Submission to the House Standing Committee on Infrastructure, Transport and Cities Inquiry

The automation of mass transit

Bus Industry Confederation

DECEMBER 2018

Contents

INTRODUCTION

The Bus Industry Confederation (BIC) is the national organisation representing the interests of the Bus and Coach Industry, both operators and suppliers.

The BIC promotes the safety, efficiency, effectiveness, accessibility and increased use of bus and coach transport in Australia.

The BIC promotes the increased use of public transport in order to reduce the economic, social, environmental and public health impacts associated with the excessive use of cars.

The Australian bus and coach industry carries more than 1.5 billion passengers annually and employs more than 50,000 people.

As the primary voice of the bus and coach industry in Australia the BIC works with all levels of Government, regulatory authorities, the industry and the community to:

- Advocate for the virtues of the "National Moving People" strategy
- Encourage investment in public transport infrastructure and services
- Implement an effective tax and pricing regime for the industry and passengers
- Coordinate and make more effective existing Federal, State and Local Government policies and programs that relate to passenger transport
- Improve public understanding of the contribution made by the bus and coach industry to Australia's economy, society and environment.
- Ensure that the accessibility and mobility needs of Australians are met, regardless of where they live or their circumstances.
- Ensure that buses and coaches operate safely and effectively
- Improve the environment and community health through greater use of public transport

FUTURE AUTOMATION – DRIVERLESS CARS AND LAND –BASED MASS TRANSIT – THE CONTEXT

Whilst this Federal Inquiry has a specific focus on the automation of mass transit, this cannot be looked at in isolation of the possible impacts of driverless vehicles in general and on social transit for transport disadvantaged and people living in low volume passenger markets.

Mass transit in the future could be very different depending on the policy setting of Governments. This submission attempts to provide this contextual view of future mass transit based on different policy outcome scenarios that may provide the Committee some ideas about how the Federal government may influence the future adoption of autonomous vehicles in general and the future role of mass transit and also social transit, which in BIC's view needs to be considered at the same time.

As background, parts of this submission refer to a to be completed and released (2019) future BIC Policy paper, authored by the Institute of Transport and Logistics Studies, Business School, University of Sydney, on Mobility as a Service (MaaS) and the changing social values and emerging new technologies that are increasing the probability of massive shifts in transport service offerings in coming decades with potentially huge benefits and/or costs.

Future energy sources for buses and moving from diesel to electric autonomous vehicles is also discussed in this submission.

AUTONOMOUS VEHICLES

Ever since the automobile frightened the living day lights out of horse and cart, we have not seen an evolution in transport technology that will have a major impact on humanity and society at large. This was until the autonomous vehicle came along. Initially the public perception of this innovation was that it was a technological novelty. In an advanced society such as Australia, vehicles such as cars are essential for daily commute and business operations. We are witnessing a technological evolution occurring where the humble car can now be operated without the need for a driver to control the vehicle's movement. Technological advances are also being applied to heavier vehicles such as trucks and buses. The BIC would note however that the concept of a driverless bus, in particular large buses, may be technologically possible but the reality of mass transit and school bus services operating in this way are much less certain for a variety of operational and personal safety and societal issues. The unknown element from a bus perspective is if it is going to be accepted by users concerned about safety and security. Measures to gain the trust of the community in relation to safety and security will be very important, but ultimately they may not be successful. This issues has the potential to block the use of driverless buses and may limit the technology to personal conveyances and may even restrict them. These issues are dealt with later in this submission. It should be remembered that driverless trains have been a reality for some time but are manned by a driver in most, if not all instances and that despite fully functioning auto pilots on today's commercial jet fleets, pilots are still a reality.

In the US, a strong push for driverless vehicles has come from expectations of significantly improved travel safety with autonomous vehicles, with expectations of accident reductions of 80+%. If realized, this is an important social benefit.

Driverless vehicles also promise more effective use of scarce road space, through the ability to operate closer to surrounding vehicles. This should save public money in terms of the need to add road space, another societal benefit. It is most unlikely that this potential benefit is taken into account in evaluating major new road projects that are due for completion within a decade or so.

As suggested below, the benefits of such projects will thus be over-stated.

Availability of a (driverless) vehicle of your choice, on-call, may be an attractive option for many people. The opportunity to work while travelling in your driverless car removes the notion of saving time having productive value, if you can work just as well in the car, as out.

As a consequence the time savings benefits attributed to many major new road projects are likely to be illusory – they will simply vanish! This compounds the errors in road project evaluation from ignoring the impact of driverless vehicles on effective road capacity.

Access to cheaper travel, where time saving has little value, in turn, may significantly reduce the pressures for workers to live close to where they work. Longer travel times lose disutility if the time can be productively enjoyed. Accelerated **urban sprawl** is a highly likely outcome, with all the adverse social consequences associated therewith. This is a major potential social risk from driverless vehicles.

Car sharing (where this is linked with driverless vehicles is hard to predict as the culture in Australia is one of car ownership) creates the possibility that access to driverless vehicles will be substantially less costly than owning your own vehicle, even if it means significant numbers of empty vehicles re-positioning themselves for their next task (using up some of the additional road space made possible by driverless vehicles!). This opportunity for **cheaper accessibility** is likely to be of benefit to some **transport disadvantaged people**, where the cause of disadvantage is a lack of financial capability. The associated dead-running, together with the likely impetus to accelerated urban sprawl from the introduction of driverless vehicles, underlines the vital importance of a proper **road pricing regime** accompanying the introduction of driverless vehicles. This will have the benefit of reducing the growth in demand for the absolute numbers of driverless vehicles, encouraging **sharing** at the margin rather than owning your own vehicle, and will reduce low value movement of such vehicles. A substantial increase in use of shared vehicles must be an important part of the introduction of driverless vehicles, to reduce the risks of sprawl and of growth in congestion (caused by use of cheaper, more accessible vehicles growing faster than the improvement in effective road capacity from driverless vehicles).

The role of mass transit, and in particular bus, whether they will be driverless or not must be considered in the future, for the same reasons these services are provided today and in the context of the outcomes such services deliver to the economy, environment and society. For example congestion management in a world of driverless cars and an increasing population will still need to be addressed and mass transit solutions will be part of this.

A road pricing regime that prices the full social costs of vehicle movement, full or empty, creates the opportunity to exercise more effective and efficient transport network management control over potentially serious adverse unintended outcomes, from greatly increased demand for limited road space and pressure for accelerated urban sprawl.

The reduced cost of private vehicle access that may accompany driverless vehicles may pose a **threat to public transport** but also provides some possible ways out. Removing labour costs from driverless taxi/Uber type services , for example, may increase demand for those services, some of which may come at the expense of public transport – although these services are increasingly becoming part of the 'public transport' mix. Similarly, increased personal travel in cheaper driverless shared cars may also reduce demand for PT trips. Such circumstances may reduce demand for some types of bus services as we know them today, and thus reduce mobility options for those at risk of social exclusion. The balance between providing services in driverless cars and small shared passenger vehicles that may be able to operate on a commercial basis and Government funded bus services today that subsidise passenger fares needs to be seriously considered in the context of social exclusion and access to opportunity. Driverless large mass transit buses may be less expensive to operate, and could allow for greater investment in more mass transit bus services. That is, if such large driverless vehicles will be accepted and used by the community.

With labour costs accounting for half the costs of bus operation, driverless buses will have cost appeal to governments seeking ways to reduce costs of public transport service provision. Smaller driverless buses have the potential to improve local access opportunities at the social safety net level, since their lifecycle cost advantage creates the opportunity to add services (in smaller vehicles) for any given outlay on public transport, which aligns with the idea of mobility as a service (MaaS). Such lower costs of service provision thus create opportunities for extending services in areas that are currently under-provided or have no services at all, including through tailoring bus sizes more closely to expected demand patterns. This is a potentially significant benefit in terms of **social inclusion** opportunities, flowing from a convergence between public and private transport as we know them today.

The introduction of driverless vehicles should be seen as an opportunity to **review mobility** in general, reflecting on the whole mobility system, the purpose and value of mobility and how it can be accomplished better in social, environmental and economic terms, recognising the potential benefits and challenges associated with driverless vehicles.

TWO FUTURE SCENARIOS AND THEIR POTENTIAL EFFECTS

As mentioned earlier in this submission BIC is currently finalising a BIC Policy paper on Mobility as a Service and the impacts of disruptive technology on mobility. Section 5 of this policy paper follows, and looks at pessimistic and optimistic scenarios for future mobility that hopefully will assist the Committee in its deliberations and putting mass transit into context in a changing mobility world

Given the uncertainties involved in predicting the way digital disruption will impact future personal travel choices, and matters related thereto, scenarios can be a helpful way to think through what the future might look like, as an aid to shaping policy responses to increase the likelihood of better societal outcomes, in terms of the policy goals being sought from the transport network. A number of papers exploring technological disruption in land passenger transport topic have taken this approach.

McKinsey & Bloomberg NEF (2016) develop three scenarios, each linked to a specific type of city environment, which they label 'clean and shared', 'private autonomy' and 'seamless mobility'. The 'clean and shared' scenario is least relevant to Australia, since it focuses on developing, dense metropolitan areas such as Istanbul, Delhi and Mumbai. Cervero et al. (2017) use 'optimistic' and 'pessimistic' scenarios, Isaac (2016) talks about a 'driverless nightmare' scenario and a 'driverless utopia' scenario, while Susan Shaheen, co-director of the University of California Berkeley Transportation Sustainability Research Centre (quoted in Mervis 2017), talks about 'utopian' and 'dystopian' scenarios.

While scenarios often discuss the impacts of *pathways* on introducing technological change, they tend to be more interested in *end-points* and, therefore, in the current context, tend to assume widespread implementation of Autonomous Electric Vehicles (AEVs). In that event, the separation of scenarios for exploring the possible future impacts of AEVs (including MaaS-type approaches to service provision) depends essentially on assumptions about the penetration of **shared mobility** (vehicle sharing and ride sharing—i.e., sharing across *time* and in *space*) and the consequences thereof, as compared to **personal ownership**. Optimistic scenarios are based on the assumption of a high level of penetration of shared mobility solutions and pessimistic scenarios on a low level of penetration, with personal vehicle use remaining dominant. We use optimistic and pessimistic scenarios below and suggest the major likely consequences of each, in terms of matters likely to impact significantly on user benefits and external costs/benefits, and hence on societal goal achievement. Neither scenario in its entirety is expected to be the eventual outcome but proposing two distinctly different futures enables some key risks and opportunity areas to be identified and policy measures to be framed to increase the likelihood of better outcomes being realized.

Table 5.1 summarizes our assessment of the broad outcomes associated with each of the two scenarios, drawing partly on McKinsey & Bloomberg NEF (2016), Isaac (2016), Cervero et al. (2017) and Litman (2018) and adding our own insights. The time frame for the table is such as permits widespread adoption of AEVs. As noted elsewhere, cyber security and privacy considerations are not included in this assessment. The following discussion focuses on user benefits and externalities. The subsequent discussion about potential impacts on public transport later in this section of the submission includes shorter time horizons.

AN OPTIMISTIC SCENARIO

The optimistic scenario assumes that there is substantial penetration of shared mobility, in part because policy settings explicitly target this outcome. We first consider user benefits from AEVs and then external effects. The discussion on the optimistic scenario in this section is more detailed than that of the pessimistic scenario because many comparisons between the two scenarios are included in this section.

User impacts

In the optimistic scenario, cheap, accessible, low/zero emission driverless vehicles are widely available on-call, either for single use or shared use but shared use mode predominates (perhaps shared in peak periods and operating point-to-point off-peak), mainly because the lower marginal user costs associated therewith outweigh potential disadvantages in terms of (for example) inconvenience, as compared to private ownership. Shared mobility brokers and/or providers (MaaS) work hard at ensuring convenience and reliability are service hallmarks. In terms of user costs, RethinkX (2016) projects this shared AV cost at four to ten times cheaper per mile than buying a new car and two to four times cheaper than operating an existing vehicle. Litman is much less optimistic on cost reduction potential from shared mobility but still sees savings. Travel time reliability benefits are also likely to occur with AEVs, with significant gains at a penetration rate of 25% or more (Atkins 2016).

Availability, convenience and cost of accessing AEVs are such that people see less need to own their own vehicles. Those who continue to own their own vehicles increasingly make them available for use by others. Also, giving up a substantial element of private vehicle ownership frees up part of the household budget for other uses. Removing the need for a driver means that travel time can be used productively, if the passenger so wishes (research is taking place on ways to reduce car sickness associated with working in the vehicle), or to catch up on lost sleep. On the negative side, cheaper travel costs will encourage additional trip making, which may add to congestion pressures unless shared mobility provides sufficient offset.

AEVs can provide new mobility opportunities for people who cannot, or choose not to, drive (for whatever reason). Older people, youth and people with a disability are often mentioned in this context but there is no reason why these improved mobility opportunities cannot also extend to other groups experiencing transport disadvantage, particularly in urban areas. Our research on links between mobility, trip making and risk of social exclusion has shown the high value of additional trip making by those at such risk (see, for example, Stanley et al. 2011 a, b; Stanley and Hensher 2011). In the early years of implementation, these benefits will probably be limited to higher income households, because of higher capital costs of AEVs but, as shared mobility choices start to proliferate, the inclusion benefit opportunity will be more widely available. Greater social inclusion is also associated with flow-on external benefits, such as improved mental health, higher employment levels, lower medical costs, etc.

The cheaper cost of AEV travel, particularly by ride-sharing, and the opportunity for new vehicular trips by mobility/transport disadvantaged people will combine to mean that the number of *person trips* increases in the optimistic scenario. Given sufficient penetration of shared mobility choices, however, this higher number of person trips can be satisfied with a slower growth in *vehicle kilometres travelled*, even though autonomous shared vehicles need re-positioning movements.

External benefits/costs

Vehicle platooning, made possible by vehicle-to-infrastructure and vehicle-to-vehicle communication, means that effective road/PT system capacity increases with widespread use of AEVs, although separate right-of-way is likely to be required to maximize this increase. Friedrich (2016), for example, has estimated the effective road capacity increase achieved by purely autonomous traffic at 40% in city traffic and 80% on highways, with other estimates even higher. For example, Bierstadt et al. (2014) suggest freeway capacity could double with 100% AVs and Fernandes and Nunes (2012) show theoretically how lane capacity could almost quadruple with optimal platooning. This, and the freeing up of parking space attributable to lower personal ownership of vehicles and a greater reliance on ride sharing, means that scarce urban space can be released for other community uses, such as local open space, in the optimistic scenario.

Taking these capacity considerations into account alongside expected slower growth in VKT, as compared to the pessimistic scenario, means that realization of the user benefits from AEVs can be achieved with lower congestion pressures under the optimistic scenario than in the pessimistic scenario.

The main benefit of AEVs is often cited as safety, widespread use expected to deliver substantially lower accident rates. The 90% or so scale of reductions often cited (e.g. Fleetwood 2017) are questioned by Litman (2018) but significant benefits are still in prospect, depending partly on the regulatory environment that is put in place. The greater use of electric AVs, fuelled by clean energy sources, and slower growth in VKT under a high penetration rate of shared mobility, should combine to deliver lower emissions of GHGs and local pollutants, with associated health benefits.

Table 5.1: Scenarios for future mobility

Societal impact criteria	**Optimistic/utopian future**	**Pessimistic/dystopian future**
USER BENEFITS		
. Trips (i.e. person trips)	> than in pessimistic scenario	< than in optimistic scenario
. Travel distance (person kilometres)	< than in pessimistic scenario	> than in optimistic scenario
EXTERNALITIES		
Economic		
. Productivity/output	Higher	Lower
. Employment	?	?
. Congestion	Lower	Higher
. Government spending/borrowing requirements	Lower	Higher
Environmental		
. GHG emissions	Lower	Probably lower but > optimistic
. Air pollution	Lower	Ditto
. Open space availability near housing	More	Less
Social		
. Safety	Lower accident rate	Lower but > optimistic
. Social inclusion	Greater inclusion	No change or worse

Cross-cutting and/or intermediate impacts		
. Expanded travel choices	Yes	For some
. Freeing up space for place making	Yes	Possibly but < optimistic
. Urban sprawl	Less pressure	Increased pressure
. VKT by private car.	< than pessimistic scenario	> than optimistic scenario
PROCEDURAL CRITERIA		
Governance		
. Integrated planning/policy	A requirement for delivery	Less likely
. Community engagement	A requirement for delivery	Less likely

With vehicle use in the optimistic scenario now paid for on a more direct pay-by-use basis, active transport is likely to account for a higher mode share than in the pessimistic scenario, with multiple societal benefits (e.g., improved health, lower congestion). The higher mode shares for active travel will, in turn, be supportive of more compact settlement patterns than in the pessimistic scenario. One implication is likely to be relatively higher urban productivity from clustering in the optimistic scenario. Also, the more compact urban form will mean a lower level of infrastructure spend on the urban fringe and beyond, easing government borrowing requirements.

It is important at this point to emphasize that that some key external benefit issues tied up in AEV discussions, such as GHG emissions savings and lower local air pollution, are important policy matters in their own right and need to be resolved in both scenarios. Similarly, much of the social inclusion benefits of AVs (and AEVs) are likely to be available under both scenarios, because of the presence of driverless vehicles in each. Second order differences may arise, however, in terms of the scale of benefits as between the two scenarios and in the rate at which these benefits arise during the transition pathway. For example, the higher levels of VKT expected under the pessimistic scenario will mean higher GHG emissions and air pollution, to the extent that this scenario has a higher level of VKT than the optimistic scenario, albeit that GHG emissions on both should be well below business-as-usual projections. Similarly, the optimistic scenario should be expected to deliver bigger inclusion benefits because it is expected to mean lower unit costs of travel (because of greater penetration of shared mobility) and less contrary pressures from accelerated urban sprawl, with fewer associated expected adverse impacts on PT availability (harder to ensure in lower density settings), all adding up to net relative inclusion gains for the optimistic scenario.

A PESSIMISTIC SCENARIO

Much of the discussion in the optimistic scenario applies to this section. The pessimistic scenario assumes that attachment to private vehicle ownership and use remains strong, such that vehicle sharing and ride sharing play only relatively small roles in future mobility provision. McKinsey Bloomberg NEF set up this kind of scenario as follows:

> *The attractiveness of the private vehicle. The advent of desirable and highly personalised cars – which would frequently also be electric – may maintain consumers appetite for a private vehicle. In this vision of the future, consumers are likely to value both their privacy when travelling and the independence of owning their own car. Accordingly, car sharing, ride hailing and ride sharing remain complementary options but do not replace commutes on a large scale.* (McKinsey Bloomberg NEF 2016, p. 34).

In this setting, the personal appeal of private ownership, reinforced by the perceived lower cost of AEVs and opportunity to use travel time productively lead to increased personal trips, with vehicle kilometres increasing at least as fast as personal trips but most probably much faster, as car owners avail themselves of the opportunity to call up their car when they want it (e.g., to collect them), send the vehicle to find its own parking space or to serve travel needs of family members or friends. With the added demand from those for whom AEVs provide a new travel opportunity (social inclusion benefit), growth in VKT will thus be faster in the pessimistic scenario than in the optimistic scenario, but the number of person trips may not increase as much as in the optimistic scenario. The pessimistic scenario has more trips on road but probably less across all modes. These various influences mean that traffic congestion is likely to increase relative to the optimistic scenario but also probably in absolute terms, more than offsetting the benefit effect of AEVs in terms of increasing effective road capacity. They also mean that car parking space will be required in greater quantity than in the optimistic scenario, reducing the opportunity to convert such space to other valuable community uses.

The opportunity to work-in-vehicle, or rest/sleep while travelling, instead of having to deal with the driving task, will be seen by some people as an opportunity to change place of residence, most likely to consume additional space by moving to the peri-urban area or even beyond, extending urban sprawl. This will be a compounding factor increasing VKT under the pessimistic scenario, also increasing attendant risks of greater social exclusion for those with fewer mobility choices and increased costs of infrastructure and service provision. The opportunity to live further out will be most available to those on higher incomes, the sprawl effect, however, tending to worsen public transport travel opportunities available to those on lower incomes.

Increased sprawl under the pessimistic scenario will be associated with reduced urban productivity, BIC Policy Paper 5 showing how productivity levels decline with increasing distance from the CBD (Stanley and Brain 2015). Also, the infrastructure costs of accelerated urban sprawl under the pessimistic scenario mean added pressure on government borrowing requirements. **We see the consequences of greater urban sprawl as potentially the biggest single risk from widespread adoption of AEVs.**

Employment impacts of AEVs are hard to assess as between the two scenarios. The removal of the need for a driver will clearly cause significant job loss in sectors such as freight, bus and taxi but offsets of some unknown proportion should follow from higher urban productivity associated with the optimistic scenario.

IMPLICATIONS FOR PUBLIC TRANSPORT

Markets subject to most pressure for change

Given the particular interests of BIC and its members, we consider the way that AEVs might impact on public transport in coming years. Removing the need for a driver makes AEVs an appealing proposition for much public transport and the potential low cost of shared AEVs opens up market opportunities for such vehicles to provide services that are currently regarded as 'public transport'. For example, micro transit (6-12 passengers) could provide frequent, demand-responsive service (Litman 2018). However, shared mobility solutions will be somewhat harder to deliver in the low density settlement patterns that characterize Australian cities and regions than in higher density settings, because of service economics. In this section we present a brief outline of public transport service economics, since some existing PT services (i.e., shared mobility) may be at considerable risk as MaaS/AEV use grows.

In service cost terms, public transport service provision confronts a constant trade-off tension between pursuing patronage or ridership, which tends to produce relatively low costs per passenger kilometer and delivers economic and environmental benefits, versus service coverage for social inclusion purposes, where costs per passenger kilometre tend to be high. This market distinction is often described as being between *mass transit* services and *social transit*, or between *ridership* and *coverage*. Figure 5.1 characterizes service by mass transit and social transit across a city and links this to characteristics of urban structure that have been shown to affect PT patronage and car use (Ewing and Cervero 2010).

In outer urban (and regional) areas, land use density and mix (diversity) are usually low and so is PT service connectivity but distance from a city's CBD is relatively high (shown in reciprocal form in Figure 5.1 as 1/Distance from CBD being low). PT service characteristics in this setting are typically relatively low frequency service levels, shorter span of operating hours, less direct routes and relatively poor travel time compared to car (including access/egress/wait stages). Accessibility is also usually poorer in low density areas, in both the sense that stops may be less accessible than in better served areas and in the broader sense that fewer access opportunities will be available by PT, within any given travel time. As distance from the fringe reduces (i.e., the CBD is closer), densities increase, land use diversity (mix) typically increases and PT connectivity improves, because PT services operate at higher frequency, over longer spans, with more direct routes. PT door-to-door travel time improves somewhat relative to that by car.

Figure 5.1: Aligning PT service with land use

PT (/CT) service characteristics

Social transit (Coverage) — **Mass Transit (Ridership)**

Frequency
Span of hours
Accessibility
Route directness

Low ⟷ High

Strategic land use influencers

Density
Diversity (land use mix)
1/Distance from CBD
Connectivity

PT operating cost per passenger and per passenger kilometer tend to be relatively lower for mass transit services, where scale economies are most likely, and higher for the social transit service, recognizing that different PT modes may perform some or all of these respective services. Thus, for example, Victorian 2016-17 Budget Paper No. 3 (DTF 2016) suggests that 2015-16 Melbourne public transport costs, mainly operating, were $5.28 per passenger for bus (of which perhaps one fifth is capital cost), $3.35/passenger for train (payments for metropolitan train services) and $1.06/passenger for tram (payments for tram services). Conversely, however, capital costs for mass transit, particularly rail and tram/light rail, are high relative to social transit, for reasons such as the high cost of land acquisition and/or tunneling (purchase/construction of dedicated right-of-way), fleet costs and signaling systems. For example, Melbourne's Metro Rail Tunnel project has an estimated cost of $11 billion, none of which is reflected in the $3.35/passenger cost.

The high capital costs and associated high patronage of rail mass transit services to central cities provides them with significant natural monopoly characteristics, which suggests multiple sources of supply are unlikely.[1] The agglomeration economies, congestion cost savings and environmental benefits (external benefits) associated with such services speak to the importance of strong governmental control over service provision, rather than leaving them to the dictates of the private marketplace, where under-provision would be expected, relative to the scale of external benefits. We conclude that these natural monopoly characteristics and external benefits are such that, in coming years, the Australian mass (trunk) transit market should be remain as *public transport* as we currently understand it. There is a need to include these trunk services in MaaS bundles, for which they will provide a fundamental ingredient. Also, given the important service role they will inevitably play therein, providers of mass transit could decide to take on a role as MaaS brokers. There is interest, for instance, from Metro Trains Melbourne in *access*

[1] Although vertical separation of track and services can be used to reduce the degree of natural monopoly.

contracts to expand their service offering to cover the first/last mile to/from stations, through innovative ridesharing programs and partnerships with ride-hailing providers (Wong and Hensher 2018). Developments in other markets, however, are less encouraging, as independent MaaS operators attempt to displace public transport with intermediate modes where the profit margin is higher and to sell more expensive mobility packages. This issue is the focus of present research at ITLS on the broker-supplier interface of MaaS service delivery.

Social transit services are much less likely to generate agglomeration economies, congestion savings or environmental benefits but can deliver significant social inclusion benefits, which our research shows has a high monetary value. Importantly, these services can be provided by smaller units than mass transit services, which makes them more open to competition from a new provider than is the case with mass transit. It is these local social transit services that we see are most likely to face competition from expanded personal travel opportunities offered through MaaS-based shared mobility services. Significantly, the valuable social inclusion benefits from social (local) transit are also likely to be available from an alternative form of local service provision, at least to some extent; they are not unique to local bus services, for example. It thus comes down to who can provide an adequate level of social (local) transit-like service most effectively, efficiently and sustainably.

This discussion can be summarized graphically, as in Figures 5.2(a) to (d). In simple terms, public transport can be categorized as either mass transit (trunk services) or local (social) transit. Some of the latter services are well patronized and others are less so, as in Figure 5.2(a). There is a general tendency at present for state governments to shift resources into expanding mass transit and well patronized local services, as in Figure 5.2(b), sometimes to the detriment of service levels on less well patronized social (local) transit service. Roll out of MaaS and AEVs can be expected to put increased pressure on the better patronized local transit services, where demand is strongest, probably replacing them with shared car/small bus-based services, particularly when these become driverless and lower cost (Figure 5.2(c)). This development direction reflects a blurring of the boundaries between PT as we have known it and private transport. Local transit services that have low patronage levels are at risk of losing all or most service in this context, particularly if governments rely on the market to provide most local PT-like services, expecting this to be at low cost (through MaaS with AEVs). We see this as a major risk exposure in terms of social exclusion: governments seeing MaaS/AEVs as almost the ultimate deregulation, with the market providing services to all at a very low cost. This greatly overestimates, we believe, what might be possible in terms of commercially-based service offerings in low volume markets. Risks are less if service delivery agreements are used to assure service continuity in some form, as discussed below. Fare discounts may remain for some types of passengers but there may be fewer services available locally, if patronage levels are poor, on which to take advantage of these discounts.

One likely PT operator response to this evolving setting is suggested in Figure 5.2(d), where the mass transit operator seeks to extend their influence across the full service spectrum, absorbing the MaaS broking role within their business model. Within this model, the PT operator may seek to directly provide a wider range of services or else sub-contract others to provide some elements. In any event, low patronage local services will remain at greatest risk.

Some operator cross-subsidy of service costs on lowly patronized social transit routes, from their revenue streams on more commercially viable services, might take place, especially if operators seek to grow market share with a view to the long term. Nonetheless, if service provision at the low patronage local end is left entirely to the private market place, then exclusion risks will increase, particularly in fringe urban/regional areas and in rural/regional settings, where demand densities are least supportive of commercially viable offerings for shared mobility. Alternatively, service delivery agreements could be used, between authorities, trunk operators and local operators (including MaaS providers and/or particular shared mobility providers), to ensure a range of service offerings continues.

The extent to which existing and developing local PT services are under threat from new (MaaS-based) service offerings will depend in part on the way future urban development takes place. Australian capital city integrated land use transport strategies are increasingly being geared to deliver more compact cities, involving increased densities in outer growth areas. For example, the Ministerial Advisory Committee for *PlanMelbourne* 2017-2050, on which one of the present authors was a member, proposed a minimum 25 dwellings per hectare for Melbourne's growth areas and Toronto is now working to new Greenfield densities of around this level. If these densities can be achieved, the boundaries between social transit and mass transit will be narrowed, tending to sustain a higher level of mass transit in the form we currently know it than if lower densities persist but still likely to see substantial involvement of MaaS and disruption of existing PT at local service level by shared mobility services.

Figure 5.2(a): Public transport route service markets – a simple characterization.

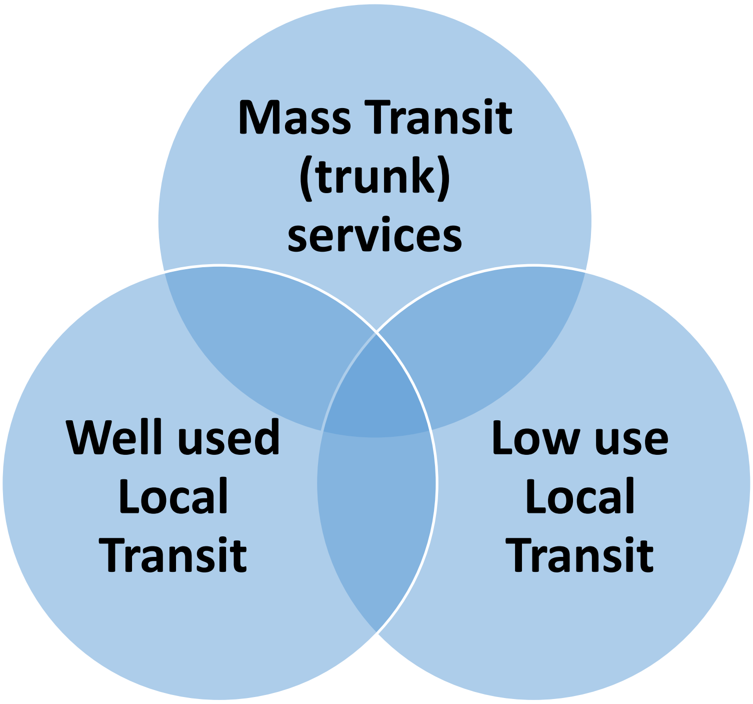


Figure 5.2 (b): Current tendency for PT service development

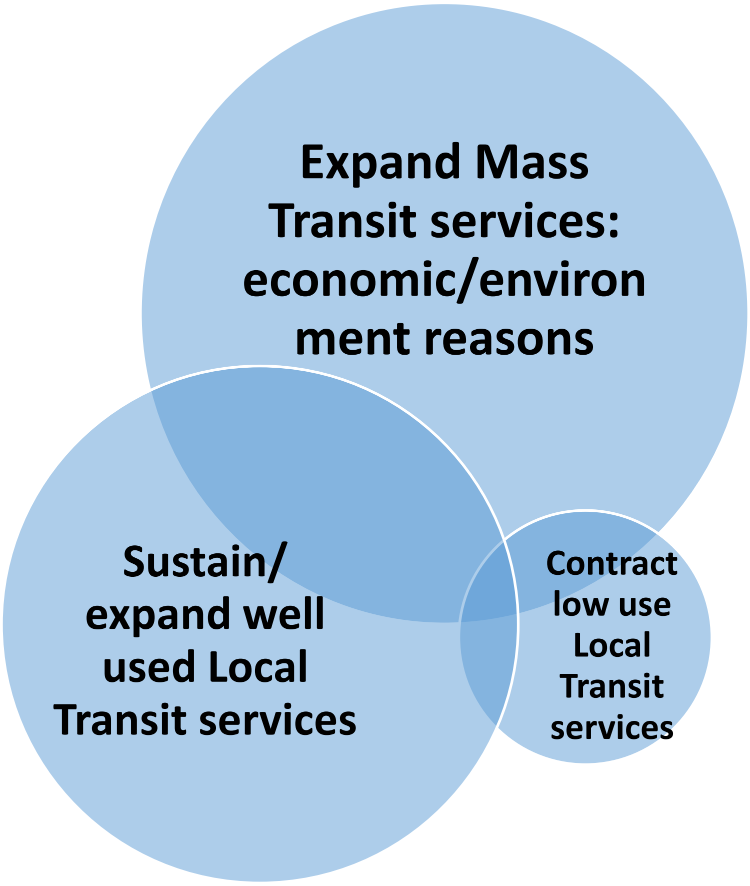


Figure 5.2(c): Possible consequence of shared mobility growth, by about 2030

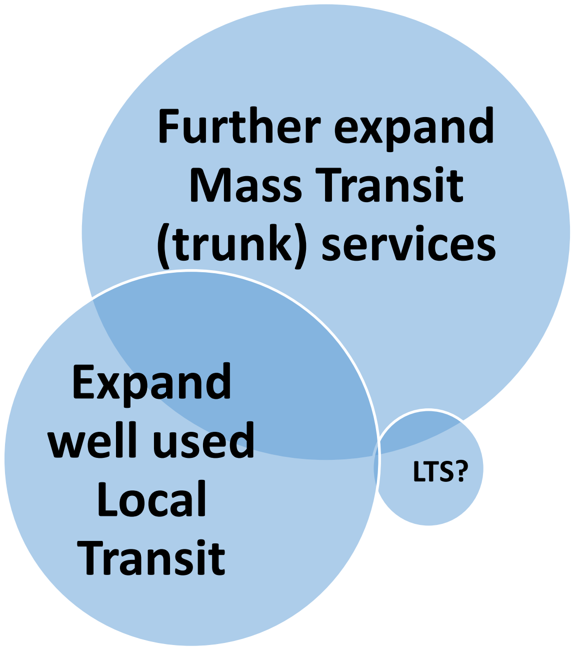
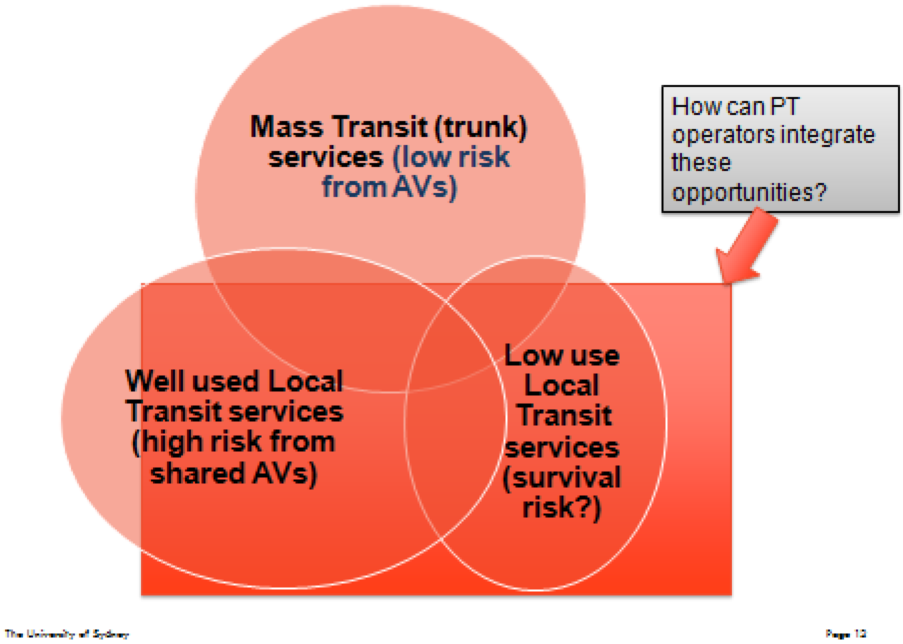


Figure 5.2(d): Likely PT operator response



Whilst the suggested future of PT operators absorbing the MaaS broking role within their business model constitutes a longer term development, much innovation is already happening, with forays into intermediate modes and new models of providing local (coverage) transit. Whilst this is evident from the innovative work of multinational multimodal operators (e.g., Transdev, Keolis) in overseas markets, local Australian operators are also keenly exploring this space. In NSW, on demand services have being trialed since late 2017 in the form of government-led pilots, with various models deployed in Metropolitan Sydney, Outer Metropolitan Sydney and (from late 2018) in Rural and Regional NSW. Existing PT operators are partnering with technology providers to deliver these new innovative services (Table 5.2). Whilst this first wave of services has been government-led, bus operators are rolling out their own on demand services independent of government as well. There are varying reasons and levels of enthusiasm for this, with the cynical seeing it as a way to impress and keep/win future tenders, given government interest in on demand services. Indeed, on-demand public transport is being integrated as part of conventional bus service contracts, as evidenced by the recent SMBSC[2] Region 6 contract offering.

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[2] Sydney Metropolitan Bus Service Contracts

Table 5.2: Public (bus) transport operators collaborating with technology providers to deliver on demand services

Bus Operator	Platform Provider(s)	Service Profile
Keolis Downer	Routematch, Via	Keoride on Sydney's Northern Beaches and Macquarie Park, Newcastle On Demand
Transit Systems	Bridj (acquisition)	Weatherill Park (Sydney), SMBSC Region 6 (future)
Premier Illawarra	TaxiCaller	Premier Illawarra On Demand
Interline Bus Services	Thoreb Australia	Interline Connect in Edmondson Park (Sydney)
Busways	Via	NSW North Coast (Rural and Regional On Demand tender)
Forest Coach Lines	TaxiCaller, Tuup (former)	NSW North Coast (Rural and Regional On Demand tender)

One of the key issues in any business collaboration is that of branding and customer ownership. There exists a view that transportation network companies delivering intermediate modes are keen to integrate additional modes (including public transport) as part of their existing branding, whilst bus operators are wary of losing their branding and identity in any MaaS-type service offering. This concern was raised prominently at the Thredbo 15 conference[3] in Stockholm (August 2017) by Workshop 7 participants on the 'uberisation' of public transport and MaaS (Mulley and Kronsell 2018). Research at ITLS is further investigating the conditions for stakeholder support/investment (including from both mode-specific operators and non-mobility providers) in MaaS broker businesses including how brand issues might affect bidding power (Hensher 2018).

[3] The International Conference Series on Competition and Ownership in Land Passenger Transport, commonly known as Thredbo (http://www.thredbo-conference-series.org)

PUBLIC TRANSPORT SERVICE SUBSIDIES

Discussion in the previous section noted that fare concessions may continue under a public transport future in which MaaS, using AEVs, provides a significant share of local PT. Those fare concessions are usually provided to assist groups of people, likely to be transport disadvantaged, to have increased travel opportunities, with seniors and young people/children usually eligible, together with a range of others (e.g., health care holders, disability support pensioners). There is no reason, *a priori*, to expect that such fare concessions will be any less relevant in coming years than they are today, to help assure better mobility opportunities for potentially transport disadvantaged groups. We thus assume that fare concessions will continue. The question remains, though, what might happen to public transport service subsidies currently provided by state governments to support PT operations?

The answer to this question depends in part on future road pricing reform. Workshop participants at the Thredbo 15 Conference (Workshop 5) developed the following formula, to enable estimation of the level of cost recovery that should be sought from system users via fares (Stanley and Ljungberg 2018):

(1) Amount to be re-covered by user fares = MSC – PTEB – MSLC

where:
MSC = (Efficient) Marginal social cost of PT service
PTEB = the net external benefits of PT (*system-external benefits*, such as agglomeration economies, health benefits and environmental benefits, should be funded by beneficiaries if possible; *system-internal benefits*, particularly Mohring network scale benefits[4], should be funded by government)
MSLC = Minimum (safety net) service level cost (which should be funded by government).

[4] The *Mohring effect* (Mohring 1972) is listed as a potential benefit of public transport in the *Externalities: system-internal* category. This benefit item essentially refers to scale or network benefits that may sometimes accrue to PT users from increased PT service levels. For example, more frequent PT services, in response to increasing demand, imply shorter waiting times, with marginal waiting costs less than average waiting costs. For example, Jansson, Holmgren and Ljungberg (2015) suggest that 30-75% of urban PT marginal costs might potentially be eligible for subsidization in an optimal pricing model, solely because of the Mohring effect.

Public transport service subsidies are currently justified, in large part, because road users do not meet the societal costs attributable to their travel choices, including congestion, air pollution, GHG emissions, accident costs, etc. If road use was priced so that users were required to fully meet the marginal social costs attributable to their road use, then a large part of the system-external benefit component of PTEB, that essentially relates to road use being improperly priced, would drop out of the PT fare setting equation, implying higher fares. Lower service costs from shared mobility solutions may mean, however, that PT fares may not need to rise. Australian urban PT cost recovery rates around 30% are common on marginal costs and, recognizing that some of the elements in equation (1) will remain under road pricing reform (PT system-internal external benefits plus social inclusion benefits), suggests the potential for fares to be at broadly similar levels to today in a system where shared mobility solutions provide much of the local transit task. [5]

Australian Governments at federal and state level have long resisted road pricing reform, in spite of numerous inquiries proposing implementation. However, the erosion of fuel tax revenues, as EVs increasingly penetrate the vehicle market and as fuel efficiencies of ICEs further improve, will force governments to confront this issue in the medium term, with mass, distance, location-based pricing probably the most efficient solution. Furthermore, we argue that road pricing reform is a crucial weapon in the policy armoury required to maximize the likelihood that AEVs will deliver net societal benefits, through the incentives that pricing reform will provide to solutions that involve shared mobility (Scenario 1). We therefore make the heroic assumption that, within a decade or so, road user charges will much more closely reflect the societal costs attributable to road use and that PT fares will need to be more cost reflective in response.

Considering equation (1), in a future road pricing setting where user charges fully reflect the social costs associated with road use, there remains a long-term argument to support PT and PT-like services because of (1) the continuing wider economic benefits (e.g., agglomeration economies) that depend on trunk PT services, (2) network economies and (3) social inclusion benefits. In the case of (2), **Mohring network external benefits**, subsidization of trunk services will be the main policy direction and subsidy arrangements should be reflected in mass transit service contracts. For (3), **social inclusion benefits**, the focus for incidence is mainly on local transit services, including those lowly patronized services that will be at greatest risk under a future with MaaS shared mobility services playing a much larger role. Should operators (who could be new local shared mobility providers rather than existing PT providers) be supported to continue to provide some services that cater for this market in particular service areas, with service rights the subject of a competitive tendering process or negotiated performance-based contracts, as we have argued should continue in the mass transit market? Alternatively, should social inclusion support be provided to (particular) users through user-side subsidies, who are then left to choose how to use that support, along the lines of the National Disability Insurance Scheme model?

[5] In support of this proposition, Thredbo 15 Workshop 5 participants concluded that, taking account of the potential scale of *externalities: system-internal* benefits, from the Mohring effect, and the value of (user) social inclusion benefits, cost recovery rates from fares for urban PT of well under 50% should commonly be expected, with rural fare cost-recovery rates lower than urban.

If social inclusion is seen as a societal priority, then some base level of shared mobility service to support or underwrite this outcome is warranted. We see no other way of assuring minimum local mobility opportunities are available to 'at risk' people. By implication, local *shared mobility contracts* should be developed to support provision of base social transit service levels, which would be expected to vary by demographic/land use setting. For example, expectations should realistically be for a lesser service level in a rural area than in a town. Requisite minimum service levels need to be set out in the contracts and might be expressed, for example, in terms of

- seat kilometres to be supplied per time period/spatial setting, where time periods and spatial settings are specified, or
- the maximum wait time for a demand-responsive service, within particular locations and time periods.

Any such clauses would require mechanisms to be in place (e.g., bonuses, penalties), to help assure compliance. In pricing such shared mobility contract services, operators would be expected to take account of opportunities for cross-subsidization from more commercially viable services, to increase their chances of placing a successful bid.

In the interests of more efficient, integrated service delivery at minimum call on the public purse, shared mobility service contracts should be as broad as possible, generally seeking to encompass route type PT services, school services and community transport service offerings. Depending on the legal context in a particular jurisdiction, shared mobility contracts would be open to bidding by mass transit operators, local transit operators and other shared mobility providers, including MaaS brokers if they so wished. They would be area-based contracts, to provide sufficient scale to achieve some service economies, with population catchments being the basis for area definition where they exist (e.g., in regional and rural areas). Fare concession reimbursements to particular categories of user would continue to be relevant to such services (and others), preferably funded from a welfare budget!

An alternative way to approach social inclusion benefits is to pay the equivalent of a service subsidy to particular categories of at-risk users, probably subsuming existing fare concessions, and enable recipients to use the money thus allocated to purchase shared mobility services on the market. This would require identification of specific categories of eligible customers, for whom the support would be available, and a means of identifying these users when they use a shared mobility service. The latter would be easy to achieve through an app-based approach, provided eligible users all had access to such technology (most, but not all, will). Shared mobility providers would then claim on the state government for services provided, as measured through the app-based system.

However, identification of people at risk of mobility-related social exclusion is no easy task. At-risk groups can be readily listed, such as youth, older people, people with a disability, recent arrivals, etc., but risks of mobility-related social exclusion do not apply to all members of such groups. Household income is not always a useful indicator, since young people from high-income households can be transport disadvantaged. Also, making service subsidy funds available only to particular identified categories of users creates a risk of service not being available to some people who do not fit neatly into the defined categories but are, nonetheless, at real risk of mobility-related social exclusion. Similarly, some people who are currently eligible for fare concessions have high incomes and are probably not at much risk of mobility-related social exclusion. In short, clearly identifying the people likely to be at risk of mobility-related social exclusion is not easy and, furthermore, we are concerned about the possible privacy implications of an individual-based test of such risk. A further concern arises with person-centred subsidies in low density settings. In such settings, fragmented service offerings might arise, reducing the likelihood of a viable base level of service being available to people at risk of mobility-related social exclusion (a concern we have with the NDIS). Diseconomies of small scale are a real risk to base local service level provision. In our view, only area-wide shared mobility contracts for some base service level, which includes flexible demand responsive transport, can deal with these concerns.

Our preference is thus for a subsidized minimum service level approach to shared mobility service (social transit), which supports individual capabilities and allows people to self-select on use, with existing fare concessions continuing. Importantly, **the subsidy for shared mobility service should be for *service*, not modes per se, and shared mobility contracts should reflect this focus.** Shared mobility contracts are most relevant in rural, regional and outer urban settings, where they could be introduced now, given sufficient institutional will to pursue more integrated service offerings.

FUTURE BUS MASS TRANSIT

The realities of a growing population, 36 million in the next 30 years, as outlined in the Infrastructure Australia (IA) Report 'Future Cities – Planning for a Growing Population" and the recommendation that there is a need to increase investment in timetable free mass public transport to reduce congestion and increase access between where people live and where they work, hardly seems surprising.

In a time of "disruption", the way we do mobility, the way we move people is changing, and a shared mobility future based around actual demand rather than latent demand is with us.

This can only be good for the travelling public but at the same time we need to recognise that at the core of our transport challenges in our cities and growing regions must be effective and efficient mass transit such as IA have recognised in the before mentioned report.

At the same time as disruptive technologies are changing the way that people connect to transport services, we are also looking toward electrification and automation of future vehicles and this presents some interesting challenges for future public transport services and mass transit infrastructure investment.

Planning and construction of new mass transit infrastructure is happening right now all over Australia. The building of Metro in Sydney and Melbourne the two big projects mentioned in the IA report.

Heavy and Light rail has seen an explosion of investment over the past decade and this will service mass transit corridors for many years to come, but what of future mass transit infrastructure investment in an electric and autonomous, driverless vehicle world. A world that all Australian Governments seem to have accepted as a coming reality and only a matter of time.

The Bus Industry Confederation agrees, it is only a matter of time, perhaps the 30 year timeframe and challenges of population growth presented in the IA report is a realistic timeline for autonomous vehicle to be fully in operation on our roads. Large autonomous buses for example have been running in very successful trials on dedicated infrastructure for some time in Europe.

The BIC holds the view that the move to autonomy will and needs to be led by mass transit bus services operating on bus priority infrastructure and dedicated bus rapid transit infrastructure such as the Brisbane Busways.

Autonomous buses will simply become the train of the future in an autonomous world where fixed infrastructure is no longer required. A train set of bus seats travelling along a transport corridor where individual bus carriages have the capacity to peel off as required to deliver passengers as close to their end destination as possible and connect to on demand services to complete the trip.

This is Mobility as a Service (MaaS) and at the core or MaaS must be a spine of mass transit that carries the bulk of the population most of the time.

A March 2014 report by BIC to Infrastructure Australia provided insights into the potential of rapid transit, in particular bus rapid transit for the consideration of all Australian Governments, which in the context of future autonomy is even more relevant for all Australian governments who are serious about future autonomy and seriously considering and planning for long term bus rapid transit infrastructure today.

It is also important in this context to recognise the Australia Infrastructure Plan Priority List, February 2016 that included the “Network Optimisation Portfolio” as a high priority initiative with a near term proposed timetable of 0-5 years.

The initiative involves a portfolio of works focussed on addressing congestion on urban road networks with comparatively high public transport and freight use. The BIC sees this as an opportunity for all jurisdictions to identify and invest in bus priority , bus rapid transit “lite” and bus rapid transit infrastructure in line with data and technology to improve network operations and in particular integration of bus, rail and ferry services and planning for future autonomous bus mass transit.

Bus is the workhorse of Australia’s mass transit systems today, carrying more passengers than rail each day and this will continue to be the case in an autonomous transport world, but the mass transit infrastructure investment will have to keep pace, be ahead of the game to deliver IA’s recommendation of increased investment in timetable free mass public transport services.

POINTS SPECIFIC TO THE BUS INDUSTRY

Market segments

In simple terms, there are three main market segments for what is known as the public transport (bus) market.

Each of these services or market segments in some way operate with Government subsidising the passenger fare.

The impact of driverless vehicles in reducing operating costs and therefore providing a possibly more commercial basis of transit operations is explored further below. As far as the current discussion stands it seems little focus has been placed on capital and IT and technical costs to operate driverless vehicles which may well create significant costs above what is currently the case for mass, local and community transit services.

Mass transit services are high volume point-to-point services that operate through what will become increasingly significant strategic transit corridors, in which a substantial proportion of future population growth will locate, as our cities seek to become more compact (~half in Vancouver). These services are high frequency, volume-based services, which need to operate with good speed and high reliability. They are likely to grow substantially as urban densities increase and are least likely to lose market share to innovations such as Uber or driverless vehicles. These services in the BIC view are unlikely to be driverless or unattended.

Local transit services are about coverage and servicing the 20 minute neighbourhood. In effect local services operating off major trunk route services to deliver passengers closer to home or end destination.

Community transit services are about people who need assistance with their travel, for various reasons (e.g. a personal disability of some type, such as physical or intellectual).

- The local transit market segment, which is currently served by local buses, could be subject to competition from migrating services such as driverless Uber type multi-passenger services, who may see an opportunity to provide a service at a profit. The provision of existing subsidised local bus services, as we know them, may be reduced in this competitive environment, meaning that those least able to pay for a local PT service may be without service. Many people who use a bus service for local transport needs are those without cars (due to low income, age/disability etc.). It is possible (likely) that the cost of an Uber or taxi or shared driverless vehicle (bus) may be too high for those on lower incomes to be able to use the vehicle. In such situations it will be unfortunate if the public local bus service is abandoned or even further diminished than it is now. This is an area where social impacts could be considerable. From a regulatory perspective, this future market segment needs to ensure all potential providers meet decent safety and environmental standards;
- The community transit clients will be joined by those who drop out of the local transit market segment, leaving an expanded number of people who will need some form of local mobility to support their social inclusion.

Operating costs

At present the major operating cost of a bus is the wages of the driver (~half the costs of urban route bus service). If the bus has become 'driverless', there will still need to be some oversight of the bus on the road. In the mass transit market, this oversight will be to assure performance expectations are met.

In the local and community transit segments, it will be to ensure that the specialized service requirements are met. A level playing field oversight will be needed to ensure fair competition and service providers are capable of meeting specialised customer needs.

Buses operating with only passengers raise a number of concerns, which are outlined below. One factor that has been recognised after actual trials of driverless buses on guided busways in France is that passengers do have concerns of trust and safety when a driver is not aboard. In this example, drivers were returned to the bus to ease concern, despite the fact that the vehicle remained self-driven. The physical presence of the driver was an important psychological factor, even if it was only for "override" capabilities if required. Trusting future technology will be a major challenge for many individuals.

Capital costs

We are not aware of the expected capital cost of driverless buses. While a driverless car will cost the purchaser more – initially $7,000 to $10,000, but diminishing over time, the cost increase for larger vehicles can be expected to be larger. As mentioned above little information also seems to be available in relation to capital, IT and technical cost of operation. Also the driverless buses on trial tend to be much smaller than the common commercial bus. This is in line with our expected market categorizations above, which sees local transit travel as the possible main change area from driverless vehicle technology

POLICY IMPLICATIONS

Context

Land passenger transport seems destined to confront major technological disruption over coming decades. This will include limited app-based MaaS offerings in the early years, with a much more rapid incursion of such services as AEVs become available. The timing of such availability is the subject of much debate but we are inclined to agree with Litman (2018) that two to three decades is probably the time frame for widespread availability. This means that there should be time to prepare for disruption and to apply policy settings that help to increase the probability that such disruption produces net societal benefits. Policy will need to address a wide range of matters, many of which are beyond the scope of the present paper. We focus here on key land use transport policy settings that will encourage shared mobility to form the dominant method of new land passenger transport provision, rather than individual ownership. The optimistic and pessimistic scenario analysis suggested that this is the key to ensuring that net external benefits, rather than net external costs, flow from the disruption.

Four matters stand out as policy priorities.

1. Implementing mandatory emissions standards for motor vehicle greenhouse gas emissions, to help drive technological change in a climate friendly direction, supported by behaviour change measures that reduce motor vehicle use.
2. Ensuring that transport users meet the social costs attributable to their road use, while ensuring affordable access is available to all at a reasonable level.
3. Managing land use to ensure that urban sprawl is tightly contained and that opportunities are used to increase the supply of open space within the built-up area, an issue highlighted in the recent report by Infrastructure Australia (2018).
4. Developing new shared mobility governance (including data availability) and strategic planning arrangements and associated service delivery contracts for provision of local public/private mobility options that support social inclusion and are integrated with mass transit offerings.

With the exception of mandatory emissions standards, these three policy areas are all key areas of policy responsibility for states, and to a lesser extent, local government at city and regional level, areas which have formed a major focus of BIC' s Moving People policy research. Issues such as policy about emissions standards, AEV safety, vehicle design, data and communications management, privacy, cyber security, ethical and legal aspects of AEVs are also important but beyond the scope of the present paper. These latter matters are primarily ones where the federal government must take the lead. Isaac (2016) includes some informative discussion on such matters.

Mandatory emissions standards

The case for introducing mandatory emissions standards is based on Australia's high rate of GHG emissions, the large and increasing motor vehicle contributions to these emissions.

By 2021, phased in from 2020, the fleet average to be achieved by all new EU cars is 95 g/km and US 2025 targets for all new light vehicles (passenger vehicles and LCVs) are 107g/km (cars 86g/km; LCVs 129g/km). CCA (2015) has proposed an Australian standard for light vehicles (new passenger cars and LCVs) of 105 g/km at 2025, showing user benefits from this standard well in excess of the costs for achievement.

Australia should move quickly to implement mandatory GHG emissions standards for motor vehicles (CO_2 emission rates), in line with European or US timelines.

Mandatory emissions standards need to be complemented by the kinds of incentives that countries which already have these emissions standards use to further incentivize increased electro-mobility, such as lower sales taxes, lower road taxes, access restrictions on dirtier vehicles, education and awareness programs and roll-out of charging infrastructure (Andwari et al. 2017). Longer term, mandatory emissions standards plus comprehensive marginal social cost road pricing (which benefits clean technologies) are likely to be the most effective way to 'encourage' greater penetration of EVs, from a level playing field starting point.

In terms of cutting motor vehicle GHG emissions, Stanley et al. (2018) show that mandatory emissions standards alone will not be sufficient to ensure that road transport makes a proportionate contribution to the currently committed 26-28% reduction in national GHG emissions by 2030. Behaviour change measures are also required, slowing the rate of growth in car use and increasing travel by active transport and transit (e.g., on-road priority to shared mobility vehicles, including AEV when available, which would help achieve GHG reduction goals and also support wider benefits from AEVs).

TRANSPORT PRICING REFORM

BIC has consistently argued for road transport pricing reform that charges users for the marginal social costs of their travel choices and, when this pricing is in place, for public transport pricing (fare setting) to better reflect marginal social costs of service provision. As argued in this submission some continued subsidies to public transport will remain defensible, because of the presence of wider economic benefits (e.g., agglomeration economies) and social inclusion benefits from PT services.

In an Australian context, perhaps the most notable development on the road pricing front in recent years has been the support for road pricing reform expressed by the Productivity Commission (Harris 2015), the Harper Competition Policy Review (Harper et al. 2015) and Infrastructure Australia (2017) at federal level, and by Infrastructure Victoria (2016) at state level. While the Productivity Commission, Harper Competition Policy Review and Infrastructure Australia reports are all strongly supportive of road pricing reform, however, none has really confronted the prospect that *efficient road user charges* might need to increase substantially, if the societal external costs attributable to road use are to be met by users. All seem more concerned about strengthening links between road expenditure, road funding and user charging, in a way that gives road users a greater say over resource allocation decisions on roads. These are worthwhile intentions but only part of the story. Infrastructure Victoria's report more readily confronts a need to use price to influence behavior, without necessarily running for cover in terms of whether some resulting transport prices might need to increase. The Victorian Government has rejected the Infrastructure Victorian pricing recommendation but IV appears committed to the long term merits of its pricing policy direction.

Stanley and Hensher (2011) concluded that the Australian fuel excise rate at that time was 5-10c/L too low to cover the external costs of road use. Updating this work, Stanley and Hensher (2017) suggest that this gap has widened and is probably around 15-25c/L today. This underlines both the urgency of reforming the way road use is priced, in the interests of improved economic efficiency, and the need to be prepared to increase the size of charges on motorists in the process of reforming road user charging, rather than artificially constraining any such pricing reform to being revenue neutral. A significant increase is warranted, generating substantial additional revenues that can be used to improve roads, public transport and other infrastructure or services that mitigate the external costs of road use.

Fuel is not the most appropriate way to price road use. Longer term, because external costs of road use relate more closely to distance travelled than to fuel use (especially as motive technologies change), a distance-based charging mechanism should be introduced, with mass and location components to better reflect, for example, road damage and congestion impacts. The trend towards more fuel-efficient vehicles, albeit slow, accentuates pressure for such a shift in the way road use is priced, because of the revenue impact on the federal government budget.

Significantly, in terms of the current paper, reformed road pricing would increase the cost of road use in areas where external costs are high, providing incentives for shared mobility solutions and reducing incentives for further urban sprawl, coming through increased ownership/use of AEVs. Mode shares for shared mobility options can be expected to be higher under an MSC pricing regime, which is what an efficient pricing system should achieve.

More radically, and linked to MaaS, Wong et al. (2017) proposes a framework that includes government in the broker model to allow road pricing to be incorporated as an input into the MaaS package price, to optimize/regulate for network efficiency (Hensher 2018). This would go some way towards ameliorating some of the potential road capacity issues (and other externalities, including on land use) arising out of demand for smaller and more flexibly routed services.

Regressive distributional consequences are a potential risk with road pricing reform. For example, outer urban residents, with low household incomes and poor public transport options, might face higher road use costs but with little opportunity to avoid these increases. Fortunately, shared mobility opportunities can help tackle this concern, by increasing the availability of demand responsive travel opportunities, supported by specific social inclusion subsidies that are provided through shared mobility contracts as proposed in this submission.

CONTAINING URBAN SPRAWL

Land use development directions in Australia's major cities are increasingly pursuing more compact settlement patterns, which can involve 'hard' growth boundaries. A major risk from widespread adoption of AEVs, should they mainly proceed down a path of personal ownership mode, is that people will choose to take some of the benefits this offers in the form of consumption of greater quantities of ex-urban land, adding to sprawl, with its associated economic, social and environmental costs.

Road pricing reform will ease these pressures, since longer trips will mean higher road use charges are in prospect, particularly if AEV roll-out leads to increased urban congestion, which is more likely under the personal ownership model. On the land use side, urban growth boundaries provide some protection here, provided they are real limits to expansion (i.e., not regularly pushed further out, or set so far out as to be ineffective). They need to be complemented by land use planning policies that keep tight control over development on the peri-urban fringe.

Higher minimum development densities on the urban fringe and beyond would also help to mitigate risks of extended urban sprawl. These are an important way of encouraging delivery of more compact urban form. Toronto is now moving to minimum greenfield densities of 80 persons plus jobs per hectare, which is around 25 dwellings per hectare, in pursuit of more contained development. This is well above current outer urban densities in Australian cities but should be the kind of minimum density outcome pursued in Australian urban greenfield settings.

Fundamental to managing urban sprawl risks from AEVs is consistent pursuit of more compact settlement patterns, through strategic land use development directions, which forms essentially a *polycentric + corridors + neighbourhoods* development model.

Spatially-oriented transport directions to support this land use direction include:

- ensuring strong radial public transport to the centre, where capacity increases are required to cater for continuing strong growth (roads simply cannot carry the expected increased demands and have high external costs in/through central/inner areas)
- improving circumferential arterial roads. Road-based public transport and freight should be prioritized in use of these roads
- providing fast and frequent trunk public transport services supporting inner/middle urban nodes and development corridors, including for circumferential movement (particularly buses[6]), linked to the cluster (node)/transit corridor development focus
- better public transport connections from outer suburbs to areas of employment/activity concentration, including the small number of high tech knowledge-based clusters
- upgraded trunk arterial roads in outer growth areas (to deal with the current backlog rather than encourage further sprawl)
- increased local public transport opportunities in outer neighbourhoods, to support delivery of 20 minute neighbourhoods
- improved walking and cycling opportunities throughout the whole city, with a particular focus on clusters/nodes and facilitating a city of 20-minute cities.

Care is needed to ensure that these transit oriented development directions do not accentuate gentrification, a tendency that has been observed in a number of settings (Stanley et al. 2017).

Shared mobility use of AEVs provides an opportunity to re-engineer elements of road space, to cater for the requirements of AEVs, prioritizing shared AEVs (and shared vehicles in the transition to AEVs), and to also take back some land from parking and vehicle movement, to support place making and active travel. Drop-off spaces will be needed for shared mobility in busy locations. Such initiatives are supportive of the preceding strategic development directions. More broadly, parking policies should be changed to reduce minimum requirements in locations that are well served by transit. Following the London example of establishing and applying connected standards between densities, public transport service levels and parking requirements would be a useful initiative. Parking spaces that are provided should be priced to better reflect the costs associated with their use (integrated with road pricing reform).

[6] See SmartBus in Melbourne and Metrobus in Sydney

IMPROVED GOVERNANCE ARRANGEMENTS

There is no clearer statement of principles that should (1) guide strategic planning directions to be pursued through governance arrangements to manage introduction of a shared mobility future (including technological change associated with AEVs) and (2) to inform processes that should characterize those strategic planning directions than the ten principles set out in Section 2.2, as follows:

1. We plan our cities and their mobility together
2. We prioritize people over vehicles
3. We support the shared and efficient use of vehicles, lanes, curbs and land
4. We engage with stakeholders
5. We promote equity
6. We lead the transition towards a zero-emission future and renewable energy
7. We support fair user fees across all modes
8. We aim for public benefits via open data
9. We work towards integration and seamless connectivity
10. We support that autonomous vehicles (AVs) in dense urban areas should be operated only in shared fleets.

The simplicity of these principles belies the difficulty of achievement, when judged by past and present failures in land use transport integration. For example, not all states can point to integrated long-term land use transport strategies and few, if any, have strategies to deliver low transport emission futures.

Planning land use, transport and related matters (e.g., affordable housing) in an integrated way involves aligning Strategic (policy), Tactical (system design) and Operational levels of thinking, which is no easy task. It is most likely to be achieved in urban and regional land use transport planning when there is a relationship of trust between the responsible government, industry and other stakeholders, with all having the opportunity to shape, in particular, system level responses to meeting high level societal outcome goals affected by land use transport development directions. Open consultative planning methods are fundamental (Stanley et al. 2017). A *trusting partnership* should be grounded in (Stanley and Smith 2013):

1. **common** core objectives tied to public policy purposes (derived from Strategic level societal outcome goals)
2. **consistency** of behaviour and direction (underpinned by broad agreement about Strategic and Tactical directions)
3. **confidence** in a partner's capacity to deliver
4. respect for each other's **competencies** and,
5. demonstrated **commitment** to good faith in making and keeping arrangements and in principled behaviour.

Agreed and shared **governance arrangements,** including service delivery contracts, provide the glue that ties the principles together.

Public transport (shared mobility) system planning arrangements, and associated service delivery contracts, should demonstrate leadership by developing improved governance arrangements for shared mobility, reflecting both (1) the five trusting partnership qualities and (2) the ten shared mobility principles. This will inevitably require a concerted effort to achieve better horizontal and vertical integration of governance arrangements across the whole land transport domain and associated domains (e.g., affordable housing).

This would constitute a major shift for the better in the way land use transport system planning is performed.

Inter-governmental processes, such as City Deals and infrastructure funding bids, provide opportunities to formally require governance arrangements that demonstrate compliance with the trusting partnership and shared mobility principles, as gateway conditions on eligibility. They should be used to drive improved planning practice along these lines, leaving scope for states and territories to define their own detailed approaches to outcome achievement. Stanley et al. (2017) have argued that a stronger voice for the **neighbourhood level** is perhaps the biggest single requirement in improved governance for more integrated land use transport planning. This applies with particular force to planning for shared mobility, since it is at neighbourhood level that many of the largest benefit opportunities will arise, both mobility-related but also in terms of improved safety, local pollution reduction and improved place-making.

> At State and Territory level, early development and implementation of service-focussed shared mobility contracts would be a positive supportive step along the transition pathway to future governance models that are better suited to emerging technological opportunities, while delivering immediate benefits from realizing a more integrated service delivery model. Integrated app-based booking/ticketing systems, with a range of on-demand service options, are fundamental to the prospects for MaaS and for shared mobility service in the immediate future and should be a requirement of shared mobility contracts

Conclusions

Finally, we suggest that driverless vehicles are a long way off yet – both in terms of technology and establishing the environment for them to run.

Initially the following questions need to be answered before further development occurs to ensure the personal safety and security of individuals on buses and that physical access and opportunities are not reduced:

- How do we establish a moral decision about how to respond to an impending accident – e.g. save the passenger or save the pedestrians who will be hit?
- How will the driverless vehicle operate in very poor visibility e.g. dense fog and snow?
- Will the car's cameras correctly interpret a view of a pothole, puddle, oil spill and shadows?
- Maps are needed with considerably more detail than is presently available, such as traffic signs, and roadworks. Such maps will need continual up-dating.
- What will be the impact on road congestion of a fleet of driverless vehicles?
- How would incidents of criminal behaviour be managed?

In summary, the move to driverless vehicles needs to be understood in association with other transport changes taking place, such as shared vehicles and road pricing reform. These matters must be treated in an integrated way, in the context of the broader societal trends and issues that have to be addressed – road safety, personal safety and security, national security, social inclusion, population growth, urban sprawl, possible job losses with technology, climate change and the need to address greenhouse gasses and traffic congestion.

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There is an opportunity to use driverless vehicles as a stimulus to review how mobility in urban and regional settings should be addressed, with policy, regulations and planning put in place to better link land use and transport in this changing technological setting. A first step however needs be a thorough analysis and future real world trials of where autonomous vehicles and what types of autonomous vehicles will be accepted by the community for use.

We appreciate that the role of Government is to try and find a delicate balance between addressing the challenges that this technology poses not just for legislation and regulations, together with the social implications, but also to be seen not to be standing in the way of innovation. The mining industry already uses driverless technology in their trucks and is apparently successful in their endeavours. However, we note that the trucks used in mines do not carry passengers in an urban setting.

We have witnessed technology impacting the taxi industry. There it has been proposed that the creation of ride sharing technology does not mean job losses for the taxi industry but has forced them to be competitive. The impact of technology cannot be said to have the same effect on the heavy vehicle industry, which is responsible, not only for public safety but also transportation of people and goods in a safe and reliable manner.