Roads Australia Study Tour

29 March – 13 April 2017

Shared, Connected and Autonomous Vehicles

Report by David Anderson PSM
Chairman

NTC AUSTRALIA
National Transport Commission

Acknowledgements

I would like to thank Roads Australia, and in particular its Chairman David Stuart-Watt and Chief Executive Ian Webb for having the foresight to conceive and organise the tour. Mandy Mees, Roads Australia's Executive Director Policy, did a wonderful job in contacting key people in the USA, UK and Sweden, arranging meetings and generally ensuring that all members of the tour group received the maximum benefit from their involvement. Her attention to detail was remarkable.

My sincere thanks also go to the National Transport Commission, my fellow Commissioners, and in particular Chief Executive and Commissioner Paul Retter, for facilitating my participation in the tour. It was of great advantage to me to have prior oral and detailed written briefings from Paul, Marcus Burke and James Williams who are deeply involved in the NTC's work in the subject areas. My hope is that my observations and conclusions will add further value to this work.

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Chairman

May 2017

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Introduction

A number of the world's major companies have decided that they can flourish by using new and developing information technology to provide innovative transport services that have not been available until now. Many believe that we are seeing a revolution in transport, particularly in road transport.

Motor vehicle manufacturers, and on line service providers are prominent in this potential transport revolution. Companies such as Volvo, Ford, General Motors, Google, Scania, Ericsson, Tesla, Uber and Lyft are only a few of the players. They are aggressive competitors, involved in disrupting traditional transport services when they see the need, and are unafraid to use the legal system to sort out intellectual property rights, or rights of access.

On the other hand, governments realise the potential societal benefits of the new technology, but also recognise their responsibilities to ensure that the public interest, including safety, is taken into account.

Access for those with disabilities, reductions in travel time and in road congestion, improved safety, and a boost to local employment, are some of the claims being made or anticipated. However, as trials of the technology proceed, and new transport services are introduced, we are beginning to understand the nature of the benefits and of one or two side-effects.

In March/April 2017, Roads Australia organised a study tour so that participants could gain first hand knowledge of developments in specific parts of the USA, the United Kingdom and Sweden. Senior representatives from government and private companies were included in the tour group. I was fortunate enough to be able to participate on behalf of the National Transport Commission, Australia (NTC), and the following summarises my observations and conclusions. I should add that they do not necessarily represent the views of the other commissioners or staff of the NTC.

Nevertheless, I have attempted to focus on the questions and related issues that are currently being considered by the NTC in collaboration with transport jurisdictions, at the request of Australia's transport and infrastructure Ministers.

Consequently, each section of this report responds to an individual question or group of related questions relevant to an aspect of the subject. My discussion in each case is limited to information gained during the Roads Australia tour. There may be other views, not covered by our itinerary, however I felt that the discussions were both general and specific and the calibre and deep involvement of the people who met with us was impressive. Therefore, the information in this report is relevant to the challenges being addressed in Australia.

The itinerary concentrated on the developments surrounding vehicle automation, and the deployment of autonomous vehicles. The many discussions and demonstrations that formed the contents of the Roads Australia tour also covered related areas of transport services, namely connected vehicles and infrastructure, and ride sharing.

Industry Timeframes

So the first key question is:

"What is industry's timeframe for the introduction of automated vehicles?"

There was some variation in the answers to this question but in most cases it was stated that full automation will not occur in the short or medium term. Other than Mike Masserman, Director of Federal and Inter-Government Relations at Lyft (San Francisco), no one was prepared to put a date on the arrival of fully automated vehicles in commercial numbers.

Lyft is a five year old company, and its main business is providing ride share services. According to Lyft, US citizens spend 30 billion hours commuting (annually), and their private vehicles are used only 4% of the time. There are 700 million parking spots in the USA alone, and 80% of car seats are empty during a private vehicle's use.

Lyft launched in 2012 and LyftLine ride sharing service was launched in 2014. Lyft already provides 50% of ride sharing trips in San Francisco and operates in 300 cities, the last 100 being added in the past 3 months. Lyft is already displacing some bus services with LyftLine.

General Motors (GM) has apparently agreed to invest US$500 million in developing autonomous vehicles, and as a result will provide Lyft with a fleet of fully automated vehicles.

Lyft and GM plan to provide shared electric autonomous vehicles for ride sharing fleets. They do not think that people will own their own automated vehicle (pod).

Mike Masserman believes that *"within 5 years, fully AVs will provide the majority of ride sharing trips in USA cities. By 2025 private car ownership will all but end in the USA's cities.*

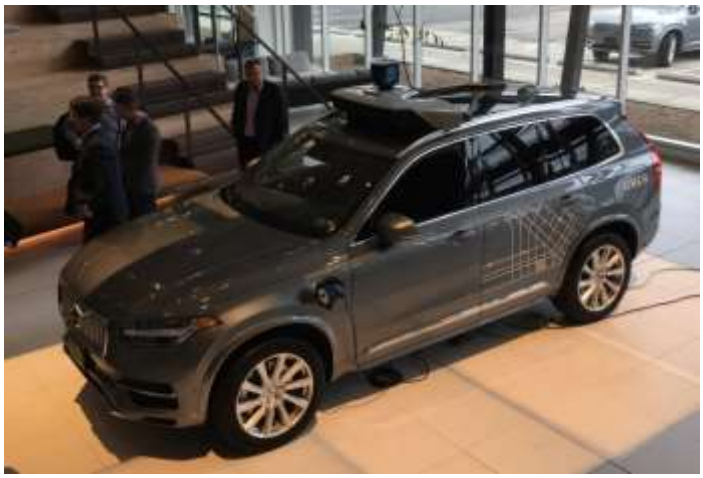
However there is a need to address the first and last mile issues. Cities need to be redesigned accordingly. Connected vehicles, using smarter infrastructure, will in all likelihood be the way to go."

Mike imagines *"massively disaggregated navigation, allocation and billing systems linked to a single control system?"*

On the other hand Uber, Lyft's main rival, based in Pittsburgh Pennsylvania, stressed that *"we are only in the 1st innings of the game, (a reference to baseball with its nine innings). The first (current) phase is about testing only, to fine tune the technology, and provide authorities and the community with confidence about the safe operation of AVs".*

In Pittsburgh, we had a valuable discussion with Jason Post, Uber's Director of Public Policy and Communications, concerning his company's views about the future of urban mobility.

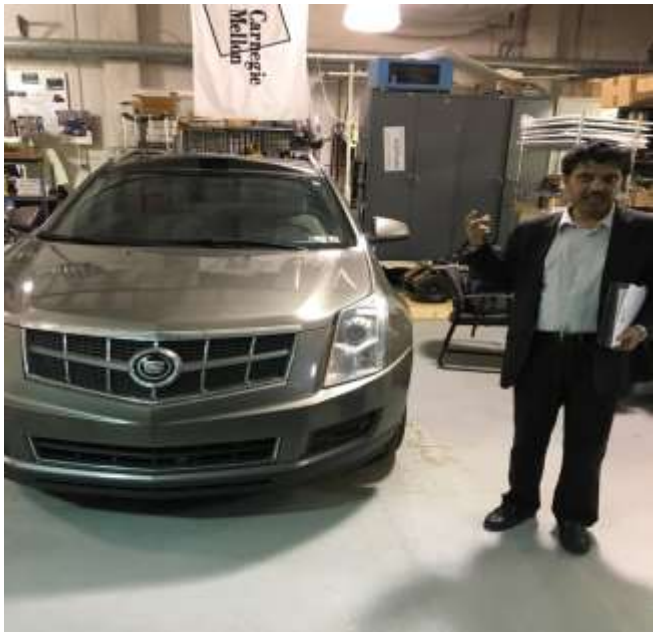
Self-driving Uber was launched late in 2016. Testing of Uber's autonomous vehicles takes place around the Pittsburgh area but always with a safety driver on board in accordance with Pennsylvania's policy.



“Uber is a platform for connecting people with money and no transport, to vehicles and people who haven't got a job. The Uber vision is for shared - autonomous and electric personal transport.”

Uber claims that the deployment of autonomous vehicles will reduce personal ownership of cars. However, there is no substantial evidence at present to support this assumption. Uber will not predict when autonomous vehicle technology will get to level 4 or 5 (reference to the SAE International Standard J3016, Levels of Driving Automation).

Carnegie Mellon University in Pittsburgh is recognised as the birthplace of vehicle automation. Some of the people we met had commenced working on this more than 30 years ago, with the invention of a vehicle to interrogate the site of the Three Mile Island nuclear power station disaster, and, since then the development of a range of military and mining vehicles. We inspected a beautifully engineered fully autonomous Cadillac, which would be difficult to recognise as anything but a normal commercially produced vehicle.



When asked about the commercial introduction of AVs, the Carnegie Mellon experts stated that:

“It is going to take a very long time for fully automated vehicles to appear, because computers cannot deal with situations that might arise that haven't been anticipated by the computer programmer. It is likely that incremental introduction will take place, focused on ring fenced applications.”

Likewise, based on their collaboration with local innovators, Swedish government representatives stated that they were assuming that *“fully autonomous vehicles will be far into the future.”*

The Ericsson Company, also based in Stockholm, provides equipment that handles 40% of the world’s IT traffic. The company’s focus is to create a networked society, not necessarily reliant on fully automated vehicles.

“Future trends in transport will be connected, electrified, automated, and shared. There needs to be lots of trials including cars, trucks, billing for road use, buses, and taxis, eventually leading to the provision of mobility as a service.”

From the above I conclude that there are differing opinions of the rate of development of AVs, with the most likely scenario being a progressive introduction of new technology over perhaps a long transition period.

Government Responses

This brings us to the next set of questions regarding the responses of governments to the evolution of automated vehicles and related technology:

How are governments intending to regulate automated vehicles?

What are the key policy issues?

What are the challenges associated with the introduction of AVs?

Who should be the legal driver?

What are the desirable timeframes for regulation given the likely rate of development of technology?

Regulate now!

We had a long and valuable discussion with Malcolm Dougherty, the Director of the California Department of Transportation (Caltrans), Bernard Soriano, the Deputy Director of the California Department of Motor Vehicles (DMV) and others (see Appendix 1).

California has already decided to regulate AVs as soon as possible. Development and administration of the regulations is the responsibility of the DMV, which works in close collaboration with the California Highway Patrol and Caltrans. According to the DMV, the regulations that have been proposed will allow AVs to operate safely on public roads.

There are two parts to the regulations.

In 2014 minimum testing regulations for light passenger vehicles were approved by the Californian legislature, and 29 companies are now authorised to do testing. During testing, AVs must have a driver/monitor and all dis-engagements of the self drive function and any incidents must be reported to the DMV. The number of such reports per month is trending down.

The second stage is the adoption of deployment standards and requirements for passenger vehicles. These regulations are still out for public comment. Although the regulations will allow companies to operate vehicles on public roads, they must assure the regulator that their vehicles are safe. Insurance of US$5 million is compulsory. The legal thinking is that when the computers are in control, the manufacturer will be accountable for any incident, and when disengaged, the driver will be accountable, although the practical details of this have yet to be worked through.

The final step will be the development of requirements for commercial vehicles.

The Director of Caltrans believes that it will take about 8 years for these regulations to fully develop. *“Consequently AVs and driven vehicles will have to coexist for many years. This could add to congestion, as AVs will operate more conservatively than driven vehicles, due to the risk aversion programmed into their software.”*

California is also reviewing road rules. The US Transportation Research Board is proposing to provide resources for all States to do this, presumably to maintain a level of consistency across the country.

A Broader Strategic Approach

The City of San Francisco is following a broader strategic, policy driven approach. The Deputy Director, Innovation and Program Delivery, Sustainable Streets Division of the San Francisco Municipal Transport Authority SFMTA, Darton Ito, advised that San Francisco had developed a comprehensive plan and made a submission for funding under the US Federal Government's 'Smart Cities Program'. The City was unsuccessful in receiving a major grant for the development of a smart city but in time would try to implement what it had proposed in its application.

San Francisco's policies are 'green' with all public passenger (transit) vehicles having zero emissions. Current mode share is 60 to 70% transit in peak commuting times. San Francisco aims to have 50% of all trips throughout the day by transit, walking or biking, in the next year or so.

In general policy terms, San Francisco promotes car-pooling and ride-sharing.
It aims to eliminate traffic deaths by 2024, although has yet to identify and adopt any initiatives to achieve this.

San Francisco is also preparing guiding principles for land development, namely:

- incentivising the use of more efficient transport;
- reducing greenhouse gas emissions;
- reducing adverse economic impacts; and
- managing information.

The City proposes to trial AV shuttles for local transport on Treasure Island in San Francisco Bay, as part of a proposed major land redevelopment. Access to the Island will remain by bus and ferry to link up with the AV Shuttles.

San Francisco is seeking more information about how law enforcement will interact with AVs.

A Co-Regulatory Approach

We held a round table discussion that was wide ranging, with the Secretary of the Pennsylvania Department of Transport (Penn DoT), representatives of the Utah DoT, AASHTO (the American Society of Highway and Transportation Officials) TRB (the Transportation Research Board) and the City of Pittsburgh.

Pennsylvania wants to govern AV trials by policy rather than by regulation at this stage. Its legislature has passed Bills formally authorising tests of AVs at the Secretary's discretion, deciding that prescriptive regulations are too slow to develop, other than the regulation that authorises policy-making.

According to the AASHTO representative at the round table, 12 American States have passed regulations of some sort, with California the most heavy-handed. Pennsylvania and Michigan are considered to be the most light handed in their approach to date.

Pennsylvania requires manufacturers to have self-certification and therefore its policy is in effect to have a co-regulatory approach. This is guided by an AV policy task force, that includes government, industry, academics, AAA (motoring organisations), trial lawyers, and truckers. *"Successful implementation will require a balancing act to cater for all of these agendas."*

Manufacturers have to submit a formal letter to the Department of Transport, spelling out how they will comply with the policy and guidelines. Sometimes the State may require a demonstration to verify these claims. The policy also requires operators to report all outcomes of trials, including incidents.

Penn DoT and Carnegie Mellon University are also working on a transport technology vision for 2040. From the information described, this seems to be similar, in concept at least, to the NTC work on behalf of jurisdictions in Australia, with short, medium and long-term actions to be proposed.

No Rules Yet

A similar round table discussion occurred in London, with representatives of the UK Department of Transport, Highways England, C-CAV (the Centre for Connected and Autonomous Vehicles), Milton Keynes County Council, ARUP consultants, the UK CAV Hub, the Society of Motor Manufacturers and Traders, and IM-Pact. (refer Appendix 1 for details of these organisations).

According to the government vehicle standards agency, the UK is trying to avoid any rule making at present. It is working on harmonisation through the European Union in Geneva. *"However, even though at present, the USA does not seem to have a consistent view on what regulatory approach it wants to adopt, the outcome of USA deliberations and final policy settings will be very influential on European practice in the long term."*

The UK representatives agreed that an evolutionary transition would be required to successfully deploy automated and connected vehicle technology.

"The roles of government should include convening and getting parties such as telecoms, land developers, the automotive industry, infrastructure builders as well as transport and private road users together.

For effective collaboration there is a need to focus on

- *Common purposes*
- *Risks and risk management*
- *Trust, and*
- *Common threats.*

It should also include evangelistic people to push the boundaries."

The policies adopted by the UK are described in a document contained in the UK Department for Transport's website, as is a recently developed Code of Practice for the testing of AVs.

The Swedish Government is also concentrating on policies to encourage the development and trialing of connected and autonomous vehicles, prior to developing any new regulations. This involves a cross functional collaboration between government, academia and industry. Sweden also has several direct links into the European work in this area.

We met with the Deputy Director General, Transport Markets and Regulation, and other representatives of the Swedish Ministry of Enterprise and Innovation, the Swedish Transport Agency, and Trafikverket (ref Appendix 1 for details), and discussed the purpose of this collaboration in more detail.

The desired attributes are:

- safety
- support for the Swedish manufacturing industry
- support for the Swedish ICT industry
- establishment of good ICT infrastructure
- early adoption of new technology
- successful transformational start ups, and
- research collaboration, far reaching and long term.

Industry Reactions to Government Strategies

We were aware of comprehensive policy guidelines and model legislation for the trialing and introduction of AVs, released by the National Highway Traffic Safety Administration (NHTSA), part of the US Department of Transportation, in 2016.

Therefore, we were interested in responses by both government and industry representatives to the questions:

"How has industry responded to developments of regulations and/or rules?"

"What is thought of the Guidelines produced by the US Department of Transportation?"

In California we discovered that Bernard Soriano, Deputy Director, California Dept. of Motor Vehicles had a strong influence on the development, not only of California's regulations, but also on the NHTSA guidance notes and policies for the introduction of AVs.

NHTSA had asked the States to assist in developing its guidelines, and a working group chaired by Bernard Soriano did so, apparently basing them heavily on the work that Bernard had almost finished for California.

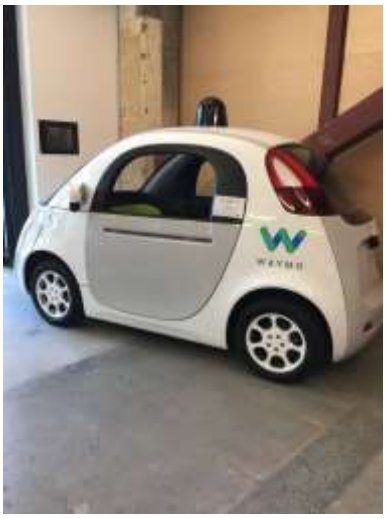
According to the AASHTO representative we met in Pittsburgh, States generally support the NHTSA guidelines and the detail contained therein. Nevertheless, as described earlier, they are proceeding to implement rules at varying pace. In our discussion at Google's Mountain View facility (Silicon Valley), with Sarah Hunter, Director of Public Policy, we were told that Google is critical of governments *"going too prescriptive (concerning the deployment of AVs) when they are yet to understand all of the development issues."* Sarah Hunter is leading Google's work in this area and in the area of drones.

Google's involvement with AVs began when one of its founders was affected by a fatal road crash involving a member of his extended family. Hence safety is the main driver at this stage. Its business philosophy has been to develop a product then worry about recouping the cost of development. It has served them well.

Google also saw the potential benefits of fully AVs for people with severe disabilities, and started trialing vehicles accordingly, off road. *"Self-driving technology won't in itself produce benefits. It has always to be used as a policy enabler"*, according to Sarah Hunter.

Google is trying to position itself as the World's leading, reliable and responsible provider of the new transport technology.

Google started (secretly) trialing on highways in 2009, and by 2012 moved onto city streets. Their trials found that Global Positioning Systems (GPS) were not nearly accurate enough for guiding AVs, so Google uses a combination of radar and Lidar (Light Detection and Ranging, a remote sensing method that uses light in the form of a pulsed laser to measure variable distances). Its vehicles have driven over 2 million miles on real roads and over a billion miles on simulators.



Google prefers stringent safety guidelines at this stage, and believes it is too early to regulate. Google has rejected the regulations proposed by California, and as a result, will release commercially in Phoenix, Arizona and Austin Texas, and not in California.

"Software developers have to work closely with vehicle manufacturers to be successful, and governments will have to work with AV providers for the same reason."

In our London discussions, David Wong (Technology and Innovation Manager, Society of Motor Manufacturers and Traders) said that manufacturers in the UK are also doing their own thing. *"Innovation has to come from industry. Trials are being used to determine how safe the developing technologies are. Most manufacturers will use cellular technology for vehicle to vehicle and probably vehicle to pedestrian communication. The government has to engage with industry if it wants to represent and promote public interests".*

As mentioned earlier, the UK authorities have avoided making rules, in order to avoid unnecessary restrictions on industry innovation.

Are there other policy issues that are of concern to industry?

Carnegie Mellon University has had as much experience as any organisation in developing AV technology. In our discussions, the Carnegie Mellon representatives referred to *"the stress between policy and regulation/legislation"*, but also had recognised that developers needed clear policy guidance. *"Although, since about 2000 the technology had developed without much difficulty, policy issues are now becoming more important."*

It can be concluded that a lack of policy is of concern from some points of view, but on the other hand Uber described its attitude as one prepared to challenge any entrenched position, presumably regardless of current government policy, and presumably to suit its corporate vision.

Safety

In all of our discussions, safety appeared as both a potential benefit, but also a significant risk associated with the deployment of autonomous vehicles. This seemed to be one area where manufacturers, software developers and governments shared common ground.

Voters expect elected governments to provide safeguards against hazards including those that might arise from the use of autonomous vehicle technology.

The key questions included:

"How do governments intend to evaluate the safety of automated vehicles?"

"How will they evalueate the claims made by manufacturers?"

"What processes are being considered?"

"Are agencies intending to reform road safety laws to recognise highly and fully automated vehicles?"

"How will enforcement agencies interact with automated vehicles?"

"What impact will a safety assurance system have on registration and licensing?"

"What is the community reaction to AVs?"

When I perused the notes I took at our meetings, I was somewhat disappointed that no one seemed to have the answers to many of these questions.

It may be fair to say that it is too early to be specific, given that the technology is still developing, and the outcomes of trials to date are not necessarily conclusive. This is clearly also affecting the timing of the introduction of legislation and regulations as discussed previously.

Although public trust and confidence is considered vital, people have little first hand experience to go on at this stage.

The Government of Pennsylvania is focusing on safety, through speaking engagements, focus groups and demonstrations. The official position is that *"Public trust is an industry responsibility, the market will decide. The public in Pittsburgh sees many AVs in operation and will be comfortable if they perform safely."*

According to the Government representatives that we met in Stockholm, Sweden has not yet formally determined how to assure the safety of AVs. A policy document concerning *'the legal road to self driving vehicles'* will be released in September 2017. Current thinking is that:

- there has to be a "driver" either inside the vehicle or outside (remote control)
- there has to be a consultation phase associated with the deployment of AVs
- no changes to current laws are proposed or required at this time, however
- the Government will clarify some of the definitions in the existing laws in November 2017.

In the meantime, the *Drive Sweden* program aims to give ordinary people experience with autonomous vehicles. *Drive Sweden* is a strategic innovation program launched by the Swedish Government in the European Spring of 2015. It involves the collaboration of many organisations both public and private. It is funded by the Swedish Energy Agency, the Swedish Research Council (FORMAS), and Sweden's innovation agency VINNOVA. (details are at *drivesweden.net*).

A component of the program will provide ordinary Swedes with the opportunity to gain first-hand experience using automated vehicles. *"The Drive Me project will see up to 100 autonomous cars on the ring road around Gothenburg, Sweden, home to Volvo Cars, driven by real people, in real traffic during 2017"*.

The Society of Motor Vehicle Manufacturers and Traders in the UK, is also preparing a paper regarding legal liability. It is likely that there will be micro insurance policies for personal damage (enabling a quick turnaround of claims) but consumer law is likely to be used for product liability (a much longer legal process).

Infrastructure Issues

As technology begins to share the driving with, and probably ultimately replace the human driver, questions arise about the changes needed in infrastructure to accommodate this and to maximise the benefits.

The key questions are:

"How are road managers preparing the road network for automated vehicles?"

"To what extent will investment in infrastructure be necessary to cater for automated vehicles?"

Signalised Intersections

There was considerable debate by the USA delegation about what needs to be done by infrastructure providers to accommodate AVs. In particular, this debate focused on signalised intersections.

In the USA, signal systems are the responsibility of local councils, but some State Governments are supplementing local government by $5 to 1 for retrofitting works. This is a big challenge as there are 2600 municipalities in Pennsylvania alone.

AASHTOs national challenge is that by 2020 every State should have a corridor fitted with intersections that can broadcast live data about signal status to assist AVs.

Communication frequency 5.9 GHz is allocated to traffic management in the USA, as it is in many other countries, but to date the full band-width has not been used as expected. Consequently the telecom industry is now seeking access to the spare capacity. This is causing further stress in the transport sector.

There is also debate regarding the use of mobile phone signaling v dedicated short range radio communications (DSRC). Mobile technology is considered by some to be too slow to enable AVs to anticipate what to do at an intersection. Others say that mobile signal status communication is definitely the way to go, especially when 4g and 5g networks are available. In practice, the DSRC range is only 300m, so a mix of technologies is desirable, said others. The installation of DSRC costs $5,000 to $20,000 per intersection.

The UK is also looking to auction off some of the 5.9 GHz band width to telecoms because it does not think it needs it all for transport, particularly if manufacturers are going to use mobile phone technology for communication.

The Swedish Government has no program to retrofit existing infrastructure.

However, most importantly, Uber and Carnegie Mellon University researchers told us that retrofitting is not essential as far as they are concerned.

Other Infrastructure

In California, as thousands of kms per day are being driven by AVs under trial, Caltrans gets feedback about where road infrastructure needs improvement, particularly where better delineation is needed. The occurrence of snow and ice (which negates delineation) is a particular problem, yet to be resolved, although Google is confident of doing so in time.

Pittsburgh was a finalist in the USA's 'smart cities' competition. It received $11 million from the program and a further $11 million was provided by Penn DoT for various improvements to infrastructure and related trials, including:

- retro-fitting buses to enable them to extend green time at intersections
- linking 160 electronic signs on parallel routes (network optimisation) so that a busy expressway will be able to "communicate" with cars
- installing DSRC on signals
- providing real time parking station information on an expressway near a railroad station, and
- upgrading bicycle facilities.

In some of these areas, Pennsylvania is many years behind Australia.

The UK is also trying to increase the retrofitting of technology to infrastructure. Motorways are covered by telecom connectivity but other roads are not; the plan is to turn the next in the hierarchy, 'A roads' into mini motorways by 2040. The strategic policy preference is to substitute unaffordable capital investment in infrastructure with smarter vehicles that can make use of the current standards of infrastructure.

Big Data is seen as a way of linking road user needs to road manager policy, through new technology fitted to infrastructure and vehicles.

However, Ericsson believes it is unrealistic to expect manufacturers to include vehicle to vehicle, or vehicle to infrastructure equipment in vehicles when buyers do not see the need for it. Consumers prefer to buy safer vehicles or those with other benefits such as access to Netflix. In Sweden there is no overarching strategy for the introduction of new technology in vehicles or on infrastructure.

Uber is also designing to suit the current state of infrastructure, and does not plan to be reliant on improvements by road managers.

Again, the jury is out on this subject, but unless governments and technology developers work together, inefficient investment in infrastructure is likely.

Funding for Infrastructure

At some of our meetings, the question of falling public revenue, and how governments would pay for the future needs of technology was raised with government representatives. The issue of “value capture” was also raised, particularly if those introducing disruptive technologies were to make large profits from the use of infrastructure, and avoid traditional charges such as for drivers’ licences and fuel tax.

Income from fuel taxes is falling in the USA, as it is in Australia. Caltrans has worked with 14 other western States of the USA on a pilot project to determine the feasibility of collecting data that could be used for distance based charging. The pilot is almost complete, and 71% of the 5,000 volunteers in the trial said that distance charging would be a more equitable way of collecting revenue for roads than via fuel taxes. The Director gave a note of warning, in that those surveyed were volunteers, so the real acceptance level is likely to be a bit lower. Educating the remainder of road users is seen to be a very big hurdle.

How to provide sufficient funding for the possible improvements to infrastructure technology also seemed a dilemma for those we met in Pennsylvania. It was clearly not resolved according to the Secretary of the Penn DoT, although she advised that there was now a separate line item in the State transport budget for new technology.

In the UK, the issues surrounding road funding were also subject to debate.
Money raised in the UK is more than the amount spent on relevant infrastructure. The government is considering how or whether to close the gap, for example through more stable funding of the national motorway system.

The representative from the Borough of Milton Keynes, where there is a strong emphasis on trialing and adopting new transport technology, said they capture part of the value gained by ride share and private hire operators from their use of the local infrastructure, through parking fees and permit fees. Uber is just one of many private hire operators in Milton Keynes, and pays the same fees as taxis.

Former Deputy Mayor of London and now Global Transport Leader at ARUP, Isabel Dedring, believes that *“we will in the future have road charging in the UK. At present road users can pay up to five different subsidy charges, and these could be rolled into one in the first instance”.*

At another level, the City of San Francisco is not sure if it can continue to provide recharging points for electric vehicles, because of the rapid change in and cost of technology.

Trialing automated vehicles

As mentioned on several occasions, many governments and private companies are involved in a wide range of trials of autonomous and connected vehicle technology. The UK has produced guidance material for the conduct of trials, (and a similar approach is proposed for adoption in Australia soon).

Examples of autonomous vehicle trials that we were told about included:

- a very slow moving AV shuttle between the local AMTRAK rail station and Harrisburg Airport
- a proposed use of fully autonomous pods in the pedestrianised areas of Milton Keynes. The Milton Keynes Council wants to determine if 40 autonomous pods could provide a transport system in the centre of the city
- the Gothenburg Ring trials in Sweden that include 100 AVs designed so that their appearance is the same as that of conventional vehicles. This is so that other drivers will not act abnormally, or try to interfere with the AVs
- an electric library bus, and
- many others that have been funded by AASHTO, TRB, and NCHRP (the National Cooperative Highway Research Program) in the USA and by the British Government through grant programs.

Given there are no AV manufacturers in Australia, nor do the major developers of new transport technology have their research bases in this country, we asked the following questions:

“How can Australia encourage the introduction of new technology in transport, through cooperation with industry?”

“What can we do to support trials of AVs in Australia?”

Although Google has effective contacts with the NTC in Australia, it is likely to concentrate on the USA market before venturing internationally on a commercial basis, according to Sarah Hunter. To enter the Australian market they would need clear import standards and a process that is efficient (speedy).

Lyft thinks that national regulations in Australia would assist the market, as opposed to a number of different approaches.

Uber wants to trial autonomous vehicles in hospitable jurisdictions, meaning:

- don't regulate the software
- promote safety
- let private companies take the risk
- accept that existing insurance arrangements are adequate, don’t impose more
- encourage ride sharing, and
- encourage the reporting of incidents

"The future (for Uber) will be working with Government but also balancing this with disruption from time to time."

Use of data from automated vehicles

In future when we have smarter infrastructure, and smarter vehicles, there is enormous potential to use the data they capture to improve the efficiency of transport planning and operation.

Key questions are:

"When and how will governments access and use automated vehicle data?"

"How do we deal with the issue of data and system security?"

The approach being adopted by Caltrans is that AV users must know what data is being collected, and for what purpose. California will soon form an industry council to consider and make recommendations regarding information management and security.

At the present time, all performance reports from AV testing in California are available on line, to help build public awareness and confidence. The public is believed to have zero tolerance to AV crashes, even though according to the Director of Caltrans, it seems immune to the 35,000 deaths per annum on USA roads involving conventional vehicles.

In Pennsylvania, no policies have been developed regarding information or computer related security. Cyber invasions have to be reported, but by whom and to whom was not pursued. However, Pennsylvania is looking to have manufacturers self certify, and it is considered that every vehicle should have a security management system.

Uber's view is that self-driving cars will have their own positioning systems and will not rely on satellites or the Internet. *"Security is not an issue because the Uber AVs will not be connected to the Internet at any time, so cannot be hacked, ever."*

Uber has also studied the data derived from its operations and has analysed them to create comprehensive information that can be used to assist cities plan transport services.

A data application *'Uber Movement'* based on the use of Uber in many countries, is already available to planners, and will be made available to the public in due course. Examples of the information that was shared with us are as follows:

- ride sharing works best in low density areas
- in London and Paris, Uber 'rush hour' statistics show that the peak usage occurs at bar closing times, ie about midnight
- greater use correlates with the peak times for alcohol involved road fatalities (presumably associated with other travel modes)
- in San Francisco, 50% of Uber trips are shared
- 10% of customers under 30 surveyed by Uber, say that they will not buy a car or will give up their current car
- car ownership is reducing in USA cities.

According to the UK representatives that we met with in London, the trend in Europe is for greater data protection, which makes deployment of AVs and the use of data much more difficult.

Sweden's Ericsson Company has considered how data and communications should be managed. Their model involves a system of 'clouds', for example *"remote traffic signals to the cloud, vehicle to vehicle cloud, Volvo cloud, road authority cloud, Swedish cloud, and Nordic cloud",* all sharing data to some extent according to agreed formal protocols. However, protocols and definitions are yet to be developed and adopted.

Understanding the effects of new transport technologies.

Many of our discussions unearthed information about the effects that this new transport technology is having, albeit in its infancy.

Therefore important questions are:

"What information is available regarding the effects of new technologies on transport systems?"

"What other effects are anticipated?"

We tried to explore not only the observations or research findings to date, but also how or whether the governance arrangements for road transport would change in time.

A number of the government representatives, particularly in the USA, consider that for the foreseeable future road ownership will remain in public hands. Transport agencies will also retain responsibility for communicating with vehicles.

The effects of ride sharing on Public Transport and congestion.

A number of jurisdictions either have the perception, or have hard evidence that shared mobility is increasing traffic volumes, as Uber and the like take patronage away from public mass transit.

In San Francisco transit (mainly bus) patronage has reduced by 8% in the past two years. There is a perception that congestion is increasing and San Francisco wishes to establish if ride sharing and the reduced use of transit is a significant factor. It is thought that AVs could be deployed at times when transit shuts down. It is also recognized that AVs may reduce parking demand, but only if parking availability is restricted.

In response to the apparent increase in congestion, (although San Francisco has no regulatory powers), the Municipal Transport Authority is trying to establish pick-up and drop-off zones for Lyft and Uber, in lieu of door-to-door operation. Lyft is prepared to try this, but Uber is against the plan.

Ride sharing has also been challenging in Pennsylvania, and in Pittsburgh in particular, with a MyCity report showing that Uber has had an adverse effect on public transport. People are voting with their feet as Uber shared ride fares are now as low as approximately 2 dollars, compared with Mass Transit at about 4 dollars.

We were advised that this trend from mass transit to ride sharing and the possibility of increased congestion, is also evident in Toronto and New York.

Former Deputy Mayor Isabel Dedring, presented the following information on how technology was changing transport systems in London.

"The City of London has control over only 17% of transport related revenue but the Mayor has significant policy setting power through the Transport for London legislation. When the congestion charge in London was put in place some years ago, the following applied:

- *the city was grinding to a halt*
- *much more public (bus) transport had been put in place prior to the introduction of the charge*
- *the City bought a clunky but extremely reliable computer system to operate congestion charging*
- *the changes affected only about 200,000 people out of millions*

London grows by the equivalent of:

- *1 car every 26 minutes*
- *9 residents every hour*
- *2 buses every day, and*
- *2 tube trains every week*

Because much road space has now been reallocated to cycling and footpaths, congestion is just as bad as it ever was, if not worse, but people do not seem to mind given the new facilities. Additionally, in London alone, there are over 1 million road openings per annum blocking traffic, because privatised utilities are allowed free reign in this respect.

There are 42,000 Uber drivers in London. It is apparent that 80% of the increase in Uber usage is coming from patronage of the Underground, thereby adding to congestion. Bus patronage is also reducing by 2% per annum.

We are seeing the beginnings of a merging of public and private transport, so we have to consider pricing policy across the board. This could be a powerful management lever.

Even though London has very good air quality, the environment "issue" is sometimes used as another lever for reform. Vehicle manufacturers offering new technology should pick up on this "Trojan horse" approach to help deal with some of the political problems" Isabel concluded.

In Sweden we were told that there were no measurable effects on public transport patronage as a result of new transport services such as ride sharing. Existing public transport is considered as the core of the system with new technology providing additional services to fill gaps.

Uber has had little if any effect in Sweden or on the performance of transport in Stockholm. There are strict laws about ride sharing and Uber has to buy taxi licences in order to operate. The Transport Ministry is confident that users will not desert public transport in favour of new technologies.

Partnerships

We were advised that some public organisations, because of the trend to the merging of public and private transport, have developed partnerships with the providers of new transport services.

For example:

- a New Jersey town pays Uber a subsidy in lieu of spending capital on extending car parks
- the Massachusetts Transit Authority wants to pay Uber/Lyft for transporting people with disabilities
- in Milton Keynes developers are beginning to understand that they will not need to provide as much parking or as many signalised intersections in the longer term. They are also expressing keen interest in developing mass transit because they see its availability adding significantly to the value of their property investments.

Milton Keynes' planners are expecting travel demand to increase by between 27 and 57% by 2040, without some form of change management intervention. The City cannot afford to build for this. Vehicle to vehicle and vehicle to infrastructure connectivity will assist in increasing the capacity of the existing network. Hence they see the need to use incentives to have people adopt connected shared vehicles. Reducing parking availability is one such "incentive".

Other Transport Issues

Autonomous Freight Vehicles (and related technology)

Our discussions rarely touched on autonomous freight vehicles. As mentioned earlier, California will deal with autonomous commercial vehicles as the third and final major stage in its development of regulations.

We did not discuss commercial vehicles per se in Pennsylvania.

The U.K. apparently has not done much to date on this subject either. It is about to launch a trial of truck platooning but representatives at our meetings were not sure for what purpose. In particular, they are not sure how to get other vehicles through the platoon when those vehicles wanted to enter or leave the motorway. It was recognized that trucks already slipstream to save fuel, so the use of autonomous vehicles or at least connected vehicles, should make this practice safer. Driving hours are also limited to 4 hrs 15 minutes before drivers have to take a break.

At Scania, just outside Stockholm, our discussion about commercial vehicle technology focused on the vehicle to driver interface, described to us by behavioural scientist Senior Cognitive Engineer, Stas Krupenia.

The Advanced Driver Assistance System uses technology in the truck's cabin to evaluate the driver's fitness and performance, including the level of fatigue. It also takes into account the driving environment, for example whether traffic is busy, the road is wet etc.

If the truck evaluates the driver as tired then it will drive more gently, for example limit its speed, resist overtaking and the like. If the driver is fit then the truck will operate "more aggressively" in terms of accelerating and braking, and reactions to driver inattention. The system includes development of a multiple heads up display with multiple alarms and other triggers.

Scania is also piloting a "traffic jam system" where the truck takes over control from the driver to give him/her a rest when the truck is very slow moving.

Scania is also doing research on the effects of driver rest breaks in the cab (for 2 up driving). As in Australia, there is no evidence linking driving hours and crashes that is reliable and comprehensive enough to inform fatigue policy.

Broad Conclusions

Involvement in the Roads Australia program provided a valuable opportunity to discuss many current issues with government and private industry representatives.

Based on the information obtained, my conclusions are:

- the development and deployment of autonomous vehicles will be progressive over a relatively long period of time, however
- there are significant benefits to be gained in the shorter term from the use of connected vehicles and other technologies that are available today
- a flexible, agile approach will be required by governments to encourage innovation and ensure that road safety is not compromised
- prescriptive regulation of AV technololgy at this stage would be premature and counter productive
- road managers must work collaboratively with technology developers to ensure that inappropriate investments in infrastructure are avoided
- trials of new technology including the use of autonomous vehicles, should be complementary and comparable, so that reliable results can be used to guide government policy
- ride-sharing and other on-line transport services, should be carefully monitored by government, so that any undesirable effects on other forms of transport are identified and managed
- increases in the use of on demand personal transport such as that offered by Uber and Lyft at the expense of public mass transport services, can increase congestion in cities
- if we want to encourage AV producers to run trials in Australia we need to maintain our close contacts with them, and create a collaborative environment, including efficient import arrangements. We also need a national approach, as opposed to varying arrangements in each state and territory.

Appendix 1 (attached) contains details of organisations and representatives consulted during the Roads Australia Tour.

Appendix 1

Organisations and Representatives Consulted on the Roads Australia Tour

In the USA – 29 March to 5 April 2017

Organisation	Name	Position
California Department of Transport (Caltrans)	Malcolm Dougherty	Director
	Greg Larson	Chief, Office of Traffic Operations - Caltrans Division of Research, Innovation and System Information
	Jim Alford	Division Chief, Innovation and System Information
	Carrie Pourvahidi	Project Manager, Distance Based Charging
California Department of Motor Vehicles	Bernard Soriano	Deputy Director
Lyft	Mike Masserman	Director of Federal and Inter-government Relations
San Francisco Municipal Transport Authority	Darton Ito	Deputy Director, Innovation and Program Delivery, Sustainable Streets Division
Google X	Sarah Hunter	Director of Public Policy
Pennsylvania Dept. of Transport (Penn DoT)	Leslie Richards	Secretary
	Leo Bagley	Special Assistant to the Secretary
	Mark Kopko	Manager, Traveler Information and Advance Vehicle Technology
	Kara Templeton	Director Bureau of Driver Licensing
	Jason Sharp	Executive Director Chief Counsel
	Roger Cohen	Director Policy Division
	Glenn Rowe	Chief Traffic Engineering and Permits
Utah DoT	Blain Leonard	Chair, AASHTO Innovation Committee
Transportation Research Board (TRB)	Ray Derr	Project Manager
America Association of State Highway and Transport Officials (AASHTO)	Jim McDonald	Program Director for Engineering
	Gummada Murthy	Associate Program Director Operations
	Patrick Zelinski	Associate Program Manager
NOCoE note1	Patrick Son	Managing Director

Note 1: The National Operations Center of Excellence (NOCoE) is designed to offer a suite of resources to serve the transportation systems management and operations (TSMO) community. The new Center offers an array of technical services such as peer exchange workshops and webinars, ongoing assessments of best practices in the field, and on-call assistance. The Center is a partnership of the American Association of State Highway and Transportation Officials (AASHTO), the Institute of Transportation Engineers (ITE), and the Intelligent Transportation Society of America (ITSA) with support from the Federal Highway Administration (FHWA).

In the USA – 29 March to 5 April (cont)

Organisation	Name	Position
City of Pittsburgh	Alex Pazuchanics	Policy Adviser
	Karina Ricks	Director Mobility and Infrastructure
Uber	Jason Post	Director, Public Policy and Communications
Carnegie Mellon University	Ramayya Krishnon	Dean of Heinz College
	Stan Caldwell	Exec Director, Traffic 21 Institute and T-Set, National University Transportation Centre
	Prof. Raj Rajkumar	Collective Research Laboratory
	Chris Hendrickson	CAV Policy and Infrastructure Investment
	Courtney Ehrlichman	Researcher (social issues), Traffic 21
	Stephen Smith	Research Professor, Robotics Institute

In the United Kingdom, 5 April to 8 April

Organisation	Name	Position
Department of Transport UK	Richard Bruce	Director, Energy Technology and Innovation
	Ian Yarnold	International Vehicle Standards Division
	Iain Forbes	Head of the Centre for Connected and Autonomous Vehicles (C-CAV) note 2
Highways England	Paresh Taylor	Head of Licensing and Monitoring
	Phil Proctor	Future Technologies Leader
UK CAV Hub note 3	Jim Campbell	Chief Executive
Milton Keynes County Council	Brian Matthews	Head of Transport Innovation and UK *Autodrive* Project Leader
	Geoff Snelson	Director of Strategies and Futures
Society of Motor Manufacturers and Traders	David Wong	Senior Technology and Innovation Manager
IM-PACT note 4	Andrew Everett	Acting Chairman
Cambridge University	John Miles	ARUP Professor of Transitional Energy Strategies at the Department of Engineering
ARUP Consultants	Tony Marshall	Director Global Highway Business
	Mark Wedlock	Associate Director- Smarter Mobility and ITS
	Isabel Dedring	Global Transport Leader

Note 2: the UK Government's Centre for Connected and Autonomous Vehicles (C-CAV), is a new policy unit based jointly in the Department for Transport and the Department of Business, Innovation and Skills. The Centre aims to help ensure that the UK remains a world leader in developing and testing connected and autonomous vehicles.

Note 3: The new Connected and Autonomous Vehicle Hub, or 'CAV Hub', was recently launched at Loughborough University's Olympic Park campus. It will oversee an 'ecosystem' for autonomous vehicle testing made up of permanent facilities, initially part-supported by public funds but intended to be economically viable in the long term. Its aim is to help enable the UK, to be the world number one for connected and autonomous vehicles.

Note 4: The Transport Systems Catapult chaired Intelligent Mobility Planning Action and Coordination Team (IM-PACT) meets to discuss ways of accelerating innovation in transport syatems and intelligent mobility. Membership of IMPACT UK is drawn from senior representatives across the wide range of influencers of future transport needs and delivery such as automotive, telecom, infrastructure and ICT supported by Government officers.

In Sweden April 9 to April 12

Organisation	Name	Position
Australian Embassy	Jonathan Kenna	Ambassador
Austrade	Kerstin Classon	Investment Manager
Swedish Ministry of Enterprise and Innovation	Maria Gelin	Deputy Director General, Head of the Ministry's Division for Transport, Markets and Regulations
	Asa Vagland	Deputy Director, Division for Transport and Society (responsible for ITS and connected vehicle)
	Catrin Tidstrom	Deputy Director, Division for Transport Markets and Regulations (responsible for autonomous vehicles)
	Ulrika Stenstrom	Legal Adviser
	Bjorn Cappelin	Deputy Director, Secretariat for EU and international affairs
Swedish Transport Agency	Jacob Gramenius	Deputy Director General
Ericsson	Peter Persson	Head of Sales Management, Industry and Society
Scania	Jakob Wijkstrom	Area Sales Manager Trucks
	Stas Krupenia	Senior Cognitive Engineer