BusNSW Post Hearing Responses

Portfolio Committee No. 6 - Transport and the Arts
Inquiry into current and future public transport needs in Western Sydney

6 March 2024

Background

On 5 February 2024, BusNSW gave evidence to the Inquiry by NSW Senate Committee No. 6 – Transport and the Arts – into the current and future public transport needs in Western Sydney. BusNSW was represented during the hearing by BusNSW President, John King, and Executive Director, Matt Threlkeld.

Questions on Notice

During the Inquiry, BusNSW took a number of questions on notice; specifically:

QUESTION 1: "*Is there an impact if you increase bus services? Is there a nexus between the rise in patronage versus the increase in services? Is there some kind of established nexus there? If we expand the bus services across the whole network by 15 per cent is there likely to be a consequential knock-on in terms of increased patronage?*"

Response

BusNSW referred the questions asked by the Committee to Professor David Hensher, Founding Director of the *Institute of Transport and Logistics Studies* (ITLS) at the University of Sydney Business School. Professor Hensher is one of the foremost experts on transport and logistics in Australia.

Professor Hensher examined the issue utilising the University of Sydney's *MetroScan Transport Infrastructure System.* This is a strategic-level transport and land use planning application system that allows for the mapping of passenger and freight activity. Professor Hensher's detailed response is included as ***Appendix A.***

In summary, there is a clear and established connection between increasing bus services and growing patronage. For example, in a scenario where bus service frequency was increased by 15% in Western Sydney, mainly covering areas in both Parramatta and areas close to Parramatta, local bus ridership increased by 21.2% in the Parramatta area (equivalent to a direct elasticity of 1.4).

There is an even more significant increase during off-peak hours (outside 7am to 9am and 4pm to 6pm) with a 21.7% increase in bus ridership (equivalent to a 1.45 direct elasticity), compared to a lower elasticity during peak hours between 7am and 9am and 4pm to 6pm at 18.5% (equivalent of an elasticity of 1.23). This finding on the differences of peak and off-peak increase aligns with past research in a number of academic studies.

A more detailed description of these findings is provided in Professor Hensher's paper ***(Appendix A)***.

QUESTION 2: *"Can I ask about the rapid transit infrastructure? Obviously you make the point in your submission that this is more cost-effective, I suppose, then putting in a metro line or other forms of - how does it compare in terms of the capacity to move people at a lower cost? Do you have an ability to quantify the benefit, I suppose, of people moved per kilometre on a rapid transit bus route as opposed to a metro?*

Response

a. Comparing Capacity of Different Transport Modes

Below is a summary of the average passenger capacity per hour for various public transportation modes, including rapid bus routes. These figures are approximate and can vary depending on factors such as vehicle size, service frequency, station capacity, and passenger behaviour. Furthermore, peak hours and special events can greatly affect the actual number of passengers transported per hour on any public transport mode.

- **Bus**: Standard buses typically have a moderate capacity in terms of passengers per hour. Depending on factors such as the bus size, frequency of service, and route demand, a single bus route can typically transport anywhere from 500 to 2,000 passengers per hour.
- **Tram / Light Rail**: Trams or light rail systems generally have higher capacities compared to buses. With larger vehicles and higher frequency of service, tram systems can transport several thousand passengers per hour along a single route. The capacity can range from 2,000 to 10,000 passengers per hour depending on the specific system and route.
- **Metro / Subway**: Metro or subway systems typically have the highest passenger capacities per hour among public transport modes. Metro trains consist of multiple carriages and operate at high frequencies during peak times, allowing them to transport tens of thousands of passengers per hour along a single route. Capacities can range from 10,000 to 50,000 passengers per hour or more, depending on the size of the system and the level of demand.
- **Rapid Bus Routes**: Rapid bus routes, while not as high capacity as tram or metro systems, can still carry a significant number of passengers per hour. Depending on factors such as vehicle size, frequency of service, and route demand, rapid bus routes can transport anywhere from 1,000 to 5,000 passengers per hour along a single route.

b. Cost of a Rapid Bus Service versus Metro

The difference in cost between a Rapid Bus Service and Metro is most evident in the capital expenditure required upfront to get a service up and running. The current estimates for the Sydney metro network forecast at $63.8 billion for 113km of new metro rail, equating to an average of $564 million/km.

The NSW Bus Industry Taskforce's Second Report proposed 40 bus rapid bus service routes and states that *"Buses represent high bang for the public dollar. The forty-year vision for a Sydney-wide network of rapid bus services is estimated to cost $10 billion. That is less than a quarter of the cost of one metro and would meet the transport needs of significantly more people across the entire metropolis."*

Aside from comparing capital investment, operational expenses, and capacity, it's essential to assess the most suitable transportation mode *for the needs of Western Sydney*. While rail is better suited for concentrated corridors with high ridership, such as urban centres, buses are ideal for serving geographically dispersed areas such as those found in the Sydney's West and provide the flexibility that they can grow and change in line with community needs.

QUESTION 3: *"Do you have a map of routes that are amenable to conversion to rapid transit for western Sydney?" "Is there an aspiration in terms of where you would like to see rapid transit? If you have that, if you could provide that to the Committee it would be useful. Is there a top three or four routes you think should be top of the list in terms of prioritisation by the government?"*

Response

In late 2023, Transport for NSW released the *On Street Transit White Paper*, which identifies 39 routes that could potentially be converted to rapid bus routes. A map of these routes is attached **(*Appendix B*)**.

BusNSW agrees with the need for TfNSW to implement some "quick wins" in relation to rapid bus routes, particularly the upgrading of existing T-ways, and connecting these to new links.

BusNSW supports the following potential rapid bus routes included in the Whitepaper and consider these should be prioritised by the NSW Government:

- Western Sydney City Deal Rapid Buses
- Upgrade T-Ways to new standard
- Campbelltown to Liverpool
- St Marys to Rouse Hill

QUESTION 4: *"How quickly is the government able to implement a rapid transit approach? What's the rough time frame - a couple of years, three years, five years? How long does it take to put the infrastructure in – "*

Rapid bus routes are quicker to implement compared to metro rail lines for several reasons. Building bus lanes, interchanges , and other infrastructure components is often less complex and can be completed more quickly than digging tunnels, laying tracks, and constructing stations. Typically, this then also leads to a lower environmental impact during construction. It should also be noted that rapid bus routes often allow for staged implementation and quicker deployment of initial services which can assist meeting immediate demand and the longer-term shift to public transport.

To establish an accurate timeframe, there is a need to consider:

- **Planning and Feasibility Study:** Evaluation of factors such as existing traffic patterns, population density, projected ridership, potential route options, and available infrastructure. Stakeholder input, from local governments, operators, and community groups, is an essential part of this study.
- **Route Selection and Design:** Following the feasibility study, a suitable route for the rapid bus corridor is selected, prioritizing key destinations, minimal travel time, and accessibility for passengers. Factors such as existing road conditions, traffic congestion, and potential impacts on other modes of transportation also need to be considered. The design phase includes determining station locations, bus stops, and infrastructure requirements such as dedicated bus lanes, boarding platforms, and signal prioritisation.
- **Required Infrastructure Upgrades:** Depending on the existing infrastructure and the requirements of the rapid bus route, upgrades may be necessary. This can include the

construction of dedicated bus lanes, bus shelters, boarding platforms, intersection improvements, and traffic signal prioritisation.

- **Bus Fleet and Operations:** Generally, the procurement of buses is straightforward given there is a well-established process. Operationally, we acknowledge that the current environment is making the recruitment of new drivers somewhat difficult (refer to Supplementary Question). Other considerations such as scheduling, frequency of service, fare collection, and integration with existing transit networks also need to be addressed.
- **Public Engagement and Outreach:** Public engagement and outreach are vital throughout the planning and implementation process to gather feedback, address concerns, and build support for the rapid bus route. This can involve public meetings, surveys, and events to inform stakeholders and solicit input from the community.
- **Regulatory Approvals and Funding:** Obtaining necessary regulatory approvals and securing funding are critical steps in establishing a rapid bus route. This may involve coordination with local and state government agencies, as well as securing funding.
- **Implementation and Launch:** Once all planning, design, infrastructure upgrades, and operational arrangements are in place, the rapid bus route can be implemented and launched. This involves finalising schedules, training staff, installing signage, conducting public awareness campaigns, and officially opening the service.

Overall setting up a rapid bus route requires a comprehensive approach that considers various factors such as infrastructure, bus priority measures, stakeholder engagement, regulatory requirements, and funding. Effective planning, coordination, and collaboration among all stakeholders are essential to the successful implementation of a rapid bus route.

Supplementary Question

In addition to the question on notice, BusNSW was asked the following supplementary question by the Committee:

"With reference to the challenges and potential solutions for scaling up bus services in Western Sydney you discussed, including driver shortages and the need for more bus depots, what immediate actions do you suggest Transport for NSW should take to address these issues and enhance bus service reliability and coverage in the region?"

Response

The current lack of bus services in Western Sydney is an issue caused by a confluence of events. The solution to the problem therefore requires a multi-faceted response.

1. ***Funding for Bus Services***

   During the 2021-22 financial year, buses carried more than 157 million passengers. This represents approximately 44% of total public transport patronage. However, currently, buses receive only 15% of transport funding and around 2% of capital investment. Moreover, funding for buses has not increased in the past decade. This will need to change if TfNSW are to enhance bus service reliability and coverage in Western Sydney.

   Depending on the area, numerous local bus routes operate regularly throughout the day, typically running from early morning until late evening seven days a week. Generally, these routes run every 30-60 minutes, with increased frequency during peak hours. Some areas boast even higher frequencies, with buses arriving every 15-20 minutes. These routes often serve as the sole transportation option for specific neighbourhoods or suburbs. However, in certain parts of Western Sydney, some local routes may only run every two hours or less and may not operate during evenings or weekends.

Furthermore, many bus services, particularly in Western Sydney, inadequately accommodate shift workers and those engaged in the nighttime economy. While weekday early morning bus services are relatively sufficient, services during the night and on weekends are either minimal or non-existent.

BusNSW advocates for the necessity of establishing a fully integrated public transport network for Western Sydney. This region currently has limited public transportation options, with private cars being the dominant mode of transport. Until a viable alternative is developed, private cars are likely to remain the primary means of transportation.

BusNSW recommends that TfNSW develop a *Medium Term Bus Plan* that provides a pipeline for government investment in bus services. This investment needs to be commensurate with the sizable proportion of patronage carried by buses. Funding should be directed towards areas of Sydney where public transport options are poor, and there should be a correlation between population growth/density changes and an increase in bus services in Western Sydney.

In the Second Report of the NSW Bus Industry Taskforce, which was released in February 2024, it was recommended that funding be provided in the short term for high priority service improvements to repair the neglect in funding over the past decade. This included $194 million of recurrent operational funding and $909 million in capital funding (bus priority, fleet and depots) over three years for services in Sydney. BusNSW supports this recommendation, particularly for funding to support high priority service improvements in Western Sydney.

2. ***Bus Infrastructure***

Beyond bus services, infrastructure for buses in Sydney is sorely needed. BusNSW recommends funding for improvements to existing depots and the construction of new depots, which will enable the smooth transition to zero emission buses, particularly in Western Sydney. Improvements are also needed for transport interchanges and driver layover areas (including toilets) to improve driver conditions and encourage new entrants to the industry.

In the Second Report of the NSW Bus Industry Taskforce, it recommended that TfNSW develop a State-wide *Medium Term Bus Plan* and Program Business Case, outlining the medium term priorities and pipeline for investment for bus services and infrastructure. The preliminary shortlisted service upgrades over 10 years are estimated to cost $645 million per annum and approximately $3.03 billion of total capital costs (on an undiscounted basis) for bus priority, new ZEB fleet, and new ZEB depots. BusNSW supports this recommendation, with a focus on bus infrastructure investment in Western Sydney.

Furthermore, the Taskforce recommended that TfNSW review bus-related infrastructure programs to ensure funding is adequate to meet current needs and to allow for development activities (i.e. planning, design, business cases, etc.) for investment decisions to deliver the *Medium Term Bus Plan*. BusNSW supports bus-related infrastructure programs for Western Sydney.

The Taskforce also recommended that TfNSW consider how to elevate the needs of bus passengers in all infrastructure programs, from strategy through planning and delivery. This includes providing stronger direction for realising bus improvement outcomes and using best practice methodologies for bus infrastructure planning and development. BusNSW believes there are opportunities for TfNSW to improve bus infrastructure planning and development in Western Sydney.

3. *Driver Recruitment and Retention*

The bus industry has one of the oldest workforces in Australia. In NSW, the average age for bus drivers is 57 years of age. Unsurprisingly, many of these drivers are now retiring from the industry, however there is simply no cohort of younger employees coming through to replace them. This has resulted in staff shortages and impacted services, particularly in Sydney.

Part of the reason for this is the view among younger Australians of bus driving as a "low value" occupation and the perceived lack of a career path within the industry. While TfNSW has implemented a number of measures to address this situation, more needs to be done. BusNSW recommends that TfNSW:

- Develop a training pathway commensurate with wage increases for NSW bus drivers.
- Implement a campaign to encourage the travelling public to treat drivers with courtesy and respect.
- Improve driver facilities at bus layovers and driver interchanges (refer above).

Regarding the shortage of drivers, despite the immediate and essential efforts to streamline regulations and launch recruitment advertising campaigns, the desired results have not been achieved, as driver vacancies still exist. TfNSW and operators must explore further strategies to attract and retain drivers in order to expedite the reduction of the shortage. Urgent action is imperative in this matter.

4. *Bus Depots*

Bus depots play a crucial role in ensuring the effective provision of bus services. Positioned strategically, they facilitate planned service delivery, thereby enhancing both cost-effectiveness and service quality for the community.

While some planning has occurred for the transition to a Zero Emission Bus (ZEB) system, there is currently no overarching strategy integrating this transition with depot capacity requirements for service enhancements. A comprehensive strategy is needed to assess both current and future depot needs, including layover facilities, while considering associated costs and benefits.

The Taskforce recognizes the investment commitment for a new depot at Macquarie Park under the ZEB Tranche 1 business case. Additionally, funding has been allocated to secure land for a future ZEB Depot as part of the Western Sydney Rapid Bus network, linking Penrith, Liverpool, and Campbelltown to the forthcoming Western Sydney International Airport. Despite these investments, the Taskforce has not identified a long-term strategic depot plan.

The Taskforce's Second Report has recommended that TfNSW immediately commence the development of a *Long-Term Depot Strategy* for Sydney to inform itself of the required locations and access needed to optimise service delivery and costs. This strategy should consider the needs of Western Sydney.

5. ***TfNSW Zero Emission Bus Program.***

   In June 2022, the then Government made a significant announcement, expressing its commitment to transitioning the entire bus fleet of the State to zero emissions. Subsequently, in December 2022, it further approved a substantial $3 billion budget to facilitate the implementation of *Zero Emission Buses* (ZEBs) along with the necessary charging infrastructure. This initiative was designed not only to foster environmental sustainability but also to stimulate the local economy by generating employment opportunities in bus manufacturing sectors.

   The transition plan outlines a timeline for the adoption of ZEBs across different regions. It targets completion in Greater Sydney by 2035, in Outer Metropolitan Regions by 2040, and in Regional NSW by 2047.

   BusNSW advocates for TfNSW to reassess the allocation of the initial 1200 Tranche 1 ZEBs and 500 Business As Usual (BAU) ZEBs. The objective is to promote a fairer distribution of this innovative technology, with a particular focus on extending its advantages to Western Sydney. Such a deliberate redistribution strategy would not only foster environmental sustainability but also improve public transportation accessibility and fairness throughout the region.

The link between Service Frequency and patronage

David Hensher, Edward Wei, Wen Liu and John Nelson
Institute of Transport and Logistics Studies,
The University of Sydney Business School, Australia

March 7, 2024

Background

It is often asserted that what makes a bus service attractive is its ability to deliver on frequency, connectivity, and visibility. While frequency, or more specifically service frequency, is extensively studies in many papers, we found a lack of a single source that could be used to respond to a request made at the NSW bus inquiry on the relationship between service frequency improvements and bus patronage growth. At the recent hearing into current and future public transport needs in Western Sydney, the following question was asked:

> *"Is there an impact if you increase the services? Is there a nexus between the rise in patronage versus the increase in services? Is there some kind of established nexus there? If we expand the bus services across the whole network by 15 per cent is there likely to be a consequential knock-on in terms of increased patronage?"*

In responding to this request, we address it as follows. First, if we increase bus services in Western Sydney alone, what will be the likely increase in bus patronage? Second, if we increase bus services across the whole of the Greater Sydney Metropolitan Area (GSMA) on the current bus network, what will be the likely impact?

Before providing the local evidence, we review some key past research on the impact of bus frequency on patronage growth. We then summarise the evidence from past research together with new scenario tests undertaken using MetroScan (Hensher et al. 2020 and Appendix herein) for local bus frequency increases in Western Sydney followed by scenario test results for the Greater Sydney Metropolitan Area (GSMA) bus network.

Past research on the impact of bus service frequency on bus ridership

This section covers past research on bus service frequency on bus ridership with a focus on direct elasticity evidence. *Direct elasticities* signify the percent change in ridership that results from a 1% change in bus service frequency, *ceteris paribus*. The elasticity of bus service frequency can vary depending on location and different scenarios. Other influencing factors can include the country and city where the bus network is located, existing transport usage and behaviour, and urban design. On the supply side, for areas with high bus service levels (as in the areas of Sydney closer to the Central Business District (CBD)), the patronage response to an increase in bus service frequency can be less than that for areas with a lower level of bus service. Paulley et al. (2006) suggest that the elasticity of service frequency is higher in the long run and for off-peak hours. Brechan (2017) points out that service frequency elasticity has more variation than bus fare elasticity.

In a study using bus service data in several US cities from 2012 to 2018, Berrebi et al. (2021) found that bus ridership is inelastic to service frequency changes with an elasticity range of 0.62 to 0.78 for weekday ridership. This is also the case in other studies. For example, in a small-scale survey of 100 respondents in Norway, Brechan (2017) found the direct elasticity effect for bus frequency on ridership is 0.6. Hence a 10% increase in service frequency results in a 6% increase in patronage, *ceteris paribus*. Higher direct elasticities of 1.1 to 1.2 have also been reported for bus in the past (Taylor et al. 2009), but most past studies on this topic show a sirect elasticity lower than 1 (i.e., relatively inelastic).

Accessing the ITLSW data base on elasticities[1] eighteen different studies shows that the elasticity of bus service frequency is between 0.5 and 0.7, with the lower elasticity for all times of day (0.575), and higher one for peak hours (0.66), as shown in Table 1.

Table 1 Direct Elasticity of bus service levels from past literature review by ITLS

		Sample Size	Average	Std Dev
Frequency				
Bus	All times of day	18 studies	0.575	0.491
	Bus peak	14 studies	0.660	0.523

What this says is that if we increase service frequency across all times of day by 10%, we will get a 5.75% increase in bus patronage, similar to the Norwegian evidence in Brechan (2017).

Todd Litman of the Victoria Transport Policy Institute reviewed past research and discussed transit fare and service elasticities in 2023[2]. According to Litman, "The elasticity of transit service expansion (routes into new areas) is typically 0.6 to 1.0, meaning that each 1% of additional transit vehicle-miles or vehicle-hours increases ridership 0.6-1.0%, *ceteris paribus*, although much lower and higher response rates are also found (from less than 0.3 to more than 1.0)." (p12). Litman has also noted some lower elasticities; for example, for a 100% increase of peak-period feeder buses, only 29% increase occurred in ridership (Fehr & Peers 2004).[3]

Daniels and Mulley (2012) have shown how the bus frequency, bus ridership and bus network coverage trade off in public transport service provision can be approached by loading up kms/hrs on better used trunk routes and using freed up kms/hrs to provide coverage through a more flexible system, commonly involving smaller vehicles and, sometimes, different (cheaper) drivers.

Following, Ho and Mulley (2014) examined capacity and frequency of Metrobuses in Sydney to identify the impact on Metrobus ridership changes. The statistical evidence in their study shows that the service level increase for Metrobus is more elastic, in a range of 0.6 to 1 level for growing patronage in Metropolitan fringe areas where the service level was relatively low. However, the same cannot be said for inner areas where the total boarding rate along the Metrobus corridor is already at a high level, and hence the response to service frequency increase is weaker with a resultant lower direct elasticity.

Hensher and Li (2012) studied ridership drivers of bus rapid transit (BRT) across a large number of countries and estimated a mean headway elasticity of -0.294. This headway elasticity is equivalent to a service frequency per hour (=60/headway) elasticity of 0.299. This means that a 100% increase in BRT frequency would increase BRT ridership by about 30%. Similarly, Alam et al. (2018) studied travel demand by bus using data covering the US Metropolitan Statistical Area Level and found a direct elasticity for average headway of -0.227 for bus, equivalent to a service frequency per hour elasticity of about 0.26 on ridership. Daldoul et al. (2016) argue that the elasticity for bus service quality can be

[1] Drawn from an extensive data base that ITLS has on the many direct and cross elasticities in the transport sector.
[2] https://www.vtpi.org/tranelas.pdf
[3] Fehr & Peers (2004), Direct Ridership Forecasting: Out of the Black Box, Fehr & Peers (www.fehrandpeers.com).

summed up in the direct elasticity of service frequency, being lower at about 0.2 in the short-run and higher in the long run at about 0.4.

In summary, the direct elasticity of bus service frequency can range from 0.2 to 0.7, with many studies noting the range of 0.6 to 0.7. However, the actual elasticity response is very much dependent on the services and areas involved. Past studies have revealed a lower direct elasticity in the range of 0.2 to 0.4. The variation in elasticity reflects the differences in many factors that have impacts on bus ridership.

If the existing bus service level is already at a high level (i.e., high bus frequency), the impact of increasing service frequency will not be as great as expected (hence at the lower level in the range of the estimated elasticities). If the bus service level is not frequent, service frequency change will make bigger difference on patronage, holding all other changes fixed.

Research on the impact of changing bus frequencies in Western Sydney

Stanley et al. (2022) showed that if we doubled bus services in Middle and Outer Western Sydney (e.g., areas such as Paramatta and Penrith), this will increase bus patronage across whole GSMA bus network by 15% and 23% for 2023 and 2033, respectively (195 million trips to 224 million bus trips in 2023, and 234 million bus trips to 288 million bus trips in 2033) (see Table 2).

Table 2 The Impact on mode trips in the GSMA with a doubling of bus services in the Middle and Outer Western Sydney (in million trips) (Stanley et al., 2022)

	Year	Base Value	Project Value	Percent (%)
Bus travel (million trips)	2023	195	224	14.9
Bus travel (million trips)	2033	234	288	23.4

If there is a 15% increase, based on the Stanley et al. study, we would predict a 3.5 to 4% increase in patronage across the whole of the GSMA network if we follow a stable (linear) direct elasticity, but there is likely to be a greater increase in patronage locally because most of the increase will occur locally (suggested to be around 0.6). These results are obtained from MetroScan (see Appendix), the integrated transport and location strategic model system developed by ITLS (Hensher et al. (2020)).

To further examine the local impact on the Western Sydney bus network, if we increase bus service frequency only in local areas, as tested in MetroScan, a scenario with a 15% increase of bus service frequency in Western Sydney, mainly covering areas in both Parramatta and areas close to Parramatta, found a more substantial local bus ridership increase of 21.2% in the Parramatta area (equivalent to a direct elasticity of 1.4).

Moreover, there is an even more significant increase during off-peak hours (outside 7 am to 9am and 4 pm to 6pm), with a 21.7% increase in bus ridership (equivalent to a 1.45 direct elasticity), compared to a lower elasticity during peak hours between 7 am and 9 am and 4 pm to 6 pm at 18.5% (equivalent of an elasticity of 1.23). This finding on the differences between the peak and off-peak increase aligns with past research by Paulley et al. (2006). The larger impact in outer metropolitan areas echoes Ho and Mulley's findings (2014).

Research on the impact of changing bus frequencies in the GSMA using MetroScan

For the GSMA network, we tested two scenarios:

- Increasing bus service frequency of the GSMA bus network by 15% in 2024, with no further increase in the following years; and

- Increasing bus service frequency of the GSMA bus network by 10% in 2024, with no further increase in the following years.

The current version of the MetroScan system (Appendix) used in the new scenarios, incorporates research undertaken in 2022 and 2023 on the transition to electric cars (Hensher et al. 2021) and work-from-home (WFH) (Hensher et al. 2023) penetration in different location, so it is a later version compared to the system applied when the study by Stanley et al. (2022) was undertaken.

As shown in Table 3, an increase in bus service frequency of 15% is predicted to increase bus ridership by 3.5% to 3.7% from 2024 to 2033. This is equivalent to a direct elasticity of bus demand of 0.24. A 10% increase in bus frequency is predicted to increase bus patronage by 2.43%.

Given that a large part of the bus network in the GSMA exists in the well-serviced inner-city areas, the response is less elastic than increasing service levels with a focus only on metropolitan fringes (e.g., Ho & Mulley 2014).

Table 3 The Impact on bus trips in GSMA with doubling of bus services in the Middle and Outer Western Sydney (in million trips)

		15% bus service frequency Increase of bus network in GSMA		10% bus service frequency Increase of bus network in GSMA	
Year	**Base Scenario Annual Bus Trips (in mil)**	**Scenario Annual Bus Trips (in mil)**	**% increase**	**Scenario Annual Bus Trips (in mil)**	**% increase**
2024	186.7	193.2	**3.482%**	191.2	**2.410%**
2025	190.0	196.7	**3.526%**	194.6	**2.421%**
2026	194.0	201.0	**3.608%**	198.7	**2.423%**
2027	198.1	205.2	**3.584%**	202.9	**2.423%**
2028	202.2	209.6	**3.660%**	207.1	**2.423%**
2029	206.4	214.0	**3.682%**	211.5	**2.471%**
2030	210.8	218.5	**3.653%**	215.9	**2.419%**
2031	215.2	223.1	**3.671%**	220.4	**2.416%**
2032	219.1	227.2	**3.697%**	224.4	**2.419%**
2033	223.1	231.4	**3.720%**	228.5	**2.420%**

Concluding Comment

These findings are a reminder of the important role of the bus in metropolitan and suburban areas. It is in the urban context that the bus most obviously fulfils its role as the "workhorse" of passenger movement (Olyslagers et al., 2021). Buses generally form a small percentage of the total volume of vehicles on a carriageway but they have the ability to carry most of the people travelling. With good design, it is possible to exceed the carrying capacity of some rail-based alternatives. Table 4 (Zhang 2009) provides a reference of transit line capacities under design conditions with BRT based on a maximum frequency of 120-300 transit units / hour, compared to the 51-72 achieved by a standard bus and the 24-48 achieved by LRT. In reality, the capacities of these transit systems vary dramatically because of such factors as operational techniques, depot constraints, demand for public transport, and road conditions.

As Western Sydney continue to expand, the findings in this paper will be relevant when considering the public transport requirements of greenfield estates.

Table 4 Line capacity of main modes of public transport

Mode	Vehicle Dimensions (length × width m)	Transit Unit Capacity (seat + standing spaces)	Minimum Headway (s)	Maximum Frequency (transit units per hour)	Line Capacity
Standard bus	12.00 × 2.50	75	70–50	51–72	3,800–5,400
Articulated bus	18.00 × 2.5	120	80–60	45–60	5,400–7,200
High-capacity bus (BRT)	22.00 × 2.50	160	30–12	120–300	9,000–30,000
LRT (partially separated ROW)	24.00 × 2.65	3 × 170 = 510 or 2 × 280 = 560	150–75	24–48	12,200–26,900
MRT	21.00 × 3.15	10 × 240 = 2,400	150–120	24–30	67,200–72,000

References

Alam, H. Nixon and Q. Zhang (2018) Factors Affecting Travel Demand by Bus: An Empirical Analysis at U.S. Metropolitan Statistical Area Level*, Transportation Research Record, Vol. 2672, Issue 8, pp 817-826.*

Berrebi, S.J., S. Joshi and K. E. Watkins (2021), On bus ridership and frequency, *Transportation Research Part A*, 148, pp140–154.

Brechan, I. (2017), Effect of Price Reduction and Increased Service Frequency on Public Transport Travel, *Journal of Public Transportation*, Vol. 20, No. 1 (http://scholarcommons.usf.edu/jpt); at http://scholarcommons.usf.edu/jpt/vol20/iss1/8.

Daniels, R. and C. Mulley (2012) Planning Public Transport Networks—The Neglected Influence of Topography*, The University of Sydney, Journal of Public Transportation, Vol. 15, No. 4, 2012.*

Daldoul, M., S. Jarboui and A. Dakhlaoui (2016) Public transport demand: dynamic panel model analysis, Transportation, Vol. 43, pp 491-505.

Hensher, D.A. and Z. Li (2012) Ridership drivers of bus rapid transit system*, Transportation, Vol. 39 (6), pp 1209-1221.*

Hensher, D.A., Ho, C., Ellison, R., Liu, W., Wu, E., Schroeckenthaler, K., Cutler, D. and Weisbrod, G. (2020) MetroScan: A quick scan appraisal capability to identify value adding sustainable transport initiatives, invited paper for *Sustainability* special issue, Transport Systems for Sustainability: Policy, Planning & Exploitation, guest edited by Rosario Macario & Vasco Reis. https://www.mdpi.com/journal/sustainability/special_issues/transport_systems

Hensher, D.A., Wei, E. and Liu, W. (2021) Battery Electric Vehicles in Cities: Measurement of some impacts on traffic and government revenue recovery, *Journal of Transport Geography,* 94, 103121.

Hensher, D.A., Wei, E, and Liu, W. (2023) Accounting for the spatial incidence of working from home in MetroScan - an integrated transport and land model system, *Transportation Research Part A (* See also and early version: https://ses.library.usyd.edu.au/handle/2123/27127), 173, 103793.

Ho,C. and C. Mulley (2014), Metrobuses in Sydney: How high capacity and high frequency services are benefiting the Metropolitan fringe*, Research in Transport Economics,* Vol. 48, pp.339-348.

Olyslagers, F., Mulley, C., Nelson, J.D (2021). Bus: From workhorse to thoroughbred. In C. Mulley, J.D. Nelson and S. Ison (Eds.), The Routledge Handbook of Public Transport (pp. 171–185). Abingdon: Routledge.

Paulley, N.R., R. Balcombe, R. Mackett, H. Titheridge, J. Preston, M. Wardman, J. Shires, and P. White (2006). The Demand for Public Transport: The Effect of Fares, Quality of Service, Income and Car Ownership. *Transport Policy*, 13, pp 295-306.

Stanley, J., D. A. Hensher, E. Wei and W. Liu (2022) Major urban transport expenditure initiatives: where are the returns likely to be strongest and how significant is social exclusion in making the case. *Research in Transport Business and Management*, 43, 100731

Taylor, B.D., D. Miller, H. Iseki and C. Fink (2009) Nature and/or nurture? Analyzing the determinants of transit ridership across US urbanized areas*, Transportation Research Part A, Vol. 43, pp 60-77*.

Zhang, M. (2009) Bus versus rail meta-analysis of cost characteristics, carrying capacities, and land use impacts, *Transportation Research Record*, No. 2110, pp. 87–95.

Appendix

The MetroScan Structure

One of the most important features of comprehensive land use and transport planning is an ability to identify candidate projects and policies that are adding value to the sustainable performance of transport networks and to the economy as a whole. There is a case to be made for having a capability to undertake, in a timely manner, a scan of a large number of potentially worthy projects and policies that can offer forecasts of passenger and freight demand, benefit–costs ratios and economy-wide outcomes. Such a framework would then be meaningful in the sense of offering outputs that are similar to those that are the focus of assessments that are typically spread over many months, if not years, on very few projects, which may exclude those which have the greatest merit. We named the system MetroScan Transport Infrastructure, or MetroScan for short. MetroScan, a strategic-level transport and land use planning application system allows for mapping of passenger and freight activity, as well as an endogenous treatment of the location of households and firms. In short, MetroScan is all-in-one forecasting and scanning system enabling us to conduct quick forecasting on the demand characteristics for cars, public transport, freight activities, and many other travel demand characteristics.

Figure 1 shows how the macro generator works by taking inputs from existing transport models, such as the road and public transport network, and any OD matrices for the starting year to be used as a base, then uses the network travel times and distances by time of day. Characteristics of households, such as dwelling, household types, or car ownership, in synthetic data carry sociodemographic and behavioural elements into the system. The scheme also uses some defaults for values and distributions to fill in gaps when input data or models do not support such information (e.g., population growth rate or inflation rate). One of the central features of the macro generator is the adoption of macrozones. These macrozones can be predefined using the standard zone definition (e.g., from the Australian Bureau of Statistics), but can also be manually defined in the system. The macro generator can aggregate any OD skims to the macrozone layer. If executed outside the system, this would be a difficult task that can require months to correct. MetroScan has this process automated so changes to any OD skim matrices can be contemplated on the macrozone level when a proposed initiative is being processed. To provide further background, the macro generator applies a data manager to manage imported networks from different origins, such as TRANSCAD, VISUM, EMME, CUBE, and other systems. While preserving the accuracy for fast scanning, the macro generator largely reduces many detailed zones to a manageable number of macrozones, including the ones made by users. By doing so, initiatives under investigation can be assessed very fast in order to generate forecasting results from travel demand and economic impact. A trade-off exists between computation time and accuracy due to the detailed level of the macrozone. For example, in Sydney, there are over 3000 detailed zones in the transport network. In practice, we would apply 60 macrozones, which could satisfy both accuracies of forecasting and efficiency of the computation process. In reality, the forecasting results for major macro zones would also provide more meaningful and actionable insights for policymakers. Many strategic initiatives also start with higher levels of macrozones and request scanning results at the same level from travel demand to economic impact factors.

MetroScan was designed to apply synthetic households as units to gain numerous responses to alterations in the system driven by both broad and in-depth policy measures as presented in Figure 2. MetroScan applies a large number of choice models on both the macro and micro level, including behavioural aspects, providing more behavioural realistic market responses robust in contrast to traditional model systems. MetroScan processes and delivers forecasts for different modes, travel purposes, and time-of-day choices for medium to long-term decisions up to 20 to 30 years (i.e., currently forecasting up to 2056). It also suggests long-term decisions or choices on vehicle types, fleet size, vehicle technology, residential and work locations, job and firm growth areas, dwelling types, and many others. Besides forecasting commuting, non-commuting trips, such as personal business and social purposes, and business trips, light commercial vehicle, and freight commodity models support business activity responses by location, volumes, and trips at macrozone levels.

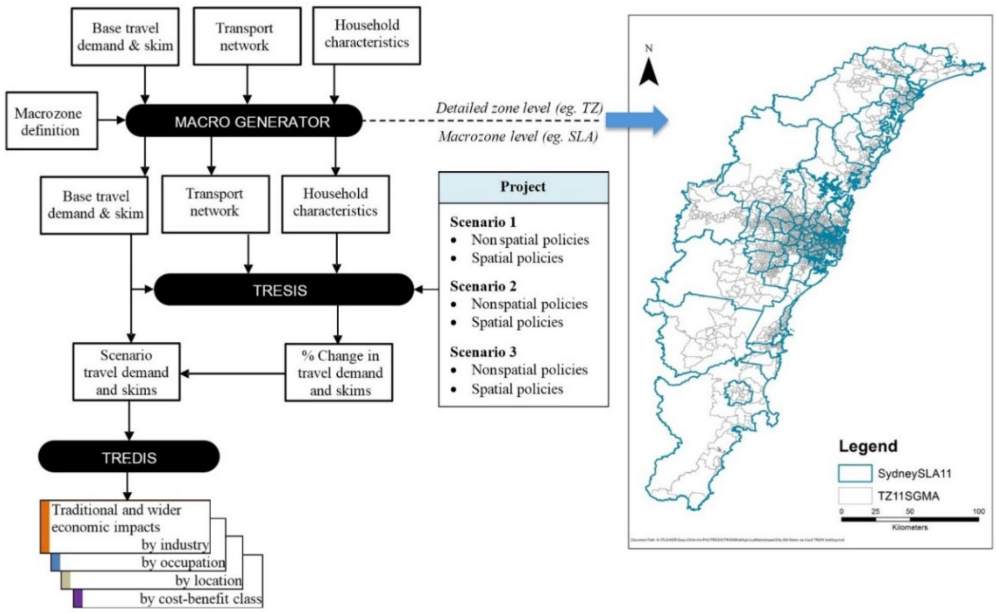

Figure 1. MetroScan framework.

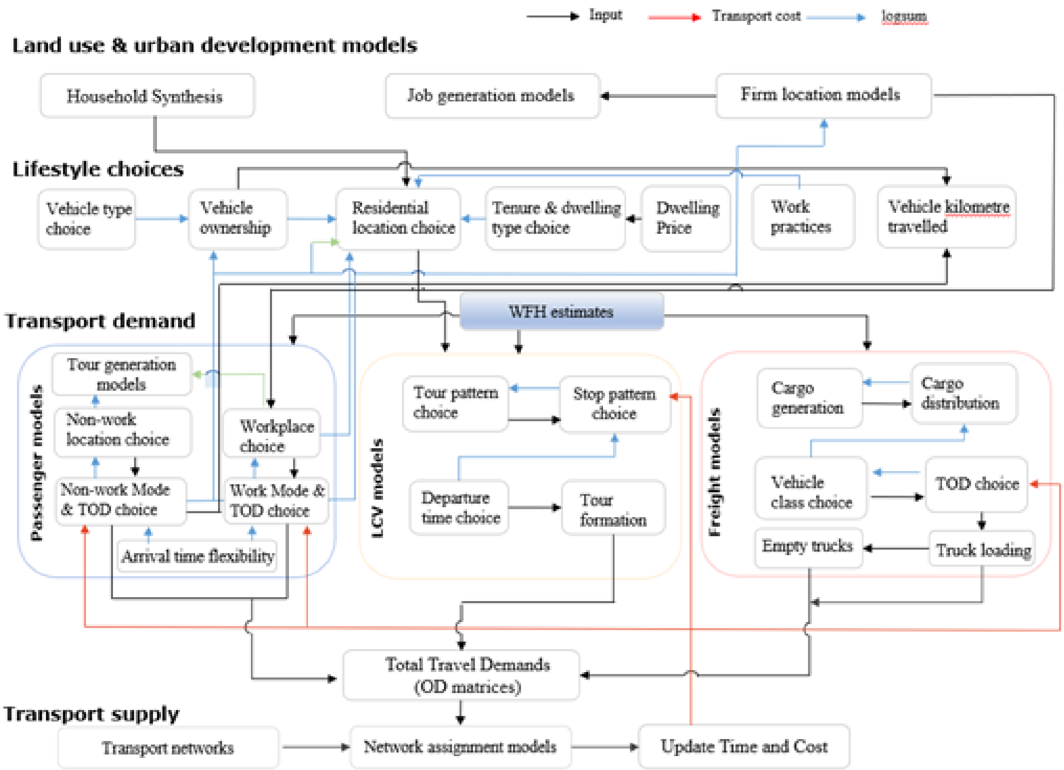

Figure 2. The demand-side behavioural model system for passenger, light commercial, and freight travel activity and the benefit-cost analysis (BCA) and economic impact modules. Source: Hensher et al. (2020).

A new direction for on-street transit

We need a fresh approach to deliver more frequent, reliable and easy-to-use bus and light rail services across Greater Sydney, Lower Hunter & Greater Newcastle, Central Coast and Illawarra-Shoalhaven.

Directions for On-Street Transit is a discussion paper which outlines a proposed approach to achieve this goal. The key components of this White Paper have been summarised below to stimulate discussion.

Agile service delivery

As an area grows, transit services should grow with it. Staging investment and scaling up over time is a cost-effective approach because there is no need for long lead times to get new services on the road. Listening to passenger needs and acting quickly to deliver continuous improvement is key to aligning services with local demand.

More reliable, frequent and easy-to-use services

On-street vehicles need dedicated lanes so they don't get caught in traffic. We need to increase and diversify our fleet so it is appropriately scaled for carrying crowds or for navigating local streets. Smart technology delivering facilities such as live service information will make the experience intuitive for passengers. These advantages would boost the image of on-street transit and allow it to rival any other mode in efficiency and reliability.

A holistic planning approach

On-street transit may help ease the housing crisis by stimulating the development of medium density housing along strategic corridors. Examples in Australia and around the world have shown that such development can be stimulated when investment in well-designed stops and smart passenger technology signals a permanent and high-quality service.

More rapid bus routes

Rapid buses deliver fast, reliable service and quality infrastructure similar to light rail, but can be implemented more quickly and with more flexible route options. 39 Rapid Bus routes (overleaf) are proposed across Sydney.

Better funding and collaboration

Delivering an enhanced on-street transit network will require greater planning and new infrastructure and vehicles. We need a clear investment plan to deliver these things in a timely and effective way. We need a cooperative framework between those with responsibility for on-street transit, including Transport, local government and operators.

On-Street Transit refers to all forms of public transport using the street network including buses and light rail. These modes account for 46% of all public transport trips.

Proposed rapid routes for Greater Sydney

What communities will benefit from a rapid bus route and why?