Connected and Automated Vehicles – Roads Australia 2017 International Study Visit

Transport Certification Australia Participant’s Report

May 2017
EXECUTIVE SUMMARY

Transport Certification Australia (TCA) participated in the Roads Australia 2017 International Study Visit, with the aim of better understanding how international jurisdictions are preparing to manage and administer connected and automated vehicles (CAVs), and to share those findings with our Members.

The Study Visit ran between 29 March and 13 April 2017, visiting four leading global cities – San Francisco, Pittsburgh, London and Stockholm – to meet with transport, automotive, technology, researchers and government leaders.

Seventeen Australian delegates participated in part or all of the Study Visit, representing a diverse range of organisations from several layers of government, and a broad cross-section of industry.

The following key observations were distilled from the various meetings and interactions from throughout the Study Visit, and represent important areas for national collaboration and policy development, to facilitate the successful large-scale introduction of CAVs into Australia.

1. **Australia is not behind the game where it matters most** – we are poised to be well prepared for the large-scale introduction of CAVs; however we need to act promptly to align national and state agencies around a harmonised national CAV program.

2. **Clarity of outcomes being sought is essential** – policy makers need to clearly articulate the public benefit outcomes being sought; without this, industry will instead drive their own agendas under the guise of those inadequately defined outcomes, potentially resulting in unintended consequences, or outcomes that are incompatible.

3. **Policy on the run is policy underdone** – commercial models for operation of CAVs and mobility as a service (inclusive of road use charging) needs to be holistic, not piecemeal; and related legislation and policies need to be developed and communicated ahead of deployments and market entrants, not ‘on the run’ once business models are in place.

4. **Public perceptions will ‘make or break’** – as in many comparable industries where innovation and disruption are active, public perception and trust must be carefully managed to avoid backlash when expectations inevitably fail to be met.

5. **Convergence is the key** – end-users (communities and dependent industries) require a choice of products and services, harmonised but not overly-constrained, and aligned with sound government policies that protect the public interest.

In summary, CAVs represent such a fundamental domain shift that we are all being (and will continue to be) disrupted across policy, technical, operational and commercial perspectives. We can’t yet know all of the challenges we will face, and existing models may not apply anymore. In response, we’re going to need all parts of Australian government and industry ‘in the room’ to ensure we cover all of the bases, and everyone has a contribution to make.

Potential opportunities for Australia are apparent within a national, coordinated and consistent framework to manage CAVs in Australia. TCA has capability and experience to contribute to this framework in the areas of advice, accreditation and administration pertaining to connected vehicle standards, security and conformance of connected and cooperative systems.

Roads Australia intends to maintain contact and relationships with the individuals and organisations that participated in the Study Visit, to build on the knowledge and insight gained and to make the benefits derived available to its Members through a series of domestic events.
## Contents

1 INTRODUCTION ..........................................................................................................................1

2 PROGRAM AND DELEGATES ....................................................................................................2
   2.1 Study Program .................................................................................................................2
   2.2 Participating Delegates .................................................................................................4

3 KEY OBSERVATIONS .............................................................................................................5
   3.1 Australia is Not Behind the Game Where It Matters Most ..............................................5
   3.2 Clarity of Outcomes Being Sought is Essential ...............................................................5
   3.3 Policy On The Run Is Policy Underdone .........................................................................6
   3.4 Public Perceptions Will ‘Make or Break’ ....................................................................6
   3.5 Convergence is the Key ...............................................................................................6

4 POTENTIAL OPPORTUNITIES FOR AUSTRALIA ................................................................7

5 NEXT STEPS ..........................................................................................................................7

APPENDIX A – ADDITIONAL NOTES .....................................................................................8
1 INTRODUCTION

Transport Certification Australia (TCA) participated in the Roads Australia 2017 International Study Visit, with the aim of better understanding how international jurisdictions are preparing to manage and administer connected and automated vehicles (CAVs), and to share those findings with our Members.

The Roads Australia delegation was a collaboration of public and private enterprise, represented by seventeen delegates from Federal and State Governments, national transport agencies, researchers and engineering, construction, traffic management and telecommunications industries.

The Study Visit ran between 29 March and 13 April 2017, visiting four leading global cities to meet with transport, automotive, technology, researchers and government leaders.

The questions posed to each meeting, and discussed at length between delegates and hosts, centred on the key themes of:

- **Strategic Frameworks** – what new paradigms are emerging, in what ways will mobility be fundamentally changed, and what institutional change is necessary to achieve this?
- **Network Ownership and Management** – what changes in road design, management and financing will be necessary, how are transport modes being integrated, and how are you facing the challenge of declining fuel tax revenues and infrastructure cost recovery?
- **Public/Private Sector Collaboration** – what collaborative mechanisms exist between government and industry, what is the future of existing road concessions, and what work is being done to ensure systems are safe from disruption and hacking?
- **Evolution and Transition** – what are your anticipated timeframes for fully autonomous vehicles and/or the end of private vehicle ownership, how do you expect automated and manually-driven vehicles to interact on the network, and what trials are in the pipeline?
- **Ride Share** – what is the relationship between government and ride-share operators, how is it impacting congestion and private car ownership, and how are regulatory, legislative and commercial arrangements evolving?
- **Freight** – what are the key aspects of connectivity and automation for freight productivity, and what new business or service models are expected?
- **Others** – how important are V2V, V2I and V2X (personal devices) in achieving anticipated outcomes, what is the expectation for services to regional/rural areas, and what is being done to align electrification with automation in terms of infrastructure and services?
2 PROGRAM AND DELEGATES

2.1 Study Program

The Study Visit program included four major cities, providing significant opportunities to meet and learn from forty-four leaders, from twenty-five different organisations.

These meetings included:

San Francisco

- California Department of Transportation, Sacramento
  - Malcolm Dougherty – Director, Caltrans
  - Greg Larson – Chief, Office of Traffic Operations Research, Caltrans
  - Bernard Soriano – Deputy Director, California Department of Motor Vehicles
- Lyft, San Francisco
  - Mike Masserman – Director of Federal & International Government Relations
- San Francisco Municipal Transportation Authority, San Francisco
  - Edward Reiskin – Director
  - Darton Ito – Deputy Director, Innovation & Program Delivery
- Google-X (Waymo), Mountain View
  - Sarah Hunter – Director of Public Policy

Pittsburgh

- Pennsylvania Department of Transportation, Utah Department of Transportation,
- Transportation Research Board, National Operations Center of Excellence
- American Association of State Highway and Transportation Officials
  - Leslie Richards – Secretary, PennDOT
  - Leo Bagley – Special Assistant to Secretary, PennDOT
  - Mark Kopko – Manager, Traveller Information & Vehicle Technology, PennDOT
  - Blaine Leonard – ITS Program Manager, Utah DOT
  - Jim McDonnell – Program Director, AASHTO
  - Gummada Murthy – Associate Program Director, AASHTO
  - Patrick Zelinski – Associate Program Manager, AASHTO
  - Ray Derr – Project Manager, TRB
  - Patrick Son – Managing Director, NOCoE
- Uber
  - Jason Post – Director, Public Policy and Communications
- Carnegie Mellon University
  - Stan Caldwell – Executive Director, Traffic21 Institute
  - Professor Raj Rajkumar – Collective Research Laboratory
London

- ARUP, Highways England, Transport for London, Transport Research Laboratory, RDM Group, Centre for Connected and Autonomous Vehicles
  - Paresh Tailor – *Head of Office of Road and Rail Relationship, HE*
  - Leon Daniels – *Managing Director Surface Transport, TfL*
  - Nick Reed – *Director at TRL, and GATEway Technical Lead*
  - David Keene – *Chief Executive Officer, RDM Group*
  - Iain Forbes – *Head of C-CAV*

- ARUP-Sponsored Roundtable Meeting, UK Department for Transport, UK Autodrive Programme, Cambridge Autonomous Bus
  - Isabel Dedring – *Global Transport Leader, ARUP*
  - Richard Bruce – *Director of Energy, Technology and Innovation, UKDOT*
  - Ian Yarnold – *International Vehicle Standards Division, UKDOT*
  - Brian Matthews – *UK Autodrive Lead, Milton Keynes County Council*
  - Geoff Snelson – *Director of Strategy and Futures, Milton Keynes County Council*
  - Andrew Everett – *Acting Chairman, Transport Systems Catapult*
  - Jim Campbell – *Lead of UK CAV Hub*

Stockholm

- Australian Embassy in Stockholm
  - Jonathan Kenna – *Ambassador*
  - Kerstin Classon – *Austrade*

- Swedish Ministry of Enterprise and Innovation, Swedish Transport Agency
  - Maria Gelin – *Deputy DG, Division for Transport Markets and Regulations*
  - Catrin Tidström – *Deputy Director, Division for Transport Markets and Regulations*
  - Åsa Vagland – *Deputy Director, Division for Transport and Society*
  - Ulrika Stenström – *Legal Adviser, Swedish Ministry Legal Affairs Secretariat*
  - Amanda Ryde – *Desk Officer, Division for Transport Infrastructure and Financing*
  - Björn Cappelin – *Deputy Director, Secretariat for EU and International Affairs*
  - Jacob Gramenius – *Deputy Director-General, Swedish Transport Agency*

- Ericsson
  - Stefan Myhrberg – *Global Head of ITS Road*
  - Peter Persson – *Head of Sales Management, Industry & Society*
  - Mats Guldbrand – *Networked Society Evangelist*
  - Mia Lund – *Experience Project Manager*

- Scania
  - Jakob Wiljkström – *Area Manager, Sales Trucks Africa and Asia-Pacific*
  - Stas Krupenia – *Senior Cognitive Engineer*
2.2 Participating Delegates

Seventeen Australian delegates participated in part or all of the Study Visit, representing a diverse range of organisations from several layers of government, and a broad cross-section of industry:

- David Anderson – *Chairman, National Transport Commission*
- Oliver Blain – *Head of NSW Government, Telstra*
- Michael Caltabiano – *CEO, Australian Road Research Board*
- Jeff Doyle – *CEO, Altus Traffic*
- Alex Foulds – *Executive Director, Department of Infrastructure and Regional Development*
- Dr Charles Karl – *National Technical Leader, Australian Road Research Board*
- Peter Kessler – *Chief Executive Construction, Fulton Hogan*
- Philip Lloyd – *General Manager Implementation, Transport Certification Australia*
- Diana Loges – *Principal Transport and Resources, ARUP*
- Madeleine McManus – *Director Monash Industry Team, Monash University*
- Mandi Mees – *Executive Director Policy, Roads Australia*
- John Merritt – *CEO, VicRoads*
- Gavin O’Connor – *Managing Director, MWH Global*
- David Stuart-Watt – *President, Roads Australia*
- Evan Walker – *Director Smart Innovation Centre, Transport for NSW*
- Ian Webb – *CEO, Roads Australia*
- Mark Williamson – *Managing Director, Transmax*
3 KEY OBSERVATIONS

Distilled from the extensive notes taken during the Study Visit (provided in Appendix A), the following key observations have been flagged as important areas for national collaboration and policy development, to facilitate the successful large-scale introduction of CAVs into Australia.

3.1 Australia is Not Behind the Game Where It Matters Most

Almost universally, governments and industry do not share as closely-aligned vision of their CAV future as they believe they have. Gaps were evident when comparing perspectives independently shared by associated organisations, with one party’s claims of alignment often highlighted by the other as an area of difference, in both directions.

While Australia does not enjoy the same level of domestic technical innovation or access to latest developments in more than a small handful of trials/testbeds, in preparing for industry reform through policy review, analysis of legislation, consideration of barriers, and proposal of regulatory options, Australia’s level of preparedness compares very favourably against the US, UK and EC.

In terms of clarifying responsibilities, contributions and collaboration between different national and state government agencies to achieve a harmonised national CAV program, Australia has some way to go. However, our challenge is significantly simpler than that faced by the absolute plethora of overlapping agencies that exist in either the US or UK. The EC has an even greater challenge to align member states.

Australia is poised to be well prepared for the large-scale introduction of CAVs; however we need to act promptly to align national and state agencies around a harmonised national CAV program.

3.2 Clarity of Outcomes Being Sought is Essential

As evidenced in many interactions, CAV technology development is outstripping policy development, allowing technology developers to drive their agenda, often creating scenarios where their technology becomes “a solution looking for a problem” that policy makers are struggling to react to.

Coupled with this, several technology-driven reforms have delivered unintended consequences, such as the advent of ‘ride sharing’ intended to reduce congestion by decreasing total vehicle kilometres travelled (VKT) actually worsening congestion by drawing people away from more efficient mass transit. Professional driver / single passenger trips are ‘ride sharing’ in name only, as the driver is only making the trip because of being paid to do so, as they were not driving to that destination otherwise, and thus generate equal or greater VKT.

Despite slogans promoting social responsibility and community benefit, it is apparent that disruptors such as Uber, Lyft and Waymo/Google are most intent on driving a business model that redirects vehicle manufacturers' revenue from private vehicle ownership, to their revenue through provision of a mobility service, whether or not that achieves social or environmental benefits.

In this way, apart from the safety benefits of removing human error from the driving task, other assumed benefits of CAVs still haven’t been fully understood or clearly proven. These industry disruptors unashamedly want to remove as much as one-third of the cost of delivering their service: the human driver labour cost.

Australian policy makers need to clearly articulate the public benefit outcomes being sought; without this, industry will instead drive their own agendas under the guise of inadequately defined outcomes, potentially resulting in unintended consequences, or outcomes that are incompatible.
3.3 Policy On The Run Is Policy Underdone

Every industry disruptor recognised that their provision of mobility as a service was only possible through use of the road transport network asset, and the desire for that asset to remain well-maintained and enhanced as demand increases. They accepted some form of service provider licensing and/or road-use charging was inevitable and manageable, as long as it is designed and communicated in a timely manner, and applied fairly across all road users.

While some government agencies have explored this policy space and enacted limited trials, definitive positions have not been articulated. In many instances, the link was missing between changing principles of regulation, licensing and insurance in preparation for CAVs, and the development of pricing restrictions or road-use charging in the face of declining fuel excise.

The commercial model for the operation of CAVs and mobility as a service needs to be holistic, not piecemeal, and related legislation and policies need to be developed and communicated ahead of deployments and market entrants, not ‘on the run’ once business models are in place.

3.4 Public Perceptions Will ‘Make or Break’

As in many comparable industries where innovation and disruption are active, public perception and trust must be carefully managed to avoid backlash when expectations inevitably fail to be met. Early systematic or fatal failures would potentially undermine or annul public benefits.

Currently much of the ‘hype’ portrayed by industry to the public presents a utopian picture where all the ills of transport (road deaths, congestion, pollution, costly vehicle ownership, etc) will all be solved by CAVs – and the messaging from politicians and governments is no different.

While CAV technology will certainly provide safer and more efficient roads through substituting the driver with something that isn’t distracted, can’t fall asleep, or whose reaction times are slow, it is unreasonable to believe it will be perfect. There will be failures, and there will be deaths caused by defective or compromised vehicle automation systems – and this risk is at its greatest during the transition where human and automated driving coexists. However, these failures and their consequences will be far fewer than human drivers currently inflict on our communities.

3.5 Convergence is the Key

There are many CAV ‘battlegrounds’ where particular technologies and deployment models are being hotly debated: Should 5.9Ghz DSRC or 5G telecommunications be deployed for V2V, V2I and/or V2X data communication? Should V2I connectivity be government-provided as a public service, or delivered through commercial arrangements? Which CAV technologies provide the safest driving experience, and how should those technologies be certified/approved?

It is all too easy to become obsessed with technology. However, to be insulated against further disruption, technology should be recognised as merely the enabler of safety, productivity and liveability reforms being sought. Leading agencies and industries are preparing to embrace a heterogeneous, interoperable CAV ecosystem, not a single silver bullet.

Under that approach, conformance is assessed through outcome/performance-based frameworks rather regulating particular technologies, requiring compatibility at appropriate interfaces for public benefit, but allowing flexibility and innovation in technical, operational and commercial elements.

Ultimately, this convergence will provide end-users (communities and dependent industries) with the choice of products and services they require, harmonised but not overly-constrained, and aligned with sound government policies that protect the public interest.
4 POTENTIAL OPPORTUNITIES FOR AUSTRALIA

In terms of Australia’s preparedness for CAVs, substantial emphasis is being placed on automated vehicles; less so on connected vehicles or the connected aspects of CAVs. However, several unanswered challenges remain with respect to connected technologies, to ensure that fundamental security, privacy, compatibility and reliability outcomes are achieved by-design.

CAVs represent such a fundamental domain shift that we are all being (and will continue to be) disrupted across policy, technical, operational and commercial perspectives. We can’t yet know all of the challenges we will face, and existing models may not apply anymore. In response, we’re going to need all parts of Australian government and industry ‘in the room’ to ensure we cover all of the bases, and everyone has a contribution to make.

The ‘traditional’ telematics industry is a natural predecessor to the emerging connected vehicle generation, and as such, much of the policy, technical, operational and commercial knowledge and experience developed by TCA translates directly into an ability to meet these challenges.

Potential opportunities for Australia are apparent in support of a national, coordinated and consistent framework to manage CAVs in Australia. TCA has capability and experience to contribute to this framework in the areas of advice, accreditation and administration pertaining to connected vehicle standards, security and conformance of connected and cooperative systems.

5 NEXT STEPS

To support progress towards a national, coordinated and consistent system to manage CAVs in Australia, Roads Australia will build on the knowledge and insight gained during the Study Visit to make the benefits derived available to its Members through:

1. Preparing a comprehensive report, for publication to its broader membership
2. A roadshow of events, workshops and industry engagements to share insights and experiences with RA members, government and industry leaders across the nation, with Study Visit participants invited to contribute and present
3. Engaging with government ministers and officials to convey key insights and interpretations of the Study Visit outcomes
4. Presenting selected video, photographic and audio content gathered during the Study Visit at the Roads Australia National Roads Summit on 31 May 2017
5. Via the Transport Reform Policy Chapter, workshops and events with Clare Gardiner-Barnes (TfNSW) and Michele Huey (Transurban), designed to support national coordination between government and industry to facilitate the introduction of driverless vehicles
6. Continuing to collect and share international experience, data and intelligence with government and industry in Australia, and continuing to foster international relationships with our hosts from the Study Visit.
APPENDIX A – ADDITIONAL NOTES

Throughout the Study Visit, a substantial number of photos and accompanying notes were taken from which this report was derived. A selection of these are provided below as a ‘mosaic’ of the experience, capturing ‘raw’ impressions of the people, events and messages conveyed.

Caltrans, Sacramento

The Roads Australia delegation met with Malcolm Dougherty (Director, California Department of Transportation) and staff, to discuss their preparedness and current regulatory response to CAVs:

- Development of state-based regulations for autonomous vehicles, in conjunction with sister agencies including police, allowing these cars on their public roadways; manufacturer testing compliance (a self-certification model, with parameters put in place and standard reporting required in return) and deployment regulations; currently 29 companies approved for testing
- Currently no federal autonomous vehicle safety regulations ... so California is moving, but not wanting to spark a patchwork of different regulations; a challenge! (safety regulations are national, but motor vehicle operational regulations are state-based)
- 27 reported crashes, predominantly manual-driven colliding with autonomous vehicle; all reports (including disengagement reports, not just crashes) are part of the public record
- Important early learnings: issues with snow (road is obscured) and ice (forming on sensors)
- Current insurance policies clearly stipulate manufacturer responsibility when in automated mode, and driver responsibility when in manual mode; still some grey area; $5m requirement
- ‘3D cruise control’ on motorways is nearly here; last-mile, low-speed shuttles are nearly here; completely driverless vehicles for miscellaneous duties are still a long way off; the biggest challenge is the mixed-vehicle transition (autonomous and manual driving together)
- For the foreseeable future, the majority of roads will remain in public hands
- Car ownership dynamic has potential to shift; the counter-argument is that real-life studies have shown an increase in VKT (not a decrease, because shared mobility - Uber, etc - has proven to draw people away from shuttles and mass transit)
- Challenge for V2I is inability to fund kit in controller boxes when already behind on potholes!
- California Road Charge Pilot Program, at the end of a nine-month journey; involving 5000 vehicles, 6 mileage reporting methods (at least one non-technology option), 4 account managers; 27m+ miles driven in the pilot so far
- Privacy and security concerns with technology (e.g. GPS); pilot focussed on technical and operational feasibility, not commercial or policy barriers
- 40,000 people killed on US roads in 2016 (an all-time high); 10% of those in California, with pedestrian fatalities representing 20% of those!
- The push for autonomous is predominantly about safety; however 50% of congestion in CA relates to incidents, not recurrent congestion, so indirect efficiency gains are expected
Lyft, San Francisco

Lyft, a relative commercial rideshare newcomer, provided insight into their view of the CAV revolution and its potential impacts on community mobility as a fundamental disruptor:

- The third transportation revolution! US: canals -> railroad -> cars -> autonomous vehicle fleets of shared, electric, autonomous (Lyft + GM); prediction: within 5 years the majority of Lyft rides will be autonomous
- 80% of the seats on the road are empty; Lyft launched in 2012; Lyft Line ride sharing launched in 2014; Shuttle dynamic bus routing launched in 2017
- City transformation will require huge private-public collaboration and partnership to manage safety, community, infrastructure and associated cost models for sustainability

SFTMA, San Francisco

Darton Ito (Deputy Director, San Francisco Municipal Transportation Authority) presented a view of the challenges being faced by ‘local government’ municipalities by the on-rush of CAVs:

- Inspired by US Smart Cities challenge (finalist); focussed on advanced carpooling (casual carpooling, dedicated lanes, concessions), vision-zero of eliminating traffic deaths by 2024 (safety), responding to community developments (e.g. automated residential/retail shuttle)
- Transit-first policy, ambitious environmental sustainability goals
- Challenges of electric vehicle charging locations, technologies, forecast rate of demand increase, government vs commercial leadership, etc

Google-X (Waymo), Mountain View

While fiercely protective of its detailed intellectual property, Waymo were otherwise very generous with their perspectives and motivations to be the first to realise the future of autonomous mobility:

- Self-driving technology company, motivated with solving the road safety problem, with 94% of crashes in the US involving human error, and delivering a consumer application benefit
- Started (secretly) in 2009, focussed on highway (level 3) automation; pivoted a few years later to focus on all-condition autonomous driving
- Manufactured their own special-built vehicle without traditional controls, and special shaping (maximised sensor field of view), materials and characteristics perfectly suited for AV development; all key systems are fully on-board and operate fully autonomously
- In a new environment, the vehicle firstly ‘builds’ its own bespoke, super-detailed map of the area through which it will be driving; then drives by comparing stored map to current real conditions
- Predicts the presence and trajectory of all other objects in the vicinity in order to decide where to move next; any ‘learning’ of a new scenario from one vehicle can be shared with other vehicles driving in the same area; signs, traffic cones, etc can all be detected
- Many different manufacturing, partnering and licensing commercial models are considered
- Hugely difficult to predict social, psychological and community reactions to mass introduction of AVs, so flexible for potential futures and researching human factors
- VTTI work into naturalistic data related to crash rates, etc is first class
- When software is changed, new software is run through 1 billion miles of simulation gathered from previous self-driving on real roads
- Desire is for regulatory compliance to be performance-based, such as "setting a driving test including all of the edge conditions you want" rather than based on a complex specification
- Difficulties with CA legislators (draft regs, taking years to finalise with uncertain outcome) so primary testing sites moved to Phoenix (Arizona) and Austin (Texas)
- While current technology prefers smooth, flat, well-marked roads, the onus is on the developers to make next-generation technology work almost universally (not expecting all roads to be always perfectly marked and maintained)

PennDOT, Utah DOT, TRB, AASHTO, NOCoE

The Roads Australia delegation was honoured to meet with a significant gathering of US experts, assembled and chaired by Leslie Richards (Secretary, Pennsylvania Department of Transport) for a dedicated half-day workshop, exchanging strategic viewpoints on preparing for CAVs:

- Continuation of conversations and connections made in Melbourne at ITSWC 2016
- Preparing for the future: Pennsylvania senate bill 427 provides for highly automated vehicles and platooning testing, introduced 24 Feb 2017 (allows up to Level 5); policy provides details of conditions for test programs, vehicles and environments
- Regulatory process too heavyweight and slow, out-paced by rate of technology change
- Self-certification model based on standard test policies and guidelines; requires consistency in reporting of testing outcomes to be effective
- Twelve states have enacted autonomous vehicle legislation, across a broad spectrum of depth and approaches (some super-detailed, some super-lightweight) which creates momentum and energy -- but also a patchwork of difference
- AV Policy Task Force includes government, industry, academia and advocacy groups
- Public acceptance requires seeing and experiencing the presence of CAVs; you don't trust what you don't understand; need to encourage how people will embrace change
- SPaT Challenge used to encourage broad V2I deployment, plus demonstrate commitment to the OEM and private industry; by 2020, at least one 'cluster' of 20+ signalised intersections equipped with DSRC/V2I in all 50 US states; investment required is ~US$5,000 per RSU; maintenance costs yet to be understood; there are 14,000 traffic signals in Pennsylvania
- 5.9GHz DRSC has been tested and proven and ready now; 5G promises equivalent low-latency but is still 2 years away in development, plus another 3-5 years in deployment and testing/acceptance by the vehicle industry and transport agencies; mixed communications environments will be a reality
- iCone portable DSRC units proposed for Harrisburg
- Pittsburgh was Smart Cities Challenge finalist, led to development of Smart Spine System
- Interstate 76 utilised for Active Corridor Management Project, adapted from a part-time hard shoulder running initiative to a corridor of 160 traffic signals (taken over from municipal control) with DSRC V2I added, and active traffic management integrated; corridor also includes rail, transit, cycle paths and active parking management (truly multi-modal)
- Opportunity to share learnings from VicRoads, especially managed motorway technologies and operations providing 25% uplift in productivity and 30% reduction in nose-to-tail incidents
- TRB are developing national guidelines for cyber-security of traffic management systems (see TRB handout, bottom of second page)
- USDOT-developed SCMS will be part of four major Connected Vehicle pilots
- AV Proving Grounds initiative by President Obama, Pennsylvania selected in January 2017, multiple facilities with city streets, closed test track, and interstate 99
- CV/AV 2040 Vision Pittsburgh, design & investment decisions, real-time data usage, impacts on infrastructure, workforce training needs, impacts on freight flow; completed July 2014
- Statewide Strategic Plan, focussed strongly on interoperability; living document, actionable information, immediate investments with day-one benefits plus longer-term enablers
- Universities in PA: Carnegie Mellon, Penn State, University of Pennsylvania
- Smart Belt Coalition between three states (MI, OH, PA) with major researchers, numerous pilot sites, active industry, urban & rural roadways, mixed terrain, four distinct seasons, etc
- Six major new NCHRP projects, covered in supplied briefing document
- Public Outreach programs through speaking engagements (58 in 2016, of various types), Harrisburg HAV demonstration (legislature and key transportation officials, 50+ riders on 1.6km loop on public roads), Pennsylvania HAV Summit (inaugural summit in Fall of 2017, outcomes will tie into CV/AV Strategic Plan)
- Real-life deployment of autonomous shuttle with Amtrak Middletown Station, a satellite Penn State campus, and Harrisburg International Airport
- Sharing of Australian 'Smart Roads' initiative
- Challenge of ride-share disruption with Uber and Lyft; evidence of increase in road congestion and erosion of public transit usage; demonstrates challenges of public/private interactions and advocating/protecting community good
- In contrast, Victoria imposes $2 per trip surcharge on Uber; not so easy in PA
- Sharing of NSW integrated transport and land use strategy, focussing on western Sydney; out for public consultation in the coming months
- As Australian government agencies, we are under much more pressure to express 'our problem' to avoid being seduced by an avalanche of pre-made solutions looking for a problem to solve (where those solution providers are simply trying to make lots of money); clearly evident at ITSWC 2016!

Uber (Volvo XC90)

Uber, the household name synonymous with disruption, provided a candid insight into their personal mobility business model and 'big data' analytics platform aimed squarely at dominating the transport services of the future:
- Hosted by Jason Post (Public Policy and Communications), email: post@uber.com
- Self-driving cars launched in Pittsburgh (with operator), a fleet "of several thousand" vehicles in commercial service
- The Future of Urban Mobility: more than 1.2b cars in the world, 22% of all carbon emissions come from vehicles, cars sit idle 95% of the time, not all neighbourhoods are well served by mass transit
- Original vision/innovation was utilising private vehicles for ride-sharing ("a better mousetrap" elastic taxi service); now evolved to "Reliable access to transport everywhere for everyone" through provision of a shared, self-driving fleet built by fitting technology to vehicles manufactured by OEM partners such as Volvo
- Three pillars of Uber's vision: Shared, Autonomous, Electric
- Current priority is testing so the technology can continue to develop ("we're in the first inning of the game")
- They believe they compete with private car ownership, not with mass transit; in fact, most Uber trips start at rail stations, and most busy periods are after 8pm through midnight
- (This is not about ride-sharing -- they aren't "sharing" a ride, because the driver/vehicle wasn't otherwise going to the destination until the passenger called them -- it's about shifting private vehicle ownership to ad-hoc hiring of Uber's fleet of vehicles and thus drive revenue!)
- Prices are driven down through massive turnover and high occupancy
- The driver doesn't know the destination until after the pick-up to avoid "destination discrimination"
- Have added "FIFO" model for airports and large events where passenger and driver aren't directly matched at booking (because it's too hard to find "your" Uber), but instead you get into the first available Uber and then link your ride/destination to that driver
- Drivers choose when and where to work; they can even drive for e.g. Uber and Lyft
- Uber Movement exposes a subset of Uber's massive data asset to help cities make data-driven transportation policy, planning and operational decisions; eventually will be public; designed not to impinge on driver or passenger privacy
- UberPOOL closes the gap on true ride-sharing, with even lower individual cost offset by increased trip time through additional pick-ups and drop-offs along the journey; not deployed everywhere, as depends on social/cultural behaviours and demand thresholds to sustain the required business model
- 50% of Uber trips are UberPOOL in some cities
- Current self-driving technology struggles in bad weather such as rain or in environmental changes such as roadworks; drops out of self-driving mode when encountering unknown situations; SAE Level 2 automation, with alert trained driver present to take control as needed
- Don't rely on / don't support Connected Vehicle technologies, all processing fully self-contained within vehicle ("no mothership"); assumes AVs will "leap-frog" connected vehicles
- A "hospitable" place for Uber wouldn't regulate software; they would ensure basic assurances for safety but step out of the way and allow companies to take on the commercial risk and manage the insurance environment; provide a framework of incident reporting
- Accepting of road pricing models, as long as it is applied evenly and consistently

Carnegie Mellon University (Roundtable and Lab Tour)
The widely-recognised 'birthplace' of the autonomous vehicle, Carnegie Mellon University shared insights into techniques for fostering research and innovation, in partnership with industry:
- Meeting Heinz College Dean, Ramayya Krishna, introducing Traffic21 / Mobility21 / Metro21
- Not-for-profit, focussed entirely on education and research, with many indirect links to industry (people moving back and forward between faculty and industry)
- Motto is "Technologies for Safe and Efficient Transportation"; a wide-ranging program including technology research, mobility research, etc as well as research into a range of social factors and policies such as ‘wage insurance’ that supports disrupted transport workers for a period to retrain in new industries, efforts to make cycling more attractive, etc
The Collaborative Innovation Centre (CIC) on campus gave birth to Google!
CAV Policy and Infrastructure Investment: started in off-road automated vehicle research in 1970s for purposes such as unmanned exploration, such as after Three Mile Island incident; on-road research began with DARPA challenge in 2007
Research into active driver warning systems demonstrates positive BCR and supports consideration for regulatory mandation of such technologies
Further support for use of policy rather than regulation of technology, due to rate of change; it is still not resolved how the US will resolve this at a national level; draft state bill 427 is likely to require some compromise to satisfy industry
Connected Automation: CMU is a key contributor to efforts by others nation-wide, such that they are confident that it is not a matter of "if" but only a matter of "when" it is mainstream; very bullish on development in pursuit of positive community outcomes (safety, etc) and therefore expects steady, incremental, organic growth towards true full-autonomy in 10 years
Strongly advocates for CV technologies to augment AV capabilities, due to enhanced safety capabilities where AV limitations exist
Static Demo of Autonomous Vehicle (in lab)
Road Surface Monitoring Research (in lab)
SURTRAC Adaptive Traffic Signal Research: real-time optimisation, decentralised control, coordinated action; reactive to local events plus information from upstream
Performance improvements observed of 24-26% in travel time, 31-40% in number of stops, 41-42% in waiting time; currently scaled to 50 intersections, 150 more on the way (supporting the Smart Spine initiative)
Provides a convenient compute platform at each intersection for DSRC/SPaT, plus potential for associated better sensing, incident detection, real-time rerouting, etc

ARUP-hosted Dinner with C-CAV, RDM, TfL, HE
By means of a well-facilitated, multi-party discussion hosted by ARUP UK, the Roads Australia delegation were challenged to think differently about the role of government in fostering, rather than regulating, the CAV revolution:
Paresh Tailor: Highways England established (wholly owned by Secretary of State) in 2013 with the challenge to increase investment, efficiency and value from transport infrastructure; coherent and consistent national approach; given 5-year funding certainty for road reform; currently 3,500-4,500 staff, half of which is in operations, plus outsourcing
Two years in, now a good understanding of the £15b programme to be delivered over 5 years; emphasis on safety (drivers and road workers), customer service, and delivery; intention to reduce politically-based motives in favour of economic (etc) ones
'Monitor' (regulator) provides governance; same agency that previously regulated rail; interesting challenge in clearing defining roles -- owner of business also wears political hat!
Ian Forbes (Head of C-CAV): clear safety benefits in automating the driving task; increasing mobility for an aging population; growth of high-value jobs in transport technology; how do you secure against cyber threats?
$0.5b of investment in CAV trials in England, 50% by government and 50% by industry; UK Autodrive enjoys a wide range of stakeholders and contributors across many areas of business, industry and government
Very open regulatory environment (defined through flexible guidance rather than statute) to allow introduction and use of AVs; new first-principle for insurers to pay when an AV is involved (but may recoup through product liability from third parties later)
- Lessons: work together, work incrementally, only solve the problems you absolutely need to now, expect to change and evolve; keep learning
- Public perception and trust is a key factor; research on social factors of AVs is still weak
- Data collection and sharing will be critical; who owns it?; who can commercialise it?; what supporting infrastructure is required and can we afford it?; how fast will it be obsolete?
- Mike Hawes: the challenge of transitioning from an automotive provider to a mobility provider, and thus an automotive industry to a mobility industry
- Philosophy: "If you want to go fast, go alone. If you want to go far, go together."

ARUP-Sponsored Roundtable Meeting

In London, Isabel Dedring (Global Transport Leader for ARUP, previously London’s Deputy Mayor for Transport, and the former Environment Advisor) hosted a significant gathering of UK experts, allowing a deep-dive into a wide range of issues and opportunities:

- John Miles: an era of great change in transport, far reaching and community changing; not just about vehicles but a true mobility reform; in the Twitter age, the consumer will judge and be the catalyst of the reform
- Network ownership & management: traditionally, governments provide roads to citizens as a public benefit; how will this change in the future when mobility becomes a service?
- Sydney has 16m private vehicle journeys / day, if it becomes a commoditised service worth $1b per week to mobility providers, how should we fund roads, and how will availability and equity be considered for more remote citizens?
- Private hire operators (e.g. Uber) lightly regulated with local variations; pursuing strategies to make true ride-share more attractive through small buses and dynamic routing, preferable to private vehicles carrying single passengers; in UK, private hires pay for license to operate
- Is a distance-based road charging fee a superior mechanism to replace registration, duty, fuel tax, etc to fund future road infrastructure investments? Advantage of micro-transactions over large annual fee; road pricing in central London affects 100,000 out of 9m residents and costs around £10 per entry, ANPR based and electronically charged; UK also has distance-based excise scheme for lorries working between UK and EU (as EU vehicles avoid MOT)
- Public/private sector collaboration: reform to widen mobile telecommunications coverage across the UK to serve connected vehicle initiatives; reform to insurance to prepare the way for autonomous vehicles; quite a lot of moving parts within public/private collaborative environments that are constantly changing and challenging
- Testing but no expectation of mandation of V2V safety technologies akin to USDOT NPRM; issues with spectrum allocation and concerns of "nailing technology colours to your mast"
- Previously roads, signs, telecommunications, TMC, etc all in house and relatively proprietary, but increasingly now need to become interoperable with multi-party collaboration including privatisation; concerns about dependence of technologies on line-markings, EV rapid-charging infrastructure, etc and multitude of needs for different technologies, as well as the transition between human/automated driving duplicating costs during that transition
- Will V2V and V2I capabilities sit alongside other vehicle safety systems and influence things such as brand differentiation and NCAP ratings in order to justify its investment?
- Evolution and transition: C-CAV exists because government has a key role in convening industry cooperation, information to broader stakeholders across a range of sectors to understand potential synergies and impacts, collectively moving conversations forward or fostering key research to remove barriers; identifying and translating common ground
- For collaboration to work, contributors must be equally motivated to manage the shared risk or capitalise on the shared opportunity, and willing to openly act and commit resources
- AVRT = affordable very rapid transit; local governments, communities and property developers working together to foster a solution to next-gen transit
- UK Lessons are that congestion will increase 27-57% growth in traffic on strategic road network by 2040, and so looking for CAV to address this issue; previous provisions made in fibre optic and cellular networks in more remote areas, but assumed correlation/co-location with strategic road networks (car phones) rather than within villages (smart phones), etc
- Unintended consequences = congestion tax for London reduced vehicles but congestion and delays still increased ... why? Increased number of traffic signals, number of buses, creation of cycling lanes, etc
- Rail network costs are very high, productivity increases are difficult, in an era when the road industry is moving towards improved performance and lower costs; where does that lead?
- Post-war agenda saw nationalisation and centralisation of power in government, taxation, services, etc; however, TfL at the city level has relatively strong power in transport decisions and policies; London low-emission targets and congestion charging was a brave, bold move delivered through clunky but reliable technology (even now, 25% of revenue is spent in operating) but was paired with public transport reform, and didn’t directly affect a large number of voters; separate initiative delivered 40% improvement in Underground delays while improving quality and aesthetics
- Isabel Dedring: the political vehicle for congestion charging was environmental (air quality); distance-based charging is inevitable but politically won’t happen soon; initiative to unify paid services that exist (tolls, London charge, etc) through one account/portal; the politics of urban road space will resist dedicating lanes only to AVs, but motorways offer potential for that
- Require common pricing strategy/platform across all transport (Oyster card, Uber account, vehicle use, etc) to allows levers to be adjusted in concert to achieve policy outcomes without unintended consequences of adjusting independently
- Ride share: Challenge of cannibalisation of public transit services by ride-share; there are 42,000 Uber drivers registered in London
- Freight: Just about to launch a freight-based trial; the technology is proven but what difference will it make in the UK environment? Platooning just 2-3 vehicles initially before considering larger convoys; safer environment compared to human-driven slipstreaming

UK Autodrive Programme

Milton Keynes County Council is home to the UK Autodrive programme, the largest UK CAV trial performing under real-world conditions, in partnership with industry:
- One of three C-CAV pilots in UK; the largest, with active OEM engagement (Jaguar Landrover) and contribution by ARUP; taking to the streets in Milton Keynes and Coventry
- Launched in Nov 2015, eighteen months into a three-year programme, progressing from behind closed doors lab work and test-track proving, into on-road ‘in-theatre’ testing
- JLR, Ford, TATA Motors, RDM Group, Coventry City Council and Milton Keynes Council, plus support from ARUP, AXA, Transport Systems Catapult, etc
- Two parts: M1 (regular car refit) and L-SATS (novel, low-speed pod, wheelchair accessible); staged exposure to increasingly complex scenarios
- M1: Testing advanced highway adaptive cruise control, GLOSA and EEBL using DSRC
- L-SATS: Aiming to deliver first five (of 40) ‘in theatre’ by Nov 2017, pre-designated pathways provided, delivering transit service by May 2018, then six months of tuning and testing as a service to determine success (or not) of intended community mobility benefit; remote emergency intervention centre has controller who observes and can take remote control
- Have reached out to the likes of Singapore to attempt to form a 'club' of real-world AV labs, but not currently engaged or active; have been approached by Uber to share experiences
- Cities Programme: national attitudes survey (pre & post); micro-simulation
- Two whitepapers produced for UK Autodrive through Gowling WLG, "Are You Data Driven" and "The Moral Algorithm"; the next whitepapers will be on Liability and Insurance, Data Haves and Have-Nots, Interoperability

Swedish Ministry of Enterprise and Innovation, Swedish Transport Agency

In Sweden, significant cultural factors play a role in the community's interest and engagement with mobility innovation, where 'green' is the only way, and efficiency is not just a buzzword:

- The Ministry's transport policy sections (org chart provided) are relatively small, but work closely with regulatory agencies to implement those policies
- Philosophy of collaboration between research, industry and government; clearly defined boundaries around IP and terms outlining what is shared and what is not
- Solid record of vehicle safety; sustainability agenda; world-leading vehicle manufacturers; strong ICT industry and infrastructure; early-adopter culture; and successful start-ups
- CAV pilots include: Wallenberg Autonomous Systems Program (WASP); Drive Me (100 normal families, studying social factors); Scania (freight platooning); Volvo (mine sites); Kiera Urban ICT Arena (Ericsson 5G test site); Drive Sweden (strategic program in mobility services); ASTAZERO (full-scale test facility)
- Involved in EC programs such as DG MOVE, DG RTD, DG CNECT, and C-ITS Platform work
- 'Open Cloud' in Gothenburg to unify data sharing between strategic innovation partners
- Currently require a driver to be present in AVs under test on public roads; existing laws and legislation have been adequate, only requiring clarifications; must have insurance for all cars; legal clarification on liability and cameras/surveillance due in Nov 2017
- Uber and carpooling exist (not legal without taxi license), have liberal taxi industry but definitions of 'sharing', payment, insurance, etc differentiate private sharing from Uber/taxis
- The Swedish deregulated bus industry would allow UberPOOL, but public services are heavily subsidised so would find it difficult to compete
- Community/cultural attraction to AVs is mobility as a service, safety, easy mode transfer
- Major benefits through connected vehicle technologies (seems manufacturer-specific rather than standardised?), with C-ITS Platform initiative attempting to achieve interoperability
- Swedish/European approach to MaaS uses public transit as the backbone with open data connecting transport agencies and industry, so that ride-sharing (etc) augments and links to those services, rather than a proprietary Uber/Lyft platform
- Truck platooning solutions under test are well developed, which the Ministry is encouraging (no legal or policy roadblocks, require just a single "driver") with a safety management system approach being considered, but not yet developed
- Public education and information is under consideration for Gothenburg trial of 100 vehicles; is it better to inform people for safety, or will that encourage people to 'interfere' with it?
- How will road infrastructure be funded in the future? As-is now, central tax base (no fuel tax or distance-based charging, etc)
- Drones are considered an aviation department issue, not a transport issue; drone-based delivery has not come to Sweden; significant privacy debate over use of drones (cameras) linked to CCTV/surveillance concerns and laws
Ericsson

The quiet achiever providing the heavy-lifting communications technology behind 40% of all internet traffic carried worldwide, Ericsson brings a unique perspective to the future world of CAVs through the eyes of the consumer that it liberates:

- 140 years old; networks, IT, media, industries; 42,000 patents, 24,000 R&D employees
- Vision: A networked society; Mission: Lead transformation through mobility
- 5G + IOT + Cloud = the 5th technological revolution, now at the inflection point from installation to transformation
- Trends in transport: connected, electrified, automated, shared, MaaS
- Connected => Cooperative => Automated
- Ericsson Connected Traffic Cloud is V2I-connecting traffic signals, bus stops and public transit vehicles in real time in Gothenburg; connecting open data interfaces; developing analytics features; developing into complete ITS platform ("The Nordic Way")
- Vehicle manufacturers share aspects of their V2V/V2I data with the Traffic Authority cloud, allowing traffic management decisions to be made, and information/actions conveyed
- 5G battle is fierce between Asia, Europe and US; while initial deployments will occur in 2018, standardisation, mass production and deployment/saturation is 3-5 years away
- Drive Sweden: test site in Kista of EZ10 automated buses (including 5G test network); platooning of Scania trucks; supporting Volvo 'DriveMe' self-driving development (in Gothenburg)
- Beware of Self-ish-Driving, i.e. self-driving AVs without connectivity or open data sharing!

Ericsson’s 5G test station
A view of the future at the Ericsson Studio
Scania

CAVs are revolutionising the movement of people, but the bigger revolution is the automation of the road freight task – a revolution that Scania has been leading through insatiable dedication to customer services and smart vehicle technologies:

- Company presentation: provide trucks, buses/coaches, engines and services; founded in 1891; employs 44,500 people worldwide; can remotely monitor vehicles to customise maintenance services based on data; modular system (engines, gearboxes, axles, cabs)
- New truck generation (Truck of the Year in 2017) is 5% more fuel efficient, has improved driver features/environment, better payload (in some instances), better 'uptime', etc
- 350,000 truck drivers in 50 countries 'compete' in Scania Driver Competitions to incentivise economic fuel use, safe driving, smart maintenance, etc
- 250,000 connected vehicles (65% of fleet), testing of truck platooning, initial testing of autonomous trucks in 'closed' areas such as mine sites
- ADAS&ME project: advanced driver assist systems, incorporating driver, environment and adaptive HMI to automatically monitor and hand over different levels of automation
- 15 research partners in academia, transport authorities; 10 industry partners, 3 companies, 2 associations (30 partners altogether!)
- Use Case: Autonomous Long-Haul Trucking, based on previous work on "traffic jam pilot" advanced cruise control in low-speed, traffic-following environments, keeping in the lane, pacing with preceding car
- Tailoring handover techniques through monitoring of driver state (e.g. awake/alert but reading a book, versus tired but looking out the windscreen) => states include sleepiness, distraction, stress, emotions, rest => testing HMI/response actions progressively through VR, full-sized simulator, real-world vehicle
- Interesting research into driver behaviour, emotion and trust; such as drivers without additional information through HUD (etc) more likely to incorrectly act to 'correct' automated action, or sit with foot poised over the brake pedal, etc