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Intelligent Transport Systems

SMART TRANSPORT FOR AUSTRALIA

ENHANCING LIVEABLE CITIES AND COMMUNITIES

Brian Negus
President ITS Australia and
General Manager Public Policy
Royal Automobile Club of Victoria (RACV)

Susan Harris
Chief Executive
ITS Australia



716 regulatory barriers to Australian automated vehicle trials



Between
2020 & 2026
semi autonomous tech introduced to most of the market

13,800km
annual typical distance driven by an Australian passenger vehicle

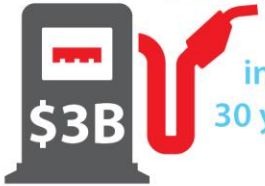


98% of Australians are concerned about growing traffic congestion



amount the average **Australian family** pays per year on **household transport**

estimated amount
Fed Gov will lose in fuel tax in the next 30 years



19% forecast growth of Australian domestic passenger task by 2026

30-35 yrs
Australian cities will double in size

800,000 km total km of roads in Australia

$25 m contribution to Australian economy
11,500 Delegates
73 Countries
3,500 Demonstrations

ITSWC16 MELBOURNE

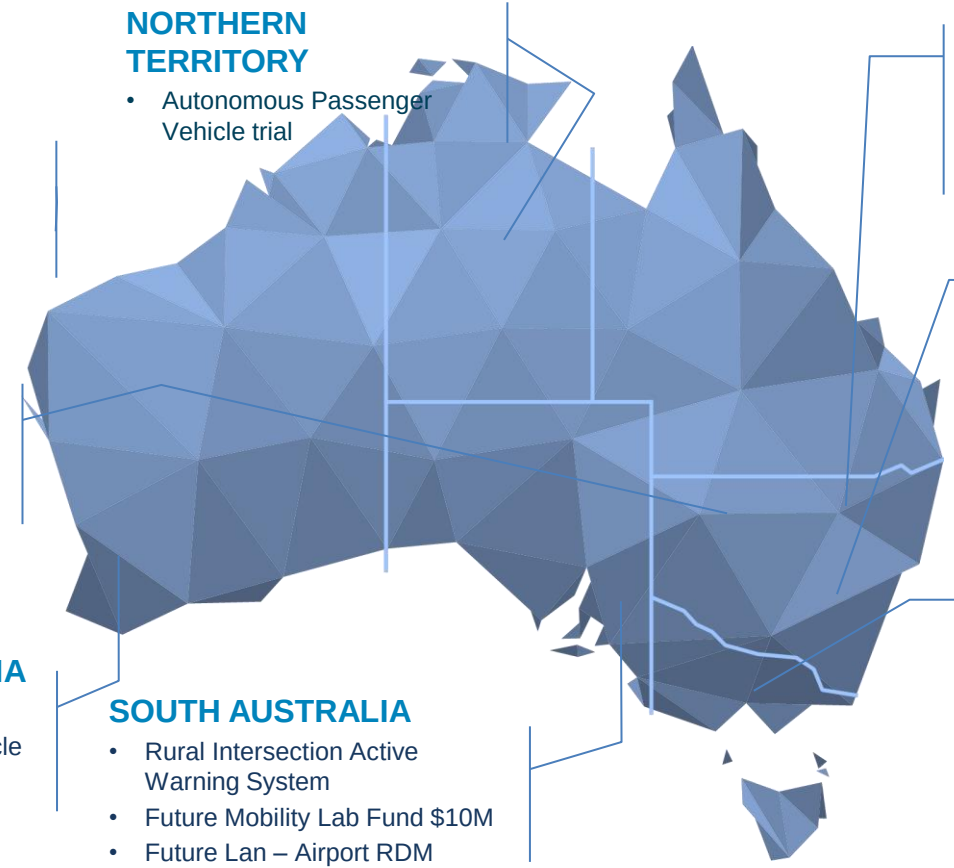


the average number of **mobile phones** per person in Australia

the expected increase in total **demand for freight** over the next 10 years



AUSTRALIAN CAV INITIATIVES



NORTHERN TERRITORY

- Autonomous Passenger Vehicle trial

QUEENSLAND

- CAVI - Connected & Automated Vehicle Initiative

NATIONAL

- Australiasian SBAS Testbed

NEW SOUTH WALES

- CITI – Cooperative Intelligent Transport Initiative
- Heavy Vehicle Priority Project
- Smart Innovation Centre

Australian Capital Territory

- 2 year Autonomous vehicle, testing driver monitoring systems

VICTORIA

- ITS Transport Technology Grant Program
- Road Safety Action Plan
- Bosch Highly Automated Driving Vehicle
- Transurban CitiLink Automated Vehicle initiative
- Eastlink Driver Assisted Technology
- University of Melbourne Multi-model tested
- HMI Technology and RACV Navya Bus Trial

WESTERN AUSTRALIA

- RAC Intellibus
- Autonomous Heavy Vehicle Platooning Trail

SOUTH AUSTRALIA

- Rural Intersection Active Warning System
- Future Mobility Lab Fund $10M
- Future Lan – Airport RDM Flinders

PATHWAYS TO CONNECTED AUTONOMY

Opportunities

1. Support **CAV trials** in Australia
2. **Leverage** trials to build public engagement
3. Foster local and international **exchange**
4. **Nationally consistent** performance based guidelines
5. Support **co-ordinated multiple brand trials**



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MOBILITY FOR SMART CITIES AND COMMUNITIES

Opportunities

6. Link ITS solutions with other government priorities
7. Emerging transport trends are considered in all major town planning activities
8. Promote Australian success stories such as our managed motorway deployments

'A congested freeway is a poorly managed freeway. As road managers, we can no longer accept poorly performing freeways as being normal.'

John Gaffney, Manager Network Operations, VicRoads

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NEXT GEN PUBLIC TRANSPORT AND MAAS

Opportunities

9. Australian demonstrations and deployments of MaaS.
10. Open, real time, dynamic road and public transport data sets
11. New tools – to research, select, book and pay across transport choices.
12. Open the market:
    - booking and payment by third parties
    - mobile ticketing for public transport.
13. Identification of first deployment



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BIG DATA, ANALYTICS, OWNERSHIP AND ACCESS

Opportunities

14. Real time dynamic data, **freely available**.
15. **Government and industry collaboration** to ensure asset owners get data needed
16. Showcase **Australian** expertise in Big Data analytics and Cyber Security
17. **High speed, low latency data networks**
18. **Reliable and ubiquitous network coverage**
19. Back office systems must be interoperable – **machine to machine connectivity**.

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FUTURE FREIGHT

Opportunities

20. Enhance driver and community **safety**.
21. Encourage freight activity to occur when passenger demand for the transport network is low.
22. Encourage ITS related **parking solutions**
23. ITS technology to **improve appropriate access for freight** to our transport networks
24. Support **supply chain visibility** and interoperability



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PRICING & FUNDING

Opportunities

Infrastructure Funding

25. **Funding security for our transport infrastructure**
26. A joint robust business case framework - government and industry
27. Ongoing **maintenance costs** budgeted for
28. All **new transport infrastructure projects** as opportunities to leverage technology.

Pricing

29. Test a range of options with the community - engagement
30. **Hypothecation**
31. Engage in the debate to **promote consensus**
32. Build discussion and understanding in the **community**
33. A **fair and equitable** approach

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FRAMEWORKS FOR SUCCESS

Opportunities

Standards and Regulations

34. **Nationally consistent**, performance based, harmonised internationally
35. Actively contribute to **international standards**

Privacy and Security

36. Nationally consistent approaches to privacy
37. **Cyber Security**
38. **Privacy of personal data** will be critical

Community Considerations

39. Retain benefits of **no fault motor vehicle insurance**
40. Enhanced transport access
41. **Promote public awareness** and acceptance

Skills and employment

42. Support initiatives to **ensure Australia has a strong skill base**
43. Explore the impact on **employment** changes - in the context of broader social change



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PLATINUM MEMBERS



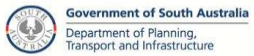


GOLD MEMBERS

























SILVER MEMBERS





















































AUSTRALIAN INITIATIVES

GOVERNMENT

Federal Government

- ❑ National Policy Framework for Land Transport Technology (& Action Plan)

National Transport Commission (NTC)

- ❑ Land Transport Regulation 2040
- ❑ Regulatory Reforms for Automated Vehicles
- ❑ Guidelines for trials of automated vehicles in Australia
- ❑ Regulatory options to assure automated vehicle safety in Australia

Austroads

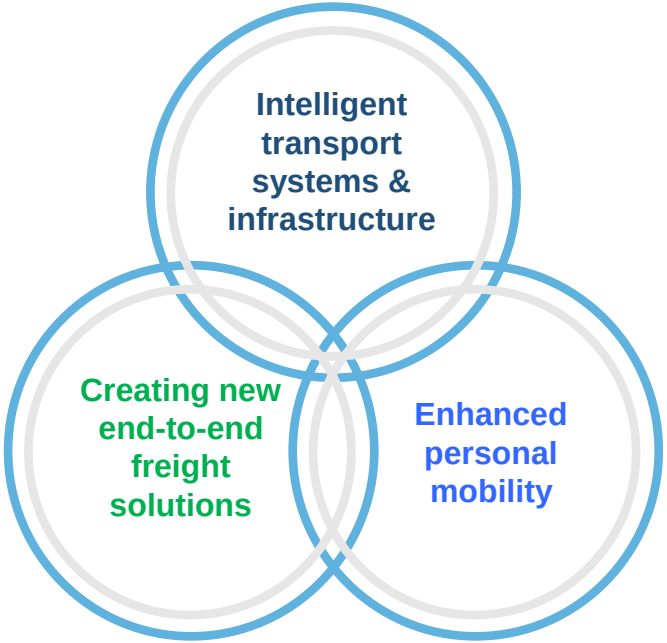
- ❑ Concept of Operations for C-ITS Core Functions
- ❑ Privacy Impact Assessment (PIA) for Cooperative Intelligent Transport System (C-ITS) data messages
- ❑ Registration, Licensing and CTP Insurance Issues Associated with Automated Vehicles
- ❑ Assessment of Key Road Operator Actions to Support Automated Vehicles



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AUSTRALIAN INITIATIVES

iMove Cooperative Research Centre

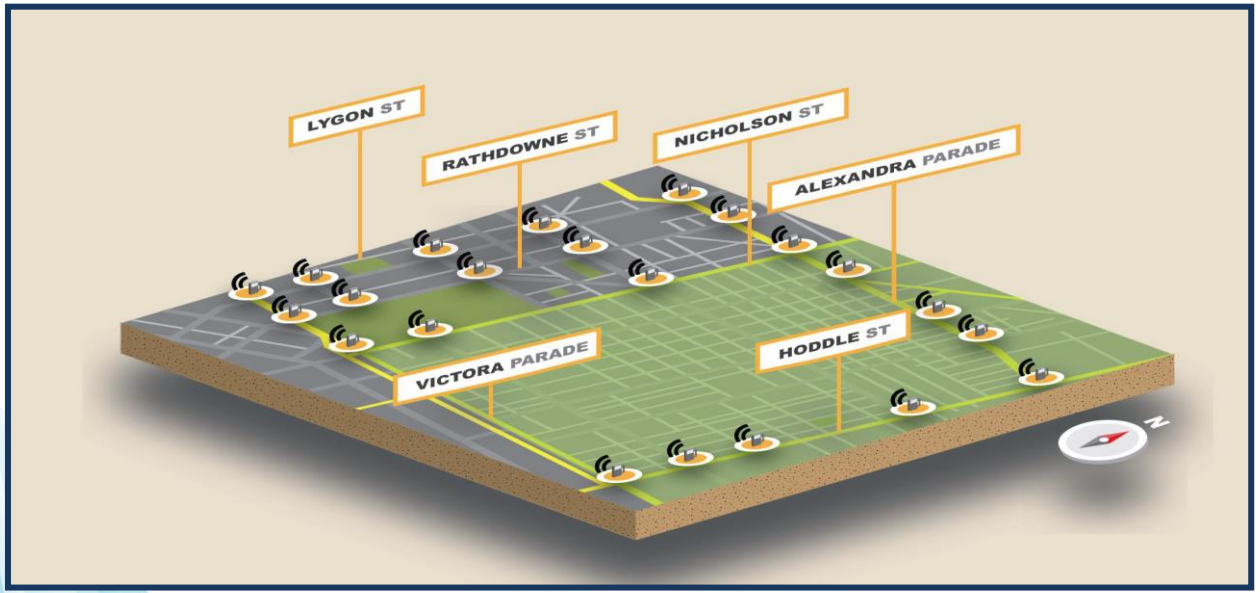


- *$245M, 10 year program*
- *$55M of Federal Govt support*
- *Three Reseach themes*
- *46 partners across industry, government and research, and growing …*

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AUSTRALIAN INITIATIVES

Melbourne ‘urban laboratory’ Test Bed



THE UNIVERSITY OF MELBOURNE

The world’s first urban laboratory (testing ecosystem) for implementing and testing of emerging connected transport technologies at large scale and in complex urban environment

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its2017
Australian Intelligent Transport Systems Summit



27 - 28 SEPTEMBER 2017 | BRISBANE CONVENTION AND EXHIBITION CENTRE

REGISTRATION OPENS MAY 2017

- ✓ 2 Days Sessions
- ✓ Attendance: 300+ intelligent transport systems executives (national and international)
- ✓ Keynote and invited speakers
- ✓ Workshop and Panel Discussion
- ✓ Optional technical tours
- ✓ Welcome Reception networking function
- ✓ Program and registration – NOW OPEN

INDUSTRY PROMOTION

- ✓ Sponsorship Opportunities
- ✓ Industry Trade Display

TRANSFORMING TRANSPORT

- ✓ Connected and Automated Vehicles
- ✓ Mobility as a Service
- ✓ Transport for Smart Cities



Hosted by ITS Australia in partnership with Queensland Department of Transport and Main Roads

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Queensland Government

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REPORT ON AUSTRALIA'S FUTURE IN INTELLIGENT TRANSPORT SYSTEMS – LEVERAGING THE 2016 ITS WORLD CONGRESS IN MELBOURNE, AUSTRALIA

SMART TRANSPORT FOR AUSTRALIA

ENHANCING LIVEABLE CITIES AND COMMUNITIES



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March 2017
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INTRODUCTION



ABOUT ITS AUSTRALIA

Intelligent Transport Systems Australia (ITS Australia) promotes the development and deployment of advanced technologies to deliver safer, more efficient and environmentally sustainable transport across all public and private modes – air, sea, road and rail.

Established in 1992, ITS Australia is an independent not-for-profit incorporated membership organisation representing ITS suppliers, government authorities, academia and transport businesses and users. Affiliated with peak ITS organisations around the world, ITS Australia is a major contributor to the development of the industry.

Key activities include convening national summits and international conferences, facilitating dialogue between transport modes and across government jurisdictions, promoting research and development and the export of Australian technologies.

ITS Australia has hosted the prestigious ITS World Congress on two occasions including in Sydney in 2001 and Melbourne in 2016.

Susan Harris
CEO ITS Australia

ABOUT THIS REPORT

This ITS Australia Report has been prepared by Fivenines Consulting. The Report describes the status of ITS in Australia, provides examples of initiatives and opportunities for their future development and deployment and then summarises future opportunities for Australian business, researchers and government in this significant sector.

It is based primarily on the formal and informal exchange of information at the 23rd ITS World Congress, held at and around the Melbourne Convention and Exhibition Centre from 10-14 October 2016.

The words of some of the leading experts on ITS topics locally and from around the world are used to highlight trends and opportunities throughout the document. The images, tables and graphs contained in this report were presented during the World Congress 2016.

The paper sets out a summary of the key messages under seven topics. Background and scene setting information is presented for each topic, followed by an explanation of the Australian context and the developments and opportunities for the Australian ITS sector.

Fivenines Consulting has a focus on analysis and strategy for the transport sector, particularly involving new technology. Robert Eames has worked with all Australian jurisdictions in transport policy, regulation and service delivery. Geoff Shanks is a former senior executive of VicRoads and has consulted locally and around the world on vehicle registration and driver licensing as well as broader aspects of regulatory and operational change.

FOREWORD





23RD WORLD CONGRESS ON INTELLIGENT TRANSPORT SYSTEMS

The 23rd World Congress on Intelligent Transport Systems, Melbourne, from 10th to 14th October 2016 was an opportunity for the ITS community to come together to discuss the Congress theme 'ITS-Enhancing Liveable Cities and Communities' in the world's most liveable city. Hosted by ITS Australia, it explored how advanced technologies will assist with increased connectivity, improved mobility and safer, more reliable and convenient transport networks.

The Congress was attended by more than 11,500 delegates from 73 countries. Opened by Prime Minister, Malcolm Turnbull, there were 663 speakers in 236 sessions and 25 associate meetings.

The 17 Technical Tours provided insights into air, sea, road, freight, public transport, research and communications centres. More than 3,500 technical demonstrations were provided by 14 demonstration partners on Melbourne's public roads and at Albert Park.

The Federal Government High Level Policy Roundtable was attended by 52 international and interstate Ministers and Mayors from more than 20 countries. A Smart City Hackathon was held on the opening weekend and more than 2,500 members of the community attended the open for public days and public discussions, and school and university students participated in a range of challenges, programs and competitions.

This provided an unprecedented opportunity to:

- Showcase Australian expertise in ITS
- Expose Australian leaders as ITS professionals to global trends and thought leaders in ITS
- Strengthen links between Australian infrastructure leaders to their international counterparts fostering on-going collaboration

The 2016 ITS World Congress in Melbourne benefited the economy by A$25 million. But what are the long term benefits of ITS for Australia? To capture key themes from the Congress and consider future opportunities for the industry, ITS Australia has collaborated with Fivenines Consulting to compile this report. We have taken the opportunity as a result of the rich information gathered to recommend a Pathway Forward to promote the development and adoption of smart technology solutions to improve safety, mobility and sustainability.

Brian Negus
President ITS Australia and
Chair of ITS World Congress Board 2016

Quotes about the 2016 ITS World Congress in Melbourne

'The ITS World Congress is the most significant meeting of the world's ITS policy makers from Government, private sector, academia and business. Good transport is critical in supporting productive, accessible, liveable cities that attract talent, encourage innovation and create jobs and growth.'

Malcolm Turnbull, Prime Minister of Australia

'Fantastic event. Best one I have attended.'

Kenneth Leonard, Director, US Department of Transportation

'What a really good World Congress. Huge learnings and great company.'

Leon Daniels, Managing Director Surface Transport, Transport for London

'You have definitely done your members proud. It may be some time until you see or hear of our team as we are all flat out trying to deal with the work generated by the congress and your efforts.'

Andrew Bull, Managing Director, Aldridge Traffic Controllers

THE TRANSPORT TASK

Transport plays an essential role in any economy, whether moving people or freight.

According to a recent report by the National Transport Commission,[1] one third of Australian freight (measured by tonne-kilometre) is delivered by road while half is delivered by rail, with the remainder delivered by sea and air. Rail freight primarily comprises bulk commodities over long distances, while road freight supports time sensitive commodities, consumer goods and construction goods in particular.

Of the estimated 427 billion passenger-kilometres, 79% is travelled by road, 17% by air and 4% by rail.

It is estimated that the total demand for freight tonne-kilometres will increase by 26% and passenger-kilometres by 19% over the next 10 years.

Increasing demand and rising expectations about quality and speed (of both freight and passenger movements) together place pressure on existing transport systems in Australia and across the world. Despite ongoing efforts in new and upgraded infrastructure it is never sufficient to fully satisfy demand.

'China's new highway construction every year is equivalent to the total amount of highway in Japan. But we face rapid growth in traffic demand and traffic congestion is still a common problem for our cities.'

Patrick Cheng, CEO, NavInfo

Congestion is a high profile symptom of the problems caused by growing demand meeting available infrastructure.

'We will be relying on technology to help manage many of our future transport challenges… because we know 98% of Australians are concerned about growing traffic congestion. We can turn this growing problem (congestion) into a revolution in transport for the betterment of us all.'

Scott Charlton, CEO, Transurban

[1] NTC Who moves what where Report Aug 2016 https://www.ntc.gov.au/Media/Reports/(D62E6EFC-36C7-48B1-66A7-DDEF3B04CCAE).pdf

The combination of pressure to provide better and more transport, and the availability and business opportunities provided by new technology, mean that the development and deployment of technology based transport improvements are of great social and economic significance.

This Report does not explore the need to improve transport solutions in detail as the subject has been widely covered elsewhere. However, it is worth identifying the key drivers as different ITS solutions respond to different needs. At a high level, change is pursued because:

- Congestion and lack of connectivity in some places create pressure for better services or infrastructure.
- Safety performance does not meet community expectations.
- New and emerging technologies offer economic benefits.
- Social equity and other policy outcomes are achieved by increasing access to transport.
- Current transportation solutions are often more expensive to operate and maintain than the technology based alternatives would be.
- Disruptive technologies are changing the way transport is provided and used.
- Existing infrastructure needs to be refreshed periodically – this is an opportunity to improve on the status quo.
- New transportation options are required to support evolving population and social needs.
- Smart technology transport solutions have a lower environmental impact.



OVERVIEW

This report is based on discussions and presentations at the 23rd ITS World Congress and the use of smart transport technology and communications systems to enhance the liveability of Australia's cities and communities.

ITS Australia has built on the discussion at this event to plot a path forward for the ITS industry in Australia. The report considers seven focus areas.

PATHWAYS TO CONNECTED AUTONOMY

Vehicles that communicate (connected vehicles) and have some degree of automation (ultimately being autonomous) are core to delivering the benefits of ITS. While much of the technology is available or in test, the potential to go further is immense. However, developing the technology is only part of the challenge because each innovation will be introduced to networks that were created without these technologies in mind and must co-exist. The pathway to connected autonomy is therefore of great importance.

National uniformity of platforms and regulations is critical so that all systems can operate safely and efficiently together and therefore maximise value to the community.

Trials and pilots already underway, often supported by essential seed funding from government, industry and academia, have generated strong engagement from stakeholders and interest from the public.

It will be essential to foster Australian expertise in this area and broaden the current skill base to build on these trials and other developments. The iMOVE CRC will accelerate this should it be established and become operational.

MOBILITY FOR SMART CITIES AND COMMUNITIES

Cost and sustainability in increasingly urbanised settings are placing intense pressure on resources. Society increasingly expects services and infrastructure to be provided in a coordinated or 'joined up' way to improve efficiency, reduce waste and make cities more liveable. Transport can only be coordinated once ITS technologies are in place.

ITS can ease congestion and make better use of infrastructure, even to the extent of dramatically increasing network capacity without adding more roadway or rail track. ITS can also optimise the deployment of new investment, reduce the need for ongoing maintenance and monitor the condition of infrastructure so that failure can be pre-empted.

Data from ITS systems is also essential to permit wise planning decisions to be made, informed by real and recent data rather than out of date, assumption based forecasts of demand.

Real time monitoring of congestion points and economic bottlenecks will allow freight and passenger movement to be optimised, giving travellers more information about their journeys.

ITS has a vital role to play in delivering priorities such as economic efficiency by reducing congestion, pollution and any environmental impact while promoting the attractiveness of smart cities to investors and potential residents.

Integrated city planning must take account of ITS opportunities such as Mobility as a Service, car sharing and connectivity in working towards the Smart City concept.

NEXT GENERATION PUBLIC TRANSPORT AND MAAS

Public and shared transport is a vital component of both the Smart City and the broader connected community. New business models require new regulatory models. Open standards for data and systems create opportunities for interoperability at a local, regional and, potentially, global level.

Mobility as a Service (MaaS) will provide a coordinated approach to delivering transport services that are currently disparate. Early trials overseas demonstrate public support for MaaS if implemented well and Australian demonstrations and deployments merit support.

Open, real time, dynamic road and public transport data sets are pre-requisites for MaaS, and commercial service providers and governments alike have a vital role to play in opening up data without limiting commercial opportunities. This will also enable multi-modal traveller information tools to support optimal user choice, probably increasing public transport usage as a result of point-to-point information becoming available.

The next step will be to identify an initial deployment within Australia.

BIG DATA, ANALYTICS, OWNERSHIP AND ACCESS

Many new data elements can now be collected as a result of the development of ITS technologies. This data provides dramatically better knowledge of transport demand and usage, as well as providing the capacity to cross-link databases to answer questions that have been unanswerable in the past. Big data will change transport and society in ways that are only beginning to emerge.

In this emerging discipline many foundation issues are still being worked through. While individual data elements may be insignificant, together they provide huge volumes of information for analysis by multiple agencies. The questions of data ownership, access and privacy are ongoing discussions.

Accessing and combining real time data enables dramatically better planned and organised services. Data has commercial value so private or franchised operations may need to be required to share data for the greater good. In addition, systems need to be interoperable, or at least able to exchange data easily.

Progress with ITS initiatives in Australia will be supported by wise policy and regulation about data sharing, industry collaboration to support integrated views of data, and high speed, low latency networks which support emerging ITS technologies.

There is also a growing shortage of people with analytical and technical skills to organise and use big data. The capacity of Australian business and government to exploit big data aspects of ITS depends on skills development and the capacity of the ITS sector to compete with other big data users in attracting capable people.

FUTURE FREIGHT

The public is more aware of the impact of ITS on passenger journeys than on freight, but arguably the freight industry is further advanced in its adoption. While the Australian freight sector is already competitive and efficient, ITS is bringing new benefits to individual operators and their clients as well as to the system as a whole.

Freight competes with passenger movements on road and rail. On both modes the speed and scale of each is different so ITS must contribute not only to freight in isolation but also to freight in mixed traffic.

Advances in vehicle and infrastructure automation through innovations such as truck platooning, combined with the intensive use of real time data from connected vehicles, assists operations, compliance and safety alike.

As with other focus areas, trials and pilots are vital if the industry is to progress and remain a world leader. Promotion of the benefits of ITS as a strategy to improve network access is critical and the Transport Certification Australia Intelligent Access Program is a model of such initiatives, particularly as it delivers performance based access.

There is more scope for the development and implementation of parking and consolidation services in congested cities, avoiding empty or part loads over the last mile.

ITS can also enable information to be used to avoid queues at concentration points such as docks and to better utilise off peak times when the freight impact on the system will be less.

TRANSPORT PRICING AND FUNDING

Transport costs are currently opaque and there is extensive cross subsidisation. ITS can help identify true trip and usage costs for the first time, allowing both explicit cost recognition and responsive pricing – whether the latter is used to reflect true costs or to steer behaviour.

Explicit costs will make it easier to justify collaborative investment by different parties and in turn make investment choices more explicit to payers (including the voter).

There is growing pressure for new transport (primarily road) pricing models and ITS is an essential enabler.

In Australia, road funding comes from funding allocations by each level of government, while usage-based recoveries have primarily come from fuel excise. This tax does not accurately reflect usage for example either space occupied on road infrastructure, peak time travel congestion or the physical impacts from vehicle mass, on the roads. With the advent of electric vehicles and share car systems this lack of equity is compounded by varying vehicle and fuel efficiencies. One of the key challenges in understanding the complexities of the taxes on road usage, and arguing for changes, is that the majority of road users do not appreciate the impact of these costs on the household budget.

At a time when demand for new and improved transport infrastructure has increased dramatically, the main source of motoring revenue taxation, fuel excise, is forecast to drop. A growing reduction each year reaching some $3 billion in 30 years is forecast.

Seeing transport as a single system is a vital element of changing road user attitudes as well as benefiting the Smart City concept. Achieving true integration will be assisted by transport pricing that includes consideration of both road and public transport costs. Transport pricing therefore contributes to Smart City outcomes.

The current multiplicity of State and Federal taxes imposed on vehicle users, including fuel excise, import duties, sales tax, luxury car tax, and registration, do not reflect the distance, location or time of travel, or the real impacts on the road network. Heavy vehicles also do not pay an equitable amount, in proportion to the impact of mass on the roads.

There is an opportunity to assess the current road pricing system and present a fairer and more equitable system for all road users. Such a system would mean that those travelling in un-congested conditions would generally pay less than now, and those travelling in congested conditions would generally pay more.

This system would lead to a better understanding of the real costs associated with road use and inevitably, increase use of public transport as users consider other modes of transport. Therefore, in looking at road funding models, improvements to the public transport system is equally essential.

It is critical that all revenue from a road user charging system is dedicated (hypothecated) to deliver transport improvements. This would ensure a level of funding security to maintain assets and meet demand growth. There would need to be consumer education and transparency in addition to an independent collection and distribution body for the road user charge. Governments would still determine the projects to be delivered, as now.

FRAMEWORKS FOR SUCCESS

Many of the technologies that make up the broad canvas of Intelligent Transport Systems will create or radically change the way transport works. The early twenty-first century is a time of massive disruption and ITS is both a disruptor in itself but is also a receiver of technology and societal disruptions. Conventional, traditional frameworks may no longer be appropriate or best suited to the way the technologies will enable people and machines to work.

Some of the opportunities for innovation will be made more effective by changes to regulatory frameworks and the development of standards.

Funding will be needed, not only to create new infrastructure, but also to support the development of some parts of the innovative agenda and the role of government in this may facilitate successful, early adoption.

Government also has an organising role in bringing people together, creating places where development can occur, and raising the profile of the solutions that ITS can offer to the problems of increasingly high-tech central places and a connected hinterland.

Australian businesses and to some extent, end users must be consulted and involved in processes leading to the development of standards and regulation.

A sustainable model for the use of private data will probably emerge from a combination of regulation and practice, shaped particularly by the actions of business both within ITS and outside.

Australia already has a rich resource of skills and experience in the ITS arena. It is essential that this is maintained and further developed.

THE WAY FORWARD

In the context of the recent ITS World Congress in Melbourne and to further support the deployment of advanced transport technology for Australia, ITS Australia has outlined a path forward to promote the development and adoption of smart transport technology by government, business and the community, as outlined in the following Focus Areas.

This approach complements the Actions outlined in National Policy Framework for Land Transport Technology as endorsed by the Australian Transport and Infrastructure Council and supported by ITS Australia.



FOCUS AREA	OPPORTUNITIES
Pathways to Connected Autonomy	1. Industry and Government to work together to support CAV trials in Australia that are complementary to other trials and deployment focused. Trials to avoid/limit duplication and encourage sharing of learnings. 2. Leverage trials to build public engagement and endorsement of emerging CAV technology. 3. ITS Australia and other industry players to foster local and international exchange and facilitate learning from trials and other activities in other major markets. 4. Nationally consistent performance based guidelines for trials encouraging Australia to be seen as an attractive CAV trial and deployment local. 5. Support co-ordinated trials involving multiple brands who can validate data with road agencies.
Mobility for Smart Cities and Communities	6. Highlight the benefits of ITS to assist in delivering other government priorities, e.g. reduced congestions, reduced fuel use (CO2 and pollutants) and smart / liveable cities. 7. Ensure emerging transport trends including CAV, MaaS, car sharing and Uber type solutions are considered in all major town planning activities. 8. Continue to promote Australian success stories such as our managed motorway deployments.
Next Generation Public Transport and MaaS	9. Encourage and support Australian demonstrations and deployments of MaaS. 10. Encourage open, real time, dynamic road and public transport data sets supplying information for a range of MaaS participants. 11. Encourage further development of personalised mobility assistant tools that allow travellers to research, select, book and pay across diverse transport choices. 12. Open the market to innovative mobility services by opening further transport offerings to booking and payment by third parties, including as a priority, mobile ticketing for public transport. 13. Identification of a starting point for first deployment as first step. Could be campus or geography based.
Big Data, Analytics, Ownership and Access	14. All real time dynamic data from government should be freely available. 15. Government and industry to seek approaches where asset owners get data needed from the private sector to enhance asset management, including: congestion management, safety attributes, asset maintenance and infrastructure planning. 16. Support the showcasing and deployment of Australian expertise in Big Data analytics and Cyber Security locally and internationally. 17. High speed, low latency data networks are key to supporting emerging ITS technologies. 18. Strategies to ensure reliable and ubiquitous network coverage, telemetry, cyber security and data integrity. 19. Back office systems must be interoperable supporting machine to machine connectivity.

FOCUS AREA	OPPORTUNITIES
Future Freight	20. Encourage the promotion and adoption of freight related ITS solutions to enhance driver and community safety. 21. Investigate the opportunity / community appetite to encourage freight activity to occur when passenger demand for the transport network is low. For example, freight moves at night and ultimately with automated vehicles and / or is focussed at communal freight hubs on the city fringe. 22. Encourage the development and promotion of ITS related parking solutions to support freight and courier services in congested cities and across the first/last mile. 23. Promote the benefits of ITS technology as a strategy to improve appropriate access for freight to our transport networks, such as via Transport Certification Australia's Intelligent Access program, with a focus on performance based access. 24. Encourage trials, demonstrations and deployment of emerging global standards to support supply chain visibility and interoperability (EPCIS), in partnership with GS1Net & ALC.
Transport Pricing and Funding	Infrastructure Funding 25. Australia needs new approaches to ensure funding security for our transport infrastructure to meet the growing demand. 26. A robust business case framework needs to be jointly developed by government and industry. 27. Ongoing maintenance costs of ITS elements need to be reflected over all project budgets. 28. All new transport infrastructure projects and major upgrades should consider opportunities to leverage technology. Pricing 29. Government and industry to explore and test a range of solutions that are acceptable to the community and provide security of funding for our transport networks. 30. Hypothecation will be essential to build community confidence in a new pricing model. 31. Engage ITS Australia members in the debate to promote consensus. 32. Encourage discussion and understanding in the community, building engagement regarding the need for a new approach to transport pricing. 33. Work towards a fair and equitable approach across the community.

FOCUS AREA	OPPORTUNITIES
Frameworks for Success	**Standards & Regulations** 34. Legislation and regulations, including road rules and vehicle standards, must be nationally consistent, performance based and harmonised internationally. 35. Australian government and industry representatives to actively participate in international standards development in ITS to support the integration of Australian requirements into international standards. **Privacy and Security** 36. Nationally consistent approaches to privacy regulation are an ideal to work towards. 37. Cyber Security is a key area for investment to ensure trust, security and safety across our transport networks and beyond. 38. Privacy of personal data will be critical to wide community engagement and needs to be pursued across the spectrum of ITS solutions by industry and government. **Community Considerations** 39. The principles and benefits to injury travellers of no fault motor vehicle insurance should be retained as insurance changes with pay as you drive insurance schemes and a potential shift in liability from the driver to the vehicle manufacturer. 40. Enhanced access to affordable and effective transport across the community as an underlying consideration for ITS deployments. 41. Seek opportunities to promote public awareness and acceptance of emerging transport technologies. **Skills and employment** 42. Support initiatives to ensure Australia has a strong skill base to actively contribute to new roles and jobs created as part of the deployment of emerging transport technology deployment and support the export of our skills and products, in part through the activities of our universities, research institutes and the iMOVE CRC initiative. 43. As the technology evolves there may be a need to explore the impact on employment changes in transport related vocations and understand the significance of these impacts in the context of broader social change.

1. INTELLIGENT TRANSPORT SYSTEMS

The term 'Intelligent Transport Systems' (ITS) covers the development and deployment of advanced information and communications technologies to deliver safer, more efficient and environmentally sustainable transport across all public and private modes – air, sea, road and rail.

The scope of ITS is broad. It encompasses fully 'connected' cities where public and private transport are connected and coordinated centrally, amongst other things, through to individual elements such as driver assistance in a vehicle, traveller information or technology based roadside infrastructure.

ITS has progressed rapidly. World Congress Chief Rapporteur Eric Sampson presented a Congress review in the closing ceremony in which he said:

'I looked back at some of the titles of papers and sessions (from previous ITS World Congresses) and was struck by how often words appeared like "Possible, Potential, Early, Prototype".

This week I've regularly heard the words "Results, Evaluation, Benefits, Business Models".

'Back in 2001 (when the ITS World Congress was hosted in Sydney) we were working out how to exploit the Third Industrial revolution. The First was mechanisation (e.g. textiles). The Second was mass production (Ford model T). The Third was (and still is) digital and location technologies.

'We're now undergoing the Fourth Industrial Revolution – Connectivity. Connectivity anywhere, all the time, between everything.'

Eric Sampson, Chief Rapporteur, ITS World Congress 2016

Intelligent transport systems comprise many component technologies – some physical, some software or computational. Many of them contribute to a variety of beneficial outcomes. However, it is how this technology gets used that creates the benefit.

'The innovation isn't in the technology… it's in the operating framework, and how the best outcomes are achieved when regulation and technology are developed in unison.'

Chris Koniditsiotis, CEO, Transport Certification Australia

This paper primarily considers road transport. Much of the technology is also applicable to rail, and many light rail and tram systems share road infrastructure. Equally significantly, the multi modal nature of public transport means that rail opportunities are relevant.

Australia has been one of the leaders in ITS from inception. The nation has been the first, or a very early adopter of, coordinated traffic signals, ramp metering and managed motorways amongst a number of other technologies.

ITS is a significant employer in Australia and the local industry is recognised as an important international player. Much new work is still in developmental or pilot stages and it is reasonable to anticipate that the number of people employed in the sector will grow in the near term.

Australia has a credible record in exporting ITS solutions. A notable example is the deployment of SCATS (Sydney Coordinated Adaptive Traffic System) as far away as New Jersey and Dublin. It is estimated that only one quarter of all traffic lights controlled by SCATS systems are in Australia.[2]

More recently Australia managed motorway technology is being rolled out in cities across the states while Australian based technology start-ups like Cohda Wireless and Seeing Machines have a global customer base.

While ITS is already one of the great disruptors of the twenty-first century, most of its influence on daily life and society is ahead.

The technology that makes up ITS is diverse and the applications are both varied and interconnected. Discretely classifying or categorising individual initiatives is impossible because of the multi-dimensional nature of many, or most of these topics. There is therefore some overlap amongst or between the seven topics that are covered in this Report. They look at ITS from different angles and have been selected because they concentrate on the benefits that ITS can deliver to sectors and the economy generally.

[2] https://en.wikipedia.org/wiki/Sydney_Coordinated_Adaptive_Traffic_System

2. PATHWAYS TO CONNECTED AUTONOMY

2.1 BACKGROUND

Automated vehicles attract keen media attention. Indeed, for popular broadcasters, ITS and automated vehicles are often synonymous. While such vehicles were showcased at the Congress, they represent one part of a much richer menu of computerised intelligence supporting travel by vehicles.

This section brings together two technology dimensions on which assisted or automated vehicles depend: information and decision making to 'drive' a vehicle, and technology to provide information to and connections between vehicles and their environment. The development of electric vehicles is a key contributing technology. Electrification of vehicle propulsion will contribute an enabling building block for connectivity and autonomy.

There are various predictions with regards to the timeline for introduction of autonomous vehicles. A fully human driver free system (no driver in any vehicle) may be a long way off but a single vehicle operating without a driver is likely to be much closer, even if restricted to certain operational modes and areas. Driver assistance and automated intervention are already present in road and rail vehicles. This section of the report explores the journey towards connected autonomy and the opportunities for Australia.



Figure 1. Anticipated timelines for introduction of CAV, Brian Burkhard, Jacobs Engineering (23rd World Congress, Technical Session 51)

Within the vehicle, assistance or automation involve a number of elements, including navigation and positioning, management of the vehicle, interaction with the roadside and with other vehicles, and decisions about speed and other tasks. Five levels of vehicle automation have been identified by SAE, and is now widely accepted that progresses from Level 0 (no assistance to the driver) to Level 5 (full autonomy).[3]

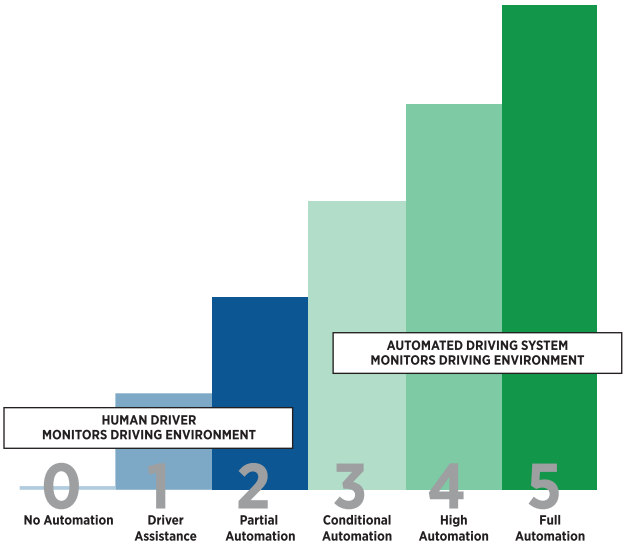


Figure 2. Levels of Driving Automation, Society of Automotive Engineers Australasia (SAE-A)[4]

When the vehicle's systems are connected with the environment an additional layer of benefits enhancing network management and relieving congestion can be achieved. Vehicle-to-Vehicle (V2V) communications enable nearby vehicles to inform each other of changes to their path or speed, preventing collisions and allowing optimal road use. Vehicle-to-Infrastructure (V2I) communications allow vehicles to interact with network infrastructure such as intersection management. "Vehicle to everything" (V2X) communications broaden the scope to include other entities, including pedestrians and devices.

[3] Level summary: 0 – full driver control. 1 – a specific function can be automated. 2 - at least one driver assistance system of "both steering and acceleration/ deceleration using information about the driving environment" is automated. 3 - safety-critical functions are controlled by the vehicle. 4 - vehicles are designed to perform all safety-critical driving functions and monitor roadway conditions for an entire trip. 5 – fully autonomous, where the vehicle performance equals or exceeds that of a human driver in every driving scenario.

[4] https://www.sae.org/misc/pdfs/automated_driving.pdf

Cooperative ITS (C-ITS) brings communications models together to support driver assistance and full vehicle automation.

Connected autonomy is intended to deliver a number of benefits.

SAFETY

Driver assistance reduces the risk of crashes and therefore fatalities, injuries and loss. This benefit is incremental in that the safety benefits increase with each further step towards full automation and as the proportion of vehicles equipped increases.

MOBILITY

Autonomous vehicles, and advanced driver assistance, offer increased mobility. They not only provide access to travel for those not able to drive and change the demand for parking, but more broadly enable changes in the structure of travel. Such ideas as pools of self-driving cars in a sharing economy will become viable as autonomous vehicles enter the road systems.

EFFICIENCIES

Drivers may become 'freed up' from the driving task and therefore able to perform other tasks. However, as time on the road may become more productive, as drivers are relieved of the cost of travel, it has the potential to increase traffic and congestion.

Connected, assisted and, particularly, fully autonomous vehicles can operate significantly more efficiently. Platooning of vehicles enables very short headways that would increase the likelihood of crashes in traditional vehicles while interaction with traffic signals potentially enables junction management to be optimised, saving fuel and time.

Vehicles connected to each other enable a more efficient, coordinated and safer use of the available road space. Vehicles connected to the infrastructure will provide more information to the control systems that monitor and optimise the road network.

Some of this is underpinned by the dramatic impact automation will have on the costs of travel. There is an avoidable and significant cost where a driver's main task is to control the vehicle (buses and trucks, for instance) and when occupied vehicles spend time on congested roads. These costs will be reduced and may be eliminated by connected autonomy.

Together, these technologies will reduce the resistance to travel, or travel friction, making new journeys viable and reducing the cost of journeys.

This will progressively reduce the costs of travel-related economic activity and deliver social benefits across society.

Unlike some other topics in this report, the end point for this one (a network of self-drive, connected vehicles) is easier to visualise than the steps leading to it. This section explores the pathway to connected autonomy.

2.2 KEY CONGRESS MESSAGES

'The three big technology topics of connectivity, electrification and automation will change the automobile and its place in society as never before. All vehicles will be connected, will increasingly be electric and will become more automated over time. Embracing this transition is also an absolute necessity due to the convergence of a number of influential megatrends: specifically changing demographics, increasing urbanisation, energy and climate risks and the exponential increase in the number of connected devices.'

Gavin Smith, President, Robert Bosch Australia

The timeline to the technical availability of connected autonomy can be predicted with some confidence, even if adoption cannot be forecast so precisely.

The development of this technology is now at a very exciting stage. Many of the problems now being addressed are about sensing the environment and much experimentation and testing has now been done and was shared at the Congress. What was a novelty is now not only real, but has both importance and urgency.



Figure 3. Indicative timeline to automated driving, Gavin Smith, Robert Bosch Australia (23rd World Congress, Plenary Session 1)

'Safer vehicles are the fourth pillar of safe systems. The other three pillars are essential to achieve a zero road toll but we know that the real key to success is making the vehicles on our roads safer. There is no doubt that will come through automated vehicles.'

Doug Fryer, Assistant Commissioner, Road Policing Command, Victoria Police

The critical interdependence of automation and connectivity was a common theme. While public attention is on autonomy and automation, less is said in the media about connectivity, and this is a critical part of the safety and efficiency outcomes.

'The convergence of connected and autonomous vehicles is the right approach. In the US we see this as primarily a safety issue. USDOT has said 80% of vehicle crashes can be avoided by using connected technology, nothing to do with automation. I would like to see Australia viewing it this way too, a huge safety opportunity in its own right.'

Peter Sweatman, Principal, CAVita

Research by the US DOT states that V2V and V2I could reduce the millions of crashes that occur each year by as much as 80%, saving lives and reducing injuries. The deployment of C-ITS depends upon clear business cases being made, particularly around safety.

'Right here, right now we have level 2 technologies which can save lives but are not mandated in Australia yet we know that if every vehicle on the roads today had this technology, we'd be saving thousands of lives in the future.'

Samantha Cockfield, Senior Manager of Road Safety, Transport Accident Commission, Australia

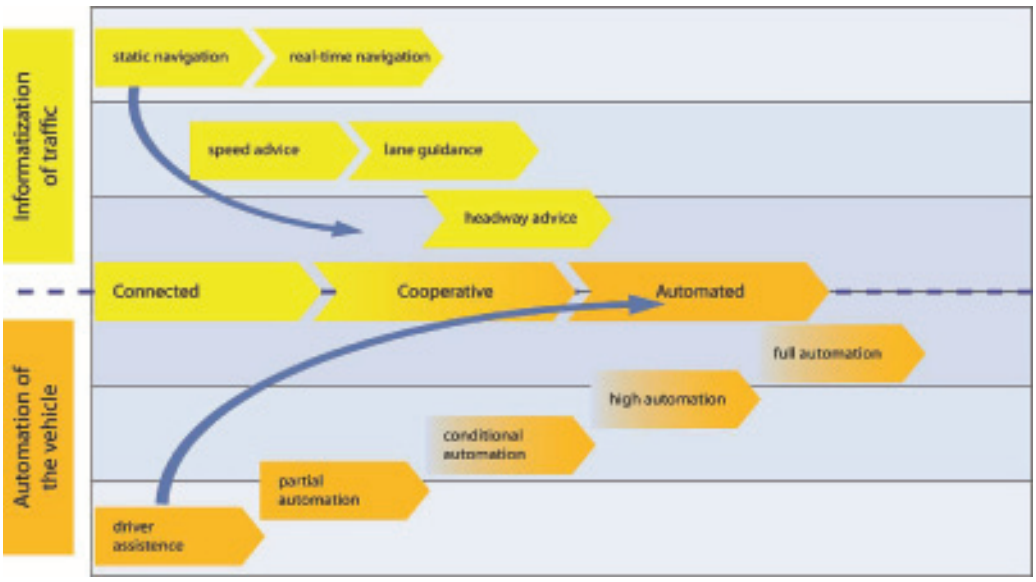


Figure 4. Indicative convergence of automation and connectivity, Wolfgang Hoefs, DG CONNECT (23rd World Congress, Plenary Session 1)

A number of people remarked on the significant change in how development is occurring. Early development was typified by defence department funded or localised research, with a focus on individual vehicle performance. Now, research is more commercial, with car makers and information systems enterprises like Google leading the research. At the same time, regulators are supporting data gathering and reporting.

'We are starting to see what is good what's bad what's ugly about these systems: where these systems can come out quickly and where they can provide help early on, but importantly we now have more open reporting in many cases. A very good example is the Department of Motor Vehicles in California where you not only have to report accidents involving these vehicles but also takeovers [where the vehicle takes over control from the driver], so we can get data to see where weaknesses are in these systems.'

Christopher Mentzer, Manager R&D, Southwest Research Institute, United States

A number of sessions explored the complex area of liability and responsibility with the growing availability of assistance and the ultimate achievement of full autonomy.

'Some people think it is fanciful that fully automated vehicles will ever come – I think it is just a matter of time. So what does legislative and regulatory change look like for us? It is going to be tricky. Who will have accountability and responsibility for a vehicle and for vehicle movement? The manufacturer? The technician? The owner? For us the definition of what 'driving' and 'in charge' is by legislation and laws is really quite tricky because at the moment it is clear that it refers to a human.'

Doug Fryer, Assistant Commissioner, Road Policing Command, Victoria Police

Autonomy is not the central or end point. Connectivity is the key and, while vehicle equipment is guided by individual purchasing decisions and how they influence manufacturers, implementation of connectedness requires investment by government and society more broadly.

'All businesses, all people make an economic, a mobility and a safety choice in transportation. The more we give them good information, the better those choices will be, and choice is the most powerful piece in transportation, not regulation and enforcement. That has to do with getting good information in their hands.'

Paul Trombino III Director, Iowa Department of Transportation

Others highlighted additional benefits. In Australia, congestion and efficiency of infrastructure are also well recognised outcomes. Wolfgang Hoefs, Head of Sector, Directorate General CONNECT, European Commission emphasised the importance of other societal, personal and productivity benefits, noting how important it is that the hoped-for benefits are both quantified and verified so that appropriate investment occurs. From a business perspective, commercial access to data, within essential data protection constraints, will create real value.

'What needs to be done is a good verification of these societal benefits because we need a good justification for any private or public investment into these solutions… When we talk about climate change, even there, automated driving might play a role.'

Wolfgang Hoefs, Head of Sector, DG Connect, European Commission

2.3 AUSTRALIAN CONSIDERATIONS

Australia is amongst the world leaders in key aspects of connected and autonomous vehicles. The country combines high level technical expertise with regulatory support, critical infrastructure and an environment that is suited to testing.

'Melbourne, rated as one of the world's most liveable cities, achieved a perfect score of 100 for infrastructure, highlighting the importance placed by successive Victorian State governments on an integrated, intelligent transport systems network. The Victorian government clearly appreciates the importance of mobility in maintaining this position and has partnered with Bosch to engineer, build and evaluate what I would describe as an aspirational automated vehicle.'

Gavin Smith, President, Robert Bosch Australia

The Bosch demonstration at the Congress was the most highly automated vehicle to operate on Australian roads to date. It is a result of considerable local work, driven particularly by the opportunity to demonstrate the capabilities at the Congress. The Bosch trial is especially significant because it is independent of any particular vehicle manufacturer. Bosch and the Victorian government have committed funds to continue this work, which is progressively building a centre of excellence in Australia. It is hoped that this will contribute to global development of vehicle automation and connectivity rather than purely create a standalone automated vehicle.

'Australia is not directly driving the development in pure automation and so the interest in Australia is to see implementation in a way that is as beneficial as can be, which means a degree of convergence between connected and automated.'

Andrew Somers, Transoptim Consulting

Australia has significant players in the connected and autonomous vehicle industry. As demonstrated at the Congress, Cohda Wireless technology, for instance, provides navigation technology that allows vehicle positioning where GPS is not available.

'GM, Ford and Toyota have committed to retaining vehicle development skills in Australia following the ending of local car manufacture in Australia. These skills are available and, in many cases, well suited to intelligent transport systems.'

Peter Sweatman, Principal, CAVita

Another critical element of the mix in Australia is the involvement of government. Government not only funds much of the large scale implementation of transport infrastructure, but also provides much seed funding for trials and for research. Local expertise provides someone Government can talk to in Australia to inform government thinking, both from a technical and policy viewpoint. While the Australian social and natural environment has a unique combination of features, local standards must harmonise internationally.

'Australia is a technology taker in the sense that we don't dictate what happens in design, although some of the design will be done here. The challenge for us is to get proliferation of the technologies across the vehicle fleet. Australia needs vehicle manufacturers to make that technology more available across their ranges and for governments, mandated through the ADR system, to recognise that this technology should be available.'

Brian Negus, General Manager Public Policy, RACV and President ITS Australia

Australian business and governments are in any case at the leading edge of some significant elements of connected autonomy. The mines sector already deploys off road vehicles that are remote controlled and semi-autonomous. Similarly, Australian ports and others have vehicles which employ a level of automation that is not yet permitted on public roads. Driverless trains are being specified for the Sydney metro.

In 2015, South Australia conducted the first on-road trial of autonomous vehicles in the Southern Hemisphere and in 2016, at the ITS World Congress, Australia's most advanced highly automated vehicle was unveiled and demonstrated in mixed traffic. A 'hands-off' demonstration was provided to delegates on a designated section of the roadway. There is also progress with trials of highly automated vehicles on Australian roads:

STATE	CURRENT CONNECTED AND AUTOMATED VEHICLE INITIATIVES
New South Wales	• **Cooperative Intelligent Transport Initiative (CITI)** trial of heavy vehicle safety applications using Cooperative ITS. • **Heavy Vehicle Priority Project** trial of applications to provide heavy vehicle priority at signalised intersections. • **Smart Innovation Centre** announced in 2016, planned to be a R&D hub for emerging transport technologies, including CAVs.
Northern Territory	• **Autonomous Passenger Vehicle** trial commenced 2016, transporting people at Darwin Waterfront, Australia's first fully operational autonomous vehicle transport trial.
Queensland	• **Cooperative and Automated Vehicle Initiative (CAVI)** incorporates two main projects – a large scale pilot of Cooperative ITS in Ipswich, and a smaller pilot of cooperative and highly automated vehicles driven on selected roads.
South Australia	**Future Mobility Lab Fund** a $10M program over three years for development, testing and demonstrations of CAV technology, connected V2V and V2I pilots and demonstrations, and research and development.
Victoria	• **Bosch Highly Automated Driving Vehicle** partnership with Transport Accident Commission (TAC) and VicRoads. • **Eastlink Driver Assisted Technology** – partnership with Victorian Government, Australian Road Research Board and La Trobe University to test network and driver assisted vehicles • **ITS Grants Program** includes project trialling CAVs in highway scenarios, C-ITS to support tram priority, and in-vehicle connected vehicle services using cellular communications. • **Road Safety Action Plan** includes $10M action to trial connected and automated vehicle technologies. • **Transurban CityLink automated vehicles** – trial of how automated vehicles interact with Australian road infrastructure • **University of Melbourne** – world first urban test bed for multimodal connected transport on a large scale in a complex urban environment
Western Australia	• **Autonomous Heavy Vehicle Platooning Trial** Main Roads WA is partnering with industry to launch a trial of autonomous heavy vehicle platooning. • **RAC Intellibus** with the support of the WA State Government, RAC is trialling a fully driverless, fully electric shuttle bus in South Perth.

Many aspects of the local environment mean that Australians must solve problems that are not present or are unusual overseas. Road trauma is significantly worse on rural roads in Australia than in cities. While this is true in other countries (54% of all fatalities in the USA were on rural roads in 2012, though only 19% of the population was rural), the combination of Australian road conditions and other road safety improvements mean it has a higher profile in Australia. The Chief Executive of VicRoads put it eloquently in an Executive Session:

'We've been spectacularly successful in reducing road trauma in our cities… But you are four times more likely to die on the road if you live in the country than if you live in the city. Very narrow shoulders, beautiful Australian gum trees within metres of the side of the road, variable conditions, variable road surfaces and always sharing the roads with other cars and trucks. Most of our accidents are just veering off to the right hand side of the road and either having a head-on or clearing up one of those trees.'

John Merritt, Chief Executive, VicRoads

Research presented at the Congress supported the particular issue of rural roads.

'Several factors contribute to the disparity between rural and urban crash fatality rates. Rural communities have vehicles which move at higher speeds over varying grades and unique terrain which can contribute to the likelihood of crashes. Rural motorists may become tired or inattentive due to infrequent traffic on trunk roads, long traveling distances, a lack of visual stimulus and fail to notice stop signs or rail crossing signs.'

Mike Haldane, Vice President, and Jeremy Neuman, Senior Embedded Firmware Engineer, Global Traffic Technologies

This issue alone makes it essential that Australian research and development continues, avoiding the risk that the urban problems are resolved, but rural ones are left unsolved.

2.4 INITIATIVES, OPPORTUNITIES AND BENEFITS

VEHICLE SAFETY

Driver fatigue is a significant contributor to crashes. Advances in technology have permitted the development and fitment of continuous driver fatigue monitoring systems in vehicles. Real-time feedback on the incidence of fatigue events in three long-haul trucking companies in South Africa has been used to significantly reduce the incidence of fatigue events.

The CITI project is a test bed for Dedicated Short Range Communication in the Illawarra area. This connects sixty vehicles, three signalised intersections and three other sites, using Cohda Wireless equipment. The installation alerts drivers to speed restrictions and phase changes at traffic lights. It also gathers information from passing, equipped vehicles, demonstrating the viability of the technology.

SOFTWARE AND CONSUMER APPS

Business and academic research continues to test the application of computer and mobile software to enable better analysis of data and big data. GPS and access to a speed limit database can tell a consumer app what the applicable speed limit is, allowing drivers to drive at an appropriate speed. Since excessive speed contributes to 40 of fatal crashes in NSW, Transport for NSW released its own free smartphone Intelligent Speed Adaptation application in 2014 – a world first.



Figure 5. Example mobile device screen showing vehicle exceeding speed limit, John Wall, Transport for New South Wales (23rd World Congress, Technical Session 27)

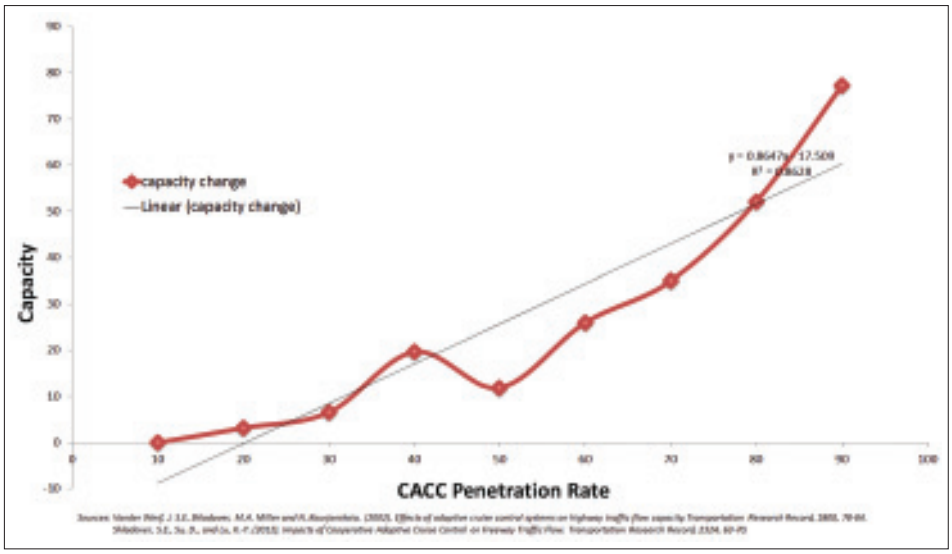


Figure 6. Impact of Cooperative Adaptive Cruise Control (CAAC) on road capacity as adoption of CAAC increases, Joshua Auld, Argonne National Laboratory (23rd World Congress, Scientific Session 10)

ROAD CAPACITY

Connected and automated vehicle technologies are likely to have significant impacts not only on how vehicles operate within the transportation system, but may also drive changes in travel behaviour and the dynamics of traffic flow. For example, connected vehicles will be able to operate more closely together (shorter headway), allowing more vehicles to fit on a road, but more trips may result from the other improvements that flow from ITS. Some work described at the Congress will support the analysis and measurement tasks that are so critical to planning and to support investment proposals. Such work seeks to balance a variety of factors to arrive at a net impact, without which capacity planning is impossible. One example of such work is a simulation model showing the impact of headway reduction highlight the dramatic impact of cooperative adaptive cruise control on road capacity.

SUPPORTING AND ENABLING INFRASTRUCTURE

Enablers being pursued by automotive manufacturers include fleet connectivity, embedded telematics, GPS accuracy, tamper-evident devices, as well as the required backhaul network (transporting communication data between end users and the central network and infrastructure).

Simple detection systems, connected into an intelligent system that potentially connects to the vehicle, could make highly dangerous rural junctions safer. A trial in Michigan is deploying a Rural Intersection Conflict Warning System to deliver this.

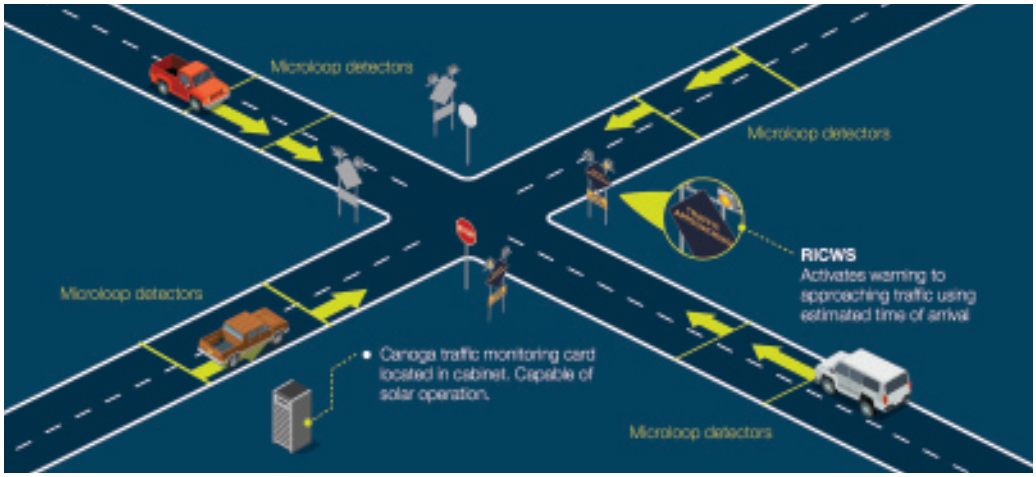


Figure 7. Michigan trial alerting drivers to potential conflict at intersection, Mike Haldane and Jeremy Neuman, Global Traffic Technologies (23rd World Congress, Commercial Session 7)

AUTONOMOUS VEHICLES

Bosch Australia demonstrated a live implementation of Australia's most advanced highly automated vehicles at the World Congress. The car had been designed to navigate roads with or without driver input and included technology to detect and avoid hazards such as pedestrians, cyclists and other vehicles.

Trials of the vehicle will be used to inform the development of regulations and infrastructure to enable similar self-driving cars to operate on Victorian roads when they become commercially available in the future.[5]

Western Australia is trialling the nation's first fully driverless, fully electric shuttle bus under plans to test automated vehicles. Internationally, trials are underway in New Zealand while in France, driverless vehicles in Lyon carry up to 15 passengers over 1.3km. A staff member is on board, but not driving and the vehicle has been authorised for road use by the Ministry.

The 2016 ITS World Congress provided the industry with an opportunity to experience the EasyMile driverless shuttle. The live demonstration showed a steering wheel was not required as one was not supplied in the vehicle.

The EZ10 has been designed to cover short distances over predefined routes in mixed use environments. Transporting 12 people (six seated and six standing) it can cater for passengers with reduced mobility. It operates autonomously following a virtual line mapped and loaded in the software of the vehicle.

[5] Victoria Government media release Victoria leads the way with self-driving vehicles 5 Oct 2016

PEDESTRIANS AND OTHER ROAD USERS

Pedestrians constitute a large proportion of road fatalities. Innovative approaches are being considered to reduce pedestrian trauma. Some of these will be predictive based on active detection by vehicles, others will engage with pedestrian 'beacons' (with present technology these are most likely to be wireless transmissions by pedestrian-carried smartphones). A typical demonstration project from Japan was presented at the Congress. In this demonstration, a combination of radar and camera scan a search area looking for and recognising pedestrians. Such systems enable warning or system intervention to avoid collision with the pedestrian.

Cyclists and pedestrians are endangered by motorized vehicles, but especially at signal controlled intersections. Another Japanese experiment uses radar to detect pedestrians and bicycles regardless of conditions at night and under bad weather so that vehicles can be alerted.

A German study proposed a protection system consisting of communication devices and an infrastructure solution. Using this, cyclists and pedestrians communicate their movement data via smartphones and a roadside unit collects the data, predicts collisions and warns (only) the affected road users via digital messages.



Figure 8. EasyMile driverless shuttle demonstrated at the 23rd World Congress

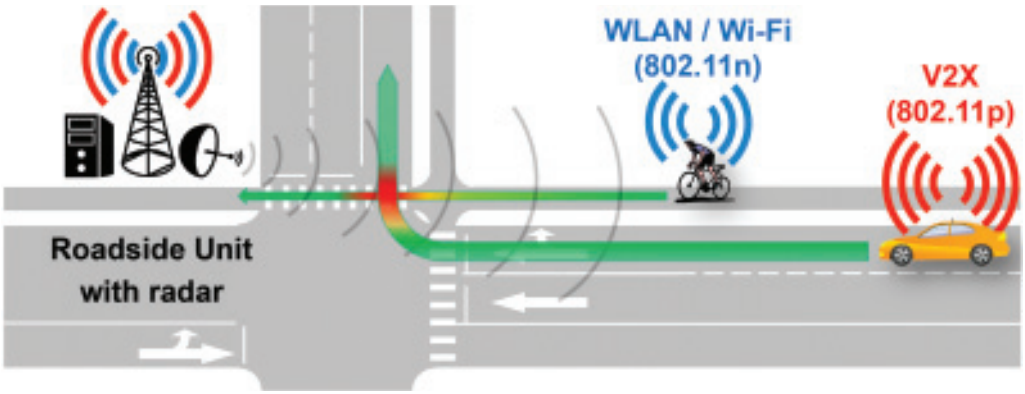


Figure 9. Conceptual collision prevention for connected vehicle and cycle with roadside radar interaction, Tim Russ, ifak (23rd World Congress, Technical Session 23)

SPATIAL AND MAPPING

Many, if not most, practical implementations require some form of mapping and location support. TomTom demonstrated a profiling tool which creates a representation of the street profile from radar surveying, allowing vehicles to establish a coarse location from GPS which is then refined by comparison of the radar model with detection from the vehicle travelling.

Work on map creation is increasingly being automated, not only for new but also for existing routes. Aisin Group demonstrated a model for automatic map creation.

Mapping is only useful to the extent that autonomous vehicles are able to interpret and utilise the information. A World Congress paper from ITS Korea and the Korean Institute of Civil Engineering and Building Technology described how to layer map and location information to best support Level 2 automation for vehicles.

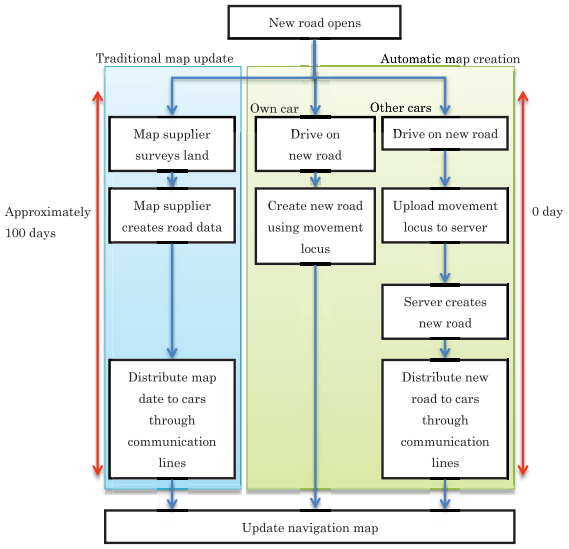


Figure 10. Comparison of traditional, delayed map updating with real time automation of map data collection exploiting connectivity with vehicles, Akira Otabe, AISIN (23rd World Congress, Technical Session 29)

Assistance for automated driving in a traffic congested situation
Simultaneous supply

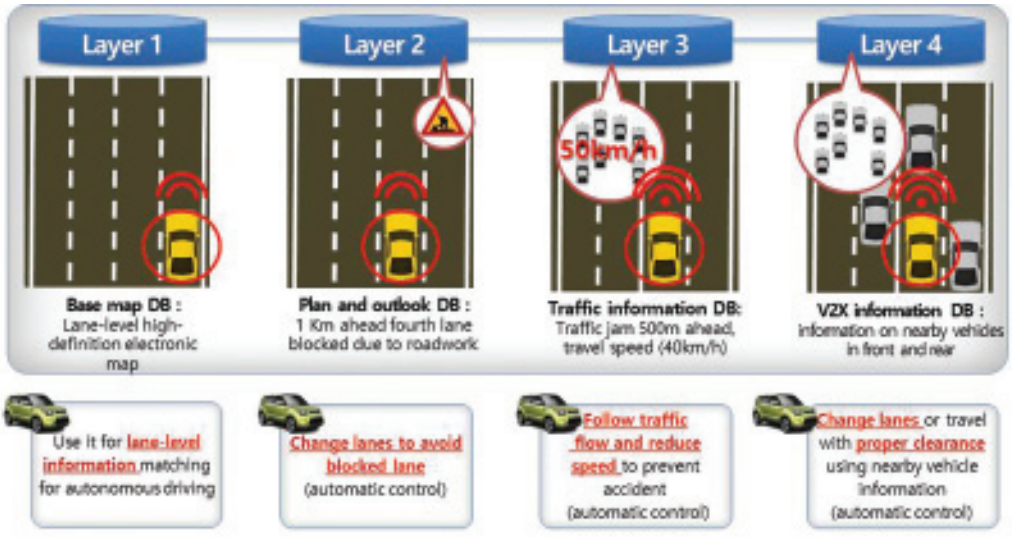


Figure 11. Consolidation of data to support progressively more sophisticated responses to congested traffic, Jiyeon Lee, ITS Korea (23rd World Congress, Technical Session 29)

GNSS/GPS precision is not yet sufficient to enable automation using this information alone. Lane positioning, stop line detection and other tasks must be performed to a higher level of accuracy. A number of solutions were presented at the Congress. One of these uses roadside infrastructure to broadcast its own, accurately known position, to enhance in-vehicle systems.

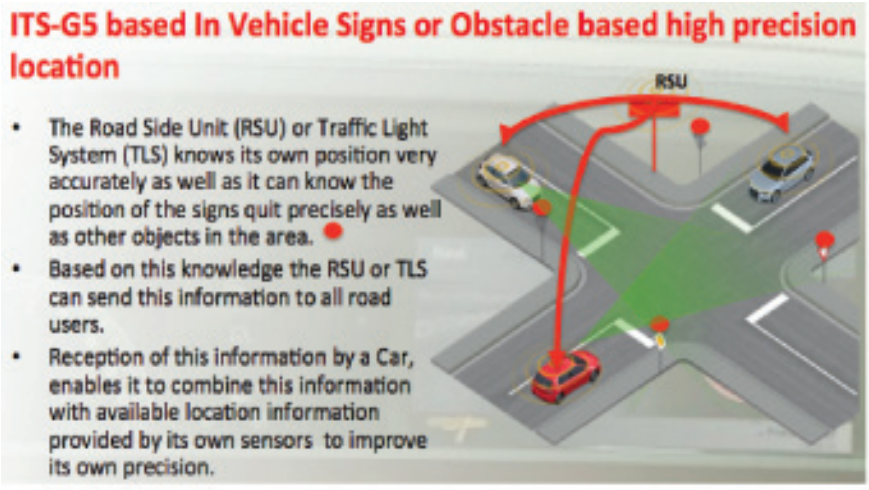


Figure 12. Enhanced GPS enabling accurate vehicle positioning, Paul Spaanderman PaulsConsulting (23rd World Congress, Technical Session 29)

2.5 CONCLUSIONS

In summary, the pursuit of automated and connected vehicles will deliver progressive and important benefits to individuals and society.

Connectivity and automation are tied closely together. Both areas of development rely on bringing many separate innovations together and integrating them in a viable and safe system.

Australian businesses make a significant contribution to connected autonomy through leading edge projects and trials. Australian governments are creating and supporting test environments through financial support and regulatory flexibility.

Many opportunities exist today and will emerge in the future for Australian businesses to develop solutions to specific problems that can be integrated into complete systems. The trial programmes that are underway[6] provide a focus for collaboration and a network of experts.

Australian business is represented in a number of connectivity projects and provides proven solutions in communications. The trials of driver assistance and automation in Australia provide a platform for these and other local businesses to maintain and grow this expertise.

[6] See Section 2.3 for list of Australian trials.

3. MOBILITY FOR SMART CITIES AND COMMUNITIES

3.1 BACKGROUND

Smart Cities aim to improve the quality of life for inhabitants through well designed, efficient and effective services, infrastructure and resources delivery leveraging emerging ICT solutions such as the Internet of Things (IoT), Big Data, sensing technology and advanced communications. Transport is a central component of a smart city, enabling people and goods to move easily, affordably and sustainably. It is one of the key enabling infrastructure elements and in a successful implementation must therefore be integrated into the planning and delivery of wider aspects of city life.

Intelligent transport systems underpin the transport elements of smart cities, from making contributions to the strategic planning and integration of services at the highest level, down to providing detectors at street level to monitor movements and activities.

While there is no universal definition of a smart city, many projects around the world pursue the general goals of the smart city movement. Many of these projects were represented or reported at the Congress.

The coverage of the smart city is broad. Fully implemented, transport will be a seamless part of a fully connected urban environment. ITS will contribute in key areas and the Congress showcased work in strategic network planning, urban transit planning, integrated passenger information, first and last mile solutions, parking, pedestrian access and flow, traffic management – both within built up areas and for smart motorways.

A fundamental principle of a smart city is that it is demand rather than supply driven, as traditional city transport provision is.

The concept aims to optimise for the individual rather than requiring the individual to fit in with centrally provided infrastructure. It sets out to optimise the usage of each resource, whether it is public transport, pedestrian space, shared road space, or bus fleets.

Hence, in the smart city, infrastructure provision takes account of all modal needs.

3.2 KEY CONGRESS MESSAGES

City growth is unsustainable with current models. Speakers talked about the need to adopt technology to deal with this. The ideas for smart cities are not new, but the capacity to start creating them is:

'You couldn't do smart cities two years ago because the technology wasn't there.'

Kirk Steudle, Director, Michigan Department of Transportation

Singapore offers one of the most advanced, integrated plans for smart city implementation:

'Singapore is uniquely constrained by its island status. It is both a city and a country. We do expect the city to grow but we are hitting the natural limits. That is the reason we need to adopt technological innovation in order to deliver a Smart City solution. There are many versions of what a smart nation should be, but our vision is a very simple one. It is encapsulated in the words of our Prime Minister:
Our vision is for Singapore to be a Smart Nation – A nation where people live meaningful and fulfilled lives, enabled seamlessly by technology, offering exciting opportunities for all.'

Men Leong Chew, Chief Executive, Land Transport Authority Singapore

Australia has similar needs:

'Australian cities will double in size in the next 30-35 years. The only way we can sustain that growth and sustain our cities as liveable and sustain the political acceptance of that growth is by applying technology to the way our cities operate. Australia is not only well placed to take up the opportunities of digital technology but we will be one of the primary beneficiaries because of the nature and the structure of our cities. We are already the most urbanised nation in the world and that will increase. We have a challenge of growth. We are in our 26th year of sustained economic growth… and that has been reflected in the way our cities have grown: 85% of our population now lives in our cities.'

Mike Mrdak, Secretary, Department of Infrastructure and Regional Development, Australian Government

At the same time, technology is developing so rapidly that the goal of an integrated, smart city is suddenly realistic. There is an explosion of new communications channels and data sources.

'The ubiquitous communications backbone is what helps to tie a lot of the smart cities concepts together.'

Kirk Steudle, Director, Michigan Department of Transportation

'We are living in an interesting time where the digital transformation is starting to emerge for real. Virtually everything that moves and changes is being measured, and connected to the network, and made available. We are wiring up the planet. Transportation is going to be essential – a key infrastructure element that creates the future.'

Jack Dangermond, President, Esri

City managers and planners are adopting technology, and particularly ITS, enthusiastically. As one delegate said, 'The Smart City concept is an easy sell - no city wants to be dumb'. However, one of the challenges identified by government delegates and urban planners is the risk of pursuing ad hoc, localised solutions rather than integrating solutions into an overall plan.

'It is inevitable that with so much brilliance in solutions, that the solution developers will seek to cherry pick the problems and choose those that best fit their answer. But it is incumbent on government to do the best that we can to articulate our particular problems.'

John Merritt, Chief Executive, VicRoads

Smart Cities cannot be planned in isolation or through independent and standalone projects.

'It is essential in developing smart cities that there is coordination between multiple agencies. Universities should be involved along with government agencies and transport providers.'

Terry Bills, Global Transport Industry Manager, Esri

Collaboration is key to successful smart city planning. Telematics and sensors, as well as transactional data sets, now provide a previously unimaginable volume of data about transport and movement in cities. To be able to draw real insights from this data, it must be shared, and to share it, cities must overcome ownership, security and privacy issues.

'In Montreal, there are 19 different operators of the public transport system. They have one back office, which is not unusual, but what is different is that each of the 19 operators' sensitive data is kept separate and secure just for them. So, they don't need to worry about their competitors seeing it but, because it is in one back office, the data is already compatible and we can use it for data analytics and big data analysis to identify new travel trends at a much earlier stage for the benefit of the citizens of the city'.

Richard Harris, International Director of ITS UK

Smart cities are an emerging concept. Many ingredients contribute to the recipe. Ingredients include big data and the cloud, congestion management tools, cooperative road networks and devices, connected and autonomous cars, urban mobility initiatives as well as safety initiatives. Many of the solutions are not fully developed, nor are the business models and businesses to progress them.

'Smart Cities are a journey, not a destination. You will make changes to your planning as well as your partners along the way.'

Scott Sedlik General Manager, Global Public Sector, INRI

Smart city solutions are helped by emerging trends in demand. In particular, the travel patterns of millennials are changing. In Australia, a smaller proportion of young people are acquiring driver licences and owning cars. The rapid take up of Uber services in Australia, ahead of regulatory endorsement, highlights the importance of the sharing economy in transport solutions for future city life.

Data and information underpin ITS and their contribution to Smart City projects. Much of the work presented and discussed at the Congress related to gathering, analysing and using data to deliver smart city components.

'In Los Angeles, all of the agencies deposit their information into a central area, a geo hub. All have their own individual mapping and analytical capabilities. This is not confined to the city agencies themselves. They have strategies in place to ensure that there is engagement with universities, the community and others so that it does not become government in isolation. The way that cities become effective smart cities is through sharing of information. Los Angeles and other similar cities are showing the way in this regard. Effective community engagement is a defining characteristic of smart cities.'

Terry Bills, Global Transport Industry Manager, Esri

Two areas where data contributes to city liveability provide examples of Congress dialogue:

Understanding pedestrian flows is a critical part of managing a smart city. The City of Melbourne has a network of pedestrian count sensors and work involving National ICT Australia (NICTA) is leading to better understanding of pedestrian clustering, allowing cityscape design that caters for pedestrian flow management.

Public transport is a key contributor to smart cities and usage depends partly on frequency and reliability of services. Time reliability is an issue not only for passengers but also for operators. Large scale data analysis from Automatic Vehicle Location (AVL) systems is being used to identify systemic problems within networks and select approaches to reduce or eliminate the delays that cause the service to be unreliable.

A number of sessions looked at innovations in urban managed motorways as ways of meeting demand for commuter and freight traffic, reducing commuter travel times and reducing freight costs. The focus is increasingly on preventing, rather than managing congestion. The techniques of managed motorways deliver the real economic and societal benefits required in the Smart City.

'You must manage demand to prevent flow breakdown and maximise productivity and that is why you must have effective ramp control'

Maurice Burley, Road Safety and Traffic Engineer, Solutions for Traffic And Road Safety

The results of managed motorway implementation are easily proven. The use of coordinated ramp signals prevents flow breakdown and maintains optimum throughput and travel times. The graphs in Figure 14a and 14b show the contrast between unmanaged and managed motorways.

Type of strategy	Sub-type of strategy	Preventive	Corrective
Priority	Exclusive lanes (Bus only streets, busways, with and contra flow bus lane)	▲	
	Route Design	▲	
	Signal Priority	▲	▲
Operational	Reserve vehicle and operators	▲	▲
	Operator training		
	Operator incentives and penalties	▲	
	Schedule adjustments	▲	
	Supervision	▲	
	Improve vehicle access (e.g. fare collection, device for boarding/alightings)	▲	▲
Control	Holding (Scheduled-based or Headway-based)		▲
	Overtaking		▲
	Expressing (Full expressing, Limited stops, Alighting only)		▲
	Short- Turning		▲
	Deadheading		▲
	Exchanging vehicle shift		▲
	Adding a reinforce shift		▲
	Providing in-vehicle message		▲
	Operator self-regulation		▲

Figure 13. Example of evidence based strategic response to data analysis of vehicle locations, Benedetto Barabino, Technomobility (23rd World Congress, Scientific Session 18)

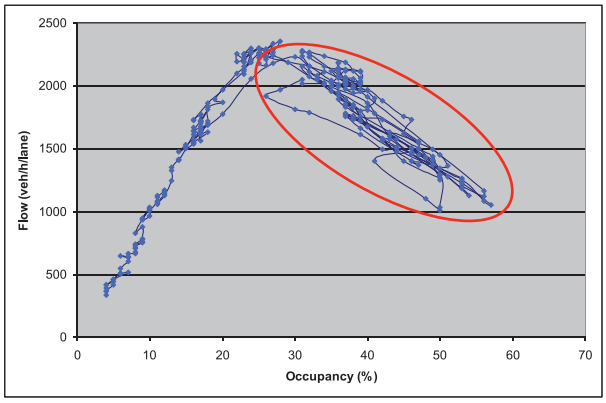


Figure 14a. Unmanaged motorway showing that flows decline as saturation is exceeded, Maurice Burley, Solutions for Traffic And Road Safety (23rd World Congress, Special Interest Session 60)

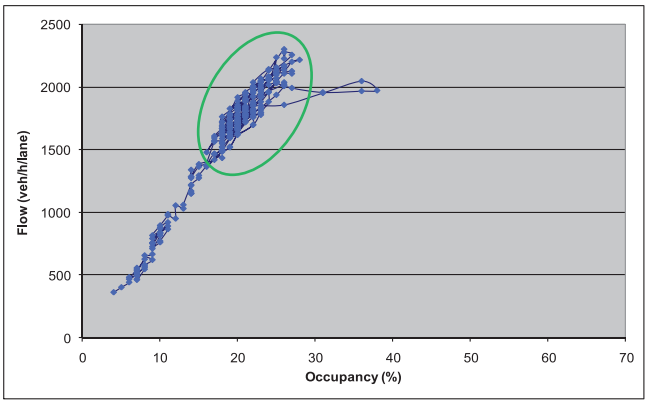


Figure 14b. Managed motorway showing prevention of volumes above saturation, Maurice Burley, Solutions for Traffic And Road Safety (23rd World Congress, Special Interest Session 60)

Some of the conclusions confirmed from the detailed measurement and analysis undertaken by VicRoads in Melbourne include:

- Additional lanes do not add proportionally more traffic. In fact, average lane capacity reduces with each additional lane added to a road from the third lane onwards. Therefore, improvements in congestion management are achievable on motorways through physical motorway design using dual-carriageway grade separation (i.e. separated carriageways for traffic in the same direction). This is often called collector-distributor with the term braiding being used when these join together in either the air or underground. The new Western Distributor in Melbourne will take this approach.
- Lane changing is starting to be better understood. Lane changing reduces the potential capacity of a road and the number of lane changes made increases exponentially as lanes are added. Slow and fast lanes are the most liable to flow breakdown so work is now under way to respond to this.
- At capacity, headways are very short, and this causes more crashes, at a time when disruption has the greatest impact.
- Freeway data is still inadequate to really understand the complexity of the freeway management problem because sampling rates of traditional equipment (loops and similar) are too slow for high throughput.
- Planning needs to consider average and total volumes rather than peak throughputs to arrive at accurate economic benefits.

Australian learnings and technology are being adopted elsewhere in the world. Colorado will implement a managed motorway model, based on Australian experience, in 2017.

'We don't have a congestion problem 24 hours a day. We have a congestion problem at peak times of day. And we are never going to build our way out of the congestion problems we have. The system is mature. It is incumbent on us to operate the system efficiently. So we need a managed motorway solution'

Shailen Bhatt, Executive Director, Colorado Department of Transportation

Within cityscapes, non-freeway road systems are being managed using similar analyses, but with different techniques. Ideas such as 'road diets', where the amount of road made available to low capacity vehicles (notably single driver cars) is deliberately reduced and the space is made available either to higher capacity / density vehicles (trams or buses) or more sustainable transport such as bicycles. South Korea is one example where high density cities are exploring using existing infrastructure in more controlled ways to increase throughput and travel times as well as reducing pollution.

'We must reduce congestion. There is no equity in single occupant car use. So we need to reduce car demand. One way to do this will be with automated, shared first/last mile vehicles occupying 'diet-freed' lanes.'

Dr Young-Jun Moon, Chief Director National Transport Technology R&D Centre The Korea Transport Institute (KOTI)

The Congress also covered some early stage and alternative approaches to travel and freight movement. While Unmanned Aerial Vehicles (UAVs) are at an early stage of development, both the technology and the capacity to use them as part of connected transport were discussed.

'We are very interested in UAVs in NZ. For a number of applications such as surveying and search and rescue, UAVs can be more practical and efficient than going on land and cheaper than using an aeroplane. In 2015 we introduced new civil aviation rules to regulate the introduction of these. We didn't wait for external international arrangements. Previous regulations in New Zealand were designed for model aircraft and not fit for purpose for these new technologies.'

Nick Brown, General Manager, Aviation and Maritime, Ministry of Transport, New Zealand

3.3 AUSTRALIAN CONSIDERATIONS

The intense concentration of the Australian population in major cities creates both a challenge and an opportunity.

Australian cities are, at the same time, some of the most dispersed and low density in the world. This combination of urbanisation but low density means that solutions that work in city states such as Singapore may not work in Australia. In particular, solutions to first and last mile problems must work differently in dispersed cities.

'2.5M people live in Western Sydney. Every day, 35% of those people leave that area for jobs elsewhere in Sydney. We already have some of the longest commuting distances in the world. The average travel time in Australia is 29 minutes each way and some of our outer urban rail users are commuting 79 to 90 minutes each way. With over 2M people in Australia commuting for over 45 minutes each way, it is unsustainable.'

Mike Mrdak, Secretary, Department of Infrastructure and Regional Development, Commonwealth Government

In significant aspects of road management, Australia is a world leader.

1. East coast jurisdictions in Australia have developed and implemented a number of managed motorway systems which have exploited ITS to deliver higher volume, free flowing urban motorways. Melbourne's motorway network was covered in some detail in the Congress, including a session on the adaptation of this system for US applications.

VicRoads has succeeded in increasing throughput on managed motorways, delivering significant economic benefits as a result of real time measurement and monitoring and the use of variable speed management, ramp metering and other techniques.

'A congested freeway is a poorly managed freeway. As road managers, we can no longer accept poorly performing freeways as being normal.'

John Gaffney, Manager Network Operations, VicRoads

2. The gains achieved by VicRoads and Queensland's Department of Transport and Main Roads, using STREAMS to alleviate motorway congestion with coordinated ramp metering, have been significant and world class. Translating these gains to better whole of network outcomes requires better connectivity between different road network systems such as STREAMS and SCATS as well as the many systems controlling the privately owned road systems.

'As well as the quantifiable benefits, STREAMS Managed Motorways realises social benefits including: community satisfaction through noticeable improvement; reduced stress; financial savings; increased comfort; and improved availability and quality of information on road networks.'

Mark Williamson, Managing Director, Transmax

3. The SCATS traffic signal system originated in Australia and is now in operation across the world. Traffic signals and other infrastructure controlled by SCATS enables integrated management of traffic through automated actions and operator interventions. The new SCATS Priority Engine (SPE) that manages the priority functionality of all types of priority requesting vehicles is planned to be included in the next release of SCATs. This will allow buses to be given signal priority, thereby optimising the system to move the largest number of people, rather than the largest number of vehicles. It will allow emergency vehicle priority and enable other priority setting rules to be created in future.

Australian cities are actively involved in the Smart City movement. Melbourne already has a number of prototype projects running, including transport related initiatives. One of these involves work with people who are blind, deaf or deaf–blind to better understand how they navigate through the city. This uses beacon technology in Campbell Arcade to transmit location-specific information to phones.

'Our vision for Melbourne as a smart city is simple: to enhance the aspects of our city that make us uniquely Melbourne, and intelligently prepare for the changing needs of the community, the environment and the economy.'

City of Melbourne[7]

At a local level, Australian councils and businesses such as shopping centres are installing electric charging points supporting more advanced vehicles that typically contain IoT equipment, supporting the adoption of such technologies, for example the Willoughby City Council renewable energy program and electric charging points at Westfield Chatswood, New South Wales.



Figure 15. Renewable energy program at Westfield Chatswood, New South Wales. Courtesy of Willoughby City Council

[7] http://www.melbourne.vic.gov.au/about-melbourne/melbourne-profile/smart-city/Pages/smart-city.aspx

3.4 INITIATIVES, OPPORTUNITIES AND BENEFITS

SMART MOTORWAY TECHNOLOGY

Smart motorways are a significant contributor to smart city operation, moving large numbers of vehicles into, out of, through and around major conurbations. The technology is well established but significant progress continues to be made. Smart motorways are operational rather than planning focused, which means that they have to respond to predictable patterns and unexpected events in real time.

New Zealand's first smart motorway is one of many worldwide. This uses ITS to automate variable mandatory speed limits (VMSL) and ramp metering to manage congestion and increase vehicle throughput on the Wellington motorway network. This particular system takes a globally innovative approach to triggering VMSL regimes (that is, setting speed limits across the network at a given time).

Automation in this and other implementations is supported by operator monitoring and potential intervention through a rich user interface such as that shown below.



Figure 16. Typical information provided to traffic operations monitoring centre staff, Bruce Walton, Jacobs New Zealand (23rd World Congress, Technical Session 39)

ROAD CONFIGURATION

The tidal flow of demand for road space in peak hours can be satisfied with fewer road lanes and less congestion if lane flow is reversible. Moveable barriers are a method of creating a solid centre median which eliminates vehicle collisions as well as preventing pedestrians from crossing away from approved locations. A successful trial in Sydney delivered an average 18 minute saving on bus trips in the morning peak from Day 1 on Victoria Road using moveable barrier systems.

In some cases, road design can be improved where high quality data informs design and operation. A simple change to road layout at intersections can improve both safety and capacity. Monitoring traffic then enables the signal timings at the junction to be optimised.



Figure 17. Moveable lane barrier vehicle in operation. Courtesy of Roads and Maritime Services, New South Wales

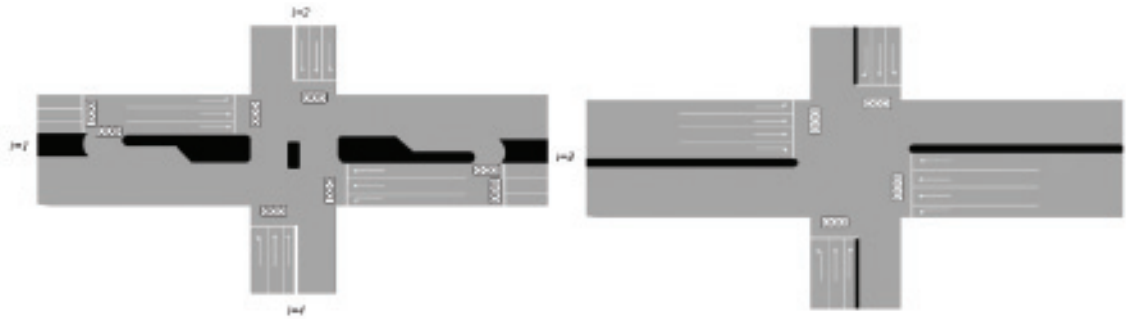


Figure 18. Non traditional approach to increasing intersection throughput requiring U turn to turn right (left diagram) instead of traditional design (right diagram). Note that no extra road space is required, Sandy Mae Gaspay, Institute of Industrial Science, University of Tokyo (23rd World Congress, Technical Session 4)

DATA COLLECTION AND ANALYSIS

Smart motorway management is underpinned by a considerable body of practical and theoretical research. This increasingly uses smartphone technology to gather data, both for research and for implementation purposes – allowing operational monitoring of vehicle movement to be matched back to the data gathered to set up the system.

It has long been known that 'shock waves' can occur in dense, fast moving traffic on a highway. Three types of events can cause an interruption to the steady flow: a vehicle accelerating sharply, one travelling particularly slowly and sudden lane changes. These make a small difference locally but send a shock wave back through following traffic, ultimately stopping traffic. New research uses smartphone monitoring in probe vehicles to predict congestion up to 30 minutes prior to it occurring, allowing route guidance, speed limits and vehicle control systems to prevent it.

ITS relies on many data capture mechanisms. While it would be ideal to install infrastructure to capture desired data, some techniques are exploiting unrelated infrastructure to acquire useful information. Many roads have optic fibre cable runs and these can be used not only to detect vehicles but also to determine their speed. A practical demonstration of this in New Zealand used an operational trial to provide real-time travel time information on a trial site north of Auckland over a distance of 40km.

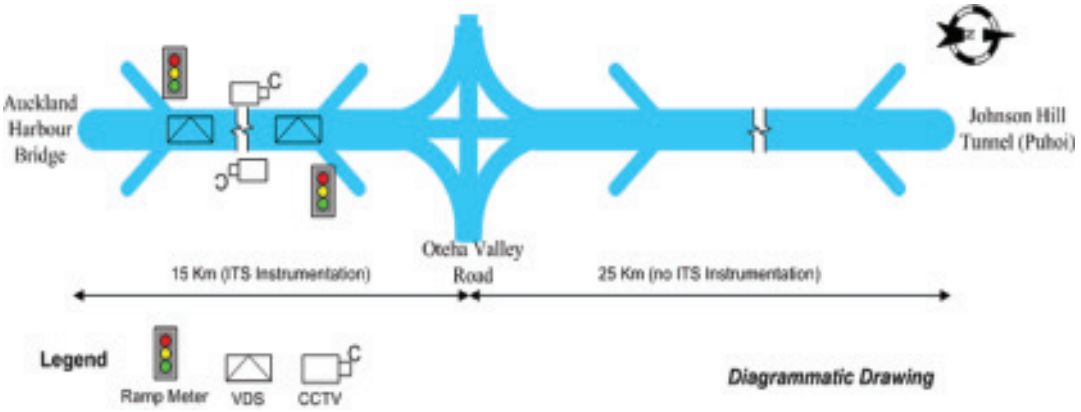


Figure 19. Schematic model of New Zealand managed motorway infrastructure with partial ITS instrumentation, Russell Pinchen New Zealand Transport Agency and Henry Wu JYW Consulting (23rd World Congress, Technical Session 33)

An alternative means of collecting traffic and trip information is to collect data directly from vehicles. When this is sampled across all traffic, vehicles providing data are called 'probe vehicles'. Different data gathering approaches are being trialled. A paper by Una, Oda, Koga and Kurauchi reports on a recent trial using taxi dispatch systems to gather data where no on-ground data gathering exists. While probe vehicle data gathering is increasingly common, this initiative links to an established system which broadcasts directly to vehicles. The study demonstrates that in the Nara model area, a total time saving of 9% in the morning peak is achievable. Such work is important for planning and preparations as Tokyo prepares for the 2020 Olympic Games.

BEHAVIOUR AND MANAGEMENT

Congestion problems at key points in the network can reduce the effectiveness of the overall network, reducing infrastructure efficiency and causing delay and congestion. Research in Japan has demonstrated that installing moving light patterns on steep uphill sections, especially ones where drivers do not sense the change in gradient, can encourage drivers to maintain their speed, therefore keeping steady flow. This is an example of physical engineering working on behaviours, highlighted by the improvements vary between times of day, suggesting that the behavioural change is affected by more than the lights alone.

Many of the challenges in road network management come from the need to coordinate a large system as one. Research from the Netherlands, for example, suggests that highly congested traffic is best managed by partitioning the network. Such an approach to traffic management is explicit only in traffic management, but is expected to deliver benefits for road users in the complexity of a smart city environment.

'Guangzhou local police leverage probe data as well as on the ground sensors to monitor the whole city. They see where they can improve the system and present information to the media and public, including traffic maps, camera photos, traffic news, traffic accident reports, regional traffic and a vehicle administration service.'

Patrick Cheng, CEO, NavInfo

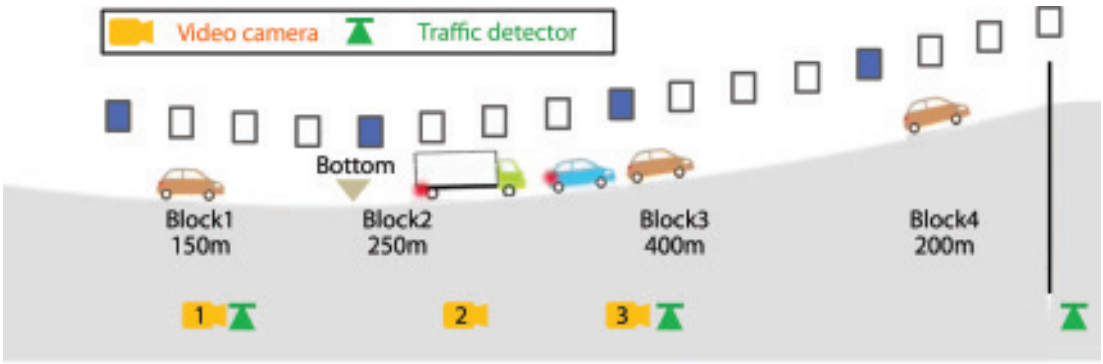


Figure 20. Trial of moving lights to encourage drivers to maintain speed on change of slope, Dai Tamagawa, Hanshin Expressway, Japan (23rd World Congress, Scientific Session 1)

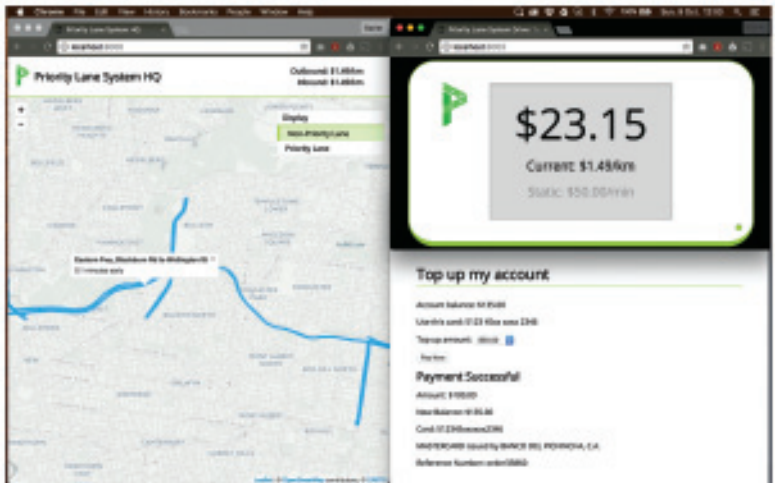


Figure 21. Road charging/pricing app concept for road users developed in the Hackathon, www.hackathon.io

In the Congress Hackathon, team Priority Lane System created a simple app to support road demand management.

Many ITS network solutions rely on providing good information to drivers and relying on them making informed decisions. Some take intervention a step further and direct traffic onto a preferred route. A test in Bavaria demonstrated that a combination of Variable Message Signs and in car devices in BMW vehicles could be used to direct drivers to use one of two alternative routes. The choice of route direction was based on network awareness of traffic conditions.

3.5 CONCLUSIONS

Smart Cities envisage a world of fully integrated transport based not only on good information but also on supporting infrastructure and city design. In many respects, Australia offers an ideal environment for such solutions to be developed. High urban concentrations, but low densities, mean that the benefits of information and infrastructure to optimise the transport problem will have the highest payoffs here.

Australian businesses have opportunities in a number of areas. including:

- Smart motorway technology
- Road configuration
- Behaviour and management

We continue to need for solutions to first and last mile problems as well as improved connection to the large 'people mover' parts of the transport network - the motorways and public transport systems. Given demonstrated strength to date, this is an area of opportunity for businesses in the Australian market.

Further progression towards a whole of network approach is required.

With major roads, the work being done by and for the States and Territories roads agencies is producing new understanding of the causes of problems – including but not limited to congestion – as well as smart solutions. Australia has significant expertise and experience in motorways, urban network management, network traffic control, and vehicle telemetry. This work is applicable to road networks worldwide and Australian universities and businesses have a continuing opportunity to lead.

Growing Australian experience in electric vehicles and the development of supporting infrastructure such as charging points offers opportunities for local and overseas business.

The integration of all transport elements into a truly smart city will require new ideas, infrastructure and software solutions, supported by big data.

Mechanisms for the interconnectivity and sharing of data are required.

Australians have demonstrated a willingness to adopt new smart city transport options such as ride share and parcel lockers. The opportunities for early movers in this area in Australia must be considerable and the experience gained here will then be applicable in overseas markets.

4. NEXT GENERATION PUBLIC TRANSPORT AND MOBILITY AS A SERVICE

4.1 BACKGROUND

Customers have greater choice of transport and ever increasing access to information through a new world of digital technology. How we use this technology to meet the changing needs and growing expectations of passengers is critical to the provision of innovative and responsive transport systems.

There is a blurring of lines between transport types. The traditional binary view of public and private transport is no longer meaningful. Traditional vehicles are being used in new ways and new service models such as bike and car share are disrupting modal provision. While the sharing economy, enabled by electronic communications, is allowing existing operations to be attacked by new entrants (such as is occurring in the taxi market), many of the new service models can also encourage new trips, enable journeys that were not previously possible and make travel economic that was previously not cost effective.

These disruptions are with us now and are starting to change travel across the world.

New developments will make further and perhaps more radical changes possible, many in the very near future.

Media coverage and on-road trials have increased public awareness of automated vehicles and in addition to these vehicles being available for private transport, there is a wider understanding that automated vehicles will also lead to public transport solutions.

Ride sharing is already high profile and providing practical improvements with a clear line of sight to shared automated vehicles. Data access and back end platform integration are key to moving to the next levels of efficiency and moving towards the goal of filling every seat in emerging transport models.

These elements and more are combined into Mobility as a Service (MaaS), which aims to provide fully connected service provision with the simplest possible customer interaction, based on point to point demand and 'trip thinking' rather than availability based provision on the 'build it and they will come' model. Importantly, system learning will allow passenger preferences to be identified – explicitly or through Artificial Intelligence – simplifying the interaction between user and system.

4.2 KEY CONGRESS MESSAGES

Discussion at the Congress pursued three main themes. One of these was a customer focus: creating simple, connected, door to door service. The second theme pursued the integration of platforms to provide the infrastructure to support the services that customers need from the first group. The final theme was the automation of vehicles and systems that will enable the overall transport network to operate more reliably, more cheaply and more responsively.

Keolis Downer sees four challenges that public transport, automation and MaaS can meet:

- Contemporary society is focused on leisure, socialisation and family
- Most people still want access to personal transport
- Digital life and virtual reality is changing how we live
- Rural areas and fragile population needs must be met

MaaS offers the integration to bring existing transport, and future transport (cost justified by the demand MaaS creates), together into an integrated service.

'The first thought of a user in MaaS is simply to get from A to B, with the MaaS platform providing them with a variety of transport options to do so, personalised to their needs. MaaS draws upon the power of the smartphone, the growth in alternative mobility options such as bike sharing, car share schemes and ride-sourcing services'.

Andrew Somers, MaaS Australia

Transport providers and infrastructure owners are the key players in shaping this and have commercial opportunities through existing infrastructure and presence.

'MaaS is essentially a co-ordination service based on big data. There is scope for one provider or many and the potential for government to play a role in coordination creates opportunities for Australian cities. Government needs to facilitate the environment, be the enabler. MaaS is unstoppable if the service is good enough.'

Sampo Hietanen, CEO/Founder, MaaS Global

Discussion about Maas in the Congress sessions and at demonstrations generally assumed the questions about MaaS are 'when' and 'how' rather than 'whether' it will take off.

Pilots around the world have demonstrated not only that the service can deliver in theory, but also that the public can change their behaviours in practice. The UbiGo pilot in Gothenburg, Sweden, providing MaaS to over 70 paying households for six months, saw increases in the use of public transport and active modes, but also a very substantial reduction in private car use (a 50% reduction), and 20 private cars taken off the road for the duration of the pilot. Public acceptance was almost total.

'After the end of the pilot phase 97% of the users wanted to keep using the service.'

Jana Sochor, Senior Researcher, Design and Human Factors, Chalmers University of Technology, Gothenburg

The concept is broadly proven and public acceptance demonstrated in some cities, but local infrastructure and local needs mean that MaaS is still at an early stage.

'In Bordeaux last year, the key questions then were whether MaaS could work outside very large cities and whether the business model would always require considerable funding support and a radically different commercial approach. Unfortunately we are not quite there yet with deployments so we are not quite there yet with all the answers!'

Eric Sampson, Chief Rapporteur, ITS World Congress 2016

Despite public concerns that more transport infrastructure is needed and local efforts made to increase the number of passengers in peak hour cars, cities suffer from low capacity utilisation. Uber report that a car is typically only used 4% of the time and this represents a significant waste of resources, or a missed opportunity. Even within a vehicle that is occupied, if it is not fully occupied, there is still a resource opportunity. Filling every seat in moving vehicles reduces cost per person, congestion and cost of running vehicles. MaaS represents an approach to better using resources, as well as providing better service.

'Our goal is to make transport as reliable as running water. But we can't do it alone and we don't want to do it alone…Sometimes you want to go as fast as you can because you are late. Other times you may want to take your time, save some money, stop on the way. In each case, Uber is not the solution but rather an input to the solution. The solution is getting to where you want to go in the way you want to get there. Uber provides an option but not the only one. We believe we have to partner with public transport alternatives, other providers and government to provide a solution to make cities better. That is what MaaS means to us.'

Mike Brown, General Manager Asia, Uber

Similarly, public transport for major cities may run at capacity in the travel peaks, but be little used off peak. Current ITS developments involving trains, trams and buses primarily concern coordination and ticketing using smart technology as well as integrated traveller information to enable optimal, connected journeys.

The consequences of effective integrated public transport provision, integrated with the remainder of the transport infrastructure, will inevitably affect the whole network.

A topic that attracted considerable interest, both in formal sessions and in the demonstrations, involved light autonomous vehicles that can support, extend and enhance public transport. These have the potential to provide more options and better service provision. While these vehicles can potentially address the 'last mile' problem (getting passengers between home or office and mass transit), the MaaS commentators see this as important but only part of the value that MaaS and autonomous vehicles can add.

4.3 AUSTRALIAN CONSIDERATIONS

Although Australia has a very low population density across the whole continent, people are highly concentrated into large cities, with higher rates of urbanisation than the UK or France. However, within these cities, the population densities are comparatively low for urban areas and large parts are poorly served by public transport.

Australians are early adopters of technology and the rapid uptake and coverage of smartphones provides an essential platform for MaaS as well as inter-modal journeys that link first/last mile solutions and public transport.

A declining proportion of Australians are acquiring driver licences in their late teens and twenties. To age 24, Victoria has experience a greater than 10% decline in uptake. This means a larger pool of people do not have access to personal, private transport and, importantly, are at the same time digital natives.[8] This will provide a spur to take up of next generation public transport and MaaS.

Set against this, the high level of car ownership in contrast to other countries means that there is a last-mile opportunity that is currently unmet and which services such as Uber pool and later automated vehicles might satisfy efficiently and affordably.

Australia has contemporary public transport ticketing and information infrastructure with high levels of take up of proximity payment cards in all capital cities. Access to these ticketing systems by third parties is a key barrier to MaaS in Australia and other countries. Public transport users increasingly rely on provider (such as Victoria's PTV and Tram Tracker apps) and independent information services (such as TripGo and Moovit) to seek timetable, interconnectivity and on time performance data.

[8] Meaning that using the internet and technology to achieve things is instinctive

4.4 INITIATIVES, OPPORTUNITIES AND BENEFITS

MaaS services are being developed and trialled overseas. Whim opened a MaaS service in Helsinki during the Congress. This offers a variety of subscription levels for varying levels of service. In each case, the subscription offers unlimited local public transport, while higher grades provide larger numbers of included trips on other transport types. Under the top plan, commuters can earn extra "mobility points" by opting for public transport and use them on perks such as the use of a Tesla car for the weekend. Key to the offering is a point to point service which removes from the passenger any need to plan the journey.

A major step in launching the Whim service in Helsinki was the mobility services gaining the ability to book and pay for transport seamlessly through the app, including ticketing for public transport.

The Finnish Government has been proactive in opening the market, including introducing supportive legislation. This need for booking, payment and ticketing of diverse transport offerings is common across MaaS initiatives and is necessary also to achieve concepts such as Cubic's one account approach to mobility.

Uber offers a third party API to pull customer experiences out of Uber data to allow planning integrated trips. TripGo is an implementation of this that offers a planned trip that pulls different modal options together to present an optimised journey.

New Jersey has introduced a subsidy for last mile commuters to get them to mass transit using ride share rather than providing (at higher cost) additional car parking spaces at the station. San Francisco and San Diego are piloting similar programmes.

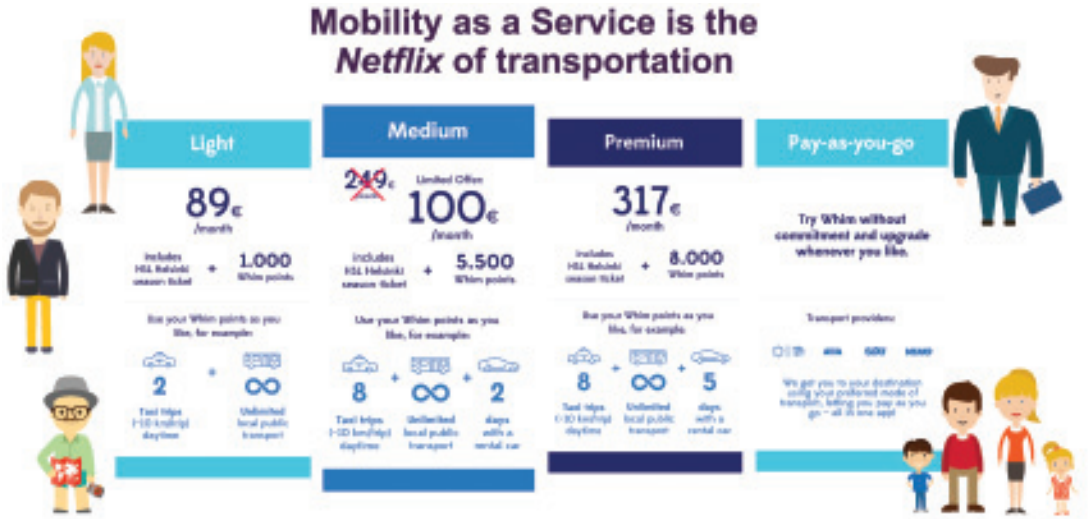


Figure 22. Subscription options for Helsinki MaaS, Sampo Hietanen, MaaS Global(23rd World Congress, Special Interest Session 66)



Figure 23. Connected bus shelter providing passenger information, Murray Robertson, Downer (23rd World Congress Commercial Session 6)

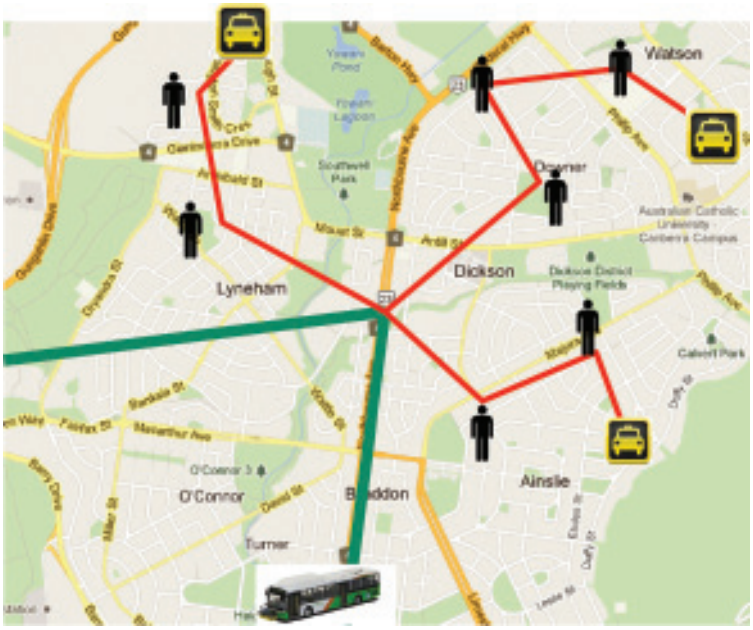


Figure 24. Multi modal concept integrating bus and (shared) taxi services to solve 'last mile' problem, Philip Kilby, Data61 (23rd World Congress, Commercial Session 6)

Integrated transport means connecting place and people in a seamless way that is efficient in resource use. Keolis Downer is developing the services it delivers to get closer to this goal. Keolis has developed a market intelligence program on mobility called Keoscopie using a ticketing database that maps individual travel patterns and respond to needs.

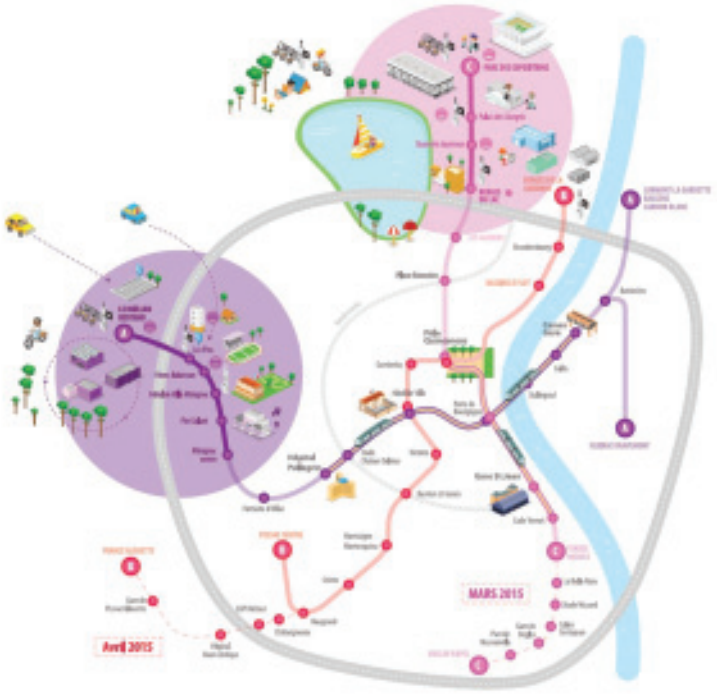


Figure 25. The essence of a customer centric network is multimodality, Sandrine Gaubert Keolis Downer (23rd World Congress, Commercial Session 6)

Important work is being undertaken and was showcased at the Congress addressing specific challenges in introducing MaaS.

The Xerox Research Centre in India is addressing the challenge for multi-modal trip planners that already offer the quickest passenger journey time, but also need to optimise the overall system by also minimising waiting time for on-demand transport vehicles. This is critical to reduce system costs and therefore reduce prices for passengers.

Public transport users will be able to benefit from the development of beacon technology. In essence, this allows detectors to sense the proximity of a smartphone with Bluetooth and integrate this information into service and charging systems. This will enable passengers to be given next service information at their location, validate or effect fare payment, and notify them that they have reached their destination.

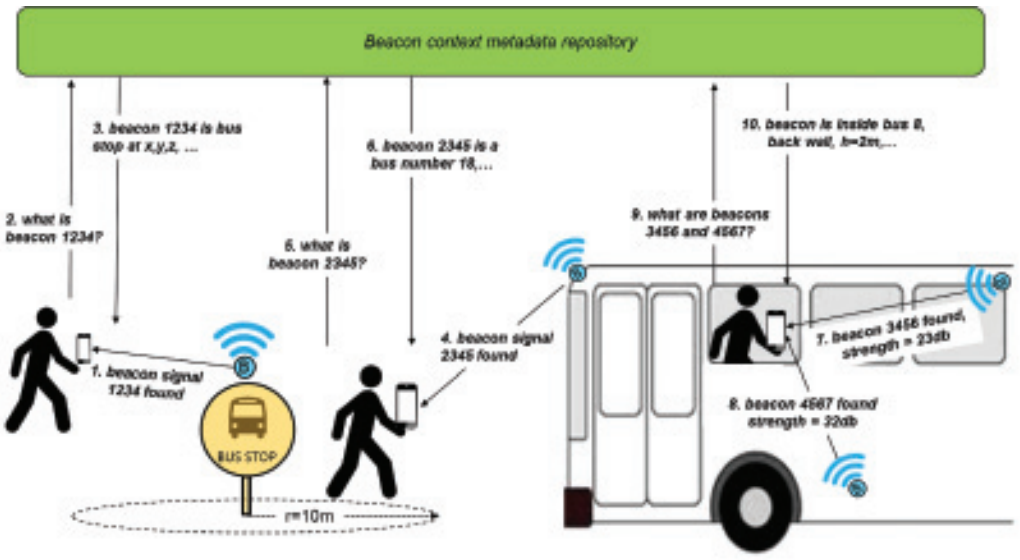


Figure 26. Mechanism to deploy connectivity between passenger device, roadside and on road infrastructure to manage service delivery, Juho Kostiainen, VTT Technical Research Centre of Finland (23rd World Congress, Scientific Session 12)

Many projects and trials are exploring practical ITS based interventions to improve the operation of public transport. One example is being undertaken by the Norwegian University of Science and Technology, Traffic Engineering Research Centre, which is investigating practical means of granting priority to buses at roundabouts and which is being evaluated using the Australian analytical SIDRA INTERSECTION model.

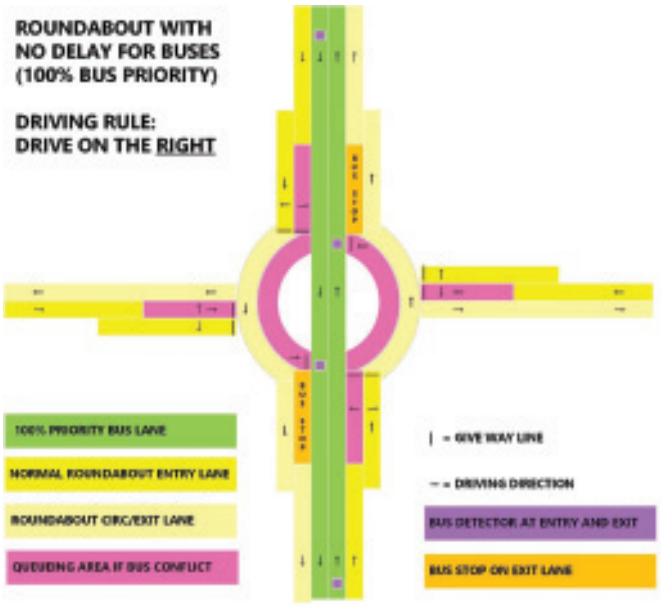


Figure 27. Norwegian trial of Australian SIDRA bus priority model, Arvid Aakre, Norwegian University of Science and Technology (23rd World Congress, Technical Session 38)

On the demand or passenger side, research is being undertaken into optimisation of taxi usage to make the best use of this resource. The goal is to achieve "an independent, affordable demand responsive transportation structure involving high quality of service and comfort similar to individual cars. The reduced fares will be achieved by raising the number of car passengers while keeping vehicles as busy as possible." [9] The research uses a simulator to develop and evaluate optimal models and demonstrates the theoretical viability of such an approach:

Traditional public transport typically provides services based on general demand patterns, vehicle available and is modified by usage over time.

Next generation public transport using ITS and data analysis tools is capable of better alignment to passenger demand. A project being undertaken by the Xerox Research Centre in India demonstrates the viability of schedule optimisation to take account of both provider and user demands. This framework generates schedules that minimise passenger waiting based on past 'big data' ticket information.

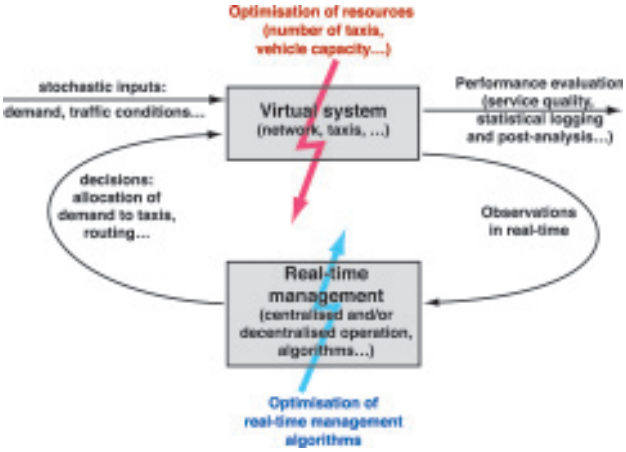


Figure 28. Schematic of taxi resource optimisation model, Jennie Lioris, IFSTTAR (23rd World Congress, Scientific Session 60)

4.5 CONCLUSIONS

Overall, next generation public transport, and the integration of the whole transport network through MaaS delivery will:

- Make better use of road and public transport infrastructure, progressively moving towards true optimisation
- Incentivise modal shift, exploiting leverage to reduce road demand and ameliorate congestion
- Potentially provide significantly better service for the disadvantaged, rural and less well off
- Offer personalised scheduling to meet individual needs
- Provide timely and accurate information to passengers about their journey

Opportunities exist for Australian businesses to develop a wide variety of products and services. No integrated, full service MaaS offering, bundling public and private transport into a subscription service yet exists, though the information infrastructure exists (timetabling) and transport networks are well developed and managed. Improving access to real time public transport data will be a key facilitator of this.

At smaller scales, there are opportunities for app developers to provide information only services, and for analysts and developers to provide services for larger subscription service providers. The opening of data by government also provides opportunities for businesses to add value to this data for the public, for intermediary businesses, and for governments themselves.

There may also be opportunities that align or integrate State and Territory or local transport offerings into a single national information service. While integration at an information level is offered by global enterprises such as Google Maps and others, the services offered do not yet exploit the full potential.

[9] Jennie Lioris, FTTAR, France

5. BIG DATA, ANALYTICS, OWNERSHIP AND ACCESS

5.1 BACKGROUND

Information is vital for transport planning decisions, but also at an individual level, where behaviours can be changed by better or full information about transport options, availability and disruptions. Information is generated from data and the volume of data available is greater, and growing faster, than ever before.

Some of this data is not new but is accessible because it is being stored, consolidated or classified in new ways. Some data is being gathered in richer forms – public transport proximity cards gather data about the end to end trip where paper tickets did not. And the Internet of Things (IoT) is creating a network of devices of all kinds which gather and report a wealth of detail about status (things like presence, temperature, location), activity (who or what was where) and volumes. It is sometimes claimed that more data has been created in the last three years than in the whole of prior history.

The term "big data" is now widely used to capture the ability of organisations to analyse large volumes of data sets to reveal patterns, trends and associations particularly relating to human behaviour and interactions.

Much of the excitement about big data comes from the capacity it brings to understand individual or collective events and behaviours. Many elements of Intelligent Transport Systems exploit big data to deliver benefits that have not been previously possible.

Some of these use data from within their own systems in ways that are closer to real time, or have more data points, or provide a longer time series. These allow entirely new conclusions to be drawn about demand and about network operations.

The relatively new feature of 'big data', and what makes the disciplines supporting it so powerful, is that previously unimaginable volumes of data can now be processed, often with useful information available in real time or with latency of a few seconds.

'Every day we have 4-5 Tb data coming into our servers.'

Patrick Cheng, CEO, NavInfo

Other applications bring together previously unrelated data sets to provide new value. This capacity to connect and process data from vehicles and traffic systems, from public transport schedules across modes and other data sets brings another dimension to the power that ITS can add. Indeed, the Congress mounted a data 'hackathon' under the sponsorship of Mastercard, encouraging developers to exploit data sets to produce innovative consumer facing applications, leveraging big data.

Some of the data sets that are relevant to transport are not purely transport related but have an impact on transport. Weather data is increasingly detailed and prediction and actual weather information has an important bearing on the planning for, and operation of transport. Big data includes the combining of such external data with transport data to support the better operation of transport of all types.

Data supports much of ITS and the use of data sets underpins the topics of the other sections of this report. This section looks particularly at the use of large data sets – the issues, challenges, opportunities and applications.

5.2 KEY CONGRESS MESSAGES

The emergence of data sets and data analysis tools is still at a relatively early stage. The full potential of big data is yet to be realised, but there the diversity of solutions now being developed demonstrates the potential.

'A key issue is the ability to understand and analyse data. Provision and sharing of data is one thing, understanding it is another. The power of machines must be utilised to achieve much of this. The significance of big data is simply that it enables big understanding.'

Jack Dangermond, President, Esri

During the Congress Hackathon developers were encouraged to compete in one of four 'challenges' using a Mastercard application program interface (API) and a data API or data set. Developers had access to a variety of comprehensive data sets including road networks, infrastructure (such as traffic signals and Bluetooth sites) and public transport timetable information. The data included some Mastercard information – an example of commercial data being made available to external parties in a controlled environment.

Access to data creates three major issues: security against cyber attack in all its forms, privacy of personal and private data, and commercial sensitivity of data where private operators provide services in a competitive market.

Exploiting data requires a mindset change about sharing transport information.

'We need to progress from individual systems and services to an integrated, coordinated and more effective suite of services. The ultimate ITS service is one where data is collected once and used as many times and in as many applications as appropriate.…Data is the key, big data, open data, and smart cities.'

Richard Harris, International Director of ITS UK

Access to data is a critical issue. Data is gathered by both business and government. Traditionally, both have protected this data, either for commercial or confidentiality reasons. Governments are now making de-identified data sets available publicly and often freely. Businesses are also providing access in many cases, particularly where they derive a business benefit from collaboration, or are required to as part of a service contract.

'It is not the truck that is important, it is the commodity in the truck. The more we understand the product, the more we can make it efficient. We look for points of inefficiency. What the data told us to do… was not to add capacity but to find an opportunity to consolidate freight.'

Paul Trombino III, Director, Iowa Department of Transportation

Data security is of vital importance. Information on where a car is joins a data set that tells a story of travel patterns and this informs infrastructure decisions. Individual trip details are important data elements for both real time and planning purposes, and form the basis of many transport data sets. However, personal trip information is considered private data and the risks of revealing such personal information mean that data analysis and applications must deal with demanding security barriers. The de-identifying of data has become a key skill to enable meaningful data to be shared without impacting on privacy.

It is therefore essential that industry and the community have confidence in the overall transport data system.

'It is critical that there is public acceptance that data sets about their personal travel are secure. To do this, we need to be transparent about why we need this data and what the benefits are to the individual as a result. This holds true for anonymised cellular data as well, which is now being widely used for travel information. While this data will likely be used for the next generation of traffic control systems, we need to be very careful in preserving individual privacy as we move into these areas.'

Terry Bills, Global Transport Industry Manager, Esri

5.3 AUSTRALIAN CONSIDERATIONS

With a strong, globally recognised tertiary sector, many ITS businesses of all sizes, and a public sector that has been keen to pilot and adopt ITS, Australia is amongst the leaders in the use of big data for transport.

Importantly, the depth of ITS expertise in Australia enables peer to peer networking and cross fertilisation of ideas.

The use of big data is reflected particularly in roads management where Australia is a world leader. The skills base covers all facets of transport, including public transport, roads management and vehicle management. The presence of major motor vehicle companies (car and truck) in Australia, with experience in Australian based vehicle development means there is a skill base available to support software and research innovation.

Structurally, the independent nature of the eight Australian jurisdictions means that each has an opportunity to look at different initiatives. This contrasts with large central agencies (such as those covering the whole of each major European country) which are more likely to have a focus on one area of research.

Australia benefits from independent initiatives with a number of collaborative institutions such as Austroads, the National Transport Commission and Transport Certification Authority. Similar benefits accrue from the independence of the automobile clubs, some of which are heavily involved in exploring the potential to exploit big data.

Australia is a world leader in managed motorways. Melbourne's M1 Monash Freeway Upgrade project has five years of operating experience. The freeway operations are optimised in real time as a single connected system using "state-of-the-art ITS control logic, ITS platforms and telecommunications systems that can collect accurate network wide field data and make whole-of-network control decisions in the field within a few seconds of all data being collected."[10] This is an excellent example of integrating multiple sources to improve traffic flow and traveller decision making.

5.4 INITIATIVES, OPPORTUNITIES AND BENEFITS

New projects and initiatives using data are purpose driven rather than being research for its own sake. These projects therefore also belong in one or more of the other sections in this report. However, some of the work brings together different themes and delivers benefits across the transport task. Imagination and curiosity are the starting points for much of the research.

PUBLIC TRANSPORT

Passenger data on public transport can be used to better manage, and plan for the management, of public transport. A trial using large data sets in a French public transport network has been able to take a more user-focussed view of trip delays than measures of schedule reliability alone can do. The latter provides a metric for the performance of the vehicle and the interaction with an individual, but this study models and assesses the impact on the end to end trip.

Total trip analysis is especially important not only because this is the customer view but also because a multi-modal trip relying on short changeovers is more sensitive to missed connections than one where there is significant connection waiting time. At the same time, from the perspective of the community as a whole, the aggregate cost of delay is greater for a full vehicle than an empty one.

The following graphics show a representation of passengers' perceived waiting cost over time and a calendar chart representing passengers' late arrival at the final destination. While superficially simple, such representations are only possible with access to individual trip information and the underlying data gathering infrastructure. With such information, more granular analyses can be undertaken, targeting peak overload or recurrent, stubborn delay occurrences.

[10] John Gaffney Manager Network Operations VicRoads

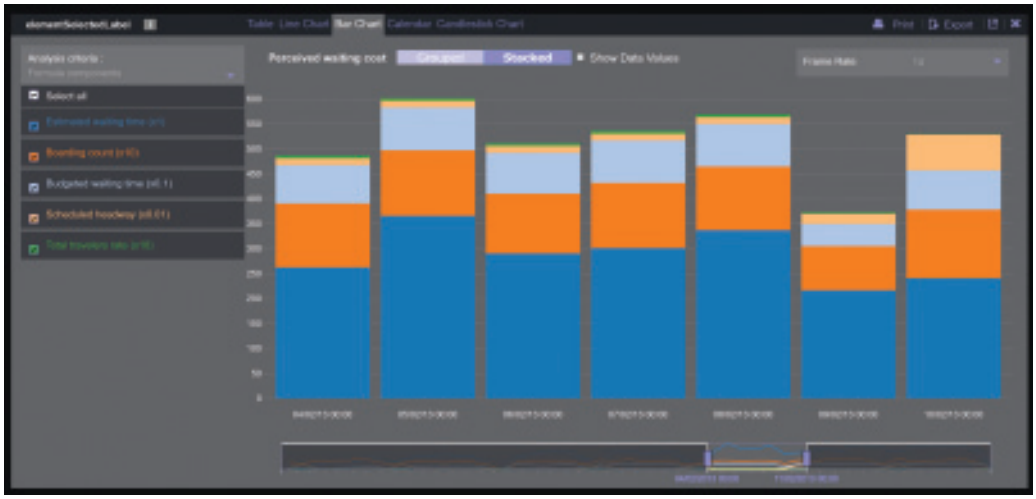


Figure 29a. Representation of passengers' perceived waiting cost over time, Frederic Roulland, Xerox Research Centre Europe (23rd World Congress, Technical Session 81)



Figure 29b. Calendar chart representation of passengers' late arrival at final destination, Frederic Roulland, Xerox Research Centre Europe (23rd World Congress, Technical Session 81)

Big data enables new insights. Work by Keolis in Dijon has identified that most public transport users after 9pm are occasional users of public transport: granular analysis can be undertaken, targeting peak overload or recurrent, stubborn delay occurrences.

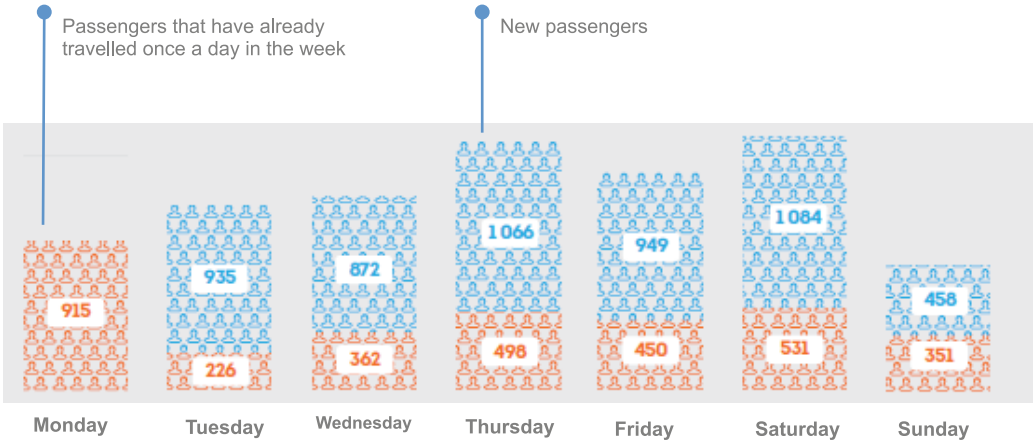


Figure 30. Distinguishing first time and repeat passengers using trip data, Sandrine Gaubert, Keolis Downer (23rd World Congress, Commercial Session 6)

The opportunity that this information provides is to identify scope for patronage growth and high frequency services for these users.

ROADS AND TRAFFIC

Many of the projects being researched, developed or trialled – both described in the Congress sessions and demonstrated in the Exhibition Hall – involve traffic monitoring and management using many sensors on static infrastructure and moving vehicles.

The established Optimodlyon project in Lyon, France, is typical of big data analytics used to provide real time and predictive information. Building on a public/private cooperative bringing in a cross section of business interests, it provides real time and forecast data about expected traffic conditions. The project does not merely seek to inform, but is aiming to deliver an 8% modal shift, a reduction of 200 kilotonnes of CO2 and a gain of 83M Euros.

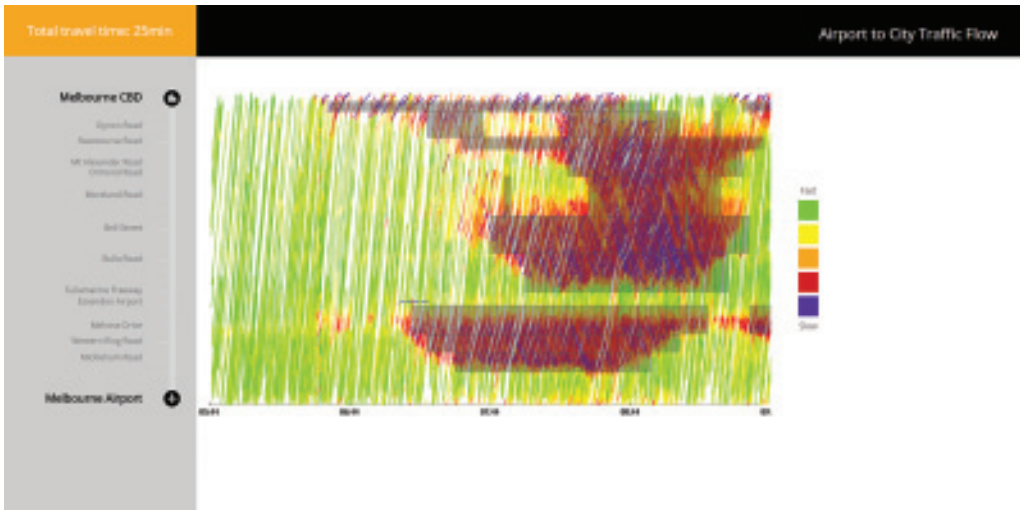


Figure 31. Real time peak hour traffic movements from Melbourne CBD to Airport Courtesy Intelematics

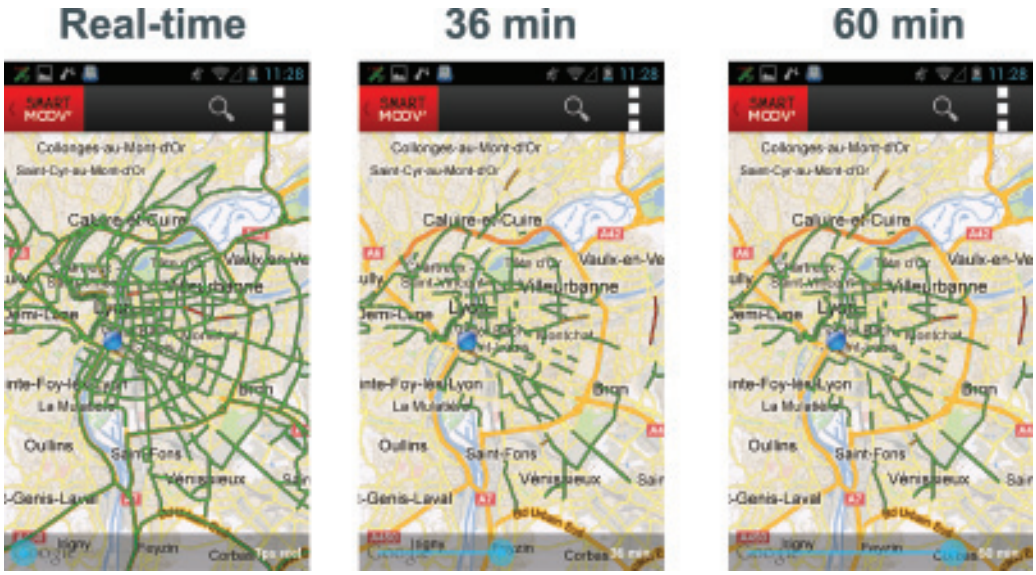


Figure 32. Lyon traffic prediction using data from all modes Courtesy OPTIMOD

Crowdsourcing[11] data offers the potential to improve knowledge of transport network performance. A trial was undertaken in 2015 to collect information on winter road conditions in the Queenstown Lakes area of New Zealand.

'Using a web based form, users could report a predefined range of incidents such as crashes, road damage, snow and ice. The location of the incident could be picked using the device's location service or could be selected from a map screen or address.'

Dale Harris, Senior GIS Road Safety Analyst, Abley Transportation Consultants

While much of the work in big data involves public transport, significant work is being done with private vehicles. Analysis of telematics data has in recent years shown that there are clear correlations between patterns of driver behaviour and the risk – not only in regards to safety but also to vehicle operation.

The potential to exploit previously unconnected data sets to produce better outcomes is allowing early steps to be made in creating previously unimaginable innovations. A research project called CHOREM (CHOReographing services for EMergency management) models the connection of many datasets, including crowdsourced data, to gather knowledge about emergency information, cross pollinate guidance systems being used by emergency services vehicles, and optimise route choices. This will, for instance, enable emergency vehicles to be given route priority at junctions, and even railway level crossings. The significance and complexity of a problem that can only be addressed with big data solutions is highlighted by the 'actor and interaction' model in Figure 33.

[11] Crowdsourcing is the practice of engaging the services of a large and undefined group of people to provide information or input into a particular task or activity that would otherwise be too difficult or impossible to solve using traditional outsourcing or data collection methods. Howe. J. (2009) Crowdsourcing: why the power of the crowd is driving the future of business. New York: Crown Business

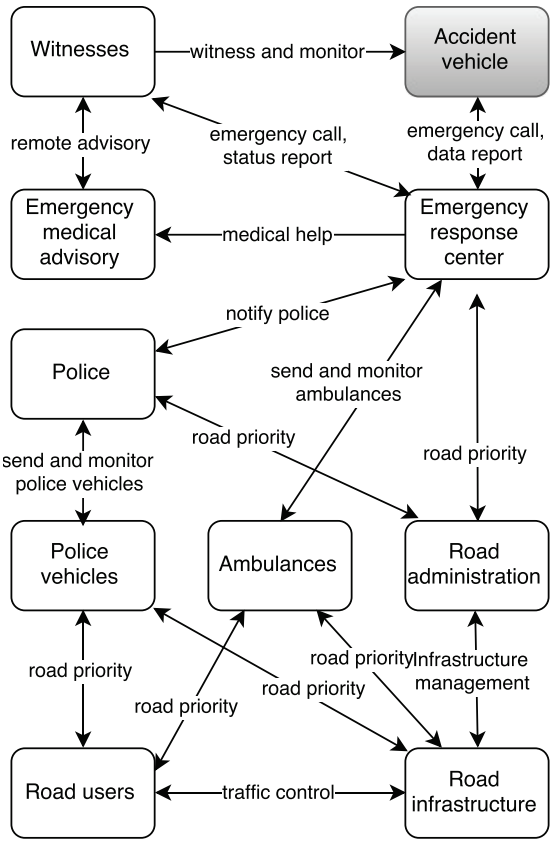


Figure 33. Interaction model illustrating data modelling complexity, Lei Chen, Viktoria Swedish ICT (23rd World Congress, Scientific Session 11)

"The concept of journey monitoring using wireless sensor technology is well established. Using appropriate hardware and strict personal privacy compliance protocols, globally unique mobile device identifiers can be harvested as those devices pass sensors. As those devices pass other sensors they are re-detected to provide transit times. With high quality sensors over a wide area, combined with sophisticated filtering and Boolean logic based algorithms complex route choice, reliability, origin/destination information can be determined."[12]

New Zealand uses the BlipTrack system over a wide area to provide both local and long distance trip information.

Such a widespread and sophisticated system allows the Department of Transport and users to exploit this in a number of ways. These range from immediate savings in travel time from real time information – 2,000 drivers saved $30,000 (NZ) in one day – through to long term planning for the Airport Access project in Wellington which delivered a more cost effective solution. "In this case the high quality data from the system fundamentally changed the outcome."[13]

[12] Richard Young Beca Ltd

[13] Richard Young Beca Ltd

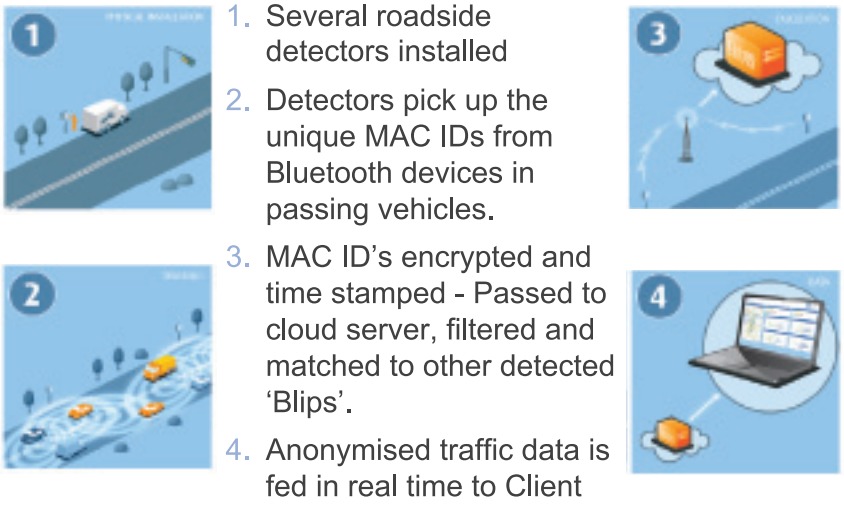


Figure 34. Mechanism for gathering probe data (BlipTrack example), Richard Young, Beca (23rd World Congress, Commercial Session 2)

DRIVER SUPPORT

A combination of different technologies with data permits new safety functionality. In vehicle traffic information takes road signs and enhances the information with, for example, speed sensitive information. In the sign in Figure 35, the right turn is indicated in yellow, but the display additionally indicates that the vehicle is travelling 5kph too fast.

Providing drivers with information about speed limits can also be delivered speed sensitively. While it is a simple concept to combine position based speed limit data with vehicle speed, practical behavioural research demonstrates significantly higher speed limit awareness and potentially greater safety with this information displayed in vehicle.

A telematics installation with back end analytical software provides information about driving related mental skills and then provides data to help 'coach' a driver towards better driving behaviours by providing risk alerts for speeding, excessive acceleration, harsh cornering, harsh braking and fatigue.

A trial with an Australian state government department showed a 21% gain in fuel economy when comparing events per kilometre and fuel used per vehicle. Over a 30,000km annual budget for business travel, this agency had the potential to save $823 per annum.

The Hackathon produced some interesting applications of big data to solve real world transport problems. Using APIs and data sets, competitors produced a variety of applications, to which they retain intellectual property rights. While the apps developed were essentially proofs of concept rather than fully functioning, they were required to demonstrate their feasibility using actual data.

One of the winning Hackathon applications (Geolicious) demonstrated a dynamic road pricing model based on geofenced roads, with pricing that responds to supply and demand. While the focus of the app is on reducing congestion, a similar solution could be used to deliver a variety of outcomes.



Figure 35. In vehicle display showing excessive speed for right turn, Kimihiko Nakano, University of Tokyo (23rd World Congress, Technical Session 21)

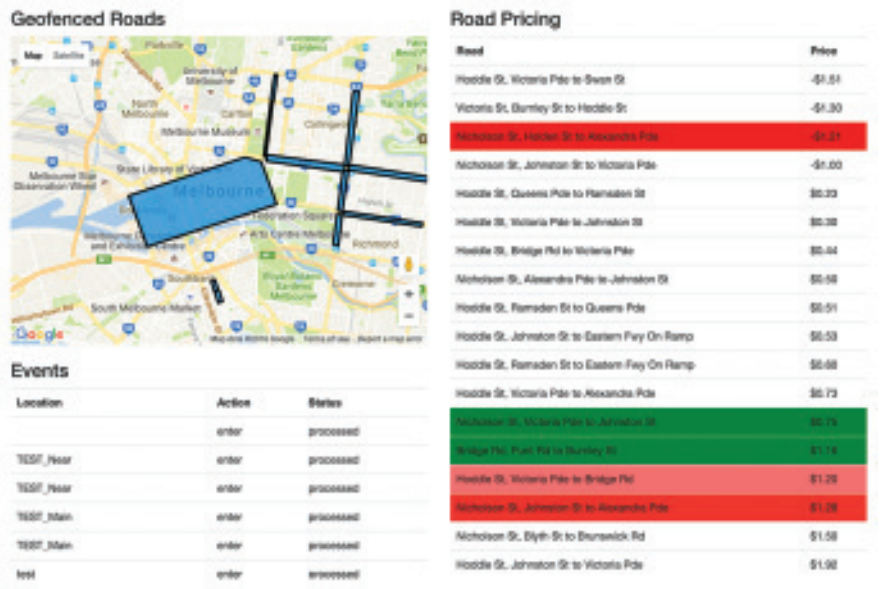


Figure 36. Hackathon app by Geolicious demonstrating road pricing information, www.hackathon.io

The other Hackathon winners were Transpoint, a loyalty scheme incentivising usage of public transport and CityMike, a project to utilize the bike share program, making it more profitable and therefore more sustainable.

BIG DATA FOR AUTOMOTIVE

Vehicles are increasingly data driven and often referred to as computers on wheels. Vehicles are both transmitters and receivers of data and the data in and out of the vehicles has multiple uses, creating opportunities for a range of analysts. This data is useful across a range of applications including but not limited to:

- Manufacturers' proprietary devices collect data about vehicle performance providing feedback on performance of parts and components and also enabling dealerships, service and repairers important customer service information. For example, dealers can communicate with the owner that a part is wearing down and that the vehicle needs to be brought in for safety repairs. This data is also relevant to monitor warranty issues and for manufacturers to improve new models.
- Vehicle owners and independent repairers require access to vehicle data to enable monitoring and repair of the vehicle.
- Vehicles also generate data on traffic conditions identifying congestion and trouble spots on the roads useful for road agencies, toll road operators and third party supply data integrators to publish information on travel times and suggested routes.
- Increasingly cars will be in a position to collect information on road conditions that are useful to road managers for the purposes of: road maintenance (identifying and fixing a crack before it becomes a pot hole); safety (adjusting telemetry or speed limits on corners consistently receiving harsh braking); infrastructure planning based in demand and vehicle type.
- Data collection is increasingly becoming the domain of investigators, including emergency services and insurers. Data on speed, harsh braking, driver behaviour and other factors making up a crash or incident can be identified, which is particularly useful in rural or remote areas where CCTV or witnesses are unlikely to be present. In the future data will be required by investigators to explain incidences related to autonomous vehicles.

The ongoing debate with vehicle data is the right of ownership and access. While manufacturers, vehicle owners, road agencies and authorities all have legitimate uses for this data, it can also reveal personal information. There is intense interest in the establishment of arrangements around who has access to what data and how this is managed.

There are a number is associated issues related to data access, ownership and privacy protection to facilitate an efficient ecosystem. This is an area of continued discussion among the industry and the community with representative bodies such as auto clubs playing a vital role in informing the public of the issues and options.

5.5 CONCLUSIONS

The emergence of data sets and data analysis tools is still at a relatively early stage. The full potential of big data is yet to be realised, but there are a diversity of solutions now being developed demonstrates the potential.

There is therefore a continuing opportunity for leading edge research in Australian universities and businesses to provide financially and socially beneficial outcomes here and overseas.

Increased availability of real time, machine readable, depersonalised data from government agencies is a key to stimulating further economic opportunities and applications from big data.

Collaborative approaches are likely to be key to realising the value of big data with initiatives that bring together large players with access to significant data sets data.

Opportunities in public transport sector management are equally important. Finding new opportunities, using new analytical tools, based on the data gathered from ITS equipment within public transport networks as well as behavioural data gathered from public transport apps, is an area of strength and an opportunity for Australian researchers.

6. FUTURE FREIGHT

6.1 BACKGROUND

Freight transport enables economic activity. The success of the Australian economy is tightly tied to the effectiveness and efficiency of the freight sector, whether delivered by road trains, small delivery trucks or rail freight. This section explores how ITS will change the way the freight sector operates and how it will both enable better practice and create entirely new approaches to the freight task.

The scope of the section includes the distribution of goods by road and rail, as well as air and sea freight where these connect to land modes.

ITS activity in the sector is largely focussed on technologies and intelligence that directly affect the sector and integration with light vehicle, commuter and other private travel is typically a lower priority goal. However, similar technologies will be deployed for other users and freight users will share infrastructure with other road users so there is overlap with other themes.

Road freight in Australia is delivered by a large number of businesses of different scales generating $3.2 billion in revenue. The three largest national operators have 14% of the total market combined, though the four largest freight forwarders control 70% of interstate freight. It is estimated that there are around 42,000 operators in the wider road freight transport sector, locally and nationally.[14]

The rail transport sector generates between $5.4 and $7.3 billion in revenue through 25 operators, primarily in bulk goods.

In common with other sectors, ITS for freight builds on many technologies and applies them to deliver capabilities that only electronic data and communication can enable. These include:

- Driver information systems
- Performance information gathering and transmitting systems
- Communications to business operators for performance and planning
- Communications to other vehicles for driver assistance/ automation and safety
- Communications to infrastructure owners (e.g. roads management, ports) to optimise road access
- Payment automation to identify actions for which a charge is levied and then deliver full function payment fulfilment
- Compliance information for regulators

The scope of this theme therefore covers both the direct opportunities for freight operations, the impact of freight on other parts of the economy, and the shared infrastructure and operations where freight co-exists with other transport.

[14] NTC Who moves what where report Aug 2016 P24

6.2 KEY CONGRESS MESSAGES

In freight potential end users often do not appreciate what ITS might offer them. While there is a general understanding of the likely impact of technology, many businesses not managing a supply chain lack a comprehensive view of the potential for change. However, within the logistics industry, progress has been rapid and many elements of ITS are already in place, with extensive developmental work well advanced.

'From a public view freight movement is mostly unseen… and often negatively….We do not see the logistics that go into this. There has been a revolution going on in the freight logistics industry making it safer, resilient, environmentally friendly and customer responsive'.

David Silvester, National Manager Planning and Freight Director, Department of Transport, New Zealand

Experts in freight futures suggest that foreseeable developments in ITS relate less to technological development and more to the operating frameworks and how regulatory and technical outcomes can be enabled using shared and individually controlled infrastructure.

'One of the challenges we have in logistics is bringing different sectors to work together. It is not so much a question of technology but more a governance issue'.

Claire Depré, Head of Sustainable and Intelligent Mobility Unit, European Commission DG MOVE

The Australian mining sector is amongst the world leaders in scale and sophistication and the increasing use of remote or automated trucks and trains in a secure environment is a clear demonstration that technology can be applied in the most physically demanding of environments.

Autonomous vehicles are not new to the Australian mining sector. Mining vehicle manufacturers have been offering vehicles and the associated infrastructure for several years, involving remote driving and levels of automation. In the Pilbara region of Western Australia there has been continued investment and successful deployments of autonomous vehicles using various communication technologies. The current trend within the mining sector is for the operational wireless communications network that is used for autonomous vehicles to also be used for other applications such as CCTV, dispatch, load and haul, and remote server access applications.

On-road operations are equally impacted by large scale technology implementations. A number of national initiatives are included in the National Telematics Framework, each of which is either operating or in advanced development:

- Intelligent Access Program (IAP)
- Intelligent Speed Compliance (ISC)
- On Board Mass Monitoring (OBM)
- Certified Telematics Service (CTS)
- Intelligent Speed Management (ISM)
- Electronic Work Diaries (EWD)

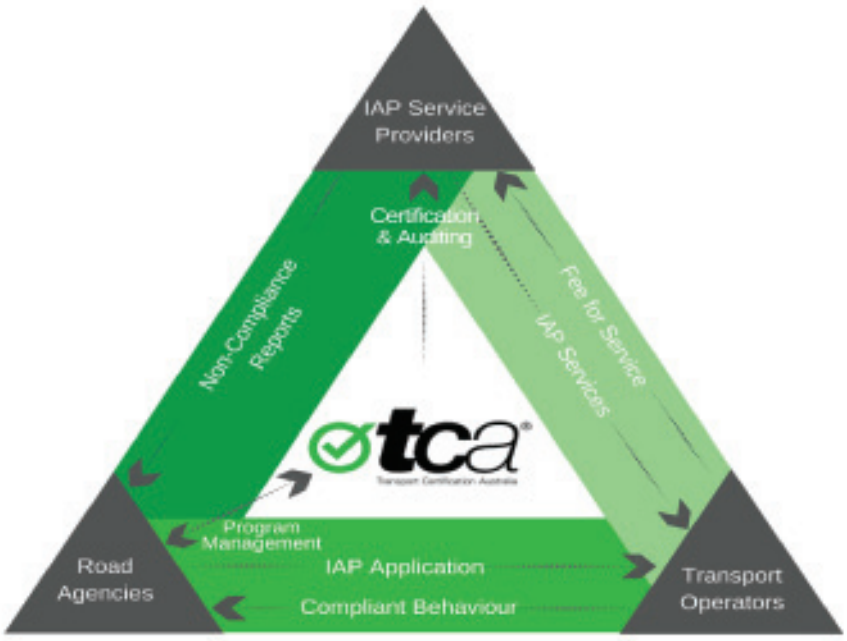


Figure 37. The TCA National Telematics Framework, Paul Corkill, Transport Certification Australia (23rd World Congress, Technical Session 7)

Australia, through membership of GS1 (an international standards organisation which provides the global standards for barcodes) is contributing to the development of standards for documentation across the supply chain. In late 2015, the Australian Logistics Council (ALC) endorsed the Australian Transport Label Guidelines and GS1 Australia is working with local partners to implement these here.

'The move to introduce freight labelling guidelines based on GS1 standards is foundational for the industry to achieve optimal interoperability and visibility across the supply chain.'

Bonnie Ryan, Industry Manager – Trade and Transport, GS1 Australia

Topics at the Congress ranged from highly technical, detailed, analytical or hardware matters through to global environmental sustainability. Many sessions had a single focus, but others were able to show how important the fine detail of ITS development is in creating real benefits for people across the world, whether economic or societal.

'Improving supply chain visibility and interoperability is critical to the efficient movement of freight and will lead to productivity improvements across the industry. As ALC research shows a 1 percent improvement in supply chain efficiency would boost GDP by $2 billion, the Australian Transport Label Guideline certainly has the potential to help us achieve this goal.'

Michael Kilgariff, Managing Director, Australian Logistics Council

Significant pilots in freight tracking in Australia have demonstrated the power of this technology. The ALC Intermodal Visibility Pilot of Electronic Product Code Information Service (EPCIS) not only shows the advantages of end to end tracking in real world supply chains, but also the capacity of Australian businesses to deploy an international standard locally.

At a local level, freight operators and infrastructure operators are implementing their own ITS projects.

The Port of Fremantle is already using a fully automated IT system at the Port itself and for its lessees' sites using variable messaging signs to provide congestion management. In addition, OneStop is a mandatory vehicle booking system for full containers which manages and evens out the available slots during the day. Container Chain manages empty containers via an app and it is compulsory for all container movements to be recorded and managed using it. Container Chain monitors the presence of loads via a geofence and instructs the driver whether to proceed or not. While more advanced than most ports worldwide, the Port recognises that the data now available provides the potential for more integrated prediction and planning, including integration with external transport data, such as road conditions.

As with consumer and passenger transport, freight is seeing disruptive technologies emerging. Amongst these, the advent of drones and 3D printing for aerial driverless and electronic delivery respectively will create new transport options. It is far from clear whether these will effect a modal switch or increase demand as a result of making new deliveries economically viable.

Pressure for change will be strong as many specialist aspects of freight ITS directly impact end consumers. The advent of parcel lockers for mail, shopping and parcel distribution is an example of an intelligent technology that includes ITS, which projects forward into consumer space and which pushes backwards into sophisticated supply chains.

Speakers in Congress sessions commented on the inevitable integration of passenger and freight infrastructure in ITS implementations while noting that freight initiatives are often independent of broader transport initiatives.

6.3 AUSTRALIAN CONSIDERATIONS

The Australian freight sector shares its structural and operational features with other countries, but the combination of attributes creates particular opportunities and challenges.

- Being an island at a considerable distance from other major trading nations, there are few entry/exit points. A very small number of very large ports means that there is a concentration of freight activity and this creates opportunities for ITS to be deployed affordably while reaching large numbers of users.
- The road transport industry is diverse in structure, but has a concentration of industry players, with large purchasers and large operators, making it easier to develop single management frameworks.
- Australia has a tradition of building and maintaining good infrastructure. ITS layers can be superimposed on this framework.
- Although federal, the increasingly integrated nature of freight transport regulation and government support enables regulatory cooperation nationally.
- National technology and operational standards are well developed[15] and these optimise the value of investment in roadside and vehicle infrastructure by enabling interoperability and ensuring that commercial and regulatory systems can operate nationally.
- Border control is more effectively managed in Australia than in almost any other developed country.
- The high functioning use of the English language within Australia and connections to English speaking sector leaders facilitate awareness of technology developments and the creation of a supporting skill base.
- Having concentrated cities into which goods are distributed and manufactured/assembled products collected allows material benefits to accrue from small technology investments.
- Australia has a tradition of being an early adopter, meaning there is a readiness to adopt technologies that might be resisted elsewhere.

The Australian transport industry has had a significant involvement in the early implementation of ITS, driven by a competitive and technologically sophisticated industry and supported by coordinating bodies including the National Transport Commission (NTC), the National Heavy Vehicle Regulator (NHVR) and Transport Certification Australia (TCA).

Heavy vehicle national law provides a basis for national implementation of modern logistics management, relying on telematics to provide information on vehicles, drivers and loads as well as other chain-of-responsibility roles in the supply chain.

The freight sector in Australia has been a leader in ITS adoption. Significant ITS initiatives are in progress and many of the key elements of a regulatory and compliance framework exist. In many respects, the Australian freight sector is adopting ITS more quickly than is the case for light vehicles, perhaps because of the commercial advantages that ITS provides and the resulting financial and competitive incentive for users to invest in the required technology.

Some developments in freight infrastructure are not direct elements of ITS but facilitate or leverage what it can enable. For instance, the development of inland ports and large distribution centres, a feature of the Australian logistics supply chain for some years, are both supported by in-vehicle, roadside and other infrastructure as well as software exploiting connected data sets. ITS considerably magnifies the benefits these sites can deliver.

[15] Particularly as a result of work by the NTC and TCA, as well as support from NHVR.

6.4 INITIATIVES, OPPORTUNITIES AND BENEFITS

While ITS is a disruptor, the freight sector is also experiencing disruption from other causes. ITS projects are therefore being developed in a sector which is rapidly changing and where the future is uncertain.

The freight task is changing quickly and radically – with the transfer of some goods (documents in particular) to electronic transmission at the same time as traditional retail models are being attacked by online purchasing for both individual consumers and retail enterprises. These developments mean that freight volumes, patterns and time pressures are changing.

Road and rail infrastructure in many key locations are at or close to capacity. Ports worldwide increasingly need to handle growing volumes of trade on a fixed footprint while it is difficult and expensive to superimpose new infrastructure on existing cityscapes. There is a real commercial urgency to respond to these needs and ITS and other solutions must be adopted to 'sweat the assets'.

ITS can deliver many benefits for freight planning, management and operation. The freight sector and the ITS industry, often supported by government agencies, are pursuing opportunities in areas such as these:

- Reducing congestion at loading, unloading and transhipment points, reducing operator costs and maximising infrastructure utilisation
- Improving the fuel efficiency of freight vehicles through connected ITS, reducing environmental impacts and reducing operator costs
- Enabling booked and integrated trip scheduling for 'last mile' distribution together with the aggregation of deliveries (especially for retail) at consolidation points outside activity centres, reducing traffic volumes and costs
- Reducing empty vehicle movements through better planning based on actual and predictive data, thereby increasing efficiency
- Reducing labour costs and addressing emerging shortages of heavy vehicle drivers through automated, driverless trucks
- Optimising routes, reducing distances and/or times travelled, and better exploiting low congestion (off peak) times for travel, creating operator savings and better infrastructure utilisation
- Enforcing route compliance by heavy vehicles, protecting infrastructure such as bridges and reducing long term network maintenance costs
- Targeted monitoring of specific freight types, particularly including dangerous goods
- Tracing and tracking of goods, placing new pressure on supply chain performance through transparency

ITS initiatives supporting the freight sector are at various stages of development. It is still unclear where the focus of industry and government will be in many respects, and the dependencies on wider infrastructure may delay technologically ready solutions.

The sections that follow set out current and expected developments relying on the application of ITS to freight.

CONNECTED DATA PROVIDING BETTER OUTCOMES AND LOWER COSTS

Availability data will allow transport operators and intermediaries to broker more efficient resource use.

Increased Just-In-Time (JIT) delivery will reduce the need for stock holding and storage.

Giving stakeholders a wider knowledge of the status and expected status of the broader supply chain will help optimise resource usage.

Connectivity between back end systems will permit a paperless supply chain, as well as paperless infrastructure management and compliance management.

Availability of road network and commercial operational data already permits better prediction of events and the development of optimised solutions, though much of the potential has yet to be identified and most of the potential has yet to be realised. Predictive real time travel information is a much sought after feature by logistics organisations being supplied by the ITS sector.

Meanwhile there is significant effort to develop a global stand for the exchange of supply chain data using the Electronic Product Code Information Service (EPCIS), an international standard for recording key events associated with the movement of goods or objects through a supply chain.

EPCIS can be integrated into an existing database or "track and trace" platform as a means to share information and provide visibility throughout a supply chain. Lead by GS1Net and the Australian Logistics Council, three major Australian businesses demonstrated the viability of the standard in their supply chains. The key events were defined for the particular supply chain and set up for capture to an EPCIS repository. The events were captured manually or by file upload, using a data capture approach best suited to the participants. The pilot proved that it is possible to overcome challenges involving different partners using different information management systems to produce significant returns on investment.

SUPPLY CHAIN OPTIMISATION

Optimisation software which uses operational research techniques is beginning to maximise output for a given input, reducing costs, delays and uncertainty.

Better dispatching and receiving minimises unproductive time at the ends of journeys by drivers and equipment.

As an example, the Bestrane Mobile Dock software is being used to provide smartphone information to drivers to control dock access to major CBD retail centre Emporium in Melbourne. Dock time allocations, changes to arrival times, identity confirmation and other critical data are available in real time to drivers and to dock staff.

Data will, in particular, enable the booking of last mile distribution services or the sharing of such distribution through consolidation centres.

Road network information will enable drivers and controllers to dynamically minimise trip times in response to predictable traffic patterns and unpredictable events.

Speed advice at intersections will allow trucks to optimise their approach speed and 'request' the infrastructure to provide a green phase extension where this functionality is available.

Multimodal integration will treat the entire transport supply chain as one, rather than managing each mode separately.

'In a learning-by-doing approach, the C-ROADS platform including InterCor will test real-life deployment activities in a wide range of Member States funded through the Connected Europe Facility (CEF).'

Claire Depré, Head of Sustainability and Intelligent Mobility Unit, European Commission DG MOVE

At a business level, ITS information makes concepts such as 'slow steaming', which picks an optimum speed to balance fuel efficiency against time based costs, attractive for transport businesses.

Entirely new business models are emerging which will affect the supply chain. Data aggregators and outsourced service providers can consolidate delivery orders for organisations that previously managed, or could not afford, their own supply chain, exploiting scale and large data pools to both reduce costs and improve quality aspects such as delivery tracking and reliability.

'If we can combine the information we have, and now combine that with the information on truck parking all over the system… and infuse that into telematics we believe we will see significant improvements in safety mobility and economics for truck movement and our focus is developing the most advanced freight system. The more we understand freight movement, we will reduce costs on freight and capital infrastructure costs.'

Paul Trombino, Director, Iowa Dept of Transportation

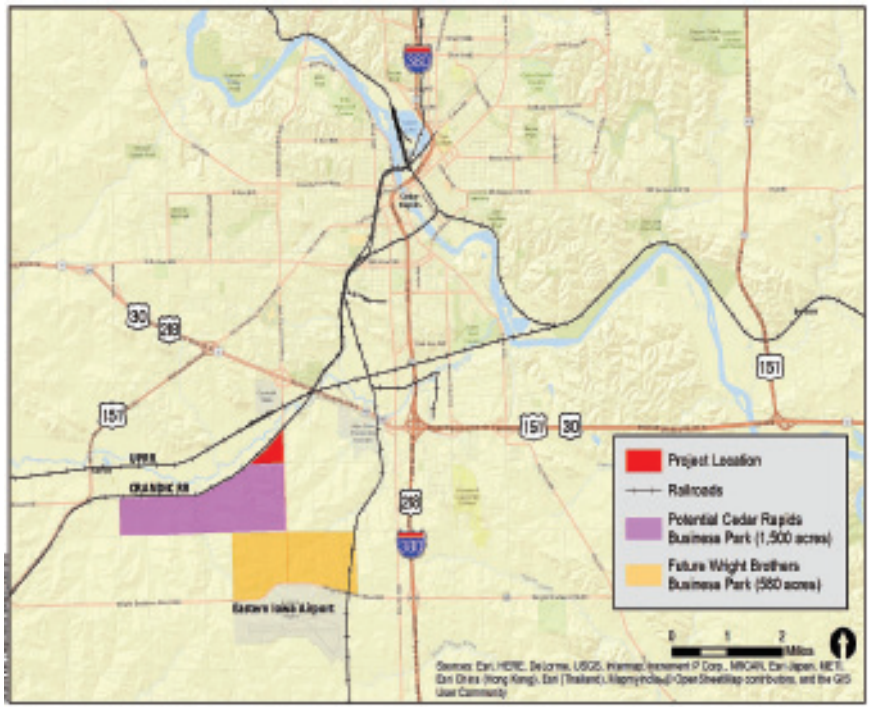


Figure 38. Iowa freight consolidation project, Paul Trombino, Iowa Department of Transportation (23rd World Congress, Executive Session 6)

AUTOMATED, CONNECTED FREIGHT VEHICLES

Vehicle automation delivers significant safety, environmental and economic benefits for freight operation.

One of the most significant applications of vehicle automation to trucks is 'platooning' where several trucks follow a lead vehicle and the following vehicles are 'controlled' through V2V data flows. Platooning reduces fuel consumption by reducing speed fluctuation and, by allowing vehicles to travel more closely together, reducing wind resistance. Vehicles travelling closer together potentially reduce congestion by making better use of the road. Platooning also reduces collision risk by making vehicle behaviour consistent within the platoon and removing some parts of the driver task in following vehicles.

Platooning does not rely on dedicated transport lanes and can co-exist with automated and non-automated vehicles.



Figure 39. Truck platooning concept on shared road, Paul Retter, National Transport Commission (23rd World Congress, Executive Session 8)

A number of trials worldwide have successfully demonstrated the technology, including trials under live road conditions with other vehicles, taking into account not only the vehicles navigating the road space but also their interaction with other vehicles and pedestrians.

Automatic acceleration, braking and assisted steering in current trials reduce the driver workload in following vehicles and improve fuel consumption given safer following distances. Tests have demonstrated 3-truck platoons with half second gaps between vehicles. Development work is targeting larger groups of vehicles, lower speed fluctuation and will resolve some of the navigation issues in steering groups of vehicles. Truck platooning can operate with different levels of communication and automation, with retro fitted devices controlling speed and spacing for following vehicles, but not steering. More sophisticated connectivity is required for full platooning with steering of following vehicles led by the lead vehicle.

LAND INFRASTRUCTURE OPTIMISATION

Existing infrastructure, whether private or public, can be better utilised through ITS.

'Multi modal integration and supply chain visibility creates an opportunity to make greater use of rail as an underutilised freight corridor – usage that can now be increased through better information.'

Martin Matthews, former Secretary, Ministry of Transport, New Zealand

Road user charging, now adopted in various forms for some freight vehicles in many countries, provides incentives for road use optimisation while freight parking efficiencies can be delivered by private and public land infrastructure through general city or operational (such as port) connected data and systems. Technology is also being used to monitor and inform drivers regarding availability of truck parking spaces on interstate highways. The parking sector is also exploring technology applications to enhance efficient use of restricted parking for couriers, especially in urban centres.

The environmental footprint of freight can be minimised through ITS support for 'eco driving' to reduce emissions and resource usage.

'We have a concept of European transport corridors, which are multi modal and where the flows of freight and passengers are heaviest. We want to use ITS to reduce bottlenecks and congestion using data sharing from a number of data sets in these corridors.'

Claire Depré, Head of Sustainable and Intelligent Mobility Unit, European Commission DG MOVE

Competition between freight and passengers for access to transport networks is an opportunity for ITS, combined with policy frameworks to support optimal access to the network.

SAFETY OUTCOMES

Safety improvements for the freight sector are being seen across a range of areas: improved technology delivering safer vehicles; driver monitoring systems to advise drivers and fleet managers of safety issue such as drowsy drivers; and regulatory arrangements such as Australia's Intelligent Access Program that monitors compliance both improving the community sense of safety and enabling improved access for coming performance based vehicles.

The largest vehicles on Australian roads are now mostly monitored through in-vehicle ITS technology and this will trickle down to lighter vehicles while, concurrently, more compliance functionality will be developed.

Regulatory management of hazardous goods is not only enabled but enhanced through telematics. Rather than rely on compliance monitoring and enforcement, emerging architectures will replace paper documentation with accessible, real time electronic documents via a secure back office system. This will provide transparency and enable immediate, information based responses to incidents.

ITS is now being established to monitor headway compliance, fatigue monitoring and will in due course progress into maintenance monitoring through automated vehicle status reporting.

Upper limits on road vehicle length and weight have historically been set recognising that a minority of operators will breach regulations and that for the heaviest vehicles such breaches can be catastrophic. The Intelligent Access Program enables real time monitoring of in-vehicle telematics (vehicle position, mass and time of travel), providing confidence that operators will be 100% compliant due to the certainty of detection. This has enabled Main Roads Western Australia to authorise Super Quad vehicles of 60m length and 199 tonnes gross mass to operate on specified public roads with specified conditions. Participants are reporting up to 25% efficiency gains.

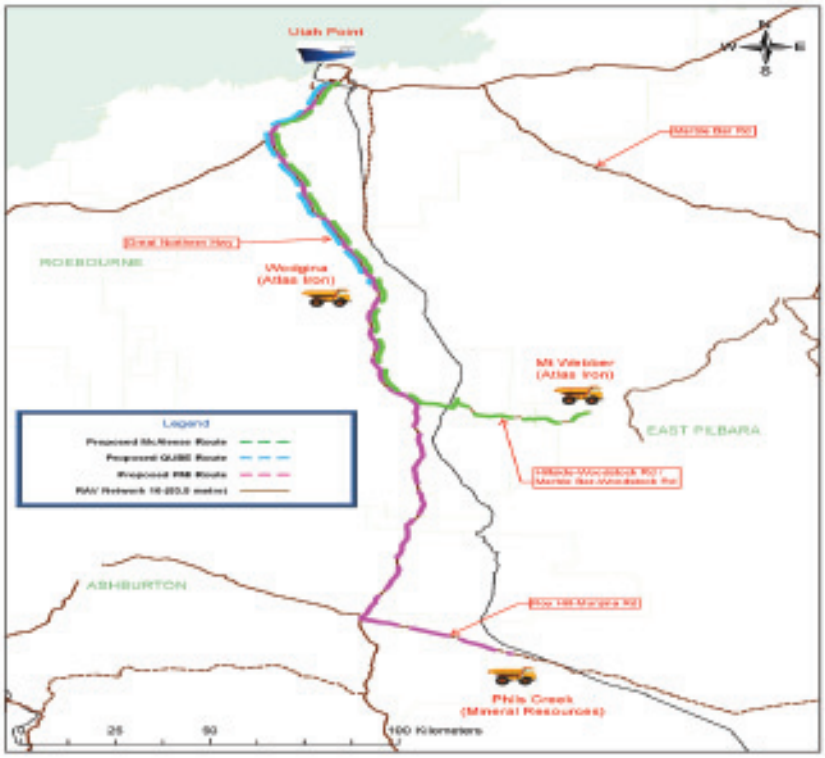


Figure 40. Super quad operational area on Western Australian public roads, Paul Corkill Transport Certification Australia (23rd World Congress, Technical Session 7)

6.5 CONCLUSIONS

Freight businesses have been some of the earliest adopters of ITS solutions in Australia. Much infrastructure exists and operators are beginning to integrate their own applications and where appropriate connect them to government monitoring systems. Continued opportunities exist across:

- Connected Data
- Supply Chain Optimisation
- Automated, connected freight vehicles
- Land infrastructure optimisation
- Safety
- Data protection and security

There are opportunities for developers to work directly with transport companies to provide proprietary solutions for specific customers as well as industry wide solutions integrating with other business operations systems.

There will be an ongoing requirement for further development of government coordinated or directed information systems and work to support these.

Major infrastructure operators – notably but not exclusively ports – have a keen interest in developing technology based solutions which will help them operate more efficiently.

Both they and industry have an interest in an integration of transport information and planning to improve individual and overall industry efficiency. The financial benefits are considerable given the cost and volume of freight movement so it is quite likely that this area will see significant investment in the next few years.

Modal integration extends this opportunity as supply chain visibility makes it easier to plan and deliver multi modal journeys – particularly integrating rail and road movement of freight. Trans-shipment points will need to be supported by technology-based physical and software infrastructure.

Opportunities are beginning to arise for the implementation of solutions involving the automation of the driving task for freight vehicles. While initially concentrated in off-road environments, this technology will move to roads with progressive extension of the automation over time. Significant opportunities will exist for implementation and support, as well as development where this is needed to respond to Australian conditions.

7. TRANSPORT PRICING AND FUNDING

7.1 BACKGROUND

Throughout the twentieth century, and the first 17 years of this one so far, many parts of the world saw a disconnect between the cost of transport and the price charged to users. The disconnect was partly a result of structural subsidies, both to public transport and roads. However, the technology simply did not exist to capture usage and the impact of that usage on the road network.

Transport pricing needs to take account of the cost of building the infrastructure, operating it and maintaining or replacing it. As transport paths occupy public space in some form, occupation of road or rail space occurs at the expense of other potential users. This is a notional cost when operating below capacity, but becomes a real cost when congestion occurs.

Different vehicles have different impacts on the road network – full cars occupy more space per person moved than full buses do, while trucks do more damage to the road surface than cars as a result of their greater weight.

In Australia, road funding has come from funding allocations by each level of government, while usage-based recoveries have primarily come from fuel excise. This tax does not accurately reflect usage – either space taken on road infrastructure or the congestion and physical impact on the roads themselves – particularly with the advent of electric vehicles and this is compounded by varying fuel efficiencies.

Technology now provides a range of possible approaches to pricing transport – options that have not previously existed.

Integrated transport management – seeing transport as a single system – is a vital element of the Smart City concept. Achieving true integration will be assisted by transport pricing that includes consideration of both road and public transport costs. Transport pricing therefore contributes to Smart City outcomes.

Trip detection, data management, and electronically supporting charging mechanisms, based on pricing planning driven from network-wide data, are the key elements that ITS contributes to transport pricing mechanisms.

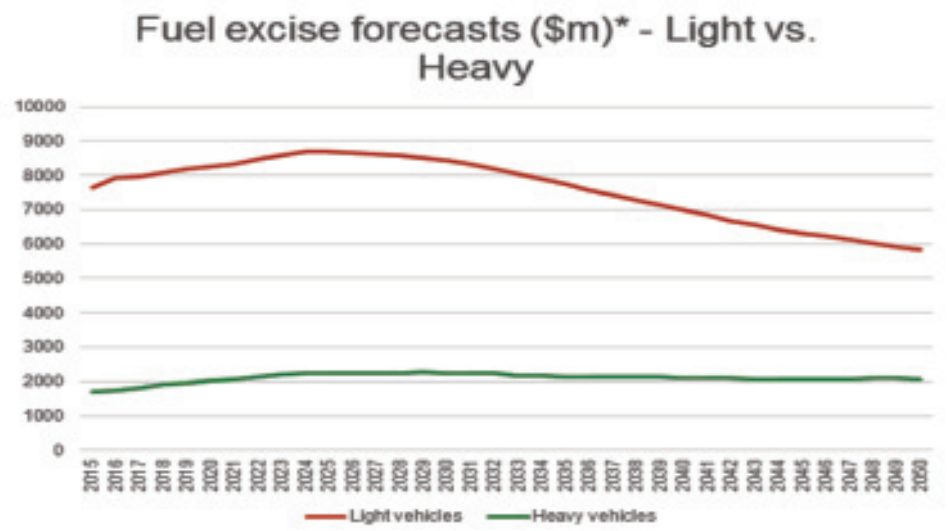


Figure 41. Forecast decline in fuel excise revenue for Australia (from a CSIRO report commissioned by the National Transport Commission), Andrew Hyles, Australian Government Department of Infrastructure and Regional Development (23rd World Congress, IBEC Session)

7.2 KEY CONGRESS MESSAGES

The sustainable and fair funding of transport assets was widely discussed. In most developed nations, there has been little transparency in transport costs, with widespread cross subsidy and systems of perverse incentives favouring one mode over another, regardless of true cost or sustainability. While a number of technical sessions looked at the specific issue of road user pricing, many strategic sessions touched specifically or tangentially on broader infrastructure funding, cost transparency and transitioning to trip related charging.

'The financing of transportation assets is the key to all of the themes identified as being important to the Australian context. The first step is to admit that there is a financing problem. Nobody wants to admit that there is a problem.'

Jack Opiola, Managing Partner and President, D'Artagnan Consulting

A repeated theme at the Congress was the interconnection between aspects of transport management. More sophisticated transport pricing clearly has the potential to deliver many benefits and any implementation must take these issues into account.

'I see tolling and its evolution into Multi-Lane, Free Flow tolling; GPS Heavy Vehicle developments; mobile telephone to smartphone evolution; wireless march from 2G, to 3G, to 4G, to 5G; Demand Management and Congestion Charging of urban areas; UBI and development of OBD-II devices and software for automobile insurance; Telematics and the evolution of the connected, autonomous vehicle markets; back office transaction processing, Bit-Coin developments and Block Chains. All of these are separate vectors, but are related and integral to state, national or regional road charging.'

Jack Opiola, Managing Partner and President, D'Artagnan Consulting

The reasons for introducing a road pricing system to replace the existing system were canvassed.

'The current multiplicity of State and Federal taxes, including fuel excise that are imposed on vehicle users, do not reflect the distance, location or time of travel and thus the real impacts on the road network. There is an increasing demand for transport infrastructure and services, while at the same time the revenue from fuel excise is reducing due to more efficient vehicles and electric vehicles coming into the market. Car share and automated vehicles will add to this dilemma.

We need a road pricing system that is based on the time, distance and location of travel. Those who travel in uncongested conditions will generally pay less than now, and those travelling in congested conditions will generally pay more. All revenue must be hypothecated to deliver transport improvements. There also needs to be an independent body to collect and distribute the revenue in proportion to the locations contributing the revenue.'

Brian Negus, General Manager Public Policy, RACV and President ITS Australia

Road pricing in Australia is often associated in the public mind with infrastructure funding through tolling of new motorways, and the topic often produces animated discussion in the media. Until recently, no significant research had been undertaken into the more nuanced public attitudes to road pricing. This is perhaps surprising since well designed road pricing offers benefits beyond paying for the building of the road and reducing congestion.

Transurban's Melbourne Road Usage Study[16] deployed GPS devices in the vehicles of 1,500 volunteers to monitor road usage in response to different congestion pricing models.

[16] "Changed Conditions Ahead" Transurban October 2016

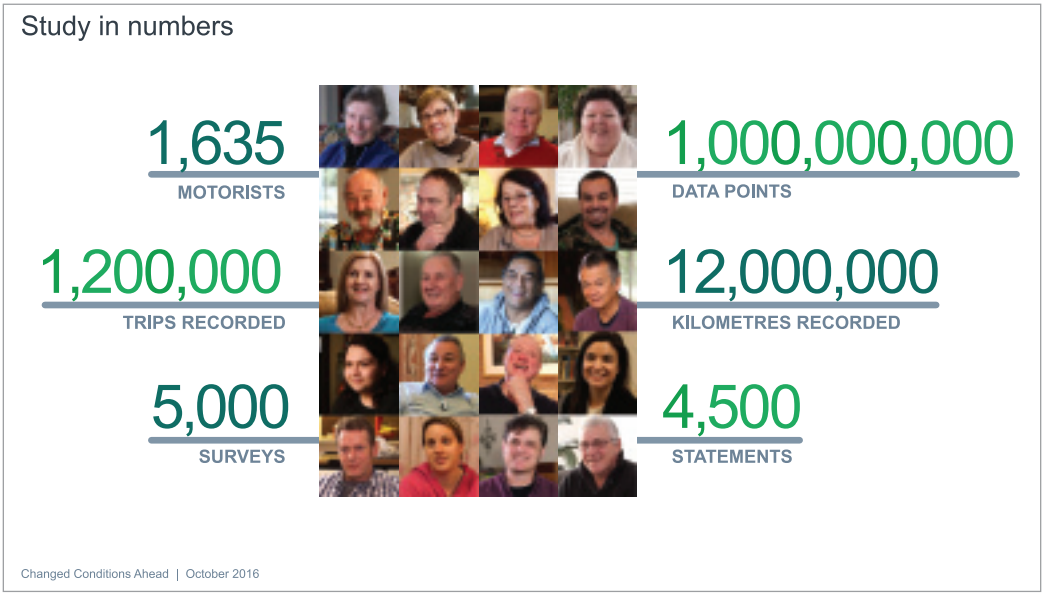


Figure 42. Scope and scale of Transurban road pricing simulation trial, Michele Huey, Transurban (23rd World Congress, Plenary Session 3)

The study demonstrated, that under simulated road pricing conditions, 'participants were open to trying a more direct and transparent way of paying for their road use'.[17] The study looked in particular at cordon pricing (similar to schemes operating in London and Stockholm) and time of day charging as well as a per km model.

The impact of behavioural change driven by road pricing could be significant in reducing congestion and therefore reducing travel times and economic costs.

[17] Michele Huey Group General Manager Strategy Transurban

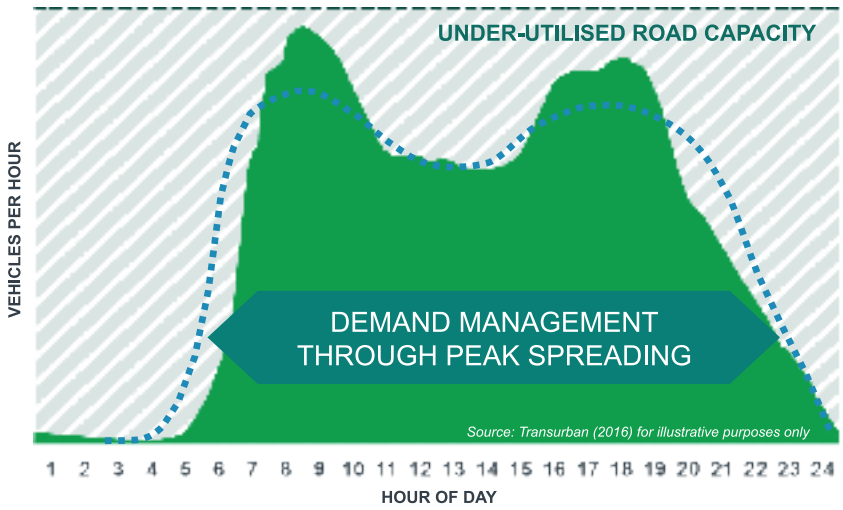


Figure 43. Potential to use demand management to better use road capacity, Michele Huey, Transurban (23rd World Congress, Plenary Session 3)

The practical issues in enabling road pricing are not trivial, but work has already been done, not only to assess what is needed, but how it might be put in place.

'Any new system would need to cover up to 8.1 million road segments, provide account services for 18 million customers, and transaction services for up to 65 million trips a day. We would need to consider the connectivity issues around linking 18 million vehicles to the network – this would require partnerships between more than 50 car brands, three major telco carriers, 10 telematics providers and thousands of fleet operators.'

Scott Charlton, CEO, Transurban

A number of road pricing investigations are in progress around the world, including a number funded under the Fixing America's Surface and Transportation (FAST) Act which established a grants programme to demonstrate the feasibility of a user-based alternative revenue mechanism.

Oregon is running a pilot involving 1,000 drivers who pay for road use on GNSS monitored distance travelled, with a tax credit for gas tax paid, using technology provided by New Zealand based EROAD. California has recently launched the largest trial to date in the USA, with over 3,500 vehicles participating.

Road pricing is not a purely economic tool – it is increasingly seen as a mechanism to promote sustainability. However, there is a tension between rewarding the use of 'green' vehicles (particularly electric) and allowing them to avoid contributing to the other costs of the infrastructure.

'…a combination of road charges for roadway maintenance and construction, and carbon taxes and other measures for improving environmental outcomes, provides the best combination of sustainability for transportation: sustainable transportation finance and sustainable environmental impacts.'

Matthew Dorfman, Partner, D'Artagnan Consulting LLP

Significant technological progress has been made in recent years and Congress technical sessions considered standardisation and performance requirements for widespread user monitoring and charging solutions. The infrastructure to provide high speed, low latency networks which can support real-time price signalling and traffic information is now well advanced. Once 5G networks are available, and able to provide sub 5 second latency over long range wireless networks, these will not only support road pricing but integrate with national fleets to provide Australia-wide connectivity. Meanwhile, new data partnerships and investment in analytics capabilities are starting to provide real-time decision support for dynamic pricing, congestion and traffic management.

Meanwhile technology is providing alternative pathways into road user charging that may be more politically acceptable.

'MaaS is a way into road pricing.'

Martin Matthews, former Secretary, Ministry of Transport, New Zealand

7.3 AUSTRALIAN CONSIDERATIONS

Road pricing is widely discussed amongst Australian policy makers. This focus is particularly driven by the decline in fuel tax revenue as vehicles become more fuel efficient and with the uptake of electric vehicles. This places some degree of equity pressure on governments as the fuel tax is not linked to time or place of travel and the burden of the tax falls increasingly on lower socio economic groups and rural communities that operate older vehicles which are more likely to be petrol fuelled, are less likely to be fuel efficient and are likely to cover greater distances.

Policy discussion about road pricing increasingly favours some form of adoption in Australia. The Harper Review[18] into competition policy recommended the implementation of road pricing and both Infrastructure Australia[19] and Infrastructure Victoria support such a reform.

A Congress presentation by the Commonwealth Department of Infrastructure suggests that the current road funding model is complicated; far from transparent; inefficient; inequitable and becoming more regressive; and is unsustainable from a revenue perspective.

'Moving to a transparent and well-conceived system of direct road user charging offers transport policymakers the opportunity to positively resolve the frailties of the existing system.'

Infrastructure Partnerships Australia/AAA, Road Pricing and Transport Infrastructure Funding: Reform Pathways for Australia

Government attention is increasingly focused on how to make road pricing operate, rather than whether to consider it.

A key part of the network in Australia is already priced on usage. Transurban manages 13 tolled roads in Sydney, Melbourne and Brisbane and there are more than 5 million tag accounts in Australia across the retail suppliers.[20] There is a clear opportunity for a central, independent clearing house that could collect road charges and redistribute it back to the rightful region is a clear opportunity, in much the same way as the tolling MOU currently operates in Australia, enabling customers to hold one account but have access to all our toll roads.

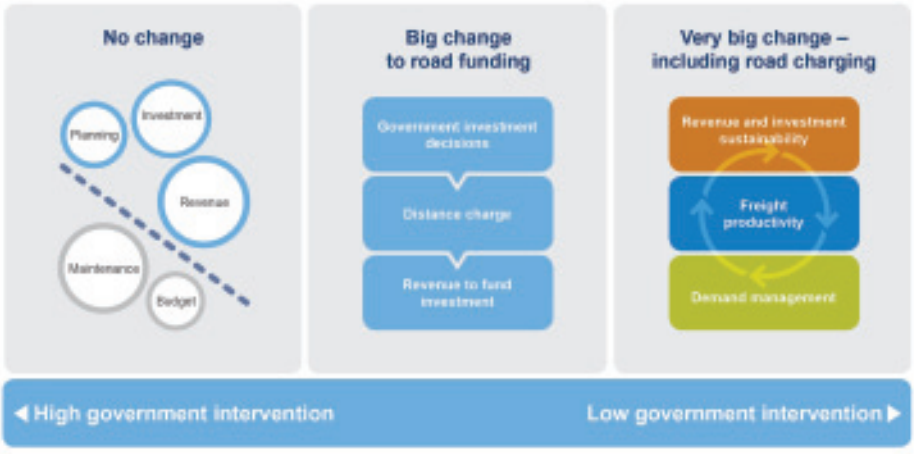


Figure 44. Options for changes to road funding models, Andrew Hyles, Australian Government Department of Infrastructure and Regional Development (23rd World Congress, IBEC Session)

[18] http://competitionpolicyreview.gov.au/final-report/
[19] 15 Year Plan
[20] Rex Wright National Toll Road Operators MOU

7.4 INITIATIVES, OPPORTUNITIES AND BENEFITS

ROAD FUNDING AND HYPOTHECATION

Countries that use the concept of consolidated revenue break the link between the collection of revenues from road use and the funding of the road network itself. Technology enables better linkage of cost and recovery. The concept of hypothecation works within consolidated revenue but explicitly returns revenue collected for road usage to the road system management, allowing appropriate economic signals to encourage appropriate investment in the road network.

'Hypothecation is a critical issue for Australia.'

Jack Opiola, Managing Partner and President, D'Artagnan Consulting

One example of this is Contra Costa (California), which uses a stream of income, based on usage and dedicated to road funding to provide certainty of investment and allows them to plan a steady flow of projects. This allows ITS projects to be funded over the medium term and for business cases to be justified within the transport budget to justify transport specific returns.

The Australian Department of Infrastructure envisages three components in Figure 45 that should be considered.

PRICING MODELS

Singapore is introducing Electronic Road Pricing 2.0. Using sophisticated technology, individuals who drive will be charged for their route. The charge will be time of day and route based. Technology is being used to facilitate the pricing mechanism to ensure that those who have a particular need to use a route at a time have a way to do so, but pay accordingly. The system will cost S$0.5Bn.

'In New Zealand, diesel vehicles are charged through road user charges based on distance and on the vehicle mass. This is an efficient way of collecting revenue from that sector that accurately reflects their cost to the system.

'Diesel vehicle owners have the option of being charged through an electronic charging system (eRUC). The distance is typically measured from the odometer corroborated via GPS information. That shows how far the truck has moved, together with the characteristics of the truck (rated weight), and that is used to calculate the payment to the State by way of a road user charge. It is a very accurate platform and is much more efficient than the previous paper based system.'

Nick Brown, General Manager, Aviation and Maritime, Ministry of Transport, New Zealand

REVENUE COLLECTION MANAGEMENT

Historically, tolling has been managed by a single entity. Technology enables the separation of the management of a road system from the revenue management. New models, described as 'open systems', are emerging where a number of providers gather data about road usage and manage revenue collection. Such arrangements are being trialled in New Zealand, Oregon and Hungary, where providers are linking the core road pricing function with additional functionality particularly related to supply chain management.

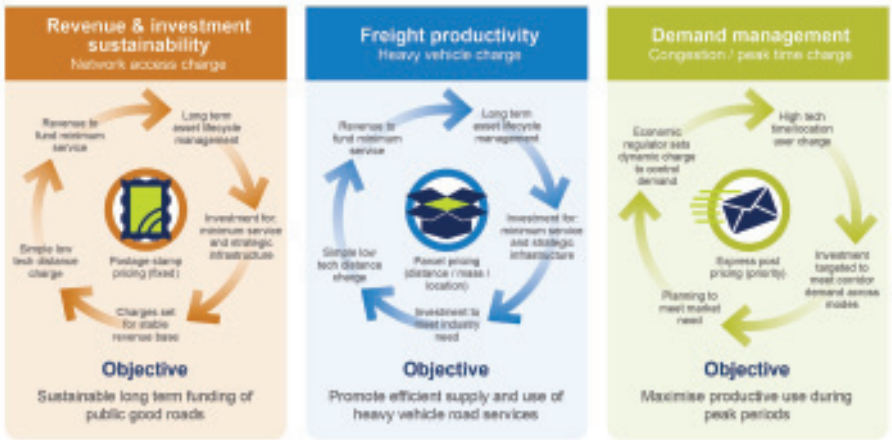


Figure 45. What a market for road services might look like, Andrew Hyles, Australian Government Department of Infrastructure and Regional Development (23rd World Congress, IBEC Session)

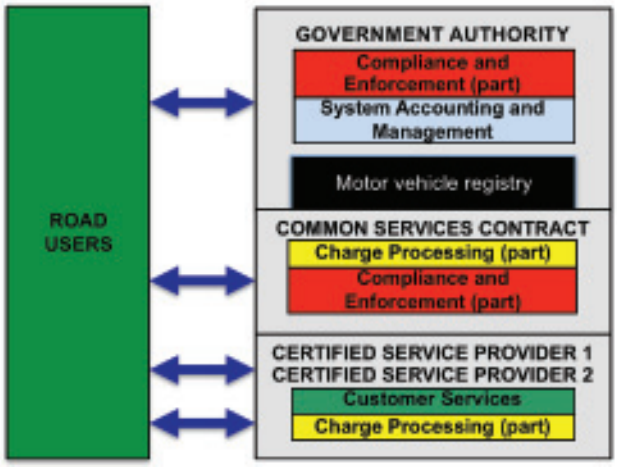


Figure 46. Open system model for road usage and charging, Scott Wilson, D'Artagnan Consulting (23rd World Congress, Technical Session 83)

Kapsch demonstrated a tolling mechanism based on a smartphone instead of a traditional gantry reader approach. This capitalises on the presence of a GNSS enabled smartphone in most vehicles to offer a more flexible and cheaper monitoring approach.

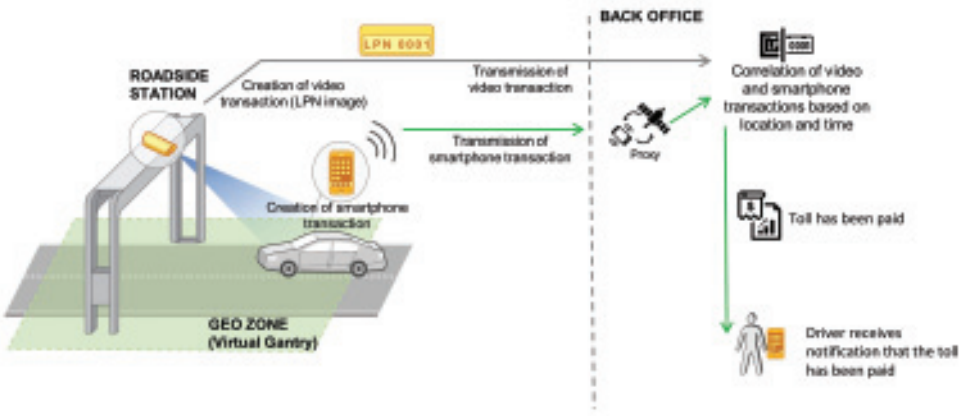


Figure 47. Tolling model using smartphones rather than dedicated devices, Thomas Siegl, Kapsch TrafficCom (23rd World Congress, Commercial Session 7)

Martin Matthews was, until recently, Secretary of the New Zealand Department of Transport. His view is that Australia cannot deal with expected growth through the current models. A paradigm shift is needed, particularly to change behaviours. Road pricing must therefore be a critical component of this.

'Private sector providers will create markets where none existed before. These guys are coming, ready or not. If governments are not ready, we will see more disruption like Uber has delivered. We therefore have to move away from a supply side focus. We could reduce investment by shifting demand. Time and location based road charging should be part of the incentive structure.'

Martin Matthews, former Secretary, Ministry of Transport, New Zealand

ALTERNATIVE PRICING MODELS

South Korea takes an integrated approach to managing congestion, using road pricing as one component, alongside concepts such as 'road diet', where car lanes are sacrificed for other transport modes (cycling and public transport now, automated shared vehicles in future) to encourage alternative modal use. A trial of 'green miles' uses a phone based app to monitor road usage. Cycling provides users with 'green mile credits' that they can then use to gain preferential access on other occasions to low carbon zones that they would otherwise be excluded from. The trial has been running for two years.

One of the interesting features of this trial is that it envisages integration of transport pricing rather than merely focussing on recovery of road use costs. The potential to widen this to allow offsets for public transport is clear.

ADDITIONAL BENEFITS OF TRANSPORT PRICING SOLUTIONS

There are clear benefits in extending the established user payment models and implementing new technologies for road funding and revenue collection. In addition, flow on benefits will arise from information and infrastructure.

With a universal payment infrastructure, micropayment becomes possible, allowing more granular cost recovery across the transport network.

7.5 CONCLUSIONS

Road pricing covering all modes, including freight, together with eventual integration with public transport pricing, will optimise the use of resources, improve economic outcomes, and reduce congestion waste. This will deliver equity, a fairer charging system for road use and a more sustainable revenue raising system than the present taxing regime.

Australia is a world leader in tolling, with one of the world's most successful commercial toll road operators and good practice has been demonstrated in the commercial operation of managed toll roads.

Australia has also undertaken, though not implemented, considerable work on new models of transport pricing, at least on the road network.

While the change is subtle, there is a noticeable growth in public discussion about road pricing.

The business opportunities are impossible to predict, but demand for infrastructure and software to support a likely growth in demand for trips creates opportunities for business as well as for government.

The wealth of information that is now available through big data will allow better and more explicit decisions about public transport pricing and relative pricing across modes to be explored, along with work to develop sufficient public acceptance of the merits of change.

8. FRAMEWORKS FOR SUCCESS

8.1 BACKGROUND

Many of the technologies that make up the broad canvas of Intelligent Transport Systems will create or radically change the way transport works. Conventional, traditional frameworks may no longer be appropriate or best suited to the way the technologies will enable people and machines to work.

Some of the opportunities for innovation will be made more effective by changes to regulatory frameworks and the development of standards.

Funding will be needed, not only to create new infrastructure, but also to support the development of some parts of the innovative agenda and the role of government in this may facilitate successful, early adoption.

Government also has an organising role in bringing people together, creating places where development can occur, and raising the profile of the solutions that ITS can offer to the problems of increasingly high-tech central places and a connected hinterland.

This section considers the role of government in regulation and policy as well as the opportunities for structured and unstructured collaboration to develop integrated rather than disconnected innovations.

The opening High Level Policy Roundtable, bringing together ministers and city leaders from around the world in an introductory summit session, is a feature of ITS World Congresses. The 2016 session covered both the need for and the key elements of the frameworks for success. The presentations, the exhibition and the demonstrations then brought Australian policy makers and regulators into contact with leading edge ITS thinking from around the world in formal and informal discussions, allowing stimulating interaction, sharing of experiences from around the world and, for many, a step change in awareness.

8.2 KEY CONGRESS MESSAGES

OVERALL ROLE OF GOVERNMENT

Government has a vital role in providing leadership as ITS reaches further and further across the transport sector, identifying what society, business and individuals consider acceptable and desirable. Government action in regulation must be in response to and proportionate to a policy problem but the dramatic changes enabled by ITS mean that broader leadership may be required than simply problem resolution.

'On the automated side, there is a significant amount of unknown territory before we get to the ultimate solution - issues around cyber security, human intervention and the interaction between humans and vehicles. It will take a lot of parties to come together.

Government needs to show leadership when it comes to the development of standards and platforms, platforms that we can all sign up to. The Government can play a huge enabling role. There is a need for a new approach to legislation and regulations. The use of scenarios and use cases on which to base the new legislation would be useful. Decisions must be based on data. Appropriate data streams need to be identified.'

Peter Sweatman, Principal, CAVita

STANDARDS AND REGULATIONS

Regulating functionality that replaces or supports human decision making creates significant problems for regulations that envisage full human involvement and responsibility.

'While the benefits of CV and AV can be made abundantly clear, the challenges to governments are often overwhelming. In a world where the traditional automotive vehicle has lived a well-matured life, nearly 100 years in the making, we are all now facing the birth of new kinds of vehicles with new needs from infrastructure, governance and policy.'

Brian Burkhard, ITS Practice Group Leader, Jacobs Engineering Group

In addition, big data and real time reporting will potentially eliminate on-road enforcement and compliance monitoring, changing the entire end to end control of road transport operations by government.

'We did a review at State and National level about the potential barriers to the use of more highly automated vehicles. We found 716 provisions across various laws that are potential barriers – particularly as you get to highly and fully automated vehicles - and most of those are related to the obligations we place on drivers, not just for the driving task itself. Two examples are the obligation to stop and assist if there is a crash and to ensure that child passengers in rear seats are wearing seatbelts. We need to establish what needs to be changed to make things like these more performance based.'

Marcus Burke, Project Director, Compliance and Technology, National Transport Commission

It will also be essential to create an environment for industry to be able to quickly and safely trial new technologies, allowing for real learning to occur and for feedback loops.

'Inconsistent rules, regulations and application procedures for automated vehicles are potential obstacles to deploying this disruptive technology in the future,'

Paul Retter, Chief Executive, National Transport Commission

A condition of the South Australian on-road trials, for instance, is that those conducting the trial must report back within six months of trial completion, providing important inputs for decision makers, local industry and those interested in funding Australian initiatives. Government has a vital role on setting the trials frameworks.

The transition of vehicles from off-road, controlled environments to on-road, mixed traffic environments is only partly about the capabilities of the technology but has implications for safety, liability and enforcement.

'We know that we need national consistency when it comes to allowing trials [of autonomous and assisted vehicles] across Australia.'

Doug Fryer, Assistant Commissioner, Road Policing Command, Victoria Police

Government has an essential role in encouraging the acceptance of mixed fleets and transitioning towards electric, connected, assisted vehicles. While industry will develop the technologies and, in many cases create the infrastructure, it is essential that government plays a leadership role if progress is to be quick and if access to these technologies is equitable.

'Adoption is going to be generational. There is always going to be a group of people who do not trust technology in any form and a group of early adopters who are already there. The remaining group, the majority, will be somewhere in the middle. That's who we can influence. We can work with them to de-mystify the technology so that they understand it and feel comfortable with it.'

Kirk Steudle, Director, Michigan Department of Transportation

PRIVACY AND SECURITY

The growth in demand for information security creates opportunities for Australian businesses here and overseas because of the critical need for resilience against external network attacks and compromised data sets.

Concern is growing about the possibility of attacks on today's real life traffic control systems resulting in major disruption. There are more than 300,000 signalised intersections in the US alone, and traffic controllers are a key element in the safe and efficient operation of a transport system. Cyber vulnerabilities may allow creating critical faults in traffic networks, cause changes that lead to non-optimal coordination plans or inefficient operation.

Aware of the threats, agencies and authorities have the opportunity to ensure traffic communications networks are secure, that security features are built into traffic management systems, software should be current and the most recent version and the system and network should be constantly monitored, with an eye on any suspicious activities.

COMMUNITY CONCERNS, RESPONSIBILITY AND LIABILITY

Increasing levels of automation are likely to impact on current ways in which jurisdictions register vehicles, licence drivers, and administer compulsory third party (CTP) insurance of vehicles.

Many issues will affect the regulatory oversight of operation and risk. Many of these can be foreseen now though, as the manner in which the technologies will be implemented is uncertain, the best responses will only emerge over time. Governments have a responsibility to actively monitor the likely impact of automation, decision assistance and similar technologies on the 'driving' task so that regulatory policy is ready to support innovation.

'The need to deliver a wide range of regulatory services to a large customer base, while following principles such as efficiency and customer satisfaction, is leading to structural changes in many regulators to reduce red tape, increase online delivery, and exploit outsourcing. While these changes are being driven and enabled by increasingly ubiquitous and interconnected information systems, changes will also arise from the introduction of vehicle technologies unimagined when the current regulatory infrastructure was being set up.'

James Holgate and Martin Small, Martin Small Consulting

The cost of transport will be affected by ITS in other ways. In particular, the insurance model will undergo dramatic change. Constant monitoring of vehicles will allow significantly better risk assessment by insurers and this will affect premiums as long as human drivers are operating vehicles.

'You can't force bad drivers to fit measurement technology without laws making this mandatory. It will make it easy for new entrants to cherry pick the best customers. The big insurers, particularly the automobile clubs, will be left with the poor risks and these customers will find their premiums unaffordable.'

T. Russell Shields, Chair, Ygomo LLC

SKILLS AND EMPLOYMENT

The ITS industry in Australia is well established and the fact that so many people from Australian business and government came to the Congress highlights the breadth and depth of both the industry and the commitment of these people to it.

Changes in industry mix – from manufacturing to service and systems – were widely discussed in the Exhibition hall and in demonstrations. Australia has leading businesses and individual experts in many fields of ITS and this strength creates optimism that the loss of manufacturing in the light vehicle sector will be at least in part replaced by high value add opportunities in software and physical design areas.

GOVERNMENT AND COMMUNITY LEADERSHIP

Government is not the only provider of leadership for ITS, but it does play an important role, alongside major corporates, high profile individuals and industry bodies such as ITS-Australia and its overseas counterparts.

Leadership is vital to bring brilliant people together, to provide a context within which they can collaborate, funding to progress their ideas, and building blocks for interoperability. Businesses are creating solutions, testing boundaries and pushing for their solution to become the standard, though having certainty that their solution will not be sidelined by technological change may be more important. Leadership, wherever it comes from, is essential.

'You need to have visionary leadership. We are very fortunate to have that in Michigan. The Governor of Michigan's twitter account is 'one tough nerd'. He understands the technology, has recognised that it is going to change things and has said that Michigan must get in front of it.'

Kirk Steudle, Director, Michigan Department of Transportation

Community engagement and consultation vary around the world. The clear need for central management and the cultural background in Singapore means that less consultation and persuasion is needed than is the case in federal nations such as Australia.

Government also has a critical role in improving quality of life through encouraging the use of emerging big data sets and supporting analytical tools. This must not only allow industry and the wider public to have access to transport data, rather than letting it become a proprietary resource, but must also use this data to make good policy decisions.

8.3 AUSTRALIAN CONSIDERATIONS

STANDARDS AND REGULATIONS

Australia has developed a number of collaborative arrangements to drive ITS initiatives, and especially Connected and Automated Vehicle Frameworks.

A National Policy Framework for Land Transport Technology was approved by the Australian Transport and Infrastructure Council in August 2016. This action plan outlines Australia's national priorities for implementing new transport technologies identifying individual measures following discussions between Australian governments and industry. It includes a series of reform initiatives to facilitate the increased testing and trialling of automated vehicles in Australia. One outcome of this framework is expected to be a clear direction to the automotive industry to converge on a preferred standard for connected vehicle communication.

The Austroads Connected and Automated Vehicle Steering Committee provides a multi-jurisdictional, whole of government approach to the development of a pathway towards connected and autonomous vehicles. The Committee hosts the Austroads Cooperative and Automated Vehicles Industry Reference Group, facilitated by ITS Australia - a national forum involving both industry and government without parallel elsewhere in the world. This initiative enables joint leadership, informed by both industry understanding and government regulatory oversight.

The Australian Driverless Vehicle Initiative (ADVI) is a cooperative of government, industry and academia, showcasing autonomous vehicles and proposing pathways to adoption.

PRIVACY AND SECURITY

Industry and governments have opportunities to explore sharing data which may have previously been considered commercially sensitive in order to create new services and products.

Trust is an essential building block for all connected ITS solutions, whether for business or the consumer. Sustainable services must be built on secure products that rely on well implemented security frameworks.

While there is a global interest in the privacy of personal data, cultural and national differences mean that different approaches are emerging. Extension of data capture from more automation and connectivity in vehicles, as well as data gathering through public transport smart cards and personal smart phones, is creating a massive data history about individuals. This data capture is at present of concern only to a minority and most users are willing to forego personal privacy to receive the benefits that new services provide. However, Australian business and government will need to be ready for this to change, possibly quickly if the topic becomes high profile for any reason.

Cyber security is critical to successful implementation of public and private technology based solutions in transport. If systems can be hacked or deceptive messages can be transmitted and accepted, there is a risk of catastrophic outcomes for moving vehicles. Cyber security is an area where Australia has demonstrated expertise and which is developing rapidly.

Issues in data protection and cybersecurity are being resolved through work that TCA is supporting in collaboration with relevant international taskforces. Solutions being developed also have the potential to support both light and heavy vehicle requirements.

COMMUNITY CONSIDERATIONS, INSURANCE AND LIABILITY

The Australian insurance industry is well established and well connected to global insurance networks. The industry is experiencing significant change as a result of both general societal and technological change as well as specific ITS driven change.

Society and government will need to ensure the ongoing viability of the insurance market to ensure that injured road users continue to receive a similar level of protection to the current no fault personal injury insurance.

The collection of many new data sets, often in real time, will give insurers dramatically improved insights into risk, both concerning an individual and across their overall books. This has the potential to make insurance unaffordable for high risk individuals, whether as a result of their observed behaviour or because they are in a high risk group. Australian societal expectations of fairness and access may conflict with commercial opportunities (which become commercial imperatives in a competitive environment when companies cannot afford to cross subsidise).

Overseas, autonomous vehicle trials are already testing legal frameworks for liability. The responsibility for a vehicle that is driven by software is not straightforward. While liability may change the community needs to remain protected.

SKILLS AND EMPLOYMENT

Funding is currently being sought to establish a co-operative research centre (CRC) – iMOVE CRC – to work with organisations and research on the development of intelligent transport systems in Australia. The CRC aims to oversee high quality research performed through collaborative partnerships which will focus on introducing rapidly evolving technologies in the areas of transport, logistics and connected mobility. This will provide a central point for Australian research in this area and facilitate the exchange of information within the sector, in addition to a range of government and industry initiatives assisting with this (see Section 2.3).

8.4 INITIATIVES, OPPORTUNITIES AND BENEFITS

The ITS journey has only just begun. ITS is already proving to be one of the major disruptors of the twenty-first century, applying technology in ways that would often have been unimaginable only a few years ago. This creates opportunities for those with imagination, but also challenges for those who need to oversee the frameworks in which it will operate.

STANDARDS AND REGULATION

The challenge in standards and regulation is not limited to the mechanics of reshaping traditional regulatory models in ways that are appropriate for new technologies. Australian authorities must also make sure that reform is done in an informed, collaborative way that accommodates Australian requirements while recognising that international trends or agreements will determine what technology standards are available here.

Australian businesses and, to some extent, end users must be consulted and involved in processes leading to the development of standards and, where appropriate, regulation.

Some of the most important areas where frameworks are needed include:

- Access and rules for the operation of assisted and autonomous vehicles on and off public roads.
- Operational frameworks for the integration of varying degrees of automation with the existing vehicle fleet.
- Development and setting of standards for interoperability (including between vehicles and roadside infrastructure), communications protocols, infrastructure and other devices such as smartphones.
- Regulatory arrangements to secure access to appropriate spectrum for connected vehicles.
- A regulatory framework for driver and vehicle accreditation to use the road network, along with responsibility and liability principles.
- New approaches to compliance and enforcement, recognising that decisions will be made by and for vehicles by software rather than humans.
- Continued support and development for open-data policies and data sharing standards and framework including where ITS exploits or connects to the broader Internet of Things (IoT).

There is a significant opportunity for Australian businesses, government regulators and industry bodies to play a role in the development of global as well as local framework development. Trials, product development and participation in international activities will all facilitate this.

PRIVACY AND SECURITY

A sustainable model for the use of private data will probably emerge from a combination of regulation and practice, shaped particularly by the actions of business both within ITS and those outside who are creating the components of the Internet of Things (IoT).

Automotive manufacturers and transport operators will, in particular, create models for data collection, storage, aggregation and reporting based on the equipment fitted to vehicles and the applications that extract and use this data. With all new private vehicles having SIM cards in the near future, and real time monitoring of trucks trickling down through the fleet, new capabilities will emerge quickly. Industry bodies and consumer organisations such as auto clubs will have a vital role to play in determining what data

should be provided routinely, what data should be provided on an opt in basis, and what data is not captured and reported.

Emerging ICT trends towards local storage of data with as-needed aggregation rather than permanent databases of personal data, will shape how ITS solutions are designed and Australian developments in this space create opportunities for local innovation.

Sitting above all this, governments will need to retain a strong influence over mass transit data, privacy, cyber security and open data more broadly, especially where commercial opportunities conflict with community expectations. In addition, government itself may have a role to play as a data aggregator or consolidator.

COMMUNITY CONSIDERATIONS, INSURANCE AND LIABILITY

Clearer risk identification will mean that insurance can be offered that rewards risk prevention and better behaviours through changes in risk costing and pricing, encouraging road users to actively manage their risk profile.

Real time data about individual trips, as well as integration with data streams from other devices, will enable entirely new products such as pay as you go models for insurance and varying levels of cover depending on time of day, drivers or trip location. These opportunities will be exploited by nimble new entrants able to select low risk and price aggressively as a result, changing the nature and form of the Australian transport insurance market.

SKILLS AND EMPLOYMENT

Australia already has a rich resource of skills and experience in the ITS arena. It is essential that this is maintained and further developed.

Government has a role in ensuring that the educational frameworks support ITS specifically and STEM[21] subjects more generally, as well as promoting skill enhancing pilots and trials.

Higher and Further Education establishments need offer both courses and research capabilities to support ITS work. This may be in direct ITS areas or supporting technologies.

Industry also has an important role to play in developing staff, promoting careers involving ITS and facilitating the exchange of knowledge through individuals and collaborative activities, as well as supporting industry and sector initiatives.

8.5 CONCLUSIONS

The successful development of ITS technologies and the introduction of these to the Australian transport context requires an effective and forward-looking framework. This framework will be made up of regulation, government oversight, funding, standards and other elements. Some parts of this framework are already in place, other parts are being developed, but there is still much to do.

Many aspects of ITS implementation are entirely new. Others represent novel approaches to existing operations or are combinations of new technologies. Regulation and standards must work together to provide consistency, integration and clarity for developers and end users alike, pragmatically recognising that Australia is a more usually a 'technology taker' than a leader.

Achieving this will require support, funding and leadership from government. This includes policy setting, participation with industry in standards development, fostering state trials, and performance based regulation that does not stifle innovation.

Industry must actively participate in innovation, collaborating and sharing knowledge to support larger goals as well as pursuing individual opportunities. Industry must also collaborate to ensure interoperability, particularly between in-vehicle installations and transport infrastructure.

Government and industry alike must recognise the need for social equity in products and services that are developed.

[21] Science, Technology, Engineering, Maths

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