Land Transport Regulation 2040

Technology, trends and other factors of change

Foundation paper
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Report outline

Title	Land Transport Regulation 2040: Technology, trends and other factors of change
Type of report	Foundation paper
Purpose	Foundation paper as part of the Land Transport Regulation 2040 work
Abstract	The National Transport Commission (NTC) is undertaking strategic work called Land Transport Regulation 2040. The key question for this work is: How could or should we regulate land transport in the future? The purpose of this paper is to provide information about technology, trends and other factors of change to stimulate discussion to inform this key question. The paper will be used in workshops and meetings from October to early December 2016.
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Executive Summary

New technology and changing consumer demand, as well as other key factors, are likely to reshape the transport system. We need to begin to consider how decisions we make today might affect the future, and how these factors and changing consumer patterns will affect transport.

Land Transport Regulation 2040

The National Transport Commission (NTC) is undertaking strategic work called Land Transport Regulation 2040 with the key question: *How could or should we regulate land transport in the future?* This work will help spark discussions about how we might need to change the way we regulate in response to the changes in the transport system.

This paper will be used in meetings, workshops and conversations the NTC will have with stakeholders throughout October to early December 2016. The NTC will provide a final report and advice to the Transport and Infrastructure Council in May 2017 including potential research and policy projects to inform future regulatory decisions.

The other papers released as part of this work are:

- a foundation paper background and supplementary questions on regulation and transport
- a fact sheet on scenario planning
- scenarios for land transport in 2040 that contains four plausible futures.

The future of transport

Scenarios and future trend analysis cannot predict the future. Instead, this type of analysis seeks to provide the means to consider current polices and decision-making processes from the perspective of potential future developments.

This paper is part of a short series that aims to support decision-makers to have structured conversations about uncertainty and to factor this uncertainty into their decisions about the future. Futures analysis is designed to make uncertainty more tangible and to qualify and quantify the impact of abstract issues and trends that are often difficult to translate into near-term effects.

By enabling more considered analysis, it can complement conventional forms of analysis and shape short to medium-term policy responses in a way that is consistent with addressing major long-term challenges.

This paper briefly explores some of the technologies and key factors that could have a significant impact on land transport in the future. The key factors that were used in developing future transport scenarios as part of this work were:

- automation
- shared mobility
- data availability and sharing
- consumer demand for convenience and new services.

There are many potential cumulative implications for transport from these factors including:

- changing demand for travel, and travel patterns as a result of changing energy costs and demographic shifts
- the rise of automated 'mobility-as-a-service' provided by the private sector.

These factors could result in very significant changes to the way transport is used, paid for, procured by private citizens, and funded by government in the future. In fact the whole concept of provision of public transport and 'public good' may change.

Getting a better understanding of these potential changes is essential to creating the resilience and adaptability within our current transport system and regulations.

Stakeholder engagement has already identified several key discussion topics for exploration throughout this work including:

- market structures under each plausible future
- compliance and enforcement approaches
- productivity of networks
- future information standards and privacy implications
- future transport demand.

1 Introduction

Over the past few years, there has been growing awareness within government, industry and the community that new technology and business models will transform Australia's transport system. Examples include new business models, such as ride sharing and car sharing apps like Uber or GoGet, and potential future technology such as fully automated and connected vehicles. These changes urge us to consider today how we could or should regulate transport in the future.

In response to emerging changes, governments are preparing to change the regulatory environment. The National Transport Commission (NTC) has been examining regulatory barriers to automated road and rail vehicles over the past 12 months. State governments have also been actively supporting the introduction of automated vehicles; for example, South Australia has introduced exemptions powers to allow trials of automated vehicles. National work is also underway to better understand developments such as cooperative intelligent transport systems (C-ITS).

The Transport and Infrastructure Council, as part of its 2015 review of the NTC, directed the NTC to continue to transition its focus to higher level strategic policy reform work. In response, the NTC has included a strategic analysis stream in its work program. The aim of this strategic work is to understand the trends, influences and changes in society that will shape Australia's transport system in the future. Decisions we make regarding infrastructure investment, funding mechanisms and regulatory frameworks often reflect our current operating environment. However, the decisions we make today need to also incorporate our understanding of the future and acknowledge that we do not know what is likely to occur. Our decisions are often based on our history of experience, but more and more we are being required to make decisions on what may yet emerge. Better decisions made now will lead to improved productivity, safety and environmental performance of Australia's transport system in the future.

In this work, we will ask key strategic questions. The aim of the work is not to provide definitive long-term solutions. Instead, the aim is to discuss and explore plausible futures so we can prepare for the unknown changes and challenges that are ahead for Australia's transport system and be better prepared to respond to new and emerging opportunities.

The first strategic stream of work is called Land Transport Regulation 2040. The strategic question for this work is: *How could or should we regulate land transport in the future?* We hope that this work will stimulate discussions about how we might need to change the way we regulate in response to the changes in the transport system to ensure our regulations encourage, not hinder, innovation.

This paper briefly explores some of the technologies and other key factors that could have a significant impact on land transport in the future. Section 2 discusses four key factors of change that were used in various combinations in developing the future transport scenarios:

- automation
- shared mobility
- data availability
- consumer demand for convenience and new services.

Section 2 also discusses some other factors of change and the how factors of change may combine in ways that produce significant changes.

Section 3 contains topics for discussion that have been raised in the workshops to date. These topics are:

- market structures
- compliance and enforcement approaches
- productivity of networks
- future information standards and privacy implications
- future transport demand.

This paper will be used in meetings, workshops and conversations we will have with stakeholders throughout October to early December 2016. These discussions will be used to help shape the final report and advice we provide to the Transport and Infrastructure Council in May 2017. This advice will include potential research and policy projects to inform future regulatory decisions.

2 Key factors for changes to the future transport system

Key points

This section provides information on four key factors that are likely to generate significant change to our future transport system. These key factors were identified by stakeholders as part of the NTC's future transport scenario development work. These key factors are automation, shared mobility, data availability and changing consumer demands.

There are also cumulative impacts that might arise from the combination of these factors, which are even more complex to consider.

As part of the development for the Land Transport Regulation 2040 work, four key factors were identified in the workshops as having the greatest impact on the transport system in the future, with the potential to both disrupt and transform services. These factors were automation, shared mobility, data sharing and changing consumer demands. These factors were used to develop four plausible scenarios of the future transport system. This scenario paper is available on the NTC's website at <www.ntc.gov.au>.

Technology will transform transport services, vehicles and infrastructure. Technology will also transform the way in which people use the transport system by allowing the emergence of new products and services that will support, and potentially drive, consumer demand in new directions. Data sharing systems will be critical to the emergence of new business models and transport services, but perception and trust around data security and safety is a key driver of behaviour in consumer markets.

Willingness to share transport services (such as pooling trips) or vehicles (such as taxis, public transport services and other ride-sharing services) is emerging as another potentially critical behavioural factor that may shape future transport system services and infrastructure. Vehicle sharing has the potential to reduce congestion, increase infrastructure and vehicle utilisation, and reduce the cost of mobility. The converse is also true if private vehicle ownership continues or increases without sharing as a dominant trend.

In this section, we present some of the new and emerging transport products and services that may transform the transport system in the future. The uptake of these new products and services depends on the convenience and value they provide for consumers. This new technology has the potential to deliver safer transport, improved competition, lower prices, better service and more environmentally sustainable transport.

2.1 Automation

Arguably, automation of mobility is the most significant factor likely to affect transport over the coming decades.

Automated trains are common in commuter metro systems around the world. Automated trains have been used for around 50 years. The first example was on the London Underground's Victoria line.

In Australia there are two examples of automated trains becoming operational over the next five years. The first is Sydney Metro, a fully automated metro rail system operating on a closed network. When completed, the line will run trains every four minutes during peak times. The other example is Rio Tinto's 'AutoHaul' rail system in the Pilbara, Western Australia. Rio Tinto's automated rail system is still in operational testing. This is the first example of an automated heavy-haul rail system in the world.

There are different ways to classify levels of automation for trains. From a regulatory and liability perspective, it might be easiest to describes trains as either:

- partially automated, with systems that assist the driver to brake or speed
- semi-automatic, with the driver only starting the train, or
- driverless, where the train is controlled externally and (optionally) an attendant, who is able to intervene in emergencies and who travels on board (NTC, 2016).

Motor vehicle manufacturers are progressively introducing increasing levels of automated driving controls in their vehicles. Automated road vehicles have some level of system automation that do not require a human driver for at least part of the driving task. Again, there are different ways of classifying different levels of vehicle automation. A useful classification system (VicRoads, 2016, p. 23) for examining the regulatory barriers and systems needed for deployment of automated vehicles describes vehicles as either:

- having no automation above driver assistance systems
- being capable of automated driving with a human driver present, or
- driverless vehicles.

The NTC is currently undertaking a project to examine regulatory barriers to increased use of automated vehicles in Australia. Further information on the regulatory barriers to automated road and rail vehicles, and various classification schemes, can be found at http://www.ntc.gov.au/current-projects/preparing-for-more-automated-road-and-rail-vehicles.

Automated vehicles are anticipated to use a range of technologies. These could include on-board vehicle sensors such as radar, ultrasound, laser and optical technology, in addition to satellite position receivers combined with accurate mapping, communications and C-ITS technology. C-ITS refers to a subset of intelligent transport systems in which the different elements of the transport network – vehicles, roads, infrastructure – share information with each other by broadcasting signals. Shared information on conditions, incidents and traffic enables the coordination of vehicle movements and the avoidance of collisions.

As manufacturers are also likely to offer different automated functions, the market is therefore expected to have vehicles with different automation functions for many years:

> **From a technical point of view, current technology for highly automated driving in controlled environments is quite mature. These vehicles use state-of-the-art sensors (radar, lidar, GPS and camera vision systems) combined with high accuracy maps allowing on-board systems to identify appropriate navigation paths, as well as obstacles and relevant signage. These prototypes operate with a driver that must stand ready to take control of the vehicle though reports from trials indicate that this option is rarely acted upon. As of 2015, there is yet no consensus on the commercial maturity of highly automated and ultimately fully automated driving.** (International Transport Forum, 2015, p. 12)

Manufacturers are progressing along different paths and there is uncertainty as to how automated vehicles will be developed and commercialised in the future. For example, some manufacturers are focused on conditional automated vehicles that will require a human driver to monitor the vehicle and to intervene if required. Others are focused on developing highly automated vehicles that do not require any human driver but only operate on clearly defined low-speed pedestrian zones with no interaction with other vehicles, such as a university campus or airport precinct.

Full automation removes all elements of the human driver, but fully automated vehicles have many operational challenges. This means that the commercial use of them is possibly decades away, depending on the environment they operate in. For example, a fully automated vehicle will require advanced sensors capable of operating in heavy rain or snow, and on poor-quality roads. Conversely, some companies are aiming for deployment of commercial automated vehicle operations in specific urban areas as soon as 2019.

Emerging automated technology includes so-called 'drones'. For transport, these are being developed to deliver goods. Examples of these include small land vehicles and small aircraft (also known as 'remotely piloted aircraft'). Domino's Pizza has been trialling a robotic delivery vehicle in Queensland, built by the Australian company Marathon Robots. Queensland Transport and Main Roads has issued a permit for the trial, in which the vehicle operates at about walking speed.

Amazon Prime and Google have been testing aerial drones for parcel delivery for some time, including in Australia (ABC News, 2014). In addition, these have a wider application outside transport including agriculture monitoring, enforcement and weather monitoring.

The potential benefits of automation in transport include the following:

- **Improved road safety with automated road vehicles.** Driver errors are responsible for around 90 per cent of crashes (US Department of Transportation, 2015), and increasing automated functions would avoid collisions or reduce the severity of collisions. Fully automated vehicles would be expected to comply with all the road rules.
- **Efficiency and productivity improvements.** This includes automated trains and road vehicles. For fully automated vehicles, the time the driver previously used to concentrate on driving, can now be spent doing other things. Fully automated vehicles may be configured to suit individual passenger's preferences (such as work, study, recreational activities, such as watching a movie, or sleep).
- **Cheaper passenger and goods transport for consumers.** LEK (2016) estimates that the cost of a shared automated vehicle may be similar to a public transport fare.
- **Improved accessibility**. OECD (2001) research suggests that, as older people develop age-related health problems, they are likely to experience difficulties in walking and using public transport before experiencing difficulties with driving.
- **Better convenience and service for consumers.**

2.2 Shared mobility

The concept of shared mobility is not new to transport. We share rides on public transport services such as trains, taxis, trams, buses and ferries. Shared mobility is also in use in the private sector – for example, commercial freight transport, aeroplanes and long-distance buses. But with new technology, the concept of shared mobility is expanding to private vehicles as a commercial market (rather than just family and friends giving one another a ride).

Car sharing allows people to rent a vehicle for a short period, often only a few hours. This is a business model variation on traditional car rental where the car is hired for one day or longer. The vehicle is picked up from a designated location (often an on-street parking space) and returned to the same or a different designated location. Companies that offer these services in Australia include GoGet, Flexicar, Hertz 24/7, Green Car Share and PopCar. This model is useful for people not wanting to own a car or those with only occasional need for a car. Car sharing offers the opportunity to reduce the number of cars in use, particularly in urban areas, and is primarily focused on higher density urban areas where people can walk to and from the vehicle when they need it.

In addition, there are peer-to-peer apps that allow car sharing of vehicles owned by private individuals. Companies that have created peer-to-peer services in Australia include Car Next Door and DriveMyCar.

Ride sharing is different from car sharing. Ride sharing makes use of shared rides pre-booked via a smartphone. For example, UberCab commenced operations in San Francisco in 2009. It allows users to book and pay for a ride using a phone application. The transaction is electronic, the trip is electronically mapped and monitored, and both driver and passenger can rate one another on service and other features of the trip. Other ride-sharing companies include Lyft, Via and Haxi. There are ride-sharing services now available in all Australia states and territories apart from the Northern Territory.

uberPOOL and similar services allow people to split the cost of a ride with another person heading in the same direction. Media announcements indicate that this service will be functional in certain Australian markets in the near future. Where this service exists in other countries, the cost of transport offered to users of this service is significantly lower than sole-traveller trips.

In San Francisco, 40 per cent of Uber trips are pooled. In the first three months of 2016, ride sharing with uberPOOL eliminated 34 million kilometres of car trips, which is equivalent to 3,800 tonnes of carbon dioxide (CO2) emissions (Uber Newsroom, 2016a). In Los Angeles, a city where the car is typically the first and only choice of transport for many, people took five million pool trips in the first eight months of the service (Uber Newsroom, 2016b).

This new emerging business model is called 'mobility as a service'. The mobility as a service concept aims to reorganise the personal transport sector and to create a door-to-door mobility service. In this model, consumers can pre-purchase mobility packages to suit their needs, similar to the range of mobile phone packages that are available to consumers. This service brings together transport operators, such as public transport, car sharing, ride sharing and bike share schemes, as well as information and communications technology, ticketing and payment integration. Australian companies are currently working on developing mobility as a service into a commercial product including MaaS Australia (see www.maasaustralia.com).

Innovation in freight transport services is taking a similar pathway to innovation in shared mobility for passenger transport. Currently there is inefficiency in freight transport, evidenced by the amount of empty backloads and time spent on paperwork. New technology can make existing freight transport much more efficient. Also, there are a number of companies producing 'smart logistics' apps. These apps are designed to replace fragmented and time-consuming legacy processes by better matching freight shippers and carriers (Meketon & Rennicke, 2016). Companies that are developing these products include TugForce, Convey and Cargomatic.

The potential impacts of shared mobility in transport include:

- efficiency and productivity improvements – this includes fewer overall vehicles needed because of increased vehicle utilisation (and therefore, vehicle turnover, likely leading to new, more environmentally friendly car fleets)
- cheaper passenger and goods transport for consumers
- improved convenience and service for consumers
- blurring the lines between private and public transport.

2.3 Data availability

The internet is one of the most transformative new developments of the last century and is often called the 'information revolution'. In the early years of the internet, online transactions and content was almost entirely generated by people. More recently, we have seen the internet become useful as a mechanism for computers to communicate with one another – the so-called 'internet of things'.

Connected vehicles are a relatively new technology. This technology allows a vehicle to communicate with other vehicles (V2V), roadside infrastructure (V2I) and other devices such as mobile phones (V2P). This technology can improve safety through giving drivers warning of dangerous conditions ahead or potential collisions. Austroads is currently leading work on preparing for the introduction of C-ITS equipped vehicles in Australia including addressing security and geo-positioning requirements (Transport and Infrastructure Council, 2016).

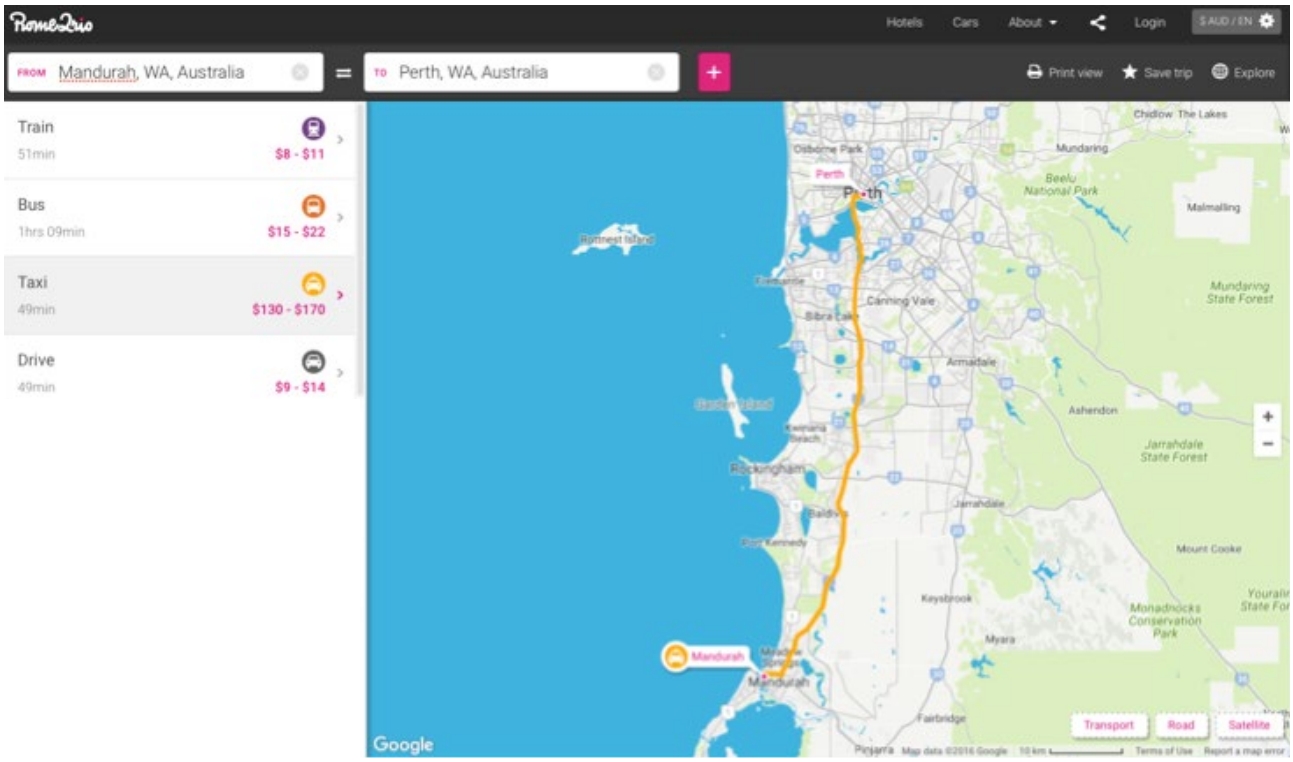
With microprocessor and sensor technology becoming smaller and cheaper, chips and sensors are increasingly being wired into everyday items. For example, new cars have 60–100 sensors on board, and the number of sensors is projected to reach as many as 200 sensors per car (Deloitte, 2015). As we begin to embed sensors into more and more devices and objects, we are creating a 'cloud' of data that enables analytics and services to be based on real-time knowledge. This is also called 'big data'. There are ways this data can be analysed to create knowledge to inform transport decisions such as traffic and incident management,

and asset condition monitoring (for example, the vehicle's sensors detect potholes or low skid-resistance areas). There will be new and innovative ways 'big data' will be used, and that could have major impacts on providers and users of the transport system. Could the data from connected and automated vehicles work together as a virtual network manager to improve overall efficiency and direct scarce resources to address the most urgent needs?

Every day, more transport information becomes available and in user-friendly formats. For example, there are electronic maps available on smartphones that provide excellent traveller information. For instance, information from Rome2Rio includes train, plane, bus, drive and ferry options and the estimated time and costs (see <www.rome2rio.com> and Figure 1). Governments can contribute to the public good by making transport information (such as timetables and the vehicle positions of trains, buses, trams and ferries) available to third parties.

While still under development, artificial intelligence systems (AIS) are likely to enable a further transformation of transport and urban network management. As an example, AIS is being investigated for improved distribution of automated vehicle fleets and intermodal connectivity, traffic control systems, predictive transport information systems for users, infrastructure monitoring and maintenance planning systems, as well as risk-based predictive traffic management designed to prevent incidents using variable speed and other systems (Agarwal et al., 2015).

Figure 1. **Traveller information available from Rome2Rio.com**



The potential impacts and implications of data availability and sharing in transport include:

- better information for consumers, which may result in better services and/or lower costs for consumers
- efficiency, safety and productivity improvements as utilisation improves
- increased economic participation, as digital marketplaces allow people to increase their utilisation of assets or unproductive time
- increasing interoperability and interdependence between data systems for transport and other services such as banking
- technology, which can potentially address information imbalances between consumers and service providers that have historically been the trigger for regulatory interventions
- perceptions and consumer trust in the underlying systems for privacy and data security, which are likely to be a key driver of willingness to share private information and participate in data sharing
- the importance of cyber-infrastructure, which is emerging as a new critical component of our community and regulatory ecosystem – the secure, private, timely, interoperable and reliable exchange of data and information.

2.4 Changing consumer demands

In past centuries, all communication, trade and business activity required the physical movement of goods and people. With the rise of telecommunications, access to services, information and social interactions are being increasingly achieved without physical transport.

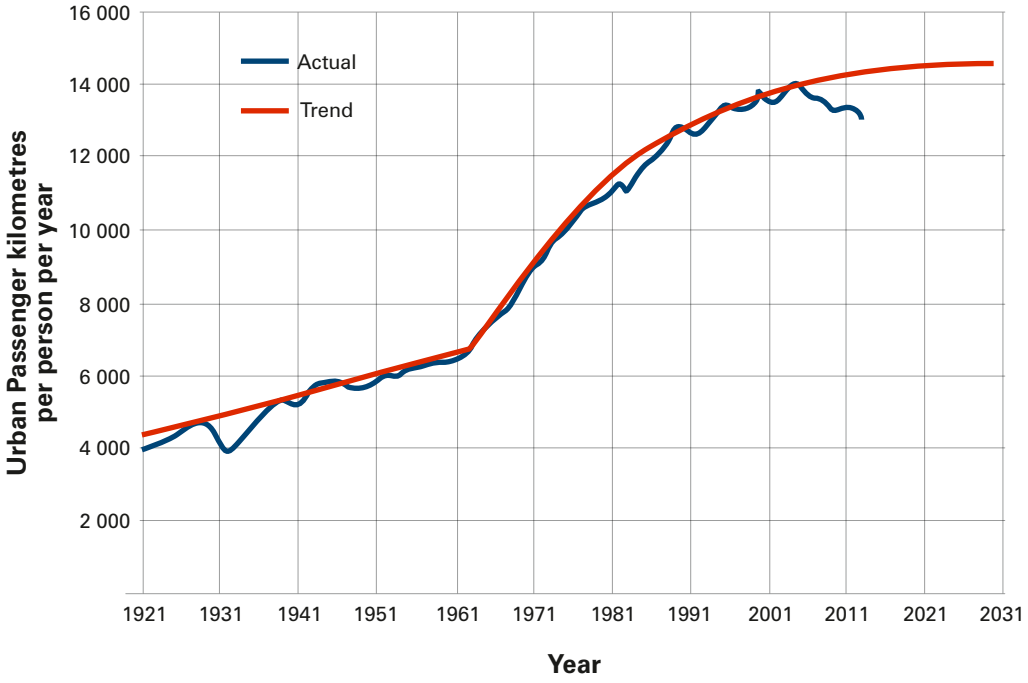
'Hyperconnectivity' is a term coined by Canadian researchers that refers to the growing trend of people to access information through a wide variety of digital communications channels. These include mobile smartphone apps, social media, email, television programming, on-demand videos, instant messaging and voice communication by telephone or through the internet. These communication methods are commonly used every day (Wellman, 2001).

Whole new business models and companies have arisen out of this hyperconnectivity opportunity – for example, the internet-enabled peer-to-peer business model.

In a recent development, some Australian councils have also turned to crowdfunding platforms to help fund community projects. Common crowdfunding projects focus on improving the fabric of local communities, rather than delivering core services, and include public parks and other spaces, community centres, free public wi-fi, shared bike networks and rooftop gardens (Logue & Hollerer, 2015; Sansom, 2016).

In a common trend across many Western nations, personal travel appears to have plateaued, after decades of rapid and consistent growth. Australia reached a point of saturation in personal travel in 2005, after which average travel per person (average kilometres travelled per capita) has declined significantly (BITRE, 2016) (see Figure 2). Some researchers claim this is a short-term trend that is attributable to economic factors (price of petrol, unemployment and the global financial crisis). Others link this personal travel plateau to saturation of people's 'time budget' for travel each day and generational changes. For example, millennials are acquiring driver's licences at lower rates and later in life than earlier generations. Research suggests that millennials are more likely to use ride sharing, car sharing, cycling and public transport as an alternative to owning a car (BITRE, 2016).

Figure 2. **Peaking of per capital passenger-kilometres, Australian all-modes, urban (BITRE 2014, p. 2)**



While personal travel has plateaued, freight transport, particularly small urban freight movements, has not. The desire for personalised, door-to-door and immediate delivery of freight is driving a continued improvement in efficiency in the logistics sector, as well as new business models. The peer-to-peer economy is supporting this, with the rise of new user applications that allow the utilisation of otherwise unused vehicle space for small loads, including in private vehicles.

While freight traffic is increasing in real terms, there is a trend that may already be supressing increased growth. As more and more people in developing countries join the middle class, and people in most developed nations achieve a level of comfort in their incomes, material consumption is beginning to level out. The OECD has identified that, even though absolute consumption of material goods is still increasing, consumption is plateauing or declining in countries with advanced economies, relative to income growth and population (Pezzini, 2016). This trend is linked with increased spending on culture and entertainment, and is part of an international (and only partially researched) trend that people are happier after purchasing an experience than a product (Van Boven & Gilovich, 2003). Research has shown a shift in consumer spending towards tourism, education and entertainment. In Australia over the six-year period from 2003–04 to 2009–10, average household expenditure on cultural services rose by 25 per cent compared with the general consumer price index rise of 19 per cent over the same period (Australian Bureau of Statistics, 2011). Film, digital media and literature have experienced the biggest jumps.

Users of Australia's transport system are likely to continue to demand a high level of service from the roads, rail, public transport and freight systems they rely upon. Increasingly though, these services might change and diversify. Where once a privately owned and driven car was the most common form of personal mobility, people might purchase transport services in the form of reliable car sharing or mobility services.

The increasingly urban location of our population is likely to entrench this trend. Globally, populations have been moving from rural to urban settings for over a century. The United Nations has identified that, recently and for the first time in human history, more than half of all people live in cities. In Australia, small regional towns have been shrinking for some time, with population following employment and education opportunities and moving towards larger regional centres and major cities.

The potential impacts of changing consumer demands in transport include the following:

- Preferences and demand for transport modes are changing over time, including the possibility of using more virtual means of communication to replace travel.
- Mobility as a service has arisen and a new market niche, and continues to evolve. With car sharing, small personal transport services on demand and plans to eventually provide on-demand automated vehicles, we are seeing the emergence of an entirely new form of mobility enabled by real-time data and information available to all via mobile smartphone apps.
- 'Peak consumption' appears to be a common trend across the Western world, as people seeking experiences rather than tangible goods at an increasing rate.
- Personal travel has peaked across the globe, starting in Australia in approximately 2004. There is significant debate about whether this trend will return to historical levels, or if people's 'travel budget' of time and money has become a limiting factor in transport.

2.5 Other factors of change

In developing future transport scenarios, and in examining the potential likely shifts in future trends, the NTC has examined a wide range of factors. The three factors listed below were considered to be some of the additional factors that would continue to shape the transport system over coming decades:

- Australia's (and the global) sustainability response
- energy availability and cost
- demographic shifts.

Australia's sustainability response

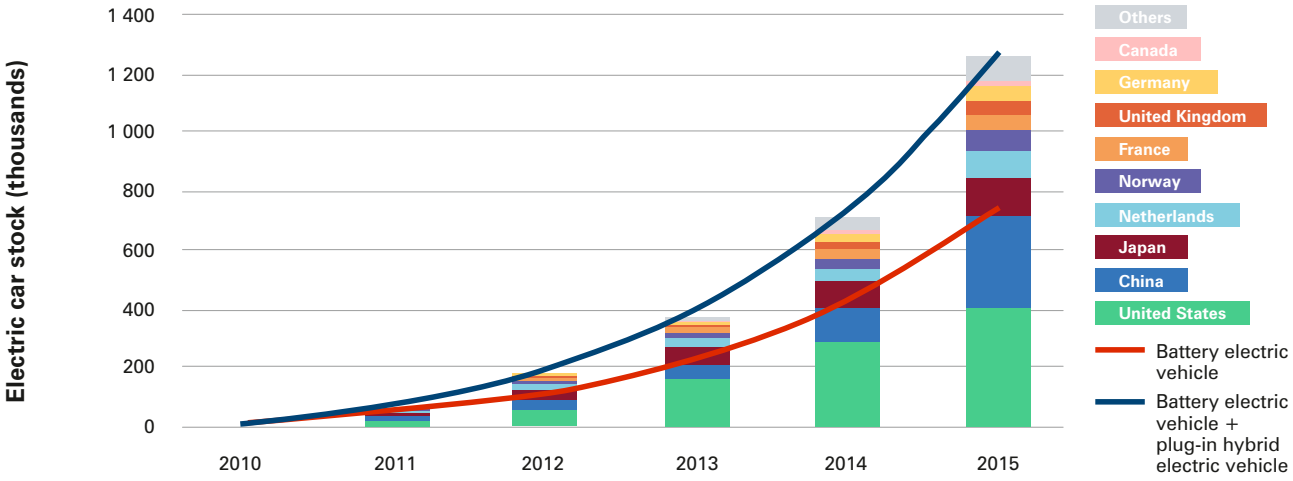
Fossil fuels are the principal form of transport fuel in Australia. In 2014 the transport sector contributed around 17 per cent of Australia's CO_2 emissions (Department of the Environment, 2016).

Climate change puts current transport infrastructure at risk. Between 27,000 and 35,000 kilometres of roads and rail lines are at risk from inundation and shifted shorelines. These assets would cost between $51 billion to $67 billion to replace (DCCEE, 2011).

The international community (through the 2015 draft UN Framework Convention on Climate Change (UNFCCC), and the UN Sustainable Development Goals) has identified that global climate change 'represents an urgent and potentially irreversible threat to human societies and the planet and thus requires the widest possible cooperation by all countries, and their participation in an effective and appropriate international response, with a view to accelerating the reduction of global greenhouse gas emissions' (United Nations, 2015a, preamble).

Australia has ratified the UNFCCC, and is a signatory to the UN Sustainable Development Goals and reporting framework, which commits to making progress on a range of specific targets and metrics, including improving the environmental sustainability of our energy and transport sectors, and improving social and economic inclusion.

Figure 3. **Evolution of the global electric car stock, 2010–2015**



NOTE: the electric vehicle stock shown here is primarily estimated on the basis of cumulative sales since 2005.

Energy availability and cost

The availability and cost of energy will continue to be a significant factor for Australia's transport system in the future. Connections between Australia's regional and remote areas, and the economic viability of many businesses, depends on low-cost transport of people, goods and information. A significant increase in the cost of fuel, or even short-term volatility in prices, is likely to have a large impact on the transport and logistics sector and eventually increase prices for consumers.

More importantly, the longer term availability of fuels, and the likely transition of vehicles to less carbon-intensive fuels such as electricity and hydrogen, will have a significant impact on existing infrastructure and businesses.

The OECD identifies that the global uptake of electric vehicles is following a standard technology adoption curve, as seen in Figure 3. As such the penetration of electric vehicles into the automotive market can be expected to continue to increase at a rapid pace, particularly as charging infrastructure is rolled out in major urban markets.

The rise of electric vehicles will result in several key impacts, including but not limited to:

1. improving environmental outcomes through reduced CO2 and other emissions leading to a reduction in deaths attributed to illness for air pollutants
2. a reduction in current revenue under existing models such as fuel excise.

Demographic shifts

Population growth (and decline) across Australia will be a key driver of transport demand into the future. Within the overall growth trends estimated by the Australian Treasury in the 2015 *Intergenerational Report* (Commonwealth of Australia, 2015), there are specific sub-trends that may affect transport differentially. Growth in dense urban centres, for example, is likely to have a disproportionate impact on economic productivity, while regional and remote populations may continue to suffer decline or stagnant populations.

The Australian Bureau of Statistics has projected the ageing of the Australian population, with most population growth coming from migration. The proportion of the Australian population aged 65 years or older in 2011 was 14 per cent, but this is projected to rise to between 23 and 25 per cent by 2056. This will mean that the proportion of Australians in the workforce will drop from five workers supporting every Australian aged 65 or older, to only 2.7 working Australians for every person aged 65 or older in 2050. In 1970 there were 7.5 workers for every person aged 65 or older.

One of the reasons the Australian, and world, population is ageing is because advances in medical sciences and healthcare mean that people will live longer. Life expectancy has risen from about 51 years for males and 55 years for females in 1900 to about 77 years for males and 82 years for females in 2000 (Commonwealth of Australia 2015).

By 2050, life expectancy is projected to rise to 87.7 years for men and 90.5 years for women (Commonwealth of Australia 2015).

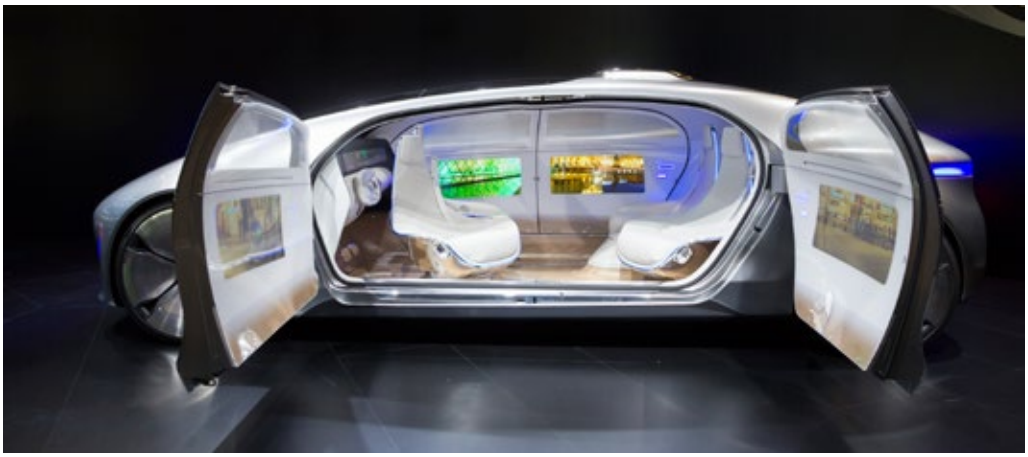
Urbanisation, particularly the growth of megacities, is one of the key emergent global trends of the 21st century (see Box 1). Australia is unlikely to have any megacities in the foreseeable future. However, Australia is well placed to supply these nearby megacities in Asia with resources and goods for their growing middle-classes.

Box 1. The rise of the megacity

The number of megacities in the world is growing (megacities are those with more than 10 million inhabitants). In the past 50 years the number of megacities increased from two to 28 megacities, with a population of 453 million accounting for 12 per cent of the world's urban dwellers (United Nations, 2015b). The majority of these megacities are in developing countries. In the next 15 years, the number of megacities is expected to double again, with approximately 41 megacities by 2030.

Megacities concentrate skills, economic opportunity and productivity. This makes them global drivers or 'hotspots' of economic growth. Some commentators believe these megacities may be more important than national economies in driving global economic growth.

Conversely, urbanisation (combined with increased consumer demand for middle-class goods and services, water and energy scarcity, and increased pollution) may generate increased global demand for 'smart city' technologies. As urbanisation increases so do the demands for sustainable developments and challenges for integrated technologies to improve the lives of urban and rural populations.



2.6 Cumulative impacts

This section discusses how some of the factors of change may combine in ways that produce significant changes. We present two of the cumulative impacts that were discussed in the workshops for developing the scenarios. These are:

- automation and shared mobility
- travel demand and energy cost.

Automation and shared mobility

While there are many technological pathways to reach the operation of a fully automated vehicle fleet in Australia, one obvious business model is that such vehicles might not be privately owned by individuals, but instead operated on a 'car sharing' model by a third party. This arrangement would mean that many households would not need a second car (and may not even own one), and vehicles would have much higher utilisation – carrying people throughout the day and 'parking up' to recharge as needed.

The rise of automated 'mobility-as-a-service' provided by the private sector has the potential for a major shift in transport behaviour. One side effect could be to significantly reduce the amount of car parking required in most destinations (such as CBDs), allowing the transformation of urban areas as roadside parking is partially reallocated and car parking structures are converted into more productive uses.

But will people want to use these self-driving vehicles? If the vehicle operator responds to consumer demands for services and provides low-cost, point-to-point services, this may be very likely. These demands might include people being able to have their favourite movies or music playing in the vehicle based on their user profile or picking up grandkids or friends (and a coffee) on the way home to reconnect face-to-face for a few extra minutes. The security and privacy arrangements for such an operation would have to have a high level of user trust to be accepted.

Different deployment models for automated vehicles could lead to widely different outcomes depending on whether the majority of new automated vehicles are privately owned or used in shared mobility-as-a-service operations.

As an example, Swinburne University has recently modelled the impact of moving to a shared automated, electric vehicle fleet in Melbourne. The results of this modelling, broadly confirming similar work in Lisbon (Corporate Partnership Board, 2015), found that the number of vehicles needed to provide the same level of service and meet today's mobility patterns under this model would drop by up to 90 per cent (Dia, 2015).

Conversely, the Queensland Department of Transport and Main Roads found that under a private vehicle ownership model, congestion could increase significantly in the short term, as vehicles move about the network with no passengers, returning to home or picking up other members of the household.

LEK (2016) estimates that the cost of a shared automated vehicle may be similar to a public transport fare. This could have a major impact on public transport services provided by governments

Travel demand and energy

Travel demand (both freight and passenger) is the largest factor driving the need to provide new road and rail infrastructure capacity and freight and passenger services. Historically, we have assumed the continuation of the long-term trend in travel demand, but if the flattening (or even reduction) of per-capita travel demand settles into a long-term pattern, this could significantly slow the need to increase infrastructure capacity for passenger cars.

The growth in total travel demand under this scenario would be in line with population growth. This is a particular issue for regional and urban areas with flat or negative population growth.

This passenger/driver trend could easily be exacerbated and translate across to the freight sector if energy costs were to increase substantially. With an ageing population, the overall patterns of travel will likely also change, increasing demand for certain types and times of travel (such as recreational travel and travel for social purposes rather than the traditional work commute).

Modelling undertaken in New Zealand (Ministry of Transport NZ, 2016) identified that some scenarios resulted in almost half as much total passenger travel demand in certain areas. The possibility that future transport demand in Australia may flatten or even shrink in many locations potentially calls into question the value of some infrastructure investments.

Some other potential impacts for transport

The two potential cumulative impacts described above are just examples of the various ways that the factors of change described in this chapter might interact to change travel and transport demand patterns in Australia. There will certainly be others that we have not described, but which could be equally important. These might include:

- more specific transport usage data and technology offering the opportunity for improved user charging that more accurately reflects the costs of travel and impacts on others such as congestion delays
- a major impact on government revenues from parking, registration, licensing and, most particularly, fuel excise from automation, electrification and changing travel patterns
- opportunities for improved traffic management, reduced CO2 emissions and other environmental impacts, as well as more targeted maintenance of the system
- improved health and wellbeing outcomes (leading to public saving in the health system) due to a combination of safety improvements driven by increased automation and a reduction in CO2 emissions.

These could potentially result in very significant changes to the way transport is used, paid for, procured by private citizens, and funded by governments in the future.

So what does all this potentially mean for transport in Australia? Given the breadth of change and the potential emerging issues we have covered, it will be impossible to predict the future with any certainty, and we shouldn't try. This work seeks to help governments and the private sector to better plan for the future. The plausible scenarios are useful to test our current decisions as well as the regulatory responses that may be required in the longer term. Getting a better understanding of these potential changes is essential to creating resilience and adaptability within the transport system.

3 Discussion topics for future transport

Based on our engagement with stakeholders so far, and the key factors of change described in the previous section, we have identified a series of key issues that are likely to arise during the workshops and other forums for discussion.

Potential impacts of the transport system were discussed in section 2. While our current work focuses on future land transport regulation, the discussion with stakeholders during the development of the scenarios and with the NTC's Industry Advisory Group have also identified other topics for discussion around future transport. Some of these topics for discussion include:

- market structures
- compliance and enforcement approaches
- productivity of networks
- future information standards and privacy implications
- future transport demand.

We expect these areas to be discussed during the workshops and meetings held during October to early December 2016. As such, we discuss each of these areas briefly below as an input to these workshops and meetings. This is not an exhaustive list of discussion topics, and we expect other topics to be raised in the workshops and meetings.

3.1 Market structures

Transport in Australia is largely provided by the private sector. The majority of personal mobility is undertaken by walking, cycling and private vehicle. Mass transit and community transport is provided by either government service providers or private sector bus, tram and train operators under contract.

The emergence of shared mobility models of service provision (including car sharing, ride sharing and small commercial passenger and similar freight services) have the potential to significantly affect the structure and size of existing markets, and to create new markets.

Rather than large numbers of individual drivers or operators, markets may emerge that begin to have the characteristics ideal for more performance-based regulation. There may be a smaller number of decision-makers operating under commercial operating systems designed to manage safety and liability.

This may also be true of the domestic freight sector if consolidation in the freight sector continues, and if the chain of responsibility laws continue to lead to the development of more safety-oriented operational systems by private sector members of the supply chain.

Competition frameworks and laws are also likely to become more important to the efficient functioning of markets, as well as data protection and interoperability arrangements.

3.2 Compliance and enforcement approaches

With the emergence of data-driven services, on-demand, automated services and automated vehicles with liability partially or fully held by the service provider (rather than the driver), there may become an emerging need for increased back-office focus on system integrity audits and data management system licensing, rather than on-road enforcement.

Indeed, with automated vehicles on our roads that are each equipped with a full array of sensors and detectors, there may be little need for on-road enforcement at all. Each and every automated vehicle could stream footage and other data of illegal or unsafe behaviour direct to enforcement personnel.

What might the key offences be under such a future? Perhaps the law would focus on ensuring the framework for data sharing and secure, interoperable transmission of private data is robust, rather than on road offences.

http://www.sydneymetro.info/northwest/project-overview

3.3 Productivity of networks

Network management by governments is done through traffic control centres and traffic management systems. These focus on responding to accidents that can lead to major delays as well as overall traffic coordination and optimisation by traffic lights. Broader network management also includes providing public transport and other options for travellers.

New technology has the opportunity to transform the way our transport networks function. Already private sector trip planning and map applications re-route traffic intelligently around delays to maximise the efficiency of individual travellers. The private sector uses a range of data sources including information provided by governments about current travel times, accidents and roadworks. There are likely to be future applications that offer the same advice, but with much richer information from individual vehicles and other sensors.

In the future, a virtual network management system may be developed to optimise the efficiency of the entire network in real time using predictive AIS to prevent congestion. There are further questions about such a system, including what the role of government might be.

- If this virtual network management system is provided by the private sector, would infrastructure pricing be the main government tool to help ensure network efficiency?
- What outcomes would government specify to private providers of these types of services?
- How would public transport services fit within this network?
- Might there be market failures with the management of such a system by the private sector? Will governments need to intervene? If so, what new capabilities might road managers need to develop to interface with and support new transport services and technologies?

3.4 Future information standards and privacy implications

Online transactions and content was almost entirely generated by people in the early years of the internet, with humans connecting to one another either directly or through platforms like social media and publishing sites. More recently the internet became useful as a 'mechanism for mechanisms' and computers to communicate with one another – the so-called 'internet of things'.

With microprocessor and sensor technology becoming smaller and cheaper, chips and sensors are increasingly being wired into everyday items so that a fridge can tell its owner when certain commonly used products are running low, and a watch can detect its wearer's heart rate and blood pressure. As we begin to embed sensors into more and more devices and objects, we will create a 'cloud' of data that enables analytics and services to be based on real-time knowledge.

One example is transport systems that monitor travel patterns. These systems could provide real-time schedule updates based on personal travel patterns, maintenance information and warnings from infrastructure and vehicles. This would also support improved service delivery and planning.

Sensor technologies and the connectivity between content-generating devices will allow infrastructure managers to monitor road and rail networks in real time and better predict usage patterns, maintenance needs and damage to the network. Transport service providers are (and will increasingly be) able to provide personalised service updates to users, and people will be able to purchase the transport services they need for each trip based on their service preferences (rather than just where the origin and destination might be and whether or not they have a driver's licence).

But who will be making the key decisions? In the past, governments built roads and rail lines, purchased mass public transport services, regulated other services for quality and safety, and oversaw the management of traffic, funding these services from the public purse.

In the future it is likely that technology will allow the market to increasingly meet some of the needs and public services that government has traditionally provided. It may, however, be that existing regulatory frameworks could either support or hamper innovation and market supply of services the community demands and the emergence of our new economy.

Information sharing and security protocols and systems may need to become important standards to provide the critical trust and public confidence in the cyber-infrastructure that underpins secure, safe and interoperable data sharing networks.

Secure, interoperable, trusted telecommunications is a fundamental requirement for some of our future transport transformations, yet transport regulation is likely to only be a part of the solution to creating the necessary cyber-infrastructure. A cross-sectoral approach from government and the private sector will likely need to collaboratively develop an appropriate response to bring about the necessary operating environment for data and information in the future.

It is also likely that technology may open the way for a fairer, more transparent, and more sustainable, transport charging and funding model. But only if certain conditions of stable, trusted, interoperable and secure data communications within transport, and between transport and other service providers, can be established and maintained.

One mechanism for this, might be the use of blockchain technology (see Box 2).

Box 2. Blockchain

Blockchain is an innovative technology and is entirely digital. The 'blockchain code' is a form of digital verification that relies on distributed elements so that no one computer contains all of the information needed to decode or verify any message. This form of encryption has been used particularly to enable digital currencies such as bitcoin. The information on bitcoin accounts is stored digitally in the network of computers that contain elements of the blockchain protocol.

Australian banks are investigating the use of blockchain to reduce transaction costs. This technology potentially allows new entrants into the banking sector using only digital currencies and having only an online presence. As the chief executive of the Australian Stock Exchange has said, 'Every now and then, something comes along that might just change everything. And this is one of those moments' (Eyres, 2016). This technology also has potentially major implications for revenue and taxation.

According to some experts, it is only a matter of time before blockchain technology is used in peer-to-peer and machine-to-machine transactions where high levels of trust and verifiability is required. It could also be used in transport system safety technologies.

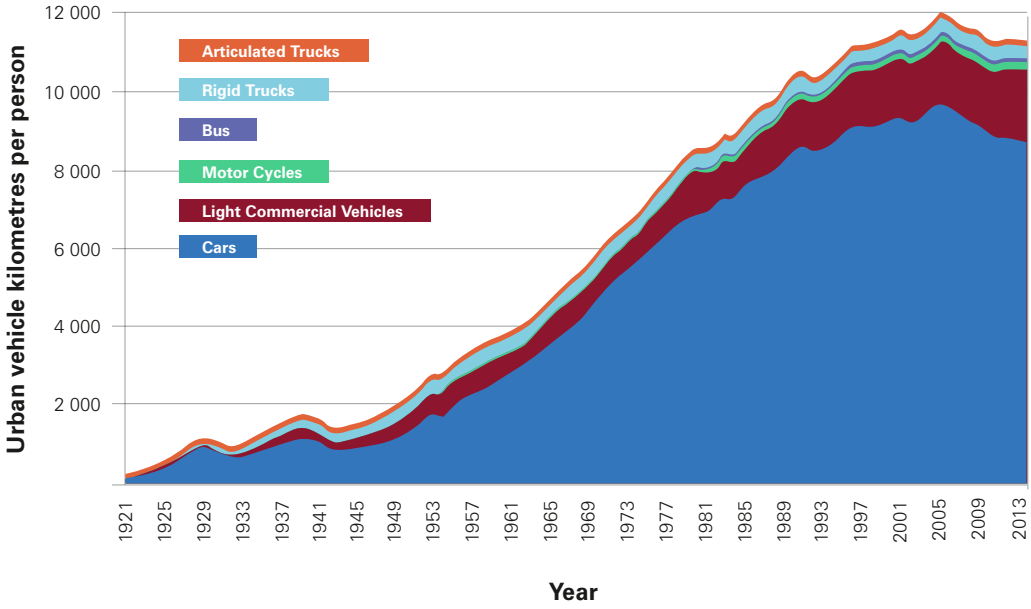
3.5 Future transport demand

Future travel demand has implications for governments as transport infrastructure owners and managers of roads, rail and ports.

Changing trends in mobility and travel demand (see Figure 4) have the potential to transform transport in Australia, potentially more than any other driver (except for technology). Recent modelling by the Ministry of Transport New Zealand (2016) identified that total travel demand may decrease in the future. This has implications for infrastructure investment decisions we are making now. The question of what to invest in, how to recover the costs of investments, and how to regulate a transport system when transport demand is declining or changing, needs further investigation. This further work could examine plausible travel demand scenarios and change patterns may be necessary to better inform policy, planning and investment decisions for Australia's transport system.

A significant challenge will be to ensure fairness in transport accessibility for the mobility disadvantaged in the future. This will be particularly critical with a high probability of an ageing and increasingly urban population, and the possibility of wide variances in consumer demand and travel patterns.

Figure 4. **Australian urban vehicle kilometres per person (BITRE 2014, p. 5)**



4 Next steps

Key points

This paper will be used in meetings, workshops and conversations we will have with stakeholders throughout October to early December 2016. These discussions will be used to help shape the final report and advice we provide to the Transport and Infrastructure Council in May 2017.

The key strategic question in this work is: *How could or should we regulate land transport in the future?* The aim of the work is not to provide definitive long-term solutions. Instead, the aim is to discuss and explore plausible futures so we can prepare for the unknown combinations of changes and challenges that are ahead for Australia's transport system and be better prepared with opportunities to respond.

This paper will be used in meetings, workshops and conversations we will have with stakeholders throughout October to early December 2016. These discussions will be used to help shape the final report and the advice we provide to the Transport and Infrastructure Council in May 2017. This advice will include potential research and policy projects to inform future regulatory decisions.

If you have any comments on this paper, we would like to hear from you.
Please email us at **enquiries@ntc.gov.au**
or call **03 9236 5000**.

References

ABC News 2014, *Google tests prototype drone in Queensland; Warwick farmer has dog food, chocolate delivered*, 1 September, viewed 30 August 2016, <http://www.abc.net.au/news/2014-08-29/google-project-wing-drone-delivery-test-warwick-queensland/5707034>.

Agarwal PK, Gurjar J, Agarwal A, Birla K 2015, 'Application of artificial intelligence for development of intelligent transport system in smart cities', *International Journal of Transportation Engineering and Traffic System*, vol. 1, no. 1, pp. 20–30.

Australian Bureau of Statistics 2014, *Arts and culture in Australia: a statistical overview*, viewed 23 August 2016, <http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/4172.0main+features212014>.

Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2014, *Information Sheet 61: Saturating Daily Travel*, BITRE, Canberra.

Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2016, *Road deaths Australia, July 2016*, viewed 16 August 2016, <http://bitre.gov.au/publications/ongoing/rda/files/RDA_July_2016.pdf>.

Commonwealth of Australia 2015, *Intergenerational report: Australia in 2055*, viewed 26 August 2016, <http://www.treasury.gov.au/PublicationsAndMedia/Publications/2015/2015-Intergenerational-Report>.

Corporate Partnership Board 2015, *Urban mobility system upgrade, How shared self-driving cars could change city traffic*, viewed 30 August 2016, <http://www.itf-oecd.org/urban-mobility-system-upgrade-1>.

Deloitte 2015, *Transport in the digital age, disruptive trends for smart mobility,* viewed 23 August 2016, <http://www2.deloitte.com/content/dam/Deloitte/tr/Documents/public-sector/transport-digital-age.pdf>.

Department of Climate Change and Energy Efficiency (DCCEE) 2011, *Climate change risks to coastal buildings and infrastructure: a supplement to the First Pass National Assessment, Department of Climate Change and Energy Efficiency*, Australian Government, Canberra.

Department of the Environment 2016, *National inventory report 2014 and Revised Kyoto Protocol national inventory report 2013*, Volume 1, Australian Government, viewed 30 August 2016, <https://www.environment.gov.au/system/files/resources/0f7d404c-edd4-4b97-b9f8-50789ce0280b/files/national-inventory-report-2014-vol1.pdf>.

Dia H 2015, *Driverless cars will change the way we think of car ownership, Seinburne University of Technology*, viewed 26 August 2016, <http://www.swinburne.edu.au/news/latest-news/2015/11/driverless-cars-will-change-the-way-we-think-of-car-ownership.php>.

Eyres J 2016, 'Blockchain and how it will change everything', *The Sydney Morning Herald*, 6 February, viewed 24 August 2016, <http://www.smh.com.au/business/banking-and-finance/blockchain-and-how-it-will-change-everything-20160204-gmmd6e.html>.

Hajkowicz S, Cook H, Littleboy A 2012, *Our future world: global megatrends that will change the way we live*, CSIRO, Brisbane.

International Energy Agency 2016, *Global EV outlook*, viewed 26 August 2016, <https://www.iea.org/publications/freepublications/publication/global-ev-outlook-2016.html>.

International Transport Forum 2015, *Automated and autonomous driving: regulation under uncertainty*, Paris.

LEK 2016, *Driverless cars: why it's time to consider their disruptive power*, viewed 30 August 2016, <http://www.lek.com/sites/default/files/Driverless-Cars_Why-Its-Time-To-Consider-Their-Disruptive-Power_ExecutiveInsights_1737.pdf>.

Logue D, Hollerer M 2015, 'Civic crowdfunding will challenge governments and charities', *The Conversation*, September 11, viewed 26 August 2016, <https://theconversation.com/civic-crowdfunding-will-challenge-governments-and-charities-46977>.

Meketon M, Rennicke B 2016, 'Make way for uber-trucking with smart trucking apps', *Forbes*, viewed 23 August 2016, <http://www.forbes.com/sites/oliverwyman/2016/07/13/make-way-for-uber-trucking-with-smart-trucking-apps/#9a01b82e4222>.

Ministry of Transport New Zealand 2016, *Future demand*, viewed 23 August 2016, <http://www.transport.govt.nz/ourwork/keystrategiesandplans/strategic-policy-programme/future-demand>.

NTC 2016, *Regulatory barriers to more automated road and rail vehicles*, Issues paper, February.

OECD 2001, *Ageing and transport: mobility needs and safety issues*, OECD Publishing, Paris.
Pezzini M 2016, 'An emerging middle class', OECD Observer, viewed 30 August 2016, <http://www.oecdobserver.org/news/fullstory.php/aid/3681/An_emerging_middle_class.html>.

Sansom M 2016, 'Crowdfunding for councils?', *Government News*, January 27, viewed 26 August 2016, <http://www.governmentnews.com.au/2016/01/crowdfunding-for-councils/>.

Transport and Infrastructure Council 2016, *National policy framework for land transport technology, action plan: 2016–2019*, Canberra.

Uber Newsroom 2016a, *Ride smarter with uberPOOL*, April 22, viewed 30 August 2016, <https://newsroom.uber.com/us-washington/ride-smarter-with-uberpool/>.

Uber Newsroom 2016b, *Uber launches POOL in San Diego*, April 19, viewed 30 August 2016, <https://newsroom.uber.com/us-washington/ride-smarter-with-uberpool/>.

United Nations 2015a, *Framework convention on climate change*, Conference of the Parties, Twenty-first session, Paris, 30 November to 11 December 2015. Preamble.

United Nations 2015b, Department of Economic and Social Affairs, Population division *World Urbanization Prospects: The 2014 Revision*, (ST/ESA/SER.A/366).

US Department of Transportation 2015, 'Critical reasons for crashes investigated in the National Motor Vehicle Crash Causation Survey', *Traffic Safety Facts*, viewed 24 August 2016, <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812115>.

Van Boven L, Gilovich T 2003, 'To do or to have? That is the question', *Journal of Personality and Social Psychology,* vol. 85, no. 6, pp. 1193–1202.

VicRoads 2016, Submision: *Regulatory options for automated vehicles*, viewed 30 August 2016, <http://www.ntc.gov.au/media/1420/ntc-discussion-paper-regulatory-options-for-automated-vehicles-may-2016-steven-huxtable-vicroads-jul-2016.pdf>.

Wellman B 2001, Physical place and cyber place: the rise of networked individualism, *International Journal of Urban and Regional Research*, vol. 25, no. 2, pp. 227–252.