Road Safety Policy & Practice

The Relevance of Australasian Road Safety Strategies in a Future Context

Brett Hughes[1,2], Torbjorn Falkmer[1] and Anna Anund[3]

[1]*School of Occupational Therapy, Curtin University, Perth, Australia*
[2]*Department of Transport, Western Australia, Perth, Australia*
[3]*Swedish Road and Transport Research Institute, VTI, Linköping, Sweden*

Corresponding Author: Brett Hughes, PO Box C102, Perth, Western Australia 6000, Email: p7safety@gmail.com, Phone Contact: +61 477 346 814.

This peer-reviewed paper was first presented as an Extended Abstract and Oral Presentation at the 2018 Australasian Road Safety Conference (ARSC2018) held in Sydney, NSW, Australia and first published in the ARSC2018 Proceedings in the form of an Extended Abstract. It was expanded into a 'Full Paper' and underwent further peer-review by three independent experts in the field. It is being reproduced here with the kind permission of the authors and is now only available in this edition of the JACRS.

Key Findings

- This paper developed and applied a rating scale to assess road safety strategies against criteria for: 1. a comprehensive framework for road safety, and 2. the anticipated changing, difficult and unpredictable nature of future transport and its context.
- The ten Australasian road safety strategies assessed were historical in nature and weak in terms of a comprehensive systems approach for safety management and readiness for future circumstances and challenges.
- The strategies could be improved by more thoroughly including concepts from systems approaches; particularly other parts (or components) and processes, broader policy tools, a greater diversity of participants and clearer relationships within the road safety system.
- The strategies could be improved by preparing for future changes impacting on road safety including technology, emerging markets and business models, and changing consumer preferences.
- The strategies could also be improved by adopting relevant analytical techniques to respond to the uncertainties of the future transport system that makes road safety outcomes more unpredictable.

Abstract

The improvements to road safety since the 1970's are becoming increasingly difficult to sustain in many developed countries. This paper analyses ten Australasian Government road safety strategies against two key criteria: 1. a comprehensive framework for road safety, and 2. the anticipated changing, difficult and unpredictable nature of future transport and its context. The analysis concludes that current Australasian road safety strategies are weak in some areas of content and do not address future challenges. Improvements are suggested to strengthen strategies' thoroughness and robustness, as well as ways that the strategies can be more resilient to future circumstances.

Keywords

System, Future, Strategy, Plan, Policy, Assessment, Road Safety.

Introduction

Road deaths in Australasia have reduced since the peak in the early 1970's. Yet, over the last few years, the long term declines have lessened, and become increasingly difficult to maintain (OECD/ITF, 2016; Beck et al., 2017). The previous target set in the National Road Safety Strategy was a 40% reduction in fatalities, whereas 34% was achieved. The current target of a 30% reduction in fatalities by 2020 is unlikely to be met, since the reduction from 2010 to March 2018 is 5%. Road deaths in Australia have not reduced in quantum over the last five years and may be increasing (BITRE, 2018). This phenomenon is not unique, but is being observed in many developed countries (OECD/ITF, 2016) and raises many questions; firstly, as to why it is occurring? Secondly, how can road safety management

continue to improve road safety, especially in times of rapid contextual change? In addition, road safety in Australia has not improved at the same rate as the most successful countries internationally. The 'Safe Systems' basis of current Australasian road safety strategies is more than 10 years old, but the underlying policy tools and parts of the system they are applied to are at least 80 years old. Thorough application of systems approaches is not yet realized (Peden et al., 2004; Hughes, 2017).

The efficiency and effectiveness of road safety strategies is important in reducing the road toll. However, assessing whether road safety strategies are valuable has been problematic (Wegman et al., 2015; Hauer, 2018; Elvik, 2012), because it is difficult to demonstrate cause and effect, especially over extended periods of time when many factors change, such as economic conditions (Sivak, 2009; Wegman & Hagenzieke, 2010; Hughes et al., 2016). Therefore, assessments that can be conducted during the development and implementation of a road safety strategy (ex ante) could be valuable and are more timely than assessments that occur long after (ex post). A confusing factor either way is the level of implementation, which is critical to success, because any well developed strategy could fail due to poor implementation.

This paper describes the assessment of current road safety strategies in Australia against two frameworks. The first is the seven elements of a newly developed comprehensive framework for road safety management based on systems theory and practice (Chapanis, 1996; Hughes et al., 2016; Hughes, 2017). The second framework is the changes that are expected in the transport system and its context that are likely to affect road safety (EU, 2016; NTC, 2016), including the changing and variable nature of future transport (Rasmussen, 1997; Eurocontrol, 2013; Bennett & Lemoine, 2014; Hughes, 2017). The contemporary Safe Systems approach described in Australasian road safety strategies (MOT, 2010; ATC, 2011) is based on important road safety principles applied to road users, vehicles, roads and speeds in order to achieve a purpose that is often stated as a target or general objective. The practical application continues the traditional policy tools of engineering, enforcement and education applied to road users, vehicles and roads.

7P Systems Framework Criteria

In contrast to road safety, safety management in other hazardous industries based on system theory and best practice, takes a more comprehensive approach and broadens the range of policy tools and that can be applied to a wider range of component parts that comprise the system. This approach also specifically recognises the full range of participants (or actors), the relationships and interactions within the system, and the necessary processes to efficiently and effectively achieve the purpose. Based on a comprehensive systems theory approach, the 7P System framework (Hughes, 2017) is shown diagrammatically in Figure 1 and described in Table 1 that can be summarised as:

Participants use *processes* based on *principles* to apply *policy tools* to affect contributing component *parts* in order to achieve a *purpose* (improved road safety). These all occur in complex interdependent *partnerships* or interactions within the system.

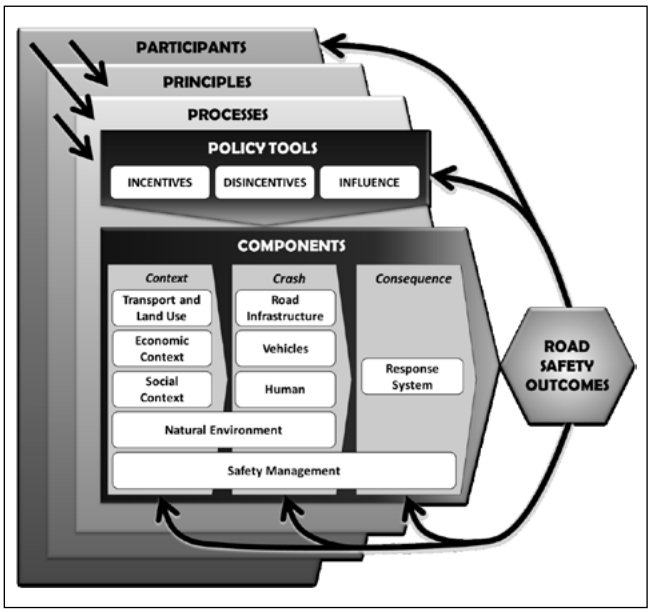


Figure 1. The 7P System framework for road safety management

Future Changes Criteria

Criteria for Future Changes were based on the changes that are expected in the transport system and its context that are likely to affect road safety (Hughes, 2017). Changes may be manageable trends (incremental and foreseeable), such as population and demographics; transport costs including fuel, vehicle prices and other charges; or economic factors such as Gross Domestic Product. Other changes have become more increasingly disruptive (unexpected, uncertain and profound). While there are numerous commentaries about future changes, several key topics commonly arise (Fishman, 2012; Eurocontrol, 2013; Deloitte, 2015; EU, 2016; NTC, 2016; USDOT, 2016), particularly automation and other innovative applications enabled by electronic, information and communications technology (EICT). Automation in road transport has evolved through several phases including Intelligent Vehicle Highway Systems and transport telematics into what is commonly called Intelligent Transport Systems (IRF, 2012; Hughes, 2017). Automation in vehicles is not new, dating back to electromechanical devices including automatic transmissions. However, the opportunities provided by EICT have resulted in modern vehicles being loaded with a multitude of applications for engine and transmission management, comfort, driver information, driver assistance and control systems. The latter have included automated braking systems (ABS) and cruise control for many years, but nowadays commonly include advanced emergency braking (AEB) (EU, 2009), while others alternative names including autonomous emergency braking, advanced emergency braking or other similar terms. Amongst the wide variety of driver assistance and

safety applications, other common technologies include dynamic or adaptive cruise control and electronic stability control (ESC). It is widely expected that automation will dramatically change road safety by dramatically reducing or eliminating driver error. It is expected that automation will also change productivity, ownership, privacy, data, terrorism and other outcomes, as has occurred in industries other than road transport. System theory and practice also suggests that new technologies and applications will introduce other new failures that will need to be managed, due to increasing complexity and because it will take some time for the maturity to occur.

In the wider context, new business models are disrupting traditional commercial enterprises. One of the most obvious of these is the sharing economy, such as Airbnb, Uber and other new information and transaction enterprises that have emerged extremely quickly over the last few years (Quick and Platt, 2015). In transport, new business models are converging with new technologies to service different transport user demands or preferences. Perhaps the most commonly described example of these developments is called Mobility-as-a-Service (MaaS) (Holmberg et al., 2015; TSC, 2016). These changes affect transport operations, types of vehicles, users, road use and other aspects that could have positive or negative effects on road safety.

The second aspect of future circumstances are the changing and variable nature of conditions, which continue to be more unpredictable and difficult to manage. (Rasmussen, 1997; Hovden et al., 2010; Eurocontrol, 2013). The historical environment that has been simple, stable, clear and certain is increasingly becoming more volatile, uncertain, complex and ambiguous (Bennett & Lemoine, 2014; Solomon & Ertel, 2014). "*Organisations today are under stress from a number of dynamic factors in their environment, such as technological changes, globalization, and market conditions. Modern socio-technical systems are characterized by increased complexity and coupling, and are as a consequence increasingly intractable*." (Hovden et al., 2010, p955). These conditions make outcomes more difficult to achieve, requiring more integration and collaboration and thus a more robust and comprehensive framework and practice.

Modern safety management takes account of the fact that the future will be different in nature to the present situation. Various analyses are currently applied to determine the impact of road safety actions, including before-and-after studies and cost-benefit analyses. However, the impact of road safety strategies as a whole provides information that can be used for performance measurement and understanding the success of the strategies (or lack thereof). These often assume steady state conditions that are not reasonable in the changing circumstances described above. Processes need to be applied to ensure that the strategies are relevant to the future. Relying on analyses that are based on historical information and perspectives introduces a risk that a strategy will not suit the future conditions. Other analytical techniques can take account of changes that are expected in the future (Kosow & Gaßner, 2008; Aven & Zio, 2011), such as real options analysis, scenario analysis and systems

Table 1. Strategies assessed

Strategy	Jurisdiction	Period of coverage
Towards Zero – Road Safety Strategy	Western Australia (WA)	2008-2020
Safer Journeys New Zealand's road safety strategy	New Zealand (NZ)	2010-2020
Road Safety Strategy*	Australian Capital Territory (ACT)	2011-2020
Towards Zero Together	South Australia (SA)	2011-2020
National Road Safety Strategy*	Australia (Aus)	2011-2020
NSW Road Safety Strategy*	New South Wales (NSW)	2012-2021
Safer Roads, Safer Queensland Queensland's Road Safety Strategy*	Queensland (Qld)	2015-2021
Towards Zero 2016/2020 Victoria's Road Safety Strategy & Action Plan	Victoria (Vic)	2016-2020
Towards Zero Tasmanian Road Safety Strategy 2017-2026*	Tasmania (Tas)	2017-2026
Towards Zero: Road Safety Action Plan	Northern Territory (NT)	2018-2022
* supported by separate action plan or work program		

dynamics (BITRE, 1999; TRKC, 2004; Leveson, 2011; Salmon et al., 2016).

Methods

Ten current road safety strategies from Australasia were downloaded from the jurisdictions' websites, as summarised in Table 1. All strategies were assessed by the lead author, to ensure consistency, according to seven systems framework criteria and five criteria representing future situations. The two national strategies were from Australia and New Zealand, six strategies were from the Australian States, and two strategies were from the Australian Capital Territory and the Northern Territory. The oldest strategy was from 2008, while the newest was from 2018. The most common horizon year was 2020 with one strategy to 2026. All strategies were based on the contemporary Safe System philosophy. The active time of the strategies varied from four to 12 years. Five strategies had action plans or work programs for intermediate periods, one of which was out of date.

A five point scale was used for assessment of the extent to which the strategies reflect the criteria. The assessment criteria are summarised in Tables 2 and 3. The score of 2 was selected to represent common attributes of an acceptable strategy, although there are no clear guidelines for development of road safety strategies in Australia. The indicative search terms were common in the road safety strategies and other relevant literature previously investigated (Hughes 2017).

The basic scoring scale is as follows, which is tailored according to the concepts and indicative search terms where appropriate to ensure relevance to each specific criterion.

> 0 - keywords or concepts not mentioned
>
> 1 - keywords or concepts directly *or* indirectly mentioned *and* not directly discussed
>
> 2 - keywords or concepts mentioned and briefly discussed *or* addressed
>
> 3 - keywords or concepts discussed *or* has actions to address
>
> 4 - keywords or concepts thoroughly discussed *and* has comprehensive actions to address.

A central mark of '2' represents that the criteria inclusion in the strategy is minimally adequate.

Table 2. Summary of 7P System criteria and scoring

7P System criteria	Description	Concepts and indicative criteria terms
1. Purpose (outcomes)	Consequences of a system when it is functioning, or something of value that is produced or as a result.	*Score 2:* goal, objective, target, aim, outcome (e.g. fatalities, serious injuries). *Higher score:* broader range and description or greater level of detail (e.g. segregation into specific factors or groups).
2. Policy Tools	Any specific intervention or countermeasure applied to improve safety including policies, programs and/or projects, e.g. pricing, education or regulation.	*Score 2:* engineering, enforcement, education. *Higher score:* funding, investment, incentives, pricing, subsidies, fees, charges, leadership, integration, implementation, participation, behaviour change, skills, expertise, capability, industry change, competition, consumer choice, innovation, research.
3. Parts (system components)	A subordinate component of a system, e.g. drivers, vehicles and roads in the road safety system.	*Score 2:* road users, vehicles, roads. *Higher score:* transport, land use, economy, society, natural environment, other users, crash response, safety management.
4. Participants (actors)	Any individual or entity that has the capability to affect road safety, including government, agency, association, company or individual person. Sometimes categorised as users or stakeholders.	*Score 2:* police, road authority, licensing authority, road safety agency. *Higher score:* additional participants (e.g. courts, educators, researchers, industry advocates & associations, community groups, general public, other government agencies, companies, media, transport users, unions, transport & other government departments, crash responders, etc.).
5. Principles	A general rule to be followed, or moral value to be used as a guide or put into practice.	*Score 2:* common Safe Systems principles. *Higher score:* additional principles (e.g. innovation, administrative efficiency & effectiveness, resilience to future change, national consistency, practicability, operational & commercial efficiency & effectiveness).

7P System criteria	Description	Concepts and indicative criteria terms
6. Processes	A series of complementary activities to achieve an outcome.	*Score 2:* common processes mentioned (data analysis, safety management, research, strategic planning, project design/ implement/ operate, communications, evaluation, etc.) *Higher score:* other processes (e.g. in-depth crash investigation, safety/risk management, scenario assessments, benefit-cost assessment, evaluation, etc.)
7. Partnerships (relationships)	The interactions between actors, policy tools, components and outcomes, which may be positive or negative, forwards or feedback.	*Score: 2:* integrate, connect, interconnect, interact, synergy, complement, conflict, dependency, etc. *Higher score:* broader range and description or greater level of detail.

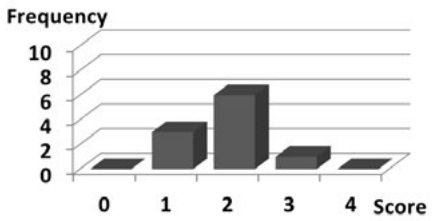
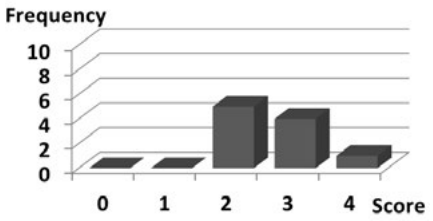
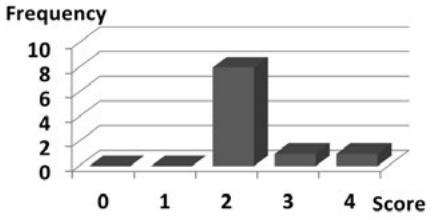
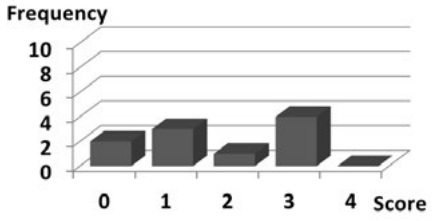
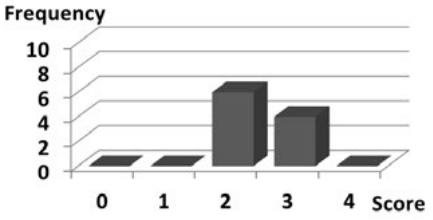
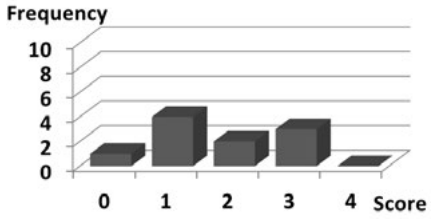
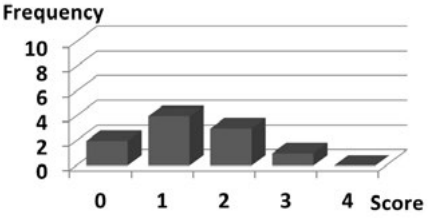
Table 3. Summary of Future Changes criteria and scoring

Future Changes criteria	Description	Concepts and indicative criteria terms
1. New technologies	New electronic information communications technology applications or vehicle types that change road transport.	*Score: 2:* electronic, autonomous, automated, driverless, disrupt, big data, innovation, etc. *Higher score:* broader description or greater level of detail.
2. New markets and business models	New ways that businesses operate commercially, or new transport market delivery structures that change the way that road transport broadly operates.	*Score: 2:* mobility-as-a-service, transport-as-a-service, market, business, demand, etc. *Higher score:* broader description or greater level of detail.
3. Different consumer demands	Changing consumer preferences or demands, or new markets that change the demand for transport.	*Score: 2:* consumer, preference, choice, demand, etc. *Higher score:* broader description or greater level of detail.
4. Nature of the future	Continuing movement away from the previous context that has been simple, stable, clear and certain.	*Score: 2:* volatile, uncertain, complex, ambiguous, scenario, future, etc. *Higher score:* broader description or greater level of detail.
5. Future situation assessment	Clear, accurate and considered appreciation of the future situation.	*Score: 2:* trend, context, estimate, future, forecast, model, economic/ social/ environmental context or effects, etc. *Higher score:* broader description or greater level of detail.

Results

Seven 7P Systems criteria were assessed, where a score of '2' represents a minimum acceptable pass. This provides 70 individual scores, as summarised in Table 4. Five strategies scored a minimum acceptable level of two or above for these seven framework criteria as a whole, with an average score of 1.97. There were only two individual maximum individual criteria scores of four, 18 scores of three and 19 scores less than two. These equate to 29% of scores above a minimum acceptable level, 44% at minimum acceptable level and 27% below an acceptable level. The highest average scores for these criteria were for 2.60 for policy tools and 2.40 for principles, while the lowest average scores were 1.30 for partnerships and 1.70 for participants and processes. Four strategies scored above an average of two for the seven framework criteria, while five strategies scored below an average of two, indicating they were basic and inadequately described a comprehensive framework.

Table 4. Summary of 7P System criteria assessment

7P System criteria and scores	Examples from the highest scored strategies	Distribution
1. Purpose Average Score: 1.8 Range: 1 to 3	Specific challenges described, specific targets described for road use and other sectors.	
2. Policy Tools Average Score: 2.6 Range: 2 to 4	Include land use or transport system planning, safety culture or safety management, incentives, trials.	
3. Parts Average Score: 2.3 Range: 2 to 4	Integrating with land use planning & active transport.	
4. Participants Average Score: 1.7 Range: 0 to 3	Recognise wider stakeholders during consultation or implementation.	
5. Principles Average Score: 2.4 Range: 2 to 3	Supporting cultural change, integrating engineering and speed management, applying best practice, appreciating safety is a lifelong issue, corporate responsibility, international collaboration.	
6. Processes Average Score: 1.7 Range: 0 to 3	Performance monitoring & management, investment decisions, governance, research, knowledge transfer (capability), innovation, evaluation. Impact analysis.	
7. Partnerships Average Score: 1.3 Range: 0 to 3	Ensuring strong alignment with stakeholders' activities, public policy integration, shared implementation, integration. Descriptions of all partners, linkages & synergies.	

Five criteria representing future changes in which the road safety strategies are expected to be applied were assessed, where a score of '2' represents a minimum acceptable pass. This provides 50 individual scores, as summarised in Table 5. There were no scores of four, only three scores of three and six scores of two, with the vast majority of scores (41) below a minimum acceptable score. These equate to six per cent of scores above a minimum acceptable level, 12% at minimum acceptable level and 82% below an acceptable level. None of the strategies achieved a total average score above one, well below the acceptable level of two for these five criteria, with an average overall score of an extremely low 0.52 for all strategies. The highest average criteria score of 1.70 was for new technologies, while all other scores averaged below 1.0. None of the strategies reflected the future situations to any degree of adequacy, with all but one of the strategies scoring zero in at least three Futures Changes criteria.

Table 5. Summary of Future Changes criteria assessment

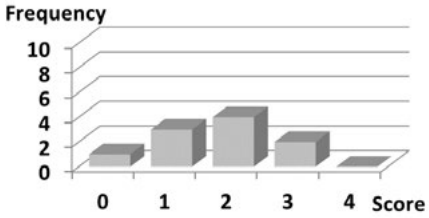
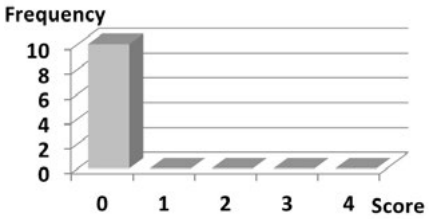
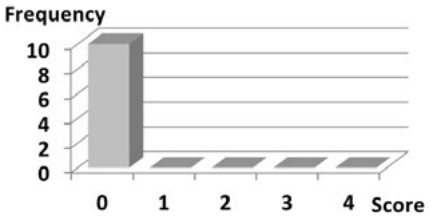
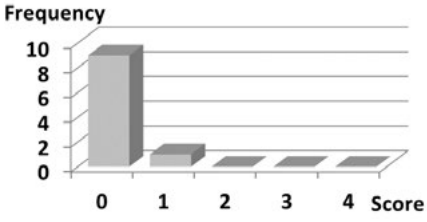
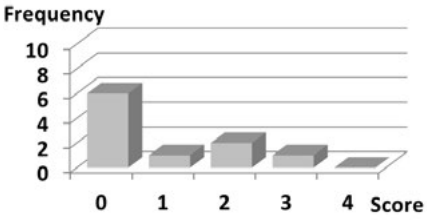
Future Changes criteria and scores	Examples from the highest scored strategies	Distribution
1. New technologies Average Score: 1.7 Range: 0 to 3	Descriptions about new technologies and potential for road safety, self-driving cars, driver assistance, Intelligent Transport Systems, camera technology and monitoring trends.	
2. New markets and business models Average Score: 0 Range: 0		
3. Different consumer demands Average Score: 0 Range: 0		
4. Nature of the future Average Score: 0.1 Range: 0 to 1		
5. Future situation assessment Average Score: 0.8 Range: 0 to 3	Appreciation of demographic, economic and social factors. Considered elsewhere in government.	

Table 6 summarises the assessment for the 7P System criteria and the Future Changes criteria as a whole. This summary illustrates the moderate level of score against the 7P System criteria overall and the low scores against the Future changes criteria.

Table 6. Summary of all criteria assessment

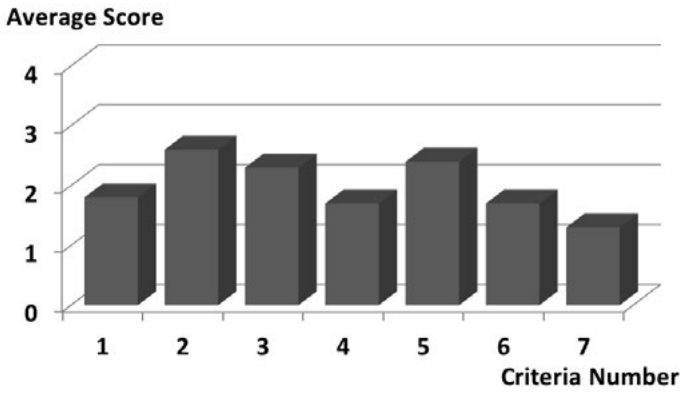
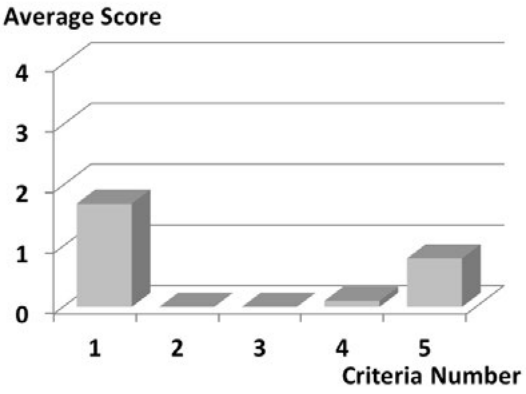
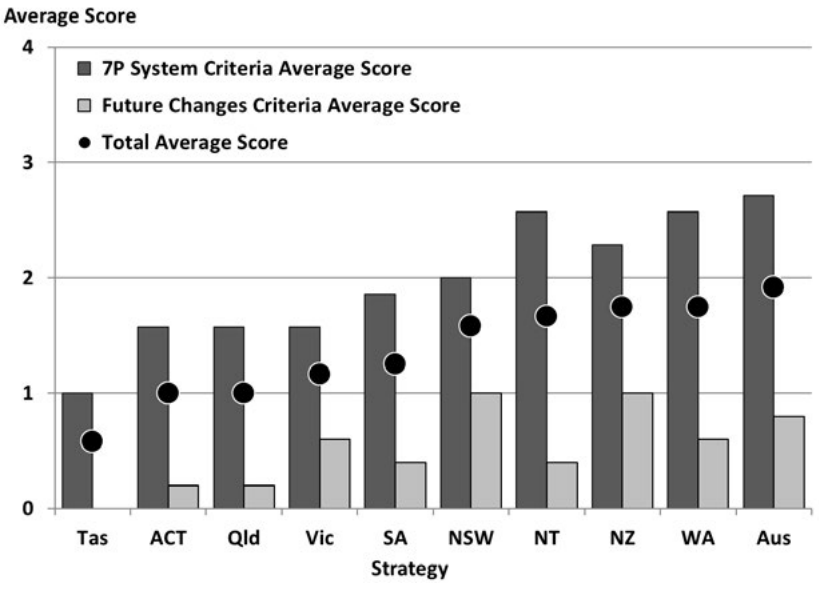
Criteria and scores	Distribution
7P System criteria Average Score: 1.97 Range: 1.30 to 2.60	
Future Changes criteria Average Score: 0.52 Range: 0 to 1.70	
All 12 criteria Average Score: 1.37 Range: 0.58 to 1.92 **Score for each strategy**	

Table 7. Summary of individual strategy assessment scores

Jurisdiction	All 12 criteria average score	7P System criteria							Future Changes criteria					
		Purpose	Policy tools	Parts	Participants	Principles	Processes	Partnerships	All 7p System criteria average score	New technologies	New markets & business models	Different consumer demands	Nature of the future	Future situation assessment	All Future Changes criteria average score
Tas	**0.58**	1	2	2	0	2	0	0	**1.00**	0	0	0	0	0	**0.00**
ACT	**1.00**	1	2	2	1	3	1	1	**1.57**	1	0	0	0	0	**0.20**
Qld	**1.00**	2	2	2	1	3	1	0	**1.57**	1	0	0	0	0	**0.20**
Vic	**1.17**	2	2	2	1	2	1	1	**1.57**	3	0	0	0	0	**0.60**
SA	**1.25**	2	3	2	0	2	3	1	**1.86**	2	0	0	0	0	**0.40**
NSW	**1.58**	2	2	2	2	2	2	2	**2.00**	3	0	0	1	1	**1.00**
NT	**1.67**	1	4	4	3	2	1	3	**2.57**	2	0	0	0	0	**0.40**
NZ	**1.75**	3	3	2	3	2	2	1	**2.29**	2	0	0	0	3	**1.00**
WA	**1.75**	2	3	2	3	3	3	2	**2.57**	1	0	0	0	2	**0.60**
Aus	**1.92**	2	3	3	3	3	3	2	**2.71**	2	0	0	0	2	**0.80**

Table 7 summarises the assessment, for each individual strategy. As a total, no strategy achieved a minimum score of 2 as an average across all 12 criteria. Of the 120 individual scores overall, this equates to 19% of all individual scores above a minimum acceptable level (3 or 4), 31% at minimum acceptable level (2) and 50% below an acceptable level (0 or 1).

Discussion

The study is limited by the published road safety strategies available and within the scope of the review. Some strategies may have additional information available in complementary documents such as actions plans. Other supporting information, such as analysis of the anticipated impacts of the strategies may be available, but is not referred to in the strategies. It is also important for a comparative assessment that strategies are compared on an equal basis, and searching for additional information can threaten the equivalence of assessments. In addition, some strategies may lean towards brevity in order to maximise readability for a general audience. This raises the question beyond the scope of the study as to the purpose of the strategies themselves. For instance, they should be written very differently if they are for public engagement and motivation, for political justification, or to provide clear guidance and requirements for professionals, practitioners and other participants involved.

The analysis found that current road safety strategies were minimally adequate for some criteria (policy tools, principles and parts) but weak on participants, processes and partnerships. However, the strategies hardly reflected the anticipated future changes to the transport context, while the changing and variable nature of future conditions was missing almost entirely from consideration and response in the strategies. Tables 3 and 4 describe examples in the strategies of criteria that were scored highest and discussed further below.

All strategies mentioned engineering, enforcement and education policy tools. However, other policy tools were rarely or never mentioned included incentives, alternative funding and investment (e.g. private sector), pricing, subsidies, fees, charges, leadership, integrating techniques, consumer choice, industry change or innovation. All strategies mentioned several types of road users, roads (sometimes with the wider infrastructure) and vehicles. Due to the Safe Systems framework, all strategies mentioned speed management as a primary issue. Interestingly other behaviours such as 'safe alcohol and drugs', 'safe fatigue' or 'safe distraction' etc., were not given the same level of significance. Also, other parts of the road safety system were rarely mentioned including land use, the economy, social context, crash response, and thorough risk and safety management.

All the strategies clearly described Safe Systems principles, but did not recognise other valuable principles to ensure the strategies were cost effective, acceptable and timely, such as innovation, administrative efficiency and effectiveness, resilience to future change, national consistency, practicability or operational and commercial efficiency and effectiveness. The Safe Systems approach clearly focusses on the number of people killed and seriously injured as the Purpose. However, more specific targets or objectives could be described for specific road user groups, contexts or causal factors.

All the strategies were weak in thoroughly describing processes that need to be applied, in order for the strategies to be successful in achieving the intended improvements to road safety. Most strategies described something about the process to develop the strategy. However, there were almost no descriptions of processes for safety management, research, project design and implementation or operation, communications, evaluation, etc. Other processes to apply best practice safety management that exist in other safety domains were also missing. These include in-depth crash investigation, thorough safety or risk management, scenario assessments, benefit-cost assessment, program evaluation, etc. None of the strategies include an evaluation of the efficiency or effectiveness of previous strategies as a whole, as opposed to individual actions in isolation. So, there is no mechanism for knowing whether previous strategies were successful in achieving their intended purpose, although some strategies proposed evaluation of the current strategy.

Any comments about the future in the strategies reflected a 'business-as-usual' approach rather than recognising any future changes. There was no discussion about the effects of new markets, business models or different consumer demands on road safety, even though these changes are recognised in wider transport policy and planning, and have been changing transport for several years. Comments about the future performance were based on continuance of trends of the past, despite transport (and its wider context) continuing to become less simple, stable, clear and certain. The little discussion in the strategies about the impact on future road safety performance was almost entirely limited to notional targets in the purpose. There were no forecasts for future performance, scenarios of alternative circumstances or assessments that took account of future uncertainty.

One important issue that emerged from the study was the timeliness of strategies. The time the strategies were intended to be relevant varied from four to 12 years, during which time considerable changes can occur to the context that the strategies operate in; the pre-crash or 'Context' phase (Hughes, 2017). It is noted that some of the older strategies scored high and some later strategies scored low. However, this issue was not assessed in this study and only ten strategies is too few to make any conclusions, so this issue could benefit from further consideration. One technique for maintaining relevance over time is to use Action Plans or Work Pans, which specify actions over a shorter period of time within the strategy period, as five of the strategies do.

While new technologies were mentioned, the comments were mainly focussed on the impact of technology on distraction, and automated enforcement. There was little discussion about new technologies to improve road safety directly (such as in-vehicle safety systems and driverless technology), and no clear actions to apply such technologies. AEB is an interesting example of technology and an opportunity for improving Australasian road safety. AEB was mandated by the European Union in 2009 for certain vehicles (primarily trucks) manufactured from 2013 and all other vehicles from 2015 (EU, 2009). As such, many new vehicles in Australasia have AEB, but it is not required under Australasian road safety regulation. The only mention of AEB in these strategies is the potential for its introduction, and only as far as conducting some investigation. Electronic brake technologies were recommended in the 2008 National Heavy Vehicle Braking Strategy, but despite the clear benefits of AEB, there are no concrete proposals for it to be a requirement in Australasian vehicles. This puts Australasian road safety at least ten years behind Europe for this safety improvement. It also indicates the general lack of appreciation of changing technology and the opportunities that arise, and the capability to apply technology to achieve road safety outcomes.

The same is true for other vehicle automation and particularly the introduction of driver assistance systems, to the point of driverless cars. Australia is planning to change the safety regulatory regime from a prescriptive rule and enforcement based regime to a performance based approach (as used in aviation, railways and other hazardous industries) by 2020 to cater for vehicle automation. The changing regulatory approach is necessary to deal with the complexity and diversity of the new technologies, and the dynamic nature of the systems that can change literally overnight (with new software downloads). Yet a government response to the introduction of such technologies is almost completely absent in Australasian road safety strategies, despite such technologies being deployed elsewhere, and sometimes mandated, at the present time. While car automation is a major focus of government and industry interest, the same or other technologies exist or are emerging for other interests such as pedestrian, cycling, heavy vehicle and motorcycle safety which also need to be accounted for to improve safety outcomes.

While most of these strategies are quite strong in terms of the Safe Systems approach, there are several improvements that can be made if the strategies are to closer match the best approaches based on systems theory and best practice safety management in other hazardous industries. The weakest aspect of the strategies analysed is the historical nature of the perspectives that they are based on; backward looking information that becomes out of date due to time, and continuing to rely on the same types of actions as those used for many years. Therefore, they do not take account of future situations, including several types of variability, or apply wider policy tools that are available to more participants or parts of the system.

As noted in the Introduction, the recent history of Australian road safety is that the intended objectives are not being met. Continuing to use the same approach is therefore unlikely to achieve the intended objectives in future. The strategies are generally only minimally acceptable. Broader, deeper and more insightful consideration of structural elements in a comprehensive framework needs to occur.

The following recommendations are made to improve Australasian road safety strategies, based on systems theory and best practice in safety. With respect to a comprehensive framework, based on Hughes (2017) that is consistent with systems theory and practice, these include:

- thoroughly appreciate the roles of all relevant participants (Leveson, 2011; Salmon et al., 2016) and develop actions to maximise the benefits of actions of participants who can positively contribute to road safety outcomes and minimise the negative effects of participants with conflicting objectives;
- explore and develop alternative policy tools to enforcement, engineering and education that broaden the range of actions that can be applied. These may include economic incentives, developing safety culture and climate (Wiegmann et al., 2007), or capability development and standards for participants with poorer skills and knowledge;
- identify other components that can be influenced to improve road safety or defend against if they would result in adverse road safety outcomes. These could include aspects of the transport and land use system, society or economic context including broader government policy;
- thoroughly describe and apply the processes required to manage road safety, including implementation. Other processes not yet widely applied in road safety include contemporary risk analysis and management such as fault tree analysis (Leveson, 2011), MORT (Johnson 1980), STAMP (Leveson, 2011), SAFETY II (Eurocontrol, 2013), and systems dynamics (TRKC, 2004; Leveson, 2011; Salmon et al., 2016);
- clearly describe numerical targets to recognise external factors (such as fatality rates versus population or vehicles, or economic indicators) and for individual target areas (such as road user groups or types of crash);
- clearly identify the relationships between participants, policy tools, components and outcomes to understand and maximise the positive synergies and minimise the negative conflicts;
- describe the outcomes or purposes of individual actions in addition to the strategies as a whole, or for specific sectors (such as heavy vehicles, geographic areas, road user groups of participants); and
- broaden the range of principles that need to guide strategies to be most effective, such as cost efficiency, innovation, best practice, and evaluation.
- With respect to ensuring that the strategies are more suitable for the future circumstances, the recommendations include:
- estimate the future road safety outcomes, with and without individual actions and the strategy itself;
- ensure the strategies are resilient to alternative futures caused by changing circumstances;
- employ contemporary futures analytical techniques (Aven & Zio, 2011), such as scenario analysis (Kosow & Gaßner, 2008), real options analysis (BTRE, 1999) and Monte Carlo simulation for analysis of future consequences caused by the strategies, individual actions, and external factors and participants;
- consider influences and factors that will change in future that will affect road safety outcomes;
- develop actions to maximise the benefits of positive contextual influences and minimise the effects of negative external influences. Automation and technology, new business models and the effects of changing consumer preferences should be the first factors to be considered;
- develop and apply techniques to manage future influences that are unpredictable; and
- ensure an appropriate time period that strategies should be applied to, so they remain relevant throughout their lifespan.

Conclusion

To summarise, this study demonstrates that Australasian road safety strategies could be developed more thoroughly, be more timely and be designed to more robustly respond to future changes in transport and economic contexts. Strategies with horizon years of 2020 or 2021 urgently need updating to maintain currency. They can be improved in accordance with the 7P System and the Future Changes criteria to be applicable and thereby successful in the future. Implementing such recommendations will bring Australasian road safety strategies up to the standard of good practice for safety management in hazardous industries. It is expected that doing so will result in further improvements to road safety that have been more elusive and difficult to achieve in recent years.

References

ATC. (2011). *National Road Safety Strategy 2011-2020*. Canberra, Australia: Australian Transport Council (ATC).

Aven, T. & Zio, E. (2011). Some Consideration on the Treatment of Uncertainties in Risk Assessment for Practical Decision Making. *Reliability Engineering & System Safety. 96.* 64-74.

Beck, B., Cameron, P.A., Fitzgerald, M.C., Judson, R.T., Teague, W. Lyons, R.A. & Gabbe, B.J. (2017). Road safety: serious injuries remain a major unsolved problem. *Medical Journal of Australia*, 207 (6): 244-249.

Bennett, N., & Lemoine, G.J. (2014). What VUCA really means for you. *Harvard Business Review*, Jan-Feb, 27.

BTRE. (1999). *Facts and furphies in benefit cost analysis: transport*. Report 100. Canberra, Australia: Bureau of Transport and Regional Economics (BTRE).

BITRE. (2018). *Road deaths Australia: March 2018*. Canberra, Australia: Bureau of Infrastructure, Transport and Regional Economics (BITRE).

Chapanis, A. (1996). *Human factors in system engineering*. New York, NY: John Wiley and Sons.

Deloitte (2015). *Transport in the digital age: disruptive trends for Smart Mobility*. London, UK: Deloitte LLP.

Elvik, R (2012). Does Use of Formal Tools for Road Safety Management Improve Safety Performance? *Transportation Research Record: Journal of the Transportation Research Board*, No. 2318, pp 1-6.

EU. (2009). *Regulation (EC) No 661/2009 Of The European Parliament and of The Council of 13 July 2009 Concerning Type-Approval Requirements For The General Safety Of Motor Vehicles, Their Trailers And Systems, Components And Separate Technical Units Intended Therefor*. Brussels, Belgium: European Union (EU).

EU (2016). *Declaration of Amsterdam: Cooperation in the field of connected and automated driving*. Brussels, Belgium: European Union (EU).

Eurocontrol. (2013). *From Safety I to Safety II: A White Paper*. Organisation for the Safety of Air Navigation (Eurocontrol). Brussels, Belgium.

Fishman, T.D. (2012). *Digital-age transportation: The future of urban mobility*. London, UK: Deloitte Development LLC.

Hauer, E. (2010). *Lessons learned from other countries*. White Papers for: Toward Zero Deaths: A National Strategy on Highway Safety. White paper no. 9. Vanasse Hangen Brustlin, Inc.

Holmberg, P-E., Collado, M., Sarasini, S., & Williander, M. (2015). *Mobility as a service – MAAS: Describing the framework*. Göteborg, Sweden: Viktoria Swedish ICT.

Hovden, J., Albrechtsen, E., & Herrera, I.A. (2010). Is there a need for new theories, models and approaches to occupational accident prevention? *Safety Science, 48*(8), 950-956.

Hughes, B.P., Anund, A., & Falkmer, T. (2016). A comprehensive conceptual framework for road safety strategies. *Accident Analysis and Prevention, 90*, 13-28.

Hughes, B. (2017). *A Comprehensive Framework for Future Road Safety Strategies*. PhD Thesis, Curtin University, Perth.

IRF. (2012). *The IRF Vienna Manifesto on ITS: Smart transport policies for sustainable mobility.* Geneva, Switzerland: International Road Federation (IRF).

Johnson, W.G. (1980). *MORT Safety Assurance Systems*. National Safety Council and Marcel Dekker Inc.

Kosow, H., & Gaßner, R. (2008). *Methods of Future and Scenario Analysis*. Bonn, Germany: German Development Institute.

Leveson, N.G. (2011). *Engineering a Safer World: Systems Thinking Applied to Safety*. Cambridge, MA: Massachusetts Institute of Technology.

MOT. (2010). *Safer Journeys: New Zealand's road safety strategy 2010-2020*. Wellington, New Zealand: Ministry of Transport (MoT), New Zealand Government.

NTC. (2016). *Land Transport Regulation 2040: Technology, trends and other factors of change.* Melbourne, Australia: National Transport Commission (NTC).

OECD/ITF (2016). *Road safety annual report 2016*. Paris: International Transport Forum (ITF), OECD.

Peden, M., Scurfield, R., Sleet, D., Mohan, D., Hyder, A., Jarawan, E., & Mathers, C. (2004). *World health report on road traffic injury prevention*. Geneva, Switzerland: World Health Organization.

Quick, L., & Platt, D. (2015). *Disrupted: Strategy for exponential change*. Victoria, Australia: Resilient Futures Media.

Rasmussen, J. (1997). Risk management in a dynamic society: a modelling problem. *Safety Science*, 27(2-3), 183-213.

Salmon, P.M., Read, G.M., & Stevens, N.J. (2016). Who's in control of road safety? A STAMP control structure analysis of the road transport system in Queensland, Australia. *Accident Analysis and Prevention*, 96, 140-151.

Sivak, M. (2009). Mechanisms Involved in the Recent Large Reductions in US Road Fatalities. *Injury Prevention, (15)*3, 205–206.

Solomon, L.K. & Ertel, C. (2014). Leadership in a VUCA world: Design strategic conversations to accelerate change. *Leadership Excellence Essentials*, February 2014, 17-18.

TRKC (2004). *Assessment of transport strategies*. Transport Research Knowledge Centre (TRKC).

USDOT (2016). *Beyond traffic 2045*. Washington, DC: US Department of Transportation (USDOT).

Wegman F., and M. Hagenzieker (2010) Editorial, special issue scientific research on road safety management, *Safety Science, 48*(9), 1081–1084.

Wegman, F., H.Y. Berg, I. Cameron, C. Thompson, S. Siegrist and W. Weijermars (2015). Evidence-based and data-driven road safety management. *IATSS research, 39*(1), pp 19-25.

Wiegmann, D.A., von Thaden, T.L. & Gibbons, A.M. (2007). *A review of safety culture and its potential application to traffic safety*. Washington, DC: AAA Foundation for Traffic Safety.