

DESIGNING NATIONAL GUIDELINES FOR AUTOMATED VEHICLE TRIALS IN AUSTRALIA

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ABSTRACT

The project brief was simple: create future proof guidelines for a form of transport that has rarely been seen and technology capabilities that have only recently been imagined while ensuring safety and ease of use for government and industry. Automated vehicles are predicted to revolutionize mobility in a way that we have not seen for over a hundred years. Increased safety on the road, improved efficiency and beneficial environmental impacts are all presented as potential benefits of more automated vehicles. However, to achieve these outcomes the technology must be trialled and tested in many different environments. In Australia, establishing that the technology can perform is crucial to both the public as users and to governments, who aim to ensure public safety. For example, it is necessary to confirm that the red dust in Central Australia doesn't inhibit cameras and that movement projection algorithms can accurately predict the course of a kangaroo. Additionally, any guidance must work within the existing transport regulatory framework. The federated states and territories of Australia manage operational aspects of road transport regulation, while the Commonwealth Government manages standards for imported vehicles or those manufactured in Australia. This article describes the policy context in which the National Transport Commission worked with the state, territory and federal governments as well as industry stakeholders to design a flexible but robust set of guidelines that both encourages trials in Australia and ensures the safety of other road users.

Keywords: Australia, automated vehicles, data, insurance, intelligent transport systems, transport, trials

1 INTRODUCTION

The introduction of automated vehicles is widely predicted to revolutionize mobility in many ways, but the most noted expectation in this area is a significant improvement in road safety [1, 2]. To achieve this improvement, on-road trials are necessary to ensure that automated driving systems can operate safely and efficiently in all required conditions. Australia is keen to encourage automated vehicle trials, but an inconsistent approach from state and territory road transport agencies about how to regulate and support trials of automated vehicles had the potential to create uncertainty and deter industry. This had been seen before in Australia's infamous colonial era rail gauge debacle.

Many of the early rail systems in Australia were built to link colonies prior to the Federation of States in 1901, so planners had given little consideration to connecting up the rail systems. This simple oversight led to Australia having around 22 different gauges across the country [3]. In 1895, the American writer Mark Twain had to leave his carriage at 5 am and change trains to cross the border from the state of Victoria to New South Wales. Twain wrote of the situation: 'Think of the paralysis of intellect that gave that idea birth' [4]. Two decades later in 1917 the situation wasn't much improved in passenger terms, for example an east–west trip from Brisbane to Perth would involve changing trains six times [5]. This inconsistency stymied both travel and transport efficiency, negatively impacting the economies of the individual state and territories as well as Australia as a whole. Further, the issue has never been entirely resolved [6]. While Australian capital cities are now linked by a uniform gauge, three different gauges are still in existence today. The significance of this historical blunder looms large in the context of automated vehicles – inconsistency across borders is not an option.

2 DESIGN AIMS

The National Guidelines for Automated Vehicle Trials in Australia (the guidelines) were designed to be bureaucracy light to ultimately promote Australia as a testbed for automated vehicles. The guidelines are also intended to help trialling organizations ensure safety when testing on Australian public roads. The guidelines aim to achieve this by providing clear guidance on the matters that trialling organizations should address as part of the trialling process for both light and heavy automated vehicles.

When designing the guidelines, Australia's National Transport Commission (NTC) considered the current function of government in regulating transport and the range of tools available to achieve optimal outcomes. Like the European Council and the National Highway Traffic Safety Administration in the United States (US), the NTC recognized that the pace of change and the level of innovation meant that traditional regulatory processes would struggle to keep pace [1, 2]. By creating national guidelines for Australia – instead of legislation – the NTC hoped to provide a more timely and flexible policy solution that encourages innovation and ensures safety.

The guidelines also aim to accommodate a range of different automated vehicle technologies and applications. Accommodating various uses of vehicle automation could have positive impacts on cities as per the United Nations 2030 Agenda for Sustainable Development [7]. For example, increasing the use of electric pods over diesel or petrol buses could help increase sustainability. This accommodating approach also meant that government did not 'pick winners' by including prescriptive requirements that might favour one technology over another.

In this way the guidelines stipulate certain requirements commensurate to the level of risk. For example, the risks posed by the trial of a single, low-speed, driverless shuttle on a set route will be different from a trial of a heavy vehicle fleet on high-speed motorways. Under this model, road agencies work with vehicle manufacturers or technology providers to adequately and safely manage the potential risks of a trial.

The Society of Automotive Engineers (SAE) created standard J3016 to provide common terminology for automated driving [8]. Unlike some other international policies (such as the 'Federal Automated Vehicles Policy' in the US) the NTC decided to not use the SAE levels of automation in the national guidelines. There were a number of reasons for this decision. First, the guidelines were designed to accommodate all levels and applications so a vehicle's level of automation was not of primary importance. The guidelines aimed at ensuring the risks with the automated driving use case were addressed by ensuring safety of process, and how this was achieved could take many forms. Second, within each SAE level there can be considerable variations of driving application and therefore risk, this could have proved unhelpful. For example, SAE level 4 includes both a low-speed shuttle that runs on a specific route but has no human driver and a regular vehicle that can undertake the entire driving task on a highway but requires human driving on all other roads. These are considerably different scenarios in practice and have very different risks. The guidelines did not reference levels of automation in order to maintain clarity.

National guidelines, as adopted and applied by all states and territories, also aim to ensure that trialling organizations will have similar trial conditions regardless of which state or territory the trial is conducted in. However, the form of implementation remains the prerogative of each state and territory. Tension between states and territories' rights to self-governance and national consistency within the Australian federation is long-standing [9]. However, in the case of trial guidelines, consistency would encourage cross-border or national trials and benefit all parties. The national guidelines also aim to allow greater information

sharing – where appropriate – about trial and research outcomes to facilitate collaborative research, support Australian competitiveness and reduce administrative costs.

3 POLICY PRINCIPLES

Federal, state and territory governments consider maintaining safety on public roads as one of their key duties. The NTC noted that the automated vehicle field is highly competitive but the market is still underdeveloped and therefore designed the guidelines to allow innovation with minimal impact on potential innovation. Correspondingly establishing safety was of equal importance to potential economic benefits. This means that government action went beyond a solely economic approach [10–12]. In this sense, the guidelines would only be effective if they met both a social cost/benefit test as well as yielding economic benefits.

Another key principle of the NTC's policy development, particularly pertinent to automated vehicles, is the avoidance of future-casting. Automated vehicle technology is still under development and it is not yet clear what designs or technologies will eventually form best practice. Given industry is in the early stages of these developments, a large degree of regulatory flexibility is appropriate to avoid creating a rigid system of regulation that is not easily implemented and is difficult to undo or update. The policy approach allows room for innovation, but is ready with appropriate regulation as needed. This is a method the NTC terms the 'fast follower' approach and aims to avoid the premature regulation of transformational technology [13].

4 OVERVIEW OF EXISTING LEGISLATIVE FRAMEWORK

While the principles of policy are important in finding appropriate policy solutions, they are useless without a clear understanding of the context, particularly the logistical and political framework in which they will operate. First, Australia is a federation: one nation with multiple perspectives. States and territories have been described as partaking in 'competitive federalism' where they both compete among themselves and also engage with the Commonwealth Government to achieve national consistency. This is reflected in the complexity of land transport regulation in Australia. The Commonwealth Government has responsibility for the Australian Design Rules (ADRs), which govern vehicles imported or manufactured in Australia as well as product liability through the Australian Competition and Consumer Commission under the *Competition and Consumer Act 2010* (Commonwealth).

State and territory governments are responsible for vehicle modifications through the Australian Light Vehicle Standards Regulations (ALVSRs), the road network, the Australian Road Rules (ARRs, covering vehicle operation and on road behaviour), driver licensing and vehicle registration. Additionally, more than 80% of Australian roads are managed by the third tier of government: local government. There is also a specific regulator for heavy vehicles – the National Heavy Vehicle Regulator (NHVR). This layered regulatory system is well established but has only evolved incrementally in line with the limited changes in land transport technology over the past century. However, automated vehicles are predicted to revolutionize transportation in ways not seen since motor cars replaced horse and cart.

One of the key complexities related to automated vehicles is the merging of the physical vehicle characteristics, managed by the Commonwealth, with the vehicle's behaviour which

is managed by states and territories. The purpose of the guidelines was to work within this existing regulatory framework while creating a simple and flexible system for safe testing.

4.1 The guidelines – a conceptual approach

The guidelines are not enforceable until they become the conditions of an exemption or permit provided by a state or territory road agency. This gives the guidelines a wider reach as trialling organizations are encouraged, whether they need an exemption or permit or neither, to consider the issues highlighted prior to trialling on public roads. Because the guidelines are designed to work within a number of state and territory logistical processes, they are not linked to any individual process and can be applied to all trials.

This approach was seen as appropriate due to the pace of innovation in automated vehicles. The rate of change challenges existing conceptions of a road vehicle so drastically that prescription was not seen as a viable option for the trialling stage. At the same time, the potential variation between trials is so significant that trial guidelines needed ultimate flexibility. Identifying these inter-linked and cross-cutting complexities was crucial to understanding the many roles the policy solution needed to perform. These factors meant that a dynamic solution was the only option. Such a policy approach has also been described as a ‘negotiated’ or ‘relational’ approach and this can take many forms [14–16].

In this case, the NTC took the issues identified through consultation as being relevant to safe trialling and made them the basis for the conditions of an exemption or a permit. The guidelines established a model where every point must be addressed, but how this is done is up to the organization. This negotiated or relational approach is significant as every trial is assessed by regulators individually – there is no prescription and no one-size-fits-all approach. Where a point is relevant to the trial, the risk assessment and contingency should be explained; where an issue is not relevant to a trial that must be stated as such. Regulators also have the ability to ask for more information or add their own conditions should they think it is necessary for a particular trial.

4.2 Guidelines operate within the existing regulatory framework

The guidelines not only needed to be easy and quick to implement but also not disrupt the existing regulatory system for transport in Australia. To achieve this, the guidelines were designed to sit within the existing framework and make use of existing exemption powers of the Commonwealth and road agencies in each Australian state and territory.

The *Motor Vehicle Standards Act 1989* (Commonwealth) requires all road vehicles, whether they are newly manufactured in Australia or imported as new or second-hand vehicles, to comply with the relevant ADRs at the time of supply to the Australian market. ADRs are national standards for vehicle safety, anti-theft and emission controls and cover issues such as occupant protection, structures, lighting, noise, engine exhaust emissions and braking. The Commonwealth Government can exempt new and imported vehicles from ADRs. This process has already been used for automated vehicles such as passenger pods that do not have steering wheels (ADR 10).

Vehicles involved in a trial could be light or heavy vehicles. ARRs and ALVSRs form the basis for state and territory road rules and in-service vehicle standard requirements. ARRs

promote road safety by establishing uniform road rules for drivers and riders of motor vehicles, riders of bicycles, pedestrians and passengers. ALVSRs form the basis for the in-service light vehicle standards in each state and territory. For states and territories that participate in the heavy vehicle national law (HVNL) scheme, in-service heavy vehicle standards are administered through the HVNL. States and territories have exemption and permit powers in relation to the road rules, traffic laws and in-service vehicle standards, although these powers sometimes differ.

Unlike light vehicles, which are regulated on a state or territory basis, heavy vehicles are regulated under the HVNL, which is administered by a single regulator – the NHVR. The HVNL established a national system of laws for heavy vehicles over 4.5 tonnes gross vehicle mass and prescribes requirements related to the following:

- The vehicle standards heavy vehicles must meet before they can use our roads.
- The maximum permissible mass and dimensions of heavy vehicles.
- Securing and restraining loads on heavy vehicles.

The Northern Territory and Western Australia have not applied the HVNL at this time and maintain their own heavy vehicle regulation.

4.3 Trial guidelines utilize existing regulatory mechanisms

If a proposed trial vehicle complies with existing vehicle standards and is used in compliance with road rules and other traffic laws, it can operate on public roads without the need for an exemption.

However, if an automated vehicle does not comply with the existing vehicle standards or road rules and traffic laws, it would require an exemption to operate on public roads. When an exemption is granted by road transport agencies, the guidelines would provide the conditions that road transport agencies would attach to an exemption (Fig. 1).

Trials must comply with all existing legislation where there is not an exemption in place. To that end, the existing regulatory framework remains intact and other road user standards are maintained.

The NTC notes that this is the first step of many in managing the introduction of automated vehicles. There is not yet the need to completely overhaul the system for road transport in Australia and for as long as there is a mixed fleet of vehicles (human and automated drivers) on public roads, the existing regulation will still be required. For this reason the guidelines are entirely oriented around the existing transport regulatory framework with periodic reviews factored in.

In the Australian state of Victoria, the increasing graduation of licences for learner drivers is an example of such an approach. It has taken many iterations of the learner licence, each capitalizing on the last in response to the growing knowledge base. Licence restrictions have continued to evolve in response to research around the ages of brain development, in-car distractions and peer influence. It is anticipated that as the number of automated vehicles grows and technical capabilities develop, more novel issues will emerge. At the same time, there will be ongoing evaluation and research taking place to help regulation keep pace and evolve.

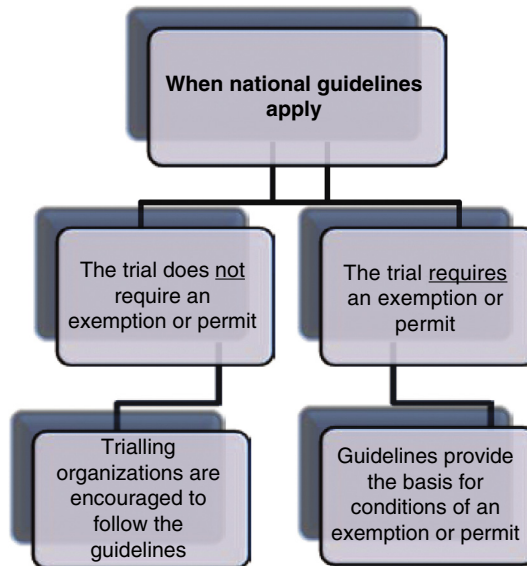


Figure 1: The right side of this diagram illustrates when national guidelines become enforceable through the existing legislative framework.

5 COMPARATIVE ANALYSIS AND CREATING CONCEPTS

In land transport, which operates in a layered regulatory system, any changes will inevitably impact other areas of governance. In developing the guidelines, the NTC considered a number of factors, including federal, state, territory and local government priorities, private infrastructure providers, civil and criminal law as well as cultural norms and community risk appetite. This is illustrated in Fig. 2.

Figure 2 does not illustrate that the community risk appetite is fluid, not static. The attitude of the community fluctuates over time in relation to the perceived pros and cons. The understanding of the risks also develops as the research and knowledge base around the technology improves. For example, understanding what the avoidable risks are compared with what is inherent with use. In addition, there is also a human or emotional acceptance level in transport which is, in some ways, disproportionately skewed to the mode of transport. For example, road transport fatalities in Australia number more than a thousand people a year and a majority of those are avoidable. This is broadly accepted as the norm. However, if a similar number of people were killed in aviation crashes each year, there would be an outcry.

Community outcry can also be a trigger for regulation changes. In the NTC consultations, many stakeholders discussed the possibility of having flexible regulation until the first automated vehicle accident causes the death of a child. After such an event, it is highly likely that regulation would tighten to reflect the reduced community risk appetite.

Once governments decided that the NTC would develop the guidelines, it was necessary to agree on the issues the guidelines would address. These would form the conditions of the exemption.

To determine the conditions that should be attached to an exemption, the NTC completed a comparative analysis of existing trial conditions in other jurisdictions, including the Japanese

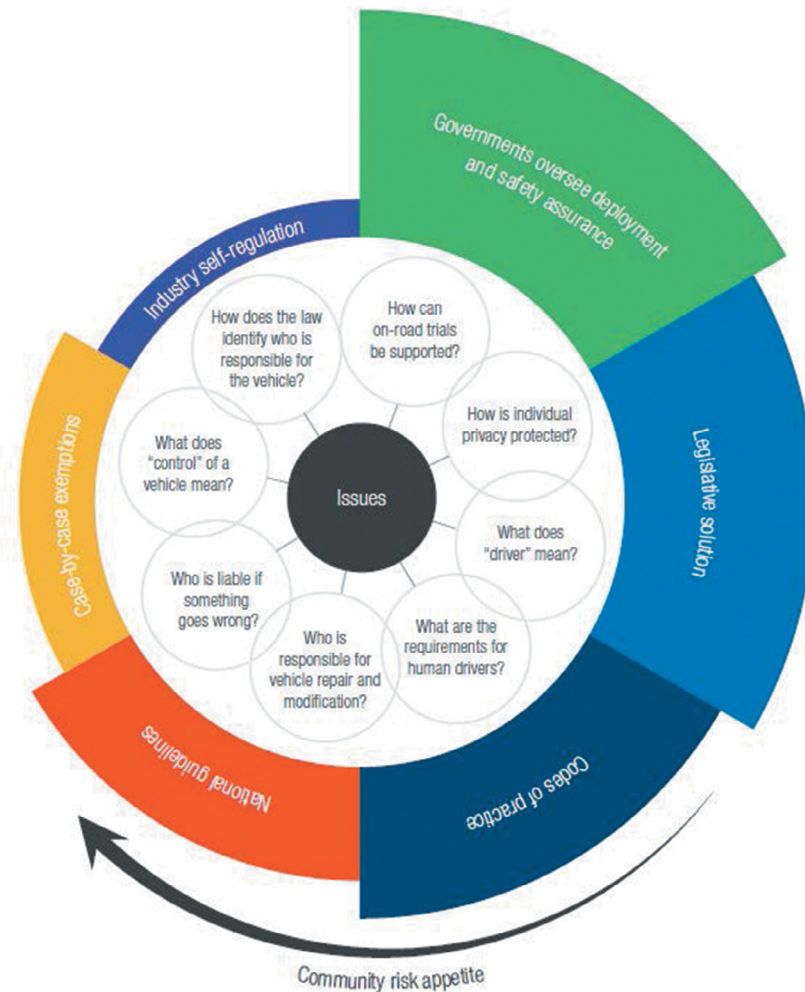


Figure 2: This diagram illustrates how the range of issues and community risk appetite can impact on the type of regulation.

Guidelines for Trialling Automated Vehicles, the United Kingdom (UK) Code of Practice, the New Zealand Information on Trialling, the legislation in place in the American states of Nevada and Florida as well as the Australian state of Victoria's adaption of the UK Code of Practice and Western Australia's Code of Practice for automated mining [17–27].

When undertaking the comparative analysis, the NTC looked at the form that the trial management should take in Australia. This was the common factor most apparent among jurisdictions. At one end of the spectrum sat Nevada and Florida with a legislative approach; at the other end, New Zealand has a general information document. Between these approaches there were guidelines and codes of practice. In an Australian context, guidelines had already been flagged in previous consultation documents as a possible approach and this was supported. However, the NTC consulted again on how the guidelines should be used by road agencies and whether the guidelines should form the basis for conditions of an exemption. The approach proposed by the NTC was supported by industry and government stakeholders.

This analysis provided a baseline and point of contrast for considering what conditions or requirements road transport agencies needed in Australia. The key areas of regulation for automated vehicle trials that appeared across multiple jurisdictions were:

- Management of trials
- Case-by-case assessment/a safety management plan
- Insurance
- Data and information

The criteria under these themes of regulation were not addressed in the same way by each of the jurisdictions examined, but each considered them. The criteria are considered complementary and interdependent.

In undertaking this comparative analysis, the NTC recognized the limits of the method, particularly the small number of cases and many variables [28]. These variables included different regulatory systems and different cultural norms including community risk appetite. The comparative analysis helped in concept formation and in assessing the existing solutions implemented internationally [29]. The NTC brought together other identified issues and presented the existing solutions to all stakeholders in a public consultation.

6 A SAFETY MANAGEMENT SYSTEM APPROACH

One of the key issues released in the guidelines discussion paper for consultation was the format of the guidelines. Typically, Australian regulation related to vehicles and transport is largely prescriptive, such as ADRs:

- ADR 10 – Steering column: a highly automated vehicle may not require steering controls ‘actuated by the driver’. This was already in the case in Australia with the driverless shuttles.
- ADR 14 – Rear view mirrors: a highly automated vehicle may not require rear view mirrors when there is no human driver at all.

The NTC proposed a safety management approach to trials, where the guidelines form the framework for a safety management plan. A safety management system approach is a co-regulatory, risk-based approach to identifying and managing safety risks. By adopting this approach, trialling organizations would need to demonstrate to the relevant road transport agencies that they have identified safety risks and how those risks are to be managed. Under Australian rail safety and workplace health and safety law, operators, employers and other parties must ensure ‘so far as is reasonably practicable’ the safety of their operations. This differs with other thresholds that have been applied internationally; the most common in work health and safety regimes is ‘as low as reasonably practicable’.

A safety management system approach enables road transport agencies to provide a clear pathway for the technology while ensuring the community is both protected and reassured of the safety of approved trials. This approach also supports innovation by allowing industry to determine the best way to manage risk. However, it is not without disadvantages. Some disadvantages include:

- Without agreed standards for automated vehicles, the road transport agencies may not be able to test or validate the safety management system.
- It can make applications more complex and expensive to prepare.
- It may require more follow-up and audits by the road transport agencies.

In their application, trialling organizations should address all criteria set out in the guidelines. If some criteria are not relevant, the trialling organization should explain in their application why these criteria should not apply.

7 KEY THEMES WITHIN THE GUIDELINES

In examining each of the different approaches to automated vehicle trials, some complementary themes emerged. First, a clear management plan for the trial was imperative, particularly from a road transport agency perspective. The main purpose of the trial would need to be communicated to road managers. Second, all approaches considered that having some kind of insurance – though usually substantial cover – was necessary. Third, all codes and guidelines recommended that there be some flexibility in how trials could be assessed using a case-by-case approach. In Australia, this took the form of a safety management plan. And finally, data – a notably broad term – was addressed by all codes and guidelines. These themes encompassed a number of individual issues and each issue needs to be addressed by a trialling organization. Where a particular issue is not relevant to the trial, the trialling organization must explain why.

7.1 Management of trials

The safe management of automated vehicle trials by trialling organizations and by road transport agencies plays a key role in ensuring the safe on-road testing of automated systems. When considering what management approach could be used in Australia, the NTC compared existing solutions implemented internationally and those that had been introduced in some Australian states.

Many of the criteria under management of trials are very similar to the kind of requirements that already exist for closing a road for construction purposes or filming in a city. Information such as the trial location, what the trial is testing, the traffic management plan, engaging with the public and infrastructure requirements are all comparable to existing requirements to operate under special circumstances on a public road [30].

One of the technology-focused criteria that needs to be addressed by a trialling organization is managing change. This criterion is designed to help trialling organizations plan for managing changes to the vehicle or infrastructure over the course of a trial. It was predicted that vehicle software or hardware may be upgraded or adapted over the course of a trial as issues are discovered and technology evolves. Software updates that substantially change the performance of the vehicle, such as changing the level of automation of the vehicle, will require a reassessment of the safety management plan. Trialling organizations are therefore asked to set out their processes for managing these changes to ensure that they maintain safety. Trialling organizations are also required to address how they would manage changes to the road network (such as variable speed limits or road works) that may occur over the course of the trial.

7.2 Insurance

All jurisdictions examined in the comparative analysis addressed the issue of insurance for automated vehicle trials. Some of these, such as the states of Florida and Nevada, had prescriptive amounts of insurance coverage that was required. The NTC, in consultation with the states and territory governments, decided to use the term ‘appropriate insurance’ to cover the trial. This was to reflect the variation of potential of risks in trials.

Another Australian-specific issue was compulsory third-party (CTP) insurance which is required for all vehicles in all states in Australia. CTP insurance covers the driver for any legal liability for injury or death as a result of an accident for which the insured party is responsible – be it for other drivers, passengers, pedestrians or cyclists.

It is important to note that CTP insurance varies across Australian states and territories. Variations include whether the system is fault or no-fault based, included in registration fees or not, whether the registered owner can choose their insurer or not. If a CTP insurance scheme is fault based it means that the party holding the insurance must be at fault for a third party to be eligible for compensation from that party.

At the time of writing the guidelines, there was a trial taking place in Western Australia that was covered by CTP insurance. At the same time, the South Australian online guidance specifically stated that their CTP insurance would not cover any automated vehicle trial. To accommodate both of these approaches the guidelines recommend that trialling organization must check with the relevant road transport agency as to whether they are covered by the state-based insurance scheme. The requirements and coverage of these schemes continue to differ between states and territories.

However, a key principle agreed to by all states and territories was that any road user injured as a result of an automated vehicle trial would be no worse off than if they were injured by a human-operated vehicle.

7.3 Safety management plan

A key feature of the Australian guidelines is the required safety management plan. This reflects the central government responsibility to ensure new technology is introduced onto public roads safely. Trialling organizations must develop a safety management plan outlining all key relevant safety risks and how these risks will be mitigated or eliminated. This was seen a critically important as automated vehicle trials continue to make headlines around the world whenever there is a crash. One of the key functions of trials in Australia is to help educate the public and encourage trust in automated vehicles. This would likely be severely damage if a major crash was to occur.

A safety management plan is a flexible, safety-focused tool that trialling organizations can use to ensure they have considered the risks associated with a trial. Some of the aspects are taken from other areas of road transport regulation. For example, fitness-for-duty is an existing concept in heavy vehicles regulation where drivers' fitness to drive is assessed and considered a key part of safety management. It would have been possible to prescribe standards around this as they already exist in the road transport context. However, that standard wouldn't allow for changing conditions of 'driving' that are likely to be tested.

Other conditions linked to system security, system failure or appropriate transition processes between a system and a human driver would have likely made the guidelines inflexible with arbitrary standards, quickly redundant. In order to avoid this kind of regulatory error, a safety management plan is required from each trialling organization that reflects the technology being tested.

7.4 Data and information

Data was one of the more contentious issues during the consultation period. One of the reasons is that the term 'data' covers many different concepts. The other reason, particularly

from a manufacturer and technology developers' point of view, is that the potential vehicle data from a trial is considerable and contains intellectual property.

For these reasons the guidelines do not mandate total data provision from a trial, though they encourage information sharing. Trialling organizations are required to comply with existing crash reporting requirements in the relevant state or territory. The minimum reporting conditions vary between the states and territories.

The guidelines accept that trials will have the potential to be varied and, as such, the guidelines do not mandate the types of data and information that should be provided to a road transport agency. However, timeframes for reporting and providing the relevant information are mandated.

The guidelines also require trialling organisations to provide the relevant road agency with ongoing monthly reports and an end of trial report. This will contribute to an increased knowledge base on automated vehicles for the benefit of future regulation development. Each road transport agency will learn from every trial and be able to make improvements. Future regulation within each state and territory and at a national level will benefit from this, which will be crucial as the introduction of automated vehicles extends beyond trials and becomes more widespread.

8 CONCLUSION

Government action must be in response to, and proportionate to, a policy problem. Legislation is not effective when it presents barriers to innovation or gaps in safety standards. To that end, the guidelines were developed with the aim of ensuring safety on public roads while encouraging innovation and economic benefits across Australia. While it is too early to comprehensively identify market failures, this project provided an opportunity to reflect on international approaches, what the next policy problems may be, and how government can continue to achieve policy objectives of improved safety and facilitation of innovation within Australia.

Longer-term, automated vehicles provide regulators, industry and the community with an opportunity to consider how the current regulatory framework for road vehicles, based on prescriptive rule sets, could change in the years ahead. This is why the safety management plan was implemented for trials. Its effectiveness will likely be assessed as a potential solution for broader commercial deployment of automated vehicles. In particular, if automated vehicles support growing trends towards mobility as a service, reduced vehicle ownership and a greater focus on a network approach to traffic management, a safe system approach to road safety, like rail and aviation sectors operate, could be an option for future transport regulation.

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