Urban Policy Implications of CAV in Bays Precinct

A LITERATURE REVIEW FOR URBANGROWTH NSW

By Robyn Dowling, Pauline McGuirk and Donald McNeill with the assistance of Hannah Della Bosca

UNIVERSITY PARTNERS

THE UNIVERSITY OF SYDNEY
Architecture, Design and Planning

UNIVERSITY OF WOLLONGONG AUSTRALIA

WESTERN SYDNEY UNIVERSITY

Contents

EXECUTIVE SUMMARY

New technologies in vehicle automation and connected transport infrastructure are rapidly emerging and are expected to significantly transform urban transport. These new technologies will also impact urban planning and the built environment. Though a fully-autonomous transport system will evolve only in the long term, planning for it needs to begin now. Peer-reviewed literature on the urban policy and planning implications of Connected and Automated Vehicles (CAV) is in its infancy but is beginning to chart the planning implications of CAV. In reviewing this literature, this report finds the following implications need to be carefully considered in planning processes for the Bays Precinct.

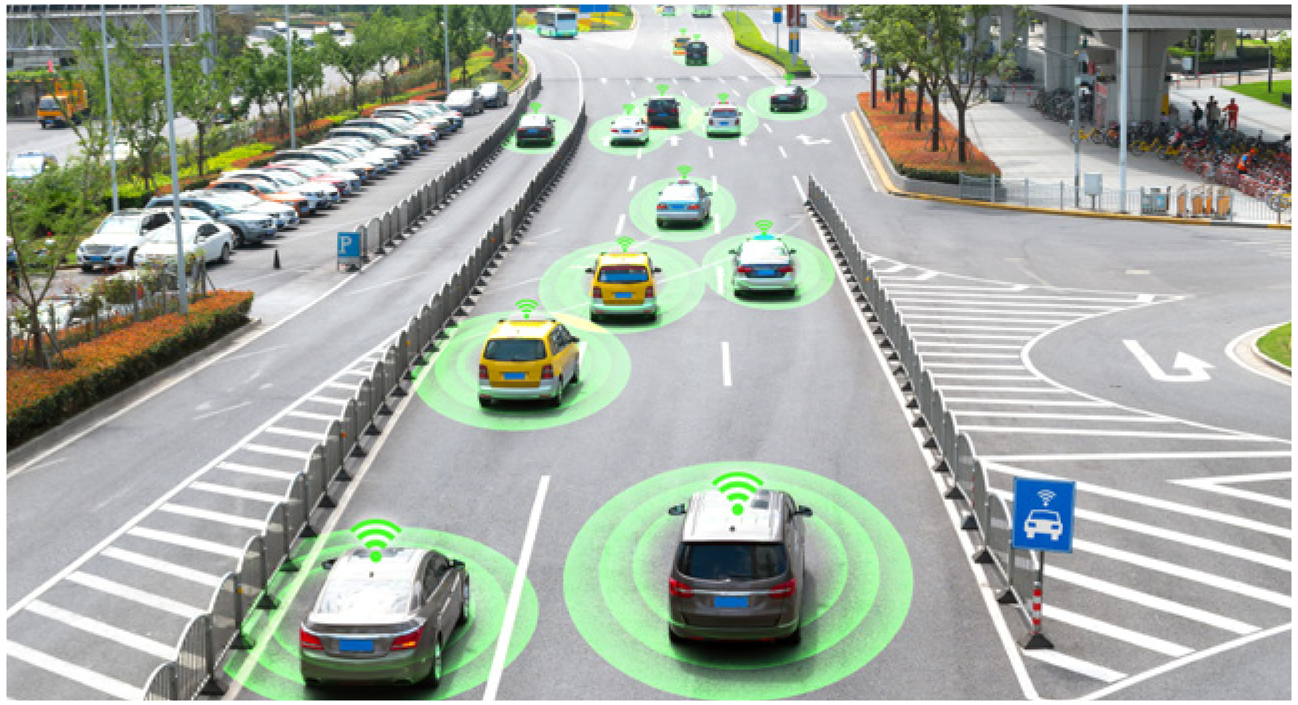
CAV has been an economic and innovation opportunity for many cities. The Bays has potential as a hub for transport innovation, working across the full breadth of the transport innovation ecosystem. This would both align with the NSW Department of Industry's imperative to better understand the nature of innovation ecosystems and present the opportunity to pursue this through the Bays (TfNSW 2016).

The trialling of CAV in real and/or controlled settings has been an economic opportunity for cities worldwide. The Bays has potential as a site for trialling CAV, especially in relation to public acceptance and infrastructural requirements.

Much popular commentary focuses on the individually-owned and used driverless car. This 'private autonomy' is not appropriate in all places, including the Bays. Shared, first-and-last-mile CAV for passenger and autonomous last-mile delivery are most likely and appropriate within the precinct. There is an innovation opportunity to create Australia's first new precinct in which forms of transport other than the private car predominate.

Shared CAV environments have a unique set of conditions to be considered.

1. *Shared CAV implies a reduction in quantities of road space, provision of smart transport interchanges and separated infrastructure in the transition phase.*
2. *Shared CAV will reduce on- and off-street parking requirements.*
3. *Building design that is adaptable and smart will better cater to a transition to CAV*
4. *The transition to an autonomous transport future that is accessible and sustainable will require strong guidance from government*



1. INTRODUCTION

The Bays Precinct sits at the nexus of a range of existing and developing land-uses that spans a working port, cruise vessel access and other maritime uses, as well as residential and commercial uses (UrbanGrowth NSW, 2012). The site occupies a unique corridor between the rapidly developing Sydney CBD and the historical character of the inner western suburbs of Balmain, Rozelle, Lilyfield, Annandale, Glebe, Ultimo and Pyrmont. Preliminary projections for the site suggest that there will be 20, 000 residents, employment for 30, 000, and 4, 000 students entering and exiting the precinct daily. These figures are likely to increase significantly over time, particularly those representing students (TfNSW, 2017). Development and activation of the Bays will occur over a 20-30 year time horizon (UrbanGrowth, 2015). This time period will be one of continuing and rapid technological change, especially with respect to transport. New technologies in vehicle automation are rapidly emerging, with potentially radical implications for the ways people and goods move around urban space, urban infrastructure, design and planning, the experience of travel, and economic innovation opportunities.

NSW government agencies Transport for NSW (TfNSW) and UrbanGrowth NSW recognize the importance of new transport technologies in general (in the Future Transport Technology Roadmap) and specifically in shaping the future of the Bays Precinct. Consequently, this review of literature into the urban policy and planning dimensions of autonomous vehicles, and their role in such a transport network in the Bays Precinct was commissioned. Drawing on the proliferating international experience with regulating, planning for, and implementing CAVs, the review draws attention to three domains of significance:

- Opportunities for the Bays as a transport innovation ecosystem and test-bed for CAVs;
- shared CAVs as an appropriate configuration of CAVs in the Bays; and
- urban design considerations for CAVs.

The report begins with the context of CAVs before addressing each of these domains in turn. A summary of recommendations and broader implications is then provided.

2. CONTEXT

2.1 Bays Precinct Plans

Planning for the Bays Precinct requires coordinating the development and refurbishment of distinct destinations across 5.5km of Sydney harbourfront. The important point for this report is that redevelopment of the Bays Precinct will occur over the long term. While planning started in 2015, the site will not be fully activated until between 2040-45. The size, location and timeframe mean that the development is seen as a once-in-a-generation opportunity to drive innovation (UrbanGrowth, 2017). Achieving an authentic sense of place by blending recreational, residential and commercial land-use is a critical planning issue. The aim is to provide residential quality, quantity and diversity (UrbanGrowth, 2015). Fulfilling the transport and mobility needs of individuals traveling within, to, from, and through the precinct is fundamental to achieving these aims, and is being addressed in a forthcoming Transport Masterplan for the site. This transport planning includes consideration of connected and autonomous vehicles, which this report explores in depth.

A guiding philosophy of Bays planning is innovation, with an attendant focus on creating an economic hub in which new and existing knowledge-intensive industries can be encouraged and developed (McKinsey Report, 2016a; UrbanGrowth, 2016).

The Brookings Report defines innovation precincts as compact geographic areas in which leading technology and research institutions and companies cluster and connect" with start-ups and business incubators (Katz and Wagner, 2014). The emerging interest for global cities in fostering innovation districts corresponds to the increasing recognition of the value of providing mixed-use spaces and work environments that encourage people with different technical specialisations and life experiences to spontaneously interact, both physically and creatively (Freedman and Calloway, 2013). In these districts, innovation is a product of regional culture in which the "hidden" social and physical dynamics of place play a central role as new avenues of knowledge acquisition and innovation (Obschonka et al., 2015). The long-term success of innovation strategies comes from precinct designs that foster initiatives that promote community, environmental sustainability and connectivity. Landry (2012) suggests that we need to approach, plan and understand innovation precincts holistically, and to acknowledge that each component of the physical landscape contributes to the co-creation of both financial value and socio-cultural values. A comparative Canadian case study suggests that there is a decreasing geospatial distinction between work, social life and home residence for the young, well-educated demographic and that this is having a growing impact on the culture and location of new economy districts (Duvivier and Polèse, 2016).

Figure 1: The Bays Precinct (Urban Growth, 2015)

2.2 Future Transport and Smart Cities

Technology is reshaping the foundations of transport (McKinsey Report, 2016a). Transport for NSW's Future Transport Technology Roadmap identifies game-changing technologies that will have an impact on transport in future, including personalised customer interactions, shared, demandresponsive services, connected and automated vehicle platforms and intelligent transport networks (TfNSW, 2016). Likewise the Federal Government Smart Cities and Suburbs program will infuse technological innovation through urban infrastructure, service delivery and city living (Department of the Prime Minister and the Cabinet, 2016). Technology alone will not transform urban transport, but the combination of disruptive business models, technology (in particular digital technologies), and changing relations of people to mobility modes will be transformative, as can be seen in the table below.

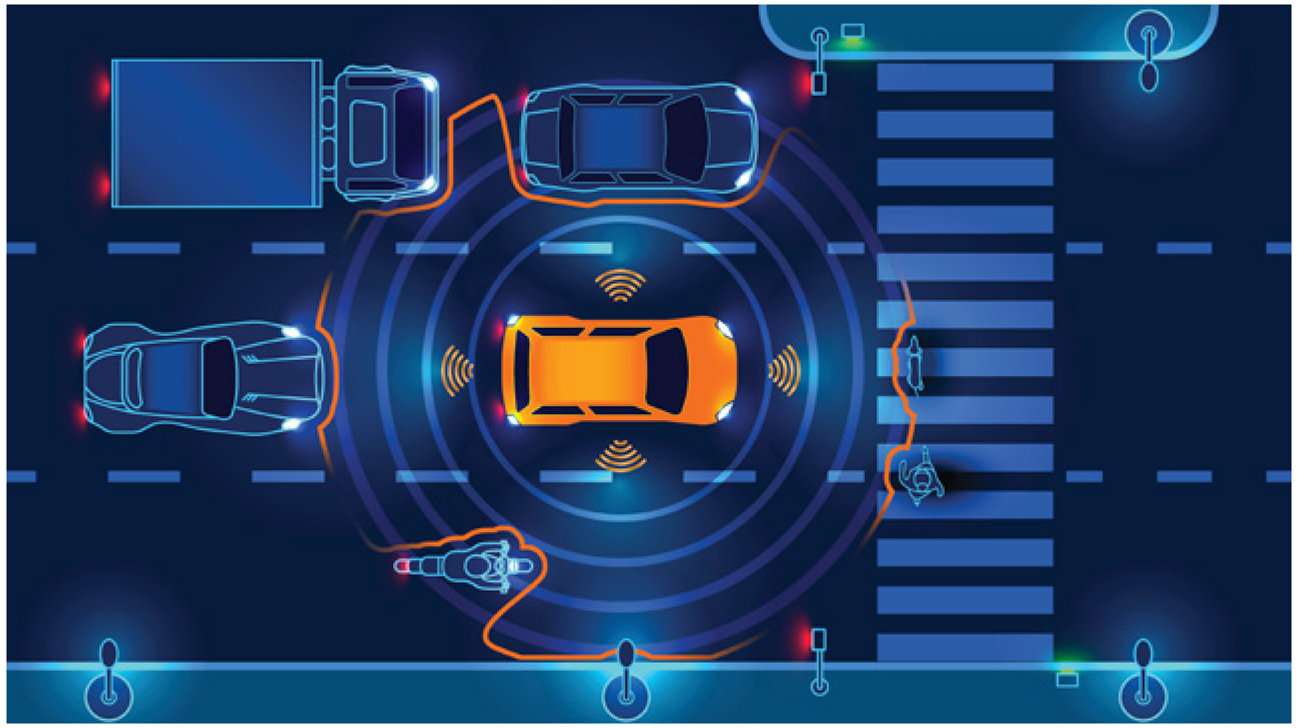
Table 1. Technological and Business Disruptions to Transport

Dimension	Impact of Technological Transportation
Means of access and ownership	Emergence of sharing e.g. car share, bike share, ride share
Business models	Entrance of corporations with technological rather than transport expertise
Transport information	Apps, real time information, personalized route guidance
Ticketing and payment	Smart cards, integrated ticketing across modes, integrated information and payment platforms
Traffic management	Real time, platooning, parking management, mobile phone app-based V2Xenabled hazard and congestion warning
Digital and physical Infrastructure	Sensors, bus stops
Vehicle technologies	Automation and electrification (across freight, private passenger transit, shared passenger transit), vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2I), and vehicle-to-everything (V2X) connectivity

The simple division between public and private transport is no longer valid with the emergence of car sharing services (Kent and Dowling, 2013; Dowling and Kent, 2015), bicycle sharing (Fishman, Washington, and Hayworth, 2014), and increasingly successful forms of mobility-on-demand that make use of smartphone apps to connect private transport providers with public users (Rayle et al., Urban Policy Implications of CAV in Bays Precinct 6 2016). The notion of mobility as a service (MaaS) signals a decline in the private ownership of transport (in particular cars) in favour of consuming services that provide mobility. There are also significant disruptions to the business of transport. Companies with technology options and expertise (e.g. Uber, Google) are entering the transport domains as transportation network companies (Kent and Dowling, 2016), while conventional transport companies (e.g. GM, Volvo) are developing partnerships with technology start-ups and new business models. Electrification is growing as a technology of vehicle propulsion (MacDonald, 2016). The integration of ticketing and of transport across modes is underpinned by the provision of real time information and monitoring. In each of these disruptions, information and communication technologies are central and critical. This is a rapidly evolving transport landscape, in which the development and implementation of CAVs is a significant component.

2.3 Connected and Automated Vehicles Overview

Automation in vehicle technology is not new. Over the past twenty years vehicles have become increasingly automated, with the addition, for example, of parking assist, lane departure warning, and electronic braking systems. There are, however, different levels of automation (see Figure 2), with distinct variation in the type of driver involvement (with fallback to a human driver required in all but levels 4 and 5 automation) and in whether automation is system limited or extensive. The promise and possibility of automated vehicles is already being realised in a diverse range of industryspecific applications, including mining (Fagnant and Kockelman, 2015), "platooning" freight trucks (Switkes and Boyd, 2016) and in combat zones to direct armed vehicles or deliver supplies (Pietras, 2015). The use of CAVs in city-based movement of people and freight is currently limited.



2.3.1 CAV Implementation Timescales

There are divergent predictions of when different levels of automation will be reached. Tangible forecasts for Australia vary widely in the timeframe for adoption of CAVs. The Australian Driverless Vehicle Initiative Roadmap suggests full automation by 2030 at the latest, whereas a 2015 report by Main Roads Western Australia titled Automated Vehicles: Are We Ready? outlined a more conservative prediction of low level CAV adoption from now to 2025, increasing level 2 and 3 adoption between 2025-2035 and continuing into full level 4 capacity and availability at a subsequent point unspecified currently. In May 2017, a Canadian report stated that the broad social impacts of CAVs would not likely be felt until CAV use was both common and affordable, predicted to occur at some point between 2040-2060 (Litman, 2017). There is agreement, nonetheless, that over the life of the Bays' development, the widespread deployment of CAVs will occur.

Figure 2: SAE Standard J301 CAV definitions (European ITS Platform, 2014)

Level	Name	Execution of steering and acceleration/ deceleration	Monitoring of driving environment	Fallback performance of dynamic driving task	System capability (driving modes)
Human driver monitors the driving environment					
0	No Automation	Human driver	Human driver	Human driver	n/a
1	Driver Assistance	Human driver + System	Human driver	Human driver	Some driving modes
2	Partial Automation	System	Human driver	Human driver	Some driving modes
Automated driving system monitors the driving environment					
3	Conditional Automation	System	System	Human driver	Some driving modes
4	High Automation	System	System	System	Some driving modes
5	Full Automation	System	System	System	All driving modes

2.3.2 CAV Implementation Scenarios and Social Implications

The critical question facing urban strategies is not whether, but how, CAV will shape how people and goods move in, out and through cities. There is at present no definitive answer to this question but considerable discussion of possibilities (Isaac 2016; Fraedrich et al. 2015). The scenarios depicted below (Table 2) represent the consolidated thinking on this topic. In the private autonomy scenario, privately-owned and used automated vehicles predominate, and automation serves to deepen car dependency. In both seamless and clean and shared mobility scenarios, shared vehicles predominate though with different outcomes in low density and high density precincts. There is a differing role for government across the scenarios, with strongest guidance assumed for the clean and shared scenario. The mixed commercial-residential characteristics of the Bays, along with its location, make the seamless mobility scenario the most likely and desirable outcome for the location.

Table 2: CAV Scenarios adapted from An Integrated Perspective on the Future of Mobility (McKinsey Report, 2016a)

Private autonomy	AVs may incentivize suburban sprawl by making the home-work commute more convenient, productive and affordable. In this scenario, the attractiveness of the private (and likely electric) vehicle remains, bringing with it corresponding infrastructure requirements such as CAV-only highway lanes. This use of CAVs will most likely benefit high income suburban dwellers.
Clean and shared	Emerging technological capability within a changing economic marketplace will transform mobility, particularly in dense, low-income metropolitan areas. Potential social uptake of electric vehicles within a shared mobility framework, alongside exponential market investment in both CAV and new energy technologies such as solar will transform public transit towards cleaner, cheaper, and more networked transport.
Seamless mobility	A high density of high income users will be able to seamlessly merge autonomous, electric and shared transport applications to achieve their own transport needs ondemand. This scenario relies on effective and efficient first-and-last mile services in combination with optimized mass transit, all operating within a framework of fullyconnected mart infrastructure to eliminate congestion and facilitate reliable, fast and easy electric vehicle charging.

These scenarios highlight the importance of a critical perspective on CAV: while CAV will provide solutions for a number of transport issues it is not without concern. Based simply on cost, for example, it is envisaged that if the lowered financial cost of driving incentivises individuals to drive who had previously taken public transit, a transition towards autonomy would increase the number of cars on the road and negate any environmental or experiential benefit (Wadud, 2017). In a review of the CAV landscape in Australia, Sun et al. (2017: 43) note that much discourses contains an "implicit assumption" that the changes that Australia's transport future will be transformed by shared-use, despite car reliance remaining a significant present and future obstacle to such a future. While the elderly and disabled are cited as groups having the most to gain with the popular uptake of truly autonomous vehicles, exactly how CAVS will enable more equitable access to transport is relatively unexplored. The Parliament of Australia is currently reviewing submissions for an inquiry into the the social issues relating to land-based driverless vehicles in Australia, with particular reference to access and equity issues for increasing the independent mobility capacity of disabled and elderly people. According to their submission to this inquiry, the Australian Driverless Vehicle Initiative is working on an interim pilot program designed to test the use of existing advanced vehicle technology for those with a 'minor' impairment, with the intent being to identify additional pilot opportunities and candidates during 2017. Deaf Australia Inc. also made a submission

asking the committee to incorporate CAV into the National Disability Strategy, while in-vehicle driving aids such as sensor-based warnings and driving assistance are positioned as technologies of particular benefit to older drivers (Marshall, Smith and Chrysler, 2014). Milos and McPherson (2016) have examined social justice considerations in the embedded ethical and social assumptions in current traffic control systems, and suggest that next-generation, connected systems have the potential to better serve more socially just outcomes, based on financial access to the efficienicies these systems represent, and ways in which non-monetary equity can be embedded in systems of vehicle prioritization.

2.3.3 Regulatory and Policy Context for CAVs

The ways in which CAVs can and should be regulated are the subject of substantial attention worldwide. National, state and local governments, road agencies and parliaments have commissioned hundreds of reports into the legal challenges posed by CAVs (STSC, 2017; Staysafe, 2017; NTC, 2016). These reports highlight critical issues of insurance and liability, data privacy, and changes to standards associated with vehicles such as the requirement for steering columns, as well as potential amendments to drivers' licencing. There is no expectation that the regulatory context will become more certain or stabilised in the short term.

Most attention currently is being focused on the regulatory facilitation of on-road trials of CAVs. In Australia, the National Transport Commission (NTC) expects the next three years to see a proliferation of trials of CAVs across Australia. CAV trials in Australia are currently restricted to specific pedestrian precincts such as the South Perth Esplanade and the Darwin Waterfront, or they occur under highly controlled conditions on closed-to-the-public roads, as in Volvo's demonstration on Adelaide's Southern Expressway in late 2015. South Australia is so far the only state to introduce specific CAV legislation South Australia Motor Vehicles (Trials of Automative Technologies) Amendment Bill in March 2016, and even so the most recently funded South Australian Future Mobility Lab Fund Projects will operate in the public yet bounded precincts of the Tonsley Innovation Precinct, Flinders University, and Adelaide Airport.

The key challenges in developing Australian guidelines for on- and off-road CAV trials in Australia are identified in the NTC 2016 discussion paper National Guidelines for Autonomous Vehicle Trials as:

- Safety
- Risk management
- Liability
- Transparency

As such, the NTC has drafted suggested guidelines for each of these areas (NTC 2016). The safety recommendations call for mandatory requirements involving the management of trials, including specific conditions of approval and bounded trial areas. Organisations would need to demonstrate that they would abide by all existing road and privacy laws and vehicle standards, and provide separate management plans for traffic issues, infrastructure requirements as well as stakeholder/public engagement. The risk management recommendations involve requiring safety management plans that outline all safety risks, and how the trialling organisation will mitigate or eliminate physical, technical and human sources of error. Liability remains a source of interest for many stakeholders, and petitioning companies must demonstrate that they have obtained an appropriate level of insurance. Finally, recommendations for transparency involve guaranteeing that all data and information involved in the trial would be collected and made available to external investigations, particularly in the case of malfunction, collision and crash scenarios.

2.4 Summary

Technological, economic and governance trends mean that a city in which the mobility of both people and goods is met by CAV will eventuate, but in the very long term. While there is currently considerable uncertainty surrounding the regulation of CAVs, it is expected that ongoing regulatory revisions will resolve many issues in the short to medium term. It is therefore incumbent upon masterplanning processes to consider the implications of CAV in specific locations. The implications for the Bays are considered in the rest of this report. These implications are of two types for the Bays. First, there are opportunities offered by CAV in relation to transport-related innovation and as a trial site for CAV. Second, there are responsibilities to masterplan a 'CAV and future-transport ready' precinct. We outline these in turn.

3. MOBILITY-FOCUSED INNOVATION AS AN OPPORTUNITY

3.1 Transport Innovation Ecosystem

Whatever the origin of an innovation precinct—whether emerging from existing user behaviour or fostered through state planning initiatives–the contemporary literature suggests that creating a cultural foundation in which new conventions and ideas are tested and encouraged through research and learning is as important as the physical initiatives in creating an environment of innovation (Ferilli, 2017; Goldberg-Miller and Heimlich, 2017; McDonald, 2017). In other words, fundamental to innovation districts is exposure to that which is novel and creatively stimulating, be it in company policy, landuse and office layout and ethos, or business model. A focus on future transport technologies as drivers of innovation is a usefully “visibility strategy” (Landry, 2012, p.260) for a fledgling innovation precinct. There is an opportunity to create a space in Sydney that represents and develops the ethos of experimentation that supports people, industries, ideas and sectors engaged in innovation and enhances its outcomes.

While claims to the benefits of clustering and knowledge sharing in agglomeration districts can be over-extended, their potential is well established. The structure of CAV development can be seen as a ‘stack’ or chain of different products (Stewart, 2017). As the Bays is likely to be developed in phases, it is possible that relatively cheap, minimally fitted start-up office accommodation could be aligned with certain zones of the precinct to provide a suitable innovation district for CAV testing. Such an approach would support and encourage not only the testing and deployment of CAV but also a wider CAV ecosystem comprised of a variety of technology, infrastructure, and service providers.

Importantly, CAV does not present opportunities for automobile production in Australia but for several different areas of intervention: first, the development and testing of sensors, such as cameras, lidar, and radar; second, the role of AI and machine learning in vehicles; third, the development of user-experience technologies, which is an essential area in bringing CAVs closer to market; fourth, market opportunities for firms to act as consultants in the areas of regulation and insurance; fifth, start-ups that can develop applications that allow CAVs to operate as fully exploited assets, whether in public sharing, on-demand models or in corporate or precinct-based closed systems. As start-ups in this area are diverse, and the technologies are new, there is scope for exploring the feasibility of a focused accelerator program in autonomous vehicles and automobility. This would draw together a combination of mentorship from industry experts, seed funding, and the aforementioned locational assets of cheap office space and ‘hard’ testing zones discussed elsewhere in the review. While a comprehensive market review of business opportunities is beyond the scope of this report, the boxes below give an indication of the types of businesses that may be targeted.

Box 1: Transport Technology and Start Up Companies

Transport Start-ups	
Zoox	Australian led Silicon Valley CAV robotics start-up, valued at A$1.9 billion
Codha Wireless	Technology firm focused on vehicle-to-vehicle, vehicle-to-infrastructure and vehicle-to-pedestrian communications.
Seeing Machines	Start-up company that evolved from the Australian National University. Focus on development and commercialisation of proprietary algorithms and hardware for Driver Monitoring Systems. Existing relationships Caterpillar, Electro-Motive Diesel, Boeing, Bosch, LG.
Australian App start-ups	
Who’s Driving	Sydney designated driver service that deploys two people, one of whom drives the customer while the other returns customer vehicle e.g. after a night out, day surgery, or any such one-way service
Scoot to You (Brisbane) **We Drive** (Melbourne) **Scooter Angels** (Sydney)	Drivers fold their scooters in the back of a customer’s car to drive them home
Spotparking	Parking payment app
Niftie	Commuting co-op , in which a community of users in areas of Sydney poorly served by public transport share in the cost of a chartered coach that runs express to the CBD.
Ingogo	Taxi payments startup based on fixed-fares including tolls, distance and traffic conditions.
Divvy	Online parking platform allowing companies and individuals to let out their under-utilised parking spaces for lower cost than on-street parking
Swift	App-based courier service
Shippit	Logistics startup offering customers more flexibility and options regarding when and how deliveries arrive.

The Bays hence has potential to evolve as a hub for transport innovation, working across the full breadth of the transport innovation ecosystem. This would both align with the NSW Department of Industry's imperative to better understand the nature of innovation ecosystems and present the opportunity to pursue this through the Bays (TfNSW 2016).

3.1.1 3.1.1 Opportunities for CAV Trials

The trialling of the multiple dimensions of CAV as an innovation district opportunity is recognized internationally. Ticoll (2015:13) notes, for example, in relation to Toronto that 'It would be in the City's interest to attract and support CAV technology and innovation development by start-up and established firms in the technology and automotive sectors' 'signature initiative''. The city of Seattle is considering an 'assertive strategy' in which to promote Seattle as a CAV innovation hub to leverage local technology industries. Both Dubai and Singapore are at the forefront of testing and integrating autonomous functionality into city-wide transport plans. In the United States, the city of Columbus, Ohio won the Department of Transportation's Smart City Challenge with a focus on transport innovation. In short, CAV trials can be an economic and innovation strategy as much as a process for resolving technical and regulatory challenges of CAVs. This section provides an overview of these trials and their potential implications for the Bays Precinct.

3.2 Background

While there are numerous trials for on-road testing of private automated cars, of more direct relevance to the Bays precinct, are precinct-level trials focused on integrated testing of multiple aspects of a given CAV mode (e.g. autonomous shuttle) within a designated precinct: from infrastructural, communications and vehicle technologies, to the design of subsidiary infrastructure (signage, bus stops etc.), to aspects of public acceptance. These precinct level trials are of three broad types.

1. *Precinct first-and-last mile[1] trials: aimed at testing specific CAV systems and their capacity to address specific precinct transit needs, for example a business park, university campus or innovation precinct.*
2. *Controlled trial sites: trials and testing can be conducted secluded from wider transport, infrastructural and regulatory systems. For example the University of Michigan Mobility Transformation Center's Mcity is a 13 hectare simulation of urban environments developed with multi-million dollar investment from car companies and additional government funding. Mcity is designed to provide the simulated testing capacity for multiple aspects of CAV technology so as to refine new technologies (Meek 2015). Many simulation test-bed sites are commercially-owned and operated, and are booked out several years in advance (Clayton Utz 2016).*
3. *Whole city 'real-world' test beds: multiple forms of CAVs, systems, and combinations can be tested while integrated with real-world mobility systems, human-transit interactions, and built environments. One such precinct is London's Greenwich Automated Transport Environment or GATEway project which operates in a multifaceted real world test bed for evaluating automated transport systems*

   (http://www.digitalgreenwich.com/driverless-cars/) *(see Box 2).*

1 The term used to describe passenger travel getting to and from public transit stops (rail/bus) or parking stations or to-thedoor freight delivery from wider distribution networks.

> **Box 2: The GATEway (Greenwich Automated Transport Environment) initiative.**
>
> GATEway is integrated as the smart mobility component of a wider smart city strategy for the Borough of Greenwich, London, and is based in the Borough's Digital Greenwich Innovation Centre. The project is funded by £8 million (A$14m) provided by the non-profit Transport Research Laboratory (TRL) a consortium of members from the energy, university, insurance sectors, and car makers, matched by Innovate UK funding. Its purpose is to create an open innovation environment for CAVs, though which to address technical, legal and societal aspects of implementation in complex, dense urban environments by testing and demonstrating "the safe and efficient integration of sophisticated automated transport systems into complex real world smart city environments" (https://gateway-project.org.uk/about/). Its planned trials will cover:
>
> - automated passenger shuttles
> - automated urban deliveries
> - remote teleoperation demonstrations
> - high fidelity simulator trials to test interactions between regular and automated vehicles.
>
> Beyond its immediate application to advancing the development and uptake ofCAV smart mobility through trials, GATEway also links innovation to wider goals of economic development and positioning the city in the emergent global complex of hardware, software and knowledge industries emerging around CAV. As a 'real world' testbed, GATEway is designed to produce "exploitable knowledge of the systems required for the effective validation, deployment, management and integration of automated transport within the smart city environment" and to "capitalise on the consortium strengths to position UK PLC at the forefront of the global marketplace encouraging inward investment and job creation".

Australian trials of CAV are still in their infancy. However, in March 2017, funding for three new Australian precinct trials (summarised in Table 3)—all focused on first and last mile solutions—was announced via the South Australian Government's Future Mobility Lab fund[2].In contrast there are many international precinct trials, especially those targeting "first and last mile" passenger mobility needs. We draw out the key learnings from these trials with regard to prospects for CAV development and use in the Bays Precinct.

2 The Future Mobility Lab fund is providing $10 million over the next three years to projects that "demonstrate, develop, or contribute to the applied research of Future Mobility technologies" (http://www.dpti.sa.gov.au/transportinnovation).

Table 3: Future Australian CAV precinct-level trials, South Australia

Precinct	Vehicle Infrastructure	Purpose	Stakeholders	Additional infrastructure
Tonsley Innovation Precinct	Driverless cargo pod	First and last mile goods transportation and delivery	SA government, RDM Group (AV pod design & manufacturing)	N/A
Flinders University	Driverless shuttle bus	First and last mile passenger mobility: transit points to campus	SA government, Flinders University, Royal Auto Association	Mobile app for ondemand hailing
Adelaide Airport	Driverless shuttle bus	First and last mile passenger mobility: carpark to terminus	SA government, Adelaide Airport	Solar-powered bus stops with LED lights, CCT, wifi and charging station

3.3 Key International Trials

Five key international trials are analysed below and summarized in Table 4. These are precinct-level trials focused on integrated testing of multiple aspects of a given CAV mode. The trials are analysed by key characteristics: intent and purpose, stakeholders, infrastructural components, governance, integration with other aspects of innovation, and evidence of public acceptance or evaluation. Following this, key observations and learnings are drawn out for the Bays Precinct.

Intent and purpose: These trials characteristically target 'first and last mile' solutions for one or more of intra-precinct mobility, mobility between two precincts (eg a campus and innovation park), the precinct's intersection with conventional public transit systems (bus, metro and mainline rail).

Stakeholders: Typically the trials are provisioned, managed and funded by multi-sectoral consortia. Technology hardware and software partners are commonly joined by a university and/or a government agency partner supplying knowledge, expertise and logistics, and often a government funding partner. Government funding partners range from the scale of provincial government through to the EU. Notably, specialist software start-ups feature as consortia partners in several instances e.g. Bestmile, a specialist automated fleet management platform start-up that commenced as a spin-off from Switzerland's EFPL University.

Infrastructural components: All the selected trials test shared mobility options as first and last mile solutions. In terms of vehicle technology, electric shuttle bus systems dominate, using relatively lowspeed (20-40k/hr), low capacity (6-15 passengers) driverless shuttles, costing US$180-250 000 per unit. The shuttles do not require additional track or wire infrastructure, though route signage and road markings are often installed to alert pedestrians and drivers. Additionally they require access to charging stations. Trial routes are commonly short (from 200m to 1.5km), and combine fixed stop services with capacity for on-demand hailing via smart phone apps. The trials generally allow for shuttles to interact with on-road and pedestrian traffic, through predominantly in controlled areas such as a university campus or tech district.

Governance: National regulatory frameworks determine the governance structure for each trial. In order to meet legislated requirements, approvals typically include the condition that an on-board officer be present at all times in the vehicle.

Integration with other aspects of innovation: Integration with some form of innovation, knowledge, eco-district or smart city strategy common. For example the Lyon Confluence Development Precinct and a driverless shuttle trial form part of the Greater Lyon Smart City initiative.

Evidence of public acceptance or evaluation: Several trials incorporate formal public evaluations of its perceived safety, comfort, speed and convenience, general acceptance and willingness to use. Where such evidence was complied, both public acceptance and appraisal are highly positive.

Table 4: Summary and characterisation of key international precinct-level CAV trials

	Lausanne, Switzerland	Wageningen, Netherlands	Singapore	Dubai, UAE	Lyon, France
Descriptor	First and last mile trial Driverless shuttle minibuses trialled on university campus over 16 days, transporting 1600 users Follow up trial of 6 CAVs on longer and more complex route connecting campus, Innovation Park, and metro station T1 2010-2014 and T2 2014 -2015	First and last mile trial Driverless shuttle minibuses on fixed route (200m) Ede-Wageningen railway station to Wageningen University, and then around campus Timeline: 1 year trial 2015-16 to extend & expand to 3 yrs	First and last mile trial Driverless shuttle minibuses on fixed route (1.5km) between Clean Tech Park and NTU campus Carried 500 people over 400 kms Timeline: Pilot phases 2016- 2019	First and last mile trial Driverless shuttle minibuses within the Dubai World trade centre, then extended to trials at Mohammed bin Rashid Boulevard and Business Bay District (700m) Timeline: Commenced 2016	First and last mile trial Driverless shuttle minibuses on fixed route (1.35km) around the Confluence development precinct Timeline: 1 year trial from 2016
Stakeholders	BestMile (EPFL Startup) (shuttle, tech support) EPFL University T1: EU FP7 funding of City Automated Transport System (CATS) project T2: EU Citymobil2 funding	EasyMile (shuttle, software tech support) Official consortium: Technical University of Delft, Spring Innovation Management, Robot Care Systems, TNO, Mapscape and Connekt. Gelderland Province	BestMile (EPFL Start up) (Navya ARMA shuttle) Nanyang Technological University (NTU) SIngapore Land Transport Authority (LTA) and JTC Corporation Funded by National Research Foundation, Prime Minister's Office (via Campus for Research Excellence And Technological Enterprise: CREATE). Google	EasyMile (shuttle, and tech support) Omnix International Emaar Properties RTA Dubai (funding and instigation)	Navly (partnership between Navya and Keolis) French Agency for Environment and the Energy and Ministry of Ecology, Sustainable Development and Energy Lyon's public transport operator Sytral
Governance	Private campus, free access and trial led to exemption from Federal Office of Transport and the Federal Office of Roads certification Approval delegated to local authority.	Pilot complied with safety requirements, so the Rijkswaterstaat (the Directorate-General for Public Works) adjusted the relevant legislation and regulations to allow	Since 2017 CAV trials can now use public roads. LTA granted flexibility to create new rules to accommodate time/place limited trials and can exempt trials from existing provisions of the RTA	Currently on restricted routes Legislative changes required before vehicles can be used on open roads.	Public safety compliance was proved, allowing operation on public roads
Infrastructure	Electric Navya Shuttle: 10 passengers Max 20km On road or pavement On board operator if required	Electric WePod Bus 6 passengers Max 40km On road or pavement On board operator if required	Electric Navya ARMA shuttle 15 passengers Max 40km On road or pavement No on board operator	Electric EZ10 shuttle bus 12 passengers Max 40kmhr On road or pavement No on board operator	Electric Navaya Shuttle 15 passengers Max 45kmhr On road or pavement On board operator if required
Interaction with vehicles, public roads	Yes, but within controlled area, campus with private roads	Yes, but within controlled area, university campus	Yes, but with controlled area, test bed precinct	Yes, but within controlled area, business areas	Yes, on public roads, after proving public safety compliance
Service Cost	Free service	Free service	Free service	Free service	Free service
On demand	No, fixed stops Overlapping on demand trial via smartphone app	Yes, fixed stops and demand via smart phone app	No, fixed stops. On demand app in development	Yes On demand	No, fixed stops, service at 10min intervals at peak
Integration with Business/ Innovation/Smart district	Yes Connected Campus with Innovation Park	Yes Intended to expand route along the Food Innovation Strip, to the Ede-Wageningen intercity railway station.	Yes Part of Jurong West Innovation District. Clean Tech is a eco-business development precinct	Yes Business Bay area	Yes Former industrial area redeveloped as eco-precinct. Precinct and trial part of Greater Lyon Smart City initiative. Lyon has Optimod centralised control system for mobility forecasting
Evidence of public acceptance	Public response evaluation through survey. Overwhelmingly positive reaction to driverless concept	High levels of customer acceptance and satisfaction recorded	No evidence	Surveys suggest public reactions are generally surprised, enthusiastic and positive	No evidence

3.4 The Bays as a Trial Precinct

CAV trialling will continue in the short to medium term, in line with the expected c30 year timeline for delivery of widescale CAV systems (NTC, 2016). TfNSW's (2016) Future Transport Technology Roadmap recognizes this need to trial all such dimensions and anticipates incubating new uses by "trialling and adopting new, world-class technologies as they emerge" to shape NSW as "the most customer-centric, innovative, digitally-enabled transportation system in Australia" (pg 6). Moreover the Roadmap includes a strategic commitment to "foster shared, demand-responsive services" and recognizes the need to "build an initial program of work focusing on accelerating the safe use of automated technology, particularly in shared mobility services" (p 88). Running pilots and controlled trials of demand-responsive transport services is a clear pathway supported by the Roadmap. Both these potentials are consistent with UrbanGrowth NSW's stated aspiration for the Bays Precinct's development to contribute "towards a globally competitive and resilient transformation" UrbanGrowth, 2015).

The Bays Precinct's offers a rich opportunity to operate as a trial precinct, and in so doing could nurture wider transport innovation through research and learning. Using the Bays as a trial site for shared first and last mile solutions could, further, stimulate early adoption and public acceptance of CAV via well-planned integration into land-use and infrastructure planning for the Bays, and for the wider city. The site is also well positioned to operate as a trial and research precinct on the embedded infrastructural requirements of CAV.

The scale of the site, its masterplanned nature, the large areas of land in government ownership (currently 80 has), and UrbanGrowth NSW's role as the master developer for the site represent a unique opportunity. UrbanGrowth NSW's networks across the NSW government departments and existing relationships with the university research sector provides a foundation from which to develop relations with the tech sector—across hardware and software dimensions—to underpin trials. Further, the landownership and controlled conditions of use of the site provide the potential to negotiate favourable and agile regulatory conditions to enable trialing CAV mobility options. The capacity to incorporate CAV conditions at the Bays in the planning and development phase provides an opportunity to simplify the environment around the CAV so vehicles can operate safely while in their trial phase, while allowing the environment to become more complex until the CAV is able to operate fully in traffic (Staysafe, 2016).

As the Inquiry into the social issues relating to land-based driverless vehicles in Australia (SCIISR, 2017) suggests, there are potentially significant barriers to the social acceptance of CAVs, particularly for shared mobility and in mixed fleet scenarios. These barriers circulate around perceptions of safety (trust) particularly in relation to the mixed fleet deployment of CAVs, concerns about data privacy (cybersecurity), and resistance to the disruption of 'sticky' cultural relationships with driving (aesthetic, affective) (Kyriakydis et al, 2015; Somers and Weeratunga, 2015). Indeed a key priority of the GATEway project in Greenwich is to advance understanding of "the public and industry perception and acceptance of automated vehicles" (https://gatewayproject.

org.uk/about/). GATEway trials include sentiment mapping techniques that track social media so as to gauge public response toexperiences. Residents and visitors are also able to provide feedback on their interactions with driverless shuttle on an interactive map. Similarly in the recently announced precinct trials in Australia, a concern has been to enact these trials to address public resistance to wider use of driverless technology, after a Royal Auto Association survey revealed that just 23 % of members surveyed responded that they would feel safe in an automated car (http://www.abc.net.au/news/2017-03-21/driverless-car-trial-at-adelaide-airport,-flindersuniversity/

8373006). Nonetheless, there is evidence that public acceptance of autonomous shuttle buses is more forthcoming (Jacobs, 2013). Public participation in trials can be one way of encouraging public interaction with CAV as a means of nurturing early adoption whilst simultaneously providing an important opportunity to gather information about how the public evaluates their experience of CAV mobility and its impacts for adoption. There is significant evidence that familiarity with CAVs and a demonstrated safety record is likely to enhance social, and thus political, acceptance (Tennent et al., 2016; Deloitte, 2017).

There is also potential to test a connected IoT environment. A connected IoT environment is one in which sensors and other electronic devices that can send and receive information are embedded into the urban environment, where they collect and communicate the information to a central database or across platforms. These sensors can be incorporated into physical infrastrucre such as road surfaces, traffic lights, and buildings and can also take the form of personal mobile devices such as smart phones. The capacity of connected devices relies on a much wider communication ecosystem facilitated by satellite and telecommunication networks (as below). Such connectivity is necessary for emerging and disruptive mobility trends, particularly mobility-as-a-service, which relies on real-time data collection and analysis to deliver efficient, co-ordinated and personalised mobility.

Activating the Bays as an site in which to trial multiple aspects of an innovative mobility eco-system is an opportunity to inform NSW and Australia's future transport planning needs and related aspirations to transition to more widerly automated transit systems. Through testing it could generate crucial knowledge around the urban design and infrastructure requirements to maximize the social, economic and environmental benefits of a transition to CAVs.

4. CAV OPPORTUNITIES: SHARED MOBILITY-ON-DEMAND FOR PASSENGERS AND LAST-MILE FREIGHT DELIVERY

One of the critical questions being asked by cities around the world is how CAV can be optimally integrated into planning processes and infrastructure provision. Given the long timescale of development in the Bays Precinct, planning for CAV needs to begin now. Yet urban design, infrastructure and planning responses to CAVs are still in their infancy, and transport plans and planners remain unaware or uncertain of the potentials and pitfalls of CAVs (Guerra 2016). Likewise, estimates of the take-up of CAVs are both tentative and variable (as section 2.3.2 outlined). Research on the adoption of automated technologies in other sectors (e.g. Strengers' (2013) work on the smart home) contains two pertinent lessons for the adoption of automated vehicles.

The first is that mobility aspirations and habits, much more so than technology per se, will shape the ways in which automated vehicles are taken up and how they shape cities. The second lesson is that automated technologies are disruptive, but that disruptions are opportunities to change mobility habits, as is evidenced on research on large scale disruptions like Olympic Games, or small scale disruptions like temporarily being without a car (Cass and Faulconbridge 2016). It is in this context that we sketch options and implications of CAV in the Bays.

How CAVs will play out in cities of the future may be dependent less on vehicle and transport infrastructure technologies than on the transitions made in transport and travel more broadly. Some, but not all, cities are already considering these implications, such as those outlined in Table 4.

Table 5: City Plans for CAV

City	Planning Document	CAV Components
Adelaide, Australia	Carbon Neutral Adelaide Action Plan 2016-2022	Encourage design and development of electric autonomous vehicles and infrastructure between 2017-2021
Columbus, USA	Smart City Grant (USDoT)	Fleet of autonomous vehicles as center of public transport strategy within connected infrastructure framework
Toronto, Canada	Driving Changes: Autonomous Vehicles in Toronto (Ticoll, 2015)	Report commissioned by the City of Toronto Transportation Services Division to inform their future planning initiatives around CAV
Boston, USA	Memorandum: Work Program for Planning for Connected and Autonomous Vehicles	Proposal for an 8 month, $50,000 examination of how CAVs can be implemented within Boston's Long-Range Transport Plan
Lyon, France	Lyon Smart City Plan	Driverless shuttle in eco-precinct
Dubai, UAE	Dubai White Paper: A Collaborative Approach to Smart City Transformation	Electric, renewable mobility highlighted as central aspect of Dubai's Smart City plan, aim to further extend existing connected infrastructure, autonomous public transport and smart parking apps
Singapore, Singapore	Smart Mobility 2030	Outlines existing data-based intelligent Transport strategy of sensors and smart infrastructure, and the development pathway for autonomous vehicles

4.1 Shared CAV as a Priority for the Bays

Ultimately, meeting the aspirations for the Bays will be more effectively served by CAV implementation as shared rather than individual transit. This is because, firstly, "between now and 2035, autonomous car fleets have great potential for increasing the market share of mobility-ondemand systems" (ifmo, 2017, p. 67). Secondly, it is aligned with the NSW Future Transport Strategy. Thirdly, the characteristics of the Bays make it well situated to adopt an approach in which CAV takes the form of shared autonomous first and last mile mobility services. The precinct is integrated with existing and planned public transport infrastructure (bus, light rail, ferry, metro) as well as roads. Hence issues of (i) intra-precinct mobility and (ii) first and last mile connectivity remain and will require resolution as the Bays evolves as a mixed use employment and residential area accessed by workers, residents and students. The mixed-used nature of proposed land use will produce diverse mobility needs across the day and night, lending itself to shared, on-demand CAV services. Such services might simultaneously: (i) resolve issues around intra-precinct and first and last mile mobility; (ii) augment the capacity of currently planned network investments while extending their catchment; and (iii) address wider aspirations to shift the modal mix away from private cars towards more socially and environmentally sustainable outcomes. Moreover, pursuing shared CAV first and last mile and intra-precinct mobility solutions at the Bays is fully consistent with UrbanGrowthNSW's aspiration to produce a Bays Precinct Comprehensive Transport and Mobility Plan based on the idea of the seven-minute city, characterized by short distances between housing, workplace, public spaces and multiple mobility options (UrbanGrowthNSW, 2015).

The first and last mile problem, defined as the "lack of adequate connectivity between transit stops and trip origin or termination points", has long been a critical factor in public transport utility and usage (Tilahun, Thakuriah, Li, & Keita, 2016, p. 359). In the public realm, multi-modal options, walking and cycling have traditionally been proposed solutions to improve this connectivity, however the viability and user-experience associated with these options continues to be an impediment to effective transport systems (Tight, Rajé, & Timms, 2016). For example, the quality and connectivity of pedestrian and cycling infrastructure varies considerably from city to city, issues that are exacerbated by personal and socio-cultural considerations of safety, comfort, and convenience (ibid.). The first and last mile problem can thus be seen as the problem of matching personal travel needs with the infrastructure of public transport. In the past, transport planning has proven ill-equipped to address first and last mile concerns, beyond, for example, the provision of 'park and ride' or a reliance on walking. It is within this framework that Sparrow and Howard (2017, p. 213) note that CAVs have the potential to combine with mass transit to overcome this issue of access that currently 'bedevils' public transport systems. The location, scale and innovative intent at The Bays, in combination with the advent of shared CAVs makes it possible to create Australia's first new precinct in which forms of transport other than the private car predominate.

The discussion of precinct trials above corresponds with the shared CAVs most appropriate to the Bays. To re-cap, these are low speed, low capacity, driverless shuttles. It may be that the aquatic vantage of the Bays Precinct site also opens up another avenue of autonomous vehicle – boats. Amsterdam is currently embarking on the world's first major research program on how autonomous floating vessels can be used to address questions of urban transport. A prototype 'Roboat' will be launched in 2017 and will be the foundation of research is also looking into using the CAVs to gather information about water quality and other environmental sensing, even using them to gather floating waste.

4.2 CAV for Last-Mile Delivery

Freight transport currently makes up around 16% of all road vehicle activity in our cities (Allen et al., 2017). Increasing urban density, a changing marketplace shaped by online shopping (Allen et al., 2017), and increasingly by app-based shopping that can be done from any smart device are increasing the prevalence of small parcel delivery within the freight sector (McKinsey 2016). A number of technologies are disrupting the traditional delivery model (allen et al 2017). McKinsey (2016b) predicts that in the next 10 years, 80 percent of parcel deliveries will be made by autonomous vehicles. Algorithms capable of maximizing delivery efficiency within dense urban areas mean that our cities will see the fastest and most effective implementation of this through autonomous ground vehicles with parcel lockers, drones, and bike couriers. In this forecast, CAVs (including drones) will deliver close to 100 percent of goods delivered directly to customers, and 80 percent of all items.

Table 6: The future of last mile deliveries, adapted from McKinsey (2016b)

Model	Method
Current	Delivery person transfers parcels between dedicated pick up point and customers using large vans.
Drones	Autonomous aircrafts can deliver parcels up to 15 kg to their destination along the most direct route and at relatively high average speed. Can be used for immediate deliveries, with estimates that one supervisor is required for every eight CAV aircraft.
Crowdsourcing	App-based task network in which deliveries can be crowdsourced. Potential for partnerships between existing services such as Uber to maximize road vehicle use.
Autonomous ground vehicles with lockers	Customers can track vehicle in real time, and be notified of specific delivery time Customers are notified of the exact arrival time and use a code to access the their parcel, like a portable mailbox. Estimates suggest that central supervisor could manage roughly eight to ten AGVs.
Bike couriers	Bike couriers deliver parcels point-to-point by bike, mostly for business-to-business documents, and prepared food.
Droids	Slow and small autonomous vehicles deliver parcels between businesses and customers using the sidewalk.
Semiautonomous ground vehicle	Use of autonomous road vehicle that allows delivery person to do alternate tasks instead of driving in order to increase efficiency of deliveries.

'Real world' applications of autonomous delivery are limited, with no rigorous evaluation of costs and benefits currently in existence. Nonetheless, there is obvious opportunity for delivery CAV in the Bays.

5. MASTERPLANNING IMPLICATIONS OF SHARED MOBILITY-ON-DEMAND FOR PASSENTERS AND LAST-MILE FREIGHT DELIVERY CAV

There is limited academic research on the detailed urban infrastructural and built form implications of CAVs in general (Guerra 2016), and of shared CAV and last-mile delivery CAV in particular. However, there is a proliferating 'grey' literature from think tanks and consultancies. This information, in combination with existing knowledge on best practice planning for multi-modal and shared mobility, highlights four issues to be considered in preparing for a CAV future:

- Limiting presence of the private car, unless for shared rides
- Transport infrastructure (roads, footpaths, bicyle paths) that is multi-modal and smart
- Transport interchanges appropriate to a smart and shared future
- adaptable building design

5.1 Limiting the Presence of the Private Car

Shared transport is most successful in precincts well served by public and active transit and in which travel by private automobile is either limited or prohibited (Kent and Dowling 2016). Thus for shared CAV to be successful in the Bays the presence of the privately-owned car in the precinct will need to be limited. Lessons can be learned from cities internationally that are actively implementing policies to reduce the presence of cars on their streets. The London congestion charging scheme is one example (Shove and Walker 2010), the recently implemented car-free Sundays in Paris is another. Oslo and Madrid, as shown in Table 7, are using a combination of measures to become car free. Notably, these plans do not take account of CAVs, but do include adopting well known measures and infrastructure for encouraging active travel.

Table 7: Examples of Limiting Presence of Private Cars

Place	Goal	Relevant examples
Oslo, pop. 600,000	Car free in the city centre by 2019	60 km of new bicycle lanes by 2019 $1 billion investment in public transport infrastructure - prioritising walking, then bicycles, then public transport modes. Special arrangements for service/delivery vehicles, and for vehicles for people with special needs Eliminating all on-street parking by the end of 2017 Existing downtown road pricing scheme
Madrid, pop. 3.2 mil	500 acres of city center car free by 2020	Redesign of 24 busiest streets for walking and cycling only. Commitment by Mayor to make Gran Via (major road/central hub) car-free by 2019 City introducing SER intelligent parking meters (prices vary with vehicle engine type/nitrogen dioxide emission levels/parking zone).

5.2 Policies to Encourage Shared Mobility-on-Demand

Many of the tools of smart mobility are being used worldwide to encourage the use of shared and on-demand transport. Referring back to the key elements of transport in Table 1 (means of access and ownership, business models, transport information, ticketing and payment, infrastructure), a number of policy options emerge. Infrastructures and traffic management systems that give priority to shared transport are important, as are campaigns to raise awareness of, and trust in, shared transport since it is unfamiliar to many. Currently, however, policies thata focus on ticketing and information are more common. These include the integration of public, private and shared transport options into trip planning apps (as undertaken in Los Angeles) or the inclusion of shared transport into integrated ticketing systems/cards (as in Los Angeles and North Carolina). There are also instances of subsidies being provided to those who use shared transit, discounted Lyft and/or Uber tickets to those who use these to and from transit stations, and in some residential districts payments to those who do not own a car. These policies involve all scales of government, including transit agencies, but local government is especially important for first-and-last mile journeys.

5.3 Transport Infrastructure that is Multi-Modal and Smart

Transport infrastructure in a CAV-focused future will be different to current infrastructure (Guala et al. 2015). Given the divergent opinions about the timeframe of CAV development, and the rapid pace of technological change in this sector, CAV-ready transport infrastructure cannot be definitively delineated. Nonetheless, a number of characteristics of shared CAV are accepted and are outlined here.

5.3.1 Street Design with a Focus on Footpaths rather than Roads

In a shared CAV environment, and with CAV in general, it is increasingly accepted that the amount of road space can be reduced for a number of overlapping reasons (Noyman 2017). These include: fully autonomous vehicles require reduced road width, shared CAV may replace private cars thus reducing the need for road space, the need for on-street parking is reduced (Noyman et al 2017). There is already considerable transport planning attention paid to mechanisms that reduce road space and increase space devoted to active travel and pedestrian precincts, summarized in the term 'road diet' (e.g Gudz et al., 2016). In a shared CAV environment, the characteristics of road diets could become standard, accompanied by building design elements as outlined below.

There will, however, be a transition period in which both autonomous and non-autonomous vehicles will operate in a precinct. In this period (which could be quite lengthy) the sharing of roads and roadrelated pace by different means of carriage will be accentuated. Conflict among users of shared spaces, whether they be footpaths (pedestrians, animals, cyclists etc) or roads (cyclists, cars, trucks) is perennial, and will need addressing in this transition phase. Speed remains a critical issue in the relationship between conflict and shared paths in urban areas (Hatfield and Prabhakharan, 2016; Nicholls et al., 2016). While it is expected that in a CAV-rich environment many of these conflicts will be resolved computationally (for example by autonomous vehicles avoiding pedestrian concentrations; Millard-Ball 2016), it is advisable for planning to minimize opportunities for conflict through separation of uses in the first instance.

5.3.2 Transport Interchanges

An environment in which first-and-last-mile shared CAV, active transport, and metro coexist will involve a dense network of transport interchanges between all these modes. Seamless interchange underpins successful public transport (both in terms of patronage and positive experience) (Chowdhury and Cedar 2015; Mees, 2010). Historically, this has been about timing and frequency of service, and more recently has been underpinned by the communication of information in real time through apps and the like. The built environment must support successful interchange between modes in order for shared CAV to work. Smart bus stops present a way of integrate new tech (e.g, solar energy), with urban/sensory design (e.g. water capture from roof to water green space) with integration of mobility options (e.g. bike parking at bus stop as first and last mile service) with smart tech (e.g. customised transport info) and collaborative innovation (new business opportunities). Table 8 below provides information on recent developments in smart bus stops, highlighting their role in providing solar-powered USB charging ports, Wi-Fi hot spots and innovative means of displaying information.

Table 8: Bus stops as Smart Infrastrucure

Where	Initiators/Partners	Features
Auckland, New Zealand The Smart Shelter	Downer with Alcatel-Lucent, Chorus, Metshelter, Solta, Samsung	Wifi, charging ports, integrated and personalised transit info and booking service in real time, touchscreen information access, area information, security
Dubai, UAE Smart shelter	In2Consulting (communications agency), Al Shamil Foodstuff Trading, Dubai Roads & Transport Authority (RTA)	24-hour operation, real-time transit information, food/ beverage/product kiosk, charging station, utilities payment , free wifi, air-conditioned waiting area
Singapore, Singapore Project Bus Stop	Infocomm Development Authority of Singapore, Land Transport Authority, National Parks Board and Urban Redevelopment Authority, DP Architects	Free wifi, e-books for download, a swing, device charging facilities, interactive smart boards, green roof with fragrant native plants, with rainwater storage for watering, bike parking, local artwork, real-time personalized transport info, access features with universal design
Sydney, Australia	Prototype winner of Climate Adapted People Shelter (CAPS) competition project. MM Creative, Penrith City Council. NSW government funding	Ventilation and shade which can be adjusted seasonally, local artwork, Opal hub that allows top-ups, public wifi, solar powered, speakers and information service, security CCTV, live tracking of buses, colour system to signal vicinity of bus, rainwater management and plant system with planter boxes, Modular design that allows adaption to weather conditions and user needs
Paris, France	Paris City Council, JCDecaux's subsidiary SOPACT, Marc Aurel (Designer)	Interactive touch-screens showing maps that highlight municipal facilities or Vélib' self-service bicycle hire, signal masts that are offset so that the type of shelter (bus, sightseeing line, taxi, airport shuttle) and the waiting time for the next service can be read from a distance, tactile labels and a button for voice announcement of waiting times, illuminated information panels at night; USB ports for device charging, wheelchair access to 100 large touchscreen digital information and service panels, 100 roofs fitted with solar panels and 50 with green roofs
Croatia Easy Bus	Energomobil (Solar power company)	Solar powered lighting, charging facilities for devices, wifi
Los Angeles, USA	City of Los Angeles, Outfront/ JC Decaux, Soofa (MIT design company).	Solar-powered, device charging USB ports, LED lighting, real-time travel information for busses, wifi hotspot

Figure 3: Singapore's Project Bus Stop (Singapore Ministry of National Development, 2016)

Figure 4: Gare de Lyon bus stop in Paris (ArchiExpo, 2016)

5.3.3 Parking

There is considerable speculation on the parking implications of potential CAV adoption scenarios. A study by Zhang et al. (2015) suggests that shared CAVs may be able to eliminate up to 90% of parking demand for clients who adopt the system, even at a low market penetration rate of 2%. A WSP/ Farrels Whitepaper entitled Making Better Places: Autonomous Vehicles and Future Opportunities used local government figures to suggest that a 100 ha CAV development zone in central London could result in approximately £1.25 billion in local land value. This was replicated ito find that such a development would result in a £300 million value addition in outer London, or a £15-£75 million across the majority of the rest of the UK. Parking plays a large role in this uptake of value as a result of increased greenspace potential and higher air quality resulting from a 30% -45% reduction in circulating traffic that currently results from drivers searching for parking spaces. The parking implications of a CAV future, with models suggesting up to a 15% reduction in required parking space if CAV use remained private (Bertoncello and Wee, 2015), resulting in 15-20% more developable area in the city (Skinner and Bidwell, 2016). Alternately, highly shared, roaming CAVs would result in up to 80% in parking demand (Martinez and Crist, 2015), and could contribute to up to 12% reduction in used road space (Ambühl et al., 2016).

As Miller and Head (2016) note, regardless of whether CAVs are primarly privately owned and thus travel unoccupied, or whether they are integrated into on-demand, shared business models, large scale adoption will reduce the footprint of parking since they can double-park themselves in smaller spaces. The potential for continuous circulation, more accurate and efficient parking means that the displacement of parking requirements will occur alongside reduction. For example, the preliminary research of Zhang et al. (2017) on the parking implications of CAV adoption in the City of Atlanta found that not only would they likely reduce parking land by up to 4.5%, they would also change paid parking use by shifting demand away from the main urban centre and into adjacent low-income neighbourhoods. Applying these findings to the Bays Precinct context highlights the potential negative flow on effect to surrounding neighourhoods of not adequately planning for and providing parking for the precinct. It is within this context that the necessity for adaptable building design becomes crucial. Shared CAVs will likely reduce the need for on-street parking as mobility by private car is foregone for shared CAV mobility. There is then a likely reduced need for on-street parking. There will, however, be an increased need for pick-up and drop-off spaces along curbs.

5.4 Considerations for Building Design

Considering the variety of adoption scenarios for CAVs and the associated impacts large scale use will have on parking and land use, it is critical that urban planning apply principles of adaptable design where possible. This will allow urban developments to meet the needs of the present while anticipating the changing needs of the future. Adaptable building design – facilitating buildings which can cater for a diversity of uses over their lifespan - is desirable from many planning perspectives, including CAV (Gosling et.al. 2008). Adaptibility in this sense becomes "a design characteristic that embodies spatial, structural, and service strategies which allow the physical artefact a level of malleability in response to changing operational parameters over time." (Schmidt et al., 2010: 17).

There are a number of elements of building adaptability that will be emphasized by CAV, though again it is important to recognize that much of these implications are not yet fully understood. Driveways as the predominate building-street interface may give way to pick-up/drop-off/waiting interfaces. Autonomous last mile delivery CAV is being incorporated into building design through elements such as a 'drone landing pad', evident in the amenity deck of the recently completed Ten50 apartment complex by Tremark Urban in Los Angeles. A significant barrier to an electric CAV future continues to be inadequate public charging infrastructure (Anderson, Lehnes and Hardinghau, 2017). Thus some consideration of charging must be anticipated and accounted for in new building design. Attention to constructing 'smart' buildings is also required. Connected autonomous vehicles communicate with nearby vehicles, road and other urban infrastructure. Buildings are a critical component of urban infrastructure, and embedding sensors etc into buildings will facilitate CAV.

The parking implications of CAV adoption are beginning to be considered in adaptable building designs. The city of Somerville are part of a partnership to create a CAV garage that can accommodate sixty percent more vehicles than a traditional parking facility of equivalent size (Meier-Burkert, 2015). In June, Daimler and Bosch demonstrated fully autonomous valet parking in the garage of the Mercedes-Benz Museum in Stuttgart, and suggest that any car parking facility can be retrofitted for CAVs and increase their capacity by up to twenty percent (Daimler, 2017). An office-park and mixed-use development is currently under consideration outside Nashville, with underground parking facilities that are being built to smaller specifications to account for the increased parking efficiency of future CAVs (Sisson, 2016). CAV parking efficiencies may be combined with a shift away from parking altogether, meaning that carparks may not only be smaller, but potentially made redundant. In Los Angeles, a development is proposed in which two levels housing a 1,000-car parking garage are being designed to eventually convert into retail or office space (Vincent, 2017). The traditional slanted garage floors and low ceilings will be redesigned to accommodate the eventual transition. In addition, elevators and stairs will be placed in office-ready configurations and knock-out panels will be inserted in the ceiling, walls and floors to create future light wells and windows.

SUMMARY AND RECOMMENDATIONS

Peer-reviewed literature on the urban policy and planning implications of CAV is in its infancy but is beginning to chart the planning implications of CAV. In reviewing this literature, we recommend that the following implications be carefully considered in processes of planning for the Bays Precinct.

1. *The Bays' potential as a hub for transport innovation, working across the full breadth of the transport innovation ecosystem. This would both align with the NSW Department of Industry's imperative to better understand the nature of innovation ecosystems and present the opportunity to pursue this through the Bays (TfNSW 2016).*
2. *The Bays' potential as a site for trialling CAV, in particular public acceptance and infrastructural requirements.*
3. *Shared, first-and-last-mile CAV for passenger and autonomous last-mile delivery are most likely and appropriate within the precinct. There is an innovation opportunity to create Australia's first new precinct in which forms of transport other than the private car predominate.*
4. *Shared CAV implies a reduction in quantities of road space, provision of smart transport interchanges and separated infrastructure in the transition phase.*
5. *Shared CAV will reduce on- and off-street parking requirements.*
6. *Building design that is adaptable and smart will better cater to a transition to CAV.*
7. *The possibilities of negative equity and environmental implications of CAV are real. The core role of government in the Bays provides the opportunity to ensure that development of any such transport innovation activity prioritises public benefit, and can work to ensure that access, equity, social inclusion and environmental are considered at all stages of the integration of CAV into the wider transport system.*

REFERENCES

Allen, J., Piecyk, M., & Piotrowska, M. (2017). **An Analysis of Online Shopping and Home Delivery in the UK**. Freight Traffic Control (FTC) 2050 Project. Retrieved from http://www.ftc2050.com/reports/Online_shopping_and_home_delivery_in_the_UK_final_version_Feb_2017.pdf

Ambühl, L., Ciari, F., & Menendez, M. (2016, May). **What about space? A simulation based assessment of AVs impact on road space in urban areas**. In 16th Swiss Transport Research Conference (STRC 2016),(Swiss Transport Research Conference (STRC)).

Anderson, J. E., Lehne, M., & Hardinghaus, M. (2017). **What electric vehicle users want: Real-world preferences for public charging infrastructure, International Journal of Sustainable Transportation**, DOI: 10.1080/15568318.2017.1372538

ArchiExpo (2016). **Gare de Lyon smart Shelter**. Image retrieved http://www.archiexpo.com/prod/metalco/product-56172-1653762.html

Bertoncello, M., & Wee, D. (2015). **Ten ways autonomous driving could redefine the automotive world**. Retrieved from McKinsey & Company website: http://www. mckinsey. com/insights/automotive_and_assembly/ten_ways_autonomous_driving_could_redefine_the_automotive_world.

Cass, N., & Faulconbridge, J. (2016). **Commuting practices: New insights into modal shift from theories of social practice**. Transport Policy, 45, 1-14.

Chowdhury, S., & Ceder, A. A. (2016). **Users' willingness to ride an integrated public-transport service: A literature review**. Transport Policy, 48, 183-195.

Clayton Utz (2016) **Driving into the Future: Regulating Driverless Vehicles in Australia**. Available from https://www.claytonutz.com/articledocuments/178/Clayton-Utz-Driving-into-the-future-regulatingdriverless-vehicles-2016.pdf.aspx?Embed=Y

Daimler (2017). **Bosch and Daimler demonstrate driverless parking in real-life traffic: World premiere in the multi-storey car park of the Mercedes Benz Museum**. Retrieved from http://media.daimler.com/marsMediaSite/en/instance/ko/Bosch-and-Daimler-demonstratedriverless-parking-in-real-life-traffic-World-premiere-in-the-multi-storey-car-park-of-the-Mercedes-Benz-Museum.xhtml?oid=23076118

Deloitte (2017), **What's ahead for fully autonomous driving – consumer opinions on advanced vehicle technology**, https://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/usmanufacturing-whats-ahead-for-fully-autonomous-driving.pdf

Department of the Prime Minister and the Cabinet (2016). **Smart Cities and Suburbs Program**. Accessed online at https://cities.dpmc.gov.au/smart-cities-program

Dowling, R., & Kent, J. (2013, November). **The challenges of planning for autonomous mobility in Australia**. In Sixth State of Australian Cities Conference.

Duvivier, C., & Polèse, M. (2017). **The great urban techno shift: Are central neighbourhoods the next silicon valleys?** Evidence from three Canadian metropolitan areas. Papers in Regional Science.

Energy Information Administration (EIA). (2017). Annual Energy Outlook Retrieved from https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf:

European ITS Platform. (2014). Image accessed from: https://www.its-platform.eu

Fagnant, D. J., & Kockelman, K. (2015). **Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations**. Transportation Research Part A: Policy and Practice, 77, 167-181.

Ferilli, G., Sacco, P. L., Tavano Blessi, G., & Forbici, S. (2017). **Power to the people: when culture works as a social catalyst in urban regeneration processes** (and when it does not). European Planning Studies, 25(2), 241-258.

Fishman, E., Washington, S., & Haworth, N. (2014). **Bike share's impact on car use: evidence from the United States, Great Britain, and Australia**. Transportation Research Part D: Transport and Environment, 31, 13-20.

Fox SJ 2016 **Planning for Density in a Driverless World**. Georgetown University Law Centre. Available from http://scholarship.law.georgetown.edu/ipr_papers/1

Fraedrich, E., Beiker, S., & Lenz, B. (2015). **Transition pathways to fully automated driving and its implications for the sociotechnical system of automobility**. European Journal of Futures Research, 3(1), 11.

Freedman, M., Calloway, E., & Tung, G. (2013). **Next City: City Design and Urban Planning Innovation for the New Era. Smart Growth Network: National Conversation on the Future of Our Communities**.

Guala, L., Alessandrini, A., Sechi, F., Site, P. D., Holguin, C., & Salucci, M. V. (2015). **Testing autonomous driving vehicles in a mixed environment with pedestrians and bicycles**. 22nd ITS World Congress. No. ITS-2060).

Guerra E (2016) **Planning for Cars That Drive Themselves: Metropolitan Planning Organizations, Regional Transportation Plans, and Autonomous Vehicles, Journal of Planning Education and Research**, 36(2) 210–224

Gudz, E. M., Fang, K., & Handy, S. L. (2016). **When a diet prompts a gain: impact of a road diet on bicycling in Davis, California. Transportation Research Record: Journal of the Transportation Research Board**, (2587), 61-67

Goldberg-Miller, S. B., & Heimlich, J. E. (2017). **Creatives' expectations: The role of supercreatives in cultural district development**. Cities, 62, 120-130.

Institute for Mobility Research (ifmo). (2017). **Autonomous Driving: The Impact of Vehicle Automation on Mobility Behaviour**. Accessed online at: http://www.ifmo.de/tl_files/publications_content/2016/ifmo_2016_Autonomous_Driving_2035_en.pdf

Issac, L. (2016). **Driving towards driverless: A guide for government agencies. WSP Parsons Bickerhoff**. Accessed online at http://www.wsppb.com/Globaln/USA/Transportation%20and%20Infrastructure/driving-towards-driverless-WBPFellow-monograph-lauren-isaac-feb-24-2016.pdf

Jacobs (2013c), **"Autonomous Vehicles – The Next Revolution: Part 3 – The Challenges"**, http://manage.globalskm.com/Insights/Achieve-Articles/Items/2013/Autonomous-vehicles-thenext-revolution-challenges.aspx accessed 24 November 2014.

Katz, B. and Wagner, J. (2014). **The Rise of Innovation Districts: A New Geography of Innovation in America. Brookings Institute**. Accessed online at: https://www.brookings.edu/wpcontent/uploads/2016/07/InnovationDistricts1.pdf

Kent, J. L., & Dowling, R. (2013). **Puncturing automobility? Carsharing practices**. Journal of Transport Geography, 32, 86-92.

Kent, J. L., & Dowling, R. (2016). **The Future of Paratransit and DRT: Introducing Cars on Demand. In Paratransit: Shaping the Flexible Transport Future** (pp. 391-412). Emerald Group Publishing Limited.

Kyriakidis M, Happee R , De Winter JCF (2015) **Public opinion on automated driving: Results of an international questionnaire among 5000 respondents Transportation Research** Part F, 32, 127-140

Landry, R., & Amara, N. (2012). **Dilemmas of practice-based innovation policy-making. In Practice-Based Innovation: Insights, Applications and Policy Implications** (pp. 65-89). Springer Berlin Heidelberg.

Litman, T. (2014). **Autonomous vehicle implementation predictions**. Victoria Transport Policy Institute, 28.

MacDonald, J. (2016). **Electric Vehicles o be 35% of Global New Car Market by 2040** Retrieved from http://www.bbhub.io/bnef/sites/4/2016/02/BNEF_EV-Forecast_2016_FINAL.pdf: Marshall, D., Smith, K., and Chysler, S. (2014). Older Drivers' Acceptance of In-vehicle Systems and the Effect it has on Safety. Mid-America Transportation Center (MATC)

Martinez, L., & Crist, P. (2015). **Urban Mobility System Upgrade–How shared self-driving cars could change city traffic**. In International Transport Forum, Paris. OECD. Retrieved from https://www.itfoecd. org/sites/default/files/docs/15cpb_self-drivingcars.pdf

McDonald, K. C. (2017). **Harbouring the City of Sydney's Fluid Renaissance: Incorporating Community, Creativity and Collaboration**. In Entrepreneurial Renaissance (pp. 47-55). Springer International Publishing.

McKinsey Report. (2016a). **An integrated perspective on the future of mobility**. Accessed online at: http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/ourinsights/an-integrated-perspective-on-the-future-of-mobility

McKinsey Report (2016b). **Parcel Delivery. The Future of Last Mile**. Acessed online at http://www.mckinsey.com/~/media/mckinsey/industries/travel%20transport%20and%20logistics/our%20insights/how%20customer%20demands%20are%20reshaping%20last%20mile%20delivery/parcel_delivery_the_future_of_last_mile.ashx

Meek A (2015) **University of Michigan's Mcity I paving the road for the future of transportation** https://www.theguardian.com/general-motors-partner-zone/2016/nov/18/university-michiganmcity-automated-road-driverless-cars).

Mees, P. (2010). **Transport for Suburbia: Beyond the Automobile Age**. New York: Earthscan.

Meier-Burkert, F. (2015, November). **Somerville will be a test laboratory for the future of urban mobility**. Retrieved from http://audi-urban-future-initiative.com/en/blog/somerville-test-laboratoryfuture-urban-mobility

Mladenovic, M. N., & McPherson, T. (2016). **Engineering social justice into traffic control for selfdriving vehicles?**. Science and engineering ethics, 22(4), 1131-1149.

National Transport Commission (NTC). (2016). **Regulatory reforms for automated road vehicles: Policy Paper** Retrieved from https://www.ntc.gov.au/Media/Reports/(32685218-7895-0E7C-ECF6-551177684E27).pdf:

Noyman, A., Larson, K., & Stibe, A. (2017). **Roadmap for Autonomous Cities: Sustainble Transformation of Urban Spaces**. Twenty-third Americas Conference on Information Systems, Boston, 2017. Retrieved from https://static1.squarespace.com/static/537a1f91e4b0ccfe943c6bc6/t/5901fe003e00be4005c2e9d4/1493302787154/Stibe_2017a_Autonomous_Cities.pdf

Obschonka, M., Stuetzer, M., Gosling, S. D., Rentfrow, P. J., Lamb, M. E., Potter, J., & Audretsch, D. B. (2015). **Entrepreneurial Regions: do macro-psychological Cultural Characteristics of Regions help solve the "Knowledge Paradox" of Economics?**. PloS one, 10(6), e0129332.

Pietras, B. (2015). **New frontiers in driverless vehicles. Engineering & Technology**, 10(3), 64-67.

Rayle, L., Dai, D., Chan, N., Cervero, R., & Shaheen, S. (2016). **Just a better taxi? A survey-based comparison of taxis, transit, and ridesourcing services in San Francisco**. Transport Policy, 45, 168-178.

Science and Technology Select Committee (STSC). (2017). **Connected and Autonomous Vehicles: The future?** Retrieved from https://www.publications.parliament.uk/pa/ld201617/ldselect/ldsctech/115/115.pdf: Shove, E., & Walker, G. (2010). Governing transitions in the sustainability of everyday life. Research policy, 39(4), 471-476.

Singapore Ministry of National Development (2016). **Project Bus Stop**. Image retrieved online at https://www.mnd.gov.sg/

Sisson, P. (2016, August). **Why high-tech parking lots for autonomous cars may change urban planning**. Retrieved from https://www.curbed.com/2016/8/8/12404658/autonomous-car-futureparking-lot-driverless-urban-planning

Skinner, R., & Bidwell, N. (2016). **Making Better Places: Autonomous vehicles and future opportunities**. WSP Parsons Brinckerhoff in association with Farrells Retrieved from http://www.wsp-pb.com/Globaln/UK/WSPPB-Farrells-AV-whitepaper.pdf .

Somers A and Weeratunga K 2015 **Automated Vehicles: Are We Ready?**, Internal Report on Potential Implications for Main Roads WA, Main Roads, Western Australia. Retrieved from https://www.mainroads.wa.gov.au/Documents/Automated%20Vehicle%20Report.RCND15%5E2381741.PDF

Sparrow, R., & Howard, M. (2017). **When human beings are like drunk robots: Driverless vehicles, ethics, and the future of transport**. Transportation Research Part C: Emerging Technologies, 80, 206-215.

Staysafe (Joint Standing Committee on Road Safety). (2017). **Driverless Vehicles and Road Safety in NSW**. Retrieved from https://www.parliament.nsw.gov.au/committees/listofcommittees/Pages/committeedetails. aspx?pk=186

Standing Committee on Industry, Innovation, Science and Resources (SCIISR). (2017). **Inquiry into the Social Issues Relating to Land-Based Driverless Vehicles in Australia** Accessed online at: http://www.aph.gov.au/Parliamentary_Business/Committees/House/Industry_Innovation_Science_ and_Resources/Driverless_vehicles

Stewart, J. (2017). **Mapped: Top 263 companies racing toward autonomous cars**. Wired. Accessed online at: https://www.wired.com/2017/05/mapped-top-263-companies-racing-towardautonomous- cars/

Strengers, Y. (2013). **Smart energy technologies in everyday life: Smart Utopia?**. Springer.

Sun, Y., Olaru, D., Smith, B., Greaves, S., & Collins, A. (2017). **Road to autonomous vehicles in Australia: an exploratory literature review**. Road and Transport Research, 26(1), 34-47.

Switkes, J. P., & Boyd, S. (2016). **Connected Truck Automation. In Road Vehicle Automation 3** (pp.195-200). Springer International Publishing.

Ticoll, D. (2015). **Driving changes: Automated vehicles in Toronto**. Retrieved from https://www1.toronto.ca/City%20Of%20Toronto/Transportation%20Services/TS%20Publications/Reports/Driving%20Changes%20Final%20(compressed).pdf: Tennant, C. et al (2016), Autonomous vehicles – negotiating a place on the road, London School of Economics & Goodyear, http://www.lse.ac.uk/website-archive/newsAndMedia/PDF/AVsnegociating-a-place-on-the-road-1110.pdf

Tight, M., Rajé, F., & Timms, P. (2016). **Car-Free Urban Areas: A Radical Solution to the Last Mile Problem or a Step Too Far?** Built Environment, 42(4), 603-616.

Tilahun, N., Thakuriah, P. V., Li, M., & Keita, Y. (2016). **Transit use and the work commute: Analyzing the role of last mile issues.** Journal of Transport Geography, 54, 359-368.

TfNSW. (2016). **Future Transport Technology: Roadmap 2016**. Future Transport NSW. Accessed online at: https://future.transport.nsw.gov.au/wp-content/uploads/2016/11/Future-Transport-Technology-Roadmap_2016__.pdf

TfNSW (2017). **The Bays Precinct Working Group** (Discussion Presentation). Classified as sensitive – not for distribution.

UrbanGrowth. (2012). **Bays Precinct Strategic Framework: Report to the NSW Government**. Retrieved fromhttps://www.shfa.nsw.gov.au/content/library/documents/64ABF9E4-DBCA-41B5-6D1E70219BC62AD6.pdf.

UrbanGrowth. (2015). **The Bays Precinct Sydney: Transformation Plan** Retrieved from www.thebayssydney.com.au:

UrbanGrowth. (2017). **The Bays Precinct Urban Transformation Program Factsheet**. Retrieved from http://www.urbangrowth.nsw.gov.au/assets/Uploads/MUTP-UrbanGrowth-NSW-factsheet-The-Bays-Precinct-2017.pdf:

Vincent, R. (2017, April). **When car ownership fades, this parking garage will be ready for its next life**. Los Angeles Times. Retrieved from http://www.latimes.com/business/la-fi-car-future-real-estate-20170405-story.html.

Wadud, Z. (2017). **Fully automated vehicles: A cost of ownership analysis to inform early adoption**. Transportation Research Part A: Policy and Practice, 101, 163-176.

Landcom
Level 14, 60 Station Street
Parramatta NSW 2150
PO Box 237 Parramatta NSW 2124
P: 9841 8600

landcom.com.au