Submission
No 17

DRIVERLESS VEHICLES AND ROAD SAFETY

Organisation: NSW Government

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NSW GOVERNMENT

The Hon. Duncan Gay MLC
Minister for Roads, Maritime and Freight
Leader of the Government
Legislative Council

BN16/00415

Mr Greg Aplin MP
Chair
Joint Standing Committee on Road Safety (Staysafe)
Parliament House
Macquarie Street
SYDNEY NSW 2000

Dear ~~Mr Aplin~~ Greg

I refer to the Joint Standing Committee on Road Safety's (Staysafe) *Inquiry into Driverless Vehicles and Road Safety in NSW,* which commenced on 24 February 2016.

I welcome the focus and guidance provided by Staysafe on this important area of transport and road safety.

Please find attached the NSW Government's submission to the Inquiry, which has been prepared by Transport for NSW in consultation with Roads and Maritime Services, the NSW Department of Justice, the NSW Police Force, the State Insurance Regulatory Authority and the Office of Local Government.

Transport for NSW will be available to provide further input into Staysafe hearings and requests for further information as needed.

If you have any questions, Mr Bernard Carlon, Executive Director at the Centre for Road Safety, would be pleased to take your call on (02) 8265 7510.

Yours sincerely

Duncan Gay MLC 16-5-16

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Submission by

NSW Government

in response to

The Parliamentary Joint Standing Committee
on Road Safety
(Staysafe)

Inquiry into Driverless Vehicles and Road Safety in NSW

May 2016

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TERMS OF REFERENCE

On 25 February 2016, the Parliamentary Joint Standing Committee on Road Safety (Staysafe) issued its terms of reference in relation to its Inquiry into Driverless Vehicles and Road Safety in NSW. They are:

That the Committee inquire into and report on driverless vehicle technology in New South Wales with particular reference to:

1. The capacity of driverless vehicle technology to deliver improved road safety outcomes including a lower road toll, and fewer accidents and injuries to drivers, pedestrians and other road users;
2. The extent to which current road safety policies and regulations in NSW anticipate the introduction of driverless vehicle technology, including driverless heavy vehicles, and any regulatory and policy changes which will be required;
3. The preparedness of NSW road safety regulators to meet the challenges extended by driverless vehicle technology;
4. The experience of other jurisdictions in Australia and overseas in adopting and adapting to driverless vehicle technology; and
5. Other related matters.

1 EXECUTIVE SUMMARY

1.1 Introduction and context

This submission looks at the safety benefits of Automated Vehicles, potential issues around their interaction with infrastructure and other technology and also notes the broader areas where connected and automated vehicles (CAVs) offer the potential to improve transport outcomes for the community.

Transport for NSW ran the Future Transport Summit on the 18 and 19 April this year. One of the outcomes of the summit will be the production of a green and a white paper and future transport roadmap. There were a number of ideas raised that will form a basis for this work and much will be based around safety technology and customer experience, with CAVs, Big Data, Open Data, Disruptive Technology and the Internet of things key focus areas of the Summit.

Transport for NSW will be reshaping itself around a much sharper focus on technology and the partnerships through the new Smart Innovation Centre which will influence the future business of the agency, with CAVs a critical area of work from both a safety and broader transport perspective.

There are different levels of automated vehicles, and a number of vehicle safety automation features have already been delivering significant road safety benefits to NSW road users over time. Anti-lock braking and stability (traction) control are now standard automated features in cars currently sold in Australia. Other automated functions such as adaptive cruise control and lane departure warning are available on an increasing number of new vehicles. As additional safety technology features continue to be adopted and incorporated into vehicle production, even greater safety benefits will be realised.

The contribution that automated vehicles will make to road safety is examined in the context of the Safe System approach that underpins the development of road safety measures in the NSW Road Safety Strategy 2012-2021 and National Road Safety Strategy 2011-2020. The approach takes into account the interaction of key components of road safety (safer people, safer roads, safer vehicles and safer speeds), and accepts that road users will make errors that result in crashes, regardless of the level of compliance in obeying road rules. Automated vehicle technology offers the prospect of significantly limiting the frequency and consequences of human error in road crashes and therefore increasing road safety outcomes, especially when integrated with C-ITS (cooperative intelligent transport systems).

Connectivity with other vehicles and infrastructure is critical to the success of automated vehicles and the NSW Government is already actively engaged in research regarding autonomous vehicle technology and C-ITS. CAVs will also improve traffic and congestion management, reduce environmental pollution, and increase transport options for the community, especially for people who have mobility issues. This will in turn improve customer service, transport outcomes and economic productivity in NSW.

This submission also outlines a number of challenges that will need to be actively managed if the potential benefits of the new automated technologies are to be fully realised and their potential risks minimised. These include changes required to the existing regulatory framework to facilitate their safe deployment, monitoring technological developments, facilitating community understanding and acceptance of the new technology, and managing the transition from conventional to fully automated vehicles.

The submission is structured to follow the order of Terms of Reference set out for the Inquiry.

1.2 The capacity of driverless vehicle technology to deliver improved road safety outcomes

The prospect of highly automated vehicles being used across NSW has the potential to contribute to significant road safety improvements in NSW. While the most substantial gains are likely to be through the elimination of driver error and risk-taking behaviour, automated vehicles also present opportunity for safer vehicle design, more advanced connection with the road network and safer speed management of vehicles.

1.1.1 Reducing crashes from driver error and risk-taking behaviour

It is expected that as vehicles become increasingly automated, the level of driver errors will be reduced and the impact of risk-taking behaviour will be minimised. Full automation could result in a virtual elimination of crashes due to driver error, and it may also largely eliminate road safety harm from high risk and/or illegal behavioural factors of speeding, drink and drug driving, fatigue, unsafe following distances and driver distraction, by transferring certain functions currently under the control of the driver to an automated system.

1.1.2 Managing the impact of vehicle speeds on crashes

Automated vehicles have enormous potential to assist in managing the impact of travel speeds on the crash outcomes of road users, particularly those that are less protected such as pedestrians and bicycle riders. Full automation of vehicles could eliminate human errors, for example not being aware of the speed limit or situations where vehicles are travelling at speeds that are not safe for the prevailing conditions. Fully automated vehicles will also have capacity to respond more quickly to unexpected situations on the road network than is currently the case for human drivers, for example when a pedestrian is crossing the road and a driver is not aware or is focussed on something else.

1.1.3 Safety benefits of existing connected and automated vehicle technologies

Drivers and other motor vehicle occupants, in particular, are already benefitting from development of various vehicle safety technologies. Bodies such as the Australasian New Car Assessment Program improve vehicle safety by raising public awareness of, and consumer demand for, safer vehicles and safety vehicles, which has influenced manufacturers to fast track safety into vehicle design.

Partially automated vehicles already exist in the NSW fleet and are in operation on NSW roads. Various individual connected and automated vehicle technologies are anticipated to deliver safety benefits before full automation of vehicles occurs. These current factors include electronic stability control, intelligent speed adaptation, adaptive cruise control, autonomous emergency braking, collision avoidance and hazard protection systems (including forward collision and lane departure warning), road signage detection, vehicle-to-infrastructure communication, post-crash notification systems, fatigue detection, and blind spot monitoring.

1.1.4 Additional safety issues to consider

Despite the overall safety benefits that are expected from the introduction of automated vehicles across the road network, there are also a range of new safety risks that these vehicles may introduce that must be managed. This includes risks associated with different levels of connectivity to other vehicles and infrastructure, new risks relating to system failures, and human factor issues such as driver over-reliance on technology, adoption of alternative risk behaviours, and distraction.

Many of these relate to the implications of a mixed fleet of vehicles that will be present on the network where vehicles of different levels of automation (and human involvement) are interacting on the same road network and using the same road infrastructure. While vehicles are currently available on the Australian market with automated vehicle technology applications, vehicles with higher levels of automation are not anticipated to be operational on a large scale for a number of decades. It will be important to fully understand the new safety implications that the transition to fully automated vehicles presents and develop appropriate monitoring and mitigation strategies prior to implementation.

The need for a nationally consistent approach to manage increased vehicle automation is an important issue. Another key consideration is how the large amount of data collected and transmitted by these vehicles will be used to improve transport and how the broader technology framework will support the use of connected and automated vehicles.

1.3 The extent to which current road safety policies and regulations in NSW anticipate driverless vehicle technology, and any changes required

It is critical that the government helps to facilitate and support the introduction of autonomous vehicle technology on our roads, collecting and building robust and consistent evidence supporting the safety benefits of the technology. This will require engagement and partnerships with the technology sector and vehicle manufacturing industry. The NSW Government has recently announced the establishment of the Smart Innovation Centre which will foster these partnerships.

The NSW regulatory framework currently supports the use of partially automated vehicles on public roads provided the vehicle is a registrable vehicle and a driver is present and takes responsibility for the safe operation of the vehicle. Current provisions also exist in NSW road transport law for exemptions to be granted from road transport law requirements in certain circumstances and in certain locations.

It is acknowledged that legislative amendments will need to be made to Road Transport Legislation to be supportive of innovation and ensure that the use of higher levels of autonomous vehicle technology on NSW roads is legal, can be trialled and can be appropriately regulated. Any regulatory changes to accommodate autonomous vehicles will also need to consider potential unintended consequences or weakening of existing regulatory controls of conventional vehicles with a licensed driver. In doing so, vehicle standards must be maintained and safety should not mainly rely on consumer laws. Potential problems associated with autonomous vehicle technology should be identified and controlled during the design-manufacture stages.

Several key issues have been identified for consideration in relation to the regulatory framework. These include the future definition and use of the term “driver” in Road Transport Legislation, the extent to which occupants of autonomous vehicles are responsible for unsafe or illegal “behaviour” of the vehicle, the ongoing application of “human factor” laws in the autonomous vehicle context (e.g. drink driving laws) and the appropriate way of dealing with driver behavioural issues, and the ongoing need for existing safety programs that address dangerous behaviours and include use of technology (e.g. the mandatory alcohol interlock program). There are also a range of issues to be considered to enable Police to investigate and prosecute offences where autonomous vehicle technology is available.

1.4 The preparedness of NSW road safety regulators to meet the challenges extended by driverless vehicle technology

Transport for NSW ran the Future Transport Summit on the 18 and 19 April this year. The outcomes of the summit will be the production of a green and a white paper and future transport roadmap. There were a number of ideas raised that will form a basis for this work and much will be based around safety technology and customer experience, with CAVs, Big Data, Open Data, Disruptive Technology and the Internet of things key focus areas of the Summit.

Transport for NSW will be reshaping itself around a much sharper focus on technology and the partnerships through the new Smart Innovation Centre will influence the future business of the agency with CAVs a critical area of work from both a safety and broader transport perspective.

The NSW Government is already actively engaged in research regarding autonomous vehicle technology and C-ITS. This includes the Cooperative Intelligent Transport Initiative (CITI) project, which involves the only large-scale deployment of cooperative intelligent transport system dedicated to heavy vehicles in the world. The project allows heavy vehicle drivers to receive safety messages about upcoming hazards and potential crashes.

In addition, Transport for NSW are partnering with the Australian Driverless Vehicle Initiative to explore the impacts and requirements of automated and connected vehicle technology in a truly Australian context, and make recommendations on ways to safely and successfully introduce them. Transport for NSW are also developing options for connected and automated vehicle on-road trials and demonstrations in NSW, and exploring legislative requirements to support this work.

NSW recognises and supports the need for a nationally consistent approach to manage increased vehicle automation, and continues to provide input into national work on automated vehicle technology.

In November 2015, the Transport and Infrastructure Council asked the NTC to identify regulatory barriers relating to the safe introduction of automated vehicles in Australia including an assessment of the current regulatory system and its ability to support increased vehicle automation. The NSW Government, along with all other Australian jurisdictions, is providing input into the NTC review.

In addition, Transport for NSW and Roads and Maritime Services are currently participating in four strategic research projects commissioned by Austroads that will identify and assess key issues to be addressed for connected and automated vehicles to be safely operated on our road networks.

1.5 The experience of other jurisdictions in adopting and adapting to driverless vehicle technology

A range of trial projects and demonstrations are underway in Australia, the United States and Europe, in particular, to assess the safety benefits of C-ITS and AV applications and forecast deployment timelines. In Australia, South Australia conducted the first on-road trial of automated vehicles in early November 2015. International jurisdictions with trials of driverless vehicle technology currently underway or proposed include the United Kingdom, Sweden, the Netherlands, France, Switzerland, Germany, Spain, Greece, the United States, and Japan.

In addition, several jurisdictions around the world are reviewing legislative and regulatory requirements for driverless vehicle technology. Australian jurisdictions, including NSW, are currently exploring legislative and regulatory instruments specifically with regard to autonomous vehicle safety. This includes the recently passed the South Australian Motor Vehicles (Trials of Automotive Technologies) Amendment Bill 2015, passed by the South Australian Parliament in April 2016.

1.6 Other related matters

Other related matters regarding driverless vehicle technology and road safety focus on a range of operational technology issues for Government and Industry to consider. These include dealing with technology failure both of the vehicles as well as the supporting connective infrastructure, ensuring consistent functionality of technology, ensuring data management and integrity, privacy issues and access to data, and liability issues.

Consideration should also be given to the impacts on congestion and urban sprawl (e.g. the impact of widespread availability of highly automated personal vehicles on congestion), and the potential for the increased availability of highly automated vehicles to result in safer and reliable transport options for customers.

Connected and automated vehicles will also collect and transmit large amounts of data which could potentially provide a rich source of real time information that can support a range of transport activities. The capacity of networks to manage and store this data will also become a critical issue.

2 INTRODUCTION AND CONTEXT

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2.1 Introduction

The NSW Government welcomes this Staysafe inquiry into driverless vehicles and road safety in NSW. For the purpose of this submission, driverless vehicles are defined as fully automated vehicles that do not require a human driver and connected and automated vehicles (CAVs) are automated vehicles that are also connected to each other and infrastructure through technology such as C-ITS.

This submission looks at the safety benefits of CAVs, potential issues around their interaction with infrastructure and other technology and also notes the broader areas where connected and automated vehicles offer the potential to improve transport outcomes for the community.

Transport for NSW ran the Future Transport Summit on the 18 and 19 April this year. The outcomes of the summit will be the production of a green and a white paper and future transport roadmap. There were a number of ideas raised that will form a basis for this work and much will be based around safety technology and customer experience, with CAVs, Big Data, Open Data, Disruptive Technology and the Internet of things key focus areas of the summit.

Transport for NSW will be reshaping itself around a much sharper focus on technology and the partnerships through the new Smart Innovation Centre will influence the future business of the agency with CAVs a critical area of work from both a safety and broader transport perspective.

There are different levels of automated vehicles, and a number of standard automated features already exist in vehicles in the current market. The contribution that automated vehicles will make to road safety is examined in the context of the Safe System approach that underpins the development of road safety measures in the NSW Road Safety Strategy 2012-2021 and National Road Safety Strategy 2011-2020. The approach takes into account the interaction of key components of road safety: safer people (the road user), safer roads (roads and roadside engineering), safer vehicles (vehicle standards and design) and safer speeds.

The Safe System approach accepts that road users are fallible and will make errors that result in crashes, regardless of the level of compliance in obeying road rules. Automated vehicle technology offers the prospect of significantly limiting the frequency and consequences of human error in road crashes and therefore increasing road safety outcomes, especially when integrated with C-ITS (cooperative intelligent transport systems).

Because CAVs are connected with infrastructure or other vehicles, they can potentially provide enormous road safety benefits to manage speed, hazards, and avoid collision among road users beyond stand-alone fully automated vehicles. In addition, CAVs will also improve traffic and congestion management, reduce environmental pollution, and increase transport options for the community, especially for people who have mobility issues. This will in turn improve customer service, transport outcomes and economic productivity in NSW.

The Transport for NSW (TfNSW) approach to CAVs also includes a strong focus on the potential customer service and transport options that these new technologies can provide. Governments and their agencies should take steps to encourage the use of CAVs in a manner that complements rather than replaces public transport. Practical actions would include providing customers with real-time information and transport options on the most efficient and cost-effective transport choices for customers. These customers include every category of road and public transport users including motorists, bus passengers, pedestrians, cyclists, rail passengers, and drivers of light and heavy freight vehicles.

This submission also outlines a number of challenges that will need to be actively managed if the potential benefits of the new automated technologies are to be fully realised and their potential risks minimised. These include changes required to the existing regulatory framework to facilitate their safe deployment, monitoring technological developments, and facilitating community understanding and acceptance of the new technology, and managing the transition from conventional to fully automated vehicles. Under any realistic scenario, governments and road users will be facing the challenges of a mixed vehicle fleet on our roads for an extended period. The duration of this transition will depend on the safety cases being demonstrated to promote community acceptance, government action to ensure a safe operating environment, and the pace of research and development of the automated vehicle and C-ITS industries.

Vehicle safety automation features have already been delivering significant road safety benefits to NSW road users over time. Anti-lock braking and stability (traction) control are now standard features in cars sold in Australia. Other automated functions such as adaptive cruise control, lane departure warning, and automatic emergency braking are available on an increasing number of new vehicles. As additional safety technology features continue to be adopted and incorporated into vehicle production, even greater safety benefits will be realised.

While governments may exercise some choices about the technologies they support and legalise, new technologies can be hard to resist and can defy regulation if there is strong market demand for them. Ultimately, the regulatory framework must be structured to support

CAV innovation and remove barriers to their safe deployment, in order to realise the road safety and economic benefits.

In terms of technological innovation, traditionally corporations have been better able to be flexible and set the pace for research and development, while government's first requirement is to protect the safety if its citizens: including drivers, passengers and other road users. This necessitates a measured approach to adopting and regulating new technologies. On the other hand, even the gradual introduction of automated and highly automated vehicles is likely to yield immediate safety benefits for road users and reduce the high cost of road crashes to the community. This assumes that those vehicles are operated legally and are subject to an appropriate safety certification and regulatory regime.[i]

2.2 Overview of automated vehicle technology

Vehicles are becoming increasingly smarter with the emergence of automated vehicle technology, which will change the way vehicles are operated and move around on the road. Vehicles that are capable of communicating with each other, road infrastructure and other devices, and can automate the control of some or all aspects of the driving task will be increasingly introduced to the market over the next few decades.

With regard to terminology, TfNSW prefers the term "connected and automated vehicles" to "driverless" or "automated" vehicles for two reasons: first, because it provides a better description of the types of technologies that are available now and are likely to be introduced in the next 10-15 years; and second, because it emphasises the important safety and other benefits that are available from incorporating automated features to vehicles and the interactions with infrastructure or other vehicles.

While the main focus of the Staysafe inquiry is on automated vehicle technology, this submission will also refer extensively to Cooperative Intelligent Transport systems (C-ITS) to demonstrate a range of safety, mobility and environmental benefits. The aggregation of automated vehicle technology and C-ITS technology comprise what is referred to as 'connected and automated vehicles'.

2.2.1 Automated vehicle technology

Automated vehicle technology involves one or more aspects of vehicle control (e.g. acceleration, braking, steering) being performed by the vehicle rather than the driver. Vehicle automation can potentially improve road safety by supporting the driver in different conditions, such as providing emergency responses in a critical situation or simply taking over some aspects of driving under normal conditions (Trimble et al., 2014). Automated vehicle applications can be autonomous (i.e. relying on in-vehicle sensors) or can be connected to other vehicles, infrastructure and mobile devices.

Automated vehicle technology is predicted to have a range of safety benefits, primarily by reducing driver workload and human error. Already there are a number of vehicles on the road that allow for some degree of control to be shifted from the driver to the vehicle, for example through the use of a combination of adaptive cruise control, automatic braking and lane keeping assistance systems.

It is important to recognise that automated vehicle technology, in the form of automated safety features in current vehicles, is already delivering significant safety benefits to NSW road users.

Drivers and other motor vehicle occupants, in particular, are already benefitting from development of individual vehicle safety technologies, which are advancing through the work of bodies such as the Australasian New Car Assessment Program (ANCAP). ANCAP has made a key contribution to improving vehicle safety by raising public awareness of, and consumer demand for, safer vehicles, which has influenced manufacturers in the design of vehicles.

Partially automated vehicles including those with electronic stability control, adaptive cruise control and autonomous emergency braking systems, already exist in the NSW fleet and are in operation on NSW roads. These types of vehicles can use on-board sensors, cameras, global positioning systems and telecommunications that gather and analyse information using complex computer algorithms to enable appropriate responses in safety-critical situations without direct driver input.

TfNSW also notes that there are other automated vehicle technologies, such as anti-lock braking and stability (traction) control that are now standard on cars sold in Australia.

TfNSW is aware that Volvo and Tesla have already produced vehicles with auto pilot/auto steer (self-driving) systems that are registered and in use in NSW.

In this sense, it is not a choice as to whether or not vehicle manufacturers develop autonomous technology in their vehicles, but when these will be made available in response to consumer demand. The more this occurs, the more likely automated vehicle technology will eventually transition into standard vehicle safety equipment.

2.2.2 Co-operative Intelligent Transport Systems (C-ITS) technology

C-ITS technology involves using wireless communication with other vehicles, infrastructure or other things (including pedestrians and mobile devices) to enable vehicle systems to work cooperatively. It relies on wireless communication to warn drivers or intervene in dangerous situations, reduce traffic congestion or increase system efficiency.

Safety-related C-ITS technologies generally communicate via the use of Dedicated Short Range Communications, which allows reliable, secure and high-speed communication between similarly equipped vehicles and between vehicles and infrastructure for distances of up to one kilometre. In doing so, C-ITS technology can enhance the benefits provided by existing stand-alone systems, and can also offer warnings that are not currently available through the use of stand-alone systems, such as intersection-based warnings and turn assistance.

Safety-related C-ITS applications generally focus on the following: collision avoidance and hazard detection, vulnerable road user safety, in-vehicle signage, road weather alert, and post-crash notification.

2.3 Continuum of technologies

There is a range of levels of vehicle automation, which changes the nature and impact of autonomous vehicle technology on the driving task. The Society of Automotive Engineers (SAE) J3016 (SAE, 2014) has developed a classification system for defining different levels of vehicle automation, and is presented in Figure 1.

According to SAE J3016, the lowest level (Level 0) no automation, is where the driver is in control of all aspects of the driving task. The five remaining levels address driver assistance (Level 1), where a system executes either steering or longitudinal control for a sustained period, through to partially automated vehicles where drivers relinquish some aspects of vehicle control on certain roads, but are still required to monitor either the environment (Level 2) or the system (Level 3) and take back control; and highly (driving mode specific; Level 4) and fully (Level 5) automated vehicles that require no input from the human occupant beyond entering destination details. Vehicles with Level 3 capability provide automatic longitudinal and lateral control in certain driving situations, with the vehicle responsible for monitoring the environment and the driver still required to monitor the system status and be available to take back vehicle control if requested (SAE J3016).

Figure 1: Society of Automotive Engineers J3016 levels of vehicle automation (Source: SAE J3016; ©2014 SAE International)

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**

Vehicles with lower levels of automation from Level 1 (driver assistance) to Level 2 (partial automation) are available now and offer significant potential safety benefits by improving the capacity of humans to drive safely. An increasing number of vehicles currently available on the Australian market contain a range of Level 2 applications that provide automatic longitudinal and lateral control combined, but require the human driver to monitor the roadway and be prepared at any time to take back full control of the vehicle. Some Level 3 applications are also currently available that require limited human interaction in performing the driving task under certain conditions, however these applications still require monitoring and intervention from the human driver.

Leaving aside the regulatory and legal barriers to operating Level 4 (high automation) and Level 5 (full automation) road vehicles in Australia, it is not yet technically feasible for them to operate safely and reliably in the full range of driving situations.

Based on current technology, the most immediate safety benefits across the full range of driving environments are available from human-controlled vehicles fitted with automated safety features. Such vehicles combine the strengths of technology (consistency, reliability, freedom from distraction and fatigue) and humans (the capacity to deal with complex and unforeseen situations). Therefore, further safety benefits may be more likely to come from adding more automated features to vehicles designed to be driven by people.

It is important to note that there may not be an orderly progression through the automation levels, with some manufacturers focusing current development toward the higher levels of automation.

2.4 Key implications of different levels of automation

While vehicles are currently available on the Australian market that include Level 1, 2 and 3 automated vehicle technology applications, vehicles with higher levels of automation (Level 4 and 5) are not anticipated to be operational on a large scale for a couple of decades. This has a number of implications for autonomous vehicle technology in the more immediate term.

2.4.1 Need to consider safety implications of the 'mixed fleet'

Automated vehicles may behave differently to vehicles that have fewer automated technologies, which may cause potential problems in mixed traffic environments. If they do behave differently, drivers of non-automated vehicles may have difficulty in reading and reacting to traffic that includes vehicles with higher levels of automation. Conversely, automated vehicles may find it difficult to predict the behaviour of human drivers and other road users who may react unexpectedly to situations they encounter on the road network.

A report from the University of Michigan Transportation Research Institute (UMTRI, 2015) released in October 2015 found that self-driving vehicles currently have a higher crash rate per million miles travelled than conventional vehicles, as well as for injuries per crash. The study performed a preliminary analysis of the cumulative on-road safety record of self-driving vehicles for three of the ten companies that are currently approved for such vehicle testing in California (Google, Delphi, and Audi). The analysis compared the safety record of these vehicles with the safety record of all conventional vehicles in the U.S. for 2013 (adjusted for underreporting of crashes that do not involve a fatality).

Two important caveats should be considered when interpreting the findings. First, the distance accumulated by self-driving vehicles is still relatively low (about 1.2 million miles, compared with about 3 trillion annual miles in the U.S. by conventional vehicles). Second, self-driving vehicles were thus far driven only in limited (and generally less demanding) conditions (e.g., avoiding snowy areas). Therefore, their exposure has not yet been representative of the exposure of conventional vehicles.

Importantly the researchers noted that the self-driving vehicles were not at fault in any crashes they were involved in, and the overall severity of crash-related injuries involving self-driving vehicles has been lower than for conventional vehicles.

2.4.2 *Vehicles with different levels of automation may respond differently to situations across the network*

A significant number of autonomous features have been introduced into vehicles over the years, which means there are already a considerable number of vehicles with various degrees of automation in the fleet.

For example, electronic stability control, which detects if a driver has executed an unsafe cornering manoeuvre and automatically reduces engine power and applies varying braking forces to different wheels to help the driver retain control of the vehicle, has been around for almost 20 years, and is now mandatory in all new cars sold in Australia.

Other systems are also becoming more common as consumers become more safety conscious. Systems that have become more common in the Australian fleet include autonomous emergency braking, electronic brake-force distribution, automatic headlights and adaptive cruise control to name but a few.

However, particularly in a mixed fleet, there will be different types of vehicles operating on our roads with varying levels of functional automation. Vehicles may also operate at different levels of automation depending on weather conditions, the type of road they are travelling on, and the level of automation that is supported by particular road infrastructure.

2.4.3 *Connectivity with other vehicles and infrastructure*

Connectivity with other vehicles and infrastructure is critical to the success of automated vehicles and the NSW Government is already actively engaged in research regarding autonomous vehicle technology and C-ITS. Effective and reliable connected infrastructure is also needed to support automated vehicle technology in a comprehensive range of conditions and locations, if CAVs are to be as safe and reliable as possible and fully acceptable to consumers.

A key reason why Level 4 and 5 automated vehicles are not expected to be operational on a large scale for a number of decades is because the infrastructure to support the technology in all conditions and locations will take time and resources to deliver.

While some manufacturers have indicated a preference for developing vehicles that can operate within existing infrastructure, at this stage in the development of autonomous vehicle technology, it seems likely that highly or fully automated vehicles will require some support from connected infrastructure in order to operate safely in all driving situations. This is because, as the need for human control of the vehicle decreases, the need for technology to safely perform the same control functions increases under more and more complex situations; many of which will require assistance from things outside the vehicle if safe and reliable control decisions are to be made by the vehicle. The need for assistance from infrastructure outside the vehicle is particularly important because safe and reliable control decisions need to be made to protect not only the automated vehicle occupant, but also road users outside the vehicle such as pedestrians, bicycle riders, motorcyclists and occupants of other approaching vehicles.

While it may be difficult to "future proof" road projects while technological standards for vehicle-to-infrastructure communication (and other standards such as for road marking and signs) are still being settled, the Transport Cluster must give careful consideration to the planning of future road infrastructure, bearing in mind that it will be supporting an increasing proportion of connected and automated vehicles. Partially automated vehicles that are currently operating on NSW roads are designed to operate with existing infrastructure and their sensors are capable of detecting and interpreting existing road markings and speed advisory signs. However, complications could arise when there are no road markings on a road or when infrastructure is not maintained in accordance with standards. Therefore, it is important that the road infrastructure is maintained to existing standards as well as to continue trialling communication between automated vehicles and infrastructure.

It is expected that higher levels of automation will be more achievable sooner if linked to and supported by connected infrastructure. This underlines the need for national agreement to be reached on common standards and systems to ensure the interoperability of Vehicle to Infrastructure ("V2I") and Vehicle to Vehicle ("V2V") communication systems. The *Policy Framework for Intelligent Transport Systems in Australia* provides guidance designed to ensure that the technology used in each jurisdiction is compatible and is developed around a set of agreed policy principles. This is currently being reviewed and updated by the Department of Infrastructure and Regional Development at the request of the Transport and Infrastructure Council.

Uniformity of road infrastructure and signage is also needed across different jurisdictions to enable highly automated vehicles to navigate effectively. Local governments maintain a large proportion of road infrastructure and signage in NSW and, despite the existing standards and guidelines, there can be local variations in signage and road quality. In responding to the uptake of automated vehicle technology, NSW Government agencies would need to take account of this, as well as the potential need to assist local government in bringing their road networks up to a uniform standard in addition to ensuring that State managed roads are up to the standards required. .

2.5 Timeframes for more fully automated vehicle fleets

There are significant technical and other challenges to be overcome before fully automated vehicles begin operating as a normal part of our fleet. As such, it is difficult to predict the rate of technological development and speed with which the current limitations of automated technologies will be overcome.

Estimates of timeframes for the global introduction of highly automated (Level 4) vehicles vary between 2020 and 2030. Estimates also vary concerning the timeframe for CAVs comprising a significant portion of the passenger vehicle fleet. One source[ii] estimates that by 2020, 9 per cent of cars will be at Level 2 with Level 3 capability in some circumstances (conditional automation, where most systems are automated but the driver may be required to intervene in some circumstances) and by 2030 25 per cent of traffic in US and Europe will be highly automated.

Key factors that might influence the timeframe for the widespread use of fully automated vehicles may include:

- technological developments that enable automated vehicles to consistently operate safely and reliably
- community acceptance of new technology
- the cost and accessibility of automated vehicle technology
- governments' ability to support implementation (through developing appropriate updates to legislation, infrastructure, vehicle standards and implementing policies such as privacy and insurance).

2.6 Potential for other benefits in addition to road safety

While the primary focus of this submission is on road safety, there are a number of other areas where automated vehicle technology offers the potential to improve outcomes for the community. These include potential for improved customer services, infrastructure productivity, congestion management, environmental performance and access to mobility for people with a disability. The value of technological innovation, including automated vehicle technology, lies in their capacity to provide better customer choices and services and improved mobility outcomes.

The NSW Government's approach to CAVs is firmly focussed on the potential safety and mobility benefits that these new technologies can bring to current and future transport customers.

Partial or conditional automation may assist elderly people who can no longer drive a conventional vehicle, or people with a physical disability. Vehicles with lower levels of automation would require the driver to be licensed and for them to take back control of the vehicle for part of their journey. However, a fully driverless vehicle could allow a partially sighted person, or someone with other physical impairments to be in a vehicle independently.

2.7 Key issues for Government to consider to ensure benefits of autonomous vehicles are realised

2.7.1 A national approach to develop a regulatory framework that supports Connected and Automated Vehicles is required

The NSW Government is committed to encouraging innovation, and recognises that a nationally consistent set of regulatory arrangements for automated vehicle technology will help underpin work in this area, noting that Australia is a single vehicle market and it would be undesirable to erect legal or technical barriers between jurisdictions.

Governments, in general, play an important role in encouraging innovation in an open and competitive technology market. For example, government agencies have an important role to play in the setting the standards for vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications that will be essential to the widespread adoption of highly automated vehicles.

The current regulatory and legal framework in Australia supports the legal operation of connected and automated vehicles up to Level 3 automation. Unresolved issues about responsibility, liability, allocation of risks, and availability of insurance must be resolved before vehicles with Level 4 and 5 automation can be legally and safely operated within the general road environment.

Accordingly, the Transport and Infrastructure Council (TIC) has agreed to the development of a national legislative and regulatory framework for automated vehicles, and has tasked the National Transport Commission (NTC) to investigate regulatory barriers to CAVs and to make recommendations to TIC in November 2016.

2.7.2 Need to proactively manage current and potential risks

It is clear that automated vehicle technology has the potential to significantly improve transport safety. However, there are a number of challenges that will need to be managed effectively if the potential benefits of the new technologies are to be fully realised and their potential risks minimised.

In particular, like every other technical system (including conventional vehicles), autonomous vehicle technology may fail from time to time. Both government and industry will need to anticipate and plan for a range of scenarios that would occur in the event of an automated vehicle system breakdown or localised failure of the system or supporting infrastructure.

2.7.3 Importance of monitoring community acceptance

Experience from other fields such as telecommunications suggests that, given the rapid technological advances that can provide substantial customer service benefits, community acceptance of automated vehicle technology is highly probable. However, this acceptance is likely to be conditional on regulators successfully managing the challenges and risks that currently exist. The potential for challenges and risks has been identified earlier in this section, and specific road safety risks are outlined in further detail later in this submission.

In terms of automated vehicle technology, community acceptance is likely to be high, especially given that the community are already experiencing the benefits of various automated vehicle technologies currently in the market. Many of these technologies are starting to be sold as standard features, and this shift in focus for vehicle manufacturers is driven by consumer demand.

Current research from the USA and UK indicates that over half of the total respondents engaged were comfortable with the concept of connected and automated vehicles, and would be more likely to use the technology if they could take back control if needed (Accenture, 2011). Additional data from Power and Associates (2012) indicated that 37 per cent of 17,400 vehicle owners surveyed would be interested in purchasing a fully autonomous vehicle at some time in the future.

2.7.4 Expanding research capacity

A strong research and evidence base is essential to ensure that future policies and programs related to the use of automated vehicles are appropriate to respond to emerging issues.

Although there is considerable activity around innovative vehicle technologies across the private sector and university research institutions, the significance of the potential benefits and impacts of these technologies is much greater than most technological changes. The NSW Government has a major interest in how these technologies are embedded in future strategic planning and policy approaches. In particular it has a key role in ensuring that that the wider community interest is considered, and public benefit and commercial consideration are carefully balanced. This is best achieved through effective collaborations and partnerships between the private sector, research institutions and Government.

Accordingly, the NSW Government is already engaged in the research and development of connected vehicle technologies aimed at improving road safety, including for heavy vehicles. This includes TfNSW establishing the state’s first Smart Innovation Centre, a new research and development hub for emerging transport and road technology that will bring together industry, investors, researchers, government agencies, vehicle manufacturers, technology providers and data analysts to maximise opportunities for technological innovation. It will be important for the NSW Government to continue to partner with private organisations to expand the research capacity and depth of information relating to automated vehicles.

In light of the rapid technological developments, the NSW Government will consider its strategic future research and development priorities and how to best deliver it through collaborations with the private sector, universities and other external institutions.

3 THE CAPACITY OF DRIVERLESS VEHICLE TECHNOLOGY TO DELIVER IMPROVED ROAD SAFETY OUTCOMES

The prospect of Level 4 and Level 5 automated vehicles being used across NSW has the potential to contribute to significant road safety improvements across all pillars of the Safe Systems in NSW.

While the most substantial gains are likely to be through the elimination of driver error and risk-taking behaviour, automated vehicles also present opportunity for safer vehicle design, more advanced connection with the road network and safer speed management of vehicles.

There are also new safety risks that must be acknowledged. In particular, there are risks associated with the transition to automated vehicles through the "mixed fleet" of vehicles on the roads with different levels of automation interacting with each other. These risks need to be mitigated in the medium term. In addition, the risks of system failure of the automated vehicle itself, and the potential for obsolescence of both vehicle and infrastructure technology, may create separate safety risks that also need to be explored.

3.1 The Safe System approach to road safety

To fully understand the safety benefits that automated vehicles could deliver, it is important to appreciate the impact that the emergence of these vehicles will have within the Safe System approach to road safety in NSW.

The Safe System approach underpins the road safety framework adopted in the NSW Road Safety Strategy 2012-2021 and National Road Safety Strategy 2011-2020. The approach guides the development of countermeasures to reduce death and injury on NSW roads.

The Safe System approach is consistent with policy approaches adopted by international road safety leaders and is a central theme of the 2008 OECD report, 'Towards Zero: Ambitious Road Safety Targets and the Safe System Approach', and the United Nations Decade of Action for Road Safety 2011-2020.

As outlined in the *NSW Road Safety Strategy 2012 – 2021*, the key principles underpinning the Safe System approach are:

- An inclusive view of the whole road transport system and the interactions between all elements: roads and roadsides, vehicles, travel speeds and all users of the system.
- An appreciation of the physical limits to what the human body can endure. The impact forces in any major crash type are well known and, if they are exceeded, can result in death or serious injury.

A fundamental principle of the Safe System approach is that the key elements (roads, vehicles, people and speeds) cannot be viewed in isolation from one another. Instead, their interactions need to be considered for effective system solutions to be implemented. Accordingly, the Safe System approach takes into account the interaction of key components of road safety: the road user (safer people), road and roadside engineering (safer roads), vehicle design and features (safer vehicles) and safer speeds.

The Safe System approach aims to create an environment in which there is an acceptance that crashes will occur; however, steps are in place to ensure the consequences of the crash should not result in death or serious injury. When an unanticipated event or human error results in a crash, the road environment, vehicle design and travel speeds need to account for this in order to reduce the risk of a crash and the severity of the outcome.

The Safe System approach requires that those who design, operate and manage the road transport system are accountable for the safety performance of the system as a whole, by delivering a safe road environment, safe vehicles, and safe travel speeds that considers the behaviour of different road users. It also requires safe and compliant road user behaviour.

The Safe System approach recognises road user behaviour as one of the key pillars to improving safety. Currently, road user behaviour can be addressed through a variety of initiatives including education, engineering and enforcement. Sanctions, such as the accumulation of demerit points, operate in combination with education initiatives and police enforcement to help deter road users from breaking the law and engaging in risky behaviour.

As automated vehicles will minimise human involvement in controlling a motor vehicle, the safe systems approach will still require road environments, vehicle systems and "user behaviour" to continue to work together to ensure that the frequency and severity of crashes are minimised. This may be particularly important for road users outside of the vehicle (i.e. pedestrians, cyclists and motorcyclists) whose safety risks may remain even as automated vehicle technology proliferates more pervasively throughout the vehicle fleet.

3.2 Safer Road Users – Reduce crashes relating to driver error and risk-taking

The Safe System approach to road safety acknowledges that people make mistakes and that the transport system should accommodate those mistakes and that human decision-making and actions, whether inadvertent or deliberate, contribute to the incidence of serious road crashes. It follows that the Safe System approach currently supports a range of education, licensing and road user compliance programs that aim to encourage and improve safer behaviour of road users in NSW.

Autonomous vehicles present an opportunity for significant gains to be made in this context. It is expected that as vehicles become increasingly automated, the level of driver errors will be reduced and the impact of risk-taking behaviour will be minimised.

3.2.1 Reducing driver error

It is well recognised that driver error is a contributing factor in as much as 90 per cent of crashes (Rumar, 1990; Singh, 2015) and, as vehicles become increasingly automated, the level of driver errors will fall. Indeed, the level of driver error involved in crashes is often used to highlight the potential safety benefits of automated vehicles.

Full automation could result in a virtual elimination of crashes due to driver error, and it may also largely eliminate road safety harm from high risk and/or illegal behavioural factors of speeding, drink and drug driving, fatigue, unsafe following distances and driver distraction.

While a reduction in driver error and risk-taking behaviour will lead to positive safety outcomes, increased automation may introduce new risks such as automated system failures. While it is speculative how regular and serious these events are likely to be, it is unlikely that automated vehicle technology would be readily accepted if system failures were commonplace.

3.2.2 Driver risk-taking behaviour

NSW crash data shows that behavioural risk factors such as speeding, drink driving and driver fatigue are among the key factors contributing to road trauma on NSW roads. In NSW, speeding contributes to around 40 per cent of fatalities, with drink-driving and fatigue each contributing to around 20 per cent of fatalities. Note that these figures are not mutually exclusive and a single fatality may involve more than one behavioural factor.

Automated vehicle technology has the potential to substantially reduce the involvement of driver risk-taking behaviour by transferring certain functions currently under the control of the driver to an automated system. Fagnant and Kockelman (2015) estimate that automated vehicles have the potential to contribute to at least a 40 per cent reduction in fatal crashes as they will not be affected by impairments such as drink and drug driving, driver distraction or fatigue.

Ultimately, automated vehicle technology has the greatest potential to eliminate driver risk-taking behaviour when technological applications reach a level at which all driving functions are transferred away from the driver's control. It follows that the magnitude of these benefits will depend on the proportion of the vehicle fleet that is fully automated.

3.3 Safer Speeds – Managing the impact of vehicle speed on crashes

Speeding, which encompasses excessive speed (driving above the speed limit) or inappropriate speed (driving too fast for the prevailing conditions), is unquestionably recognised as a major contributing factor in both the number and severity of traffic crashes in NSW. In NSW speed is a factor in about 40 per cent of road deaths.

Speeding increases the risk of having a crash, and increases the risk of serious injury or death in the event of a crash. Studies of survival and impact speed show that small increases in travel speed can result in large increases in braking distances and impact speed, resulting in both an increased risk of a crash and a more severe outcome. This is especially the case for crashes with less protected road users such as pedestrians and cyclists.

The likelihood of crashes is increased at higher driving speed increases because driving speed increases, the time that a driver has to identify and react to a dangerous situation decreases. High speeds are also associated with extremely high risks of losing control of the vehicle on corners, curves or if evasive action is needed.

The severity of crashes is also increased at higher vehicle speeds because the higher the speed in a crash, the greater the amount of kinetic in impact. This means that the probability of death or injury, and the severity of injuries that occur in a crash, increase exponentially with vehicle speed.

Results from research on speed risk are consistent with the laws of physics and well-established knowledge in the field of biomechanics (Elvik et al., 2004). Lower speeds:

- allow road users more time to assess hazards and avoid potential crashes;
- reduce the distance travelled while reacting to the hazards;
- reduce the vehicle stopping distance after application of the brakes;
- provide a greater opportunity for road users to avoid a collision;
- make it less likely that a driver will lose control; and
- reduce the impact forces in the event of a crash, reducing the severity of the outcomes.

Automated vehicles have enormous potential to assist in managing these issues in a range of ways. Firstly, full automation of vehicles could eliminate human errors regarding high travel speeds for conditions, for example not being aware of the speed limit or situations where vehicles are travelling at speeds that are not safe for the prevailing conditions.

Fully automated vehicles will also have capacity to respond more quickly to unexpected situations on the road network than is currently the case for human drivers. For example when a pedestrian is crossing the road and a driver is not aware or is focussed on something else. This will directly address the critical factor in the relationships between speed and crash outcomes and stopping distance.

Stopping distance, a critical factor in the relationships between speed and crash outcomes, is the combination of the distance travelled by the vehicle during the reaction time of the driver, and the distance travelled once the brakes are applied.

The reaction time of the driver does not depend on speed, but the greater the speed, the greater the distance travelled during the period it takes for the driver to react and the longer the braking distance. Fully automated vehicles have potential to allow vehicles to react much quicker than currently available and may also be able pre-empt situations that human drivers are currently not aware of or distracted by – reducing both the likelihood and severity of crashes.

3.4 Safer Vehicles and Safer Roads – Opportunities for new safety benefits

While most analysis on safety benefits of autonomous vehicles has focussed on the benefits that automated vehicles have in reducing driver error, increased automation and connectivity of autonomous vehicles also present opportunities for improvements in safe design and operation of vehicles and the way in which they interact with the future road network.

For example, from a Safer Vehicles perspective, it is expected that automated vehicles will have increased capacity to safely interact with vulnerable road users such as pedestrians and bicycle riders. This is because automated vehicles will likely have advanced systems that monitor the road environment for external hazards or potential risk scenarios, such as vulnerable road users that may also be using the road.

Systems that detect pedestrians, cyclists and motorcyclists through roadway sensors and vehicle-to-infrastructure communication, vehicle-to-mobile device communication, or vehicle-to-vehicle communication (in the case of motorcyclists), or other detection systems and warn the driver of the presence or location are being developed to specifically address improving the safety of vulnerable road users through C-ITS. Other systems focus on adaptive signal design that can detect vulnerable road users and adjust the signal phasing accordingly, for instance increasing the green phase for slow pedestrians or cancelling a phase if the pedestrian leaves the detection area.

While further work is needed to fully identify the safety benefits for pedestrians and other vulnerable road users, the emergence of this technology is likely to see increased safety for vulnerable road users. However, key issues to be addressed include accommodating the less predictable nature of the movement of non-automated vehicles and the interactions of a mixed fleet of vehicles. In addition, further consideration will be needed to assess the safety impact of a change in the nature of interactions between vehicles and vulnerable road users.

With regard to road design, automated vehicle technology presents greater opportunities for increased use of vehicle-to-infrastructure communication across the road network. This technology will be able to provide information to connected vehicles to help them to respond safely to hazards or unexpected events and to avoid crashes. Possible applications could include information about speed limits, traffic signals, intersection collision warning (where devices on roadside infrastructure detect the potential for a collision) and rail level crossing systems. This opportunity to alert vehicles to changes in road conditions, road works or the road environment in real time will improve their ability to safely respond to hazards on the road and thereby reduce crashes.

3.5 Estimated crash and casualty reductions

3.5.1 Existing research

It has been anticipated that full automation and connectivity will eventually lead to vehicles that cannot crash under normal operation, and the US Federal Highway Administration predicted that a 50 to 80 per cent reduction in highway crashes could result from highways with separated lanes for automated vehicles (FHWA, 1997).

Analysis of the potential safety benefits of vehicle-to-vehicle collision avoidance technologies was conducted for Austroads in 2011 (Taranto, Young & Logan, 2011). It was estimated that a reduction of 25 to 35 per cent of serious casualties could result from the widespread application of these technologies.

The Centre for Automotive Safety Research (CASR) have also examined the safety benefits of a current commercially available C-ITS system and in simulated crash scenarios found that between 37 and 86 per cent of simulated crashes could be avoided, with the highest reductions associated with fully autonomous braking systems (Doecke, Grant & Anderson, 2015).

It should be noted that, while there are expected safety benefits from automated vehicles, there has not been enough testing to demonstrate conclusive results. So far, testing has often involved automated vehicles being driven in limited conditions that are less demanding and not representative of conditions experienced by conventional vehicles (Schoette & Sivat, 2015). Further testing would be required to demonstrate robust and consistent evidence of crash reduction benefits.

3.5.2 Estimated crash and casualty benefits in NSW

Early actuarial advice by Finity Consulting (commissioned by the State Insurance Regulatory Authority) suggests that, once fully rolled out, autonomous vehicles will reduce the likelihood of injuries for car drivers and passengers by 80 per cent, for cyclists by 70 per cent, for motorcyclists by 40 per cent, and for pedestrians by 45 per cent.

Figures 2 and 3 below show that the estimated number of injuries due to motor vehicle crashes in NSW could drop from 22,000 in 2015 to a range of between 7,000 to 13,000 injuries by 2050. This highlights the possibility for the number of people injured on NSW roads to halve over the next 35 years as a result of the introduction of automated vehicles.

Figure 2: NSW projected injuries per year based on historical data (1971 to 2015) and future projections to 2050 *(source: Finity Consulting)*

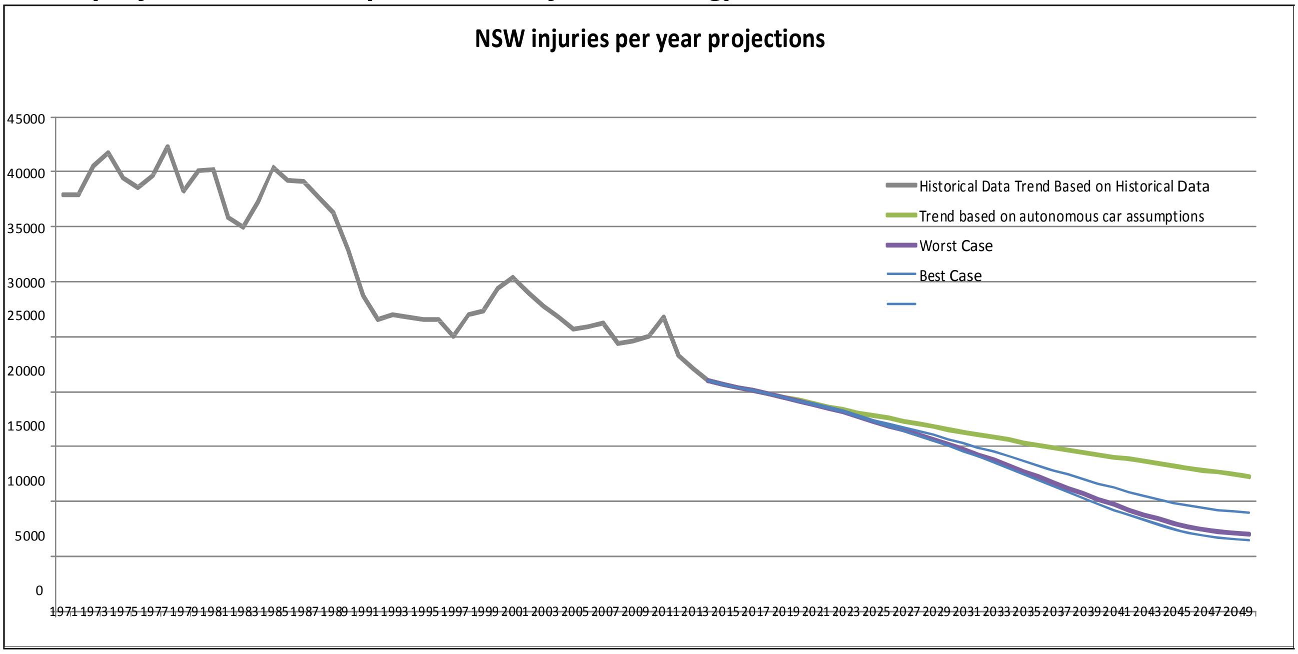
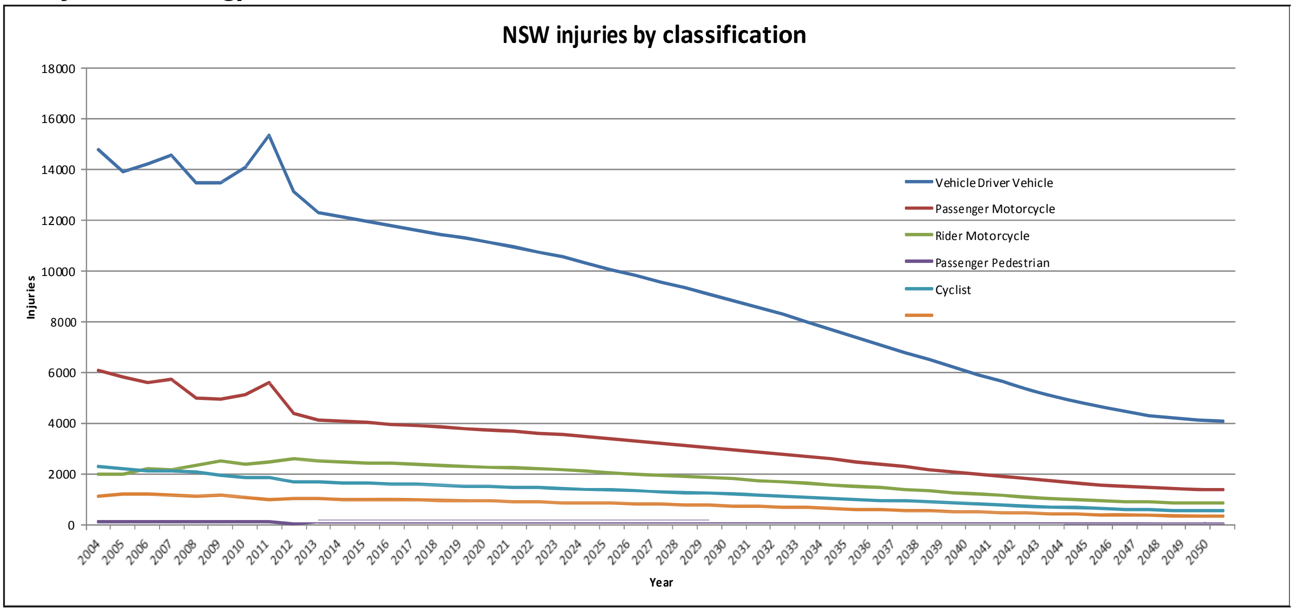


Figure 3: NSW injury reductions by type of road user (based on figure 3) *(source: Finity Consulting)*



3.6 Safety benefits of existing connected and automated vehicle technologies

While fully automated vehicles are likely to be some time away from being readily available, there are a number of other connected and automated vehicle technologies that are currently available or being developed that also have potential to deliver safety benefits in the more immediate term.

It is important to recognise that autonomous vehicle technology, in the form of automated safety features in current vehicles, is already delivering significant safety benefits to NSW road users.

Drivers and other motor vehicle occupants, in particular, are already benefitting from development of various vehicle safety technologies, which are advancing through the work of bodies such as the Australasian New Car Assessment Program (ANCAP). ANCAP has made a key contribution to improving vehicle safety by raising public awareness of, and consumer demand for, safer vehicles, which has influenced manufacturers in the design of vehicles.

Partially automated vehicles, including those with electronic stability control and autonomous emergency braking systems, already exist in the NSW fleet and are in operation on NSW roads. These types of vehicles can use on-board sensors, cameras, global positioning systems and telecommunications that gather and analyse information using complex computer algorithms to enable appropriate responses in safety critical situations without direct driver input.

Transport for NSW (TfNSW) is aware that Volvo and Tesla have already produced vehicles with auto pilot/auto steer (self-driving) systems which are registered and in use in NSW.

TfNSW also notes that there are other autonomous vehicle technologies, such as anti-lock braking and stability (traction) control that are now standard on cars sold in Australia.

This section provides an overview of some of this emerging connected and automated vehicle technology and the anticipated safety benefits that can be delivered before full automation of vehicles.

3.6.1 Electronic stability control

Anti-lock braking systems are available that allow the wheels on a motor vehicle to maintain traction contact with the road surface according to driver inputs while braking, preventing the wheels from locking up (ceasing rotation) and avoiding uncontrolled skidding. Anti-lock braking systems have improved considerably since first being deployed, to now not only prevent wheel lock under braking, but also electronically control the front-to-rear brake bias. Electronic stability control, which detects if a driver has executed an unsafe cornering manoeuvre and automatically reduces engine power and applies varying braking forces to different wheels to help the driver retain control of the vehicle, has been around for almost 20 years, and is now mandatory in all new cars sold in Australia.

3.6.2 Electronic power steering

Electric power assisted steering uses an electric motor to assist the driver of a vehicle with steering. Sensors detect the position of the steering column, and a computer module applies varying amounts of assistance to be applied depending on driving conditions. In the event of component failure or power failure that causes a failure to provide assistance, the mechanical linkage serves as a back-up. By incorporating electronic stability control, electric power steering systems can instantly vary assist levels to aid the driver in corrective manoeuvres.

3.6.3 Intelligent Speed Adaptation

Large scale trials of Intelligent Speed Adaptation (ISA), which automatically alert drivers of vehicle speed when the posted speed limit has been exceeded, have found that mandatory limiting systems would reduce injury crashes by up to 20 per cent and fatal crashes by up to 37 per cent and dynamic ISA limiting systems would reduce injury crashes by 36 per cent and fatal crashes by 59 per cent (Carsten et al., 2008; Carsten and Tate, 2005).

3.6.4 Adaptive cruise control

Adaptive cruise control is an optional cruise control system for vehicles that automatically adjusts the vehicle speed to maintain a safe distance from vehicles ahead. It does not use satellite or roadside infrastructure nor of any cooperative support from other vehicles. Hence control is imposed based on sensor information from on-board sensors only. Sensors used to measure the distance between the adaptive cruise control equipped vehicle and the target vehicle include cameras, radar and lidar laser systems.

The Norwegian Centre for Transport Research estimates that adaptive cruise control could reduce the number of total crashes by 5.9 per cent and more specifically rear end collisions by up to 49 per cent (TOI 2014).

3.6.5 Autonomous Emergency Braking

Autonomous emergency braking which automatically applies the brakes using radar, camera or lidar based systems is another current technology with significant safety benefits. A Swedish study found that it reduced rear-end crashes by between 35 per cent and 41 per cent (Rizzi, Kullgren & Tingvall, 2014). This is already flowing into the market, with both low-speed and high-speed versions of the technology currently available.

3.6.6 Collision avoidance and hazard protection systems

Collision avoidance and hazard protection applications automatically recognise and avoid hazards that a driver fails to detect, unable to detect (for instance out of the line of sight) or detects too late to take evasive action. These applications include the use of vehicle sensors and communicating with roadside infrastructure, or other vehicles to build a picture of surrounding vehicles or other hazards to warn drivers of dangerous situations, or intervene to avoid a crash, or reduce the impact of a crash.

Examples of these systems include forward collision and lane departure warning systems. Forward collision warnings coupled with lane departure warning has been shown to result in significantly faster reaction times to steer away from lateral crash threats (Lerner et al., 2014).

Intersection movement assist uses vehicle-to-vehicle communication to exchange vehicle location information and warn the driver when it is not safe to enter an intersection. This technology can be combined with radar systems to detect non-connected vehicles. Similarly, right turn assist C-ITS uses vehicle to vehicle communication to warn a driver of a potential collision with an oncoming vehicle while making a right turn at un-signalised intersections. This application is likely to provide the largest benefits when sight distances are compromised or the driver’s view is blocked by other vehicles. These applications should reduce crashes due to driver inattention or distraction, and may also reduce the impact of crashes due to travelling at an inappropriate speed. As nearly half of all injury and serious injury crashes in NSW occur at intersections, these applications are predicted to have significant safety impact.

Pedestrian detection systems also exist that use technological communication (e.g. mobile phone devices such as the pedestrian’s phone) to detect the location of pedestrians beyond the driver's line of sight and warn the driver of their presence and location. Variants of this application can also illuminate the crossing and surrounding areas to increase the visibility of pedestrians.

Other applications in this area include electronic emergency brake light which issues a warning to the driver when vehicles out of sight are braking rapidly, cooperative forward collision warning which detects the threat of rear end crashes, overtake warnings that indicate it is not safe to overtake due to vehicles travelling in the opposite direction and blind spot/lane change warnings that indicates to drivers it is not safe to change lanes due to vehicles in their blind spot. There are also red-light violation systems that warn drivers when there is a risk of running a red-light or extend signal phasing to avoid potential collision, and this can be applied to rail level crossing warning and curve advisory speed warning systems.

3.6.7 Platooning

Platooning uses vehicle-to-vehicle communications to synchronise the movements of vehicles in a platoon and vehicle-to-infrastructure communications to help maintain consistent speeds along the length of a road.

There is little available field evidence for the road safety benefits of platooning technology. The Final Report into the European Union's Safe Road Trains for the Environment (SATRE) project estimated that a platoon led by a heavy vehicle and consisting of light vehicles could reduce the involvement of the light vehicles in crashes by up to 50 per cent (Jootel 2013). This figure should be treated with caution as it is purely based on exposure measures to crashes for heavy vehicle drivers.

3.6.8 Road signage detection

Automatic vehicle detection of road signs is another potential C-ITS application, for example stop sign warnings that provide drivers with a warning if their approach speed is too fast given the distance to the sign. Weather system warning sensors are another application, which can provide advance warning of unsafe conditions especially ice on the roadway or fog so that drivers can adapt their behaviour. Similarly, road surface conditions warning systems can provide advance warning of a change in road condition.

3.6.9 Vehicle to Infrastructure communication

Vehicle to Infrastructure (V2I) and Infrastructure to Vehicle (I2V) communication systems generally operate on dedicated short range communication protocols similar to the vehicle to vehicle C-ITS. Examples of applications include speed limit information, red light violation warnings, intersection collision warning (where devices on roadside infrastructure detect the potential for a collision) and rail level crossing systems. There is also the potential to provide signal priority for emergency vehicles thus reducing response time to road crashes.

3.6.10 Post-crash notification systems

Post-crash notification systems alert relevant emergency services in the event of a crash, which are becoming more common, and have the potential to reduce the time that emergency services take to respond to a crash.

3.6.11 Adaptive front lighting systems

These are headlights and associated lights that adjust their direction and intensity to provide additional illumination on curves, turns, and hills and to highlight potential hazards.

3.6.12 Attention assist (fatigue detection)

This is a drowsiness detection system that warns drivers to prevent them falling asleep momentarily while driving. It will prompt them to take a break before their fatigue reaches a level that may result in a crash.

3.6.13 Automatic headlights

These headlight control systems automatically switches the headlights on and off according to ambient light levels.

3.6.14 Blind spot monitoring

This detects other vehicles in adjacent lanes in the driver's "blind spot" and alerts driver of their presence.

3.7 Additional safety issues to consider

Despite the overall safety benefits that are expected from the introduction of automated vehicles across the road network, there are also a range of new safety risks that these vehicles may introduce that must be managed.

Many of these relate to the implications of a mixed fleet of vehicles that will be present on the network where vehicles of different levels of automation (and human involvement) are interacting on the same road network and using the same road infrastructure. While vehicles are currently available on the Australian market that include Level 1, 2 and 3 automated vehicle technology applications, vehicles with higher levels of automation (Level 4 and 5) are not anticipated to be operational on a large scale for a number of decades. This has a number of implications for autonomous vehicle technology in the more immediate term. Failing to explore and appropriately mitigate the safety implications that the transition to automated vehicles presents may negatively impact on community acceptance of the new technology.

3.7.1 Automated vehicles may behave differently to other vehicles that have less automated technologies

Automated vehicles are expected to behave differently in sensing hazards and avoiding them in time; whereas drivers of non-automated vehicles may have difficulty reading and reacting to traffic hazards that include vehicles with higher levels of automation. Conversely, automated vehicles may find it difficult to predict the behaviour of human drivers and other road users who may react unexpectedly to situations they have been programmed for on the road network.

Particularly in a mixed fleet situation, there will be vehicles operating on our roads with different levels of functional automation. Vehicles may also operate at different levels of automation depending on weather conditions, the type of road on which they are travelling, and the level of automation that is supported by particular road infrastructure.

A simple example of the changing dynamic that automated vehicles may introduce is an example of a pedestrian crossing a road. Currently, some pedestrians may manage their own risk when crossing the road by making eye contact with a human driver before crossing a road. However, making eye contact with an automated vehicle will probably not be possible, and pedestrians will have to develop different risk management and safety strategies for automated vehicles.

3.7.2 Risks associated with different levels of connectivity to other vehicles and infrastructure

Vehicle connectivity is an important aspect of optimising the benefits from the deployment of autonomous vehicles. Effective and reliable connected infrastructure is needed to support automated vehicle technology in a wide range of conditions and locations if the technology is to be demonstrably safe enough to be fully accepted by users.

Partially automated vehicles that are currently operating on NSW roads are designed to operate with existing infrastructure and their sensors are capable of detecting and interpreting existing road markings and speed advisory signs. Transport for NSW is currently exploring how higher level automated vehicles will communicate with traffic signals and other fixed infrastructure and what changes to signage and infrastructure are required to support fully automated and mixed fleet environments.

As more automated vehicles begin operating on NSW roads, the extent to which different types of vehicles and infrastructure are connected with each other will impact the level of safety benefits (or risks) that may emerge. The main safety risks associated with different levels of connectivity may arise when vehicles are not connected to infrastructure or to other vehicles, and do not receive critical information from other CAVs. If not properly mitigated, these risks arising from a lack of connectivity in some vehicles or differing levels of connectivity and automation in others, may lead to inappropriate vehicle responses and unintended outcomes, potentially resulting in crashes and casualties.

3.7.3 New risks relating to system failures

Autonomous vehicle technology, like every other technical system (including conventional vehicles) will fail from time to time. Both government and industry will need to anticipate and plan for a range of scenarios that would occur in the event of a system breakdown or localised failure of a system or supporting infrastructure.

In addition, increased level of automation of the driving task creates inherent IT security risks that may have a road safety impact. For example, safety impacts of an automated vehicle that has been "hacked" have not yet fully been explored and will need to be properly addressed.

3.7.4 Impact on human factors

While automated vehicle technology will clearly provide safety benefits to some degree, it can also lead to changes in driver behaviour. There are various human factors issues to be considered as new safety risks could be introduced, especially if technology still requires human 'driver' intervention in certain circumstances.

(a) *Driver over-reliance on technology*

Over-reliance on automated vehicle technology may occur when drivers delegate full responsibility for driving tasks to an autonomous vehicle system, or delegate responsibility for other driving tasks that the system was not designed to address.

Over-reliance can occur because of a loss of vigilance or drivers misunderstanding the functionality and limitations of the technology, and creates problems when the system is no longer active, such as when drivers use a non-equipped vehicle or when drivers are required to regain vehicle control.

Over-reliance has been observed in a number of ISA studies, where drivers, for example, forget to change speed upon entering a different speed zone when the ISA is no longer active (Comte, 1998; Hjälmdahl & Várhelyi, 2004).

A possible mitigation strategy for the risks associated with over-reliance on technology could involve educating users of autonomous vehicles about the capabilities and limitations of autonomous vehicle technology, and ensuring that autonomous vehicles provide timely warnings when the system requires human intervention.

(b) *Adoption of other risky driving behaviours*

As the level of vehicle automation increases, users may adopt other risky behaviours to experiment with the system, or to improve their mobility and compensate for factors such as lost time due to lower speeds created by some systems.

The period of mixed traffic, where automated vehicles will share the road with non-automated vehicles, may also present issues in terms of the behaviour of drivers of non-automated vehicles. For example, if drivers of non-automated vehicles expect automated vehicles to behave in the same way as non-automated vehicles, and this expectation is not met (van Loon & Martens, 2015). This may increase collisions involving non-automated vehicles and automated vehicles which will need to be monitored in crash data.

Alternatively, drivers of non-automated vehicles may adopt similar behaviours to automated vehicle platoons which are incompatible with safe manual driving. An example of this was recently identified in a simulator study which found that drivers of non-automated vehicles adopted closer following distances based on the behaviour of automated vehicles (Gouy et al., 2014).

(c) *Lack of driver situational awareness*

Until vehicles become fully automated (Level 5) and no longer require any human input, the driver will need to be prepared to reclaim manual control of the vehicle under certain conditions.

A whole host of factors including loss of skill, loss of situation awareness and overreliance can cause issues with drivers regaining control of an automated vehicle. Reduced situation awareness, for example, has been associated with a delay in appropriate braking when a failure in adaptive cruise control was encountered (Rudin-Brown & Parker, 2004; Young & Stanton, 2007).

The introduction of automated vehicle technology can also reduce processing demands for their users that may lead to a loss of vigilance in some situations, such as being distracted or fatigued. A loss of vigilance can lead to reduced situational awareness and an inability to cope with a sudden increase in demand, as can occur during a system failure or the occurrence of a safety-critical event outside of the capacity of the system, where drivers need to take back vehicle control (Stanton et al., 1997; Ward, 2000).

A challenge for technology designers will be that, unless they are designing a Level 5 autonomous vehicle which requires no human intervention at all, they will need to consider maintaining an optimal level of driver workload. This will need to ensure that drivers are not overloaded in critical situations and are sufficiently stimulated to remain involved in the transportation task. The level of workload experienced by drivers is likely to differ substantially across different levels of automation, with loss of situational awareness becoming more problematic as automation increases.

The removal of the need for drivers to monitor the driving environment could also lead to a loss of situation awareness, further impacting the success of a driver's ability to successfully resume manual control when required.

While C-ITS that provide alerts to drivers may provide critical safety information, it is important that these systems are clear, do not overload the driver, do not overly fatigue the driver and provide an optimal level of workload for the driver that does not overload but also provides sufficient information.

(d) *<u>Loss of driver skill</u>*

Automating components of the driving task may lead to a loss of skill and this problem is likely to increase as the level of vehicle automation increases (Toffetti et al., 2009). If humans do not perform a task for a period of time, they begin to lose the skill to perform that task effectively even if they could perform it to a high standard previously.

Loss of skill can lead to particular problems in the event of automation failure where the driver is required to regain manual control. A challenge for system developers, manufacturers and governments will be designing automation and implementing policies to ensure that drivers are able to maintain a minimum level of driving skill (i.e. by requiring intermittent manual control) or by removing the need for drivers to intervene at all in the driving task.

(e) *<u>Distraction</u>*

Automated vehicle technology can pose a distraction risk if it presents confusing or too many alerts or if it diverts the driver's attention away from safety-critical events (i.e. away from a hazard in the road and toward an in-vehicle technological display). A challenge for C-ITS developers is to design these technologies so that they direct a driver's attention to important information or events, but do not distract the driver from critical events or delay drivers from taking appropriate action.

A highly automated vehicle also opens up the possibility for drivers to conduct other tasks. The introduction of automated vehicle technology may also lead drivers to engage more frequently in distracting or non-driving activities while using the vehicle, because the systems automate part of the driving task, freeing up the user's attention and time to engage in other activities (Smiley, 2000).

In a fully automated system this may be appropriate; however, if human intervention is required, driver distraction and inattention may be an issue if part of the driving task is automated and the driver feels their attention is not required. Indeed, Jamson et al. (2013) found that drivers became more heavily involved in secondary entertainment tasks when driving a highly automated vehicle compared to when driving in manual mode.

(f) *Reaction of other road users*

Recent pedestrian behaviour is causing increasing road safety concerns, especially as there is a growing trend to distraction by smart-phones and similar devices. There is a possibility that as more autonomous systems are introduced into vehicles, pedestrians will become even less vigilant around vehicles as there may be an expectation that the vehicles will stop automatically should a person step out onto the road in front of them. The risk of pedestrian injury will be high especially in a mixed fleet where not every vehicle will have autonomous emergency braking, or until the autonomous emergency braking systems are standardised to respond to unexpected pedestrian behaviour. Such pedestrian behaviour also has the potential to cause significant congestion as vehicles constantly stop to avoid them.

(g) *Vehicle enthusiasts and the aftermarket industry*

Modifying standard vehicles – for functional, performance or aesthetic purposes – and even building unique vehicles is a common pastime among motoring “enthusiasts”. It is the basis of a multi-million dollar aftermarket industry.

As more and more autonomous systems are introduced into vehicles, the scope for modifying them reduces, either because the systems are too complex to be altered or they are fundamental safety features that cannot be changed. These enthusiasts and the associated industry need to be considered in establishing the regulatory and environmental framework to accommodate autonomous vehicles.

Alternatively, there is the future possibility for a new type of ‘vehicle modification’ sub-culture to emerge surrounding customisation of vehicle software rather than physical vehicle design, particularly as the level of automation increases and becomes more readily available. Regulators will need to consider what ‘modified automated’ vehicle regulation will be required.

4 THE EXTENT TO WHICH CURRENT ROAD SAFETY POLICIES AND REGULATIONS IN NSW ANTICIPATE DRIVERLESS VEHICLE TECHNOLOGY, AND ANY CHANGES REQUIRED.

4.1 The role of government in facilitating autonomous vehicle technology

It is important that the government helps to facilitate and support the introduction of autonomous vehicle technology on our roads, collecting and building robust and consistent evidence supporting the safety and other benefits of the technology.

The Government's key role is to explore policy and regulatory issues relating to autonomous vehicle technology, supporting and initiating research and development to investigate safe and productive deployment of connected and automated vehicles in partnership with the private sector and research institutions. The NSW Government has recently announced the establishment of the Smart Innovation Centre which will foster these partnerships.

One of the key responsibilities of governments is to ensure the safety of all road users operating within the road environment where an automated vehicle will be present on the road network. This is particularly important when a 'mixed' vehicle fleet is in operation, and should consider identification of safety risks for all road users including:

- Occupants of the automated vehicle
- Operators of non-automated motor vehicles
- Bicycle riders
- Pedestrians
- Motorcyclists
- Heavy vehicles

In doing so, vehicle standards must be maintained and safety should not be mainly relying on consumer laws. Instead of being reactive after products are already in the market, all potential problems associated with autonomous vehicle technology should be identified and eliminated or controlled during the design-manufacture stages.

It is also important that road network owners and managers are involved in working through automated vehicle safety issues to produce a safe, efficient and customer-focused road network.

Other issues for governments to consider include:

- early engagement with technology sector and vehicle manufacturing industry to ensure that it can facilitate, respond and influence direction of new technology
- monitoring crash type, crash locations, and reasons for crashes to inform whether regulation is required.
- the ability of highly automated vehicles to comply with road rules that apply in specific situations and not based on sensing or communicating with infrastructure such as traffic lights and signage. Examples of such rules include speed zones that apply when wig-wag lights at the back of the bus are operational, or requirements to leave a minimum distance when passing a bicycle rider on a road.
- how to balance the mix of driver-controlled vehicles and vehicles with increasing levels of autonomous systems, including – ultimately – fully automated vehicles, on the same roads.
- monitoring and reviewing legal and compensation systems to assess their adequacy and effectiveness;
- training and information for enforcement personnel
- privacy issues arising from the large amount of data collected from connected and automated systems

4.2 Autonomous vehicles and NSW Road Transport Legislation

4.2.1 NSW Legislation and Regulation relating to road safety

In NSW, the primary legislation relating to the use of motor vehicles on roads and road related areas is the Road Transport Act 2013 (the Act). Collectively, the Act and the following Regulations made under the Act are often referred to as "Road Transport Legislation":

- Road Rules 2014
- Road Transport (General Regulation) 2013
- Road Transport (Driver Licensing) Regulation 2008
- Road Transport (Vehicle Registration) Regulation 2007

With regard to road safety, the Road Transport Legislation includes the legislative framework for the following items that relate to road safety in NSW:

- A licensing scheme for the use of motor vehicles on NSW roads
- Safety and traffic management, including rules concerning behaviour of road users on roads and road related areas (including penalties for offending behaviour)

- Vehicle registration scheme for use of certain vehicles on NSW roads

There are also a range of other NSW legislative instruments that impact on the safe use of vehicles and safety outcomes for users of the NSW road network. These include:

- *Passenger Transport Act 1990*
- *Crimes Act 1900* (in relation to certain criminal driving behaviour)
- *Motor Accidents Compensation Act 1999* (in relation to administration of an insurance scheme for certain types of road users injured in crashes involving a motor vehicle)
- *Roads Act 1993* (in relation to management of road network in NSW).
- *Dangerous Goods (Road and Rail Transport) Act 2008* (In relation to the transport of dangerous goods in NSW),

In addition, heavy vehicles used nationally are also required to comply with the Heavy Vehicle National Law (HVNL) – as applied in NSW through the *Heavy Vehicle (Adoption of National Law) Act 2013.* The regulatory framework under the HVNL prescribes the following specifically in relation to heavy vehicles over 4.5 tonnes GVM:

- The standards heavy vehicles must meet before they can use our roads
- The maximum permissible mass and dimensions of heavy vehicles
- Securing and restraining loads on heavy vehicles
- Ensuring parties in the chain of responsibility are held responsible for drivers of heavy vehicles exceeding speed limits
- Preventing drivers of heavy vehicles from driving while impaired by fatigue
- Nationally consistent penalties.

In addition to the above, the design of vehicles used in NSW is governed by the Commonwealth *Motor Vehicle Standards Act 1989*, and the associated Australian Design Rules (ADRs). The vehicle standards specified in the Road Transport (Vehicle Registration) Regulation 2007 must be consistent with the ADRs.

The *Motor Vehicle Standards Act 1989* and ADRs are administered by the Commonwealth Department of Infrastructure & Regional Development (DIRD), and Transport for NSW understands DIRD is working internationally to ensure the ADRs do not stifle progress with developing autonomous vehicles.

4.2.2 Legislative and policy issues to be considered for autonomous vehicles

While there are already vehicles with auto pilot/auto steer (self-driving) systems that are registered and in use in NSW, the NSW Road Rules 2014 currently mandate that a driver must have proper control of a vehicle for it to be operated lawfully on a road or road related area. Within these Rules a driver is defined as “a person who is driving a vehicle…”.

Therefore, the driver must have control of the vehicle even if some of the safety critical control functions are being operated automatically.

However, the NSW regulatory framework currently supports the use of partially automated vehicles on public roads provided the vehicle is a registrable vehicle and a driver is present and takes responsibility for the safe operation of the vehicle. Current provisions also exist in NSW road transport law for exemptions to be granted from road transport law requirements in certain circumstances and in certain locations.

It is acknowledged that legislative amendments will need to be made to Road Transport Legislation to ensure that the use of higher levels of autonomous vehicle technology (Levels 4 and 5) on NSW roads is legal and can be appropriately regulated without stifling innovation. Regulatory changes should also not lead to unintended consequences or weakening of existing regulatory controls of conventional vehicles with a licensed driver.

Transport for NSW has identified the following key issues to be considered in relation to the regulatory framework:

- the future definition and use of the term “driver” in Road Transport Legislation.
- whether different rules and conditions should apply to vehicles (and their use) based on their level of automation.
- the extent to which occupants of autonomous vehicles require training, experience, minimum fitness standards or knowledge of road transport law before “using” an autonomous vehicle on NSW.
- the extent to which occupants of autonomous vehicles are responsible for unsafe or illegal “behaviour” of the vehicle; and what level of responsibility occupants are obligated to intervene to prevent road crashes.
- the ongoing application of “human factor” laws in the autonomous vehicle context, such as drink and drug driving laws, including the appropriate way of dealing with driver behavioural issues when human intervention is required to take control of an automated vehicle.
- the ongoing need for existing safety programs that attempt to address dangerous behaviours, particularly those that include use of technology as a key safety control (for example, the mandatory alcohol interlock program for repeat and high range drink drivers).
- developing an appropriate enforcement framework that recognises different levels of “driver control” in different vehicles and traffic situations.

- ensuring that vehicle design rules and vehicle standards appropriately balance priorities of not stifling innovation and ensuring safety of all road users.

- assessing whether any additional items are required to ensure that vehicle modifications are adequately dealt with in the context of autonomous vehicles.

- identifying the extent to which IT security and related issues (such as hacking) should be addressed in Road Transport Legislation.

- the extent to which rules may be required to ensure road safety in circumstances where autonomous vehicles (or supporting infrastructure) experience system failure or malfunction.

- identifying appropriate mechanisms to ensure that "autonomous vehicles" are operating within current, local laws at all times (including vehicles that may be "visiting" from another jurisdiction).

In addition to these issues affecting vehicle use generally, there are also a range of issues that will need to be considered in the context of heavy vehicles specifically. This includes:

- the impact of autonomous heavy vehicles on existing chain of responsibility requirements.

- the impact on current enforcement regimes that use random road intercepts.

- the applicability of vehicle sanctions and ability for an autonomous heavy vehicle to comply.

- the appropriate conditions, locations and standards required for autonomous heavy vehicles to be used on certain lengths of roads.

4.2.3 Prosecution and enforcement issues relating to autonomous vehicles

NSW Police Force has also advised that there are a range of issues to be considered to enable Police to investigate and prosecute offences where autonomous vehicle technology is available. Key items that will require consideration from a prosecution perspective include:

- The extent to which Police are able to access and investigate information embedded within an automated vehicle as part of a crash investigation.

- The extent to which defendant's prosecuted for a certain offence (e.g. speeding, disobeying traffic control signals) may claim that a malfunction occurred in some part of the autonomous vehicle technology function. Police would have very limited ability to verify if that was the case.

- Resource implications of police being required to investigate malfunction of autonomous vehicle technology as a defence in every incident they investigate.
- Additional training required for Police prosecutors in relation to any amendments made in relation to autonomous vehicles.

4.3 Autonomous vehicles and the NSW Compulsory Third Party scheme

4.3.1 Overview of the NSW Compulsory Third Party Scheme

Compulsory Third Party (CTP) insurance is compulsory in all Australian States and Territories and is designed to ensure that compensation is available to those who are injured in motor vehicle crashes. In NSW, motor vehicle owners are required to purchase a CTP insurance policy or 'Green Slip' before Roads and Maritime Services (RMS) can register the vehicle or renew its registration. The Green Slip covers the driver of a motor vehicle against personal injury claims from third parties – other road users (including pedestrians) who are injured in a crash involving the vehicle.

The NSW CTP scheme is a modified common law, primarily fault-based scheme operating under the Motor Accidents Compensation Act 1999 (MAC Act). A person injured, but not at fault, in an accident can make a claim for a range of benefits under the CTP scheme, including medical and related costs, past and future economic loss, and for those with permanent injuries, payments for non-economic loss or 'pain and suffering'.

The NSW CTP scheme also provides some benefits irrespective of fault: it covers the first $5,000 of treatment costs and lost income under an Accident Notification Form (ANF). The ANF scheme allows for early notification and quick payment of treatment expenses and lost income incurred within the first six months of a crash. An injured person who is not at fault in the crash may still lodge a full personal injury claim if they reach the $5,000 limit under the ANF and have ongoing medical treatment or rehabilitation needs, or require further time off work.

The CTP Scheme is privately underwritten and Green Slip insurance policies are only available from private insurers licensed by the State Insurance Regulatory Authority (SIRA). There are currently six insurers in the market – NRMA, QBE, Allianz (Allianz and CIC-Allianz) and Suncorp (AAMI and GIO). Prices vary between insurers and SIRA offers a complimentary price comparison service and encourages motorists to 'shop around' for their Green Slip.

The NSW Government does not set Green Slip prices. Green Slip prices are set by the private CTP insurers based on an assessment of industry data and their claims experience, within Guidelines set by SIRA. The prices for different types of vehicles reflect the cost and frequency of injury claims against a particular vehicle class (e.g. passenger vehicle, motorcycle, taxi cab) in one of five CTP rating districts.

Having set the base Green Slip price, CTP insurers use a variety of risk-rating factors to offer a discount to drivers considered to have a low risk profile or to impose a loading to those with a higher risk profile. The CTP insurers use the age of the owner or driver as the primary risk-rating factor. The insurers also use other factors such as the age of the vehicle, the geographical zone in which the vehicle is garaged and driver or rider safety record.

4.3.2 Impact of autonomous vehicles on the CTP scheme

The introduction of autonomous and driverless vehicles raises a range of considerations for SIRA as the regulator of the NSW CTP scheme.

A significant factor in the setting of Green Slip premiums in NSW is the cost of claims when a vehicle is at fault in a crash. It is likely that CTP premiums in NSW will reduce as a result of the introduction of autonomous and driverless vehicles due to the significant reduction in casualties and fewer injuries. Lower CTP premiums could increase competition in the CTP market as insurers try to maintain their share of premium income.

While the introduction of autonomous vehicles may ultimately reduce the incidence of motor vehicle crashes, evidence of a clear reduction in risk by autonomous vehicles would be required, which demonstrates that autonomous vehicles reduce the propensity or severity of a motor vehicle crash, before insurers would adjust risk rating factors in their prices. In early adoption, there may also be some risk that crashes occur because of technology failures.

The introduction of autonomous vehicles and related technologies also has the potential to increase the quality of data available on the cause of a crash and could assist in reducing the incidence and size of fraudulent CTP insurance claims.

4.3.3 Considering liability for motor vehicle crashes involving an autonomous vehicle

The introduction of driverless and autonomous vehicles has the potential to significantly reduce the number of motor vehicle crashes arising from human error and it is more likely that, when crashes do occur, they would be as a result of technological failure, rather than driver error. In those circumstances it may be difficult to determine who is responsible for the crash, as there may be more than one party who could be deemed responsible.

This poses challenges for the current NSW CTP scheme, which, as noted above, is a primarily fault-based scheme. This means that a person injured in a motor vehicle crash in NSW can make a claim for compensation under the motor accidents scheme if they can establish the crash occurred through the fault of another vehicle owner or driver.

When operating an autonomous vehicle, the driver is no longer in control of the vehicle and, in most cases, the driver could not be held at fault in the case of a crash. Where the vehicle may be able to be manually overridden by the driver, the driver could, however, be deemed to be responsible for the crash.

Where the driver is not at fault in a motor vehicle crash, the question then arises as to who could be held responsible for the crash, for example, the car manufacturer, the technical systems manufacturer, or the network supplying the GPS information. It is also anticipated that there would also still be crashes involving cars manually operated by drivers and autonomous cars and this adds further complexity to the determination of fault.

In a single vehicle crash, the following could be deemed potentially liable for the crash:

- The safety component technology is at fault.
- The software that governs the safety component technology is at fault.
- The car was improperly maintained (for example, a safety device was poorly calibrated following its repair).
- Someone else was at fault (e.g. someone ran the car off the road).
- Something else was at fault (e.g. poor infrastructure - the traffic signals didn't interact with the car).
- The driver is at fault (they overrode the safety features).

The possible implication of different parts of a system in causing a crash adds a significant degree of complexity to the determination of fault. It is noted that the *Motor Accidents Compensation Act 1999* currently imposes strict timeframes on insurers for the determination of liability. From a CTP regulator perspective, the introduction of autonomous vehicles will require detailed consideration as to how fault can be efficiently determined and applied in the event of a crash.

The difficulty in determining fault when a crash occurs may lead to more disputes and a greater reliance on dispute mechanisms, which may also impact on the NSW CTP scheme.

A significant consideration will also be the extent to which manufacturers of driverless and autonomous vehicle technologies will be held responsible in motor vehicle crash. Should manufacturers bear liability for significant claims costs arising from injuries sustained in crashes involving driverless or autonomous vehicle technologies, this may discourage the development and delivery of new safety technologies. It is noted that Google, Mercedes Benz and Volvo, at present, have all stated they will bear full responsibility for crashes caused by their driverless and autonomous cars.

In order to support innovation in, and production of, technologies that would reduce the incidence and severity of road crashes and trauma, consideration may need to be given, in the future, to affording manufacturers of such technology some form of legal protection, much in the same way that pharmaceutical companies have protection for their vaccinations.

In any event, legislation will likely be required to establish the allocation of fault clearly, so as not to impede injured people pursuing a claim.

5 THE PREPAREDNESS OF NSW ROAD SAFETY REGULATORS TO MEET THE CHALLENGES EXTENDED BY DRIVERLESS VEHICLE TECHNOLOGY

5.1 Current NSW Government activities

Transport for NSW ran the Future Transport Summit on the 18 and 19 April this year. The outcomes of the summit will be the production of a green and a white paper and future transport roadmap. There were a number of ideas raised that will form a basis for this work and much will be based around safety technology and customer experience, with CAVs, Big Data, Open Data, Disruptive Technology and the Internet of things key focus areas of the summit.

Transport for NSW will be reshaping itself around a much sharper focus on technology and the partnerships through the new Smart Innovation Centre will influence the future business of the agency with CAVs a critical area of work from both a safety and broader transport perspective.

Connectivity with other vehicles and infrastructure is critical to the success of automated vehicles and the NSW Government is already actively engaged in research regarding autonomous vehicle technology and C-ITS.

5.1.1 Establishing a Smart Innovation Centre

The NSW Government has announced the establishment of a Smart Innovation Centre (SIC) to provide collaborative support, facilities and expertise to promote research and innovation and position NSW as a leader in accelerating deployment of emerging transport technologies.

The SIC will function as an international standard collaborative research group that brings together investors, researchers, government agencies, vehicle manufacturers, technology providers and data analysts to maximise the potential opportunities afforded by new technologies.

The SIC will both shape the Governments activities around CAVs and also how innovative technology ideas are imbedded in the core business of transport for NSW.

5.1.2 The Cooperative Intelligent Transport Initiative (CITI) project

The NSW Centre for Road Safety (CRS) in TfNSW currently runs the CITI project, which involves the only large-scale deployment of cooperative intelligent transport system dedicated to heavy vehicles in the world. The project 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. Drivers received messages warning of intersection collisions, forward collision danger, heavy braking ahead, traffic signal phase and speed limits.

The CITI project testing facility is based south of Sydney in the Illawarra region, and was formed from a collaboration between TfNSW and Data61 (a CSIRO company) with funding from the Federal Government's Heavy Vehicle Safety & Productivity Program. Stage one of the project completed in November 2015 has seen 58 heavy vehicles, two light vehicles and a motorcycle fitted with the technology. Three sets of traffic signals are also fitted with C-ITS along with a solar powered trailer that provides speed zone alerts to trucks descending the Mount Ousley pass north of Wollongong City.

More than 500 million safety messages have been collected so far by researchers working on the CITI project. This data will be used to better understand how C-ITS technology works under Australian conditions and assist in quantifying the safety, efficiency and environmental benefits of connected vehicles.

This work conducted by CRS in collaboration with the CSIRO and a number of universities provides a strong base to extend research into the development of autonomous vehicle technology.

5.1.3 Strategic transport planning developments

As part of the NSW Premier's Innovation Initiative, the Transport cluster is working with private sector data and freight partners on a Freight Signal Priority proof of concept. This is designed to reduce congestion on key freight routes by coordinating traffic signal timing.

5.1.4 The Australian Driverless Vehicle Initiative

TfNSW has recently partnered with the Australian Driverless Vehicle Initiative (ADVI) to explore the impacts and requirements of automated and connected vehicle technology in a truly Australian context, and make recommendations on ways to safely and successfully introduce them.

As part of the project, TfNSW will be nominating representatives for the following three ADVI sub-committees:

- Scientific Research Group: representatives with national and international scientific and technical merit; responsible for planning, scientific and technical oversight, and reporting on demonstrations and research activities;
- Policy and Risk Group: representatives with background in insurance, risk, legal, policy development; responsible for planning, development and coordination of all discussion and position papers, policy and risk forums and other activities;

- Media and Advocacy Group: representatives with strong background in media relations, government relations, advocacy and/or promotion; responsible for planning, implementation and reporting of all media and advocacy activities.

5.1.5 Participation in technology forums

The NSW Government has participated in a range of forums to continually understand current and emerging research and policy issues associated with autonomous vehicle technology.

In 2015 CRS researchers presented at a number of conferences and workshops on connected vehicles including; the Australian Intelligent Transport Systems Summit (Melbourne), Australasian Road Safety Conference, Automated Vehicle Conference (Adelaide), ITS and Road Safety Forum (Qatar) and International ITS Innovation Forum (Abu Dhabi).

TfNSW hosted the Future Transport Summit in April 2016 at the Australian Technology Park, with emerging vehicle technologies one of the key themes.

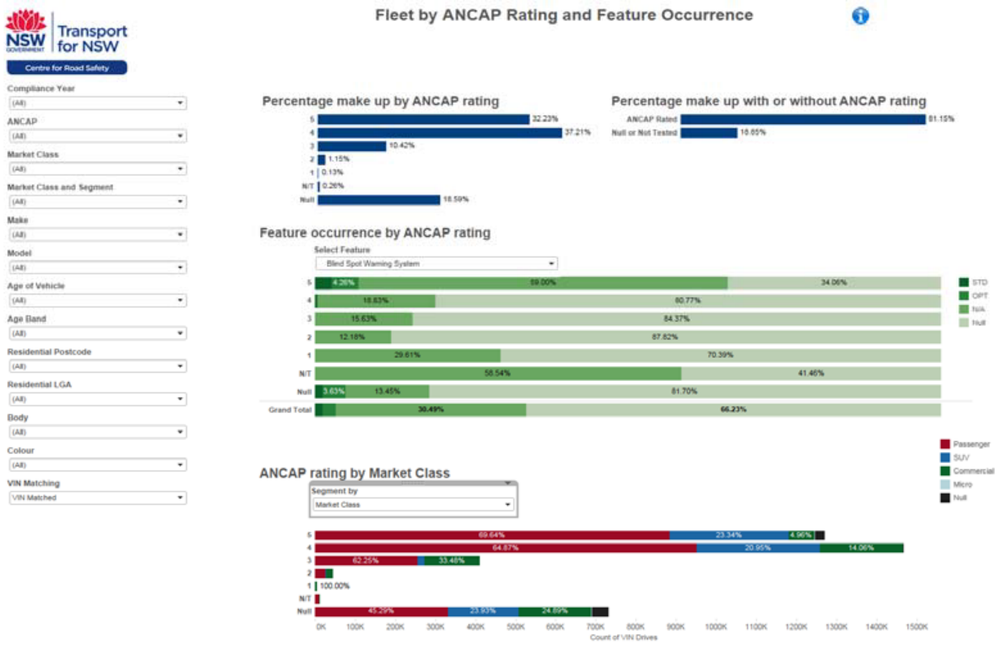
5.1.6 Increasing understanding of the safety features in NSW vehicle fleet

The CRS is currently developing a fleet safety data visualisation tool in two phases. Phase 1 aims at better understanding of the safety level of the NSW registered fleet of light motorised vehicles (but not including plant vehicles and motorcycles). This will enable users to analyse aspects of registration trends such as:

- The uptake trends of a particular safety feature such as Electronic Stability Control systems in the fleet.
- The trends in ANCAP ratings of vehicles registered in NSW.
- The average ages, ANCAP ratings or safety levels of registered vehicles in particular locations in NSW.

An example showing the ANCAP rating breakdown of vehicles registered as at August 2015 is shown below. The graphics in the image below show:

- The breakdown of the NSW fleet that have received certain ANCAP ratings
- The extent to which vehicles in each ANCAP rating band have the safety feature of "Blind Spot Warning System" installed as a standard or optional feature
- The extent to which different market class of vehicle has received certain ANCAP ratings



Phase 2 of the project will see the addition of NSW light vehicle crash data so they may be compared against registered fleet of phase 1 for a specified time period.

These data visualisations will be useful in establishing crash trends and the levels of safety specifications associated with the vehicles involved. The data will enable high level analyses profiling vehicle age, vehicle types, crash locations and severity of the crash. These refined analyses will assist the CRS in making informed decisions on policies and strategies to promote the purchase of safer vehicles.

5.1.7 Exploring legislative requirements to support on-road trials and demonstrations

TfNSW is currently working to establish a legal framework to permit on-road trials and demonstrations to enable the safe testing of autonomous vehicle technology in NSW. This will enable better understanding of operational and other issues in a real-world driving context, and is seen as a necessary first step to allowing the use of automated and connected vehicles on NSW roads in the longer term.

Removing legislative impediments to allow the safe testing of autonomous vehicle technology on NSW roads provides a pragmatic approach and will enable NSW to position itself at the forefront of emerging transport and vehicle technologies.

The introduction of specific legislation to facilitate trials will increase market certainty that trials can be legally conducted in NSW, and will ensure that trials are undertaken consistently and with appropriate conditions to ensure the safety of motor vehicle occupants, other road users and broader public safety.

There are a number of potential regulatory barriers to conducting a trial outside of the scope of road transport law (such as consumer protection, liability, insurance and common law issues) that may also need to be addressed through the proposed legislative framework. For example, the importation of vehicles to Australia is governed by Commonwealth legislation and vehicle import approval from the Commonwealth will be required to import vehicles that do not comply with National Standards in order to participate in any proposed trial or demonstration in NSW.

Appropriate public liability or other insurance arrangements may be also required for vehicles participating in trials or demonstrations, if CTP insurance requirements do not apply or are not considered suitable.

5.1.8 Work undertaken by State Insurance Regulatory Authority (SIRA)

The SIRA is responsible for regulating the CTP personal injury insurance scheme for motor vehicles registered in NSW. A key objective of the SIRA is also to provide funding for measures for preventing or minimising injuries from motor crashes and safety education. To this end, the SIRA has established a partnership with the CRS within Transport for NSW, which is the Government’s lead agency for road safety, to contribute to the development and funding of work being delivered under the NSW Road Safety Strategy.

In recognition of the fact that autonomous vehicles will become a feature on NSW roads over the next decade or two, SIRA has commissioned actuarial and legal advice on the potential issues and impacts arising from the introduction of autonomous and autonomous cars.

SIRA is also leading the national discussion on this issue through the Heads of Australian and New Zealand Motor Accidents Insurance Schemes (Heads of MAIS) to ensure a consistent approach to the regulation of autonomous vehicles across jurisdictions.

5.2 Input into national work on autonomous vehicle technology

NSW recognises and supports the need for a nationally consistent approach to manage increased vehicle automation. In anticipation of the increased deployment of connected and automated vehicles, and to ensure a nationally consistent approach, both the National Transport Commission (NTC) and Austroads are undertaking work to identify and address issues that may currently impede the safe and reliable introduction of autonomous vehicle technology on Australian roads.

5.2.1 National Transport Commission review

In November 2015, the Transport and Infrastructure Council asked the NTC to identify regulatory barriers relating to the safe introduction of automated vehicles in Australia including an assessment of the current regulatory system and its ability to support increased vehicle automation.

The NSW Government, along with all other Australian jurisdictions, is providing input into the NTC review.

The scope of the NTC's review examines the following:

- an agreed classification system for automated vehicles including agreed automation functions;
- the role of government in regulating automated vehicles including registration systems, accident compensation funds and enforcement guidelines;
- road traffic law including the Australian Road Rules that assume the presence of a human driver able to exercise human judgement;
- policy challenges associated with the regulation of the driver including driver training and licensing;
- the regulatory challenges of human factors i.e. the transition when humans must take back control of the vehicle; and
- the need to test the safe operation of automated vehicles including validation of international test results through on-road trials in Australia.

The review has identified that States and territory legislation in regards to autonomous vehicle technology aims to ensure:

- the vehicle continues to comply with the design rules while it is used on roads
- there are rules for safe driving
- vehicle operators are licensed

- vehicles can be identified for compliance and enforcement purposes
- citizens are protected from criminal behaviour and negligence.

In relation to autonomous vehicles, following the NTC project it is anticipated that the NSW regulatory and legislative framework will need to be closely examined to determine any changes required to ensure that:

- vehicles with non-human drivers are operated in a way to reduce risk for all occupants and other road users
- vehicles used on NSW roads are constructed and maintained to ensure safety for all road users, including occupants
- responsibility for who is in control of an automated vehicle when a safety standard is breach (i.e. an AV causes a crash)
- the road environment within which AVs operate is maintained and managed effectively
- the role of human occupants in an AV is clearly defined (e.g. whether occupants require a licence. Or whether a fitness to drive standard is required)

5.2.2 Austroads projects

Transport for NSW and Roads and Maritime Services are currently participating in four strategic research projects commissioned by Austroads that will identify and assess key issues to be addressed for connected and automated vehicles to be safely operated on our road networks. These projects include:

- assess the safety benefits of connected and automated vehicles
- impacts of automated vehicles on registration and licensing and compulsory third party insurance arrangements
- assess key road operator actions to support automated vehicles
- establish a Cooperative ITS operational framework

While the project to establish a Cooperative ITS operational framework is longer term, the other projects are expected to be completed by the end of 2016.

6 THE EXPERIENCE OF OTHER JURISDICTIONS IN ADOPTING AND ADAPTING TO DRIVERLESS VEHICLE TECHNOLOGY

6.1 Trials of autonomous vehicle technology

A range of projects are underway in Australia, the United States and Europe, in particular, to assess the safety benefits of C-ITS and AV applications and forecast deployment timelines.

6.1.1 Australian Jurisdictions

South Australia conducted the first on-road trial of automated vehicles in early November 2015. South Australia also hosted Australia's first Driverless Vehicle Summit in November last year

The Royal Automobile Club of Western Australia will trial a driverless and fully electric shuttle bus later this year which will include autonomous features such as radar cruise control, lane detection warning systems and multi-sensor technology that provides 3D perception that allows it to map the environment, detect obstacles on the road and interpret traffic signs.

6.1.2 United Kingdom

The United Kingdom government has said that it will allow the testing of autonomous driving trucks on the country's motorway network this year (Autocar report, 2015). It will trial heavy vehicle platooning, where a lead vehicle leads a number of trucks following in close formation, controlled by autonomous driving software, to save on fuel and limit environmental damage. The trial will be limited to testing the effect on heavy vehicle convoys on traffic flow, as well as how they will work on the United Kingdom's road network. However, no dates or locations for the trial have been announced.

6.1.3 Sweden

Volvo is scheduled to test autonomous cars with ordinary drivers on public roads in 2017. In 2015, the car maker announced 100-car public trial in partnership with Swedish authorities which will see members of the public behind the wheel, in normal traffic conditions. The trial will use 30 miles of roads around Gothenburg, marking Volvo's first public pilot of fully autonomous vehicles.

6.1.4 Netherlands

In the Netherlands, The Ministry of Infrastructure and Environment has announced that during the Dutch presidency of the European Union in 2016 they will initiate the "European

Truck Platooning Challenge 2016". This Platooning challenge will involve various brands of automated trucks will drive in columns (platooning) on public roads from various European cities to the Netherlands[1].

Throughout the Challenge, the Netherlands intends to adopt a "learning by doing" methodology, involving partnerships between the truck industry, logistics services, research institutes and Government agencies.

Also, in January 2016 the first driverless public buses were trialled on Netherlands roads. According to reports the "Wepod" took six passengers down a 200m stretch of street 'in the first trial of its kind (Telegraph UK, 2016). The pods, which are being tested by researchers at Wageningen University, have been equipped with cameras, and there are plans for the driverless shuttle bus to take passengers between the towns of Wageningen and Ede in the province of Gelderland. Media reports have indicated that while "the vehicles will initially ride on a fixed route, but it is expected to expand to more routes and other regions in the Netherlands from May 2016 onwards".

6.1.5 France

In October 2015, four self-driving trials designed by PSA Peugeot Citroën travelled 360 miles between Bordeaux and Paris (Techinsider, 2015). According to media reports, there was no driver involved for the entirety of trip and that, during the drive, the cars were able adjust their speed and change lanes successfully.

France has also established a public-private initiative in the VEDECOM Institute, focussing on sustainable mobility. VEDECOM "comprises more than 40 members of different industry and service sectors (automotive, aeronautics, system engineering, electronic components, ITC, numerical simulation, infrastructure management, transport operators, digital and energy grid operators), of several research and higher education institutions, and of local communities". According to recent media reports, VEDECOM receives an annual grant of €54 million to run 15 research programmes in the field of vehicle electrification, autonomous driving and connectivity and mobility and shared energy. In October 2015, VEDECOM trialled a prototype automated vehicle in Bordeaux during the World ITS Congress, claimed to be the first test of such a prototype in a town centre in France.

6.1.6 Switzerland

In May 2015, Swisscom commenced trials of the first driverless car on Switzerland's roads. The trial used a Volkswagen Passat equipped with sensors, computers and software that enabled the car to drive, steer and brake through the streets of Zurich (Mobile Europe UK (12 May 2015). The trial was completed in collaboration with UVEK, the Swiss Federal

Department of Environment, Transport, Energy and Communications and Germany's Autonomos Labs (The IMC, 20 May 2015).

In November 2015, BestMile (a Swiss startup founded by recent graduates from the Swiss Federal Institute of Technology) announced a partnership with a major Swiss transport operator for a two year project involving automated shuttles in the town of Sion. According to media release from BestMile, the project will involve smart vehicles have capacity for nine passengers operating on public roads from the spring of 2016 (BestMile Press Release, 4 November 2015). The vehicles used in the trial are intended to focus on the "last mile issue" by using driverless vehicles to "bridge the gap between the last stop of public transport and the final destination of the user" (The Local, 5 November 2015).

6.1.7 Germany

As detailed into the *"Pathway to Driverless Cars"* report published by the UK Department of Transport in early 2015, a number of tests of automated vehicles have been completed on German roads, these include:

- In June 2011 AutoNOMOS labs' modified VW vehicle was the first vehicle to be certified for automated driving in the states of Berlin and Brandenburg. It has covered thousands of kilometres driving in both Berlin city centre and the autobahn.
- In January 2012 BMW demonstrated an automated 5-series capable of slowing for traffic, accelerating up to speed and performing lane changes when necessary on a German autobahn.
- In January 2014, BMW announced it intends to conduct a fleet trial of its 'highly automated driving' technology in 2015. Some current production BMW vehicles feature 'Traffic Jam Assist' capable of automated steering, acceleration and braking up to 25 mph

In addition, in October 2015 it was reported that German carmaker Daimler was "trialling a self-driving truck under real traffic conditions on a German motorway for the first time" (Daily Mail, October 2015) using a Mercedes-Benz truck. The truck, which is claimed to be the world's first series-production autonomous truck, was reported to travel 8 miles on the A8 motorway between Stuttgart and the town of Dekendorf.

6.1.8 Spain

The *"Pathway to Driverless Cars"* report published by the UK Department of Transport in early 2015, identifies a number of tests of automated vehicles that have been completed in Spain, including:

- In 2012, Spain allowed an open road platooning test of three Volvos and a semitrailer on a highway near Barcelona under the FP7 project SARTRE.
- In addition, several Spanish cities (Castellon, Leon and San Sebastian) have been involved with the European FP7 projects Citymobil and Citymobil 2, hosting demonstrations of automated transport over a period of several days in their cities.
- The Spanish Government were also supportive of the CSIC's (Spanish National Research Council) Platero vehicle project. In 2012, it completed an open road test without the input of a driver for approximately 60 miles on a highway near Madrid.
- In February 2014, the Spanish Government invested 10 million Euros in the CTAG (Automotive Technology Centre of Galicia) to build 0.7 hectares of offices and 1.5 hectares of outdoor test tracks, where 350 employees will be involved in investigation and testing of the most recent advanced driving technologies.73
- Also, Scania is working in collaboration with IDIADA (Spanish proving grounds and research laboratory) to test their entire platooning system on Spanish roads during the autumn of 2016.

6.1.9 Greece

In October 2015, French built CityMobil2 buses started on-road testing in the regional town of Trikala in Greece. The driverless buses used in the trial will seat 10 people and travel a 2.4 kilometre route involving a mixed traffic environment that includes bicycles, pedestrians and other cars (Associated Press, 8 October, 2015).

6.1.10 United States

The United States has been identified as the home of most of the greatest efforts to develop Automated Vehicles, with a range of technology companies and vehicle manufactures developments (Main Roads Western Australia, 2015).

The most high profile automated vehicle development in the United States has been led by Google. In particular, the Google "self-driving car' project, where prototypes of Toyota Prius and Lexus RX have been retrofitted for over 1 million km of test driving on limited access highways. In addition, Google have developed custom-build pod cars with emphasis on low speed urban driving. While Google have identified some limitations in regard technology performance, Google's prediction is that many of these issues will be resolved over the next five years. However, notwithstanding these issues, in May 2015 the head of Google's self-driving car project reported that "Over the 6 years since we started the project, we've been involved in 11 minor accidents (light damage, no injuries) during those 1.7 million miles of autonomous and manual driving with our safety drivers behind the wheel, and not once was the self-driving car the cause of the accident." (Urmison, C, 11 May 2015).

Other car manufacturers have also utilised legislation in some American states to progress tests of automated vehicles on US roads. For example, information on the Californian Department of Motor Vehicles (DMV) website indicates that as of March 22, 2016, DMV has issued Autonomous Vehicle Testing Permits to the following organisations (California Department of Motor Vehicles, 2015):

- Volkswagen Group of America
- Mercedes Benz
- Google
- Delphi Automotive
- Tesla Motors
- Bosch
- Nissan
- Cruise Automation
- BMW
- Honda
- Ford
- Zoox, Inc.

As a condition of the testing on public roads in California, the California DMV requires every manufacturer authorised to test autonomous vehicles on public roads to submit an annual report summarising “disengagements of the technology” (i.e. moments when human drivers where required to take over control of the vehicle), which are publicly available on the California DMV website. Of the disengagement reports published in 2016, Google, Nissan, Mercedes-Benz, Volkswagen, Bosch and Delphi Automotive “all reported such disengagements, some occurring as often as once every one to two miles” (LA Times, 15 January 2016). Notable, Tesla Motors reported no disengagements, however they also did not report on how many miles they had driven (Govtech.com, 12 January 2016).

In addition to the testing in California, other recent automated vehicle tests and research that have commenced elsewhere in the United States including:

- Ongoing automated vehicle research conducted in Pittsburgh through the General Motors -Carnegie Mellon Autonomous Driving Collaborative Research Lab

- In February 2016 Uber announced the establishment of a new Advanced Technologies Center in Pittsburgh. It has been reported that the company will build temporary roadways to test self-driving cars (theverge.com, 24 February 2016).

- In January 2016, Ford announced that it had completed "successful tests of driverless cars in snowy conditions" at a model city developed by the University of Michigan (BBC, 11 January 2016).

6.1.11 Japan

In 2013, Nissan Motor Corporation carried out "the first public road test of Autonomous Drive on a Japanese highway" using the electric Nissan LEAF vehicle (Nissan Motor Corporation News Releases, 25 November 2013). In 2015, Nissan commenced testing a prototype automated vehicle in "actual traffic conditions on both highway and city/urban roads to develop and further enhance Nissan Intelligent Driving for public use" (Nissan Motor Corporation News Releases, 29 October 2015).

In October 2015 the government and local authorities in Fujisawa, Kanagawa Prefecture, near Tokyo have stated that a street test of a self-driving taxis will begin there by March 2016. The announced trial will involve transporting residents from their homes on a journey of about 3km to supermarkets (Nissan Motor Corporation News Releases, 29 October 2015).

6.2 Legislative and Regulatory reviews in other jurisdictions

6.2.1 Australian jurisdictions

Australian jurisdictions, including NSW, are currently exploring legislative and regulatory instruments specifically with regard to autonomous vehicle safety, particularly in regard to trials of automated vehicles.

In particular, South Australian parliament recently passed the Motor Vehicles (Trials of Automotive Technologies) Amendment Bill 2015, introduced by the South Australian Government in September 2015 and passed by the Parliament in April 2016. This Bill proposes a legislative framework for the management of trials of automotive technologies in South Australia and includes the following key features:

- provides the Minister with powers to issue exemptions from the relevant provisions of the *Motor Vehicles Act 1959 (South Australia)* and any laws that regulate drivers and use of motor vehicles on roads.

- measures to ensure that the general public are kept informed of any trials taking place, including ensuring that details of upcoming trials are publicly available and ensuring that the Minister prepares and tables a report in Parliament within 6 months of a trial being completed.

- confidentiality clauses to protect commercial-in-confidence details of companies participating in trials in South Australia
- requirements for all trial proposals to be supported by risk management plans and proper public liability insurance
- new offences targeting companies who engage in unauthorised trials, companies engaging in authorised trials who breach a condition of exemption, and for any person who hinders and authorised trial or interferes with equipment used in the trial.

The Australian Capital Territory has also recently drafted a legislative instrument to facilitate a trial of autonomous vehicle technology, and the Western Australian government will move to introduce legislation to support their trial later in 2016.

6.2.2 International agreements

In 2014, the United Nations Working Party on Road Traffic Safety (WP.1) approved an amendment to the Vienna Convention on Road Traffic of 1968 with regard to autonomous vehicles.

The agreed amendments to the Vienna Convention in 1968 relate to Article 8 - which sets out that every moving vehicle shall have a driver and that every driver shall at all times be able to control his vehicle. One agreed amendment was to state that 'systems which influence the way vehicles are driven', as well as other systems which can be overridden or switched off by the driver, are deemed to be in accordance with Article 8. While further changes may be required in future to permit autonomous vehicles, the amendment process commenced in 2014 indicates a significant milestone in terms of the recognition of automated systems in this important document.

6.2.3 United States

While the regulation of vehicles and drivers is a state issue in the United States, in 2013 the National Highway Traffic Safety Administration (NHTSA, 2013) released a Policy paper that included the following statements concerning regulatory and legislation relating to autonomous vehicles:

- The NHTSA does not recommend that states authorize the operation of self-driving vehicles for purposes other than testing at this time.
- There are a number of technological issues as well as human performance issues that must be addressed before self-driving vehicles can be made widely available. Self-driving vehicle technology is not yet at the stage of sophistication or

demonstrated safety capability that it should be authorized for use by members of the public for general driving purposes.

- Should a state nevertheless decide to permit such non-testing operation of self-driving vehicles, at a minimum the state should require that a properly licensed driver (i.e., one licensed to drive self-driving vehicles) be seated in the driver's seat and be available at all times in order to operate the vehicle in situations in which the automated technology is not able to safely control the vehicle.
- As innovation in this area continues and the maturity of self-driving technology increases, we will reconsider our present position on this issue.

In February 2016, NHTSA issued an update to this policy (NHTSA, 2016) that included the following:

- Essential to the safe deployment of such vehicles is a rigorous testing regime that provides sufficient data to determine safety performance and help policymakers at all levels make informed decisions about deployment.
- NHTSA will continue its extensive research program to maintain its broad and deep understanding of new technologies. This knowledge base is essential in the agency's efforts to determine what new tools might be necessary to ensure advanced technologies achieve their life-saving potential.

In addition, in January 2016 the US Department of Transportation committed to the following milestones (http://www.nhtsa.gov :

- Within six months, NHTSA will work with industry and other stakeholders to develop guidance on the safe deployment and operation of autonomous vehicles, providing a common understanding of the performance characteristics necessary for fully autonomous vehicles and the testing and analysis methods needed to assess them.
- Within six months, NHTSA will work with state partners, the American Association of Motor Vehicle Administrators, and other stakeholders to develop a model state policy on automated vehicles that offers a path to consistent national policy.
- Encourage manufacturers to submit rule interpretation requests where appropriate to help enable technology innovation.
- When interpretation authority is not sufficient, encouraged manufacturers to submit requests for use of the agency's exemption authority to allow the deployment of fully autonomous vehicles.
- DOT and NHTSA will develop the new tools necessary for this new era of vehicle safety and mobility, and will consider seeking new authorities when they are

necessary to ensure that fully autonomous vehicles, including those designed without a human driver in mind, are deployable in large numbers when they are demonstrated to provide an equivalent or higher level of safety than is now available.

In regard to US states, as of March 2016 the following states appear to have enacted legislation concerning autonomous vehicles:

- California
- Florida
- Michigan
- Nevada
- North Dakota
- Tennessee
- Utah
- Washington D.C.

There are also a range of other states that are currently planning or considering legislation.

However, the focus of this legislation varies from state to state – with some limited to definition of autonomous vehicles, while others include authorisations for trials. There are also some legislative instruments that aim to address the use of communications devices for operators of an autonomous vehicle.

6.2.4 Europe

A non-regulatory approach has been used in the United Kingdom. In 2015 the United Kingdom Department for Transport (2015) published a voluntary code of practice with requirements for on-road trial approvals, including safety, insurance and engagement with transport and highway authorities and the media.

In regard to initiatives taken by specific EU member states, a 2015 report prepared by the UK Department of Transport identified the following European jurisdictions as being involved in actively planning for the trialling of automated vehicles:

- Finland
- France
- Germany
- Italy

- Netherlands
- Spain
- Sweden

Transport for NSW will continue to monitor developments of autonomous vehicles in Europe.

6.2.5 Asia

Japan issues special licence plates to allow the testing of autonomous vehicles on public roads. Singapore has established the Singapore Autonomous Vehicle Initiative to allow for public road testing.

In February 2016, Korea announced that it had streamlined regulations to allow for testing of automated vehicles in designated locations from March 2016. To get approval for a test drive, applicants are required to hold appropriate insurance and have appropriate measures that prevent their cars from being hacked (The Korea Herald, 11 February 2016).

7 OTHER RELATED MATTERS

7.1 Operational technology issues for Government and Industry to consider

7.1.1 Technology failure

Autonomous vehicle technology, like every other technical system (including conventional vehicles) will fail from time to time. Both government and industry will need to anticipate and plan for a range of scenarios that would occur in the event of a system breakdown or localised failure of a system or supporting infrastructure.

CAVs will also collect and transmit large amounts of data which could potentially provide a rich source of real time information that can support a range of transport activities. The capacity of networks to manage and store this data will also become a critical issue.

7.1.2 Consistent functionality of technology

It is important that the design and function of specific autonomous vehicle technologies is consistent across vehicles and regions so that drivers do not have to learn multiple systems and warning types and their vehicle can function regardless of the region they drive it in. To make this happen, vehicle standards need to be consistent to enable reliable technological functionality. Please refer to Section 3 of this submission for more discussion of the need for consistency of vehicle standards in relation to driverless vehicle technology.

7.1.3 Powering the vehicles

It is highly probable that more and more of the high-tech vehicles will be electrically powered; this is already the case with the Tesla vehicles. It is essential that sufficient charging locations are established to ensure that these vehicles can be used beyond their fully charged range. As with the other technologies incorporated in these vehicles, the type of charging connections and infrastructure must be standardised at an early stage in this process to ensure their compatibility across the fleet.

7.1.4 Data management and integrity

Governments will also have to develop policies and mechanisms to manage safety and security risks arising from the software of an autonomous vehicle system. A key issue of manufacturers are acutely aware of is the risk of software being hacked and mitigating the consequences that could arise from this.

7.1.5 Privacy and access to data

The data held and transmitted by autonomous vehicles will assist manufacturers and government identify and address problems with autonomous vehicle technology and the connectivity between vehicles and infrastructure. If road agencies and manufacturers are able to share access to appropriate data, there is potential for required infrastructure improvements and connectivity with autonomous vehicles to progress more quickly than if access to data is limited. Access to data will also be able to overcome shortcomings with the technology and help develop appropriate remedial action.

To enable this to occur there are a range of issues to consider, including:

- Ensuring that privacy of individual vehicle users is protected at all times
- Maintaining security of data collected by road agencies and manufacturers
- Addressing barriers to sharing of data between Government and industry, including Intellectual property rights and patents.

7.1.6 Liability issues

Consideration should be given to identifying requirements for a driver's duty of care when using an autonomous vehicle. Regardless of current licensing requirements, people occupying autonomous vehicles must be capable of dealing with problems that are likely to arise. Drivers, particularly of buses, have a range of road safety responsibilities that extend to their passengers, for example ensuring that the vehicle occupants are seated or are wearing seatbelts.

Several manufacturers have already announced that they will accept liability for their vehicles when they are driving in automated mode.

Consideration could also be given to developing a competency-based system to ensure people can respond to reasonably foreseeable problems, which may be a variation on the current licensing requirements or induction training by the vehicle manufacturer.

7.2 Broader Impact on Transport

There the potential for increased use of automated vehicles in public transport to improve the effectiveness and efficiency of public transport services, such as through 'platooning' of public transport across the network. Additionally, widespread use of automated vehicles could reduce congestion in urban environments with potentially less crashes and more capacity from the existing road network.

The Government's initial work through the CITI trial has also found that connected vehicles collect and transmit large amounts of data, both from their interactions with each other and with infrastructure as well as through their on-board systems. As the use of CAVs is expanded there will be an increasing amount of data collected and transmitted. This big data will provide the opportunity to integrate with a range of other transport activities, providing a large source of real time information that can be used to investigate and manage issues such as congestion.

These benefits are most likely to be realised if the introduction of autonomous vehicles is associated with greater use of multiple-occupancy or “on-demand” vehicles. However, an alternative scenario, where current patterns of personal vehicle use are maintained, could tempt commuters away from mass public transport modes and on to the road. The resulting congestion could also be exacerbated if autonomous vehicles were making additional trips, for example to or from remote parking locations.

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