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27th September 2019

The Secretary
Legislative Council Select Committee-
Greater Hobart Traffic Congestion
Legislative Council
Hobart Tas

Dear Sir/Madam

The Tasmanian Bus Association submits a submission to the Select Committee –Greater Hobart Traffic Congestion.

Please find attached a submission together with a two studies undertaken by the Bus Industry Confederation and jointly funded by the Tasmanian Bus Association;
1 Improving public transport service:
Hobart – A corridors case study

2 Review of bus rapid transit and branded bus service performance in Australia and future opportunities

Thanking the Legislative Council select committee for inviting the association to make a submission on traffic congestion in greater Hobart.

Yours sincerely

Shane Dewsbery
President
Attach:

TasBus

Tasmanian Bus Association

Legislative Council Select Committee

GREATER HOBART TRAFFIC CONGESTION

Summary

This policy paper has been produced by the Tasmanian Bus Association (TasBus) to help Government, commuters and policy makers understand the importance of public passenger transport and its associated strategic infrastructure for Tasmania's future - a future of bigger cities, more people and an older population.

In that future buses will continue to play a central role in mobility for the vast majority of Tasmania's population.

To meet the future demands action is needed now in the following areas:

1. Creation of a Transport Advisory Panel
2. Increased public passenger transport services, including better services for tourism
3. Using alternative technology and Intelligent Transport Systems
4. Infrastructure to alleviate congestion
5. Making the best economic use of Hobart's northern rail corridor

Each of these actions, together with some changes an could undertake immediately at a low cost, is covered in more detail within the paper

1. Introduction

Public passenger transport is integral to the future of Tasmanian cities, towns and villages. It plays a critical role in determining the quality of life across the state, economic growth, and protection for the environment. Public passenger transport provides improvements in health, education and other social opportunities through the access it provides to services across the whole of Tasmania.

(TasBus) believes Tasmania's public passenger transport system makes a positive contribution to the environment, the social fabric and Tasmania's economic growth.

The key to achieving these outcomes for all Tasmanians is improving the frequency, coverage and priority of Tasmania's bus services.

In advocating for improved public passenger transport in Tasmania, TasBus supports:

- Bus services that are delivered by modern and environmentally friendly vehicles and fuels;
- Good urban and regional planning practices that encourage connections between bus services and active transport modes, such as walking and cycling; and
- Targeted transit oriented development along public passenger transport corridors.

2. The Tasmanian Bus Industry

The bus industry in Tasmania (including Metro Tasmania) encompasses more than 1200 buses (210 in the Metro fleet) and employs over 1200 Tasmanians (450 Metro staff).

The bus industry services approximately 500 contracts, travelling about 18 million kilometres per year (9.3 million travelled by Metro). Each day there are around 65,000 trips taken (33,000 on Metro). Of these trips, students account for around 69% or about 46,500 trips (16,300 on Metro).

3. The Tasmanian Bus Association

TasBus is the peak body representing the Tasmanian Bus and Coach industry.

In Tasmania, buses represent the model that best serves a relatively small state with a dispersed population and hilly topography. The role of buses will increase as the years go by and more residents seek to live around the fringes of our 4 major population centres.

The goals of TasBus are to work in cooperation with the community and the Tasmanian Government to:

- Deliver mobility and accessibility for Tasmanian communities using innovative bus systems;
- Encourage Government investment into services, modern and safe vehicles, and network infrastructure;
- Deliver connectivity between villages, towns and cities;
- Build on the Tasmanian Tourism brand and product; and

.

4. Tasbus Vision Statement

Building a sustainable transport future for Tasmania

The future growth of Tasmanian cities, towns and regions is heavily dependent on quality public passenger transport services. The bus industry is the sole provider of public transport for all Tasmanians including in our cities, urban fringe communities, regional towns and rural areas.

Our vision is:

to deliver high quality public passenger transport
as a viable alternative to the private motor vehicle
for all Tasmanians.

Tasmania's unique lifestyle and beautiful environment provides one of the most livable places on the planet. TasBus wants this preserved and built upon. TasBus believes that convenient and reliable bus services, as an alternative to the private car, is a vital component for maintaining Tasmania's lifestyle and living standards.

5. Our Principles

Three core principles underlie the actions we propose

- **Providing Better Passenger Information** - Encouraging the use of buses as an alternative to private vehicles through increased public awareness, acceptance and usage of buses and building partnerships between key stakeholders.
- **Delivering Quality Buses and Quality Bus Services** - Achieving the provision of high frequency bus services delivered with high quality infrastructure that enhances the attractiveness, efficiency and utility of bus services.
- **Implementing Transit Corridor Strategies** - Working with the Tasmanian Government and communities to develop and implement a long term approach to integrated land use and transport planning which will grow the population around designated transit corridors.

6. Urgent Transport Issues for Tasmania

Tasbus considers there are 6 critical issues that can be effectively addressed by action to improve Tasmania's public passenger transport services and associated infrastructure. These are:

- A growing and ageing population;
- A geographically diverse population, social isolation and transport disadvantage;
- A car dependent population and rapidly growing costs (including urban congestion) of private motor vehicle use;
- Climate change and pollution;
- Personal health; and
- Implementing a Transport Access Strategy

Each of these urgent issues is outlined in Attachment 1.

7. Areas for Action

TasBus has identified a number of areas for action, together with some specific measures, which we consider will deliver high quality bus services in Tasmania to address the urgent issues we have outlined above.

a) Create a Transport Advisory Panel

TasBus proposes the Tasmanian Government creates a transport authority with the specific purpose:

- to undertake the ongoing strategic assessment of Tasmania's passenger transport needs;
- regulate its provision; and
- oversee the delivery of all passenger transport services across the state.

We propose that in the first instance this advisory panel could oversea the immediate implementation of the following specific initiatives which Tasbus considers will promote and develop Tasmania's public passenger transport system:

One ticket – delivering integrated ticketing and standardized fares, zones and concessions through the extension of the Metro Tasmania Green-CARD to all metropolitan and non-metropolitan services, and other modes as necessary. This will provide efficiencies and incentives in the system and encourage more use of passenger transport including by commuters travelling into CBDs from urban fringe areas and by tourists visiting the State and wishing to visit areas and attractions outside the major centres.

One network – by planning and coordinating all major public passenger transport routes, services, connections and infrastructure to deliver a seamless system.

One system – by marketing this seamless system through consistent network branding and passenger information to allow existing services to become better utilized. Increased Passenger Transport Services, including Better Services for Tourism

Following on from Project 2018, the advisory panel described above can deliver better coordination and integration of regional, urban fringe and metropolitan passenger transport services under a common brand for all Tasmanians and visitors to our State.

Once implemented the focus should turn to increased service coverage and frequency in areas identified as being "transport poor" by the many past reports which have looked at transport disadvantage in Tasmania. Tasbus believes this can be achieved and coordinated through Mobility and Accessibility Committees and Industry established between the proposed advisory paneland Local Governments.

TasBus considers that a public passenger transport plan for Tasmania which includes increased and improved services for rural and urban-fringe communities outside the morning and afternoon peak periods, with frequencies of no longer than 1 hour will offset the disadvantage faced where "transport poverty" exists.

We also consider that implementation of this approach must include a consistent approach to timetabling across Tasmania to make catching a public passenger transport service easier.

b) Alternative Technology and Intelligent Transport Systems

TasBus considers that support for the rapid uptake of alternative technologies and intelligent transport systems (ITS) will improve the system for the Government, operators and users.

ITS applications such as commuter real time information, integrated ticketing, operations software etc. together with alternative fuel technologies have been shown elsewhere to drive efficiencies in both the metropolitan and regional fleets.

An investment plan to implement these improvements is needed as a priority to ensure Tasmania's public passenger transport system does not languish at a time when it can deliver real benefits to the local communities across the State and the economy.

c) Making Best Economic Use of Hobart's Northern Rail Corridor

The current northern rail corridor within Hobart should be protected from non-passenger transport related development to enable future passenger transport and urban renewal options to be implemented without un-necessary delay.

In particular, Tasbus considers that when considering passenger transport options for this corridor bus-way and "track-less tram" options be given due consideration. These options would remove the need for users of the corridor to change mode, a significant impediment to transit use, as has been proposed in a number of the recent studies into the viability of this corridor as a passenger transport corridor. It would also allow the use of this corridor to seamlessly integrate into the broader transport network within Hobart and deliver better last mile connectivity for users. Modern technology such as intelligent transport systems and progress with future autonomy of vehicles would indicate that fixed infrastructure such as light rail is fast becoming obsolete and that other forms of rapid transit will provide the same mobility and patronage outcomes and much less the cost of light rail and provide much greater flexibility and utilization. (*please find attached a Moving People Policy titled Improving public transport service :Hobart- A corridors case study undertaken by the Bus Industtry Confederation and jointly funded by The Tasmanian Bus Association)*

d) Infrastructure

The current congestion issues in Hobart require both short and long term fixes. The immediate short term should focus on passenger transport services. To assit in reducing the number vehicles in total on the roads.

In addition to the planned clearway in Macquarie Street this should be extended the total length of Macquarie Street followed by a clearway in Davey Street The cleraways once complete should be utilized only by passenger transport (buses and Taxis) and in the future to be accessible to cars carrying 3 or more passengers (T3)

At the same time as the clearways in the CBD are being developed there should be priority made in upgrading traffic lights such as on the Brooker Highway intersections to give buses priority at light changes togetrher with consideration of a Bus lane only on this road utilizing the current emergency lane .

8. Conclusion

This paper offers a way forward for the incoming Tasmanian Government to address the needs of all Tasmanians and visitors to our State.

Implementing the actions outlined will ensure Tasmanians and visitors are able to effectively and efficiently move around our State with reduced reliance on the private motor car and participate to the fullest extent in their local communities and the Tasmanian economy at a sustainable cost, both individually and for society as a whole.

Attachment 1
Urgent Transport Issues for Tasmania

a) A Growing and Ageing Population

The Tasmanian population at the 2016 Census was measured at 517,588 with a median age of 42. This median age was the highest of all states and territories.

The Tasmanian population grew by 14,614 from 2011 to 2016.[1] The percentage of Tasmanians aged 65 and over grew from 16.3percent to 19.4 per cent of the population between 2011 and 2016.

An ageing and expanding population will bring with it new challenges for Tasmania's transport network as the number of Tasmanians who are no longer able to drive, due to aging related factors, increases and the overall population grows, and with that growth more congestion is experienced on our roads as people seek to access employment and services from more dispersed locations.

b) A Geographically Diverse Population, Social Isolation and Transport Disadvantage

Tasmania is the only state or territory where population growth in the capital city has been lower than in the rest of the state. This highlights Tasmania's highly dispersed population and population growth across the State.

Analysis of ABS 2016 census data indicates that only 21 of Tasmania's 97 settlements has a population exceeding 2,000 people. Additionally, Tasmania had the lowest percentage of its total population, out of any state or territory living in its capital city, Hobart. This rate of urbanization, at 35 per cent of the total population in the capital city, was significantly below the national average, where more than two thirds of Australia's population has been found to live within the capital cities[2].

The split between rural and urban population in Tasmania has been identified from the 2016 Census as 58.4 per cent urban (living within the major centres of Hobart, Launceston, Devonport and Burnie) and 41.6 per cent rural (living in smaller towns and villages and in rural areas).

Tasbus agrees with TASCOSS's assertion that transport is fundamental to connecting people to opportunity:

"Tasmania's highly dispersed population is also an issue in terms of social inclusion. While rural communities may be well-connected, they often lack basic services. Young people, particularly those from diverse groups, can be very isolated, and further exacerbated by lack of access to support services, education, recreational activities and transport. Plentiful and affordable food and child care, health and education services may also be limited".[3]

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[1] Australian Bureau of Statistics, 2016 Census Community Profiles, Time Series Profile, http://www.censusdata.abs.gov.au/census_services/getproduct/census/2016/communityprofile/6?opendocument.

[2] 2071.0 - Census of Population and Housing: Reflecting Australia - Stories from the Census 2016, http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/2071.0~2016~Main%20Features~Snapshot%20of%20Australia,%202016~2

[3] TasCOSS, 2009, *"Just Scraping By: Conversations with Tasmanians Living on Low Incomes"*, TasCOSS, Sandy Bay.

The research shows that not everyone has the same opportunities and capacity to access the goods and services they need to effectively participate in their communities. Data illustrates the differential access to transport experienced by groups such as sole parents, people on low incomes and people with a disability. Across Tasmania there are areas where people experience disadvantage in relation to accessing goods and services – in some areas the disadvantage is related to low income, in others it is related to being small and geographically isolated.

Better public transport will assist these groups better participate in our society.

c) A Car Dependent Population and Rapidly Growing Costs of Private Transport

We consider that there would be many instances across Tasmania where, if services that are currently restricted only to student, were available to the wider community, considerable benefits could be obtained for many regional and remote communities.

We consider that the biggest challenge for public transport exists outside our 4 main cities and that changes to student transport offer Government the opportunity to leverage of existing student services and extend opportunities to others in those communities. In many instances such change may improve the viability of services that may currently be at risk due to low student patronage.

As our members have seen following the introduction of urban fringe general access services in a number of areas previously serviced only by a student service, this model can deliver for all and meet many of the community expectations Recent Tasmanian Government data indicates that there are more than 310,000 cars in Tasmania with approximately 80 per cent of all trips being taken in a car.

2016 Census data indicates 56.2 per cent of all households in Tasmania have access to two or more cars. In Tasmania's rural communities and regional towns nearly 88% of households have access to one or more cars.

This high level of car ownership has impacts where:

- people are forced into car ownership due to lack of available alternatives;
- are unable to drive; and
- on the wider Tasmanian economy through traffic congestion.

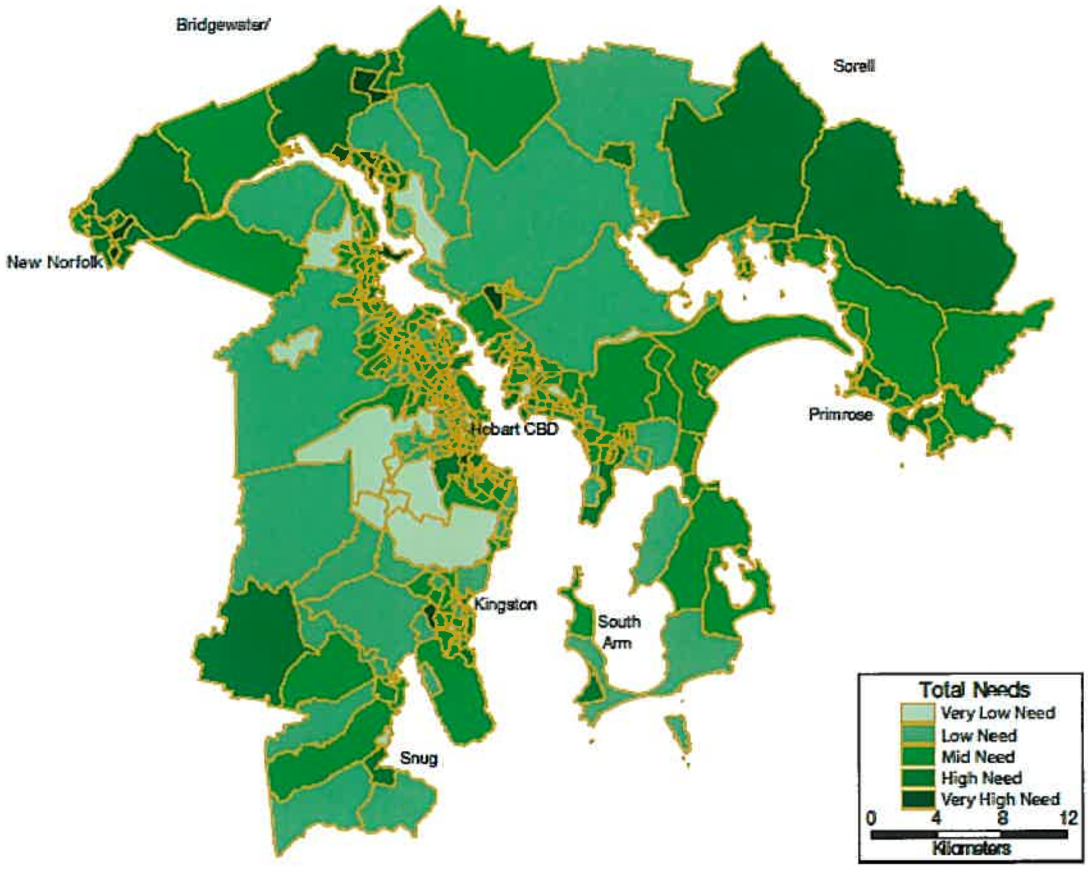
The cost of traffic congestion In Hobart was estimated at $60 million in 2013 and is expected to cost the Tasmanian economy $70 million by 2020. Tasbus consider that the specific projects proposed in this paper can play a significant role in addressing congestion in our urban centres.

There is an identified link between high rates of car ownership, the location of suburbs, low incomes and a lack of passenger transport services. Currie and Sernberg (2007) identified that lower income households in outer suburban areas were more likely to own more than one car and had the lowest accessibility to passenger transport. The researchers found that this in turn led to "Transport Poverty" a concept which suggests that the higher the transport costs as a factor of the household budget, the more vulnerable people are to changes in fuel prices and other costs related to driving.

Similarly, research by Currie (2003) demonstrated that in Hobart the gap between demand for bus services and the provision of bus services was highest in the outer suburbs. The research found that 19% of identified zones in the A.M. Peak had no service and this increased up to 35% on Sundays. The researchers concluded that for Hobart "in fringe localities, persons most vulnerable to transport disadvantage live in areas where passenger transport is more likely to be limited relative to inner city areas."[4] Since 2003 there have been only

[4] Currie, G, et al, 2003, "Quantitative Approaches to Needs Based Assessment of Public Transport Services: The Hobart Transport Needs Gap Study", 26th ATRF Conference, Wellington, 1-3rd Oct. 2003

limited changes to the service levels available in the outer suburbs and Tasbus concludes that similar results would hold today.



d) Climate Change and Pollution

Road transport is responsible for 92 per cent of greenhouse gas emissions with cars being the major contributor.[5]

The challenges of increased population, climate change, pollution and crowded cities will make additional use of cars in the future a more difficult proposition. Public transport, and in the case of Tasmania's major centres, buses, needs to be a frontline solution and supported by the Tasmanian Government to address transport related carbon emissions and air pollution.

[5] Department of Infrastructure, Energy and Resources, 2010, *"Tasmanian Urban Passenger Transport Network"*, Tasmanian Government.

e) Personal Health

Bus use and health benefits from increased activity are linked. The Bus Association of Victoria recently showed that people who used passenger transport undertook five times more physical activity than commuters who drive; 41 minutes a day compared to 8 minutes a day.[6]

People who used passenger transport, because they walked or cycled to catch the bus or train met their daily requirements for physical activity while people who drove would have to make additional time to get the exercise they needed.[7] Research from the New Zealand Government indicates that the annual health benefits of walking and cycling are almost $2000 per person per annum and other research indicates passenger transport users are also more likely to walk in between using passenger transport systems.

According to the Tasmanian Government submission to the House of Representatives 2008 Inquiry into Obesity in Australia almost 49 per cent of Tasmanians reported being overweight or obese in 2004. Projections showed this percentage was on the rise. ABS figures for 2016 reported that 67.5 per cent of Tasmanians aged 18 or over were overweight or obese, indicating a significant increase across the adult population over those 8 years.

f) Transport Access Strategy

TasBus has contributed to a draft Transport Access Strategy for Tasmania. However, a final strategy that fully considers our comments and concerns has not yet been adopted by a Tasmanian Government. In general, Tasbus is in agreement with the general principles of the draft strategy but believes it must be more action orientated and focus on deliverables.

Tasbus is of the view that in the absence of an adopted Transport Access Strategy, the Tasmanian Government will be faced with ever increasing costs associated with expanding the road network in order to try and cope with more private car journeys and the rapidly increasing costs of those in our community who face transport disadvantage.

TasBus considers that an effective Transport Access Strategy must have a strong focus on the most efficient use of Tasmania's investment in transport infrastructure, both the hard infrastructure of roads, cycle ways, railways, the vehicle fleet and pedestrian facilities, and the investment in soft infrastructure such as the extensive bus route network and the passenger information that could be made available to users of the transport system.

TasBus is of the view that transport access, while critical for those facing transport disadvantage, will become increasingly important for all users of the transport system, irrespective of the mode that individual users seek to use for any particular journey.

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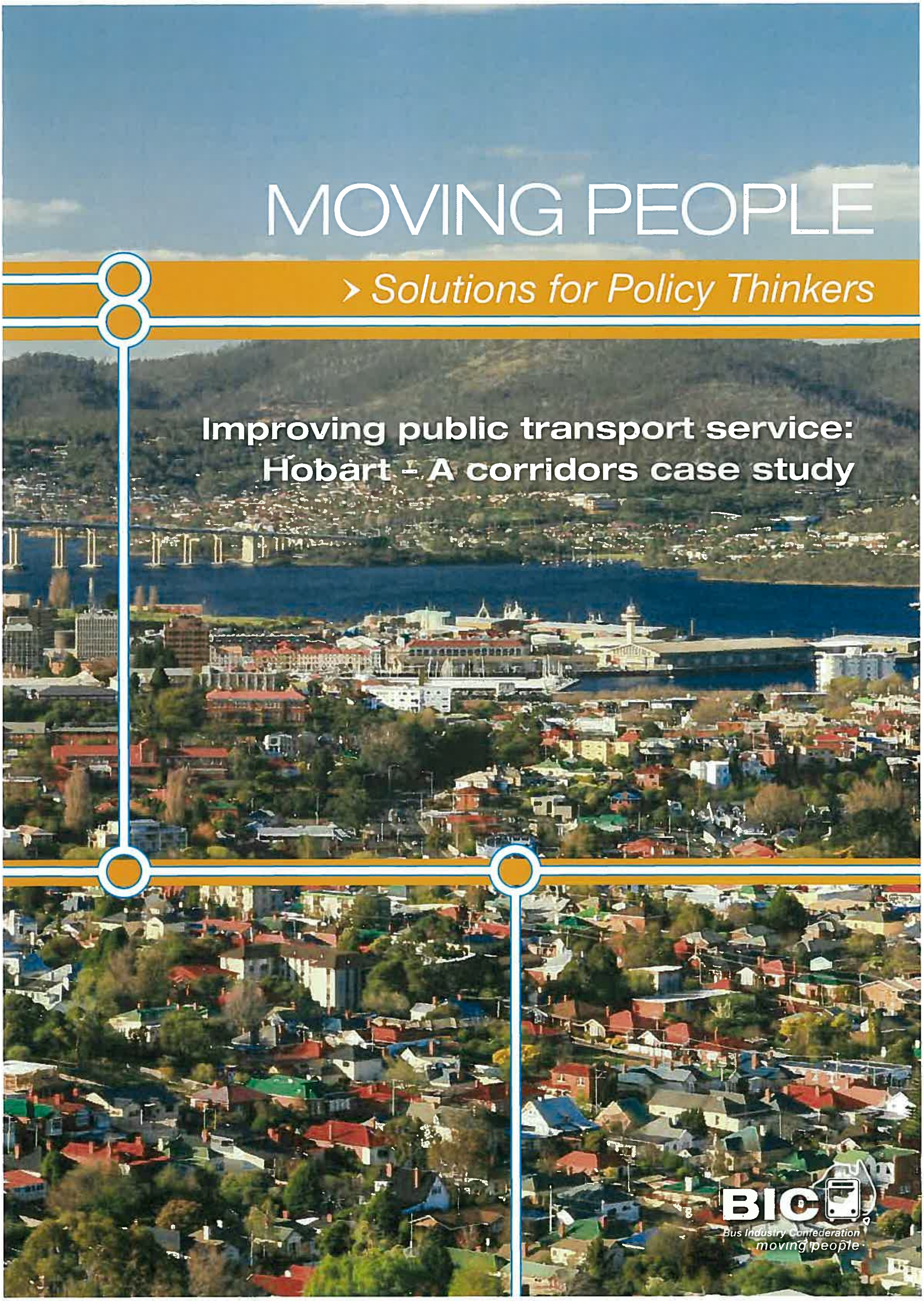
[6] Bus Association of Victoria, 2010, *"Public Transport Use a Ticket to Health"*, Bus Association of Victoria, Melbourne.

[7] Ibid.,^

MOVING PEOPLE

› *Solutions for Policy Thinkers*

Improving public transport service: Hobart - A corridors case study



BIC

Bus Industry Confederation

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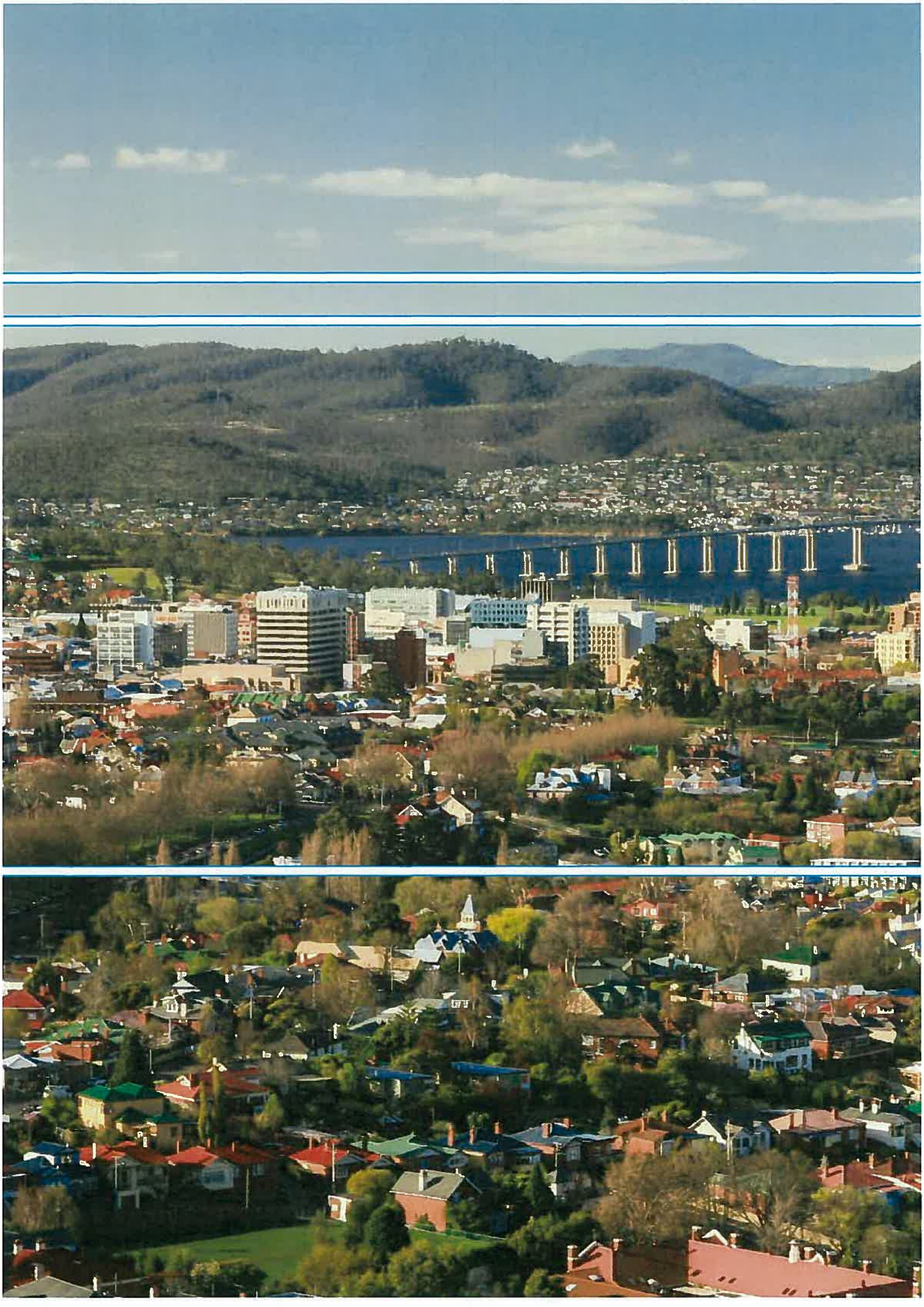

MOVING PEOPLE

› Solutions for Policy Thinkers

Improving public transport service: Hobart - A corridors case study

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Foreword

This special edition research paper was commissioned by the Bus Industry Confederation (BIC) to provide an independent perspective on the Hobart light rail debate and the need for transport decisions to be made within a broader land use setting framework and on the basis of an agreed assessment process for rapid transit and public transport infrastructure projects for Australia, (see the BIC report, "Rapid Transit: Investing in Australia's Transport Future" 2014).

The BIC advocates for an assessment process that does not look at public transport projects in isolation but addresses the value the project will add to improving the existing road and public transport network (or not) and also looks at alternative uses of the proposed funding for projects like Hobart light rail, that may provide a better overall outcome, in this case, for Hobart or even Tasmania.

Contents

Figures

Tables

1. Setting

There have been a large number of reports written on public transport development options in Hobart's northern corridor in the last eight years, as summarised by Infrastructure Tasmania (2016). Most have looked at possible development of light rail along the old rail corridor and others have looked too at substantial upgrading of bus services, including the possibility of a busway being implemented. More modest improvements have also been considered, including looking at ways in which the current bus service could be enhanced, through measures such as increasing frequency, straightening out routes and providing improved running times. This paper considers such opportunities, focusing mainly on the Hobart northern corridor but also looking at the eastern and southern corridors, to test whether the time might be right for a step up in mass rapid transit or whether upgrading existing services is a more effective approach.

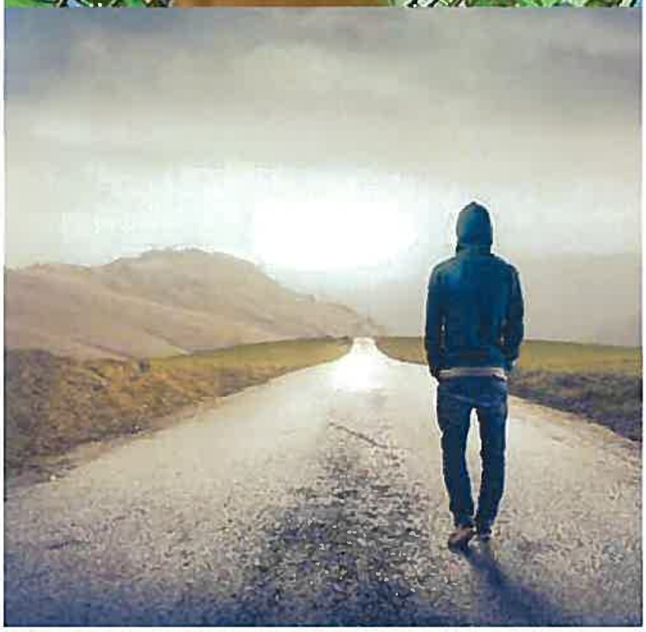
Australia's Bus Industry Confederation (BIC) is the peak body for the bus sector in Australia. It represents the interests of operators and suppliers, recognising that the best interests of its members will be best achieved when they can demonstrate they are clearly adding value to their communities. The BIC has been exploring opportunities to upgrade urban bus service levels in Australia, including where Bus Rapid Transit (BRT) might be the most appropriate development opportunity. The BIC is aware of the interest in Light Rail Transit (LRT) on the part of many people in Hobart, particularly as a development opportunity in the northern corridor. It has asked the Institute of Transport and Logistics Studies (ITLS) at the University of Sydney Business School to examine the corridor and suggest whether LRT or BRT might be a preferred option in that corridor, or whether some other approach to upgrading public transport might be more appropriate at this stage.

This paper reports the ITLS initial findings. They are based on a review of the main studies that have been undertaken, our research in other cities around the world (by the authors and other ITLS experts), consultations with a number of experts in the area and site visits. The views expressed are our own and are in no way attributable to any of those with whom we have held consultations.

Section 2 of the report sets the scene for considering urban transport prioritisation by discussing common goals and related land use transport development directions, with a focus on key built form variables and how they impact travel. Section 3 talks more specifically about land use transport development directions for Australia's major cities and Section 4 discusses Hobart development against the background of sections 2 and 3. It focuses particularly on development density, because of the important role this plays in land use transport integration. Section 4 then discusses public transport in the Main Rd corridor, looking at opportunities for light rail, bus rapid transit and other bus priority enhancements. It also includes consideration of some bus service upgrade opportunities in Hobart's eastern and southern corridors. The section finishes with a discussion about governance arrangements for the delivery of improved public transport services in Hobart. Section 5 considers the provision of public transport services in low patronage settings, to balance somewhat the dominant focus in the report on trunk services.

The report's conclusions are presented in section 6 and there are two included Appendices. Appendix A summarises some of the detail on LRT evaluations in the corridor and presents some comparative information about other LRT projects in Australia. Appendix B presents some summary thinking about transit corridors, which should play a stronger role in Hobart thinking about land use transport integration.

2. Land use transport development directions: Goal setting, land use and then transport



Before discussing the particular matter of development in Hobart's northern corridor, it is useful to think briefly about urban land use transport development directions for cities, since decisions about major transport infrastructure should be taken in this context. There is much common ground here between Australian cities and cities in the US, Canada and in many European countries. These development directions have been summarised by Stanley and Brain (2015) in a report written for the Australian Council of Learned Academies, as input to an ACOLA report to Australia's Chief Scientist on sustainable mobility (ACOLA 2015). Stanley and Brain argue that, if Australia's cities and regions are to sustainably improve the wellbeing of their citizens, present and future, and protect the planet in so doing, then goals in the following form are needed for strategic land use transport planning:

1. Increase economic productivity
2. Reduce environmental footprint
3. Increase social inclusion and reduce inequality
4. Improve health and safety outcomes
5. Promote intergenerational equity—this goal is likely to be achieved if the preceding goals are met
6. Engage communities widely
7. Pursue integrated land use transport plans.

Reflecting the commonality of focus noted above, the Southern Tasmania Regional Land Use Strategy 2010-2035 reflects these goals, indicating that it is:

> *'strategically underpinned by the concept of 'Sustainable Development' and guided by the following planning principles:*
>
> - Inter-generational equity;
> - The precautionary approach;
> - Social Equity;
> - Efficiency;
> - Conservation of biodiversity; and
> - Community participation' (STRPP 2013, p. 17).

That Strategy then sets out ten strategic directions that reflect these principles, across economic, social and environmental platform objectives, including a focus on integrated land use transport planning and the creation of vibrant and attractive activity centres and strong, healthy, liveable communities.

In structuring integrated land use transport planning, ITLS strongly supports Professor Robert Cervero's view that the dominance of major transport infrastructure projects in city shaping, and in the economic, social and environmental performance of a city, is such that it is crucial for land use transport planning to start with a clear vision of the kind of city that is desired and then use transport and other measures to help deliver that result (Cervero 2014).

Access to jobs, education, services, family and friends, recreational and cultural opportunities and the like are common reasons why people live in, and need to move around, cities and regions. The concept of accessibility, of being able to reach places to undertake activities, ties land use and transport together. The most comprehensive review of connections between the built environment and travel, which underpins much contemporary international thinking about integrated land use transport planning, is the meta-analysis by Ewing and Cervero (2010), who talk about the following five 'Ds' of built form in terms of how they impact (in particular) on car travel distances (vehicle kilometres of travel, or VKT):

1. density—higher densities support more local activity opportunities, higher public transport service levels and walking. Destination density is particularly important

2. diversity of land uses makes it easier to undertake activities locally, associated with concepts such as mixed-use development and jobs/housing balance

3. design—particularly creating interesting places where people want to be, are safe and feel safe, and promoting interactions between people and with the natural environment, which is important to well-being

4. destination accessibility—which is about ease of access to trip destinations and developing activity nodes and corridors which link these nodes and

5. distance to transit, supported by fine-grained pedestrian opportunities, embedded in design elements such as intersection density and street connectivity. For example, Ewing and Cervero (2010) find that halving the distance to the nearest transit stop is associated with a 29 per cent increase in transit trips.

Ewing and Cervero report impact elasticities, which show the relative sensitivity of response variables (primarily VKT in their case) to changes in a range of causal influences (the respective Ds). Most individual reported elasticities are small but the combined effect of a number of measures can be important, particularly when regional and local measures are both used. This underlines the importance of integrated approaches to land use transport policy and planning, encompassing integrated regional and local scales of thinking. For example, combined elasticity values for VKT with respect to multiple built-environment variables can total about -0.2 to -0.3, based on the values reported by Ewing and Cervero, as summarised in Table 1. This suggests that having a range of supportive land use transport measures might reduce car use in the applicable area by perhaps 20 to 30 or so per cent over a long period of time, given the length of time it takes to change some elements of the built form. This would be additional to impacts on VKT that might result directly from improved public transport.

Table 1: Weighted average elasticities of vehicle miles of travel with respect to built environment variables

Built Environment Variable	Measure	Number of Studies	Weighted Average Elasticity of VMT
Density	Household/population density	9	-0.04
	Job density	6	0.00
Diversity	Land use mix	10	-0.09
	Jobs-housing balance	4	-0.02
Design	Intersection/street density	6	-0.12
	Per cent of 4-way intersections	3	-0.12
Destination accessibility	Job accessibility by automobile	5	-0.20
	Job accessibility by transit	3	-0.05
	Distance to downtown	3	-0.22
Distance to transit	Distance to nearest transit stop	6	-0.05

Source: From Ewing and Cervero (2010) Table 3

This order of impact magnitude is supported by research by Bento et al. (2005), who found that population centrality, the jobs-housing balance, city shape and density, in combination, had a significant effect on the amount of vehicle travel in US cities, as did public transport service levels. The effect of moving a sample of households from a city like Atlanta (733 persons per km2; 7000 rail miles of service/km2; 10,000 bus miles of service/km2) to a city with the characteristics of Boston (1202 persons/km2; 18,000 rail miles of service/km2; 13,000 bus miles of service/km2), which amounts to about a two-thirds increase in density and 80 per cent increase in transit service kilometres, was a projected reduction in annual vehicle (car) travel of 25 per cent. With public transport mode shares only accounting for a small percentage of total trips, a reduction in car trips of this order can mean a very large relative increase in PT mode share but it will not be achieved overnight, given the time it takes to increase densities.

In terms of starting integrated land use transport planning at a regional scale, many cities in Europe, Canada, Australia and much of the US now commonly focus on achieving more compact urban settlement patterns, the logic of triple bottom line goal achievement suggesting compactness as a worthwhile direction for regional development (e.g. to reap economies of agglomeration, reduce social exclusion and reduce a city's environmental footprint). We note that this development direction is reflected, for example, in the Hobart City Council's Sustainable Transport Strategy 2009-2014 (HCC 2009).

The international focus on achieving more compact cities has often concentrated on increasing densities through high-rise development in central/inner areas, where accessibility levels are usually highest, but there is now also considerable interest in medium density development around major transit nodes and along strategic transit corridors, including in inner and middle urban areas. Vancouver, for example, has been very successful at focusing infill development along strategic transit corridors and this approach is becoming more common in cities like Sydney and Melbourne.

Regional scale thinking needs to be complemented by local or neighbourhood level thinking to best reflect the various D's of land use transport integration. Neighbourhoods are key building blocks to achieve a well-functioning city, strong communities arising from well-resourced and well-functioning neighbourhoods (Stanley et al. 2015). Such neighbourhoods will be good for people, the environment and economic participation. All neighbourhoods need to offer the activities and social infrastructure to meet essential needs: personal wellbeing, mental health and social equity; a sense of place and belonging; participation and choice; and the ability to successfully adapt to external challenges. The ability to be mobile and be able to access friends, activities, government and business, is a requirement to achieve most such needs. However, it is unusual to see neighbourhood level thinking embedded in strategic land use transport planning. The idea of the 20 minute city (sometimes called the 20 minute neighbourhood) seeks to achieve this embedding. Some cities that have demonstrated an explicit systemic focus and understanding at a neighbourhood level, integrated with top-down regional thinking, include Portland (Oregon), Vancouver, Freiburg (Germany), Berlin, Malmö (Sweden), New York and Melbourne, with its recent work on the 20 minute city or 20 minute neighbourhoods, building on Portland's work.

The idea of a 20 minute city is that land use transport planning should aim, in part, to ensure that most (but not all) of the activities that people need for a good life are available within a 20 minute trip by foot, bicycle or public transport (not having to have a car) from where they live. This requires a range of local activities and it also requires local mobility choices, particularly safe walking/cycling opportunities and an adequate service level on local public transport (discussed in more detail in sections 4 and 5). Good mobility opportunities and availabilities of local services and infrastructure can, in turn, most easily be provided where urban densities are planned for this purpose, thereby also reducing the need to travel (also discussed in Section 4). Initiatives like 'complete streets' should be integrated with ideas like that of the 20 minute neighbourhood. Minimum urban development densities are a fundamental requirement for the delivery of 20 minute neighbourhoods, as discussed in Section 4.2.

3. Broad strategic land use transport development directions for Australian cities

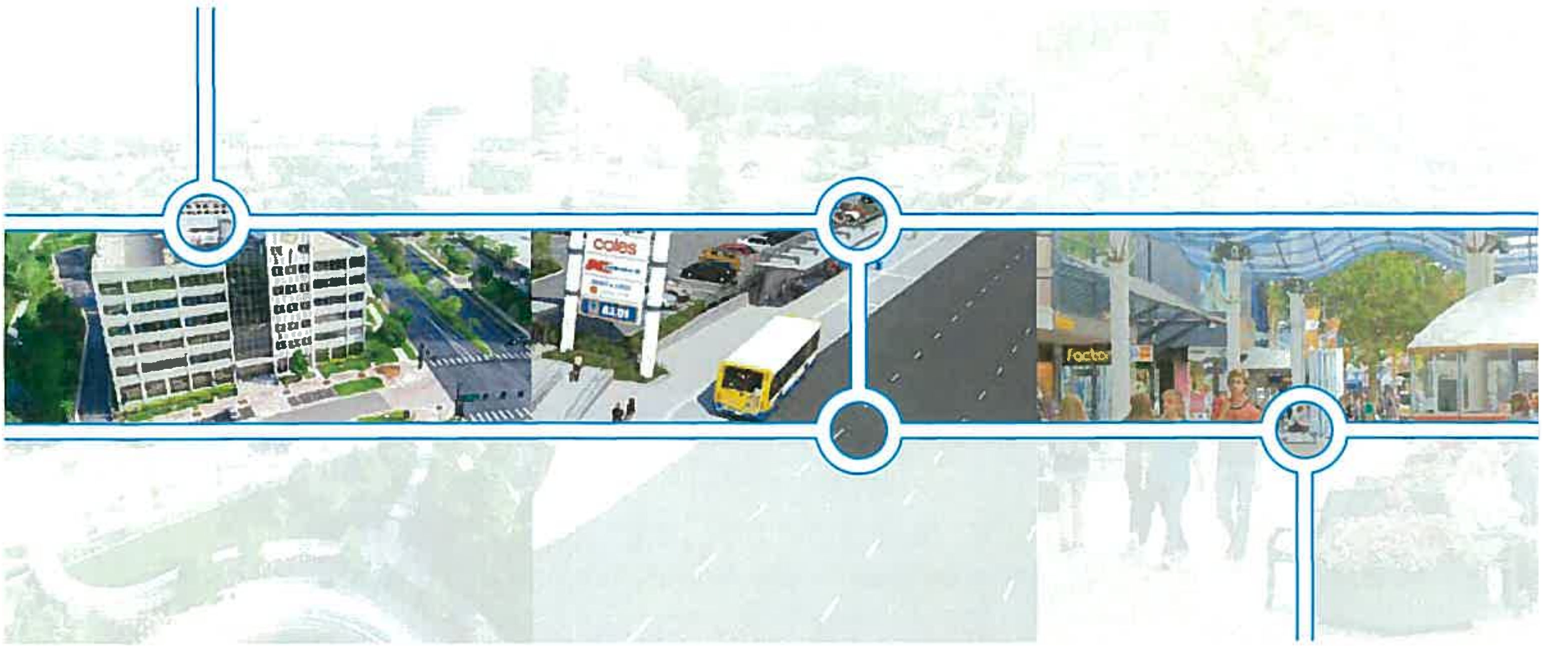
The main land use implication for Australian capital cities from the preceding discussion involves pursuit of more compact settlement patterns, anchored by:

- the CBD and close surrounds, because of the wider economic benefits (in production and consumption) that flow there-from
- for cities with over a million or so population, a small number of additional high tech/knowledge-based inner/middle urban clusters (at a rate of about one per million city population), which should form the basis for a polycentric city and focal points for inner/middle urban area growth
- major urban renewal opportunity areas (e.g. in areas that have lost large numbers of manufacturing jobs)
- supportive mixed use activity centres, that mainly provide a sub-regional population-serving role
- major transport corridors that link the core nodes to the centre, to each other and to outer areas and tie in the renewal opportunity areas
- a series of constituent 20 minute cities/ neighbourhoods.

This land use development direction is increasingly being embedded in integrated strategic long term land use transport plans for Australia's major cities, recognising the need for local nuance. Supportive strategic transport directions are an essential part of delivering on these land use directions, along the following lines:

- ensuring strong radial public transport to the central areas of our cities, to support their agglomeration economies—this is highly relevant to Hobart's main radial corridors
- good arterial roads across the entire city (including to the central city in smaller cities, where road performs the major movement role for freight and people, including by road-based public transport)
- fast and frequent trunk public transport services, supporting inner/middle urban nodes/corridors. Hobart Metro's Turn up and GO initiatives are in accord with this direction. In larger cities, this direction includes circumferential movement, such as Melbourne's SmartBus and Sydney's Metrobus networks, linked to the cluster (node) development focus
- better public transport connections from outer suburbs to areas of employment/activity concentration (recognising that job creation in outer suburbs is very difficult at anything greater than about 300 jobs per 1000 population, much less than is needed to provide local jobs for all who want them)
- supportive local public transport access, which is hardest in the lowest density settings
- high priority to walking and cycling throughout the whole city.

Governance arrangements should support integrated delivery of these development directions across all levels of government.



4. Hobart context

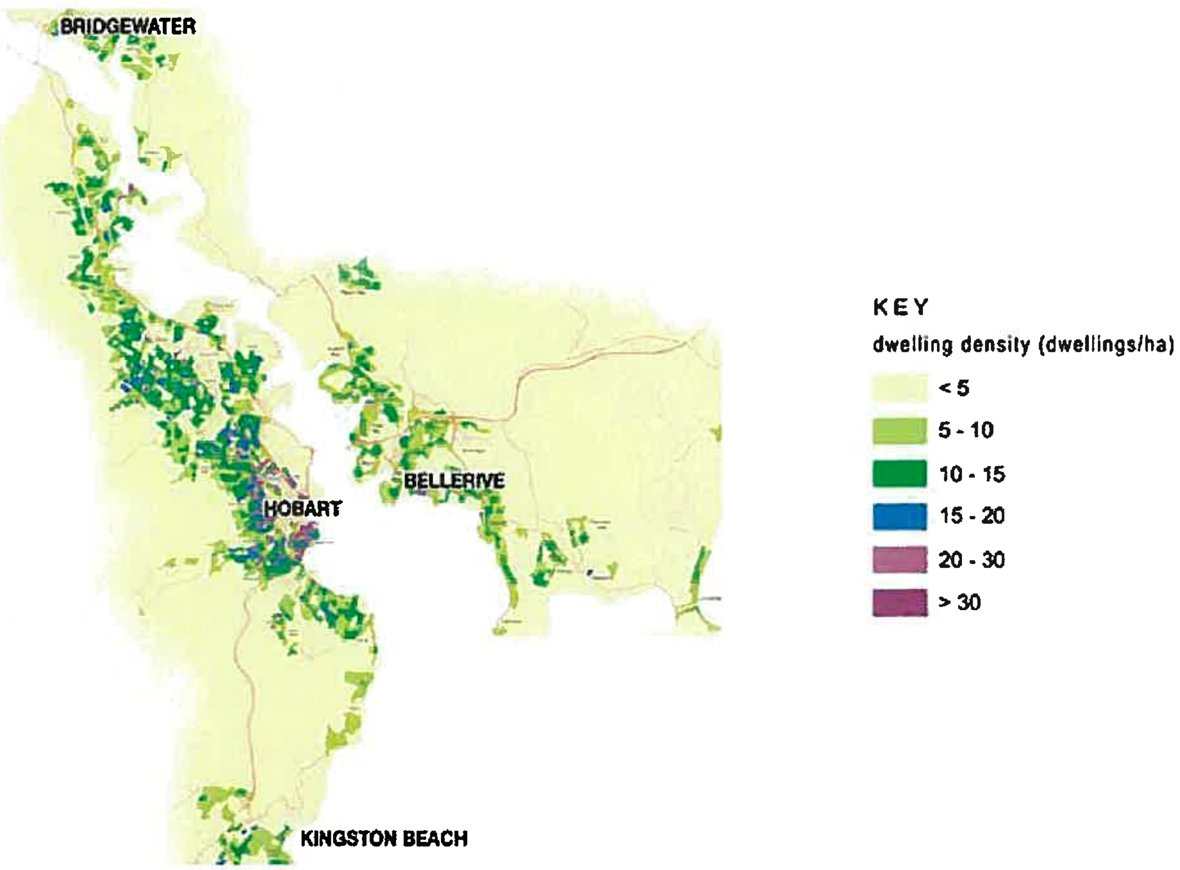
4.1 Population and densities

At the time of the 2011 Census, Greater Hobart had a population of 212,000, some 11 per cent higher than in 2001 (a growth rate of about 1 per cent per annum over the decade). The population increase over this period was largely concentrated in the outer Local Government Areas (LGAs) of Kingborough (+6000, rounded), Clarence (+4500), Brighton (+2900) and Sorell (+2700). The LGAs of Hobart and Glenorchy, which are most relevant to the northern corridor, only added 4300 people over the decade, or about 430 a year, with the Glenorchy increase (~2200 over the decade) slightly larger than that in Hobart (~2100). In short, only 20 per cent of Greater Hobart's population growth over the decade was in the two municipalities.

The language of compact settlement patterns is part of the Hobart land use transport planning lexicon but delivery is not. Greater Hobart has established a fixed urban boundary, which is supportive of compact settlement, but our consultations have suggested that there is room for about 30-40 years' growth within that boundary. Whereas the larger capital cities are typically planning on 70 per cent of their urban dwelling growth happening as urban infill and are achieving this (or higher), Hobart is currently achieving only about 15 per cent infill development. This will do little to lift densities, which are currently extremely low in Greater Hobart, as shown in Figure 1.

The average dwelling density in new suburban fringe developments in Melbourne is about 15-18 dwellings per hectare (dw/Ha), putting it in the blue groupings of Figure 1, which is more comparable to a middle urban setting in Greater Hobart's northern corridor. In contrast, we are advised that greenfield dwellings in Hobart are typically developed at ~7-10 dw/Ha, well below the Melbourne rate. This low density may be seen as an advantage for Hobart by some, in terms of providing living space for residents. However, it also ensures relatively long work trip lengths, enforces car dependency and its attendant consequences and makes effective public transport provision very difficult. The population growth rates in the Cities of Glenorchy and Hobart over the 2001 to 2011 decade, at 5.2 and 4.4 per cent respectively (for the decade), shows how slowly population densities increased over that period (the same rate as population, in gross terms). Dwelling density increased at about the same rate as population density in Glenorchy over the decade (at 5.3 per cent), but more slowly than population density in City of Hobart (at 1.2 per cent, compared to 4.4 per cent for population density), implying increasing average persons per dwelling in Hobart but not Glenorchy. On both population and dwelling measures, densities are low and increasing only very slowly.

Figure 1: Dwelling density in Greater Hobart



Source: City of Hobart

4.2 Linking public transport service levels to density

Of all the practical things that can be done to deliver more compact cities, integrated planning of land use and transport is fundamental, particularly as this relates to the provision of public transport and active transport, especially walking. Cities like London, Vancouver, Toronto and Portland (Oregon) understand this very clearly and are well down the path of implementation at regional and local levels. London, for example closely links development densities to public transport service levels and may seek developer contributions for new developments that infringe thresholds in the Public Transport Accessibility Level/density link. For lower density cities, the public transport service level/density link has been illustrated in the Ontario Ministry of Transport's Transit-Supportive Guidelines (OMOT 2012), as shown in Table 2.

The Ontario Guidelines emphasise that these thresholds are:

> *'... suggested minimum density thresholds for areas within a 5-10 minute walk of transit capable of supporting different types and levels of transit service. The thresholds presented are a guide and not to be applied as standards. Other factors such as the design of streets and open spaces, building characteristics, levels of feeder service, travel time, range of densities across the network and mix of uses can also have a significant impact on transit ridership. Mobility hubs and major transit station areas may require higher minimum densities.' (OMOT 2012, p. 24)*

The Ministerial Advisory Committee advising Victoria's Planning Minister on the state's long term planning strategy, of which one of the current authors is a member, has recently proposed minimum average densities in Melbourne's growth suburbs of 25 dwellings/ha, helping the case for supportive base public transport service levels in the 20-30 minute headway range, as part of the delivery of 20 minute neighbourhoods. Densities at which LRT/BRT are suggested as appropriate are much higher in Table 2, at about 70 dw/Ha. Very few parts of Greater Hobart are anywhere near this density, suggesting that the case for rapid public transport (LRT/BRT) is likely to be very hard to sustain, unless there is a concerted push on increasing densities, through measures such as Transit Oriented Development.

Table 2: Suggested density thresholds for transit service

Transit Service Type	Suggested Minimum Density
Basic transit service (one bus every 20-30 minutes)	22 units per ha/50
Frequent transit service (one bus every 10-15 minutes)	37 units per ha/80
Very frequent bus service (one bus every 5 minutes with potential for BRT or LRT)	45 units per ha/100
Dedicated Rapid Transit (LRT/BRT)	72 units per ha/160
Subway	90 units per ha/200

Source: Based on OMOT (2012), p. 24

Figure 2: Glenorchy Interchange, an on-road, dedicated bus-only facility with six bus stands (viewed westbound)

Figure 3: Main Rd at Glenorchy, showing on-street parking (viewed southbound)

4.3 Public transport in the Hobart northern corridor

4.3.1 Main Road

Hobart's Main Rd/New Town Rd/Elizabeth St corridor serves as the primary transit corridor to Hobart's northern suburbs, connecting the suburbs of Glenorchy, Derwent Park, Moonah, New Town and North Hobart with the Hobart CBD. As a council-owned major arterial, Main Rd carries 19,700 vehicle movements at its peak load point (Tasmanian Government 2011), and complements the role that the Brooker Highway plays as a high-speed dual carriageway catering for freight traffic and longer distance travel. A range of residential, commercial and industrial land uses have frontage onto Main Rd, or close thereto, which also serves as the access route for important trip attractors including shopping centres, schools, hospitals, churches, hotels, parks and other community facilities.

The corridor, for the purposes of this study, is 7.5 km in length, beginning at Glenorchy Interchange (Figure 2), where six bus stands offer a spacious facility to terminate buses and to accommodate customers making onward connections. It is at the town centres of Glenorchy, Moonah and North Hobart where congestion is particularly acute. The combination of a reduced speed limit, significant on-street parking (Figure 3), traffic calming devices[1] and pedestrian facilities (Figure 4) can result in delays for all motorised modes. Light industrial developments can be found at Derwent Park, which is also the location for Metro's sole Hobart depot. An interchange facility exists at this location, built to serve the northern suburbs before Glenorchy interchange was commissioned. Despite now serving little purpose, it continues to cause delays for southbound services, which must detour into the off-road facility. Today, its sole benefit is to provide better accessibility for customers using the 69 space park and ride facility and bike racks, which are provided by Metro at this location. Further south, residential properties are prevalent in New Town, ranging in densities from low to medium.

Buses then divert around Elizabeth Mall (via Campbell St/ Argyle St) to enter the Hobart City interchange (Figure 5).

Main Rd is primarily single carriageway, with one lane in each direction, although there are segments with two lanes, as well as dedicated turning lanes at some intersections. A total of 24 traffic signals can be found on the corridor, including a southbound bus-only light at Main Rd/Eady St in Glenorchy. This unusual design encourages private vehicles to use Brooker Hwy, although they are able to continue south on Main Rd by completing a U-turn at the Eady St/Elwick Rd/King George V Ave roundabout. Based on bus running times, peak period travel from Glenorchy to Hobart CBD is around 50 per cent slower than during off-peak times (34 min as compared with 23 min). Bus priority measures along the corridor have been estimated to speed up travel times by as much as 10 min during the peaks. Implementation is contingent upon adequate resolution of the challenges facing Main Rd, including limited widening opportunities, competition for road space and the diverse mix of road uses.

Main Rd serves as the trunk route for bus services, with routes branching out at Glenorchy to suburbs like Claremont, Bridgewater and Brighton. Under this configuration, the layering of routes along Main Rd provides a high frequency corridor, branded as Metro's Turn up and GO service. There has been a trend globally towards the consolidation of route bus services onto fewer, higher frequency routes, to capitalise on the patronage-coverage trade-off first espoused in Walker (2008). Metro's Hobart Network Review, implemented in January 2015, represented the first system reimagining in 30 years, and was, at heart, guided by these network planning principles. With no change in service kilometres, the reallocation of resources permitted higher frequencies on major corridors, whilst lower patronage routes saw their services diluted, now operating either every two hours in the inter-peak and evening, or not at all, with services running in the peak-period, peak-direction only.

Figure 4: Main Rd at Glenorchy (evening), showing on-street parking and pedestrian crossing facilities (viewed southbound)

Figure 5: Hobart City Interchange, an on-road, dedicated bus-only facility with ten bus stands and a Metro information centre (viewed southbound)

1 Some of these devices make it difficult for Metro to operate its larger, 14.5 m steerable tag axle fleet

Metro Tasmania is the largest public transport operator in Tasmania, being a state-owned company that is working under contract to the Tasmanian government. Metro owns and operates 218 buses, of which 148 run in Hobart, with a peak availability of 141 buses. This fleet delivers 1,600 services per weekday in Hobart, of which more than one third service the northern suburbs. Private operators play a smaller role, providing just 10 per cent of services in Greater Hobart. As a non-urban operator, O'Driscoll Coaches also run along Main Rd, but do not compete directly with Metro, as their services face pick up and set down restrictions along the route (to better cater for customers travelling longer distances). O'Driscoll Coaches has been adding capacity on its New Norfolk services in recent years and seen a corresponding increase in patronage. It is estimated that up to 25 buses per hour operate along Main Rd in the AM peak, of which around 15 are route services (Table 3), and 10 dedicated school services. During the weekday inter-peak, six buses per hour operate on average in each direction. This makes Main Rd the busiest of all major public transport corridors in Greater Hobart (barring perhaps the Tasman Bridge, where there are no stops or catchment in either direction).

Metro's northern suburb services carry approximately 2.2 million passengers per year. Metro advises that these services are already near capacity, with inbound buses in the AM peak frequently reaching capacity on arrival into Moonah. This is likely an artefact of Hobart's narrow peaks, a result of its size, economic structure and geography, which also increases the costs of service provision. This arises from the many drivers who are employed, and the buses which are procured, to service the peaks exclusively, being idle at other times of the day.

Metro's Greencard smart ticketing system requires validation only upon boarding, resulting in poor data relating to customers' alighting patterns. By assuming symmetric return journeys, we have been able to estimate passenger alightings and generate load profiles for the Main Rd corridor, from data kindly made available by Metro. Passenger patterns are shown but numbers (y-axis) have been redacted, to protect Metro's commercial confidences (Figures 6 and 7). The data shows that significant passenger movements occur north of the city on Bathurst St/Campbell St and Argyle St/Liverpool St. Furthermore, it shows high passenger turnover at Moonah Shops, North Hobart, as well as at the Metro Depot where park and ride facilities are provided.

Table 3: Main Rd approximate headways for route services by direction, operator and time period

	AM Peak	Inter-Peak	PM Peak	Evening	Saturday	Sunday
INBOUND						
Metro	6-10 min	10 min	7.5-10 min	30 min	15-30 min	30 min
O'Driscoll[2]	5 trips	4 trips	2 trips	2 trips	9 trips	3 trips
OUTBOUND						
Metro	7.5-10 min	10 min	6-10 min	30 min	15-30 min	30 min
O'Driscoll[2]	1 trip	6 trips	5 trips	2 trips	9 trips	3 trips

Source: Authors, from timetables

2 O'Driscoll Coaches operating as Derwent Valley Link to New Norfolk and Bothwell

Figure 6: Main Rd inbound load profile (weekday average)

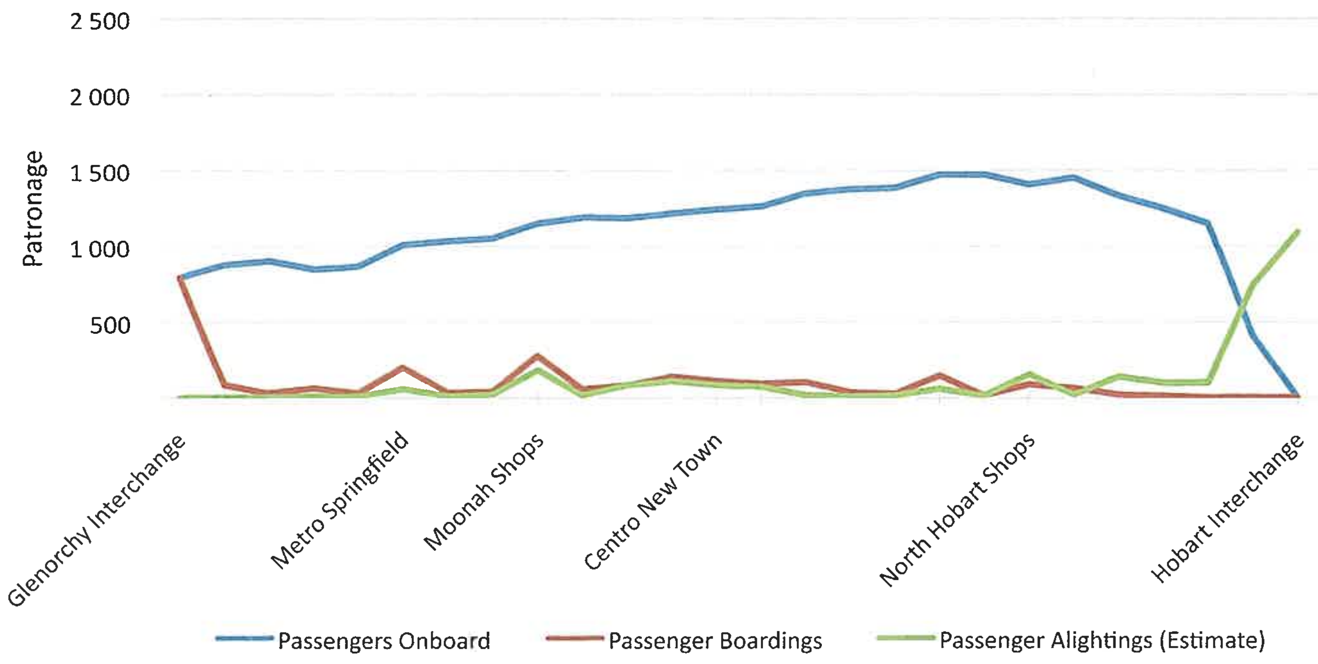
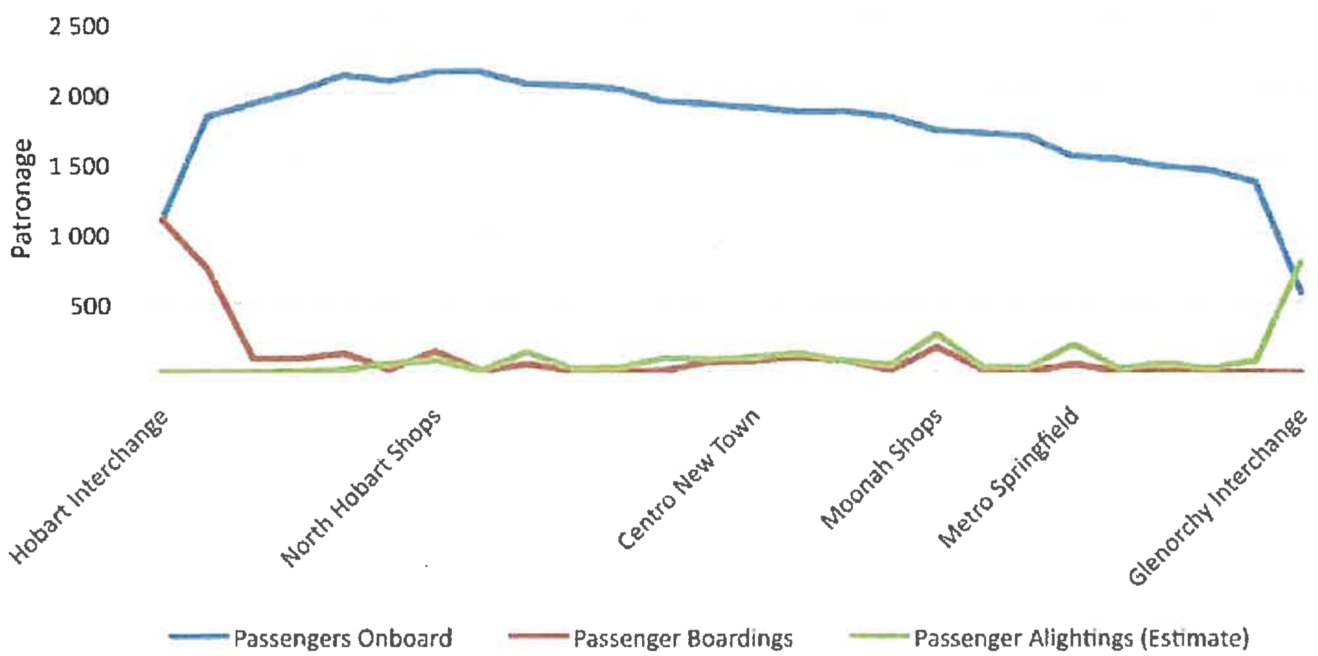


Figure 7: Main Rd outbound load profile (weekday average)



4.3.2 Railway corridor

The northern rail corridor has become available since 2014, when freight services between Hobart and Brighton ceased, with the construction of a new intermodal transport hub at Brighton. Historically, the railway has been double track between Hobart and Claremont but one track has now been decommissioned and replaced with a cycleway, which runs the full length of the rail corridor. The railway follows a less direct route than Main Rd, with vastly different catchment characteristics between Hobart City and Glenorchy, as compared with that of Main Rd. The rail line runs virtually parallel to Main Rd between Glenorchy and Moonah, about 30 metres away at its closest and 250 metres at the furthest. The potential public transport service catchment of the railway would therefore be quite similar to Main Rd through this section, although the line is situated some distance away from the activity centre of Moonah Shops. The rail corridor is also quite derelict, with significant investments required to regenerate the area, attract development and enhance its connectivity with existing trip attractors on Main Rd.

The section of route between Glenorchy and New Town is relatively straight and well suited for high speeds (Figure 8). Further, the rail easement is wide, so a double track railway or two lane carriageway can be accommodated without property acquisition or removal of the cycleway.

There are seven level crossings between Glenorchy and New Town, of which Elwick Rd and Derwent Park Rd can be considered important collector roads. All level crossings have been permanently open since 2014 but future use of the rail corridor will need to consider how these at-grade intersections with crossroads are treated. There are also three underpasses and one overpass at Risdon Rd, which may pose as limiting infrastructure. Further engineering studies are required to determine their suitability for any new transport developments.

At New Town, the rail corridor deviates significantly east towards Brooker Hwy. Between Queens Domain and Macquarie Point, the railway follows the bank of the Derwent River and is hence circuitous, narrow and not suitable for high speeds. The sharpest bends occur at Pavilion Point (under Tasman Bridge) and behind the Hobart Cenotaph. Between New Town and Hobart City, the line is bound by Queens Domain and the Derwent River, and hence there is no adjacent catchment of any type (population or employment). The railway terminates at Macquarie Point, about 650 metres short of the current Hobart City Interchange and there are no corridors available to access the CBD without property acquisition or a reallocation of road space. There appear to be stabling facilities for trains at both Macquarie Point and the Tasmanian Transport Museum at Glenorchy but whether it is practical to use them in future is questionable.

Figure 8: Level crossing at Sunderland St, showing cycling facilities and corridor width (viewed northbound)

4.3.3 Brooker Highway

Brooker Hwy is an urban arterial and national highway managed by the Tasmanian state government. It is an important freight corridor, transporting 2.7 million tonnes per annum (2008-09), and carrying 50,000 vehicles per day at its peak load point (Tasmanian Government 2011). It is a dual carriageway until Granton and limited access for some of its length between Hobart City and Glenorchy. In this section there are nine sets of traffic signals and two roundabouts, of which one is signal-controlled. The highway is two lanes in each direction but there are a number of intersections in Glenorchy, Derwent Park and Moonah where it widens to three lanes. This can increase intersection throughput, though it may also be argued that the subsequent merge after the signals results in a bottleneck for through-traffic. Between Glenorchy and the CBD, there is one grade-separated trumpet interchange with the B36 Domain Hwy, which provides a more direct route from the northern suburbs across the Tasman Bridge.

Land use patterns along the highway consist primarily of low density residential. These are most prevalent at Moonah and Lutana, where a number of bus stops provide access to these homes. There are a limited number of trip attractors in terms of schools, parks and even a cemetery, but the Brooker Hwy is a pedestrian-hostile, high-speed environment and so bus stops along this section of route record significantly less patronage than that of Main Rd (every transit user is also a pedestrian). On approach to Hobart, the highway is flanked on one side by Queens Domain and on the other by residential developments in North Hobart. However, these have frontage onto adjacent roads where bus services also operate, so there are no bus stops providing access from Brooker Hwy in this area.

The Brooker Hwy between Hobart City and Glenorchy carries about 15 per cent of northern suburb bus passengers, whilst the other 85 per cent travel by Main Rd (Tasmanian Government 2011). This reflects bus services on Brooker Hwy operating primarily in the peak-period, peak-direction only (Table 4). The sole exception is Route X20 to Bridgewater, which offers a quicker service for this community during the day. Travel times on Brooker Hwy between Glenorchy and Hobart City are some 25 per cent quicker than Main Rd (25 min compared with 34 min peak travel time). Service allocations for route services are roughly even in peak periods between Main Rd and Brooker Hwy. It is unclear, at present, the patronage mix between these two corridors at peak times, and further investigation is required to understand the importance of destinations along Main Rd.

Table 4: Brooker Hwy approximate headways for route services by direction, operator and time period

	AM Peak	Inter-Peak	PM Peak	Evening	Saturday	Sunday
INBOUND						
Metro	7.5 min	30 min	60 min	*No service*	*No service*	*No service*
Tassielink[3]	*No service*	2 trips	*No service*	1 trip	1 trip	1 trip
O'Driscoll[4]	1 trip	*No service*	*No service*	*No service*	*No service*	*No service*
OUTBOUND						
Metro	60 min	30 min	7.5 min	*No service*	*No service*	*No service*
Tassielink[3]	*No service*	2 trips	1 trip	*No service*	1 trip	1 trip
O'Driscoll[4]	*No service*	*No service*	1 trip	*No service*	*No service*	*No service*

Source: Authors, from timetables

3 Some services operate on specific days only
4 O'Driscoll Coaches operating as Derwent Valley Link to New Norfolk

4.3.4 Hybrid alignment

The choice of route in the corridor can be considered largely independent of the choice of transport technology, be it bus-based or rail-based. Indeed, it is best practice in transport planning to select the desired corridor first, then choose the most appropriate mode to meet the particular transport demands and challenges on that corridor, all the while adopting land use policy in line with these transport developments (Walker 2012). Previous studies of future transit options between Glenorchy and Hobart City have considered the Main Rd, railway and Brooker Hwy corridors in isolation and as mutually exclusive (Tasmanian Government 2011). Regardless of mode, it is clear that each corridor is accompanied by a range of strengths and weaknesses.

Perhaps the greatest weakness of the rail corridor alignment is the lack of catchment between New Town and the CBD, compounded by the difficulty of linking Macquarie Point to the CBD, particularly in light of patronage data showing high passenger turnover north of the CBD and in North Hobart. Coupled with the time penalties associated with the topography and eastward detour, it is unlikely to compensate for the extra travel time arising due to congestion on Main Rd (clearly, depending on what scenario is implemented there). We believe this is a very substantial penalty against the rail corridor, at least between New Town and Hobart City, for both BRT and LRT.

The Brooker Hwy corridor is also affected by a less than ideal catchment. Not only are there insufficient trip attractors on the highway, it also skips the major activity centres of Moonah and North Hobart on Main Rd. Whilst it may be argued that a significant number of peak services (indeed, half of all route services) already operate there with some success, any investment in BRT/LRT schemes should concentrate resources on a single corridor to improve returns, including the provision of a stronger stimulus for urban renewal. Use of Brooker Hwy will result in a dilution of services, whilst challenges with serving Main Rd remain.

Use of the rail corridor is most preferable between Moonah and Glenorchy, so as to serve Main Rd destinations whilst improving right of way for the service. Detailed modelling is required to confirm that the detour can save travel time and not detract Main Rd customers who face increased walking distances. Under a hybrid alignment for bus-based or rail-based services, the vehicle would then join New Town Rd/ Elizabeth St near New Town High School (perhaps using Bromby St), for a more direct entrance into Hobart CBD, whilst also serving a larger catchment.

4.4 The LRT case

There has been considerable interest in possibly developing a light rail transit service in Hobart's northern corridor, on the disused rail line. A 2011 evaluation of a possible project from Hobart to Claremont (ACIL Tasman 2011), suggested a potential benefit-cost ratio of 1.1 at a 7 per cent real discount rate, highly dependent on exceedingly optimistic 'sparks effects'—essentially a huge patronage boost attributable to the initiative's characteristics. Strong 'sparks effects' had the effect of lifting year 1 projected weekly patronage to 90,000, over three times the base (no sparks) patronage estimate and about 2-3 times current patronage in the corridor. Zero 'sparks effects' delivered an expected BCR of zero. The Ewing and Cervero (2010) work cited in Section 2 suggests that the probability of achieving zero sparks effects is far higher than that of achieving strong sparks effects in such a low density setting.

Development of the subsequent business case for light rail in the northern corridor (ACIL Tasman 2013) looked at Hobart to Glenorchy, sensibly dropped the strong 'sparks effect' and opted instead for a 20 per cent sparks effect, which has more plausibility[5]. Figure 9 shows the route and feeder bus services for this stage 1 LRT. The evaluation estimated capital costs of $70-78 million (or about $8-9m/km) and annual operating costs of $2.3-2.5m for the first 20 years of operation, then $3.2m per annum. However, to achieve a BCR of 1.1 again, at a 7 per cent real discount rate (for OOSM1[6] = '3 stops; fast system', the best rated option in the evaluation), this evaluation made the heroic assumption that there are no transfer penalties associated with modal transfers (between bus and LRT). Standard transfer penalties (of 5 minutes) reduced the base BCR to zero and a 2 minute penalty reduced it to 0.48. These are not encouraging results for a viable project, which is not surprising given Hobart's densities.

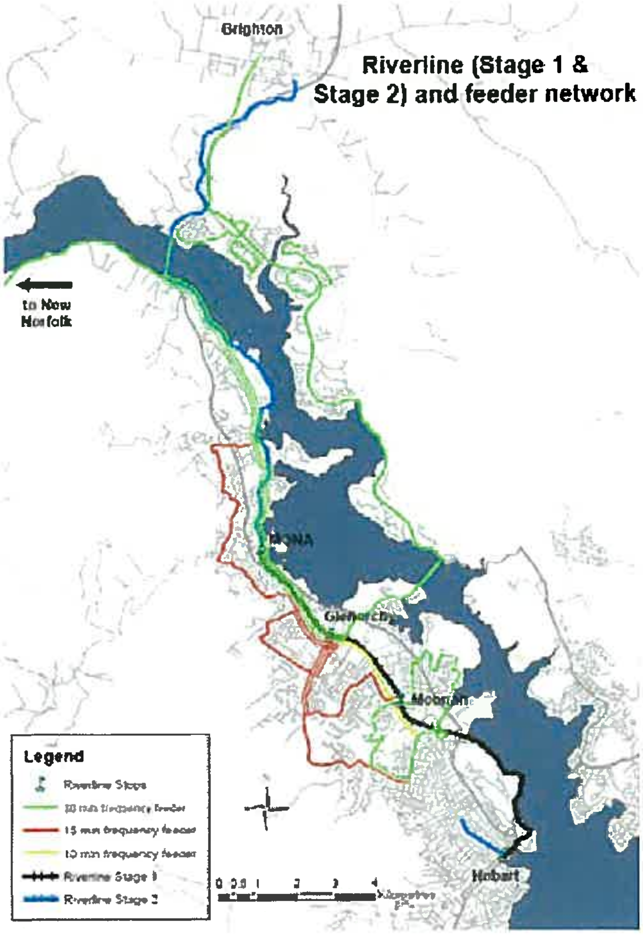
Professor Bent Flyvberg, now at Oxford University, coined the term 'optimism bias', to explain why major transport projects often cost more than expected and deliver lower patronage levels. Strong sparks and zero transfer penalties are useful analytically to show the kind of extreme and unrealistic assumptions that are needed to deliver a good economic result on the Hobart LRT but, if they were taken as plausible contexts for such an evaluation, they would aptly fit Flyvberg's description.

The business case report (ACIL Tasman 2013) assumed accelerated Transit Oriented Development (TOD) would take place around the LRT stops, creating an additional 50 units of development annually for 20 years (on top of an assumed base increase of 100 units annually in the North Hobart corridor, which extends past Brighton, although most of the development was expected to be between Glenorchy and Moonah). The emphasis on TOD in the evaluation is appropriate. We are not in a position to comment in detail on the likelihood of achieving this scale of impact but note that the gain of 150 units a year is a strong driver of LRT patronage growth in the business case evaluation. At an assumed 1.4 persons per dwelling, as used in the business case, this TOD would represent about half the rate of annual population increase that was achieved in Glenorchy and the City of Hobart combined over the 2001-2011 decade.

5 The effect of the 20 per cent 'sparks effect' was to increase LRT mode share by 20 per cent above base estimates

6 Optimal Operating Service Models, of which four were tested (see Appendix A)

Figure 9: LRT route



Source: PWC (2014), Figure 1, p. 5.

Vancouver is one of the most successful cities internationally at increasing densities around its frequent transit network. Almost half the population increase in metropolitan Vancouver between 2001 and 2011, and a little over half the growth in dwelling numbers over the decade, was located close to the frequent transit network (defined as within a 500 metre buffer of local bus and streetcar routes and a kilometre of rapid transit). This was a very effective transit corridor/station based development strategy, which has been instrumental in that city realising its strategic goal of developing a more compact urban area. This is a rare example of such a successful city-wide development strategy around transit (a key element of TOD). Toronto, for example, also aims for a compact settlement strategy based strongly around high frequency transit but achieves much lower rates of such development than Vancouver. However, it is more realistic for a local government area within a city to aim for half its growth to be concentrated in one particular trunk transit corridor.

The rate of sustained TOD development assumed in the LRT business case is a relatively ambitious target for the relevant Tasmanian governments (local and state) to pursue, given the lack of medium density development in the corridor at present and the slow rate of densification being currently achieved in Greater Hobart. However, policy and planning measures should certainly strive towards achieving such a densification outcome. In this regard, we note that Infrastructure Tasmania has proposed:

> *'Infrastructure Tasmania works with Glenorchy and Hobart City Councils to develop a detailed understanding of opportunities for land use planning and rezoning in relation to increased residential and commercial density adjacent to the rail corridor. This work should include identification of all potential locations for high-density residential development, the density target and ultimate dwelling yield. The investigation should identify sites within close proximity to potential light rail stations and required conversion of industrial land to residential or mixed use. Councils should also identify supportive planning scheme provisions that facilitate ease of re-zoning and future development.'* (Infrastructure Tasmania 2016, p. 18).

This is the right starting point to progress thinking about what is possible and how it might best be achieved in terms of accelerated densification.

The economic case for LRT is weak, based on the various studies that have been undertaken. Could non-economic arguments change the outlook sufficiently for LRT to warrant an early start on the project? The business case (ACIL Tasman 2013) mentions Melbourne research on social exclusion, notes the relatively low socio-economic status of Hobart, but does not pursue valuation of potential social inclusion benefits from LRT, primarily arguing that these benefits are not currently included in project bids to Infrastructure Australia. The Victorian government, however, has recognised the value of these benefits. One of the current authors led the valuation work on social exclusion in the relevant Melbourne research and Professor David Hensher from ITLS was also intimately involved (see, for example, Stanley et al. 2011; 2012; Stanley and Hensher 2011). The Melbourne research showed that enabling an additional trip by a person at risk of social exclusion was worth about $20 for someone of median household income, increasing proportionately as household income reduces. The value is not mode-specific; it relates to additional trips. Local service coverage is the key to access provision to support trip making by people at risk of social inclusion and, in a Hobart setting, this coverage is largely provided by bus. Thus, the issue of reducing risks of social exclusion are certainly relevant to Hobart public transport provision but will mainly be a potential benefit for bus, not light rail. This thinking underpins ideas like minimum public transport service standards to support inclusion.[7]

Although the LRT economic case is weak at present, there are good grounds for retaining the option for possibly developing LRT at some future time in Hobart's northern corridor, which means keeping the rail line available for such a purpose. If densities can be substantially increased over the next decade or so in the Glenorchy/Moonah area, through accelerated and sustained medium density mixed-use transit oriented development along the Main Rd section of the corridor, in particular, then the case for LRT (or BRT) should be revisited. Greater demonstrated evidence of medium density mixed-use development happening in the corridor would provide increased confidence that the state and corridor councils are serious about developing a more compact urban form and, accordingly, strengthen the case for rapid transit in the corridor, which may be LRT.

7 Stanley and Hensher (2011) show, for example, that social inclusion benefits are the largest single benefit from route bus operations in Melbourne

Infrastructure Tasmania's (2016) recommendation about engaging with the private sector to gauge interest in higher density development in the corridor is an important early part of this process.

Appendix A in this report presents further discussion of the light rail option, including additional detail and comment on the business case evaluation results, together with some comparisons with other light rail projects in Australian cities. The latter comparisons suggest that the Hobart costs may be on the low side and would obviously need close verification should further work be undertaken on the project. Appendix B includes some discussion about transit corridors.

4.5 Bus rapid transit

Metro currently carries 2.2 million passengers a year in the northern corridor—counting all services that use Main Rd, its busiest corridor.[8] There are additional loadings from private route operators, who operate through the corridor from further afield, as well as dedicated school services which run on the route. Metro has been re-designing services in the corridor in recent times, to a Turn up and Go model, with additional through services. The target is for 90 per cent of corridor residents to be living within 400 metres of a high frequency route, with services departing every 10 minute during the day (weekdays 07:00 to 19:00). PWC (2014) suggests that this has been effective, with patronage increasing by 3.4 per cent to the time of their report, after years of stable or slowly declining patronage numbers. Service kilometres have not increased in total, as the higher frequencies have come from a re-organising of existing service kilometres, including removal of some underutilised services. Would a BRT in the corridor drive sufficient increased numbers to be worthwhile?

Bus rapid transit has often been seen as inferior to light rail transit but there is evidence of a shift back towards BRT, as governments around the world increasingly recognise that bus-based transport can provide the same (or even better) mobility benefits as LRT at significantly lower cost (Hensher 2007). For example, in relation to the Appendix A example of Canberra, studies have shown that Canberra's Capital Metro corridor built as BRT could provide the same benefits as light rail but at only half the cost (Terrill, Emslie and Coates 2016). On the Gold Coast, the benefit-cost ratio of BRT was 2.53, somewhat higher than that of LRT at 2.3, with infrastructure costs 10 per cent lower, rolling stock costs 61 per cent cheaper but with operational costs 32 per cent higher (GoldLinQ nd, p. 18).

A primary benefit of BRT is its ability to integrate with existing bus modes, as services can be through-routed to form the trunk system, rather than relying on connections and transfers at either end. Customers prefer a one-seat journey and penalise transfers highly, with recent experiments conducted in Canberra showing a 30-45 per cent decrease in patronage when a connection was introduced (Wong 2014). Through-routing also permits higher frequencies on the system, although the vehicle capacities are usually smaller, leading to higher labour costs for the same number of passengers carried. This is countered, however, by savings in infrastructure costs, fleet costs and depots costs.

The quality of BRT systems differ in terms of their right-of-way, busway alignment, fare collection method, intersection treatment and station design, amongst other factors. The Institute for Transportation and Development Policy has developed a metric through which to rank BRT systems worldwide (ITDP 2014). In Australia, Brisbane's busways receive a silver score of 77, as one of the most infrastructure-intensive systems in the developed world. The grade-separated environment, including elevated carriageways in the suburbs and underground stations and tunnels in the CBD, allows the system to operate virtually independent of general traffic. Less costly implementations of BRT are exemplified by Sydney's Liverpool-Parramatta T-Way, North West T-Way, M2 Busway and Melbourne's Doncaster Area Rapid Transit services. These bronze or basic BRT services feature at-grade intersections, lower quality stops, and may include sections where services run on-road in dedicated bus lanes.

As noted, LRT is usually more costly than BRT in capital terms. The cost of a BRT scheme in Hobart will depend entirely on the specifications to which it is built. Use of the railway corridor is possible by converting the tracks into a road carriageway. The railway easement is sufficiently wide for opposing lanes between Glenorchy and New Town. South of New Town to Macquarie Point, the corridor is limited by bridges, embankments and cuttings which prevent the construction of opposing lanes without removing the cycleway. It has been suggested that passing lanes could be constructed, much like passing loops on a railway, to allow opposing buses to pass. We believe this is impractical given the greater variability of buses as compared with light rail, which operates with blocks and signals. This is exacerbated by the higher frequency expected from BRT in a through-routed network. Passing lanes will also need to be located at stops, or be sufficiently long such that vehicles need not come to a halt.

Studies in Hobart's northern corridor suggest that LRT between Hobart and Glenorchy would cost $70-78 million and that a longer BRT between Hobart and Claremont would be some $40m more costly (PWC 2014). We are not aware of like for like capital cost comparisons but expect that they would not be very different between LRT and BRT between Glenorchy and Hobart, although vehicle capital cost comparisons might favour bus, because of the current availability of many vehicles (as well as lower per unit costs). An objective choice between LRT and BRT, or some other alternative, needs equivalent capital and operating cost comparisons to be in place.

There are currently about 25 buses an hour running along the corridor during the AM peak, or about one every two minutes, including Metro, school and private route services. If a BRT was to operate on the rail alignment, it would probably need to operate in the peak direction only during the peak period, because of the lack of room for dual lanes between New Town and Macquarie Point. This proposal is problematic on a number of fronts. Firstly, it assumes that all customers travel into Hobart CBD and out at peak times. The increasing diversity of trips is recognised by Metro in its latest network with new direct routes from the eastern shore to Glenorchy (Route 605), as well as better headway regularity on its Turn up and GO corridors during the day. Secondly, it adds confusion for passengers who do not follow these expected travel patterns. Customers making trips in the opposite direction, or returning home before PM peak arrangements have taken effect, will be forced to rely on coverage services

8 Multiplying the 90,200 weekly patronage estimate for the LRT in the ACIL Tasman (2011) report suggests annual LRT boardings of over twice the current bus loadings in the corridor, or nearly triple by year 10.

which call at different stops, operating on different routes and to different times. What was previously a simple commute has now had many added variables, resulting in unnecessary complexity for the travelling public. Also, the proposal is difficult to implement operationally, especially during transition periods when the BRT switches direction. Will a late running bus hold up the BRT transition and hence delay all subsequent trips? Or will the vehicle be forced off the busway, inconveniencing customers and further delaying the bus and driver. There will also be no way for buses to overtake a vehicle broken down on the BRT, potentially leading to lengthy traffic jams until the vehicle can be towed away. Such a system will have no resilience against a single point of failure. A single-lane, reversible BRT for Northbourne Ave (on the Capital Metro corridor) has previously been proposed by the alternative government in Canberra but has since been withdrawn.

Many of the reasons why LRT is a poor performer at present for Hobart also apply to BRT, such as development densities and capital costs. To be economically viable as a BRT, the LRT experience suggests that any service in the corridor would need to operate direct and as quickly as possible, while keeping capital costs to a low level. The indirect easterly loop in the rail line to Macquarie Point, however, takes most current public transport travellers out of their way, and lacks activity density that will generate patronage, until such time as Macquarie Point is an activity centre. North Hobart is a far more direct route to the city centre along the northern corridor, albeit hampered by traffic congestion.

We believe a high quality BRT is currently only likely to be an effective option between Glenorchy and New Town High School. A lower quality scheme featuring bus priority enhancements, for instance in the form of continuous bus lanes, would then run on New Town Rd/Elizabeth St into Hobart CBD. This hybrid scheme operates on the same corridor to that we suggest in Appendix A as a possibly more effective light rail corridor than the full rail corridor. We expect that the corridor would be more economically efficient being built as BRT, due to its likely lower cost and better integration qualities. Naturally, once a corridor has been selected, a full cost-benefit analysis of BRT and LRT is required to determine which is the best mode overall for implementation.

4.6 Bus priority enhancements

Metro's northern corridor bus service improvements noted in section 4.4 are currently hitting capacity constraints. AM Peak buses are often full for half the route from Moonah. There is very little priority given to bus operation in the corridor, with only one B-light in operation. PWC (2014), in its report Riverline—Hobart Light Rail Strategic Assessment, included an option to 'improve bus frequency on key corridors', building on the early success of the Turn up and GO initiatives noted in section 4.4. They saw this option as supporting improved access to the CBD and reduced car dependency but confronting challenges in terms of the limited capacity for additional bus movements.

Bus priority enhancements represent the most cost effective solution for improving public transport on Hobart's northern corridor (and elsewhere in Hobart), particularly in the short to medium term. Research has shown that minor initiatives to clear bottlenecks and pinchpoints have a far higher benefit-cost ratio (often up to 20-30) than new infrastructure which seeks to add capacity to a road or rail network (BCR around 1-2) (Eddington 2006; Infrastructure NSW 2014). The Main Road Draft Transit Corridor Plan (Tasmanian Government 2014a, b, c) was developed by the Tasmanian Department of State Growth, in conjunction with Hobart City Council and Glenorchy City Council, and aims to provide increased bus priority, optimise bus stop locations and rationalise on-road parking. These changes are expected to improve peak travel time by around 10 minutes on the corridor. As Main Rd is a council asset (unlike Brooker Hwy, which as a road with state/national significance, is administered by the Tasmanian state government), it is the responsibility of council to implement the plans.

Given the limited road space available on Main Rd, it is imperative that this be allocated to the most spatially efficient mode of transport—in peak periods this is bus. Each component of the Main Road Draft Transit Corridor Plan (Tasmanian Government 2014a) attempts to allocate more space to buses in an effort to improve their running times. Where space permits, the plan attempts to add a queue jump for buses at key intersections. Given that congestion builds up from an intersection rather than occurring mid-block, queue jumps allow the greatest time savings per unit of road space allocated to buses. A caveat is that the design must ensure the turning lane is long enough to ensure a bus can enter despite queued through-traffic, and that turning traffic is not queued so far back as to block this access (usually not an issue as they are free left hand turns). Where space does not permit, the plan calls for turning lane exemptions to allow buses to head straight through an intersection. Whilst not ideal, this is an improvement on the status quo, but intersection design and signal phases must ensure that sufficient opportunities are provided for the turning lane to clear. As an example, the current missing left turn signal from Main Rd southbound onto Risdon Rd does not represent an optimal signal phasing and design for this particular type of intersection treatment.

The Main Road Draft Transit Corridor Plan (Tasmanian Government 2014b) also proposes a rationalisation of bus stops to improve bus travel speeds. At present, there are some sections of the corridor where bus stops are located just 200 metres apart. The plan proposes that stops be located 400 metres apart (a 5 minute walk), thus trading increased walking distances for faster bus travel times. Bus stops on Canberra's Flemington Rd (Capital Metro) corridor are located 1 km apart, the same distance as heavy rail station spacing in Sydney's inner suburbs. There was no political pain attached with their implementation, as these stop spacings were designed at the outset for this section of the frequent network. However, in other parts of Canberra where bus stops have been rationalised to improve Disability Discrimination Act compliance, the government has faced a backlash from the community. The lesson here is for the council to manage this process very carefully.

Reforming on-road parking is also a key part of the Main Road Draft Transit Corridor Plan (Tasmanian Government 2014c). This involves removing parking spaces around intersections to increase throughput, as well as relocating parking spaces associated with the bus stop optimisation program. This has been a contentious component of the plan, with heavy opposition from businesses and homeowners, and the council understandably reluctant to offend ratepayers. Glenorchy City Council (despite in-principle support) has faced political pain with the attempt at removing just three parking spaces on Main Rd southbound outside the Metro depot to construct a new bus stop (such that southbound services will no longer need to divert into the depot, potentially saving 3 minutes on every run). The implementation difficulties here draw attention to the allocation of responsibility for the road and, in particular, whether responsibility should sit with the state government. We return to this matter in section 4.8.

Clearways are another mechanism to manage the allocation of road space to improve bus travel times, with a focus on peak periods. It is possible that time limited parking restrictions, suited to Hobart's narrow peak periods, may garner greater community acceptance than an outright removal of parking spaces.

Clearways already exist in Hobart on the Davey St/Macquarie St couplet. These operate between 07:30 and 09:00 in the morning and provide for a dedicated turning lane for left turning traffic. There is the potential to implement similar part time clearways on Main Rd, for the peak-period in the peak-direction. To provide some context, part time clearways in Melbourne operate from 07:00-09:00 for the AM peak, and from 16:00-18:00 in the PM peak. In Sydney, these operate from 06:00-10:00 in the AM peak and from 15:00-19:00 in the PM peak. Clearly, our proposals for Hobart are minor in scale and should have minimal effects on businesses in the area, particularly if they operate for only about 90 minutes one-direction in each peak.

Part-time clearways should operate along the full corridor. One difficulty, however, is that clearways on Main Rd may have the effect of simply shifting the bottleneck down the road, because of the prevalence of traffic calming devices and pedestrian crossing facilities at the major activity centres. Should these be dismantled, vehicle speeds will rise and pedestrians face greater difficulty crossing the road, thereby compromising the relatively pedestrian friendly environment currently in these centres. Peak direction time limits on the clearways can be accompanied by lowering of speed limits if necessary, to help deal with such concerns.

Short term operational improvements at Metro may also help to reduce running times. At present, the Metro depot is used as a location for hotseating (change of driver). Although this is an efficient location for drivers to take crib breaks, as well as begin and end their shifts, it does result in a few minutes of delay for through passengers. It is prudent for Metro schedulers to explore alternative arrangements for hotseating when the next round of shifts are built.

4.7 Opportunities for other corridors

4.7.1 Eastern Shore

The Eastern Shore is Metro's latest addition to its Turn up and GO network, having been introduced following the Hobart Network Review implemented in January 2015. The corridor runs east from Hobart City, to Rosny Park, Bellerive and Howrah, via the A3 Tasman Hwy, Rosny Hill Rd, Cambridge Rd and Clarence St. Major destinations along the route include the Rosny Park Interchange (Figure 10), which serves Tasmania's largest shopping centre Eastlands, as well as Bellerive Shops and Shoreline Central (Figure 11). The Eastern Shore corridor, together with buses from the B32 East Derwent Hwy, Cambridge Rd (north) and B33 South Arm Hwy, are the only route services to use Tasman Bridge. The latest data shows the Tasman Bridge carrying up to 75,000 vehicles per weekday (Tasmanian Government 2016), the highest volume of any state road in Tasmania (Tasmanian Government 2012). A tidal flow system on the bridge proper and a contra-flow lane on the highway's eastbound carriageway between the CBD and Tasman Bridge work to enhance capacity in the peak-direction. Buses travelling through Rosny Park experience some delays from the town centre's many traffic signals and high intersection density. This congestion is arguably more severe on approach from the west, as the local arterial network lacks the capacity to soak up peak traffic being funnelled out of the A3 Tasman Hwy. Travel times on Cambridge Rd and Clarence St in Bellerive and Howrah are far less variable, though disruptions can occur during major events at the Blundstone Arena.

Figure 10: Rosny Park Interchange, an on-road, shared [with general traffic] facility with six bus stands (viewed southbound)

Figure 11: Shoreline Central, an on-road, shared facility with two bus stops (viewed westbound)

Since the launch of Metro's new network, trunk corridor services on the Eastern Shore now operate every 10 min or better from 07:00 to 19:00 Monday to Friday (Table 5). As a result of this, service levels now compare more favourably with the service offering on Metro's northern suburbs Main Rd corridor. Tassielink, a private interurban operator, also operates along the corridor, but only as far as Rosny Park, before re-joining the A3 Tasman Hwy. Their services do not compete directly with those of Metro, but rather serve commuters travelling to destinations further afield, including Colebrook, Port Arthur and the East Coast.

Table 5: Eastern Shore approximate headways for route services by direction, operator and time period

	AM Peak	Inter-Peak	PM Peak	Evening	Saturday	Sunday
INBOUND						
Metro	7.5 min[9]	10 min	10 min	30 min	20-30 min	30 min
Tassielink[10]	3 trip	5 trips	3 trips	*No service*	6 trips	*No service*
OUTBOUND						
Metro	10 min	10 min	7.5 min[9]	30 min	20-30 min	30 min
Tassielink[10]	1 trip	5 trips	5 trip	*No service*	6 trips	*No service*

Source: Authors, from timetables

A number of traffic management improvements could be made to enhance bus operations on the Eastern Shore corridor. It is clear that the largest single bottleneck on the Hobart road network is the Tasman Hwy. The current tidal flow/contra-flow arrangements fail to adequately prioritise higher efficiency vehicles. The introduction of a peak-period, peak-direction bus or high occupancy vehicle (HOV) lane can improve journey times for a large number of commuters, whilst only modestly increasing the trip time for other users. There are three inbound lanes on the highway in the AM peak on approach to the CBD. The right lane is routed into Liverpool St (which is how buses access the Hobart City Interchange), but uses the eastbound carriageway under a contra-flow arrangement between Tasman Bridge and the CBD. This is a potential safety risk, as larger vehicles are likely to cause greater damage in the advent of a head-on collision. The middle lane branches out to Liverpool St, but will cause significant weaving as motorists cross between the left and right lanes, again ruling it out from consideration on safety grounds. The left lane is most suitable, except that it is routed into Davey St, precluding use by buses under the existing network configuration.

A possible solution here is to build a right turn from left only queue jump for buses to access Liverpool St from the A3 Tasman Hwy. Whilst this will involve some infrastructure costs and delay motorists travelling into the CBD, it can balance the competing objectives of safety, allocating bus priority and ensuring route integrity. The designation of the left-hand through-lane on the inbound carriageway of the A3 Tasman Hwy at the B32 East Derwent Hwy as a bus or HOV lane will complement this proposal and further improve the flow for priority vehicles. Bus or HOV lanes are more difficult to allocate in the PM peak outbound direction, as buses branching out into the suburbs will need to use both the left and right lanes of the carriageway. However, evidence suggests that the wider PM peak window (arising from the non-coincidence of school and work finishing times) causes less delay, and so there is less urgency and it can be considered as part of a larger package of works.

Allocating bus priority on the Tasman Bridge and its approaches will likely bring the greatest benefits for the Eastern Shore corridor. However, additional time savings may be made by restricting the Rosny Park Interchange to buses only (as it originally was at inception), installing better bus priority throughout the Rosny Park town centre, as well as reconfiguring Shoreline Central roads so that both eastbound and westbound buses need not travel in loops to service the stops. This can be done by signalising the intersection of Rokeby Rd and the B33 South Arm Hwy to permit all traffic movements rather than just left in and left out.

Perhaps most importantly, designation of a bus or HOV lane on the Tasman Bridge would be a powerful statement about the importance of making more efficient use of congested infrastructure and an assertion of the important role of public transport in achieving this objective. It would be a material contributor, we believe, to building a stronger public transport culture in Hobart.

9 Excludes Routes 605 which operates peak-period, peak-direction only between Shoreline Central, Rosny Park and Glenorchy Interchange. A total of 6 trips are scheduled per working day

10 Tassielink service to Colebrook, Port Arthur and the East Coast only operate along the Eastern Shore corridor as far as Rosny Park Interchange. Some services operate school term or school holidays only

4.7.2 Southern Outlet

The A6 Southern Outlet is a limited access dual carriageway that connects Hobart City with the southern town of Kingston. The highway begins at the Davey St/Macquarie St couplet, approximately 1.5 km southwest of the CBD. It crosses mountainous terrain and offers a more direct route to Kingston than the sole alternative of B68 Sandy Bay Rd/Channel Hwy, which is a circuitous single carriageway following the side of Mount Nelson and the Derwent River bank. For this reason, and coupled with strong population growth in Kingston, the A6 Southern Outlet carries a daily average of 33,900 vehicles (2015), a figure that is growing by 3 per cent per annum. The highway features Tasmania's sole bus lane, converted from a breakdown lane which begins on the inbound carriageway 1.7 km north of Olinda Grove, and continues for 700 metres before finishing abruptly 250 metres from Davey St. This is to allow general traffic to enter the left lane and make left turns at both Davey St and Macquarie St (both two way roads from this point on). Bus services follow Davey St/Macquarie St and the A6 Southern Outlet, exiting at the Kingston interchange to join the Channel Hwy. The Kingston Central stops offer poor customer amenities for what are the largest stops in southern Hobart (Figure 12). However, a park and ride facility is provided a short distance from the centre, on a branch where approximately half of services continue south, to offer reasonably frequent services into the Hobart CBD (Figure 13).

Figure 12: Kingston Central, an on-road, shared [with general traffic] facility with two bus stops (viewed northbound)

Figure 13: Park and ride facility at Kingston, located on Dension St 300 m southwest of Channel Court (viewed northbound)

As is evident in Table 6, Metro's service offering for the Southern Outlet is highly peaked, with high frequency in peak times (buses departing every 5 min), but no service in the evenings and on Sundays. Technically, alternative services are available via the B68 Channel Hwy / Sandy Bay Rd, but travel takes up to 10 min longer (28 min compared with 18) than on the A6 Southern Outlet. This represents a peak-first service allocation which offers good services for nine-to-five workers in the CBD at the detriment of commuter classes with other travel patterns (shift workers, students and senior), who may be more likely to use transit (Walker 2012).

The Southern Outlet is the only corridor where genuine competition between operators exists. Tassielink is free from any pick up and set down restrictions, frequently conveying Metro customers who have missed their service. Indeed, on Sundays, Tassielink is the only operator of Southern Outlet services, as all Metro services divert via the B68. The integrated ticketing system[11] allows customers to make use of their Metro Greencard on board Tassielink services. However, the fare structures remain separate, the result being that when one reaches their day cap on Metro services, he/she will continue to be charged by Tassielink as normal for their services.

Table 6: Southern Outlet approximate headways for route services by direction, operator and time period

	AM Peak	Inter-Peak	PM Peak	Evening	Saturday	Sunday
INBOUND						
Metro	5 min	15 min	15 min	*No service*	20-30 min	*No service*
Tassielink	3 trips	4 trips	3 trips	*No service*	6 trips	6 trips
OUTBOUND						
Metro	15 min	15 min	5 min	*No service*	20-30 min	*No service*
Tassielink	2 trips	4 trips	4 trips	1 trip	6 trips	6 trips

Source: Authors, from timetables

The abrupt termination of the A6 Southern Outlet bus lane metres from the Davey St/Macquarie St couplet is a major bottleneck for the system. Whilst we recognise the limited space available to widen the road at that section, we believe there are opportunities to reconfigure the intersection to ensure that buses receive full priority through the signal. For example, general left turning movements can be made from the second left lane (shared with through traffic), allowing the leftmost lane to be used as a queue jump for buses. Smart light technology will be required to ensure that the B-phase is able to clear all buses, so that no vehicles remain to obstruct any left turning movements. Although this proposal will add another phase to the signals, as well as slightly reduce throughput at the intersection, it will speed up journeys significantly for bus users from Kingston. The current 700 metre length of the bus lane is generally sufficient, though on rare occasions traffic may be backed up past this point. In such circumstances of bumper-to-bumper traffic, buses could be granted special permission to use the hard shoulder,[12] as is currently allowed on the Eastern Freeway in Melbourne.

The Tasmanian government's impending assumption[13] of ownership of the Macquarie St/Davey St couplet represents the first time the state government has taken control of urban arterials, which may increase the opportunity to provide continuous bus lanes along both streets. The couplet, a major cross city route for traffic, has been recognised to be close to or at capacity, though there has been a surprising reduction in traffic over the past year in the order of 1,000-3,500 vehicles per day (Tasmanian Government 2016). To maintain some parking spaces, access for taxis, and to ensure that stopped buses do not block other bus traffic, the bus lane could be designated as the second left lane, as is the case on Sydney's George St (and now Elizabeth St), the busiest north-south transit corridor in the Sydney CBD. This would benefit not only Kingston customers, but also passengers travelling to and from Sandy Bay, the University of Tasmania, South Hobart, and beyond.

Finally, we suggest greater integration between operators, particularly relevant on the A6 Southern Outlet where competing operators supplement each other's services. Moving private operators onto Metro's Greencard is a logical first step, but much more is required in terms of integrating fare structures, coordinating services to minimise connection times and producing joint customer information, which are relevant for the system as a whole, not just one operator. In the Kingston example, for instance, this means reducing the effective fare penalty for choosing different operators for forward and return journeys, better scheduling to ensure that the departures for Metro and Tassielink do not coincide (thereby enhancing effective frequency), and timetables and maps which show both operators' services as available.

11 Installed at the expense of Tassielink
12 Shoulder widths vary and may need to be widened on some sections for safe passage
13 Subject to council agreement at the time of print

4.8 Governance

Setting strategic transport (including public transport) service priorities, including infrastructure upgrade requirements, means resolving tensions between regional and local level issues, often involving conflicts between movement and place-making. For example, providing for bus priority operation along Main Rd is an effective way to support regional operation of public transport but may have adverse local consequences, such as on businesses that rely on on-street car parking, as illustrated in Figure 12. A way to manage this conflict is to minimise the times for which bus priority is sought and ensure that off-street parking is available in close proximity. The latter seems to be the case along parts of the commercial section of Main Rd. Appropriate governance arrangements can help to tackle these conflicts.

Governance arrangements, with respect to the division of responsibilities between various layers of government, should be determined primarily by the incidence of benefits and costs associated with matters of policy concern. Local government currently has responsibility for traffic management along Main Rd. This seems an inappropriate allocation of responsibilities, given that this corridor is the busiest public transport (bus) route in Hobart. In the absence of an LRT or BRT running along the rail line or Brooker Highway, traffic management along Main Rd should be a state responsibility. This would simplify the process of taking decisions of regional significance, such as assuring peak-period bus priority operation along the entire corridor. Local councils along the route clearly need to be closely engaged in negotiating traffic management solutions but should not have final decision-making responsibility on the major urban public transport corridor.

This is an important governance issue. It is apparent that Hobart is a 'car city' and lacks a public transport culture. Implementing the strategic land use transport directions set out in the Southern Tasmania Regional Land Use Strategy (STRPP 2013) will not succeed unless there is significant change in this regard. While the car will remain the major personal means of travelling longer distances in Hobart, public transport, walking and cycling need to play greater roles, to ease congestion pressures, support social inclusion and lower the environmental footprint of transport in Hobart. Building a public transport culture is an important part of this transition. It depends substantially on better PT services, which have started in Hobart, and must be supported by operating priority, improved vehicles, stops, information, and so on. Melbourne pursued this path for buses with some vigour between about 2005 and 2010 and achieved a patronage increase of over 30 per cent in a short period. Brisbane and Perth have done likewise, Perth including rail more strongly in the mix.

Governance arrangements that support building a public transport culture are integral to success. Responsibility for Main Rd switching to the State Government is part of this process (as is the dedication of a bus or HOV lane on Tasman Bridge, as noted above). More importantly, responsibility for public transport system planning should be accorded a higher priority within the state government. At present, for example, Metro plays the major role in terms of bus system planning, which effectively equates to public transport system planning in the city, and is achieving patronage gains in the process. As a contracted public transport service provider, Metro should not be responsible for public transport network planning. Their responsibility should be at operational level, with input to the strategic planning process. Public transport strategic planning should sit firmly and identifiably in state government, arguably in a Public Transport Authority, whose role is to build a public transport culture in Hobart (or, preferably, Tasmania as whole).

5. Public transport service provision in low demand settings

With Metro increasingly focused on trunk (patronage-driven) service offerings, what is happening to low patronage local (coverage) bus services? In many outer suburban areas and in many regional settings, population numbers and/or densities may be so low (e.g. 7-10 dwellings per hectare as in Hobart) that it is very difficult to achieve reasonable boarding levels on a network of local public transport services (which will usually be bus services). Stanley and Hensher (2011) have argued that a minimum boarding rate of about 8 passengers per hour is sufficient to economically justify a local bus service, based primarily on the quantified social inclusion benefits from the service. This can be considered in multiples. Thus, for example, if an hourly service attracts 8 or more boardings per hour, this meets the target (anything less than an hourly headway for a capital city route service is of dubious value). If two 30 minute headway services each meet this target, then a 30 minute service would be justified. Individual services can be subjected to this test. If a service fails to meet the benchmark boarding rate, for reasons such as densities being too low, options include:

- replacing it with a lower cost service (such as smaller buses or taxis; see below)
- continuing it, particularly if removing the service would lower boarding rates on other services along the route.

Smaller buses

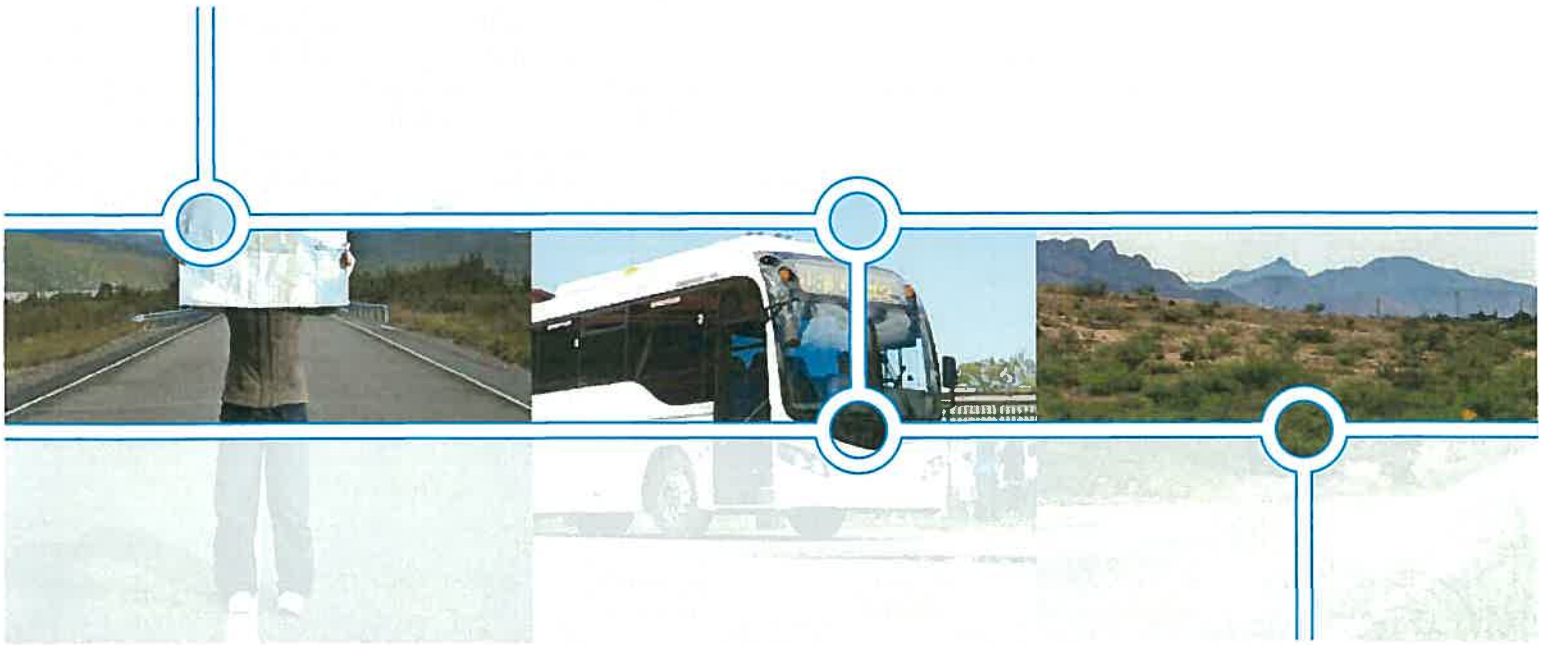
Capital costs of route buses typically account for about one quarter of total costs. Smaller buses have lower capital costs and, prima facie, might be expected to reduce total service delivery costs. However, international experience suggests that opportunities for downsizing buses are likely to be minimal. UK deregulation, for example, led to an influx of smaller vehicles, most of which have since disappeared, being replaced by larger vehicles on successful routes and removed completely on poorly patronised routes (Professor Chris Nash, University of Leeds, personal communication).

Demand responsive/flexible services

Demand responsive and flexible transit services are advocated by some analysts in low volume settings. Various evaluations of such schemes have been undertaken and they typically reflect the inherently costly nature of more closely aligning service provision with the requirements of individual clients. Labour primarily drives the cost of various forms of public transport service, because it is the largest cost component. The key to providing cost-effective public transport services in a low patronage setting is thus labour cost, not vehicle cost.

Social enterprise model: ConnectU

BusVic and the BIC research in Warrnambool, Victoria, showed substantial unmet travel demand from people largely unable to use public transport and without other means of transport. At the same time, that there was a range of underutilised transport assets in the community, particularly community buses and cars. ConnectU, a local social enterprise, commenced providing transport service in October 2012 as a locally initiated response to this research, supported by groups such as BusVic, the Bus Industry Confederation and Warrnambool Bus Lines. To deal with the labour cost problem, ConnectU uses volunteers to provide most of the transport service. It achieved patronage growth of a staggering 17.5 per cent per month compound over its first two years of operation but lack of resources has constrained further growth. The service is a form of cost-effective community transport, which provides a solution



to transport for transport disadvantaged people who are unable to use route services. It could take on a larger role, with suitable resourcing, co-ordinating across route, school, community and other local transport needs, which would enable costs to be reduced. Delivering such an outcome primarily depends on achieving:

- strong community support at the local level, for asset pooling, service integration and use
- state government encouragement for service integration
- changes in federal funding arrangements, to support co-ordinated local transport needs facilitation, rather than more narrowly focused transport funding (through, for example, HACC programs).

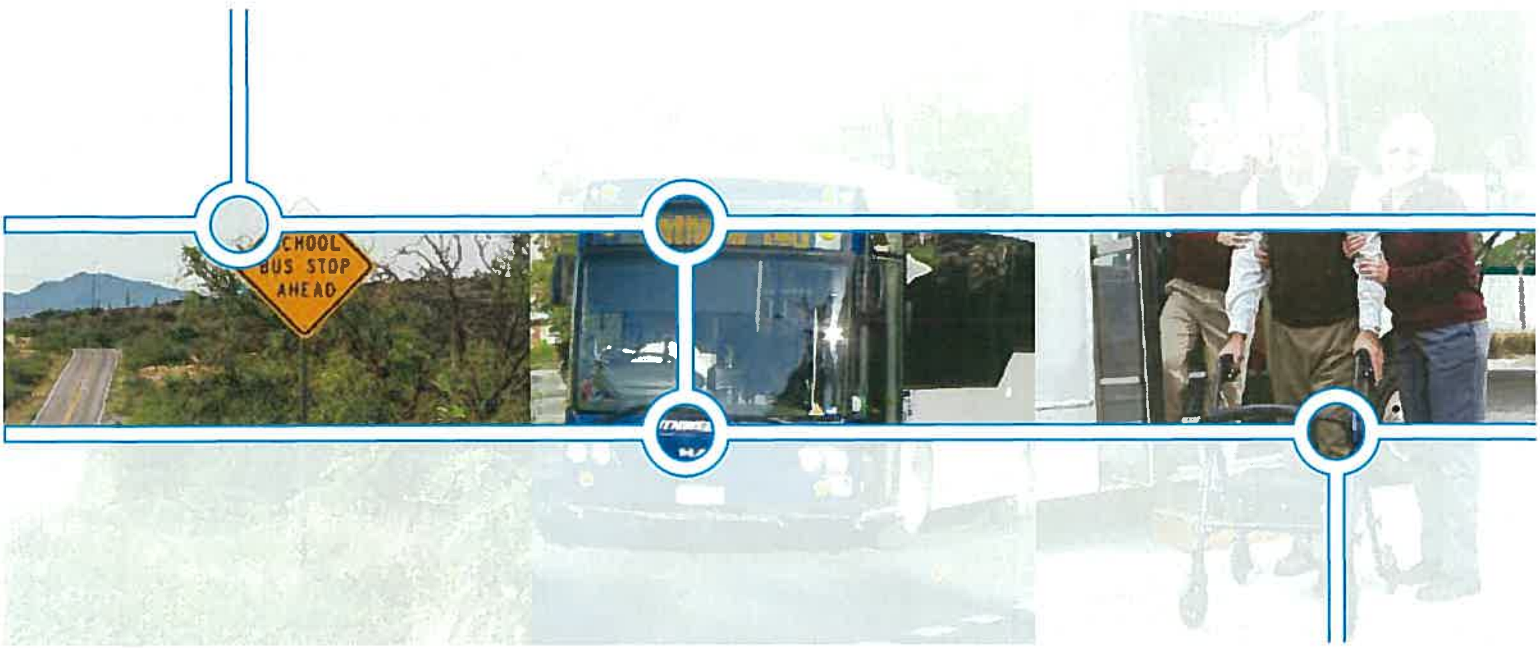
This general approach to service provision in low volume settings is consistent with conclusions reached by the UK House of Commons Transport Committee in its recent report on Passenger transport in isolated communities. That Committee concluded:

> *'Total transport' involves pooling transport resources to deliver a range of services. For example, it might involve combining hospital transport with local bus services. That new approach could revolutionise transport provision in isolated communities by making more efficient use of existing resources. We recommend that the DfT initiates a large-scale pilot to test the concept in practice.' (UK House of Commons Transport Committee p. 3)*

A similar approach has been proposed by the Ontario Ministry of Transport:

> *'All public transportation services within a community should be coordinated to expand or provide more efficient transit service. This can include coordination between conventional or specialised agencies; long term care agencies; social service agencies; hospitals, ambulance and patient transfer operators; school boards and school bus companies; intercity bus companies; taxi operators; and volunteer groups.*
>
> *The level of coordination between agencies should be tailored to local conditions, and can include shared information or referral, joint acquisition and sharing of supplies and services, use of excess capacity, joint use of resources, and centralised services for intake and dispatch.' (OMOT 2012, p. 105)*

The local coordination function should be performed by the entity best placed to do this in any local context. Having local government as a champion is a cornerstone for success, with the range of ways this can be manifest with support for the program. If Metro continues to focus service on high frequency trunk services, as is appropriate, then an approach like ConnectU, extended somewhat, might be an efficient way to support local mobility opportunities. The Tasmanian Government should support trials of this approach, as are currently being progressed in South Australia.



6. Conclusions

Hobart is a very low density, car dependent city. While land use transport planning in the metropolitan area generally talks about achieving a more compact settlement pattern, development directions are still very strongly geared to low density outer urban growth. The central area is the city's dominant activity hub but the topography, development pattern more broadly and low priority accorded to public transport over time mean that there are only a few major trunk transport corridors serving the centre and a high reliance on the car in those corridors. This setting makes effective and efficient trunk public transport operation problematic, particularly without operating priority.

A number of studies have looked at using the old railway line along the northern corridor as a possible light rail corridor, to provide public transport operating priority. However, the lack of proximate customers and circuitous nature of the route mean that this fares poorly in economic terms. Bus rapid transit faces similar challenges. The report concludes that the most cost-effective way to upgrade public transport in Hobart is to improve bus operation along existing arterial roads, with bus priority at peak periods in peak directions, with some possibility of a short section of BRT in the northern corridor on the rail line where it runs close to Main Rd. The analysis suggests that 'low-hanging fruit', such as clearways (cheap signage) and intersection treatments (queue jumps) can support significant mobility improvements for public transport passengers (10 minute travel savings), without the need to spend large amounts on LRT or a full BRT system in the medium term. This is in accord with the fundamental infrastructure planning principle of making the most efficient use of existing infrastructure before seeking to add to that infrastructure. It also emphasises the importance of infrastructure decisions being informed by cost benefit analysis. When more capital-intensive options are needed, governments should let the analysis indicate the preferred mode, rather than start with a pre-conceived answer.

LRT or full BRT over longer distances needs to wait for more evidence of successful transit oriented development (TOD) at scale in the relevant corridor(s). Consultations between state and local governments and the development sector are an early priority in this regard, to chart a pathway to stronger TOD in Hobart. North Hobart to Glenorchy seems likely to be a good opportunity in this regard, which raises questions about the eventual route of a BRT or LRT. While development along the current rail line may help stimulate Macquarie Point regeneration, the off-centre location of this development poses challenges for the most effective trunk public transport route to/from the north.

The report has also looked at ways in which existing bus services in the southern and eastern corridors might be improved, to increase patronage, with the associated economic, social and environmental benefits. We have highlighted, in particular, the opportunity for a bus or HOV lane on the Tasman Bridge as a high profile initiative that would stand as a clear and highly visible statement of support for public transport.

Upgrading bus services along existing arterial roads, such as the Main Rd corridor, raises governance questions. The report has argued that the major Hobart trunk public transport corridors, which are mainly on arterial roads, should be under state government control, not controlled by local government, to ensure that regional priorities hold sway over local concerns. Ways of minimising regional/local conflict have been suggested, such as use of clearways for a narrow time window. The report also suggests that a public transport authority could be an important way of raising the profile of public transport and helping to build a much-needed public transport culture in Tasmania's towns and cities.

Improving peak bus operation to increase public transport use, by getting people out of their cars, poses risks of accentuating an already peaked public transport service, with implications for fleet size and utilisation. One way to reduce risks of accentuating a narrow peak, with the costs this may entail, is to offer public transport fare reductions in the shoulder period, when capacity is available. This would have a minimal impact on Metro revenues but would ease pressures to increase fleet size solely for peak operation, through beneficial effects on peak spreading (as demonstrated in Melbourne and Canberra).

The improvements suggested in this report will assist public transport operators providing service within the corridors and those providing services through the corridors under consideration. It has been beyond the scope of the report to suggest other initiatives, outside the corridors of interest, which might assist the latter operators. This is worthy of investigation, because increasing longer distance use of public transport can help to ease traffic pressures and their associated costs in the trunk corridors.

In terms of the Tasmanian Government possibly seeking federal funding support for urban public transport improvements, the analysis in this report suggests that a focus on place-making and infrastructure initiatives to support increased mixed-use densities along the main Hobart trunk public transport corridors, plus assistance to implement relatively low cost traffic management improvements, is where the initial priority should be. This requires the federal government to take an integrated land use transport view of urban development and the public transport role therein and to support integrated packages of initiatives that best support city development, with the kinds of public transport initiatives identified in this report being a vital part of the package. In Hobart's case, it could extend to assistance with fleet upgrades, given the high average age of route buses. This approach requires broader thinking than is embedded in simply providing funding support for one-off big infrastructure projects.

Appendix A: Light rail in the northern corridor

Light rail to Hobart's northern suburbs has been on the agenda for the better part of the last decade, with various levels of support from major political parties in Tasmania. A number of proposals have been suggested, including running the line to Claremont, Granton, Bridgewater and Brighton, the full length of the discussed railway. Major studies have deemed the final stations to be unviable and today there is only serious consideration for light rail as far as Glenorchy. Over the years, the light rail proposal has been subject to numerous studies, ultimately culminating in a business case that is ACIL Tasman (2013). The business case conducted cost-benefit analyses for four identified options, each with an increasing number of stations built:

- Option 1 (Fast System): stops at Glenorchy, Moonah and Elizabeth St
- Option 2 (Northern Focus): stops at Glenorchy, Derwent Park, Moonah and Elizabeth St
- Option 3 (Suburban Focus): stops at Glenorchy, Derwent Park, Moonah, New Town and Elizabeth St
- Option 4 (High Access Focus): stops at Glenorchy, Derwent Park, Moonah, New Town, Macquarie Point and Elizabeth St.

Some comparative data on each of these four options are summarised in Table A2, contextualised with reference to other light rail systems in Australia either recently opened or currently under construction. The included examples of light rail on the Gold Coast, in Sydney and Canberra are new systems in their own right rather than extensions of an existing system, to offer greater comparability by precluding the network effects which arise in the case of extensions. An exception to this is the Sydney CBD and South East Light Rail which, although complementing the existing Inner West Light Rail, is effectively a new line in its own right (apart from sharing the same operator in the future). Note that some cost information for these projects are commercially sensitive and hence not available in the public domain.

The ACIL Tasman (2013) business case suggested construction costs of $70 to $78 million depending on operating model, which is low by Australian standards. This is due to a number of factors, including the existing available alignment (hence no need for property acquisitions), low infrastructure costs associated with the lack of tunnels and bridges required, a limited number of stops and a limited number of light rail vehicles (resulting in relatively high headways). Patronage estimates are 5.2 million passenger boardings[14] in the first year of operations which is a questionable 136 per cent increase on the 2.2 million passengers currently carried by Metro's northern suburb services. In addition, the proposed 15 minute peak headway represents a decrease in current service levels, which currently operate as frequently as a bus every 6-10 minutes. By contrast, the Sydney CBD and South East Light Rail is only assuming a 56 per cent increase in patronage compared with existing bus customers along the corridor (NSW Government 2013). The results show that a three-stop system (Option 1) appears to offer the highest benefit-cost ratio (1.12-1.58). However, this is reliant on a zero transfer penalty and significant sparks effects to make the investment worthwhile, as discussed in section 4 of the current report.

The business case modelled the composition of light rail passengers, with 91 per cent calculated to arrive by feeder bus, 1.1 per cent accessing the station by foot and 7.9 per cent choosing to park and ride (ACIL Tasman 2013, p. 34). The modelling assumed that 'since bus stops are pervasive across Hobart, this means that it is almost always quicker to get on a bus to access an LRV[15] stop rather than by car, bicycle or foot' (ACIL Tasman 2013, p. 33). Wait time uncertainty associated with the poor reliability of buses, the need to pick up and set down passengers en route, and the often circuitous routing of coverage services, which add delays for through-riders, makes this assumption a difficult one to accept. On top of this is the transfer time required when connecting between both within mode or between modes.

Even if connection times were finely coordinated, a buffer is generally required between the penultimate and final timing points of a bus route to help ensure reliability. It is not practical for a light rail vehicle to be delayed were an arriving bus to be running late. In addition, connecting times for return journeys from the city to the suburbs would be significantly longer, as it is clearly not the case that feeder buses are being proposed to run so frequently that they can meet every arriving light rail vehicle. Finally, it is operationally inefficient to coordinate every single connection (particularly concurrently in both directions). Buses may be forced to layover longer than required in order to maintain the integrity of connections, and this may lead to a rise in peak vehicle requirements as well as labour costs.

For these reasons, a zero transfer penalty as assumed in the business case is a completely unrealistic proposition. The sensitivity analysis in ACIL Tasman (2013) modelled longer transfer penalties and it is clear that, under more realistic scenarios, the light rail proposal is no longer an economically viable venture (Table A1). An additional comment is that transfer penalties cannot merely account for the actual time required to make the connection. This is because passengers are inherently averse to making transfers. Natural experiments conducted during a recent network change (September 2014) in Canberra found, given all else equal, a patronage decline of 30-45 per cent when customers previously enjoying a one-seat ride were now forced to make a connection for the same journey (Wong 2014).

The business case's 1.12-1.58 benefit-cost ratio for Option 1 is dependent upon a 20 per cent sparks effect, which seeks to capture the community's inherent preference for rail-based transport over bus-based modes. This preference has been well documented for decades (Hensher 1999), and has translated into higher patronage forecasts, and greater land value increases assumed for light rail projects. In the Gold Coast, for example, supporters now argue how the light rail system has morphed into a tourist icon, helping to support economic activity in the region. Too often, however, analysts have spruiked these wider economic benefits, including on tourism and development, as though they were the major end goal of mass transit. If the objective of government is to boost tourism and development, then cost-benefit analyses must be undertaken to determine whether building a transport project is more cost effective than other forms of investment (as an example, in tax concessions and community infrastructure) to support tourism and development.

14 Based on the business case figure of 16,450 one way trips per day, annualised by the authors by a factor of 315

15 Light rail vehicle

Table A1: Benefit-cost ratio sensitivity analysis for alternate transfer penalties

	Five minutes	Two minutes	One minute	Zero minutes
Benefit-Cost Ratio				
4%	0.00	0.67	1.11	1.58
7%	0.00	0.48	0.79	1.12
10%	0.00	0.36	0.59	0.84
Net Present Value				
4%	-$83,453,527	-$25,251,088	$8,309,913	$44,326,000
7%	-$75,710,900	-$37,231,886	-$14,998,119	$8,706,000
10%	-$69,572,184	-$42,687,482	-$27,121,490	-$10,635,000
Internal Rate of Return	N/A	1%	5%	8%

Source: ACIL Tasman (2013, p. 33)

The low level of walk-up customers (1.1 per cent) is symptomatic of the lack of catchment along the proposed light rail corridor. As discussed in section 4, there are few residential developments and virtually no major trip attractors along the light rail route, and the current growth trajectory favouring greenfield developments in the south (Kingston) and far north (Austins Ferry and beyond) are of little help. The Gold Coast light rail, by contrast, is located within walking distance to more than 20 per cent of Gold Coast residents, as well as the hotels of 50,000-60,000 tourists (GoldLinQ 2008, p. 18). The Gold Coast is a highly linear city with many trip attractors on the corridor, including a hospital, university, and three major urban centres, resulting in a 25 per cent increase in public transport usage (both light rail and buses) one year after opening (July 2014). Even Canberra, one of the most heavily sprawled cities in the world, has been concentrating development along the Capital Metro corridor (Figure A1), to build density along its frequent network first introduced in Transport for Canberra (ACT Government 2012), making the corridor a more viable candidate for light rail.

The experience of Canberra in its journey towards light rail is proving to be an excellent comparison with the current debates in Hobart. Canberra is also a sprawling, low density city with a similar population to Hobart, and has been reliant on buses as the only mode of public transport, whose mode share (7.8 per cent compared with 6.4 per cent for Hobart in 2011) has been stagnant for decades. Like Hobart, Canberra's economic structure also features a large proportion of university students and public servants, though it differs in that the city is experiencing a far higher rate of population growth than Hobart. An LRT/BRT debate has emerged in recent years, primarily along the Gungahlin-City (Capital Metro) corridor. Both major parties have toyed with the idea of light rail, particularly gaining prominence in the lead up to territory elections. It was only with the 2012 Parliamentary Agreement between ACT Labor (in minority government) and Green crossbencher Shane Rattenbury that a firm commitment to build light rail was made. This political decision, rather than a rational debate based on transport needs, exemplifies the choice versus blind commitment analogy introduced in Hensher (1999).

The business case for Capital Metro boasted a benefit-cost ratio of 1.2 (ACT Government 2014: 103), of which a high component were land use and wider economic benefits. Many commentators have criticised their inclusion, most recently the Grattan Institute through its latest report "Roads to riches: Better transport investment":

> *'The business case for Canberra light rail, published in 2014, reported an estimated business cost ratio of 1.2. However, land use benefits and wider economic impacts, which are typically excluded from project evaluations by Infrastructure Australia because the risks of overestimating them are so high, account for almost three fifths of the projected benefits. If these land use benefits and wider economic impacts are excluded, the benefit-cost ratio is just 0.5 – well below the level needed to deliver a net benefit to the community.' (Terrill, Emslie and Coates 2016, p. 42)*

The uncanny similarity with the experience so far in Hobart is telling. Given the tendency for recent infrastructure appraisals to be very optimistic on the scale of wider economic benefits, we believe a benefit-cost ratio close to one on the transport component should be required, including social inclusion benefits, before wider economic benefits are included, to highlight the role played by the latter in making the economic case. Wider economic benefits are a legitimate addition but should be treated with suspicion if they exceed about one-third of the size of the transport benefits. The future success of Capital Metro in Canberra, given its history, will be an important lesson for Hobart.

Canberra also faces major institutional challenges in its transport cluster as previous planning decisions had sat within the operator and there was a strong disconnect between government policy and implementation. A range of reforms in this space, including establishment of a new integrated transport agency Transport Canberra come July 2016, is a widely applauded move. We have suggested this as an appropriate way forward for Tasmania too (see Section 4.8).

Figure A1: Population density within 500 m of Canberra's Capital Metro corridor in 2011.

(Source: ACT Government 2014, p. 61)

The engineering assessment in ACIL Tasman (2013) discussed a range of cost inputs relating to rail gauge, track replacement and the procurement of rolling stock. Many light rail proponents have argued that presence of the existing tracks permit significant cost savings, which allow light rail to be competitive with bus-based rapid transit. However, the existing tracks have been deemed unsuitable (sinking?) for passenger rail, especially at higher speeds. A full track replacement has been recommended by the business case, with the option to widen the present narrow gauge (1067 mm) to a standard gauge (1435 mm)[16]. Although this would incur a higher capital cost at the outset, it would allow savings in the procurement of 'off the shelf' or second-hand light rail vehicles, suitable to the operating environment of Hobart. Although some light rail manufactures do produce vehicles for the metre gauge (1000 mm), an estimated premium of 10 per cent of the vehicle cost will be incurred for modification to Hobart's 1067 mm gauge.

What is missing from the analysis of LRT and BRT in the northern corridor is consideration of a hybrid alignment, using the heavy rail corridor between Glenorchy and New Town High School, before switching to New Town Rd / Elizabeth St (perhaps using Bromby St) for the remainder of the journey into Hobart CBD. This would avoid the circuitous route along Derwent River, where tight turning radii will restrict LRT operations to 40 km/h or less, as well as expand the catchment for the service. The authors believe that although this would deliver more benefits for the LRT, it will also cost significantly more than any of the four options proposed in ACIL Tasman (2013). This is based on current experience from Newcastle (NSW), where a primarily on-road route has been selected for light rail, rather than using the recently closed heavy rail corridor, an outcome which will cost an additional $100 million. Part of the reason for this, we believe, is to facilitate a sale of the former rail corridor (prime harbourfront real estate).

16 All light rail systems in Australia operate to standard gauge, including in Melbourne, where heavy rail runs to a broad gauge (1600 mm)

Table A2: Comparison of light rail projects recently opened or currently under construction in Australia with the four operating parameters proposed for Hobart (ACIL Tasman 2013, ACT Government 2014, GoldLinQ nd, NSW Government 2013)

	Gold Coast	Sydney	Canberra	Hobart (Option 1)	Hobart (Option 2)	Hobart (Option 3)	Hobart (Option 4)
DESCRIPTION							
Name	G:link	CBD and South East Light Rail	Capital Metro	Fast System	Northern Focus	Suburban Focus	High Access Focus
Consortium (Lead Operator)	GoldLinQ (Keolis Downer)	ALTRAC (Transdev)	Canberra Metro (Deutsche Bahn)				
Opening	Jul-14	Early 2019	2019				
Length	13 km	12 km	12 km	8.6 km	8.6 km	8.6 km	8.6 km
Stops	16	19[17]	13	3	4	5	6
Fleet Size	14	30	14	3	3	3	4
Vehicle Capacity	309	466	207				
Peak Headway	7.5 min	4 min (trunk), 8 min (branch)	6 min	15 min	15 min	15 min	15 min
Annual Patronage	6.18 million (2014-15)	31.4 million (2021)	4.8 million (2021)	5.2 million[18]	?	?	?
COST PROJECTIONS							
Total Cost	$1.2 billion ('14)	$1.6 billion ('13)	$823 million ('14)	$74 million ('13)	$74.3 million ('13)	$74.7 million ('13)	$82.7 million ('13)
Price/km	$92 million ('14)	$133 million ('13)	$69 million ('14)	$8.6 million ('13)	$8.6 million ('13)	$8.7 million ('13)	$9.6 million ('13)
Capex	N/A	N/A	$619 million ('14)	$71.3 million ('13)	$71.6 million ('13)	$72.0 million ('13)	$79.7 million ('13)
Opex	N/A	N/A	$204 million ('14)[19]	$2.7 million ('13)[20]	$2.7 million ('13)[20]	$2.7 million ('13)[20]	$3.0 million ('13)[20]
BENEFIT-COST RATIO							
Transport	N/A	2.2	0.5	?	?	?	?
Wider Benefits	N/A	0.3	0.7				
Total	2.3	2.5	1.2	1.12-1.58	1.06-1.49	1.06-1.49	0.86-1.21

17 Total stops for the system, which includes two branches (10 stops on the trunk, 5 stops on the Kingsford branch and 4 stops on the Randwick branch)
18 Based on the business case figure of 16,450 one way trips per day in the first year of operations, annualised by the authors by a factor of 315
19 Whole of life, extending 30 years from the anticipated commencement of operations
20 Annual operational and maintenance costs combined (effective for years 1-5 of operations)

Appendix B: Transit corridors

The Main Rd corridor provides Hobart's best opportunity to develop a transit corridor in the city. Transit corridors are areas adjacent to trunk public transport routes that link the major nodes within an urban area or which the private development market has 'chosen' as suitable for higher density development, extending 400-800 metres laterally from those routes, depending on the public transport service level (faster trunk services with dedicated right of way are consistent with longer walk distances). The corridors should include a mix of land uses and the Vancouver experience shows that they are major opportunity areas for accommodating urban growth in an efficient manner, by corridor infill. Key land use considerations for local/state authorities in relation to transit corridors include the following:

- transit corridors should be identified and formally included in a city's strategic land use transport plan and in the relevant local authority plans, with target development densities specified and indicative achievement dates, depending on the significance of the particular corridors
- such corridors will typically be along arterial roads, like Main Rd, which means a focus on allocating decision-making responsibility for traffic management and resolving competing demands for use (e.g. between movement and place-making)
- nodes should be planned where transit corridors intersect and these should have a focus on mixed-use intensification
- corridors should include a full range of main street type uses, such as retail, cultural, personal services, institutional, office, active and passive recreation (places to sit and observe), together with residential, and permeability along the building line should be high (i.e. an absence of barrier effects along the building), to encourage walkability and associated public transport use
- densities and building types along the corridor should integrate with the scale and intensity of the local neighbourhoods and development should encourage greater integration between areas on both sides of the trunk public transport route, rather than forming a barrier to interaction (requiring specific local initiatives for achievement)
- provision for affordable housing and social/ community infrastructure should be included.


New Norfolk 130
DERWENT VALLEY LINK

Bothwell 140
BOTHWELL LINK
MAN

CB60
DERWENT VALLEY LINK
18

Metro Tasmania
Metro
727
727
SCANIA
MET 727

References

ACIL Tasman (2011), Hobart to Northern Suburbs Light Rail Business Case, Prepared for the Department of Infrastructure, Energy and Resources, July.

ACIL Tasman (2013), Stage 1 Light Rail Business Case: Hobart to Glenorchy, Report prepared for the Department of Infrastructure, Energy and Resources, May.

ACT Government (2012), Transport for Canberra: Transport for a Sustainable City 2012-2031, Canberra, Australia.

ACT Government (2014), Capital Metro: Full Business Case, Canberra, Australia.

Australian Council of Learned Academies (2015), Delivering sustainable urban mobility: Final report, October, accessed 28 April 2016 at http://www.acola.org.au/PDF/SAF08/SAF08_FullReport_web.pdf

Bento, A.M., Cropper, M.L., Mobarak, A.M. and Vinha K. (2005). "The Effects of Urban Spatial Structure on Travel demand in the United States", The Review of Economics and Statistics, vol. 87, no. 3, pp. 466-478.

Cervero, R (2014), 'Land use/transport integration: implications for infrastructure in North American and Australian cities', in Stanley, J and Roux, A (eds) Infrastructure for 21st century Australian cities: Papers from the ADC Forum National Infrastructure and Cities Summit, Melbourne: ADC Forum.

Eddington, R. (2006), The Eddington Transport Study—Main Report: Transport's Role in Sustaining the UK's Productivity and Competitiveness, Norwich, United Kingdom.

Ewing, R. and R. Cervero (2010), 'Travel and the built environment', Journal of the American Planning Association, vol. 76, no. 3, pp. 265-294.

GoldLinQ (2008), Gold Coast Rapid Transit: In Brief—Draft Concept Design and Impact Management Plan October 2008, Gold Coast, Australia.

GoldLinQ (nd), Gold Coast Rapid Transit Concept Design Impact Management Plan: Volume 2 Chapter 11—Economic Environment, Gold Coast, Australia.

Hensher, D. A. (1999), 'A bus-based transitway or light rail? Continuing the saga on choice versus blind commitment', Road & Transport Research, vol. 8, no. 3, p. 3-21.

Hensher, D. A. (2007), 'Sustainable public transport systems: Moving towards a value for money and network-based approach and away from blind commitment', Transport Policy, vol. 14, no. 1, pp. 98-102.

Hobart City Council (2009), Sustainable transport strategy 2009-2014, Hobart: Hobart City Council.

Infrastructure NSW (2014), State Infrastructure Strategy Update 2014, Sydney, Australia.

Infrastructure Tasmania (2016), Review of a proposed light rail system in Hobart: Final advisory report, January, accessed 20 April at http://www.stategrowth.tas.gov.au/__data/assets/pdf_file/0004/129613/Light_Rail_Strategy_210116.pdf

NSW Government (2013), CBD and South East Light Rail: Business Case Summary, Sydney, Australia.

ITDP (2014), The BRT Standard, Institute for Transportation and Development Policy, New York, United States.

Ontario Ministry of Transport (2012), Transit Supportive Guidelines. Ministry of Transportation. Government of Ontario.

PWC (2014), Riverline—Hobart Light Rail Strategic Assessment, Report prepared for Department of Infrastructure, Energy and Resources, March.

Southern Tasmania Regional Planning Project (2013), Southern Tasmania Regional Land Use Strategy 2010-2035, as amended 1 October 2013, accessed 20 April 2016 at http://stca.tas.gov.au/rpp/wp-content/uploads/2011/05/land_use_strategy_2013_Amended_8thnov_web.pdf

Stanley, J. and Hensher, D. (2011). 'Economic modelling', in G. Currie (ed.) New perspectives and methods in transport and social exclusion research, Bingley, UK: Emerald.

Stanley, J., Hensher, D., Stanley, J.R., & Vella-Brodrick D. (2011). Mobility, social exclusion and well-being: Exploring the links, Transportation Research Part A, vol. 45, no. 8, pp. 789-801.

Stanley, J.K., Stanley J.R., & Hensher, D. (2012). Mobility, Social Capital and Sense of Community: What Value?. Urban Studies, vol. 49, no. 16, pp. 3595–3609.

Stanley, J. and Brain P. (2015). Delivering sustainable urban mobility: Economic perspectives, Report prepared for the Australian Council of Learned Academies, February.

Stanley, J., Stanley, J. and Davis, S. (2015), 'Connecting neighbourhoods: The 20 minute city', Bus and Coach Industry Policy Paper 4, Canberra: Bus Industry Confederation.

Tasmanian Government (2011), Glenorchy to Hobart CBD Transit Corridor: High level review of corridor options, Hobart, Australia.

Tasmanian Government (2012), Tasman Highway – Tasman Bridge Eastern Approaches Upgrade, Hobart, Australia.

Tasmanian Government (2014a), Main Road Draft Transit Corridor Plan: Bus Priority information sheet, Hobart, Australia.

Tasmanian Government (2014b), Main Road Draft Transit Corridor Plan: Bus Stop Optimisation information sheet, Hobart, Australia.

Tasmanian Government (2014c), Main Road Draft Transit Corridor Plan: On-street Car Parking information sheet, Hobart, Australia.

Tasmanian Government (2016), Hobart Congestion Traffic Analysis—2016, Hobart, Australia.

Terrill, M., Emslie, O. and Coates, B. (2016), Roads to riches: Better transport investment, Grattan Institute, Melbourne, Australia.

UK House of Commons Transport Committee (2014), Passenger Transport In Isolated Communities. http://www.publications.parliament.uk/pa/cm201415/cmselect/cmtran/288/288.pdf. Viewed 7th August 2014.

Walker, J. (2008), 'Purpose-driven public transport: creating a clear conversation about public transport goals', Journal of transport geography, vol. 16, no. 6, pp. 436-442.

Walker, J. (2012), Human Transit: How Clearer Thinking about Public Transit Can Enrich Our Communities and Our Lives, Island Press, Washington, D.C.

Wong, Y. (2014), ACTION Network Review: A Comparative Study of Network 12 and Network 14, Australian National Internships Library, Australian National University, Canberra, Australia.

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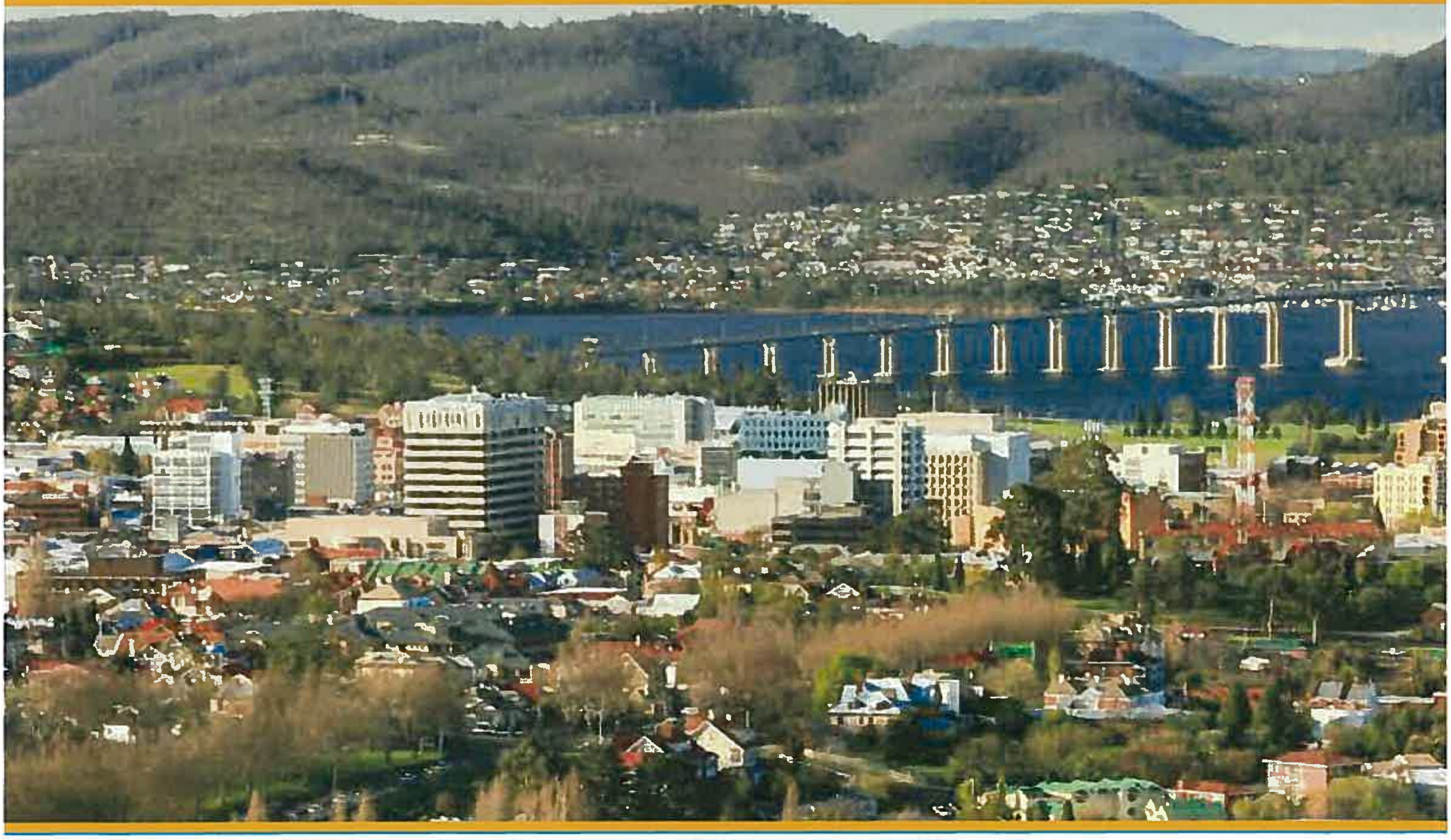

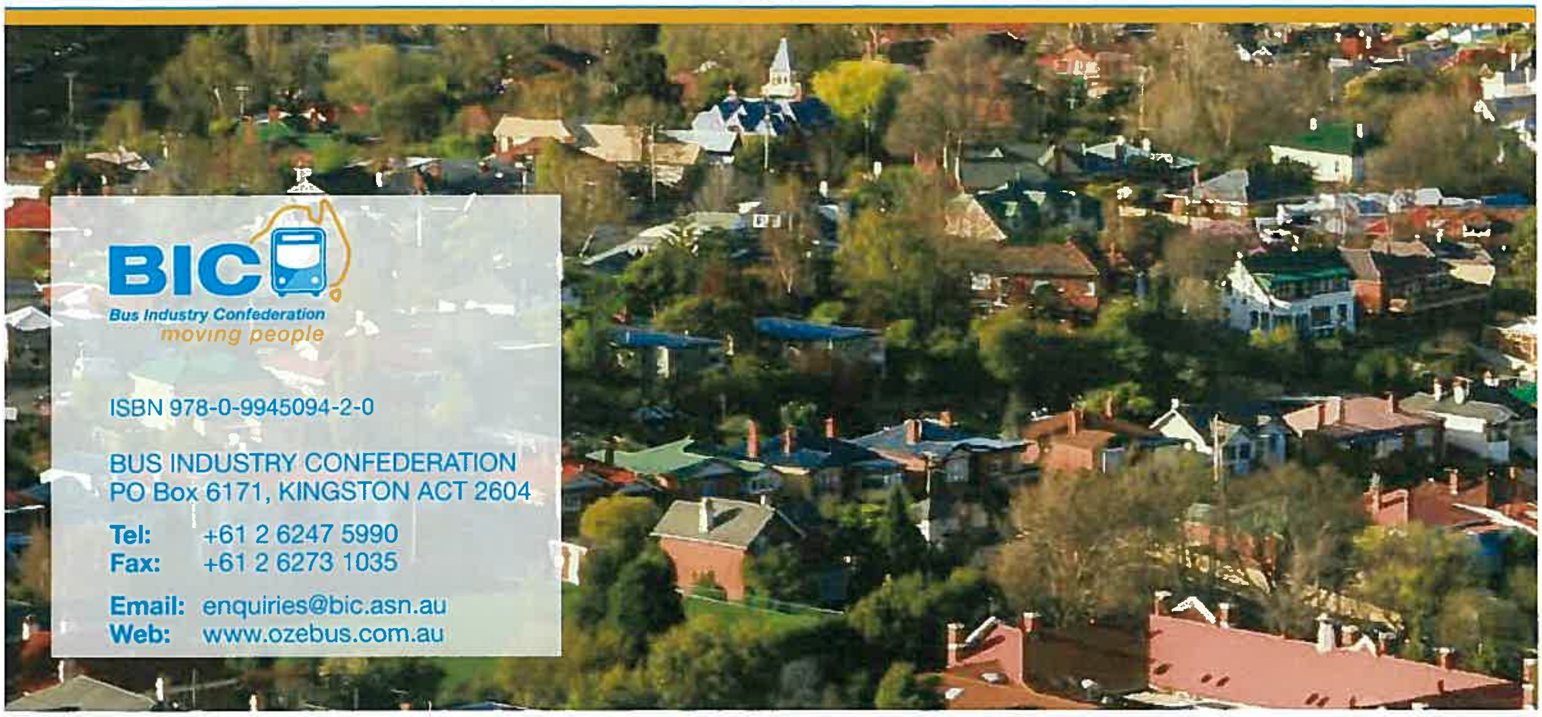

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MOVING PEOPLE

› *From Workhorse to Thoroughbred*

Review of bus rapid transit and branded bus service performance in Australia and future opportunities

Bus and Coach Industry
Policy Paper 12

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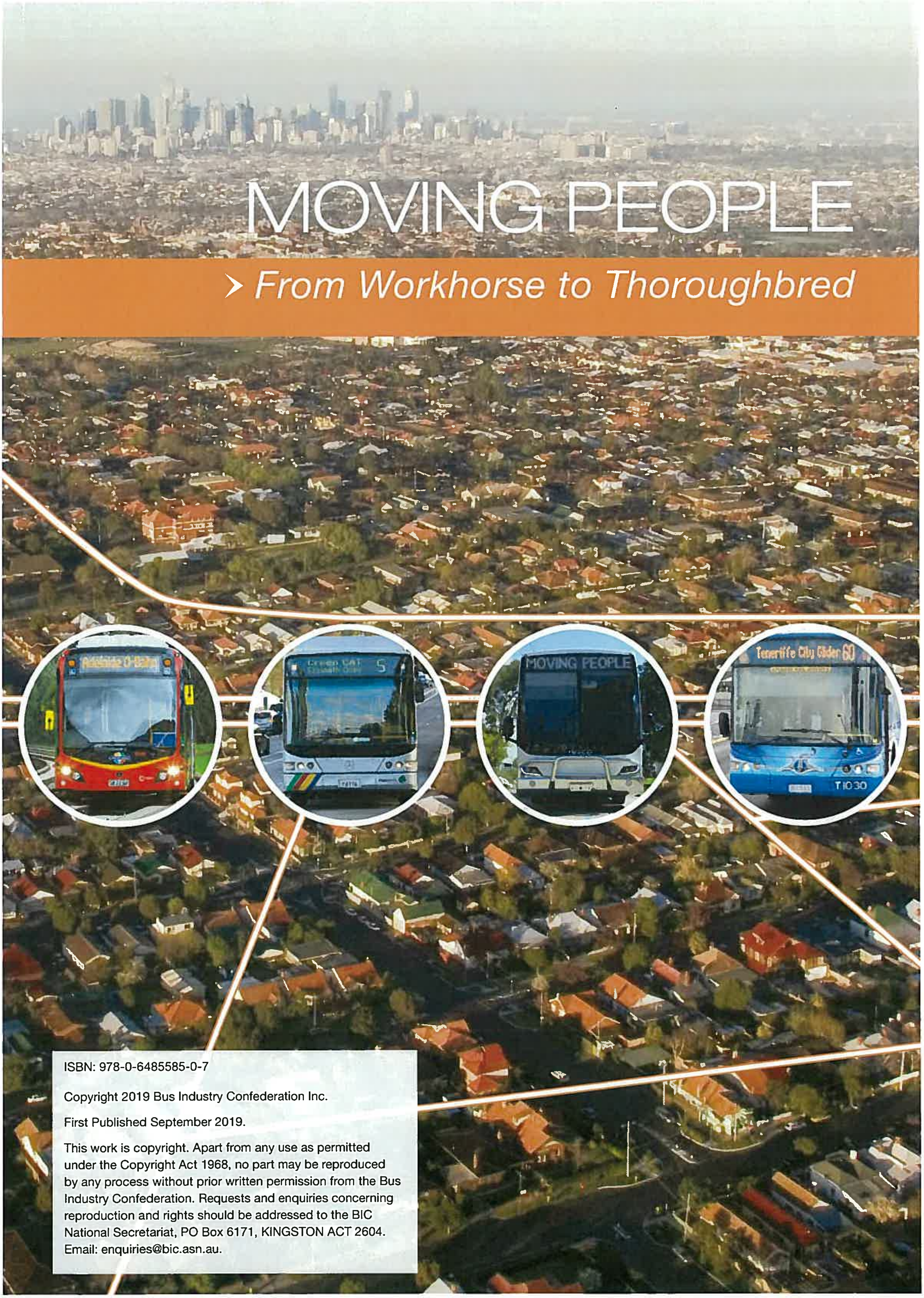

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MOVING PEOPLE

> *From Workhorse to Thoroughbred*

Policy Paper 12

Review of bus rapid transit and branded bus service performance in Australia and future opportunities

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Executive Summary

Bus rapid transit (BRT) on dedicated right-of-way and branded bus services (BBS) with a distinct visual identity have been implemented in various forms around Australia over the past three decades. A major public policy debate has surrounded the relative success of these bus priority and branding measures as compared with generic route services in attracting patronage. In this report, we develop a metric known as a (gross) performance ratio to quantify the success for each of 7 BRT and 20 BBS systems as compared with regular route buses across six Australian capitals. We identify the distinctive locational characteristics of various bus priority and brand identity initiatives as a way of controlling for influences that are not under the control of the offered services, so that we can meaningfully compare the various systems, giving a net performance ratio. This allows an informed comparison between systems and cities, controlling for operating environment and other service characteristics.

The results reinforce the merits of upgraded bus services both as standalone initiatives and also as an alternative to expensive, rail-based infrastructure investment. Specifically, we point to four key findings of policy relevance:

- Australia has had some success with BRT and BBS, but in general, states and territories have not fully committed to nor funded in most instances these services to form the core of the transport network and thereby deliver the best patronage results.
- The analysis of different BRT and BBS systems show that service productivity is higher than standard route services and that this could be improved through a variety of hard and soft factors including greater bus priority, turn-up-and-go frequency, increased service span, and the provision of real time passenger information.
- Passenger boardings on BRT and BBS increases with the frequency of services and service kilometres (as quantity measures) and BRT/BRT boardings can be higher than light and heavy rail at a fraction of the cost for the equivalent service characteristics between rail and bus.
- Australian BBS have had varying success but there is real room for expansion through simple and long-term consistency in marketing, common livery, network simplicity and customer information.

We conclude this report with a discussion of future technologies which are fusing bus and rail characteristics (specifically the notion of 'trackless trams'), as well as best practice from abroad in terms of network legibility and brand identity—all helping upgrade the image of the bus from workhorse to thoroughbred. We conclude with findings and recommendations.

Foreword

This research Policy Paper (12) is part of a policy series of publications aimed at decision and policy makers, academics and students. The Policy Series focuses on land transport, land use, integrated planning and urban development challenges in Australia.

The Bus Industry Confederation (BIC) has commissioned the Institute of Transport and Logistics Studies (ITLS) at the University of Sydney Business School to undertake a review of bus rapid transit (BRT) in Australia. Given the limited implementation of fully-fledged BRT schemes to date, our scope was extended to encompass a range of upgraded bus services, commonly referred to as BRT-lite, branded bus services (BBS) or buses with a higher level of service. Whilst BRT is typically defined by its right-of-way quality, BBS is distinguished by its brand identity within the broader network structure, often operated with a dedicated fleet, and usually complemented with some level of bus priority consistent with its premium brand. Both constitute high frequency, trunk services which serve primarily a mass transit (patronage) than a social service (coverage) function. We consider both BRT and BBS in this study.

ITLS presents this report with a view to inform industry and government on the merits of upgraded bus services. We begin by revisiting what is a common story around Australia (and indeed across developed economies) in terms of the difficulty in getting community and political traction for bus-based initiatives as compared with rail. We then review the operating characteristics of present BRT and BBS systems around Australia and evaluate their success by determining the performance proposition of these premium services in contrast to generic route services. A sophisticated methodology to test for and control relevant operating environment factors is described, to allow for an informed comparison between systems and cities. We conclude by exploring emerging bus technologies and branding experience from abroad in the context of future development opportunities for bus services in Australian cities, as well as summarising key findings and recommendations.

Acknowledgements

Special thanks for the Bus Industry Confederation (BIC) and its Executive Director Michael Apps for their support in seeking data from all state and territory transport authorities and in providing funds for this project. This report contributes to the research program of the Volvo Research and Educational Foundations Bus Rapid Transit (BRT+) Centre of Excellence. Special thanks to the Foundation for partial funding support.

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1. The BRT debate: What happened?

The humble bus is often criticised. The underappreciated workhorse carries more people than trains even in cities with extensive rail systems (e.g., London), yet the age-old adage that buses are boring and trains are sexy holds stronger than ever. This belief resonates in Australian capitals despite buses accounting for the bulk of the passenger transport task from their sheer spatial availability, especially for shorter journeys in the inner city and as first/last mile services to rail in middle and outer suburbs (Wong and Hensher, 2019). As a result, the importance of bus dominates rail in passenger trip terms, and in the view of the authors, this is rarely appreciated by the community nor public policy makers. Despite this fundamental patronage/fact for buses as compared to rail, and the greater cost, rail has been the preferred modal choice for Australian governments at state and federal levels for decades. The well-documented saga that is **choice versus blind commitment** (Hensher, 1999, Hensher and Waters, 1994) continues to manifest itself around Australia, most recently in Canberra (Capital Metro), the Gold Coast (G:Link) and Sydney (CBD and South East Light Rail, and the proposed Parramatta LRT). It is often the case in the view of the authors, that these project decisions were based on questionable wider economic benefit calculations (Stanley and Wong 2016, Hensher et al. 2019) to justify these rail-based rapid transit projects in the absence of an agreed rapid transit project assessment tool such as the Australian Rapid Transit Assessment Guidelines (ARTAG) recommended in the Bus Industry Confederation's Rapid Transit report (BIC, 2014) prepared for Infrastructure Australia. In an ideal world, we as a community ought to consider a transport problem objectively and then select the most appropriate transport mode to meet that challenge. This is a rational but often unpopular approach given that bus rapid transit (BRT often being most cost effective) simply does not typically resonate with the community nor carry the same political benefits as rail. This is often the result of the public's existing experiences and biases on buses and trains (Hensher et al., 2019a). Indeed, bus services are conventionally perceived to be slow, polluting and unreliable (with poor service frequencies and ride quality) as there has been a constant failure to argue that service quality is a result of right-of-way (i.e., linked to congestion-induced travel time delay) and not traction technology (rubber versus steel wheels). It is therefore difficult for the public to imagine a bus-based service offering (BRT) which carries over many of the characteristics intrinsic to rail (although the recent interest in 'trackless trams' is encouraging). As we look around Australia on the BRT/LRT debate, it is an unfortunate reality that this battle might already be lost. Brisbane has traditionally been the sole exception, but time will tell if Perth joins this bandwagon. In the meantime, what are our alternatives?

Over the past two decades, BRT-lite or branded bus services (BBS) have emerged as a cost-effective reform to improve the bus network. There is growing interest around Australia in these schemes with a dedicated brand identity (fleet, stops, marketing, etc.), coupled with some level of bus priority and operating on estimated wait times (at least from the customer perspective) as opposed to traditional timetables and schedules. Often, they are developed and implemented together with wider network rationalisation, simplifying route structures and stopping patterns and consolidating services onto high frequency trunk corridors.

Interestingly, BBS is not usually delivered in the context of a bus versus rail debate, but rather in a politically-motivated environment to deliver better bus services at a fraction of the cost base—and to do so quickly.

In presenting the case for BBS, the authors are not condoning BRT creep.[1] Many other studies have confounded the BRT/BBS distinction which is problematic—e.g., Currie and Delbosc (2010) which includes Melbourne's BBS SmartBus amongst BRT initiatives, itself accounting for 174% of the 200% quantified increase in Australasian BRT route length (2006-10) to which the study refers. It is therefore important to note our use of terminology: **BBS is not BRT.** Whilst a distinct brand identity is an important element of quality BRT systems (ITDP, 2014), the essential characteristic of BRT remains its dedicated right-of-way and off-vehicle fare collection which delivers travel time benefits and operational efficiencies. The few BRT schemes in Australia (Brisbane being the sole system recognised by ITDP[2] and ranked silver—see Li and Hensher (2019)) rate poorly on brand identity, which together with service simplification constitute two of the most cost effective ways to grow bus patronage (Currie and Wallis, 2008). BBS (which by contrast usually enjoys more limited bus priority in Australia) enters the fray as a package of measures to change perceptions and the image of the bus (Devney, 2011). The rationale for BBS is that its distinct brand identity attracts patronage by making the bus network more legible and easier to navigate. Further, reforms usually follow best practices in network design, including a more appropriate mix of patronage versus coverage-oriented services (Walker, 2008, Nielsen et al., 2005), refined stop spacing and positioning, and adding cross-town orbitals to create a more 'gridded' network (thereby enhancing connectivity) as opposed to the traditional focus on radial routes in and out of the CBD. Our evaluation of BBS within this BRT/BBS review will encompass this broad suite of policy initiatives, whilst continuing to treat BBS separately to BRT.

1 BRT creep describes how the right-of-way requirements for strict BRT has gradually been disregarded (often with the intention to mislead), and results in misunderstanding within the community of what constitutes BRT.

2 The Institute for Transportation and Development Policy (ITDP) is a non-profit which has developed *The BRT Standard* to score systems around the world.

2. An overview of BRT and BBS in Australia

The aim of this report is to evaluate the performance of BRT and BBS schemes in Australia, relative to generic route services in their respective six capital cities. Studied systems are summarised in Table 1, and scored according to their BBS (fleet deployed and brand identity) and BRT bus priority characteristics. The authors have excluded services operating outside the standard contractual framework such as airport shuttles and tourist products. The first characteristic refers to whether a system is operated using a **dedicated fleet.** This allows for more specialised fleet characteristics including dedicated liveries and vehicle type (e.g., double-decker buses), but also reduces operational flexibility, resulting in increased vehicle and driver requirements. **Brand identity** refers to the prominence of a service against the broader network structure—*none*, where the service is unnamed (in contrast to the *infrastructure* name which often still exists); *weak* means that whilst the brand exists, it is not applied prominently nor consistently across customer-facing material; for *medium*, the brand is recognised consistently in timetables, network maps, bus stops and on the bus destination; and finally, *strong* signals a prominent branding applied across all mediums plus a fleet operated in dedicated livery. **Bus priority** can refer to a dedicated carriageway separated by a physical median or a dedicated lane with the potential for traffic conflicts (usually kerbside). The three levels refer to the proportion of the service granted each quality of bus priority. Signal priority in the form of induction-loop queue jumps and transponder-activated signals is captured within this characteristic.

As noted, premium bus services in Australia score highly either on brand identity or bus priority—but never both! This is peculiar and very much unlike implementation in other parts of the world, and certainly contravenes the BRT best practices espoused in ITDP (2014). However, we do note the tendency for branding elements not to accompany developed-world BRT implementation (especially in the US)—an example of BRT creep, but also the different institutional contexts at play.[3] As such, all upgraded bus services in Australia can be categorised as either BRT or BBS—and can be considered mutually exclusive. In the following sections, a comprehensive overview of the BRT and BBS systems in each of six Australian capitals is offered, with a particular focus on system-specific challenges and constraints.

Table 1: BRT (green) and BBS (blue) schemes evaluated, scored according to their service characteristics

City	Service	Fleet deployed	Brand identity	Bus priority
Sydney	T-way (Liverpool-Parramatta)	Mixed	None	Medium
	T-way (North-West)	Mixed	None	High
	M2 Busway	Mixed	None	Medium
	Metrobus (Phase 1)	Mixed/Dedicated	Medium	Low
	Metrobus (Phase 2)	Mixed/Dedicated	Medium	None
	B-Line	Dedicated	Strong	Low
Melbourne	SmartBus (Original)	Mixed/Dedicated	Strong	None
	SmartBus (DART)	Mixed/Dedicated	Strong	Low
Brisbane	Bus Upgrade Zone (BUZ)[4]	Mixed	Weak	High
	CityGlider	Dedicated	Strong	None
	Great Circle Line	Mixed	Weak	None
Perth	Central Area Transit (CAT)	Dedicated	Strong	None
	CircleRoute	Mixed	Weak	None
	Transperth 950	Mixed	Weak	Low
Adelaide	O-Bahn	Mixed[5]	Weak	High
Canberra	Rapid	Mixed	Weak	Low

3 In developing economies (Africa and South America), BRT often results from the formalisation of the informal minibus taxi sector, and hence is almost always set up as an independent company (and brand) from the outset. There are accompanying advantages and disadvantages to this model.

4 There is no system name for Brisbane's busway infrastructure, but the high-frequency BUZ network is closely aligned. All BUZ services use at least the CBD component of the busway (Cultural Centre to Roma St), and most use the majority of the entire busway corridor. TransLink routes 66 and 111 are dedicated busway-only trunk services which will be analysed separately as part of this research.

5 There is a dedicated O-Bahn fleet for maintenance and operational purposes, but no customer-facing brand elements.

3. Sydney

3.2 Liverpool-Parramatta transitway

Announced in 1998 and commencing service in February 2003, the Liverpool-Parramatta T-way was the first fully-fledged BRT in NSW and originally envisaged as the initial stage for a broader network of transitways across Western Sydney. The service links a series of intermediate destinations, including two TAFE colleges, a hospital, large shopping centres at Bonnyrigg and Prairiewood, Sydney's largest blue-collar employment zone at Smithfield/Wetherill Park, and the major hubs of Liverpool and Parramatta. Although the corridor itself was identified as early as 1975 in various Parramatta region transport plans, it was only in *Action for Transport 2010* (Department of Transport, 1998) that the entire transitway network was devised, and included an additional seven corridors (Parramatta to Rouse Hill, Blacktown to Castle Hill, Blacktown to Wetherill Park, Blacktown to Parramatta, Parramatta to Strathfield and Penrith to St Marys) to be constructed during the period 2003-10. Only the initial two (and the second, only partially) were ever constructed—as the North-West T-way. The remainder of the proposals have since been redesignated and incorporated within 40 strategic bus corridors. In the latest iteration, *Sydney's Bus Future* (Transport for NSW, 2013), these corridors have been divided between 13 Rapid bus routes and 20 major Suburban bus routes but little progress has been made (beyond the B-Line) to bring them into reality.

The transitway itself is 31 km long with 35 T-way stations, spaced on average 861 m apart. The system is unique by incorporating a mix of different bus priority qualities to take advantage of land availability along a former motorway reservation and a Sydney Water pipeline, whilst minimising cost on entry into the Liverpool and Parramatta CBDs. As such, there is 20 km of dedicated bus carriageway (both on dedicated alignments and as a carriageway in the road median such as on Hoxton Rd), plus 11 km of kerbside bus lanes (e.g., Parramatta Rd), accommodated either on the existing roadway or through road widening. Dedicated carriageway exists between Woodpark and Wetherill, and Horsley to Memorial stations, whilst dedicated lanes lie between Parramatta and Woodpark, Wetherill and Horsley, and Memorial to Liverpool stations (Figure 1). Signals in the carriageway sections are transponder-activated, requiring additional fleet infrastructure. The transitway operates as a closed system (the only in Australia) as route T80 although generic route services enter three T-way stations at Bonnyrigg, Prairiewood and Horsley. Between December 2017 and August 2018, Bonnyrigg station was also serviced by the Wetherill Park BRIDJ on demand service (the only such instance on a BRT in Australia) but this has subsequently been withdrawn due to low patronage.

Figure 1: Route map of the Liverpool-Parramatta T-way

Note: Map shows the 35 stations and how the corridor once crossed the operating areas of five incumbent operators.

Source: New South Wales Audit Office 2005: 16

The transitway infrastructure was built and owned by the NSW Government and an engineering reason for the excess cost related to a policy decision to have the dedicated carriageway sections of the system future-proofed for future conversion to LRT. The extra costs of 'over-engineering' to accommodate LRT is linked to the right-of-way geometry—LRT is limited to less than 6% gradient whilst BRT can handle 9% (Levinson et al., 2003). This constitutes an additional cost, but smoother bends and less steep climbs improve passenger comfort (a benefit difficult to quantify) by bringing additional rail characteristics to bus. The transitway is unique in how the procurement for an operator became a controversial process—for other BRT/BBS, it is simply allocated to the incumbent operator. The NSW Audit Office (2005) identified a number of factors for STA's competitive bid. Firstly, it was the sole bid which assumed no subsidy was required for the service. Forecasting patronage is difficult (especially in the two-month timeframe provided at the time), but the assumption made was 65% higher than STA's usual forecasts. The ambitious assumptions were not met initially, despite strong growth recorded—56% patronage growth, with 47% being new journeys (Currie, 2006)—as much of the variation depends on the rate of 'ramp-up'. A number of other assumptions were also optimistic—for instance, the bid was based on an expected 55 min peak running time.

This compares with up to 68 min peak (and 53 min off-peak) presently experienced. The outcome resulted in a number of dissatisfied bus operators who remained sceptical of how STA arrived at its near breakeven bid. The issue of fair competition and idea of building "trusting partnerships" (Stanley, 2010) between operator and regulator is an important issue, and would manifest itself in how well the system was able to integrate within the broader network structure.

At the time, five local bus companies operated services in the area traversed by the transitway—WestBus, Baxters, Hopkinson, Oliveri and Busabout (refer to Figure 1). Existing services were of a heavily east-west nature serving the heavy rail South/Cumberland Lines. The transitway constituted the first effective public transport north-south link across the region, enhancing connectivity and allowing travel to key destinations without circuitous routing or multiple interchanges. The interface of the transitway with existing route services is hence of enormous importance. The five incumbent operators had little incentive to cooperate with providing feeder services to the transitway, believing that the trunk operator would attract patronage away from them. Two operators estimated that they lost 30% of their patronage, as a result of the 400 m 'exclusion zone' on each side of the transitway (NSW Audit Office, 2005). Existing operators were not receptive to re-routing their services to feed the transitway and to provide integrated service, further compounded by the 'resentment' from the initial tender process. This issue was compounded by an interchange penalty in terms of a further fare payment for customers wishing to transfer, which existed before the MyZone system (introduced April 2010) brought together the fare structure across both STA and private bus operators (including TravelTen and other periodic tickets). The lack of integrated service has been identified repeatedly as a major limitation for the system reaching its full potential (NSW Audit Office, 2005, Currie, 2006, Currie and Delbosc, 2010).

The merits of closed and open BRT systems have been debated at length around the world, but the need to integrate feeder services has never been called into question. What is unique with the Liverpool-Parramatta case is the active resistance faced and how fragmentation of ownership and competition issues could prove an obstacle for achieving an integrated network so critical to the 'shuttle' operation. Many of the lessons would be incorporated in the development of the North-West transitway and remain topical to this day. The need for a sense of 'ownership' by other relevant operators is vital, and the issue of integration remains today especially at contract boundaries.[6] By virtue of the standalone service and independent operator, however, meant that for many years, the transitway operated as a BBS. A fleet of 17 T-way liveried buses were operated (Figure 2) until October 2013 when it was incorporated as part of SMBSC[7] Region 3 (won by Transit Systems). The full potential of this change in terms of better network design—including more through-routed services remains to be seen.

Recently, T80 was designated as Sydney's first Rapid route, following the hierarchy outlined in *Sydney's Bus Future* (Transport for NSW, 2013). This change is somewhat puzzling since there are no customer-facing brand elements and many other services already meet the level of service (frequency, hours of operation, etc.) required running on the identified strategic corridors but are not afforded the same designation. Further, there is an increasing fragmentation of the upgraded bus service brand in Sydney—T-ways, followed by the introduction of Metrobus and now B-Line. It would appear every new government is keen to make their stamp by launching their own branded initiative!

Figure 2: T-way liveried bus operated by Western Sydney Buses

6 This is especially true where multiple operators service the same corridor. There is little to no integration in timetables (despite Transport for NSW setting the standards), and smarter scheduling can deliver higher effective frequency for the customer at zero additional cost (concept explained in Section 8.2).

7 Sydney Metropolitan Bus Service Contract.

3.2 North-West transitway

The North-West T-way was opened in two stages in March 2007 between Parramatta and Rouse Hill (along Old Windsor Rd) and in November 2017 between Blacktown and Parklea (along Sunnyholt Rd). Unlike the Liverpool-Parramatta T-way, the North-West T-way heavily emphasised running integrated services from its first day of operations. The transitway was linked to early plans for the large-scale Parklea Release Area, which from the outset aimed to have sufficient infrastructure in place early ahead of demand and development (Clifton et al., 2014). Construction was completed in time for the opening of a major regional and employment hub at Rouse Hill (the Rouse Hill Town Centre). Buses were a focus from the beginning, rather than using the 'off-centre' Richmond branch of the Western Line. Early projections in the strategic planning process aimed to have 60% of people using Sunnyholt Rd travelling in just 4% of vehicles—i.e., buses (Pund and Fleming, 1997).

The 24 km system is primarily a dedicated bus carriageway with at grade intersections,[8] except for 2 km between Old Windsor Rd at Briens station to Parramatta where it reverts to 3 km of on road bus lanes. The speed limit is 80 km/h on the carriageway and 40 km/h at stations. Originally proposed to incorporate signal priority, this was scrapped in favour of the Sydney-wide rollout of the Public Transport Information and Priority System (PTIPS)—then scheduled for 2009. There are a total of 58 stations, with average spacing 700 m on Sunnyholt Rd and 1 km on Old Windsor Rd (Currie and Delbosc, 2010). Stations are not equipped with real time passenger information (unlike with the Liverpool-Parramatta T-way) as a cost reduction exercise. There are two park and ride facilities at Riley and Burns stations offering a total of 400 car spaces.

Whilst a new trunk service was offered on the North-West T-way, the majority of routes comprised of existing services which had been re-routed to travel via the transitway for part or all of their journey. A T-prefix was added as the customer-facing 'brand' element for this network—including T6x series routes (ex-Parramatta and operated by ComfortDelGro as Hillsbus), T7x series routes (ex Blacktown and operated by Busways). There remained some non-T routes and X-sufficed routes on the transitway which join the M2 busway at Abbott station. Privately operated CBD express coach services have begun in recent years which use the transitway and offer travel time savings plus guaranteed seats, despite their higher fare.[9] In 2019, Sydney Metro Northwest will open and parallel the T-way between Bella Vista and Rouse Hill. How this might affect the existing network structure remains to be seen.

3.3 M2 busway

The M2 busway predates both the Liverpool-Parramatta and North-West T-ways, opening in May 1997 as part of the F2 freeway between North Ryde and Seven Hills. As part of the business case, high 'latent demand' was identified for express bus services to Epping, and so 16 km of median bus lanes were implemented between Windsor Rd to Beecroft Rd, earmarked for future conversion to LRT should there be sufficient demand. A dedicated, bus-only ramp was constructed to Epping station, presumably intended for busway customers to connect with existing Northern Line services to access the CBD.[10] Some criticised that the bus lanes were merely a device to justify the motorway, given the limited catchment surrounding the corridor (including large unpopulated areas), and the original single stop provided for at Pennant Hills Rd where there were no other public transport links (Goldberg, 1993). The approach appeared to contravene principles of land use and transport planning.

The *Passenger Transport Act 1990* was amended to permit private bus operators (who operated outside the STA-dominated inner suburbs) to apply to operate direct services into the Sydney CBD.[11] Westbus commenced its Hills-City Express from Castle Hill and Winston Hills to the CBD in mid-1996 via Victoria Rd and the new Glebe Island Bridge (Anzac Bridge today). When the M2 motorway opened, the travel time on these services reduced by up to 35% and patronage experienced significant growth. Additional routes were subsequently added from Bella Vista, Baulkham Hills, Blacktown, Seven Hills, and later from Rouse Hill to the City as well as the Macquarie Park precinct. It is the M2 busway that saw the reintroduction of articulated buses to Sydney streets after a more than 20 year absence.

The M2 busway is unique (as with the Adelaide O-Bahn) in that it caters for high-speed, line-haul travel between the CBD and outer suburbs with very few stops in between. Use of a motorway corridor is appropriate in this case since the focus is on speed and not on fostering a strong, development-oriented corridor. In terms of the merits of different motorway-based BRT alignments, Levinson et al. (2003) proposed that a separate right-of-way is most desirable (as in the case of the O-Bahn, given that the motorway was never built), followed by priority on one side of the motorway (eg., Brisbane's South East busway), and finally within the motorway medians (as is the case here with the M2 busway). One challenge with motorway medians is poor pedestrian access to stations and the difficulty of integrating them within the surrounding area to promote transit-oriented development. The two original, and median-situated stations at Oakes Rd and Barclay Rd indeed suffer from this issue, and poor land use/transport integration including a lack of connecting bus services, inadequate parking, and inappropriate densities/zoning for what is excellent accessibility (one-stop away from the CBD). Recently, ComfortDelGro's OurBus on demand trial in the North Rocks area focuses on alleviating this access/egress issue to the M2 busway. The median placement of the busway, and construction of an island platform necessitates a 'crossover' of the busway to align doors on the correct side. Two further kerbside stations were constructed beyond the median busway (to the west) at Cropley Dr and Gooden Reserve in Winston Hills.

8 Although five are grade separated at Cumberland Hwy, Prospect Hwy, Seven Hills Rd, Norwest Blvd and Old Windsor Rd.

9 Operated by North Sydney Bus and Coach and powered by the software platform Niftie. See https://www.niftiecommute.com

10 This access ramp was removed in 2012 as part of the M2 motorway widening, a connection used by Routes 611 and 740. As part of the works, the M2 busway was shortened by 450 m and a high occupancy vehicle (T2) lane added inbound between Terrys Creek and Lane Cove Rd.

11 Forest Coach Lines (now SMBSC region 14) took advantage of this and in 1992 became the first private bus operator in 40 years to operate bus services (from Terrey Hills) into the Sydney CBD. Originally, such services were not permitted to pick up or set down en route through other operator's territory, but this has been changed in recent years as government assumes greater patronage risk.

Kerbside bus lanes (of a minimum width and without a physical median separation) are provided only a few hundred metres before and after each station, so buses are required to quickly de/accelerate to leave/join high-speed 100 km/h (formerly 90 km/h) motorway traffic—with associated safety concerns. In all four stations, passenger amenity is a challenge as it is arguably a hostile environment for waiting passengers on a high-speed roadway.

After many years of proposals, the future Sydney Metro Northwest (opening early 2019) will largely duplicate the *function* of the M2 busway. Until the opening of the stage two Sydney Metro City and Southwest (projected for 2024), passengers will interchange at Chatswood for existing suburban services into the CBD. Buses in the Hills district will be rerouted as feeder services to Metro stations with the vast majority of direct services into the CBD discontinued—barring those directly on the M2 corridor. Based on available information and assumptions, analysis of different origin-destination pairs (Clifton et al., 2014) showed that most beneficiaries will be travellers to the Macquarie Park precinct and Chatswood—both important activity centres presently not well served by the M2 busway. Customers directly near Metro stations will also benefit, but in general, travel time to the CBD will increase, plus there will be the need to make two interchanges. Some of these realities are less well understood and demonstrates the often misunderstood benefits of open BRT systems in providing direct one-seat journeys, and even travel time savings, as compared to a hub-and-spoke model with rail.

3.4 Metrobus

We now turn to a series of BBS initiatives which have been launched in Sydney in recent years. Metrobus constituted Sydney's first instance of high frequency branding at a network level (as opposed to individual routes[12]), originally operated with a dedicated fleet of red buses, and was launched in two phases between 2008 and 2011. Phase 1 began as a trial with Routes 10, 20, 30 40 and 50 (later M-prefixed as Phase 2 launched), based on providing additional capacity (as a 'top-up' service overlaid on existing routes) along busy corridors to inner suburban centres 20-30 min from the CBD. These five Metrobus routes crossed the CBD, effectively merging what would otherwise be two separate routes terminating in the CBD. This negates the need to layover and use the scarce commodity that is road space, but the length of route can reduce service reliability. Buses ran every 10 min in peak, 15 min inter-peak and every 20 min evening and weekend, but service span was initially limited to around 8PM, linked to the periods supplementary service was thought to be required. Metrobus was unique in that there was no customer facing timetable (this was later reintroduced), effectively working on estimated wait times—a first for Sydney.

Phase 1 Metrobus were completely cashless, prepay-only services, following a successful trial on the City to Bondi Beach Route 333 service (Byatt et al., 2007). Metrobus utilised a dedicated fleet of high capacity (including articulated and three-axle rigid) and standard two-axle rigid buses. Five 'super' buses with different seating arrangements such as longitudinal seating were also tested (Figure 3). A bright red livery was applied (with the original design being route-specific, showing for example major locations M10 would call at) and each vehicle featured quality passenger information systems including next stop displays and audio announcements. No additional bus priority was forthcoming, as the services used existing bus lanes on the major arterials they served.

Figure 3: One of the original 'super' buses deployed on Metrobus, trialling high capacity longitudinal seating

Photo: Mark Bean

12 Route-specific branding has previously been implemented on Metro-Line (Routes 200/400), City-Link (Routes L23/L28/L38) and Ferry-Link—all have now been discontinued.

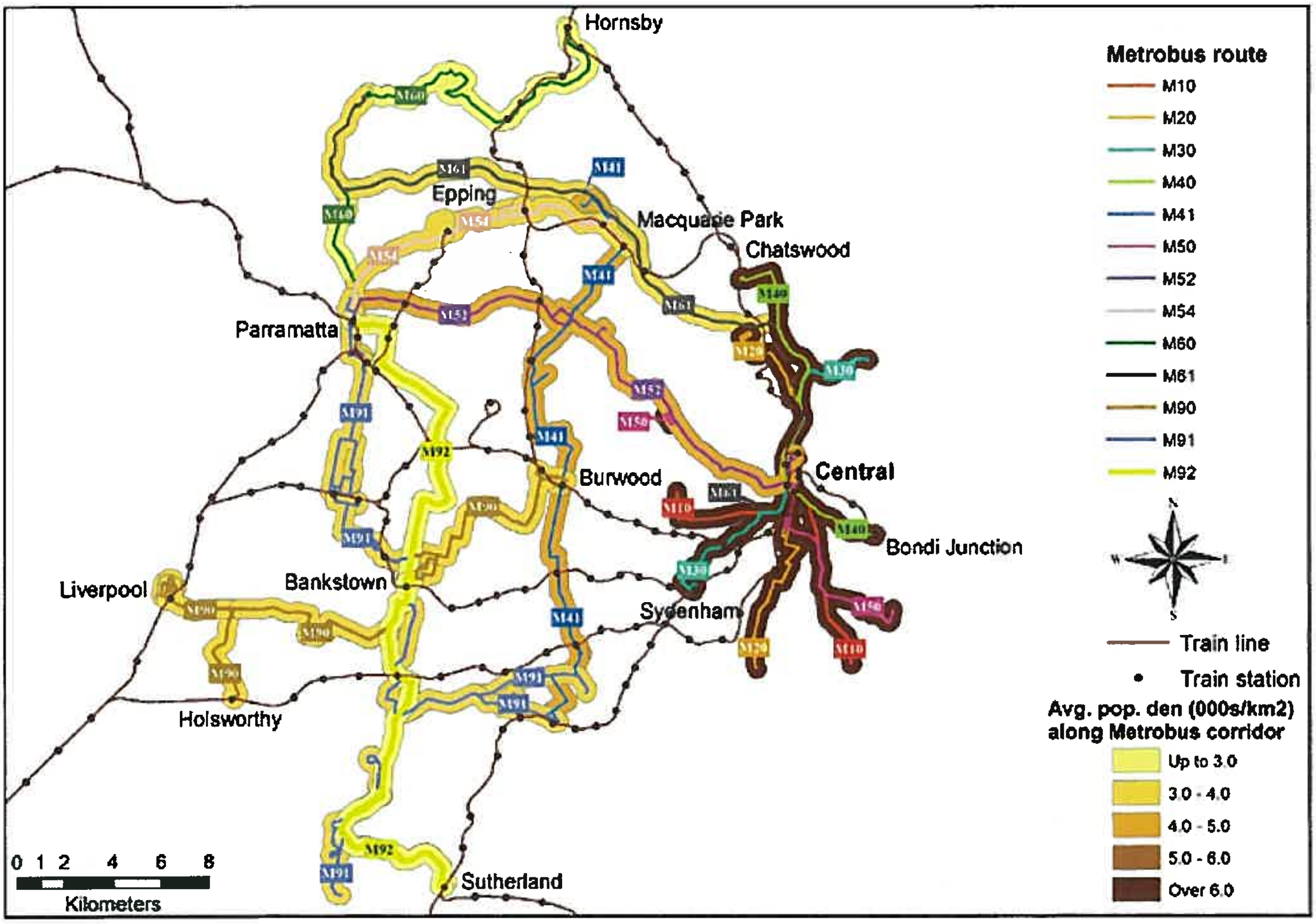
Metrobus Phase 2 significantly expanded the original network but also confounded the original philosophy behind the Metrobus concept. Phase 2 routes expanded the geographic reach of Metrobus, with six new routes as cross-town orbitals and two as radial trunks from CBD to Parramatta (via Victoria Rd) and Castle Hill (via M2 motorway)—all of which were corridors poorly serviced by rail. Barring one route, Metrobus Phase 2 was simply a redesignation of existing services now in branded form and operating with a dedicated new fleet (Table 2). For the first time, private operators (i.e., Transdev and ComfortDelGro) were brought in to operate some of these services. The entirety of the Metrobus network is shown in Figure 4. The expansion compromised original Metrobus ideals as Phase 2 routes all accepted cash fares with some (e.g., M52) even operating different stopping patterns (limited stops, short works and head offs). Customer-facing timetables were also offered unlike with Phase 1. Shortly after the entire network had been launched, a political decision was made to utilise mixed scheduling, thus deploying Metrobus-liveried fleet on regular route services and further confounding the BBS vision. This enabled fleet and driver savings as well as use of newer vehicles on the rest of the network (particularly weekends), but at the expense of branding and legibility for the customer. In the future, there are plans for Metrobus to be redesignated with the B-prefix, but nothing concrete has yet to be announced.

Extensive analysis on the performance of the Metrobus network was conducted by Ho and Mulley (2014). Phase 2 routes serving the metropolitan fringe were found to be far more successful in boosting patronage than on their Phase 1 equivalents serving inner suburbs where public transport networks were already denser. Boardings per kilometre for Phase 1 were lower than pre-existing (competing) routes on the same corridors with the reverse being true for Phase 2. This suggests that Metrobus and general bus services were viewed as substitutes in the inner areas, confirming much anecdotal research that passengers will board the first service to arrive. In the middle and outer suburbs, Metrobus services appear more as complements with evidence of a definite opt-in for the new services. Further, it was found that patronage appeared to take at least six months to ramp up to a 'steady state'. The configuration of Metrobus routes with respect to bus/rail complementarity/integration was also investigated and there exists enormous potential for better network presentation including frequent network multimodal branding (regardless of bus or rail) to better convey to the travelling public the spatial availability of high quality, turn-up-and-go services.

Table 2: Eight new Metrobus routes announced as part of Phase 2 expansion

Metrobus route	Original route	Date commenced
M41	*New*	19 December 2010
M52	L20/520	8 August 2010
M54	548	10 October 2010
M60	600	7 March 2011
M61	610X[13]	20 December 2010
M90	900	6 December 2010
M91	910	7 February 2011
M92	962	14 March 2011

Figure 4: Metrobus network, including both the original Phase 1 and subsequent expansion Phase 2 routes, overlayed on operating environment characteristics



Source: Ho and Mulley, 2014: 341

13 For a period of time, additional Route 610X ran the exact same corridor (City to Castle Hill via the M2 motorway) as a 'top-up' service—this fragmentation of service identity confused customers. Presently, Route 610X constitute extensions of the M61 service beyond Castle Hill to Rouse Hill.

3.5 B-Line

The Northern Beaches is an extremely challenging region of Sydney with only three roads leading in and out of a population of more than 250,000—Spit Bridge, A38 Warringah Rd and A3 Mona Vale Rd (for a total of 14 traffic lanes counting both directions). Both rail and road-based initiatives to improve public transport along the A8 corridor from the CBD to Mona Vale have been studied extensively over past years (Hensher et al., 2019b). The corridor has been a particular priority for the NSW Liberal National government over its present term (2015-19), given the prominence of ministers (and leaders) representing electorates at both state and federal levels on the Northern Beaches. What began as BRT became a BBS scheme named B-Line which was finally launched in November 2017 after a period of planning and works. This express service features just 9 stops along a 27 km route from Wynyard to Mona Vale, via major load points at Neutral Bay Junction, Spit Junction, Brookvale and Narrabeen.

B-Line is operated by the State Transit Authority with a dedicated new fleet of 38 bright yellow Gemilang-bodied double-decker MAN A95s[14] (34 peak requirement plus 4 spares) plying the route delivering service every 5-15 minutes (Figure 5). A key part of the program is its strong visual identify reflected through stop upgrades with real time passenger information, coupled with new commuter car parks and minor bus priority infrastructure improvements. These involve lengthening a few bus lane pinch points and relocating bus stops to the departure side of traffic signals, to take advantage of the Public Transport Information and Priority System (PTIPS). Land acquisition was also made to construct several indented bus bays. Whilst we do not promote this in general due to the delays incurred by buses returning back to general traffic lanes (despite the yield-to-bus requirement), it is sensible in the case where the nearside is a bus lane, and with the various stopping patterns on this corridor it enables buses to pass one another.

Accompanying B-Line are network changes across the Northern Beaches region based on route rationalisation, and increased frequencies at the expense of additional connections. Whilst Metrobus already had a focus on marketing its high service frequency, B-Line is the first where the key performance indicator for the operator is not on time running but headway regularity. The authors recommend taking the customer perspective since there is evidence to show customers arriving at their stop/station randomly once headways drop below 12 min (Clifton et al., 2018). There was also no compromise in timetable construction, with regular departures at clock face intervals (despite leading to longer layovers than required, and hence more resources). The original intention was for B-Line to be extended to Newport, but due to concerns from local residents about large vehicles and infrastructure changes this is no longer on the agenda. However, an innovative new, on demand service named Keoride[15] has been launched providing bookable, shared first/last mile connections to the B-Line terminus. There are plans for further B-Line type services along other Sydney corridors in the future.

Figure 5: A double-decker B-Line bus

14 Note axle weight limits were increased on the corridor to permit these vehicles to operate on NSW roads

15 Operated by Keolis Downer in partnership with GoGet (who supplied the vehicles) and technology provider Via (formerly Routematch).

3.6 Other initiatives

Whilst the T-way and M2 busway represent the major BRT schemes and Metrobus and B-Line the major BBS schemes present in Sydney, a number of other bus priority and branding initiatives also exist, but being limited in scale and as isolated examples are beyond the scope of the present study. Indeed, bus lanes on the Sydney Harbour Bridge[16] and M1 Warringah Freeway approach (southbound) were game changing when first initiated. The Moore Park busway which was converted from an old tram reservation was also an important initiative. The Inner West T-way or bus-only Bennelong Bridge which connects new developments at Wentworth Point to the Rhodes peninsular is a bold new undertaking. The project's geometry is very similar to the immensely successful Eleanor Schonell 'Green' Bridge in Brisbane which promoted public and active modes of transport to the 'isolated' peninsular that is the University of Queensland's St Lucia campus (Charles-Edwards et al., 2015). Bennelong Bridge is unique in that Wentworth Point developers contributed to the cost of construction in exchange for government approval to build greater densities in their developments. In the future, there are proposals to convert the bridge into LRT connecting Parramatta and Strathfield via Olympic Park, Wentworth Point and Rhodes.

A number of BBS initiatives have also been launched over the years, with many still active and selected services illustrated in Figure 6. Forest Coach Lines launched **Route 197** in 2008 as a quasi-BBS with a dedicated fleet of liveried buses plying the A3 between Mona Vale and Macquarie University (with a dog-leg into Gordon station). Mixed scheduling was soon implemented after the initial phase although it helped to garner recognition and publicity in the region. The route has seen service levels increase considerably over the years and has since grown to become a major trunk corridor in the region. Also in 2008, the free Sydney **CBD shuttle** commenced with a fleet of green liveried buses. The shuttle concept was extended into ten suburban and regional CBDs (including Parramatta, Liverpool, Bankstown) approaching the 2011 NSW election. The shuttles were quickly implementable and as a BBS showcased effectively action on public transport. Most of these shuttles were subsequently discontinued upon the change of government.

In September 2018, two BBS were launched in Sydney. Route 333 **Bondi Link** was 'upgraded' to a (government-proclaimed) B-Line style service and included a fresh livery for many vehicles plying the routes (although the fleet is not dedicated) to effectively 'sell' the service upgrade (headways as short as 3 min in the peak). **Station Link**, a joint venture between Transdev and ComfortDelGro, was introduced on seven routes to replace trains for the temporary shutdown of the Epping to Chatswood Rail Link (for conversion to Sydney Metro Northwest). A prominent pink front and branded sides (consistent with the colour of passenger information used for other service disruptions including bus route changes in the CBD to accommodate light rail construction) on a fleet of 60 new buses were procured (and housed in a temporary depot in Camellia). The temporary branding 'wrap' can be removed quickly and easily for future incorporation as part of the generic route fleet.

A number of BBS schemes have also been proposed by bus operators, state and local governments. SMBSC region 14 operator Forest Coach Lines (now a member of ComfortDelGro Australia since October 2018) in association with SHOROC, a partnership of councils in Sydney's North East, has been lobbying heavily for a B-Line style service along the A38 Warringah Rd, between Dee Why and Chatswood, complementing/replacing the existing heavily patronised Routes 280 and 136. The rapid corridor (designated route B2) has been touted to cost AUD 7 million in capital for 13 buses, with operating costs at AUD 6 million per annum (AUD 2.5 million of which would be recouped from ticket sales). It would feature seven stops at Dee Why Beach, Skyline Shops, Northern Beaches Hospital, Forestway Shops, Jamison Square, Crown of the Hill and Chatswood Interchange. The main attraction is its quick deployment potential, able to be up and running in just 6 months. Elsewhere in Sydney, attention has turned to the Parramatta Rd corridor with the opening of WestConnex M4 East, which will offer major opportunities for urban renewal and the revitalisation of the corridor, shifting away from a roadway prioritising throughput to one with an emphasis on place. Again, various technologies have been considered including traditional LRT, 'trackless trams', BRT and BBS. Media attention and speculation is high, but it remains to be seen what will materialise. Again, these proposals exist outside the scope of this study but are ripe topic areas for future research into their potential, performance, and success.

Figure 6: Other BBS initiatives

16 The bus lane and Cahill Expressway general traffic lane replaced two tram tracks which formerly ran on the eastern side of the Sydney Harbour Bridge (mirroring heavy rail tracks on the western side).

4. Melbourne

4.1 SmartBus

Bus transport in Melbourne has never garnered the same political attention as Sydney, partly because of the extensive tram network available throughout the inner (and some middle) suburbs. A recent departure from this has been the BBS initiative SmartBus, which following a period of trial from 2002 was formally launched in 2005 and progressively expanded growing to nine routes by 2010 (Figure 8). Although originally a policy initiative of the Kennett Liberals (to be called MetLink[17]), they were only implemented in the Bracks and Brumby Labor era. Of the nine routes, three provide a circumferential link with the many radial rail and tram corridors into the CBD, two connect key destinations in the middle suburbs, whilst the remaining four are radial Doncaster Area Rapid Transit routes which connect Manningham Shire via the M3 Eastern Freeway to the Melbourne CBD. SmartBus as BBS uses dedicated vehicles with a distinctive livery, branded bollards at all stops plus real time passenger information at interchanges (Figure 7). There is a high level of service with long hours of operation and higher service frequencies (10-15 min daytime headways and 30 min in the evenings and weekends). As BBS, SmartBus mainly operates in mixed traffic but enjoys limited bus priority treatment including queue jumps (signal priority) and bus lanes. Present operators of SmartBus routes include Ventura Bus Lines, ComfortDelGro and Transdev.

The three cross-town orbitals (Table 3) are unique in that they realise the principles of a gridded public transport network allowing anyway-to-anyway travel (not just CBD-centric), long promulgated by experts (and now even more advanced with the Suburban Rail Loop proposal). SmartBus routes 901, 902 and 903 combined several shorter services and provide a premium, branded offering with a higher level of service span and frequency. As evident, considerable travel time savings are realised from the upgrades, and the relative growth in patronage has exceeded the growth in service kilometres, implying a service elasticity exceeding unity (Loader and Stanley, 2009). Some of these passengers may be attributable to existing users, but others reflect a modal switch from car to bus. It is worth nothing that Route 901 has become the longest metropolitan bus route in Australia, at 115 km in length, connecting nine railway stations and over 100 bus routes, and taking 4.5 hours to traverse.[18] Because of this, the route offers tremendous connectivity, but also leads to great operational difficulties—including the need for hotseating and extended dwells at major timing points to maintain reliability. There has been a push to split up the route for some time now.

The absence of quality public transport priority has continued to limit the full potential of SmartBus. In many cases, bus lanes are non-existent or too short, but recently there has been greater focus on increasing and trialling the use of intermittent bus lanes as a compromise in congested road networks (Currie and Lai, 2008, Currie and Sarvi, 2012). The SmartBus network has not been extended since 2010, though this is not due to an absence of activism from the bus industry. Bus Association Victoria has continued to push heavily for its proposed BRT and high capacity bus network, featuring 23 routes across greater Melbourne (BusVic, 2018). A core component of the plan is to connect the six national employment and innovation clusters in East Werribee, Sunshine, La Trobe, Parkville, Monash and Dandenong.

Figure 7: Distinctive SmartBus vehicles and real-time stop infrastructure

Table 3: Original three SmartBus routes and measures of their success (Currie and Sarvi, 2012: 65)

SmartBus route	SmartBus 901	SmartBus 902	SmartBus 903
Previous route(s)	Route 665/830	Routes 888/889	Route 700
Previous travel time (min)	57	87	98
New travel time (min)	43	68	74
Travel time reduction (%)	14	37	24
Patronage growth (%)	42	47	21
Passengers previously driving (%)	34	29	21

Source: Currie and Sarvi, 2012: 65

17 This later became an umbrella brand for all government-contracted tram, train and bus services (succeeding The Met and later replaced by PTV).

18 Sydney's L90/190 from Palm Beach to Wynyard (formerly, Railway Square), Brisbane's Great Circle Line (Routes 598/599) and Perth's CircleRoute (Routes 998/999) are also unusually long for urban bus routes.

4.2 Doncaster Area Rapid Transit

Manningham shire, comprising the major centres of Doncaster and Templestowe, houses a population of 120,000 but remains the only local government area in Melbourne without access to heavy rail. As part of the Brumby government's The Victorian Transport Plan (Victorian Government, 2008), AUD 360 million was allocated to implement SmartBus in Manningham shire, offering a premium service into the CBD (Lonsdale St) via the M3 Eastern Freeway and Hoodle St (see Figure 8). Doncaster Area Rapid Transit (DART) is the policy name for this initiative. Some element of bus priority was implemented including dedicated bus lanes on Hoddle St in the AM peak in the peak direction, and the ability for buses to use the hard shoulder to bypass heavy traffic on the motorway. A high-quality park and ride facility with 400 spaces and indoor waiting rooms was constructed at Doncaster, also facilitating interchange between SmartBus and regular route services. Despite these investments, SmartBus was deemed to be an interim solution and more permanent infrastructure (either bus or rail) has continued to be proposed for construction along the Eastern Freeway median to service Doncaster and Templestowe.

In 2017, and as part of Victoria's market-led proposal program, the incumbent bus operator Transdev proposed an AUD 550 million BRT concept based on the construction of a dedicated bus-only carriageway in the Eastern Freeway median. This would have been just 10-16% of the estimated AUD 3-5 billion cost of constructing heavy rail to Doncaster. A dedicated bi-articulated fleet (similar to the present proposal for Brisbane Metro) would be procured and off-vehicle fare collection arranged so as not to delay station dwells. This proposal was not successful, however, as part of the North East Link, BRT is again on the agenda, but built on one side of the Eastern Freeway (similar to the South East Busway in Brisbane), with stations constructed at the overpasses with Chandler Highway, Burke Rd and Bulleen Rd.

Figure 8: SmartBus network, showing cross-town orbitals, plus radial DART services to the Manningham shire

Source: Public Transport Victoria

5. Brisbane

5.2 Busway

Brisbane has enjoyed the greatest bus-based investment out of any Australian city. This investment has been infrastructure-heavy, and Brisbane's busway network (the South East, Northern and Eastern corridors) is world class, and perhaps the best implementation at scale of BRT in any developed economy, supported initially by a champion in government. One of the primary reasons bus has been able to get such high political traction is due to the division of responsibilities between bus and rail modes in Brisbane. With a population of 1.1 million, Brisbane City Council covers roughly half of the population in the Brisbane metropolitan area—unlike other Australian capitals where the central local government area covers only the CBD and some surrounding inner suburbs. The Council has the responsibility for running its own bus service (Brisbane Transport, now Transport for Brisbane)—the only such instance in Australia—whilst the state government continues to oversee the commuter rail network as Queensland Rail's CityTrain. As such, there has always existed an element of disconnect between bus and train networks. Buses rarely fed into the railways, but rather competed with the train directly. One reason is that the level of service on the trains is poor, although it is equally the case that the lack of a hub-and-spoke system hinders the development of a quality railway.

A McCormick Rankin (now MRCagney) report for Brisbane City Council in the 1990s proposed that four to five major busways be constructed in Brisbane. Each of these were to parallel an existing train line, with the explicit intention being to shift demand from rail to bus. The idea was for railways to serve longer distance commuting, whilst shorter trips were transferred onto the busway system, following the model set up in Ottawa, Canada. During the period post-2000, the first busway (**South East**) was opened to service, extending in the following decade to reach 27 km by 2014. The entire system exists as open BRT, with all services through-routed extending beyond the busway trunk on-street into residential suburbs, although there is some push to turn this into a closed system (see Brisbane Metro). All stations are high quality and feature disabled access and real time passenger information, though not off-vehicle fare collection. Management of the busway infrastructure is by TransLink but services are operated (primarily) by Transport for Brisbane, but also (in the South East) by Clarks Logan City Bus Service, Mt Gravatt Bus Service and Transdev Queensland.

The South East busway is hailed as best practice in BRT design by several commentators (Levinson et al., 2003, Mees, 2010). The majority of this busway was built beside the M1 Pacific Motorway, and was not based on the principles of transit-oriented design, but rather as a response to future growth in suburbs further south east. As such, many of the stations exist as commuter car parks, with only a couple on South Bank being true activity nodes. The South East busway offered a staggering 70% saving in travel time upon launch, reducing journeys from 60 to a mere 18 min for the length of the route (Levinson et al., 2003). Initially, the system saw 56% patronage growth, with 26% of all passengers having shifted from their cars (Currie, 2006).

New Zealand's first BRT, Auckland's Northern Busway, shares many of the features of Brisbane's South East busway (including running beside a motorway), but this is beyond the scope of the present study.

In 2006, a 1.9 km extension that is the **Northern busway** was completed. Whilst short, this was an important addition since it included a CBD bus tunnel (connecting with Roma Street railway station) and a new underground bus station at King George Square, complementing the existing underground Queen Street Mall terminal which was fast becoming cramped. Further stages of the Northern busway opened in 2009 and 2012, being built on viaducts to the Royal Brisbane and Women's Hospital and Kedron. The **Eastern busway** opened in 2009 with the Eleanor Schonell 'Green' Bridge and connected the University of Queensland's St Lucia campus to the South East busway at Buranda station and subsequently (from 2011) onto Langlands Park. The Eastern busway is significant in linking the university (which previously existed effectively as an isolated peninsular) onto the busway network and was crucial in increasing public transport and active mode share for those travelling from east of the Brisbane River, as well as redistributing where students and staff chose to reside (Charles-Edwards et al., 2015). Whilst Brisbane's busways operate as an open system with all services through-routed, there exists two services (Routes 66 and 111) which run the trunk alignment only. We will assess these routes independently in the subsequent analysis as a point of comparison between closed and open systems, to test how traffic congestion when operating outside the BRT dedicated corridor might impact on service performance.

Despite the busways' success in exceeding patronage targets, there exists a number of limitations arising from how the busway was designed. Queuing is particularly prevalent at key bottlenecks, the most significant of which being at Cultural Centre station and across Victoria Bridge. Peak movements at this point increased from 150 per hour in 2006 to 259 in 2010 (Currie and Delbosc, 2010)—and remains at an average headway of just 14 seconds in the peak. Two problems exist relating to platform design and also system throughput. Firstly, buses generally arrive in a random sequence in a platoon of three to five vehicles (from the previous green signal phase). The platforms are up to 80 m long and there is no information for passengers in terms of which bus will arrive where. Time is hence lost in the station as passengers cross each other's paths to find their bus. This delay has been estimated to cost 10% of the theoretical capacity of the station (Jaiswal et al., 2010). Longer platforms which can be split into route groups (but necessitating wider right-of-way to enable overtaking and turning manoeuvrers) can alleviate this problem but space is at a premium at this station. A staggered platform design is one solution which can increase bus throughput per hour per direction from 20-60 in a conventional design to 60-90 movements, though this has already been well exceeded (Levinson et al., 2003). Because of constraints at Cultural Centre station, buses are banked up waiting to pick up/drop off and these can extend hundreds of metres across Victoria Bridge (southbound) and also to the South East busway tunnel portal (northbound) where there are two sets of traffic signals. The result is that during the green phase, buses are not able to proceed and thereby further delaying the system. A big impetus for developing Brisbane Metro is to alleviate this bottleneck.

5.2 Bus Upgrade Zone

The Bus Upgrade Zone (BUZ) was introduced in 2003 as a frequent network branding scheme, where services run at least every 15 min in the daytime and evenings (everyday) and every 10 min or better in peak periods. The BUZ brand acronym is featured on bus destination displays and the BUZ logo can be found at stops (Figure 9), although far less prominent than other BBS brands. The BUZ network is more or less synonymous with bus services running on the three busways so can be deemed equivalent in this analysis. The frequent BUZ network has seen proven success, accounting for more than half the growth in overall bus patronage with significant off-peak and weekend growth.

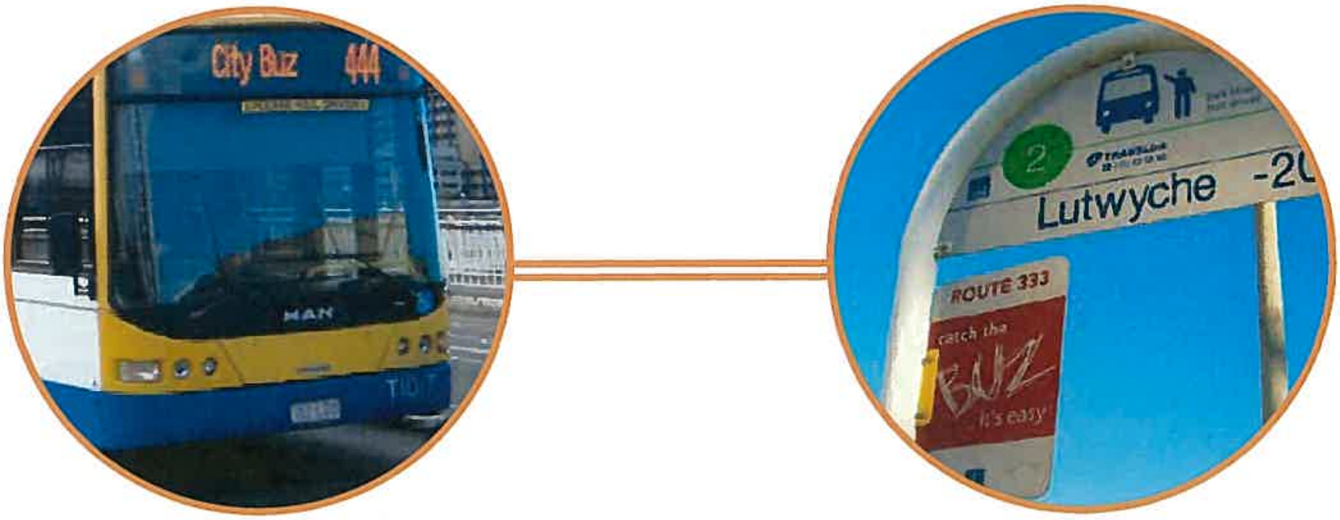
An exception to the BUZ network running on the busways are the downtown circulators known as **CityGlider**. These use a dedicated fleet and there are two routes in operation—Blue (Route 60) and Maroon (Route 61). These were launched in 2009 and 2013 respectively. Whilst not free, the services are popular and the branding prominent on both vehicles and at stops. The **Great Circle Line** (Routes 598/599 depending on direction) is another BBS although on timetables only and without a dedicated fleet. The service connects major centres in the middle suburbs including Chermside, Cannon Hill, Sunnybank, Indooroopilly, Toowong and Mitchelton. The service is not particularly frequent, running every half hour on weekdays (no ramp up in peaks) and hourly on Saturdays, with no service on Sunday. An end-to-end trip takes around 4 hours though it does play a crucial role in connecting key centres. Transport lobbyists have suggested that that Great Circle Line be scrapped, and the resources deployed onto 16 cross-city bus services instead, better aligning with people's travel patterns. Both CityGiders and the Great Circle Line will be benchmarked as part of this analysis.

5.3 Brisbane Metro

Brisbane's busways are largely dedicated carriageway and grade-separated, although it interacts with the general road network at key bottlenecks including both ends of Victoria Bridge, leading to the queuing of buses and significant delays of up to 50% longer journey times than scheduled. The core rationale for Brisbane Metro is to reduce vehicle movements by moving from an open to a closed BRT, using larger vehicles and streaming passenger movements at stations. The project was originally conceived as a guided, rubber-tyred metro operating two metro trunk routes. Metro 1 would operate between Eight Mile Plains and Roma St, whilst Metro 2 would run between the Royal Brisbane and Women's Hospital and the University of Queensland at St Lucia. A rail-based system although higher cost does provide greater capacity—25,000 as compared with 22,000 people per hour per direction (Infrastructure Australia, 2018b). It was subsequently determined that a bus-based solution would provide greater value for money.

The present proposal is to procure a dedicated fleet of 60 bi-articulated, branded ('metro') buses to ply two routes. Vehicles will feature less seating and carry 150 people. For the first time, off-vehicle fare collection would be implemented, and all-door boarding and alighting permitted with up to four sets of doors per vehicle. Metro services would run every 3 min in peak and 5 min off-peak. Most existing through-routed services would be truncated at their nearest busway station, requiring passengers to interchange, although a limited number of express services would continue to run into the CBD at peak periods. The program is coupled with infrastructure improvements including grade separation and a new underground station at the Cultural Centre, a new Adelaide St tunnel, changes to North Quay, existing busway station upgrades, and changes to remove cars from Victoria Bridge. For customers, Brisbane Metro should save 30% travel time in the AM peak and 50% travel time in the PM peak. In peak times, there would be 340 fewer buses at street level at the Cultural Centre station. Infrastructure Australia (2018b) states the project's benefit-cost ratio at 2.4, with a net present value of AUD 1.2 billion (at a 7% real discount rate).

Figure 9: BUZ branding as seen at bus stops and identified on the bus destination



6. Perth

6.1 Central Area Transit

Perth is the original home of free downtown circulators in Australia (older than Melbourne's City Circle Tram and later the Free Tram Zone, for instance). The free Central Area Transit (CAT) features four bus routes in the Perth CBD, two in Freemantle and three in Joondalup. Only the Perth CATs (Red, Blue, Yellow and Green) will form the focus in this study. The Red and Blue CAT were launched by MetroBus in 1996, replacing the City Clipper services which had operated since 1973. The fleet of 16 vehicles were very technologically advanced for their time, being fully air-conditioned and having the ability to kneel for those with disabilities (Figure 10). The vehicles were radio antenna equipped to enable tracking, and real time information was presented at stops in both visible and audible formats. In 2002, Yellow CAT was introduced and in 2013 following a review, Green CAT joined the network. The high-frequency CAT services are unique in being fare-free, but this leads to the issue of data logging and so patronage counts have been conducted manually until automatic passenger counters (which are notorious for their unreliability) are installed. Passenger surveys show the CAT routes to be the most successful and well-regarded on the Perth metropolitan network, with customer satisfaction routinely reaching 94% or more (Department of Transport, 2011). Presently, the CATs are jointly funded by the Western Australian state government and the City of Perth (through a city-wide parking levy). A proposal is underway to offer a night-time 'black' CAT service to provide service round the clock.

Figure 10: A CAT bus in its iconic silver livery

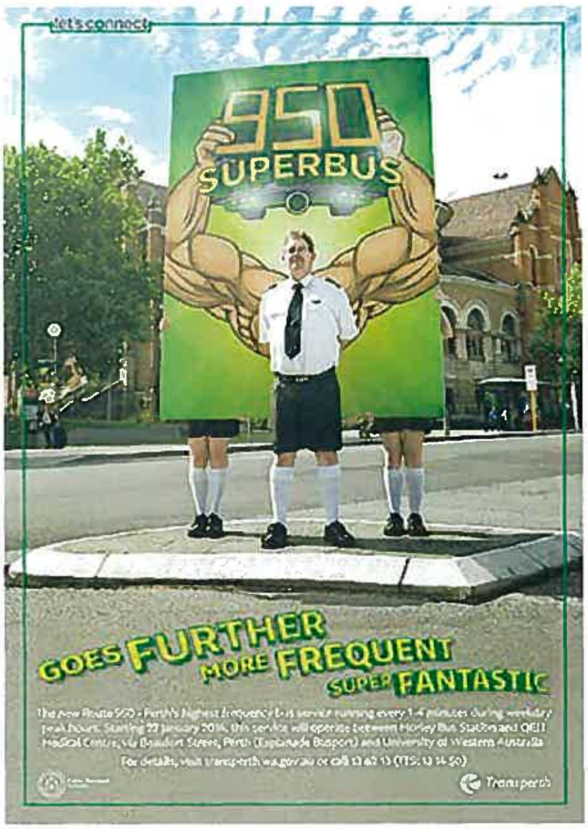
6.2 CircleRoute

Similar to Brisbane's Great Circle Line, Perth also has an orbital BBS called CircleRoute (Routes 998/999), which opened in stages from 1998. The CircleRoute was designed to provide the first rapid cross-suburban service linking important suburban centres and train lines in an otherwise strongly radial network. Key destinations include Morley, Bayswater, Belmont, Carlisle, Bentley, Willetton, Murdoch, Fremantle, Cottesloe, Claremont, Shenton Park, Wembley, Churchlands, Innaloo and Stirling. The limited stops service takes 3.5 hours to traverse the entire 78 km route. Services operate every 15 min on weekdays and every 30 min in evenings and weekends. As part of the launch, every household within 500 m of the route received a CircleRoute brochure and timetables. Currently there is a focus in Perth of developing on-road rapid transit (i.e., LRT or BRT), and one proposal is for a future inner 'CircleRoute' to link Glendalough on the Joondalup Line with Canning Bridge on the Mandurah Line, as well as Subiaco and the University of Western Australia before entering the CBD from the east via Victoria Park (Department of Transport, 2011).

6.3 Transperth 950

Route 950 was introduced in January 2014 and quickly became the highest frequency bus service in Perth. Also known as Superbus (Figure 11), the route replaced Routes 21 and 22 from Morley to Perth CBD and Routes 78 and 79 from Perth CBD to Nedlands—similar to the Metrobus Phase 1 concept in Sydney to through-route services through the CBD. The route has been identified as a potential BRT corridor in the Public Transport Plan for Perth in 2031 (Department of Transport, 2011). Services operate every 3-4 min to Morley and every 1-2 min to the University of Western Australia. The route capitalises on existing bus lanes from Morley through Inglewood to the CBD. Although there is no Superbus-specific branding onboard buses, the 9XX series have now been earmarked as high frequency routes in Perth (as the CircleRoute 998/999 are), so can be thought of a rudimentary form of BBS. Transperth is looking to consolidate other strategic routes into through-routed services and implementing greater bus priority as a result of Route 950's success.

Figure 11: Promotional material for Superbus route 950



Source: Public Transport Authority Annual Report 2013-2014)

7. Adelaide

7.1 O-Bahn

Adelaide's O-Bahn is one of the world's longest and fastest guided busways, but its inception bore typical resemblance to technology being selected for technology's sake. These political circumstances may be traced back to the launch of the *North East Area Public Transport* Review (Department of Transport, 1978) which determined BRT and LRT to be most appropriate to serve the new growth area of Tea Tree Gully, out of an option set which included heavy rail and freeways up the River Torrens valley. The incumbent Labor government opted to pursue LRT technology by means of extending and modernising the Glenelg tram line. Whilst there was bipartisan agreement on the need for new transport infrastructure to service the north east, their political rivals opposed the LRT technology as a matter of policy difference and so this became the central issue in the 1979 South Australian election. One of the first acts of the Liberal government subsequently elected was to scrap plans to extend the tram, so they were left to construct a transport corridor with a number of technologies already having been 'ruled out'.

A worldwide search thus began for alternative technologies and the government quickly looked to Germany and their kerb-guided bus then being experimented in the city of Essen. Coined the O-Bahn[19], the system was conceived by Daimler-Benz to enable dual-mode buses to safely share tram tunnels, thereby avoiding traffic congestion on the surface. The guidance system is essential so that buses would travel along a controlled, fixed path, minimising the lateral width required both on straight stretches and when manoeuvring on curves (Levinson et al., 2003), important within the limited confines of the tunnel diameter (which specifies the loading gauge or maximum vehicle cross-section). Whilst the ability to operate on a narrow right-of-way is especially important in constricted environments such as road medians, at elevation and within tunnels, this was not a driving factor in Adelaide since there already existed a corridor of sufficient width (then earmarked for a motorway) along the River Torrens linear park, though minor infrastructure savings could be attributable to a narrower guideway structure—2.7 m as compared with 3.6 m for traditional BRT (Rogers, 2002). Another advantage of kerb-guided bus is its ability to offer precision docking at stations not unlike that provided for in a rail system (Phillips, 2006). However, this was not the case in Adelaide as buses exit the guideway to access stations, so the roadway can widen to allow for overtaking.

The 11.8 km Adelaide North East Busway (ANEB) or O-Bahn opened in two stages in 1986 and 1989. The busway begins at Hackney Rd in the inner north suburb of Gilberton and follows the River Torrens to the north east. There are a total of just three stations on the O-Bahn at Klemzig, Paradise and Tea Tree Plaza (originally named Modbury), each built with significant park and ride facilities, bicycle access, storage and parking. At 4-5 km, these are some of the longest station spacings in the world for BRT, followed in second place by the average 1.8 km spacing in Hangzhou, China (Hensher and Golob, 2008). O-Bahn's alignment caters for longer distance service than shorter trips by contiguous residents. The bus network is designed around a high frequency trunk along the full length of the busway with services through-routed beyond Tea Tree Plaza on-street into outer residential suburbs. Feeder buses provide interchange opportunities with the 'line-haul' O-Bahn at the two intermediate stations.

Because of active guidance control, a higher service speed can be operated safely on the system. The O-Bahn was designed for a maximum speed limit of 100 km/h, and with only two intermediate stops saw an end-to-end average speed (including stops) as high as 80 km/h (9 min to cover the entire length of route). Together with its dedicated alignment (unlike where BRT is built on a median or parallels a roadway where the travel time differential with private car can be far more marginal), the O-Bahn offers a staggering 38% in journey time savings, reducing a 40 min trip into the Adelaide CBD to just 25 min (Levinson et al., 2003). As such, O-Bahn has been immensely successful in attracting patronage, with 24% initial growth and some 40% of passengers shifting from cars (Currie, 2006). This is against a backdrop of subdued growth and even patronage decline on other radial routes out of Adelaide CBD. Most customers (around 80%) were found to be travelling from the outer suburbs with just 20% of passengers originating from one of the three busway stops. Customers have also commended O-Bahn's impressive ride quality, in part because of the high-quality engineering of the trackway components which are superior to normal street pavements. O-Bahn buses are equipped with guide wheels which engage with the vertical kerbs of the busway. Adelaide is unique in that it pioneered an innovative safety feature where a metal inner tyre is fitted to prevent full deflation in the event of a puncture, thus allowing a loaded bus to be driven off the busway at speeds of up to 50 km/h. Hence, there is a dedicated O-Bahn fleet for operational and maintenance purposed, but to date there exists no customer-facing brand elements.[20] Upon opening, the initial fleet comprised of 41 rigid and 51 articulated Mercedes-Benz buses. To comply with the maximum fleet age of 25 years, these were renewed with a total of 160 new buses delivered between 2007-2012 (Figure 12). Modern buses are far more advanced and lightweight, but with a heavier chassis no longer available, are more prone to vibrations and have hence had to be speed limited to 85 km/h on the busway (Currie and Delbosc, 2010). This issue showcases the long-term risks associated with selecting new BRT technologies—particularly proprietary technologies tied to one manufacturer. O-Bahn's working life has been estimated at 30 years so there are continual issues with renewal and replacement as the infrastructure ages.

19 The 'O' is short for omnibus (for all people), whilst 'bahn' is German for railway.

20 O-Bahn is presently incorporated as part of the Go Zone frequent network, but the brand exists at stops and stations only (not as vehicle liveries). Go Zone is beyond the scope of the present study.

That said, kerb-guided buses remain the most successful of all guidance technologies on buses (mechanical, optical or magnetic—see Section 12.2). Kerb-guided busways have (apart from Essen and Adelaide) also been implemented in Ipswich (UK), Leeds (UK), Nagoya (Japan), Bradford (UK), Sussex (UK), Edinburgh (UK), Cambridge (UK), Euclid (US) and Sao Paulo (Brazil). Whilst some implementations are sensible, with the same benefits not able to be accrued from other modal technologies,[21] most systems were built as a compromise solution replacing an earlier LRT proposal, and driven by a fixation on showcasing an innovative transport technology. The O-Bahn story in Adelaide is a case in point, as a pure political decision arising from government and the opposition taking rigid positions on policy and hardware far removed from the advice of technocrats (Rogers, 2002). Although the O-Bahn has grown to become the most heavily patronised public transport corridor in South Australia, its success cannot be attributed to the choice of kerb-guided bus technology. Whilst there have been proposals to extend the O-Bahn further north east to Golden Grove and even to southern suburbs via the Seaford railway line, none has progressed beyond consultation and so the system remains a standalone showcase of technology driven by modal ideology.

7.2 O-Bahn City Access Project

One of the greatest limitations of the O-Bahn is that its dedicated infrastructure and right-of-way ends at Gilberton and so buses are caught in congested mixed traffic as it traverses the final 4.4 km along the Inner Ring Route into the CBD. The AUD 160 million O-Bahn City Access Project was announced in 2015 and opened in December 2017, with a claimed 7 min in travel time savings per user per day. It provides for dedicated bus lanes along the median of Hackney Rd (whilst maintaining at-grade intersections with cross streets), plus a 670 m bus-only tunnel under the Adelaide Botanic Garden and into the CBD at Grenfell St / East Terrace. One criticism of the project is a concentration of services onto Grenfell/Currie St leading to increasing bus movements and greater passenger loads at bus stops, as well as longer access/egress for some customers as services are withdrawn from North Terrace and King William Road.

Figure 12: The latest Custom-bodied Scania articulated buses operating on the O-Bahn

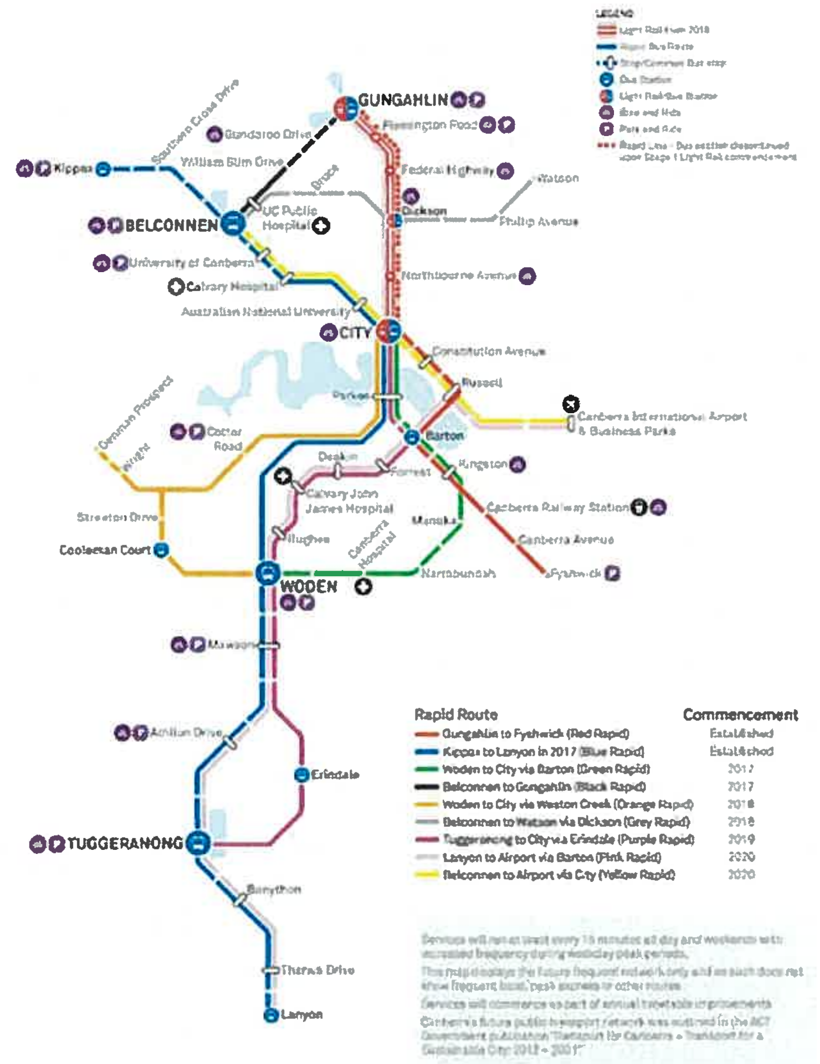
21 For example, where space is constrained such as on a former railway alignment.

8. Canberra

8.1 Rapids

Canberra's Rapid routes serve as the city's frequent trunk network. They represent a limited application of BBS ideals with excellent branding at stops and stations, as well as on marketing material, but generally no branded vehicles. Services operate every 15 min or better from first to last service but remain strongly weekday-centric as Canberra (unique amongst Australian capitals) operates a separate network of different routes (numbers and structure) on weekends. For many years, there existed only two Rapid routes—the Blue Rapid (300 series) and Red Rapid (200 series) services—which connect Canberra CBD with its four town centres[22] of Belconnen, Woden (Phillip), Tuggeranong (Greenway) and Gungahlin. In recent policy developments, an expanded strategic transport corridor network was envisaged in the 2012 masterplan *Transport for Canberra* (ACT Government, 2012). In subsequent years there was no progress on these additional Rapid corridors (despite clear progress targets set) but coming into the 2016 territory election, the Canberra Liberals released their bus-based alternative to ACT Labor's light rail proposal, and so the government was caught 'on the backfoot' and quickly set out their own plans for an expanded Rapid network integrating with LRT, operating seven days a week (Figure 13). Two routes have subsequently been added (for a total of four), with five more on the way to be implemented in April 2019 and coinciding with the light rail's opening.

Figure 13: Transport Canberra's Rapid network (2017).



22 Canberra's spatial structure consists of five independent 'towns' (built around a town centre and multiple group centres), each of which were meant to be self-sufficient to reduce cross-regional commuting. In reality, this exacerbated journey distances since very few centres had the necessary scale to house the workplaces, schools, facilities and other opportunities required to meet people's day-to-day livelihoods.

The present **Blue Rapid** brand evolved from the *Intertown 333* operating non-stop between Belconnen, City, Woden and Tuggeranong town centres. The importance of this trunk corridor has been established for decades with the NCDC (1976) even considering modes such as rail for its development. The hub-and-spoke model worked well for a number of years, as staff at interchanges held connecting buses to allow transfers between the Intertown trunk and local suburban routes. A variety of factors including funding cutbacks led to a deterioration of this model, and in a *Review of ACTION's Services* (Graham, 1997), a 'direct service' model (implemented in 1998) was proposed where trunk services would be through-routed as multiple local services to suburbs in Belconnen, Woden and Tuggeranong—similar to an open BRT system as routes overlayed on the trunk provide frequent service. Stops were also added to the Intertown route (including diversions to major hospitals and a group centre), thereby changing the non-stop service into one serving multiple en route trip generators. Apart from offering one-seat rides and allowing a reduction in the size of interchanges redeveloped (e.g., at Belconnen), the scheme was not without its detractors (Mees, 2012, Mees, 2011), who criticised the inability to operate more specialised fleet (e.g., articulated buses on the trunk and minibuses in the suburbs). MRCagney (2015) also observed very poor loading on the suburban component of through-routes and thus suggested truncation for operational savings. Increasing route length also reduced reliability and despite a very high combined frequency, there continues to be severe platooning in the absence of active headway management. One improvement has accompanied new bus priority constructed including the Belconnen to City transitway (inbound bus lanes and signal priority), adding to existing high occupancy vehicle lanes on Adelaide Ave.

The **Red Rapid** is a relatively more recent addition to Canberra's network. The service was born out of a recommendation in the *ACT Strategic Public Transport Network Plan* (MRCagney, 2009) for a limited stop service between the new town of Gungahlin and Kingston via the City and Parliamentary Triangle. A trial service began in late 2009 as the 727 REDEX (Rapid Express Direct) running from 7AM to 7PM (hence the name 727) every 15 min. These launched with a liveried fleet which was soon discontinued as the service formed a permanent fixture in late 2010 (renamed as Red Rapid 200) but operating as a trunk-only service until through-routing into Gungahlin suburbs was introduced in 2014 (becoming the 200 series). The Red Rapid corridor features a very successful inbound bus lane on Flemington Rd but at the same time suffers from severe congestion along Northbourne Ave. It is this section between Gungahlin and the City which has been the constant focus of BRT/LRT proposals over past years and will form stage one of Canberra's light rail system. The **Black Rapid** (Route 250) between Gungahlin and Belconnen town centres replaced a suburban route in 2014 and has grown in service frequency in the years since, concentrating service resources from other parallel (and circuitous routes) in surrounding suburbs onto the main corridor. The **Green Rapid** was launched in 2017 and brought together two individual routes (combined as part of the Green Line) to form a high(er) frequency and more direct service connecting Inner South suburbs with the City and Woden.

Beyond the Rapids, Canberra also operates a peak period, peak direction express bus service branded **Xpresso** (700 series). The idea behind these services is to provide a quicker journey from residential suburbs in Belconnen, Woden and Tuggeranong into the City and Parliamentary Triangle, by offering a one-seat ride and bypassing local town centres.[23] Alternative travel will necessitate a connection between a suburban route and their respective Rapid trunk (for most suburbs which do not enjoy a through-routed Rapid). Originally, Xpressos existed as an independent network with limited overlap with suburban routes, but in 2014 these were better aligned (including more intuitive route numbers) to operate as a variant of existing route services. A number of Xpressos also operate from Woden bus station to the Parliamentary Triangle and business parks at Campbell Park, Majura Park and Fairbairn. The Xpresso product as a peak-first offering is notoriously resource intensive and responsible for Canberra's high operational peak-to-base ratio (Wong, 2014). Split shifts (which are limited to 30% of all shifts as per their enterprise bargaining agreement) could well involve one or two inbound Xpresso trips in revenue service with the rest of the time spent dead running. The Xpresso product in providing such a direct (but time-limited) service offering also encourages people to travel within peak periods, hindering efforts to smooth peak demand. The recommended approach is to alter variables such as service frequency and perhaps stopping patterns in response to demand, but never entire route structures (Walker, 2012). For these reasons, the Xpresso network will be discontinued and kilometres redistributed including on upgrading and extending the Rapid network as part of the next network launching April 2019.[24] There is one other BBS in Canberra—the Free City Loop—using a dedicated fleet of liveried midibuses, but these are beyond the scope of the present study.

23 There are no Xpressos operating from Gungahlin since direct services are provided by the through-routed Red Rapid (200 series).

24 Under current proposals, the only Xpresso-type services (though no longer branded as such) which will remain are Routes 180, 181 and 182 operating from southern Tuggeranong (Gordon, Condor and Banks) to the City via Tuggeranong Parkway and Monaro Highway, bypassing both Tuggeranong and Woden town centres.

8.2 Lines

Canberra's frequent network has also included the Green and Gold Lines, although the former has been upgraded to the Green Rapid and the latter will be replaced by Rapid route R5 in April 2019. Despite its eventual phasing out, the concept of branding frequent corridors where routes overlapped is sound and offers great potential for broader application. On the advice of Jarrett Walker, a public transport consultant, the ACT Government took a tangle of infrequent routes which individually offered scattered frequency due to poor scheduling (including bunching),[25] but after a clever revision of timetables built up effective frequency on corridors where the routes overlapped for zero additional cost (Wong, 2014).

Routes 2 and 3 were branded to form the Gold Line and Routes 4 and 5 the Green Line, and both combined the 20-30 min headways of individual routes to offer a 10-15 min service where they overlapped. Importantly with the branded signage at stops and marketing material, this combined frequency is legible, and together with the Blue and Red Rapids, offer extensive service coverage around the City and Parliamentary Triangle (Figure 14). One of the authors in this present report (in his previous role) extended this concept of improving effective frequency by better scheduling routes on other corridors including Athllon Dr, and also between key origins and destinations including at the group centres Erindale, Chisholm, Calwell and Weston.

Figure 14: Canberra's City and Parliamentary Triangle frequent network

Source: Walker 2010

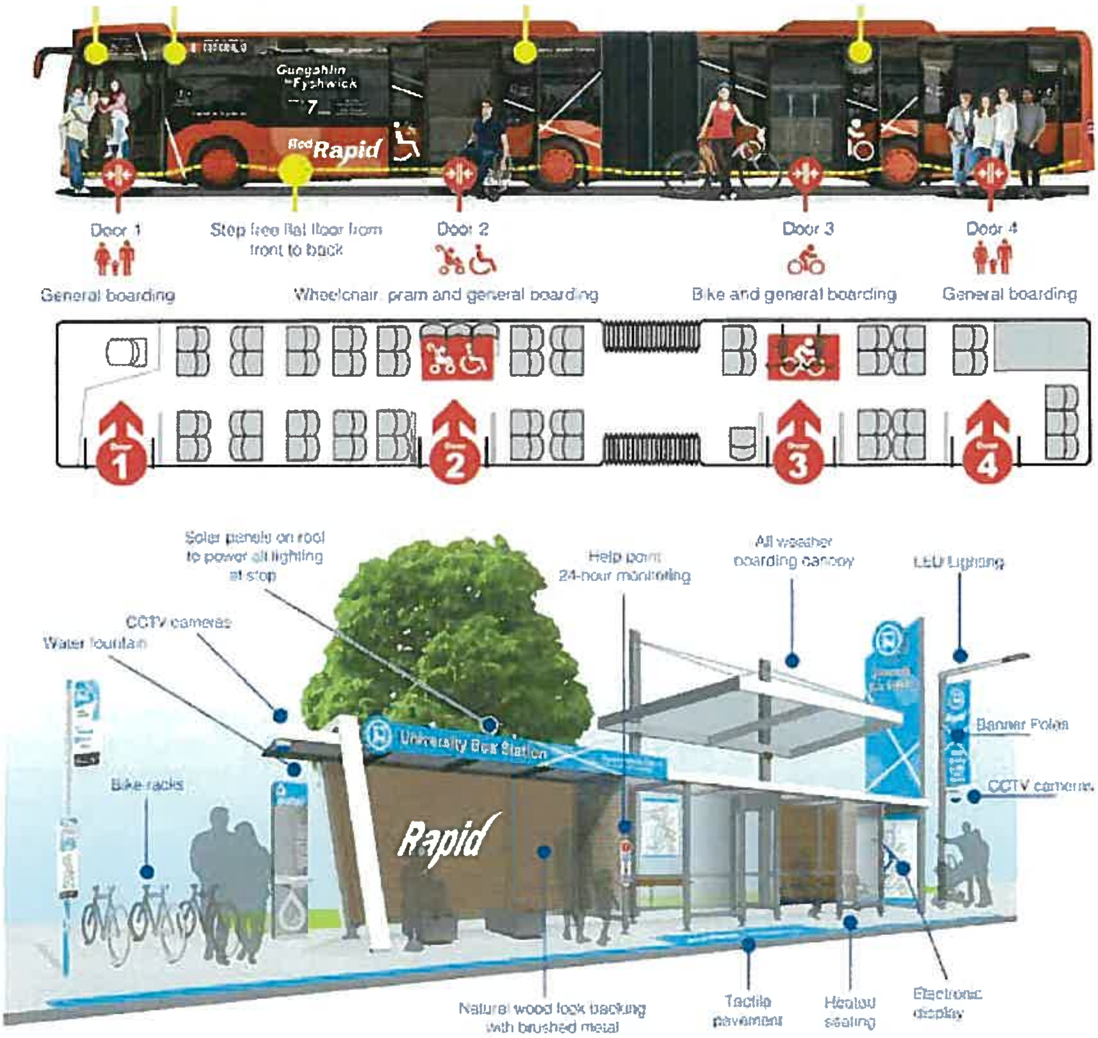
25 Such issues are very severe in Sydney at SMBSC contract boundaries, including on the A3 Ryde Rd and A38 Warringah Rd, and even within a single operator (e.g., Richmond Rd).

8.3 Alternative proposals

Walter Burley Griffin designed Canberra with wide avenues and medians which were earmarked for streetcars over 100 years ago. In the time since, LRT proposals have emerged time and time again, and been the subject of countless studies. This bus versus rail debate has again ensured in recent years surrounding the Gungahlin to City light rail corridor. The ACT Labor government undertook in the 2012 election to conduct another study, but when forced into minority government with the Greens promised to construct LRT in their coalition agreement. Contracts were signed just prior to the 2016 election, and as part of their election platform the Canberra Liberals undertook to terminate contracts should they win government—akin to the Andrews Labor government in Victoria who threatened to cancel the East-West Link contract which they followed through upon winning in 2014. Led by Alistair Coe, the opposition offered their alternative vision *Canberra's Transport Future* (Canberra Liberals, 2016), based on a significant expansion of the Rapid network, including upgrading to true BBS standards. This prompted the Labor government to hastily release their own Rapid expansion plans which (despite some delays) are being carried out having been re-elected (Figure 13).

Canberra's Transport Future included an AUD 20 million boost to ACTION's annual operating budget, six new Rapid services, free travel after eight paid journeys (adapted from Brisbane and Sydney), a seven-day network and services running until 1AM on Thursday, Friday and Saturday nights. Of particular interest is a new Rapid bus fleet, each colour-coded and significant upgrades to Rapid bus stops and stations (Figure 15). The fleet of Mercedes Citaro articulated buses[26] would have offered comprehensive passenger information systems, four double-doors plus all-door boarding. Customer features on the proposed stops would rival even the best BRT systems in the developed world. Some bus priority would also have been delivered including bus lanes on Northbourne Ave. The entire package of proposals if implemented (although unlikely given their allocated budget) would have become Australia's best BBS.

Figure 15: Route-specific branding for buses and stations on an expanded Rapid network proposed by the Canberra Liberals for the 2016 ACT election



Source: Canberra Liberals 2016

26 Incidentally, these proposed vehicles are not permissible on Australian roads, being the European standard 2.55 m wide. The maximum allowable width (excluding mirrors) on Australian roads is 2.5 m.

9. Gross performance comparison

Having showcased each BRT and BBS in Australia with a focus on system-specific challenges and constraints, we now evaluate their relative success according to our devised index of performance (see below). A number of characteristics have been selected, segmented by individual BRT, BBS and generic route services as inputs into our criteria for comparing and assessing the performance of each system:[27]

- Total vehicle service kilometres
- Average service headway (every x min) in weekday AM and PM peak (directional), weekday inter-peak, and weekends. The weekday time of day segments are: AM peak (7:00-9:00AM; 2 hours), inter-peak (9:00AM-4:00PM; 7 hours), and PM peak (4:00-6:30PM; 2.5 hours)
- Percentage of route distance that is in priority lanes or carriageway in each of the weekday AM and PM peak (directional), weekday inter-peak, and weekend periods[28]
- Average speed (km/h) in weekday AM and PM peak (directional), weekday inter-peak, and weekend periods
- Total passenger boardings per annum
- Average number of passenger boardings per vehicle service kilometre.

Whilst more detail has been provided for Sydney (appended as a report companion), to be able to compare the six cities in Australia (Sydney, Melbourne, Brisbane, Perth, Adelaide and Canberra) where there exists varying quantum of BRT and BBS, the data set is limited to the items summarised above. In addition, it must be recognised that some comparisons make more sense within the one metropolitan area given differences in the scale of services and the characteristics of the service delivery areas with respect to population density, road quality and the overall supply of public transport (including the presence of competing modes). For example, the overall vehicle service kilometres in Sydney are ten times greater than Canberra and cover a much greater catchment area and population with much greater traffic congestion in peak periods. We do, however, define a number of features of the various systems that represent either a service-specific feature or a context-specific setting potential influence to capture these effects as summarised in Table 4 in Section 11.

The authors have developed a performance indicator to capture the relationship between patronage, service kilometres and service frequency. This indicator, which we call the **gross performance ratio (GPR)**, is defined as the ratio of passenger boardings per service kilometre to the frequency of provided services. This measure enables us to comment on the success of each service offering in attracting passengers, consequent on the amount of service kilometres delivered and its embedded service frequency. This aligns well with two important drivers of patronage growth—connectivity (correlated with service kilometres) and frequency.

It is important to add some clarity on why headway is included to adjust the patronage per service kilometres in the GPR index. In arriving at an average headway (the inverse of service frequency), we accounted for headways during three times of day; namely (i) peak period peak direction (as the peak), (ii) inter-peak (measured at 12PM as the trough), and (iii) weekend (usually flat). We then defined average headway as (peak + trough + flat)/3. This approach allows us to capture peaks and troughs and overcomes concerns such as the performance metric being heavily impacted by the span of hours of service. A service with shorter span of hours (e.g., Perth CAT buses) will score highly because the average headway is higher. If we had defined headway as a straight up average, this would have been conflated with service kilometres. Under our formula, headway has a partial correlation of -0.32 with passengers per service kilometre.

In assessing each BRT and BBS system, it is necessary to define a suitable level or scale of analysis. Importantly, there exists an inverse relationship between greater aggregation and the inherent level of variance in each characteristic which is essential for explaining the causes of variability in performance. For this reason, some of the studied BRT and BBS systems of interest are considered in totality (as one unit), whilst for others particular routes (or series of routes) are assessed and compared independently. The rationale is explained below.

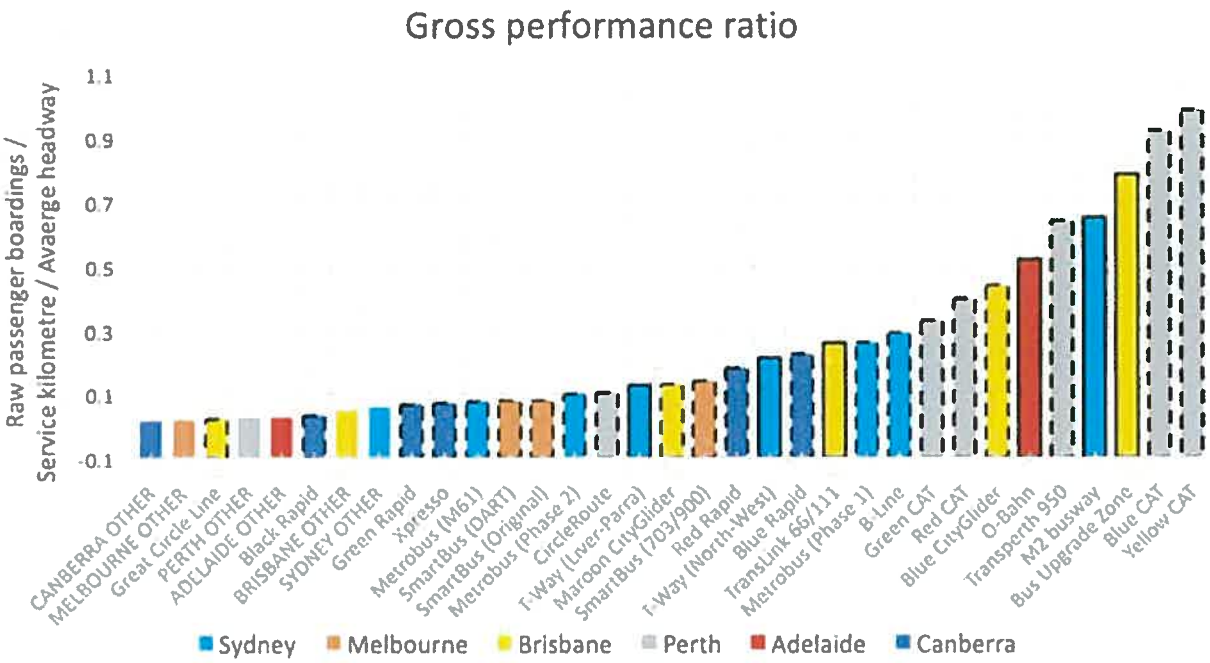
- Sydney's Metrobus Phase 1 and 2 serve different functions ('top-up' versus cross-town orbital) so are segmented for analysis. Metrobus M61 is also assessed separately since it is unique in running express (and at high speed) along the M2 motorway unlike other frequent stopping trunk services which ply major arterials.
- Melbourne's SmartBus is segmented into Original (Routes 901, 902 and 903), Doncaster Area Rapid Transit (DART), and Routes 703/900. These are (respectively) cross-town orbitals, radial express routes via the M3 Eastern Freeway, and shorter connections in the middle suburbs.
- Brisbane's TransLink routes 66 and 111 operate on the busway trunk only and are assessed separately to Bus Upgrade Zone (BUZ) services which capture all busway services including through-routes into residential suburbs in mixed traffic. This tests for differences between closed and open BRT operations and how it might impact on performance statistics.
- Brisbane's CityGliders are assessed independently (Blue and Maroon) since they face different operating environments (and by extension, traffic levels). The Maroon CityGlider operates on significant parts of the South East busway.
- Perth's Central Area Transit or CAT (Red, Blue, Yellow and Green routes) are separated for analysis to capture greater detail in their relative performance.
- Canberra's four Rapid services (Blue, Red, Black and Green) are analysed independently given different operating environments and serving different patronage functions.

27 The authors thank state and territory agencies for the provision of data.
28 This accounts for time-limited priority such as peak-only bus lanes.

What interests us is the relationship between patronage, service kilometres and service frequency. Figure 16[29] compares the patronage per service kilometre against the service frequency over a seven-day period (weekdays and weekend), which we refer to as the gross performance ratio index. It shows the relationship between the number of bus passengers, the amount of provided service kilometres and service frequency (average headway). We would want to see growing patronage when we increase vehicle service kilometres and introduce more frequent services (shorter headways). A high patronage per service kilometre (a larger value) and a higher service frequency (a lower value) will increase the performance ratio. Conversely, a smaller number for the ratio suggests a lower relative level of performance. As examples, the M2 busway in Sydney (rank 4) has a relatively high patronage per service kilometre and a relatively high service frequency, resulting in a higher performance ratio. In contrast, the Liverpool-Parramatta T-way (rank 18) has a relatively lower service frequency and passengers per service kilometre, resulting in a lower performance ratio. Another way of viewing this is to consider how effective the provided service kilometres and associated service frequency are in attracting patronage.

Figure 16: Rank of gross performance ratio defined as raw passenger boardings per service kilometre divided by average headway.

Note: Column outlines represent service type: BRT in solid outline, BBS in perforated outline, and generic services without outline



It is important to clarify how the assessment of the performance of each of the services being compared within and between the six capital cities is justified. Specifically, we fully understand that the locations in which specific services are operating vary greatly between geographical jurisdictions. Influences such as alternative public transport on offer (notably rail), levels of traffic congestion on the roads, population density and other land use factors, all can influence the success of a specific bus-based service.

In this study, the authors acknowledge all of these potential influences (see Table 4 in Section 11). We propose a normalisation process (to be introduced) to obtain what we call a **net performance ratio (NPR)** (in contrast to a gross or unadjusted performance ratio), enabling us to make comparative assessments of what is actually provided by focussing on how well bus services appear to be performing at present, controlling for the role of other effects.

At a very broad strategic level, this provides encouraging evidence on the performance of particular services, and is very useful in messaging the value of BRT and BBS. The focus is on the demand side and not on the cost of providing the service where additional costs are required when there is investment in bus priority infrastructure and dedicated branding of vehicles and stops.

29 Column colours correspond with the (primary) bus livery colour in each city.

10. Rationale for normalisation

Whenever any form of transport service is compared there is always the risk that we end up making comments that amount to comparing 'apples and oranges' and hence relative performance assessment is questionable and of limited value. When there is an interest in comparing the performance of bus systems, it is essential that this is undertaken in such a way that clear and valid statements can be made about how one system performs relative to one or more other services. It is often the case that individuals make comments on how efficient one system is compared to another. The authors are often asked how such individuals can make such comments! A common concern is that "surely they are not comparing like with like?"

While one can never be sure what a specific study actually does to form a view (factual or otherwise) as to how well one system compares with another (or indeed an entire sector), there are nevertheless some good practical and meaningful principles to adhere to so that sensible debate can occur. The great majority of commentary appears to be based on a simple comparison of key performance indicators (KPIs) measured in terms of what we call the gross level (e.g., passengers per service kilometre as observed). The failure to recognise sources of influence on such KPIs that are not under the control of the system (such as location) and which vary by contextual setting is very poor analysis, resulting in nothing more than a comparison of 'apples with oranges'.

So what should be done? As a start, identify those features of service provision that incur a disproportionate performance impact across the systems being compared—that the system has effectively no control over—and are a recognition of the reality of operating in a specific jurisdiction. To make a valid comparison, these differences must be recognised and accounted. We call this **'normalisation'**, although some people often talk of 'standardisation'.

In the context of metropolitan bus operations in Australia, with a focus on performance related to passengers accommodated by the provision of service kilometres and service frequency, the main influences that are outside the control of most systems are likely to be associated with the location of the services. If there are circumstances that give a particular service an advantage over another simply because of external contextual influences, then these must be controlled for; examples would include location such as city and intra-city geographical service areas (e.g., the CBD or inner suburbs). Such spatial contextual influences are proxies for population density, the availability of competing modes and other considerations.

How does normalisation work? The most popular method involves replacing the impact of a specific influence not under the control of the system (but essentially under the control of the operating environment), with an average (or median) level (across all sampled systems) of a factor that may influence performance. The same rule would apply to all selected influences that need to be 'normalised' as a way of removing the influence of these factors on the comparison of system performance. However, the story does not stop there.

Before we can normalise the KPI of interest, we need to find out what role these normalisation criteria play in explaining differences in the level of the KPI of interest, so that we can then ensure that this role is used as a weight to allow for the replacement of the system-specific level of (as an example) direct competition with other services of the sample of all operations being compared. These weights are obtained using a regression model that assures that all influences on differences in a KPI are accounted for (which includes those influences under the control of the system).

A final comment is a question for all analysts—are valid methods being used to undertake a comparative assessment of performance? As an example, a gross KPI cannot be used to make statements about whether one operation is more or less efficient or has a higher level of performance than another operation (in situations that are potentially so different). A real fear and concern of the authors, is that this is exactly what is happening in many sectors, including the bus transport sector.

11. Net performance comparison

While the gross performance measure presented in Figure 16 (section 9) is interesting, it is also potentially misleading and requires appropriate adjustment to obtain a strictly 'apples with apples' comparison.

To achieve this, we estimated a series of linear regression models designed to identify contextual characteristics that, together with system descriptors, can explain systematic variations in the gross performance ratio index. Table 4 summarises these service-specific and context-specific effects and identifies those which emerged as statistically significant used in the normalisation of the performance ratio.

Table 4: Service-specific and context-specific effects tested for how they influence passenger boardings.

Note: Asterisked (*) attributes are statistically significant and form part of the normalisation model

Category	Attribute (1/0)	Description
Bus priority	Dedicated carriageway*	Substantial section of route (>30%) on dedicated bus-only carriageway separated by a physical median
	Dedicated lane*	Substantial section of route (>30%) on dedicated bus-only lane with the potential for traffic conflicts
	Signal priority	Substantial amount of grade separation or signal priority either as induction loop-queue jumps or transponder-activated signals
	Premium stations	Substantial number of premium stations featuring better customer amenities
Brand identity	Soft branding	Distinct service branding in marketing material, stops and bus destination display
	Hard branding	Exclusive use of branded fleet reducing operational flexibility
Service type	Downtown circulator	CBD loop service
	Radial inner	CBD to inner suburbs route
	Radial outer*	CBD to inner plus outer suburbs route
	Cross-town/Orbital*	Route connecting suburban CBD locations
	Feeder/Coverage	All other services connecting to the high frequency network
Other	Direct competition*	En route competition for a significant section of the corridor (>60%)
	Free service	Service is fare-free
	System-specific dummies*	Controls for all other system-specific effects not otherwise captured
	City-specific dummies*	Controls for all other city-specific effects not otherwise captured

The final model identified 17 influences plus a constant. The model included six city-specific dummy (1,0) variables for Sydney (Syd), Brisbane (Brs), Canberra (Can), Melbourne (Mel), and Perth (Per) (Adelaide being the base); and seven system-specific dummy (1,0) variables for Perth's CAT services (PCat), Brisbane's busways (BBWay), Brisbane's CityGlider services (BCGlid), Canberra's Rapid services (CRapid), Melbourne's SmartBus (SMetB), Sydney's B-Line (SBLine), and Sydney's M2 busway (SM2Bw). Three variables represented location effects—radial/outer (Outer), cross-town/orbital (Orbital) and the presence of competition on the corridor (Comp). Finally, we found both dedicated carriageway (PricWay) and dedicated lane (PriLane) to be statistically significant influences on gross performance. Branding attributes (both hard and soft) did not emerge as statistically significant despite evidence from the literature to the contrary (Currie and Wallis, 2008), perhaps because of unique ways in which branding affects travel choice and behaviour. It has been found that 'hard' factors such as service span and frequency drive modal shift, but once people become regular users it is the 'soft' factors which retain patronage (Hensher et al., 2010). Therefore, the importance of distinct branding should not be dismissed.

Equation 1 is the final formula used to obtain the NPR, using the normalisation procedure explained in the previous section. First we estimate this model using GPR as the dependent variable in order to obtain the parameter estimates. This is a linear regression model with all parameter estimates having t values greater than 1.96 which means that all parameter estimates are significantly different from zero at the 95% confidence level. The overall explanatory power of the model (R-squared) is 0.729 which tells us that 72.9% of the variation in the dependent variable (i.e., GPR) is explained by the variation in the levels of the explanatory variables. To obtain the NPR we use this equation but replace the levels of specific variables (excluding ones that refer to a service dummy variable) by the average of the sample of services. These include PricWay, PriLane, Outer, Orbital and Comp.

Figure 17 summarises the net performance ratio evidence and Figure 18 compares the gross and net performance ratios for the 27 BRT and BBS systems relative to generic route services in the six Australian capitals. As can be seen, there are a number of changes after normalisation that are important to recognise and comment on. The most notable adjustment is the elevation of Brisbane's BRT Routes 66 and 111 (running trunk-only), which exhibited the greatest absolute difference between net and gross performance (moving up from rank 12 to rank 6). However, it does not perform as well as its BUZ cousin despite the latter including suburban running in mixed traffic. This may be attributed to a lower level of service on individual routes relative to a combined service offering. Perth's four CAT services and Route 950 show consistently high performance, despite a slight drop in absolute performance (though its relative rankings remain relatively unchanged) upon normalisation, accounting for the impact of free fares (in the case of CAT) and high service frequency. Adelaide's O-Bahn exhibits the greatest negative adjustment post-normalisation (moving down from rank 6 to rank 13), which means that much of its performance may be linked to system-specific characteristics such as its high operating speed and right-of-way. It means that the O-Bahn ought to perform better than it presently does for its given level of infrastructure and geographic setting. The best normalised performance ratio for Sydney is associated with the M2 busway (rank 5)—and this is considering the impact that NorthConnex construction had on service performance during the period of data collection. Melbourne's SmartBus (Original) perform similarly to Sydney's Metrobus (Phase 2), with both being cross-town orbitals serving the metropolitan fringe. Finally, Canberra's Blue and Red Rapids perform well, though they remain mid-range in the context of all Australian systems.

Of special interest is the performance ratio for all services that are not classified as BRT or BBS. The regular services in each city under the gross performance ratio were ranked 26th (Sydney), 27th (Brisbane), 29th (Adelaide), 30th (Perth), 32nd (Melbourne) and 33rd (Canberra). After normalisation, their rankings changed to 21st (Sydney), 23rd (Perth), 25th (Adelaide), 26th (Brisbane), 27th (Melbourne) and 28th (Canberra). The improvement of Perth and Adelaide is noticeable. What we find is that the performance ratio for generic routes is (relatively) low and supports the proposition that the services provided on regular route services have a worse performance ratio than the majority of BRT and BBS. The exceptions are a number of BBS with performance close to generic route level being Brisbane's Great Circle Line, and Canberra's Green Rapid, Black Rapid and Xpresso services. Poor performance in Canberra is consistent with Australia-wide benchmarks of farebox recovery and other performance indicators (MRCagney, 2015).

To gain a better appreciation of how normalisation has influenced the ranking of systems, Figure 18 compares the gross and net performance ratios. Reading from left to right, the larger negative values indicate that performance has deteriorated after normalisation, in contrast to the right-hand side where performance has improved. Clearly, normalisation has had a noticeable impact on the relative performance of the 33 systems and services, but a large majority have changed only slightly (between -0.5 and +0.5). The top three rankings (Perth's Yellow and Blue CATs, and Brisbane's BUZ) have remained unchanged post-normalisation.

What is very noticeable is the presence of high performing services that are not privileged to have a significant amount of bus priority, and indeed the Perth services stand out as having virtually no bus priority and compete in mixed traffic. One has to be careful in inferring anything about the influence or not of bus priority since the traffic streams in many situations where BBS exists may not justify a dedicated lane given achievable average speeds in mixed traffic (including consideration of stop distances and traffic type—e.g., circulation versus through-traffic). Our regression model of the proportion of a route that is afforded bus priority (either dedicated carriageway or lane) is poorly correlated with average speed, and the reason is largely due to the high incidence of mixed traffic distances in the overall route operation where any gains on a dedicated corridor are dissipated by the performance when off the corridor, resulting in a lower average speed. Sydney's M2 busway and Brisbane's BUZ services (the two top performing BRT) are a case in point where significant sections of route are in mixed traffic off-corridor (both being open BRT systems). Despite limitations, our robust methodology has identified the important attributes driving the system performance of BRT and BBS in Australia. Through a normalisation process, we have benchmarked and ranked the 27 service offerings in Australia, and found a very strong endorsement of the relative performance benefits associated with both BRT and BBS.

Equation 1

The equation used to undertake the normalisation:

$$NPR = 0.1068-0.772*Syd+0.0199*Brs-0.0189*Can+0.1396*Per+0.0293*Mel +0.3065*PCat+0.3678*BBWay +0.0509*BCGlid+0.0763*CRapid +0.0726*SMetB+0.1486*SBLine+0.0244*SM2Bw+0.1252*PricWay +0.0977*PriLane-0.1048*Average\ Outer-0.0879*Average\ Orbital +0.1038*Average\ Comp$$

Figure 17: Rank of net performance ratio defined as normalised passenger boardings per service kilometre divided by average headway.

Note: Column outlines represent service type: BRT in solid outline, BBS in perforated outline, and generic services without outline

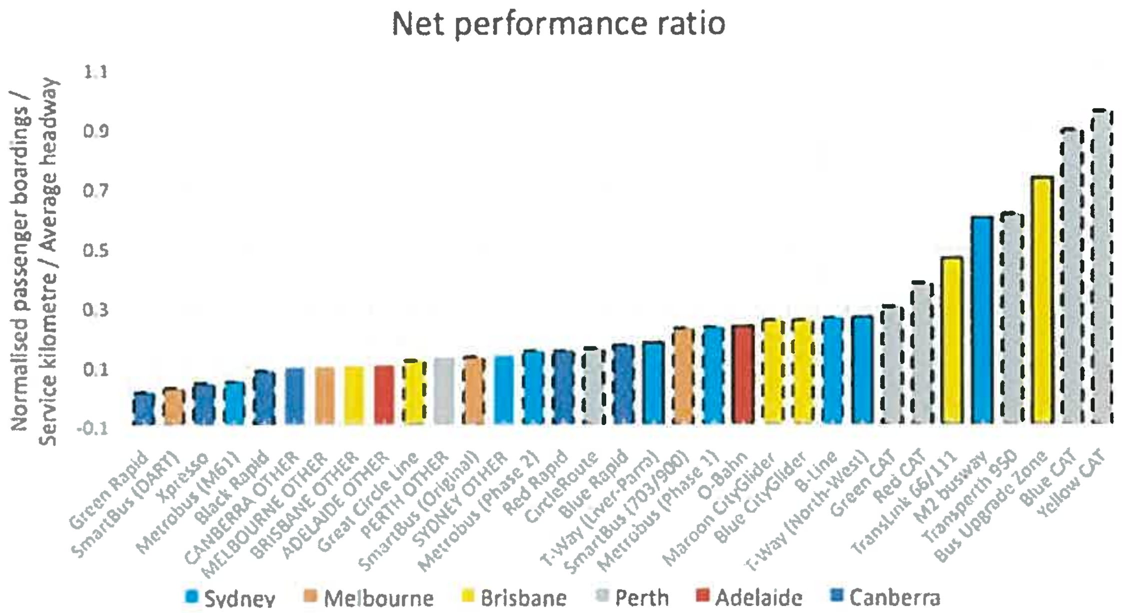
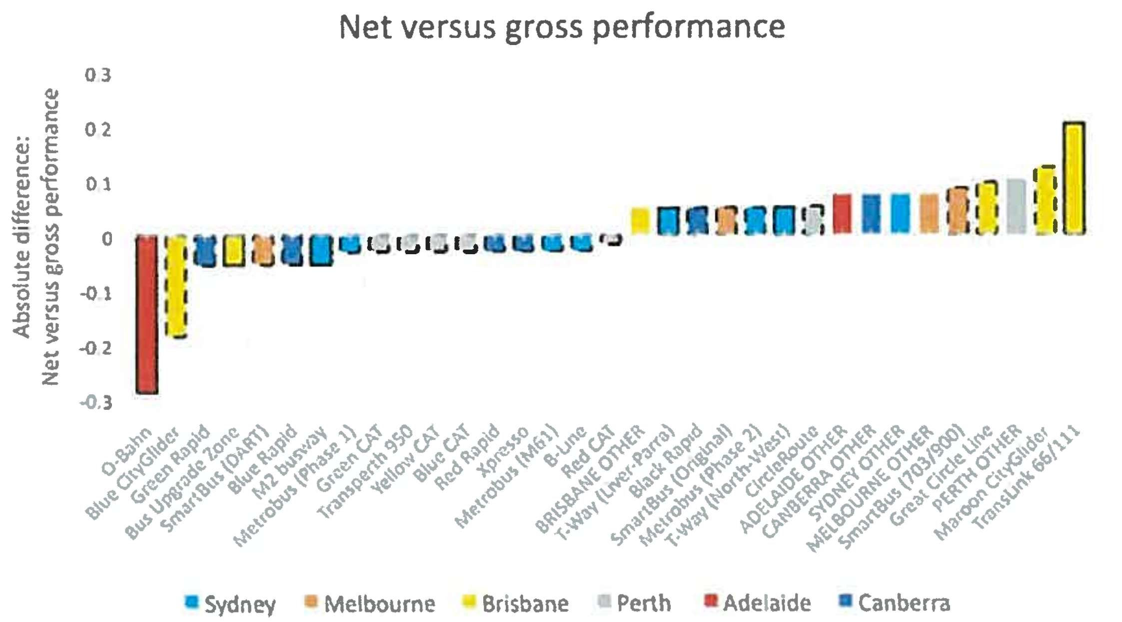


Figure 18: Difference (net minus gross) in the performance ratio of systems under net and gross performance calculations.

Note: Column outlines represent service type: BRT in solid outline, BBS in perforated outline, and generic services without outline



12. Best practice from abroad

12.1 Route and service-specific branding

Two examples from Seoul, South Korea and Auckland, New Zealand have been used to showcase the extremes of service-specific versus route-specific branding. Seoul has implemented a simple citywide colour scheme which makes the structure of the bus network obvious at a glance (Figure 19). The four distinct service types include:

- trunk (blue)—mostly radial corridors on dedicated right-of-way
- branch (green)—feeder buses connecting suburbs to local centres
- rapid (red)—express buses operating from Seoul CBD to across the metropolitan area
- circulation (yellow)—orbital services, which tend to be perpendicular to blue and red routes.

Whilst most bus networks are hierarchical to some extent (e.g., patronage versus coverage functions), this is rarely communicated well to the customer—vehicles look the same, but occasionally route numbers will have some pattern to them so as to hint at the importance of each route. However, most customers will see all routes as generic. There is value in a system similar to that in Seoul so customers can observe at a glance which service type they should board. It also helps in orienting people when the route structure is visible in its most potent form.

The alternative to the Seoul approach is route-specific branding which has been implemented in many cities but particularly prominently (in our region) in Auckland, New Zealand. Over the past few years, Auckland has been undergoing a period of network reform which has finally concluded and now sees the number of people living within 500 m of the frequent network (defined as where services run every 15 min or better) doubled from 215,000 to 530,000. On the frequent network, many of the core routes are branded—including three circulators in the CBD and inner suburbs, Northern suburbs BRT and other specialised services (Figure 20). Northern Express services utilise headway gap displays in the driver's cab so they may see how they are tracking to schedule. Movable off-vehicle ticket validators are also used in peak periods so passengers can use the rear door to board and alight. The 380 Airporter even competes with the commercially-operated SkyBus and provides a frequent and inexpensive connection to Manukau and Onehunga town centres / train stations. Amongst many New Zealand cities, BBS schemes are quite a common fixture—as is the case in the United Kingdom outside London. We believe the economically deregulated environments in these countries has raised the level of competitiveness in the bus industry and so private operators leverage branding to expand the patronage base. The important role of competition in fostering cost efficiency, cost effectiveness and innovation is well known but it is how they are operationalised, for example, through branding and product distinction which is of real interest (Wong and Hensher, 2018).

Quality bus partnerships in the United Kingdom also showcase how public and private enterprise can work together to deliver BRT and BBS and other cooperative intervention initiatives (Hensher et al., 2010). In Leeds, articulated Wright Streetcars (Figure 21) have been operating as Route 72 Hyperlink (formerly *ftr*) to Bradford, based on commitments from the Passenger Transport Executive (in West Yorkshire) to deliver bus priority and from FirstGroup to purchase new fleet and deliver a reliable service. The selection of vehicles mimics light rail in design and appeal to the emotional and biological elements within us. Drawing on this comparison, we will now consider various proposals for optically-guided bus (trackless trams) which has garnered immense interest recently in Australia.

Figure 19: Service-specific liveried buses in Seoul, South Korea.

Note: Red is rapid, green is branch, blue is trunk and yellow is circulation

Photo by Minseong Kim

Figure 20: Route-specific liveried buses in Auckland, New Zealand.

Figure 21: Route 72 Hyperlink connecting Leeds and Bradford, operated by the distinctive Wright StreetCar

Photo by Calum Cape

12.2 Optically-guided bus (trackless trams)

Optically-guided bus is the latest in a long line of initiatives to repackage existing bus as premium rail-based technology. The name 'trackless trams', design of the vehicles and modest deployment cost has appealed to many, and the concept has gained traction in Australia, led by prominent individuals including Professor Peter Newman of Curtin University (a well-known critique of bus-based systems). In *The West Australian* on 28 December 2017,[30] the headline read "Trackless trams could be the answer to Perth's traffic woes", citing that the "Experts say the new technology could be a game changer for Perth". It is 'trackless' because the vehicles are guided by on-board optical systems that follow painted stripes on the road. The news story goes on to quote Professor Newman:

> *....The trackless tram has a number of unique features that makes it particularly attractive, especially the price [...] It is estimated to cost between $10-$17 million per kilometre—about four times less the cost of a standard light rail like the MAX system proposed by the previous Barnett government. It could also be made locally [...] We have been working on light rail for Perth for several decades—we now believe technology like the trackless tram will be a game-changer for Perth and cities like it [...] It is cheap, involves little disruption, can be rapidly brought to market and has all the passenger comfort and ride-quality attributes of light rail—yet it is a new kind of bus on the road....*

As a result, it does not require the digging up of streets and disruption to businesses, houses or traffic while it is being built. The trackless tram would be electric and powered by lithium-ion batteries that are recharged at each station in 30 seconds. Planning has begun on this 'new' concept of public transport that experts believe will be a game changer for Perth.

Despite the clever use of the phrase 'trackless trams' to give some continuing emotional attachment to light rail (Hensher, 1999), what we are referring to is a high quality BRT system that ticks all the boxes of the Gold Standard (ITDP, 2014)—something that currently does not exist in Australia. Such a BRT system also recognises the value for money proposition where the same level of service can be provided for a cost considerably lower than LRT. As suggested by Hensher et al. (2019b) in evaluating options for the Northern Beaches of Sydney (where the B-Line was introduced in 2017), if we were to spend the same amount on BRT Full as on LRT at the LRT cost level, then BRT Full would deliver a significantly higher benefit-cost ratio, travel benefits and economy wide impacts making it undeniably a much more attractive investment (and value for taxpayers' money) than LRT. The resulting service coverage, frequency, connectivity and visibility would mean that the Northern Beaches (together with the Lower North Shore) of Sydney would see improved accessibility that only BRT and not LRT can provide for the same dollar outlay of investment. This is a very important finding and recognises that the served catchment area can change substantially for a given budget in a way that supports many more 'corridors' of service frequency that is typically not identified in an overly constrained corridor interpretation of project appraisal. Maybe it is time to rethink the context within which benefit-cost analyses are undertaken?[31]

Hensher et al. (2019a) present evidence from a survey of public transport preferences undertaken in five countries (Australia, UK, Portugal, USA and France) by ITLS and the Volvo Research and Educational Foundations Bus Rapid Transit (BRT+) Centre of Excellence on the key drivers of community preferences for BRT and LRT. Service levels can be used effectively to deliver value for money BRT over LRT in the exact same corridor (and indeed many more corridors of BRT) for the same dollar sum as LRT, as clearly noted by Newman for Perth. We hope that the Perth view of a future bus-based system that delivers exactly what the light rail supporters want will send a signal that BRT has great merit and should not be discarded simply because of some emotional attachment to light rail and a misguided view that light rail can carry more passengers than a bus-based system. What matters is not vehicle capacity but service capacity and BRT definitely delivers on this metric. If we have to make our buses look like light rail to win the debate then so be it!

Whilst we applaud the recognition for the role of upgraded bus and BRT (and 'trackless trams'), a certain level of dogma fuelled by more wilder claims about the technology and its potential has taken hold. Many misconceptions have been promulgated which prompts us to set out the facts and debunk the myths.

Myth 1: Optically-guided bus is a revolutionary new technology.[32]

Optical guidance systems date back to the late 1980s[33] and have been deployed with limited commercial success since the early 2000s—we count just three applications in Rouen (Normandy, France), Castellón (Castelló, Spain) and Las Vegas (Nevada, United States).

30 See https://thewest.com.au/news/wa/trackless-trams-could-be-the-answer-to-perths-traffic-woes-ng-b88698244z

31 See http://sydney.edu.au/business/itls/thinking/2018/refocussing-benefit-cost-analysis-start-with-a-budget

32 An abridged fact check of these three myths has been published in The Conversation: https://theconversation.com/looking-past-the-hype-about-trackless-trams-107092

33 See pioneering work on vision-based vehicle guidance systems by Dickmanns et al. and Pomerleau

Whilst mechanically-guided bus remains the most popular—including [Adelaide O-Bahn styled] kerb-guided bus and to a more limited extent rail guidance systems—magnetic[34] and wire guidance technologies have also been trialled to deliver the same benefits including precision docking, lane assist, reduced road footprint and a better ride quality, but doing so for lower cost due to the absence of continuous physical infrastructure.

The three systems in Rouen, Castellón and Las Vegas are all based on the optical 'self-steering' guidance system developed in France by Matra under the trade name Visée, later rebranded as Optiguide upon acquisition by Siemens. The technology utilises a roof-mounted, forward-facing camera to detect a 'virtual rail' in the form of twin, white dashed lines painted on a darker road surface. The image is transmitted to an on-board computer which combined with the speed, yaw and wheel angle of the bus determines the correct path to be followed and in turn adjusts the vehicle's steering mechanism as required. In partnership with Renault, the Civis[35] concept was developed into a transport system based on Irisbus Agora articulated buses fitted with the optical guidance system.

The most extensive deployment has been on the Rouen BRT called TEOR (Transport Est-Ouest Rouennais), inaugurated in February 2001 (Figure 22). The system has subsequently grown to three lines totalling 32 km all using the same guidance technology. The second deployment has been in Las Vegas along Las Vegas Boulevard North on the Metropolitan Area Express (MAX) BRT, which launched in 2004 but was discontinued in 2016. This system was unique in that optical guidance was used for station docking only and not general lane assist. For many years, the technology was deactivated due to poor reliability arising from the desert sun, dirt, grease and oil build-up on the road diminishing the pavement marking's contrast, despite the system stated to work even if just one-third of the stripes are visible. The third implementation (before Zhuzhou) has been in Castellón (Transporte Metropolitano de la Plana), which is an 8 km trolleybus route launched in 2008.

Figure 22: The TEOR optically-guided bus which has operated since 2001 in Rouen (Normandy, France)

Photo by Florian Fèvre, Mobilys, https://www.mobilys.net

So what is different this time round?

The present incarnation doing the rounds is admittedly a more advanced deployment of previous optical-guidance technologies. Led by Dr Feng Jianghua, the research arm of Chinese manufacturer CRRC[36] has used high speed rail technology (in particular, relating to the latest Fuxing series) to independently develop what it calls autonomous rail rapid transit or ART (智轨列车). The system is more akin to light rail than any of its predecessors. The vehicle dimensions are larger (2.65 m wide[37] by 3.4 m high), and can be lengthened or shortened by adding/removing sections from each consist. The vehicles (Figure 23) are electric, using supercapacitor batteries which are mounted on the roof and charged via a collector at stations only (which feature an electric 'umbrella'). This allows the vehicles to be 100% low floor (330 mm floor height), as opposed to low entry for most diesel fleets in Australia. Note that the supercapacitor technology is not new, and has been launched in Shanghai (buses), Nanjing (light rail), Guangzhou (light rail) and Ningbo (buses) over the past decade. Despite this, 'new energy buses' in China (including Shenzhen's 16,400 strong electric fleet—the largest in the world) has not taken up this technology, relying instead on traditional lithium-ion batteries.[38]

A major advantage of the CRRC system is its multi-axle hydraulic steering technology and bogie-type wheel arrangement which is designed with less overhang thus requiring less clearance in turns. On the Zhuzhou test track (and as an example for comparison), the vehicles require just 3.83 m of swept path clearance, as compared with 5.74 m for a standard rigid bus. Each section of the 32 m vehicle is around 10.5 m long, and a minimum turning radius of 15 m is required. The cost of deployment is said to be USD 7-15 million per kilometre, as compared with USD 20-30 million for light rail and USD 70-150 million for metro. Capital costs for each vehicle is USD 2.2 million.

Figure 23: CRRC's optically-guided bus (trackless tram) now operating in Zhuzhou (Hebei, China)

34 Most prominent being the Phileas bus, using guidance technology from FROG (Free Ranging On Grid) Navigation Systems.

35 A derivative called Cristallis was also offered which featured a different driver seating configuration to allow driver-operated fare collection.

36 CRRC is the world's largest rolling stock manufacturer, formed by the merger of CNR and CSR in 2015

37 Hence does not meet Australian 2.5 m width limit as specified by the NHVR.

38 Supercapacitor (or ultracapacitor) buses recharge rapidly, but store just 5% of the energy that lithium-ion batteries can, and are thus limited to around 5 km per charge plus suited only for very predictable routes with frequent stops.

Myth 2: Optically-guided bus offers improved ride quality.

This is true but to an extent only, and has as much to do with traction technology, route alignment and driver behaviour as it has with the optical-guidance variable. Ride quality is a direct result of rubber versus steel traction—think rubber-tyred metros compared with their steel counterparts. The track gauge (narrow, standard or broad) and axle loads (light or heavy) also determine the quality of ride on a railway. Another important factor is the alignment geometry. Light rail can handle only 4-6% gradients whilst rubber-tyred traction can reach 9%. A higher quality bus corridor with smoother gradients and curves will hence offer better ride quality. Pavement quality is another important factor which makes a marked difference to the ride experience.[39]

Optically-guided bus offers a much smoother ride, but this is primarily due to its advanced automation. It is true that the existing bus can be 'jerky', and this has a lot to do with buses getting more powerful (and lighter) over the years. An average bus engine generated 230 horsepower 20 years ago but today this can be up to 330 hp—important for uphill climbs but also allowing the driver (the opportunity) to accelerate quicker. One suggestion is to apply an acceleration limiter (perhaps more accurately the first derivative of acceleration or jerk limiter) in buses so as to limit the potential g-force experienced by passengers. The need for harsh braking is also an issue but linked to the level of bus priority afforded (i.e., traffic signals and traffic congestion) as well as driver training.

Myth 3: Optically-guided bus will be game changing for the provision of transport services and infrastructure.

Two issues with optical guidance technologies have not been considered in the present debate such as the Civis. These remain proprietary technologies so there are always huge risks when locked into a single supplier. Secondly, the technology remains unproven for snow, heavy rain and fog conditions—and environmental constraints can be quite problematic as proven in the Las Vegas case. The potential success of the technology, however, is not related to whether the buses are optically-guided or not (nor linked to any of the above described characteristics, for that matter).

The modern, sleek, rail-type appearance of these vehicles certainly appeals to the cultural and biological elements within us. There is the potential for optically-guided bus to challenge the age-old adage that "buses are boring, and trains are sexy" and what we term at ITLS as choice versus blind commitment in the bus and rail debate. The challenge always is to avoid being emotionally fixated on technology, but rather choosing the appropriate mode to meet a particular transport requirement. However, the core characteristics of transport service are 'invisible' to the customer—frequency, service span, travel time and connectivity. Running on the road, right-of-way quality remains the critical defining factor. What good is a 'trackless tram' if it continues to be stuck in traffic?

In car-dominated Australia, governments have struggled to reallocate road space away from inefficient private cars (averaging just 1.1 people per vehicle for journey-to-work) to spatially-efficient mass transit. Whenever bus priority is built, it usually arises from the widening of a road rather than any redesignation of existing road space.[40] As long as this mentality holds, we will struggle to improve the relativity of bus as compared with car—and this is the most important element for attracting users onto public transport.

That said, if 'trackless trams' can radically alter the political paradigm and garner the necessary support amongst the community for the sensible reallocation of road space including the provision of at-grade signal priority, then there exists a huge opportunity for the cost-effective deployment of high quality mass transit. After all, priority is the key to efficiency and urban amenity. ITLS research has shown there to be huge latent demand for public transport in the middle and outer suburbs of Australian capitals. We believe this to be where the technology holds its greatest potential, and can readily be deployed along cross-town and orbital strategic corridors presently serviced by (for example) Metrobus in Sydney and SmartBus in Melbourne. Time will tell whether 'trackless trams' can shift the conversation including altering the idea of permanence and fixed infrastructure from one synonymous with rail to the pressing issues of right-of-way quality and public transport priority.

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39 A prominent example of how pavement quality affects the ride may be found in Melbourne's Albert Park where roads are built with high specification concrete to accommodate the Australian Grand Prix.

40 Historically, the (incorrect) argument made for LRT has been that it does not take away from road capacity, but rather adds to public transport capacity.

13. Discussions

It is an unfortunate reality that bus-based investment has at times struggled to gain political traction in Australia. An example is Infrastructure Australia's national priority list (Infrastructure Australia, 2018a), which is dominated by road projects and urban rail (Brisbane Metro perhaps being the sole exception). Economic analysis has shown time and time again that BRT investment offers far greater value for money than LRT schemes, yet the notion of 'bus stigma' holds truer than ever. In popular media and culture, the bus is painted as a grimy last resort, not a first choice for the travelling public. It is up to academics and Industry to debunk the myths and advocate for sensible policymaking—to showcase the importance of bus as an underappreciated workhorse of our cities. The purpose of this report is to showcase the many BRT and BBS schemes (27 in total) in Australia and to perform some benchmarking (through a sophisticated normalisation process) so as to demonstrate their productivity as compared with regular route services in Australian capitals. The authors have established an evidence base with which to prosecute the value of investing to upgrade bus-based services in Australia.

BRT is not a revolutionary new technology, but a timeless geometric reality. Indeed, the origins of the BRT concept can be traced back to 1939 when the world's first exclusive bus lane was opened in Chicago (Deng and Nelson, 2011). Not being a 'technology', it has struggled to gain the same attention as emerging concepts such as autonomous vehicles, on demand buses and even shared electric scooters. NSW's *Future Transport 2056* strategy is a case in point where there is little recognition of how geometric realities such as right-of-way and transport corridors might limit the potential operation of future technologies (Transport for NSW, 2016). The philosophy of allocating public transport priority continues to be problematic. The conversation is always around building additional road space (through land acquisition or otherwise) to accommodate a bus lane rather than reallocating existing road space for the bus. What is important is the travel time relativity between private car and public transport that can attract users onto more sustainable, spatially-efficient modes. Government mentality continues to be on 'growing the pie' (with links to the concept of Pareto efficiency) and improving both roads and public transport—and so the **relativity** between modes remains unchanged and thus it is little wonder governments struggle to improve public transport mode share (which is almost a universally stated aim). What this does is buy a few more years of accommodation for growth. Not only must there be a far more optimal allocation of road space (with success breeding success), but also the need to incorporate a road pricing mechanism with inputs by time of day, geography and modal efficiency (including passengers per vehicle and proportion of time on the road network). The authors believe future developments such as mobility as a service (MaaS) offers immense opportunities to bring the entire transport system into equilibrium (Wong et al., 2017).

On the topic of relativity, railways with their usually dedicated alignment performs well because there exists not the same corridor competition. BRT even with dedicated carriageway often parallels an existing roadway and therefore relies solely on congestion to increase this relativity. Adelaide O-Bahn, Brisbane's busway (especially the Eastern busway to the University of Queensland's St Lucia campus) and to a lesser extent Sydney's Liverpool-Parramatta T-way are excellent examples of where this is not the case and so perform extremely well in terms of attracting modal shift. Another issue with BRT is the confusion between vehicle capacity and corridor capacity. It is well known that when implemented well BRT routinely offers throughput above 20,000 (and even up to 45,000) passengers per hour per direction—as is the case in many Latin American cities such as São Paulo, Porto Alegre, Bogotá and Curitiba (Hensher and Golob, 2008).

In terms of modal ideology, the preference for rail is driven by both cultural and biological factors. Ride quality is invariably better on a guided system where there is less lateral movement, although we have also explained how pavement quality and corridor geometry might also contribute to passenger experience. It is very much the case that public perception depends very much on their experience of bus and rail systems (Hensher et al., 2019a). ITLS research has shown that people with greater exposure to quality BRT systems (eg., residents in BRT-extensive cities) are more likely to support bus-based investment as compared with rail. Their preferences are conditioned based on experiences of vehicle amenity, network legibility and susceptibility to delays (see previous commentary on bus priority). It is also the case that rail networks are marketed better (simpler) whilst buses remain unnecessarily complicated. BBS and initiatives such as 'trackless trams' are a deliberate effort to make bus and tram feel as similar as possible, although some commentators argue that 'trackless trams' are not BRT—something we dispute if delivered at the Gold Standard (ITDP, 2014). Despite the additional cost and sacrificing operational flexibility (and this is a trade-off policymakers will have to evaluate), the authors have shown there to be great benefit to BBS which in many cases even outperforms BRT. This is despite many being marred in controversy from the outset and introduced only as a quick political fix.

Whilst our modelling has shown branding factors to rate marginally in terms of affecting travel choice, the authors believe there is still value, especially around frequent network branding and network simplification (Currie and Wallis, 2008). It is usually the case that 'hard' factors such as service span and frequency drive modal shift but once people become regular users it is the 'soft' factors which add value to retain patronage (Hensher et al., 2010). It remains a curiosity why BRT systems in Australia lack quality branding or BBS elements. The importance of branding cannot be understated given the complexity of many bus networks. In the same way that street directories (and online maps today) show a hierarchy of roads for different purposes (motorway, arterial, collector and local), frequency mapping can help communicate where all-day, turn-up-and-go services may be accessed. Especially in Sydney, there is a severe fragmentation of frequent network brands (and linked to different political persuasions when implemented) and so we call for a coordinated multimodal (bus and rail) approach for showing the spatial availability of frequent services across the metropolitan area. There are also enormous opportunities to extend this frequent network through clever scheduling (especially on corridors at contract boundaries) to improve effective frequency for zero additional cost (Wong, 2014)—easily implementable 'low-hanging fruit'.

Whilst this constitutes a comprehensive review and benchmark of all BRT and BBS systems in Australian capitals, there remains a number of opportunities for further empirical research. Supply-side constraints such as the costs of construction and ex-post cost-benefit analyses have not been considered, but these are difficult to do at scale and as a comparison. It is more readily conducted at the margin and so we suggest two key areas for future focus. The first revolves around understanding the secondary benefits of public transport priority (Currie and Sarvi, 2012). Whilst passenger travel time savings are well known and usually a key metric for road authorities implementing bus lanes and signal priority, what is less researched is its impact on operating costs, fleet resources, modal shift and even changes in land use. A better understanding has practical implications for future project appraisal. Secondly, it is important to understand the value uplift potential of bus-based projects. Rail is often hailed as transformative and there has been work done investigating the impact of BRT (Mulley and Tsai, 2017), but none so far for BBS incorporating the best branding elements of rail. This is an important research gap considering the potential of BBS to upgrade the image of the bus and as an ever more attractive alternative to fully-fledged BRT or rail-based schemes in an increasingly financially-constrained environment.

14. Recommendations

There are many findings in this report that we summarise as a set of recommendations for a progressive commitment to positioning bus-based services within the broader remit of government to provide value for money investment in public transport in our cities but also throughout Australia.

Fundamentally, the focus should be on the customer and giving them improved access to public transport, and this requires a recognition of the need to service all of metropolitan areas and not to focus on a few corridors that may deliver high patronage. Rail, in particular, is expensive, albeit popular, but typically is radial and directionally focussed on the central areas of cities (lacking circumferential service support). Changing land use is showing up significant gaps in public transport service levels that require cross-regional travel which is commonly serviced by the car due to the paucity of sufficiently attractive travel times provided by public transport. Greater frequency in localised corridors often carries the high risk of poor coverage and connectivity throughout an urban area creating disparities in equitable levels of public transport service provision. The great appeal of the bus is its flexibility in adjusting to changing demands for improved public transport and this is especially true where the opportunity exists to provide a dedicated corridor solution.

The need to find ways to make public transport more attractive in such settings suggests a greater role for bus, especially where it can be offered with significant bus priority. There is often a high amount of bus capacity in a metropolitan area but the great majority of that capacity has to compete every day with the car and other traffic in congested road settings. The call to 'solve' this by investing in more heavy rail (including metros) is a positive move but it is a very expensive one, and often ignores the possibility of a BRT or even BBS treatment as an initial first investment which may even have sufficient merit in time to continue as the preferred solution. The opportunity to deliver value for money for the taxpayers' dollar has never been so real, as the call for greater investment in transport infrastructure comes at a time of increasingly scarce funding, given demands on the budget from other sectors such as health and education.

This report has provided evidence of the patronage appeal of BRT and BBS in contrast to regular road-based public transport services. There are a number of key recommendations, reinforcing those made in the Bus Industry Confederation's Rapid Transit report (BIC, 2014), which we present as a synthesis from both reports.

Recommendation 1

In any assessment of future investment in public transport, the full range of public transport options should be assessed on a level playing field including the prospect of improving the service levels of existing services (which includes moving some existing regular bus services to BBS). This should be recognised through Infrastructure Australia and equivalent state organisations.

Recommendation 2

Greater visibility of bus services, approaching that of rail, should be a priority. While the patronage benefits have to be weighed up against the costs of upgrading public transport, the need for greater visibility of bus-based transport is clear and shown in this report as a significant contributor to potential patronage growth, after controlling for the environment within which the comparison of services are made.

Recommendation 3

Road-based rapid transit be delivered in small-scale forms and incrementally ramped up so as not to require a massive initial investment. These require minimal expenditure on physical and network infrastructure and include change of service measures, branded buses and priority measures for existing routes through to dedicated right-of-way, where practical, by reallocating existing road capacity.

Recommendation 4

There should be greater government and community support in recognition of roadbased rapid transit due to its wider range of service types and flexibility of operation that can uplift the community and social inclusion value of an entire public transport network.

Recommendation 5

Given that road-based rapid transit provides the flexibility to operate on a closed and/or open system, including the provision of similar operation and customer service characteristics of rail-based rapid transit, then it should always be assessed as an possible alternative to a rail solution, especially light rail, and the recent interest in 'trackless trams' offers an appealing setting within which to promote this initiative.

Recommendation 6

The secondary impacts (network effects) of public transport priority on congestion, infrastructure savings, mode choice, social inclusion and land use are not well understood and has been identified as a research gap requiring further study. There is also a need for a coordinated multimodal approach in the assessment of frequent (trunk) services across Australia through the development of a consistent national benchmarking methodology so as to place different modes, cities and operational paradigms on a level playing field in service assessment and project appraisal.

References

ACT GOVERNMENT 2012. Transport for Canberra: Transport for a Sustainable City 2012-2031. Canberra, Australia: Environment and Sustainable Development.

Bean, M. 2014. Photo. Accessed online: https://www.busesworldwide.org/material/galleries/763.jpg [24 May 2019]

BIC 2014. Rapid Transit—Investing in Australia's Transit Future. Canberra, Australia: Bus Industry Confederation.

BUSVIC 2018. Moving People Victoria: 10 Priorities for Victoria. Melbourne, Australia: Bus Association Victoria.

BYATT, M., OSCURO, G. & ROOKES, M. 2017. Improving efficiency: An evaluation of Sydney buses "Bondi Bendy" prepay service. 10th International Conference on Competition and Ownership in Land Passenger Transport (Thredbo 10). Hamilton Island, Australia.

CANBERRA LIBERALS 2016. Canberra's Transport Future for all Canberrans. Canberra, Australia.

CAPE, C. 2014. Photo. First Yorkshire Hyperlink ftr bus. CC BY 2.0. Accessed online: https://commons.wikimedia.org/wiki/File:First_Yorkshire_Hyperlink_ftr_bus,_15_February_2014_(02).jpg [11 July 2019]

CHARLES-EDWARDS, E., BELL, M. & CORCORAN, J. 2015. Greening the commute: Assessing the impact of the Eleanor Schonell 'Green' Bridge on travel to the University of Queensland, Australia. Urban Policy and Research, 33, 61-78.

CLIFTON, G., MULLEY, C., HO, L., HO, Q. C. & YEN, B. 2018. How the distribution of arrival times at a railway station varies with headway: A study using smart card data. Conference on Advanced Systems in Public Transport (CASPT) and TransitData 2018. Brisbane, Australia.

CLIFTON, G. T., MULLEY, C. & HENSHER, D. A. 2014. Bus rapid transit versus heavy rail in suburban Sydney—Comparing successive iterations of a proposed heavy rail line project to the pre-existing BRT network. Research in Transportation Economics, 48, 126-141.

CURRIE, G. 2006. Bus rapid transit in Australasia: Performance, lessons learned and futures. Journal of Public Transportation, 9, 1.

CURRIE, G. & DELBOSC, A. 2010. Bus rapid transit in Australasia: An update on progress. Built Environment, 36, 328-343.

CURRIE, G. & LAI, H. 2008. Intermittent and dynamic transit lanes: Melbourne, Australia, experience. Transportation Research Record: Journal of the Transportation Research Board, 49-56.

CURRIE, G. & SARVI, M. 2012. New model for secondary benefits of transit priority. Transportation Research Record: Journal of the Transportation Research Board, 63-71.

CURRIE, G. & WALLIS, I. 2008. Effective ways to grow urban bus markets—A synthesis of evidence. Journal of Transport Geography, 16, 419-429.

DENG, T. & NELSON, J. D. 2011. Recent developments in bus rapid transit: A review of the literature. Transport Reviews, 31, 69-96.

DEPARTMENT OF TRANSPORT 1978. North East Area Public Transport Review: Transportation Alternatives between Lower Portrush Road and the City of Adelaide. Adelaide, Australia.

DEPARTMENT OF TRANSPORT 1998. Action for Transport 2010: An Integrated Transport Plan for NSW. Sydney, Australia: NSW Government.

DEPARTMENT OF TRANSPORT 2011. Public Transport Plan for Perth in 2031. Perth, Australia.

DEVNEY, J. 2017. Changing perceptions of the bus with branded services. 34th Australasian Transport Research Forum (ATRF). Adelaide, Australia.

GOLDBERG, J. L. 1993. The F2 Castlereagh Expressway Affair: A Case for Reform of the NSW Roads and Traffic Authority. Urban Policy and Research, 11, 132-149.

GRAHAM, R. 1997. Review of ACTION's Services. Sydney: ACT Department of Urban Services.

HENSHER, D. A. 1999. A bus-based transitway or light rail? Continuing the saga on choice versus blind commitment. Road & Transport Research, 8, 3-21.

HENSHER, D. A., BALBONTIN, C., HO, C. & MULLEY, C. 2019a. Cross-cultural contrasts of preferences for bus rapid transit and light rail transit. Journal of Transport Economics and Policy, 53, 47-73.

HENSHER, D. A., ELLISON, R., HO, C. & WEISBROD, G. 2019b. How well does BRT perform in contrast to LRT? An Australian case study using MetroScan_TI. In: FERBRACHE, F. (ed.) *Developing Bus Rapid Transit: The Value of BRT in Urban Spaces.* Cheltenham, United Kingdom: Edward Elgar Publishing.

HENSHER, D. A. & GOLOB, T. F. 2008. Bus rapid transit systems: A comparative assessment. *Transportation,* 35, 501-518.

HENSHER, D. A., MULLEY, C. & YAHYA, N. 2010. Passenger experience with quality-enhanced bus service: The Tyne and Wear 'Superoute' services. Transportation, 37, 239-256.

HENSHER, D. A. & WATERS, W. G., II. 1994. Light rail and bus priority systems: Choice or blind commitment? *Research in Transportation Economics,* 3, 139-162.

HO, C. & MULLEY, C. 2014. Metrobuses in Sydney: How high capacity and high frequency services are benefiting the Metropolitan fringe. *Research in Transportation Economics,* 48, 339-348.

INFRASTRUCTURE AUSTRALIA 2018a. Infrastructure Priority List: Australian Infrastructure Plan. Canberra, Australia: Australian Government.

INFRASTRUCTURE AUSTRALIA 2018b. Project Evaluation Summary: Brisbane Metro. Canberra, Australia: Australian Government.

ITDP 2014. The BRT Standard. New York, United States: Institute for Transportation and Development Policy.

JAISWAL, S., BUNKER, J. & FERREIRA, L. 2010. Modeling bus lost time: Additional parameter influencing bus dwell time and station platform capacity at bus rapid transit station platform. 89th Transportation Research Board (TRB) Annual Meeting. Washington, D.C., United States.

KIM, M. 2014. Photo. Rapid, Branch, Trunk, Circulation. CC BY-SA 4.0. Accessed online: https://commons.wikimedia.org/w/index.php?curid=37028872 [11 July 2019]

LEVINSON, H. S., ZIMMERMAN, S., CLINGER, J., BAST, J., RUTHERFORD, S. & BRUHN, E. 2003. Bus rapid transit, Volume 2: Implementation guidelines. In: TRANSPORTATION RESEARCH BOARD (ed.) Transit Cooperative Research Program. Washington, D.C., United States.

LI, Z. & HENSHER, D. A. 2019. Performance contributors of bus rapid transit systems within the ITDP BRT standard: An ordered choice approach. *16th International Conference on Competition and Ownership in Land Passenger Transport (Thredbo 16).* Singapore.

LOADER, C. & STANLEY, J. 2009. Growing bus patronage and addressing transport disadvantage—The Melbourne experience. Transport Policy, 16, 106-114.

MEES, P. 2010. *Transport for Suburbia: Beyond the Automobile Age*, London, United Kingdom, Taylor & Francis.

MEES, P. 2011. Submission in Response to Transport for Canberra. Royal Melbourne Institute of Technology (RMIT).

MEES, P. 2012. Fifty years of public transport planning in Canberra. 35th Australasian Transport Research Forum (ATRF). Perth, Australia.

MRCAGNEY 2009. ACT Strategic Public Transport Network Plan: Final Report. ACT Government.

MRCAGNEY 2015. ACTION Expenditure Review. ACT Government.

MULLEY, C. & TSAI, C.-H. 2017. Impact of bus rapid transit on housing price and accessibility changes in Sydney: A repeat sales approach. *International Journal of Sustainable Transportation,* 11, 3-10.

NCDC 1976. Intertown Public Transport: Alternatives for Canberra. Canberra: National Capital Development Commission.

NIELSEN, G., NELSON, J., MULLEY, C., TEGNER, G., LIND, G. & LANGE, T. 2005. Public Transport—Planning the Networks. *Best Practice Guide 2.* Stavanger, Norway: HiTrans.

NSW AUDIT OFFICE 2005. Liverpool to Parramatta bus transitways. *Performance Audit.* Sydney, Australia: Audit Office of NSW.

PHILLIPS, D. 2006. An update on curb guided bus technology and deployment trends. Journal of Public Transportation, 9, 163-180.

PUBLIC TRANSPORT AUTHORITY. 2014. Case Study: 950 Superbus. Public Transport Authority Annual Report 2013-2014. Accessed online: http://www.pta.wa.gov.au/portals/0/annualreports/2014/content/operational/performance-report/spotlight-950-superbus.asp [9 July 2019]

PUND, G. & FLEMING, D. 1997. Planning and delivering effective bus services in a new residential area. *Australian Planner,* 34, 78-82.

ROGERS, L. 2002. O-Bahn Busway: Adelaide's Experience. *Transportation Research Record: Journal of the Transportation Research Board,* 1-5.

STANLEY, J. & WONG, Y. Z. 2016. Improving public transport service: Hobart—A corridors case study. *Moving People > Solutions for Policy Thinkers*. Canberra, Australia: Bus Industry Confederation.

STANLEY, J. K. 2010. Goal achievement with trusting partnerships at the tactical level. *Research in Transportation Economics,* 29, 99-105.

TRANSPORT FOR NSW 2013. Sydney's Bus Future: Simpler, Faster, Better Bus Services. *In*: NSW GOVERNMENT (ed.). Sydney.

TRANSPORT FOR NSW 2016. Future Transport Technology Roadmap. Sydney, Australia: NSW Government.

UNSWORTH, B. 2004. Review of Bus Services in New South Wales, Final Report. Sydney, Australia: NSW Ministry of Transport.

VICTORIAN GOVERNMENT 2008. The Victorian Transport Plan. Melbourne, Australia.

WALKER, J. 2008. Purpose-driven public transport: Creating a clear conversation about public transport goals. *Journal of Transport Geography,* 16, 436-442.

WALKER, J. 2010. *canberra: a new circulator network for the national core* [Online]. Human Transit. Available: http://www.humantransit.org/2010/11/canberra-a-new-circulator-network-for-the-national-core.html [Accessed 2 October 2014].

WALKER, J. 2012. *Human Transit: How Clearer Thinking about Public Transit can Enrich our Communities and our Lives, Washington,* D. C., United States, Island Press.

WONG, Y. Z. 2014. ACTION network review: A comparative study of Network 12 and Network 14. *Australian National Internships Library.* Canberra, Australia: Australian National University.

WONG, Y. Z. & HENSHER, D. A. 2018. The Thredbo story: A journey of competition and ownership in land passenger transport In Alexandersson, G., Hensher, D. A., & Steel, R. (Eds.), Competition and Ownership in Land Passenger Transport (Selected papers from the Thredbo 15 conference). *Research in Transportation Economics,* 69, 9-22.

WONG, Y. Z. & HENSHER, D. A. 2019. State of the Industry: Vital Statistics · Strategic Outlook. Canberra, Australia: Bus Industry Confederation.

WONG, Y. Z., HENSHER, D. A. & MULLEY, C. 2017. Emerging transport technologies and the modal efficiency framework: A case for mobility as a service (MaaS). *15th International Conference on Competition and Ownership in Land Passenger Transport (Thredbo 15).* Stockholm, Sweden.

Appendix: Included routes in each service cluster

City	Service cluster (Table 1)	Service cluster (Figures 1, 2 and 3)	Included routes
Sydney	T-way (Liverpool-Parramatta)		T80
	T-way (North-West)		S8, T60, T61, T62, T63, T64, T65, T66, T70, T71, T72, T74, T75, 602X, 607X, 613X, 616X, 617X, 619, 705, 706, 708, 711, 715, 740, 744, 745
	M2 Busway		M61, 602X, 607X, 610, 610X, 611, 612X, 613X, 614X, 615X, 616X, 617X, 618X, 619, 620N, 620X, 621, 622, 627, 628, 642, 642X, 650, 650X, 652X, 653, 740
	Metrobus (Phase 1)		M10, M20, M30, M40, M50
	Metrobus (Phase 2)	Metrobus (Phase 2)	M41, M52, M54, M60, M61, M90, M91, M92
		Metrobus (M61)	M61
	B-Line		B1
Melbourne	SmartBus (Original)	SmartBus (Original)	901, 902, 903
		SmartBus 703/900	703, 900
	SmartBus (Doncaster Area Rapid Transit)		905, 906, 907, 908
Brisbane	Bus Upgrade Zone (BUZ)	Bus Upgrade Zone (BUZ)	66, 100, 111, 120, 130, 140, 150, 180, 196, 199, 200, 222, 330, 333, 340, 345, 385, 412, 444, 555
		TransLink 66/111	66, 111
	CityGlider	Blue CityGlider	60
		Maroon CityGlider	61
	Great Circle Line		598/599
Perth	Central Area Transit (CAT)	Red CAT	1
		Blue CAT	2
		Yellow CAT	3
		Green CAT	5
	CircleRoute		998/999
	Transperth 950		950
Adelaide	O-Bahn		500, 501, 502, 502X, 503, 506, 507, 528, 530, 540, 541, 541X, 542X, 543X, 544, 544X, 545X, 546X, 548, 556, 557, 559, 578, C1, C1X, C2, C2X, J1, J2, M44, N502, N541, N542
Canberra	Rapid	Blue Rapid	300, 313, 314, 315, 316, 318, 319, 343 (weekend 300 trunk-only)
		Red Rapid	200, 251, 252, 254, 255, 259 (weekend 200 part-only)
		Black Rapid	250 (weekday-only)
		Green Rapid	6 (weekend 938)
		Xpresso	705, 712, 714, 717, 718, 719, 720, 725, 726, 732, 743, 744, 749, 765, 767, 783, 775, 791, 792 (weekday-only, peak-period peak-direction)

Solutions for Policy Thinkers Series

EXECUTIVE SUMMARY

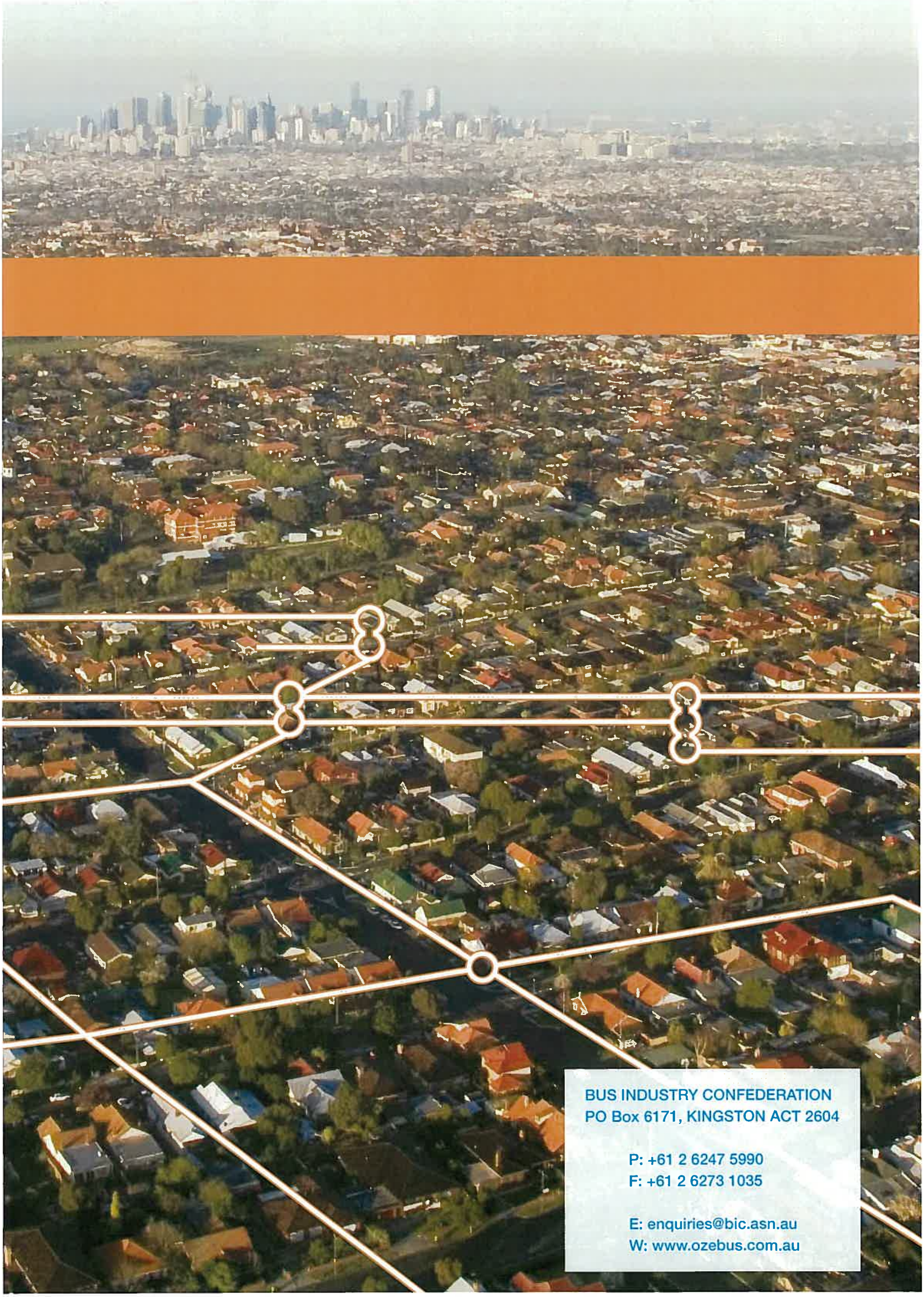
TITLE	SUMMARY DESCRIPTION
Policy Thinkers Series - 11 Published June 2019 **Moving People in the Future: Land passenger transport and "new" mobility technology**	This Paper explores socio-economic trends and their interaction with new technologies, largely by developing optimistic and pessimistic scenarios about how the future of land passenger transport might emerge in coming years. Policy measures to help ensure that emerging transport technologies are net contributors to social welfare are outlined, including transport pricing reform, urban land use/transport planning to promote more compact towns and cities and to slow urban sprawl, together with shared mobility contracts to support social inclusion from local transport.
Policy Thinkers Series - 10 Published - May 2018 **The value of getting there: mobility for stronger Australian regions**	Mobility is a fundamental requirement for well-functioning regions and for the wellbeing of their residents (and visitors). This Paper first examines the potential for agglomeration economies from mobility improvements in Australian regions, concluding that this prospect is most likely to be relevant for those regions with the largest urban centres (e.g. 200,000 population).
Policy Thinkers Series - 9 Published - June 2017 **Improved public transport services supporting city productivity growth: *an Australian city case study***	Australian cities are increasingly pursuing compact settlement. This paper explores the opportunities to use urban structure to promote productivity growth. It examines the contribution of population and employment density and travel times.
Policy Thinkers Series - 8 Published - August 2016 **Local government roles in C21 integrated land use transport planning**	This Policy Paper examines ways in which local government can support the major development directions and, based on the conclusions from the governance Policy Paper 6, be recognised as a vital partner in so doing. In this Paper we examine desirable development directions for our cities and regions, then explore local government roles in these directions, at both the strategic and local levels.
Policy Thinkers Series - 7 Published - April 2016 **National Guidelines: Bus Services Procurement and Bus Service Contracts**	The bus and coach industry has, for a long time, fostered relationships with academics, industry experts and government, to grow public transport services and patronage and to help develop contractual frameworks that support this growth. These connections and experience have been utilised in preparing the enclosed guidelines. These guidelines have been framed with public value uppermost in mind, while recognising the importance of a financially viable bus industry if quality bus services are to be provided on a sustainable basis for our communities.
Policy Thinkers Series - 6 Published - October 2015 **Governance for integrated urban land use transport policy and planning**	Australia is relatively unusual in having state governments responsible for (speaking for) capital cities. This role is more commonly associated with local government in some format. The difficulties Australian cities have in establishing and pursuing integrated strategic land use transport policy directions over time is partly a function of our adversarial political environment. This Paper looks at governance, with a particular focus on integrated governance in land use transport policy and planning and how it might be improved in Australian cities, to enable them to deliver better economic, social and environmental outcomes.
Policy Thinkers Series - 5 Published - October 2015 **Urban land use transport integration and the vital role for Australia's forgotten inner/middle suburbs**	Australia's capital cities are all seeking to achieve more compact settlement patterns, as an essential element for improving their long term sustainability. The inner/middle suburbs are vital to successful outcomes. This is where most urban Australians live and work. This paper examines how strategic land use transport policy in our major cities can be shaped to promote productivity growth and better share the benefits from this productivity growth more widely among city residents.
Policy Thinkers Series - 4 Published - March 2015 **Connecting Neighbourhoods: The 20 minute city**	A '20 minute city' is one in which most people are able to undertake most activities needed for a good life within a 20 minute walk, cycle or public transport trip from where they live. This Policy Paper puts forward that a neighbourhood structure embedded in a 20 minute city, with good local and regional transport choices, is likely to promote many positive outcomes in terms of personal and societal wellbeing, enhance liveability (which is already a strong international brand for our cities), as well as being cost effective to service and supportive of increased economic productivity. Flowon effects will include lower traffic congestion levels, improved health outcomes, lower accident costs, reduced emissions (greenhouse gases and air pollutants) and greater social inclusion.

TITLE	SUMMARY DESCRIPTION
Policy Thinkers Series - 3 Published - October 2014 **Public transport: funding growth in urban route services**	BIC's various *Moving People* publications have made the case for increasing the provision of public transport services in Australia's cities, both because of the benefits these deliver for service users but also, and perhaps more importantly, for the wider nationally significant economic, social and environmental benefits they deliver. A current Australian infrastructure backlog of about $150b had been estimated. Public transport forms an important part of this backlog.
Policy Thinkers Series - 2 Published - June 2014 **Sustainable transport in Australian cities: targeting vehicle kilometres of travel**	Overall urban densities in our cities need to increase by 50-100 per cent over the next 30-40 or so years, with allowance for local circumstances. This will enable greater availability of local services, including local public transport. Minimum density targets of about 35 people plus jobs per hectare should be adopted in land use/transport strategies/plans for our cities, to both support development of 20 minute neighbourhoods and provide an effective market for local and trunk public transport. This Paper takes a unique approach to understanding the challenges of Australian cities and the interrelationship between land use strategies and reducing vehicle kilometres travelled.
Policy Thinkers Series - 1 Published - March 2014 **Pricing opportunities for Australia: Paying our way in land transport**	Pricing is the hot button issue in the infrastructure and transport policy space. Paying our way for the use of our roads is the key to ensuring that infrastructure gets built when and where it is needed. The BIC supports the development of a comprehensive user pays system for all road users that is based on the costs of maintaining and building roads and externalities related to driving that will generate future revenue to fund infrastructure and pay for better public transport services.

Special Edition Policy Papers

EXECUTIVE SUMMARY

TITLE	SUMMARY DESCRIPTION
Published - April 2019 **Coach solutions for driving land transport tourism**	This Paper outlines a 10 year strategy policy for driving land transport tourism. There are 9 key areas that all levels of government and industry should adopt to increase travel by coach to generate dispersal of tourists from major cities and attractions to regional Australia and grow Australia's tourism economy.
Published - May 2018 **Australian Government's role in the development of cities**	Cities are becoming more complex and this poses challenges for policy and planning. Links between land use, transport, economic productivity, housing markets and social exclusion illustrate this complexity. Integrated governance is central to tackling such cross-cutting issues. Awareness of the importance and urgency of taking more integrated approaches to city strategic land use transport policy and planning is widespread and practice is generally improving. However, the rate of improvement in land use transport planning capability in Australia, and more broadly, is running ahead of improvements in governance (and funding arrangements).
Published - July 2016 **Improving public transport service: Hobart – A corridors case study**	Hobart faces more traffic congestion problems and slower public transport unless city planners make sensible land-use and transport decisions going forward. This report finds that Hobart is very low density and car dependent, and that structural changes in the economy were leading to the highest productivity jobs being located in central or inner parts of the city. The study also found that jobs were moving in at the same time as people were moving out for cheaper housing, and Hobart's fringe densities were as low as they went in Australian cities.
Published - March 2014 **Rapid Transit: investing in Australia's Transport Future**	This report has been developed as a result of the Bus Industry Confederation undertaking a two week Rapid Transit Study Visit of North America in August and September of 2012 and information collected by the BIC's internal research program. The report analyses the advantages of building Rapid Transit against benefits which can be achieved by simply improving existing transport networks, modal considerations notwithstanding.
Published - December 2012 **Moving People Solutions for a Liveable Australia**	This policy statement sees the BIC taking the lead in the national discussion on how we fund *moving people* infrastructure and services in the future. The aim of the report is to generate discussion about how Australia should shape its future land transport policy, to promote national goals for productivity, sustainability, liveability and social inclusion.



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