



UNIVERSITY
OF WOLLONGONG
AUSTRALIA

University of Wollongong
Research Online

Faculty of Engineering and Information Sciences -
Papers: Part B

Faculty of Engineering and Information Sciences

2016

Perth's urban rail renaissance

Philip G. Laird

University of Wollongong, plaird@uow.edu.au

Publication Details

Laird, P. (2016). Perth's urban rail renaissance. AusRAIL PLUS Proceedings 2016, Rail - Moving the Economy Forward (pp. 1-8). Canberra, Australia: Australian Railway Association.

Research Online is the open access institutional repository for the University of Wollongong. For further information contact the UOW Library:
research-pubs@uow.edu.au

Perth's urban rail renaissance

Abstract

Over the past thirty five years, instead of being discontinued from use, Perth's urban rail network has been tripled in route length and electrified at 25,000 volts AC. The extensions include the Northern Suburbs Railway (with stage 1 opened in 1993 and this line reaching Butler in 2014), and, the 72 kilometre Perth Mandurah line opening in 2007. Integrated with a well run bus system, along with fast and frequent train services, there has been a near ten fold growth in rail patronage since 1981 when some 6.5 million passengers used the trains to 64.2 million in 2014-15. Bus patronage has also increased. These increases are even more remarkable given Perth's relatively low population density and high car dependence. The overall improvements in Perth's urban rail network, with many unusual initiatives, have attracted international attention. However, ongoing improvements in public transport and also road pricing are needed to contain road congestion.

Disciplines

Engineering | Science and Technology Studies

Publication Details

Laird, P. (2016). Perth's urban rail renaissance. AusRAIL PLUS Proceedings 2016, Rail - Moving the Economy Forward (pp. 1-8). Canberra, Australia: Australian Railway Association.

PERTH'S URBAN RAIL RENAISSANCE

Philip Laird
MSc (VUW) MSc (ANU) PhD (Calgary)
FCILT, Comp IE Aust
University of Wollongong NSW Australia

Summary

Over the past thirty five years, instead of being discontinued from use, Perth's urban rail network has been tripled in route length and electrified at 25,000 volts AC. The extensions include the Northern Suburbs Railway (with stage 1 opened in 1993 and this line reaching Butler in 2014), and, the 72 kilometre Perth Mandurah line opening in 2007.

Integrated with a well run bus system, along with fast and frequent train services, there has been a near ten fold growth in rail patronage since 1981 when some 6.5 million passengers used the trains to 64.2 million in 2014-15. Bus patronage has also increased.

These increases are even more remarkable given Perth's relatively low population density and high car dependence.

The overall improvements in Perth's urban rail network, with many unusual initiatives, have attracted international attention. However, ongoing improvements in public transport and also road pricing are needed to contain road congestion.

1. INTRODUCTION

The Greater Perth region is now home to about two million people and, like Western Australia, has seen a long period of strong population growth. How Perth planners have chosen to improve its urban rail system in a city with a relatively low population density and high car usage is a story that has attracted global attention.

Perth's public transport with its modern electric trains and buses is world class and has been well planned and well received by the traveling public. In the case of rail, patronage went from a low of about 6.5 million passengers in 1981 [1] to 64.2 million in 2014-15 [2], a near ten fold growth. This factor exceeds the urban rail passenger growth of any other Australian city.

Perth bus patronage has also increased and is now over 84 million passengers per year [2].

Perth's rail transport demonstrates many innovations. One such is the use of the centre parts of freeways for the new railways to the north, and then to the south, of Perth. Further innovative features include relatively few stations to allow for faster train services. Many of these stations have bus interchanges and extensive provision for car parking.

As seen by the Bureau of Infrastructure, Transport and Regional Economics [3, p56]

In recent years, Perth's train services have been upgraded and extended. With frequent services, good reliability standards and high average speeds over much of the network, the Transperth network arguably delivers Australia's highest-standard CBD commuter railway. The network plays to the relative strengths of urban railways—mass-transit, radial, commuter services.

Crucially, the rail operation is not confined to these strengths. Non-commuter travel is encouraged by high service standards in off-peak periods, including weekends.

This assessment is supported by by Schwandl [4, p7] from an international perspective :

With the electrification of the existing suburban rail system having being completed in 1991, and a totally new 100 km north-south route added in stages between 1993 and 2007, Perth now boasts what is probably Australia's most efficient suburban rail service.

A system map follows below.



Figure 1 Perth suburban rail network showing future line to the Perth Airport and Forresterfield

<http://www.urbanrail.net/au/perth/perth.htm>

2. NOTATION

- AC Alternating current
- BITRE Bureau of Infrastructure, Transport and Regional Economics
- CBD Central Business District
- EMUs electric multiple units
- km kilometre
- mm millimetre
- PTA Public Transport Authority
- QEII Queen Elizabeth II hospital)
- UWA– University of WA
- WA Western Australia

3. PERTH RAIL INITIATIVES

The first line in Perth was opened in 1881 between Fremantle to Perth and then Guildford and used steam trains. The system was extended in the late 19 th century with some contractions after World War II, and took nearly twenty years to change from steam trains to diesel trains [5].

All Perth's urban rail track is a 1067 mm narrow gauge except for a short East Perth to Midland section which is dual gauge (narrow plus standard (1435mm) gauge).

In September 1979, the Perth to Fremantle passenger service was closed by Sir Charles Court's government in order to build a freeway along the coastal suburbs. Perth's urban railways had contracted to 48 kilometres. Although his Minister for Transport said it was 'futile' to oppose this decision, it was met by the formation of a 'Friends of the Railways' group by academic and then Fremantle Councillor Peter Newman to lobby for the reinstatement and upgrading of the railway. The public gave strong support for building a state of the art rail system [6].

A change in 1983 of the Government of Western Australia led to the reinstatement of the Perth - Fremantle passenger service later that year. This was followed in 1991 by electrification of the then existing three lines (Armadale, Midland and Fremantle lines) at 25,000 volts AC using "A Class" electric multiple units to replace older diesel multiple units (which were then sent to Auckland New Zealand). By 1990, the annual patronage of Perth's rail system was about 10 million passengers per year.

After electrification of the existing lines, the next initiative was the construction of the Northern Suburbs Railway (NSR) that became fully operational in March 1993 to Joondalup. The first 22.5 km of line was built in the median of the Mitchell Freeway. Details of planning of this line are given by Martinovich [7].



Figure 2 A B series EMU approaching Leederville on Perth's Northern Suburbs Line with part of the Mitchell Freeway and the CBD in the distance – a 2014 photo by John Hoyle.

By the year 2000, patronage on the growing Perth rail system had grown to about 20 million passengers per year. To accommodate the unexpected growth on the Joondalup line, additional "A Class" electric multiple units had to be ordered. Figure 3 shows this growth and subsequent passenger growth, that includes the surge of growth following the opening of the Perth-Mandurah line in 2007.

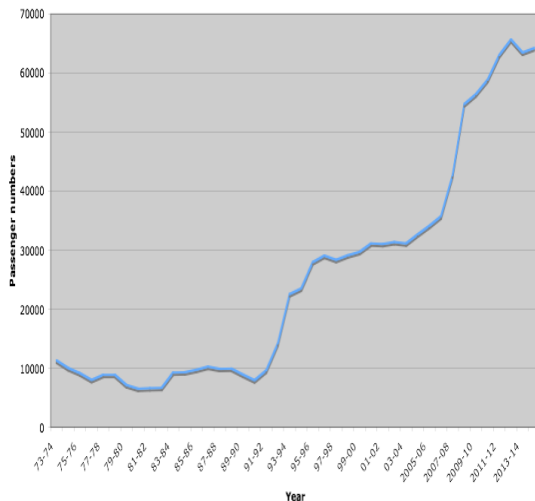


Figure 3 Perth rail patronage from 1973-74 to 2014-15 [1,2]

It is of note that during the 1990s when Perth's system was electrified and extended with patronage doubling from 10 to 20 million passengers per year, the Adelaide system patronage remained static at about 10 million passengers per year [8, p58].

In 2004, the Northern Suburbs Railway was extended to Clarkson, and in September 2014 it was further extended to Butler - some 40 kilometres from Perth.

Along with use of the median freeway strip, further innovative features include relatively few stations to allow for faster train services. Many of these stations have bus interchanges and generous provision for car parking. By way of example, Butler station has spaces for 930 cars.

Also in 2004, new B class electric multiple units were put into service. The new high powered trains were capable of operation at 130 km/h. Like the A class sets, they were built at Maryborough in Queensland.

In July 2013, a \$360 million project to sink the Fremantle rail line near Perth station was

completed. The "Perth City Link" project was funded jointly by the State and Commonwealth Governments and the City of Perth, and allowed for CBD revitalisation.

The Perth railway station upgrade was enhanced by a new nearby underground BusPort completed in July 2016.

In addition, Perth was the first of Australia's cities in 2007 to introduce integrated smart card ticketing. For Seniors, their SmartRider card was conveniently tied with their Western Australian Seniors card (as opposed to having to carry two cards as still required in NSW).

On 1 July 2014, to ration increasingly scarce parking spots, paid parking was introduced at Perth rail system stations.

4. THE PERTH - MANDURAH RAILWAY

In December 2007, the 72 km Southern Suburbs Railway between Perth and Mandurah was completed at a cost of some \$1.2 billion. By March 2008, assisted by a world class service, patronage on the new line was 80 per cent above projections. During the weekday peaks, there are now six trains an hour each way between Perth and Mandurah travelling at speeds up to 130 km/h.

Many train journeys take as little as 49 minutes, which compares favourably with a 70 minute journey time by car. The Perth Mandurah trains average speed of about 85 km per hour is high by Australian standards.

The Perth to Mandurah line was initially going to gain access through part of the Armadale line, and this provided for in 1999 legislation. After a change of Government, the route was changed in 2002 to give more direct access to the CBD from the southern suburbs. This was described as a "Business Class" outcome, and allowed for journey times to be cut by 20 minutes. As a result, use was again made of land in the middle of a freeway and Perth gained two new underground stations (Esplanade and Perth underground).

The cost for the new double tracked line, with its 11 stations was about \$1.3 billion. This was an average of about \$18 million per kilometer, with costs contained during the 48 month construction period despite the mining boom in Western Australia then under way. The average cost compares very favourably with 21 other urban heavy rail projects that were then underway [9].

To complement Perth's expanding railways, a \$300 million contract for the supply of 93 electric multiple units (EMUs) in 31 three-car sets and construction of a railcar depot was awarded to EDI/Bombardier at Maryborough in 2002.

In 2005, when the project was in full swing, the responsible WA Minister, the Hon Allanah MacTiernan MP [10] noted that

"The big picture plan is designed to future-proof Perth delivering a sustainable and exciting city for the 21st Century. We need to build resilience into our city if we are to manage growth and deal with/withstand the global challenges of climate change and oil depletion.... While buses will always be an important part of our public transport system, the evidence is that rail services have the greatest ability to attract commuters who have a choice. If we are to get people out of their cars and onto public transport, rail is a much better bet."

Since 2011, over 20 million passengers per year have used the Perth - Mandurah railway.

A new station on the line at Aubin Grove is currently under construction with a related Russell Road upgrade. The new station will have approximately 2000 parking bays, and cater for bus feeder services along with bicycle facilities and connections to local bike paths.

Looking back, the Perth Mandurah railway had some initial challenges as well as the need for enabling legislation. To quote from then Deputy Project Director Peter Martinovich [11]

"Even after the decision to electrify the rail network in 1985, in mid 1988 transport planners recommended to the State Government a consultant's report to build a bus system to serve the northern suburbs. And then, despite electrification of the existing railway and building of the Northern Suburbs Railway (NSR), initial proposals in the early 1990's for a mass transit mode to serve coastal suburbs south of Perth linking the cities of Rockingham and Mandurah, heavily favoured buses. It was only the assertive efforts of rail planners in support of the State's Department of Planning and Urban Development in 1992-94 that resulted in government acceptance of a rail route from Perth to Mandurah."

Of particular note regarding how Perth Mandurah was completed, on time and within budget, those responsible took the time to reflect on what could have been improved. It was observed [12] that it would be helpful to:

1. Tighten and manage project scope or ensure a suitable model is in use that allows for variations to be more successfully managed;
2. Make better use of contract management clauses and tools available to manage poor performance and program management;
3. Develop a means to deal with interface issues resulting in scope change by initial works packaging;
4. Ensure specifications are set to appropriate level with key elements prescriptively defined. Take a more proactive approach to risk management with appropriate interventions included in standard specifications.
5. Ensure suitable investment in the retention of appropriately skilled technical expertise in house.

The point about adequate in house technical expertise is an important one. It was also the subject of a recommendation (#22) of the House of Representatives Standing Committee on Transport and Regional Services [13].

It is also of note that the Perth Mandurah project won numerous awards for excellence and innovation, including for the two rail tunnels and two new underground stations as well as for the project as a whole [14]. In addition, no fewer than three awards to the Deputy Project Deputy Project Director Peter Martinovich with two being presented at AusRail 2007, (see Figure 3).



Figure 4 [6] Mr Martinovich receiving an award from the National Chairman Mr Ravitharan of the Railway Technical Society of Australasia

5. CURRENT PERTH RAIL OPERATIONS AND FUTURE PROJECTS

Perth's urban heavy rail system is operated by Transperth which is an agency of the Public Transport Authority of Western Australia that was formed in 2003. The urban rail system now comprises five lines radiating from Perth city centre, with through services on the Fremantle and Midland lines, and, on the Butler and Mandurah lines. The fifth line is to Armadale which has a short spur line to Thornlie that opened in 2005.

During the daytime, train services are offered every 15 minutes. This frequency of service compares very favourably with urban rail services offered in most other Australian capital cities.

A new Perth Stadium station is being built to replace a Belmont station that closed in 2013. At a cost of \$298 million, the new station will be integrated with an improved bus and pedestrian approach. It is due to open in 2017.

Contracts were signed in April 2016 for the main package of works at \$1.176 billion a new Forrestfield and Perth Airport Link to connect with the existing Midland Line near Bayswater Station. This will involve a tunnel under the Swan River. The project is expected to cost about \$2 billion and be completed by 2020. The expected benefits include faster journey times than by car to the Perth CBD. In a 2016 statement, WA Premier Colin Barnett noted that a recent \$490 million payment from the Australian Government to the State would go towards the project, and, that it was " the biggest expansion of the city's rail system since the Mandurah rail line was completed."

In June 2016, EDI Rail Bombardier Transportation Pty Ltd, was awarded a contract by the Public Transport Authority to supply an additional 10 three-car commuter trains (with 30-cars). These trains will also be made in Maryborough, but with final fitout(s) taking place in Perth. The contract, at about \$511 million, extends an earlier one that included the delivery of nearly 70 "B series" EMUs and will also include the maintenance of TransPerth's full "A" and "B" series fleet through to 2026.

A report Public Transport for Perth 2031 envisages further rail projects. Along with an airport link, these projects include extension of the Northern Suburbs Line from Butler further north to Yanchep, followed by an east west rail

link from Cannington to Fremantle via Murdoch.

Further plans to extend Perth's rail network called "Metronet" that were outlined in December 2012 by the main opposition party in Western Australia before a state election. These plans included a new north circle route with an Ellenbrook line and a link to the Joondalup line with new stations, a new south circle route to include the Airport line, extension of the northern line from Clarkson to Yanchep, the Armadale line to Byford and two new stations on the Mandurah line.

Metronet was raised again in 2015 by the WA Leader of the Opposition Mr McGowan, with the WA Government costing the indicative costings. Metronet was raised again in 2016 when the federal Leader of the Opposition Mr Shorten committed \$1 billion to part funding Metronet, albeit at the expense of withdrawing federal funding from a controversial Port Freight Link road project.

A July 2016 publication [15] of the Government of WA looking to when the population of Perth will reach 3.5 million persons notes, inter alia, that in 2015 the avoidable cost of congestion in Perth was estimated at \$2 billion per annum (and without change, by 2030 this will be between \$4.4 billion and \$5.7 billion per annum), and Perth will need to do its part in achieving in reducing greenhouse gas emissions with more use of public transport. The report outlines future plans for both heavy and light rail as well as roads and cycleways.

For heavy rail, these are firstly extending existing lines for a population of 2.7 million ...

- the Forrestfield Airport Link;
- extending the Midland line to Bellevue;
- extending the Joondalup line to Yanchep;
- and
- connecting the Thornlie line to Cockburn Central, providing a link between the Armadale and Mandurah lines.

"Beyond a population of 3.5 million, the East Wanneroo Rail Link will include a rail spur to Ellenbrook; the Stirling- Murdoch Orbital will be extended from Murdoch to Thornlie and Stirling to Morley; and the Forrestfield Airport Link will be extended to join the Thornlie line."

It is also of note that the Australian government has given past assistance to certain urban rail

projects in Perth along with other cities, and has made commitments for further funding.

This goes back to 1974 with the introduction of Commonwealth funding of urban public transport in Australia's major cities under the *States Grants (Urban Public Transport) Act* by the Whitlam Government. The initiative was in [16] "...recognition of the need for national Government to accept a share of responsibility for the public transport systems of Australian cities. This was essential if the serious deterioration in our urban environment attributable to over-reliance on the motor car as a means of transport was to be overcome."

6. LIGHT RAIL PROPOSALS

Like many other Australian cities, Perth once had a tram network. In Perth, electric trams operated from 1899 on one line, then on an expanding network to the early 1940s, and from the late 1940s, a contracting network with trams replaced by buses. The last tram in Perth operated in 1958 [5].

In September 2012, the Government of WA announced plans for a new 22 km light rail system in Perth, with two branches to the north of the CBD, to be called the Metro Area Express (MAX). One reason for its completion was that MAX would (as per the 2012 Perth Central Business District Transport Plan) "...complement and integrate with the existing heavy rail and bus services."

Detailed planning, engineering and design then took place, and initially, construction of a first phase of MAX was expected to start in 2016.

However, due to critical State budget pressures [17], the WA Government deferred the MAX Light Rail project, with overall completion of the project then due in late 2022. There were also suggestions (for example by Gemma Green of Curtin University) that one part of MAX had merit, the other did not.

In June 2016, WA Transport Minister Dean Nalder ahead of the release of a long term transport plan (in mid July) stated that there would be no light rail to the north.

Citing the construction and extension of light rail in Adelaide, the Gold Coast, Sydney and Melbourne, in June 2016 Green's Senator Scott Ludlam released a 15 year transport plan to include a 65 km light rail link, to include a

link between the University of WA and Curtin University.

The July 2016 publication [15] of the Government of WA I notes, inter alia, for light rail, that there will be "an inner orbital link connecting UWA–QEII (University of WA - Queen Elizabeth II hospital) to Canning Bridge, via the Perth CBD, Victoria Park and Curtin–Bentley.

Stage 1 UWA–QEII to Curtin–Bentley – by 2.7 million

Stage 2 Curtin–Bentley to Canning Bridge – by 3.5 million."

7. PERTH BUSES

As noted in a Perth Central Business District Transport Plan [18], buses play an "essential role" that with rail, supports and reinforces "the concentration of employment and commuting activity in central Perth, with around 120,000 jobs in this area representing nearly 18 per cent of all jobs in the metropolitan area."

The plan also notes that in down town Perth "Over the last decade, public transport patronage has increased by 67 per cent, with bus trips accounting for 56 per cent of all trips."

Buses also play an essential role in Greater Perth, not only for single mode trips (including from suburbs to the CBD, and a circle route) but also feeding the rail network. This is often at purpose designed stations that facilitate an easy transfer between bus and rail, which, within an hour, incurs no extra fare payment.

Transperth owns over 1300 buses, that are leased to a number of private companies that operate the services. Since 2011, over 80 million trips per annum have been taken by Perth bus passengers.

Incidentally, Transperth also operates a single cross river ferry service, currently with less than 500,000 passengers per year. Privately operated ferry services from Perth to Rottnest Island and Fremantle operate along with wine and river tours.

Following a 1995 Perth Metropolitan Transport Strategy, a Perth parking tax implemented in 1999 with the proceeds being applied to a free Central Area Transit or CAT bus in downtown Perth.

As noted by Richardson [19] "Ten years after implementation of the Perth parking policy:

inter alia "the mode share of journey to work in central Perth has shifted significantly from car to public transport – car 17% down and public transport up 27%;..."

Today there are no fewer than four free CAT services in down town Perth, plus two in Fremantle, and a further two free services in Joondalup. In addition, Transperth operates services to and from Perth's international airport.

In giving a positive assessment of Perth's urban rail services, BITRE [3] noted, inter alia, "well-connected feeder buses and ample car parking — expands network catchment and encourages rail-centred travel beyond the radial spines."

BITRE [3] also noted this approach by Transperth sums up the ethos, as attributed to Mees and Dodson [20], "in low [urban] densities the 'masses' must be brought or come to the railways".

Mees [21] also noted that the success of the Perth rail revival (p 127) "has demonstrated that high densities are not required for successful urban rail"

8. SOME COSTS AND BENEFITS

Transperth rail, bus and ferry operations in 2014-15 cost all up some \$1267 million with only \$214m recovered in user charges and fees, with a large operating subsidy of \$737m from the State Government and a deficit of \$256m.

The high subsidy reflects the many concessions that are on offer. This includes free off peak travel to seniors with concession fares applicable at peak hours. Even at full fares, Perth fares with a nine zone system are "inexpensive".

On the other hand, in 2011, the cost of Greater Perth's road congestion was estimated by Infrastructure Australia to be 1.784 billion [22]; and by 2031 when Perth's population could be 3.3 million, the cost of road congestion could expand some nine fold to \$15.865 billion.

Yet, projects by WA Main Roads to reduce road congestion were found [23] by the WA Auditor General to have had limited effect as "Main Roads and the Department of Transport have a blind spot, with neither agency having a clear road map as to how to best manage congestion."

Clearly an integrated approach is needed and unless public transport is maintained and improved, road traffic congestion will impose a growing and significant economic cost on Perth and Western Australia.

Accordingly, ongoing upgrading of Perth's public transport will be needed on top of the progress made to date.

9. CONCLUSIONS

Over the past thirty five years, instead of being removed and replaced by buses, Perth's rail network was tripled in size has been electrified using modern high voltage equipment with new rolling stock.

Integrated with a well run bus system, along with ample car parking at stations plus fast and frequent train services, rail patronage went from a low of about 6.5 million passengers in 1981 to over 63 million in 2012, a near ten fold growth.

Bus patronage has also increased and is now over 80 million passengers per year.

The increases in rail and bus patronage are even more remarkable given Perth's relatively low population density and high car dependence. The overall improvements in Perth's public transport illustrate the value of urban rail upgrades to world class standards. In turn, these upgrades have attracted attention from other States and overseas (including South Australia and New Zealand when electrifying their urban railways in Adelaide and Auckland respectively, with electric trains operating from 2014).

However, ongoing improvements in Perth's public transport and road pricing are needed contain road congestion and its negative impact on productivity.

ACKNOWLEDGEMENTS

The author would like to thank the School of Mathematics and Applied Statistics of the University of Wollongong along with the Railway Technical Society of Australasia and conference organisers for the opportunity to present the paper at AusRail in Adelaide. However, the responsibility for the findings and views expressed in this remains with the author.

REFERENCES

1. <http://www.pta.wa.gov.au/news-and-media/transperth-patronage>
 2. Public Transport Authority of Western Australia 2014-15 Annual Report
 3. Bureau of Infrastructure, Transport and Regional Economics, 2012, Understanding Australia's urban railways.
 4. Schwandl R Urban Rail Down Under; Metropolitan railways and trams in Australia and New Zealand, Robert Schwandl Verlag, Berlin 2011
 5. Longhurst D, 2008, 48 months, 48 minutes, building the Perth Mandurah railway Rowlhouse Publishing, Perth
 6. Laird P, 2008, The Railway Technical Society of Australasia - The First Ten Years, RTSA Canberra
 7. Martinovich P, 1992, Northern suburbs transit system. Background and technical aspects. Proceedings, Ninth International Rail Track Conference, Perth
 8. Laird P, Newman P, Bachelors M and Kenworthy J, 2001, Back on Track: Rethinking Transport Policy in Australia and New Zealand UNSW Press
 9. Martin S, 2012, Costing Australian passenger rail projects; how much did we pay for and what did we get, Conference on Railway Excellence, Adelaide, Proceedings.
- See also Martin S and Laird P, 2016, Meeting Australia's 2025 land transport challenges, Conference on Railway Excellence, Melbourne
10. MacTiernan A, 2005, Keynote presentation to AusRail Plus, Sydney
 11. Martinovich P, 2007, The Challenges of Expanding Perth's Rail System, AusRail Plus, Sydney
 12. Waldock R, Martinovich P, Cartledge A and Hamilton R, 2008, New Metro Rail Project – Lessons Learned, at http://www.ceiid.wa.gov.au/Docs/KNF_200805/MAY08-NewMetroRailProject.pdf
 13. House of Representatives Standing Committee on Transport and Regional Services, 2007, The Great Freight Task: Is Australia's transport network up to the challenge?
 14. PTA of WA, 2003-2008, The Ontrack collection-New Metrorail project newsletters published during construction of the Mandurah Line 2003-2008 Issues 1-18
 15. Transport @ 3.5 Million, 2016, Department of Transport, Public Transport Authority and Main Roads, Western Australia
 16. Prime Minister's December 1972 policy speech.
 17. <http://getthebiggerpicture.wa.gov.au/max-light-rail>
 18. 2012 Perth Central Business District Transport Plan 2012
 19. Richardson E, 2010, Extracting maximum benefit from parking policy – 10 years experience in Perth, Australia, Association for European Transport
 20. Mees P and Dodson J, 2011. Public transport network planning in Australia: assessing current practice in Australia's five largest cities. Research Paper 34. Brisbane: Griffith University.
 21. Mees P, 2010, Transport for Suburbia - beyond the automobile age, Earthscan, London
 22. Infrastructure Australia, 2015 Australian Infrastructure Audit, Sydney.
 23. WA Auditor General, 2015 report "Main Roads Projects to Address Traffic Congestion"