21ST CENTURY PUBLIC TRANSPORT SOLUTIONS FOR CANBERRA

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Cover pictures of Trackless Trams and a Guided Electric Transit System vehicle sourced from Monash University and Infrastructure Technology Solutions Group

Table of Contents

Preface

Light Rail — 2B or not to be

This paper has been compiled because of the grave concerns we have, not only about the future of public transport in Canberra but also for the ACT's financial position, due to the excessive and the disproportionate amount of money that has been and still is being spent on the ACT Labor/Greens Government's light rail project.

This expenditure has contributed to the Territory's AAA rating being downgraded to AA+; a rating that has not been experienced since 2003. As former Chief Minister Jon Stanhope has noted:

> ***"A "AAA" credit rating is not merely a token, and maintaining it is not an end in itself. However, a rating downgrade is a clear signal to lenders that the risk of lending to an entity suffering such a downgrade has increased, which inevitably results in higher interest costs."*** **(Stanhope and Ahmed 2023a)**

Of even greater concern is S & P's Global forecast that the ACT ratio of debt to operating revenue will reach ***154% by 2026.***

The continuing expenditure on Light Rail Stage 2A by the Government will only add to the Territory's growing debt and increasing interest charges. The majority of Canberrans are paying for this without receiving any benefits (Riotact 2023c).

This substantial re-allocation of Canberran's money is depriving the other public services such as public housing, hospitals, schools, policing, women's refuges and roads. The increasing Light Rail debt will directly and indirectly impact on the lives of families in Canberra, who are already under enormous stress, further increasing costs of living and housing.

Higher interest costs, resulting from the credit rating downgrade, will drive up the cost of providing public services or will reduce their provision.

Back in 2012, the Government concluded that ***bus rapid transit*** between Gungahlin and the CBD would produce net benefits worth $243 million. It chose instead to build a light rail line that would generate minimal net benefits of only $11 million. The ACT Government has consistently made second-rate public transport investments.

In 2019, without reviewing the costs and benefits of other options, the Government concluded ***Stage 2A of light rail would cost only $268 million***, with a net cost of $138 million. ***The estimated cost is now expected to exceed $1.2 billion***. In 2024, without having reviewed the costs and benefits of other options, the government now proposes to throw good money after bad, on Stage 2B.

> ***There is simply no justification for the ACT Government to be spending massive amounts of money on Light Rail Stage 2A and 2B, to service less than 10% of Canberra's commuting public. That is why Light Rail Stage 2B must not proceed.***

Executive Summary

Why did Canberrans get expensive Light Rail?

The decision by the ACT Government to proceed with the construction of Light Rail Stage 1 after the 2012 ACT elections, was not based on a thorough investigation. Analysis of the best available public transport system for Stage 1, which was only revealed later, showed that a Bus Rapid Transit (BRT) system was better. Further, the ACT Government's decision did not consider whether light rail was suitable for Canberra's unique topography; one that the Territory's existing bus services had no problems coping with.

The decision to proceed was merely based on a political agreement between the Green's sole member of the Legislative Assembly, Shane Rattenbury (who held the balance of power) and Labor's Katy Gallagher, the then ACT Chief Minister.

In return for his support, the Green's representative got light rail and so did all Canberrans. The public was told that Light Rail Stage 1 would cost only $614 million. The Auditor-General calculated the nominal cost at $1.78 billion!

Light Rail is not the answer to Canberra's Public Transport Problems.

Public transport is evolving rapidly. Older modes and technologies are improving. New technologies offer more efficient, more environmentally friendly and less costly services. The ACT is being locked into a rigid, inflexible and expensive public transport system that is unsuited to Canberra's topography.

An integrated system of electric vehicles, bus rapid transit, trackless trams and high occupancy vehicle lanes offers an efficient, low-emissions 21st century transport system that provides fast, comfortable and frequent public transport.

The ACT Government has persistently made second-rate public transport investments. In 2012 the Government was advised that **bus rapid transit** between Gungahlin and the CBD would produce net benefits worth $243 million (Auditor General, 2016). It chose instead to build a light rail line that would generate only minimal benefits.

The decision to build Light Rail Stage 1 was made in spite of the ACT Government estimating (in its August 2012 submission to Infrastructure Australia***) that bus rapid transit offered a superior benefit-to-cost ratio of 1.98 (business as usual) or 3.78 (higher density land use)*** **— both ratios much higher than for light rail.** This information was in the Government's hands prior to the 2012 election but was not made public at that time.

In 2019, again without reviewing the costs and benefits of other options, the Government announced it would proceed with Light Rail Stage 2A — it would cost $268 million and produce only $150 million worth of benefits. ***To date, the Government has already signed three major contracts to the value of $839 million and our current estimate of the total spent or committed to date, is $1.2 billion. (see Table 1).***

However, while the overall cost will be supported by a Commonwealth Government infrastructure contribution of $343.9 million, it is not on the announced basis of a 50/50%,

but is on an approximately 30/70% basis. Canberrans will be paying more than 70% of the total cost of Stage 2A, which will be used by less than10% of the commuting population.

In 2024, still without having reviewed the costs and benefits of other options, the ACT Government plans to proceed with Stage 2B of light rail. In 2019, it estimated that Light Rail Stage 2B would cost more than $905 million (plus an estimated 17% for wire-free operation) which brings the total to $1.059 billion. However. the estimated benefits were only $1.067 billion, so the net benefit would be only $8 million.

However, in light of the engineering and construction complexities that the ACT Government is facing, the cost to complete Stage 2B is now in the billions of dollars and the net benefits will be negative.

Canberra had one of the nation's highest public transport patronages in the 1970's and 1980s. From 1973 to 1976 it increased by 73 per cent, from 8.4 million to 14.5 million, one of the most dramatic increases reported anywhere in the developed world (Paul Mees).

The high patronage proved that with an appropriate level of funding and planning and despite Canberra's large footprint, Canberrans would use buses. However, ACT Governments failed to maintain the quality and connectedness of public transport services (see Mees' references).

Transport Canberra claims that the public transport network is at the "core" of Canberra's integrated transport system. Yet, Canberra's public transport provides only 4% of trips and 5% of distance travelled. The ACT Government has failed to attract commuters to public transport.

Transport Canberra's 2022-23 Annual Report stated that its ageing diesel and gas-powered bus public transport fleet used 10.9 million litres of diesel fuel and 74,190 Gigajoules of compressed natural gas **and *contributed 50% of the total ACT Government emissions*.**

Removing the pollution from the usage of diesel and compressed natural gas-powered buses provides a good justification for the rapid electrification of all Canberra's 451 buses, which generate more greenhouse gas emissions than the car travel that they displace.

The ACT Government plans to have only 106 electric buses in operation in 2026 and is reported to have allocated $83.5 million for the purchase of 94 of these vehicles. However, the remainder of the ageing, polluting buses will not be fully replaced until 2040. Scrapping Light Rail Stage 2B and investing the funds saved to replace the balance of the fleet with electric buses would bring this target forward by at least a decade and greatly reduce emissions.

Light rail is an expensive approach to meeting Canberra's public transport needs. It is inflexible and services only a small percentage of the commuting population. Other options can offer fast, flexible services at lower cost than light rail.

The ACT Auditor-General's ***Report 5 of 2016***, noted that the ACT Government's estimate of the Stage 1 Light Rail transport benefit-cost ratio was only 0.49. It questioned the wider economic benefits (WEBs) claimed by the ACT Government, which were disproportionately large by comparison with other transport infrastructure projects.

The Auditor General has also been highly critical of the business case for Light Rail Stage 2A, which omitted some costs and provided a very poor benefit to cost ratio of 0.38. Even when *unexplained Wider Economic Benefits (WEB)* were included, the benefit cost ratio was still only 0.56.

In this report, our current cost estimate for the completion of Light Rail Stage 2A, is approximately $1.2 billion (see Table 1). The track length of Stage 2A is 1.7km. This suggests a cost per kilometre of approximately $722 million. When compared with the average cost of light rail, around $100-120 million/km, this would make it the most expensive section of light rail ever built**.**

The expenditure on Stage 2A provides yet another example where actual costs of light rail are significantly higher than the initial estimates. This was also the case for Light Rail Stage 1. Canberrans continue to be misled by figures which do not fully reflect the full costs of the projects.

Identifying all the costs involved in both Light Rail Stages 1 and 2A for this paper has proved difficult because of the Government's lack of transparency and its propensity to redact vital financial information relating to their Light Rail projects.

In the words of Dr Leo Dobes,

> "***The MPC (2019) economic analysis fails not only because alternative modes to the proposed tram are not considered but because it lacks analytical transparency in not providing a full list of impacts (resource use, externalities and benefits generated) with discussion of their relevance and value"***

Stage 2B engineering challenges

An excessive amount of public transport expenditure continues to be concentrated on the single light rail line from Gungahlin to Commonwealth Park (Stages 1 and 2A). This expenditure will dramatically increase if construction of Light Rail Stage 2B proceeds because it faces major design challenges in crossing Lake Burley Griffin and navigating around and through the Parliamentary Triangle, State Circle and the Yamba Drive roundabout.

The ACT Government acknowledges that a new bridge would be required between the existing Commonwealth Avenue bridges. In addition, seven other bridges will be required on Adelaide Avenue and Yamba Drive. Commuters will need lifts and escalators to access the tram stops which will be situated in the middle of Adelaide Avenue. Complex intersections will be required to enable trams to cross lanes of traffic.

The ACT Government has already been warned by the NCA that Light Rail Stage 2B faces major heritage and engineering problems navigating around Parliament House, which could block the currently preferred route.

> ***"Federal Parliament has been advised by the NCA's chief executive, Sally Barnes, that "the engineering challenges might be too difficult or too expensive to overcome, and the NCA was now open to looking elsewhere."***
> (ABC news 2023)

However, despite all the construction complexities and challenges that Light Rail Stage 2B faces, not to mention a cost in billions of dollars, the ACT Government's position is that:

> ***"A business case for light rail stage 2B won't be available until the next term of government, Transport Minister Chris Steel has confirmed today (20 November 2023)" and "a business case cannot be formulated until the planning approvals have been given the green light by the National Capital Authority (NCA)"*** City News, 2024)

Despite the ACT government having no planning approvals, it has allocated $50 million "to progress the planning and design phases" (City News, 2024) despite there being the likelihood that their business case may determine that Stage 2B may not be viable. It should be noted that the Government is well advanced in its construction of the Woden Bus/Light Rail station, relating to Stage 2B, without waiting for Commonwealth Government approval. Is this a case of putting the cart before the horse? For such a massive, complex and expensive undertaking, this approach is remarkable and reckless.

The former ACT Chief Minister, Jon Stanhope and former senior ACT Treasury official, Khalid Ahmed have expressed concern about the billions of dollars that are being spent on light rail:

> **"*Expenditure forecasts in the 2023-24 Budget are illusory and almost certain to be exceeded by hundreds of millions of dollars. Treasurer Barr has few choices – cut spending, raise taxes or both. More likely he'll keep borrowing."*** (Stanhope and Ahmed, 2023c)

Bus Rapid Transit

Bus Rapid Transit (BRT) is the obvious solution for rapid public transport on the Stage 2B route. It offers cheaper, faster, more frequent and more adaptable transport than light rail. BRT requires fewer transfers between bus and/or light rail services, costs half as much, can be built more quickly, is twice as cost-effective, and will be at least ten minutes faster than Light Rail Stage 2.

The ACT Auditor General found that using BRT on the Stage 2B route (Commonwealth Park to Woden) would cost about $450 million providing significant savings compared with light rail.

Trackless trams

Trackless trams offer the possibility of delivering integrated transit and land development and is competitive with light rail on speed, capacity and ride quality while being similar in cost to BRT. Trackless Trams lack of the construction disruption of light rail, and their ability to be rapidly implemented mean that they are also far more cost effective than light rail. They offer comfort and accessibility similar to light rail, are faster and more flexible, cost about half as much, can be deployed very quickly, and are twice as cost-effective.

Trackless trams are rubber-tyred. They are guided by magnetic nails embedded into the road surface about one metre apart along the route creating a virtual track. The ride is the equal of light rail, and its configuration is flexible. Carriages can be added or taken off to meet commuter demand. A three-carriage trackless tram can carry up to 300

commuters compared with a maximum of 207 on light rail. The vehicles are considerably cheaper than light rail.

Electric-powered trackless trams are designed to adapt to most roads, have a high safety performance and are environmentally sound, green, with low energy consumption. While driverless trackless trams are possible, drivers are used to ensure safe operation in mixed traffic where unexpected events can occur, and in assisting with navigation and passengers where needed. Drivers can override the programmed track for the vehicle when necessary.

As part of an Australian road certification process, a zero-emission trackless tram was demonstrated in Perth in November 2023. Other cities and regions across Australia investigating the introduction of Trackless Trams, include Melbourne, Sydney, other parts of Perth and the Sunshine Coast of Queensland.

Autonomous electric cars

Autonomous electric cars offer 24x7, on-demand door-to-door ride sharing. These are being tested in the USA and China. The future use of a shared fleet of autonomous cars promises shorter commute times for their users. Shared use of autonomous cars offers lower emissions, and reduced demand for car parking space in the CBD.

High occupancy vehicle lanes

High occupancy vehicle (HOV) lanes provide many of the benefits of bus rapid transit. A strategic section of HOV lane can be configured in a matter of weeks, at a small fraction of the cost per kilometre of bus rapid transit or light rail.

Other issues

Town planning influences public transport needs. Canberra is regarded as one of the best examples of only a small number of planned capital cities in the world. However, this status is now under threat.

Light rail, Stage1, has reduced the unique “Bush Capital” image that was Northbourne Avenue (the “gateway to Canberra”) to a tramway of poles, wires, scrawny brittle gums, grasses, weeds and concrete.

An important consideration with Light Rail Stage 2B is the opportunity cost or the loss of potential gain from other public spending initiatives. Unnecessarily spending considerably more on an expensive solution, like light rail, reduces funds available for other needs which could include health, education, social housing, city maintenance, improvements to bus infrastructure, sports and cultural and recreation facilities.

Findings

The billions of dollars being spent on Light Rail Stage 2 could be better spent on faster and more modern transport technology described in this paper, at a fraction of the cost, with far less disruption and with more short and long-term benefits to Canberrans

Light Rail is detrimentally affecting the ACT’s budget. The ACT Government’s management of its budget has drawn strong criticism from Jon Stanhope, a previous Chief Minister. The Government has significantly increased rates and land taxes while

supporting unrestrained development, controlling the sale of land to maximise profits, increasing other charges and reducing expenditure on many of Canberra's essential services.

ACT governments need to consider all the available transport technologies as well as appraise emerging technologies that are suitable to solve Canberra's public transport problems.

The public transport sector is rapidly evolving. The construction of light rail from Civic to Woden would prevent the adoption of more advanced public transport systems.

Recommendations

We recommend that the ACT Government:

1. Completes Light Rail Stage 2A ground works only, while undertaking a thorough evaluation of the future adoption of a trackless tram system to replace light rail.
2. Take no further action on Light Rail Stage 2B and cancel existing contracts or amend them, to provide for bus rapid transit, as soon as practicable.
3. Accelerate the acquisition of electric buses so that the transition to zero emissions public transport is completed by 2030.
4. Prepare and publish full cost benefit analyses and a business case for the use of Bus Rapid Transit between the City and Woden.
5. Extend the existing Adelaide Avenue T2 lanes to Civic and Woden.
6. Prepare and publish a plan for the use and management of T2 and T3 lanes, electric buses, Bus Rapid Transit, trackless trams, and autonomous cars in the ACT, integrating these modes with Light Rail Stage 1 to provide all Canberrans with a fully integrated public transport network.
7. Seek funding from the Commonwealth Government to collaborate with other cities to investigate and trial emerging public transport modes including trackless trams.

We recommend that the Commonwealth Government:

8. Stick to its statement made during the election campaign not to support projects, such as Light Rail Stage 2B, where the benefits do not stack up. The Commonwealth Government should reject the claimed wider economic benefits of this project unless the ACT Government identifies and fully justifies these benefits, and provides evidence that they can be achieved.
9. Respond to ACT Government requests for Stage 2B funding by instituting a public inquiry into the project, either through the EPBC Act or through a reference to the Joint Standing Committee on the National Capital and External Territories. Such an inquiry should only take place when the business case and the environmental impact statement prepared under the EPBC Act are publicly available.

1. Introduction

This paper:

- sets out the background to the 2012 ACT Labor-Greens decision to proceed with light rail
- examines the issues and challenges associated with Canberra's public transport
- examines the cost of Stage 1 and the benefits
- takes a close look at Light Rail Stage 2
- discusses currently available options and solutions for Canberra
- considers land use issues
- provides a financial analysis of the options
- assesses heritage and environmental impacts, and
- discusses possible future developments.

The paper concludes that Light Rail Stage 2B should not proceed. It finds that, in comparison with alternative solutions, Light Rail Stage 2B will be slower, less flexible in its routing, have greater environmental impacts, be far more expensive and will impose a substantial financial burden on all Canberrans for many decades to come. Alternative solutions will provide our city with an affordable public transport network that will better meet the needs of Canberrans.

Notes, designated by superscripted numbers, can be found in the Notes section at the end of this paper.

References can also be found at the end of this paper. Links to documents on the internet are provided.

2. Canberra's Public Transport

Canberra's public transport system once enjoyed one of the highest per-capita patronages in the nation, with per capita usage rates reaching 96 annual trips in 1985.

> ***"Patronage tripled from 8.4 to 24.0 million in the 12 years from 1973 to 1985, and per capita usage rates doubled from 48 annual trips to 96. In the three years to 1976 alone, patronage increased 73 per cent, from 8.4 to 14.5 million boardings."***
>
> ***"the (ACT) public transport system was underfunded from the mid-1980s"*** ***(***Mees, 2011)

The belief that Canberra is a "car city" by design ignores the success of public transport in Canberra from the mid 1970's until the mid-1980's but it has gained traction since then and has ended up influencing the Government's agenda for urban infill with a capital-intensive transport system, based on light-rail.

Hoping to reduce urban-sprawl, the Greens supported urban in-fill and, attracted by the zero-emissions of transport powered by 100% renewable electricity, promoted light rail. The outcome, resulting from a desire to justify the cost of light rail by promoting urban development, was the construction of high-rise developments along the light rail route, displacing many public housing tenants in the process.

Public transport expenditure has been concentrated on the single light rail line from Gungahlin to Civic. In the meantime, fast and flexible electric buses have been increasingly used around the world, negating the emissions argument used to support light rail, providing fast flexible services at lower cost.

Current situation

According to Transport Canberra, the public transport network is at the "core" of Canberra's integrated transport system. But public transport trips take twice as long as car trips (ACT and Queanbeyan-Palerang Household Travel Survey 2017) and public transport provides only 4% of trips and 5% of distance travelled in the ACT (*ACT and Queanbeyan-Palerang household travel survey 2022).*

Transport Canberra has stated that, as Canberra grows, the role of public transport in delivering social, economic and environmental outcomes for the city will become critical. However, these aims will not be achieved with the current approach. In 2012 the then Chief Minister committed to 10.5% of journeys to work by public transport by 2016. However, census results show that the proportion of Canberra commuters using public transport fell from 9% in 1991 to 8% in 2016 and 7% in 2021.

The main problem facing Canberra's public transport system is that it is not coping with urban growth and provides only slow, subsidised travel, serviced mainly by old fossil-fuelled buses. An analysis of Canberra's commuter's travelling habits indicates that:

- Based on the 2017 Household Travel Survey, travelling by public transport takes, on average, twice as long as travel by car[1]— this is one reason why in the 2021 census 83% of Canberra's commuters travelled by car.

- A recent study has reported that public transport travel costs the Canberra community between $13 and $108 per passenger depending on the time of day (Mortazavi *et al,* 2024). This falls far short of an effective, efficient and well patronised public transport system.
- According to the ACT and Queanbeyan-Palerang household travel survey, 2022, each day, the average Canberran travels:
    - 1.5 km on public transport
    - 19.3 km as a car driver
    - 6.9 km as a car passenger
- Canberra's public transport generates more pollution than the car travel it displaces (Arundell, 2023), and most public transport trips are journeys to or from work[3].
- Without public transport an extra 12,000 car parking spaces would be required[4]. However, despite the increasing cost of car parking, commuters prefer to use their vehicles rather than use public transport because public transport is time consuming, inflexible and relatively unreliable.
- Public transport would further reduce traffic congestion if it was improved and made more attractive.

Buses in Canberra are publicly owned, operated, managed and maintained and this is in contrast to many other Australian cities where some or all of the services are contracted to the private sector, mostly through periodic competitive tendering. Transport Canberra employs over 1000 staff of which around 800 are bus drivers. Weekend bus services are infrequent and often cancelled without notice and this appears to be a consequence of an agreement with the union on pay and conditions. This ongoing disputation has reduced the ACT Government's ability to operate the current bus services in the best interests of Canberrans.

However, it is ironic that in an election year, the ACT Government has suddenly resolved its dispute with Transport Canberra's bus drivers by agreeing to more generous pay conditions and other benefits, particularly for weekend drivers and a new clause that commits the Government and the drivers to "further consider rostering arrangements." Unfortunately, this is of little comfort to commuters, who have had to put up with inadequate weekend bus services for years. (Canberra Times, 3 February 2024).

A large proportion of the ACT Government's 451 buses (largely powered by diesel and compressed natural gas) are ageing as Figure 1 shows and are due to be replaced. As buses age, they become more expensive to maintain and less reliable which leads to reduced customer satisfaction, reduced usage and less likelihood of attracting new customers.

As Canberra's population grows so must the number of buses in the fleet be increased to meet the increased demand. This requires an increase in expenditure in all the associated infrastructure and an increase in the workforce — more routes and drivers, improved depots, bus maintenance, bus storage, midday and overnight layover as well as driver break facilities.

The ACT Government, announced in May 2023 that it would purchase 94 electric buses over the next 3 years, increasing the number of electric buses to 106. Electric buses will

represent only 20% of the total fleet by 2026. While this is a positive step, the ***replacement of the total fleet may not be completed until 2040.***

FIGURE 1 – ACT bus fleet composition in 2020

Bus Type	Count	Average Age	Fuel			DDA	Euro-emissions standard					
			EV	Diesel	Gas		No	2	3	4	5	6
Renault PR100-2	34	28.5				No	34					
Irisbus AGORALINE	19	18				Yes		19				
SCANIA CNG	54	15.5				Yes			54			
MAN CNG	16	12				Yes				16		
MAN DIESEL	89	10				Yes				2	87	
SCANIA 14.5m	26	9.5				Yes					26	
SCANIA Articulated	44	6				Yes					33	11
Scania Euro VI	168	3				Yes						168
Yutong E12	1	0				Yes						
Total	451	11	1	380	70		34	19	54	18	146	179

Source: ACT Government 2020, Zero-emissions transition plan for Transport Canberra, page 9.

According to the Transport Canberra 2022-23 Annual Report, its public transport fleet used 10.9 million litres of diesel fuel and 74,190 Gigajoules of compressed natural gas, as well as an undisclosed amount of electricity. Removing the pollution from this usage of diesel and compressed natural gas provides a good justification for the rapid electrification of Canberra's bus fleet.[5] However, rather than accelerate the replacement of a substantial proportion of its ageing fleet (some are 30 years in age), the ACT Government has chosen a slow staged replacement of the current fleet.

Expenditure on light rail is diverting and will continue to divert much needed funds that should be spent on purchasing electric buses. This underfunding is depriving most Canberra public transport commuters (the majority of whom use buses) of a modern, emission-free, public transport service.

If the funding for Light Rail Stage 2B was invested in electric buses and Bus Rapid Transit (BRT) along the same route, the entire fossil-fuelled bus fleet could be replaced immediately which would reduce the total ACT Government emissions by 50% (33,432 tonnes CO_2-e per annum).

In deciding to proceed with light rail, the challenges posed by Canberra's topography were ignored. This is in spite of the ACT Government estimating (in its August 2012 submission to Infrastructure Australia) that for Stage 1, bus rapid transit offered a superior benefit to cost ratio of 1.98 (business as usual) or 3.78 (higher density land use). These figures were twice as high as those for light rail. This information was in the Government's hands prior to the 2012 election but was not made public until the following year.

The ACT Government's 25 Year Light Rail Vision (2015), for a large-scale light rail network for Canberra, one that would include some 80-100 kilometres of track, is totally unrealistic. The full implementation of its vision is not only many decades behind but it's

cost will amount to tens of billions of dollars; a cost which Canberran's will never be able to afford. It is a *square peg in a round hole approach* to solving Canberra's public transport problems; one that should be about developing a public transport system that suits Canberra's unique topography.

The raising of London Circuit is a prime example of this. Instead of choosing a transport system that is adaptable to the terrain that light rail has to confront, the ACT Government has chosen to dump 60,000 tons of infill, at very considerable cost, to change the topography so that 42 tonne, 200-passenger light rail vehicles can cope with an incline that a 13 tonne 100-passenger bus can manage with ease.

2.1 Light Rail Stage 1

Stage 1 of Light rail was the result of an agreement (after the 2012 ACT elections), between the Green's sole parliamentary representative, Shane Rattenbury (who held the balance of power) and the then ACT Labor Chief Minister, Katy Gallagher (now Federal Minister of Finance). A condition of the agreement was that the Government proceed with the construction of light rail from Gungahlin to Civic in return for support of her minority Government. The public was later told that the cost was estimated at $614 million.

This was not the result of a thorough investigation and analysis of available public transport options (other than light rail and bus rapid transit), to determine one that was best suited, considering the Territory's unique topography and Canberra needs.

In the ***2012 Parliamentary Agreement***, commitments were made to "the construction of a light rail network" and to "creating a Canberra wide light rail network master plan." After the 2016 elections, a ***new Parliamentary Agreement*** was signed between the minority Labor Government and the Greens, committing to complete light rail, Stage 1, by early 2019, and to begin the design and scoping for Stage 2 (A and B) to Woden.

In 2016 the ACT Government revised the estimated cost of Stage 1, from Civic to Gungahlin, to "approximately $939 million (present value in January 2016) or $1.78 billion (nominal value) over 20 years" (ACT Auditor-General's ***Report 5 of 2016***).The Auditor General noted that the *project's transport benefit-cost ratio was only 0.49* and questioned the claimed wider economic benefits (WEBs) which were disproportionately large by comparison with other transport infrastructure projects. She noted that there was no agreed methodology or robust data available to support the WEBs calculation provided by the ACT Government.

Because the ACT Government has been locked into its agreement between Labor and the Greens to build light rail, it is now blind to any other solution that is more effective, efficient, sustainable and less costly than its light rail solution.

The ACT Government is ignoring emerging public transport technologies such as electric trackless trams, which are presently operating in China, and offer similar ride capabilities to light-rail but much cheaper, faster and operationally more flexibly.

Looking beyond electric buses and trackless trams, the advent of autonomous electric cars will offer 24x7, on demand door-to-door ride sharing. These are being tested in several USA and Chinese cities and are being readied for mass deployment in the coming decade.

3. Light Rail Stage 2

In 2019, the ACT Government estimated that the total project costs for Light Rail Stage 2A would be $268 million but would provide estimated benefits of only $150 million (Auditor General, 2022). The requirement to operate wire-free in the Parliamentary Triangle was estimated to add $28 million to the cost (17% of the capital cost of $162 million). That meant that the benefits of the project would fall short of its costs by $146 million!

It is important to note that light rail construction costs, reported in the media when contracts are signed, make up only part of the total costs. Other costs are incurred including Government project administration, borrowing, relocation of services, consultant reports, etc (see Table 1). Identifying all the costs involved is difficult because of the Government's lack of transparency in relation to light rail as Dr Leo Dobes noted in his submission to the ACT Legislative Assembly Standing Committee on Public Accounts.

> ***"The MPC (2019) economic analysis fails not only because alternative modes to the proposed tram are not considered, but because it lacks analytical transparency in not providing a full list of impacts (resource use, externalities and benefits generated), with discussion of their relevance and value."*** (Dobes, 2021)

The expected route for Stage 2 runs from Civic, across Lake Burley Griffin at Commonwealth Bridge, travels around State Circle, down Adelaide Avenue, and terminates on Callam Street at Woden Town Centre. While the route from Civic to Commonwealth Park (Stage 2A) has been determined, the route for Stage 2B (Commonwealth Park to Woden) has not been finalised because of the complexities facing the ACT Government in traversing Lake Burley Griffin and the Parliamentary Triangle. ***The projected light rail travel time for the Stage 2 route is 27.5 to 32.5 minutes, compared with less than 20 minutes for the current rapid bus service.***

The ACT Government split Stage 2 into Stage 2A and 2B. Stage 2A will have three stops at City West, City South, and Commonwealth Park. It requires extensive earthworks raising London Circuit to the same level as Commonwealth Avenue and includes a new bridge over Parkes Way. Five new light rail vehicles required to service Light Rail Stage 2A have been purchased — they have the ability to run on wire free tracks. Power supply and transmission as well as traffic signalling, road improvements and tree plantings will also be required. The existing 14 light rail vehicles are to be converted to wire-free running, at an additional cost.

While the Government's Stage 2A Business Case provided travel time and patronage estimates for both Stage 2A and Stage 2B, it has not released any estimates of the impact of Stage 2A on bus passenger numbers, or on numbers of car trips.

The track length of Stage 2A is 1.7km. Thus, the overall cost to date per kilometre is estimated to be approximately $722 million, making it, on this measure, likely to be the most expensive light rail in the world.

The Auditor General's September 2021 report revealed that the ACT Government's Business Case for Light Rail Stage 2A had estimated the capital cost to be $162 million and the total cost to be $268 million with total benefits of $150 million including

$48 million of “wider economic benefits” (WEBs). **In December 2023 the ACT Government announced a contract for capital works for Stage 2A by $577 million**. This means that neither Stage 2A, nor Stage 2 as a whole, can be considered to be cost effective.

TABLE 1 – Costs of Light Rail Stage 2A (Civic to Commonwealth Park)

Component	Costs ($m)
Capital works - Raising London Circuit (original contract plus variations to date) - Depot expansion, 5 trams, retrofit batteries, etc - Stage 2A track & stations **Total capital works committed to date**	 81 181 577 **839**
Other costs - “Agency costs” including salaries since 2016 (estimate) - Enabling works, planning, relocation of utilities, earthworks, etc **Total other costs to date**	 50 339 389
Total funds spent/committed to date	**1,228**

Note: Due to the ACT Government’s lack of transparency, commercial in confidence secrecy, redacted details, and creative accounting, it is very difficult to provide precise and compete data in this Table.

However, as Table 1 shows, by December 2023, the Government had already spent or committed an estimated $1.2 billion to Light Rail Stage 2A (of which the Commonwealth Government will contribute $343.9 million). This contribution represents only around 28% of the costs to date. ***Canberrans will be paying over $884 million (net of the Commonwealth’s contribution) or more than 70% of the total cost.***

The Auditor General’s report was highly critical of the business case for Stage 2A, with costs not estimated for conversion to wire-free operation, benefits overstated and a very poor benefit to cost ratio of 0.38, including WEBs 0.56 (see excerpts from the Auditor General’s report, at Appendix A).

In summary, the Auditor General noted that the claimed “Wider Economic Benefits” relied on agglomeration benefits, and that the estimation of meaningful agglomeration elasticities “has proved elusive, with no believable elasticities estimated for Canberra”, and found that the ACT Government’s Business Case:

- assumed that London Circuit would be raised to meet Commonwealth Avenue
- failed to provide adequate information on the costs of development of the Acton waterfront.
- did not recognise disruptions costs during construction to road users, pedestrians, residents and businesses
- presented a so called "blended benefits cost ratio" presented in the Business Case that was highly questionable, and
- relied on accelerated development of the Acton Waterfront as a significant component of the claimed benefits from Stage 2A.

So it was with some surprise that Canberrans learned that the Commonwealth Government would contribute $343.9 million to the cost of Stage 2A, given that Finance Minister Gallagher had said:

> ***"Canberrans rightly expect that their taxpayer money will be spent with the best bang for buck and deliver the best outcome for our city, and that is the approach that they will get from the Albanese Labor government."*** (City News, 2022).

The Finance Minister's definition of "best bang for buck' needs to be questioned, particularly when $85.9 million, previously allocated to the upgrade three major roads on the southside, was subsequently diverted to light rail and the total cost of Light Rail Stage 2A is expected to exceed$1.2 billion for 1.7 kms of track. The so-called 50/50% funding arrangement must also be questioned, when it can be seen from Table 1 that the Commonwealth is contributing less than 30% to the total estimated cost of the project while Canberrans will be paying over 70%.

The ACT Legislative Council's Standing Committee on Public Accounts held an Inquiry into the Auditor General's Report on Stage 2A in May 2022. The Committee's report, containing a few minor critical comments, was published in March 2023 (Legislative Assembly Standing Committee on Public Accounts, 2021). The Auditor-General's many criticisms were, in effect, ignored.

With the expected cost of the project to exceed $1.2 billion (before the Commonwealth Government contribution), there is little wonder why the Territory's finances are in dire straits as the former ACT Chief Minister, Jon Stanhope and former senior Treasury Official, Khalid Ahmed, wrote in their article in December 2023, "Deeper in debt, but where's the money gone?"

> ***"The ACT faces annual interest payments of nearly $600 million on a staggering projected deficit of $16 billion and still Andrew Barr, as treasurer, keeps borrowing at a billion a year. He taxes us to nation-leading levels while essential services, such as health and housing, falter. So, where's the money gone?"*** (Stanhope and Ahmed, 2023b)

The expenditures on Light Rail Stages 1 and 2A are just further examples of the ACT Government's continuing inability to control the costs of its projects; an inability that has resulted in the actual costs consistently exceeding its initial estimates by significant amounts. For example, the 2016 Acton Waterfront contract when signed was valued at $9 million but the Auditor General found that "by September 2020 the Contract Price had increased to $46.8 million for what is approximately two thirds of the works identified in the original RFT" (ACT Auditor General, 2022).

Similarly, the raising of London Circuit was expected to cost about $60 million. The work is incomplete, but the cost has already escalated to more than $80 million, an increase of over 33%. Throughout the light rail project, Canberrans have been and continue to be misled by reported headline figures which do not fully reflect the full costs.

3.1 Proposed Light Rail Stage 2B

The ACT Auditor General's 2021 report also examined Stage 2B. The ACT Government had estimated that Stages 2A and 2B would have a combined cost of more than

$1.2 billion, not including the cost of retrofitting the existing light rail vehicle fleet with wire-free technology. Total benefits were estimated at $1,217 million, with a *net* benefit of only $16 million and a very marginal benefit-to-cost ratio of 1.01.

The estimated benefits claimed by the ACT Government included $349 million of transport benefits, $402 million in "city shaping" benefits and *$466 million of unexplained "wider economic benefits."*

Stage 2B costs, as presented in the Government's Stage 2A business case, did not include the operating costs of Major Projects Canberra. The Government had estimated that Light Rail Stage 2B alone would cost $905 million and would offer net benefits of $269 million. The real costs for Stage 2B are now in the many billions of dollars because of the construction complexities.

Building light rail to Woden would involve challenges (lake crossing, hills and heritage issues) not encountered in constructing Stage 1. However, it appears that Canberra's topography was again ignored in the decision to proceed with light rail.

The Commonwealth Avenue bridges renewal project will strengthen the bridges to T44 (44 tonnes) and accommodate the 1992 Austroads Bridge Design Code. However, they will not be able to carry light rail or trackless trams as their fully loaded weight is more than the maximum (44 tonnes).

The Government is now searching for solutions to the complex problems arising from having to cross the lake with light rail and navigate around Capital Hill and Parliament House. A new Commonwealth Avenue bridge will need to be built to take over 100 tonnes in weight, if 2 trams, fully loaded, are on the bridge simultaneously.

The challenge to construct the light rail from Commonwealth Park to State Circle, and from State Circle to Adelaide Ave poses huge problems that Bus Rapid Transit (BRT) does not have. The obvious solution is to replace light rail with a more appropriate, suitable and adaptable transport system at far less cost.

The ACT Government's obsession with light rail has caused the planners to 'turn a blind eye' to the rapid advances that are occurring in transport technologies and the impact they are expected to have on urban transport.

Instead, the ACT Government is making a huge investment in antiquated technology and attempting to put a positive spin on it. The Government has claimed that "we know that people will walk 800 metres to 1 kilometre to tram stops to use light rail as opposed to 400 to 500 metres to a local bus stop" (City News, 2015).

This spin is fallacious, particularly if the tram takes much longer than the current bus service to reach its destination. Booz Allen Hamilton's 2003 ACT Transport Demand Elasticities Study estimated that each 10% increase in walk time reduces public transport patronage by 2.5%. In addition, each 10% increase in in-vehicle travel time reduces patronage by 3.7%. And when Canberra's extreme seasonal weather and time poor commuters are factored in, no wonder people will choose to drive.

People may walk greater distances to reach *faster* transport services. Otherwise, they will choose to drive their cars. As previously mentioned, the ACT Government ignored its own 2012 report that showed Bus Rapid Transit (BRT) between Civic and Gungahlin would have been twice as cost effective as light rail. If BRT had been introduced

instead of light rail, Canberra would now have rapid public transport all the way from Gungahlin to Woden. This system would have been easily adapted to the new trackless tram technology.

Problems with Light Rail Stage 2B include:

- The determination of the actual route to be taken to overcome the complex problems of getting around the Parliamentary triangle, and the length of the route, as this will determine the light rail travel time.
- Requirement of expensive retrofitting the existing light rail fleet with batteries to enable wire-free running in the Parliamentary Triangle.
- The 12 stops on the route from Civic to Woden would dictate how long the journey will take. The number of stops and their location also determines how many overhead bridges are required to enable passengers to access the stops. Providing disabled access to the proposed stops will require escalators and lifts. The cost of this would be significant.
- When trams break down or one is involved in an accident, trams that are following cannot overtake and the service is stopped until it is repaired. The irony is that buses are then needed to transport passengers around the obstruction. This inability for one tram to overtake another makes it impossible to provide an express service.
- Where there is available space, bypass tracks could be added. However, such duplications of track require complex signalling systems, adding many millions of dollars to the costs. During operation, all-stops services would be delayed while waiting for express services to pass, increasing the travel time for all-stops passengers.
- Despite the billions of dollars that are being spent on Light Rail, Stage 2, it will only take trams to Woden and there will be no light rail service through to Tuggeranong, Canberra Hospital, the Woden Valley suburbs and beyond.
- Unlike current bus services, which can usually provide seats for most passengers, a tram seats only 66 of its 207 passengers, including 12 seats which are set aside for the elderly, pregnant women and mobility impaired. The lack of seating in the trams compared to buses is unsatisfactory, particularly during peak hours. After a day at work, passengers would not be attracted to light rail if they have to stand for more than 35 minutes from Civic to Woden and then, if they need to take a bus to their final destination, after a wait of up to another 30 minutes.
- The ACT Government has a poor track record on costs and benefits (Auditor General reports on Stage 1 and Stage 2A). The final cost of Stage 2 will undoubtedly be well in excess of the Government’s previously forecast cost.
- The Transport Minister has confirmed that Canberrans travelling, particularly from the southside to the city/northside, will face massive traffic disruptions during the construction phase for many years due to the complexity of the Stage 2B construction work. (Canberra Times, 2023).

- There will be on-going disruption of traffic as trams cross from Commonwealth Avenue into and out of the middle of State Circle, from State Circle into and out of the middle of Adelaide Avenue, and as they negotiate the Yamba Drive roundabout.
- The need for eight new bridges, including a new Commonwealth Bridge, as well as strengthened crossings over culverts increases costs and poses traffic management and other challenges.

The conclusion from this analysis is that Light Rail Stage 2B is an unsuitable transport solution for south Canberra.

4. Cost-effective, low-emissions public transport solutions

The ACT is responsible for the generation of 30 tonnes of carbon dioxide equivalent (CO_2-e) emissions per capita per year[6]. That is five times the 2019 world average of 6.4 tonnes. Only six countries caused more than 30 tonnes of CO_2-e emissions per capita per year (Our World Data).

In 2022-23, Canberra's fossil-fuelled buses emitted the equivalent of 33,432 tonnes CO_2. That equates to 270 g CO_2-e emissions per passenger-kilometre., which is one third more emissions than those from equivalent car travel[8].

The Climate Council's 2023 report ***Shifting Gears*** says, "*To maximise emissions reductions, we need to electrify all public transport by 2035 at the latest, and ideally by the end of this decade.*"

The ACT Government currently plans to have a ***zero-emission public transport system by 2040***. This means that fossil-fuelled buses will continue to operate until 2040, unless this replacement is accelerated.

4.1 Electric Buses

The ACT Government appears likely to spend millions of dollars between now and 2040 on buying or leasing fossil-fuelled buses. These funds would be better spent on additional electric buses. As reported in the Canberra Times, in March 2021, a new diesel bus costs about $550,000.

The Government is reported to be paying $83.5 million to buy 94 battery electric buses (The Riotact, 2023a). On that basis, replacing all of Transport Canberra's remaining fossil-fuelled buses with battery electric buses would cost only $360 million.

FIGURE 2 – A Transport Canberra electric bus

Source: Transport Canberra website

Electric buses cost more to buy than diesel buses, but they cost less to maintain and operate, they are quieter and less polluting, and they are popular with passengers.

Replacing all of Canberra's fossil-fuelled buses with zero emissions electric buses would cost the ACT Budget an additional $23 million (estimated) per year until 2040 and will cut annual emissions by about 33,432 tonnes CO_2-e per year.

The Australia Institute's ***Stuck in the slow lane*** report identifies the following benefits of electric buses:

- **Reduced noise pollution**: electric buses are up to 20 dB(A) quieter than diesel buses
- **Better air quality**: buses make up just 0.5% of Australia's registered vehicles, but account for up to 6% of key air pollutants and produce roughly 1.4m tonnes of CO_2 e pollution each year. Electric buses emit no pollutants while operating, thus removing a significant source of air pollution
- **Reduced carbon emissions**: electric buses emit no greenhouse gases while operating. As the ACT uses 100% renewable electricity, recharging the batteries of electric buses in the ACT causes no direct greenhouse emissions.
- **Reduced road congestion**: as electric buses are popular with passengers; they are likely to increase public transport use and reduce private car use, and
- **Reduced fuel and maintenance costs**: while initial purchase costs are higher for electric buses than diesel buses, the reduced fuel, maintenance, and pollution costs have seen multiple studies conclude that there is a strong economic case for their uptake.

The report ***Stuck in the slow lane*** also finds that:

- Electric buses are economically viable and already operating internationally — cities with bus fleets that are significantly larger than those operating in Australian cities have been able to achieve full electrification.
- The city of Shenzhen in China, for example, fully electrified its 16,359-strong bus fleet—more than twice the size of Sydney's fleet, which is Australia's largest — in under a decade.
- Polling by The Australia Institute shows that more than seven out of ten of Victorians support the target of a zero-emissions bus fleet by 2030, and
- Electrifying bus fleets is an easy first step that state (and territory) governments can take toward achieving their net zero goals.

4.2 Bus Rapid Transit

An investment in bus rapid transport (BRT) offers much greater benefits than an equivalent investment in light rail. BRT offers faster travel that not only benefits public transport users, but also encourages car drivers to switch to public transport.

This will reduce traffic congestion and transport emissions. Each 10% reduction of public transport in-vehicle travel time is estimated to increase patronage by 3.7% (Booz Allen Hamilton 2003).

The ACT Greens, the Public Transport Association of Canberra and the Belconnen Community Council have been reported as supporting BRT (The Riotact, 2023b).

According to the ACT Government's estimates back in 2012 (ACT Government 2012):

- BRT costs 53% less than light rail
- BRT offers a benefit-to-cost ratio from 1.98 (business as usual) to 4.78 (higher density land use), and
- BRT offers between 1.3 times the net benefits of light rail (higher density land use) and 22.5 times the net benefits of light rail (business as usual).

Bus Rapid Transit systems, unlike conventional bus services, *typically operate on dedicated lanes and corridors,* separated from other forms of road traffic. The South East Busway in Brisbane is an example of a BRT system.

Guangzhou's single 22 km BRT line carries 800,000 passengers per day and has a one directional passenger throughput of 23,500 passengers per hour per direction (Far East Mobility, undated). According to the Stage 2A Business case, daily public transport patronage between Civic and Woden is expected to grow from 13,900 trips in 2026 to only 23,000 trips in 2046. Thus, BRT would easily meet the needs of south Canberra residents.

BRT reduces bus travel times. According to Transport Canberra bus timetables, on-road buses currently take less than 20 minutes to travel between Civic and Woden. Light rail is currently estimated to take between 27.5 and 32.5 minutes[8]. Proposed changes to the route are likely to increase these times.

Bus Rapid Transit on the City to Woden route

Information in the ACT Government's 2012 submission to Infrastructure Australia and its business case for Stage 2A indicated that Bus Rapid Transit between Civic and Woden would cost about $480 million less than light rail and offer net benefits of $1-2 billion greater than those of light rail.

Based on the revised cost estimate for stage 2A (in excess of $1.2 billion) and the cost of stage 2B, which will be in the billions, the savings, if BRT is proceeded with, will also be in the billions.

The ACT Government revealed in its August 2012 submission to Infrastructure Australia, that for the Light Rail Stage 1 route, bus rapid transit offered a superior benefit to cost ratio of 1.98 and net benefits of $243 million, at less than half the cost of light rail. Light rail offered net a benefit to cost ratio of only 1.02, and net benefits of only $11 million.

Based on the information in the ACT Government's August 2012 submission to Infrastructure Australia, BRT's benefit-to-cost ratio, between Civic and Woden, was calculated at 1.24. The conclusion was that BRT offered much greater "bang for buck" than Light Rail Stage 2A or 2B.

4.3 Trackless Trams

This paper provides detailed information about Trackless Trams because it is likely that readers are not familiar with this technology. Trackless Trams are a new form of low impact, intelligent, medium volume, mass transit vehicle. The Digital Rapid

Transit/Trackless Tram (DRT) vehicle has been built by leading rail industry manufacturer CRRC and has been trialled on a track at its factory in Nanjing, China.

The DRT Trackless Tram has been successfully operating for the past three years in the Chinese City of Lingang, used by several hundred thousand passengers.

Trackless Trams utilise digital magnetic markers or “nails” to guide the vehicle along a virtual track, replacing the traditional “iron in the road” rail.

Magnetic nails embedded about 15 cm into the road surface about one metre apart along the route guide the rubber-tyred but tram-like vehicles around a virtual track. Construction is quick, with minimal impact on communities.

Electric-powered Trackless Trams are designed to adapt to most roads, have a high safety performance and are environmentally sound, green and low energy consumption. They can also be powered by hydrogen fuel cells.

FIGURE 3 — Trackless Trams

Source: Monash University

The construction of a Trackless Tram network is far less expensive, far quicker, and far less disruptive than a light rail construction. The ride is the equal to light rail, and its configuration is flexible in that carriages can be added or taken off to suit commuter demand (maximum commuters 300 on a three-carriage tram versus 207, maximum, for light rail.

Trackless Trams can combine several autonomous vehicle guidance technologies including self-guiding, “virtual rail” lines, and follow these lines along its corridor. Guidance systems include imaging recognition for optical guidance, satellite navigation, radar point scanning and inertia management.

Such systems are likely to be used for many autonomous vehicles in the future, especially transit systems that operate in mixed traffic. The lines marked on the road provide optical guidance while also clearly identifying the path of the vehicle for pedestrians and other motorists.

Additionally, a differential global positioning system uses fixed positions along the path of the vehicle to constantly update the relative location signals sent and received from satellites — increasing the location accuracy to the order of 10 – 15 cm from what can be up to 15 m with traditional GPS.

Radar and light point scanning enhances the vehicle's ability to recognize route signs, network characteristics and dynamic interferences that may occur, fitting this data to the information sourced from the other guidance technologies to create an overall sense of the surrounding environment.

The high precision achieved through the combination of these technologies adds to the appeal of the Trackless Tram by significantly increasing ride quality, improving the safety of the network, and reducing the damage caused to the road surface.

An on-board inertia management unit measures the pitch, yaw and roll, adjusting orientation and speed to stabilise the vehicle and create a ride quality characteristic of a rail-based tram or train.

Connection to the broader traffic control system through an on-board intelligent transport system can control intersection timings and provide real-time feedback to the traffic control centre, driver and passengers.

Although it is possible to be driverless, Trackless Trams have drivers due to their use in mixed traffic where unexpected events can occur, while also assisting with navigation and passengers where needed. Drivers can override the programmed track for the vehicle if there is an accident or blockage.

Australian adoption of Trackless Trams

A new, zero emission Trackless Tram has been demonstrated in Perth, after undergoing a series of tests as part of a process to have it certified for use on Australian roads.

An associated symposium highlighting this technology, under the auspices of the Sustainable Built Environment National Research Centre and Curtin University, was conducted in November 2023 in the City of Stirling, Perth, WA.

With Australian Government funding of $2 million through the Urban Congestion Fund for a business case, the City of Stirling is working with experts to assess a range of technology to support the Trackless Tram system from Glendalough Train Station to Scarborough Beach.

This major urban regeneration project is part of the City's broader vision to revitalise its centre to become Perth's second CBD and transform it into a vibrant, urban area with increased jobs and housing. Under the City's vision, Trackless Trams would extend 7 km from Glendalough Station to Scarborough Beach to offer contemporary, sustainable transport that's less disruptive and more cost effective to build while retaining the benefits of light rail.

FIGURE 4 — Trackless Tram demonstration, City of Stirling, November 2023

Source: City of Stirling website

The City has appointed ARUP consultants to conduct a pre-feasibility study into medium capacity transit systems along the Scarborough Beach Road Activity Corridor including new technologies such as trackless trams. SMEC has been appointed to deliver a more comprehensive body of work, with the development of a preliminary business case to address project definition and purpose, land use and planning, the preferred system, engineering and sustainability, delivery methodology and risk.

Other cities and regions across Australia are also investigating the introduction of Trackless Trams, including Melbourne, Sydney, other parts of Perth and the Sunshine Coast of Queensland

The advantages of Trackless Trams include:

- **Construction**: Utilising an existing road network, a service can be realised with low cost, low impact construction and long-life cycle. Vehicles can be assembled in Australia or fully imported.
- **Efficiency**: With the use of a dedicated lane (ideally), operators can set the tidal function, providing convenient and attractive public transport, while efficiently moving large volumes of passengers. The vehicle can also move in mixed traffic, if required.
- **Zero emissions**: These vehicles are zero emission and can be powered using a hybrid-hydrogen power source or on-board super capacitor batteries, with recharging at station platforms.
- **Precision**: The DRT can deliver high-precision positioning and guidance, to a centimetre-level control trajectory, and centimetre-level vehicle real-time positioning, maximizing the utilisation of road resources and assisting with passenger egress.

- **Value Capture**: As a medium volume public transport option, this technology has the capability to attract commercial and residential commuters. Platforms and stations are architecturally designed to enhance local communities.

Trackless Trams deliver higher capacity and better ride quality than bus rapid transit, as the vehicles are electrically powered and automatically guided along their alignment with new technology axles and wheels. The vehicles are cheaper than light rail as shown in Table 2 below.

TABLE 2 — Comparison of Australian construction costs for light rail, BRT and Trackless Trams

Costs	Light Rail $m/km	BRT $m/km	Trackless Trams $m/km
Cost from manufacturer Vehicles including recharge stations & communications	15	6	6
Total cost including road works, depot, service relocations, design & management	49-100	18	16

Source: Bodhi Alliance and EDAB Consulting and Manufacturing, cited by Newman P *et al*, 2018, Delivering Integrated Transit, Land Development and Finance: A Guide and Manual with Application to Trackless Trams

While the data in the Table is useful to understand relative costs, it should be noted that the ACT experience with light rail suggests that the cost per kilometre is much higher than the estimates presented here.

Professor Peter Newman and colleagues in a 2018 report noted that:

> ***"Light rail in recent years has begun to be very expensive due mostly to the cost of replacing services in the road when laying tracks. In Sydney the cost is over AUS$120m per km, Perth's proposed but abandoned light rail called MAX was $80m per km, the Gold Coast and Canberra around $50m per km.***
>
> ***The costs of a trackless tram system were estimated by the Bodhi Alliance and EDAB consulting, in a report prepared for the Inner West Council and City of Canada Bay in Sydney's west. This report estimated the cost at $5.59 million per kilometre of a route, including vehicle costs.***
>
> ***By comparison, the cost of installing a tram was estimated along that road at $15.31 million per kilometre, and the tram/bus system (higher capacity, elongated buses) at $5.51 million per kilometre, essentially the same cost as the TT system. However as outlined above, the patronage capacity is higher for Trackless Trams".*** (Newman P *et al*, 2018).
>
> ***It should be noted that Canberra's cost/km has been shown to be well over the figures quoted by Prof Newman in the above***.

4.4 High Occupancy Vehicle Lanes

High occupancy vehicle (HOV) lanes are traffic lanes that are reserved for vehicles with more than one occupant.

Well-designed HOV lanes get more people to work more quickly than general traffic lanes. They can reduce traffic congestion and transport emissions by encouraging car drivers to become bus and/or car passengers.

HOV lanes can be provided quickly and at extremely low cost, by simply installing appropriate signage along sections of general traffic lanes. Added HOV lanes require less space than bus rapid transit or light rail, and cost less.

- T2 transit lanes are available only to buses, taxis, motorcycles and car with two or more occupants.
- T3 transit lanes are available only to buses, taxis, motorcycles and car with three or more occupants.
- Bus lanes are available only to buses, taxis, motorcycles.

Inexpensive T3 lanes provide more people with faster travel and also encourage drivers to become passengers. Canberra's bus lanes and T2 transit lanes have for many years been carrying more Canberrans to work, more quickly. They can meet the expected public transport demand on the Civic-Woden route until 2046.

According to the Light Rail Stage 2A Business case, daily public transport patronage between Civic and Woden is expected to grow from 13,900 trips in 2026 to 23,000 trips in 2046. The Business Case for Stage 1 of light rail estimated that in 2031 Stage 1 of light rail will carry 20,207 passengers per day, including 5,193 in the morning peak and 5,012 in the afternoon peak.

A T3 lane can serve more people than a bus lane (provided that the T3 lane does not become congested). The results of the Transit Lane Warrants Study (AECOM 2012) indicate that a trunk road that carries 4,750 public transport passengers per hour could carry:

- 4,750 people per hour in 105 buses in a bus lane; or
- 5,800 people per hour In a T3 transit lane, in 634 vehicles – 105 buses, 215 motorcycles, 132 taxis and 230 cars with three or more occupants.

That indicates that for the foreseeable future, public transport demand on the Civic-Woden route could be more than adequately served by a T3 lane**.**

5. Other Considerations

In this chapter we discuss environmental and heritage considerations, planning and land use issues and opportunity costs. Transport decisions take place in the context of the distribution of land use and the demographic, social, economic, environmental and technological parameters shaping the city.

5.1 Environment and heritage

Light Rail Stage 2B will require the approval of the Commonwealth Parliament, which has responsibility for some of the land through which the Stage 2B route must pass. The Parliament can be expected to require a full analysis of the impacts and alternatives to the proposal.

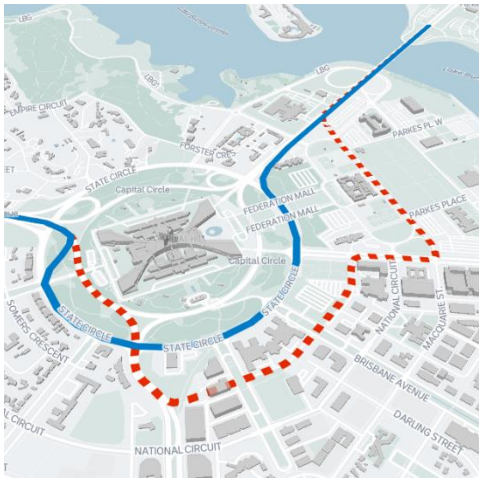
It is therefore of concern that the Commonwealth Government Minister for Federal Infrastructure, Transport, Regional Development and Local Government, Catherine King, appears to be supporting light rail Stage 2B, before a full analysis has been carried out. She is reported to have said:

> ***"We're partnering with the ACT Government on Stage 2A, and obviously the ACT Government will come to us when it's ready to talk about Stage 2B of the project."*** (Riotact, 2022)

The ACT Government's Light Rail Stage 2B project has been reported to be facing major heritage and engineering problems navigating around Parliament House:

> ***"NCA chief executive Sally Barnes told federal parliament yesterday that new technical difficulties had emerged in linking light rail from Commonwealth Avenue to State Circle, a road near Parliament House lined by heritage-listed rock cuttings. Ms Barnes said the engineering challenges might be too difficult or too expensive to overcome, and the NCA was now open to looking elsewhere."*** (ABC News, 2023)

Figure 5 — Possible Light Rail routes around Parliament House



Source: ABC News, 2023

Note: The currently preferred blue route crosses the Lake and reaches Adelaide Avenue via State Circle. The Red route leaves Commonwealth Avenue and takes King Edward Terrace, Kings Avenue and National Circuit before crossing State Circle to reach Adelaide Avenue.

Further, if the Commonwealth Government is asked to consider providing funding to the construction of light rail Stage 2B, it will need an Environment Impact Statement (EIS) which meets the requirements of the EPBC Act. This will need to include an analysis of the environmental impacts of alternatives to light rail. Here electric buses, Bus Rapid Transit (BRT) and Trackless Trams have advantages over light rail in that they do not need a steel track laid on a concrete base.

The currently preferred route proposed for Stage 2B will require the removal of trees from the centre of Commonwealth Avenue and from land inside State Circle for the light rail track. The alternative BRT transport solutions use existing roads

Light rail will require new bridge across lake Burley Griffin, between Commonwealth Avenue and State Circle, between State Circle and Adelaide Avenue and across Hopetoun Circuit, and across Yarralumla Creek at the Yamba Drive roundabout. These structures will require large quantities of steel, concrete, time and money.

There are also heritage considerations in relation to the Parliamentary Triangle and the vistas from it which would be impacted by light rail.

The conclusion is that light rail has a greater impact on the environment than the alternative transport solutions discussed in this paper**.**

5.2 Planning and land use issues

Before self-Government Canberra had a population just under 320,000 and was administered by the Commonwealth Government. The city was well planned and appropriately funded, with its on-going development under the control of the National Capital Development Commission (NCDC).

The NCDC legacy includes new towns with town centres with significant employment, higher order retailing and community facilities, the network of group and local centres, extensive cycle and pedestrian networks, peripheral road parkways, the intertown transport spine linking the town centres with central Canberra and a highly valued open space network.

The NCDC was responsible for the “Development of the City of Canberra as the National Capital of the Commonwealth" and for planning. One of its four principal tasks was to give Canberra an atmosphere and individuality worthy of the National Capital. Over a period of 31 years the Commission implemented much of this vision. Under its management, Canberra developed into a city with its own unique character.

The Commonwealth Government, as the “guardian” of the National Capital is amongst other things, responsible and accountable to all Australians for the development and enhancement of Canberra as the National Capital; one that belongs to the nation and is not the sole domain of the ACT Government.

FIGURE 6 — Northbourne/Macarthur Avenue intersection *before* Light Rail Stage 1

FIGURE 7 — Northbourne/Macarthur Avenue intersection *after* Light Rail Stage 1

Source for both pictures: Google street view

This guardianship is now vested in the National Capital Authority (NCA). The ACT Government's role is to ensure any planning and development under the Territory Plan is ' in a manner not inconsistent with the National Capital Plan; one which prevails over the Territory Plan; both intended to be complementary."

Canberra is one of only a small number of planned capital cities in the world and has been regarded as one of the best examples of such planning. However, this status is now under threat. Canberra's planning system has become what was described

recently by one commentator as opaque. The uniqueness that was Canberra, is gradually being diminished by the proliferation of multi-story apartments, urban in-fill, reduction in open spaces and loss of tree canopy.

Light rail, Stage1, has contributed to this. It has reduced the unique “Bush Capital” image that was Northbourne Avenue (the “gateway to Canberra”) to a tramway of poles, wires, scrawny brittle gums, grasses and concrete — one that now resembles just another unattractive suburban tram line.

The Commonwealth Government still has a responsibility, to all Australians, to ensure that Canberra is planned, developed and maintained at a standard that befits the Nation’s Capital. When the ACT self-government came into being, the guardianship of the National Capital, previously vested in the NCDC, was transferred to the NCA.

> ***“In taking over, the ACT Government’s role was to ensure any planning and development under the Territory Plan, would be “in a manner not inconsistent with the National Capital Plan; one which prevails over the Territory Plan; both intended to be complementary.”*** (NCA, undated).

In Canberra it is widely considered that the National Capital Authority (NCA) lacks the expertise to manage the processes relating to Light Rail Stage 2B and, in recent years has failed to demonstrate independence from the ACT Government. For example, when giving approval to the raising of London Circuit, the NCA ignored the ACT Auditor General’s negative report and issues raised in the majority of submissions. Given the impact on the Parliamentary Triangle, the Commonwealth Government should not leave decisions on Light Rail Stage 2B to the ACT Government.

The ACT Government consistently argues that light rail is a requirement for high density, and indeed imputed benefits from higher value land use (typically from denser residential accommodation) comprise the majority of "wider economic benefits" used to artificially bolster light rail benefit-to-cost ratios. However, the highest density developments in Canberra have been successfully undertaken in the Belconnen Town Centre, unhindered by the absence of a light rail service.

5.3 Opportunity costs

An important consideration with Light Rail Stage 2 is the opportunity cost - the loss of potential gain from other alternatives when one alternative is chosen. Spending considerably more on an expensive solution, like light rail, reduces funds available for other needs which could include health, education, social housing, city maintenance, improvements to bus infrastructure, sports and cultural and recreation facilities.

The ACT Government decision to divert $85.9 million, previously set aside for major road upgrades, to the light rail Stage 2A project was heavily criticised (The Riotact, 2022), as had the funds been invested on the roads, they would have benefited a far greater proportion of the Canberra commuting population than its expenditure on light rail.

The billions of dollars being spent on Light Rail Stage 2 could be better spent on faster and more modern transport technology described in this paper, at a fraction of the cost, with far less disruption and with more short- and long-term benefits to Canberrans.

This project continues to soak up billions of dollars of the Territory's budget —- an expenditure that has already impacted on the Territory's previous AAA credit rating. It is also negatively impacting on most of Canberra's other public services such as hospitals, schools, social housing, policing, roads and general maintenance.

The billions of dollars that are being spent on light rail Stage 2 will add to the Territory's Budget deficit — one that has been increasing each year for more than 10 years. Canberra will have the highest state/territory debt per capita in Australia next year at $28.4k (higher even than Vic: $19.5k). ACT interest payments on Territory debt are currently more than $1 million per day and are estimated to reach $3,000 per household in 2026, by far the highest in the nation.

The ACT Government's management of its budget has drawn strong criticism from Jon Stanhope, a previous Chief Minister. The Government has significantly increased rates and land taxes while supporting unrestrained development, controlling the sale of land to maximise profits, increasing other charges and reducing expenditure on many of Canberra's essential services.

The ACT Government's *lack of transparency* in what will be the most expensive infrastructure project in the history of the ACT under self-government, is of great public concern. As previously mentioned, Dr Leo Dobes noted the difficulties in assessing the business case due to the redacted and opaque presentation of information in his submission to the ACT Legislative Assembly Standing Committee on Public Accounts.

6. Future Developments

Fully autonomous electric vehicles are very likely to be a commercial reality within the next 3 to 5 years. These vehicles drive themselves. Used as a shared fleet, they can provide most of Canberra's transport needs for commuters, students and shoppers, supplying a 24x7, door-to-door service could prove cheaper than both traditional public transport and the private car. Autonomous electric vehicles produce no tailpipe emissions and as undistracted drivers, promise to greatly reduce the burden of traffic accidents.

ACT governments need to consider all the available transport technologies as well as appraise emerging technologies that are suitable to solve Canberra's public transport problems. These should be fully intergratable to provide optimum solutions as there is "no one size fits all" answer to providing a sound public transport network.

ACT Governments also need a vision to be able to meet the future public transport demands of Canberra's growing population. For example, had past ACT governments factored in an adequate median strip on the Tuggeranong/Gungahlin expressways, a BRT or trackless tram, with connecting bus routes, could have been constructed to link Tuggeranong to Gungahlin (and beyond). The ACT Government's 25-year Light Rail Vision is not only unachievable, enormously expensive but also very one dimensional.

Due to growing populations, major cities, throughout the world continue to face challenges in meeting commuter demands for better, quicker, less congested transportation systems. For Canberra, solutions need to be innovative, visionary and affordable and appropriate.

6.1 Autonomous Vehicles

ARK Research have described autonomous vehicles as "one of the most productive innovations of all time", estimating that autonomous vehicles will add 20% to global GDP over the next decade by improving productivity through cheaper transport and reducing the death toll from road accidents by 1.5 million annually (ARK Invest, 2023).

In Scotland, the ***CAVForth self-driving bus service*** came into public service in May 2023, and is described as "the world's most ambitious and complex autonomous bus system". Serving a ***14-mile route*** that crosses the Forth Road Bridge on the outskirts of Edinburgh, the buses drive themselves along ordinary roads, obey traffic lights, and mix with pedestrians and cyclists. Passengers seem to be unaware that the buses are not manually driven. This is due to the presence of a driver, currently required by UK Law, who sits behind the steering wheel and can take manual control, should the need arise.

Major car and technology companies are investing billions of dollars each year in the research and development required to bring autonomous vehicles to market. Some of the largest investments have been made by Waymo (a Google subsidiary), Cruise (backed by GM and Honda), Tesla, Intel and their former subsidiary, MobileEye, and in China, by Baidu and others.

Waymo and Cruise have been gaining experience for several years with large public trials of shared fleets of autonomous vehicles in San Francisco, Phoenix and Austin. Tesla's long-running beta program is accumulating over 1.5 million km each day in "Full Self Drive" mode.

Former Intel subsidiary, MobileEye is running “Mobility as a Service” trials in Munich and Darmstadt, and since July, driverless “taxis” have been accepting fares in Beijing, in a program soon to be extended to Shenzhen. The benefits of 24x7 on-demand, door-to-door, cheap and safe mobility cannot be underestimated.

Simulation of Autonomous Vehicles in Canberra

A simulation (see https://canberraautonomouscars.info/) of a shared fleet of autonomous vehicles in Canberra shows that this technology can provide 24x7 on-demand, door-to-door mobility at a fraction of the cost of existing private cars or public transport.

The simulation demonstrates how a fleet of 34,000 vehicles operating as a shared fleet can replace almost the entire private car and public transport fleet, providing 1.1 million journeys each weekday:

- About 95% of journeys begin within 1 minute of a car being requested, and 99% begin within 3 minutes. Outside the morning peak, there are almost no waits longer than 2 minutes.
- Average car occupancy during the morning peaks to popular commuting destinations is well over 2 people, compared with Canberra’s average peak time car occupancy of 1.24 people [AECOM, 2012, Transit Lane Warrants Study], reducing the number of cars on the road by 38% and effectively eliminating road congestion.
- The unsubsidised fare for a typical 10km trip is $4.84 during peak periods and $3.08 off peak (less than one eighth of the actual costs of providing current public transport, and much cheaper than private transport and even more so when parking costs are included).
- The fleet generates a surplus of around $125m per year after all capital, financing and operational costs.
- About 2,800 full-time-equivalent positions are needed to service the fleet.

The Canberra simulation presents strong evidence that a 24x7 on-demand, door-to-door public transport system based on an autonomous car fleet could soon be the best option for meeting Canberra's transport needs.

The simulation demonstrates that a fleet of autonomous cars can provide a service that:

- is at least as flexible, reliable and convenient as the personally owned car
- is much cheaper than either car or alternative mass transit options
- comprehensively meets the city's transport-related goals:
    - Increase the use of public transport by providing a superior alternative to the private car.
    - Optimise frequency and service reliability with a 24x7 on-demand door-to-door service utilising a decentralised fleet of thousands of autonomous vehicles less vulnerable to a single physical system failure than a single unduplicated transport corridor.

- Affordable capital and operational costs with a significant operating surplus at high usage levels, which allows for a significant community subsidy for transport for those in need, and leverages and better utilises Canberra's extensive road infrastructure already built and paid for rather than constructing a duplicate in the form of rail.
- Grow a more diversified Canberra economy through greater transport efficiency, and through the development of expertise and support in the deployment and management of a transport infrastructure likely to be emulated in other cities.
- Stimulate sustainable, urban redevelopment throughout Canberra by efficiently supporting both higher population densities and the traditional "bush capital" approach as options, and by releasing land used by carparks and garages to more socially and economically useful purposes.
- Increase social and economic participation through increased mobility of all citizens regardless of location, age, health, physical capabilities and income.
- Revitalise not just the Northbourne Avenue corridor but all Canberra's main travel routes by supporting higher population densities whilst reducing traffic congestion and travel times for all Canberrans.
- Reduce carbon and other emissions across all of Canberra by using electric vehicles with "zero tailpipe emissions" and creating a very large and predictable market for renewable electrical energy.

The public transport/transport sector is rapidly evolving and there are a number of innovations coming on stream/will come on stream in the future. The construction of light rail from Civic to Woden will totally constrain the development/introduction of far better, more advanced/modern public transport systems for many years to come (Stage 1 has already done this). Future governments will find it very difficult and very costly to dismantle the light rail system in favour of more efficient options.

7. Findings and recommendations

Since the 2012 decision to adopt light rail, public transport has been evolving rapidly. While some older technologies are being improved. new ones are emerging. These are very likely to offer better choices in years to come; by providing more efficient, environmentally friendly and less costly services that are better suited to Canberra's topography than light rail.

The ACT Government has been warned by the NCA that its light rail 2B project faces major heritage and engineering problems circumnavigating Parliament House which may block the preferred light rail route near Parliament House. Federal Parliament has been advised by the NCA's then chief executive, Sally Barnes, that the engineering challenges might be too difficult or too expensive to overcome, and the NCA was now open to looking elsewhere".

Locking the ACT in to a light rail public transport system *at **any price*** is a major mistake and has already contributed to the ACT losing its AAA Credit rating.

Proceeding with the construction of Light Rail, Stage 2B, from Civic to Woden, and subsequently throughout Canberra, would seriously constrain, both physically and financially, the introduction of far better, more advanced, modern public transport technologies.

The continued expenditure on light rail, often referred to as "gold plated" would also be catastrophic for the ACT's budget.

Light Rail Stage 2B fails to meet the "bang for buck" test. It would be inflexible, slower than the current express buses and serve only a very small percentage of Canberra's population.

The ACT risks being locked into an old, outdated transport system that is more than 130 years old; one which, despite some modernisation, will continue to be rigid, inflexible, and expensive to maintain.

Extending light rail to the airport, Belconnen and to Canberra's outer suburbs will cost tens of billions of dollars and many decades to construct. Meanwhile, Canberrans will have to wait very patiently and pay a huge price, for their "gold plated" light rail public transport system

These are costs that Canberrans cannot afford. There are many other competing demands for government funds such as hospitals, school, policing, social housing and the like. Diverting public funds to light rail is costing Canberrans dearly and is already leaving Canberrans with greatly reduced services, both in timeliness and quality.

Canberra's topography presents the ACT Government with a challenge in providing not only a cost effective, efficient, emission-free public transport network for Canberra's city and suburbs, but also one which will attract commuters and entice them to use. Overall, light rail is not suited for it.

Commuters need cost effective public transport solutions that are quicker and efficient. These solutions need to be both innovative, bold and visionary. This paper has described electric buses and bus rapid transit, trackless trams and increased use of

high occupancy vehicle lanes which are much less expensive and meet Canberra's needs.

A suitable emission-free public transport system for Canberra can be achieved by taking advantage of the most up to date transport technology. This will attract commuters, move them quickly to their destination while successfully overcoming the topographical challenges.

If all this can be achieved, Canberra would truly have a 21st Century public transport network.

This analysis finds that:

- Travel on Canberra's current public transport system takes twice as long as car travel, costs about $15 per passenger journey, and causes greenhouse emissions comparable to those of car travel.
- Bus Rapid Transit offers faster, more frequent and more flexible services than light rail, requires fewer transfers between bus and/or light rail services, costs half as much, can be built more quickly, and is twice as cost-effective.
- Canberra's high occupancy vehicle (HOV) lanes provide the same types of benefits as bus rapid transit. A strategic section of HOV lane can be provided in a matter of weeks, at a small fraction of the cost per kilometre of bus rapid transit or light rail.
- Trackless trams offer comfort and accessibility similar to light rail, are faster and more flexible, cost about half as much, can be deployed much more quickly, and are twice as cost-effective.
- The future use of a shared fleet of autonomous cars promises shorter commute times for their own occupants and also for other commuters. They offer lower emissions, and reduced demand for car parking space in the CBD.
- Light rail is unsuitable for Canberra because it is an expensive, outdated transport system which, despite some modernisation, will continue to be rigid, inflexible and expensive to maintain as well as being unsuitable for Canberra's topography

7.1 Recommendations

We recommend that the ACT Government:

1. Completes Light Rail Stage 2A ground works only, while undertaking a thorough evaluation of the future adoption of a trackless tram system to replace light rail.
2. Take no further action on Light Rail Stage 2B and cancel existing contracts or amend them, to provide for bus rapid transit, as soon as practicable.
3. Accelerate the acquisition of electric buses so that the transition to zero emissions public transport is completed by 2030.
4. Prepare and publish full cost benefit analyses and a business case for the use of Bus Rapid Transit between the City and Woden.

5. Extend the existing Adelaide Avenue T2 lanes to Civic and Woden.

6. Prepare and publish a plan for the use and management of T2 and T3 lanes, electric buses, Bus Rapid Transit, trackless trams, and autonomous cars in the ACT, integrating these modes with Light Rail Stage 1 to provide all Canberrans with a fully integrated public transport network.

7. Seek funding from the Commonwealth Government to collaborate with other cities to investigate and trial emerging public transport modes including trackless trams.

We recommend that the Commonwealth Government:

8. Stick to its statement made during the election campaign not to support projects, such as Light Rail Stage 2B, where the benefits do not stack up. The Commonwealth Government should reject the claimed wider economic benefits of this project unless the ACT Government identifies and fully justifies these benefits, and provides evidence that they can be achieved.

9. Respond to ACT Government requests for Stage 2B funding by instituting a public inquiry into the project, either through the EPBC Act or through a reference to the Joint Standing Committee on the National Capital and External Territories. Such an inquiry should only take place when the business case and the environmental impact statement prepared under the EPBC Act are publicly available.

Notes

1 The ACT 2017 Household Travel Survey reported an average public transport trip time of 47 minutes, for 48,807 trips covering 453,354 km. Vehicle drivers made 806,806,543 trips, travelling 7,568,378 km at an average of 20.05 minutes per trip.

2 Canberra's public transport operating cost subsidy was $6.80 per boarding in 2021-22 (Transport Canberra Annual Report 2021-22). Transport Canberra's Quarterly Data Reports show an average of 1.43 boardings per journey for the quarters ending 30 June 2022 to 31 April 2023.

3 The census of 10 August 2021 recorded that 14,678 Canberrans travelled *to* work by public transport. If the same number travelled *from* work by public transport, then 29,356 public transport commute journeys were made that day. That is 60% of the 48,983 public transport journeys that the ACT Government's Open Data Portal reports for that day.

4 The ACT OCSE Investigation into Scope 3 Greenhouse Gas Emissions report estimated the ACT's 2018 per capita carbon footprint at 34.7 t CO2-e. That included emissions from electricity generation. The ACT Greenhouse Gas Emissions Inventory Report 2017-18 reported 1,467.8 kt of emissions from electricity generation for a population of 416,244. That implies 3.5 tonnes per capita from electricity generation. The ACT Greenhouse Gas Emissions Inventory Report 2019-20 reported zero emissions from electricity generation, as a result of the ACT Government's policy of 100% renewable electricity. Subtracting 3.5 tonnes per capita of annual emissions from electricity generation from the annual carbon footprint of 34.7 tonnes per capita leaves a carbon footprint of 32.2 tonnes per capita per year.

5 Transport Canberra's 2022-23 annual report confirms that its bus fleet used 10.9 million litres of diesel fuel and 74 GJ of compressed natural gas (CNG) in 2022-23. Using 2023 National Greenhouse Account Factors of 51.53 kg CO2-e for CNG and 38.6 GJ/kl and 70.2 kg CO2-e/GJ for diesel, this fuel use is estimated to have caused 33,432 tonnes of CO2-e emissions. The ACT Government's Open Data Portal confirms 14 million bus boardings, and Transport Canberra's Quarterly Data Reports show an average of 1.4 boardings per journeys. On that basis, bus travel causes the equivalent of 3.4 kg of CO2-e emissions per journey. The 2022 Household Travel Survey reported 51,200 daily public transport trips and 645,000 km of daily public transport travel, for an average journey distance of 12,6 kilometres. It also reports 8,209,700 daily km of travel as vehicle drivers and 2,914,600 km as vehicle passengers, for an average occupancy of 1.355. 3.4 kg of CO2-e emissions for a 12.6 km trip equates to 270 g CO2-e per passenger-kilometre. At 269 g CO2-e per km and an average occupancy of 1.355, car travel causes an average of 199 g CO2-e per person per km.

6 The *City to Gungahlin Transit Corridor Infrastructure Australia Project Submission* estimates that ACT car travel in 2031 would be 2,072,900 kilometres under business as usual, 2,032,600 kilometres with bus rapid transit between Civic and Gungahlin, and 2,030,300 with light rail between Civic and Gungahlin.

7 Leon Arundell's analysis of Green Vehicle Guide emissions data showed that petrol/electric hybrid cars average from 136 to 152 g CO_2/km, petrol cars average 201 g CO_2/km and diesel cars average 220 g CO_2/km.

8 The ACT Government's Light rail Stage 2A business case estimates City to Woden travel times at 25 to 30 minutes, plus in the order of 2 to 2.5 minutes if wire-free operation is required.

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Appendix A

Extracts from the ACT Auditor General's report - Canberra Light Rail Stage 2a: Economic Analysis

On 10 September 2019, a redacted version of the City to Woden Light Rail: Stage 2a City to Commonwealth Park Business Case (Stage 2a Business Case) was made publicly available. It provided details for the design and construction of light rail between the City and Commonwealth Park and the ongoing operation and maintenance of that component of the light rail system. The Stage 2a Business Case also includes information associated with the economic analysis for Light Rail Stage 2a. *The purpose of the audit was to review the effectiveness of the economic analysis for the Light Rail Stage 2a Business Case".*

Project Cost estimates

For the purpose of the economic appraisal, the September 2019 Stage 2a Business Case identified a present value figure of $162 million (2019, discounted at 7 percent) for capital costs associated with the construction of Light Rail Stage 2a. *However, the capital cost of Light Rail Stage 2a is expected to be higher than what was estimated in the Stage 2a Business Case*. *Capital cost estimates in the Stage 2a Business Case did not include costs associated with retrofitting the existing light rail vehicle fleet with wire-free technology. This cost was estimated at approximately 17 percent of the estimated capital cost*. *This is a requirement of Commonwealth approval for Light Rail Stage 2a.*

At the time of the preparation of the Stage 2a Business Case there was a very strong likelihood that wire-free technology would be required for any extensions towards and through the Parliamentary Zone, but this cost, and other costs associated with urban design finishes, were not explicitly included in the capital cost estimate for Light Rail Stage 2a.

Project benefit estimates

For the purpose of the economic appraisal, the Stage 2a Business Case identified a present value figure of $150 million (2019, discounted at 7 percent) in benefits associated with Light Rail Stage 2a. This compared with a present value figure of $268 million (2019, discounted at 7 percent) of estimated costs for the project. The Auditor-General's report No. 8 of 2021 revealed that the costs associated with retrofitting the existing light rail vehicle fleet with wire-free technology would add approximately 17 percent ($46 million) to the estimated capital cost. That implies a capital cost of about $314 million. A $181 million contract was subsequently let for Depot expansion, 5 trams, retrofit batteries, etc.

The Auditor General noted that,

> *"A significant amount of the benefits identified for Light Rail Stage 2a are predicated on the project being a catalyst for the acceleration of development of the Acton Waterfront. Neither the Stage 2a Business Case or Economic Appraisal Report provides information or evidence on how Light Rail Stage 2a is expected to accelerate development at the site. Should the Acton Waterfront not be developed as fast as is hoped, then the timing and quantification of the expected benefits of Light Rail Stage 2a are at risk*."

The economic appraisal was developed in the context of a series of ‘transformational projects and revitalisation activities. As well as the Acton Waterfront Development, these other projects include raising London Circuit to be at-grade with Commonwealth Avenue; and a National Capital Authority proposal to reconfigure Kings and Commonwealth Avenues as grand boulevards and the development of Section 100 (formerly Section 63) at City Hill.

The implementation of Light Rail Stage 2a is dependent on the raising of London Circuit and will be influenced by the National Capital Authority’s plans for the Commonwealth Avenue Bridge. Any failure to implement these projects on a timely basis will have a negative impact on the expected benefits of Light Rail Stage 2a.

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Benefits Management

The Stage 2a Business Case identified a commitment to the development of a Benefits Realisation Plan for Light Rail Stage 2a. This has not occurred. Benefits management activities should be undertaken at the earliest possible Stages of a project to ‘ensure that a mindset of accountability and structured approach towards achieving set benefits is embedded from the early Stages of planning’.

Benefits management activities should include the development and implementation of a Benefits Realisation Plan; the 2016 Australian Transport Assessment and Planning envisages that benefits planning occur when options for the transport initiative are being considered and the business case is being developed.

Key Findings, Page 6, Para 2.61

For the purpose of the economic appraisal, the Stage 2a Business Case identified a present value figure of $23 million (2019, discounted at 7 percent) for development costs associated with the accelerated development of the Acton Waterfront.

The Auditor-General noted that:

> *“Inadequate information was provided in the Stage 2a Business Case in relation to the development costs, the methodology for quantification and the assumptions underpinning the estimate*. “
>
> *“The expected costs associated with Light Rail Stage 2a, including costs associated with the accelerated development of the Acton Waterfront, should be updated in revised, publicly available documents*. “

Key Findings, Page 6, Para 3.72

The Auditor-General noted that,

> ” *The Benefit Cost Ratio for Light Rail Stage 2a, calculated to two decimal places, was 0.38 excluding Wider Economic Benefits and 0.56 including Wider Economic Benefits. These were rounded up to 0.4 and 0.6 respectively for the Stage 2a Business Case. “The Stage 2a Business Case also includes a ‘blended indicative*

Benefit Cost Ratio' for: Gungahlin to Woden (Stage 1 and Stage 2 combined); and Gungahlin to Commonwealth Park (Stage 1 and Stage 2a combined). The 'blended indicative Benefit Cost Ratio' for both routes was calculated at 1.20 (rounded up from 1.18). The 'blended indicative Benefit Cost Ratio' was calculated by Major Projects Canberra independently of EY as its economic advisor."

"Douglas Economics advised that the 'blended BCR is novel; no example of blending the result of a past investment with a future investment is known' and also noted it 'has no relevance to the [Light Rail Stage 2a] investment decision because the Stage 1 costs are 'sunk', i.e. cannot be recovered."