solving and innovating.
Physical characteristics	Urban, geographically small compared to its population.	Largest State with a small population, vast rural road network.	Largest population, mixture of urban and rural, split by mountain range.
Socio-political environments	Has had strong bipartisan political support, but conservative Ministers have softened on speed management, particularly lately. Road safety is generally embraced well in all 3 lead agencies.	Whole of government consulting and planning structures. Have Minister for Road Safety indicating a good commitment.	Media promotion of speed cameras as revenue raising devices has limited some enforcement activities.

Figure 6 – Summary of 3 States' characteristics

The different starting points and institutional arrangements make it difficult to compare achievements. Usually starting from a low base (low rates of fatalities and injuries) make it harder to achieve sizeable further reductions. But instead Victoria and NSW have produced better road safety results in recent times albeit using slightly different approaches because of the political environment - Victoria biased towards speed enforcement whereas NSW biased towards infrastructure retrofitting and new highways. Nevertheless both introduced a combination of *Safe System* infrastructure and speed reduction measures that have demonstrated site-specific reductions. WA has fallen short of investing the levels of funding that were estimated by MUARC to be needed for engineering improvements, and they have delayed other policy initiatives that may have helped to get closer to their reduction targets.

Discussion

Unlike Victoria, WA is a vast sparsely populated State. This brings significant and different challenges to improving road safety. It was only in 1999 that WA adopted a more "scientific approach" to road safety resulting in a sharp drop in road fatality rates (12.2 in 1998 down to 8.7 in 2001). While the WA Government adopted an ambitious goal of eliminating road fatalities, since introducing the State's Arriving Safely

Strategy 2003-2007, based on *Safe System* goals, the road fatality rate has fluctuated but overall has increased. However, the key strength evident in WA is a strong bipartisan political commitment to road safety. With this and the needed resourcing to refit the road traffic system in WA, this situation is likely to be turned around.
In terms of rates per 100,000 population road deaths between 2003 and 2008[8] reduced by 6.5% in NSW and 3% in Victoria but rose by 3% in Western Australia [38]. It is clear that NSW has out-performed the other two State jurisdictions in the period following the Australian Transport Council adoption of *Safe System* principles for road safety. It is not entirely clear why this is the case, albeit a significant portion of the improvement in NSW is attributed implementation of the road reviews and infrastructure retrofitting and remedial works. Moreover, NSW has combined enhanced speed enforcement and mass media campaigns with effectively targeted *Safe System* engineering works such as median and roadside wire rope barriers.

Each of the three jurisdictions formally embraced the *Safe System* approach, but their starting points and institutional arrangements differ. Performance is conditional by starting point characteristics of the problem, the road safety management capacities and institutional arrangements, and the physical and socio-political environments.
It is important to have the optimal conditions in place to achieve optimal results. For road safety, getting the institutional arrangements right is fundamental, forming the foundation of effective programs [39]. These foundations must include the knowledge and technologies to inform and address the actions, the management capabilities and resources to carry out the actions, and the political and management commitment to support the actions [40]. Political commitment has not been consistently sustained over the past two decades and continues to be volatile [12].

Just as Sweden has stalled in its progress towards Vision Zero, so too has Western Australia. In both cases it seems that the tangible commitment to actions required have been lacking somewhat. However, following critical reviews of the practices in these jurisdictions by global experts, efforts have been stepped up.

By contrast, NSW has taken on the challenge of re-fitting its road infrastructure achieving good results. Although Victoria has performed well, through strong enforcement and infrastructure improvements, the challenge for Victoria is to more fully address the problem of vulnerable road users – including pedestrians, cyclists and motorcyclists. However, all Australian jurisdictions have challenges with the intrinsically more dangerous form of road use – that of motorised 2-wheel road travel.

Victoria and NSW have embraced the new science of the *Safe System* approach that calls for a good understanding of the types of crashes that involve the most harmful forces resulting from dissipating kinetic energy and they are focusing attention on these in their infrastructure road safety work. Both jurisdictions are faced with limitations to the necessary speed management through public controversy over speed limits and speed enforcement.

WA has demonstrated a formal commitment to an ambitious road safety goal. The institutional arrangements are inclusive and complex, and the Government's Strategy "Towards Zero" emphasises the need to consult the community on road safety actions

[8] Note that the Government changed its road fatality reporting system after May, 2009.

and to engage with the corporate sector to more broadly share the responsibility for road safety. While the Office of Road Safety is very actively seeking to educate the community on road safety, there are times when decisive action by Government is needed regardless of whether there is obvious support. For example, both Victoria and NSW and Victoria continue to suffer community backlash to speed camera enforcement. But as speed reduction is vital to achieving reductions in road trauma, vocal anti-speed limit enforcement demands must be managed. At the same time it is important to educate the community about the actual injury risks inherent in the current road infrastructure system and about what needs to be done in short, medium and long terms to make it a "Safe System".

It seems that the WA approach incorporated even more community consultation than did Victoria and NSW prior to, during and after the introduction of their *Safe System* road safety strategies. There are some indications that WA has gained some considerable community support for their *Towards Zero* strategy, for example, they have attracted active participation and financial investment in community and organisational road safety initiatives. Hypothecation of red light and speed infringement fines to fund road safety may have also assisted in gaining community support in that State.

Limitations

It is too early for a full critical analysis of the successes and failures of the Australian *Safe System* approach strategies. These strategies generally have had only 3 years of operational measures thus far. By its nature – focus on redesigning the road infrastructure and management – this type of strategy would need 10 years of implementation before an accurate assessment can be made.

Summary and Conclusions

The *Safe System* approach and its predecessors, *Vision Zero* and *Sustainable Safety,* represent a substantial shift in how road safety problems and solutions are conceived. It requires researchers and practitioners to embrace the new scientific basis for analysis and actions. And in order to achieve safety results whilst maintaining a good level of community support, an injection of funding for refitting the road infrastructure is needed. Moreover, two of the primary levers of the *Safe System* are forgiving roads/roadsides and speed management set to levels needed for sustaining human health. These two aspects bring significant engineering and political challenges.

The *Safe System* approach recognises the inherent vulnerability and fallibility of human road users and invokes active and passive mitigation strategies that encourage system self-correction on a number of fronts. It requires that these characteristics be taken into account in the design and management of the road traffic system. A *Safe System* approach is the only way to achieve the vision of zero road fatalities and serious injuries, as this approach means that the road system is designed to expect and accommodate human error and correct for it [7]. It does not just build infrastructure and put in place road rules with the assumption that road users will use the road in the way that the designers intended.

The challenges of the *Safe System* include the following:

- the infrastructure engineering fraternity will be required to fundamentally change the focus of their work from building roads which accept that a certain

level of death and injury will always occur, to building roads which recognise human error, encourages self correction, and if human error does occur, reduces the crash forces to not only survivable levels, but also to levels where a road user can fully recover from the event;

- motor vehicle manufacturers will need to design cars with both active and passive safety. The vehicles must perceive when the driver is about to loose control of the vehicle and actively correct the vehicle either back on track or away from the crash trajectory or, if a crash is imminent, slow the vehicle down faster than the driver can while activating all restraint systems into crash mode. The passive crashworthy systems must then activate during the crash event.
- motor vehicle drivers will be, in many instances, required to drive more slowly than they might like until inherent safety of the road traffic system can be assured;
- the aims of no harm to humans may seem unrealistic to the community and many of its leaders;
- additional resourcing may be required to meet the needs of infrastructure re-engineering, especially in countries with vast road networks and small populations; and
- technological developments to vehicles and equipment need to be better informed by research into human behavioural capabilities, choices, susceptibility to errors and capacity to withstand physical force.

The ability to meet these challenges will be in part determined by the level of political and managerial commitment and leadership [40] that will be required of Governments to pursue ambitious road safety objectives.

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Disclaimer
The views expressed in this paper represent a majority view but are not necessarily those of each author. In addition, these views do not necessarily represent the views of the institutions of the authors.

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