



SMART TRANSPORT & MOBILITY SYSTEMS

JOINT SUBMISSION TO THE AUSTRALIAN GOVERNMENT
NATIONAL CITIES PERFORMANCE FRAMEWORK

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This paper represents the current position of the Australia & New Zealand Driverless Vehicle Initiative (ADVI), ClimateWorks Australia, Electric Vehicle Council (EVC), iMOVE Cooperative Research Centre (CRC), Intelligent Transport Systems Australia (ITS-A) and Parking Australia (PA) as a collaboration of their wider membership. It does not purport to reflect the position of individual member organisations nor commit them to a particular direction or technology position.

This policy position is subject to change as new information and knowledge arises, and as the dialog across the supporting organisations evolves. All assumptions are based on the best available information and no responsibility is taken for any errors or omissions. Any use of the information provided in this position paper is at the discretion of the reader.

EXECUTIVE SUMMARY

A collective representing over 380 public and private sector organisations that define transport and mobility in Australia recommend that the Government consider including smart transport and mobility system indicators in the National Cities Performance Framework (NCPF).

Seven input indicators are suggested for inclusion, reflecting “best first steps” towards preferred transport and mobility outcomes for Australian cities:

Planning indicators - input indicators which reveal the extent to which a city is preparing for smart transport and mobility system deployment:

1. Consideration of smart transport and mobility systems in all major city and transport planning activities
2. Electric Vehicle charging infrastructure deployment plan

Data & Access indicators - input indicators that focus on enablers for smart transport and mobility system planning and third-party innovation:

3. Real time monitoring of congestion points and economic bottlenecks - multi-modal, including both traffic and public transport
4. Open, real-time, dynamic road traffic data availability
5. Open, real-time, dynamic public transport data availability
6. High speed, low latency data network coverage
7. Mobile ticketing for public transport, including booking and payment by third parties, also multi-modal, including both traffic and public transport

The suggested indicators reflect the need for an integrated approach to smart transport and mobility system planning tailored to the local context, along with the characteristics of Australian cities that have implications for transport system design and operation. They align with the Australian Government’s Smart Cities policy priorities - specifically “Jobs and Skills”, “Infrastructure and Investment” and “Liveability and Sustainability” - and correlate to the outcome and impact indicators included in the draft NCPF.

The justification for inclusion of the suggested indicators can be summarised as follows:

- Smart transport and mobility systems are inevitable, however the consequences for Australian cities will reflect our approach to implementation;
- NCPF indicators will raise awareness and understanding of smart transport and mobility systems and the benefits that they will provide Australian cities to engender greater motivation and uptake; and
- The inclusion of input indicators will provide guidance on measures that will help realise the preferred outcomes from smart transport and mobility systems.

The supporting organisations invite the Government to engage in further discussion in support of the detailed design and implementation of the suggested indicators.

TABLE OF CONTENTS

1. ABOUT US.....	4
2. WHAT IS THE OBJECTIVE OF THIS SUBMISSION?.....	4
3. WHAT ARE SMART TRANSPORT AND MOBILITY SYSTEMS?.....	5
4. HOW DO SMART TRANSPORT AND MOBILITY SYSTEMS INTERACT WITH SMART CITY POLICY OBJECTIVES?.....	10
5. WHY ARE SMART TRANSPORT AND MOBILITY SYSTEMS RELEVANT TO AUSTRALIAN CITIES?	15
6. WHAT MEASURES WILL HELP PROMOTE SUCCESSFUL ADOPTION OF SMART TRANSPORT AND MOBILITY SYSTEMS?	19
7. WHAT SMART TRANSPORT AND MOBILITY SYSTEM INDICATORS ARE SUGGESTED FOR INCLUSION IN THE NCPF?	22
8. WHY SHOULD SMART TRANSPORT AND MOBILITY SYSTEM INDICATORS BE INCLUDED IN THE NCPF?.....	25
REFERENCES.....	26
APPENDIX A – SUPPORTING ORGANISATIONS	28
APPENDIX B – CONTACTS	31

1. ABOUT US

This submission is supported by a broad cross-section of Australian smart transport and mobility system stakeholders represented by:

- Australia & New Zealand Driverless Vehicle Initiative (ADVI)
- ClimateWorks Australia
- Electric Vehicle Council (EVC)
- iMOVE Cooperative Research Centre (CRC)
- Intelligent Transport Systems Australia (ITS-A)
- Parking Australia (PA)

These six not-for-profits represent over 380 public and private sector organisations that collectively define transport and mobility in Australia.

For a more detailed description of each organisation refer to Appendix A.

2. WHAT IS THE OBJECTIVE OF THIS SUBMISSION?

This submission seeks to raise awareness and understanding of smart transport and mobility systems, including:

- The role of transport and mobility systems in Smart Cities
- The relevance of smart transport and mobility systems for Australian cities; and
- Measures that will facilitate smart transport and mobility systems adoption and help realise the beneficial outcomes of this for Australian cities.

Following on from this, the submission recommends indicators for inclusion in the Australian Government's National Cities Performance Framework (NCPF).

As city populations increase and the amount of vehicles on the road continues to rise, we must take action now to tackle the transport issues for both people and goods. The iMOVE Cooperative Research Centre (iMOVE CRC) is working with its 45 partners to use technology and data to create improvements in our transport networks.

iMOVE and its partners aim to support decision making by travellers in the planning and conduct of journeys by utilising real-time data from the transport network. Likewise, real-time data will support the development by iMOVE's partners of new systems to track and move freight effectively.

Optimising movement in this way is crucial to the long-term success of our cities and we need to make sure we are achieving satisfactory progress. To do this we need to measure and review overall system performance. The suggested indicators form a sound basis on which to do this.

- Ian Christensen, Managing Director, iMOVE CRC

3. WHAT ARE SMART TRANSPORT AND MOBILITY SYSTEMS?

Smart transport and mobility systems are defined by paradigm shifts from ownership to usership, transportation to mobility, and internal combustion engines to electric powertrains. These shifts are symbolised in the outlook of global automotive industry executives, 59% of whom believe that half of today's car owners will not want to own a car in 2025, and more than every second of whom believe that diesel is dead (KPMG 2017).

Key concepts within smart transport and mobility systems include:

- **Intelligent Transport Systems** - connection, control and optimisation of the transport system
- **Connected Electric Autonomous Vehicles** - vehicle connection to their users, each other and surrounding infrastructure, a shift to electric propulsion, and less reliance on drivers
- **Mobility-as-a-Service** - the evolution of car and ride share into user-centric, multimodal mobility services that include public transport and emerging first and last mile mobility options

While each of these brings with it different challenges and opportunities, they share characteristics with other Smart City concepts. Key drivers are increased urbanisation, digitalisation, and societal and environmental pressures. The transition is characterised initially by enhancements to existing products and services, then paradigm shifts based on new business models.

Intelligent Transport System (ITS) is a holistic term that describes the technology ecosystem which enhances the transport system's operating capabilities (US DOT 2016). ITS's earliest roots go back to the 1960s with research and development efforts aimed at improving transport safety, environmental performance and convenience. Early innovations included vehicle navigation and location, loop detectors in road infrastructure, dynamic message signs, ramp management, and traffic management centres. More recently Cooperative Intelligent Transport Systems (C-ITS) based on Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communications have been increasingly used to improve coordination between elements across the transport system.

Connected Electric Autonomous Vehicles is a term that describes the convergence of new vehicle technologies. Connectivity of vehicles has grown from basic location and navigation, to the more recent focus on entertainment and personal, V2V and V2I communications. Connected vehicle technology is an enabler for car share business models, and is a cornerstone of vehicle automation.

While opinion varies on when fully automated vehicles will arrive, much of this conjecture relates to the speed of regulatory reform. From a technology perspective, Tesla has been producing vehicles with full self-driving hardware since 2016 (Tesla 2016). Figures 1 and 2 illustrate the evolution of vehicle automation based on manufacturer announcements.

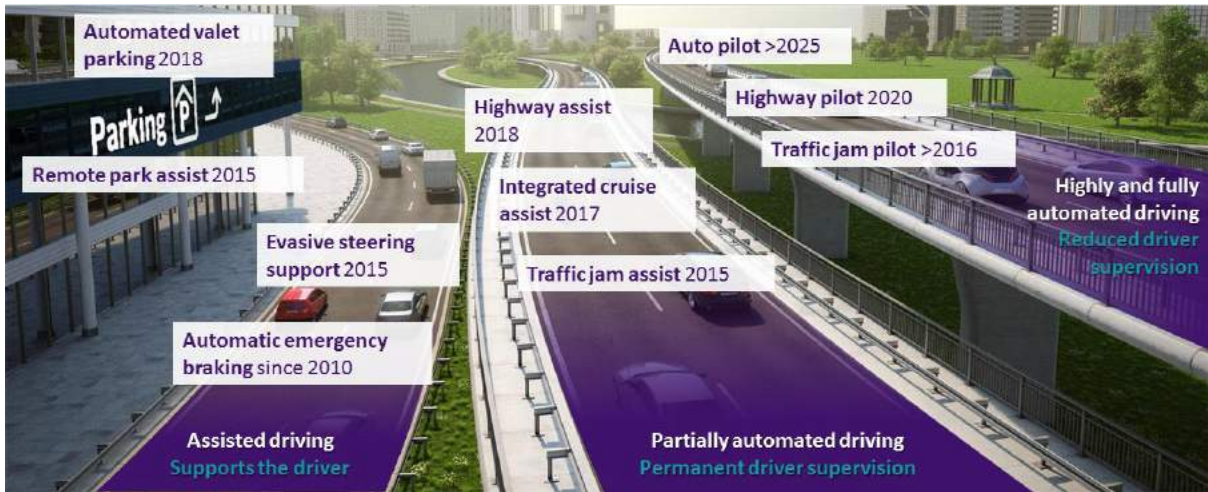


Figure 1. The progression of vehicle automation (Bosch 2016).

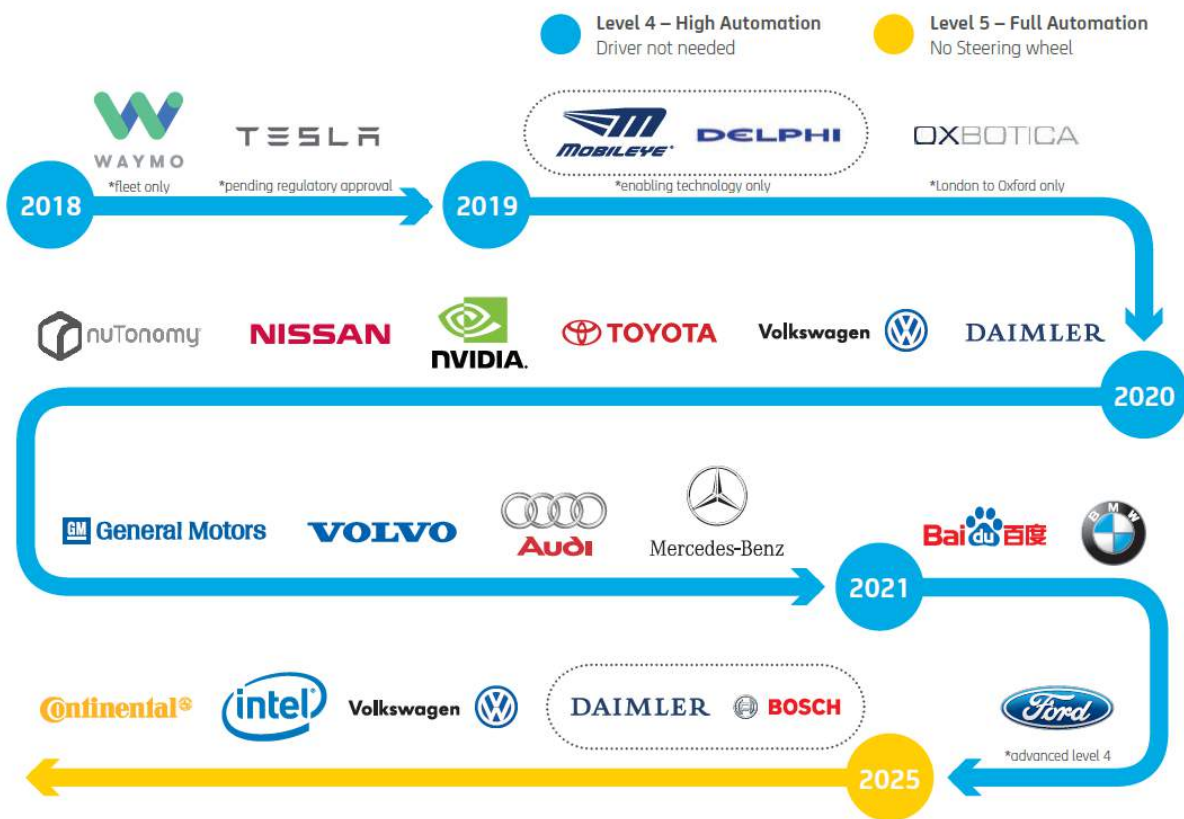
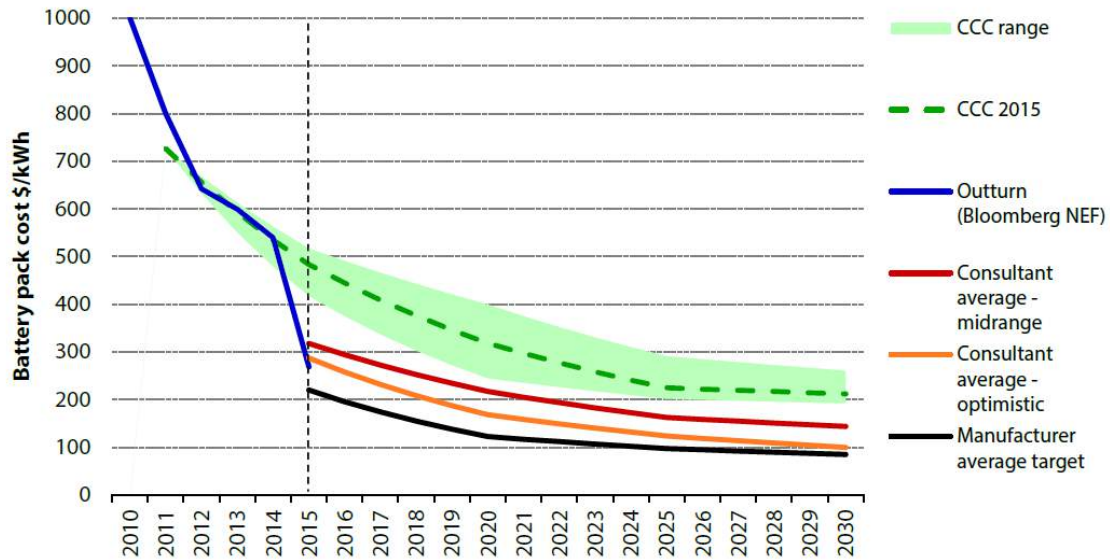


Figure 2. Timeline to full vehicle automation (NRMA 2017).

The development of electric vehicles is a key contributing technology. Electrification of vehicle propulsion will contribute an enabling building block for connectivity and autonomy (ITS-A 2017). Urban air quality standards and global commitments to limit the effects of climate change are forcing a move away from internal combustion engine technology. With reference to Figure 3, battery cost reductions are ahead of forecasts, bringing forward the expected point at which the total cost of ownership for electric vehicles will be lower than that of internal combustion engine alternatives.



Source: Consultant optimistic average: Aurora Energy 'Breakthrough', Bloomberg New Energy Finance 'Aggressive', Morgan Stanley, Goldman Sachs 'Tesla', National Academy of Sciences 'Optimistic', ICCT 'Optimistic', McKinsey & Co., Bain & Company; Consultant midrange: Aurora Energy 'Consensus', Bloomberg 'Conservative', Morgan Stanley, Goldman 'Industry', National Academy of Sciences 'Midrange', Ricardo, Accenture, ICCT 'Midrange', BNP Paribas, Bain & Company; Manufacturer average target: Tesla, Ford, GM, Audi, Renault-Nissan.

Figure 3. Electric Vehicle battery cost estimates (UK CCC 2017).

Mobility-as-a-Service (MaaS) is a total mobility solution based on individual needs. It is evolving from service models which provide vehicle transport without the cost of ownership. Car share has quickly grown in popularity from its origins in university campuses, while rideshare or hailing services such as Uber have arrived even more quickly. MaaS combines multiple transport modes such as car and rideshare with public and even active transport options. Crucially, MaaS offerings are designed to out-compete conventional car transport options via a sleek user experience with dynamic journey planning and streamlined payment processes. Figure 4 is a conceptual model of the MaaS system provided by Whim - an actual MaaS system operator who recently won the Best Mobile Service award in their home country (MaaS Global 2017a).

As was highlighted for vehicle electrification above, technology convergence will translate to the automation of MaaS systems. Figure 5 illustrates how public transport will become increasingly automated alongside car and ride sharing, all of which will ultimately underpin a fully-automated, multimodal travel experience.

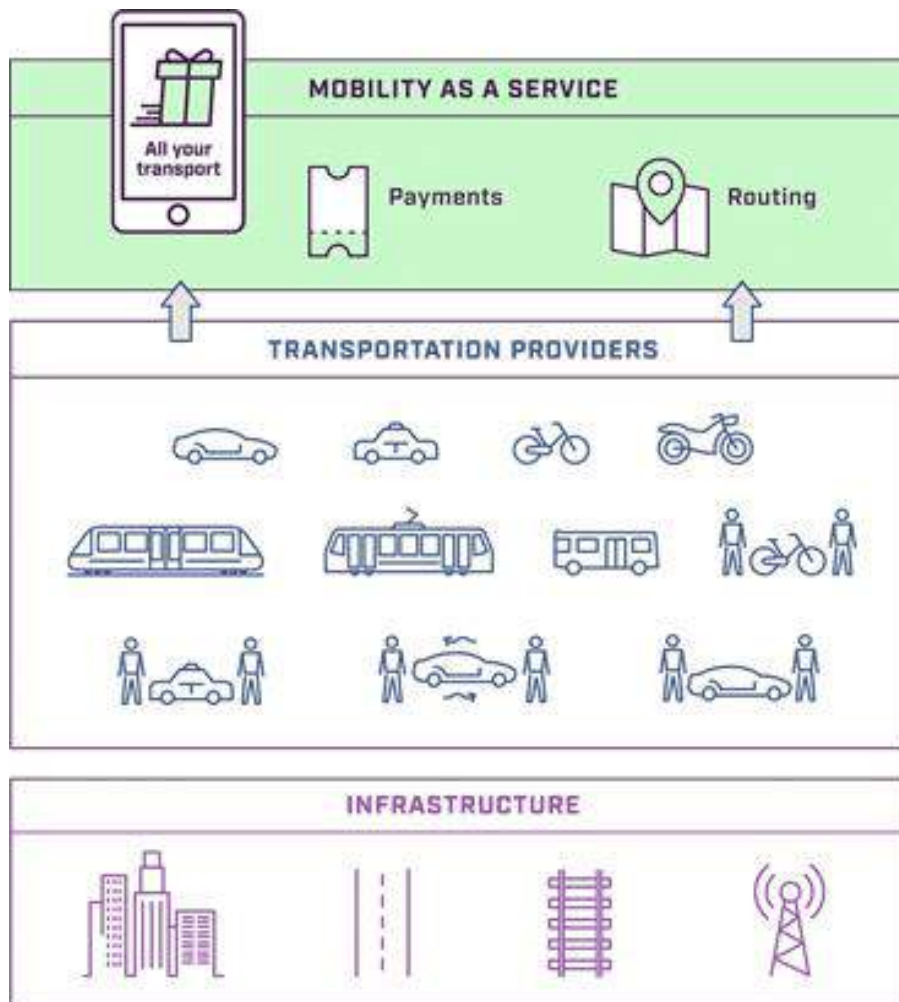


Figure 4. Mobility-as-a-Service system model (Maas Global 2017b).

"Last and first mile" is used to describe options to move people from a transportation hub, especially railway stations, bus depots, and ferry slips, to their final destination. Traditional solutions to the first mile problem in public transit have included the use of feeder buses, bicycling infrastructure, and urban planning reform. Critics also claim this promotes a reliance on cars, which results in more traffic congestion, pollution, and urban sprawl. Other innovative methods of alleviating the last mile problem include pod cars (personal rapid transit), and motorized shoes have been proposed with varying degrees of adoption. In 2015, Ford Motor Company received a patent for a "self-propelled unicycle engageable with vehicle", which is intended as a last mile commuter solution (USPTO 2015). Other recent options include personal e-bikes, e-scooters and similar which offer great potential to reduce congestion and pollution.

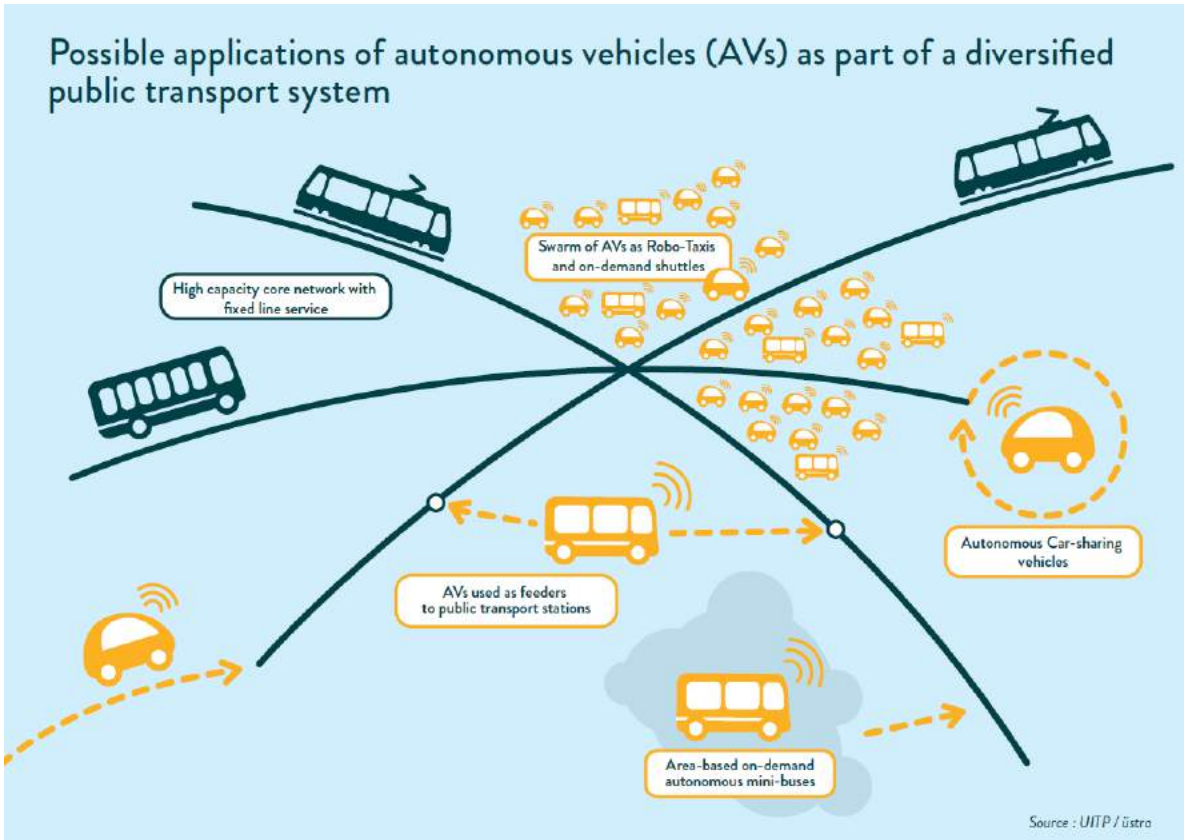


Figure 5. Vehicle automation as an enabler for public and private transport systems (UITP 2017).

4. HOW DO SMART TRANSPORT AND MOBILITY SYSTEMS INTERACT WITH SMART CITY POLICY OBJECTIVES?

As was the case for the origins of Intelligent Transport Systems, the continued evolution of transport and mobility systems is being driven by individual and community benefits. Recognition of these benefits is compelling public and private sector investment around the world. Importantly, these efforts are being tailored to the local context and increasingly coordinated to ensure the positive synergies are realised and negative outcomes avoided.

This transition and its imperatives are effectively summed up by the following quote from a report co-authored by Bloomberg and McKinsey & Co (BNEF & McKinsey 2016):

Today, a small number of cities, such as Amsterdam, Singapore, and Stockholm, are singled out as having effective mobility. With varying degrees of emphasis, they have efficient public transit, encourage cycling and walking, and have managed to limit congestion and pollution. By 2030, we expect a number of additional systems to be at the leading edge of the next phase of advanced mobility. In broad terms, the best will combine shared mobility, autonomy, and electrification with integrated energy systems, public transport, and infrastructure. In specific terms, cities will navigate these possibilities differently. Local conditions—such as population density, wealth, the state of road and public-transit infrastructure, pollution and congestion levels, and local governance capabilities—will determine what changes occur, and how quickly.

The choice and mix of measures must be tailored to the local context, entailing that preferred approaches are city-led. In recognition of this the United States Department of Transportation launched a Smart City Challenge in 2015 by inviting applications from mid-sized cities which leveraged smart transport and mobility solutions for community benefit. Results of the application process revealed the diversity of interests around common themes - refer to Figure 6.



Figure 6. Smart transport and mobility system priorities as revealed through analysis of the 78 city submissions to the US Department of Transport Smart City Challenge (US DOT March 2017a).

At the city level, measures may be implemented in sequence or parallel. Figure 7 illustrates one approach which includes changes to the built environment alongside deployment of smart transport and mobility solutions. The expected results are consistent with the Australian Government’s Smart Cities policy priorities.

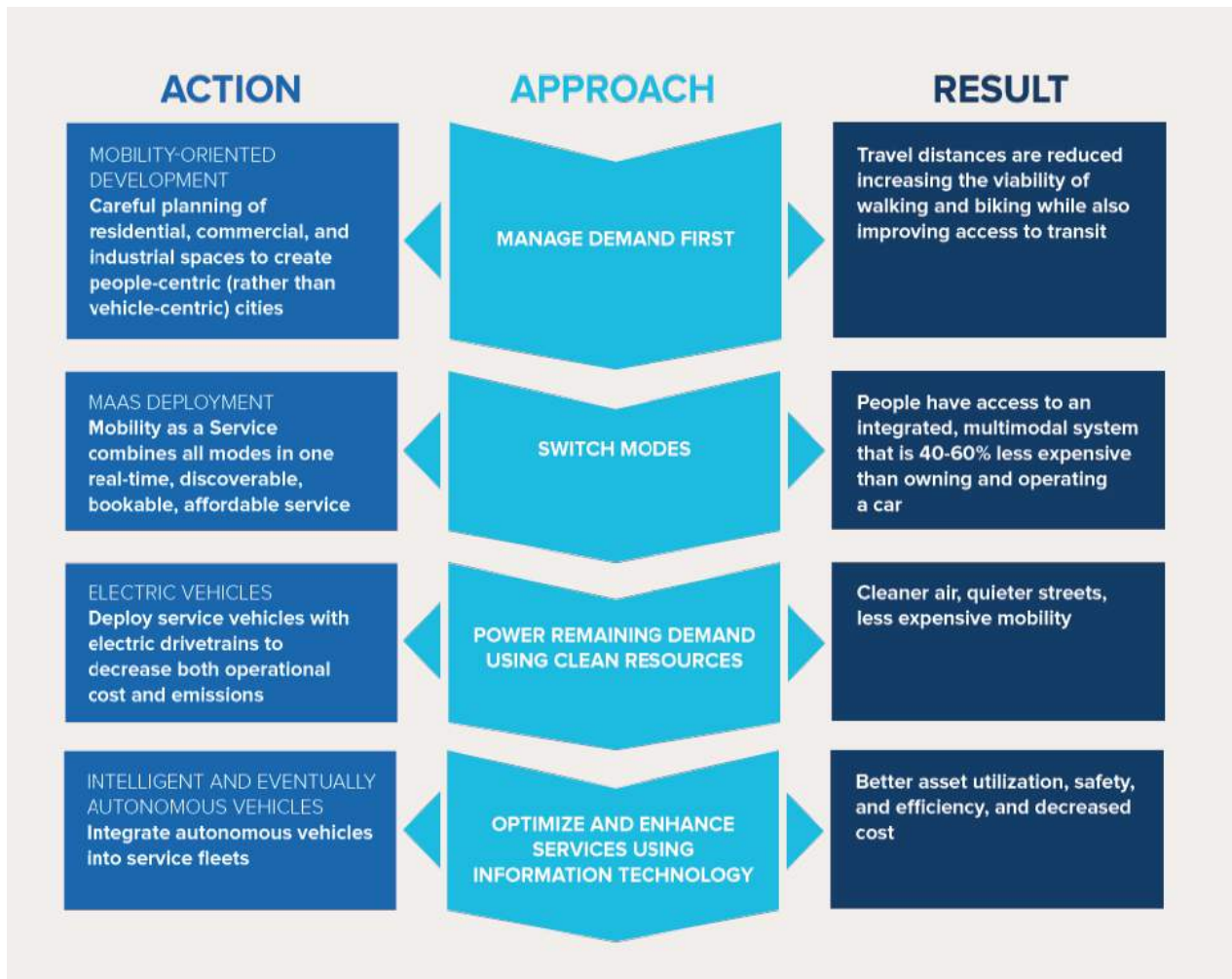


Figure 7. How urban systems are evolving for individual and community benefit (RMI 2017).

The interrelationship between the built environment and transport systems should be recognised for its impact to transport, buildings and urban infrastructure. The move away from car ownership via car/ride share and MaaS alongside vehicle electrification and automation will significantly impact future planning and requirements in all areas. Figure 8 provides an illustration of this in the evolution of a multi-storey car park in response to vehicle automation.

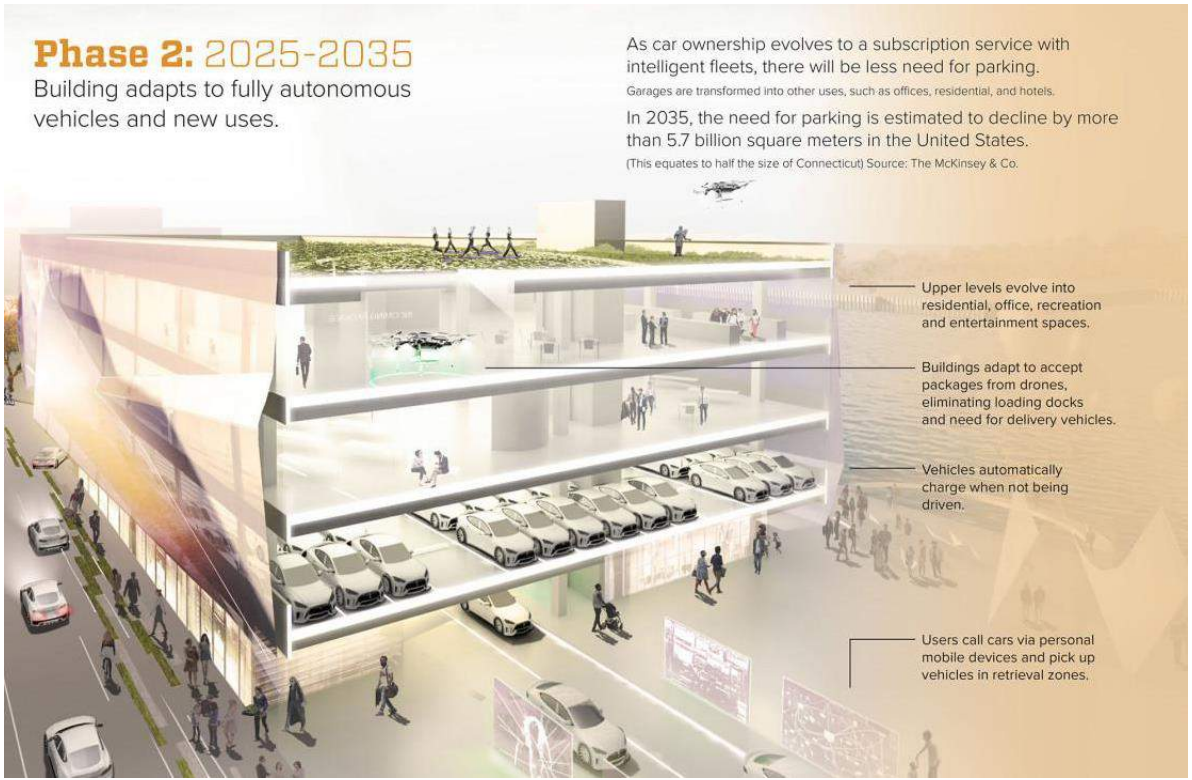


Figure 8 (a) and (b). The evolution of a multi-storey car park in response to vehicle automation - near and mid-term (Arrowstreet 2017).

This speaks to the importance of a holistic and coordinated approach. Vehicle electrification and automation have the potential to dramatically decrease the dollar and time costs of transport. If unchecked, this is likely to result in an increase in the distances travelled, and by extension increased congestion, urban sprawl and greater energy demand with resultant emissions impacts. In contrast, facilitating a concurrent transition to electrification,

automation and sharing will deliver maximum benefit - refer to Figure 9. Policy makers from across government must increasingly cooperate among themselves and with diverse private sector participants to comprehend these challenges, coordinate efforts and ensure the preferred outcomes.

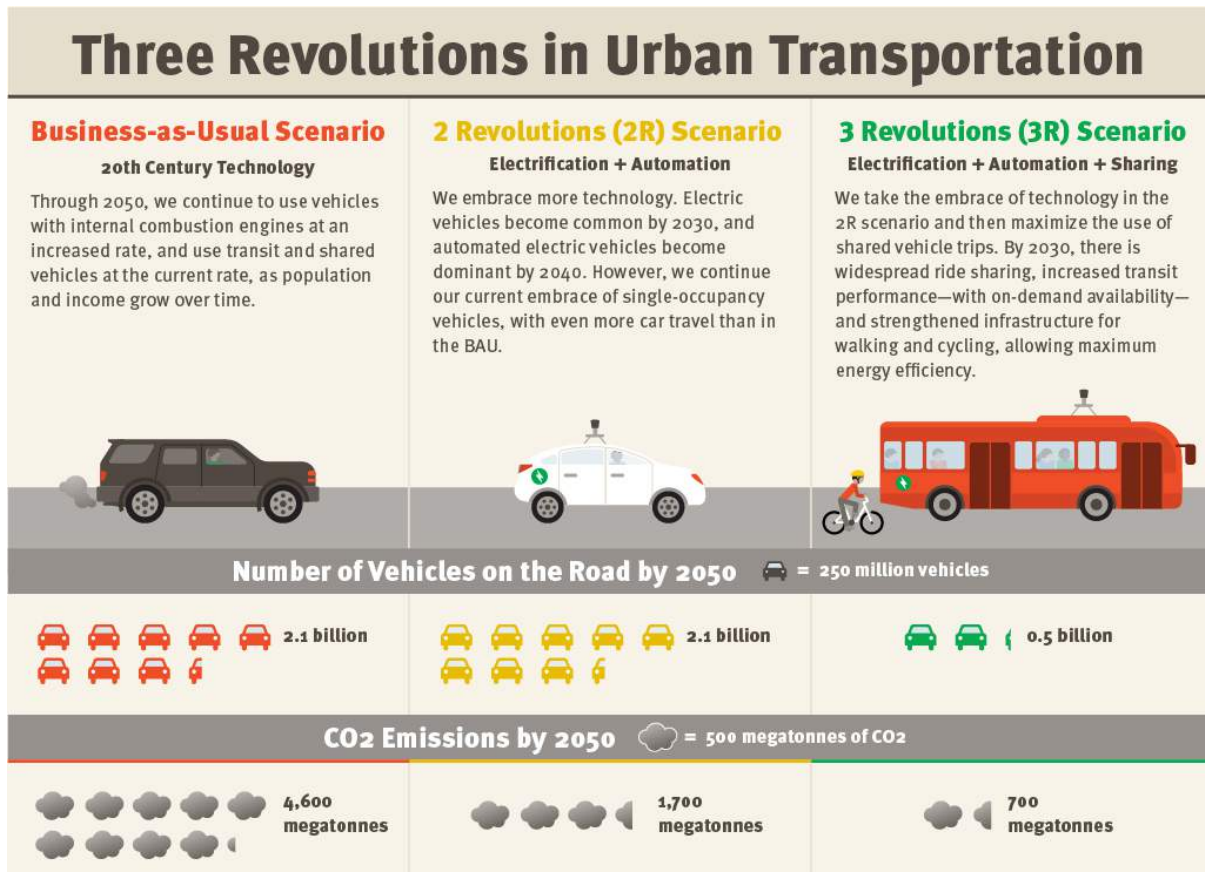


Figure 9. The interrelationship between smart transport and mobility system technologies (UC Davis & ITDP 2017).

5. WHY ARE SMART TRANSPORT AND MOBILITY SYSTEMS RELEVANT TO AUSTRALIAN CITIES?

Australia stands to benefit from smart transport and mobility systems more than most. We have a proven track record for innovation in the space, which combined with a switch from imported fuel to locally-produced electricity will protect and grow jobs and investment. The negative consequences of the urban sprawl and car dependency which characterises Australian cities may also be addressed.

The characteristics of the Australian operating environment lend themselves to transport and mobility system innovation. High urban concentrations, but low densities, mean that the benefits of information and infrastructure solutions to address the transport problem will have the highest payoffs here.

In October 2016 Melbourne hosted the 23rd World Congress on Intelligent Transport Systems, which was attended by more than 11,500 delegates from 73 countries. The event provided an opportunity to showcase Australian ITS expertise, which has been effectively summed up in the following quote from the post-event report (ITS-A 2017):

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

Vehicle electrification will also protect and enhance Australian employment. Whilst Australia is currently on a trajectory towards complete oil import dependency (ABC 2016), all electricity consumed in Australia is produced here (AER 2017). In 2015-16, 11,150 people were directly employed in renewable energy activities in Australia (ABS 2017). The local economy of regions such as the Latrobe Valley in Victoria and the Hunter Valley in NSW is inextricably linked to the electricity sector. Supporting the shift toward vehicle electrification will increase demand for electricity, greatly enhancing employment opportunities for Australians.

Future investment in industries associated to the electric vehicle eco-system also presents the opportunity increased job creation through areas such as infrastructure deployment, innovation, customer service, technology, and manufacturing of components and batteries.

The rationale for early adoption of autonomous electric vehicles by Australia has been examined and quantified as follows (MacroPlan 2017):

- 16,000 jobs (direct and indirect) replacing the 40,000 jobs in the Traditional Motor Vehicle (TMV) sector
- \$15 billion annual production of autonomous vehicle components and services
- Avoiding extreme traffic congestion (\$52 billion per annum by 2031)
- Reduced peak infrastructure costs
- Increased efficiency of public transport
- Creation of an Australian innovation value chain
- Reduction in carbon pollution

The instigation for transport and mobility innovations are of course real problems that are experienced by the innovators and those around them. Benchmarking of Sydney's mobility system highlights the sustainability challenges it faces that are consistent with cities like it globally (SBA 2016):

- High reliance and inefficient use of private vehicles have resulted in a carbon intensive mobility system with Sydney achieving its lowest scoring mobility system indicator for the Emissions of Greenhouse Gases
- Long journey to work times that are exacerbated by congestion are likely to impact economic productivity and have resulted in a low proportion of Sydneysiders feeling satisfied that they are able to access job opportunities

As a reflection of this, Sydney has been identified as a global metropolis which has the potential to adopt electric autonomous vehicle systems ahead of global averages (BNEF & McKinsey 2016). Figure 10 provides a conceptual model of how a city characterised by developed suburban sprawl may evolve in response to this technological disruption. The convergence of energy and transport systems can be seen within the context of an urban environment which is characteristic of most Australian cities.

As was set out in the previous section, this scenario brings both risk and opportunity. Left unchecked, the enhanced adoption of electric autonomous vehicles by Australian motorists may result in increased congestion, urban sprawl and emissions. Conversely, measures to promote sharing models stand to deliver widespread benefit across the Australian economy.



Figure 10. A conceptual model of how the electrification and automation of private vehicles is forecast to play out in a city characterised by developed suburban sprawl, as is the case for Australian cities (BNEF & McKinsey 2016).

The consultants AECOM noted this in their assessment of the potential benefits for Sydney from increased carsharing (AECOM 2016). They estimate that an increase in the carshare fleet to 9,000 vehicles would translate to 90,000 fewer private cars, equating to around 2 percent of all cars in Sydney. This many Sydney carshare users would drive 180 million fewer kilometres per year than if they owned cars, and free up more than 1.2 million square metres of street space for other purposes - refer to Figure 11.

SYDNEY 2036: LESS CARS, MORE SPACE

2011

2016

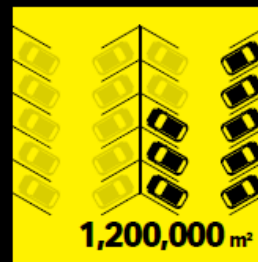
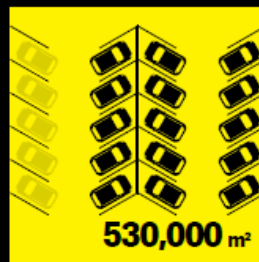
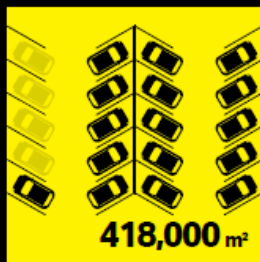
2036

ONE CARSHARE VEHICLE REMOVES 10 PRIVATE CARS FROM OUR STREETS



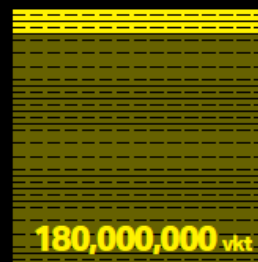
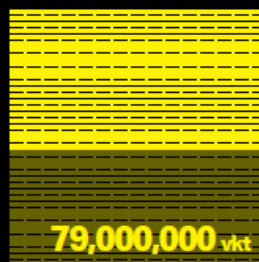
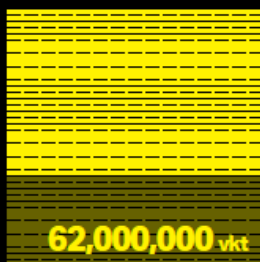
= 10,000 Private cars

EVERY PRIVATE CAR THAT DOESN'T REQUIRE PARKING FREES UP 13.5 SQM OF STREET SPACE



= 100,000 m²

AND CARSHARERS DRIVE 2,000 KM LESS THAN PRIVATE CAR OWNERS EACH YEAR



= 10,000,000 vkt (Vehicle KMs Travelled)

This analysis uses Census data and assumptions about how people might choose to travel in the future. These are optimistic outcomes that could be possible if stakeholders support carshare schemes across the Sydney metropolitan area.

Sources: AECOM analysis supplemented by data from Philip Boyle & Associates, 2016

Figure 11. Impacts of increased car share for Sydney (AECOM 2016).

6. WHAT MEASURES WILL HELP PROMOTE SUCCESSFUL ADOPTION OF SMART TRANSPORT AND MOBILITY SYSTEMS?

By definition, promoting adoption of smart transport and mobility systems requires systems thinking. Rather than a single measure, a holistic and coordinated approach is required across the transport and mobility ecosystem to help realise the best outcomes and avoid undesirable side effects. Well-reasoned and iterative planning informed by attentive monitoring and analysis will help bring stakeholders along and deal with uncertainty. While the challenge may seem daunting, the consequences of inaction require a commitment to succeed.

The transition to a smart transport and mobility system is characterised initially by enhancements to existing infrastructure then paradigm shifts via innovation. The following quote by the Secretary of the US Department of Transport describes both the journey and the challenge (US DOT 2017b):

Can we imagine a future in which traffic jams decline? Absolutely. Essentially, three strategies need to be employed - all of which demand increased funding and new, more adaptive policymaking at all levels of government.

First, we clearly have to take better care of our legacy transportation systems. We cannot cross bridges that have fallen apart or connect commerce to ports in disrepair. Most obviously, the question of sufficient resources must be confronted squarely.

Second, we must fund and prioritize new projects based on future projections, not arcane precepts of mobility. Living patterns are changing, as are transportation tastes. As is the nature of freight movement. Rather than plunge our heads in the sand, policymakers and practitioners should understand these trends and plan with them in mind.

Third, we must use technologies and better design approaches that will allow us to maximize the use of our old and new transportation assets. Doing so may involve adapting for innovations in vehicle safety and automation, improving federal, state, and local coordination, and adopting best practices in the design of infrastructure.

While focused primarily on road transport, the post-event review of the 23rd ITS World Congress staged in October 2016 describes the status of ITS in Australia, identifies key messages from the conference, provides examples of initiatives from elsewhere, and summarises a list of 43 opportunities for Australian business, researchers and governments grouped under the following focus areas (ITS-A 2017):

- Pathways to Connected Autonomy
- Mobility for Smart Cities and Communities
- Next Generation Public Transport and MaaS

- Big Data, Analytics, Ownership and Access
- Future Freight
- Transport Pricing and Funding
- Frameworks for Success

Analysis undertaken by the International Council for Clean Transportation of lessons on the critical first steps to accelerate the electrification of transport from some of the world's preeminent electric mobility cities (ICCT 2017a). While the 14 metropolitan areas studied comprise just 1.5% of the world's population and 5% of global passenger vehicle sales, they represent around one third of the global electric vehicle market. The common strand among these cities' electric vehicle activities is that they all are actively addressing the key prevailing barriers of cost, convenience, and consumer information through a systems approach. Figure 12 illustrates the findings from further detailed analysis into six significant variables with a correlation to EV adoption for U.S. metropolitan areas. While this rigorous approach has revealed some invaluable insights, the variance of the findings also illustrates how local and systemic factors can influence outcomes.

Variable	200 U.S. metropolitan areas			50 U.S. metropolitan areas		
	BEV	PHEV	EV	BEV	PHEV	EV
Model availability, BEV	X			X		X
Model availability, PHEV		X			X	
Model availability, EV			X			
BEV incentive	X					
PHEV Incentive		X				X
EV incentive			X			
Public charging per capita (Level 2)	X	X	X			
Public charging per capita (DC fast)	X	X	X	X		X
Workplace charging per capita				X	X	X
High occupancy vehicle lane incentive					X	
City promotion actions					X	
Regression adjusted R-squared	0.61	0.63	0.64	0.92	0.89	0.94

BEV = battery electric vehicle; PHEV = plug-in hybrid electric vehicle; EV = electric vehicle (including BEV and PHEV); X = significant variable (p-value < 0.05).

Figure 12. Summary of six significant independent variables for six statistical regressions on electric vehicle share in US metropolitan areas, which highlights the effectiveness of a systems approach (ICCT 2017b).

Bloomberg and McKinsey & Co provide recommendations to governments in support of successful deployment of smart transport and mobility systems (BNEF & McKinsey 2016):

Governments and regulators could capture societal benefits by addressing bottlenecks to adoption of advanced mobility. In this context, government could craft regulation that is in sync with technology development and ahead of consumers: this includes support for self-driving vehicle pilot programs and incentives to stimulate uptake of electric vehicles, particularly in urban areas. Public investments in charging infrastructure and

dedicated lanes for self-driving vehicles could stimulate uptake of electric and autonomous technologies. Incentives to steer autonomous vehicles toward shared rather than private use will help curb demand increases from zero-occupancy rides and maximize the social returns from this innovation. Regulators should also consider preempting the potentially adverse effects of increased mobility and loss of fuel tax revenue, for example by using connectivity to facilitate infrastructure pricing or introduction of ultra-low zones.

A detailed analysis of the various measures is outside the scope of this consultation, and so the submitting organisations invite the Australian Government and other transport and mobility system stakeholders to engage in further discussions on what measures should be considered, including a detailed design and implementation plan. Moreover it is contended that relying on market forces alone will fall somewhat short of delivering the desired outcomes, and that all levels of government - but particularly the Federal Government - needs to proactively manage the smart transport and mobility transition.

7. WHAT SMART TRANSPORT AND MOBILITY SYSTEM INDICATORS ARE SUGGESTED FOR INCLUSION IN THE NCPF?

Seven smart transport and mobility system input indicators are suggested for inclusion in the first iteration of the National Cities Performance Framework (NCPF):

Planning indicators - input indicators which reveal the extent to which a city is preparing for smart transport and mobility system deployment:

1. Consideration of smart transport and mobility systems in all major city and transport planning activities
2. Electric Vehicle charging infrastructure deployment plan

Data & Access indicators - input indicators that focus on enablers for smart transport and mobility system planning and third-party innovation:

3. Real time monitoring of congestion points and economic bottlenecks - multi-modal, including both traffic and public transport
4. Open, real-time, dynamic road traffic data availability
5. Open, real-time, dynamic public transport data availability
6. High speed, low latency data network coverage
7. Mobile ticketing for public transport, including booking and payment by third parties, also multi-modal, including both traffic and public transport

The suggested indicators:

- Draw on insights from Sections 4, 5 and 6 of this submission, specifically the need for an integrated approach tailored to the local context, along with the characteristics of Australian cities that have implications for transport system design and operation
- Align with the Australian Government's Smart Cities policy priorities, specifically "Jobs and Skills", "Infrastructure and Investment" and "Liveability and Sustainability"
- Are input indicators which reflect "best first steps" that can be built upon as the NCPF evolves in line with Australian Smart City implementations

Our approach builds on the outcome and impact indicators included in the draft NCPF by working back to the inputs that best correlate to them. Table 1 illustrates this relationship along with other characteristics of the suggested indicators.

GROUPING	INDICATOR No.	INPUT INDICATOR	DATA SOURCE	OUTPUT	DRAFT NCPF INDICATOR									
					Higher economic growth	Higher employment	A more skilled workforce	Jobs accessible within 30 min	Share of public transport	Share of active transport	Peak travel delay	Cost of congestion	Average time without power	Air quality
PLANNING	1	Consideration of smart transport and mobility systems in all major city and transport planning activities	City planners State planners	Improved transport system planning	X	X		X	X	X	X		X	X
	2	Electric Vehicle charging infrastructure deployment plan	City planners State planners	Enabler for connected/ autonomous vehicle systems Address transport externalities	X	X						X	X	X
DATA & ACCESS	3	Real-time monitoring of congestion points and economic bottlenecks	Road system manager (for cycle and vehicular traffic data) City government (for pedestrian movements)	Improved transport system planning Optimisation of passenger and freight movements	X	X		X	X	X	X		X	X
	4	Open, real-time, dynamic road traffic data availability	Road system operator	Dynamic route planning	X	X		X		X	X		X	X
	5	Open, real-time, dynamic public transport data availability	Public transport system & franchise operators	Enable Mobility-as-a-Service (MaaS) solutions	X	X	X		X		X		X	X
	6	High-speed, low latency data network coverage	Telco's	Intelligent Transport System (and Smart City) enabling infrastructure	X	X	X	X	X		X		X	X
	7	Mobile ticketing for public transport, including booking and payment by third parties	Public transport system operator	Enable Mobility-as-a-Service (MaaS) solutions	X	X	X		X			X		X

Table 1. Seven input indicators suggested for inclusion in the National Cities Performance Framework (NCPF), and their relationship to the draft NCPF outcome and impact indicators (red = Jobs and Skills, blue = Infrastructure and Investment, green = Liveability and Sustainability).

To illustrate how these input indicators correlate to the draft NCPF outcome and impact indicators, consider the following examples in relation to real-time monitoring of congestion points and economic bottlenecks (ITS-A 2017):

- 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.
- Motorway management via the use of coordinated ramp signals prevents flow breakdown and maintains optimum throughput and travel times - refer to Figure 13 (a) and (b) which shows the contrast between unmanaged and managed motorways.

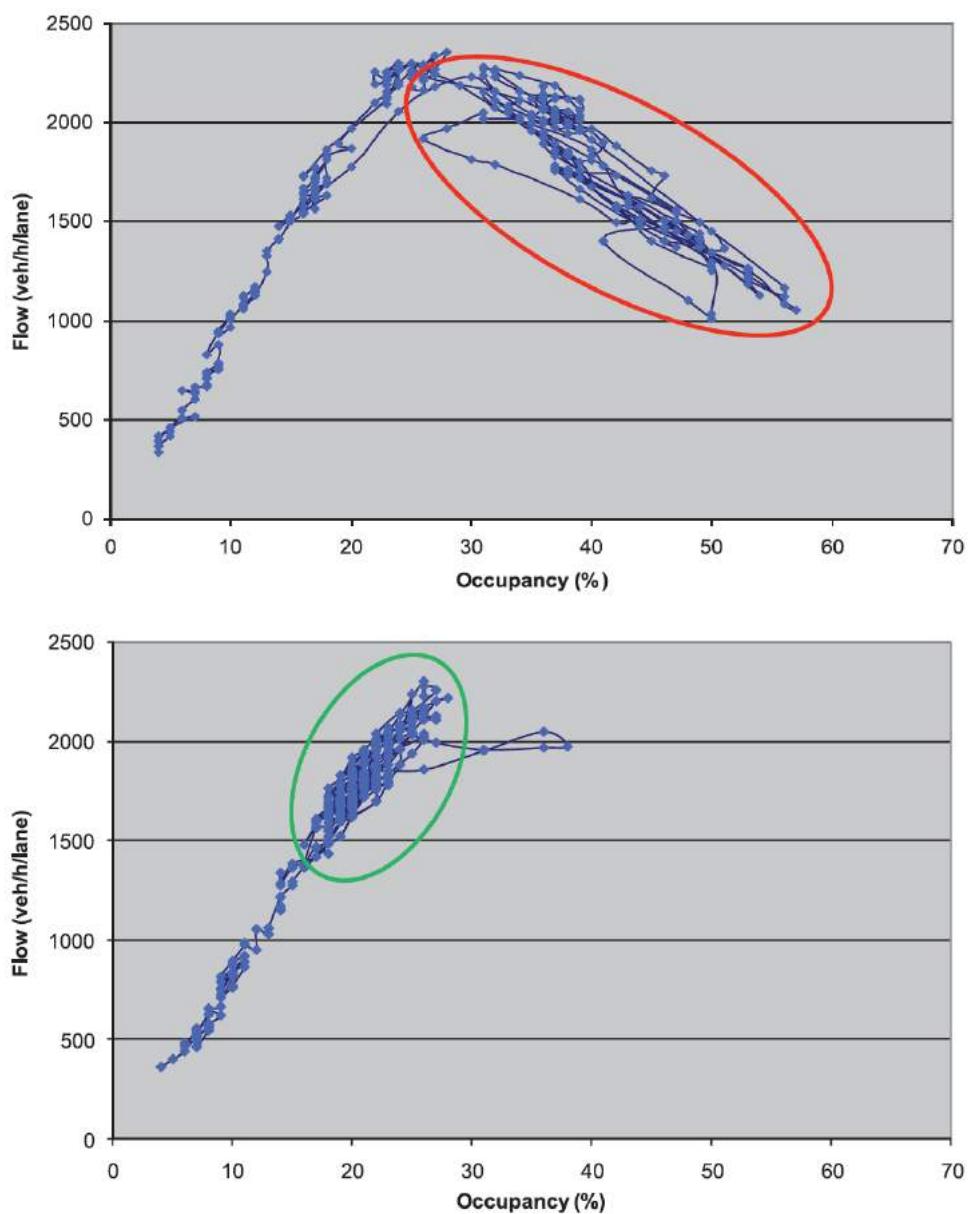


Figure 13 (a) and (b). Motorway traffic flows which show how unmanaged flow declines when saturation is exceeded (top) as compared to managed flow which keeps volumes close to optimum/below saturation (bottom, ITS-A 2017).

8. WHY SHOULD SMART TRANSPORT AND MOBILITY SYSTEM INDICATORS BE INCLUDED IN THE NCPF?

The justification for inclusion of the suggested indicators can be summarised as follows:

- Smart transport and mobility systems are inevitable, however the consequences for Australian cities will reflect our approach to implementation;
- NCPF indicators will raise awareness and understanding of smart transport and mobility systems and the benefits that they will provide Australian cities; and
- The inclusion of input indicators will provide guidance on measures that will help realise the preferred outcomes from smart transport and mobility systems.

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APPENDIX A – SUPPORTING ORGANISATIONS

Australia & New Zealand Driverless Vehicle Initiative (ADVI)

The Australia & New Zealand Driverless Vehicle Initiative (ADVI) is a partnership of government, industry and academic partners working collaboratively to research, investigate and help inform the development of robust national policy, legislation, regulation and operational procedures and processes to bring driverless vehicles safely and successfully to Australian roads.

ADVI has representatives from the following sectors:

- Automotive industry
- Communications and technology industries
- Legal and advisory industries
- Insurance and banking industries
- Defence industry
- Mining industry
- Taxi and car sharing services
- Parking industry
- Automobile clubs
- Media and industry facilitators
- Local Councils
- State and Commonwealth Governments
- Australian research partners
- International research partners
- Industry associations

The key thrust of the Australia & New Zealand Driverless Vehicle Initiative is to build momentum by rapidly exploring the impacts and requirements of this new technology in a truly Australian context and making recommendations on ways to safely and successfully bring self-driving vehicles to Australian roads.

To do this we will raise public awareness through live demonstrations involving government, industry, research entities and the media. The intention is to provide an avenue to showcase the involvement and contributions of collaborating partners involved in this important initiative.

For more information refer to <http://advi.org.au/>.

ClimateWorks

ClimateWorks Australia is a leading independent organisation acting as a bridge between research and action to identify, model and enable end-to-end solutions to climate change.

Since our launch in 2009, ClimateWorks has made significant progress and earned a reputation as a genuine and impartial adviser to key decision makers from all sides of politics and business. Our collaborative approach to solutions that will deliver the greatest impact encompasses a thorough understanding of the constraints of governments and the practical needs of business. We do this by looking for innovative opportunities to reduce greenhouse gas emissions, analysing their potential, resolving obstacles and helping to facilitate conditions for our transition to a prosperous, net zero emissions future by 2050.

ClimateWorks was cofounded by The Myer Foundation and Monash University and works within the Monash Sustainable Development Institute.

For more information refer to <https://climateworksaustralia.org/>.

Electric Vehicle Council

The Electric Vehicle Council is the national body representing the electric vehicle industry in Australia. Representing companies involved in providing, powering and supporting electric vehicles, our mission is to accelerate the electrification of road transport for a sustainable and prosperous Australia.

The Electric Vehicle Council is an industry-led organisation representing and coordinating the broader electric vehicle industry in Australia. Representing companies involved in providing, powering and supporting electric vehicles, its members sell over 350,000 new vehicles per year in Australia, and have over 6 million Australian customers.

For more information refer to <http://electricvehiclecouncil.com.au/>.

iMOVE CRC

The iMOVE CRC is a new national intelligent transport R&D centre funded through the Cooperative Research Centres programme.

It is supported by 46 industry, government and research partners including the federal departments of 'Industry Innovations and Science' and 'Infrastructure and Regional Development', state road authorities, retailers, logistics and insurance companies, technology developers, automobile clubs and many of Australia's top universities.

The ten-year centre will undertake industry-led research that uses emerging technologies to improve Australian transport systems nationally. It will deliver fast and predictable freight systems and enhanced mobility for Australians on the roads and public transport.

For more information refer to <http://imovecrc.com/>.

ITS Australia

Intelligent Transport Systems Australia (ITS-A) 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-A 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-A 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.

For more information refer to <http://www.its-australia.com.au/>.

Parking Australia

Parking Australia is the national body representing the interests of the parking industry in Australia.

The role of Parking Australia is to provide leadership, education, technical and other information to all parties who may be associated with the parking industry.

Since 1986, the association has represented a broad cross-section of local government and statutory authorities, car park management companies, equipment suppliers, consultants, property developers and property owners.

Parking Australia was founded in Perth in 1986 as an outcome of a Capital Cities Lord Mayors' Conference. The Lord Mayors felt there was value in having an organisation that would bring together the various elements of, and promote excellence in the control and management of parking facilities.

Following its establishment, the association has represented a broad cross section of local government and statutory authorities, parking operators, service providers and suppliers to the parking industry.

The association holds biennial conventions aimed primarily at informing the decision makers in the government sector, developers and owners of properties, and other related professionals, of current best practice, latest technologies, knowledge and information spanning all relevant issues in parking.

The recently established Future of Parking Committee heads up research, strategy and position regarding the role of parking in from today and beyond.

For more information refer to <https://www.parking.asn.au/>.

APPENDIX B – CONTACTS

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