Australian Government
Department of Infrastructure and Regional Development

Social Impacts of Automation in Transport

Submission to the House of Representatives Standing Committee on Industry, Innovation, Science and Resources

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Acronym List

ADRs	Australian Design Rules
ANCAP	Australasian New Car Assessment Program
ARTC	Australian Rail Track Corporation
ATC	Automatic Train Control
ATMS	Advanced Train Management System
ATO	Automatic Train Operation
ATP	Automatic Train Protection
BITRE	Bureau of Infrastructure, Transport and Regional Economics
C-ITS	Cooperative Intelligent Transport Systems
COAG	Council of Australian Governments
ERTMS	European Rail Train Management System
ESC	Electronic Stability Control
ETCS	European Train Control System
EU	European Union
GDP	Gross Domestic Product
GNSS	Global Navigation Satellite System
GoA (0-4)	Grade of (Rail) Automation
GPS	Global Positioning System
MOC	Memorandum of Cooperation
NTC	National Transport Commission
NZ	New Zealand
ONRSR	Office of the National Rail Safety Regulator
RISSB	Rail Industry Safety and Standards Board
RSNL	Rail Safety National Law
SAE	Society of Automotive Engineers
SBAS	Satellite Based Augmentation System
UN	United Nations
US	United States
UTO	Unattended Train Operation

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1 Introduction

Automated transport technologies have significant potential to improve many aspects of life for Australians. Automation in road vehicles is an emerging technology that has developed rapidly over the last decade. In the future, automated road vehicles could deliver benefits such as improved safety, more efficient and productive transport networks, more liveable city environments and better access to transport services for those unable to drive. Several trials of automated road technology are planned or already underway in Australia.

Automated rail is a mature technology with many successful deployments around the world. Internationally, deployments have increased network capacity, reduced costs, improved safety and delivered environmental benefits. While fully automated rail technology is not yet available in Australia, deployments are planned on both passenger and mine haul routes.

Although outside of the scope of this Inquiry, automation technology is also available or being developed for maritime applications, including the future possibility of unmanned cargo vessels.

Taking advantage of the opportunities from automation technology and other emerging transport technologies is essential in order to address persistent challenges in the transport sector. Innovative new approaches are required to make further progress in reducing the social and economic costs of crashes, delivering infrastructure projects in a budget-constrained environment and managing the impacts of a growing population (particularly in urban areas).

For the potential benefits of automation to eventuate, governments need to consider carefully the social issues that may arise. In relation to automated road vehicles, public trust in the safety, security and privacy of this emerging technology is a key consideration and immediate priority. Similarly, a clear legal framework is required to provide certainty to both suppliers and users of automated vehicles. Automation technology also has a number of possible impacts on labour markets, public transport and mobility for people with a disability or those living in regional areas.

Given the early stage of development of automated road vehicles, more real world experience is required to fully understand and respond to these possible social issues. Further trials will also provide the broader community with a better understanding of this emerging technology, particularly its potential capabilities and limitations.

Unlike in the road sector, there is already an established regulatory and legal framework for the safe operations of automated rail. Social issues in the rail sector are more likely to relate to labour market impacts and public confidence in technology. These concerns have been successfully managed in other countries where automated rail systems have been deployed. In Australia, state level governments will play a primary role in addressing any social concerns in relation to automated rail.

Proactive action by governments at all levels in Australia is already underway to pursue the realisation of the potential benefits of automation technology. As detailed in this submission, the Department's current focus is to work with state and territory governments to establish a single, nationally consistent regulatory framework for automated road vehicles, as a strong foundation for building public confidence and support for this promising, emerging technology. Consistent with the Australian Government's role as a significant investor in transport infrastructure, the Department is also working to understand how automated technology will impact on infrastructure design, planning and delivery.

2 Road

2.1 State of technological development

2.1.1 What is an automated road vehicle?

An automated road vehicle (hereafter 'automated vehicle') can be defined as a vehicle that does not require a human driver for at least part of the driving task (National Transport Commission, 2016a). This definition encompasses a wide range of capabilities, from systems that automate a single aspect of the driving task (e.g. adaptive cruise control which controls acceleration/deceleration), to future systems that may be responsible for all elements of the driving task at all times. For clarity, this submission avoids alternative terms that may refer to some or all of these capabilities, including 'autonomous', 'self-driving' and 'driverless'.[1]

Authorities in Europe, the United States and Australia have adopted the Society of Automotive Engineers' (SAE) International Standard J3016 as a common language for describing the capabilities of an automated vehicle. The SAE standard has six levels of driving automation from no automation (Level 0) to full automation (Level 5). Classification of automated vehicles (illustrated in Figure 1) is based on whether the system:

- manages steering, acceleration and braking on a sustained basis;
- requires a human driver to monitor the driving environment and respond as needed;
- can operate without handing over control ('falling back') to a human driver; and
- can operate in all situations ('driving modes').

On this basis, SAE has defined the following levels of automation:

- **No automation** (SAE Level 0) — human driver is responsible for all aspects of the driving task.
- **Driver assistance** (SAE Level 1) — in some circumstances the system is capable of either steering *or* acceleration/deceleration (including braking), with the expectation that the human driver performs all remaining aspects of the driving task.
- **Partial automation** (SAE Level 2) — in some circumstances the system is capable of *both* steering and acceleration/deceleration. The human driver must monitor the driving environment and respond as needed.
- **Conditional automation** (SAE Level 3) — Level 2, but when the system is operating in automated mode the human driver is not required to monitor the driving environment. The human driver must respond to requests from the driving system to intervene.
- **Highly automated** (SAE Level 4) — Level 3, but no human monitoring or intervention is required when the system is operating in automated mode.

[1] Noting that 'driverless' is the commonly used term in relation to rail, and thus, Section 3 – Rail below, uses that term.

- **Fully automated** (SAE Level 5) — automated system in control all of the time, and in all road environments.

Vehicle manufacturers may choose to allow a human driver to take back control from the automated driving system, even where the system is capable of driving without intervention (i.e. SAE Levels 4 and 5).

Figure 1: SAE Standard J3016[2]

SAE level	Name	Narrative Definition	Execution of Steering and Acceleration/ Deceleration	*Monitoring* of Driving Environment	Fallback Performance of *Dynamic Driving Task*	System Capability *(Driving Modes)*
***Human driver* monitors the driving environment**						
0	No Automation	the full-time performance by the *human driver* of all aspects of the *dynamic driving task*, even when enhanced by warning or intervention systems	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	the *driving mode*-specific execution by a driver assistance system of either steering or acceleration/deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	Human driver and system	Human driver	Human driver	Some driving modes
2	Partial Automation	the *driving mode*-specific execution by one or more driver assistance systems of both steering and acceleration/ deceleration using information about the driving environment and with the expectation that the *human driver* perform all remaining aspects of the *dynamic driving task*	**System**	Human driver	Human driver	Some driving modes
***Automated driving system* ("system") monitors the driving environment**						
3	Conditional Automation	the *driving mode*-specific performance by an *automated driving system* of all aspects of the dynamic driving task with the expectation that the *human driver* will respond appropriately to a *request to intervene*	System	**System**	Human driver	Some driving modes
4	High Automation	the *driving mode*-specific performance by an automated driving system of all aspects of the *dynamic driving task*, even if a *human driver* does not respond appropriately to a *request to intervene*	System	System	**System**	Some driving modes
5	Full Automation	the full-time performance by an *automated driving system* of all aspects of the *dynamic driving task* under all roadway and environmental conditions that can be managed by a *human driver*	System	System	System	**All driving modes**

The extent to which a vehicle is automated, and in particular, whether a human is required to monitor the road environment and/or be ready to take back control, has significant implications for the social, policy and regulatory impacts.

2.1.2 Currently available automated technology

Vehicles with sophisticated automation features (SAE Levels 1 and 2) are already commercially available in Australia. This includes innovative features such as self-parking, traffic jam assist and lane change assist. In these examples, the system is capable of simultaneously controlling steering, acceleration and braking under the supervision of the

[2] Copyright © 2014 SAE International. The summary table may be freely copied and distributed provided SAE International and J3016 are acknowledged as the source and must be reproduced AS-IS.

driver. Vehicles with higher levels of automation are already in use in closed, off-road environments, such as mining sites, enclosed tracks and private property.

2.1.3 Future developments

Most major vehicle manufacturers, as well as several large technology companies and universities, are developing vehicles with higher levels of automation (SAE Levels 3 and above), including vehicles that are designed to require no human control.

By 2020 several manufacturers expect to offer vehicles that can undertake all necessary driving functions under certain conditions, but may need to hand back control to a human driver in certain conditions or places (SAE Level 3).

Highly automated vehicles (SAE Level 4), which do not require human intervention when performing some types of driving, are expected by many analysts to be made commercially available in the period 2020-2030. Reaching true SAE Level 5 capability, where the automated system is in control at all times and in all road environments, is a much more complex engineering problem. It is not known if or when these vehicles might become commercially available.

It should be noted, that due to technical limitations, early deployments of automated vehicles may have significant restrictions as to the geographic areas or road conditions in which they are able to operate (e.g. only on well-maintained highways, or only in low-speed urban areas).

Like other vehicle technologies, it will take time for automated driving technology to penetrate throughout the vehicle fleet. For example, modelling commissioned by the Queensland Department of Transport and Main Roads suggests that saturation of highly automated vehicles in the Australian fleet could occur roughly between 2050 and 2060 (TransPosition, 2016).

Penetration models generally assume that take-up will be similar to that of other automotive technologies. It is possible that this assumption will not hold in the future, particularly if other developments have a disruptive effect on business models in the automotive sector. For example, wider use of car and ride-sharing business models at the expense of private vehicle ownership could increase vehicle utilisation and lead to faster fleet renewal. Policy and regulatory settings can also affect penetration rates, as could social acceptance, costs and other factors.

The broader community does not have a clear understanding of the potential capabilities, deployment timeframes and limitations of automated vehicle technology. To date, there has been a level of ‘hype’ in public debate in both Australia and overseas: the 2016 Gartner Research Hype Cycle listed automated vehicles to be one of several technologies with ‘inflated expectations’[3]. Managing community expectations around automated vehicle technology will be fundamental to addressing any subsequent social issues.

[3] For further information, see http://www.gartner.com/newsroom/id/3412017

2.1.4 Technology enabling automated driving

Automated road vehicles will use a range of different technologies in the process of sensing the road environment, planning movements and executing the desired course of action.[4] The specific technologies used will have implications for how governments manage and maintain the road network in the future, and whether governments will need to support deployment with new digital infrastructure (e.g. accurate satellite positioning or mapping services).

Technologies used by automated vehicles include:

Figure 2: Roadside infrastructure for vehicle-to-infrastructure communications

Image courtesy of Cohda Wireless

- **Radar** (long, medium and short range) — currently used in applications such as adaptive cruise control and autonomous emergency braking.
- **Cameras** — currently used for applications such as lane keep assist (relies on visible lane markings).[5]
- **Ultrasound** — a short range sensor currently used in parking assist functions.
- **LIDAR** (light detection and ranging) — detects objects based on reflections from short laser pulses and can operate in 360 degrees around the vehicle. Can operate in challenging conditions such as snow and rain. A LIDAR device is visible on the roof of the vehicle in Figure 3.
- **High resolution maps** — several manufacturers are developing systems that rely on comparing sensor data with high-resolution maps of the road environment collected in advance.
- **Global Navigation Satellite Systems** (GNSS) — GNSS, such as the Global Positioning System (GPS) available in Australia, are widely used for high-level navigation. In the Northern Hemisphere high accuracy, high integrity GNSS services are available that are suitable for safety-critical functions.
- **Secure wireless communications** — can be used to share information between vehicles and with roadside infrastructure (illustrated in Figure 2). When used with automation this can enable applications such as platooning, where several vehicles follow each other at a short distance, relying on wireless communications to coordinate braking, acceleration and other driving behaviours.
- **Advanced computer science techniques** — such as machine learning, a type of artificial intelligence where the system improves based on prior experiences. Artificial intelligence could help solve difficult problems such as dealing with different right-of-way rules and behavioural norms around vehicle–vehicle and vehicle–pedestrian interactions in different countries.

[4] For information, see http://www.itf-oecd.org/automated-and-autonomous-driving
[5] For information, see https://mycardoeswhat.org/safety-features/lane-keeping-assist/

Figure 3: Waymo highly automated test vehicle (formerly the Google self-driving car project)

Source: Waymo.com

2.1.5 Complementary technological advances

Technology in the land transport sector is undergoing a period of rapid change. While automation is an important development in its own right, other emerging technologies will also have significant benefits (and challenges) for Australia's transport system. Key trends include:

- **Connectivity** — the next generation of vehicles will be able to communicate wirelessly with each other and with roadside infrastructure for a range of safety and efficiency applications, including collision warnings, speed limit notifications, and improved travel information. Australian research indicates that collision warnings from this technology (known as Cooperative Intelligent Transport Systems or C-ITS) could prevent 25-35 per cent of serious crashes in Australia (Austroads, 2011).

- **Big Data and the Internet of Things** — a wide array of sensors, both inside and outside the vehicle are increasingly collecting data. This technology is sometimes referred to as the 'Internet of Things', a term which also includes a range of non-vehicle applications. Advanced analysis techniques such as machine learning can use this data to provide new insights and optimise the operation, maintenance and planning of infrastructure assets.

- **New business models** — mobile phones applications that facilitate sharing economy business models such as car-sharing (e.g. GoGet) and ride-sharing (e.g. Uber) are already providing new mobility options for consumers. 'Mobility as a Service' is an emerging business model which aims to provide seamless access to the widest variety of transport services (public and private), either on a subscription or 'pay as you go' basis. These new business models could accelerate long-term trends away from car ownership, and impact on travel patterns and infrastructure use.

- **Zero and low emission vehicles —** electric vehicles are falling in cost and hydrogen fuel cell vehicles are commercially available overseas and will be deployed in Australia in the short-term.[6] Given that domestic transport is the second largest energy user in Australia, large-scale deployment of these technologies would have significant implications for environmental outcomes (BREE, 2014).

Automation is expected to complement many of these technologies. For example, Tesla vehicles are electric and have increasing levels of automation. Australia's future transport system could be based around vehicles that are connected, automated (in part or in full), shared and zero emissions, if all of these aspects converge in the long-term.

2.1.6 Deployment models

The social impacts of automated vehicles depend on how they are used, which business models become popular, and which complementary technologies they are deployed with.

For example, several developers have indicated that they expect initial deployments of automated vehicles to occur through a fleet of shared vehicles, similar to the ride-sharing services currently available.[7] This would have the positive effect of improving mobility in Australia's densely populated urban areas and providing an incentive for travellers to move away from private car ownership and make better use of public transport.

In an alternative scenario, where automated vehicles are predominately privately owned, a number of perverse outcomes might occur. For example, automated vehicles may make long round trips without passengers to avoid paying for parking. The increased comfort and reclaimed time while using an automated vehicle (if regulation does not require a human driver to monitor the road) could reduce the perceived costs of travel time and provide an incentive for longer commutes, reduced public transport use and greater urban sprawl. Noting the potential for longer trips, the environmental impacts of automated vehicles will depend on the extent to which they utilise low emission technologies.

The impacts of different deployment models will also depend on a range of other factors, such as the extent to which vehicles communicate and cooperate with each other, the availability of data for network optimisation, and integration with public transport.

Figure 4 illustrates, for discussion purposes, how different deployment models might impact on real world outcomes. Future Scenario 1 illustrates that if automated vehicles are privately owned and powered by internal combustion engines (similar to current practice), there could be increases in vehicle kilometres travelled, greenhouse gas emissions and urban sprawl. In future Scenario 2, many of these negative impacts are avoided through the use of shared mobility business models and low emissions technologies.

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[6] For example, see: http://www.hyundai.com.au/hyundai-info/news/2016/august/hyundai-secures-order-for-20-next-generation-hydrogen-fuel-cell-vehicles-in-australia

[7] For example, see: https://media.ford.com/content/fordmedia/fna/us/en/news/2016/08/16/ford-targets-fully-autonomous-vehicle-for-ride-sharing-in-2021.html

Figure 4: Future Automated Vehicle Deployment Scenarios[8]

		Scenario 1	Scenario 2
Deployment characteristics	Business model	Private ownership	Shared mobility / Mobility as a Service
	Fuel type	Internal Combustion Engine	Low emissions technology
	Connectivity	Not wide spread	Vehicle-to-Vehicle and Vehicle-to-Infrastructure
	Data sharing	Difficult	Efficient
	Integration with public transport	No specific strategy	Targeted strategy
	Response to policy issues by all governments	Slow, ineffective or uncoordinated	Timely, coordinated and effective
Deployment outcomes	Safety	Improved	Improved
	Vehicle Kilometres Travelled	Large increase	Small increase
	Greenhouse gas emissions	Large increase	Potential decrease
	Urban sprawl and demand for road infrastructure	Increase	Potential for improved utilisation of existing assets

Actual deployment is likely to be some combination of these extreme scenarios. More real world experience of how consumers respond to automated vehicles is required to understand the potential future role for government in avoiding or mitigating any negative impacts.

[8] Adapted from Issac, 2016 and ITF, 2015b.

2.2 Current attitudes towards automated vehicles

Some early research into the attitudes of Australians towards automated vehicles has been conducted. For example, a 2014 survey of 500 Australians by the University of Michigan (Schoettle and Sivak, 2014) found:

- A majority (61.0 per cent) of Australians were aware of 'self-driving' vehicles, with a similar number (61.9 per cent) having a positive general opinion.
- Sixty-seven per cent of Australian respondents expressed an interest in having automated vehicle technology[9] and that 25 per cent stated they were willing to pay more than $3,000 for highly automated capability. Around 30 per cent of respondents would be unwilling to pay anything extra for an automated vehicle.
- A majority of respondents expected better safety, cost of insurance, fuel consumption and environmental outcomes (but not shorter travel times or reduced congestion).
- A majority were 'moderately' or 'very' concerned about some aspects of automated driving technology, including:
    - system failures (including safety and security);
    - riding a vehicle with no driver controls;
    - automation of commercial vehicles and public transport;
    - legal liability;
    - automated vehicles getting 'confused';
    - unoccupied trips by automated vehicles;
    - interactions between automated vehicles and vulnerable road users; and
    - data privacy.
- A significant percentage would watch the road even when not required (43.4 per cent) or would not ride in an automated vehicle (21.2 per cent).

This research also found that Australians were more positive in a range of areas compared to the public in the USA, but similar to the UK.

Other research into public opinion towards automated vehicles in Australia reiterates many of these themes, including safety, security, legal liability, and concerns about not being able to take back control of an automated vehicle (RAC (WA), 2016). Longitudinal research in this area is planned for Australia.[10]

In the Department's view, the cautious approach of many Australians towards automated vehicles is appropriate to the current stage of technological development. Most Australians do not yet have direct experience of more highly automated vehicles (SAE Level 3 and above) on public roads. It is likely that public attitudes will evolve quickly with direct experience from further trials and gradual increases in automated technology into the vehicle fleet. Trials and real world deployments will also provide an opportunity for both

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[9] This figure is consistent with other studies, see for example Ellis, B, Douglas, N and Frost, T 2016, *Willingness to pay for driverless cars*, 2016 Australasian Transport Research Forum available at https://www.arrb.com.au/admin/file/content128/c6/ATRF2016_Full_papers_resubmission_125.pdf
[10] The Australian Driverless Vehicle Initiative has announced its intention to undertake an annual public perception survey, see http://bit.ly/2jCZAR8. Results from the inaugural 2016 survey have not been made publically available.

governments and industry to communicate with the public about how their concerns are being addressed, and adjust approaches in response to feedback.

Perth Automated Shuttle Bus Trial

The Royal Automobile Club of Western Australia is trialling a highly automated shuttle bus in South Perth on a public road with regular traffic. While the 'Intellibus' is capable of operations at SAE Level 4, a 'chauffeur' is present on the vehicle at all times during the trial to ensure safe operations and to take manual control if necessary. The shuttle travels at low speeds (below its top speed of 45 km/h) and uses a variety of sensors including GNSS, LIDAR and cameras. The vehicle is clearly marked as an automated vehicle to assist other road users who may need to interact with it.

The Department helped facilitate this trial by providing conditional vehicle import approval under the standard processes of the *Motor Vehicle Standards Act* (see item 2.4.1.1). This is currently the only trial in Australia where members of the public can experience riding in an automated vehicle.

Image courtesy of the Royal Automobile Club of Western Australia

The Department recognises that future regulatory frameworks will need to provide certainty in many of the areas of current concern (particularly safety, security and legal liability). Work in these areas is already underway (see item 2.4.4). There is also a strong commercial incentive for developers to design products that provide the user with a sense of control, comfort and reliability (see item 2.4.2 for further discussion about the roles for government and industry).

2.3 Present and future social issues

This section explores the potential social benefits and challenges of automated road vehicles.

2.3.1 Passenger and non-passenger safety

Social acceptance of automated vehicles will be fundamentally dependent on whether the public considers automated vehicles safe - to vehicle occupants, other road users and others near the road environment. A lack of trust in the safety record and benefits of automated vehicles will limit uptake. It is also the most critical social issue in the interim period as we move towards the development and deployment of higher-level automated vehicles.

Potential opportunities

Road crashes in Australia kill about 1,300 people per year. The cost of road crashes to society has been estimated to be $27 billion annually, or 1.8 per cent of GDP (based on a willingness-to-pay methodology of valuing human life) (Transport and Infrastructure Council, 2016a) (BITRE, 2014b, p.28). International evidence indicates that human error may be a factor in more than 90 per cent of crashes, and that road user distraction or inattention is a contributory factor in around 10-30 per cent of road accidents (Singh, 2015), (TRL, TNO and Rapp Trans, 2015, pp. 54-55). This does not necessarily mean the driver is the cause of the crash; however, it does indicate that human error may be the predominant factor in most road accidents.

If automated technology reduces or eliminates human errors, as is generally expected, then benefits for road safety may be substantial. The expected safety benefits of automated vehicles extend to other vulnerable road users, such as pedestrians and cyclists, since vehicles with higher levels of automation (i.e. SAE Levels 4 and 5) will be able to detect their presence and take evasive action automatically (Somers and Weeratunga, 2015).

However, it should be noted that the effect of higher levels of vehicle automation on road safety remains untested at a large scale and may not be immediate or linear (ITF, 2015a). Importantly, the expectation of near zero fatalities with highly automated vehicles may not be realistic, including for the duration of a mixed fleet (Sivak and Schoettle, 2015) (ETSC, 2016). More trials and real-world experiences are required to understand the safety impacts of higher levels of automated driving.

Real world data is already available on the safety impacts of lower levels of automation. For example, Electronic Stability Control (ESC), a SAE Level 1 automation function, has been observed to reduce crashes by typically 20 per cent (Thomas, 2014), (BITRE, 2014b, p.34).

Potential challenges

While automated vehicles have significant potential for improved safety, care needs to be taken to identify and control any potential new risks. Potential safety risks include:

- failure of the automated driving system, including software and hardware components;

- failure of critical supporting infrastructure, such as communications networks for vehicle-to-infrastructure communications;
- issues relating to interactions between human drivers and the automated system ('human factors'), including failure to take back control, skill attrition and over reliance on the automated driving system;
- potential problems when vehicle operations are modified by over-the-air updates, changing operational parameters;
- issues relating to human drivers mixing with automated vehicles on the road, where the different risk-taking profiles may cause difficulties in traffic;
- decisions made by manufacturers as to whether to continue in closed testing environments or to move to testing by consumers (though regulators can manage problems with immature technologies);
- cybersecurity risks such as hacking; and
- increased consequences of: vehicle defects, poor maintenance, unauthorised modification, and poor physical infrastructure.

Complexities may also arise from how automated and non-automated vehicles co-exist with potentially different driving behaviours, for example different driving speeds and reaction times. Interactions between automated vehicles and vulnerable road users (primarily pedestrians and cyclists) pose potential risks, with scope for automated vehicles to fail to detect or accurately predict the behaviour of vulnerable road users.

The Department recognises the critical importance of passenger and non-passenger safety and is working with state and territory governments to develop an appropriate regulatory framework. In November 2016, the COAG Transport and Infrastructure Council agreed that a national performance-based assurance regime should be developed to ensure the safe operation of automated vehicles, in line with international practices (NTC, 2016b). Such a safety assurance regime will give consideration to issues such as an automated vehicle's ability to obey speed zones and traffic controls, interact safely with other road users and perform safely in all likely road and environmental conditions (NTC, 2016b). An initial briefing on process and technical performance requirements under the safety assurance regime is expected to be provided to transport ministers in May 2017.

National guidelines are in development to support safe trialling of automated vehicles on public roads.[11] Safe testing activities on public roads will help to accumulate a safety record for automated vehicles and assist governments and industry to engage the public on this issue.

2.3.2 Efficiency and productivity

Estimates show the avoidable social cost of metropolitan congestion in Australia will reach around $30 billion a year by 2030 (BITRE, 2015, p. 1).[12] Based on historical trends in freight activity and Treasury projections of likely future real GDP growth, Australia's road freight task is projected, by 2030, to increase to 1.8 times its 2010 level (BITRE, 2014a). A constrained fiscal environment and the limited availability of land in Australian capital cities

[11] For information, see http://www.ntc.gov.au/current-projects/automated-vehicle-trial-guidelines/
[12] In the 2016 Infrastructure Plan, Infrastructure Australia estimates the cost of congestion in Australia's major cities to be $53.3 billion in 2031.

reduces the capacity of governments at all levels to fund new infrastructure to address these problems.

Potential opportunities

Automated vehicles have the potential to improve the efficiency and productivity of Australia's transport networks by:

- increasing average traffic speeds and by safely reducing following distances between vehicles;
- optimising driving behaviours and routes, especially for trips involving multiple passengers with varying origin-destination needs;
- reducing stoppages and delays from traffic incidents;
- encouraging the use of public transport through low-cost, on-demand first and last mile connections;
- providing more alternatives to private vehicle ownership; and
- facilitating more efficient movement of freight.

Such structural changes to the transport network have the potential to reduce road congestion costs in the future. Modelling by the Bureau of Infrastructure, Transport and Regional Economics (BITRE) indicates that under a fast penetration scenario, in which highly automated vehicles account for up to 30 per cent of the light vehicle fleet, and vehicle kilometres travelled are identical to a traditional vehicle fleet, aggregate congestion costs on the Australian road network are estimated to fall from around $37 billion to around $27 billion in 2030 (BITRE, 2015).

Potential challenges

While automated vehicles may be able to make travel more efficient, changes in traveller behaviour may influence whether travel efficiency and transport infrastructure utilisation improves overall. As described in item 2.1.6, users may be free to undertake other productive/leisure activities whilst commuting, reducing the non-monetary costs of travel and encouraging longer trips. More comfortable and convenient travel could also encourage a shift away from public transport use.

Truck platooning (see below), while potentially an efficient way to transport freight, could cause concerns with human drivers about overtaking or road visibility. It should be noted that unlike European countries, heavy vehicles with multiple trailers are widely used in Australia, potentially reducing the relative benefits of automated platooning.

European Truck Platooning Challenge

Platooning is an application of automated driving technology that uses wireless communications to allow two or more vehicles to safely travel closer together. While travelling in a platoon, the lead vehicle communicates with subsequent vehicles sending commands about when and how to undertake steering, acceleration and braking.

Potential benefits of platooning include:

- improved traffic safety;
- reduced costs and fuel consumption (due to reduced drag on following trucks);
- improved traffic flows; and
- less road space required to move an equal quantity of freight.

In 2016, the Netherlands hosted the European Truck Platooning Challenge (during its presidency of the Council of the European Union). The Challenge involved six different manufacturers collaborating to send a platoon of automated trucks on public roads across five European countries.[13] All the vehicles had a driver. The trial demonstrated the potential benefits of platooning, as well as the capacity of the European regulatory system to support a multi-jurisdictional trial.

Image courtesy of the European Truck Platooning Challenge

Governments in Australia and around the world are undertaking trials of automated vehicles in order to gain more real world experience about the potential efficiency benefits. These trials will help to inform consideration of how infrastructure investment, planning, policy and regulation might need to change to optimise productivity and efficiency benefits.

2.3.3 Environment

The transport sector accounts for 16 per cent of Australia’s greenhouse gas emissions. Light vehicles account for the largest share – 10 per cent of Australia’s total emissions (Climate Change Authority, 2014, p. 17). As the Australian population and economy grows,

[13] For information, see: https://www.eutruckplatooning.com/

so will the transport sector, which is projected to be the largest energy consumer in the Australian economy by 2049-50 (DEE, 2016).

The social impact of increased fuel consumption in road vehicles is well established: rising energy costs, which affect all sectors within Australian society (especially low-income households); increased greenhouse gas emissions; and reduced air quality caused by noxious vehicle emissions.

Potential opportunities

Improved light vehicle efficiency has been identified as one of the lowest cost emissions reduction opportunities in the Australian economy (DEE, 2016). Automated vehicles may be able to undertake more efficient driving behaviours and reduce per vehicle fuel consumption, air pollution and emissions. Vehicle platooning (in both passenger and freight applications) is projected to reduce fuel consumption by as much as 20 per cent (Somers and Weeratunga, 2015, p.8). There may be additional benefits if automated vehicles also use low or zero emissions technology, such as the potential for fleets of electric automated vehicles to re-charge automatically.

Potential challenges

Environmental benefits may not be realised if automated vehicles make longer and more frequent trips, if they travel without passengers at certain times, and if there is reduced use of public transport. As discussed in item 2.1.6, potential changes in traveller behaviour will be influenced by future ownership trends and whether shared mobility business models become popular. There may be differences in the preference for automated vehicle ownership between urban and rural areas of Australia.

Governments have a number of policy levers that can influence evolving market development, including information provision, road user pricing models and the provision of public transport services, discussed below. The Department anticipates that governments will continue to influence market development towards positive social goals such as efficiency and sustainability.

2.3.4 Access and equity

Potential opportunities

Australian governments see the ability to move around the community, or mobility freedom, as underpinning all aspects of life for all people. Automated vehicles have the potential to provide mobility to groups such as people with a disability, older people and children who currently have difficulties accessing transport services in our community (IGA, 2016, p. 7). They may also provide an opportunity for governments to service public transport needs in regional areas more effectively and efficiently.

In 2015, almost one in five Australians reported living with disability (18.3 per cent or 4.3 million people). More than half of people with a disability aged 15 to 64 years participated in the labour force (53.4 per cent), which is considerably fewer than those without disability (83.2 per cent) (ABS, 2016b). Highly automated vehicles could improve these outcomes simply by providing more convenient access to transport services for people with a disability (IGA, 2016, p. 7).

The emergence of automated vehicles also provides immense potential for older Australians to continue to engage and participate in the community. In 2015, there were an estimated 3.5 million Australians aged 65 and over, representing one in seven people (15.1 per cent). Around half of Australia's older population have a disability (ABS, 2016b).

Retirees who move to country and regional areas frequently find themselves at risk of losing access to transport, particularly if they are no longer able to drive, and public transport links are poor. Highly automated vehicles will enable older people to continue to visit the doctor, do their shopping and participate in the community (Siorokos, 2016). As with current restricted driving licences, people with a disability or medical conditions could qualify for a licence to operate an automated vehicle subject to passing whatever threshold is necessary for a vehicle with that level of automation (Tranter, 2016). Austroads is currently investigating how licencing requirements may need to be adjusted for automated vehicle technology.[14]

The National Accessible Public Transport Advisory Committee is convened by the Department to provide a mechanism for all governments, the public transport industry and the disability sector to discuss accessible public transport issues affecting people with a disability. Members of this committee have expressed enthusiasm about the benefits that automated vehicles may offer people with disability to more fully participate in all areas of Australian life.[15]

Potential challenges

In order to realise the full benefits of automated technologies, governments need to strike the right balance between encouraging the uptake of this technology, and ensuring that accessibility considerations are taken into account.[16] This includes issues such as:

- provision of wheelchair accessible vehicles, including methods for securing wheelchairs when a human driver is not present;
- the accessibility of smart phone applications, which are likely to be an essential tool for accessing automated transport;
- any potential changes to urban planning to allow safe and efficient boarding for passengers with a disability;
- appropriate licencing arrangements; and
- whether existing policy approaches and incentives in the disability sector should be adjusted or retargeted.

The Department will continue to engage with stakeholders on these issues.

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[14] Project BR1982 *Investigation of potential registration & licensing issues due to the introduction of automated vehicles,* for further information, see http://www.austroads.com.au/drivers-vehicles/connected-and-automated-vehicles/projects
[15] National Accessible Public Transport Advisory Committee – Canberra 7 June 2016
[16] National Accessible Public Transport Advisory Committee – Canberra 7 June 2016

2.3.5 Public transport

Potential opportunities

Public transport provides many Australians with access to employment opportunities, education and training, government services and social activities. The Department recognises the importance of these opportunities from a social perspective. Automated vehicles have significant potential to improve public transport services and deliver increased social benefits, particularly for people who do not live close to major public transport hubs or routes with regular services, including in regional areas (discussed further under 'impacts on regional Australia', below).

The main opportunities include:

- improved first and last mile connections to existing services, particularly if automated vehicles are deployed as a low-cost, on-demand service;
- new mobility options in areas not linked by public transport and in areas of low patronage; and
- potential reductions in the need for investment in new services and infrastructure (if automated vehicles create large efficiency benefits).

As discussed in item 2.1.5, the emerging 'Mobility as a Service' business model seeks to reduce barriers between different transport modes by providing consumers with easy and flexible access to the widest possible range of services. If this model matures in Australia, it could provide an incentive for travellers to move away from private vehicle ownership and make increased use of automated vehicles and public transport as part of a new, flexible approach to travel.

Potential challenges

However, it is also possible that automated vehicles could compete for trips with existing public transport services, especially because of increased convenience, comfort and privacy. Early modelling (based on data from the Netherlands) suggests that the costs of using shared automated vehicles could be significantly lower than owning a traditional vehicle, and that these costs could be commensurate with public transport fares.[17] If this scenario were to eventuate, it could affect the economics of public transport networks and future investment, and increase congestion on the road network.

An efficient public transport network is likely to be required for the foreseeable future. This is particularly true for heavy rail services, which will continue to have a significant capacity advantage over future fleets of automated vehicles.[18] Modelling by the International Transport Forum demonstrates that the best outcomes are achieved when automated vehicles are effectively integrated into existing public transport networks (ITF, 2015b).

Over time, it may be necessary for government policy to encourage and to provide an incentive for the efficient integration of public transport and automated vehicles (e.g. drop-off

[17] For further information, see: https://www.bcgperspectives.com/content/articles/transportation-travel-tourism-automotive-will-autonomous-vehicles-derail-trains/?chapter=2
[18] Estimates by Professor Peter Newman, Curtin University, see: https://theconversation.com/going-down-the-same-old-road-driverless-cars-arent-a-fix-for-our-transport-woes-50912

zones for automated vehicles at rail stations). This need will be determined by real world experience.

2.3.6 Liveability of cities and communities

In Australia, approximately two-thirds of the population reside in the capital cities and their metropolitan areas, and population growth in urban areas (1.7 per cent) is outpacing the rest of the country (0.7 per cent) (ABS, 2016a). As a result, the social and economic impact of automated vehicles will be most evident in cities.

Potential opportunities

If automated vehicles do not generate increased travel, then potential improvements in congestion, sustainability and accessibility will serve to improve the liveability of Australian cities and communities. Some analysts envision a future where city structures are transformed and public spaces become cleaner and safer, leading to increased social connectedness and enhanced societal wellbeing[19].

Reduced requirements for parking space could create surplus land for higher value urban redevelopment and community use. The realisation of these social and structural benefits will require proactive management through changes in land use planning policy and regulations (ITF, 2015b).

Potential challenges

However, automated vehicles also have the potential to encourage urban sprawl, as improved comfort and convenience may induce people to accept longer travel times during which they can work or undertake non-work activities. Most Australian cities have lower urban densities compared to overseas comparisons.[20]

Changes may also be required to urban planning, such as areas designated for drop-off and pick-up of passengers by shared automated vehicles. The opportunity to reduce parking spaces in higher value urban areas, if not well managed, could create problems such as privately owned automated vehicles travelling greater distances to park on the urban fringe. Future government policy may need to address such issues.

In April 2016, the Australian Government released the *Smart Cities Plan*, which sets out its vision for Australia's cities, and its commitment to enhancing their liveability through smart policy, smart investment and smart technology.[21] City Deals, which coordinate government investment in individual cities, are an important vehicle for delivering on the *Smart Cities Plan*. In the future, as technology matures, it may become appropriate for automated vehicles to play a greater role in cities policy at all levels of government.

[19] See for example, https://www.pps.org/reference/what_is_placemaking/
[20] See https://chartingtransport.com/2015/11/26/comparing-the-densities-of-australian-and-european-cities/
[21] For more information, see https://cities.dpmc.gov.au/smart-cities-plan

2.3.7 Impacts on regional Australia

Much of the focus on connected and automated vehicles is in the context of smart cities. However, given Australia's geographic profile, consideration of the impact of automated vehicles on rural and remote communities is essential.

Automated vehicles offer the potential to improve safety in regional Australia. Between 2010 and 2015, 65 per cent of road fatalities occurred in regional, rural and remote Australia (BITRE, 2016). Available evidence suggests that human factors, such as distraction and alcohol, are the primary causes of these crashes (Siskind et. al, 2011). Given that automated vehicles could significantly reduce the human element of driving, the potential to reduce crash rates is high.

Automated transport also has the potential to fill gaps in public transport services in some regional areas, with significant social benefits for residents, including increased access to employment opportunities. For example, on-demand public transport services using small automated vehicles with low operating costs could significantly improve service coverage in satellite towns around Australia's major cities. This type of automated transport could be cost competitive with regional rail links or bus services, or could fill last-mile service gaps. The Department will monitor the progress of deployments in regional Australia, given the reduced commercial incentives for the private sector to provide services, relative to city environments.

A significant challenge to the deployment of automated vehicles in regional areas is the provision of supporting infrastructure (see 2.3.1.1, below). Depending on how technology develops, this could include requirements for both physical infrastructure (e.g. sealed roads, signage, road markings) and digital infrastructure (e.g. mapping data or communications infrastructure). Improving infrastructure in regional Australia would require a concerted effort by all levels of government.

In addition, policy makers will need to remain mindful that ownership and business models may be different in rural and regional areas compared with urban areas.

2.3.8 Legal issues and insurance

Legal certainty for consumers is essential for social acceptance of automated technology. This includes ensuring that automated vehicles are legally authorised, that appropriate insurance and compensation for injuries sustained in a crash is available, and that a human driver will not be held responsible for the actions of an automated system. Legal uncertainty in these areas would also provide a disincentive to suppliers planning to bring their products to market in Australia.

The insurance industry will need to evolve in response to automated driving technology. The risks of using a vehicle will change, potentially requiring changes in traditional underwriting criteria, such as the age and experience of the human driver.[22] There will be a shift towards greater liability for manufacturers of automated systems, and some manufacturers have already indicated their willingness to accept such arrangements.[23] Determining fault in the

[22] For further information, see: http://www.iii.org/issue-update/self-driving-cars-and-insurance
[23] For further information, see: http://fortune.com/2015/10/07/volvo-liability-self-driving-cars/

event of an accident may also become more difficult, especially where both a human driver and an automated system can control the vehicle. Access to data from an automated vehicle will therefore be increasingly important (NTC, 2016b).

Positively, the reduced risks and improved data from automated vehicles could reduce the costs of insurance for consumers.[24]

The insurance industry is already working to understand the evolving market place, including by collaborating in automated vehicle trials.[25] Some firms have already released new products to take account of advances in technology.

Insurers preparing for technological change

The vehicle insurance industry is aware of the challenges of technological change and insurance firms are starting to respond. For example, in June 2016 UK firm Adrian Flux released what it called ‘the UK’s first personal, driverless car insurance policy’. The policy covers loss or damage from failure to install updates or security patches, satellite navigation failures/outages, software failures, hacking, and failure of the human driver to use the manual override.[26]

Insurers in Australia are also preparing for change by participating in groups such as the Australian Driverless Vehicle Initiative[27] and contributing to reviews of current policy.

Australian governments recognise the need to provide legal certainty for the operation of automated vehicles. In November 2015, the Transport and Infrastructure Council tasked the NTC with identifying whether there are any regulatory barriers to the introduction of automated vehicles in Australia.

The NTC’s final report, released in November 2016, concludes that many aspects of Australia’s legal system are flexible and able to accommodate new technology (e.g. civil liability and the Australian Consumer Law).[28] However, other driving related legislation (e.g. the Australian Road Rules and third party insurance legislation) assumes that a human driver will be present and in control of the vehicle, meaning that some reform will be required. These reforms and other NTC projects are discussed in item 2.4.4, below.

Australian governments, through the Transport and Infrastructure Council, will continue to monitor and respond to legal issues to provide certainty to the Australian community.

[24] The Future of Motor Insurance, http://media.swissre.com/documents/HERE_Swiss+Re_white+paper_final.pdf
[25] For example, insurer AXA is a participant in several autonomous vehicle trials in the UK – see http://www.axa.co.uk/about/our-company/driverless-cars/
[26] For further information, see: https://www.adrianflux.co.uk/driverless-cars/driverless-car-insurance-has-arrived
[27] For further information, see: http://advi.org.au/partners/
[28] For further information, see: http://ntc.gov.au/roads/technology/automated-vehicles-in-australia/

2.3.9 Security

Automated vehicles will be dependent on a wide array of electronics, sensors and software components and could be vulnerable to cyber-attack. Cybersecurity vulnerabilities have been found in current vehicles. For example, in 2015 Fiat recalled 1.4 million Chrysler vehicles following the demonstration of a software vulnerability by two cybersecurity researchers.[29] Cybersecurity vulnerabilities not only risk physical safety but could also compromise sensitive personal data.

The Department understands that robust security measures are necessary to ensure public confidence in automated technology. Poor public perceptions about the security of automated vehicles would represent a significant barrier to broader uptake.

Protecting cybersecurity will be a shared responsibility between governments and industry, and public and private sectors will need to work closely together on security management. It will be equally important to communicate to the public that cybersecurity risks are being controlled or mitigated.

Given that Australia is a relatively small market for road vehicles, policy in this area will need to align with other markets, so as not to create a barrier to trade. The Department is engaging with international bodies who are developing standards and guidance for automated vehicle cybersecurity, such as the World Forum for the Harmonisation of Vehicle Standards (see item 2.4.3). Separately, collaborative work is underway with state and territory governments to develop a security management plan for connected and automated vehicles, focusing on the security of wireless communications between vehicles, and with roadside infrastructure.[30]

2.3.10 Privacy and data

Automated vehicles will create large amounts of data.[31] This data is likely to be a valuable resource in a range of applications including:

- providing new information and services to consumers, e.g. real-time travel information;
- infrastructure planning and investment decision-making;
- optimising approaches to traffic management and asset maintenance;
- remote diagnostics, maintenance, 'over-the-air' updates and continual improvement of automated driving features; and
- crash investigation and determining fault.

Appropriate use and sharing of data will benefit consumers, manufacturers and government agencies.

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[29] For information, see: https://www.wired.com/2015/07/jeep-hack-chrysler-recalls-1-4m-vehicles-bug-fix/
[30] See Appendix B, National Policy Framework for Land Transport Technology
[31] For information, see: http://www.computerworld.com/article/2484219/emerging-technology/self-driving-cars-could-create-1gb-of-data-a-second.html

Some of the data generated by an automated vehicle could be personal data. There are public concerns about who will collect this data, how it will be stored, and how manufacturers, governments or other corporations might make use of this consumer-generated data.[32] A particular concern is that automated vehicles are likely to have accurate satellite positioning capability and could map the location history of a vehicle (NTC, 2016a). There is also the risk that a cyber-attack could expose personal data to malicious or improper use.

The Department supports the view that personal data should have strong protections, in line with community expectations. Entities handing personal data from automated vehicles will be subject to existing privacy laws, including the *Privacy Act 1988* (Cth) and the Australian Privacy Principles, state and territory-based Information Privacy Principles, and state and territory-based laws which prohibit covert surveillance of individuals.

Fundamentally, it will be important for governments to weigh up the potential productivity, efficiency and mobility benefits of data with potential opportunities to monitor regulatory compliance. In a number of states in the United States and in New Zealand for example, governments have had to make clear legislative commitments around individuals owning the location data generated during trips to ensure that users were not discouraged from taking up innovative technology. These commitments restrict the capacity to use this data in road user charging systems.

Recent public consultation by the National Transport Commission (NTC) (see item 2.4.4.1) considered whether current privacy legislation will continue to be fit for purpose for automated vehicles (NTC, 2016a). The NTC found that the potential for future privacy risks depends on the extent to which automated vehicles generate personal information, and that until privacy risks are better understood, existing privacy laws are likely to remain fit for purpose.

However, the NTC also found that:

> ‘The Privacy Act has a low threshold to exempt enforcement activities from the Australian Privacy Principles, and the benefits of automated vehicles may not be realised if consumers are uneasy about government access to their personal information, or if government access is inconsistent or unclear’ (NTC, 2016b, p.71).

On this basis the Transport and Infrastructure Council has agreed that the NTC would ‘develop options to manage government access to automated vehicle data, having regard to achieving road safety and network efficiency outcomes and efficient enforcement of traffic laws, balanced with sufficient privacy protections for automated vehicle users’ (NTC, 2016b, p.66).

The Productivity Commission is also undertaking a public inquiry into data availability and use, which is considering issues around privacy and control. The Inquiry’s draft report proposed a number of reforms to improve public confidence in data processes.[33] A final report is expected in March 2017.

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[32] For example, see: www.mycarmydata.com.au
[33] The Committee’s draft report is available at http://www.pc.gov.au/inquiries/current/data-access#draft

2.3.11 Infrastructure investment and digital infrastructure

The Australian Government's *Principles for Innovative Financing* set out goals for its investment in Australia's land transport infrastructure, and expectations for how projects are selected and innovative funding and financing decisions are considered.[34] One such principle is that transport proposals are assessed against the extent to which technology solutions are used to optimise the capacity of existing and new infrastructure. Automation in vehicles is one more technology solution that can be considered.

As previously discussed, automated vehicles could change traveller behaviour and impact demand for infrastructure and public transport services (positively or negatively). This could have significant implications for the way governments plan and invest in infrastructure. The Department and its state and territory counterparts are already considering the possible impacts through traffic modelling and forward-looking planning.

Automated vehicles may also require the deployment of new kinds of digital infrastructure (e.g. communications infrastructure, accurate satellite positioning) or may require aspects of physical infrastructure to be designed and maintained to a particular standard (e.g. road signage, line markings, road geometry). At the current time, given the early stage of automated vehicle development and trials, there is significant uncertainty about what the exact future requirements might be.

An additional challenge is that not all developers of automated vehicles will use the same enabling technologies (see item 2.1.4), meaning that it is possible that different vehicles could have different technical requirements. There are also different approaches to the design and maintenance of physical infrastructure across Australia, which in the past has presented a barrier to the deployment of technologies such as automatic speed zone recognition.

Austroads is currently investigating these issues, discussed in item 2.4.4.1. The Australian Government is also funding a test-bed to investigate the potential benefits of improved satellite positioning technology, including for automated transport (also discussed in item 2.4.2). Any increases in the costs of providing infrastructure (or transport services) from increased demand or changing requirements will be a challenging issue for governments to address, given the current constrained fiscal environment and competing fiscal demands.

2.3.12 Road related revenues

Automated vehicles will also impact road-related revenues at all levels of government. While safety improvements and the more efficient use of existing infrastructure could reduce costs, thereby placing decreasing pressure on government revenues, future scenarios could also see decreased revenue from registration and licencing fees (resulting from reduced private ownership of vehicles), from parking fees and fines, and from traffic violation fines. Reduced costs may directly offset some revenue reductions (for example, the reduced need for parking facilities could offset reduced parking revenue).

[34] For information, see: http://investment.infrastructure.gov.au/whatis/innovativefinancing.aspx

Other technological advances, such as more efficient internal combustion engines and electric vehicles, will place pressure on fuel excise revenues.

The size of these effects could be significant. For example, the International Transport Forum has modelled that vehicle ownership could drop to as low as 10 per cent of the current fleet (for a medium-sized European city), which would have a significant effect on registration revenue (ITF, 2015b). Research at the local government level in the United States suggests a significant likely reduction in traffic violation and parking fines affecting local government revenues (Desouza, 2015).

Reform of Australia's current model for charging and investing in roads will be necessary to ensure the financial sustainability of road infrastructure funding into the future. Equity and fairness will be key issues for this reform to ensure road user charging more fairly reflects road users' specific use of road assets and the provision of services to meet their needs. Work is underway through the Transport and Infrastructure Council to investigate the benefits, costs and options to introduce cost-reflective road pricing for all vehicles.

2.3.13 Labour market impacts

Alongside information and communications technology, transport is an important 'enabling service' for Australian industry. With potential improvements to safety and productivity, automation in transport and logistics could be a key factor in driving broader economic growth in other sectors. In order to realise the potential productivity, efficiency, and safety benefits, it will be necessary to manage any disruption to existing job roles.

The Department acknowledges that a range of current roles could experience varying degrees of disruption. For example, a number of professional driving roles could be automated to some extent in the future, including taxi, freight and public transport drivers. Around 247,000 Australians were employed driving trucks, buses and taxis in 2015.[35]

Associated industries may also be affected, for example occupations that deal directly with the cause and effect of accidents such as insurers, crash repairers, road rule enforcement officers (including some police officers and council parking infringement officers), accident and emergency workers and crash investigation workers. Businesses involved in the supply of vehicles to market (manufacturers, car dealerships) could also be affected if the overall size of the vehicle market decreases due to greater use of shared mobility at the expense of private vehicle ownership.

However, there are also a number of factors that could lead to new employment opportunities and make this transition easier.

Firstly, early models of automated vehicles may need to hand back control to a human driver or be limited in the scope of their operations, meaning that professional drivers will still be required. Professional driver roles may evolve to place a stronger focus on non-driving tasks, such as customer service. Some challenging or specialist driving tasks may require a human driver for an extended period.

[35] For information, see: http://joboutlook.gov.au/alpha.aspx

Secondly, a long transition period is anticipated for automated technology, particularly higher levels of automation that do not require human oversight (see item 2.1.3). There have been difficulties in attracting younger workers into some parts of the sector, leading to labour shortages. A gradual increase in the automation of driving roles may assist with managing these shortages.[36]

Lastly, automation will create new business and job opportunities that could offset possible losses. There could be new roles in supplying, maintaining and operating automated vehicles, or other roles that use automated vehicles as a platform to deliver new kinds of services to the market. As with other disruptive technologies, it difficult to anticipate the opportunities that may arise with automated vehicles.

Automated vehicles could also improve labour market participation for people who are effectively excluded from the market, such as people with disabilities, if they are better connected with employment centres.

These factors may mean that an overall large, negative impact on the workforce from automated vehicles is unlikely.

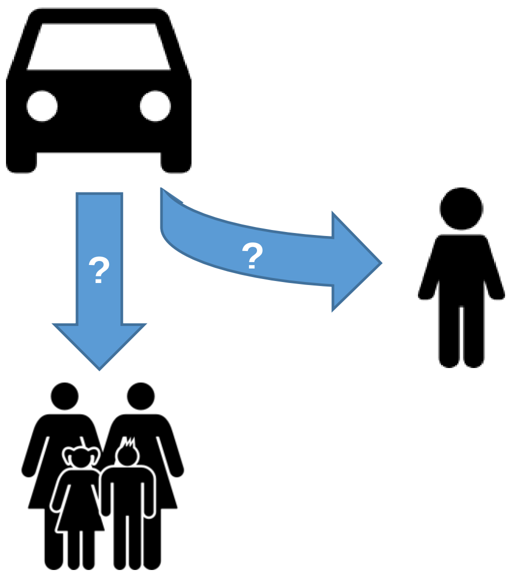
However, past experience in other sectors that have undergone technological transformation indicates that new roles tend to require higher skills and education, particularly in science, technology, engineering and mathematics (STEM), and are higher paid positions (Hajkowicz, et al., 2016). This can create a barrier to retrain or reskill displaced employees so they can transition to new roles. Government education policies continue to focus on equipping students for the future workforce by increasing participation in STEM education and improving digital literacy.[37]

2.3.14 Ethical considerations

Some stakeholders have raised concerns about how automated vehicles might act in ethically challenging situations. A commonly used hypothetical scenario is the ‘trolley problem’, where the vehicle must choose between staying on course and injuring a larger number of people, or diverting and injuring one (see Figure 5). There are many formulations of this hypothetical situation, including whether the vehicle should prioritise the safety of its occupants over pedestrians. Some analysts argue that automated vehicles will need to engage in ‘crash-optimisation’ because some crashes, such as a pedestrian running directly in front of a vehicle, will be unavoidable (Lin, 2015).

[36] ABS data from 2015 (Labour Force, Australia, Cat. No. 6202.0) indicates that 38.7 per cent of bus and coach drivers and approximately 12 per cent of truck and delivery drivers are over 60 years of age.
[37] For information, see: https://www.education.gov.au/inspiring-all-australians-digital-literacy-and-stem

Figure 5: The 'trolley' problem for automated vehicles



Designed by the Department of Infrastructure and Regional Development from Flaticon

Community concerns about automated vehicle decision-making in such scenarios could be a social barrier to adoption.

International regulators are seriously considering ethical issues. The US Department of Transportation's draft Automated Vehicle Policy (U.S. Department of Transportation, 2016), released in September 2016, suggests that manufacturers address ethical issues consciously and transparently with input from various stakeholders.

However, a number of factors mean that ethical considerations may not present a large social barrier to the adoption of automated vehicles.

Firstly, if automated driving leads to large safety gains, 'lose-lose' situations would become increasingly uncommon. Automated driving systems may have advantages over human drivers in avoiding such situations before they occur, such as monitoring the external environment in 360 degrees at all times, without human risk factors such as fatigue or inattention. Programming of early test vehicles includes strong, defensive driving behaviours.[38]

Secondly, manufacturers may take a pragmatic approach to resolving situations with ethical dimensions, such as by programming a vehicle to brake at an optimal rate in a straight line. This could be superior to human reactions in difficult situations, particularly where there is limited time for human decision-making, including the human reaction time.

Finally, there are practical difficulties in realising 'ethical' decision-making by automated vehicles. For example, the Australian community may not agree on the optimal decision in different situations (e.g. including those illustrated by the trolley problem). There may also

[38] For example, trial vehicles from the Google Self-driving Car Project (now Waymo), see: https://www.theguardian.com/technology/2014/may/28/google-self-driving-car-how-does-it-work

be uncertainty about a vehicle's capacity to evaluate different courses of action in such a situation (Ford, 2016). Given that there is a lack of precedent for governments to intervene with formal regulation of ethical decision-making of automated systems, it is likely that vehicle manufacturers will largely self-regulate in this area in the future. International developments and further real world testing will inform Australia's approach.

2.4 Government actions

2.4.1 Australia's current regulatory framework

2.4.1.1 Australian Government

The Australian Government is responsible for developing and implementing national vehicle standards (the Australian Design Rules) and regulating the first supply of vehicles to market. It is a significant funder of infrastructure and represents Australia's interests in international policy-making bodies, such as the United Nations World Forum for the Harmonisation of Vehicle Regulations (refer to item 2.4.3).

The Australian Government also plays a role in advocating for a nationally consistent approach to regulation of motor vehicles.

Australian Design Rules

The *Motor Vehicle Standards Act 1989* (the Act) and associated regulations provide the legislative basis for the Australia Government to control the safety, environmental performance and security of new and used vehicles supplied to the Australian market. Under the Act and the Motor Vehicle Standards Regulations 1989, the Australian Government maintains a system that generally requires road vehicles to meet national design and performance standards – the Australian Design Rules (ADRs) – that are established and maintained in line with community expectations and international standards. The ADRs apply equally to vehicles manufactured in Australia and vehicles imported into Australia.

The ADRs are becoming increasingly harmonised with United Nations (UN) vehicle regulations. Harmonisation ensures that vehicles built to the most recent safety, environmental and anti-theft standards are supplied to the Australian market at the least cost. It also ensures that Australians can access the latest vehicle technologies (including automated vehicle technologies).

Current government policy is that each new or amended ADR must be subject to a stringent regulatory impact process before introduction. The regulatory impact process involves establishing: market failure; that there are no other non-regulatory options available that could achieve the same outcome; and that regulation is the option that would lead to the greatest net benefit to the community. Real world crash data provides the basis for this analysis. Finally, there must be a full offset of the compliance costs of each ADR by the amendment or removal of existing regulatory cost burdens.

On 10 February 2016, the Government announced a package of reforms to the Act and its associated regulations, delivering modernised legislation to increase community safety, provide greater choice and competition in the Australian vehicle market and remove unnecessary red tape on businesses. The reforms follow a review of the regulatory framework (including an extensive consultation process) that began in 2014.

The Government also announced its intention to accelerate the harmonisation of Australian vehicle standards and requirements with the United Nations Regulations, maintaining the ADRs as the mechanism for implementing these standards in Australia.

The ADRs are designed to be flexible in response to changes in technology and do not specifically prohibit the deployment of automated vehicles. However, the ADRs do require traditional design features such as steering wheels and windscreens and could be a barrier to deployment if these features are not present in future vehicles (e.g. highly automated vehicles designed to operate without human oversight). The UN vehicle regulations and the ADRs will continue to evolve and will respond appropriately to automated technology.

Consumer education and the role of ANCAP

While the ADRs set design and performance standards for vehicles, the Australian Government has also supported complementary consumer awareness programmes, such as the Australasian New Car Assessment Program (ANCAP) and the Green Vehicle Guide, that play a role in creating demand beyond a minimum regulated standard in some areas (such as emerging crash protection or fuel performance technologies) in some vehicle categories.

Consumer education programs such as ANCAP complement regulatory systems by encouraging consumers to consider safety in vehicle choice.

2.4.1.2 State and territory governments

State and territory governments have primary responsibility for:

- compliance with standards after first supply to market (‘in-service standards’);
- funding most Australian roads;
- road operations and maintaining existing assets;
- registering vehicles;
- licencing drivers; and
- enforcing the Australian Road Rules.

In-service standards

Once a vehicle has been found to conform to the relevant ADRs, regulation of the ongoing use of the vehicle is a matter for the states and territories. The states and territories base their laws on nationally consistent standards and rules, including the Australian Light Vehicle Standards Rules, the Australian Road Rules and the Heavy Vehicle National Law.[39]

Registration, licensing and road operations

State and territory governments regulate the ongoing use of vehicles through their registration processes. The registration processes manage the initial and ongoing responsibility to ensure the vehicle is fit for use on public roads through inspection and registration. The registration processes also considers the roadworthiness of modified vehicles.

Driver licensing fulfills other requirements, such as initial and/or ongoing driver knowledge, fitness and competence, and additional training or competency requirements that might

[39] Heavy vehicles are regulated in a different way to light vehicles. An explanation of the heavy vehicle regulatory system is available at https://www.nhvr.gov.au/law-policies/heavy-vehicle-national-law-and-regulations

apply to that type of vehicle. For example, additional licensing requirements apply to motorcyclists.

States and territories are also responsible for public transport services (directly or through contractual arrangements) and road operations (including monitoring and managing traffic flows, setting speed limits to road, weather and traffic conditions, etc.).

2.4.2 Roles and responsibilities for reform

Ensuring Australia's readiness for automated vehicles requires a coordinated response across all levels of government, as well as close collaboration with industry and other stakeholders, including the public.

The private sector will drive the deployment of automated vehicles in Australia as it responds to consumer demand. There are strong commercial incentives for the private sector to build public support for automated vehicle technology, including by addressing some social issues.

However, governments must establish the right policy and regulatory settings to ensure that community expectations of safety, security and privacy are met, and that unnecessary barriers to deployment and innovation are removed. Government intervention may be necessary where coordinated action is required, where commercial incentives are insufficient to achieve outcomes in the national interest, or where public investment will benefit the network as a whole.

2.4.2.1 Public sector governance

The COAG Transport and Infrastructure Council has agreed on the strategic priority of adopting innovative transport technologies and is currently working towards a nationally consistent approach to the deployment of automated vehicles (Transport and Infrastructure Council, 2016b).

The Council has agreed on the following four roles for government in facilitating the deployment of emerging technologies[40]:

- **Policy leadership** — providing a clear, nationally coordinated approach across different levels of government, effectively managing the transition between old and new technologies, and raising public awareness and acceptance of new technologies.
- **Enabling** — ensuring that the private sector is able to bring beneficial new technologies to market, including by supporting investment in digital infrastructure and/or data streams.
- **Supportive regulatory environment** — ensuring that community expectations of safety, security and privacy are appropriately considered in new technology deployments, that regulatory barriers are removed in a proactive fashion and that there is certainty about future regulatory requirements.

[40] For further information see Appendix B, National Policy Framework for Land Transport Technology

- **Investment** — investing in research, development and real-world trials that benefit the entire transport network customer base or provide a sound basis for government decision-making.

These roles will have different implications at different levels of government, reflecting the division of responsibilities in the current regulatory framework. For example, one of the Department's main responsibilities in creating a supportive regulatory environment is to ensure that the ADRs appropriately respond to automated driving technology. At the state level efforts will be more focused in areas such registration, licencing and changes to road operations.

2.4.2.2 Intergovernmental bodies

In addition, there are two intergovernmental bodies helping to increase Australia's readiness for the adoption of automated driving technology:

- *The National Transport Commission (NTC)* is an independent advisor to the Transport and Infrastructure Council on reforms to Australia's land transport system. The NTC is currently undertaking a range of projects related to the safety and legal aspects of automated driving (see item 2.4.4.1).
- *Austroads* is the peak organisation of Australasian road transport and traffic agencies and provides evidence-based policy and guidance on the design, construction and management of the road network and associated infrastructure. The deployment of automated vehicles is a strategic priority for Austroads and it has established a Connected and Automated Vehicle Program (see item 2.4.4.1 for further information). [41]

The contributions of intergovernmental bodies are coordinated through the Transport and Infrastructure Senior Officials' Committee, a forum of road and transport agency heads that supports the Transport and Infrastructure Council. Two other intergovernmental bodies, the Australian Road Research Board (ARRB)[42] and Transport Certification Australia (TCA)[43], are assisting with specific tasks that will assist road agencies in preparing for automated vehicles.

2.4.3 International context

United Nations (UN)

The UN World Forum for the Harmonization of Vehicle Regulations, commonly known as 'Working Party 29 (WP.29)', is the international body responsible for the development of UN vehicle regulations. WP.29 administers the 1958 and 1998 Agreements regarding UN vehicle regulations and Global Technical Regulations (GTRs), respectively. [44] It has

[41] For information, see: http://www.austroads.com.au/drivers-vehicles/connected-and-automated-vehicles/overview
[42] https://www.arrb.com.au/home.aspx
[43] http://www.tca.gov.au/
[44] Australia is a party to: the United Nations Agreement concerning the Adoption of Uniform Technical Prescription for Wheeled Vehicles, Equipment and Parts which can be Fitted and/or be Used on Wheeled Vehicles, and the Conditions for Reciprocal Recognition of Approvals Granted on the Basis

established an Intelligent Transport Systems/Automated Driving (ITS/AD) working group. The Department participates in this working group.

The working group has developed definitions for automated systems that are based on the SAE taxonomy (see item 2.1.1), linking these to the functional characteristics of known systems. This is an important step in a comprehensive program to develop a suite of regulations relating to automated vehicles.

WP.29 and the ITS/AD working group have set out guidelines for developing and modifying UN regulations with respect to automated vehicles, the scope of which is being extended to cover highly and fully automated systems. These regulations will cover automated vehicles that, when activated appropriately, do not require monitoring from a human operator (SAE Levels 3-5).

A step-by-step approach is being taken in the development of UN Regulations in collaboration with relevant industry bodies and other stakeholders. For example, regulations for automated steering, eSafety, eSecurity and event data recorders are under development in line with these guidelines.

In addition, WP.29 has decided that the current principle in road use law of the driver having the responsibility to control the vehicle at all times is no longer completely in alignment with emerging vehicle technologies. Consequently, it has engaged with another party that is responsible for the Vienna Convention on Road Traffic, known as Working Party 1 (WP.1). Coordination between WP.29 and WP.1 seeks to address inconsistencies between the Road Traffic Convention and vehicle regulations.

In a first step, WP.1 has now amended the Convention such that the requirement for a driver to be in control of a vehicle can be deemed to have been met, provided that the vehicle systems are in conformity with the UN vehicle regulations or can be overridden or switched off by the driver.[45]

US-EU-Japan Trilateral Working Group on Automation in Road Transport

The United States, European Union (EU) and Japan have a formed the Automation in Road Transportation trilateral working group to exchange information on the status of vehicle automation research and development, and government initiatives in North America, Europe and the Asia-Pacific. The Department engages with this working group to benefit from its learnings. The trilateral working group has subcommittees on issues including human factors, legal issues and security standards, in which Australian agencies such as ARRB and TCA are participating or observing.

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of these Prescriptions of 20 March 1958 (the 1958 Agreement); and the United Nations Agreement concerning the establishing of Global Technical Regulations for Wheeled Vehicles, Equipment and Parts which can be fitted and/or be used on Wheeled Vehicles of 25 June 1998 (the 1998 Agreement).

[45] For information, see: http://www.unece.org/info/media/presscurrent-press-h/transport/2016/unece-paves-the-way-for-automated-driving-by-updating-un-international-convention/doc.html

European Union (EU)

The EU and its member states are actively preparing for automated vehicles. Key initiatives include:

- **Amsterdam declaration** (April 2016) — outlines the commitment of EU member states to a co-ordinated approach to the deployment of automated vehicles. [46]
- **Testing and trials** — significant activities are planned or underway, including by brands such as Volvo, Peugeot, Jaguar Land Rover and Ford.
- **Testing guidelines** — the UK has developed a code of practice for testing automated vehicles, with recommendations for safety and minimising potential risks.[47]
- **Connected vehicle technology** — the EU is preparing for connected vehicles as a complementary technology, including through a European Strategy on Cooperative Intelligent Transport Systems.[48]

United States

Activities in the US include:

- **Testing activities** — a large number of firms are developing automated driving technology. In California alone, 21 entities have obtained approval to test automated vehicles on public roads.[49] Some testing activities are open to the public with oversight by a professional driver (see below). [50]
- **Federal Automated Vehicles Policy (September 2016)** — provides guidance on best practices for the safe design, development and testing of vehicles. It includes a model state policy to facilitate nationally consistent deployment of vehicles (U.S. Department of Transportation, 2016).
- **State level actions** — Eight US states have passed legislation relating to automated vehicles, and two have issued executive orders.[51] There are currently different requirements for testing and deployment of automated vehicles across states, including a majority of states that do not have specific automated vehicle regulations.
- **Automated Vehicle Proving Grounds** — the US Department of Transportation has designated 10 locations as 'proving ground pilot sites', with the aim of encouraging safe testing and information sharing.[52] The designation does not include funding assistance.

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[46] For information, see: https://english.eu2016.nl/documents/publications/2016/04/14/declaration-of-amsterdam
[47] For information, see: https://www.gov.uk/government/publications/automated-vehicle-technologies-testing-code-of-practice
[48] For information, see: https://ec.europa.eu/transport/themes/its/c-its_en
[49] For information, see: https://www.dmv.ca.gov/portal/dmv/detail/vr/autonomous/testing
[50] For information, see: http://www.abc.net.au/news/2016-12-16/self-driving-uber-runs-red-light/8128700
[51] For information, see: http://www.ncsl.org/research/transportation/autonomous-vehicles-legislation.aspx
[52] For information, see: https://www.transportation.gov/briefing-room/dot1717

- **Policy research** — US authorities are undertaking research into policy issues, similar to work occurring in Australia, such as the applicability of vehicle standards, insurance and liability issues.[53]
- **Investment in connected vehicles** — the US has invested heavily in connected vehicle technology, which is complementary to automation. This includes a US$45 million dollar investment in three pilot projects in Wyoming, New York and Florida to test safety and mobility applications in real world settings.[54]

Uber testing of automated vehicles

In September 2016, Uber began offering customers in the city of Pittsburgh the opportunity to opt-in to its trial of an automated ride sharing service. A safety driver is present during the trial in case human intervention is required.

This is one of the limited opportunities available for the public to experience vehicles with higher levels of automation. There have been some concerns in relation to vehicles running red lights, which Uber claims occurred while under driver control.

While this trial is adding to the social understanding of automated vehicles, it is also illustrating the potential for public concern and the legal issues that could arise, particularly from vehicles that have dual driving modes.

Image Courtesy of Uber

[53] For information, see: http://ops.fhwa.dot.gov/regulationpolicy/avpolicyactivities/index.htm
[54] For information, see: http://www.its.dot.gov/pilots/

New Zealand

- **Testing guidance** — NZ has released information for entities wishing to test automated vehicles. Testing is able to be undertaken under existing laws, and special permits or licences are not required.[55]
- **Testing activities** — the first trial of a highly automated vehicle will occur at the Christchurch International Airport in 2017.[56]

2.4.4 Actions underway in Australia

There are a range of reform actions underway through all levels of government to support the development, trialling and introduction of higher levels of automated vehicles. Many involve a collaborative approach with a number of the stakeholders discussed above.

2.4.4.1 National initiatives

National Policy Framework for Land Transport Technology

In August 2016, the Transport and Infrastructure Council agreed to a National Policy Framework for Land Transport Technology (see **Appendix B**). The Policy Framework fosters a nationally consistent approach by governments to the deployment of emerging transport technologies. The Policy Framework is a collaboration between the Australian, state and territory governments, Austroads and the NTC.

The Policy Framework is underpinned by a three year action plan, which includes:

- establishing a regulatory framework for testing automated vehicles;
- developing national operational guidelines to support the on-road use of automated vehicles;
- undertaking priority trials and research of intelligent transport systems (including connected and automated vehicles);
- developing a connected vehicle (Cooperative ITS) infrastructure road map;
- publishing a connected vehicle (Cooperative ITS) statement of intent on standards and deployment models;
- developing a nationally agreed deployment plan for the security management of connected and automated vehicles; and
- investigating options to provide enhanced geo-positioning information to the land transport sector.

Regulatory reforms for automated vehicles

In late 2016, the Transport and Infrastructure Council tasked the NTC with leading a number of reforms to the regulation of automated vehicles, particularly in relation to legal and safety

[55] For information, see: http://www.transport.govt.nz/ourwork/technology/specific-transport-technologies/road-vehicle/autonomous-vehicles/testing-autonomous-vehicles-in-nz/
[56] For information, see: http://www.christchurchairport.co.nz/en/about-us/media-centre/media-releases/2016/new-zealands-first-trial-of-autonomous-vehicle-announced/

issues. This work followed a 12 month investigation into potential regulatory barriers to automated vehicles, including two separate rounds of public consultation.[57]

The agreed reforms include:

- developing national guidelines governing conditions for trials of automated vehicles;
- developing national enforcement guidelines that clarify the regulatory concepts of 'control' and 'proper control' for different levels of driving automation;
- designing and developing a safety assurance regime for automated road vehicles;
- developing legislative reform options to clarify the application of current driver and driving laws to automated vehicles, and to establish legal obligations for automated driving system entities;
- supporting jurisdictions in reviewing current exemption powers to ensure legislation can support on-road trials;
- supporting jurisdictions in reviewing injury insurance schemes to identify any eligibility barriers for occupants of an automated vehicle, or those involved in a crash with an automated vehicle; and
- developing options to manage government access to automated vehicle data that balances road safety and network efficiency outcomes and efficient enforcement of traffic laws with sufficient privacy protections for automated vehicle users.

Operational aspects of automated vehicles

Austroads, on behalf of its road agency members, is investigating and responding to the operational impacts of automated driving technology. This includes projects on registration and licencing; investigating impacts on road operators and network infrastructure (for example, future physical and digital infrastructure requirements); and evaluating the potential safety benefits of automated vehicles.[58] Austroads is also involved in determining standards, security and use of spectrum for connected vehicles.

2.4.4.2 Australian Government initiatives

Satellite Based Augmentation Systems (SBAS) Testbed

In January 2017, Minister for Infrastructure and Transport, the Hon Darren Chester MP and the Minister for Resources and Northern Australia, Senator the Hon Matthew Canavan, jointly announced an investment of $12 million for a two-year program looking into the future of geo-positioning technology in Australia.[59] This project will test instant, accurate and reliable positioning technology, in particular, the potential of SBAS technology to contribute to many industries including transport, agriculture, construction, and resources. Improving

[57] For intformation see: https://www.ntc.gov.au/roads/technology/automated-vehicles-in-australia/

[58] For information, see: http://www.austroads.com.au/drivers-vehicles/connected-and-automated-vehicles/projects

[59]For information, see: http://minister.infrastructure.gov.au/chester/releases/2017/january/dc010_2017.aspx

the accuracy of geo-positioning information may be a key enabler of the development of automated and connected vehicles.

Spectrum

Radiofrequency spectrum is the range of electromagnetic radiation that is used for communications purposes. It is the backbone of any networked communications system including mobile phones and navigation devices, and is an essential infrastructure requirement for connected and automated vehicles. Spectrum is a critical input to a networked digital economy and society, and a finite resource that needs to be managed efficiently.

The Australian Communications and Media Authority is considering spectrum allocation for connected vehicle technology (using the 5.9GHz band).[60] More broadly, the Australian Government is also improving arrangements for spectrum access by implementing the recommendations of the Spectrum Review, which will reduce the regulatory burden and improve access to new technologies.

Memorandum of Cooperation with US Department of Transportation

In August 2016, the Secretary of US Department of Transportation and the Minister for Infrastructure and Transport announced a Memorandum of Cooperation to enable cooperation and sharing of best practices on infrastructure and transport, including intelligent transport systems and automated vehicles. This will provide Australia with a valuable opportunity to learn from, and ensure consistentcy with, the approaches of leading international regulators.

2.4.4.3 State and territory government initiatives

Trials and demonstrations

Several state governments are planning or have undertaken trials and demonstrations of automated vehicles (see full list at **Appendix A**). As road owners and managers, state and territory governments are best placed to undertake trials. The Department provides support for trials, for example by facilitating import approvals for appropriate vehicles.

Key examples include:

- **New South Wales** — is undertaking several projects to trial wireless communications between heavy vehicles and road side infrastructure for safety and vehicle priority applications.
- **Victoria** — announced on 5 October 2016 that it has invested $1.2 million with automotive parts manufacturer Bosch to develop a highly automated vehicle in Clayton, Victoria. The trial aims to better understand driver behaviour in automated vehicles and to inform future approaches to regulation and network operations.

[60] For information, see: http://www.acma.gov.au/theACMA/proposed-regulatory-measures-for-the-introduction-of-c-its-in-australia

- **Queensland** — has announced a large scale pilot of Cooperative ITS in Ipswich, and a smaller pilot of cooperative and highly automated vehicles driven on selected roads.
- **South Australia** — partnered with Volvo to deliver the first on-road demonstration of an automated vehicle in the Southern Hemisphere in November 2015.[61]
  South Australia has also enacted laws allowing for on-road trials of automated vehicles, which require applicants to undertake a trial assessment process with the South Australian Government and have sufficient insurances to protect the public.[62]
- **Western Australia** — the Royal Automobile Club of Western Australia, in conjunction with the Western Australian Government, is trialling an automated shuttle bus in South Perth.[63] This trial is open to members of the public.
- **Northern Territory** — the Northern Territory Government has announced a six month trial of an automated shuttle bus at the Darwin Waterfront during 2017.

2.4.4.4 Funding programs

Several states have committed funding programs for a range of purposes relating to automated vehicles, including:

- The New South Wales Government is establishing a **Smart Innovation Centre** in Western Sydney as a research and development hub for emerging transport and road technologies. The scope of the centre includes tests and pilots of connected and automated vehicle technologies.[64]

- The South Australian Government has announced a $10 million grant program, the **Future Mobility Lab Fund**, to accelerate the development and implementation of connected and automated vehicles. Projects will focus on testing, trials in real-world conditions and research and development activities.[65]

- The Victorian Government has announced a $4.5 million **Intelligent Transport Systems Grants Program.**[66] The government has announced three projects, focusing on wireless communications and research into interactions between automated vehicles and physical infrastructure.[67]

[61] For information, see: http://dpti.sa.gov.au/news?a=179468
[62] For information, see: http://driverlessvehicles.sa.gov.au/
[63] For information, see: http://intellibus.rac.com.au/
[64] For information, see: http://www.transport.nsw.gov.au/programs/smart-innovation
[65] For information, see: http://www.dpti.sa.gov.au/transportinnovation
[66] For information, see: http://www.austroads.com.au/news-events/item/325-vicroads-its-transport-technology-grant-program
[67] For information, see: http://www.premier.vic.gov.au/tech-trials-to-bust-congestion-on-our-road-network/

3 Rail

3.1 State of technological development

3.1.1 Grades of Automation

Train automation refers to the process by which responsibility for operational management of a train transfers from the driver to the train control system. There are various Grades of Automation (GoA), defined according to which basic functions of train operation are the responsibility of the automated rail system (see Figure 6).

For example, a Grade of Automation 1 (GoA1) corresponds to 'on-sight operation', where a human driver is responsible for normal operations, with the automated system only intervening to avoid a crash. Grade of Automation 4 (GoA4) refers to a system in which vehicles operate fully automatically without any operating staff on board, which would generally occur within a closed network system (UITP, 2011).

Figure 6: Grades of Automation

Grade of Automation	Type of train operation	Setting train in motion	Stopping train	Door closure	Operation in event of Disruption
GoA 1	ATP with driver	Driver	Driver	Driver	Driver
GoA 2	ATP and ATO with driver	Automatic	Automatic	Driver	Driver
GoA 3	Driverless	Automatic	Automatic	Train attendant	Train attendant
GoA 4	UTO	Automatic	Automatic	Automatic	Automatic

ATP - Automatic Train Protection
ATO - Automatic Train Operation

Source: UITP (Union Internationale des Transports Publics), International Association of Public Transport)

The key elements for automated rail systems are (UITP, 2011):

- **Automatic Train Protection (ATP)** is the system and all equipment for basic safety. It avoids collisions, red signal overrunning and exceeding speed limits by applying brakes automatically. A line equipped with ATP corresponds (at least) to a GoA1.
- **Automatic Train Operation (ATO)** insures partial or complete automatic train piloting and driverless functionalities. The ATO system performs all functions of the

driver, except for door closing. The driver only needs to close the doors, and if the way is clear, the train will automatically proceed to the next station. This corresponds to a GoA2. Many newer systems are completely computer controlled, while still electing to maintain a driver or a train attendant of some kind to mitigate risks associated with failures or emergencies. This corresponds to a GoA3.

- **Automatic Train Control (ATC)** automatically performs normal signaller operations such as route setting and train regulation. The ATO and the ATC systems work together to maintain a train within a defined tolerance of its timetable. The combined system will marginally adjust operating parameters such as the ratio of power to coast when moving and station dwell time, in order to bring the train back to the timetable slot defined for it. There is no driver, and no staff assigned to accompany the train, corresponding to a GoA4. This Grade of Automation is also referred to as Unattended Train Operation (UTO).

3.1.2 Automation in the rail industry - a mature technology

The use of automation in train operations has been increasing over a long period. Fully automated, driverless rail networks have been in operation for over 30 years. These driverless networks have mostly occurred on purpose-built, closed networks, which have a single operator and infrastructure owner performing a single task in isolation from other rail operations. There are currently 55 driverless metro lines operating in 37 cities worldwide, with the first Australian line under construction (see below) (UITP, 2016).

Sydney Metro: the first Australian driverless deployment

Australia's urban rail systems will undertake a step-change over the coming years with the completion of Stage 1 of the Sydney Metro project – the $8.3 billion Sydney Metro Northwest railway. Sydney Metro Northwest is an example of automated rail technology previously unseen in Australia. While the rail vehicles will be driverless, with controllers monitoring the entire system from an Operations Control Centre, train attendants will be present, corresponding to GoA3 (BITRE and ARA, 2015).

In the 30 years since the implementation of the first driverless metro lines, the growth rate for this technology has doubled in each passing decade. Current forecasts, based on confirmed projects, indicate that by 2025 there will be over 2,300 kilometres of driverless metro lines in operation worldwide (UITP, 2016).

While driverless metro lines generally operate on a closed network, significant portions of rail systems use open access networks. On an open access network there are often multiple operators performing different tasks (such as passenger and freight rail), creating a barrier to introducing driverless rail for individual operators. For this reason, the incentive to invest in driverless freight rail has been limited to-date and greater productivity gains can generally be realised by investing in limited grades of automation or the rail infrastructure network itself.

However, where freight providers operate within closed networks, the barrier to driverless rail can be overcome. This is particularly evident in the Pilbara region of Western Australia, where Rio Tinto is currently developing a driverless system known as AutoHaul.

AutoHaul: autonomous heavy haul

AutoHaul will be the world's first fully-autonomous heavy haul, long distance railway system. In 2016, system development continued with submission of regulatory approvals, completion of full system functionality, improvement of system performance and reliability and gradual integration into operations. There have been delays in implementation but it is expected to be operational in 2017.

3.1.3 Pre-automation technologies in Australia

European Train Control System

European Train Control System (ETCS) technology is being considered for metropolitan rail systems in Brisbane, Sydney and Melbourne. ETCS replaces traditional colour light signalling that keeps trains apart with a digital solution that allows trains to run closer together safely, and to travel at their optimal speeds and braking distances (Lavis, 2015). While not necessarily a driverless technology, ETCS does provide a pathway to automation in the future through systems such as ATO, which combines the advisory data with the signalling data to directly control the train's traction and braking systems (Siemens, 2016).

Automated Freight Systems

The Government owned Australian Rail Track Corporation (ARTC) is continuing to develop its Advanced Train Management System (ATMS), a new technology specifically designed for and by the ARTC that uses digital GPS navigation and broadband communications to locate and route freight trains in real time. While this is an automated system, it is not intended to become fully driverless.

ATMS, jointly delivered by ARTC and Lockheed Martin Australia, will allow enhanced safety, greater efficiency and increased capacity of rail infrastructure. Once fully developed, ATMS technology will be capable of broader application both in Australia and internationally. ARTC is currently deploying ATMS on trains operating between Port Augusta and Whyalla in South Australia. Phase 1 trials of ATMS in early 2016 have demonstrated the reliability of the system on real rail traffic.

3.2 Current attitudes towards automated rail

From a technical perspective, the advantages of driverless rail over conventional rail systems are widely agreed. However, from a passenger's perspective, the debate is more open-ended and often based on public perceptions of safety, rather than reality. These perceptions generally relate to the absence of a driver capable of responding to emergencies (Frasczyk, Brown and Duan, 2015, pp.78-86).

Public perceptions of a reduction in safety have been a much bigger issue for automated road vehicles and are a regular discussion point in the aviation industry, as arguably the driver and pilot are much more visible to the travelling public on those modes. While it may remain to some extent an ongoing concern in relation to automated rail operations, overseas experience through the introduction and operation of 55 fully automated driverless lines demonstrates that the public will accept and use driverless rail technology. This supports the argument that negative public perception is a hurdle that rail has mostly overcome through a long history of successful implementation.

3.3 Present and future social issues

3.3.1 Improved network capacity

With the number of people living and working in our cities growing, upgrading the capacity of Australia's rail networks is vital. The implementation of driverless rail systems allows operators to optimise the running of trains, increasing the average speed of the system, shortening headways[68] by up to 75 seconds, and reducing dwell time in stations (in optimal conditions) to 15 seconds (UITP, 2011, p. 3).

By not needing drivers, operators gain flexibility and can make better use of assets. Driverless rail systems can better match supply and demand, reducing oversupply at off-peak hours and enabling operators to allocate trains in response to sudden surges in demand (UITP, 2011).

3.3.2 Cost savings

Automated rail has greatly reduced operational costs compared to conventional railways. Staffing costs can be reduced, even in cases of line conversion where staff are likely to be retrained and deployed to other functions (e.g. monitoring of automated trains).

Acceleration and deceleration patterns of automated rail are adjustable to reduce energy consumption and maximise energy recovery, therefore significantly reducing energy costs.

There are also significant savings with communications-based train control systems as they allow for the removal of traditional trackside infrastructure, such as track circuits and colour signals, and the associated high costs of maintenance. New communications-based equipment is far more reliable, resulting in fewer delays.

Investment in automated rail is not viable in every circumstance. In some situations, costs associated with converting to an automated system will outweigh any forecast operational savings.

3.3.3 Safety

Automated rail systems offer safer operations by reducing the human-risk factors, with well-designed systems proving more reliable than conventional railways (UITP, 2011). Upgrading to a more modern system design also brings a number of added safety and security functions.

[68] The average interval between trains.

Safety and Security Standards – the Sydney Metro Northwest project

Safety and security considerations are central design features of the Sydney Metro Northwest project. Trains are being designed, built and operated to the highest safety standards, with more than 300 Australian and international safety standards stipulated in the operations contract for the trains and the associated equipment. High levels of security will prevent trespasser access, such as platform screen doors that keep people and objects away from the tracks and allow trains to enter and depart stations faster. Obstruction detectors will prevent trains departing stations if any door is not fully closed.

In an emergency, passengers can leave the train when directed by using either tunnel walkways or the wide built-in ramps, which fold out from the front and the back of the trains. There will be extensive use of surveillance cameras, both on-board trains and in tunnels, and a modern communications system will control the trains, tunnels, tracks, platforms and platform screen doors (departmental correspondence with Sydney Metro Northwest, as cited in BITRE and ARA, 2015).[69]

Source: Transport for NSW (http://www.transport.nsw.gov.au/newsroom/media-releases)

3.3.4 Environmental benefits

Fully automated rail systems can be a contributing factor to urban sustainability by improving energy efficiency, reducing tunnel temperatures and cutting carbon emissions by using coasting and regenerative braking (where, on an electrified network, kinetic energy from braking feeds back into the electricity supply) (Boscolo, Heydecker and Fujiyama, 2017).

[69] For information, see http://nwrail.transport.nsw.gov.au/ and departmental correspondence

Aurizon driver assist system

Australian freight rail company Aurizon utilises an in-cab real time driver assist system on its electrified central Queensland coal network. The UGL Ltd. EcoRun system advises drivers on optimal settings for their trains, such as how much power to use; when to brake or decelerate along given sections of track (according to the specifics of a given train); and how much fuel they have saved. UGL Ltd. estimates EcoRun can provide fuel savings of between 4-15 per cent depending on train type (BITRE and ARA, 2016).

3.3.5 Regulatory barriers to deployment of automated systems

The NTC has advised that:

> *'…there are unlikely to be regulatory barriers to the introduction of more automated trains in Australia because the rail sector has adopted an accreditation model based on operators satisfying the relevant regulator that they have the competency and capacity to manage the identified tasks.'* (NTC, 2016a)

It further concluded that no further analysis of automated rail is required in Australia at this time.

3.3.6 Labour market impacts

Most driverless rail systems are purpose-built closed systems. This means that rather than losing routine driving positions, these positions were never created in the first place. However, some roles may become redundant or staff will require redeployment with the introduction of automation on open access rail networks, or on closed systems currently using drivers.

Potential opportunities

The introduction of driverless rail technology can change demand for staff qualifications and experience. Instead of confining staff to cabins in a driving specific capacity, staff need to be deployed along the line and in contact with customers. Front-line staff require a customer-oriented outlook and some technical knowledge in order to reset defective equipment or manually drive the train in the unlikely case of a system failure. Operation Control Centre staff require demanding qualifications and skills to perform emergency operations, potentially without the support of on-board staff. Traditional operational tasks also evolve towards maintenance, merging two fields traditionally separate (UITP, 2011).

In general terms, driverless rail system staff require a deeper knowledge of all key systems, as well as a global overview on the functional interactions between them, creating professional development opportunities. In cases where it is possible to make a direct comparison, indicators show that staff working in driverless rail systems benefit from higher levels of job satisfaction compared with those in conventional rail systems (UITP, 2011).

Potential challenges

The most significant social challenge from automation of rail networks in Australia is the potential impact on employment. Some stakeholders are already raising concerns that automation will see jobs in the public transport sector diminish, despite solid year-on-year growth in public transport patronage across the country (Rail, Tram and Bus Union, 2015). This challenge will require careful management and appropriate communication about the productivity and safety benefits associated with driverless rail systems.

In the case of line conversion to driverless rail, it may be necessary to retrain and deploy staff to other functions. An example of this is the conversion of the Paris Metro Line 1 from a driver-operated network to a driverless network. This process took close to a decade, and operators worked closely with unions to redeploy all staff.

While there are exceptions for driverless freight operations on closed networks, no strong desire has been voiced from industry for freight trains to move towards driverless operations. As discussed previously, most freight rail operators work on open and often complicated networks, and there are greater productivity gains by investing in limited automation and in the rail infrastructure network.

3.3.7 Variation between automated systems

While not a barrier to the introduction of automated systems in itself, if there is significant variation in systems adopted in Australia, it has the potential to generate inefficiencies in how the Australian rail network operates as a whole over time. Recent work by the NTC concluded that:

> *'There may be operational challenges related to establishing a safety case for automated trains that are operating on shared systems and interact with other types of trains.*
>
> *These could be addressed, in part, through the development of international and national standards. However, under the accreditation model, these challenges are the responsibility of rail operators to identify and manage and are not regulatory barriers'* (NTC, 2016a).

This is potentially the case for the introduction of the satellite based ATMS being trialled by ARTC and any potential communication-based train control systems to be implemented in urban areas (such as ETCS) where the trains need to interact (note that neither of these systems are intended to be driverless at this stage).

This issue has been identified in the National Rail Vision and Work Program recently endorsed by the Transport and Infrastructure Council where states and territories have agreed to:

> *'Work with infrastructure managers to identify rail network control systems being introduced and where possible and desirable, ensure interoperability and compatibility'* (Transport and Infrastructure Council, 2016c, p.5).

Rail infrastructure owners are aware of these issues and are working together.

There is also an opportunity to harmonise automated train technology, including data sets. For example, the release of NSW transport data has seen the private development of multiple different transport apps to assist with trip scheduling, booking and alerts.[70]

[70] NSW Transport, 2017, *Transport Apps*, http://www.transportnsw.info/en/travelling-with-us/keep-updated/apps.page

3.4 Government actions

3.4.1 Australia's current regulatory framework

Most rail networks in Australia are owned by state and territory governments, who have established their own business enterprises to manage the networks, or who have leased or contracted out the management of their networks to the private sector. A relative exception to this is the interstate network, which is largely operated by the Australian Government-owned ARTC. Examples of contracted rail infrastructure managers include: Aurizon in Queensland; Genesee and Wyoming in South Australia and the Northern Territory; Brookfield and the Pilbara rail operators in Western Australia; and Metro Trains in Melbourne.

States and territories have primary responsibility for managing rail operations and are responsible for rail safety laws. These laws have now been harmonised across jurisdictions through the adoption of the Rail Safety National Law (RSNL). The RSNL provides a framework for safety management without prescribing what a particular operator must do to ensure its operations are safe. This approach allows for different types and sizes of operations and for industry innovation. The RSNL establishes the Office of the National Rail Safety Regulator (ONRSR) as the body responsible for rail safety regulation in Australia.

All operators are required to provide evidence that their system and technology is safe under national rail regulations. This is referred to as safe working and includes the operating rules for signalling systems and rolling stock, which must be adhered to by above and below rail infrastructure managers.

Under the co-regulatory framework, it is the rail industry's role to develop and apply safety management systems (including standards) to ensure that their operations are safe, with ONRSR providing the overarching regulatory framework and accreditation process.

The Rail Industry Safety and Standards Board (RISSB) is an industry owned and operated body that develops and manages national rail industry standards, rules, codes of practice and guidelines. Nationally harmonised operational and management standards improve safety, efficiency and productivity. In developing its standards, RISSB, similarly to the ONRSR, is focussing on outcomes and performance rather than prescriptive rules.

3.4.2 Roles and responsibilities for reform

As confirmed by the NTC, there is no need for regulatory reform in the rail sector to enable the introduction of automated train control systems (NTC, 2016a, p.7) (see item 3.3.5).

3.4.3 International context

As outlined above, safe rail operations are managed by signalling systems and the rules around safe rail operations are consistent worldwide. This applies to all rail networks, including fully automated driverless networks. Infrastructure owners and operators must ensure their rules and regulations for signalling and driver train separation are safe and meet the minimum requirements.

European Union

Perhaps the largest example of automation in rail operations is occurring in the European Union, which has developed trans-European networks that promote interoperability and technical harmonisation. The European Rail Train Management System (ERTMS) is a major project that aims to replace the different national train control systems operating across Europe using the previously identified ETCS network, described in item 3.1.3, above. It is a legal requirement that all new, upgraded or renewed tracks and rolling stock in the European railway system should adopt ETCS, while allowing for interoperability with older legacy systems.

3.4.4 Actions underway

While jurisdictions have primary responsibility for rail network management and investment in metro train control systems, the Australian Government has taken a lead in development of interstate digital control systems and in ensuring that the communications infrastructure required for increased levels of train automation is available and secure.

Advanced Train Management System (ATMS)

The Australian Government is investing $50 million towards the implementation of the ATMS by ARTC. As described in item 3.1.3, ATMS technology will allow trains to run closer together on the interstate rail network, increasing capacity of the existing network, while enhancing safety.

Spectrum allocation for urban rail communications

In 2013, the Australian Government allocated radiocommunications spectrum in the 1800 MHz band for use by passenger rail operators in Sydney, Melbourne, Brisbane, Perth and Adelaide. This spectrum, and the protocols and standards that use it, allows transmission of a large quantity of data (not just voice) and will allow operators to implement next generation train control systems such as ETCS.

4 Conclusion

Both automated road and rail transport present significant opportunities for the Australian community.

As highlighted in this submission, automated road vehicles have the potential to provide a significant boost to road safety, productivity, environmental performance and transport accessibility. Taking advantage of innovative new approaches, both through automated vehicles and other emerging land transport technologies, is essential in order to address persistent challenges in the transport sector.

The Department acknowledges that there are significant (but surmountable) social issues that need to be addressed before the potential benefits of automated road vehicles can be fully realised. These include ensuring the safety, security and privacy of automated technologies, developing new legal frameworks, managing potential labour market impacts and building equitable outcomes for all Australians, particularly those in regional Australia and Australians with a disability. Automation is a potentially disruptive technology that will affect many aspects of how governments provide transport infrastructure and services, from public transport to infrastructure planning. The Department will continue to work towards nationally consistent approaches to these challenges.

More trials and real-world experience is required to understand the future impacts, and this work is already underway across Australia. Establishing a robust, nationally consistent regulatory framework for automated road vehicles is a key role for governments, which will serve as a foundation for building public confidence in these new technologies.

Automated rail is a more mature technology that already has an appropriate regulatory framework in Australia. While some concerns have been raised in relation to labour market impacts and customer experience, international experience provides a strong indication that these concerns can be managed. The Department will continue to leverage international experiences in the deployment of automated rail in Australia.

The Department will continue to work with a broad range of stakeholders towards a smooth adoption of automated vehicles in Australia.

5 Reference List

Australian Bureau of Statistics. (2016a, March 30). *Regional Population Growth, Australia, 2014-15*. Catalogue number: 3218.0. Retrieved from Australian Bureau of Statistics: http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/3218.0Main+Features12014-15?OpenDocument

Australian Bureau of Statistics. (2016b, October 18). *Disability, Ageing and Carers, Australia: Summary of Findings, 2015*. Catalogue number: 4430.0 Retrieved from Australian Bureau of Statistics: http://www.abs.gov.au/ausstats/abs@.nsf/mf/4430.0

Austroads. (2011). *Evaluation of the Potential Safety Benefits of Collision Avoidance Technologies Through Vehicle to Vehicle Dedicated Short Range Communications (DSRC) in Australia*. Reference number: AP-R375-11. Retrieved from https://www.onlinepublications.austroads.com.au/items/AP-R375-11

Boscolo, F., Heydecker, B., & Fujiyama, T. (2017). *The Optimisation of Automatic Train Regulation on the London Underground.* Retrieved from University College London: https://www.ucl.ac.uk/resilience-research/research/atr

Bureau of Infrastructure, Transport and Regional Economics. (2014a*). Freightline 1 - Australian freight transport overview.* Canberra. Retrieved from http://bitre.gov.au/publications/2014/files/Freightline_01.pdf

Bureau of Infrastructure, Transport and Regional Economics. (2014b). *Impact of road trauma and measures to improve outcomes (Report 140)*. Canberra. Retrieved from https://bitre.gov.au/publications/2014/files/report_140.pdf

Bureau of Infrastructure, Transport and Regional Economics. (2015). *Traffic and congestion cost trends for Australian capital cities, Information Sheet 74*. Canberra. Retrieved from https://bitre.gov.au/publications/2015/files/is_074.pdf

Bureau of Infrastructure, Transport and Regional Economics. (2016). *Road trauma Australia 2015 statistical summary.* Canberra. Retrieved from https://bitre.gov.au/publications/ongoing/files/Road_trauma_Australia_2015.pdf

Bureau of Infrastructure, Transport and Regional Economics and Australasian Railway Association. (2015). *Trainline 3 - Statistical Report.* Canberra.

Bureau of Infrastructure, Transport and Regional Economics and Australasian Railway Association. (2016). *Trainline 4 - Statistical Report.* Canberra. Retrieved from https://bitre.gov.au/publications/2016/files/train_004.pdf

Bureau of Resources and Energy Economics. (2014). *Australian Energy Projections to 2049-50.* Canberra. Retrieved from https://industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/aep/aep-2014-v2.pdf

Climate Change Authority. (2014). *Light Vehicle Emissions Standards for Australia - Research Report.* Canberra. Retrieved from http://climatechangeauthority.gov.au/files/files/Light%20Vehicle%20Report/Lightvehiclesreport.pdf

Department of the Environment and Energy. (2016). *Quarterly Update of Australia's National Greenhouse Gas Inventory: December 2015.* Canberra. Retrieved from https://www.environment.gov.au/system/files/resources/7c0b18b4-f230-444a-8ccd-162c8545daa6/files/nggi-quarterly-update-dec-2015.pdf

Desouza KC, Swindell D, Smith KL, Sutherland A, Fedorschak K, and Coronel, C. (2015). *Local Government 2035: Strategic trends and implications of new technologies.* The Brookings Institution. Retrieved from https://www.brookings.edu/wp-content/uploads/2016/06/desouza.pdf

European Transport Safety Council. (2016). *Prioritising the Safety Potential of Automated Driving in Europe.* European Transport Safety Council. Retrieved from http://etsc.eu/wp-content/uploads/2016_automated_driving_briefing_final.pdf

Fraszczyk, A., Brown, P., & Duan, S. (2015). *Public Perception of Driverless Trains.* Urban Rail Transit, 1(2), 78-86.

Ford 2016, *Response to Federal Automated Vehicle Policy Request for Comments*, available at https://www.regulations.gov/document?D=NHTSA-2016-0090-1094

Hajkowicz, S., Reeson, A., Rudd, L., Bratanova, A., Hodgers, L., Mason, C., & Boughen, N. (2016). *Tomorrow's Digitally Enabled Workforce*. Brisbane: CSIRO. Retrieved from http://www.data61.csiro.au/Our-expertise/Expertise-Strategic-insight/Tomorrows-Digitally-Enabled-Workforce

Insurance Group Australia. (2016). *Submission to NSW Government Joint Standing Committee on Road Safety (StaySafe) Inquiry into Driverless Vehicles and Road Safety in NSW.* Sydney. Retrieved from https://www.parliament.nsw.gov.au/committees/inquiries/Pages/inquiry-details.aspx?pk=1972

International Transport Forum. (2015a). *Automated and Autonomous Driving: Regulation under uncertainty*. Paris. Retrieved from http://www.itf-oecd.org/sites/default/files/docs/15cpb_autonomousdriving.pdf

International Transport Forum. (2015b). *Urban Mobility System Upgrade - How shared self-driving cars could change city traffic*. Retrieved from http://www.itf-oecd.org/sites/default/files/docs/15cpb_self-drivingcars.pdf

Issac, L. 2016, *Driving towards driverless: A guide for government agencies*, WSP Parsons Brinckerhoff. Retrieved from http://www.wsp-pb.com/en/WSP-USA/CONNECTED-AND-AUTOMATED-VEHICLES/OUR-PROJECTS/DRIVING-TOWARDS-DRIVERLESS-A-GUIDE-FOR-GOVERNMENT-AGENCIES/

Lavis, G. (2015). *Transport Select Committee Inquiry: Rail Technology,* written evidence from Network Rail. Retrieved from http://digitalrailway.co.uk/wp-content/uploads/2016/04/Rail-Technology-Inquiry-Network-Rail-Written-Evidence-FINAL.pdf

Lin, P. (2015). *Why Ethics Matters for Autonomous Cars*. In M. Maurer, J. C. Gerdes, B. Lenz, H. Winner, M. Maurer, J. C. Gerdes, B. Lenz, & H. Winner (Eds.), Autonomes Fahren: Technische, rechtliche und gesellschaftliche Aspekte (pp. 69-85). SpringerLink.

National Transport Commission. (2016a). *Regulatory barriers to more automated road and rail vehicles - Issues paper.* Retrieved from http://www.ntc.gov.au/Media/Reports/(66E42530-B078-4B69-A5E3-53C22759F26E).pdf

National Transport Commission. (2016b). Regulatory Reforms for Automated Road Vehicles. Retrieved from http://www.ntc.gov.au/Media/Reports/(66E42530-B078-4B69-A5E3-53C22759F26E).pdf

Rail, Tram and Bus Union. (2015). *Statement to the Productivity Commission's Inquiry into the Workplace Relations Framework*. Retrieved from http://www.pc.gov.au/__data/assets/pdf_file/0007/189718/sub0231-workplace-relations.pdf

Royal Automobile Club (Western Australia). (2016). *Autonomous vehicle survey.* Royal Automobile Club (Western Australia). Retrieved from http://intellibus.rac.com.au/media/Autonomous%20Vehicles%20Survey_FINAL%20HR.pdf

Schoettle, B., & Sivak, M. (2014). *A Survey of Public Opinion about Autonomous and Self-Driving Vehicles in the U.S., the U.K, and Australia*. University of Michigan. Ann Arbor: University of Michigan Transportation Research Institute. Retrieved from https://deepblue.lib.umich.edu/bitstream/handle/2027.42/108384/

Siemens. 2016. *Background information: Automated driving by rail*. Retrieved from https://www.siemens.com/press/pool/de/events/2016/mobility/2016-09-innotrans/background-automated-driving-e.pdf

Singh, S. (2015)*. Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey.* Washington DC: National Center for Statistics and Analysis. Retrieved from https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812115

Siorokos, M. (20 June 2016). *Transcript of evidence to the NSW Government Joint Standing Committee on Road Safety (StaySafe) Inquiry into Driverless Vehicles and Road Safety in NSW.* September 2016, (p. 3).

Siskind, V., Steinhardt, D. A., Sheehan, M. C., O'Connor, T., & Hanks, H. (2011). *Risk factors for fatal crashes in rural Australia*. Retrieved from http://eprints.qut.edu.au/40492/1/c40492.pdf

Sivak, M., & Schoettle, B. (2015). *Road Safety with Self-Driving Vehicles: General Limitations and Road Sharing with Conventional Vehicles.* Ann Arbor: University of Michigan Transportation Research Institute. Retrieved from https://deepblue.lib.umich.edu/bitstream/handle/2027.42/111735/103187.pdf?sequence=1&isAllowed=y

Somers, A., & Weeratunga, K. (2015*). Automated Vehicles: Are we ready?* Perth: Main Roads WA. Retrieved from https://www.mainroads.wa.gov.au/Documents/Automated%20Vehicle%20Report.RCN-D15%5E2381741.PDF

Thomas, P. (2014). *Driverless vehicles: from technology to policy.* London: PACTS Conference Report, Parliamentary Advisory Council for Transport Safety. Retrieved from http://www.pacts.org.uk/wp-content/uploads/sites/2/Pete-Thomas-Conference-Report.pdf

Transport and Infrastructure Council. (2016a*). National Road Safety Strategy 2011-2020 Implementation status report*. National Road Safety Strategy. Retrieved from http://roadsafety.gov.au/performance/files/NRSS_Implementation_report_Nov2016.pdf

Transport and Infrastructure Council. (2016b). *Strategic Work Programme*. Retrieved from http://transportinfrastructurecouncil.gov.au/publications/files/Council_Strategic_Work_Programme.pdf

Transport and Infrastructure Council. (2016c). *National Rail Vision and Work Program*. Retrieved from http://transportinfrastructurecouncil.gov.au/publications/files/National_rail_vision_and_work_program.pdf

TransPosition. (2016). *Conceptual sensitivity modelling and analysis on the introduction of autonomous vehicles,* prepared for Department of Transport and Main Roads, unpublished, cited with permission.

Tranter, D. (20 June 2016). *Transcript of evidence to the NSW Government Joint Standing Committee on Road Safety (StaySafe) Inquiry into Driverless Vehicles and Road Safety in NSW* September 2016, (p. 17).

Transport Research Laboratory, the Netherlands Organisation for applied scientific research (TNO) and Rapp Trans. (2015). *Study on good practices for reducing road safety risks caused by road user distractions*. Brussels: European Commission.

U.S. Department of Transportation. (2016). *Federal Automated Vehicles Policy: Accelerating the Next Revolution In Roadway Safety.* Retrieved from https://www.transportation.gov/sites/dot.gov/files/docs/AV%20policy%20guidance%20PDF.pdf

Union Internationale des Transports Publics (International Association of Public Transport). (2011*). A global bid for automation: UITP Observatory of Automated Metros confirms sustained growth rates for the coming years.* Brussels: UITP.

Union Internationale des Transports Publics (International Association of Public Transport). (2016). *Statistics Brief - World Report on Metro Automation - July 2016*. Brussels: UITP.

Appendix A: Current Tests and Trials of Connected and Automated Vehicles

State	Trial	Description
NSW	Cooperative Intelligent Transport Initiative (CITI)[1]	• The CITI is a Cooperative-Intelligent Transport System (C-ITS) testing facility in the Illawarra region, south of Sydney. CITI allows heavy vehicle drivers to receive safety messages about upcoming hazards and potential crashes. The messages come via technology attached to other vehicles, as well as structures such as traffic signals. • Applications being tested include: ○ intersection collision warnings; ○ forward collision warnings; ○ heavy braking ahead warnings; ○ traffic signal phase information; and ○ speed limit information. • There are 60 vehicles fitted with C-ITS. • The Australian Government contributed $715,000 to the project.
	Smart Innovation Centre[2]	• In April 2016, the New South Wales Government also announced the establishment of a Smart Innovation Centre in Western Sydney as a research and development hub for emerging transport and road technology. The scope of the centre includes tests and pilots of connected and automated vehicle technologies.
	Heavy Vehicle Priority Project signalised intersections[3]	• The New South Wales Government announced a C-ITS trial to reduce the number of times trucks stop at traffic lights by connecting around 110 trucks to roadside infrastructure. • The trial aims to improve travel time at more than 100 intersections across Sydney, resulting in smoother overall traffic flow for all road users. • The trial will detect a heavy vehicle approaching traffic lights and provide more green time, reducing the slow stopping and starting of heavy vehicles.

[1] For information, see http://roadsafety.transport.nsw.gov.au/research/roadsafetytechnology/cits/citi/index.html
[2] For information, see https://www.transport.nsw.gov.au/programs/smart-innovation
[3] For information, see http://www.rms.nsw.gov.au/about/news-events/news/ministerial/2016/160419-future-transport-trucks-talk-to-traffic-lights.html

Victoria	Bosch Automated Vehicle[4]	• In October 2016, the Victorian Government announced it has invested $1.2 million with automotive parts manufacturer Bosch to develop a highly automated vehicle in Clayton, Victoria. • The vehicle is designed to navigate roads with or without driver input and includes technology to detect and avoid hazards such as pedestrians, cyclists and other vehicles. • Trials of the vehicle will inform the development of regulations and infrastructure to enable similar self-driving cars to operate on Victorian roads when they become commercially available in the future.
	ITS Grants Program[5]	• On 30 August 2016, the Victorian Government announced three trials of technologies aimed at reducing congestion. • Intelematics will receive $765,000 over 18 months to use technology to allow vehicles to pass through consecutive waves of green lights and enable road users to make smarter decisions through messages about the state of the traffic ahead via GPS and a smart phone app. • Yarra Trams, in partnership with the Australian Road Research Board (ARRB), will receive $669,000 over 18 months to trial a signalling system to give trams priority at intersections with traffic lights. • ARRB, Connect East and LaTrobe University will receive $578,000 for their project to enable roadside infrastructure such as traffic lights and electronic speed signs to communicate with vehicles. This project will also test semi-automated vehicles on the Eastlink freeway to assess whether the latest technology is compatible with current infrastructure such as road signs and line markings.
	Victorian Road Safety Action Plan[6]	• The Victorian Road Safety Action Plan includes a $10 million action to trial connected and automated vehicle technologies.
	National Connected Multimodal Transport Test Bed[7]	• Victorian Government announced on 6 January 2017 it is supporting researchers from the University of Melbourne's School of Engineering studying connected data from vehicles, cyclists, pedestrians and infrastructure in a five square kilometre area in inner Melbourne. • The test bed will be comprised of thousands of sensors and wireless units fitted to roads, traffic signals and vehicles, and results from the project will be used to obtain insights on managing smart transport systems and road networks more efficiently. • The test bed pilot is scheduled to launch in April 2017.

[4] For information, see http://www.premier.vic.gov.au/victoria-leads-the-way-with-self-driving-vehicles/
[5] For information, see http://www.premier.vic.gov.au/tech-trials-to-bust-congestion-on-our-road-network/
[6] For information, see https://www.towardszero.vic.gov.au/what-is-towards-zero/road-safety-action-plan
[7] For information, see http://www.premier.vic.gov.au/world-first-hi-tech-transport-research-for-melbourne/

Western Australia	Automated Shuttle[8]	• The Royal Automobile Club (WA) and the WA Government are working together to deliver a trial of a highly automated shuttle bus along a route in South Perth. • The trial is offering trips to members of the public and there is a survey of public attitudes. • The trial involves a number of stages, with each stage involving increasing levels of complexity, including a greater number of obstacles, or traffic signals and road markings, then finally interactions with road users.
	Autonomous Heavy Vehicle Platooning Trial[9]	• The WA Government is working with several mining companies, the Australian Driverless Vehicle Initiative, and heavy vehicle automation specialist Peloton on a trial of truck platooning. Initial plans are for a trial on private mine haul roads.
Queensland	Cooperative and Automated Vehicle Initiative[10]	• In November 2016, the Queensland Government announced that Ipswich will be the host site of a large-scale test-bed to test cooperative and highly automated vehicles on public roads. • This will include a trial of around 500 motorists, who will have their vehicles retrofitted with C-ITS technology over a four year period. • The devices will provide safety warnings to the driver about a range of conditions – for example, a pedestrian crossing at a signalised intersection, a red light runner or a queue ahead that is not visible to a driver. • The Queensland Government is also working with Bosch to secure some cooperative and highly-automated vehicles for testing. • Beyond the project, the test-bed will be available for use by industry, academics, and government to continue to test new technologies.
South Australia	Future Mobility Lab Fund[11]	• In October 2016, the South Australian Government announced a $10 million grant program to accelerate the development and implementation of connected and automated vehicles. Projects will focus on testing, trials in real world conditions and research and development activities.
	Automated Vehicle Demonstration[12]	• The South Australian Government, the Australian Driverless Vehicle Initiative, Volvo and others conducted the first on-road demonstration of a driverless vehicle in the Southern Hemisphere in Adelaide in November 2015.
Northern Territory	Driverless shuttle bus trial[13]	• In December 2015, the Northern Territory Government announced a six-month trial deployment of the EasyMile EZ10 'driverless' vehicle at the Darwin Waterfront. • It will see the driverless vehicle transport visitors from the Waterfront precinct to Stokes Hill Wharf on a repeat loop. The highly automated vehicle is also a zero emissions vehicle and can carry up to 12 passengers.

[8] For information, see http://intellibus.rac.com.au/
[9] For information, see http://www.austroads.com.au/images/CAV/MRWA_platooning_trial.pdf
[10] For information, see http://statements.cabinet.qld.gov.au/Statement/2016/11/24/australias-largest-intelligent-vehicle-trial-to-be-held-in-qld
[11] For information, see http://www.dpti.sa.gov.au/transportinnovation
[12] For information, see http://www.dpti.sa.gov.au/driverlesscars
[13] For information, see http://newsroom.nt.gov.au/mediaRelease/22676

TRANSPORT AND INFRASTRUCTURE COUNCIL

NATIONAL POLICY FRAMEWORK FOR LAND TRANSPORT TECHNOLOGY

ACTION PLAN: 2016–2019

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Use of the Coat of Arms

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Table of contents

1. The Transport and Infrastructure Council

The Transport and Infrastructure Council brings together Commonwealth, State, Territory and New Zealand ministers with responsibility for transport and infrastructure issues, as well as the Australian Local Government Association.

In November 2015 the Council agreed on a long-term vision for an infrastructure and transport system that will enhance Australia's productivity, competitiveness and liveability and shape the work of the Council over the coming decades. The Council will continue to place a strong focus on those policy issues that would benefit from collaboration across the three levels of government.

Capitalising on the opportunities afforded by emerging technologies is a key part of realising the Council's vision. To that end this document outlines in detail Australia's approach to emerging transport technologies (including Intelligent Transport Systems) and builds on previous work by the Council in its 2011 *Policy Framework for Intelligent Transport Systems in Australia*[1].

More information on the work of the Council is available from <*www.transportinfrastructurecouncil.gov.au*>.

[1] Available from <*http://transportinfrastructurecouncil.gov.au/publications/*>

2. Introduction

Transport technology (both internationally and in Australia) is changing rapidly, bringing with it many potential benefits for our transport networks. These benefits include improved transport productivity, more efficient use of existing infrastructure, reduced congestion and avoided deaths and injuries.

Governments, industry and research institutions are actively exploring the best ways to develop and deploy new transport technologies. For example, Australian governments are already preparing for connected vehicles, which can communicate with other vehicles, road-side infrastructure, and with other devices such as mobile phones. This will enable vehicle and transport systems to cooperatively work together to deliver optimised transport outcomes. Automated vehicles are another emerging technology with significant potential to improve the safety, efficiency and convenience of transport (especially for seniors and the disabled). These technologies are complementary to each other, and together could radically transform the ways that people travel and that our infrastructure and cities are constructed.

Transport infrastructure is also improving. Cost-effective sensors and improved communications technology are facilitating more efficient models of operating and maintaining roads and railways. Improved information flows, such as real-time public transport information, are increasingly providing travellers with access to more flexible, efficient and convenient transport services. Digital systems, including smart phones, are generating unprecedented amounts of data, which can be shared and analysed to improve infrastructure planning and operations.

Australian governments recognise that these on-going advances in transport technology have the potential to fundamentally improve the safety, efficiency, sustainability and accessibility of Australia's transport systems. Australian governments are focused on implementing the right policy settings to support and take advantage of these opportunities.

On this basis, this policy framework outlines an agreed national approach to policy, regulatory and investment decision-making for technologies in the land transport sector. This framework will be underpinned by a three year action plan, outlining governments' short to medium term priorities.

This document details:

- the national policy framework objective;
- the strategic context for new transport technologies;
- key issues for government;
- the role for governments in the deployment of new transport technologies; and
- a three year national transport technology action plan.

3. Framework Objective

The objective of this framework is to foster an integrated policy approach by governments to the development and adoption of emerging transport technologies, in order to achieve improved transport safety, efficiency, sustainability and accessibility outcomes.

This framework will:

- facilitate the efficient and timely uptake of transport technologies to meet consumer demands and improve service delivery;
- guide the consistent implementation, integration and uptake of transport technology across all jurisdictions and all land transport modes;
- outline the role for government on issues such as regulation, standards and investment, in order to provide certainty to industry and the community; and
- promote innovation and competition through support for compatible and interoperable transport technologies and open access to transport data.

The action plan accompanying this document will ensure that individual actions by Australian governments are appropriately prioritised, efforts are not duplicated and that key learnings from individual projects are shared appropriately.

Rapid Advances in Vehicle Automation

Vehicles with a relatively high level of automation, such as self-parking or traffic jam assist, are already commercially available in Australia. Most major vehicle manufacturers, as well as several large technology companies and universities, are developing vehicles with higher levels of automation, including vehicles that are designed to require no human control. It is significant that automated test vehicles now have several million kilometres of experience in real-world conditions.

Over the next two decades many analysts predict that highly automated vehicles will become a significant part of the vehicle fleet, although it remains unclear how quickly this transition might occur and how often (if ever) human drivers will need to take over control. In the long-term, the potential benefits of automation include improved safety, reduced congestion and pollution, and enhanced mobility for the young, elderly and disabled. Passengers may also benefit from increased leisure or productive time, and reduced costs from sharing an automated taxi. Automated vehicles could also reduce the need for parking space in city areas.

However, it is also important for policy makers to consider what other effects automated vehicles might have on transport networks. For example, more convenient travel might mean longer and more frequent car trips, increased urban sprawl or reduced use of public transport. Appropriate policy and regulatory decision-making will be key to ensuring that the potential benefits of automation materialise, and that any downside risks are appropriately managed.

The Potential of Connected Vehicles

The next generation of connected vehicles, called Cooperative Intelligent Transport Systems (C-ITS), are an emerging technology that allows a vehicle to communicate with other vehicles (V2V), road-side infrastructure (V2I) and other devices, such as mobile phones (V2P). This technology has an exciting potential to improve safety by providing drivers with warnings of imminent collisions or dangerous conditions ahead. Austroads has previously estimated that full deployment of C-ITS equipped vehicles with collision avoidance applications could prevent 25-35 per cent of serious crashes[2].

Mass production vehicles with V2V capability are expected to enter the US market by 2017. Australian governments are already preparing for the introduction of C-ITS equipped vehicles in Australia (including addressing security and geo-positioning requirements). In the future, automated vehicles may use V2I to interface with traffic lights, or V2V to detect vehicles not in line of sight. Experts believe that a combination of connected and automated technology is required to realise the largest potential improvements to congestion and safety.

2 Austroads 2011, *Evaluation of the Potential Safety Benefits of Collision Avoidance Technologies Through Vehicle to Vehicle Dedicated Short Range Communications (DSRC) in Australia* (Report AP-R375/11), available at <*https://www.onlinepublications.austroads.com.au/items/AP-R375-11*>

4. Strategic Context

4.1 How Can Current and Emerging Transport Technologies Help?

Efficient transport networks are an important enabler for a competitive, productive and growing economy, and for facilitating connections between people. Decisions about transport infrastructure can have a significant impact on other policy areas, such as the amenity and liveability of our cities. Finding innovative ways of moving goods and people can create new business opportunities, generate value for travellers and help to build a flexible and adaptable economy that will sustain Australia's well-being into the future.

Current and emerging technologies can help to achieve these important outcomes by improving transport safety, efficiency, sustainability and accessibility.

4.1.1 Safety

Technologies such as seat belts, road-side breath testing, speed cameras, airbags and improved vehicle standards have been key contributors to improved road safety outcomes in Australia. Between 1970 and 2015, the annual road fatality rate declined from 30.4 to 5.1 deaths per 100,000 people, despite strong growth in vehicle ownership. Even with this progress, the economic cost of road crashes is estimated to be around $27 billion annually[3], in addition to the immeasurable social cost.

Through the National Road Safety Strategy (NRSS) 2011-2020[4], the Transport and Infrastructure Council has adopted the long term vision that no person should be killed or seriously injured on Australia's roads. The NRSS is based on the Safe System approach which calls for a holistic view of the road transport system and the interactions between roads, travel speeds, vehicles and road users. Emerging transport technologies have considerable potential to reduce the number and severity of crashes by providing warnings to drivers, or by reducing the need for human decision-making potentially achieving a system with safety performance similar to or better than air, maritime and rail transport. Such technologies include:

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3 Bureau of Infrastructure, Transport and Regional Economics 2010, *Cost of road crashes in Australia 2006 (Report 118)*, available from <*https://bitre.gov.au/publications/2010/files/report_118.pdf*>

4 National Road Safety Strategy (NRSS) 2011-2020, available at <*http://roadsafety.gov.au/*>

- **Driver advisory and assistance systems**, such as blind-spot warnings, speed limit advisories, lane departure warnings and electronic stability control. In the future, connected vehicle technology will improve the types of warnings that drivers are able to receive; and
- **Automated systems,** including adaptive cruise control, lane keep assist and autonomous emergency braking. Autonomous emergency braking, for example, is estimated to prevent 20–40 per cent of certain crashes[5]. In the future, higher levels of automation, including vehicles that require no human control, may significantly reduce the number of road deaths, potentially by as much as 80 or 90 per cent[6].

Through the NRSS and the supporting Action Plan for 2015–2017, there is an agreed programme of work underway to both implement priority vehicle safety standards and accelerate the market uptake of vehicle technologies with significant safety potential. The Action Plan lists targeted technologies including autonomous emergency braking, lane departure warning and intelligent speed advisory systems.

4.1.2 Efficiency

Demand on Australia's infrastructure is growing, driven by population growth, increasing economic output and long-term urbanisation trends. The social and economic costs of congestion are estimated to reach around $30 billion a year by 2030[7]. Australia's freight network is also growing, with demand for road and rail freight expected to more than double between 2010 and 2040[8].

Building new infrastructure is not always the solution to meeting growing demand. Major infrastructure projects are complex and expensive to deliver, particularly as all Australian governments face competing demands for public spending. In Australia's capital cities, the limited availability of land can be a significant constraint. These factors mean that there is a need to use existing infrastructure more efficiently.

The use of technology has significant potential to improve the efficiency of existing assets. For example:

- **Smart infrastructure**, such as signals on motorway on-ramps or variable speed limits, can significantly improve traffic flows at relatively low cost. Emerging systems can remotely

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5 Bureau of Infrastructure, Transport and Regional Economics 2014, *Impact of road trauma and measures to improve outcomes* (Report 140), available at <http://bitre.gov.au/publications/2014/report_140.aspx>

6 Ibid

7 Bureau of Infrastructure, Transport and Regional Economics 2015, *Traffic and congestion cost trends for Australian capital cities*, available at <*https://bitre.gov.au/publications/2015/is_074.aspx*>

8 Bureau of Infrastructure, Transport and Regional Economics 2014, *Freightline I – Australian freight transport overview*, available from <*https://bitre.gov.au/publications/2014/freightline_01.aspx*>

monitor assets and predict the need for maintenance, helping to reduce costs and prevent disruptions to travellers. Better communications on railways can safely allow shorter following distances between trains;

- **Real-time information** can help travellers plan an efficient journey, including facilitating optimal route selection, efficient connections with public transport and access to transport related services like parking. Real-time information can also enable transport system operators to better respond to incidents and manage demand. A related area is on-demand transport, where smart phones can be used to provide more convenient access to transport and mobility services, including across different transport modes;
- **New vehicle technologies**, including automated and connected vehicles, could bring a step change improvement in mobility. Automated vehicles may be able to travel closer together, or be summoned on-demand for more convenient first and last mile trips. Communications between connected vehicles and road-side infrastructure could allow traffic management to be optimised; and
- **Data** generated by these applications is an additional resource that can be analysed to improve planning, investment decision-making, and transport operations, such as by adding new public transport services during anticipated peak periods. Data can also support the design and delivery of new infrastructure. For example Building Information Modelling (BIM) can be used to create highly detailed and shared digital models of new infrastructure, improving investment and operational decision-making over the entire life of an asset.

Smarter Infrastructure and Traffic Management

Australia has a strong record of success in implementing smart infrastructure and traffic management systems. One of the earliest smart traffic management systems – coordinated traffic signals that respond to changing traffic conditions – was pioneered in Australia and is now exported overseas. Australia was also an early adopter of electronic tolling, and importantly was able to achieve a nationally consistent system of electronic tags and receivers that communicate over the 5.8 GHz radio frequency band. This means that motorists need only use one tag, regardless of who owns and operates the particular toll road.

More recently, active traffic management measures that integrate systems such as variable speed limits, on-ramp signalling and variable message signs have been demonstrated to significantly improve traffic flow on motorways in Melbourne, Brisbane and Sydney. These types of investments tend to be low cost and high return, and can delay the need for expensive civil construction works. For example, the installation of ramp metering on the Monash Freeway in Melbourne increased throughput by 19 per cent during the morning peak – reducing the need to build an additional lane.

Smart infrastructure capabilities will continue to improve. Data61 (part of the CSIRO) is trialling a bridge monitoring system using 2,400 sensors to maximise the service life of the Sydney Harbour Bridge road deck without significantly increasing expenditure. In this example, continuous machine learning and predictive analysis of the sensor data provides early warning of problems before bridge users are affected.

In Queensland, an Emergency Vehicle Priority (EVP) system has been successfully trialled, which automatically provides green lights for emergency services vehicles responding to incidents. This system improved travel times by up to 20 per cent, with no measurable impact on congestion.

Image courtesy of VicRoads

4.1.3 Sustainability

Energy use and CO_2 emissions are closely linked to the transport sector because fossil fuels are the principal form of transport fuel in Australia. In 2014-15, domestic transport was the second largest energy user in Australia (behind electricity generation), and contributed to around 17 per cent of Australia's CO_2 emissions.

As Australia's population and economy grows, so will the transport sector, potentially leading to increased energy usage and emissions. Transport is projected to be Australia's main form of energy usage by 2035. Road vehicles, particularly light passenger and commercial vehicles, are forecast to continue to be the single largest source of emissions in the transport sector.

Many transport technologies that provide efficiency benefits also have flow on environmental benefits because shorter trips and free flowing traffic imply fuel savings and emission reductions. Driver assistance systems can be programmed to provide information on environmental performance, for example on optimal gear selection. Greater uptake of low and zero emission vehicles, shared mobility and active travel options would also have significant environmental benefits.

4.1.4 Accessibility

Australia's transport systems must serve the needs of all users, including the elderly and those with a disability. Australian governments see the ability to move around the community as underpinning all aspects of life for all people. This is an important issue as Australia's population ages and lives longer, and the number of non-drivers grows.

Technology can help address this problem by facilitating more convenient access to transport. This can include providing real-time public transport information or on-demand transport services (such as flexible bus services). In the future, fully automated vehicles may also provide greater mobility to those unable to drive themselves.

4.2 Key Issues for Government in Deploying New Transport Technologies

There are a number of operational and policy challenges for governments associated with the deployment of new transport technologies. It is essential that governments get the right policy and regulatory settings in place in order to eliminate unnecessary barriers to deployment, encourage innovation and support technology uptake in the transport and infrastructure sectors.

4.2.1 Safety, Security and Privacy

The safety, security and privacy of any new technology is of primary importance. For example, ensuring that connected and automated vehicles can be safely operated on public roads will be key to maintaining community confidence and support. This includes protecting such systems from cyber-attacks. New vehicle technologies could also create large amounts of personal data. Australian governments are already taking steps to ensure that any personal data is afforded appropriate levels of protection, in-line with community expectations. Monitoring and evaluation of security and privacy requirements is required given the complex and ubiquitous nature of the emerging digital data environment.

4.2.2 Digital Infrastructure

New technologies are likely to require access to new types of digital infrastructure. For example, some in-vehicle devices might require access to more accurate satellite positioning information, highly accurate 3D maps, a shared security system or fast mobile broadband. Upgrades to traffic signals may be required to enable them to communicate wirelessly with approaching vehicles. Australian governments, as part of the action plan to this document, will investigate what digital infrastructure will be required in the future, and the best way to provide it.

4.2.3 Data

Many new transport technologies create large amounts of data. This data can be used to provide real-time information to travellers, or to improve the way that governments operate, maintain and invest in infrastructure assets. This data doesn’t necessarily have to come from vehicles or road-side infrastructure – smart phones, smart street lights and many other devices connected to the ‘internet of things’ can provide useful information. The increase in the number of these devices has led to an unprecedented increase in the amount of data available (a trend commonly referred to as ‘big data’). A key issue for Australian governments is fully exploring the potential of big data in the transport sector and addressing challenges in data access, capture, storage and analysis.

Automated Vehicles – What Needs to Happen Next?

While Australia is a world leader in some aspects of automation, such as the automated trains and heavy vehicles already being used in the mining industry, automated passenger vehicles are yet to undergo significant real-world testing in Australian conditions. Australian governments need to ensure that, in the near future, real-world testing (and eventually deployment) is able to occur in a safe and efficient way. A significant dimension of this is demonstrating to the public that automated vehicles are reliable and safe to use.

This preparatory work is already underway. The National Transport Commission is investigating what regulations are outdated and need to be changed. Austroads, on behalf of State and Territory road agencies, is examining what public authorities might need to do to ensure our infrastructure is ready for automated vehicles, as well as the potential implications for vehicle registration and driver licensing.

In 2015 the Australian Driverless Vehicle Initiative[9] demonstrated a highly automated Volvo XC-90 on a closed road in Adelaide – a first in the Southern Hemisphere. Further public demonstrations and trials in partnership with industry and government will continue.

The action plan to this document outlines the commitment of Australian governments to accelerate work to test and deploy automated vehicles.

Image courtesy of the Australian Driverless Vehicle Initiative

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9 See <*www.arrb.com.au/transport/self-driving-vehicles.aspx*> for more information

4.2.4 Standards and Interoperability

Consistent standards are required to achieve interoperability between equipment and services from different vendors and different jurisdictions. Interoperability can be difficult to achieve due to significant jurisdictional differences in infrastructure conditions, patterns of use and pre-existing information technology systems.

Previous work in this area has included the development of a National Intelligent Transport Systems Architecture. This 'Architecture' is effectively a guideline for transport agencies that provides for a consistent approach to describing, developing, and integrating intelligent transportation systems and applications.

Australian governments will continue to collaborate to ensure that interoperability issues are addressed and will adopt international standards and deployment approaches unless there is a clear need for a unique Australian requirement.

4.2.5 Disruption and Change

One of the biggest challenges for government is that the technological environment can evolve rapidly, creating new and sometimes unexpected policy issues and disrupting established markets and business models. For example, the increasing popularity of transport services such as Uber, Coseats and Catchalift bring potential benefits such as cheaper and more flexible transport options, but also concerns over competition with taxis, safety, insurance standards and pricing. It can often take considerable time for regulation to respond to these changes.

Governments and government agencies will also experience this disruption and change. Traditional sources of transport related revenue, such as vehicle registration, driver licensing and fuel excise will be impacted as the size and characteristics of the vehicle fleet shift. Transport agencies will need to invest in new skills such as data analysis, as the importance of using information technology and data to improve the efficiency of existing infrastructure assets grows. Some roles, such as the enforcement of road rules, may change or become obsolete, as human decision-making is increasingly removed from the driving task.

The way that physical infrastructure is designed may also change. For example, automated vehicles may require less extensive road signage and reduced parking space in city areas. Investment in infrastructure that caters for technological advancements will need to be balanced against the risk of constraining unforeseen innovations.

Given the transformative potential of emerging transport technologies, it is likely that the transport sector will experience more disruptive changes in the future. This policy framework will assist governments in preparing for those changes that are able to be anticipated, while taking a flexible approach to unexpected issues as they arise.

5. Australia's Approach

5.1 What Role for Government?

Australian governments are strongly committed to encouraging the deployment of new transport technologies. In many cases the private sector will bring new technologies to market on a commercial basis, in order to meet demand from consumers. This may require little, if any, government intervention.

In other situations there will be a strong rationale for government action. This may occur where the largest benefits require coordinated action, where there are limited incentives for consumers to take up beneficial technology, or where public investment will benefit the network as a whole. Some emerging technologies may require government (and industry) to support enablers such as security systems or communications infrastructure. Where governments do act, meeting the needs of travellers for a safe, efficient and convenient transport system should be a priority.

Governments will also ensure that an appropriate regulatory environment is maintained. Proponents of new technologies will need to demonstrate the appropriate levels of safety, security and privacy. Governments will remove or amend regulation that becomes obsolete or outdated.

On this basis, Australian governments will undertake four main roles relating to the deployment of transport technology:

1. **Policy leadership:**

- provide a clear, nationally coordinated approach across different levels of government, being responsive to changes in the technological environment;
- facilitate collaboration between parties, including industry and researchers;
- raise public awareness and acceptance of beneficial new technologies; and
- efficiently manage transitions between old and new technologies (such as between human-controlled and automated vehicles). This includes considering flow-on effects to other transport modes and related policy areas such as urban planning.

2. **Enabling:**

- ensure that the private sector is able to bring beneficial new technologies to market, including by supporting investment in digital infrastructure and/or data streams (such as highly accurate geo-positioning systems and real-time information on road conditions); and
- support private sector innovation in the transport sector, such as by providing open and consistent access to transport data. Where practical, data will be aggregated to the national level.

3. **Supportive regulatory environment:**

- ensure that community expectations of safety, security and privacy are appropriately considered in new technology deployments;
- remove regulatory barriers to new technology in a proactive fashion;
- wherever possible, provide certainty about future regulatory requirements.

4. **Investment:**

- invest in research, development and real-world trials that benefit the entire transport network customer base or provide a sound basis for government decision-making (including in collaboration with the private sector).

5.2 Principles for Government Action

Australian governments have agreed on the following policy principles to inform a consistent approach to the delivery of the roles identified in section 5.1. A principles based approach has been adopted to provide flexiblity and to acknowledge that important differences between jurisdictions will impact on decision-making.

Policy Principles

1. Government decision-making on transport technologies will be based on capacity to improve transport safety, efficiency, sustainability and accessibility outcomes.
2. New technologies should be implemented in a way that is consumer centric (i.e. designed to meet the needs of those using the service). This includes consideration of:
    a) options to deliver transport information and services in a way that is consistent and familiar, and
    b) the diverse needs of travellers, in particular travellers with a disability, vulnerable road users such as cyclists and pedestrians, and users of multiple modes of transport.
3. Where government investment is required to support the deployment of new technologies, that investment will be evidence based, consistent with long-term strategic planning and will deliver value for money.
4. Where feasible, government agencies will avoid favouring particular technologies or applications, in order to encourage competition and innovation. New applications should support interoperability, backwards compatibility and data sharing, and should account for possible future transitions to other technology platforms.

5. Planning for transport technologies will build on existing infrastructure networks (including public transport) and seek to leverage existing consumer devices (such as smart phones) where appropriate.
6. When considering regulatory action, governments will consider low cost approaches such as collaborative agreements or self-regulation before pursuing formal regulation.
7. If required, best practice regulatory approaches will be adopted to ensure regulation is cost efficient, transparent, proportionate to the risk, fit for purpose and done in consultation with affected stakeholders. This includes adopting relevant international or regional standards, unless there is a compelling reason for a unique Australian requirement.

Case Study: Connected Heavy Vehicles

The Cooperative Intelligent Transport Initiative (CITI) is one of the world's first large scale test projects of vehicle-to-vehicle and vehicle-to-infrastructure communications in heavy vehicles. The trial is taking place on 42km of accident prone road between Port Kembla and the Hume Highway, New South Wales. The Australian and New South Wales governments are funding the $1.4 million project on a 50:50 basis.

The first stage of the project, completed in November 2015, involved 58 heavy vehicles, two light vehicles and a motorcycle being fitted with wireless communication devices, in order to share collision warnings with each other. Participating vehicles are also receiving speed and red light warnings from specially installed road-side infrastructure along the route. The University of Sydney's Australian Centre for Field Robotics is currently analysing data collected as part of the trial to determine the accuracy of the system. Stage Two of the project aims to install communication devices in an additional 60 vehicles, including buses and passenger vehicles, by the end of 2017.

In April 2016 the New South Wales Government announced a further trial of vehicle-to-infrastructure communications in heavy vehicles. During the trial the timing of traffic signals at more than 100 locations in Sydney will be adjusted to accommodate approaching heavy vehicles. The trial hopes to demonstrate that reducing the need for slow acceleration and deceleration by heavy vehicles can improve traffic conditions for all road-users.

Image courtesy of Dominic Wall

6. National Transport Technology Action Plan (2016-2019)

This action plan outlines Australia's national priorities for implementing new transport technologies. The individual measures described below have been identified and agreed through discussions between Australian governments and with industry.

The action plan will be a three year program of work (2016-2019), and accordingly focuses on issues that can be addressed in the short term. Changes in the technological environment can occur rapidly, making it difficult to plan beyond this three year horizon. A more viable and agile approach is to review and evaluate the action plan on an annual basis to ensure it responds to new and emerging issues, and achieves long-term outcomes over time.

#	Action Item	Lead	Timing
1	**Establish a regulatory framework for testing automated vehicles** Testing of automated vehicles on public roads in Australia is an important step towards realising the potential benefits of automated technology. In particular, real-world testing and trials are necessary to ensure that automated systems can operate safely and efficiently in Australian conditions, and for building public confidence. Australian jurisdictions will commit to remove any identified barriers, and ensure that manufacturers are able to safely test automated vehicles in real-world conditions by the end of 2017. This work will be informed by the National Transport Commission project to identify regulatory barriers to automated road and rail vehicles and by work undertaken by Austroads and its road agency members on consistent guidance for supporting on-road testing.	Transport and Infrastructure Senior Officials' Committee (TISOC) /National Transport Commission	Late 2017
2	**Develop national operational guidelines to support the on-road use of automated vehicles** The future deployment of automated vehicles may require road managers to change the way that road transport systems are developed, operated and used. This may include the design and maintenance of various road attributes, the management of traffic, the registration of vehicles, and the training and licensing of drivers. To optimise the potential safety and mobility benefits of automated vehicles, guidelines for road agencies and other road operators will be developed that outline a nationally consistent approach to these operational functions. This will include guidance on how infrastructure being developed today can be prepared for future technologies, allowing these technologies to be deployed at lower cost when they eventually become available. This work will include consultation with a range of stakeholders including the National Transport Commission, the Commonwealth, jurisdictions, and industry.	Austroads	Late 2017

#	Action Item	Lead	Timing
3	**Undertake priority trials and research of Intelligent Transport Systems** Over the term of this action plan Australian governments, researchers and the private sector will move to undertake more trials and demonstrations of Intelligent Transport Systems. This will include smart infrastructure, connected vehicles and automated vehicles (particularly following the removal of regulatory barriers in Action 1). It is in Australia's national interest to trial solutions to the most pressing transport problems first, and to share learnings between governments to avoid the need for the same trial to be undertaken in several jurisdictions. To facilitate this outcome senior transport officials will collaborate on a prioritised schedule of proposed trials (in consultation with interested research and industry stakeholders) and establish a formal mechanism for sharing technical outcomes.	TISOC	2016-19
4	**Develop a connected vehicle (Cooperative ITS) infrastructure road map** Industry consultation during the development of this framework highlighted that certainty about the provision of connected road-side infrastructure is critical for industry planning, and for ensuring that there is a strong commercial incentive to make connected vehicles available to the Australian market at an early stage. A connected vehicle infrastructure road map will be developed to provide greater certainty to industry on infrastructure deployment methods and indicative timeframes, to ensure that Australia is well placed to take advantage of this emerging technology.	TISOC	Mid 2017
5	**Publish a connected vehicle (Cooperative ITS) statement of intent on standards and deployment models** Industry has highlighted the need for an early understanding of the connected vehicle standards and deployment models likely to be adopted in Australia. A statement of intent will provide industry with this guidance. This work will examine both non-regulatory approaches to deployment which could be adopted by convention, as well as regulatory standards which may form part of Australia's formal framework of vehicle regulation (and corresponding links with international standards set by the United Nations). Industry consultation and foundational work on approaches to standards and compliance models already completed by Austroads will inform this project.	TISOC/ Commonwealth	Early 2017

#	Action Item	Lead	Timing
6	**Develop a nationally agreed deployment plan for the security management of connected and automated vehicles** Preventing cyber threats and malicious acts will be the key challenges in deploying connected and automated vehicles. The model emerging internationally to address cyber security issues is referred to as a Security Credential Management System (SCMS). A SCMS verifies the identity of a device (such as an individual vehicle) so that messages received from that device can be trusted. This action will explore the options for meeting emerging security management requirements, and consider the costs, risks, feasibility and timing of those options as well as looking at overseas experience. Consideration will also be given to the role of government, and to whether other telematics and intelligent transport services could also utilise an SCMS. The output from this action will be a nationally agreed plan for security management, including whether a national SCMS is required in Australia.	TISOC/ Austroads	Mid 2018
7	**Investigate options to provide enhanced geo-positioning information to the land transport sector** Future transport technologies will require access to positioning information with higher levels of accuracy and integrity (for example in order to tell which lane a vehicle is travelling in, rather than just on which road). Some international markets are meeting these higher level positioning requirements using satellite-based augmentation services across select geographic regions. In Australia, however, access can be limited to subscription services, proprietary equipment and private positioning networks (especially outside of urban areas) without a consistent performance standard. This action will investigate options for next-generation delivery of enhanced positioning (including private sector involvement) for the land transport sector.	Commonwealth	Late 2017
8	**Improve the availability of open data in the transport sector** Governments can assist industry, researchers and the public to develop innovative solutions to transport problems by providing open access to transport data. Australian governments are committed to an open-by-default approach to transport data and through this action will improve the availability of open access transport data. In particular, existing jurisdictional data sets will be consolidated into national level information in a shared format, and made available through a common portal. New datasets will also be created, including improved information on speed zones across Australia and a national map of low-gear warning zones (which could be used to provide safety warnings to drivers).	All jurisdictions	2016-19

#	Action Item	Lead	Timing
9	**Explore options to increase the uptake of telematics and other technologies for regulatory and revenue collection purposes** Vehicle telematics can deliver significant benefits for industry, government and motorists, particularly in terms of safety, productivity and protection of infrastructure assets. For example, heavy vehicle operators in Australian can already, on a voluntary basis, provide telematics data to regulators for compliance purposes, in exchange for increased access to the road network. Similarly, some insurance firms offer motorists reduced premiums if they can demonstrate, through voluntary telematics data, that they are low-risk drivers. Wider adoption of telematics would allow governments to implement more efficient models of revenue collection. Improved telematics uptake could also inform infrastructure planning, ensuring that future investments meet user demands. In view of these potential benefits, this project will explore strategies for government and the private sector to accelerate the deployment of telematics and associated technologies.	TISOC	Mid 2017
10	**Evaluate low–cost technologies to improve safety at rail level crossings** Crashes at rail level crossings tend to be particularly serious, causing an average of 37 fatalities annually in Australia. Technology based solutions have a significant potential to address this problem at low-cost compared to expensive civil works such as grade separation. For example, vehicle-to-infrastructure communications are able to warn road users of approaching trains in real-time. This project will explore the merits of the accelerated uptake of smart safety technology at level crossings, and how technological solutions could be better incorporated into rail safety planning.	TISOC	Late 2017
11	**Explore how data from telematics and other intelligent transport systems can be used to optimise operations and planning for port precincts and intermodal terminals** The efficiency of Australia's supply chains is a critical economic issue, given that even small improvements to supply chain efficiency can significantly improve Australia's global competitiveness and productivity. This project will seek to explore how granular data collected from telematics devices and intelligent transport systems can be used to improve supply chain efficiency, focusing on understanding and optimising transport movements within port precincts as well as freight distribution patterns in nearby metropolitan areas. The value of any data collected for planning future intermodal terminals will also be considered. A key challenge in collecting freight data is that different supply chain participants use different data standards and collection practices. The potential of a national freight labelling standard to improve data consistency and supply chain visibility will also be examined.	Commonwealth	Mid 2017

#	Action Item	Lead	Timing
12	**Investigate options for interoperable public transport ticketing** Electronic public transport ticketing has become widely adopted in Australia, and has improved the convenience and efficiency of public transport. However, in many cases electronic tickets only work in a single city, or in some instances, only on a particular transport mode. This reflects the complexity and costs of deploying ticketing systems, and differing investment schedules in different locations over time. Into the future, as ticketing technology matures and existing systems require renewal, governments will have an opportunity to deploy systems that are interoperable across Australia and make better use of personal electronic devices such as smart phones. This action will investigate options for achieving this outcome over time, further increasing convenience and creating value for tourists and inter-state travellers.	TISOC	Late 2017
13	**Investigate the costs, benefits, and possible deployment models for Automatic Crash Notification** Minimising the time that it takes emergency services to reach the scene of a crash is an important factor in preventing deaths and serious injuries. Automatic Crash Notification (ACN) uses sensors inside a vehicle to determine when a serious crash has occurred, and then provides emergency services with the exact location of the crash by transmitting data over the mobile (cellular) network. This technology is already available in a limited number of vehicles, and it may be worthwhile for governments to consider ways to encourage broader adoption. This project will consider the costs and benefits of different operational models and how ACN data could be better integrated with existing systems belonging to emergency services authorities.	TISOC / Austroads	Mid 2017
14	**Explore the merits of adopting new safety and traffic management technologies** Governments face the ongoing challenge of deciding which transport technologies to adopt and when. Timing is a particularly important consideration – technologies need to be mature and the benefits proven before public funds can be committed to implementation. In the immediate future, Australian governments will explore the costs and benefits of the broader adoption of the following promising technologies: • **Traffic Signal Prioritisation** – green lights for emergency services and public transport vehicles at signalised intersections; • **Managed motorways** – techniques to maintain traffic flow on motorways, such as ramp signalling and variable message signs; and • **Vehicle safety systems** – such as autonomous emergency braking for heavy vehicles and anti-lock braking for motor cycles.	TISOC	2016-19