# Hypothetical
# Thought Leadership Paper

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## Overview

It was Bill Gates who reportedly said: "We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten. Don't let yourself be lulled into inaction." Those words certainly ring true within a driverless vehicle context.

Governments and societies around the world acknowledge that automated and driverless vehicle technologies are here, and within a decade, driverless vehicles will be at the centre of Australia and New Zealand's intelligent mobility services (Roads Australia, 2017).

Many of our vehicles already have automated systems in place, such as autonomous emergency braking, lane keep assist, and electronic stability control. However most of these technologies require the human driver to still be in control.

Over the next 10 years it is critical that governments consider and address a range of challenges, including the repositioning of local markets and regulation, reshaping government institutions, reassessing planning assumptions, interpreting benefits for society, assuring safety and capturing a financial return for the community (Roads Australia, 2017).

It is important for consumers to prepare themselves for waves of change, especially given that public acceptance will be key in achieving the greatest societal benefits from AVs (Roads Australia, 2017).

But, what does a road network in 2027 look like? Have Automated, Driverless and Connected Vehicles been successfully implemented as an integrated mobility solution for Australia and New Zealand? Currently much of the research into driverless vehicles focuses on the technology, rather than how it should be implemented. Planners are still making transport decisions based on outdated assumptions of what future transport systems will look like (Catbagan & Duffy, 2017). Integrated mobility solutions, referred to Mobility as a Service (MaaS), offers multiple modes as an alternative to vehicle ownership (Haratsis, 2017). MaaS combines all the available transport modes via a single mobile app, providing a viable alternative to vehicle ownership and providing savings on car expenses (Catbagan & Duffy, 2017). But is it possible for driverless vehicles to provide an alternative to vehicle ownership through the implementation of MaaS?

The introduction of Automated Vehicles (AVs) provides a 'chicken and egg' type of situation. In order for the most benefit to be seen from this technology the infrastructure, operations, regulations, business model, and traffic management plans for this technology need to be in place. However, in order to decide what infrastructure and operational plans are most appropriate and effective, the technology needs to be tried and tested. This makes the most critical question: how will this technology work once it has been implemented?

## *Objectives*

This paper provides a series of hypothetical scenarios about the introduction and adoption of all levels of AVs, as well as background about changes to the mobility services in Australia, explanation of what was needed to make those changes, and how they contributed to a successful future. It follows with a description of what the world could look like with successful integration of AVs, as well as the impact if AVs are not properly planned and coordinated, through assessing the role of the vehicle, ridesharing, the user, the community, the government, and the economy.

This paper provides an overview of the social equity concerns and considerations regarding equal access to transportation technologies for everyone in the community. It is critical to address public concerns, acknowledge risks, and identify needs to be included in government policy.
Finally, an overview of the opportunities is provided where modelling can be used to fill data and knowledge gaps to better consider hypothetical scenarios.

It is important to spark industry and community debate, and advocate to governments about the need to proceed in a way which encourages acceptance. This paper contains views from various sources and provides a balanced discussion of the topic, without imposing one position over another.

## *Risks and Barriers*

The acknowledged risks include increased congestion, social divide and social equity, the impact on the economy, the production or loss of jobs, and community acceptance.

The many barriers to the implementation of AVs are acknowledged, which it is of the upmost importance to define these hypotheticals to be best-prepared for a range of scenarios.
Many barriers have already been overcome, but some still remain. While technological hurdles are relatively easy to tackle, the social barriers that impact on community acceptance can be more complicated to address.

ADVI recognises community concern about liability issues, insurance, hacking and the challenge of recognising technology as a ‘driver’ within legislative frameworks. Critics highlight a range of ethical concerns to be considered by governments, business, consumers and the wider transportation industry.

Critical issues to be considered include:

- How will it operate?
- How to achieve social equity in the introduction of AVs?
- What laws will govern their use? What will the regulations be?
- What will the travel management plans look like?
- What will the business model and operational model look like?
- Who will be liable after a crash? What will be the role of insurers? In particular, compulsory third-party insurers?
- How do you achieve consumer acceptance?

- How will AV transition into regional travel?
- What does the AV industry look like? What will be the jobs in transportation?
- What will be the funding base? Will it be road user pricing?
- What are the network infrastructure requirements?

## *History*

Transport and mobility services are an ever-changing industry. It only took 15 years (from 1900 to 1915) for Australia to farewell horse drawn carriages and welcome the motor vehicle (Haratsis, 2017).
Rapid adoption of new transportation technology occurs when they are embraced by the community and offer clear benefits. The introduction of the first motor vehicles in Australia were largely utilised by doctors, and the public soon gave their tick of approval on the back of the far quicker response time to treat patients (Lee, 2003). Drawing on this experience, it is reasonable to assume Australians are more likely to accept AVs if they see potential improvements to their livelihoods and social activities.

In 2008, Moriarty and Honnery undertook a case study of the City of Melbourne, which had a then population of 3.8 million. About 90% of passenger travel was undertaken by car, a pattern which had persisted for several decades. Contrast this with 1947, when 80% of urban passenger travel was undertaken by public transport, mainly electric trains and trams. Even more alarmingly, the transition to 80% dominance of the car only took 15 years. Overall surface vehicular travel for each of Melbourne's 1.2 million residents in 1947 was 3600 passenger-km, less than a quarter of the 2008 level (Moriarty & Honnery, 2008).

This growing dependency on motor vehicles has come at a cost. Roads have become increasingly congested, and while cars have become faster, traffic moves slower despite increased road capacity as a short-term solution. We also see transport as a significant contributor to pollution, particularly from congestion. Road transport continues to cause unacceptable death and serious injury, with an estimated 90%+ caused by human error. While significant improvements in road safety occurred from the mid-1970's, these improvements have now markedly slowed, leaving many asking what will be the next road safety silver bullet to saves lives and prevent personal injuries.

## Integration of Automated Vehicles

So, what does 2027 look like where AVs are successfully part of an integrated mobility solution? There are a vast number of projections which have been identified within literature, and each of these projections varies greatly. This is likely attributable to the risk and barriers which are identified in the generation of these projections, and the methods which are identified to overcome them. One explanation has been provided by Haratsis (2017), which says that the timing of AV introduction is largely dependent on regulation of the technology and consumer acceptance.

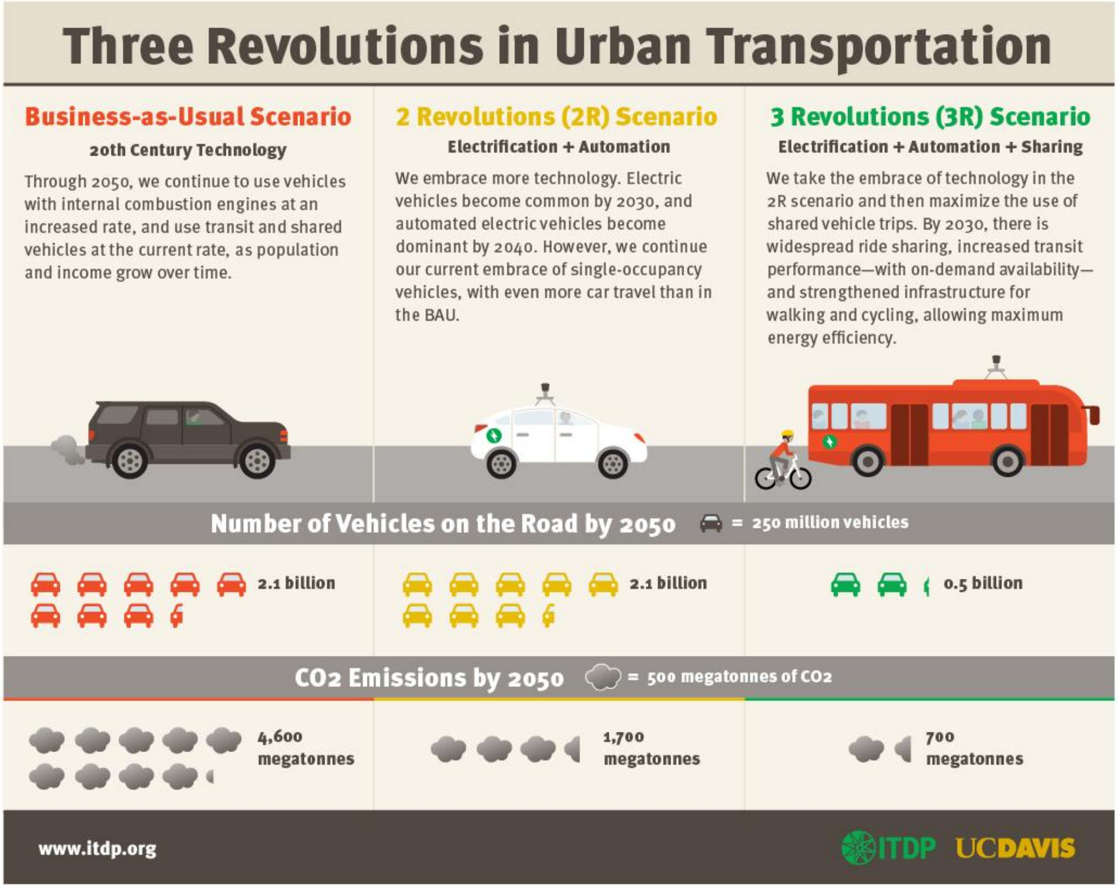
The Institute for Transportation and Development Policy (2017) proposes three possible future scenarios for the implementation and adoption of AVs, as shown in Figure 1. The first is a business-as-usual scenario where through to 2050 there remains continued use of vehicles with internal combustion engines at an increased rate, and use of transit and shared vehicles at the current rate, as population and incomes grow over time.

The 2 Revolutions (2R) scenario is where technology is embraced. Electric vehicles become commonplace by 2030, and automated electric vehicles are dominant by 2040. There is continued use of single-occupancy vehicles, with even more car travel than in the business-as-usual scenario – meaning congestion will only get worse.

The 3 Revolutions (3R) scenario suggests that technology is embraced and shared transit is maximised. By 2050, cities have ubiquitous private car sharing, increased transit performance—with on-demand availability—and strengthened infrastructure for walking and cycling, allowing maximum shared trip efficiency (Institute for Transportation and Development Policy, 2017). However, there will be barriers to overcome in terms of personal safety and security within private car sharing models. This is due to the unpredictability of who you might be sharing the car with.

Additionally, as can be seen from Figure 1, this revolution has vastly lower $CO_2$ emissions than the other revolutions. This is not only due to a decrease in the use of the private car, but it is also due to decarbonised electricity production. Therefore, another barrier to be overcome will be electricity sources in Australia and New Zealand.

Figure 1 The Three Revolutions in Urban Transportation Infographic (Institute for Transportation and Development Policy, 2017)




There is a more simplistic view of the future to also consider regarding vehicle ownership, proposed by Homburg (2015) – where people continue to own cars or don't.

These revolutions will be fundamentally underpinned by how the transportation system will operate. In order to achieve the most benefit from the introduction of new technologies, as well as an ideal mode share there needs to be supporting infrastructure, not just physically, but digitally.

***The Role of the Automated Vehicle Technology***

Key findings from a Roads Australia study (2017) showed that all new vehicles will have the capability to operate at level 5 automation within a decade. The study also proposed a mixed driverless and manual/auto fleet for up to 20 years, with shared driverless and manual road sections/lanes within the next 5 years. The report identifies truck platooning as the most likely first step towards widespread integration of driverless technologies.

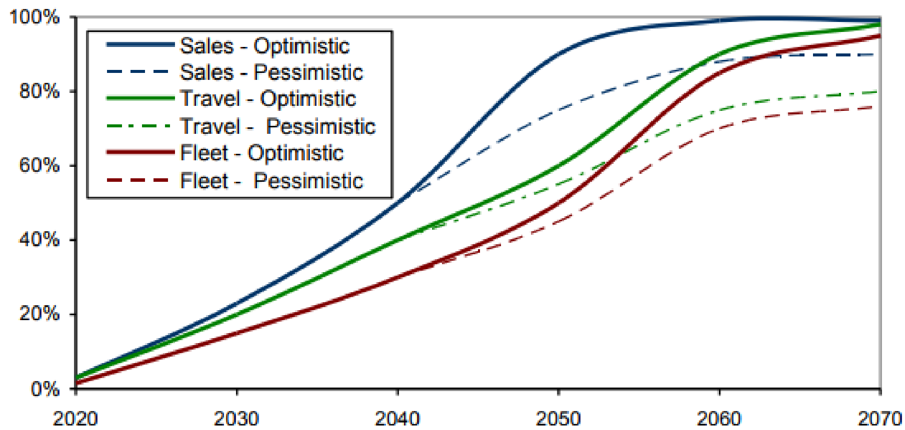
There will however, be unpredictable difference in the uptake of AVs in urban areas compared to rural areas, primarily due to isolation and lack of supporting infrastructure.

Haratsis (2017) expects that by 2025 AVs will be an aspirational commodity, and commonplace on Australian roads. Level 4 automation will be entrenched into society, and by 2035 over 80% of new vehicles sold will be AVs. It is also forecasted that by 2030 individually-owned cars will represent only 40% of the Australian fleet, and represent only 5% of the kilometres travelled. The other 95% of kilometres travelled will be represented by mobility services, such as ride sharing (Haratsis, 2017).

An alternate view by Litman (2017) suggests that if AV implementation follows the patterns of other vehicle technologies it will take one to three decades to dominate vehicle sales, plus one or two more decades to dominate vehicle travel. He proposes that even at market saturation it is possible that a significant portion of vehicles and vehicle travel will continue to be self-driven, indicated by the dashed lines on Figure 2. It is predicted that vehicles will remain self-driven in rural areas much longer than they will in urban areas. However, driverless vehicles are substantially different to all other increases in vehicle technology, and therefore, these levels of adoption may not be an accurate guide.

If accurate, in the 2040s, AVs will represent about half of all new vehicle sales, one third of the nation's fleet, and 40% of all vehicle travel. Only in the 2050s would most vehicles be capable of automated driving. Just as we see now vintage and antique vehicles on our roads, current vehicles will not entirely disappear but are likely to be less common over time. There may even be areas where internal combustion engines are not permitted, as recently announced in France and the UK (Litman, 2017).

**Figure 2 Automated Vehicle Sales, Fleet and Travel Projections (Litman, 2017)**

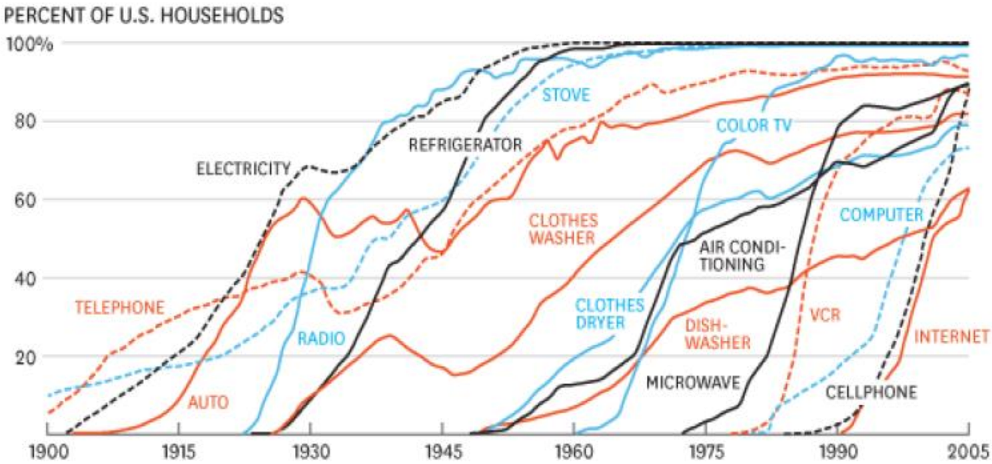



Penetration of AVs into the Australian and New Zealand markets will largely be based on the perceived need for the technology. Litman (2017) based estimations on the implementation patterns of other vehicle technologies, but patterns of adoption of technology have varied through time; consider the smart phone as one example.

Figure 3

Figure 3 shows a summary of the uptake of different technologies in households in the USA.

**Figure 3 Technology diffusion rates (Felton, cited in Haratsis, 2017)**




Another alternate view is that as late as 2025, it is predicted that 17% of new vehicles sold will contain no automated technology, while another 79% will have Level 3, 4 or 5 automated technologies. This suggests that full AVs are a long way off for a host of reasons, including legislation, liability, and the complexities and costs associated with the technology (Chappell, 2017).

A further barrier is the current trends in vehicle purchasing. Over the last decade, light vehicle sales have boomed and funded transformations within the industry. The outlook sales are darkening. Light vehicle sales in July 2017 in the USA fell 6.9% from the previous year, representing a decline for the 7th straight month. New vehicle incentives rose 4.7% from the previous year; new-vehicle sales still dropped by 15% (Chappell, 2017). However, there may be other economic imperatives impacting and reducing new car sales. These would need to be researched to determine their level of effect.

If we are now in a post-peak era for car sales, and that peak era is what funded advancements in technology, how will automotive companies continue to advance? Is the answer invested in AVs? The transport industry will need foresight to strategically plan for the future (Chappell, 2017). However, in Australia, we haven't quite passed peak vehicle ownership in the same way that the USA has. In fact, it has increased faster than population growth. In Sydney, vehicle ownership grew from 53.8 cars per 100 persons in 2006 to 55.3 in 2016. It grew even faster in Brisbane; from 60.6 to 63.9 over the same period. Melbourne saw the smallest increase in car ownership of 61.3 to 61.7 cars per 100 persons (Davies, 2017). It needs to be noted that these differences can also be affected by population growth, public transport infrastructure, urban expansion, and the extent of regional centres.

*The Role of the Economy*

In 2016, ADVI undertook a study of the economic impacts of AVs on jobs and investment. ADVI asserted that the scale and distribution of the economic benefits of the introduction of AVs will depend on how well the introduction of AVs is managed. The report provides an overview of the future cost of traffic congestion, the economic loss in road crashes, the avoidable costs, and the economic benefits of jobs and investment.

ADVI proposes two economic scenarios which could emerge from the introduction of AVs:

1. Minimum public intervention, where AVs simply replace traditional vehicles over time in an unplanned fashion; or
2. Creation of a new Mobility Ecosystem, where AVs are the catalyst for economic change for road funding, public transport freight and logistics, and urban planning.

ADVI strongly advocates for the second scenario, which includes government intervention and targeted social policies to assist in the management of transition. If determination of roll-out is left to the manufacturing sector, their only concerns will be business development and ownership of connected cities – which could lead to a disastrous outcome for regulation, safety, etc. This needs to be a nationally uniform scheme that is consistent across all states and territories.

The second scenario also maximises the economic benefits of AVs, which include:

- minimising the risks of increasing traffic congestion,
- transitioning of car ownership to sharing,
- maximising the efficiency of public transport,
- maximising intermodal facilities, and
- devising a new approach to road freight movement (ADVI, 2016).

The report asserts that AVs will have both direct and indirect economic impacts, and generate an important range of economic multipliers. Direct economic impacts refer to the development of the vehicles themselves, whereas indirect economic impacts refer to the use of the vehicle and enabling supporting infrastructure (ADVI, 2016).

Direct economic impacts include:

- transportation industry sector economic growth,
- time savings,
- increased productivity,
- increased personal safety,
- reduced travel costs or increased productivity of travel time, and
- increased accessibility and increased safety (Haratsis, 2017).

The jobs and investment forecasts outlined within the ADVI (2016) report show that based on achieving 1% of the global intelligent mobility market, Australia would generate $15 billion in revenue, as well as create about 7,500 direct jobs and 16,000 indirect jobs, requiring between $1.5-$2 billion annual investment based on traditional car manufacturing parameters (ADVI, 2016).

The introduction of AVs present Australia and New Zealand with an opportunity to take leadership and establish a new industry, with key sectors developing and supplying the new mobility ecosystem and associated mobility services. This will negate the risk of the unplanned introduction of AVs (ADVI, 2016).

Because motor vehicles have arguably had the greatest impact on the design of our cities and homes, the second scenario also offers potential for more efficient use of our roads through improved urban design. Road capacity will no longer need to be increased, and better uses found for redundant mass car parks. Homes will no longer need double garages and driveways, meaning smaller homes or greater outside areas (Homburg, 2015).

***The Role of Ride-Sharing***

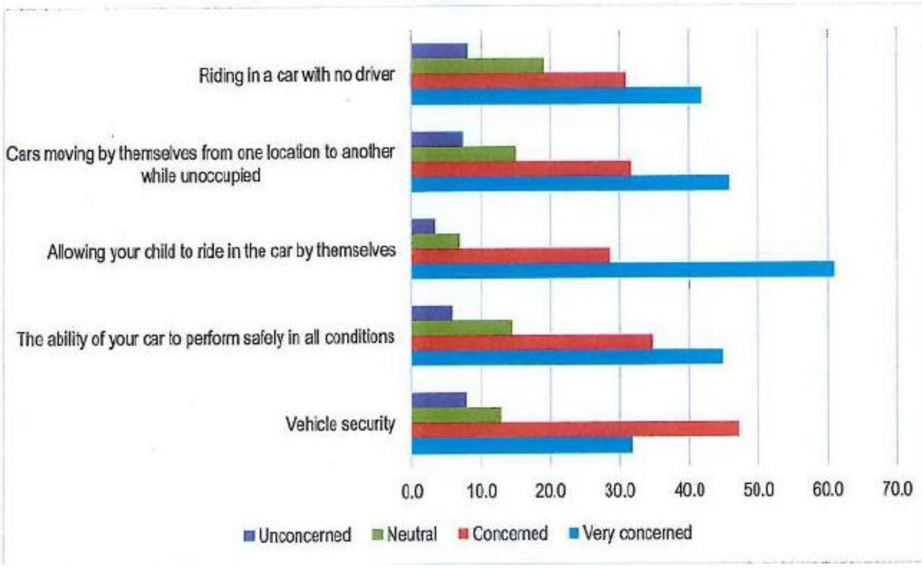
Roads Australia (2017) cites dramatic growth of ride-sharing in London, Paris and the USA, which has caused a sudden decline in the use of public transportation and vehicle ownership. This is a stepping stone towards large driverless vehicle fleets, prompting car manufacturers to revisit their business models. Lyft predicts that the availability of customised mobility will end private car ownership in major US metropolitan cities by 2025 (Roads Australia, 2017).

A study published by Schaller Consulting (2017) flags the astronomical growth in ride-sharing services. In June 2015 there were 18,000 vehicles operating as ride-share in New York City, providing about 5 million trips per month. By the end of 2016, there were more than 50,000 ride-share vehicles in New York, operating about 16 million trips per month.

Both the USA and UK report 8-9% reductions in mass transit patronage, which is attributed to increasing on-demand services and ride sharing. San Francisco has seen an increase in congestion as a result (Roads Australia, 2017). Considerations about the impacts of ride-sharing on networks must be made in Australia and New Zealand, and whether a decline in public transportation patronage, and increase in road congestion is likely. Other contributing factors to a reduction in mass-transit, and an increase in road congestion may be the procession of jobs and business out of the central business district of Australian cities, economic downturn, and security and safety concerns on public transportation. Haratsis (2017) argues that the consequent travel congestion caused by increased vehicle numbers will create the necessity for managing personal mobility in new ways.

*The Role of the User and the Community*
Public and private enterprises across the world agree that there is zero community tolerance for the failure of a driverless vehicle (Roads Australia, 2017). However, this is based on the fact that 93% of all accidents are caused by human error currently, meaning there is significant tolerance in the community for accidents caused by human error. Therefore, it is important to shift the focus towards changing the public perception of the cause of accidents. Figure 4 provides an overview of the community's concerns when it comes to the introduction of AVs.

**Figure 4 Perceived Concerns about Fully-Automated Vehicles (ADVI, 2017; cited in Haratsis, 2017)**




AVs will benefit people in different ways. The most common recognised benefit is increased accessibility to mobility. People living with disability will have a new method of transportation (in the case of Level 5 automation). Families facing school drop-offs and pick-ups will have their schedules streamlined. People living in higher density areas will not need to own a car, but still have one readily accessible. Regional/rural areas will benefit from a reduction in the impacts of fatigue and animal collisions.

*The Role of Smart Cities*
A city's urban form is currently influenced by the preferred mode of transport, and many challenges arise from the motor car in its present form. AVs may provide a game changer in terms of the urban form of the city (Homburg, 2015). Homburg (2015) outlines three main levels in which AVs could impact urban form at the dwelling level, at the suburban level, and metropolitan level.

At the dwelling level, if vehicles are still individually owned then space can be saved because the vehicle would drop passengers off and park itself, saving room because doors would not need to be opened as detailed in **Error! Reference source not found.**. If vehicles are on longer owned, parking space in our homes can be utilised as living space, as shown in

Figure 6.

**Figure 5 Dwelling with Owned vehicle (Homburg, 2015)**


**Figure 6 Dwelling with no vehicle owned (Homburg, 2015)**


At the suburban level, cars that park themselves will park closer together, increasing the efficiency of multi-storey car parks by 25%. Inner city carparks will become redundant, with cars returning to remote depots after hours. Movement patterns would also eventually change, with the cars dropping off passengers and moving to their next destination – fundamentally changing how people arrive and depart (Homburg, 2015).

At the metropolitan scale, cars will travel closer together, freeing up space within the street system. If parking within an urban dwelling is no longer required, urban densities will increase. However, if vehicles are able to become workplaces, densities could decrease (Homburg, 2015). This is because longer commuting times could be used for productively, making them more acceptable and manageable.

Benefits are only likely to be realised if supporting infrastructure is in place. Wireless connectivity networks within urban areas allow vehicles and traffic management systems to communicate in real-time, and enables them to share information on signal phasing and changing traffic conditions. Armed with this data, AVs would be able to optimise speeds and routes to minimise journey times and ease congestion (McCarthy et al., 2016).

These digital infrastructure requirements will create 'smart cities'. Cities and road infrastructure authorities play a critical role in achieving that transition by ensuring technology is in place to support the networks (McCarthy et al., 2016).
Revaluating how we move and the infrastructure required for mobility are both challenges and opportunities. Cities must become safer, healthier, more active, more sustainable, and comfortably planned to accommodate a growing population. By coming together to build the cities of tomorrow, we also can ensure that generations to come will have the dynamic, vibrant experiences that encourage continued innovation and progress (Kwant, 2017).

***The Role of the Government***

Roads Australia (2017) outlines many changes that governments need to make in anticipation of these changes. The challenge is that trust must be put in the hypothetical scenarios outlined in this paper, and assumptions need to be made. Roads Australia (2017) states that road user charging must anticipate the transition of AVs, as well as future projects and concessions allowing for likely change. It is predicted that urban roads will be managed by private fleet operators and government concessions.

The government's key AV goals need to focus on safety, social, equity, reduction in environmental impact, improving liveability, public health and recouping the value of public assets (Roads Australia, 2017).

The government will need to implement a business model for how AVs will be managed, their operations, and their regulations. Furthermore, travel management plans will need to be developed to ensure that AVs transition well into the new idealised mode share model with active transportation and public transportation.

## *Social Equity*

One of the most important AV considerations is social equity and equal access to transportation by everyone. However, unintended consequences from the introduction of AVs could lead to unfair impacts (Litman, 2017), and exacerbate existing barriers and increase in equality. This means policy makers must also consider how AV technology can improve the lives of those who need it the most.

Integration of AVs is likely to differ in urban settings compared to rural areas. AV technology offers a solution to reduce the high proportion of accidents on rural roads caused by fatigue. Lane keep assist features can help drivers stay on the road and within a lane, in turn decreasing the number of run-off-the-road and head-on collisions.

## *Opportunities*

Access to large databases, including transport/traffic models and geographic information systems data sets, is crucial for the modelling of AV scenarios. This data could be used for rapid and live scenario modelling, as well as multi-modal input models – which could, in turn, be used to answer the question of what if? This raises the key issue of privacy – who owns the data? Who can access the data? Where is the data stored? Can the data be re-identified?

Roads Australia (2017) stated that big data is essential for AVs to operate safely, and should be shared transparently in order to benefit the public.

Much of this data will be generated by the vehicles themselves, providing insight on how and when people travel, transport networks used, and congestion levels on those networks. The value of this intelligence is significant, as many cities are already trying to tap into data for the way people travel. Private companies must work collaboratively with governments, and we have already seen the City of Boston, Massachusetts, strike a data-share agreement with Uber to assist with city planning (McCarthy et al., 2016).

## *When can we expect all of this to occur?*

As outlined in the section on The Roles of Automated Vehicle Technology, there are different predictions of when AVs will be fully-integrated into our road network.

While each are based on different assumptions and different predictions, the most critical factor will be community acceptance and a perceived need for AV technology, which will influence the three proposed revolutions by 2050 (Figure 1).

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