ENGINEERS AUSTRALIA

CELEBRATING OUR CENTENARY

Road Safety

Transport Australia Society Discussion Paper

October 2019

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Purpose

This document has been produced by the Transport Australia society (TAs) of Engineers Australia as a discussion paper with an aim to improve road safety. It does not represent a formal position statement of Engineers Australia but is intended to inform discussion to reduce the massive social and economic impact of road crashes.

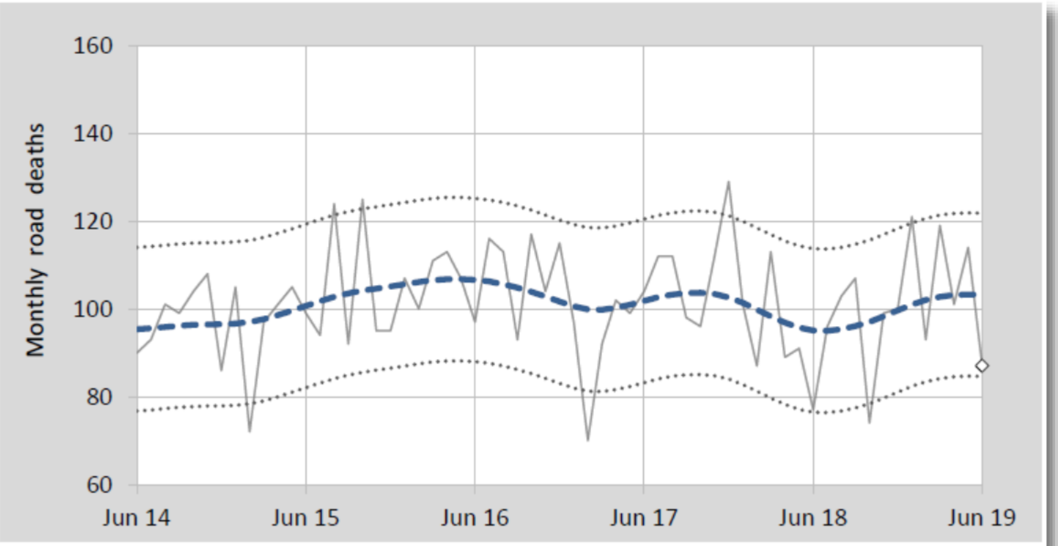
Background

From the 1970s to the 1990s Australia was a world leader in reducing road crash casualties, however progress has plateaued in recent years. This paper summarises research and discusses priorities for action to improve performance in reduction of road trauma

Since records began in 1925 road crashes on Australian roads have killed over 190,000 people. Despite doubling the population and a threefold increase in registered motor vehicles, road trauma has decreased substantially since its peak of 3,798 deaths in 1970 to 1,226 in 2017.[1]

Every day around 5 people die and 60 are seriously injured and/or maimed. Road crashes are a major health problem and casualties are at epidemic proportions demanding serious attention from all sectors of the community.

The economic cost amounts to more than $30 billion each year, which is almost twice the estimated cost of road congestion, yet road safety receives much less funding. TAs' role is to focus engineers' attention on this significant issue and to encourage the integration of engineering solutions with other complementary professions to establish and apply best practices that achieves safer communities.



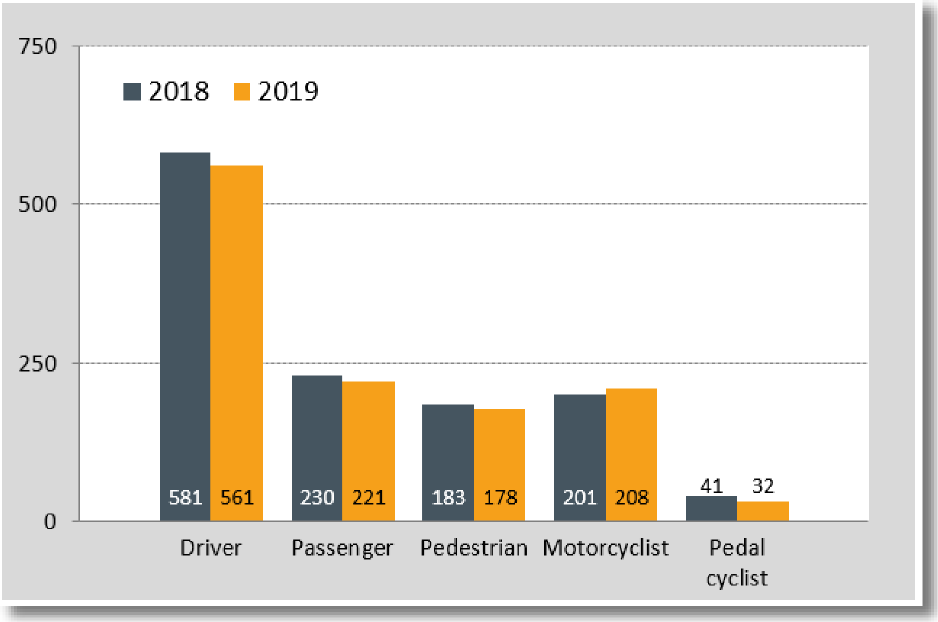
Note: Shown is a trend and a 90 per cent prediction interval for the monthly observations.

Road deaths in Australia have plateaued and begun increasing over the past five years[2]

National, State and Territory "Safe System" road safety strategies have been implemented since the mid-2000s with the objective to reduce the annual number of deaths and serious injuries by at least 30 per cent by 2020. Based on current trends, it is unlikely this target will be achieved. While these strategies are soundly based on the Safe System approach, implementation effort has been mixed. The economic, social and transport context of road safety continues to change. Furthermore, the reductions in road trauma achieved have now plateaued, with further improvement becoming increasingly difficult.

[1] Office of Road Safety, https://www.infrastructure.gov.au/roads/safety/, July 2019.

[2] Bureau of Infrastructure, Transport and Regional Economics (BITRE) (2019). *Road Deaths Australia, June 2019*, Department of Infrastructure, Regional Development and Cities, Canberra.



Road fatalities are distributed across different user groups[3]

[3] Bureau of Infrastructure, Transport and Regional Economics (BITRE), June 2019, https://www.bitre.gov.au/statistics/safety/

Australia's Road Safety Philosophy

Historically, road engineering has assumed no driver error, provided ample response time is provided. Sight distance is used in road design and depends upon the design speed of the road which determines the response time. The design speed informs appropriate speed limits. Sight distance does not extend far beyond traditional conflict road approaches to an intersection which means road user compliance with traffic signals and right of way rules are crucial and assumed in road engineering design. This traditional road engineering approach to safety was known as EEE, an acronym for three principles: Engineer the road, Educate the drivers and then Enforce the road rules.

In 1997, a new road safety philosophy evolved. *Vision Zero* originated in Sweden and due to its success was adopted across various nations worldwide, and evolving to the *Safe Systems* framework used in Australia today. The framework works for the premise that road crash casualties are ethically unacceptable in society. Responsibility for road safety shifted from the driver to shared responsibility between drivers and road system designers.

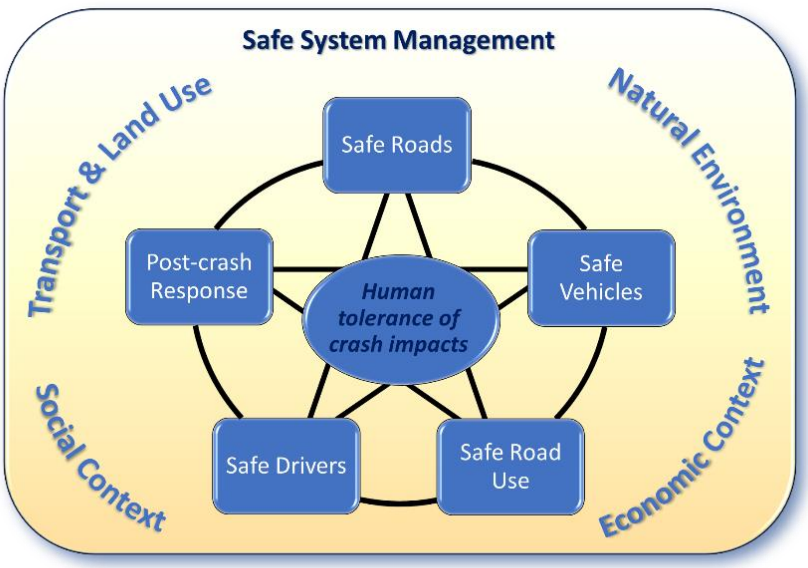
The concept of human tolerances for serious crashes, or safe collision speeds, were introduced as follows:

- 30km/h vulnerable road users (e.g. pedestrians, cyclists)
- 50km/h side impact vehicle – vehicle crashes
- 70km/h lane departure crashes
- Eliminate the above and speeds > 100km/h could be safe.

These tolerances are complied with regardless of user behaviour in efforts to avoid serious injury or death in the event of a crash. Road design compliance with human tolerance led to improved road safety and statistics and saw Sweden become the world leader in this field.

The Safe Systems approach embedded road safety principles in all elements of the road system to enable the human tolerances and an acceptable level of risk. That is:

- Safe roads (road design and operation);
- Safe vehicles (vehicle in-crash safety and crash prevention technologies);
- Safe people (driver education and enforcement), and;
- Best practice post-crash care.



Integrated Road Safety System Management

This approach has been applied in Sweden since 1997, and was subsequently adopted by the Netherlands and the United Kingdom. By 2012 those three nations had achieved the lowest casualty crash rates in the OECD, which were 40% to 50% below Australian rates.

Australia was one of the first countries to formally adopt Safe Systems in the national road safety strategy of 2001–2010 with various states following suit in their own road safety strategies too.

Australia's preeminent road design standards, Austroads' Guides to Road Design (the Guide), states:

> *Adopting a Safe System approach to road safety recognises that humans, as road users are fallible and will continue to make mistakes, and that the road design and operation of the road system should not penalise people with death or serious injury when they do make mistakes.*[4]

However, the Guide also advises in a section titled *Fundamental Considerations*:

> *The design of roads should be based on the capabilities and behaviour of all road users, including pedestrians, cyclists, motorcyclists…*[5]

As the capabilities and behaviour of any person can vary widely, a minimum threshold level of capability and behaviour must be decided in order to embed to the Safe System principle in Austroads' fundamental design considerations.

When detailing Austroads' highest road design priority, *Speed* Parameters, the Guide advises:

> *The speed to be adopted, which typically provides some margin over the proposed posted speed limit, directly influences the principal parameters used in road design which include:*
>
> - *sight distance*
> - *stopping distance*
> - *horizontal curve radii*
> - *pavement superelevation*
> - *traffic lane width.*[6]

These factors still rely on driver compliance which demonstrates that Australia's detailed road design process remains traditional in practice. Essentially, in practice, Australia is still operating on the EEE principles, despite the theoretical approach.

Australian roads overwhelmingly comply with Austroads' requirements and there has been significant reduction in road trauma since the early 1970s peak. However, in the past two decades, improvements in road safety have not kept pace with the four leading countries and have fallen short of safety improvements achieved in hazardous industries, as the following chart shows.

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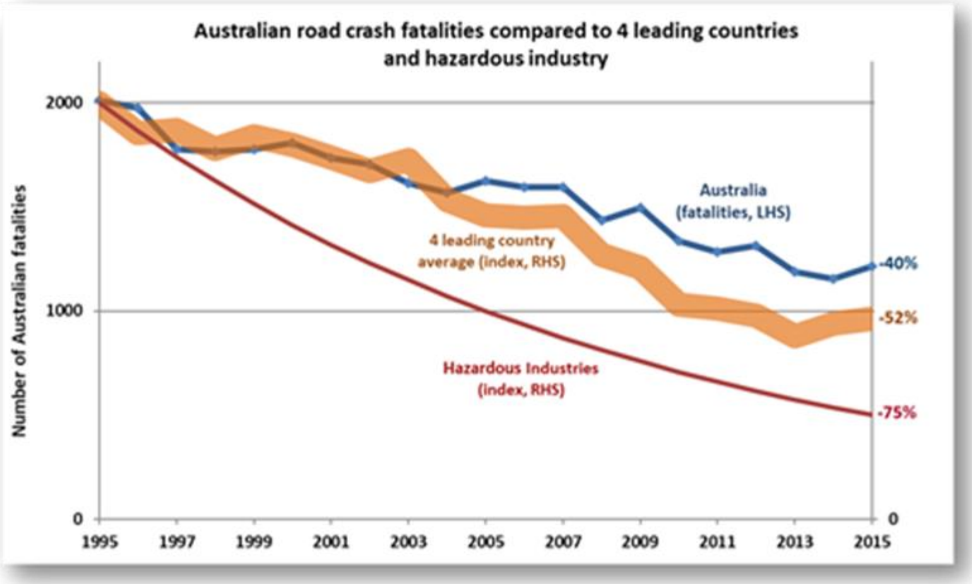
[4] Austroads Guide to Road Design Part 3 Geometric Design Section 1.5 Road Safety, Subsection 1.5.1 providing for a Safe System, Austroads, Sydney, 2016.
[5] Austroads Guide to Road Design Part 3 Geometric Design Section 2 Fundamental Considerations, Subsection 2.1 General, paragraph 1 sentence 2, Austroads, Sydney, 2016.
[6] Austroads Guide to Road Design Part 3 Geometric Design Section 3 Speed Parameters, Subsection 3.1 General, paragraph 2 sentence 3, Austroads, Sydney, 2016.



Road deaths trend in Australia and selected countries 1995 to 2015 [7]

We continue to engineer the roads to the Austroads standard, investment in driver education, and heavy enforcement regimes. However, the responsibility for road safety continues to rest primarily with road users, particularly drivers. In practice, Australia, to its detriment, has not adopted and implemented Safe System.

There are some good news stories in Australia. Due to its high propensity to apply Safe System type road design solutions, Victoria has commenced a systematic program to fit wire rope median safety barriers[8]. Victoria has made more substantial road safety gains than some other states.

Australia's road design standards and holistic road safety approach needs to be overhauled in practice in accord with Safe System. Australia's road safety management needs to be reformed.

[7] P7Safety, adapted from OECD/ITF Road Safety Annual Report 2016 and Evolution of Safety Management Systems, I. Sutton, 2013.
[8] Median wire rope barriers are cited as one of the most effective road engineering interventions in Swedish research, reducing rural highway road fatalities by over 70% to 80%.

Discussion

1.1 Australia lags

Once a world leader in road safety, Australia now lags behind the safest countries around the world. There are multiple reasons for this, not all of which are clear. On one hand Australia has universally 'adopted' the Vision Zero/Safe Systems approach which is regarded as the best approach to manage road safety.

The National Road Safety System (NRSS) Inquiry found that the current approach needs to be better managed and implemented. Some elements of the Safe Systems approach, notably road design, have not been updated to incorporate the Safe Systems philosophy. Other factors may have also contributed to this outcome. Other factors include:

- An increasingly heterogenous vehicle fleet
- Driver distraction through increased use of mobile phones
- Increased walking and cycling in urban areas
- Population growth, and;
- Increasing pressure on infrastructure.

Due to the factors described above, Australian casualty crash rates have not reduced to the levels of the leading nations up to 2016, and have since plateaued.

In addition to the fact that Australia has not achieved best practice in road safety in recent years, road crash casualty rates have ceased falling in most OECD countries since approximately 2012 despite ongoing improvements in vehicle crashworthiness. Between 2010 and 2016, the three countries that have been most successful in reducing road trauma, and have considerably lower rates than Australia are Sweden, the UK, and the Netherlands. Each have improved road safety by just 3.6% total on average[9].

These countries have already implemented initiatives that have not yet occurred in Australia such as mandatory Emergency Autonomous Braking (AEB) and truck underrun protection bars[10] and have a greater community, business and professional appreciation of road safety. There is significant opportunity for greater innovation and uptake of new technologies and implementation of best practice to be applied in all aspects of road safety. A number of initiatives not currently employed in Australia are included in the engineering solutions explored below.

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[9] ITF (2018). *Road Safety Annual Report*. International Transport Forum (ITF)/OECD.

[10] In 2009, the EU mandated both AEB and underrun protection bars for all trucks from 2013 and all passenger vehicles in 2015 (Regulation (EC) No 661/2009).

Photo Credit: D Wilkins

1.2 Engineering solutions

Australian road design guidelines need to be reformed so that they prioritise Safe Collision Speeds based on the human tolerances, at least comparable to updates in road design priorities that have occurred in the Netherlands, Sweden and UK since 2000. This will require changes to road and intersection design practice.

Major design decisions affected include:

- Permissible intersection types. For example, traffic signals are not themselves safe particularly on roads with speeds greater than 50km/h
- Provision of significantly more safety barriers on roads with foreseeable traffic speeds above 70km/h
- Increased application of variable speed technologies on motorways and expressway
- Expanded use of audible road marking
- Safety barrier protection of cycle lanes and speed lowering traffic devices ahead of and through pedestrian precincts. For example, speed humps, lateral shifts or chicane intersections and school zones.

Current guidelines permit the construction of road elements that would conflict with these principles (e.g. signalised intersections in speed environments of 70 to 80 km/hr) and limit the use of what have proven to be the most effective engineering safety treatments (e.g. wire rope barrier in the median of narrow two-lane rural roads). Roads with the most collective risk, where the overwhelming majority of the road safety problem lies, need a program of improvements which make them inherently safe.

High quality vehicles are crucial for road safety. New vehicles should have more safety features installed including warning systems (e.g. lane departure), passive safety (e.g. underrun protection bars for trucks) and active devices (e.g. Autonomous Emergency Braking). Older cars and new cheap cars continue to operate on Australian roads unnecessarily and should be discouraged.

Engineers will continue to lead the development and deployment of innovations to improve vehicle quality and for driver warnings, crash avoidance, occupant or pedestrian protection and maintenance. Little regulatory attention to vehicle safety has been applied since 2006 and the subsequent end of local vehicle manufacturing. Either the development of vehicle design safety rules needs to be reinvigorated in Australia, or consideration should be given to folding Australian vehicle design rules into a best practice foreign vehicle testing regime, such as the European Union. This might also beneficially reduce vehicle importation costs.

Information, communications and electronic engineering have the potential to improve road safety through data collection and analysis, warning systems, traffic management systems, enforcement and control systems. Often under the banner of Intelligent Transport Systems, Smart Roads or Smart Vehicles, these include active monitoring of freeways and highways, automated enforcement for speed or alcohol, information systems, automated vehicle control, active warning systems either in-vehicle or on-road and many other systems either already available or being developed for future deployment.

Engineers will play a leading role in the development of autonomous vehicles which have the potential to dramatically improve road safety. However, their performance, cost, path to market, regulatory environment, potential undesirable consequences and several other factors are fraught with difficulties and their timing for deployment remains uncertain. Therefore, they should not be seen as a panacea for other issues such as safer road design. Nevertheless, automation technologies have already contributed to improving road safety (such as ABS braking) and the further development and deployment of new systems is supported.

1.3 Safe road use

The behaviour of road users and others affecting road safety outcomes is an important factor in road safety. Safe System adopts the principle of not blaming drivers for mistakes because drivers are human and will never be completely devoid of error. However, some road safety campaigns, government statements and media reporting continue to do so in order to change behaviour, such as describing the greatest proportion of crashes caused by driver error, in simplistic isolation.

The most important behavioural factor in crashes is excessive speed. As speed increases, driver reaction time increases, peripheral vision decreases, braking distance increases, but most importantly the kinetic energy of a crash increases exponentially. The human body has limited tolerance to absorb physical energy, so crash energy needs to be reduced. Specific safe speeds should be used in road design and traffic management to ensure safety[11]. Speed limits should reflect the safety risk which takes account of the road standard, the surrounding environment (such as adjacent land use) and operating conditions (such as vehicle type and volumes).

This is a complex issue involving road designs, human perceptions, situational awareness and capability in response to the road environment, vehicle capability and other factors such as the weather or individual trip circumstances. Lowering speed limits is supported where changes to road design cannot remove hazards, and road designs that provide clues to drivers regarding safe travelling speeds (self-explaining roads), as well as skills and education that fosters driving at safe speeds.

Other user actions are also important in reducing the road toll. Distraction is an important factor, that can be worsened or improved by technology. Alcohol and other drug use, failure to wear a seatbelt, fatigue are other key behavioural issues, which also have the potential to be improved by engineering technology or behaviour change programs.

[11] World Road Association (2016). Pedestrians/cyclists <30km/h, Side crash < 50km/h, Lane departure (head on, run off road, roll over) and rear end <70km/h.

Some behaviours intersect with broader participants, such as company practice (including safe trip planning and occupational health), political decision making, the media and general community actions. In other safety domains, such as railways and aviation, this is often called *safety culture*, which broadly describes the common ways of operating in a manner fundamentally focussed on safety.

1.4 Collaborative solutions

Transport has never operated in isolation and is now more connected with business, land use, economics, society, health and the natural environment than ever before. As a primary objective of transport, road safety therefore needs to reflect and respond to its multifaceted context and all of the agencies, companies, organisations and individuals that affect road safety outcomes.

Road safety management has primarily relied on key government agencies at all levels, particularly road authorities, police, transport agencies and road safety agencies. Other key contributors include land use planners, health departments, education departments, training organisations and others. Nevertheless, the broader community, business and the media are generally not heavily involved in road safety despite their potential to contribute to greater road safety outcomes. In addition, the support of the majority of stakeholders, including the general public, are generally required for major decisions and reforms.

To achieve the most cost efficient and effective outcomes and minimise the negative effects of other actors' activities, engineers must collaborate to develop and implement complementary solutions. Implementation of vision zero and safe systems has tended to be a conversation between experts in Australia, rather than a public discussion. The latter is crucial to engaging the level of public support that will be required for widespread and effective implementation.

The best road safety management can only occur if professionals have the capability. Many people involved in key agencies start work in road safety with little or no knowledge or experience. Road design is usually carried out by separate groups of professionals to road safety analysis. Quality professional training is scarce. Training organisations at all levels need to provide for updated continuing professional development training in road safety to all individuals who are responsible for designing elements of the road system, and in complementary fields such as land use planning, public policy, transport economics, occupational safety, and health. Investment is required to train staff at all levels in organisations to ensure sufficient awareness of road safety as an occupational safety issue[12] and to complement road safety outcomes.

All participants who can contribute to improving road safety should be collaboratively engaged to do so.

1.5 Readiness for the future

In contrast to the past, the future context in which to manage safety is becoming increasingly difficult, different and unpredictable. The clarity and certainty of being able to predict the future and then plan and provide for it is becoming less reliable. New tools and techniques are required to ensure resilience in the face of various alternative futures that may occur.

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[12] It has been estimated that around 30% of road vehicle travel is in work time and is therefore occupational. If this translates to the same proportion of deaths and serious injuries, then around 350 Australians die on roads annually while at work.

Changing demographics are recognised in traditional planning, but changing behaviours, lifestyle and consumer preferences are already affecting transport demand as never before. Technological advances in communication speed, connectivity and digital platforms are facilitating seamless interactions between humans, the physical world, vehicles, infrastructure and transactions.

Changes to business models and systems, (e.g. bitcoin, blockchain, and the sharing economy) change the transport system in ways that need to be accounted for in road safety management. Data resulting from digital transport platforms may exponentially increase the amount of useful information that can be applied. However, the data provided must be appropriately collected, managed and analysed to maximise value.

Most road safety strategies fail to recognise the changes that are currently occurring. Basing road safety management on past experience and slow-moving historical trends is becoming increasingly irrelevant. New road safety information and methods are required.

1.6 Safety systems management

Following several high-profile catastrophes in the 1980s, systems approaches have been applied in hazardous industries to overcome the weaknesses of management based on a simple human-machine-environment model and blaming operators. This is similar to the way that aviation has managed safety for many decades. A system is the whole group of people, organisations and resources that together achieve a purpose. Taking a systems approach to safety management ensures that all the important interactions between the different components, context, policy tools and participants are appreciated and maximised to achieve the safest possible outcomes.

In road safety:

> *…the practical realization of the systems approach remains the most important challenge for road safety policy-makers and professionals…*and *Making a road traffic system less hazardous requires a "systems approach" – understanding the system as a whole and the interaction between its elements, and identifying where there is potential for intervention.*[13]

While Safe System/Vision Zero goes some way to adopting a system approach, it falls well short of the integrated and holistic safety management of other hazardous industries. The system approach applies integrated, multidisciplinary and multifaceted responses in response to complexity and uncertainty. A Safe System for road safety can therefore be described as *the optimal interacting combination of participants, policy tools, parts and processes to minimise road trauma.* Recent reviews of road safety strategies and practice generally indicate that they can more thoroughly apply systems safety management and be more future focussed, as occurs in other hazardous industries[14].

System approach depends on organisational leadership to develop joint responsibility for safety by collaboration. Thorough risk management tools and techniques are applied and a culture of safety is developed based on *no blame*, with enforcement being a secondary activity. Therefore, applying

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[13] Peden, M., et al., (2004, p13 and p157). *World health report on road traffic injury prevention*. Geneva, Switzerland: World Health Organization.

[14] e.g. Hughes, B.P., A. Anund and T. Falkmer (2019). *The Relevance of Australasian Road Safety Strategies in a Future Context.* Journal of the Australasian College of Road Safety, 30(1), 34-45) and presented at the ACRS Conference, Sydney, 2018.

systems approaches used to manage other safety critical industries complements and extends the EEE/DVR and Safe System/Vision Zero approaches by incorporating:

- Clear and specific statements of purpose or outcomes linked to management actions;
- Broader policy tools (incentives, disincentives and influence, including sophisticated culture and behaviour change techniques);
- All relevant parts of the system (including other transport and land use, the economic and social context and emergency response)
- Collaboration between all participants that can make a positive contribution (complementing current authorities), and
- Robust safety management and operational processes (including detailed risk analysis, design and implementation).

More thoroughly applying comprehensive and integrated responses based on systems approaches, with engineering making a major contribution, offers the best opportunity to improve road safety.

Recommendations

TAs offers the following recommendations to substantially improve Australia's road safety.

Australia's road system and design standards should be reformed to prioritise Safe Collision Speeds by design, ahead of criteria secondary to road safety such as sight distance, stopping distance, horizontal curve radii, pavement superelevation and traffic lane width, which still remain important considerations.

Proposed recommendations are detailed below.

1.7 Road safety management

All activities that contribute to reducing road trauma need to be focused through the lens of Safe Collision Speeds by design (not reliance on fallible road users) managed within appropriate systems and processes and underpinned by staff capability and other resources (such as funding, equipment and data).

- Governance of road safety needs to be strengthened, particularly at the Commonwealth level where there is insufficient significance, leadership, effort and guidance. TAs supports the Commonwealth Government's initiative to establish an Office of Road Safety which needs to take a lead in national leadership, investment, programs, initiatives and collaboration.
- Crash analysis (collision investigation and 'in-depth crash investigation') should focus on serious crashes and how the system design allowed inherently unsafe speeds to occur (independent of all road user fallibility factors).
- Road safety strategies urgently need revision, to ensure they are current, or action plans provide timely updates, and implementation of them needs to be enforced. Most Government 2020 safety targets will not be met on current trends.
- The perceptions and attitudes of the general community, business, governments, elected officials, professions and the media that road safety responsibility rests with the road user needs to be challenged and complemented with a focus on road system design, to make road safety preeminent and develop a culture of safety.
- More formal and on the job training is required to ensure that all professionals have adequate and relevant skills, knowledge and experience, so that their priority focus is on improving road system design to reliably ensure Safe Collision Speeds when something inevitably goes wrong.

1.8 Engineering solutions

Safe Collision Speeds based upon tolerance of the human body to absorb kinetic energy without incurring serious injury should fundamentally guide all road design to ensure safety to prevent serious injury and death when road crashes inevitably occur. This can be achieved through reducing the opportunity for crashes (exposure), reducing the likelihood of a crash (avoidance) and reducing crash forces.

The safety focal points within Australia's current road design standards and guidelines (such as sight distance, stopping distance, horizontal curve radii, pavement superelevation and traffic lane width) which depend upon infallible road users and permit the use of inherently unsafe designs such as traffic signals, are in urgent need of reform. Reform can be achieved, through prioritisation of road system design to more reliably and more often ensure inevitable crashes are within Safe Collision Speeds (independent of road user behaviour). More effort is required to:

- Update road design standards to match safe systems principles. This includes that roads are designed for safe speeds, are 'self-explaining' and offer no surprises. Roads should have consistent standards and an appearance that naturally causes drivers to choose speeds which are at or below the tolerances for serious crash risks relevant to the speed and collision type, is relevant to their operating environment (e.g. terrain) and conditions (e.g. high activity areas), and provide guidance and control for hazard points,
- ensure roads are more forgiving when drivers make mistakes by providing crash protection or recovery zones, full separation from side roads, separated pedestrians and cycling routes, median barriers, shoulder barriers where hazards are within the clear zone, tactile road marking, and intelligent speed and warning signs, or otherwise provide new transport corridors,
- target speed limits based on risk, in conjunction with more appropriate road design, improvements to driver skills and education that foster driving at safe speeds,
- protect or separate vulnerable road users (pedestrians, cyclists, motorcyclists and others who are disproportionately represented in road safety statistics),
- manage traffic and safety on local roads, including Local Area Traffic Management to lower vehicles speeds to 30km/h or lower, particularly through high risk areas such as pedestrian precincts, and use of roundabouts to lower vehicle speeds to within safe limits,
- maximise the value of independent road safety audits in accordance with the safe system principles,
- provide more rigorous guidelines governing departure from standards and compensatory measures to address known deficiencies and provide the greatest safety outcomes.
- Vehicle regulations should require higher quality active and passive safety features as a minimum requirement and optional safety features should be subsidised, including active technology.
- Four star crash rated cars should be the minimum for all new vehicles (unless exempted for functional purposes, such as cranes or specialist agricultural equipment).

Technology should be more commonly used to:

- detect risks (e.g. congestion, broken down vehicles, crashes and roadworks), advise traffic (via variable speed and warning signs and direct communications), and manage traffic control,
- collect and analyse data to inform safety management, and
- automate enforcement.

1.9 Transport planning and traffic assessment

Road safety should be a primary objective of road planning and transport planning generally.

Road safety should not be traded off or with other objectives such as road capacity or efficiency in design, or the value of time or vehicle operating costs in microeconomic cost benefits analysis (e.g. benefit cost ratio, net present value or return on investment) because the cost of a human life is immeasurable. Given the total cost of road trauma in Australia is larger than the total cost of road congestion, current crash valuation methodologies appear flawed.

The safest forms of transport should be used wherever possible, such as freight and passenger rail, active and other public transport and the safest trucks (e.g. high productivity vehicles and Performance-Based Standards (PBS) vehicles).

More effort should be applied to:

- In-depth crash assessment that investigates and makes recommendations on all parts of the system that can be improved, as occurs in other transport safety investigations.
- Traffic modelling and safety modelling that inform designs and safety improvements.
- Further analysis to better identify the causes for declining improvements in casualty crash rates and possible remedies.

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