How Autonomous Vehicles Will Support the Unstoppable Rise of the City

David Pearce

Partner, MinterEllison
david.pearce@minterellison.com

Abstract: *The widespread adoption of Autonomous Vehicles promises to radically transform public and private transportation. Driverless cars and other forms of Autonomous Vehicles will fundamentally alter how we move about our cities, and also change cities themselves. While there is a risk that Autonomous Vehicles will actually make cities less liveable and promote de-centralization, the more likely outcome appears to be that Autonomous Vehicles will significantly contribute to urbanisation and the unstoppable rise of the city.*

This paper explains the current state of play with Autonomous Vehicles, and predicted timelines for their widespread rollout. The authors discuss how Autonomous Vehicles are likely to impact congestion, our road networks and our cities more generally. Consideration is given to our changing legal and regulatory landscape, and the critical role that regulators will have in delivering public benefits from Autonomous Vehicles, particularly through promoting a shared model of Autonomous Vehicle usage and autonomous, and connected public transport systems which solve the 'first and last mile' challenge.

Stream: *The unstoppable rise of the city*

Keywords: *Autonomous vehicles, roads, cities, car parking, infrastructure, planning, funding, liability, regulation.*

Urbanisation and the Challenges for Cities

Urbanisation is a core component of economic and social development.[1] Through the benefits of 'agglomeration economics',[2] the city has been described as the 'engine room' of a modern economy. The global movement of people towards cities continues to accelerate. At the turn of the 20th century, 20% of the world's population lived in urban areas,[3] but by 1999 this had risen to approximately 50%.[4] The world's urban population is growing by 60 million per year, and by 2050 it is estimated that two thirds of the world's population will live in a city.[5] In Australia this trend is even more pronounced, with 85% of our population now living in cities.[6]

The unstoppable rise of the modern city is inhibited by factors intrinsically tied to population growth, key among them being increased pollution and traffic congestion.[7] Both reduce the amenity of a city and its attraction to residents, and congestion significantly reduces productivity. A recent audit of Australia's road network infrastructure confirmed that our urban road networks are facing increasing pressure as populations grow, and growing road congestion is causing substantial economic and social costs.[8] The current urbanization model, which largely favours low-density arrangements and an over-reliance on industrialized forms of transport, is contributing to pollution, urban sprawl, and the diminishing the economic benefits of agglomeration.[9]

Just as the advent of mass public transport and the introduction of the modern automobile allowed our cities to expand their boundaries in the past,[10] Autonomous Vehicles (**AVs**) have the potential to transform our modern cities and permit them to grow beyond their current limitations. The widespread adoption of connected AVs has the potential to bring about great improvements in the efficiency of our transport networks, and reduce their environmental impacts, particular if the uptake of AVs is accompanied by the predicted rise in electric cars and shared vehicle ownership or other forms of Mobility as a Service (**MaaS**).

---

[1] See generally, Department of Economic and Social Affairs, The United Nations, 'World Urbanization Prospects – Highlights' (2014), available at <https://esa.un.org/unpd/wup/Publications/Files/WUP2014-Highlights.pdf>.
[2] Edward Glaeser, 'Introduction' in Edward Glaeser (eds), *Agglomeration Economics* (The University of Chicago Press, 2010) 1, available at <http://www.nber.org/chapters/c7977.pdf>.
[3] The World Health Organisation, *Hidden cities: Unmasking and overcoming health inequities in urban settings* (2010) 4, available at <http://www.who.int/kobe_centre/publications/hiddencities_media/ch1_who_un_habitat_hidden_cities.pdf?ua=1>.
[4] United Nations Population Fund, *Global Trend Towards Urbanisation*, (2010) UNESCO Teaching and Learning for a Sustainable Future <http://www.unesco.org/education/tlsf/mods/theme_c/popups/mod13t01s009.html>.
[5] Above n 1, 1.
[6] itsaustralia, 'Smart Transport for Australia: enhancing liveable cities and communities' (Report, itsaustralia, March 2017) 29.
[7] Above n 3, 7; see generally NRMA, 'Accelerating Our Smart Transport Future' (Report, NRMA, 2016), available at < https://www.mynrma.com.au/images/About-Education/Accelerating_our_Smart_Transport_Future.pdf>.
[8] Above n 7, NRMA, 5-8.
[9] World Economic Forum, 'Inspiring Future Cities & Urban Services: Shaping the Future of Urban Development & Services Initiative' (2015) 3, available at ,http://www3.weforum.org/docs/WEF_Urban-Services.pdf>.
[10] Praveen Thakur, Robert Kinghorn, Renan Grace, 'Urban form and function in the autonomous era' (Paper presented at the Australasian Transport Research Forum, Melbourne, 18 November 2016) 2, available at <http://atrf.info/papers/2016/files/ATRF2016_paper_138.pdf>.

AVs will also transform the current cityscape as our reliance on certain existing infrastructure, carparks key among them, decreases. Beyond this, the introduction of AVs will have wide reaching impacts on many aspects of society; shifting the emphasis when it comes to the creation and maintenance of transport infrastructure, and bringing about a raft of legal issues to be solved. These issues are discussed further below.

The 'Levels' of Autonomy

While the term 'Autonomous Vehicle' can refer to many different things, it is commonly understood that '*an Autonomous Vehicle is one that is capable of completing journeys safely and efficiently, without a driver, in all normally encountered traffic, road and weather conditions*'.[11] While this describes the 'pinnacle' of AV technology, there are many different levels of vehicle automation. The Society of Automotive Engineers International has published the '*Taxonomy and Definitions for Terms Related to On-Road Motor Vehicle Automated Driving Systems*' which sets out the following 6 levels of driving automation from 'no automation' to 'full automation':

(a) Level 0 – no automation – full time performance by the human driver;

(b) Level 1 – driver assistance – an automated system on the vehicle can sometimes assist the human driver with either steering, or acceleration/ deceleration;

(c) Level 2 – partial automation – human driver but an automated system can actually conduct some parts of the driving task - both steering and acceleration/ deceleration;

(d) Level 3 – conditional automation – driving undertaken by an automated system with human drivers required to intervene as necessary;

(e) Level 4 – high automation – driving undertaken by an automated system under certain conditions/ environments with backup systems in place if human driver does not respond to request to intervene; and

(f) Level 5 – full automation – no requirement for human intervention.

Intelligent Transport Systems

Vehicles are only one side of the coin when it comes to realising the true potential of AV technology. If AVs represent the core hardware in our future road networks, the supporting software will be 'Intelligent Transport Systems' (**ITS**). These are advanced information and communications technologies which deliver safer, more efficient and environmentally sustainable transport.[12] ITS encompasses more than any single AV, and includes notions such as vehicle-to-vehicle (V2V) communications, vehicle-to-infrastructure (V2I) communication, and ultimately vehicle-to-everything (V2X) communications.

V2X envisions that AVs will be able to communicate with fellow AVs, network infrastructure such as intersection and roadside management, and finally other road users and devices.[13] With a fully integrated ITS, data will be continuously collected through the network of sensors and AVs about traffic flow and congestion, as well as road usage patterns. In the future this will permit an improved smoothing of traffic flow and network volume, targeted investment and maintenance into transport infrastructure, more accurate means of funding and tolling, and efficient autonomous ride sharing services.[14]

The Current State of Play

Many current vehicles already carry technology falling within levels 1 and 2 of the above SAE taxonomy. Adaptive cruise control is an example of a level 1 technology, and certain vehicles currently on the market possess level 2 technologies such as 'self-parking' or 'autopilot assist', which allow the car to steer, accelerate and brake whilst requiring a human driver in control of the vehicle.[15] As for when the remaining levels of automation in vehicles will be rolled out, there are differing opinions.

---

[11] WSP Parsons Brinckerhoff and Farrells, 'Making better places: Autonomous Vehicles and future opportunities' (Report, 2016) 6.
[12] Above n 6, 15.
[13] Ibid.
[14] See generally above n 6; Infrastructure Australia, 'Australian Infrastructure Plan' (Report, Australian Government, February 2016) 51; Accenture, 'The new road to the future: realising the benefits of autonomous vehicles in Australia' (Report, 2014) available at <https://www.accenture.com/t00010101T000000__w__/au-en/_acnmedia/Accenture/Conversion-Assets/DotCom/Documents/Local/en-gb/PDF_3/Accenture-Realising-Benefits-Autonomous-Vehicles-Australia.pdf#zoom=50>.
[15] Jane Cowan, 'Driverless cars: Everything you need to know about the transport revolution', *ABC News* (Online), 11 March 2017 <http://www.abc.net.au/news/2017-03-11/everything-you-need-to-know-about-driverless-cars/8336322>.

The more objective commentators suggest that while vehicles capable of urban autopilot (level 4) might be available from as early as 2022,[16] level 5 AVs meeting the above definition are unlikely to be in production until the mid-2020's.[17] Many of the leading automotive companies are, however, suggesting that this timeframe will be much shorter.[18] Audi, Toyota and Nissan promise a level 4 AV by 2020,[19] Ford suggests it will have a fully self-driving vehicle by 2021,[20] and perhaps most ambitiously; Mercedes believe we will see level 5 AVs at the start of the next decade.[21]

While technology, economics and consumer behaviour will drive the mass uptake of AVs, the law will also play an important part. Regulators in Australia and around the world are currently engaged in the process of updating their laws governing vehicle standards, operation and insurance in order to safety facilitate the adopting of new technologies.[22] While major technology developments are being led out of the United States, Asia, and Europe, Australia is supporting the testing and trialling of AV technology.[23] In 2015 South Australia conducted the first on-road trial of AVs in the Southern Hemisphere,[24] and since then many local road agencies have begun investing in their own AV and ITS programs.[25] Yet highly or fully automated vehicles cannot operate legally on public roads without the various state road agencies providing the necessary legislative exemptions to organisations seeking to run AV trials.[26] In response to the ongoing trials of AV technology, in November 2016 the National Transport Commission of Australia (**NTC**) set out to develop national guidelines for on-road trials of AV technology in an attempt to harmonise the process and '*promote Australia as a test bed for [AVs]*',[27] and in May 2017 the NTC delivered its '*Guidelines for trials of automated vehicles in Australia*' which offer a framework for future trials.[28]

Internationally it is a similar story. In January 2016 the United States proposed spending $4 billion over the next 10 years on research and infrastructure to promote driverless cars, and in late 2016 the US Department of Transport set out its Federal Automated Vehicle Policy which covered topics like regulation, registration and certification, privacy and system safety.[29] Europe has been slower to adopt, largely in part to restrictive regulations which require that a driver remain in control of any vehicle travelling faster than 10km per hour,[30] however the first European AV trials occurred in February throughout London,[31] and the first European Conference on Connected and Automated Driving took place in April,[32] signalling Europe's willingness to adopt AV technology.

AVs are big business!

While AVs promise to disrupt their existing business model, leading automotive manufacturers appear to have accepted this is inevitable and are vying to be the leader in this field. General Motors and Ford have each spent approximately $1 billion purchasing software and technology companies who are developing AV technology, and Tesla has already begun implementing Level 3 AV technology into some of its vehicles. While the desire for these

[16] The Boston Consulting Group, 'Revolution in the Driver's Seat: the road to autonomous vehicles' (Report, April 2015) 7.

[17] Australian Driverless Vehicle Initiative, 'Economics Impacts of Automated Vehicles on Jobs and Investment' (Position Paper, 30 September 2016) 6.

[18] Nick Jaynes, *Here's the timeline for driverless cars and the tech that will drive them* (27 August 2016) Mashable Australia <http://mashable.com/2016/08/26/autonomous-car-timeline-and-tech/#FjZqZNSwVEqM>.

[19] Philip Ross, *CES 2017: Nvidia and Audi say they'll field a Level 4 Autonomous Car in three years* (5 January 2017) IEEE Spectrum <http://spectrum.ieee.org/cars-that-think/transportation/self-driving/nvidia-ceo-announces>; *Nissan announces unprecedented autonomous drive benchmarks* (27 August 2013) Nissan <http://nissannews.com/en-US/nissan/usa/releases/nissan-announces-unprecedented-autonomous-drive-benchmarks#>; Becca Caddy, *Toyota to launch first driverless car in 2020*, Wired <http://www.wired.co.uk/article/toyota-highway-teammate-driverless-car-tokyo>.

[20] Sam Naylor, *Ford aims to sell a fully self-driving car by 2021* (17 August 2016) Auto Express <http://www.autoexpress.co.uk/ford/96711/ford-aims-to-sell-a-fully-self-driving-car-by-2021>.

[21] *Future Mobility: Bosch and Daimler join forces to work on fully automated, driverless system* (April 2017) Daimler <http://media.daimler.com/marsMediaSite/en/instance/ko.xhtml?oid=16389692>.

[22] See generally, National Transport Commission Australia, 'Regulatory reforms for automated road vehicles' (Policy Paper, November 2016) 8, which suggests that regulatory barriers exist that prevent the progress of AV technology.

[23] Above n 6, 20

[24] Ibid.

[25] Ibid 21.

[26] National Transport Commission Australia, 'National guidelines for automated vehicle trials' (Discussion paper, November 2016) 5, available at <http://www.ntc.gov.au/Media/Reports/(FEAAC3B0-8F38-2C35-5FBC-4968034E6565).pdf>.

[27] Ibid.

[28] National Transport Commission Australia and Austroads, 'Guidelines for trials of Automated Vehicles' (Report, May 2017), available at <http://www.ntc.gov.au/Media/Reports/(00F4B0A0-55E9-17E7-BF15-D70F4725A938).pdf>.

[29] Federal and State Officials face sharp curves in regulating driverless cars.

[30] See for eg Joanna Plucinska and Joshua Posaner, *Self-driving cars hit European speed bump* (31 August 2016) Politico <http://www.politico.eu/article/uber-volvo-self-driving-cars-eu-regulations/>; Dave Keating, *EU Commission drives home merits of autonomous vehicles* (6 April 2017) Euractiv <https://www.euractiv.com/section/automated-vehicles/news/eu-commission-drives-home-merits-of-autonomous-vehicles/>. Note that the Vienna Convention on Road Traffic 1986 has now been amended to reflect the transition to Level 3 AVs – see for eg United Nations Economic Commission for Europe, *UNECE paves the way for automated driving by updating UN international convention* (23 March 2016) UNECE <https://www.unece.org/info/media/presscurrent-press-h/transport/2016/unece-paves-the-way-for-automated-driving-by-updating-un-international-convention/doc.html>.

[31] Aatif Sulleyman, 'Europe's first driverless car trials will take place in London in February' *Independent* (online), 16 January 2017 <http://www.independent.co.uk/news/first-driverless-car-trials-nissan-europe-take-place-london-february-leaf-a7529826.html>.

[32] See Connected Automated Driving, *1st European Conference on Connected and Automated Driving (CAD)* (4 April 2017) <http://connectedautomateddriving.eu/mediaroom/1st-european-conference-connected-automated-driving-cad-together-shaping-future/>.

automotive manufacturers will be to integrate AV technology into their existing private ownership model, industry disruptors such as Uber and Lyft are also in the race to develop their own AV technology in an effort to automate their ride sharing service. Established technology companies such as Intel and Google are also buying up AV technology developers in an effort to becoming the go-to source for AV computing systems.[33] Amazon is investing in both AVs and drone technology as the delivery models of the future.[34]

AVs and the Modern City

The continued evolution and growth of our modern cities is a key to Australia's continued economic growth. There is concern that the pace of growth in Australia's four biggest cities will be unsustainable within current urban development models.[35] That we will need to reconsider our built environment and connecting infrastructure was acknowledged by the Federal Government in its latest Infrastructure Plan.[36]

Irrespective of the projections for future urbanisation, the current urban population is already placing a heavy burden on our cities. Our existing roads and public transport infrastructure are generally at or near capacity, and are considered particularly vulnerable to future population growth.[37] Simply put, the growing number of people who live and work in the city bring with them a growing number of vehicles. In 2011, the avoidable social cost of traffic congestion in Australian cities was estimated to be approximately $13.7 billion. This cost, which stems from increased travel times, constrained productivity, and higher levels of pollution through intensified vehicle emissions, is in itself an alarming figure, without even taking into account that it is expected to rise to around $54 billion per annum by 2031.[38]

Ultimately, maximising the productivity of our cities, and permitting them to grow, will mean making better use of our existing infrastructure, not simply creating further infrastructure.[39] This is where the widespread adoption integration of AVs, and ITS, have the possibility to make real change; operating in tandem, they will allow for much more efficient use of road infrastructure.

It is commonly believed that the widespread adoption of AVs will lead to huge improvements in congestion and efficiency around the city. In a purely mechanical sense, a fleet of fully connected AVs will have the ability to 'platoon'; creating large rafts of AVs operating in sync, which will be able to react together almost instantaneously. The ability of such platoons of vehicles to accelerate and decelerate together drastically cuts down on the headway and lateral clearance which is needed between each vehicle, and this will allow for shorter travel time, and more efficient of infrastructure.[40] Early studies suggested that AVs could increase existing network capacity by 42%.[41] The potential improvement is more pronounced on high speed roads such as highways, where it is speculated that AVs may allow up to six times the existing capacity.[42] Once ITS are introduced, this efficiency gains of AVs can be further leveraged through the ability to smooth out network usage and redirect traffic through uncongested corridor. Infrastructure Australia has estimated that this could potentially triple the current utilisation of our existing roads.[43]

Changing land use

AVs also have the potential to transform our urban land usage. CISCO has estimated that 30% of all traffic congestion in urban areas is caused by drivers looking for available parking spaces,[44] and in London, a city well versed with congestion, it is thought that this figure might be as high as 45% of city centre traffic. With statistics like these it is not hard to believe that globally it is estimated that the cost associated with people looking for available parking spaces is around $3.9 trillion a year.[45] With an ITS that is constantly monitoring parking space availability and feeding information to AVs, this inefficiency could be drastically reduced as AVs are directed towards the nearest parking space.[46]

---

[33] See for eg Guilbert Gates et all, 'The Race for Self-Driving Cars', *NY Times* (online), 14 December 2016 <https://www.nytimes.com/interactive/2016/12/14/technology/how-self-driving-cars-work.html?_r=2>.
[34] See for eg Matthew Roco, *Amazon wants to use self-driving vehicles* (24 April 2017) Fox Business <http://www.foxbusiness.com/markets/2017/04/24/amazon-wants-to-use-self-driving-vehicles.html>.
[35] Above n 6, 28.
[36] Above n 14, Infrastructure Australia, 6.
[37] Above n 7, NRMA, 5.
[38] Infrastructure Australia, 'Productive Cities' (Fact sheet, Australian Government, February 2016), available at <http://infrastructureaustralia.gov.au/policy-publications/publications/files/IA_J16-2330_Fact_Sheet_Cities_v1.1.pdf>.
[39] Above n 7, NRMA, 3, where it says "*simply building new infrastructure and throwing money at ad hoc projects will not of themselves solve congestion, improve travel times or future proof our infrastructure and transport services*".
[40] Above n 6, 16.
[41] Above n 14, Accenture, 9.
[42] TTM, *How do we design our cities for driverless cars?* (13 October 2016) TTM <http://www.ttmgroup.com.au/2016/10/how-do-we-design-our-cities-for-driverless-cars/>.
[43] Above n 14, Infrastructure Australia, 7, 25.
[44] Above n 7, NRMA 18.
[45] Ibid.
[46] Above n 7, NRMA 19.

Even this line of thinking, however, might not fully appreciate the transformative value which AVs stand to have on urban design and planning. For AVs with full autonomous capability, it is not hard to imagine a situation where there is technically no need for an AV to park near to their drivers. An AV could instead return to offsite parking bays, only returning when needed. In such a scenario the general design of urban centres would need to accommodate a substantial shift from long term parking to an increased pattern of pick up and drop off activities.[47] If the rise of AVs also sees the rise of a ride sharing model of transport, there may be no need for AVs to park at all;[48] constantly on the move as they collect and drop off passengers throughout the city. While there is obviously a range of potential outcomes based on how readily people will adopt ride sharing as their sole means of transportation (as discussed below), the potential upside in terms of urban planning and development of a ride sharing economy built on AVs is staggering.

While this upside might seem purely aesthetic in the abstract, WSP Parsons Brinkerhoff and Farrells commissioned a paper which sought to demonstrate in tangible terms the likely impact AVs would have on urban development and infrastructure needs. The paper argued that new urban development areas which are designated as dedicated AV zones could offer between 15% to 20% additional developable area compared with a typical central urban layout, brought about through the removal of almost all parking spaces, but also from roadside simplification.[49] Noting that approximately 16% of Central London was covered in parking spaces,[50] or around 8,000 hectares or urban space, it was estimated that 50% to 70% of this space could be released once AVs were commonly in use,[51] which equated to hundreds of millions of pounds in additional land value.[52]

This scenario applies just as readily to Australian cities, with Infrastructure Australia identifying that the removal of parking spaces will allow for the more productive use of land, the increased densification of the city, and the more efficient utilisation of existing transport infrastructure.[53] By reducing the clutter of inner-city centres, more land can be devoted to amenities and green space, which will encourage people to live closer to the CBD.[54] This, in turn, may flow on to many positive externalities, such as increased agglomeration economies, labour market deepening and other urban consolidation benefits.[55]

Beyond the improvements in terms of infrastructure and efficiency, the widespread use of AVs also has great potential for environmental benefit, particularly if they are electric. A study undertaken by Fagnant and Kockelman has indicated that each shared AV could replace around 11 conventional vehicles on the road. Further, the study indicated in in scenarios whereby the introduction of AVs increased the total kilometres travelled by vehicles, the decreased number of increasingly efficient cars resulted in an overall benefit in emissions impact.[56] Perhaps more dramatically, a study undertaken in the US suggested that the introduction of a largely automated, and electrical system of shared urban transport has the ability to reduce carbon dioxide emissions from light-duty road vehicle transportation by up to 90% in the long run.[57] Higher fuel efficiencies will also be possible from the ability of AVs to 'platoon'.[58] As discussed below, however, the range and scale of environmental benefits ultimately achieved depends on whether society will move away from our current model of private vehicle ownership to one that is largely based on ride sharing.

The road forward

Despite the obvious benefits which AVs promise to bring, there are obstacles to widespread adoption,. While many argue that AVs possess better perception, faster decision-making skills and more accurate execution than human drivers, concerns remain over the safety and reliability of AVs. The fatal Tesla auto-pilot crash in May 2016 curbed public confidence in AV technology, despite investigators ultimately clearing the company.[59] Beyond safety, cyber

---

[47] See generally Austroads, 'Assessment of Key Road Operator Actions to Support Automated Vehicles' (Research Report, 2017).
[48] See further, above n 14, Accenture, 10.
[49] Above n 11, 10.
[50] With general figures of 15% to 30% parking coverage not uncommon for modern cities such as New York, Paris, Vienna, Boston and Hong Kong.
[51] Above n 11, 15.
[52] Above n 11, 10.
[53] Above n 14, Infrastructure Australia, 24, 36.
[54] Above n 10, 10.
[55] Ibid.
[56] Above n 17, 5, citing David Fagnant and Kara Kockelman, 'The travel and environmental implications of shared autonomous vehicles, using agent based model scenarios' (2014) 40 *Transportation Research Part C: Emerging Technologies* 1.
[57] RethinkX, 'Rethinking transportation 2020-2030: the disruption of transportation and the collapse of the internal-combustion vehicle and oil industries' (Report, May 2017) 51, available at <https://static1.squarespace.com/static/585c3439be65942f022bbf9b/t/590a650de4fcb5f1d7b6d96b/1493853480288/Rethinking+Transportation_May_FINAL.pdf>.
[58] Above n 6, 16.
[59] Neal Boudette, 'Tesla's self-driving system cleared in deadly crash', *NY Times* (online) 19 January 2017 <https://www.nytimes.com/2017/01/19/business/tesla-model-s-autopilot-fatal-crash.html?rref=collection%2Ftimestopic%2FNational%20Highway%20Traffic%20Safety%20Administration&action=click&contentCollection=timestopics&region=stream&module=stream_unit&version=latest&contentPlacement=6&pgtype=collection>.

security poses one of the biggest concerns in relation to AVs.[60] After two hackers demonstrated the ease with which they could remotely disable a vehicle which had only basic electronic interfacing,[61] fears have persisted that creating vehicles which are increasingly independent from their drivers, and dependent on unsecure networks for their core operation, allows for a future of hackable vehicles,[62] in instances where even a momentary outage of automated operation could lead to a fatal car crash.

Public sentiment aside, we still require significant development in our digital infrastructure before we can fully realise the potential of AVs. Fleets of truly connected AVs will require an immersive digital network capable of constantly capturing, storing, and transferring tremendous amounts of data with little to no latency. Such an Internet of Things[63] will in itself will require further development in the fields of wireless communication and connectivity, wide scale network integration, data management, and cyber-security.[64]

Private Ownership versus Ride Sharing

It is fair to say, then, that the potential benefits which have been canvassed above are far from guaranteed. The recent Austroads report into AVs noted that '*any assessment of the impacts of automated vehicles should be considered through the lens of the uncertainty around what the AV future will look like.*'[65] Even assuming that we are able to surmount the technological challenges facing the rise of the AV, the most pervasive obstacle to truly realising their benefits might be the social resistance to change. The most simplistic way of conceptualising this is to consider the distinction between our current model of private ownership, and the idealised future model of widespread ride sharing.[66]

In a future where society embraces a ride sharing economy, and private vehicle operation is limited or even completely non-existent, the roads and cities of the future will dominated by AVs. Our ITS will have a wealth of information from which to monitor road usage and smooth congestion. The efficiency and environmental benefits described above will be realised. Our urban environment will be dramatically freed up by the decreased reliance on parking, road usage and number of vehicles.[67]

If, however, we maintain our model of private ownership, there is a strong case to suggest that the numbers of cars on the road will remain the same, if not increase due to the increased efficiency and decreased cost of operation.[68] An analysis undertaken by KPMG has demonstrated that if AVs are introduced into a model of private ownership, we may in fact see a significantly increased demand for road infrastructure.[69] Further, a private ownership model would likely mean that road networks will suffer from 'zero occupancy' trips with AVs returning home or travelling off-site, thereby increasing the vehicle kilometres travelled, and ultimately congestion.[70] In such a scenario, any impacts on urban development would be minor, and we would likely experience increased urban sprawl as the incentive to live closer to the CBD diminishes in the face of AV transportation.

Regulators will have a significant role to play, particularly when it comes to the level of 'support' they provide to ride sharing and mobility as a service. The recent experience in Australia with Uber and other ride sharing services seeking to disrupt established taxi services may play out on a much larger scale. By increasing regulatory costs associated with individual vehicle ownership (e.g. registration fees) and incentivising ride sharing (e.g. through mandating dedicated ride share roads, lanes or zones), regulators have the power to significantly 'tip the scales' towards a shared usage model in order to reduce congestion and improve liveability in cities.

---

[60] Alex Webb, *Cybersecurity is biggest risk of Autonomous cars, survey finds* (19 July 2016) Bloomberg Technology <https://www.bloomberg.com/news/articles/2016-07-19/cybersecurity-is-biggest-risk-of-autonomous-cars-survey-finds>.

[61] See for eg Andy Greenberg, *Hackers remotely kill a jeep on the highway – with me in it* (21 July 2015) Wired <https://www.wired.com/2015/07/hackers-remotely-kill-jeep-highway/>.

[62] See for eg Andy Greenberg, *Securing driverless cars from hackers is hard. Ask the ex-Uber guy who protects them* (12 April 2017) Wired <https://www.wired.com/2017/04/ubers-former-top-hacker-securing-autonomous-cars-really-hard-problem/>; Jemima Kiss, *Your next car will be hacked. Will autonomous vehicles be worth it?* (14 March 2016) SXSW Interactive <https://www.theguardian.com/technology/2016/mar/13/autonomous-cars-self-driving-hack-mikko-hypponen-sxsw>.

[63] https://informationcounts.com/autonomous-vehicles-and-the-internet-of-things/

[64] Roads Australia, 'Connected and Autonomous Vehicles' (Research paper, 2016), available at <http://www.roads.org.au/Portals/3/RA%20Connected%20and%20Autonomous%20Vehicles%20-%20Research%20and%20Insight%20report%20final....pdf?ver=2016-12-15-111013-500>.

[65] Above n 47, 19.

[66] Ibid 7; see further Taede Tillema et al, 'Driver at the wheel' (Report, Netherlands Institute for Transport Policy Analysis, 14 October 2016), available at <https://english.kimnet.nl/publications/reports/2015/10/14/driver-at-the-wheel>.

[67] Above n 47, 19-20.

[68] International Association of Public Transport, 'Autonomous Vehicles: a potential game changer for urban mobility' (Policy brief, UITP, January 2017) 5, available at <http://www.uitp.org/sites/default/files/cck-focus-papers-files/PolicyBrief_Autonomous_Vehicles_LQ_20160116.pdf>; Sam Lubell, *Here's how self-driving cars will transform your city* (21 October 2016) Wired <https://www.wired.com/2016/10/heres-self-driving-cars-will-transform-city/>.

[69] Above n 10, 8.

[70] Above n 64.

Sharing roads with 'robots'

Regardless of where society ends up, that AVs will increasingly share our roads is undeniable. An analysis commissioned by the Department of Transport and Main Roads in Queensland estimated that, based on current vehicle expenditure and the quantity of new vehicle sales and take-up rates, 20% of the vehicles on the road will be autonomous between 2034 (aggressive) and 2045 (conservative), and 100% will be autonomous between 2048 and 2057.[71] As these figures demonstrate, human drivers will have to contend with increasing numbers of AVs, and many have speculated that this will cause a number issues.[72] Whether the concern is that human drivers will take advantage of an AV's cautiousness and 'bully' them,[73] or that there will always be a disconnect between a human's unpredictability and an AV's scripted and precise nature, a challenge going forward will be providing for both the driven and the driverless on our roads.

The suggestions for transition are varied. In the early stages of integration and technological advance, it may be sufficient to simply allow the status quo to persist; especially in AVs where the human driver is still required. As the reliance on the human driver decreases, and the number of AVs on the roads increase, it may be necessary to introduce 'AV lanes', or to specifically designate which areas permit AV technology usage, such as highways, and which areas do not, such as congested cities.[74] Alternatively, as has been suggested above, the solution might come from designating certain areas as 'AV zones'.

The wider impact – industry, public transport and road users

Although AVs have the potential to fundamentally change our modern cities, they will undoubtedly also change many aspects of our modern society. AV technology is already having a tangible impact on the construction industry, with Rio Tinto's 'mine of the future' in Western Australia utilising autonomous haulage system trucks, autonomous drilling systems, and autonomous long distance railway systems.[75] Beyond this, manufactures are currently working towards automating other heavy vehicles,[76] and it's not hard to conceive of a time in the near-future where AVs have penetrated everything from the agricultural industry, to long distance freight,[77] to disaster relief.[78]

Public transport has also been identified by many as an industry which is ideally suited for the integration of AV technology. Since June 2016, Swiss operator Carpostal – Postauto has been operating two electric autonomous shuttles for passengers in the city centre of Sion, and French transport group Keolis has been running an autonomous shuttle service since September 2016 to service 'last mile' trips in Lyon.[79] Relevantly, it has been highlighted that automated public transport systems could further contribute to the growth of the modern city. An automated urban public transport network could connect existing mass transit hubs to city centres by performing 'last mile' journeys,[80] which would reduce the need for privately owned vehicles in the city centres. In addition, the creation of a high frequency or on demand automated public transport system in cities would increase mobility at a lower cost on resources and infrastructure than existing forms of privately owned transport.[81]

While the addition of an autonomous crane or bus might be the physical manifestation of the impact which AV technology can have on society, many of the potential impacts are far more subtle. Given that AVs and ITS allow us to more efficiently utilise our given infrastructure, there will likely be a shift away from new construction to the upgrading, operation and maintenance of our existing infrastructure.[82] Any newly constructed transport infrastructure

---

[71] See generally, above n 64.

[72] For a study undertaken in this field, see TRL, 'Driver responses to encountering automated vehicles in an urban environment' (Project report, February 2017), available at <https://gateway-project.org.uk/wp-content/uploads/2017/02/Driver-responses-to-encountering-automated-vehicles-in-an-urban-environment-1.pdf>.

[73] See Russ Mitchell, *Human drivers will bully robot cars, says CEO of Mercedes-Benz USA* (15 November 2016) LA Times <http://www.latimes.com/business/la-fi-hy-live-updates-2016-la-auto-show-human-drivers-will-bully-robot-cars-1479247249-htmlstory.html>.

[74] See for example Taede Tillema, George Gelauff, Jan van der Waard, 'Towards a self-driving future' (Presented at ITF-OECD round table, Ottawa, 6 December 2016), available at <https://www.itf-oecd.org/sites/default/files/docs/self-driving-future.pdf>, and above n 66, Taede Tillema et al.

[75] See Rio Tinto, *Mine of the Future* <http://www.riotinto.com/australia/pilbara/mine-of-the-future-9603.aspx>.

[76] See for eg Matt Alderton, *The robots are coming! Driverless dozers and the dawn of autonomous vehicle technology in construction* (16 November 2015) Redshift <https://redshift.autodesk.com/autonomous-vehicle-technology-in-construction/>.

[77]See for eg Leslie Hook, *Out of road: driverless vehicles and the end of the trucker* (30 March 2017) Financial Times <https://www.ft.com/content/2d70469c-140a-11e7-b0c1-37e417ee6c76>, and Ryan Petersen, *The driverless truck is coming, and it's going to automate millions of jobs* (25 April 2016) TechCrunch <https://techcrunch.com/2016/04/25/the-driverless-truck-is-coming-and-its-going-to-automate-millions-of-jobs/>.

[78] Dan Prescott, *Autonomous heavy equipment positioned to be next disruptive technology* (6 May 2013) SAE International <http://articles.sae.org/12084/>.

[79] Above n 68, UITP, 3.

[80] See generally above n 68, UITP; Katie Sadler, *First and last mile: emerging autonomous public transport* (14 February 2017) Eurotransport <https://www.eurotransportmagazine.com/22134/transport-extra/autonomous-public-transport/>.

[81] Above n 68, UITP, 4.

[82] A study undertaken in Melbourne has demonstrated that the introduction of ITS on our roads will allow for efficiency gains which equate to constructing another 0.5 to 0.8 lanes on a four-lane carriageway, for a far smaller cost than the construction of a new lane, see above n 14, Infrastructure Australia, 25.

will likely include the ITS technology,[83] and governments will need to start embedding these ITS technologies into the existing road network to pave the way for future use by AVs.[84] The increasingly reliance on smarter infrastructure will see tech companies attached to many transport infrastructure construction contracts, and the emphasis in the industry may well shift to those companies who operate and maintain the ITS technology necessary for the roads of tomorrow.

An integrated network of AVs and ITS will also open up for new means of tolling roads, and for funding infrastructure projects. The data which will be obtainable from a network of integrated AVs will allow for precise road usage modelling, and the integration of an ITS will permit for more transparent and accurate access and usage charging. This wealth of data allow funding to go to those roads that are the most heavily used, and will decrease the likelihood of maintenance gaps.[85]

The legal landscape

Much of the legal speculation around AVs is concerned with how to regulate AVs, and who will be liable when something goes wrong. At present in Australia, regulation regarding road rules, and by extension the trialling, and operation, of AVs is governed by the States, and many of these laws and regulations are fast becoming outdated in the face of AV technology.[86] Our laws presently assume that vehicles will always be driven by a human, and legislative notions such as 'proper control' of a vehicle typically require at least one hand on the steering wheel. The NTC has identified 716 laws, rules and regulations which are likely to require revision in the face of AV technology.[87]

In terms of where legal liability falls for accidents involving AVs, the question will likely depend on what level of automation is involved. For vehicles exhibiting level 2 levels of automation, such as are commonly on our roads today, the human driver remains responsible for the operation of the vehicle, and liability will remain solely with them (other than where a vehicle defect is at fault). For level 3 AVs, where the vehicles have something akin to Tesla's highway 'autopilot', the scope of transferring liability away from the driver and onto the vehicle manufacture increases as the amount of control over the vehicle is taken away from the human driver. In the final levels of automation, where the requirement for a human driver is approaching non-existent, there are good arguments for imposing strict liability on manufacturers.[88]

The NTC has weighed in on these issues in its policy paper addressing regulatory reform. To address the raft of existing laws, rules and regulations which inhibit AV technology, the NTC introduced its national guidelines for AV trials in Australia, and recommended that the State and Territory road and transport agencies review their current exemption powers to ensure that they are conducive to AV technology, standards, and trials.[89] While the NTC has recommended that we strive to harmonize our existing scheme of regulations and exemptions, it has foreshadowed that we will need to redefine our existing notions of 'control', 'driver' and 'driving' in the near-term, and eventually develop a complete regulatory framework to support the operation of AVs.[90] As a part of this, the NTC has indicated that it will be necessary to review our existing compulsory third-party and national insurance schemes to identify any potential eligibility barriers for occupants of an AV, or those involved in a crash with an AV.[91]

Our regulators will be seeking to support public safety and confidence in AV technology, and provide legal certainty, without 'over regulating' too soon, which may stifle innovation and produce other unintended consequences. Given that technological developments and consumer demands are moving forward so rapidly, and effective regulation takes time, this will be a significant challenge for our policy makers in the coming years.

Conclusion

AVs will transform our cities. There remains a lot of uncertainty in terms of how, when and in what form; but the question of 'if' appears to be settled. The advent of AV technology has already altered, and disrupted, the trajectory of many industries, and given the potential benefits AVs stand to bring it is not hard to see why. The extent to which society embraces this new trajectory remains to be seen, and given the multitude of competing interests, technologies and solutions, the road forward is unlikely to be smooth.

[83] Above n 14, Infrastructure Australian, 27.
[84] Above n 7, NRMA, 17.
[85] Above n 14, Infrastructure Australia, 25, 83, 85.
[86] Above n 22, 8.
[87] Denise Cullen, 'The legal impact of driverless vehicles' (2017) 33 *Law Society of NSW Journal* 40, 41.
[88] Interestingly, Volvo have stated that they will accept full liability when one of its cars is in autonomous mode – see Andrew Somers, 'The future community changes and benefits of driverless cars' (Presentation given at International Driverless Cars Conference, Adelaide, November 2015) 15, available at <http://dpti.sa.gov.au/__data/assets/pdf_file/0006/246822/Andrew_Somers_Presentation.pdf>.
[89] Above n 22, 11.
[90] Ibid, 12.
[91] Ibid.

Something which cannot be disputed, however, is the potential impact that AVs stand to have on our urban infrastructure and modern cities. Through the more efficient and reimagined use of urban infrastructure, to the myriad of social, environmental, and economic benefits, AVs will have a transformative impact on our modern cities, permitting them to grow and develop in a manner which we can only speculate about.

According to the NRMA '*[o]f all the transport-related technological advances set to reshape our transport future, the potential of autonomous vehicles to boost the Australian economy and reimagine mobility is unmatched*.'[92]

[92] Above n 7, NRMA, 13.