



Joint Select Committee on Road Safety
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Australian Parliamentary Road Safety Inquiry 2020

“What got us here won’t get us there; we need to do something differently”

It’s 2020! So, let’s decide to finally get serious about road safety in Australia.

Instead of doing the same things again and getting the same inadequate results, let’s commit to doing things **better** and **differently**.

I’m not sure if I was pleased or despondent to see the announcement of yet another Inquiry into road safety in Australia. On one hand it offers yet another opportunity to break through on this important but heretofore intractable social and economic issue. On the other hand, we’ve heard it all before, the ‘solutions’ have always been the same, the delivery has been lukewarm and the outcomes have been underwhelming and overpromised.

So, I’m not going to write what most others will. They’re probably right, at least to a certain degree. But it hasn’t been enough. We can try harder, but that won’t be enough either. Basically,

- **Unless we embrace complexity and appreciate the future context, road safety will continue to fail to reach our intended objectives, and**
- **The management of road safety would be substantially different (and better) if the practices of other hazardous industries, such as aviation, were applied.**

I’ve noticed that other hazardous industries have adopted approaches that are far more sophisticated than road safety which is stuck in an 80-year-old policy rut. I also see that New Zealand has recently revised that paradigm significantly in its new road safety strategy.

Revolutionising road safety management will require courage to change the status quo, enthusiasm to pursue change and an open mind to seek and adopt new opportunities. So, I hope you’re up for the challenge; Australian lives depend on it. I therefore offer my comments from a strategic perspective for your consideration.

This submission describes that a systems approach is a valuable way that a new direction can occur. While the specific details in each location are different, the underlying nature of road safety in most western countries is very similar, so the strategic issues are common. At least the Kiwi’s have now shown the courage to adopt some new approaches.

Despite the rhetoric of road safety being updated about every 10-15 years, for the last 80 years road safety has relied on the 3E's (engineering, enforcement and education) being applied to drivers, vehicles and roads. In fact, the vast majority of all road safety is road engineering and driver 'education' and enforcement.

This submission is based on the most recent and progressive advances that can be applied to road safety following thorough research into systems approaches to managing safety that have been successfully applied to other safety critical industries. The underlying propositions of this submission are:

- continuing to manage road safety as has been done in the past is unlikely to achieve the improvements that are desired for the future;
- road safety is far more difficult, complicated and unpredictable now than in the past; and
- other safety critical industries have achieved greater safety improvements by applying systems approaches that road safety should learn from.

So,

- **new approaches are required to improve road safety;**
- **systems approaches, successfully applied in other safety critical industries, offer the best opportunity to improve road safety; and**
- **road safety can best be improved by adopting a new comprehensive, systems-based approach.**

Applying a systems-based approach requires all elements to be thoroughly managed (which they aren't at present), including ***participants, processes, principles, policy tools***, component ***parts***, ***purpose*** (improving road safety) and interdependent ***partnerships*** or interactions within the system.

In summary, this submission describes that ***thoroughly and diligently adopting systems approaches to road safety strategy, policy, planning and practice has the potential to significantly improve outcomes***, as others have found in other fields of safety management. These comprehensive, sophisticated, contemporary and proven techniques offer the opportunity to efficiently and effectively achieve the next reductions in road trauma that are necessary, but have become increasingly elusive recently. We certainly need much more holistic, efficient and effective ways of operating than our traditional practice.

I wish you the very best for your noble quest in the face of numerous challenges. And I'll be pleased to provide more information or discuss with you further, if I can help at any time.

Kind Regards,

Dr Brett Hughes



Executive Summary

- ❖ This submission is based on the most recent and progressive advances in safety that can be applied to road safety.
- ❖ The propositions underlying this submission are:
 - continuing to manage road safety as has been done in the past is unlikely to achieve the improvements that are desired for the future;
 - road safety is far more difficult, complicated and unpredictable now than in the past; and
 - safety critical industries have achieved greater safety improvement by applying systems approaches that road safety should learn from.
- ❖ Therefore:
 - new approaches are required to improve road safety;
 - systems approaches, successfully applied in other safety critical industries, offer the best opportunity to improve road safety; and
 - road safety can best be improved by adopting a new comprehensive, systems-based approach.
- ❖ Thoroughly and diligently adopting systems approaches in road safety has the potential to significantly improve outcomes, as others have found in other fields of safety management. In particular, applying systems approaches to road safety strategy, policy, planning and practice offers the opportunity to efficiently and effectively achieve the next reductions in road trauma that are necessary, but have become increasingly elusive recently. We certainly need much more holistic, efficient and effective ways of operating than our traditional practice.
- ❖ **A new Australian road safety strategy must thoroughly apply contemporary systems-based approaches of safety management** to ensure:
 - the **purpose** (targets, aims or objectives) is clear and appropriate;
 - all the relevant **participants** who contribute to the outcomes are involved;
 - there are clear **principles** to guide participants' involvement;
 - robust **processes** occur for the development, choice and implementation of interventions;
 - all the most appropriate **policy tools** are applied (incentives, disincentives and influence);
 - all **parts** of the systems are considered and managed (including, but not narrowly limited to road users, vehicles and road infrastructure); and
 - the above aspects are integrated in **partnerships** to maximise synergies and minimise undesirable negative consequences.
- ❖ Specific new responses and countermeasures are suggested for inclusion in a new Australian road safety strategy.



Submission to Joint Select Committee on Road Safety - Parliament of Australia

Introduction

This submission is from Dr Brett Hughes, who has extensive experience in road safety and all facets of transport generally. Brett is the principal of P7Safety, established for independent transport research and advocacy, primarily focussing on road safety. The main topic of Brett's recent research has been comprehensive road safety strategies, and how the quality of national road safety strategies can be improved to better meet future conditions.

Brett has come to this position on road safety after a 40 year career in all aspects of transport, a recently completed and well regarded PhD on road safety, and other research and participation in road safety. This submission focusses on how to improve future Australian road safety strategies, based on unique and progressive research into international in road safety strategies. The work has been informed by extensive experience in transport policy, planning, analysis and research for safety, productivity and sustainability in all modes of transport and in government and private sectors.

This submission focusses on how to improve future Australian road safety strategies, so that the best interventions are developed, chosen and implemented. The submission is based on unique research into international in road safety strategies, which is publicly published and peer reviewed¹. This research is unique, partly because the topic is surprisingly uncommonly examined, and secondly it involved analysing over 120 road safety strategies internationally. The work has been informed by extensive experience in transport policy, planning, analysis and research for safety, productivity and sustainability in all modes of transport and in government and private sectors.

Background observations

Most road safety research focuses on the detailed level, i.e. specific interventions. However, individual countermeasures can only be optimised and integrated if the underlying strategy is properly developed to be robust, efficient and effective. Road safety *strategies* are rarely researched or analysed. So, the quality of national road safety strategies is often unknown and are not necessarily efficient, effective or relevant for future conditions.

There are still many things we can do to reduce road trauma, but these are invariably focussed at the operational level. Unfortunately, the evidence around the world is that **the successes of the past aren't continuing**, so it is very likely that road safety will deteriorate in future, as several countries are experiencing. I am sure you are well aware that road safety is a complex issue, which therefore **requires systematic and structural responses**.

In general, road safety is doing some things better than in the past, but still within the limited framework of engineering, enforcement and education (3 E's) applied to drivers, vehicles and roads - a framework that is at least 80 years old. There has also been some commentary that perhaps the simple solutions of the past aren't sufficient to achieve the future outcomes we intend. In other

¹ Hughes, B. (2017). *A Comprehensive Framework for Future Road Safety Strategies*. PhD Thesis, Curtin University ([click to download](https://espace.curtin.edu.au/bitstream/handle/20.500.11937/59647/Hughes%20B%202017.pdf?sequence=1&isAllowed=y))
<https://espace.curtin.edu.au/bitstream/handle/20.500.11937/59647/Hughes%20B%202017.pdf?sequence=1&isAllowed=y>.



words "We cannot solve our problems with the same thinking we used when we created them."². I'm sure we can do some of the current practice things better, but the results will be limited.

Research into road safety management most recently indicates that¹:

- almost all road safety management is incremental and not strategic or holistic;
- many professionals talk about 'systems', but few have much idea what a system is, so systems concepts are poorly applied, and their full value isn't achieved;
- the Vision Zero or Safe Systems framework is a general and vague philosophy rather than a practical framework that engineers, police and other professionals can easily relate to and apply thoroughly;
- some countries claim to apply the Safe System approach, but don't incorporate systems concepts;
- road safety generally doesn't recognise post-crash management or the wider transport & land use, economic or social contexts that we know are important when considering transport elsewhere;
- we seem to be reaching the limits of road safety improvement within our current thinking, so new approaches are required; and
- we need approaches that look forward to a different future, rather than rely on historical information and previous approaches that have limitations.

As an example, New Zealand's MoT was willing to critically review and challenge road safety thinking and potentially move in a new direction if it is considered worthwhile. Their insight reflects systems approaches; comprehensive information, holistic perspective and appreciation of feedback:

*" allow for a more complete understanding of the drivers of change in road trauma and a more **holistic approach to policy evaluation**, to ultimately create a stronger policy feedback loop and enable the impact of road safety interventions to be continually strengthened."*Error! Bookmark not defined.

I would like to make a brief submission that addresses the Terms of Reference. Unfortunately, this is not possible, because:

1. road safety is far too complex to address simply. In fact, the oversimplified approach is one of the core failures of past road safety management, and
2. the Terms of Reference are already skewed towards simplistic and inadequate approaches, specifically relying heavily on the Safe System concept.

Systems approaches

Other hazardous industries followed a similar model to road safety (human-machine-environment compared with driver-vehicle-road) up until the industrial catastrophes of the 1980s (e.g. Piper Alpha, Bhopal, Challenger and Chernobyl). Analysis of these catastrophes determined that the **simplistic, linear, reductionist and backward-looking approaches of the past, which were often 'blame' based, weren't going to be adequate to ensure safety for the future**. So, safety critical industries such as offshore petroleum, chemical, railways and aerospace slowly adapted and adopted systems theory and practice. By contrast, aviation has developed a systems-based approach since its

² Attributed to Einstein, probably wrongly.



inception, which was based on ‘just culture’ (or ‘no blame’), comprehensive crash analysis and system improvement.

New Zealand have pointed to a different direction for road safety:

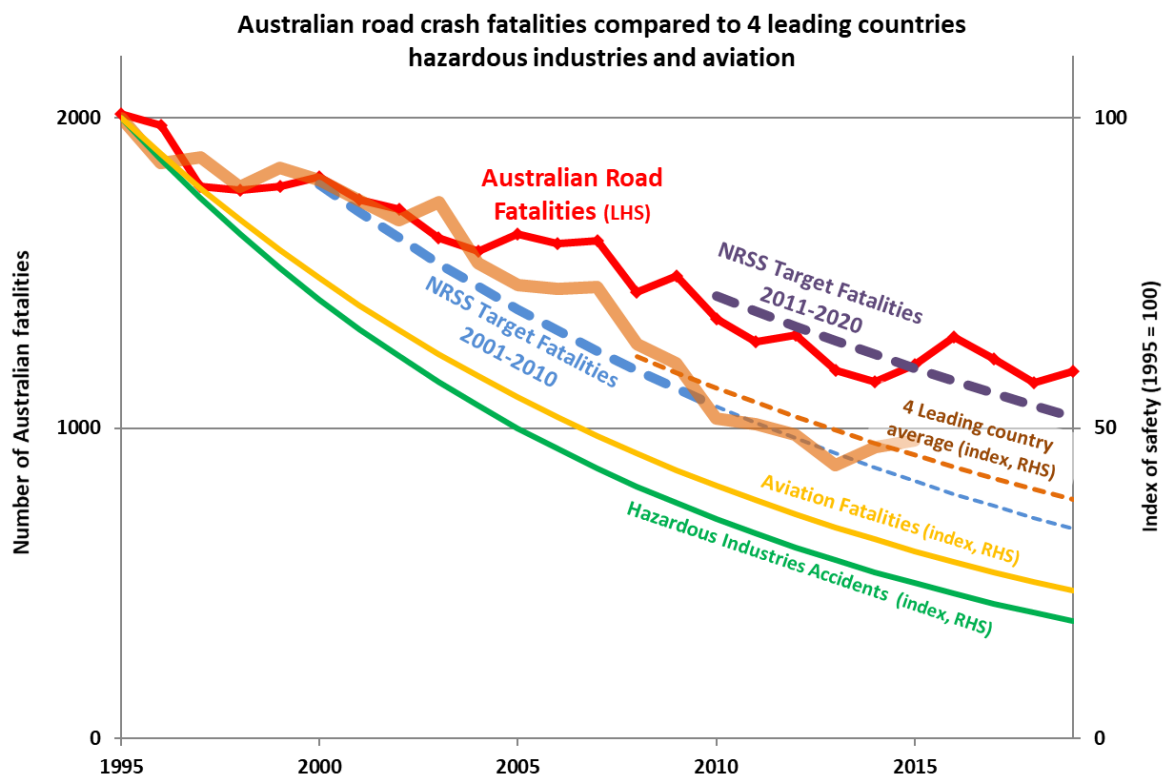
*Recent research improves our understanding of factors that affect traffic risks and identifies new safety strategies. **Applying this knowledge requires a paradigm shift.** The current paradigm favours targeted safety programs that reduce special risks such as youth, senior and impaired driving.*

A new paradigm recognizes that all vehicle travel imposes risks, and so supports vehicle travel reduction strategies such as more multimodal planning, efficient transport pricing, Smart Growth development policies, and Traffic Demand Management (TDM) programs.³

Systems approaches recognise that all parts and participants in the system make a contribution to achieving the objectives. Unlike road safety, systems safety and reliability is based on thousands of academic studies⁴ that are put into practice in the real world. It also recognises that human operators cannot be blamed in isolation when system failures occur. **Nearly all failures occur as a result of a combination of contributing factors and participants**, many of which have been traditionally ignored. By comparison, road safety generally identifies only a few causes and tends to blame drivers in isolation.

The graph below comparing Australia’s road safety performance with other safety critical industries reveals that;

- hazardous industries and aviation have achieved greater improvement than road safety; and
- road safety improvements have stalled in many developed countries (particularly in leading countries like Sweden, the Netherlands and the UK).



³ <https://www.transport.govt.nz/multi-modal/keystrategiesandplans/road-safety-strategy/>

⁴ For example, authors such as Perrow, Chapanis, Ackoff, Rasmussen, Hollnagel, Leveson, Dekker and Salmon offer fairly consistent approaches and have over 150,000 academic citations between them.



Australia has made good progress in improving road safety, but has failed to achieve targets set in the National Road Safety Strategies (NRSS) in 2000 and 2010 and simply isn't making enough progress, as the chart above and the following table show.

Years	NRSS Target	Actual Result	Target fatality rate change	Actual fatality rate change
1991-2000	-		-	2.4% decrease per year 521 less deaths
2001 - 2010	1071 deaths in 2010	1353 deaths in 2010	5% decrease per year 739 less deaths 40% less deaths	2.8% decrease per year 457 less deaths 25% less deaths
2011 - 2019	1035 deaths in 2019	1182 deaths in 2019	3.5% decrease per year 318 less deaths 24% less deaths	1.3% decrease per year 171 less deaths 23% less deaths

In other words, **Australia has not yet achieved the target it set for 2010.**

There were 1182 road deaths in Australia in 2019, but if improvements had been achieved according to other scenarios under other conditions the number of fatalities in 2019 would have been as shown in the following table.

Scenario	Average improvement	Road safety if scenario achieved	
		2019 deaths	Additional lives saved
Actual Australian result	2.4% pa	1182	-
2010 NRSS Target (from 2010)	3.5% pa	1035	147
4 leading road safety countries (from 1995)	3.6% pa	898	284
Aviation accidents (from 1995)	3.8% pa	798	384
2001 NRSS Target (from 2001)	5.0% pa	677	505
Aviation fatalities (from 1995)	5.8% pa	478	704
Other hazardous industries (from 1995)	6.7% pa	381	801

Our previous road safety strategies have failed to achieve their objectives or keep up with other best practice. **Around twice as many people are dying on Australian roads than should be.**

Willingness to critically review and challenge road safety thinking and potentially move in a new direction is crucial. This submission describes that a systems approach is a way that this that the new direction can occur.

Inadequate contemporary road safety management

In practice, the fundamental approach to road safety management has not changed since the Alness Report into Road Safety presented to the UK Parliament, circa 1937⁵. All modern road safety strategies (including Australia's) rely on road engineering and driver education and enforcement (the 3 E's)⁶.

⁵ House of Commons (1939). 5 July Debate (vol 349, cc1333-453).

⁶ Hughes, B.P., Anund, A., & Falkmer, T. (2016). *A comprehensive conceptual framework for road safety strategies*. Accident Analysis and Prevention, 90, 13-28.



Road safety management in developed countries⁶ is characterised by:

- a focus on road users, vehicles and road infrastructure;
- applying the policy tools of education, enforcement and engineering;
- ownership by road authorities, road safety agencies, police and transport departments;
- detailed research into micro-level issues rather than strategic, system or holistic issues; and
- 'backward-looking' or historical perspectives based on past information which is often out of date.

As a result:

- too few key participants manage road safety and generally operate in isolation ('silos');
- only a narrow range of policy tools are used;
- 'external' factors are ignored;
- other participants who can make a positive contribution are excluded;
- the general public are disengaged and disagreeable;
- data and information is narrow and weak, so causes and factors are not properly identified;
- good strategies are independently and poorly implemented; and
- road safety is not prepared for its future context.

Over the last 20 years an increasing number of countries have adopted 'Vision Zero' or 'Safe System' approaches to road safety. While these seem to have been successful⁷ it is frightfully difficult to determine due to time and confounding factors (as Hauer and Wegman found), and the fact that these approaches are vague and differently applied. While these approaches use similar philosophy, it is interesting to note that how they are described, their practices vary significantly⁸ and they continue to change without apparent reason. Furthermore, many countries that have adopted these approaches are now finding that improvements have stalled⁹. So, the question arises, "Will road safety strategies based on 'Vision Zero' or 'Safe System' be successful in future?"

Like many other similar countries, road safety in Australia has not improved recently at the same rate as previous periods, despite applying the Safe Systems approach, as shown in the historical summaries above and below¹⁰. In fact, 2019 is similar to 2013 and targets are not being met. This is not to imply that Safe Systems doesn't work, but rather, it is certainly not achieving the objectives it is intended (or perhaps *promised*). A typical response to this situation is to blame the level of effort applied (often targeting elected officials). So, the response is to try harder (or 'double-down'). While this will (probably) work at least to some degree, it is unlikely to be sufficient. So, different approaches that are complementary are required as well.

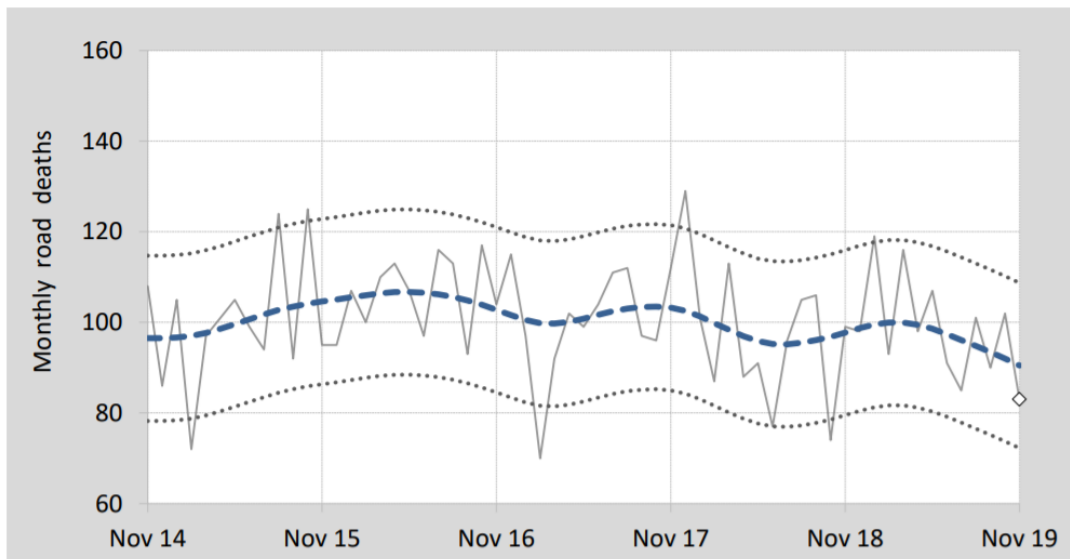
⁷ Due to the time it takes for strategies to be developed implemented and analysed, and confounding factors in the intervening period, researchers (such as Hauer and Wegman) find it almost impossible to demonstrate that road safety strategies are successful.

⁸ Hughes, B.P., Anund, A., & Falkmer, T. (2015). *System theory and safety models in Swedish, UK, Dutch and Australian road safety strategies*. Accident Analysis and Prevention, 74, 271-278.

⁹ ITF (2016). *Road Safety Annual Report 2016*. International Transport Forum (ITF), OECD, Paris.

¹⁰ BITRE (2019). *Road Deaths in Australia*, November 2019, Canberra.

Australian Monthly road deaths – last five years with trend and error bounds



The future is difficult and unpredictable

Our future society and business environment and practices continue to become more unpredictable and difficult to manage. There are several commonly occurring themes regarding future conditions that road safety doesn't take account of:

- 'disruptions' including
 - new technologies (electronic, information, electric, nano-tech, etc) that are increasing automation, equity and accessibility and reducing cost (as has occurred in previous industry revolutions),
 - social changes (generational differences, aging population, changing lifestyles or expectations, etc.),
 - new business models (sharing economy, cryptocurrency, big data and analysis); and
- the world continues to become more volatile, uncertain, complex and ambiguous (VUCA, apparently first coined by the US military during the Cold War).

Road safety strategies are dated and backward looking. Think about it: collect 5 years of data; wait for a year for it to be finalised, cleaned, validated and analysed; take 2 years to develop a strategy, a year for planning and implementation before starting, and another 3 years before more data collection, cleaning, validation and analysis, before we find out if we might have been successful. How many external influencing and confounding factors have changed over that time? The same is true when new countermeasures are implemented and tested. The International Transport Forum (2015)¹¹ and the International Traffic Safety Data and Analysis Group (IRTAD)¹² found that two-thirds of the improvement in road safety in Europe between 2008 and 2010 (which were celebrated at the time), were likely due to the economic downturn¹³. **Australia has generally failed to understand these issues relying too much on opinion and conjecture, rather than good science, hard information and thorough analysis.**

¹¹ ITF (2015). *Why Does Road Safety Improve When Economic Times Are Hard?* .ITF), OECD, Paris.

¹² e.g. Infometrics (2013). *Econometric Analysis of the Downward Trend in Road Fatalities since 1990*. Report for MoT New Zealand.

¹³ ITF (2018). *Road Safety Annual Report 2018*. International Transport Forum (ITF), OECD, Paris.

Oversimplification

Legend:

- Driver error
- Behaviour and inexperience
- Impairments and distractions
- Injudicious action
- Pedestrian error
- Road environment
- Vision affected by
- Vehicle
- Other

Error Type	Contributing Factor	Number of Deaths
Driver error	Failed to look properly	42,189
Driver error	Poor turn or manoeuvre	15,560
Driver error	Loss of control	12,151
Driver error	Failed to judge other person's path or speed	21,211
Driver error	Sudden braking	6,264
Driver error	Swerved	3,439
Driver error	Following too close	6,040
Driver error	Exceeding speed limit	5,102
Driver error	Junction overshoot	2,290
Driver error	Other	2,447
Driver error	Failed to judge vehicle's path/speed	2,785
Driver error	Distraction in vehicle	2,886
Driver error	Illness or disability	2,240
Driver error	Impaired by alcohol	4,499
Driver error	Failed to look properly	8,687
Driver error	Careless, reckless or in a hurry	4,074
Driver error	Other	2,447
Driver error	Failed to judge vehicle's path/speed	2,785
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¹⁵ *Road Accidents in Britain* (2018). Data from UK Department of Transport.



There are two common responses to this dilemma of failure to meet our road safety objectives:

1. Try harder. While putting more effort into something normally brings some result, we should strongly **resist continuing to put effort into activities that are inefficient.**
2. Tweak the model. Surprisingly, the contemporary road safety management *frameworks* are based on philosophy and not proven scientific theory or holistic safety management. So we should strongly **resist continuing to put effort into activities that are ineffective.**

There is a need to do road safety differently, and avoid oversimplification; *“There is always an easy solution to every human problem - neat, plausible, and wrong”¹⁶*

This submission proposes a different response: *adopt systems-based safety management that has been proven to be successful in other hazardous industries.*

Improving road safety management

Reviews of Australasian and other road safety strategies^{14,17} confirm the descriptions above and highlight:

- a comprehensive application of systems approaches would expand the number of participants involved, the policy tools employed and other the parts of the systems that can be influenced to improve road safety; and
- road safety strategies do not take account of, and are therefore not prepared for future conditions.

Based on other inquiries and strategy development, it is likely that the Inquiry will be offered two overly simplistic solutions:

- ‘Vision Zero’ or ‘Safe Systems’; and
- more effort is required to applying traditional road safety techniques.

These both have some merit. But like every successful road safety intervention, they have a valuable but limited benefit – there are no silver bullets.

Because of the issues raised above,

- **continuing to manage road safety as has been done in the past is unlikely to achieve the improvements that are desired for the future;**
- **road safety is far more difficult, complicated and unpredictable than in the past; and**
- **safety critical industries have achieved greater safety improvement by applying systems approaches, which road safety should learn from.**

So,

- **new approaches are required to improve road safety;**
- **systems approaches, successfully applied in other safety critical industries, offer the best opportunity to improve road safety; and**
- **road safety can best be improved by adopting a comprehensive approach based on systems theory and successful practice.**

Thoroughly and diligently adopting systems approaches in road safety has the potential to significantly improve outcomes, as others have found in other fields of safety management. In

¹⁶ Attributed to H.L. Mencken (1927) https://en.wikiquote.org/wiki/H._L._Mencken.

¹⁷ A subsequent study of US Strategic Highway Safety Plans (SHSP's), submitted for publishing, provides very similar results.



particular, applying systems approaches to road safety strategy, policy, planning and practice offers the opportunity to efficiently and effectively achieve the next reductions in road trauma that are necessary, but have become increasingly elusive recently.

Appendix 1 to this submission provides a thorough introduction and summary of a comprehensive approach for your consideration. The framework covers objectives, principles, components, countermeasures, participants, processes and interrelationships. The research indicates that **all this is required to properly manage road safety**, as other safety critical industries have found and applied. Appendix 2 is a copy of research that describes weaknesses in Australasian road safety strategies and how they can be strengthened to more thoroughly reflect systems approaches and be relevant to different future contexts.

While the approach provided is extensive, a complex system such as road safety requires comprehensive management. The approach can be scaled and adapted to suit national, county or sectoral perspectives (such as towns, highways, trucks, vulnerable road users or demand management). Essentially the approach ensures:

- the **purpose** (targets, aims or objectives) are clear are proper;
- all the relevant **participants** who contribute to the outcomes are involved;
- there are clear **principles** to guide participants' involvement;
- robust **processes** occur for the development, choice and implementation of interventions;
- all the most appropriate **policy tools** are applied (incentives, disincentives and influence);
- all **parts** of the systems are considered and managed (including but not limited to road users, vehicles and road infrastructure); and
- the above aspects are integrated in **partnership** to maximise synergies and minimise undesirable negative consequences.

Examples and further information

It is beyond this introduction to provide many examples of how systems approaches can be applied to road safety. However, a few simple examples are provided at the end of the Appendix 1. This submission is based on years of research by many authors in various fields, but their conclusions are extremely consistent and coherent. The attached summary and PhD thesis¹⁸ referred to provide comprehensive and thorough background, information and analysis with examples.

Nevertheless, the specific countermeasures are suggested for inclusion in the new strategy:

1. Ensure the new strategy thoroughly applies systems-based approaches of safety management.
2. Train road safety professionals in system-based safety.
3. Ensure that every road safety program explicitly considers and applies complementary actions by other participants to ensure integration and complementary efficiency.
4. Improve vehicle standards:
 - a) Introduce improved mandatory safety features,
 - b) Aim for 4 star crash rated cars. 3 star should be the legal minimum,
 - c) Introduce zero blind spots for trucks, as London is doing. This can be achieved with mirrors and cameras.

¹⁸ <https://espace.curtin.edu.au/bitstream/handle/20.500.11937/59647/Hughes%20B%202017.pdf?>



5. Commence in-depth crash investigation to understand more detailed causes and contributors to crashes. This occurs in other countries and in all hazardous industries.
6. Improve driving capability, not just vehicle control skills to pass a test.
7. Improve and rigorously apply road safety standards.
8. Adopt and apply the concept of 'Safety Culture' for all participants.
9. Trial voluntary, community led, incentive and education schemes, such as "Bucks for Buckles".
10. Enforce "Chain of Responsibility" legislation.
11. Incentivise training for professionals, employers, industries, road users and the general public.
12. Involve road safety professionals employed in land use planning with land use planning required to include road safety assessments.
13. Deploy point-to-point speed enforcement on all highways leading from cities within one day's drive.

Conclusion

Road safety is a **complex** topic.

There are millions of road users operating millions of vehicles, travelling billions of kilometres on thousands of kilometres of roads all requiring integrated and robust management.

We have relatively unskilled operators driving vehicles that could be safer on roads that could be better in a complex, uncertain, changeable and unpredictable environment.

Too many people, including professionals and officials, will provide simple answers that are inadequate.

Road safety isn't rocket science – it's far more complex than that¹⁹.

Therefore,

- ❖ **new approaches are required to improve road safety;**
- ❖ **systems approaches, that have been successfully applied in other safety critical industries, offer the best opportunity to improve road safety; and**
- ❖ **road safety can best be improved by adopting a new comprehensive, systems-based approach.**

Thoroughly and diligently adopting systems approaches in road safety has the potential to significantly improve outcomes, as others have found in other fields of safety management. In particular, applying systems approaches to road safety strategy, policy, planning and practice offers the opportunity to efficiently and effectively achieve the next reductions in road trauma that are necessary, but have become increasingly elusive recently.

I'll be pleased to provide more information or discuss with you further, if I can help at any time.

¹⁹ There are only about 2.5 million components in the space shuttle and about 3 million parts in a Saturn V rocket. The aerospace environment is far more predictable, all participants are highly skilled and operations are far more controllable.

Appendix 1

Applying a ***P7 Approach*** to Road Safety Strategies

Applying a **P7 Approach** to Road Safety Strategies

We know the world is dramatically changing. While change has always occurred, it has continued to accelerate over many years. Our economic, social, environmental and political landscape¹ is becoming more and more volatile, uncertain, complex and ambiguous². Therefore:

We cannot solve the problems using the same kind of thinking we use when we created them.³

The present world is already different from the past, on which we've based our road safety policy analysis, strategies and planning. But the future will be even more different. We tend to look at problems from a historical perspective favouring what we know and can see from the past, and how we have previously responded to challenges. Unfortunately, this approach stifles innovation and doesn't work in complex systems or when circumstances change unexpectedly.

In short: theories, models, philosophies, and methods stemming from an earlier era of scientific thought and developed for simpler, mostly physical systems are largely inapplicable for a mind, a society, an economy, or an ecosystem.

Unfortunately, by far the usual practice is for people to apply the simplest possible interpretations to complex situations.⁴

or simply:

What got us here won't get us there.⁵

In the past, governments and their agencies could act successfully in glorious isolation. Now, nearly everything is connected to everything else. But agencies still operate, and policy tools are applied, independently. But it doesn't work well anymore, because doing so loses synergies and creates undesirable consequences. Additionally, we're quite good at **tactical** and **operational** change, not so good at **strategic** change and awful at **systemic** or **structural** change. So, **we need new integrated and holistic ways of tackling problems and delivering solutions.**

Road safety strategies worldwide are characterised by historical perspectives and analysis of the situation. They universally rely on engineering, enforcement and engineering countermeasures applied to drivers, vehicles and roads. However, this reductionist and simplistic approach is nearly a hundred years old. It does not recognise other countermeasures, factors or influences affecting road safety outcomes. So, our traditional road safety strategies approaches cannot respond to future challenges such as social, technological, business and political changes that are continually occurring and accelerating. The current Safe Systems approach⁶ represents an initial example of applying some aspects of systems thinking, but there is much more than can be done based on systems theory. Current road safety strategies do not thoroughly incorporate contemporary safety management techniques that have been successfully applied in other high risk operations such as aviation, or hazardous industries. In order for road safety to continue to improve, **systems approaches offer a great opportunity for the next 'step change' to improve strategy, policy, planning and practice in road safety.**

¹ PESTLE – e.g. www.pestleanalysis.com/what-is-pest-analysis.

² VUCA – e.g. Bennett, N., & Lemoine, G.J. (2014). What VUCA really means for you. *Harvard Business Review*, and Solomon, L.K. & Ertel, C. (2014). Leadership in a VUCA world: Design strategic conversations to accelerate change. *Leadership Excellence Essentials*.

³ Attributed, probably wrongly, to Einstein.

⁴ De Greene, K. (Ed.). (1993). *A systems-based approach to policymaking*. Boston, MA: Kluwer Academic.

⁵ Goldsmith, M. (2007). *What got you here won't get you there: How successful people become even more successful*. New York, NY: Hyperion.

⁶ ATC (2011). *National Road Safety Strategy 2011-2020*. Canberra, Australia: Australian Transport Council.

Systems Approaches

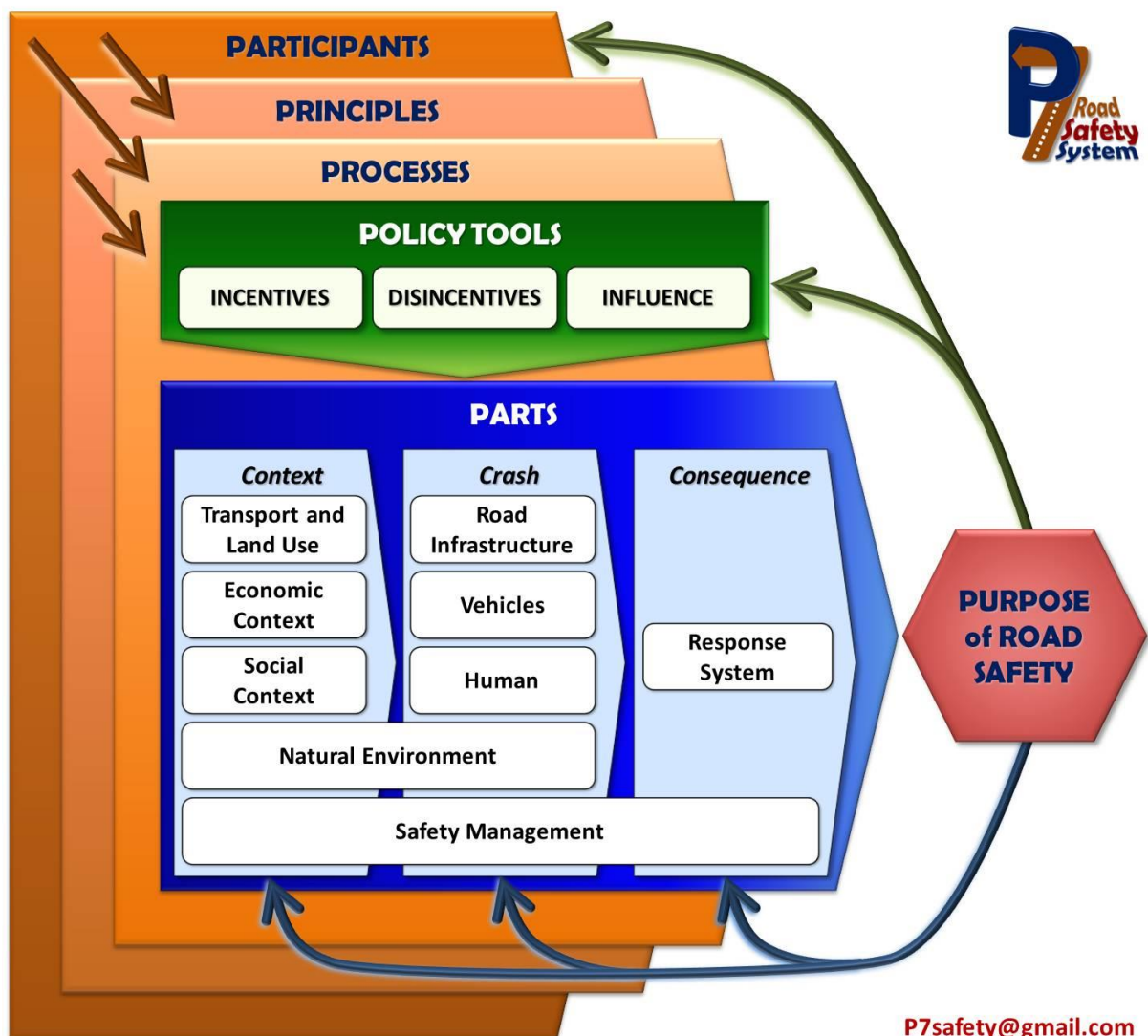
Systems approaches developed from a thorough theoretical and practical basis, justified research and evidence from successful practice to address complex systems, circumstances and issues. A socio-technical system can be defined as:

an interacting combination, at any level of complexity, of people, materials, tools, machines, software, facilities, and procedures designed to work together for some common purpose.⁷

This **Systems Approach** applied to road safety is summarised and shown diagrammatically below⁸.

A fundamental characteristic of systems is that the outcome being achieved is greater than the sum of the individual Participants, Policy Tools or Parts of the system operating in isolation. **Systems approaches** maximise the positive and complementary interactions, and minimise the negative or contradictory interactions. Applications of systems theory requires:

understanding the system as a whole and the interaction between its elements, and identifying where there is potential for intervention⁹.



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⁷ Chapanis, A. (1996). *Human factors in system engineering*. New York, NY: John Wiley and Sons.

⁸ Hughes, B. (2017). [A Comprehensive Framework for Future Road Safety Strategies](#). PhD Thesis, Curtin University (click to download).

⁹ Peden et al. (2004). *World health report on road traffic injury prevention*. Geneva, Switzerland: World Health Organization.

The P7 Approach for Road Safety Strategies

The essential constructs of the systems approach for road safety strategies include:

- **Purpose** – a clear statement of the objective (or outcomes), which can also relate to its measurement, estimation, forecasting or setting of a target (realistic, aspirational, etc.).
- **Participants** – all individuals and groups who can affect the system.
- **Principles** – a broad way of behaving that is expected to be followed, or guidance for action.
- **Parts** – components of the system including the wider transport and land use systems, social and economic factors, roads and other infrastructure, vehicles of all types, drivers, operators and other users, crash responses, information, policies, physical environment, safety management, and research, etc.
- **Policy Tools** – the actions that Participants apply to the Parts of the system to achieve the Purpose.
- **Partnerships** – relationships or interactions between Parts of the system, Participants and Policy Tools.
- **Processes** – a toolkit of techniques for management, strategic planning, research, assessment, policy/program/project development, implementation, delivery, evaluation, monitoring and reporting, etc.

Unfortunately, especially in a world of complexity, for every difficult problem:

There is always an easy solution to every human problem - neat, plausible, and wrong.¹⁰

There is a risk of overly simplifying problems and their solutions. Unless a comprehensive **systems approach** is taken, there is a risk that the best possible outcomes will not be achieved most cost efficiently.

A further complication of complex systems is that they have multiple purposes, which is especially true for Government. **Systems approaches** have been identified as relevant for Governments:

public services should be understood as complex adaptive systems, and not according to the mechanistic models that have traditionally dominated government thinking.

So, Governments should:

focus on the skills needed to deal with social complexity, in order to achieve high levels of systems thinking and a basic understanding of behavioural change."

Systems approaches have strong theoretical¹², research and practical foundations. With a diverse history in biology and electronics, it has been successfully applied in several relevant fields, such as safety, reliability engineering and information technology, but not in government policy, planning and service delivery. So, if it was applied to these activities we might say:

Participants use processes based on principles to apply policy tools to affect contributing parts, in order to achieve a purpose (economic, social and environmental improvement). These all occur in complex interdependent partnerships or influences of change within the system.

¹⁰ Attributed to H.L. Mencken (1927) https://en.wikiquote.org/wiki/H._L._Mencken.

¹¹ APSC (2007). *Tackling wicked problems: A public policy perspective*. Canberra, Australia: Australian Public Service Commission (APSC), Australian Government.

¹² Leveson, N.G. (2011a). *Engineering a safer world: Systems thinking applied to safety*. Cambridge, MA: Massachusetts Institute of Technology, and Von Bertalanffy, L. (1968). *General system theory: Foundations, development, applications*. Harmondsworth, UK: Braziller, Inc.

Underpinning the framework is considerably more detail¹³ that describes a multitude of potentially relevant Parts of the system, Policy Tools, Participants and Processes that should at least be considered in road safety, strategy, policy, planning and practice.

A '**safe system**' might therefore be described as '**the optimal interacting combination of participants, policy tools, parts and processes to minimise road trauma.**'

Many existing and emerging problems are more intractable (perhaps 'wicked'⁹) than ever before. So, simple solutions often don't work well now – and they certainly won't be effective in future. In other cases, the simple solutions have been successfully applied, but more complex and difficult solutions are required. In other words, we've nearly shot all the 'silver bullets', so we need to create and apply new approaches. Applying **systems approaches** can improve understanding and consideration of the whole subject, providing a deeper knowledge on how dynamic, complex, interconnected behaviour contributes to road safety outcomes.¹⁴

Purpose

If outcomes are the beneficial or adverse consequences of a system when it is functioning, or something of value that is produced or as a result, then a system's Purpose is simply the desirable outcomes that are intended to be achieved. In systems, every Part of the system makes a contribution to achieving the outcomes, and the outcomes of the system are greater than the individual parts operating independently. Therefore, failure or suboptimal performance of any individual Parts of the system reduces the best Purpose of the whole system being achieved.

While the Purpose of road safety is straightforward in principle (to reduce road trauma), the practical description becomes much more problematic¹⁵. Road trauma can be measured in terms of people killed and seriously injured (KSI's, economic costs or simply crashes according to different levels of severity). All of these can be measured in absolute numbers, but ratios (e.g. number per capita) can be much more useful for comparisons between jurisdictions and takes account of at least one macro-economic factor (population change).

As for other uses in organisations and operations, performance measures are useful for monitoring, assessing progress and managing people, resources and processes. Modern contemporary road safety strategies describe 'targets', such as expected reductions over time, or 'zero harm' as a longer term aspirational objective. **Systems approaches** aim to apply targets to increase the efficiency and effectiveness of road safety policies, programmes and projects to improve road safety performance. It is wrong to assume that "*if you can't measure it, you can't manage it*" (a costly myth according to Deming¹⁶), so quantitative performance assessment is valuable, but it is not sufficient and should be in conjunction with qualitative performance assessment.

Traditional analytical techniques such as quantitative modelling can be useful for measuring performance as described. However, analysis to determine system performance or its management is more difficult. New performance assessment techniques are required to take account of the systems nature of road safety, particularly interconnections between Parts of the system, Participants or Policy Tools. Such performance measurement may also require new and different analytical techniques, such as system dynamics, to more usefully inform the management of road safety systems.

¹³ The nine components in the systems framework for road safety contain 75 subcomponents.

¹⁴ Underwood, P. & Waterson, P. (2013). Systemic accident analysis: Examining the gap between research and practice. *Accident Analysis and Prevention*, 55, 154-164.

¹⁵ Hughes, B.P., Hopkins, S. (2011). *Outcomes-based national road safety performance measures*. Proceedings of Australasian College of Road Safety Conference³, Melbourne, Australia.

¹⁶ Deming, W.E. (1994) p35. *The New Economics*. Cambridge, MA: Massachusetts Institute of Technology.

Parts

Transport planners, policy makers and others involved in managing transport systems readily relate to vehicles, infrastructure, drivers and other users as the key tangible Parts of the system. In systems theory, a Part is any subordinate part of the system that is essential to contributing to the outcome or Purpose. Traditionally in road safety, Parts of the system are limited to drivers, vehicles and roads (sometimes road infrastructure or the road environment). However, it has been demonstrated over a long period of time that other Parts of the system are equally significant in achieving outcomes, including some that are less tangible and not necessarily physical. These broader Parts of the system include the Transport and Land Use Context, Economic Context, Social Context, Natural Environment, Vehicles, Human, Infrastructure, Response System and Transport Management. Both the social system and economic factors have been identified as contributing factors earlier¹⁷, but are not commonly included in road safety research, analysis or strategies. Each of these groups of Parts have considerable detail, as illustrated in Attachment 1, which describes the sub-parts that apply to road safety.

Thoroughly employing **systems approaches** to achieving road safety objectives ensures that any and all of the Parts of the system and sub-parts that can be applied to improve outcomes are properly managed.

Policy Tools

While there is considerable literature on processes for policy development and analysis of policies, there is little information on the variety of Policy Tools that could be applied. This can lead to narrow perspectives if policy developers do not have appreciation of a wide range of instruments that governments can apply in order to achieve outcomes. They simply don't know all the 'tools' that are available in the 'toolbox'. The following arrangement for the complete range of potential Policy Tools available to governments that can be applied to road safety, was developed based on theoretical background¹⁸, research and practice¹⁹. A more comprehensive list, with 16 sub-tools, is provided in Attachment 2.

INCENTIVES	DISINCENTIVES	INFLUENCE
Funding & investment (increased volume or deployment) Financial incentives, pricing & subsidies	Regulation, enforcement, penalties & sanctions Taxes, fees, levies & charges	Leadership, integration, implementation & participation Standards & guidelines (voluntary) Behaviour change (education, information, awareness) Skills, expertise, capability & professional practice Industry change, competition & consumer choice Innovation & research (new information & techniques)

¹⁷ e.g. Haddon, W. (1980). Options for the prevention of motor vehicle crash injury. *Israel Journal of Medical Sciences*, 16(1), 45-65.

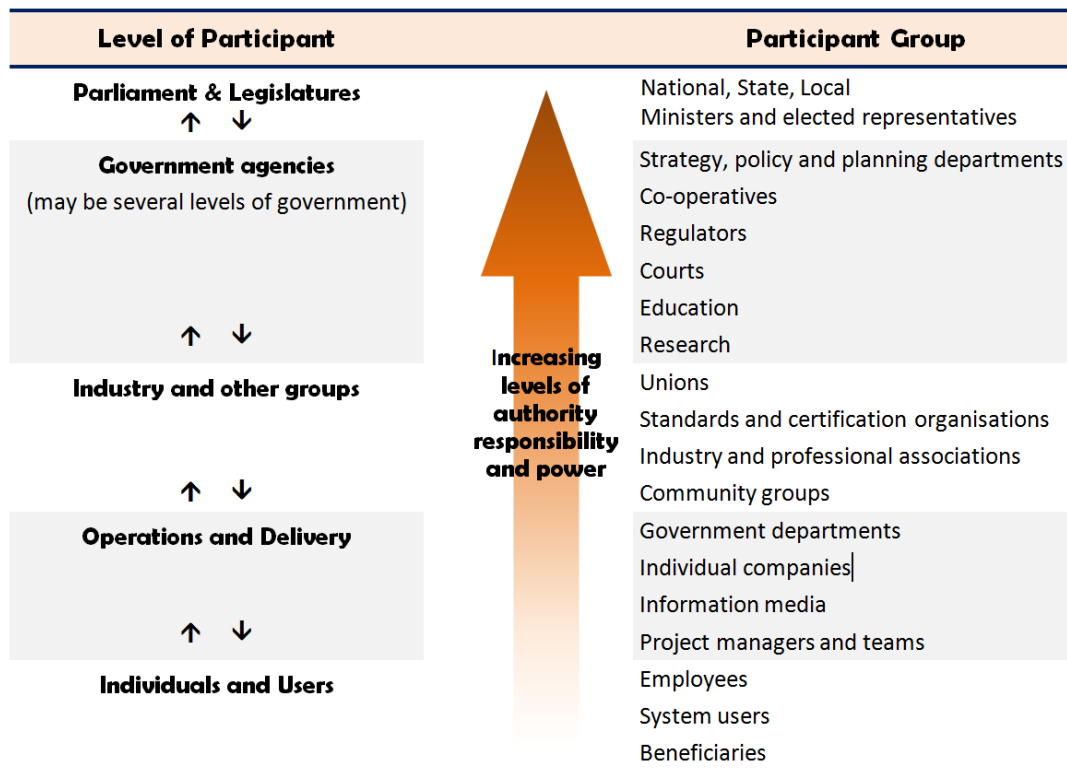
¹⁸ e.g. Vedung, E. (2003). Policy instruments: Typologies and theories. In: Bemelmans-Videc, M-L., Rist, R.C., & Vedung, E. (Eds), *Carrots, sticks and sermons*. New Brunswick, NJ: Transaction Publishers.

¹⁹ Hughes, B. (2017). [A Comprehensive Framework for Future Road Safety Strategies](#). PhD Thesis, Curtin University ([click to download](#)).

Participants

A Participant²⁰ is any individual or entity that has the capability to affect outcomes, including government, agency, association, company or individual person. Sometimes, Participants are categorised as customers, users or stakeholders. Participants vary according to levels *authority*, *responsibility* and *power*, as summarised in the following diagram. To manage the most important, the different characteristics of Participants needs to be taken into account; positive or negative, active or passive, strong or weak, many or few, skilled, knowledgeable, experienced or influential.

Systems approaches recognise the importance of the roles and impacts of all relevant Participants, so that their contribution and benefits can be maximised and their negative effects and disadvantages are minimised. Participants can complement the Purpose or detract with it, being either conflicting or competitive. Other Participants who are passive may be activated to become either positive or negative depending on the motivation.



The Mendelow Matrix²¹ is a common way of characterising Participants in business, as shown in the following diagram.

		Level of Interest or Engagement	
Influence or Power	High	Meet their needs, Keep satisfied	Key Participant, Engage closely
	Low	Least Important, Minimise effort	Show consideration, Keep informed
		Low	High

²⁰ In systems theory, literature and practice, 'participants' are normally called 'actors'.

²¹ Mendelow, A. (1991). 'Stakeholder Mapping', Proceedings of the 2nd International Conference on Information Systems, Cambridge, MA.

Partnerships

A fundamentally important characteristic of systems is that the outcome being achieved is greater than the sum of the individual Participants, Policy Tools or Parts of the system operating in isolation. The object of applying **systems approaches** is to maximise the positive and complementary interactions and minimise the negative or contradictory interactions.

The Partnerships between Participants, Policy Tools or Parts of the system are integral to the success of systems. Positive interactions (interdependent and complementary) are fundamental to a system achieving its Purpose. Negative interactions (independent or conflicting) may exist, but are inconsistent with a system achieving its Purpose. Partnerships are recognised as an essential element of the systems, but are often complex to describe. **Systems approaches** recognise and maximise the positive interactions, but may not always recognise negative interactions that also require management. This can be especially important in road safety where 'push back' can occur through community responses or individual's psychological responses.

Principles

Principles for safety management are a broad way of behaving that are expected to be followed or guidance for action, that reflect, or are reflected in, values, beliefs, norms, and other actions in an organisation²², and are acknowledged as being important to guide decision making and actions.

Principles that Participants use in developing road safety strategies are diverse, however leading road safety strategies include principles similar to those described by OECD/ITF²³:

- *People make mistakes that can lead to road crashes.*
- *The human body has a limited physical ability to tolerate crash forces before harm occurs.*
- *A shared responsibility exists amongst those who design, build, manage and use roads and vehicles and provide post-crash care to prevent crashes resulting in serious injury or death.*
- *All parts of the system must be strengthened to multiply their effects; and if one part fails, road users are still protected.*

Processes

Processes are complementary activities to achieve an outcome. Since time occurs in one direction, processes often occur linearly and sequentially. However, different activities in Processes can occur simultaneously. Processes occur in many situations in order to achieve road safety outcomes including management, research, policy deployment and implementation²⁴. Processes relevant to road safety include strategic planning, risk analysis, behaviour change, culture change, project management, engineering design, performance monitoring and evaluation, and so on.

It is important to appropriately apply any and all relevant Processes in order to efficiently and effectively achieve the system's Purpose. However, the management of Partnerships between Participants is particularly important. Collaboration is essential in complex systems and/or when dealing with complex problems that have multiple Parts, Participants and Partnerships or interactions.

²² Hine, D.W., Lewko, J., & Blanco, J. (1999). Alignment to workplace safety principles: An application to mining. *Journal of Safety Research*, 30(3), 173-185.

²³ OECD/ITF (2016, p26). *Zero road deaths and serious injuries: Leading a paradigm shift to a safe system*. Paris: International Transport Forum (ITF), OECD.

²⁴ Hughes, B. (2017). [A Comprehensive Framework for Future Road Safety Strategies](#). PhD Thesis, Curtin University ([click to download](#)).

While getting several Participants to work together to achieve an outcome sounds obviously necessary, it is often not easy and can require considerable skill and effort. However, not doing so risks the outcomes not being achieved. People and organisations have individual information, perceptions, beliefs, values, and culture. These can lead to many attitudes, such as bias, defence or enthusiasm resulting in either positive or negative behaviours that affect the system's Purpose, or otherwise passivity. There is a rich body of literature, describing many techniques about communications, cooperation, collaboration and behaviour change processes for individuals and organisations. Successfully applying **systems approaches** requires thorough application of Processes to manage Participants' interactions while maintaining a clear focus on the system's Purpose.

Next Steps

The analysis and evidence describes that all safety critical industries moved on from the human-machine-environmental view of safety about 30 years ago following a series of catastrophic 'accidents' (Piper Alpha, Challenger, Bhopal, etc). These disasters occurred due to system failures, not one individual person, equipment or operating environment fault that could be treated in isolation. These industries recognised that complex systems require systematic risk management, not reactionary and tactical responses in isolation. These industries started to adopt systems approaches that had an extensive history in aviation, IT and resilience engineering. Road safety started to move in that direction, especially some early examples, so current road safety strategies reflect some systems principles, but not yet very thoroughly.

Ever since road safety emerged as an issue with early cars, there have been various narratives or underlying philosophies describing the approach at the time. However the practical application is education, enforcement and engineering applied to drivers, vehicles and roads; an approach unchanged for over 80 years. Furthermore, all road safety strategies are backward looking and based on historical analysis and longstanding techniques. The future changes to technology (e.g. automation), new types of business (e.g. Uber) or user preferences (public transport over cars) aren't taken account of. Despite a modern narrative, the vast majority of road safety actions in all road safety strategies worldwide are driver education and enforcement, and road engineering. The easy wins in road safety have been achieved, so now we need to move along the more difficult safety systems path.

The proven, practical way to improve road safety then is:

1. Adopt a comprehensive safety management approach based on systems theory and practice in other domains.
2. Use more robust processes to apply a broader range of policy tools to more of the different parts of the road safety system on collaboration with other participants.
3. Adopt concepts, tools and techniques that have successfully been applied in other safety critical industries including safety culture, detailed crash analysis and robust safety management processes.
4. Take a forward looking view to the future circumstances.

Conclusions

Thoroughly applying **systems approaches** offers the potential to significantly improve emerging, contemporary and intractable problems that can't be solved by simple solutions. Doing so can overcome barriers and provide multifaceted and multisectoral solutions via collaborative partnerships, built on synergies focussed on achieving holistic and integrated outcomes.

This framework highlights opportunities to apply techniques from other safety domains that have been found to be effective including: Safety Management Systems, thorough risk management, safety culture, safety case, economic incentives, subsidies, industry change, holistic policy integration and collaborative participation, as well as new analytical techniques like systems dynamics, scenario planning and real options analysis.

Applying the **P7 Approach** offers the opportunity to efficiently and effectively achieve the next improvements to road safety that are necessary, but have become increasingly elusive recently. The framework can potentially be used in many different ways, yet to emerge or be explored. It could be used as a guide for developing road safety strategies as a whole or for individual countermeasures. The lists of Participants, Policy Tools and Parts can be used as a checklist for strategies, policies, standards or research, as well as countermeasure design and implementation. Based on this framework, some examples of applying the **P7 Approach** in road safety are described in Attachment 3.

It's obviously not easy, but thoroughly and diligently applying the **P7 Approach** to road safety strategy, policy, planning and practice has the potential to significantly improve outcomes, as others have found in other fields of safety management. We certainly need much more holistic, efficient and effective ways of operating than our traditional practice.

The original research can be downloaded [from Curtin University Library here](#). For further information, questions or comments, please contact Brett Hughes,

So that others may learn, and even more may live. (M Bromiley)

Dr Brett Hughes

Attachment 1 - Details of Parts of the system

SYSTEM PART	SUB-PART DESCRIPTION
Transport and Land Use Context	<p>Transport alternatives, other modes, company operations</p> <p>Spatial arrangement, co-location</p> <p>Accessibility - remoteness, location, service levels</p> <p>Transport integration</p>
Economic Context	<p>Economics, finance, funding</p> <p>Population, employment structure</p> <p>Environment, energy, climate change</p> <p>Legal - regulation, liability, privacy, insurance, courts, corrections</p>
Social Context	<p>Politics and government</p> <p>Law - role and response</p> <p>Social norms, nurture, background, traditions, rituals</p> <p>Ethnic practices</p> <p>Spiritual beliefs</p> <p>Literacy, intellect, education</p> <p>Employment - practices, demands, restrictions</p> <p>Activities, travel purposes</p>
Natural Environment	<p>Daylight, dawn, dusk, night, sun</p> <p>Weather and atmospheric conditions - rain, fog, snow, smoke, wind, temperature</p> <p>Adjacent environment - topography, trees, grass, water</p> <p>Wildlife</p>
Road Infrastructure	<p>Surface - friction, colour, smoothness, cracks, edges, shoulders, unsealed, pothole, concrete asphalt, seal, manhole, drain, repair, cycle facility, drainage, grit, spills, footpaths</p> <p>- wet, dry, snow, ice, other</p> <p>Geometry - alignment geometry, curve, crest, dip, gradient, level, lanes, crossfall, physical dimensions, dual carriageway, passing lane, shoulder, median</p> <p>Signs, regulatory, advisory, pavement marking, signal, manned, speed limits, active/passive, reflectors, colour, illumination, reflectivity, access control, street design, bus lanes, roadworks</p> <p>Lighting - roadway, features and adjacent</p> <p>Obstacles - pylons, gutter, kerb, culvert, bridge, pole, other street furniture, safety barrier, tunnel, building, overpass, tree, bus facilities</p> <p>Intersection type - intersection, junction, roundabout, grade separation, merge, railway crossing, crosswalk or crossing point, angled, pedestrian crossing, island</p> <p>Road type - freeway, highway, city street, residential, rural, bridge, tunnel</p> <p>Miscellaneous - driveway, midblock, parked cars, stopped buses, lighting, glare, road debris, previous collision, landslides, work zones, tram / light rail</p> <p>Traffic volume, type, interaction</p> <p>Safety devices - guardrail, barrier, rest stop, fence, service area, route guidance, landslide protection</p> <p>Maintenance</p>

SYSTEM PART	SUB-PART DESCRIPTION
Human	<p>Participants - Driver, rider, passenger, witness, acquaintance, occupant, road workers</p> <p>Age and sex</p> <p>Impairment - alcohol, drugs, medicines, carbon monoxide, drowsiness, sleep, disablement (seizures, pain, blackouts, disabilities), fatigue</p> <p>Driving Process* - strategy, tactics, perception, alertness, reaction, attention, distraction, error correction, response to incidents and conditions</p> <p>Abilities - physical, vision, hearing, mental state, injury, illness, disability, health</p> <p>Capability - natural, learned, skill, intelligence, education, experience</p> <p>Attitude, motivation, demeanour, emotion, psychological state, behaviour</p> <p>Time (day, week, month, season), type of trip</p> <p>Capability - licence, restrictions</p> <p>Helmets, clothing and other protection</p> <p>Clothing - visibility, protection, interference</p>
Vehicles	<p>Type - car, truck, trailer, motorcycle, bicycle, bus, farm machinery, other</p> <p>Design*- standards, maintenance, damage, modifications, inspections</p> <p>Wheels and tyres* - size, type, tread, pressure, condition, chains</p> <p>Brakes*</p> <p>Controls*- steering, pedals, levers, switches</p> <p>Body type* and mass</p> <p>Seat belts, child restraints and other protection</p> <p>Lights*- external, internal, type, performance, colour, reflectors</p> <p>Cargo - type, characteristics, mass, strength, shape, hazardous</p> <p>Structure*- frame, doors, panels, safety features, crashworthiness, fittings, mirrors, mountings, flammability</p> <p>Suspension</p> <p>Engine, transmission, fuel type</p> <p>Instruments</p> <p>Electrical components and circuits</p> <p>Colour</p> <p>Glass - colour, type</p> <p>Movement - speed, direction, angle, acceleration, coasting, deceleration, turning, overtaking, reversing, force, vibration</p> <p>Liquids and fluids</p> <p>Type of impact - speed, angle, physical dimensions</p> <p>Active safety and other technology - Antilock brakes, electronic stability control, adaptive cruise control, speed control, etc.</p> <p><i>Note : * Generally applicable to motor vehicles, but may be applied to others</i></p>
Crash Response	<p>Emergency & rescue services</p> <p>Crash reporting and incident management</p> <p>Health treatment – first aid, emergency treatment, injury treatment, Rehabilitation, permanent care & adaptation</p>
Safety Management	<p>Risk Management - identification, assessment, countermeasures, revision</p> <p>Information - research, data, investigations, benchmarking</p> <p>Capability - skills, knowledge, experience, of all participants</p> <p>Capacity - financial, human, system, technology</p> <p>Systems - processes, structures, procedures, standards</p> <p>Integration - collaboration, coherence, synergy, co-ordination, optimisation</p> <p>Implementation - policy, planning, design, installation, maintenance, monitoring, revision</p> <p>Communication - content, contact, medium</p> <p>Culture - attitudes, beliefs, values, commitment</p>

Attachment 2 - Details of Policy Tools

POLICY TOOL	DESCRIPTION	EXAMPLE OF DETAILS
INCENTIVES		
Funding & investment	Application of finances to increase the amount of facilities, services, assets, product or level of deployment	Purchasing of vehicles, tools, systems and equipment, infrastructure investment, services delivery, deployment of staff, engineering production, maintenance and product delivery
Financial incentives, pricing & subsidies	Voluntary monetary or in-kind payments, costs and rewards to encourage desired behaviour or practice Financial transfers and cross subsidies	Inducements or rewards for good behaviors, or disincentives or penalties for poor behaviors Taxes and charges that provide road safety benefits (e.g. alcohol excise) Discounts for insurance and registration, payments to service providers
DISINCENTIVES		
Regulation, enforcement, penalties & sanctions	Activities to develop and apply a legislative authority	Legislation, rules, orders, enforcement, penalties, sanctions, mandatory application of standards
Taxes, fees, levies & charges	Financial charges applied to discourage undesirable behaviour or practice	Payments for costs incurred, fees to encourage behaviour change, levies to fund policy tools
INFLUENCE		
Leadership, integration, implementation & participation	Desktop, office, personal and relational activities regarding the planning and delivery of policies, programs and projects to optimise safety outcomes – excludes actual delivery of a policy	Leadership – advocacy, campaigning, general background information, strategic planning, development, assessment, selection of effective and efficient policies, programs and projects, outcomes monitoring Integration – coordination, optimisation, information exchange, output management Implementation – planning, programming, timing, impact assessment Participation – dialogue with stakeholders, negotiation, agreements, engagement
Behaviour change	Activities that encourage people to behave more safely – separate from, but may be linked to incentives, pricing, subsidies and regulatory mechanisms	Education, information, awareness, rational encouragement, individualised information, mass campaigns
Skills, expertise, capability & professional practice	Development of personal capacity, competency and fitness to undertake a task Development of professional skills and practice	Training, experience, knowledge, skilling Medical, physical and intellectual fitness for duty
Standards & guidelines	Voluntary application of written authoritative agreements or references with respect to design and practice	Formal and informal standards and guidelines for good practice – may be recommended, desirable or minimum
Industry change, competition & consumer choice	Application of strategic advantage to provide a market advantage – influences in markets that result in a desired outcome	Performance enhancement, lower costs, improved service, provision of market information (price, performance or quantity)
Innovation & research	Investigation and development of new information with respect to behaviour, practice, product or operations and initial deployment to prove and refine applicability	Basic and applied research, pilots, trials, evaluations, new general and specific information, continuous improvement

Attachment 3 – Examples of Applying Systems Approaches in Road Safety

Bucks for Buckles

Around 65 cities in Kansas, USA have participated in an annual campaign called 'Bucks for Buckles' for many years, which is innovative and proactive for several reasons:

1. the primary participants are members of the public, not the normal safety agencies,
2. there is complementary funding and authority support by the normal safety agencies, but their role is secondary,
3. the program is based on an 'incentive' rather than a punishment,
4. drivers who are found to be non-compliant are talked to by their peers, and
5. there is no direct enforcement.

Therefore, this program is different and demonstrates elements of a comprehensive and holistic systems approach because:

1. it is not a traditional driver education or enforcement program,
2. it involves different participants,
3. it is community and peer based, and
4. it is based on a positive incentive (or 'nudge' theory).

Speed Zoning

While speed is acknowledged as a key issue in road safety, it would be simplistic to presume that simply installing new speed signs with lower limits would achieve the desired purpose. Firstly, there may be different types of users; parents driving to the school, truck drivers from a transport depot around the corner or delivery riders on motorcycles from the fast food outlets. Direct engagement with these users via modern targeted behaviour change programs can contribute to safety improvement. Does the analysis suggest that the problem changes by time of day, such as at night time, or school hours? Can the road environment be changed to demonstrate to drivers what appropriate speed is, by making an attractive, active slow speed environment (not just by 'hard' traffic calming?). Finally, what role can enforcement play? I say finally, because enforcement is often short lived, inefficient, costly and resented by drivers. So, employing more effective measures in collaboration with participants can lead to more sustainable outcomes at lower cost, leaving enforcement as a last resort, not a first ineffective and inefficient response.

Safety culture

Other hazardous industries, including aviation and railways, have embraced 'safety culture' as a core concept in improving safety. Safety culture; the underlying nature of an organisation's approach to safety, is a mature safety management concept with proven results. However, the concept is almost completely absent in road safety. Impatience, not using indicators, not keeping left, tailgating, roadworkers speeding through roadworks, etc. are all common indicators of poor attitudes, or road safety culture. The safety culture approach aims to change people's understanding and rationale for their actions, rather than enforce compliance with rules and regulations. The unwillingness of elected representatives, managers or decision making to prioritise road safety is representative of poor corporate safety culture. Applying a systems approach would describe participants' Partnerships with each other and the related parts of the system, to inform which of them and their behaviours are most significant and therefore warrant the most attention in changing. Describing the attitude and beliefs that drive the behaviours of these participants would then lead to prioritising the policy tools to employ to change behaviour that would best improve road safety¹.

¹ da Costa Canoquena, J.M. (2017). *Developing a Theoretical Framework for Improved Practical Application of a Coordinated Response in Road Safety*. PhD Thesis, Centre for Accident Research and Road Safety - Queensland (CARRS-Q).

Drugs and society

Salmon et al. (2017)² describe the application of systems approaches to investigate the emerging, but very complex problem of driving under the influence of either illicit or prescription drugs. Their example illustrates several system characteristics including appreciation of broad societal factors, application of multiple policy tools, complex feed-forward and feedback interactions, and more sophisticated analytical processes. These all need to be considered and appropriately included in order to inform the development, selection and prioritisation of policy tools operating together. In this example Salmon et al. describe that the wider context of social influences can result in greater adverse changes to road safety than the amount of improvement resulting from the road safety countermeasures. In this case, road safety effort increases, but road safety continues to degrade. The framework can contribute to such assessments by guiding the researcher regarding participants, policy tools and parts of the system that are involved in the particular subsystem that are being investigated, in the same way that the researchers apply in this example.

² Salmon, P., Hulme, A., Read, G., Thompson, J., & McClure, R. (2017). Rethinking the causes of road trauma: society's problems must share the blame. The Conversation. <http://theconversation.com/rethinking-the-causes-of-road-trauma-societysproblems-must-share-the-blame-82383>.

Appendix 2

The Relevance of Australasian Road Safety Strategies in a Future Context¹.

¹ Hughes, B.P., Anund, A., Falkmer, T. (2019). *The Relevance of Australasian Road Safety Strategies in a Future Context*. Journal of the Australasian College of Road Safety, February, pp 34-45.
(http://acrs.org.au/wp-content/uploads/JACRS_Vol30_Issue1_Feb2019.pdf)
Presented at the Australasian Road Safety Conference, Sydney Australia, October, 2018.

The Relevance of Australasian Road Safety Strategies in a Future Context

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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.

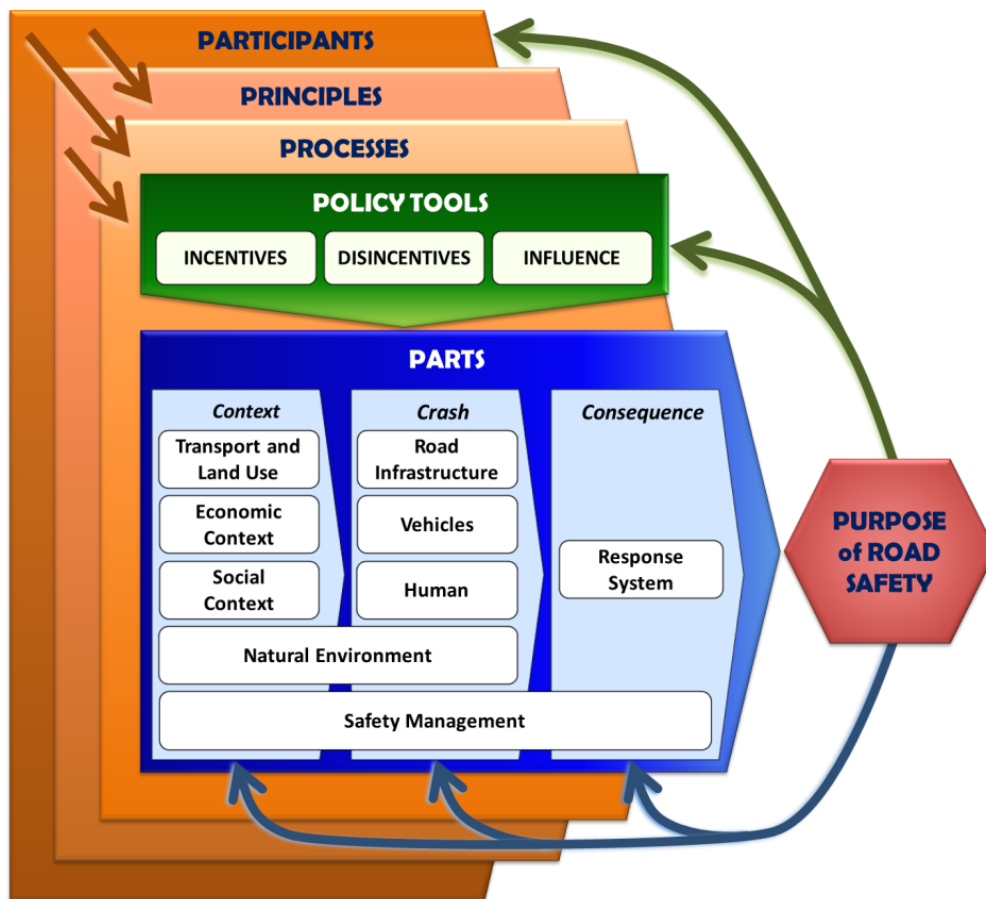


Figure 1. The 7P System framework for road safety management

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 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.

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		

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.	<i>Score 2:</i> goal, objective, target, aim, outcome (e.g. fatalities, serious injuries). <i>Higher score:</i> 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.	<i>Score 2:</i> engineering, enforcement, education. <i>Higher score:</i> 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.	<i>Score 2:</i> road users, vehicles, roads. <i>Higher score:</i> 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.	<i>Score 2:</i> police, road authority, licensing authority, road safety agency. <i>Higher score:</i> 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.	<i>Score 2:</i> common Safe Systems principles. <i>Higher score:</i> additional principles (e.g. innovation, administrative efficiency & effectiveness, resilience to future change, national consistency, practicability, operational & commercial efficiency & effectiveness).
6. Processes	A series of complementary activities to achieve an outcome.	<i>Score 2:</i> common processes mentioned (data analysis, safety management, research, strategic planning, project design/implement/ operate, communications, evaluation, etc.) <i>Higher score:</i> 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.	<i>Score: 2:</i> integrate, connect, interconnect, interact, synergy, complement, conflict, dependency, etc. <i>Higher score:</i> 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.	<i>Score: 2:</i> electronic, autonomous, automated, driverless, disrupt, big data, innovation, etc. <i>Higher score:</i> 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.	<i>Score: 2:</i> mobility-as-a-service, transport-as-a-service, market, business, demand, etc. <i>Higher score:</i> 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.	<i>Score: 2:</i> consumer, preference, choice, demand, etc. <i>Higher score:</i> 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.	<i>Score: 2:</i> volatile, uncertain, complex, ambiguous, scenario, future, etc. <i>Higher score:</i> broader description or greater level of detail.
5. Future situation assessment	Clear, accurate and considered appreciation of the future situation.	<i>Score: 2:</i> trend, context, estimate, future, forecast, model, economic/ social/ environmental context or effects, etc. <i>Higher score:</i> 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.	<table><caption>Frequency Distribution for Purpose</caption><thead><tr><th>Score</th><th>Frequency</th></tr></thead><tbody><tr><td>0</td><td>1</td></tr><tr><td>1</td><td>4</td></tr><tr><td>2</td><td>7</td></tr><tr><td>3</td><td>2</td></tr><tr><td>4</td><td>1</td></tr></tbody></table>	Score	Frequency	0	1	1	4	2	7	3	2	4	1
Score	Frequency													
0	1													
1	4													
2	7													
3	2													
4	1													
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.	<table><caption>Frequency Distribution for Policy Tools</caption><thead><tr><th>Score</th><th>Frequency</th></tr></thead><tbody><tr><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td></tr><tr><td>2</td><td>6</td></tr><tr><td>3</td><td>5</td></tr><tr><td>4</td><td>2</td></tr></tbody></table>	Score	Frequency	0	1	1	1	2	6	3	5	4	2
Score	Frequency													
0	1													
1	1													
2	6													
3	5													
4	2													
3. Parts Average Score: 2.3 Range: 2 to 4	Integrating with land use planning & active transport.	<table><caption>Frequency Distribution for Parts</caption><thead><tr><th>Score</th><th>Frequency</th></tr></thead><tbody><tr><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td></tr><tr><td>2</td><td>6</td></tr><tr><td>3</td><td>5</td></tr><tr><td>4</td><td>2</td></tr></tbody></table>	Score	Frequency	0	1	1	1	2	6	3	5	4	2
Score	Frequency													
0	1													
1	1													
2	6													
3	5													
4	2													
4. Participants Average Score: 1.7 Range: 0 to 3	Recognise wider stakeholders during consultation or implementation.	<table><caption>Frequency Distribution for Participants</caption><thead><tr><th>Score</th><th>Frequency</th></tr></thead><tbody><tr><td>0</td><td>3</td></tr><tr><td>1</td><td>4</td></tr><tr><td>2</td><td>2</td></tr><tr><td>3</td><td>5</td></tr><tr><td>4</td><td>1</td></tr></tbody></table>	Score	Frequency	0	3	1	4	2	2	3	5	4	1
Score	Frequency													
0	3													
1	4													
2	2													
3	5													
4	1													
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.	<table><caption>Frequency Distribution for Principles</caption><thead><tr><th>Score</th><th>Frequency</th></tr></thead><tbody><tr><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td></tr><tr><td>2</td><td>7</td></tr><tr><td>3</td><td>5</td></tr><tr><td>4</td><td>1</td></tr></tbody></table>	Score	Frequency	0	1	1	1	2	7	3	5	4	1
Score	Frequency													
0	1													
1	1													
2	7													
3	5													
4	1													
6. Processes Average Score: 1.7 Range: 0 to 3	Performance monitoring & management, investment decisions, governance, research, knowledge transfer (capability), innovation, evaluation. Impact analysis.	<table><caption>Frequency Distribution for Processes</caption><thead><tr><th>Score</th><th>Frequency</th></tr></thead><tbody><tr><td>0</td><td>2</td></tr><tr><td>1</td><td>5</td></tr><tr><td>2</td><td>3</td></tr><tr><td>3</td><td>4</td></tr><tr><td>4</td><td>1</td></tr></tbody></table>	Score	Frequency	0	2	1	5	2	3	3	4	4	1
Score	Frequency													
0	2													
1	5													
2	3													
3	4													
4	1													
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.	<table><caption>Frequency Distribution for Partnerships</caption><thead><tr><th>Score</th><th>Frequency</th></tr></thead><tbody><tr><td>0</td><td>3</td></tr><tr><td>1</td><td>5</td></tr><tr><td>2</td><td>4</td></tr><tr><td>3</td><td>2</td></tr><tr><td>4</td><td>1</td></tr></tbody></table>	Score	Frequency	0	3	1	5	2	4	3	2	4	1
Score	Frequency													
0	3													
1	5													
2	4													
3	2													
4	1													

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.	<table><caption>Frequency Distribution for New technologies</caption><thead><tr><th>Score</th><th>Frequency</th></tr></thead><tbody><tr><td>0</td><td>2</td></tr><tr><td>1</td><td>4</td></tr><tr><td>2</td><td>5</td></tr><tr><td>3</td><td>3</td></tr><tr><td>4</td><td>1</td></tr></tbody></table>	Score	Frequency	0	2	1	4	2	5	3	3	4	1
Score	Frequency													
0	2													
1	4													
2	5													
3	3													
4	1													
2. New markets and business models Average Score: 0 Range: 0		<table><caption>Frequency Distribution for New markets and business models</caption><thead><tr><th>Score</th><th>Frequency</th></tr></thead><tbody><tr><td>0</td><td>10</td></tr><tr><td>1</td><td>1</td></tr><tr><td>2</td><td>1</td></tr><tr><td>3</td><td>1</td></tr><tr><td>4</td><td>1</td></tr></tbody></table>	Score	Frequency	0	10	1	1	2	1	3	1	4	1
Score	Frequency													
0	10													
1	1													
2	1													
3	1													
4	1													
3. Different consumer demands Average Score: 0 Range: 0		<table><caption>Frequency Distribution for Different consumer demands</caption><thead><tr><th>Score</th><th>Frequency</th></tr></thead><tbody><tr><td>0</td><td>10</td></tr><tr><td>1</td><td>1</td></tr><tr><td>2</td><td>1</td></tr><tr><td>3</td><td>1</td></tr><tr><td>4</td><td>1</td></tr></tbody></table>	Score	Frequency	0	10	1	1	2	1	3	1	4	1
Score	Frequency													
0	10													
1	1													
2	1													
3	1													
4	1													
4. Nature of the future Average Score: 0.1 Range: 0 to 1		<table><caption>Frequency Distribution for Nature of the future</caption><thead><tr><th>Score</th><th>Frequency</th></tr></thead><tbody><tr><td>0</td><td>10</td></tr><tr><td>1</td><td>2</td></tr><tr><td>2</td><td>1</td></tr><tr><td>3</td><td>1</td></tr><tr><td>4</td><td>1</td></tr></tbody></table>	Score	Frequency	0	10	1	2	2	1	3	1	4	1
Score	Frequency													
0	10													
1	2													
2	1													
3	1													
4	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><caption>Frequency Distribution for Future situation assessment</caption><thead><tr><th>Score</th><th>Frequency</th></tr></thead><tbody><tr><td>0</td><td>7</td></tr><tr><td>1</td><td>2</td></tr><tr><td>2</td><td>3</td></tr><tr><td>3</td><td>2</td></tr><tr><td>4</td><td>1</td></tr></tbody></table>	Score	Frequency	0	7	1	2	2	3	3	2	4	1
Score	Frequency													
0	7													
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4	1													

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																																												
<div>7P System criteria</div> <div>Average Score: 1.97</div> <div>Range: 1.30 to 2.60</div>	<div>Average Score</div> <table><thead><tr><th>Criteria</th><th>Average Score</th></tr></thead><tbody><tr><td>Purpose</td><td>2.1</td></tr><tr><td>Policy Tools</td><td>2.9</td></tr><tr><td>Parts</td><td>2.6</td></tr><tr><td>Participants</td><td>2.0</td></tr><tr><td>Principles</td><td>2.7</td></tr><tr><td>Processes</td><td>2.0</td></tr><tr><td>Partnerships</td><td>1.6</td></tr></tbody></table>	Criteria	Average Score	Purpose	2.1	Policy Tools	2.9	Parts	2.6	Participants	2.0	Principles	2.7	Processes	2.0	Partnerships	1.6																												
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<div>Future Changes criteria</div> <div>Average Score: 0.52</div> <div>Range: 0 to 1.70</div>	<div>Average Score</div> <table><thead><tr><th>Criteria</th><th>Average Score</th></tr></thead><tbody><tr><td>New Technologies</td><td>2.1</td></tr><tr><td>New Markets & Business Models</td><td>0.2</td></tr><tr><td>Different Consumer Demands</td><td>0.2</td></tr><tr><td>Nature of the Future</td><td>0.2</td></tr><tr><td>Future Situation Assessment</td><td>1.1</td></tr></tbody></table>	Criteria	Average Score	New Technologies	2.1	New Markets & Business Models	0.2	Different Consumer Demands	0.2	Nature of the Future	0.2	Future Situation Assessment	1.1																																
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<div>All 12 criteria</div> <div>Average Score: 1.37</div> <div>Range: 0.58 to 1.92</div> <div>Score for each strategy</div>	<div>Average Score</div> <div><div>7P System Criteria Average Score</div><div>Future Changes Criteria Average Score</div><div>Total Average Score</div></div> <table><thead><tr><th>Strategy</th><th>7P System Criteria Average Score</th><th>Future Changes Criteria Average Score</th><th>Total Average Score</th></tr></thead><tbody><tr><td>Tas</td><td>1.0</td><td>0.6</td><td>0.6</td></tr><tr><td>ACT</td><td>1.6</td><td>0.2</td><td>1.0</td></tr><tr><td>Qld</td><td>1.6</td><td>0.2</td><td>1.0</td></tr><tr><td>Vic</td><td>1.6</td><td>0.6</td><td>1.2</td></tr><tr><td>SA</td><td>1.9</td><td>0.4</td><td>1.3</td></tr><tr><td>NSW</td><td>2.0</td><td>1.0</td><td>1.6</td></tr><tr><td>NT</td><td>2.6</td><td>0.4</td><td>1.7</td></tr><tr><td>NZ</td><td>2.3</td><td>1.0</td><td>1.8</td></tr><tr><td>WA</td><td>2.6</td><td>0.6</td><td>1.8</td></tr><tr><td>Aus</td><td>2.7</td><td>0.8</td><td>1.9</td></tr></tbody></table>	Strategy	7P System Criteria Average Score	Future Changes Criteria Average Score	Total Average Score	Tas	1.0	0.6	0.6	ACT	1.6	0.2	1.0	Qld	1.6	0.2	1.0	Vic	1.6	0.6	1.2	SA	1.9	0.4	1.3	NSW	2.0	1.0	1.6	NT	2.6	0.4	1.7	NZ	2.3	1.0	1.8	WA	2.6	0.6	1.8	Aus	2.7	0.8	1.9
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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).

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

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 including 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 Plans, 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.

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