Australian Light Rail and Lessons for New Zealand

Neil Douglas¹ & Daryl Cockburn² ¹Economist Douglas Economics ² Urban Planner Cockburn Architects Email for correspondence: DouglasEconomics@gmail.com

Abstract

The populations of Wellington and Auckland are forecast to increase and in both cities, Light Rail is seen as a way of meeting future transport demands in an environmentally considerate way. Over the last decade, there have been several Light Rail projects in Australia that have had varying degrees of success. This paper looks at them through the eyes of eight Australian experts who were asked to provide some 'bullet points' about what they saw as noteworthy and of relevance to New Zealand. Their ideas have been interworked amongst observations about costs, construction disruption, route planning, performance and economics, demand and wider city development and tourism appeal. Cost comparisons are also made with Heavy Rail and Busway projects. If nothing else, this paper shows that retrofitting mass transit public transport into Auckland and Wellington to cater for increasing populations will be expensive.

1 Introduction

Since the 1990s, Auckland and Wellington have, from time to time, considered Light Rail. None of the proposals have come to fruition. As we head towards 2020, visions of LRT are reappearing in both cities. A 22km CBD to Airport route has reached an advanced stage of planning for Auckland and a joint initiative between Central and Local government is considering LRT as part of a package of proposals in *'Let's Get Wellington Moving'.*¹ One catalyst for revisiting LRT is a 'renaissance' of Light Rail across the Tasman.



Figure 1: LRT in Australia

¹ A joint initiative between the Wellington City Council, Wellington Regional Council and the NZ Transport Agency set up in 2014.

Adelaide, Canberra, Gold Coast and Newcastle have all introduced Light Rail. In Sydney, the Darling Harbour service has been extended to Dulwich Hill. The CBD-SE LRT, which started construction in 2015, has regularly hit the headlines for all the wrong reasons with cost blowouts, construction slow-downs and a class action by badly affected businesses. Construction of Parramatta Stage 1 LRT commenced in 2019 but Stage 2 looks in doubt. Melbourne is of course, the home of the street-car tram (yesteryear's Light Rail). Brisbane is the odd city out having considered LRT but instead plumping for a bus Metro system to add to its Bus Rapid Transit (BRT) network. Hobart has a sketchy and probably optimistically costed proposal. Perth saw its MAX project abandoned in 2016.

Perth is also the home of long time rail stalwart Peter Newman who has become famous (now infamous to some) for his advocacy of Trackless Trams. Peter is one of the eight Australian experts who were asked to provide some 'bullet points' on how they saw Australian developments and what 'lessons there might be for New Zealand.

Table 1: Australian Experts

#	Expert	State & Occupation	Bullet Points	Sections
1	Rodney Forrest	NSW ex Treasury	Hidden costs & business disruption	7
2	Peter Thornton	NSW Consultant	Contracting out the risk is risky	7
3	Dr Tim Brooker	NSW Consultant	Route planning & politics	8&9
4	Dr Peter Tisato	SA Consultant	Evidence & careful implementation	8 & 10
5	Prof Graham Currie	VIC Academic	Operational speed & street cars	9
6	Tom Frost	QLD Consultant	Remember what the public want	13
7	Brendan O'Keeffe	QLD City Engineer	Rubber v steel wheel technology	16
8	Prof Peter Newman	WA Academic	New technology & Trackless Trams	16

Codes: NSW New South Wales; SA South Australia; VIC Victoria; WA Western Australia.

The views of the experts have been interworked amongst observations on costs, construction disruption, route planning, performance and economics, demand, wider city development and tourism appeal.

After looking at the increasing need for mass public transport in Auckland and Wellington in section 2, a sobering account of soaring costs of LRT construction across the Tasman is provided in section 3. However by standing LRT next to urban Heavy Rail makes LRT costs look cheap with Busway pretty similar as section 4 shows.

Over-engineered LRT standards imported from the USA and overzealous regulations are singled out as culprits in section 5 for LRT cost escalation with Christchurch, Melbourne and Germany offered as saner cost solutions in section 6.

Section 7 delves underground to identify utility diversions as a particularly expensive and time consuming construction component. Politicians who change routes can also be blamed as section 8 mentions.

So what do you get for your billion dollars building LRT? Well, section 9 explains that it's unlikely to be a rapid unless it's defined by the NZ Government. Section 10 finds that unfathomable Wider Economic Benefits and long term land use change are needed to bolster the economics. However, for politicians its votes and not economic appraisals that count as section 11 explains.

The Gold Coast Light Rail joins a string of 'activity' pearls together as section 12 lists as well as causing some disagreement amongst the analysts about what constitutes a new public transport trip. Down on George Street in Sydney, the LRT stops were originally too brutalist for Mayor Moore's liking in section 13 whereas it's been the replacement of Heavy Rail and tram track dangers to cyclists that's caused consternation in Newcastle in section 14. Heading west to Parramatta in section 15, the sun may be going setting on Light Rail particularly if, as is described in section 16, the rubber wheeled Brisbane Metro or the Chinese Trackless Tram prove their mettle. Neither of these bus systems are likely to have the 'vibe' of steel-wheeled Light Rail as section 17 point out. Section 18 brings our trip around Australian Light Rail to a terminus by listing some lessons that might be worth remembering for New Zealand.

2 Transporting the ever increasing masses

Let's Get Wellington Moving (LGWM) forecasts Wellington City's population will grow by a quarter from just over 200,000 to just under 250,000 between 2016 and 2043.² One proposal to get Wellington 'moving' is 'mass transit'. For LGWM purposes, it could be Light Rail, bus rapid transit, a Trackless Tram or something else on a route probably to the airport but along an alignment not fully determined.

Auckland Transport plans are further advanced. A Cross City Rail Link is under construction and details of a CBD to Airport LRT are being determined. As can be seen from Figure 2, the population of Auckland within walking distance of the proposed CBD to airport Light Rail is forecast to rise from 90,000 in 2016 to 138,000 in 2046. Higher population growth is expected on the western Heavy Rail corridor with much less growth on the Northern Busway. Thus in terms of transportation 'burden', the proposed Light Rail corridor sits in the middle of the three corridors. Employment growth is focussed in the CBD where LRT would disgorge its passengers. CBD population is forecast to increase from 90,000 to just under 160,000.



Figure 2: Auckland's Forecast Growth in 'narrow walk-up' Corridor Population & Employment

Source: data provided by Auckland Forecasting Centre. Notes: HR = Heavy Rail; BWAY = Busway.

² <u>https://getwellymoving.co.nz/about/population-growth/</u>

Having established a need, how much would a Light Rail cost to build and how much disruption would it cause? What will people think of the Light Rail when it's built and how many are likely to use it? What other benefits would a Light Rail provide? The rest of the paper looks at the recent experience of Australia in planning and building Light Rail to provide answers to these questions.

3 Soaring LRT construction costs

Let's get the 'bad news' over with first! Australian Light Rail construction costs have soared to around \$125 million per kilometre as the dashed curve in Figure 3 shows. The curve is based on 14 recent projects for which details are given in the Appendix.³

Most of the projects have been built e.g. Gold Coast Phases 1 and 2 with the southwards extension to Burleigh Heads (3A) at Business Case stage.

The 12 kilometre Sydney CBD-South East (CBD-SE) LRT continues to be constructed after a consortium 'go slow'. The cost passed \$3 billion in July 2019 after the dispute between the construction company Acciona and the NSW Government was settled in court.⁴ Residents, businesses and traffic continue to endure construction disruption at the time of writing (August 2019).



Figure 3: Australasian LRT Costs \$m/km (local currency and in year of estimate)

Note: The figures are in nominal dollars (i.e. dollars of the year of estimate) with no exchange rate adjustment for NZ. The symbols denote city. The 'prediction' line is based on only the Australian LRT estimates (i.e excludes MEL Tram). Details of each project are given in the Appendix.

³ Christchurch tram, Melbourne tram extension, Wellington LRT and Auckland LRT are shown on Figure 3 but were not included in fitting the green dashed regression line. See Appendix for details. ⁴ <u>https://www.abc.net.au/news/2019-06-03/sydney-light-rail-bill-passes3-billion-as-compo-settled/11172434</u>

Some LRT schemes remain proposals such as Hobart or have been abandoned such as Perth MAX (another LRT proposal for Perth emerged in 2019).

Of course, \$125 million per km is an average cost and a 'predicted' figure from the dashed green regression. As can be seen from the scatter, the costs of the projects vary enormously reflecting context, engineering challenges, LRT technology and the year of estimate. The lowest cost was \$6m/km for Hobart (where the proposed LRT would run mostly on existing rail lines and involve only a short street section) to \$250m/km for Sydney CBD-SE (where utility diversion has proved problematic).

For Wellington, adopting the \$125m/km figure, gives a cost of \$1.625 billion to build the infrastructure from the rail station to the Airport (13 kms).⁵ Auckland's proposed 22 km route from the CBD to the Airport would cost \$2.75 billion.

By comparison, a 2018 'preliminary' estimate for Auckland CBD to Airport LRT was \$3.7 billion (\$168 million/km). The figure was up from the \$2 billion figure in the 2016 Business Case. The estimate compares with \$1.6 billion for 'advanced buses'.⁶

The 'opportunity cost' of Auckland LRT can be assessed against the Housing & Urban Development Minister Phil Twyford's ambition to build more \$650,000 'affordable' homes. Phil Twyford is also the Transport Minister so the opportunity cost of the \$3.7 billion LRT is 5,700 affordable homes.

For Wellington, the cost for LRT between the rail station and Kilbirnie was \$858 million in the 2013 GWRC 'Spine Study'. The cost per kilometre was \$80 million and included a tunnel. Although considered costly at the time, it now looks quite reasonable in light of recent Australian experience.

4 How to Make Light Rail Look Cheap

Despite high unit costs, there is a way to make LRT infrastructure look cheap. It's by standing LRT next to a city centre underground Heavy Rail project!

Figure 4 shows the kilometre cost of nine urban Heavy Rail passenger projects (red squares) that are either at planning stage, being constructed or completed. Lying way below them are the Australian LRT projects (green diamonds) from Figure 2. Nine busway projects (blue circles) that date back to the 1985 Adelaide O-Bahn (which cost \$8m per kilometre) are also plotted. Two NZ LRT projects are shown (black triangles), the Christchurch heritage tram (red triangle) and the proposed Melbourne tram extension project (blue triangle).⁷

The Auckland CBD Rail link (ACRL) is the most expensive project graphed at \$1.26 billion per km. The twin 3.5 km rail tunnels under Auckland's CBD linking Britomart with Mt Eden have been costed at \$3.5b (up from \$1.5b in 2017 to provide more long-term capacity). Melbourne Metro at \$1.09b/km, Sydney City Metro at \$839m/km

⁵ All figures are in 'local' dollars for the year that the estimate relates to (it need not be the reference year). The exchange rate was \$NZ1 = \$Aus0.95 in August 2019 so no conversion of NZ costs into Australian dollars was considered necessary.

⁶ <u>https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12057244;</u>

⁷ Project details are presented in the Appendix.

and Brisbane CRRL at \$529m/km involve challenging CBD tunnelling. Their unit costs make the \$250m/km for Sydney CBD-SE LR look cheap by comparison.



Figure 4: Comparing Australasian LRT, Heavy Rail and Busway Infrastructure Costs

Another reason for ACRL having the highest Heavy Rail unit cost is that the project is well underway. Its costs are therefore set in pretty firm concrete so to speak whereas the Australian trio of city rail tunnels are far less advanced. The likelihood, based on experience, is that their costs will increase. Crossrail in London (the forerunner for the Australasian CBD rail projects) suggests a 175% increase which would raise the cost of Melbourne Metro to \$2 billion a kilometre.⁸

The three most expensive busways on a per kilometre basis featured major engineering works. For example, the Eastern Busway in Brisbane involved a viaduct, tunnel, a motorway underpass and a railway underpass plus six stations.

Massively escalating infrastructure costs begs the question whether *'predict and provide'* continues to be the right approach. Have cities reached their optimal size? Should population be a spread out to the bush and coastlands? A 'conversation' between RailCorp's senior planner and NSW Treasury about a \$5 billion 'through city' rail tunnel under Sydney CBD back in the mid-2000s comes to mind. The Treasury economist remarked that it would be cheaper to send the jobs to Brisbane than build infrastructure costing \$13,000 a commuter. In 2019, Brisbane is now faced with a \$5 billion bill for a cross city rail tunnel to provide commuter moving capacity.

Why not direct people to the Northern Territories where a \$15,000 subsidy for families willing to relocate to Darwin has been announced as part of a ten year \$50 million 'Population Growth Strategy'? The aim is to create 21,000 jobs and add \$10 billion to the NT economy.⁹ In New Zealand, a \$3 billion provincial growth fund has

 $^{^{8}}$ The 2003 Crossrail Business Case estimate was £10 billion. In 2019, with construction well underway, the cost had escalated to £17.6 billion, NAO (2019).

⁹ <u>https://www.news.com.au/finance/economy/australian-economy/15000-on-offer-to-families-willing-to-relocate-to-the-nt/news-story/82c33b3660d509aae1292d47993dfbfd</u>

been established to promote growth outside the main cities.¹⁰ The fund was intended to be spent over three years and amounts to 80% of the \$3.7 billion cost of Auckland's proposed CBD-Airport LRT.

5 Over engineered, over regulated & over supervised

Why have construction costs soared so much? Much can be attributed to the 'standard' of LRT. Contrast the installation of tram tracks at the intersection of Brunswick and Wickham Streets in 1920s Brisbane in Figure 5 with LRT track preparatory works in George Street Sydney nearly a century later in Figure 6.

The two well-dressed Brisbane ladies strolling over the unfinished tram tracks in Brisbane would have had to wait for over a year to cross through the wired-off construction site in George Street Sydney!

A major component of the \$3 billion cost of the Sydney CBD-SE LRT is meeting a 'rail standard' that would befit a coal train running down George Street rather than pedestrian friendly light rail.

Today's LRT engineering standards can be sourced to America where street-car systems were barred from applying for Federal funding. As a 'loop around', engineering consultancies started drawing up heavy rail solutions. These standards were then exported to Australia.¹¹

A project manager working on Perth MAX thoughtfully considered that the escalating costs were due to his wife (and others like her)! She was a manager in Occupational Safety and Health (OSH). Form filling, sundry nit-picking and micro-management was making project management decidedly tedious and time consuming. It's not the cost of the guys with jack hammers that has increased but the teams of road traffic managers, cohorts of white collar supervisors and huddles of contract lawyers.

Another area of concern is project accreditation. In Australia, Light Rail is not distinguished from Heavy Rail in the accreditation process – and Heavy Rail accreditation is not cheap. It also makes running Light Rail services amongst Heavy Rail freight trains legally difficult if not impossible even if safe passage could be practically ensured.

The escalation of costs and the implications for the economic justification of three LRT projects has not gone unnoticed. The NSW Audit office reviewed the Sydney CBD-SE¹² and the Newcastle¹³ LRT projects.

¹⁰ <u>https://www.growregions.govt.nz/about-us/</u>

¹¹ Mention should also be made of Edinburgh's 14 km City to Airport LRT which cost £776 million (at \$Aus 100million per km).

¹² The 2016 NSW Auditor-General report concluded that TfNSW did not effectively plan and procure the CBD-SE Light Rail to achieve best value for money with costs higher and benefits lower than the Business Case. <u>https://www.audit.nsw.gov.au/our-work/reports/cbd-and-south-east-light-rail-project</u>

¹³ The NSW Auditor-General's report on Newcastle LRT identified a lack of proper procedures in the decision to replace the existing Heavy Rail with Light Rail noting a lack of community consultation and

The ACT Audit office reviewed Canberra LRT.14



Figure 5: Construction Comparison - Brisbane 1920

Two women stroll across tram tracks being constructed at the Brunswick & Wickham St intersection whilst a member of the public checks the track work. Photo courtesy of the State Library of Queensland



Figure 6: Construction Comparison - Sydney George St 2017

Digging up and fencing off George St Sydney 2017 Photo Neil Douglas

the public announcement of the LRT decision before a Business Case had been completed. <u>https://www.audit.nsw.gov.au/our-work/reports/newcastle-urban-transformation-and-transport-program</u>

¹⁴ The ACT Audit looked at the inclusion of Land Use and Wider Economic Benefits in the Benefit Cost Appraisal which turned a BCR from 0.5 to 1.2 but which did not accord with Infrastructure Australia guidelines (see Figure 10).

https://www.audit.act.gov.au/__data/assets/pdf_file/0007/1179943/Report-No.-5-of-2016-Initiation-ofthe-Light-Rail-Project.pdf

6 Look to Christchurch, Melbourne & Germany

Instead of importing over-engineered standards from the USA, the designers of Wellington and Auckland LRT could stay closer to home. One place to look would be Christchurch and if an overseas example is needed then Melbourne - the home of the world's largest urban tram network. If an example further afield is desired then Germany would be worthwhile.

Construction costs for the Christchurch city tram link look to be of the order of \$6.5 million a kilometre. This cost is based on the Lichfield/Poplar Street extension.¹⁵ Admittedly, it's a single track loop of 17 stops using heritage trams that cater for tourists paying \$25 for a 50 minute circuit (5kph). Nevertheless, laying the tracks did require relocation of man holes and sewer traps and workarounds of the telephone duct cabling. Figure 7 shows the Colombo/High/Hereford Street intersection works in 2010.

Figure 7: Installing Christchurch Tram Tracks

Photo by Brent Efford circa 2010 of works at the Colombo/High/Hereford Street intersection

Melbourne typically uses only one layer of concrete to the top of the sleepers, hardfill and asphalt above with no reinforcing other than in the sleepers.¹⁶ In 2014, the Victorian Greens proposed that 56 km of tram extensions and in-fill routes could be built for \$1.36 billion - a cost of \$24m per kilometre (including stops, termini and overhead power). The costs were based on actual outlays for tram renewals, DFT (2014).

¹⁵ Christchurch built their system in short often disconnected chunks sometimes when other street works were required and some time before the track was expected to be put into service. This not only lowered overall costs but greatly reduced disruption to businesses. An example is Cashel Mall, where tracks were laid as part of pedestrianizing and redeveloping the Mall (before the 22/2/2011 earthquake). The 2019 extension will avoid a turnaround in High Street. 81% of submissions supported the extension. The costs were taken from Christchurch City Council High Street Revitalisation and Tram Extension Hearings Panel Agenda 15th August 2019. https://christchurch.infocouncil.biz/Open/2019/08/BLHP_20190815_AGN_3944_AT_WEB.htm

https://www.youtube.com/watch?v=i559VzMuSII and https://www.youtube.com/watch?v=Ra5KWMUS4Ko

Germany is developing a pan-European standard for Light Rail. The German rail firm DB Engineering & Consulting is part of the Canberra Metro Consortium that built the 12 km Canberra LRT for less than the estimate in the ACT Government Business Case.¹⁷ Here the question is why all the deep concrete slab was necessary in the depot and why ballasted track between road junctions was not sufficient.

7 Major construction costs are 'hidden'

For Sydney CBD-SE LRT, ex NSW Treasury economist Rodney Forrest commented that the costs of diverting the electrical and telecoms cabling plus the water and sewerage pipes were reviewed by NSW Treasury.

It could be argued what wasn't properly determined as shown by the evidence later on was how much compensation would be paid to residents and businesses during construction and who would be responsible for utility works up side-streets that stretched up to a hundred metres in some cases.

What eventuated was a 'construction go slow' with lawyers for the Spanish consortium Acciona wrestling with their NSW Government counterparts over responsibility. Initially suing for \$1.2 billion for digging up and replacing Ausgrid powerlines, the case was eventually settled for \$576 million in June 2019.

Peter Thornton an engineer and transport planner considers that what cannot be accurately measured cannot be accurately priced or priced within reasonable margins of error or remain within a contractor's typical contingency. Governments have learnt about patronage risk so now contract on the basis of a fee for service. The same should apply to construction where there are utilities buried in urban streets. Despite best endeavours, it is impossible to measure the absolute quantum of utilities or the work needed to deal with them in complex environments. It would be better that such inherently unmeasurable work is not contracted on a fixed price basis but according to competitive rates. There should also be a high degree of scrutiny by old fashioned supervisors who wield a "big contractual stick" to ensure value for money for Government and the public.

France typically excludes utility diversion costs on the basis that utilities are not the responsibility of the transport system. However for any meaningful Cost Benefit Appraisal (CBA), utility diversion costs should be included but they should be offset by asset betterment particularly when new improved and enlarged piping/cabling replaces is installed.

For some Sydney CBD businesses, construction disruption has caused bankruptcy. By mid-2018, 60 businesses had joined a class action for \$40 million in

¹⁷ Canberra LRT runs down a wide and straight median strip where ballasted track could have sufficed in some sections. It was therefore less affected by utility diversions. Removing trees was a contentious issue however. In the end, more trees were put in (1,200) than were taken out (450).

compensation. The amount was on top of the \$9 million in rental assistance that the NSW Government handed out to affected businesses.¹⁸

Construction disruption rarely features in 'Business Cases'. Economists argue disruption is a 'transfer payment': people will shop, drink or dine elsewhere. In other words, one owner's business loss is another's gain. This assumption is more for project advocacy and ease of analysis than realism however.

Neither is putting in underground Heavy Rail likely to be free of disruption. Much depends on the method of construction and the location of the construction portals. Auckland City Rail Link (ACRL) has caused major disruption. Work started in early 2016 and moved street by street using cut and cover techniques. Work is not expected to be completed until 2023 which is a construction period of seven years.

The Shakespeare Hotel in Albert Street lost their lunch-time trade for two years costing them \$1.5 million in lost revenue. In total, 16 nearby business owners have been badly affected by ACRL construction with six forced to close. The ACRL *"shattered the lives of 100 families"* according to business owner Sunny Kaushal who is seeking compensation from Government. 'Heart of the City' spokesperson Tania Loveridge cited the need for a Sydney LRT style construction hardship fund.¹⁹ The mental stress on business owners and residents of construction disruption has never been taken into account in Cost Benefit Appraisals so far but it should be.

Given the experiences of Sydney and Auckland it would be a courageous minister who'd consent to Wellington's Lambton Quay and Auckland's Dominion Road being dug up for an LRT service without a firm handle on the costs and timescale.

8 Politicians pick difficult routes & unrealistic timescales

Sydney transport planner Dr Tim Brooker recalled that the proposed route for the Sydney CBD-SE LRT was a former heavily patronised tram route to Randwick. So in principle, implementation should have been straightforward but the route chosen by the politicians didn't follow the traditional route via Anzac Parade/Oxford Street and Elizabeth Street. Instead, to satisfy different priorities, the route was changed to George Street and via the cricket and football stadiums.

Previous route evaluations undertaken in the 1990s and 2000s ranked George St last amongst alignment contenders because of traffic and business disruption. The less trafficked streets of Elizabeth, Castlereagh and Pitt ranked higher in both the 1995 and 2001 route assessment studies.

Transport economist Dr Peter Tisato's advice, in assessing the one kilometre extension of the Adelaide LRT along North Terrace to the Festival Plaza, is *"not to*"

¹⁸ "Sydney light rail: businesses join class action to sue NSW Government for \$40 million" Sydney Morning Herald 29th August 2018. <u>https://www.abc.net.au/news/2018-08-28/sydney-light-rail-saga-sees-60-businesses-sue-nsw-government/10173534</u>

¹⁹ Reymer L, (2019) "Families have been shattered: Compensation refused for businesses impacted by City Rail Link construction" AM News Show 23rd July 2019.<u>https://www.newshub.co.nz/home/new-</u> zealand/2019/07/families-have-been-shattered-compensation-refused-for-businesses-impacted-by-city-rail-linkconstruction.html

rush".²⁰ He argues that the North Terrace extension probably has merit but the project was hurried by politicians so as to be complete before the March 2018 election. Six months after the election, the line remained unopened due to the need to find and repair some major electrical faults that ultimately required German expertise. The 1 km extension was originally costed at \$90 million but increased to a reported \$124 million. Construction finished in October 2018.²¹

9 So what do you get for your billion dollars?

So what do you get when you've spent your billion dollars on Light Rail? Well, the average speed of the fourteen Australian LRT projects listed in the Appendix is 25kph. Speeds range from 15kph in Adelaide CBD to 40kph for Gold Coast Stage 2. Seen in this context, the forecast 49kph for Wellington LRT (running on-street throughout) in the Regional Council's 2013 Spine Study looks highly optimistic.

By European standards, 25kph is quite high. North American systems are faster, and as mentioned in Section 4, are more Heavy Rail than Light Rail in standard. For the Heavy Rail Australasian projects, the average speed was 55kph so obviously the benefit from spending so much more on tunnels is a long-term reduction in travel time (as well as passenger capacity).

How do Busway projects compare? The average speed for the Australasian projects reviewed was 28kph which is similar to LRT.

Given the slow speeds of some of the LRT systems reviewed it is unlikely that they would be considered 'rapid rail' which has become a basis for central government funding in New Zealand. The Ministry of Transport has defined 'rapid rail' as *"public transport capable of moving a large number of people, for example light rail and dedicated bus routes. Common characteristics of rapid transit include frequent services, fast loading and unloading capability, and largely dedicated or exclusive right-of-way routes."* (NZTA MoT GPS page 59). Given there is no actual speed threshold, Auckland CBD - Airport LRT (≈30kph) should qualify for funding.

Professor Graham Currie of Monash University stresses that 'rapid' high quality, high capacity public transport corridor needs segregated right of way: *"don't build a streetcar system like the legacy system of Melbourne"*. It may be popular but at an average speed of 16kph, Melbourne trams are slow and the system is unreliable due to ageing infrastructure, road traffic interference and lack of junction priority.

There are also transfers to consider. Dr Tim Brooker points out that Sydney CBD-SE LRT is half the length of the main corridor to La Perouse (14 km southeast of Sydney

²⁰ No one can accuse the transport planners of the Greater Wellington Regional Council (GWRC) of rushing to solve the worsening traffic problems in the capital city! The introduction of a new hub and spoke bus system that had been eight years in the planning got off to an atrocious start in mid-2018 with most of the suburban bus hubs unfinished and under-costed by a factor of 4. Costing \$2 million each, the bus stops were finished nine months after the new hub system commenced operations. Such planning doesn't instil much confidence that GWRC could manage the introduction of a new Light Rail system.

²¹ The construction work at the North Terrace and King William Road Intersection is shown in this time lapse video: <u>https://www.youtube.com/watch?v=YwWh6c-Xmdl</u>

CBD) and 85% of the length of the subsidiary route to Coogee so passengers will still have to interchange onto bus when travelling the full length of the corridor.

Market research for the Sydney CBD-SE LRT assessed the cost of transfers, see Douglas and Jones (2016).²² Transfers involving bus imposed a higher penalty of 8 minutes associated with the inconvenience and anxiety of transferring than the 5 minute penalty for Rail and Light Rail transfers.

Tim Brooker also considers that the capacity of the Sydney CBD-SE LRT will be insufficient during the peak hour as Light Rail is only likely to be able to provide passengers with a reasonable degree of comfort (i.e. avoiding sardine overcrowding) on the inner section of the route.

Douglas and Jones (op cit) estimated the set of crowding functions in Figure 8 for rail, bus and LRT for the CBD-SE LRT. Crowded seating added between 23% and 34% to the perceived cost of onboard travel time. Standing added 60% and 84% and crush standing 103% to 153%.

Also shown are the maximum passenger capacities. Buses were estimated to be able to carry 150% of their seating capacity with passengers standing in the aisle. Double decker trains had a seating capacity of 200% with passengers standing in the downstairs vestibule and aisles. The longitudinal seating of LRT by providing greater standing room was estimated to give a multiplier of 300% of seating capacity.



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(1) Passengers / Seats

Source: Douglas & Jones (2016)

Although the crowding multipliers for a given load factor were lower for LRT, standees on a crowded Sydney CBD-SE Light Rail are still likely to perceive their

²² "Developing a Suite of Demand Parameters for Inner Sydney Public Transport" by Douglas & Jones (2016) Australasian Transport Research Forum 2016, Melbourne, Australia.

travel cost higher than would seated passengers on a crowded bus. So to keep the cost of crowding down and avoid long waits at LRT stops, Tim Brooker foresees the need to retain bus services on the Sydney CBD-SE LRT corridor.

The Sydney market research also attempted to quantify the perceived quality advantage that LRT has over Bus. Respondents were found to rate the German Variotram used on the Darling Harbour - Dulwich Hill service at 80%. Buses were rated lower at 68% and double deck trains rated the lowest on 64%.

LRT also rated higher in terms of the perceived quality of its stops scoring 74% versus 66% for rail stations and 62% for bus stops.

The market research attempted to distinguish quality differences from intrinsic modal features using Stated Preference surveys.²³ Figure 9 shows two show cards. The left hand card features a choice between travelling by good quality LRT versus poor quality LRT. The right hand card shows a choice between travelling by averagely rated LRT and averagely rated Bus.



Figure 9: Example of Sydney CBD-SE LRT Market Research Show Cards

The intrinsic modal preference for LRT over bus (i.e. independent of quality) was be worth 10% of travel time so for a 25 minute trip, the preference would be worth 2.8 minutes in favour of LRT.

10 Congestion, land use & wider economic benefits?

On street LRT occupies road space so for LRT to produce a decongestion benefit, patronage diversion from car needs to be enough to offset the reduction in road space for remaining road users.

For Wellington, AECOM (2013) forecast LRT would make road congestion worse. The disbenefit was worth \$32 million in Present Value terms over a 30 year period. By contrast, Canberra LRT was forecast to produce a small decongestion benefit of \$2 million.

For Adelaide, the rhetoric was that LRT would improve congestion but Peter Tisato questions whether this actually occurred since there have been no formal studies. And LRT land-use benefits? Peter Tisato argues that there has been *"a lamentable*"

Source: Douglas & Jones (2016)

²³ The survey was simple for respondents to answer but complex in design (featuring a full factorial experimental design of 243 questions) in order to estimate the separate and interactive effects of travel time, cost and quality for bus, LRT and Heavy Rail.

lack of studies particularly ex-post ones to demonstrate an increase in inner-city development relative to fringe development".

For Canberra, including land-use and wider economic benefits (WEBs) on the 12 km LRT route from Gungahlin to Civic raised the Benefit Cost Ratio from 0.5 to 1.2, see Figure 10. The ACT Audit Office was unhappy that the Transport Department's appraisal failed to conform to Infrastructure Australia guidelines which would have excluded land-use and WEBs from the core evaluation and would have left the Government advocating a project where each dollar reduced economic welfare by 50 cents.

IA's guidelines although sensible given the *"assumption laden black-box WEBS formulae"* Douglas and O'Keefe (2016) contrast with the NZ Economic Evaluation Manual which includes WEBs in the 'core evaluation'.²⁴ Despite their inclusion, Wellington LRT still only managed a miniscule return of 5 cents per dollar of investment.

Wellington Spine Study AECOM				Canberra LRT				
	Benef	it / Cost \$	Sm PV	Benefit/Cost	\$m PV	Share		
	Rue	Bus		Bus Operating Cost Saving	54	5%		
Benefit/Cost	Priority		LRT	PT User Benefits	245	25%		
	Fliolity	Transit		Road Decongestion Benefits	2	0%		
Public Transport User Benefits	35	96	56	Accident Benefits	7	1%		
Road User Benefits	-18	-24	-32	Health Benefits	5	1%		
Wider Economic Benefits (25%)	4	18	6	Externality Benefits	14	1%		
Total Benefit	21	90	31	Residual Value	81	8%		
Capital + Operating Costs	46	127	680	Land Use Benefits	381	39%		
Car Parking Cost Savings	-10	-23	-8	Wider Economic Benefits	198	20%		
Total Cost	36	104	671	Total Benefits	987	100%		
Net Present Value	-16	-14	-641	Capital Cost	619	75%		
BCR	0.57	0.87	0.05	Operating Cost	204	25%		
Benefits/ costs discounted at 8% over 30) years			Total Cost	823	100%		
				NPV	164			
Wellington O				BCR	1.20			
				BCR (Transport Benefits)	0.50			
11kms				Benefits/Costs discounted at 7% per year 30 years				
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Figure 10: LRT Cost Benefit of LRT in Two Capital Cities

Source: Aecom (2012); ACT Government (2014)

²⁴ WEBs played a controversial part in the evaluation of the Auckland CBD Rail Link. In May 2011, the National Government announced it was unconvinced by the wider economic benefits for the tunnel option but that it would not stand in the way of Auckland Transport continuing planning and route designation work so long as Auckland would pay for it.

11 Politics trumps economics!

Canberra LRT demonstrates politics trumps economics!

 Joint Council and Chris Calvi Freeman of Wellington City Council visited Canberra to see how Australia's capital city had progressed LRT. Photograph by Neil Douglas.

Figure 11: Local councillors from Wellington make a study visit to Canberra

Economic appraisals don't vote and as a condition to support a Labor led government, the ACT Greens wanted LRT built. As a consequence, much of the 'debate' was whether the public was pro or anti LRT and whether Canberra could afford it or not.

Surveys established that more than half thought Government was investing in LRT to upgrade transport options and/or reduce road traffic congestion, see Figure 12. Just less than half (48%) thought that Light Rail was better for the environment and for job creation. The percentage was 10% points higher than for bus (38%). Ten percent thought the ACT Government was investing in LRT 'for political reasons' with a further 5% giving generally 'unsupportive' comments,

In terms of affordability, just over half of respondents had concerns about cost and affordability despite ACT having the highest GDP per capita of any state/territory in Australia.

In May 2016, the contract to build and operate the Canberra LRT was awarded to the Capital Metro consortium for a cost of \$704 million (10% less than the Business Case estimate of \$783 million). The consortium will be paid back over a 20 year concession period at \$65 million per year. To pay fund the payments, the ACT Government sold \$400 million of assets with the Federal Government providing \$66 million. The remaining funds will be sourced from General Government Service revenue which totalled \$5.1 billion in 2016/17.²⁵

²⁵ https://the-riotact.com/how-are-we-paying-for-light-rail-in-canberra/186324



Figure 12: Market Research on public opinion about Canberra Light Rail

A range of methods to fund Wellington LRT were considered as part of the 2012-13

Spine Study, see Ellis and Douglas (2015). 70% of the funds were raised by a region wide 10% fare increase, a 10% charge on car parking, a 5c regional fuel tax and a \$1.50 cordon charge on vehicles entering Wellington in the AM peak. The remaining 30% would be funded through rates.

Canberra Metro commenced service on April 20th 2019. During the first month when no fares were charged, passenger numbers averaged 17,300 trips per day. When fares were introduced, patronage declined by 14% to 14,900 trips per day.²⁶ Nevertheless, passenger volumes were still within 2% of Business Case forecast for 2021 of 15,120 per dav.27

Longer term, the Canberra Government is expecting land-use intensification to push up demand on the Light Rail corridor. We will have to wait and see what materializes.

Urban consolidation and the associated savings in physical, social and transport infrastructure (compared to green field development) was all the rage back in the 1990s but fell out of fashion. Today it's all about unprovable econometric WEBs.²⁸

²⁶ https://www.canberratimes.com.au/story/6201161/light-rail-passenger-numbers-down-in-first-paidweek/ ²⁷ There has been debate about how patronage should be measured given bus/LRT transfers.

²⁸ It would nice to see Urban Consolidation Savings making a return, perhaps with Infrastructure Australia taking the lead by establishing the marginal infrastructure cost of developing and redeveloping different types of location.

Figure 13: Canberra LRT



Photo supplied by Canberra Metro Operations

In the late 1990s, the economics of the Sydney Airport Rail Link (ARL) rested partly on the redevelopment of Green Square, Mascot and Wolli Creek. The population and employment projections were ambitious. *"Assume Chatswood on Day 1"* the State Rail Planning Manager instructed the consultants. *"Really?"* they replied. The assumption was duly made pushing the BCR above 1. When the Sydney 2000 Olympics was announced, the ARL got built. Patronage turned out to be much lower than forecast and the operator went bankrupt. Now in 2019, the apartment blocks are there for everyone to see as they look through the train windows at Wolli Creek just as the State Rail Planning Manager predicted (although the Central Industrial Area around Green Square still has some 'regeneration' to achieve). The State Rail Planning Manager was just a decade or so ahead of his time.

Around the same time in the mid-90s, Wellington was looking to convert the Johnsonville Line to LRT and achieve infrastructure savings from Transit Orientated Development. Douglas and Cockburn (1993) showed how increases in suburban residential densities could be achieved along the 10.4 kilometre single track rail corridor through in-fill housing subject to sympathetic planning rules.

12 G-link a 'string of pearls'

The G-link links together 20 kilometres of the Gold Coast from Broadbeach South to Helensvale. The 19 stations shown in Figure 14 connect many of the Gold Coast's trip generators and attractors.





Stage 1 (Broadbeach South to Gold Coast Hospital) which involved 13 kilometres of street running cost \$123 million a kilometre to build. Stage 2 (Gold Coast Hospital to Helensvale rail station), which utilised an existing rail corridor, was built at around half the unit cost rate (\$58m/km). A 6.7km (Stage 3a) the southern extension to Burleigh Heads was at Business Case stage in August 2019 and has construction costs of \$106 million a kilometre.

When completed the patronage for Stage 1 was 6.3 million trips in 2014-15. It increased to 8 million trips in 2016-17. After Stage 2 was completed in 2017-18, patronage rose to 9.5 million trips.²⁹

Translink Annual Reports showed that the 6.3 million LRT trips in 2014-15 were counterbalanced by a decline in bus trips of 6.2 million. The net impact on public transport was therefore only 100,000 trips.³⁰ After Stage 2 and the connection to the Heavy Rail network at Helensvale, many of the additional 1.5 million trips would have been rail transfers which will overstate the actual increase in public transport trips.

²⁹ It should be noted here that some of this patronage increase can be attributed to the Commonwealth Games (held 4th-15th April 2018) that attracted 1.27 million tourists according to an Economic Impact study by Griffith University (2018).See Griffith University study (2018) https://publications.qld.gov.au/dataset/economic-impacts-of-the-gold-coast-2018-commonwealth-games-2018-post-games-report/resource/2e1b689f-560b-4296-be68-f02a012205c2

³⁰ Keys (2016) has questioned the claimed public transport patronage increase for the G-link *"Light Rail Development in Australia 2012 – 2016"*

https://www.atrf.info/papers/2016/files/ATRF2016 Full papers resubmission 40.pdf

An aim for the G-link was to remove 40,000 car trips per day (14.6 million trips a year).³¹ Given that total patronage has only reached 9.5 million 'trips' by 2017-18 this aim looks difficult to achieve.

Few 'Before & After' (B&A) studies have been undertaken to determine the source of LRT patronage so it's difficult to assess the source of G-link demand. ³² No B&A study has been published for any of the recently completed Australian projects. ATAP report M1 (p 10-11) does give a figure of between 10% and 13% for previous car drivers, ATAP (2017). If applied to the 9.5 million G-Link passengers in 2017-18, previous car drivers would have accounted for 1 million trips. This figure is clearly well short of the Translink target of removing 14.6 million car trips.

In terms of funding, the justification for Federal assistance for G-link Stage 2 was made easier by the 2018 Commonwealth Games taking place on the Gold Coast and also by Australian Prime Minister (Malcolm Turnbull) being rather fond of rail transport.

A world class sporting or cultural event would probably be needed to galvanise support for Wellington LRT. A 'string of pearl' stops would also be possible: South Island Ferry Terminal; Aotea Quay Cruise Ship Terminal; Wellington 'cake tin' Stadium (football/rugby and cricket); Rail Station; Cable Car; Te Papa national museum; Courtenay Place entertainment district; Basin Reserve cricket pitch; Newtown regional Hospital; Kilbirnie Sports Centre and Wellington International Airport.³³

13 Access to 'brutalist' stations

Tom Frost, Director of the transport consultancy NineSquared points out that most of the new Australian LRT services tended to have larger and expensive 'stations' than Melbourne tram stops which may lose one of the key perceived benefits of the Melbourne system, which is 'ease of access'. For example, the Canberra LRT by being positioned in the median strip means pedestrians will have to cross a busy double carriage way to get to the 14 stops placed roughly a kilometre apart.

As previously mentioned, the new LRT systems have characteristics closer to Heavy Rail rather than Light Rail. The Mayor of Sydney objected to the brutalist concrete stations and long tram lengths planned for George Street.³⁴ Figure 15 shows an artist's impression of the LRT stop outside Sydney's Town Hall on George Street.

Douglas, Bradley and Jones (2019) for a review of all four studies. ³³ Douglas and Cockburn (2013) looked at the first stage of a rapid LRT that could connect some of

³¹ TransLink 2008, *"Gold Coast Rapid Transit; Draft Concept Design & Impact Management Plan.* ³² Two B&A studies have been undertaken Croydon London and Tenerife. See Thomas (2002) for Croydon and for Tenerife see Gonvalez et al (2016). Patronage assessments have also been undertaken of Sheffield LRT by WS Atkins (2000) and Manchester LRT by Knowles (1996). See

³³ Douglas and Cockburn (2013) looked at the first stage of a rapid LRT that could connect some of Wellington's key activity centres together <u>http://wellington.scoop.co.nz/?p=59349</u>

³⁴ "What we are expecting is a sensitive urban project, not a heavy rail, suburban railway through the heart of a global city [along George Street]," Clover Moore told Fairfax Media (November 15, 2016) <u>https://www.smh.com.au/national/nsw/clover-moore-threatens-to-halt-47m-payment-for-sydney-light-rail-20161114-gsoxmz.html</u>



Figure 15: Artist impression of LRT stop outside Sydney Town Hall

Source: City of Sydney Council

14 Tear down that wall and watch out cyclists!

Heading north, the impetus for Light Rail in Newcastle was removing the severance of Heavy Rail on the urban- waterfront environment. The price was severing the direct service to Newcastle city centre

The rail line acted like the *"Berlin Wall for around 100 years"* said Parliamentary Secretary for the Hunter Scot MacDonald. The Heavy Rail line stopped workers, tourists and families from walking between the waterfront and the city centre.

Proponents argued that replacing heavy rail with LRT would reinvigorate the pedestrian heart of Newcastle. Opponents went on about underhand property deals and the removing the direct rail service to Sydney.³⁵ What was possibly a first was a Green party MP (Dr Mehreen Faruqi) actually opposing Light Rail's introduction. She opposed the Newcastle proposal because she believed it would make public transport worse for Novocastrians and would be a waste of money.

The early days of LRT saw passenger numbers averaging 4,259 per day in February 2019 which was double the Business Case expectations of 1,600.³⁶ Of course, many trips were simply transfers from intercity trains at Wickham. The 2010 CityRail Compendium estimated that there were 4,500 boardings and alightings at Civic and Newcastle stations. If all these passengers now interchanged at Wickham, there would be no extra rail passengers resulting from LRT's introduction.

³⁵ In 2014, two MPs resigned from the NSW parliament after a NSW Independent Commission Against Corruption (ICAC) inquiry both had accepted illegal donations from developers. The Lord Mayor of Newcastle and property developer Jeff McCLoy also resigned after the inquiry revealed he had given illegal donations to several Liberal MPs as well.

https://theconversation.com/will-it-be-the-end-of-the-line-for-newcastles-train-or-for-baird-38534 ³⁶ https://www.newcastleherald.com.au/story/5948224/passenger-data-shows-light-rail-off-to-a-flyingstart/



Figure 16: Wickham Interchange

The new Light Rail – Heavy Rail interchange at Wickham where long distance rail passengers who previously had a direct service into Newcastle city centre now transfer. Photo by Scott De Martino

Overhead wiring for LRT was ruled out for aesthetic reasons (it would have been somewhat illogical to argue it was okay for LRT but not for Heavy Rail). Instead, the Light Rail vehicles have storage batteries recharged at the six stations on the 2.7 km route. This decision was estimated to have added \$35 million to the project. Costing more was the decision to run down Hunter and Scott Streets which added \$100 million.

There now remains the question of what to do with the Civic and Newcastle stations (see Figure 16). In the short term they have been used for events.



Figure 17: What do you do with a disused rail stations?

With parallel Light rail constructed, Newcastle's heavy rail line was redundant offering up development opportunities but raised the question as what to do about Civic station? Photograph Neil Douglas

There are now LRT tracks in Hunter and Scott streets. One tragic casualty from their introduction was cyclist Danny Egan who got his wheel stuck in a tram track whilst

crossing the light rail on 10th July 2019 causing him to fall off his bike and hit his head.³⁷ He died in hospital.

Newcastle's light rail website advises riders to 'take care near tracks [as] wheels can catch in the tracks or can slip and cause a fall'. It also advised cyclists to slow down before crossing the tracks and aim to cross at a right angle.

As Danny Egan had had a drink, it's been said his accident was alcohol related but he wouldn't had the accident if the tracks hadn't been there. LRT tracks have also caused accidents elsewhere. In Edinburgh, a landmark ruling in June 2019 awarded damages to two people thrown off their bikes and injured after their wheels got trapped in the tracks of the relatively new LRT. The judge ruled the design and materials used were to blame and awarded undisclosed damages.³⁸

Edinburgh's LRT tracks have been regarded as more dangerous than other cities. A study by Maempel et al (2018) found 191 cyclists had been injured between May 2009 and April 2016 in accidents related to the city's LRT tracks. In 2017, a cyclist died after her wheels got caught in the tracks in the central city and she fell into an oncoming minibus.

The cost of tram track related accidents has rarely been factored into Benefit Cost Appraisals. Usually only the 'good news' is included of improved safety from diverted car users. For Newcastle, the net realised benefit of LRT is now unfortunately \$6.6 million less (2013/14 prices) as a result of the cyclist fatality based on figures in TfNSW's 'Principles & Guidelines' (2018).

For Wellington, the basis for "Light Rail" proposals up until the GWRC's 2012/13 'Spine Study' (seven proposals in all) was the exact opposite of Newcastle. The idea was for Light Rail to replace trains on the Johnsonville line (a 10.4 km single track suburban rail line out of Wellington) and be extended through the city to provide seamless public transport.

Dr Dave Watson, the Transport Planning Manager of Greater Wellington Regional Council for over a decade in the 1990s-2000s considered: *"We always came to the same conclusion. Light rail as a stand-alone service (Station to airport) was not a winner. We needed to extend to Johnsonville or even the Hutt. We looked at operating standard units and light rail on the same tracks and then allowing the light rail to extend into the City. We saw no problem with this".³⁹*

LRT would 'penetrate' the CBD removing the bus-rail transfer impediment for some rail passengers and introducing a LRT v Heavy Rail transfer for passengers off other rail lines. Rail would thereby capture a greater share of the regional travel market.⁴⁰ It is therefore the opposite of what Newcastle has done.

³⁷ https://www.msn.com/en-au/news/australia/pictured-father-of-three-cyclist-who-died-after-falling-from-his-bike-in-freak-accident-when-his-wheel-slipped-into-a-light-rail-track/ar-AAEgsSy

³⁸ <u>https://www.theguardian.com/uk-news/2019/jun/28/edinburgh-cyclists-win-damages-judge-rules-tram-tracks-to-blame-two-incidents</u>

³⁹ Email to Neil Douglas dated 6th March 2015.

⁴⁰ There are parallels with Karlsruhe Germany where there is a tram-train system. <u>https://en.wikipedia.org/wiki/Karlsruhe_model</u>

For Wellington, the plan was kyboshed probably for 30 years, when the stations and tunnels on the Johnsonville line were reconfigured for new electric 'Matangi' heavy rail trains.

Since 2017, bus transport in Wellington city has deteriorated. The 100% electric trolley buses, which replaced the trams in the mid-1960s, were themselves withdrawn in 2017. The Regional and City councils were unwilling to upgrade the electricity supply so dismantled the overhead wiring at a cost of \$8-\$11 million.



Figure 18: A line of diesel buses in Willis Street Wellington August 2019

The golden mile of Wellington is acts as an elongated bus stop during the Peak. On Willis St, the middle bus is a 15 year old ex-Auckland diesel that replaced the city's 100% electric trolley buses in 2017. Photo by B. Smyth

NZBus, which operated a fleet of 60 trolley buses, announced they would be converted to Wrightspeed technology in 2016.⁴¹ The conversion failed as was predicted by several electrical engineers.⁴² In their place, Wellington got old diesel buses from Auckland.

During their 50 years of operation, the trolley buses provided an electric bus system that was ultimately unique in the southern hemisphere. The unwillingness to invest around \$300 million to modernise the buses (onboard rechargeable batteries, power supply and overhead wiring) to achieve a fully electric bus system in Wellington city questions the logic of investing \$1.5 billion to install overhead wiring and track for one Light Rail corridor.

⁴¹ <u>https://www.forbes.com/sites/samabuelsamid/2016/04/22/new-zealand-adopts-wrightspeed-jet-and-battery-power-for-buses/#1da30bdd238d</u>

⁴² See Efford (2018) "I told you so" http://wellington.scoop.co.nz/?p=107342

15 Sunset in the West for Light Rail?

Construction works for the \$2.4 billion Parramatta Stage 1 commenced in 2019. LRT could have been introduced earlier in Western Sydney had it been seriously considered in the 2006 North West Transit Link evaluation. The project 'proponent' was RailCorp who runs Heavy Rail so it was not unexpected when Light Rail and Transitway were rejected as options by the study team.

Indeed, it was only late in the day that the report's title got changed from 'North West Rail Link' to 'North West Transit Link'. As Douglas and Brooker (2016) contend, the NWTL exemplifies the 'one way' progression of Business Cases as well as retrospective advocacy for decisions already made. The 2006 economic evaluation concluded that a \$1.9 billion heavy rail link connecting the North West sector (Rouse Hill – Castle Hill) to the heavy rail system at Epping produced a higher BCR (1.4) than either Light Rail costing \$1.4 billion or Transitway costing \$600 million. This result was largely due to providing a direct service rather than an enforced interchange at Epping which would have resulted with LRT or Transitway.

By November 2011, TfNSW's submission to Infrastructure Australia saw costs quadruple to \$8 billion and the service changed to single deck metro style trains shuttling back and forth to Chatswood, TfNSW (2011). Rail passengers now need to interchange where once they had a direct service to Sydney CBD. Douglas and Thornton (2019) provide an assessment from a passenger's perspective.

Despite the service changes, LRT and Transitway were never revisited and nor was the choice of corridor. An alternative, considered in the 2006 evaluation, was to connect the NW sector to Parramatta by Transitway at a cost of \$760 million. Given that similar numbers of commuters from the NW sector travel to Parramatta CBD as they do to North Sydney/Sydney CBD, it would probably have been sensible to have assessed the benefits of linking the NW sector to the 'second city' of Parramatta. The failure to address these 'higher order' questions, given the limited funds for big transport projects that shape the metropolitan landscape, was and remains a big weakness in the NSW planning process.

Parramatta Stage 1 has 16 stops and utilises the existing Carlingford rail line (converted it to dual track Light Rail) before turning west to Parramatta CBD along new street sections. It then does a 'fish-hook' around Parramatta Park to Westmead. Figure 18 provided a route map.

Passengers wanting to transfer to/from the Heavy Rail system at Parramatta will be faced with a 150 metre walk (straight line distance) from the LRT stop in Parramatta Square.⁴³ Rail passengers who previously used the Carlingford Line to travel to Sydney CBD will now have to travel backwards to Parramatta Square and then transfer. They will have more services (every 7 minutes in the peak) newer vehicles and modernised stations but it is unlikely to compensate them for what looks like a very poorly conceived transfer.

⁴³ A \$2.6 billion redevelopment of Parramatta Square involving six new buildings is planned. <u>https://www.cityofparramatta.nsw.gov.au/council/parramatta-square</u>

West of Parramatta, LRT heads north around Parramatta park. Here, the acres of car parking reduces the likelihood that significant numbers of medical staff and hospital visitors will divert to Light Rail.



Figure 18: Parramatta Light Rail

The circuitous alignment and poor network connectivity contributed to a Benefit Cost Ratio of 0.73 meaning the LRT would lose 27 cents for each dollar invested. Only when Wider Economic Benefits were included did Stage 1 manage to become economic with a BCR of 1.06. However since the BCR was calculated in 2015, the 'blow out' of construction costs from \$1 billion to \$2.4 billion wasn't included. Stage 1 must now be decidedly uneconomic with a BCR of around 0.44 (ceteris paribus) likely.

In terms of design and engineering, Stage 1 has catenary-free (battery storage) sections and one kilometre of aesthetic 'green track' where grass and/or shrubs will be planted between and beside light rail tracks around Cumberland Hospital, Robin Thomas Reserve and Tramway Avenue.⁴⁴

Despite the low economic return, the NSW Government continues to see Parramatta Light Rail as a catalyst for residential and commercial redevelopment and intends *"to share in the value uplift"*.⁴⁵ To do this, the NSW Government has agreed to a Special Infrastructure Contribution (SIC) proposed by the WestLine Partnership.⁴⁶ It was proposed to set the SIC at \$200 per square metre of gross floor area of new residential developments. This was subject to consultation and when consulted, the Peak development group Urban Taskforce (representing apartment builders)

releases/making-it-happen-western-sydney-parramatta-light-rail-network-unveiled

⁴⁴ See Western Sydney University 2019 report on green track.

https://researchdirect.westernsydney.edu.au/islandora/object/uws%3A48951/datastream/PDF/view ⁴⁵ https://web.archive.org/web/20151208175129/http://www.transport.nsw.gov.au/media-

⁴⁶ The WestLine Partnership was started in late 2014 to investigate development opportunities in the Sydney Olympic Corridor see Deloitte (2015) *"Restarting Sydney's Heart Light Rail the Engine of Change"* <u>https://www2.deloitte.com/content/dam/Deloitte/au/Documents/public-sector/deloitte-au-ps-deloitte-light-rail-report-final-24022015-0215.pdf</u>

considered the levy "*way too steep*" as it would raise the price of a two bedroom unit in the LRT corridor by \$20,000.⁴⁷

Stage 2 which has a cost of \$1.1 billion is planned to connect Stage 1 to Olympic Park via Ermington, Melrose Park and Wentworth Point with 10-12 stops along a 10 km two-way track taking 25 minutes.

However the major increases in Stage 1 costs mean Stage 2 (which had already been pared-back from reaching Strathfield), may not happen or will be deferred. The June 2019 reduction in project staff numbers is pointer to this possibility.⁴⁸

16 Steel wheels good, rubber wheels better?

Seven hundred kilometres north, Brisbane has decided to go for a bus based 'Metro' system thus continuing its association with bus Rapid Transit. Brendan O'Keeffe, Principal Engineer Policy and Strategy of Brisbane City Council argues that Bus Rapid Transport was selected because *"it has more flexibility in being able to be incorporated into the existing street environment. It is also considered better able to integrate with traditional bus services which means both 'modes' will get a benefit. Whereas mixing buses with trams was identified as causing a number of operational inefficiencies. And, not having to completely dig up the streets to relocate services and lay track also featured highly in Brisbane's evaluations with work for BRT consisting of pavement strengthening where required".*

Brendan O'Keeffe views the Bus Metro solution for Brisbane as "providing a greater choice of propulsion systems (overhead trolley bus, electric battery, diesel hybrid and diesel)". By contrast, he sees LRT as "limited to overhead wiring or third rail traction" and "there would be no need to strengthen culverts and bridges and for Brisbane, a key cost element for an LRT system would have been strengthening Victoria Bridge to get trams across the river".

In Perth, long-term rail advocate Professor Peter Newman of Curtin University has "come to the realisation that a trackless tram rather than conventional Light Rail is the technology to adopt between heavy rail core routes and bus capillary feeders".

Peter Newman still argues that "Wellington needs light rail as always, my views have not changed on this but they have changed on the technology to do this and I now believe that a Trackless Tram will do everything I always wanted to achieve with light rail but at one tenth of the price".

Rather than \$50 million a kilometre, the trackless tram (TT) according to Peter Newman could be installed at \$5 million a kilometre. The TT is manufactured by CRC, a Chinese rail company dating back to the 1930s that employs 18,000 staff. CRC has adapted High Speed Rail technology (stabilisers, hydraulic double axles)

 ⁴⁷ Bajkowski (2015) Government News Dec 2015 *"Is the Value Capture Price Far Too High?*" <u>https://www.governmentnews.com.au/sydney-light-rail-is-the-value-capture-price-far-too-high/</u>
 ⁴⁸ Project staff numbers were reduced in June 2019 which raises doubt about Stage 2 progressing. <u>https://www.smh.com.au/national/nsw/looking-for-jobs-second-stage-of-parramatta-light-rail-line-in-doubt-20190807-p52er4.html</u>

for buses and developed GPS Optics to keep the vehicle 'on track', Special tyres, electric battery powered (with a 50km recharge claimed to take 10 mins) and lighter than a conventional bus means that according to Peter Newman "the ride feels like Light Rail, looks like Light Rail but is also able to go around accidents when required".

For Perth, Peter Newman envisages that the TT would be paid for by developers in a partnership and would not destroy the street economy for several years since construction is implementable and could utilise an existing bus depot and a Main Roads Control Centre. Peter Newman also claims TT can handle steeper grades of 13% compared to LRT's 6% which he thinks is very relevant to Wellington and Auckland.

Auckland Transport has considered trackless trams sending a delegate of managers to the 6.5 km trial track in Zhuzhou in 2017. Their greatest concern was the operation and longevity of the batteries because the CBD-Airport route is 22 kilometres long.

From their field-visit report it would appear that the AT delegation was reasonably impressed with the trial system. Indeed, they put forward recommendations to their senior management for further investigations on specific aspects. For reasons unknown, these further investigations do not seem to have proceeded.

Figure 19: Auckland Transport engineers visit the Trackless Tram in Zhuzhou China



In mid-2019, Peter Newman visited Wellington and presented the case for TT. Wellington City's Mayor was duly impressed and announced his intention to visit Zhuzhou.⁴⁹

However the Trackless Tram is not without its critics. Wong (2018) has reviewed the manufacturer's claims about optical guidance and remarks that although such guidance dates back to the late 1980s, it has had limited commercial success with

⁴⁹ The City Mayor's announcement was to the annoyance of Regional Council councillors who are responsible for planning the public transport system.

only three applications since the early 2000s: Rouen, France; Castellon, Spain: and, Las Vegas, USA.⁵⁰,

Brent Efford (2019) wrote a critical article called *'Sham trams'* soon after Peter Newman's visit to Wellington.⁵¹

Clearly it's prudent to be cautious about manufacturer claims until they are proven in operation. Performance on Wellington's poor road surfaces and hills is an 'unknown' but substantial road strengthening costs would seem likely.

What is important is to establish the corridor(s) where a mass transit system would best operate and how it would be integrated into the existing transport system.

17 It's the vibe!

Think of Melbourne and you think of trams. The image probably sticks because other Australasian cities dismantled their networks from the 1950s onwards, replacing them with buses leaving Melbourne with a system unique to the southern hemisphere.

Nowadays, tourism authorities latch onto whatever transport asset they think sells their city to the world. The Gold Coast features its G-link, Wellington its cable car, Christchurch its heritage tram and Sydney its harbour bridge and until 2013, its mono-rail, which whizzed around the *Welcome to Sydney*' arrival video but otherwise failed to attract plaudits.

Movie & TV Directors shooting a scene on a Tram or Light Rail route will usually try to boost *'street ambience'* by filming a tram passing. The dings of the bell and the squeal of the wheel add to the soundscape. Contrast this to what has become the fate of Elizabeth Street, where the roar of buses, the screech of brakes and the smoke from diesel exhausts makes for a noisy, dirty and vibrating experience.

In 2019, the new Light Rail enabled Canberra to join the transport asset marketing club. As can be seen in Figure 20, the ATRF conference organisers have already latched on to Light Rail with their web-site banner.





 ⁵⁰ <u>https://theconversation.com/looking-past-the-hype-about-trackless-trams-107092</u>
 ⁵¹ The article discusses the technology and its appropriateness for Wellington. <u>http://</u>wellington.scoop.co.nz/?p=120553

No doubt, Auckland and Wellington, if and when they do build Light Rail, will similarly showcase their transport asset.

18 Lessons worth learning?

If Auckland and Wellington planners and politicians want to accommodate many more people into their urban centres then more mass public transport will be needed. Retrofitting the infrastructure is likely to be expensive and disruptive.

For LRT, the fixed infrastructure cost of recent Australian projects has reached \$125 million per kilometre. Justifying such costs is nigh on impossible using 'conventional' cost-benefit analysis so unsurprisingly, project proponents have resorted to 'Land-Use' and 'Wider Economic Benefits' to get their Benefit Cost Ratios a tad over 1.0.

The main alternatives to LRT look to be not much cheaper and in the case of Heavy Rail, probably six times more expensive when tunnelling is involved although capacity and speed will ultimately be greater. Grade separated Bus Rapid Transit is also expensive, probably as much as Light Rail per kilometre if tunnels or overpasses are needed. Trackless trams could be a cheap solution but the technology remains untried outside China and there is a long list of questions such as road strengthening and battery performance that need answering.

For LRT, the North American '20cms of concrete' version of 'Light' Rail needs questioning. It's not just the financial cost but the disruption costs to businesses and residents that stem mainly from utility diversion. These 'hidden' costs have been seriously underestimated in recent Australian Business Cases to 'sell' the project to the public. The detrimental impacts on the mental and physical health of business owners, employees and residents needs to be at least acknowledged. It's not just a 'transfer payment' as some economic consultants have blithely assumed.

Rather than blindly follow North American and now NSW standards, Auckland and Wellington could look to Melbourne, the home of the tram. There is unlikely to be too much of an adverse impact on travel times since the average speed of the Australian LRT projects has only been around 25kph compared to 16kph for Melbourne trams.

For Newcastle and Parramatta, Light Rail has worsened rail connectivity. Newcastle Light Rail now enforces a transfer at Wickham and Parramatta LRT will mean travelling backwards, walking 150 metres to Parramatta rail station before heading to the CBD. These transport disbenefits need to be offset by big gains in civic amenity which is very hard for economists to put a value on.

Also needing greater consideration is the potential for LRT tracks to cause cycling accidents, possibly fatal ones, as has been the case of Newcastle and Edinburgh. Track design and signing must aim to avoid such accidents in the future. LRT Business Cases have included crash cost savings from diverted car users but have understated or omitted altogether the potential for cycling accidents.

The different characteristics of cities, indeed of individual transport corridors makes it unwise to make blanket recommendations about technology. The debate over steel versus rubber wheels, fixed v flexible systems and power supply will continue. New Zealand is in no position to lead or dictate technology so it is hoped that pointing out some lessons from 'big brother' Australia's recent experience with Light Rail will help Auckland and Wellington accommodate population growth more cost effectively and without so much construction disruption and future dangers to cyclists. ١



Figure 21: At last (but not 'in-service' yet) Sydney CBD-SE LRT in Devonshire St. Aug 28th 2019

Photo Scott De Martino Henry Royce: "The quality will remain long after the price is forgotten"

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We'd like to thank Murray King for suggesting we write a paper after attending a presentation given by Neil Douglas at the Chartered Institute for Logistics in October 2018. The presentation gave the thoughts of the Australian experts. https://cilt.co.nz/wp-content/uploads/2018/11/Neil-Douglas-LRT-presentation.pdf.

A short paper was duly written and appeared in the December edition of the NZ CILT magazine.

https://cilt.co.nz/magazine/australian-light-rail-systems-and-lessons-for-new-zealand/

LRT developments have continued a pace and so we thought it useful to do an 'updated and extended' version. In doing so, we'd like to thank Brent Efford, John Davies, Keith Flinders, Dave Hinman, Mathew Hounsell, Mike Mellor, Lindsay Oxlad, Derek Scrafton, Ian Wallis, Don Wignall and two anonymous reviewers plus roving photographers Scott De Martino and Rainer Koenig.

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Appendix: Cost Graphs of Busway and Heavy Rail Projects



Figure A1: Busway infrastructure costs





Australasian Transport Research Forum 2019 Proceedings 30 September – 2 October, Canberra, Australia Publication website: <u>http://www.atrf.info</u>

Appendix: Details of LRT, Busway and Heavy Rail Projects

Table A1: LRT Projects													
City	Project	Status	Cost \$m	Length kms	Cost \$m/km	Speed Kph	Passengers million p.a.	Comment					
Adelaide	Events Centre Extension	Opened 2010	100	2.8	36	15	9	Glenelg (SW ADL) to city. Only remaining tram line. Extended three times in 2007 Vic SQ - Station/Uni (1.2kms); 2010 to Events Centre (2.8kms) and 2018 to Festival Plaza along King William Rd (1km). 3					
Adelaide	Festival Plaza Ext	Completed 2018	124	1	124	nk	nk	services with 33 stops. Takes 11 minutes from Railway Station to Events Centre. Free in City Centre.					
Canberra	Stage 1 Gungahlin- Civic	Opened May 2019	707	12	59	29	5.4	12km route between Gungahlin & Civic with 14 stops. 14 LRVs operated by Capital Metro. 14,876 trips per day in 1st week of fare paying. June 2019 (down 14% on free month average). Business case forecast 15,120/day in 2021. Contract awarded to Capital Metro consortium for \$704 million in May 2016 which was lower than Business Case \$783 million. 450 trees were removed before construction. 1,200 were planted after track installation. https://www.canberratimes.com.au/story/6080841/canberra-light rail-by-the-numbers/ https://www.canberratimes.com.au/story/6201161/light-rail- passenger-numbers-down-in-first-paid-week/					
Canberra	Stage 2 - Civic Woden	Business Case 2018	1450	11	132	24	nk	Includes dedicated bridge over Burley Griffin Lake. Wire-free sections e.g. Alinga St. to Sydney Av. Overhead wires on Adelaide Avenue. 30 trees felled from Commonwealth median from Lake Burley Griffin to Coronation Drive. Travel time of 25-30 minutes. Parts of Callum St. in Woden closed to cars, with shared zone for LRT, pedestrians and cyclists. Woden bus interchange overhauled. Construction could start 2020/21 and operational 2023/24. https://www.canberratimes.com.au/story/6015859/cost-of- canberras-light-rail-stage-two-revealed/					
Sydney	Lilyfield- Dulwich Hill	Opened 2014	176	5.6	31	19	10.2	Central - Darling Harbour - Pyrmont LRT opened in 1997. In 2000 it was extended to Lilyfield and extended to Dulwich Hill in 2014. Patronage exceeded forecasts with 9.9 million trips in 2016 versus 7.2 million forecast in EIS. Hounsell (2018). 10.2 million in 2017. https://www.atrf.info/papers/2018/files/ATRF2018 paper 61.pdf					

Gold Coast	G-link Stage 1	Opened 2014	1,600	13	123	25	7.7 (2015- 16)	Dual track between Broadbeach South & Gold Coast University Hospital. Funded by federal, state & local government delivered via a Public Private Partnership.
Gold Coast	G-link Stage 2	Opened Dec 2017	420	7.3	60	40	9.5 (2017- 18)	Northern extension partly along existing rail alignment to Helensvale rail station to give 20.3km link with 19 stops serviced by 18 LRVs.
Gold Coast	G-link Stage 3	(Busn Case 2019)	709	6.7	106	nk	na	Planned 6.7-km southwards extension to Burleigh Heads.
Hobart	Glenorchy	Proposal	55	9	6	34	nk	ACIL Tasman 2013 study. Uses 8.6km of existing track from Glenorchy with added 400m passing loop and street extension from Mawson Place to Elizabeth St (including traffic management, intersection modification, overhead equipment & depot and stop construction). <u>https://www.stategrowth.tas.gov.au/ data/assets/pdf file/0006/</u> <u>88629/The Light Rail Business Case - Hobart to Glenorchy 2013.pdf</u>
Newcastle	Newcastle	Operation al Feb 2019	290	2.7	107	14	1.56	Replacement of Heavy Rail from new interchange at Wickham to Newcastle Beach. Follows Heavy Rail line for 1.4kms then down Hunter and Scott Streets. Catenary-free with batteries charged by overhead bars at 6 stops (added \$35 million to project costs). Operated by 6 trams (5 section vehicles 33 metres long carrying 207 passengers (60 seated) costing \$4.6 million each (including 20 years of maintenance). Passenger numbers averaged 4,259 per day in Feb 2019 (double the forecast 1,600). <u>https://www.newcastleherald.com.au/story/5128157/newcastle- light-rail-nearly-twice-the-price-of-canberras/</u> <u>https://www.newcastleherald.com.au/story/5948224/passenger- data-shows-light-rail-off-to-a-flying-start/</u>
Parramatta	Parramatta Stage 1	Const. began 2019 - complete 2023	2,400	12	200	nk	nk	Conversion of Carlingford-Camelia rail line to LRT with new street running to Westmead via Parramatta's CBD and around Parramatta Park. 16 stops. Catenary-free (battery storage) sections. 1km of aesthetic 'green track' (planting grass or shrubs between and beside light rail tracks) included around Cumberland Hospital, Robin Thomas Reserve and Tramway Avenue.

Parramatta	Parramatta Stage 2	Project Announce d 2017	1,100	10	110	24	nk	Connect Stage 1 to Olympic Park via Ermington, Melrose Park, Wentworth Point with 10-12 stops over a 10 km 2way track. 25mins Olympic Park - Camellia. Leaked 2016 report estimated cost of Stage 1 and Stage 2 at \$3.5b. In June 2019, project staff numbers were reportedly reduced shedding doubt on project. <u>https://www.smh.com.au/national/nsw/parramatta-light-rail-line- via-sydney-olympic-park-gets-green-light-20151208-glhxhg.html http://www.parramattalightrail.nsw.gov.au/stage-2-parramatta- cbd-sydney-olympic-park</u>
Perth	МАХ	Aband- oned	1,900	22	86	nk	30+	Metro Area Express (MAX) proposed (in 2010 with opening in 2018) to run south from Polytechnic West Balga to CBD with spur lines to Queen Elizabeth II Medical Centre in Nedlands and eastern end of Victoria Park Causeway. Project abandoned in 2016.
Sydney	CBD-SE	2020 Opening	3,000	12	250	22	31+	Circular Quay along George St to Town Hall (catenary free) to Central then Moore Park then forks to Randwick & Kingsford. Construction began 2015 planned opening 2019 delayed to 2020 with cost overrun and disruption to residents and businesses. Cost more than double original estimate to exceed \$3 billion (ABC News) after \$560 million settlement to construction consortium Acciona. <u>https://www.abc.net.au/news/2019-06-03/sydney-light-rail-bill- passes3-billion-as-compo-settled/11172434</u>
Australia LRT	Average	na	1,002	9	100	25	7	Simple average of 13 Australian projects
Melbourne	Tram Extension	2016	1,360	56	24	16	nk	Victorian Greens 2004 proposal to extend 17 tram routes and fill in 'missing links'. Based on costs for track renewal projects (probably mid 1990s): \$15m/km incl overhead works; \$1.7m per DDA compliant tram stop; \$5m per tram terminus (\$2012/13); \$5m per substation (routes >5km) & \$2.8m per road intersection. Tram stops 500 metres apart. In general each route has a new terminus and 2 intersections. \$1.36 billion between 2015 & 2019 with escalation of 3.2% p.a. Source: DFT (2014) Melbourne trams average 16kph. https://www.abc.net.au/news/2017-05-19/melbourne-trams- among-slowest-in-the-world/8541228

Melbourne	Tram Extensions	2016	1360	56	24	16	nk	Victorian Greens 2004 proposal to extend 17 tram routes and fill in 'missing links'. Based on costs for track renewal projects (probably mid 1990s): \$15m/km incl overhead works; \$1.7mn per DDA compliant tram stop; \$5m per tram terminus (\$2012/13); \$5m per substation (routes >5km) & \$2.8m per road intersection. Tram stops 500 metres apart. In general each route has a new terminus and 2 intersections. \$1.36 billion between 2015-19, with escalation of 3.2% p.a. Melbourne trams average 16kph. https://www.abc.net.au/news/2017-05- 19/melbourne-trams-among-slowest-in-the- world/8541228
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City	Tram/LRT	Status/ Cost Year	Cost \$m	Length Kms	Cost \$m/km	Speed kph	Passengers Millions p.a.	Comment
Christchurch	Heritage Tramway Extension	2019	3	0.2	12	5	0.28	Heritage trams with tourist orientation. 3.9km standard gauge single track city centre circuit (2.5km loop opened Feb 1995. 1.4-km extension Feb 2015). 50mins around loop 17 stops (ticket \$25). 7 trams with 1 restaurant car at night. \$3 million extension planned Aug 2019 along Lichfield and Poplar Streets (approx 0.2km) which would remove turnaround in High St. Privately run. 280,000 passengers used the 2.5km loop in 1998, 85% tourists (Bruce 1998). <u>http://www.stuff.co.nz/the-press/christchurch-</u> <u>life/avenues/features/3276760/The-tramway</u> <u>https://www.viator.com/tours/Christchurch/Christchurch-Hop-On- Hop-Off-Tram/d400-3352P9</u>
Wellington	Spine Study	2012 Study	858	10.7	80	49	nk	Includes Victoria tunnel (\$400m). Estimates by David Langdon (AECOM) in a \$1 million Spine Study for GWRC published in 2013. Figure excludes \$80million for 22 LRVs. Predicted travel time of 13 minutes from Kilbirnie to Railway station compared to 24.5 minutes for 'reference case' bus. PT demand surprisingly forecast to decrease by 0.6% in AM peak in 2021. http://www.gw.govt.nz/assets/Transport/Regional-transport/PT- Spine-Study/PTSS-Final-Reports-2013/FINAL-PTSS-Option- Evaluation-Report-for-web.pdf
Auckland	Airport	2018 Prelim Est.	3700	22	168	30	nk	Airport to CBD via Mangere, Onehunga, Mount Roskill then Dominion Rd to Queen St & Wynyard Quarter waterfront terminus. 2/3rds of route would be grade-separated Light Rail with 1/3rd dedicated lanes along Dominion Rd and Queen St (which would be pedestrianised). 44 minute travel time. <u>https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid= 12057244</u>

Table A2: Busw	ay/Transitway	Infrastructure Costs
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Busway	City	Cost Year	Kms	Cost \$m	Cost \$m/ Km	Speed kph	Notes
O-bahn	Adelaide	1986	12	98	8	24	Guided busway (elevated concrete track to cope with plasticity of alluvial soils of Torrens river valley) connecting central Adelaide with north-eastern suburbs. The \$8m cost includes buses. Includes 3 interchanges Klemzig, Paradise, Tee Tree Plaza. 30 minutes travel time from Tree Tee Plaza to 2kms south of Klemzig. Source: Busway Information, Paper Four: Environment. South Australian Department of Transport (1983).
South Eastern Busway	Brisbane	2001	13.2	453	34	nk	Grade separated bus-only road from Brisbane CBD to Wooloongabba in Sept 2000 and Eight Mile Plains April 2001. 8 Stations. <u>https://www.brisbanetimes.com.au/national/queensland/southeast-queensland-transport-infrastructure-rollout-since-1975-20100702-ztu7.html</u>
Liverpool- Parramatta Tway	Sydney	2003	31	346	11	29	Runs from Parramatta CBD along Great Western Highway to S. Wentworthville along own alignment next to Sydney Water pipeline to Prospect reservoir, then along old freeway reservation through to Hoxton Park. At Brickmakers' Creek Liverpool follows own alignment to Liverpool railway/bus interchange. Buses have traffic signal priority at road intersections. Has 35 stations 800 metres apart, Service T80 travels full length. Takes 62-67 minutes. 2.77 million passengers used Tway in 2012. <u>https://en.wikipedia.org/wiki/Liverpool%E2%80%93Parramatta T- way</u>
NorthWest TWay	Sydney	2006	24	323	13	nk	North-West T-way is a continuous bus roadway with ten bridges/underpasses and including 3kms of bus lanes between Parramatta, Blacktown, Rouse Hill in Western Sydney. Cost refers to the design and maintain contract awarded to Leightons who started construction in 2005 and completed works in 2007. <u>https://en.wikipedia.org/wiki/North-West T-way</u>
Northern Busway	Auckland	2007	6.2	306	49	31	Constructed in stages 2005-2009. Segregated busway infrastructure cost \$221 funded by Central Gov't as technically a 'State Highway' Wignall and Wallis (2019). Stations cost \$85m and funded by local authorities. Operational speed of 80kph. Timetabled to take 12 minutes from Albany Park & Ride to Akoranga (including intermediate stops at Constellation, Sunnybrook and Smales Farm) and then 15mins over harbour bridge etc to Britomart. Source Wignall (2019)

Average			11	392	80	28	
O-bahn East Terrace Extension	Adelaide	2017	0.85	160	188	nk	Extension of O-Bahn system from Gilberton into cross-city priority bus lanes on Grenfell Street to improve reliability and travel time. Included centrally aligned priority bus lanes along Hackney Road and a 670 metre bus tunnel. <u>https://www.dpti.sa.gov.au/infrastructure/public_transport_projects/o- bahn_city_access</u>
S.E. Busway Extension	Brisbane	2014	0.85	36	42	nk	0.85km extension of the SE busway to School Road Rochedale constructed 2012-14 costing \$36 million passing under the Gateway Motorway. No new stations. Source: Brendan O'Keeffe.
Eastern Busway	Brisbane	2011	2.55	692	271	nk	Built in stages between 2007 & 2011 to link University of Queensland - South East Busway/Buranda (Boggo Rd \$226m 1.5km) and then to Coorparoo via Stones Corner (\$466m, 1.05km). Complex engineering work with route either on viaduct o in tunnel, underpass under motorway and underpass under railway. 6 stations.
Northern Busway	Brisbane	2007	8.25	1110	135	29	From King George Square (Brisbane CBD) to Kedron Brook built in stages. 1st stage Roma St -Herston opened 2004 cost (2.8km, \$135m). 2nd stage (inner Northern Busway) linked the Roma St to SouthEast Busway tunnel section through King George Square opened in 2008 (1.25 km, \$333m). The 3rd stage opened in 2007 linked Herston to Windsor (1.2km, \$198m). In 2009, the Windsor-Kedron section was completed (3km, \$444m).

Table A3: Heavy Rail Projects

Project	City	Cost \$m	Year of Estimate	Length kms	New Stations	Cost \$m/Km	Speed kph	Pax mil p.a.	Notes
Airport Rail Link	Sydney	930	2000	10	5	93	55	13.6	Construction cost in 1994 Economic Evaluation was \$598million. Outturn cost in 2000 was \$900 (\$700m Govt, \$200m private funding of stations). In addition to 4 new stations, a new interchange station at Wolli Creek was constructed costing \$30 million. 11 mins from Wolli Creek to Central. 13.6 million ons and offs at Airport Line and Wolli Creek stations in 2013 (TfNSW Train Stats).
Brisbane Airtrain	Brisbane	220	2000	8.5	2	26	46	2	Privately owned. Opened 2001. Provides rail link to Brisbane CBD (15.9 kms from Central station) via connection at Eagle Junction. The line is on an elevated pre-stressed concrete viaduct. Airport Line stations at Brisbane Airport International & Domestic Terminals. Nearly went bankrupt in 2003 but recovered with 2 million passengers 2008. 11 minutes timetabled between Eagle Junction and Domestic.
Epping Chatswood	Sydney	1,200	2009	13	5	92	49	8.2	Underground tunnel with 3 new stations (4th at Delhi Rd would have been possible with bridge option at Lane Cove in National Park). Provides alternative North Shore line to Hornsby. New stations had 8.2 million ons and offs in 2013 (TfNSW Train Stats) up from 4.2m in 2010 (CityRail Compendium 7th Ed.).
South West Rail Link	Sydney	2,000	2013	11.4	2	175	76	nk	Extension of the Sydney suburban rail network from Glenfield (Inner West line) through 'farm-land' to a new station at Leppington (with a new intermediate station at Edmondson Park). Construction contract awarded in 2010 with works completed in April 2014 (a year ahead of schedule and \$100 million less than the budgeted \$2.1b). Future extension to new Badgery's Creek Western Sydney Airport. Timetable gives 9 minutes to travel Leppington to Glenfield. <u>https://www.news.com.au/national/breaking- news/south-west-rail-link-completed/news- story/8ce1ca6df7583598c9803361f4549139</u>

NW Metro	Sydney	5,190	2017	19	8	273	50	12.6	Main construction began 2014 & complete May 2019. 15.5km twin tunnels plus 4 km overground (skytrain) costing \$340 million including 270m cable stayed bridge over Windsor Rd. 8 new rail stations, single deck, driverless single deck rolling stock. Kellyville & Rouse Hill above ground, Tallawong & Cherrybrook in cuttings, Castle Hill, Hills Showground & Norwest underground. Epping - Kellyville tunnels longest and deepest in Sydney (67 m below Pennant Hills / Castle Hill Road intersection). Tallawong to Epping timetables at 23 minutes. Trains every 10 minutes (4 mins Peak). Total project cost including trains & reconfiguration of Epping-Chatswood \$8.3 billion. 12.6 million passengers based on first week's figures published in SMH. https://www.tunneltalk.com/Australia-28Jun2017- Sydney-Metro-City-and-Southwest-project-award.php
Metro City & SouthWest	Sydney	13,000	2017	15.5	5	839	nk	nk	15.5km nearly all in tunnel from Chatswood-Sydney under the harbour with 5 new stations (Crows Nest, Victoria Cross, Barangaroo, Pitt St and Waterloo) and new platforms/reconfiguration at Martin Place and Central stations. 13.4km conversion of Sydenham-Bankstown for single-deck driverless train operations. Business Case approved in 2016. Construction started 2017 and was complete in 2024. Includes 750 metre tunnel under Sydney Harbour using hybrid tunnel boring machine to cope with harbour sediment layer. https://www.tunneltalk.com/Australia-28Jun2017- Sydney-Metro-City-and-Southwest-project-award.php

Average		4,804	2,012	11	4	486	55	14	
Auckland City Rail Link	Auckland	4,400	2019	3.5	2	1,257	nk	nk	Pair of 3.5 km rail tunnels under Auckland's CBD creating a loop linking Britomart terminus to the existing rail line at Mt Eden. Original cost estimate \$1.5b, 2017 est \$3.4b with Central Govt 50% funding. Costs in NZ\$ (Aug 2019 exchange rate \$1NZ=\$0.95Aus). 2 new underground stations (Aotea Station & Karangahape Station). Britomart converted from a terminus to a through station & Mount Eden Station completely rebuilt as an interchange station with 4 platforms. <u>https://www.stuff.co.nz/business/112097410/auckland- crl-project-cost-rises-to-44-billion</u>
Cross River Rail	Brisbane	5,400	2018	10.2	4	529	nk	31.8	10.2 km of rail track (5.9 km in tunnel incorporating 4 underground stations (Boggo Road, Albert Street, Roma Street and Woolloongabba) and 2 upgraded surface stations. Tunnelling to start in late 2020. Infrastructure Australia claimed benefits overstated. Business Case forecasts 32 million boardings/alighting and transfers at underground stations in 2026 (106,000 per day).
Melbourne Metro	Melbourne	10,900	2018	10	5	1,090	nk	nk	Two 9-kilometre tunnels between South Kensington & South Yarra with 5 underground stations linking Sunbury & Cranbourne/Pakenham lines. Operations forecast to begin 2026. Victorian Business Case BCR of 1.1 (1.5 with WEBs included). <u>https://www.theage.com.au/national/victoria/melbourne- metro-to-boost-australian-economy-infrastructure- australia-20170119-gtuc6y.html</u>