Australian Government

Department of Infrastructure and Transport

Bureau of Infrastructure, Transport and Regional Economics

Rail

Understanding Australia's urban railways

Bureau of Infrastructure, Transport and Regional Economics

Understanding Australia's urban railways

Report 131

Cover photograph courtesy of John Hoyle

Ownership of intellectual property rights in this publication

Disclaimer

Creative Commons licence

Use of the Coat of Arms

An appropriate citation for this report is:

Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2012, *Understanding Australia's urban railways*, Research Report 131, BITRE, Canberra ACT.

Contact us

This publication is available in PDF format. All other rights are reserved, including in relation to any Departmental logos or trade marks which may exist. For enquiries regarding the licence and any use of this publication, please contact:

Bureau of Infrastructure, Transport and Regional Economics (BITRE)
Department of Infrastructure and Transport
GPO Box 501, Canberra ACT 2601, Australia

Telephone: (international) +61 2 6274 7210
Fax: (international) +61 2 6274 6855
Email: bitre@infrastructure.gov.au
Website: www.bitre.gov.au

Foreword

This report provides an overview of the urban railway systems in Sydney, Melbourne, Brisbane, Perth and Adelaide. Passenger and freight services are considered. The report explores network and service provision, patronage trends, the urban freight rail networks and plans for capacity and network expansion. The report seeks to explain the role of rail in each city's transport task.

The report was undertaken by Jeremy Dornan with guidance from Peter Kain. Comments on the draft report were provided by Dr Gary Dolman, Dr David Gargett, Leanne Johnson and Godfrey Lubulwa from BITRE.

The authors would like to acknowledge the assistance of a number of organisations and individuals who contributed to this study. Comments were provided by the Public Transport Authority (Western Australia); the Department of Transport (Western Australia); the Department of Transport (Victoria); and the Department of Transport and Main Roads (Queensland). In addition, feedback was provided by John Hoyle, who, with Colin Butcher, also provided photographs. While BITRE is grateful for their assistance, the views expressed in this report are those of BITRE and should not be attributed to any other individual or organisation.

Gary Dolman
Head of Bureau
Bureau of Infrastructure, Transport and Regional Economics
July 2012

At a glance

- Well-functioning urban transport networks are essential for the free-flow of people and freight. Urban railways are an important form of conduit for those movements. More generally, urban railways are central to a broad range of government objectives, including liveability of cities, the environment, social inclusion and economic productivity.

- Rail has key strengths in long-distance urban travel and in radial-based commuting travel linking city centres with suburbs. Services are geared to those tasks but, with typically poor service standards in the off-peak, rail does not fulfil its potential in other travel markets. The challenge for urban passenger rail services lies in how well they can serve non-radial and non-commuting tasks.

- Perth and Melbourne have experienced significant patronage growth in the decade since 2001–02. Brisbane saw strong growth for most of the decade although patronage levels have fallen since 2008–09. Sydney's patronage declined in the first half of the decade but has grown modestly since 2005–06. Adelaide's patronage grew early in the decade but has declined since 2008–09.

- Experiences in Perth show that service quality improvements can make rail an attractive alternative to car travel: fast, frequent services with good station bus/car interchanges and facilities have drawn patronage into the system. Nonetheless, uncongested roads and low-cost car parking increase the competitiveness of private car travel relative to rail.

- Patrons are travelling for a purpose: vibrant leisure facilities and strong employment growth in Melbourne have led to a surge in commuting and leisure travel. Other non-transport factors, such as rising petrol prices, have affected each city's patronage levels, but in varying degrees due to the effectiveness of the rail services as substitutes for car travel.

- Each urban railway has its own capacity constraints and pinch points, none more so than Sydney. In that city, especially, the overlapping alignment of individual passenger services has generated interface issues that constrain capacity and weaken reliability. In addition, the Brisbane–Melbourne interstate freight services share Sydney's urban track, whereas in the other cities, the interstate freight is largely separated from the urban tracks. Government investments are directed at easing those interfaces, to facilitate competitive rail freight operations and to ensure unhindered passenger rail operations.

- Governments have made large investments in passenger and freight urban railways in the last 20 years. Perth's passenger system has expanded rapidly with more than two-thirds of the network built within the last 20 years. While Adelaide's passenger network has seen little investment, the State and Federal governments are now providing significant investment, with network expansion, electrification, provision for track standardisation, additional trains and higher service frequency. Brisbane's passenger system has grown significantly with the addition of the Gold Coast line. Sydney opened its Airport line, the Chatswood–Epping line and the line to Olympic Park. The Southern Sydney Freight Line is being completed on the south side of Sydney. In Melbourne, the central station at Spencer Street was rebuilt, the South Morang extension was completed, new electrified services commenced and key capacity-enhancement projects undertaken.

Contents

Figures

Tables

Executive summary

Rail can play an important role in a city's transport system. A rail system that is integrated with other transport modes can help to transport large numbers of people—with different origins and destinations. Urban rail can therefore play an important role in minimising urban congestion and facilitating transport energy efficiency. In addition, along with other public transport modes, urban rail can help governments achieve social equity goals by providing transport for people who do not have access to private vehicles. Rail is often central to State and local government planning processes as they provide dedicated corridors that link employment, social and residential centres.

Australia's urban passenger rail networks each have distinct characteristics and challenges. Sydney and Melbourne have the most extensive systems which were expanded in the late 19th century and electrified in the early 20th century. Perth and Brisbane have modernised their networks relatively recently—Brisbane in the late 1970s and Perth in the early 1990s. Perth has also expanded its passenger network extensively in the last 20 years. Following Perth's lead, the South Australian government has commenced its extensive Rail Revitalisation Program, modernising the network through electrification and track enhancements, although elements were scaled back in the May 2012 State Budget.

Patronage patterns

In general, urban patronage has grown in the last decade, although those growth rates vary considerably across cities. Perth and Melbourne have experienced significant growth. Brisbane experienced rapid patronage growth for most of the decade but patronage has declined substantially since 2008–09. Sydney and Adelaide have both experienced relatively modest growth since 2001–02. Patronage is influenced by external factors (such as changes to oil prices, employment, population and disposable income) and internal factors (changes to road and rail networks, changes to rail service quality, and fare changes).

Rail's share of the passenger transport task varies greatly between cities. In 2006, Sydney's CityRail network had the greatest journey to work mode share at 14.5 per cent, followed by Melbourne (10.1), Brisbane (7.2), Perth (5.1) and Adelaide (2.5). Sydney's rail patronage is also greatest in absolute terms while Adelaide's is the lowest.

Ridership data often hide the characteristics of the usage of the network—commuting tasks *can* involve very long journeys. For instance, on a weekday, Sydney train users travel, on average, around twice the distance of motor car drivers and almost three times the distance of bus users.

Service provision

Australian rail systems are geared to commuter travel. Peak period frequencies are significantly higher than off-peak frequencies, although Perth is the exception to this rule. In addition, the networks are radial with lines branching from the CBD into the suburbs. This results in urban rail being relatively competitive in CBD commuting; for instance, rail's share of journeys to work to Sydney's CBD is around 46 per cent. However, CBD commuting is only a small part of the overall transport task. Australian urban rail networks are generally uncompetitive for non-CBD work journeys and other travel, with services not being aligned to desired journeys and generally with poor frequencies.

Each State government seeks to encourage public transport patronage through urban consolidation schemes. The metropolitan plans generally involve measures to encourage greater residential and employment densities around transport nodes. Urban consolidation policies seek to enhance patronage by concentrating demand for public transport into 'centres'.

However, the quality of service provision is also important in competing for patronage. By itself, rail is unable to compete with the flexibility of private vehicles. Nevertheless, a rail system that is well integrated with other modes of transport can significantly increase the number of origins and destinations served by the network. Service frequencies and the facilities for transfers between rail and other modes are therefore important. Perth, in particular, has focused on maximising access between railway stations and other modes.

Freight

The metropolitan freight networks have unique operational characteristics and functions. Brisbane, Melbourne, Adelaide and Perth effectively have two freight networks each—the interstate standard gauge and the local broad or narrow gauge system. There are also a number of dual gauge tracks. By contrast, Sydney's metropolitan system is a single, standard gauge, shared by local and interstate freight and passenger services.

The freight tasks on the urban networks can be broadly categorised by function. Domestic and international freight are the broadest freight tasks, with domestic freight in a city being either terminating freight or transiting freight. International freight can also be land-bridged. There is a land-bridging task between Melbourne and Adelaide, with the Port of Melbourne providing Adelaide with an additional international interface. Transiting freight is common in Sydney and Adelaide because of their respective positions along the North–South, and East–West corridors.

Each passenger network interfaces with freight rail to an extent. The interface between passenger and freight services can be challenging for capacity utilisation due to different operational characteristics. Passenger trains move relatively faster than freight trains but also stop more frequently. Freight trains will usually be significantly longer and heavier than passenger trains meaning they use more track space, have slower acceleration and take more time to clear level crossings and junctions. Such shared track is very common across the world and can be an efficient use of infrastructure and resources.

Each city has seen a number of recent developments in their rail freight networks. Two programs which have seen significant expenditure in freight rail are the One Nation and Nation Building programs. The One Nation program was undertaken during the first half of the 1990s and included projects such as the Melbourne–Adelaide rail gauge standardisation and the Port of Brisbane (Fisherman Islands) connection to the standard gauge network. In their respective 2012–13 budgets, the Commonwealth and South Australian governments announced funding for separating the standard gauge interstate line from the Adelaide urban passenger broad gauge tracks at Goodwood and Torrens junctions.

The Australian government has also provided funds to the Australian Rail Track Corporation to enhance track capacity, reducing the interface between freight and passenger rail on Sydney's metropolitan network. This work includes the Northern Sydney Freight Corridor Program. The Australian Rail Track Corporation is also funding the Southern Sydney Freight Line.

Outlook

Each State government is seeking to enhance the reach and capacity of their respective passenger and freight networks. Long term plans for Sydney, Melbourne and Brisbane include relieving capacity constraints at the centre their networks. Perth and Adelaide do not share the capacity constraints of the larger networks. Plans for Perth and Adelaide include potential extensions and upgrades of existing heavy rail lines.

Introduction

Railways can perform important tasks in moving passengers and freight in urban environs. The rail corridors can provide vital conduits through built-up urban areas, providing effective ways of moving passengers and freight, en masse. The effectiveness of those conduits through the urban areas is also critical to the effectiveness of train movements between cities, especially for rail freight.

The performance of our urban railways is important because it affects other key policies: railways complement and support environmental, congestion and urban planning policies.

This report therefore aims to provide a deeper understanding of our urban railways—what tasks they perform and the challenges faced in improving their roles—to aid policy development. It is important to appreciate the core infrastructure and operational characteristics of each system.

This report provides an overview of Australia's five urban rail networks. It compares the unique characteristics and challenges that each system faces. It focuses on the quality of current passenger services, future network expansion and the freight operations.

Chapter 2 provides an overview of, and comparison between, the physical characteristics of the urban railway networks of Sydney, Melbourne, Brisbane, Perth and Adelaide. Patronage trends are presented. The following chapter reviews each metropolitan passenger network in turn, considers each system's development over the last 20 years and development plans that are underway. Data on train service quality are presented. The final chapter considers the freight train activities across the urban systems.

Comparison of Australian urban rail networks

This chapter provides an overview of Australia's five metropolitan heavy rail networks—in Sydney, Melbourne, Brisbane, Perth and Adelaide.[1] The data reflect the diversity between railway systems which is largely a result of the urban forms and the historical development of the railway networks under successive state governments. The different track gauges are perhaps the best known manifestation of this diversity.

The five cities in this study are home to over 60 per cent of Australia's 22 million population. To put these urban railway systems in context, there are 4.5 million residents in Sydney, 4 million in Melbourne, 2 million in Brisbane, 1.7 million in Perth and 1.2 million in Adelaide.[2] The urban railway systems are of varying importance to the passenger and freight tasks that are vital to the economic vibrancy and liveability of those cities.

Table 1 provides a comparative framework which can be used to better understand the unique operational characteristics of the urban railway systems in each city.[3]

---

[1] Hobart, Canberra and Darwin do not have urban rail networks. Newcastle is served by the Sydney CityRail operations. State and Australian government funding is being used to construct a light rail operation in the Gold Coast.

[2] Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2011a, pp.22–24

[3] An explanation of the statistics for each network can be found in the Explanatory notes section.

Table 1   Key network characteristics of urban railways[4]

	Sydney	Melbourne	Brisbane	Perth	Adelaide
Metropolitan					
Dedicated metropolitan passenger route length (km)	181	234	86	168	88
Dedicated metropolitan freight route length (km)	33	66	81	121	62
Shared metropolitan passenger/freight route length (km)	156	196	134	1	30
Total metropolitan route length (km)	370	496	301	290	180
Electrified metropolitan route length (km)	337	359	220	169	-
Metropolitan lines under construction (route-km)	47	28	23	8	6
Metropolitan stations (number)	176	219	123	69	84
Average distance between metropolitan stations (km)	1.9	2.0	1.8	2.4	1.4
Non-metropolitan					
Non-metropolitan passenger route length (km)	714	-	172	-	-
Electrified non-metropolitan route length (km)	300	-	172	-	-
Non-metropolitan stations (number)	131	-	23	-	-
Systems					
Electrical system (overhead, for passenger trains)	1 500 kV DC	1 500 kV DC	25 kV 50 Hz	25 kV 50 Hz	Not electrified**
Gauges					
Urban passenger lines (mm)	1 435	1 600	1 067	1 067	1 600
Interstate* freight lines (mm)	1 435	1 435	1 435	1 435	1 435
Intrastate freight lines (mm)	1 435	1 600	1 067	1 067	1 600

Notes: The "metropolitan" and "non-metropolitan" areas are defined in Annex A.
         * Some intrastate freight operate on interstate tracks in Sydney, Melbourne, Perth and Adelaide.
         ** Part of Adelaide's urban passenger network is being electrified, to 25 kV 50 Hz.

Networks

The geographical reach of Australia's urban operations is extensive, even if the network coverage is not dense—see Table 1. CityRail operates Sydney's passenger rail network; however, two-thirds of CityRail's route length lies beyond the metropolitan area, with services connecting with surrounding cities and towns such as Newcastle (168 km from Sydney Central Station), Lithgow (156 km from Sydney Central), Wollongong (83 km from Sydney Central and Goulburn (225 km from Sydney Central). Similarly, Brisbane's Queensland Rail services extend beyond the operator's metropolitan boundaries (at Beenleigh and Caboolture) to Varsity Lakes (90 km from Brisbane Central) and Gympie (173 km from Brisbane Central).

---

4   Data on route length was taken from an internal BITRE railway database. Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2011b

Using each city's definition of "metropolitan" or "suburban" network, Melbourne has Australia's largest urban passenger railway network.[5] That heavy-rail network is complemented by the world's largest tram network, including two heavy-rail lines (St Kilda and Port Melbourne) that have been converted to "light rail" operation. Sydney has the next largest metropolitan network, followed by Brisbane, Perth and Adelaide. Sydney and Adelaide have single light rail operations.[6]

Each city has very different styles of passenger service operation. The most distinctive is that of Perth, where recent line extensions (Clarkson) and line construction (Mandurah) have generated a pattern of stations sited at some distance from each other. Access to the stations is provided principally by bus and park-and-ride, complemented by policies encouraging Transit Oriented Development (TOD) with walking access. As is evident in Table 1, therefore, while Perth's network is more than 40 per cent longer than Adelaide's, it has around 18 per cent fewer stations.

Within cities, there is wide variation in station provision—Annex E presents the average distance between stations on each urban line. Perth's new lines, built along road corridors and land reserve corridors to new suburbs, have wide station spacing; traditional inner-city operations (such as on the historic Fremantle line) have the close station spacing found in other cities. This reflects the fact that more than two-thirds of Perth's network has been built within the last 20 years. The State has taken advantage of greenfield housing sites, and a base of good local road systems, to apply wider station spacing—with consequent benefits in far superior train speeds and competitive operation.[7] For instance, the average train speed for stopping services on the Mandurah line is around 85 km/h, compared with around 38 km/h on the Fremantle line.

Each system has network expansion plans or lines under construction. These latter include Brisbane's Springfield line, Sydney's Southern Sydney Freight Line and the South West (Leppington) Line; Melbourne's Regional Rail Link (Deer Park–West Werribee); Adelaide's Noarlunga line (to Seaford); and Perth's Clarkson line (to Butler).

With technological and operational blurring increasing between definitions of heavy rail and light rail systems, attention is also drawn to light rail projects under construction (and not included in the Table 1 data)—the 13 km Gold Coast Transit (to the south of Brisbane) and Sydney's 5.6 km light rail extension from Lilyfield to Dulwich Hill.

Passenger services in Brisbane, Sydney and Perth are fully-electrified; in Melbourne, the Stony Point, Melton and Sunbury lines have non-electrified sections; work is underway to electrify the Sunbury line. Work is planned to electrify most of Adelaide's passenger network (excluding the Belair line); the Noarlunga/Tonsley line is being electrified during 2012–13. That network will use the modern 25 kV AC overhead system, as used in the relatively-recently electrified Brisbane (from 1979) and Perth (from 1991) networks. The older electrified systems of Melbourne (from 1919) and Sydney (from 1926) use the 1 500 kV DC system.

---

5   Defined by route kilometres.
6   "Metro Light Rail", linking Sydney Central railway station and Lilyfield (7 km), operates for much of its route over former railway tracks. Similarly, Adelaide's 15 km tram (or "light rail") service, linking Glenelg and Adelaide Entertainment Centre via Adelaide Railway Station, uses a former railway corridor for much of its alignment.
7   Martinovich, 2008, found that if station spacing on the Mandurah line had been reduced from 3 km to 1 km, then journey time would have increased by over 60 per cent, average train speed would have fallen by 75 percent, rolling stock requirements would have increased by 70 per cent, and patronage would have fallen significantly.

A feature of the Brisbane, Melbourne, Adelaide and Perth systems is that their urban passenger networks use a different track gauge from the interstate network going through those cities; this gauge differential has restricted the operational interfaces between the urban passenger and freight operations. These cities also have some dedicated freight lines—see Table 1. There are notable examples of intrastate freight operations transiting the urban passenger network. These include the north coast intermodal freight, and coal from the Toowoomba district to the Port of Brisbane; the movement of steel products between Melbourne and Long Island; and the limestone trains between the Barossa Valley and Osborne (in the Port Adelaide area).

Sydney uses a single ("standard") gauge and CityRail's passenger services share routes and track capacity with interstate, and intrastate, freight trains. To ensure that commuter passenger services can be provided reliably, freight services incur a curfew; this bans their movement over parts of the network during peak commuter train weekday periods. A separate, dedicated freight line between Sefton Junction and Macarthur—the Southern Sydney Freight Line—is being constructed to provide a segregated freight path through southern Sydney; this line will link onto a small dedicated freight network centred on Port Botany.

International perspectives

It can be useful to provide an international context to the provision of urban railways in Australia. Table 2 presents a snapshot of a small number of Australian, European and American urban railway networks. Two important provisos need to be made in making the comparisons.

- The perspectives presented are tempered by the inability to identify a consistent measure of "city", "urban", "suburban" and "metropolitan" across the chosen cities.[8] Table 2 has been compiled in the absence of such data being available; the ordering of cities has been made according to the level of route-kilometres of heavy rail network in areas of greater metropolitan city that have not necessarily been consistently compiled.

- The quality of competing modes impacts on the case for, and viability of, urban rail networks. High levels of urban population density support the case for a greater density of urban routes (capturing economies of density in service usage). However, the viability of, and rationale for, such network provision will be lower where the high-quality, uncongested competing road network enables convenient, low cost, private transport. For instance, Phoenix in USA has a metropolitan population of over 4 million persons but no heavy-rail network; however, the road network capacity is relatively high. Similarly, some cities, Melbourne especially, have extensive tram and light rail networks that can both complement the heavy-rail operations and substitute for heavy rail services.

These strong provisos inhibit the reader's ability to make inferences from comparing infrastructure provision in the respective cities. In particular, inferences should not be drawn from the table as to an "optimal" or desirable level of infrastructure provision. Further, the varying level of network provision reflects varying degrees of legacy decisions, such as building lines at a time when competing transport modes were weaker; and building when low levels of urban development made it relatively low-cost to acquire land for rail corridors.

---

8   In 2011 the OECD, with the European Commission, identified methodologies for consistently defining city areas and, thus, populations and other parameters. See Organisation for Economic Co-operation and Development (OECD), 2011, pp.5–6

Table 2   International comparisons of urban railway systems

City	Population (m)	Heavy rail route km		Stations/ route km	Operator/operation
		Urban/suburban/ greater metropolitan	City total		
New York – urban	8.4	1 062		0.44	MTA Subway
New York – greater metropolitan	18.8	1 174	2 236	0.24	MTA subsidiaries; PATH
Chicago – urban	2.9	358		0.40	Chicago Transit Authority
Chicago – suburban	9.6	785	1 143	0.30	Metra
Los Angeles – urban	3.8	28		0.57	Metro Rail
Los Angeles – suburban	9.9	824	1 032	0.07	Metrolink
St Petersburg – urban	4.6	110		0.59	St Petersburg Metro
St Petersburg – suburban		568	678	0.18	Russian Railways
Paris – urban	2.2	202*		1.49	Metro
Paris – suburban	11.0	366*	568	0.43	Réseau Express Régional (RER)
Berlin – urban	3.4	146		1.18	Berlin U-Bahn
Berlin – suburban	5.0	332	478	0.50	Berlin S-Bahn
Melbourne – greater metropolitan	4.1	426*	426	0.51	Metro trains Melbourne
Sydney – greater metropolitan	4.6	337	337	0.52	CityRail
San Francisco – urban		167*		0.26	Bay Area Rapid Transit (BART)
San Francisco – suburban	6.9	124*	291	0.25	Caltrain
Montreal – urban	1.6	71		0.96	Société de transport de Montréal
Montreal – suburban		169	240	0.27	Agence métropolitaine de transport
Santiago – urban	5.3	104		1.04	Metro de Santiago
Santiago – suburban	6.7	134	238	0.15	Empresa de los Ferrocarriles del Estado
Brisbane – greater metropolitan	2.0	220	220	0.56	TransLink
Perth – greater metropolitan	1.7	169	169	0.41	Transperth
Adelaide – greater metropolitan	1.2	118	118	0.71	Adelaide Metro

Note: * Some of the cities have significant networks of other rail services, such as the 250 route-km tram/light rail network in Melbourne; the 40 route-km of light rail in Paris; and the 60 km of tram and cable car operations in San Francisco. Note, also, that definitions of city areas (urban, suburban and greater metropolitan) are notoriously difficult to apply systematically. Urban boundary definitions from overseas are taken from Jane's, 2011 and developed by local authorities; hence the absence of definitions for some cities. For Australian cities, greater metropolitan populations are based on ABS Statistical division estimates in June 2010 (Australian Bureau of Statistics, 2011).

Sources: Australian data are taken from other tables in this report; overseas data are derived from Jane's, 2011.

Despite these provisos, it is possible to make observations from Table 2. Australia's urban railway networks are generally extensive (*in route-kilometres*), although given the large scale of the urban areas, the networks do not provide a dense web of lines. This is a reflection of — consistent with — low urban density of settlement. For instance, Adelaide's metropolitan area is slightly larger than Greater London; its population (around 1.2 million) is considerably less than that of Greater London (around 9 million).

Why are Australia's urban railways different to Europe's?

In many European cities, heavy passenger rail networks were developed primarily for inter-city travel or, alternatively, as underground inner-urban 'metro' systems. For example, in Berlin, operations are based around three-tier network and service structures: the U-Bahn, S-Bahn and DB Regio, for inner-urban, suburban and regional trips, respectively.

By contrast, Australia's urban railways were built to connect the local port to surrounding hinterland and, from the late 19th century, to support suburban expansion. This provided workers with access to cheaper land, albeit remote from industrial and commercial centres. The result is geographically-extensive networks that are radial in nature, designed to carry passengers from their suburban homes to city-centre employment.

A distinctive feature of some overseas urban railway infrastructure—especially in the larger cities—is the provision of separate "metro" (urban) and suburban networks. There should not be a presumption that such infrastructure form is necessarily superior (or inferior) to a single urban system. "Metro" systems might be categorised as inner-city location services with short-distance ridership and high-frequency operation; "suburban" systems can be categorised as longer-distance train operations with patrons taking longer journeys on lower-frequency services. Berlin's U-Bahn and Paris's Metro illustrate the inner-city networks. By contrast, Sydney's inner city, suburban and interurban tasks have been performed within a single, integrated network (CityRail).[9]

Service provision

The urban passenger rail systems are funded by public (State) entities. Apart from Melbourne, the services are operated by government authorities or corporate businesses. Melbourne's heavy rail system is privately operated, with limited "metropolitan" services (to Melton and Sunbury) provided by the government country passenger train operator, V/Line. Franchising of the urban operations commenced in 1999, with the current franchising contract being won by Metro Trains Melbourne (MTM) in 2009. The next chapter considers service quality attributes for each of these entities.

---

9   The 2012 restructuring in NSW will result in Sydney Trains providing urban services while NSW Trains will provide interurban (and long distance) services.

Rolling stock

Australia's urban passenger railway rolling stock is generally modern, with the last of the 1970s stock in the process of being phased out. Operators are in the ongoing process of procuring additional or replacement stock; Perth has recently completed a large procurement process, related in part to the additional stock needed to serve the Mandurah railway. As part of its Rail Revitalisation programme, Adelaide is purchasing 22 three-car electric multiple units (EMUs).

Most of the rolling stock is air-conditioned. As is evident in Table 3, Sydney in particular, has non-air-conditioned stock. However the introduction of stock that is currently being built for Sydney and Melbourne will result in the phasing out of the remaining non-air-conditioned fleet.

Train formations. Most of the train services are provided using "multiple-unit" stock— permanently-coupled carriages. At present, diesel multiple units (DMUs) are used to operate Adelaide urban services[10], some non-metropolitan Sydney services and some outer Melbourne services. Other Sydney and Melbourne services, and all Brisbane and Perth services, are operated by electric multiple units (EMUs)—see stock levels for each city in Table 3. The characteristics of Adelaide's rolling stock, with large numbers of one- and two-car multiple-units, enables the local provider, Adelaide Metro, to cater for the modest traffic levels with a broad range of train configurations, from single carriage vehicles (with a driving unit at each end) to four-car trains. Apart from Adelaide, and some two-car operations in Perth, the standard EMU across the cities is a three-car train—four-car in Sydney—and during peak operations the EMUs are paired to form six-car trains (eight-car in Sydney).

---

10   Adelaide's 2000 class railcars are DMUs and its 3000 class railcars are DEMUs (Diesel-electric multiple units).

Table 3   Key service characteristics of urban railways

	Sydney	Melbourne	Brisbane	Perth	Adelaide
Operators	CityRail*	Metro Trains Melbourne**	Queensland Rail	Transperth	Adelaide Metro
Ownership	Public	Private (government franchise)	Public	Public	Public
Rolling stock in service					
Vehicles (no.)	1 618 [11]	987 [12]	627 [13]	234 [14]	100 [15]
Air-conditioned vehicles (no.)	1 120	945	627	234	100
Carriage format	Predominantly double-deck	Single-deck	Single-deck	Single-deck	Single-deck
Multiple-unit formats					
1. Metropolitan	116 three-car; 201 four-car 2 eight-car	384 three-car	201 three-car	48 two-car; 46 three-car	30 one-car; 20 two-car; 30 cars in various multiple-unit configurations
2. Non-metropolitan units***	75 three-car; 45 four-car 21 two-car DMUs		8 three car		
Common train formations	EMUs coupled as eight-car Some three-car units coupled as six-car	EMUs coupled as six-car	EMUs coupled as six-car	EMUs coupled as six-car on new lines	Diverse, up to four-car

Note: "EMU": Electric Multiple Unit; "DMU": Diesel Multiple Unit

* From 2012 to be Sydney Trains (urban Sydney) and NSW trains (non urban, Newcastle urban and long distance).
** Some metropolitan services are provided by V/Line, the State government country service operator; carriages/ units required for those services are not included in the table.

*** CityRail's DMU fleet are used for local services from Newcastle, for Kiama–Bombaderry shuttle trains and Central/Campbelltown–Goulburn services.

Sydney is the only system to use double-deck carriages, both on suburban and electrified inter-urban services. Suburban single-decked were gradually replaced with double-deckers from 1964; electrified inter-urban stock switched to double-deckers from 1970. The objective of this policy—facilitated by relatively generous height restrictions—was to increase the passenger-carrying capacity of the system. The Melbourne system experimented with operating a double-decker train in the 1990s but did not proceed with this format.

Fleet size. The levels of rolling stock required by the different systems are a function of a range of factors, including:

• traffic levels (as illustrated by Adelaide's relatively-short train formations);

• the size of the network and the length of individual lines;

---

[11] CityRail, 2011a
[12] VicSig, 2011
[13] Queensland Rail Limited, 2011a, p.61
[14] Public Transport Authority of Western Australia, n.d.a
[15] Ly, 2011, pp.18–26

- the range of different services on each part of the network (such as offering stopping, semi-fast, and express services on a given line); and

- the average speed of trains on those services (with faster operations requiring fewer train sets).

In addition, long routes to outer-urban and inter-urban destinations, such as Perth–Mandurah, require relatively high stock levels to provide regular services. However, this is partly offset by high-line speeds, enabling higher rolling stock utilisation. Martinovich (2008) indicates that if Perth had chosen one kilometre spacing between stations rather than three kilometre spacing, then rolling stock requirements would have increased by 70 per cent. Higher utilisation is achieved through higher average service speeds where station spacing is relatively long.[16] This is illustrated in Figure 1.

Figure 1   Station spacing and illustrative train speeds
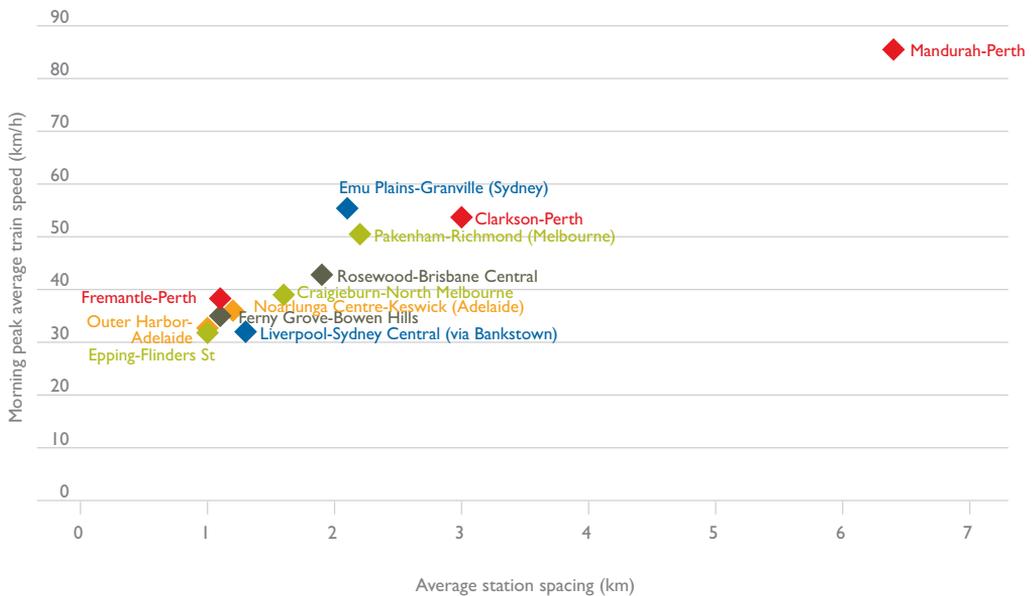
The role of Australia's urban passenger railways in the development of suburbs explains much of the close spacing of stations on the older lines. Mees and Dodson have observed that Australian lines were often built as a way of supporting urban expansion with consequent short distances between stations relative to European services (for instance, averaging just one kilometre between stations on Melbourne's Epping line compared with multiple kilometres on European suburban networks).[17] A consequence, however, of this spacing is that the regular stops provide one reason for relatively slow speeds on older lines. (Figure 1)

Train capacity. The carrying capacity of a "train" or a "carriage" varies widely across the systems. The carriage length, width and height are important factors affecting capacity. For example, Sydney's carriages are wide and high relative to Brisbane and Perth carriages—the larger track

---

16   In the absence of ensuring the provision of complementary non-rail public transport, long intervals between stations can result in public transport-dependent users being stranded from the wider city. Long station spacing can be implemented without stranding urban residents as long as rail and other public transport modes are adequately integrated.

17   Mees and Dodson cite Davison as observing the role of urban railways in urban development. Mees & Dodson, 2011, p.5

gauge and loading gauge in Sydney enables wider, partially double-decked carriages. The result is that Sydney seating is five abreast; in Brisbane and Perth, however, the carriages are limited to four seats abreast and formation is on one deck. Conversely, the Sydney carriages are around 20 metres in length, compared with about 24 metres in the other two cities. Another contrast with Sydney is that while about half of the carriages in Melbourne's (broad-gauge) system are five abreast, the other half is configured to be four seats across.

Train capacity can also be defined in terms of passengers seated. Inevitably, that capacity can be raised simply by placing seats closer together. Maximising the number of seats on a train can then have adverse effects on standing space, with passengers on a crowded train sensing a heightened feeling of overcrowding. These aforementioned factors are just some of the reasons why there will be wide variations in carriage capacity data, whether that capacity is defined as "seated-only" capacity or whether inclusive of standing passengers.

While it is not desirable, therefore, to measure carriage or train capacity across the systems, it is possible to provide guidance as to the ball-park measure. For example, one estimate of a non-driving (or "trailer") carriage on a Melbourne train suggests a passenger capacity of 254 for a single car, with around two-thirds being standing passengers.[18] Allowing for loss of floor space due to driving cabins, this might suggest capacity for a three-car unit of around 700 passengers, or 1 400 for a six-car train. Thus, for example, with around fifteen six-car trains arriving at Melbourne Southern Cross from Craigieburn per two-hour morning peak, there would be train capacity for around 21 000 passengers. This provides an order of magnitude of train carrying capacity for each system, subject to considerable variation in service frequency, train length and internal seating and standing space.

Service pattern

The urban timetables are aligned around a city-centre operation, with city-centre stations at Sydney Central, Melbourne's Flinders Street and Southern Cross, Brisbane's Central and Roma Street, Perth Station (including Perth Underground), and Adelaide Railway Station. Underground loop lines in Sydney and Melbourne—the City Circle, and City Loop, respectively—provide additional dispersion of stations in the central areas. Services on each rail line generally go to those central stations.

Although major central city stations are provided, often urban services operate through the stations. For instance, in Brisbane a portion of the Airport line services continue through Roma Street to (interurban) Gold Coast destinations; Beenleigh line services continue through to Ferny Grove. In Sydney, Northern Line services operate through Central. In Perth, Mandurah line services continue through Perth Station to Clarkson while Fremantle line trains continue on to Midland. Services in Melbourne and Adelaide, however, terminate in the city centre stations.

---

18   Coxon et al., 2011, p.13

Patronage

Urban railways provide transport conduits through urban areas, enabling the mass movement of passengers and freight across suburbs and links with city centres, separated from road networks. At their broadest task, the passenger services provide a role as an alternative to private cars and so help to de-congest roads by diverting people to the rail conduits.

Rail operations can also provide vital services for those without cars. By way of illustration, concession fares represented around two-thirds of tickets sold on Adelaide Metro (public train, tram and bus services) in 2010–11.[19] That is, much of the patronage is people with limited access to private transport. The challenge for operators is to attract large numbers of patrons for whom public transport is a *discretionary* (not only) option.

Patronage patterns

The urban railway networks and services are diverse and these attributes, and those of alternative transport networks (car, bus, ferry and tram), determine the extent to which each city's population uses the rail system.

Table 4 presents patronage figures for the different systems. In terms of patronage, Sydney has the largest number of patrons, with more than 800 000 users each day. Indeed, Sydney's rail system attracted nearly 30 per cent more patrons than Melbourne in 2010–11, although Melbourne residents are also served by an extensive web of light rail/tram operations.

These patronage data can obscure important characteristics of network usage, particularly journey length patterns. For instance, commuting tasks can involve very long journeys: a Sydney commuter from Campbelltown can expect a 75 minute journey to Sydney Central or 46 minutes from Cronulla, a Melbourne Hurstbridge commuter experiences a journey of around one hour to Flinders Street, a Beenleigh commuter will also experience a one-hour journey to Brisbane Central while Noarlunga and Mandurah commuters experience journeys of around 50 minutes to their Adelaide and Perth city terminals, respectively.

Some patrons therefore travel relatively long distances; these trips are longer, on average, than for commuters using other modes. For instance, on typical weekdays Sydney train users travel, on average, around twice the distance of motor car drivers and almost three times the distance of bus users.[20] This needs to be borne in mind when reviewing the traffic task performed, shown in Table 4 and the journey-to-work mode shares presented in Table 5.

---

19   Department of Planning, Transport and Infrastructure South Australia, 2011a, p.62

20   The estimates of average weekday distances for 2009–10 were: train, 17.6 km; vehicle driver, 9.7 km; vehicle passenger, 7.5 km; bus, 6.5 km; and walk-only, 0.8 km. See Bureau of Transport Statistics, 2011, p.38. Car and bus are the main access modes. Xu et al., 2011, pp.6, 8

Table 4   Urban railway patronage (million passenger journeys)

	Sydney	Melbourne	Brisbane	Perth	Adelaide
Patronage 2010–2011	295 [21]	229 [22]	55 [23]	59 [24]	9 [25]

Note: Sydney and Brisbane patronage figures include the broader inter-urban patronage numbers (such as Newcastle and the Hunter Valley, and Gympie and Varsity Lakes, respectively).

The urban railways are aligned to fulfil weekday commuting movements to and from city centres. As is evident in Figure 2, showing Sydney's weekday patronage on CityRail, the task is very strongly skewed to morning and afternoon travel-to-work commuting tasks. A similar pattern is evident in Perth—see Figure 3.

The extent to which the railways contribute to that commuting task varies widely across the cities. This is evident in Table 5.[26] Note that there has been strong patronage growth in Melbourne and Perth since those Census data; this may have increased rail mode shares in those cities.

Table 5   Urban railway journey-to-work mode shares, 2006

	Sydney	Melbourne	Brisbane	Perth	Adelaide
Rail journey-to-work mode share (%)	14.5	10.1	7.2	5.1	2.5

Source: Bureau analysis of ABS Census of population and housing 2006, method of travel to work, count of employed persons aged 15 years and over based on place of usual residence.[27] Mode shares defined as percentage of travellers who caught a train for all or part of their journey to work. Mode share calculations excluded census respondents who did not specify their travel mode.

The relatively low rail commuting task (Table 5) partly reflects the fact that city centre employment is not the dominant or even major location of work activities. For instance, the 2006 Census data found that only around 14 per cent of Sydney commuting tasks were to the city's CBD.[28] An analysis of that Census for Melbourne found, similarly, that only around 19 per cent of Melbourne metropolitan employment was located in central Melbourne.[29]

Thus, while the rail networks perform well in providing attractive commuter—and retail/entertainment—services centred on city centres, they offer far less attractive services for non-radial movements.

21   RailCorp, 2011, p.22

22   Department of Transport Victoria, 2011a, p.18

23   Queensland Rail Limited, 2011a, p.61

24   Public Transport Authority of Western Australia, 2011a, p.27

25   Department of Planning, Transport and Infrastructure South Australia, 2011a, p.62

26   An alternative way of measuring mode share is by passenger kilometres travelled rather than by passenger journeys. This measure is not restricted to the commuting task. In 2006 the rail mode share by passenger kilometres for each city was: Sydney (9%), Melbourne (5%), Brisbane (5%), Perth (2%), Adelaide (1%). Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2009. For a detailed analysis of public transport's mode share, see Bureau of Infrastructure, Transport and Regional Economics (BITRE), forthcoming, b.

27   Australian Bureau of Statistics, 2011

28   Xu et al., 2011, p.5

29   "Central Melbourne" is defined here as the Melbourne Local Government Area (consisting of Melbourne CBD, Carlton, Docklands, Southbank and the northern section of St Kilda Road. See Department of Transport Victoria, 2008, pp.4, 49

Sydney has a dispersed commuting task relative to other cities, with Chatswood, North Sydney and Parramatta being examples of alternative commuting destinations. For instance, for North Sydney and Chatswood, 43 per cent, and 30 per cent, of workers use the train respectively.[30] Nonetheless, non-commuting patronage is relatively poor, with the task performed at 0800 on a weekday being more than six times the task performed two hours later; the equivalent peak/off-peak ratio for Perth is around four times the task performed two hours later. Can changes (such as in infrastructure, mode integration, service quality and fares) enhance more efficient use of the networks—that is, can trains attract greater off-peak and non-city commuting patronage?

Figure 2   Urban rail weekday patronage pattern, Sydney, 2009–10
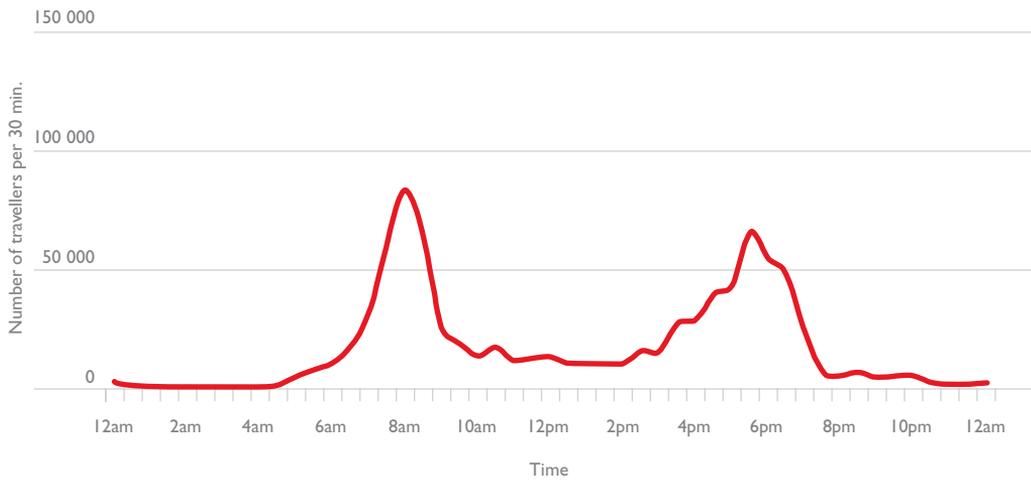
Source: Bureau of Transport Statistics NSW, 2009–10 Household travel survey: summary report. Adapted from figure 3.10.3 'Motorised (unlinked) trips for selected modes by time of day, average weekday, 2009–10'.[31]

Figure 3   Urban rail weekday patronage pattern, Perth, 2011
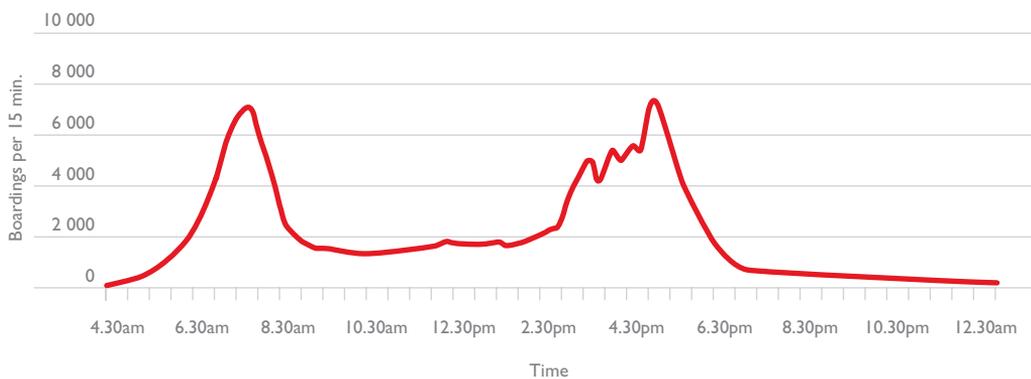
Source: Department of Transport Western Australia, 2011, Public Transport for Perth in 2031. Adapted from 'Typical weekday public transport patronage'.[32]

---

30   Mees & Dodson, 2011, p.7
31   Bureau of Transport Statistics NSW, 2011, p.27
32   Department of Transport Western Australia, 2011, p.41

Patronage trends

There has been a stark contrast in patronage trends across the cities. As a broad comment, urban rail patronage has generally grown in Australia over the last decade but with very diverse experiences. The Perth and Melbourne systems have recorded strong growth; some of the decade's gains have been lost in Brisbane in the last two years while Sydney and Adelaide have recorded only relatively modest growth (Figure 4).

Factors that explain patronage trends consist of national (external) factors and local, network-specific factors. National factors, such as economic activity (influencing employment activity and disposable income) and petrol prices will influence rail patronage in similar ways, encouraging similar patronage trends. However divergent patterns can arise when strong local factors dominate; these include fare and network changes, employment growth and road infrastructure improvements.

In the absence of detailed data, it is not possible to ascertain the extent to which changes in real fares and eligibility for fare discounts will have influenced each city's patronage. During the period to 2011, however, Brisbane has increased fares in real terms (that is, above-inflation). Annual fare rises from January 2010 to January 2014 are being set to 15 per cent for each annual revision. Off-peak fares will rise by a lower amount.[33]

Figure 4   Index of urban railway patronage in Australian cities
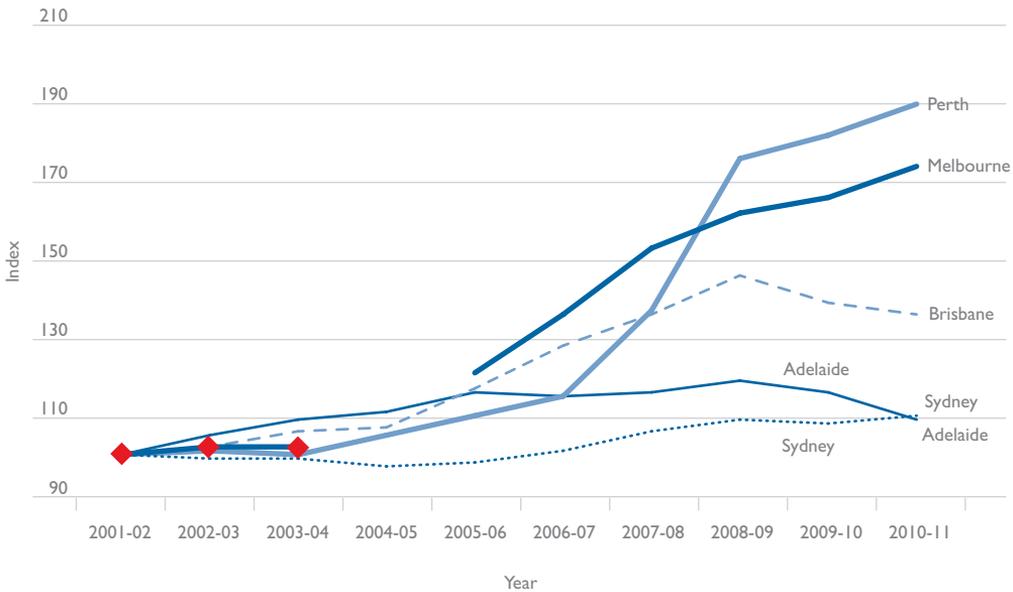
Note: See Annex A for details on data sources. Refer to next chapter for discussion of city-specific factors influencing patronage. There is a break in the Melbourne data between 2003–04 and 2004–05. The Brisbane index number for 2010–11 has been revised to account for a revision to Queensland Rail methodology during that year—see Annex A

33   TransLink Transit Authority, 2011a, p.68

The national, macro-economic factors will have impacted on each system in a similar way. In particular, residents of each city will have faced the same petrol/diesel price fluctuations, impacting on everyday car operating costs: there were marked fuel increases in the 2006–08 period—see Figure 5. Despite this adverse impact on car operating costs, there is evidence that "car affordability" (the number of weeks of earnings required to purchase a vehicle) has continued to improve (that is, the number of weeks of work required to buy a vehicle has declined).[34] Other factors that influence car usage include mortgage interest rates and disposable income. To the extent that consumers prefer to drive if they can afford it, a decline in disposable income encourages a degree of switching back to public transport.

However a person's propensity to switch to urban rail services in response to fuel price and disposable income changes depends on the quality of those public transport substitutes. That is, switching to urban rail services depends on the network and service attributes of each city. As noted above, for non-radial journeys especially, the train is often not a practical and attractive substitute for car journeys.

Figure 5   Real average annual petrol prices, cents per litre
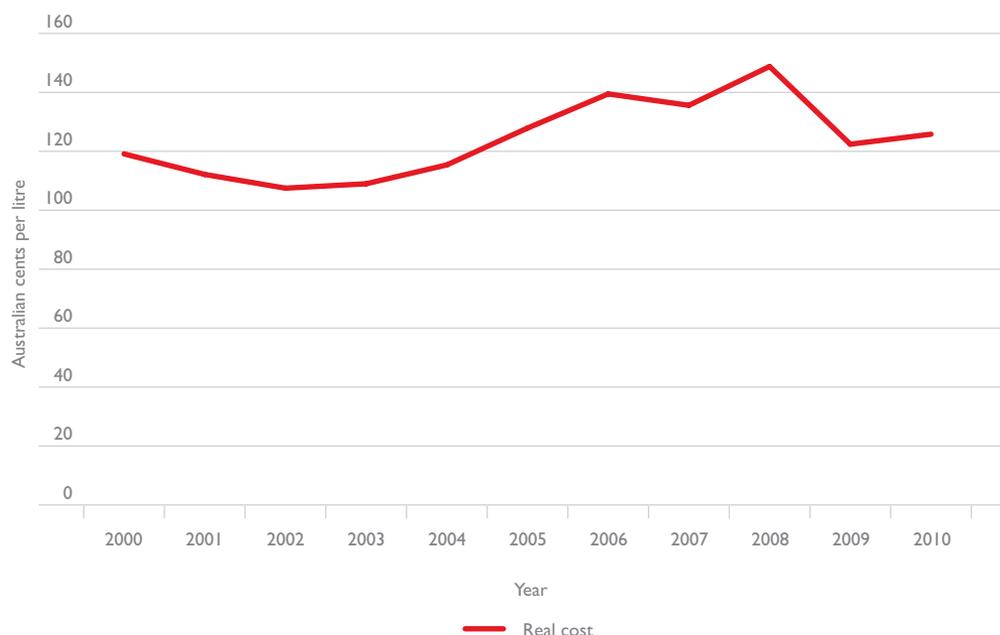
Source: Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2012, Appendix A

Reasons for changes in patronage levels also vary with internal conditions in each city. These include population growth, central city employment growth, parking costs and road congestion. For instance, there was a strong expansion in car parking in Perth CBD between the 1960s and 1990s (from 18 000 spaces in central Perth in the mid-1950s, to 62 250 spaces in 1998), with around three-quarters being all-day parking spaces for employees. This encouraged car commuting; this experience is likely to be repeated in the other cities. In Perth, however, this parking expansion trend led the State Government to adopt a 1998 "Perth Parking Policy" to integrate car access with planning for other transport modes.[35] The application of differential city parking policies across cities will therefore lead to divergent trends in rail patronage.

34   Department of Transport Victoria, 2008, p.64
35   Brown et al., 1999, p.370

Perth[36] and Melbourne[37] experienced the most significant growth in patronage in the last decade (Figure 4). Much of the surge in Perth's patronage in 2006–07 reflects the opening of the Mandurah line. The city's patronage growth is a strong reflection of the network's recent expansion. The current Perth network is, at 169 route-kilometres, now almost three times the size of the system in place in 1990 (then being around 60 route-kilometres). The two new lines built from central Perth—to Clarkson and Mandurah—provide relatively high-frequency (a minimum of four trains per hour) as well as the highest average speed timetables (off-peak and peak) across the five urban systems.

The strongest rate of patronage growth in Melbourne was between 2005–06 and 2007–08. This corresponds with a rapid growth in employment in inner Melbourne. Between 2006 and 2008, the City of Melbourne Local Government Area (LGA) gained 50 400 jobs. That employment growth represents 7 per cent per annum, compared with 3 per cent per annum growth experienced from 2002–06.[38] Being serviced by relatively good public transport networks, strong inner Melbourne employment growth will encourage public transport patronage. In 2006 almost two-thirds of employed public transport users were commuting to a job in the City of Melbourne LGA.[39] Melbourne was also experiencing relatively strong population growth in the period.[40]

In the other cities, patronage trends were less uniform. Brisbane experienced strong growth for most of the decade, partly offset by patronage declines in the last two years.[41] Sydney's[42] patronage declined in the first half of the decade. While the city experienced substantial population and employment growth between the 2001 and 2006 census, this growth was strongest in outer areas, where radially-focused public transport offers a weaker alternative to car transport, especially with new roads being opened (including the M5 East Tunnel).[43] Adelaide's patronage growth has been relatively weak, against a background of relatively low population growth. Adelaide's rail network is centred on the city centre; retail amenities in the city are strong but this, in turn, is achieved by extensive, low-cost, parking stations. Adelaide's train services have also been severely disrupted by the infrastructure renewal work of the Rail Revitalisation programme, involving extended periods of line closures from 2008–12.

Another aspect of service quality that can lead to differential patronage trends across the system is the revenue-collection systems. Over time, improvements in ticketing systems, including electronic stored-value and smart cards, will have improved overall service convenience. This can be particularly important where ticketing facilitates within-mode and cross-modal transfers. Stored value ticketing, such as Adelaide's pioneering (1987) Crouzet-system[44] *multi-modal* ticketing, are being replaced by smart cards—the "metrocard" in Adelaide, "Go Card" in Brisbane, "Myki" in Melbourne and "SmartRider" in Perth.

36   Public Transport Authority of Western Australia, 2011b
37   Department of Transport Victoria, 2011a
38   Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2011c, p.122
39   Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2011c, p.181
40   Gaymer, 2010, p.4
41   TransLink Transit Authority, 2011d
42   CityRail, 2011b
43   Bureau of Infrastructure, Transport and Regional Economics (BITRE), forthcoming; Kerr, 2003
44   The Crouzet system uses a magnetic strip for ticket validation.

In conclusion, the five urban railway systems offer very different types of networks and services and different attractiveness relative to alternative modes (especially to road transport); this results in varying responsiveness to fare changes and, more generally, divergent service competitiveness across the networks. Thus, despite common influences of national economic activity and fuel prices, the cities have had starkly different patronage experiences.

Funding

Cost recovery

It is unusual for urban public transport anywhere in the world to be self-funded, that is, for systems to fully recover their operating and capital costs through the fare box. The evidence suggests that Australia's urban railway systems are no different.[45] The level of revenue that is achieved can be a function of a number of factors. One factor is government policies that intentionally set below-cost-recovery fares that are designed to encourage public transport usage. For instance, there are policies focusing on "externality" aspects of private modes. These policies may subsidise public transport to encourage diversion of travel from congested roads (where it is politically, socially, financially or environmentally difficult to expand capacity) or to encourage a shift to environmentally "clean" (or "green") trains. Governments also provide public transport on equity grounds, providing a service for those who do not own or have access to private vehicles.

Even where governments seek full cost recovery, it may not be achievable. In particular, public transport modes exhibit varying degrees of economies of density[46]; if operators can capture those economies then cost recovery can be improved. Usually, however, sufficient patrons cannot be attracted to ensure full cost recovery. This can arise because alternative private transport systems are attractive/preferred. In this context, setting high fares may discourage transit usage to the extent that sufficient patrons are lost such that cost recovery worsens.[47] Furthermore, removing the worst-financially-performing links in the transit system can degrade the coverage of the overall network, reducing patronage further and potentially worsening the economies of density.

There is no rule-of-thumb for what constitutes an "acceptable" or "sustainable" recovery ratio: the extent of the externalities (such as congestion and pollution), the quality of the private alternative systems (fast, uncongested roads), a government's budgetary situation, and the economies of density that can be captured are factors that influence the outcome. Table 6 presents data on urban transit cost recovery by operator. As is illustrated in the table, cost recovery in the rail and transit operations is well below full operating cost recovery.

---

45   The "fare box recovery ratio".

46   In this context, economies of density arise where increases in traffic volume, such as on a train, are accommodated with less-than-commensurate increased in fuel and manpower. For instance the cost of running a full eight-car train may be only marginally more than the cost of running that train with only a handful of passengers.

47   In economic terms, public transport fares are very price-elastic because transit users are price-sensitive and many have good alternative transport (that is, the motor car).

Table 6   Cost recovery

	Sydney	Melbourne	Brisbane	Perth	Adelaide
Cost recovery, urban railways	20% (2010–11)	na	na	na	na
Cost recovery, public transport	na	na	22.6% (2010–11)	23.2% (2010–11)	na

Sources: Audit Office of New South Wales, 2011, pp.26, 114; TransLink Transit Authority, 2011a, p.67; Public Transport Authority of Western Australia, 2011a, p.21

Funding expenditure

The urban passenger railways have been traditionally funded by the respective State governments. The Whitlam government formally commenced Commonwealth investment in urban railways, with the passing of the *States Grants (Urban Public Transport) Act 1974*. Subsequent Commonwealth investment protocols included the *States Grants (Urban Public Transport) Act 1978*, the *Australian Bicentennial Trust Fund Act 1982* and funding through the *Building Better Cities* program.[48]

The Commonwealth's current commitments amount to $7.3 billion investment in urban passenger transport projects. This funding includes investing in new railways in Brisbane, Sydney, Melbourne and Adelaide. The Commonwealth is also providing substantial funding for the construction of a new light railway in the city of the Gold Coast and for the Perth City Link project. Studies for investigating further infrastructure developments have also been funded, including a completed study of the Cross-River Rail Link in Brisbane and of the proposed Melbourne Metro.

48   See Laird, 1994, for a review of Commonwealth funding through to 1994.

Urban passenger operations

This chapter provides a profile of the five urban passenger rail systems. The governance, structure and recent network changes are discussed and projects under construction are outlined. Service standards (such as rolling stock, station-access profiles and service frequencies) are considered. Finally, patronage patterns are considered and interpreted.

Sydney

Summary

Sydney's metropolitan heavy rail network has been operated by RailCorp. CityRail is the operational division within RailCorp that runs urban passenger services. At the time of writing, the NSW government had announced that it will split RailCorp into two entities, Sydney Trains and NSW Trains, which would operate services for urban and Newcastle/regional/intercity passengers, respectively.

Sydney has a network based around the North–South and East–West (via Lithgow) corridors, with the North Shore, Bankstown and East Hills lines providing key inter-linkage routes across those corridors. There are relatively few branch lines. Relatively modest, but costly, extensions to the network have opened since 1990, while the South West Rail Link is currently under construction.

Investment is underway to address capacity issues on the system and to improve the robustness and performance of the network.[49] Complex passenger train service inter-twining, and extensive passenger and freight train sharing of capacity, provide challenges for operating fast and reliable services. The Rail Clearways Program, the new Southern Sydney Freight Line and the Northern Sydney Freight Corridor Program are infrastructure responses to these issues.

The urban passenger train operations are supplemented by extensive inter-urban services. The Sydney suburban system is served by electric double-deck (EMU) train sets, generally with four- and up to eight-car sets. Service frequency is very variable, especially from the extremities of the suburban system; off-peak services to central Sydney are relatively low. However, key retail and service centres, such as Parramatta, Strathfield and Chatswood, have frequent peak and off-peak services.

---

[49] Sydney's transport policy has been guided by the "Metropolitan Plan for Sydney 2036". NSW Government, 2010. The plan included a number of projects which were announced by the former government. A ten-year plan, NSW 2021, was released in September 2011. NSW Government, 2011

The suburban/inter-urban system generates the heaviest use of an urban rail network in Australia. The NSW government has instituted a programme of strategic station car parking expansion, to capture new traffic from widely-dispersed catchment areas. Strategies formulation for increasing train and track capacity are underway.

Figure 6   Sydney's passenger rail network
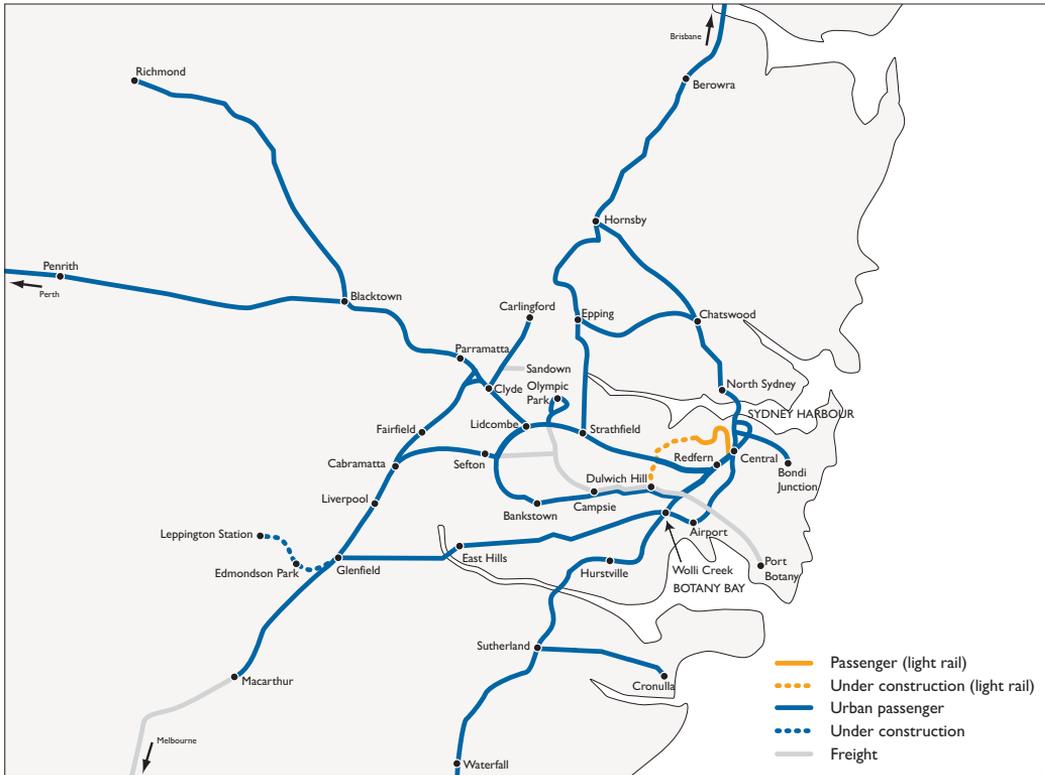
Network

CityRail's network (Figure 6) is standard gauge, with a system of lines converging on Sydney Central Station and a short underground line, the City Circle. The passenger operations consist of metropolitan (suburban) services as well as key intercity services to regional centres such as Newcastle, Lithgow, Goulburn and Wollongong.

CityRail restructuring

RailCorp is the owner of the greater Sydney metropolitan railway network. The corporation is also the provider of urban, interurban and long-distance passenger trains and these have traded under the CityRail and CountryLink passenger service brands.

In May 2012, the NSW Government announced that RailCorp would be restructured. CityRail's Sydney urban passenger services, together with ownership of the RailCorp greater metropolitan network, will be transferred to a new entity, Sydney Trains. The Sydney-based interurban and long-distance (CountryLink) services, together with the Newcastle metropolitan passenger services, will be transferred to a new entity, NSW Trains.

The new structure has some parallels with the service-provider structure adopted in Victoria. Metro Trains Melbourne provides urban rail service in Melbourne while V/Line provides Melbourne-based interurban and long-distance rail and coach services.

An important feature of CityRail's primary suburban network spines is that the lines are also part of the main North–South interstate corridor, the Perth (via Lithgow) main line and the Illawarra line serving Wollongong/Port Kembla. This is a key distinction between Sydney and the other urban networks. The suburban, inter-urban and CountryLink passenger trains as well as national and intrastate freight share these corridors, each service having its own speed (and thus capacity) requirements.

By contrast with other cities, the network has a relatively small number of branch lines—the Carlingford, Cronulla, Olympic Park, Eastern Suburbs and Richmond railways. Most of the system is double-track or greater; there are single-track sections on most of the Carlingford branch and on the Schofields–Richmond section of the Richmond branch.

The system forms an important part of Sydney's transport network and has (with its interurban and Newcastle system) the highest patronage level of the five urban rail networks.

Network activities from 1990

Table 7 lists the major changes to Sydney's metropolitan railway network from 1990.[50] In route length and coverage, the changes are relatively modest, but have nevertheless been costly additions. The Cumberland connection enabled direct train services to commence between Blacktown/Parramatta and Liverpool/Campbelltown. The Olympic Park line provided the keystone transport infrastructure link to the principal venues that were built for holding the 2000 Sydney Olympic Games and subsequent major events. Similarly, the Airport Rail Link provided an important public transport link for the Olympics and, more generally, for connecting Sydney Airport with central Sydney and the wider urban railway network.

---

[50] Table 2 lists projects which expanded the network. It excludes projects which enhanced the capacity and/or reliability of the network such as duplications and turnbacks.

Table 7   Major Sydney railway constructions since 1990

Line/Project	Opened	Route length (km)
Cumberland service (west-side rail link between Western and Main South lines)	1996	0.9 [51]
Olympic Park branch	1998	4
Airport Line	2000	7
Epping–Chatswood rail link	2009	15

The most significant financial investment in the period was the construction of the Epping–Chatswood line. The three intermediate stations, and most of the line, is underground; Chatswood and Epping stations were also reconstructed.

Network extensions currently under construction

The New South Wales government is currently constructing extensions to the rail network. Figure 6 depicts the existing passenger network together with the South West (Leppington) Rail Link and the (Dulwich Hill) light rail extension.

The South West Rail Link will be an 11.4 km railway that will serve the 'South West Growth Centre'.[52] It will include new stations at Edmondson Park and Leppington as well as a stabling facility at Rossmore. The line will join the passenger network at Glenfield station, which is being upgraded. The project is due for completion in 2016.

The Central Station–Lilyfield light rail service is also being extended using the heavy rail corridor of the redundant Dulwich Hill – White Bay freight line. The light rail line is being extended by 5.6 km from Lilyfield to Dulwich Hill. The line operates separately to the CityRail network but there is an interchange with heavy rail at Central Station and a planned interchange at Dulwich Hill. The current plan is for the light rail extension to open in 2014. Annex C sets out network development plans for Sydney and the other cities. Inevitably, such project lists are open-ended, with short and long-term aspirations.

Network capacity enhancement projects

Of the five cities, arguably Sydney has the most challenging network capacity issues especially as the core urban lines also form the backbone of the North–South corridor. Each city has challenges in planning for future patronage but Sydney's *existing* network provides significant capacity challenges.

Sydney's passenger railway network is cast around the North–South interstate spine and the East–West "via Lithgow" spine to Perth; this escalates capacity and service reliability issues. It also means that policy focus on the network necessarily needs to consider urban *and* interstate transport aspects. The spines carry CityRail suburban, CityRail inter-urban, CountryLink country passenger services, mixing stopping and express services; this provides its own scheduling

---

51   Quinlan & Newland, 2000, p.6. This is the length of the Y-link not the route length of the Cumberland service.

52   The NSW Department of Planning and Infrastructure defines 'Growth Centres' as areas which 'will accommodate 181 000 new dwellings and land for employment for around half a million new residents over the next 25–30 years.' Sydney currently has two 'Growth Centres' in the north–west and south–west, respectively. NSW Department of Planning and Infrastructure, 2011

and capacity challenges. The spines also carry important local and interstate freight arriving/departing and transiting the city.

There are major infrastructure enhancements being undertaken, in network operational form and in traction power supply:

- **Operational separation.** A major historical legacy of the Sydney system's development is the multitude of operational interfaces and integration. Much of the lines are integrated *operationally* into a single network rather than operationally discrete elements of a coherent passenger service. The passenger timetable is cast around 14 *operationally* interconnected metropolitan rail services converging on Central Station. The result is that capacity is less than it could be while also leaving services on separate lines prone to delays incurred on other lines. Recognising this issue, in 2005 RailCorp commenced a Rail Clearways Program[53] to separate 14 interconnected metropolitan rail lines into 5 groups of independent operations—'clearways'.

- **Upgraded traction power supplies.** New rolling stock, such as the Waratah trains, require additional power for enhanced train acceleration and to power the now-standard air-conditioning of carriages. This has led to the Traction Supply Upgrade Waratah Program, which is being undertaken over a number of years.

Capacity for meeting growth projections

Despite the 'clearways' work, Transport for NSW has indicated that the CityRail network will become capacity constrained in the CBD from 2021.[54] This is important if the system is to be able to manage general traffic growth and for the system to accommodate new services—such as trains from the South West (Leppington) line, which is currently under construction.

A range of investments and strategies are being considered. Capacity-enhancing strategies include construction of new tracks into the city centre (from across the Harbour), modernised signalling and a fundamental recasting of rolling stock design:

- **New tracks.** The radial nature of the CityRail network, combined with significant operational interfaces between lines, means that capacity constraints in the CBD act as a bottleneck for the entire system. One option that is being investigated for CBD capacity enhancement is a second harbour crossing, which would connect to a new tunnel under the city centre. Some trains approaching from the North, the Bankstown line and from Hurstville would use the new tracks.[55]

- **Single-deck services.** Recasting of rolling stock provision may be an option for capacity enhancement. Transport for NSW (2011a, p.10), indicate that part of the reason for Sydney's capacity constraints is long station dwell times: double deck carriages have only two doors, which limit the rate of passenger ingress and egress. Longer dwell times reduce the maximum possible train throughput on a given line. The stock recasting that is being considered would involve introducing single-deck trains on the planned North West Rail Link and some inner urban operations. Reduced station dwell times would enable higher service frequency. Double-deck stock would continue to be used for longer-distance services.

---

53 CityRail, n.d.
54 Transport for NSW, 2011a, p.23
55 Transport for NSW, 2012a

The options for long-term capacity enhancement are still in draft form and will be further developed for the release of the Transport Master-Plan for NSW in November 2012.

Figure 7   Sydney double-deck trains

Note: Photograph courtesy of John Hoyle.

The photograph shows a Tangara four-car urban EMU (introduced from 1988), on the left, and a double set of the "OSCAR" class inter-urban four-car EMU (introduced from 2006).

Service quality

Sydney's urban passenger fleet is the largest of the five networks.[56] The fleet is unique because all urban carriages are double-deck. There are 626 new "Waratah" class carriages that are currently under construction[57]; these will run in eight-car EMU sets, enabling the withdrawal of the last non-air-conditioned carriages from the network.[58] RailCorp are also introducing "OSCAR" class outer-suburban four-car sets, totalling 99 carriages. The delivery of the "Waratah" stock will result in a net 11 train increase in the CityRail fleet.[59]

Average time between trains

Average time between trains is an important component of rail service quality and, therefore, competitiveness with other transport modes. CityRail train frequencies depend on the time of day, service demand and capacity constraints on different parts of the network. As a general rule, the average time between trains in peak hours is 15-minutes or less, with an average time of 30 minutes in off-peak at suburban stations. Stations at major centres have lower average times; and there are higher average times at smaller stations and on the Carlingford line.[60]

56   CityRail, 2011a
57   RailCorp, n.d.
58   Audit Office of New South Wales, 2011, p.90
59   Transport for NSW, 2011a, p.3
60   Transport for NSW, 2011a, p.3

Figure 8 illustrates average time between trains for services arriving at Sydney Central, from stations that are at the end of lines or are at major centres or junctions.[61] Time intervals are provided for morning peak train arrivals at Sydney Central for the period between 0700 and 0900. An off-peak train interval average is also provided, based on arrivals at Sydney Central for the period between 1300 and 1500 on a Saturday afternoon. The difference between peak and off-peak interval times illustrates the extent to which the system is geared toward the commuting task.

A rule-of-thumb measure of high-standard train frequency is a maximum 15-minute gap between services. The 15 minute gap is regarded as the maximum time that a person would expect/wish to wait for a train if they had not consulted the timetable or if they were connecting from other public transport services. Figure 8 shows that end-of-line stations do not fare well with such turn-up-and-go behaviour.

Figure 8 also presents average service intervals for trains passing through illustrative key transport hubs and urban service/retail centres, such as Chatswood, Parramatta and Strathfield. The service quality through such centres can provide indications of the value of the network in providing transport tasks other than radial-based commuting services to city centres.

Figure 8 shows that major transport hubs and urban centres are well served, even in the defined Saturday "off-peak" period, 1300 to 1500. Thus, while Sydney's services are focused on the city centre[62], the suburban centres such as Parramatta, Strathfield, Chatswood and Hurstville play an important role as transport interchanges as well as destinations in their own right. Indeed, these suburbs are major employment centres; Parramatta's station is the fourth busiest on the network[63] and is frequently referred to as Sydney's second CBD.

The NSW government's metropolitan strategy seeks to concentrate employment in "centres" to decrease pressure on the CBD while also maximising public transport trips.[64] Accessibility, frequency of services and interchange facilities at these non-radial destinations are important in attracting passengers and ensuring that rail effectively works with other modes to enhance the reach of the public transport network and improve its competitiveness.

---

61 The majority of Olympic Park and Carlingford services require passengers to change trains at Lidcombe and Clyde respectively.
62 The exception is the Cumberland line.
63 Transport for NSW, 2011a, p.16
64 NSW Department of Planning and Infrastructure, 2005

Figure 8   Average time between trains for services arriving at Sydney Central
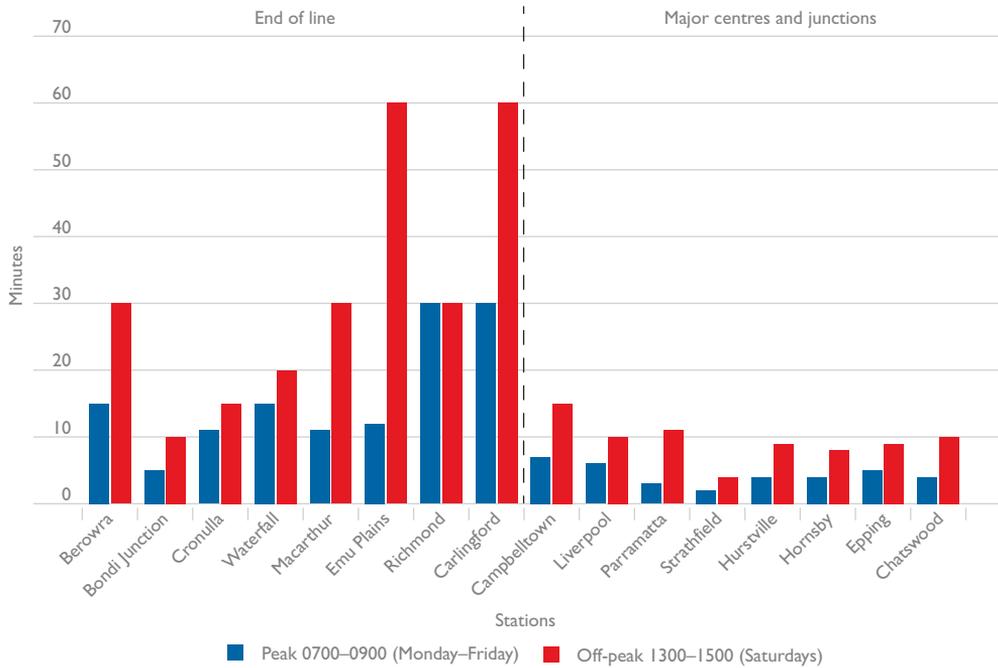
Note: The average time between trains was calculated using CityRail timetables in October 2011.

Figure 8 also illustrates that average train intervals vary greatly throughout the network. Strathfield has the best train interval (or, put another way, highest train frequency) with an average 2 minutes between trains during the peak and 4 minutes between trains in our defined off-peak period. Strathfield railway station benefits from short train intervals due to its location at the junction of the Northern line with the Inner West, South and Western lines. It is a major interchange station which also serves regional and interstate CountryLink passengers and abuts a bus interchange. By contrast, stations on branch lines such as Carlingford and Richmond have relatively long intervals between trains in both the peak and off-peak.

Station facilities

The success of individual stations relies on more than good service frequency/low waiting time and fast train services. Station accessibility—with good walking, bus services, car-parking facilities and road links—are also crucial. Sydney stations at large commercial hubs generally have bus interchanges; CityRail commuter parking is not provided in such circumstances. Commercial parking may be available but hourly rates are generally aimed at encouraging short-term use rather than commuting. Indeed, with stations such as Parramatta and Chatswood, the locations are commuting destinations in their own right (as alternative working locations to central Sydney).

The NSW government has a policy of encouraging patronage by providing car parking aimed at the commuter market. A range of locations have been identified for the provision of station car parking facilities.[65] Targeted locations for the scheme include commuter stations with good road capacity and available land.[66] Existing facilities at Macarthur, Campbelltown and Glenfield on the South Line (with some East Hills and Cumberland services) tap into those wider, more dispersed catchment areas where, for many, use of the car is essential to access the station. In those situations, tapping the market relies on would-be travellers having easy access to cost-effective (or free) station parking.

---

[65] Transport for NSW, 2012b

[66] Stations that have been identified are: Granville, Sutherland, Padstow, Canley Vale, Kiama, Moss Vale, Oak Flats, Lindfield and Gordon. These complement other stations built with the same objective, at Campbelltown, Holsworthy, Morisett, Tuggerah, Wentworthville and Windsor.

Patronage

Patterns

The CityRail network has the largest patronage level in the country (Table 4). Weekday commuting is an important task for Sydney's urban railway network (Table 5). Around 46 per cent of Sydney CBD workers travel to work by train.[67] In addition, rail's mode share of work trips is over 25 per cent to North Sydney, Chatswood, Bondi Junction, and St Leonards; the share is 24 per cent to Parramatta.[68]

Figure 9   Passenger journeys travelled in 2011, by route (percentage, colour-branded)
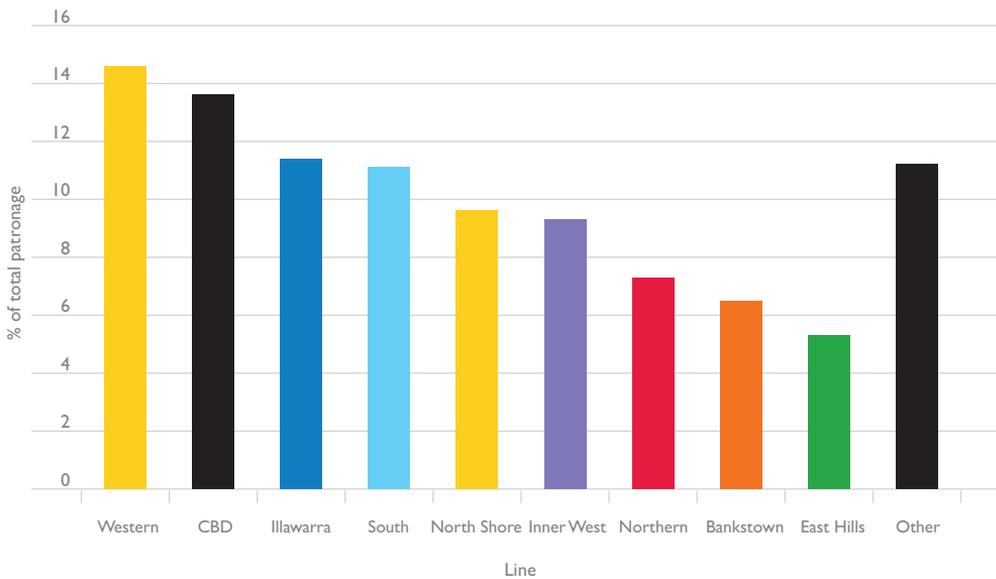
Source: Data extracted from Audit Office of New South Wales, 2011, p.28

---

67 Mees & Dodson, 2011, p.7
68 Transport for NSW, 2011a, p.5

Figure 10   CityRail network by route

Source: CityRail network map retrieved from CityRail, n.d.b.

Note: The new Sydney Trains operations correspond to the CityRail suburban lines; the interurban lines shown here will be operated by NSW Trains.

The patronage is spread across the network routes fairly evenly; Figure 9 shows the CityRail colour-branded passenger journeys, split by identified route. The routes are presented in the map in Figure 10. As noted earlier (page 13), however, the data make no allowance for the length of journey involved. Thus, for example, if Western line passenger journeys are relatively long, then that line's "task" (defined in terms of passenger-kilometres) is greater than that presented here.

CityRail provides services for a range of markets (page 26) including intercity, suburban and shorter metropolitan trips. Data in Figure 11 shows the distribution of trip time spent on a CityRail train. A small proportion of travel involves very long journeys, approximately 50 per cent of CityRail trips have a duration of under 30 minutes and many trips are less than 10 minutes.

Figure 11   Time spent on rail, CityRail

Note: A small number of trips extend beyond 100 minutes.
Source: Transport for NSW, 2011a, p.6.

Trends

Sydney's heavy rail patronage growth has been relatively weak in the last decade. A number of factors will be at play in this outcome:

- **Vehicle operating costs.** As with the other systems, higher fuel prices (impacting on car operating costs) will have encouraged patronage growth.
- **Service quality.** A local factor influencing patronage is train punctuality, which has been improved, albeit by slowing down some of the services.
- **Rail and road network expansions.** The rail network expanded with the opening of the Chatswood–Epping link, but there have also been large additions to Sydney's road network.

- **Employment growth patterns.** In recent years, economic conditions slowed growth in CBD employment.[69] Sydney's pattern of strong population growth in outer suburbs (page 18) was matched by a growing dispersion of employment opportunities. In the years 2001–06, there were 47 300 jobs added in Sydney; 75 per cent (35 500) were located in Sydney's "outer sector".[70] Nearly 40 per cent of employment opportunities were located at least 20 km from the CBD in 2006.[71] The dispersion of employment and population, as well as slow CBD growth does not favour rail patronage, with a network based largely on a CBD-centred radial structure of services. A BITRE analysis has shown that only 3 per cent of "outer sector" jobs in Sydney were accessed by rail in 2006.[72] In addition, a Bureau of Transport Statistics (BTS) report estimated that public transport mode share is 75 per cent to the CBD, 32 per cent to 'centres'[73] and only 10 per cent to other locations.[74]

Transport for NSW projections suggest that demand for Sydney's rail services will increase, driven by projected population growth. Sydney's population is expected to grow by 1.7 million to 6 million people by 2036.[75]

---

69 Independent Pricing and Regulatory Tribunal, 2011, p.17
70 Bureau of Infrastructure, Transport and Regional Economics (BITRE), forthcoming (Table 4.4)
71 Blake & Milthorpe, 2010, p.8
72 Bureau of Infrastructure, Transport and Regional Economics (BITRE), forthcoming
73 "Centres" are: Parramatta, Wollongong CBD, Newcastle CBD, Bankstown, Blacktown, Campbelltown, Chatswood, Hornsby, Liverpool, North Sydney/Milsons Point, Penrith, St Leonards/ Crows Nest, Central Industrial Area/Airport and Macquarie/North Ryde.
74 Blake & Milthorpe, 2010, p.11
75 Transport for NSW, 2011a, p.9

Melbourne

Summary

Most of Melbourne's metropolitan rail network (Figure 12) is operated for Public Transport Victoria (a State government agency) by a private joint venture of MTR Corporation of Hong Kong, John Holland and United Group Rail. The venture is branded as Metro Trains Melbourne (MTM). There are limited V/Line (government) trains that serve some stations on the defined metropolitan network (west to Sunbury and Melton).

Melbourne has a spoke-shaped network, fanning out from central Melbourne. By contrast with Sydney, the network is based around a web of branch lines. In the last 20 years, and currently, the network development has focused on electrification, capacity enhancements and extension of suburban services along erstwhile V/Line country tracks.

The passenger network is largely separated from freight operations. Non-urban and urban passenger trains share tracks, although the government has deemed that there are sufficient capacity and reliability issues to justify construction of separate tracks for west and northern regional and country trains to access central Melbourne.[76]

The network has enjoyed good patronage growth in the last few years, fuelled especially by strong employment growth in central Melbourne.

There are generally good peak period service levels from line termini stations and major centres. There are fewer off-peak services with, in most measured cases, an average 20-minute interval between trains. Nonetheless, weekend patronage has grown faster even than weekday traffic in recent years.

---

76 Melbourne's transport policy has been guided by the "Victorian Transport Plan 2008". Victorian Government, 2008. The plan included a number of projects which were announced by the former government.

Figure 12 Melbourne's passenger rail network
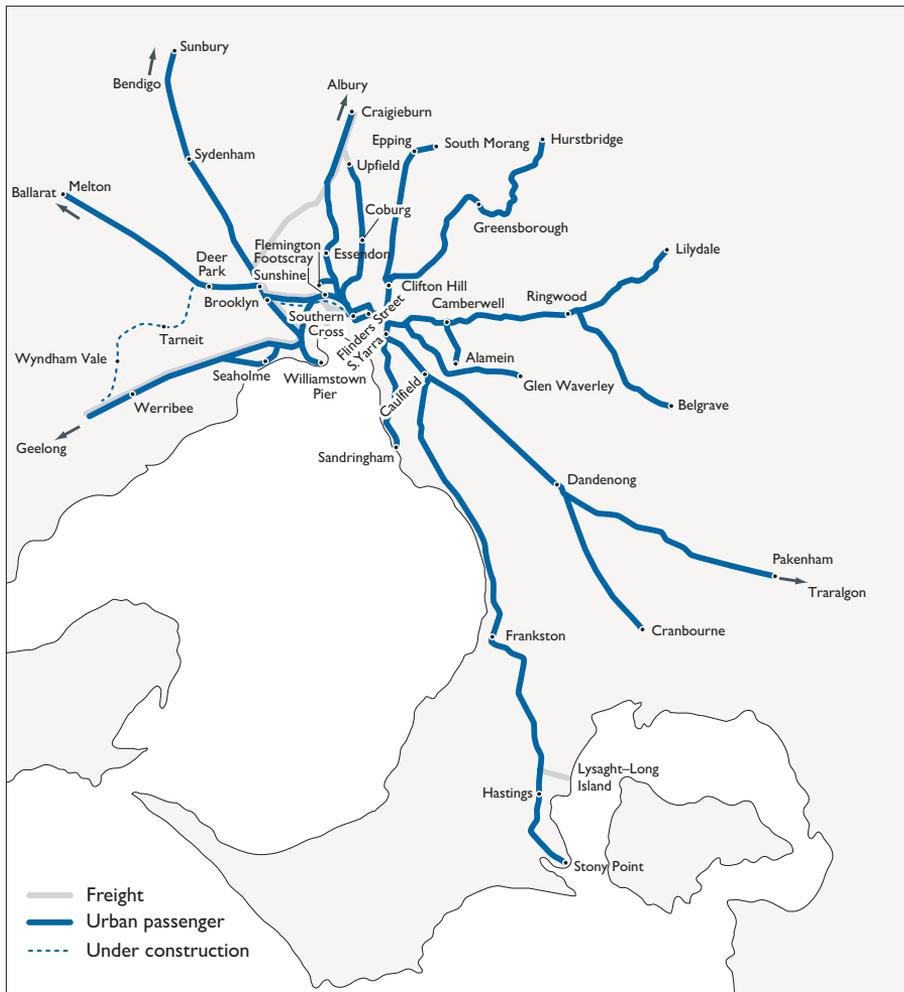
Network

The urban passenger system, operated by Metro Trains Melbourne (MTM) (under franchise from Public Transport Victoria) operates on broad gauge track, centred on the Melbourne Flinders Street and Southern Cross stations. An overhead viaduct links these two termini, along with a short underground railway, the City Loop (running underneath central Melbourne); lines converge on this infrastructure from North Melbourne, Jolimont and Richmond. From those latter stations there are webs of branch lines to the west, north-east, and south-east. Uniquely among the five cities, Melbourne's extensive heavy rail network operates with a significant light rail (tram) system (excluding most outer suburbs).

The broad-gauge metropolitan passenger services share track with some freight trains as well as V/Line's regional passenger services. The most significant freight service operates over the broad-gauge Frankston line, operating between central Melbourne and Long Island, near Hastings on the south-east edge of the city. Interstate (and some intrastate) freight services operate on standard-gauge tracks, which effectively segregates the operations from the urban passenger trains; this is a stark contrast with Sydney.

Apart from MTM's Frankston–Stony Point line and the V/Line Sunbury and Melton services, the train traction is powered by overhead electric catenary.

There are a number of sections of the network that are single track—such infrastructure standards should not necessarily imply "inferiority" and can be fit-for-purpose for meeting achievable and desired service levels. The Altona, Cranbourne and Stony Point branches are single-track. There are sections of single-track on the Hurstbridge line, especially at the Hurstbridge end. Similarly, the extremities of the Upfield, Lilydale, Belgrave, and Alamein are single-track. The extremity of the Epping line has been converted to double-track in connection with the extension of that line to South Morang. Sections of the Caulfield–Dandenong line are being triplicated. There are other sections of triple-track, enabling peak-time express trains to overtake stopping trains.

Network activities from 1990

During the period since 1990, the State government has focused on line enhancements and capacity-relieving projects—Table 8 lists longer route enhancements. Others, such as the short Clifton Hill–Westgarth line duplication in 2009, have provided important capacity and reliability enhancements to long-standing bottlenecks.

In addition, the Epping line has been extended to South Morang, with services commencing in April 2012. The work involved constructing a 3.5 km extension to South Morang, as well as duplicating the single-track line between Keon Park and Epping.[77]

Table 8   Major Melbourne railway constructions since 1990

Line/Project	Opened	Route length (km)
Dandenong–Cranbourne electrification	1995	14
St Albans–Sydenham electrification	2002	5
Broadmeadows–Craigieburn electrification	2007	10
Epping–South Morang	2012	3.5

Network extensions currently under construction

The Victorian government is seeking to increase network coverage and capacity. Figure 12 illustrates the existing passenger network and lines under construction.[78] The works associated with electrifying the Sydenham (Watergardens)–Sunbury line (15 route km) will increase service capacity. In 2012, V/Line diesel-drawn trains will be replaced by longer six-car electric trains; the Victorian Department of Transport says that the new electric trains will have double the capacity of the current trains.[79]

Other capacity-enhancing work is planned. The Victorian government is seeking to disentangle its urban and regional passenger services. As with Sydney, the Melbourne urban passenger services share tracks with inter-urban and country passenger trains. This is particularly

77   Department of Transport Victoria, 2011b
78   Figure 12 illustrates network extensions which are currently being constructed. Proposed projects are excluded. Upgrades, duplications and other capacity enhancements could not be effectively shown on the map.
79   Department of Transport Victoria, 2011c

prominent on western tracks into Melbourne Southern Cross station, with suburban passenger services sharing line capacity with long-distance/inter-urban Geelong, Ararat/Ballarat, Bendigo and Warrnambool services.

To address capacity and reliability issues arising from this shared track usage, the State and Australian governments are funding the Regional Rail Link (shown on Figure 12). The project involves constructing 27 route km of track between West Werribee (on the Geelong line) and Deer Park, on the Melton/Ballarat line. Warrnambool/Geelong and Ballarat services will then use existing Ballarat tracks through to Sunshine, where these, and Bendigo, regional trains will run onto new dedicated tracks through to Melbourne. Twin tracks are being constructed beside existing operating track corridors between Sunshine and Melbourne Southern Cross station, with new platforms at the latter location.[80]

Capacity for meeting growth projections

The Victorian Government predicts continued patronage growth on its network. The Regional Rail Link and Sydenham electrification (discussed above) are expected to increase capacity of the Northern Rail Group (NRG),[81] which in turn may pressure the existing capacity in the city loop. The Victorian Government is investigating the construction of twin 8 km rail tunnels from South Kensington in Melbourne's West, passing under the CBD and ending at the Domain. The 'Melbourne Metro' project would seek to enhance central Melbourne's capacity by physically separating services from the NRG into three operations – the Sunshine-Domain metro, Cross city metro and the Northern loop metro.[82]

Annex C sets out network development plans and aspirations for Melbourne.

Service quality

Melbourne has the second largest urban passenger fleet. The majority of Melbourne's fleet is air-conditioned. There are 14 non air-conditioned three-car 'Hitachi' train sets which were introduced from 1972[83]; these will be withdrawn as additional air-conditioned X'trapolis trains are introduced into service.[84]

---

80   Department of Transport Victoria, 2011d
81   The NRG includes the lines to Craigieburn, Sydenham, Upfield, Werribee and Williamstown. Wapling, 2011
82   Wapling, 2011, p.5
83   VicSig, 2011
84   Department of Transport Victoria, n.d.

Figure 13   Metro Trains Melbourne train, Footscray station

Source: Photograph courtesy of John Hoyle.

Average time between trains

Service frequency and speed are important components of rail service quality and competitiveness. Melbourne's services are configured around express and all-station services. Figure 14 illustrates the average time between trains arriving at Melbourne Flinders Street station, reported by train origin point. Frankston and Sandringham have the lowest time, with an average 8 minutes.

Peak frequencies vary considerably across services, with smaller branch lines generally running fewer trains. Hurstbridge, a relatively isolated railway station, has the highest peak average time between trains, of 24 minutes.

For most lines, the peak average time between trains is much better than off-peak, with service quality being primarily geared to the commuter service task. Most of the off-peak services are based on an average 20-minute gap between trains. Some of the smaller branch lines use shuttle services during the off-peak period, with passengers on the Alamein and Williamstown services being required to change trains at Camberwell and Newport for trains to and from Melbourne.

Figure 14   Average time between trains for services arriving at Flinders Street
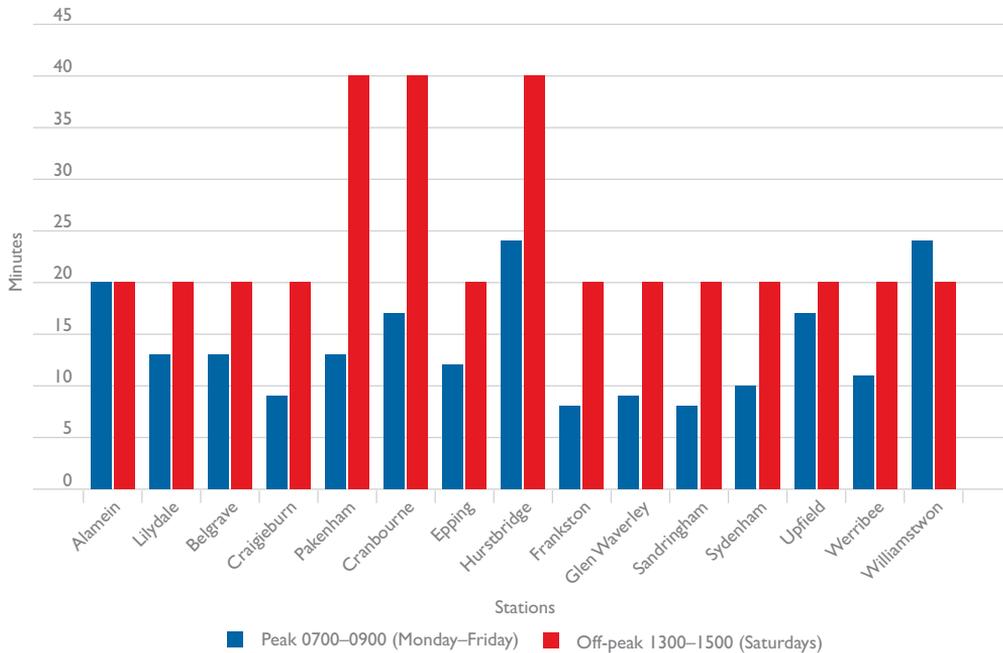
Note: The average time between trains was calculated using Metro Trains Melbourne timetables in October 2011.

The pattern of high-frequency peak services and much lower off-peak frequencies is repeated for major centres and junctions. The structure of the network into branch lines means that stations which are closer to the city loop will generally have higher service standards than more remote stations. Thus, although Melbourne's network is designed as a radial system, with lines converging on central Melbourne, the rail system provides service standards that enable some suburban centres to provide attractive service quality to non-CBD destinations.

Figure 15 illustrates the average time between trains arriving at Flinders Street from major centres and junctions. South Yarra railway station has the lowest average time, with just over 2 minutes in the peak period; the station is located at the junction of the Sandringham and Pakenham lines. The Pakenham line also has two junctions before South Yarra at Caulfield and Dandenong with the Frankston and Cranbourne lines respectively. South Yarra is also a retail centre with shops and restaurants lining its two main roads—Toorak Road and Chapel Street.

Figure 15   Average time between trains arriving at Flinders St Station from major centres and junctions
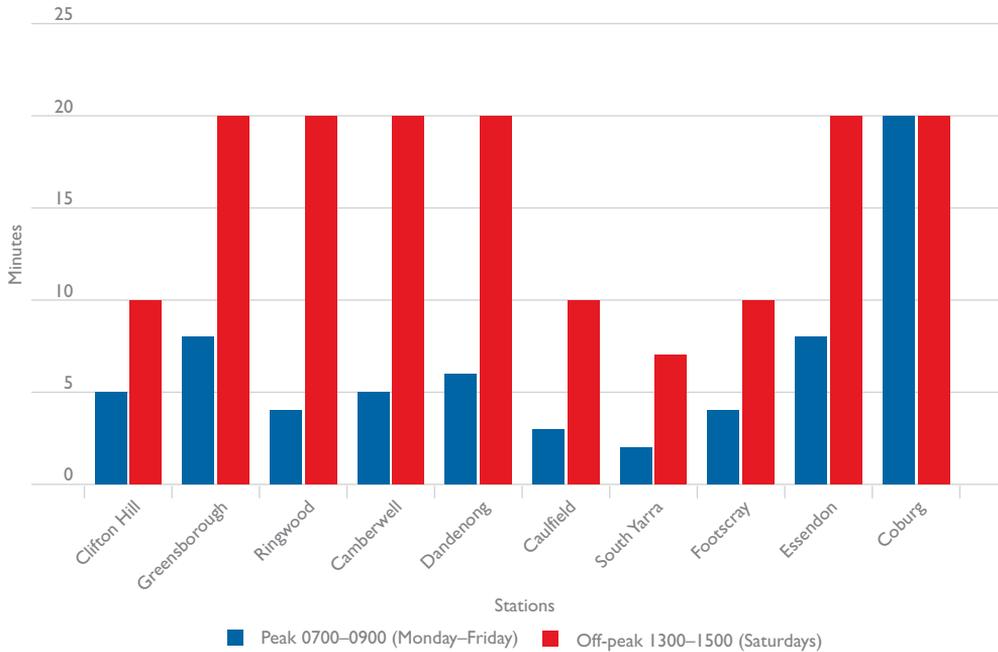
Note: The average time between trains was calculated using Metro Trains Melbourne timetables in October 2011.

Patronage

Patterns

In common with the other urban rail systems, trains perform a relatively strong role in the commuting task to the city centre. Of employed residents in the Melbourne Working Zone[85], 9.4 per cent use the train to journey to work, with 2.2 per cent using tram/light rail and 1.4 per cent using bus. Tram/light rail has a dense network/service in the inner suburbs, so it has a relatively high mode share (13.5 per cent) in those suburbs.[86] Trains carry over 70 per cent of Melbourne residents *who use public transport* for journeying to work.

Melbourne's passenger rail network is the most widely-used public transport mode in the city, albeit less prominent than in the commuting-only task. In 2009–10, it recorded 44 per cent of public transport boardings for all journey purposes, with 35 per cent for tram/light rail and 20 per cent for bus.[87]

---

85   This is the equivalent of a "greater" Melbourne area, including Werribee, Melton, Sunbury, Craigieburn and through to South West Gippsland, as presented in Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2011c, p.18.

86   Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2011c, p.166.

87   Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2011c, p.193.

Despite rail's predominance in the city's public transport commuting task, there is limited integration of usage between the different transport modes, with only 10 per cent of rail passengers (for all journey purposes) linking with buses or trams.[88] In a related issue, a Victorian Parliamentary inquiry noted the Census data pattern showing relatively low public transport usage in outer suburbs[89]; the Inquiry suggested this may arise in part because there is limited car parking at outer suburban railway stations.[90] The same Inquiry suggested that this "low" public transport usage also arose because the rail network was structured in radial paths, limiting cross-town or orbital movements.[91] In this context, the suggested poor cross-modal integration would work against using cross-town bus routes with radial rail services.

Trends

Figure 4 shows that, from 2004, Melbourne heavy-rail recorded strong growth driven by factors external to the train operations. In common with other cities, urban rail operations attracted patrons who faced higher car running costs due to rising fuel prices. Against this background, the motor vehicle mode share (expressed in passenger kilometres) fell from 92 per cent to 90 per cent between 1998 and 2009.[92] Specific local factors that impacted on the patronage included strong employment growth in central Melbourne and population growth.[93]

The strong central Melbourne employment growth is reflected in the rise in weekday traffic — by 41 per cent — in the five years from 2004, averaging 736 000 per weekday. However, there was a stronger increase in weekend patronage over the same period, with Saturday patronage rising by 56 per cent, to an average 342 000; and Sunday patronage rising by 92 per cent, to an average load of 282 000.[94] The focus of the patronage was on stations in central Melbourne although strong growth was also recorded at some suburban stations.[95]

The rapid growth in rail patronage generated capacity challenges for Metro Trains Melbourne. The operator had to react to the unexpected circumstances, to secure adequate capacity. The company supplemented peak-time train capacity by postponing the scrapping of non-air-conditioned Hitachi carriages and increasing utilisation of track capacity.

---

88 This contrasts with some station usage data for Perth—see page 39. Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2010, p.159

89 Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2011c, p.166, reports that in 2006, 10.4 per cent of employed residents in the "inner" sector of Melbourne used the train to get to work; 12.3 per cent of employed residents in the "middle" sector used the train and 6.4 per cent of "outer" sector residents used the train to journey to work.

90 It might also be speculated that what is lacking is secure station parking.

91 Parliament of Victoria, 2008, p.273

92 Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2011c, p.161

93 Gaymer, 2010

94 Editor, Table Talk, 2011, p.5

95 Editor, Table Talk, 2011, p.5 indicates that weekend Flinders St Station patronage in 2009–10 averaged 77 860 and with 46 510 at Southern Cross, with 40 470 at Melbourne Central and 13 240 at Parliament. Suburban Box Hill recorded an average 8 400, an increase of 134 per cent from 2004–05. The increase at Southern Cross was 159 per cent, supported by stronger leisure attractions in the area and strong V/Line patronage growth into the station.

Brisbane

Summary

Brisbane's urban passenger rail services (Figure 16) are provided by Queensland Rail, a government-owned operator. Queensland Rail works with TransLink, the statutory authority that is responsible for the planning, integration and provision of public transport services.

As with other cities, Brisbane operates a radial rail network. In route-kilometres the system is the third-largest of the five cities, and is based around a spine of Caboolture in the north to Beenleigh in the south (with Sunshine and Gold Coast inter-urban operations beyond) and Ipswich/Rosewood in the west. Branch line services operate to Shorncliffe, the Airport, Doomben, Ferny Grove, Cleveland and Richlands. Much of the metropolitan track is shared by passenger and freight trains. Operations are also meshed with busway corridor systems. Radial busways in Brisbane interchange with the rail network at numerous points.

Network capacity issues relate especially to accommodating projected passenger and freight traffic growth on the system.[96] Patronage on the system grew through the first half of the last decade but has subsequently fallen, in part because of rising real fares. The system itself is focused primarily on commuter operations, with typical off-peak operations involving 30-minute train intervals.

---

96 Brisbane's transport policy is guided by "Connecting SEQ 2031: An Integrated Regional Transport Plan for South East Queensland". Queensland Government, 2011.

Figure 16   Brisbane's passenger rail network

Network

The urban passenger network is focused on the central Brisbane stations of Roma Street, Brisbane Central and Fortitude Valley (formerly Brunswick Street), and with most trains also serving South Brisbane and South Bank (formerly Vulture Street). In recent years, TransLink have constructed bus-only corridors ("busways") into the city centre; some of these operations connect with Queensland Rail services at Roma Street and other central Brisbane railway stations. More generally, the objective has been to coalesce the dedicated rail and bus corridors within the city and, indeed, the busways and passenger railways are presented on the same maps for would-be travellers.

There are three components of urban rail operations in Brisbane:

• the Queensland Rail narrow-gauge network;

• the privately-owned narrow-gauge Airport line, owned by Airtrain, which in operational terms fits seamlessly into the Queensland Rail network; and

• the interstate standard-gauge freight (and limited intercity passenger) line, forming the northern end of the Brisbane–Melbourne North–South rail corridor. The line connects to Brisbane Roma Street and to a freight-only dual narrow/standard gauge branch[97] to the Port of Brisbane at Fisherman Islands.

The passenger rail network uses narrow gauge trains, principally owned by Queensland Rail. Train services operate to urban and inter-urban destinations. Inter-urban services connect Brisbane with the Gold Coast (Varsity Lakes), the Sunshine Coast and Gympie.

The construction of the Airport branch was completed in 2001. The line was built by Airtrain Citylink Limited. The company owns the line under BOOT terms (Build, Own, Operate, Transfer) for a period of 35 years. Passenger services on the line are provided by Queensland Rail trains operating between Domestic/International airport terminals, Brisbane Roma Street and the Gold Coast (Varsity Lakes).

The suburban network is dominated by three core lines: the Beenleigh line (with inter-urban services beyond, to Varsity Lakes), the Ipswich/Rosewood line (with country passenger and freight services to Toowoomba and westward to Quilpie and Goondiwindi), and the North Coast line (with inter-urban and country passenger services and freight). Apart from this core spine, there are passenger services operating on branch lines to Shorncliffe, Cleveland, the Airport, Ferny Grove, Doomben and the new Richlands line (being extended to Springfield). Most of the urban network is at least double-track, apart from the Airport line, the Doomben line and the extremities of the Shorncliffe and Cleveland lines. The inter-urban Sunshine Coast line is mostly single-track and the Gold Coast line is largely double track.

---

97 For part of its route, the Fisherman Islands freight line parallels the Cleveland branch but the lines are operationally separate.

Network activities from 1990

Table 9 lists the major railway projects in the Brisbane area since 1990. Included in the table is the 49 km Gold Coast line, constructed progressively between 1996 and 2009.

Table 9   Major Brisbane railway constructions since 1990

Project/line	Date	Route length (km)
Gold Coast line, Beenleigh–Helensvale (inter-urban)	1996	28
Gold Coast line extension, Helensvale–Nerang (inter-urban)	1997	10
Gold Coast line extension, Nerang–Robina (inter-urban)	1998	7
Eagle Junction–Brisbane Airport	2001	9
Gold Coast line extension, Robina–Varsity Lakes (inter-urban)	2009	4
Darra–Richlands	2010	5

Note: The Doomben line (3.4 km between Eagle Junction and Doomben) was closed in 1993 and re-opened in 1998.

Two urban lines were constructed. The Airport branch line was opened in 2001. In addition, the Darra–Richlands line is the first stage of the Darra–Springfield transport corridor. The 4.5 km dual track line was completed in December 2010 and opened for service in January 2011.

Numerous capacity enhancement projects were also undertaken, such as additional tracks at Corinda–Darra, Caboolture–Beerburrum, Mitchelton–Keperra, Salisbury–Kuraby, Helensvale–Robina and Ormeau–Coomera.

In 2011, passenger trains serving stations on the 4 km Corinda–Yeerongpilly line ceased. Freight trains regularly use the line.

Network extensions currently under construction

Figure 16 shows Brisbane's urban and inter-urban rail network, including the projects under construction. The first section of the Springfield railway—between Darra and Richlands—was completed in 2010.[98] The second section, 9.5 km in length between Richlands and Springfield, is due to open in 2013.

Construction for the Moreton Bay Rail Link (Petrie – Kippa-Ring) commenced in mid 2012. Preparatory road works are underway to connect the road network around the new rail line. The railway will be 12.6 km of dual track with six new railway stations. The project will also involve an additional track between Lawnton and Petrie. The railway is due for completion in 2016.[99]

---

[98] Queensland Rail Limited, n.d.a
[99] Department of Transport and Main Roads Queensland, 2011

Network capacity enhancement projects

Capacity on the Ferny Grove line is being enhanced by duplication of the remaining single-track section between Ferny Grove and Keperra.[100] The duplication was completed in April 2012 and associated passenger access works at Ferny Grove station are ongoing.

Capacity for meeting growth projections

As with the other urban systems, there are general capacity constraints on Brisbane's network; "capacity" can be taken as a given issue for any system, with inevitable pinch points. Such issues are heightened, especially, when set against population, employment, freight traffic and then anticipated patronage growth projections.

To cater for the additional freight and passenger traffic, the Queensland government is considering plans to increase line capacity, especially in central Brisbane. The plans for "Cross River Rail" have two facets of augmenting capacity. In the first instance this would happen by separating the different services that currently interface directly at Roma Street. The disentangling of services would increase effective capacity in the same way as Sydney's "Clearways" programme increases physical separation between individual service operations.

The second form of capacity augmentation is additional trackage. The Cross River Rail scheme concludes that achieving the separation of the services and, more generally, to provide more track capacity, will require twin 10 kilometre tunnels that will run between Yeerongpilly and Victoria Park. [101] [102]

Annex C sets out major network development plans for Brisbane. Inevitably, such project lists are open-ended, with short- and long-term aspirations.

Service quality

Queensland Rail runs an air-conditioned electric fleet on Brisbane's metropolitan network.[103] The fleet is the third largest in Australia. Approximately 40 per cent of the fleet are EMUs dating from 1979–87, with the progressive modernisation of the fleet leading to the phasing out of older stock. An order for 64, three-car EMUs has been introduced over a number of years with the final 6 EMUs delivered in December 2011.[104] Queensland Rail is also considering the purchase of a further 200, three-car EMUs, of which 91 will replace existing rollingstock and the rest will expand the fleet. This procurement is subject to approval by the new government.

Average time between trains

Queensland Rail operates all-stops and express trains. Figure 17 illustrates average time between trains for services arriving at Brisbane Central, from stations that are at the end of lines or are at major centres or junctions.

---

[100] Queensland Rail Limited, 2011b

[101] Queensland Government and Australian Government, 2011

[102] Emerson, 2012

[103] Queensland Rail Limited, n.d.b

[104] Queensland Rail distinguishes between its EMUs based on the type of service they perform. Suburban Multiple Units (SMUs) are designed for metropolitan operations while Intercity Multiple Units (IMUs) are for intercity services.

Figure 17   Average time between trains for services arriving at Brisbane Central
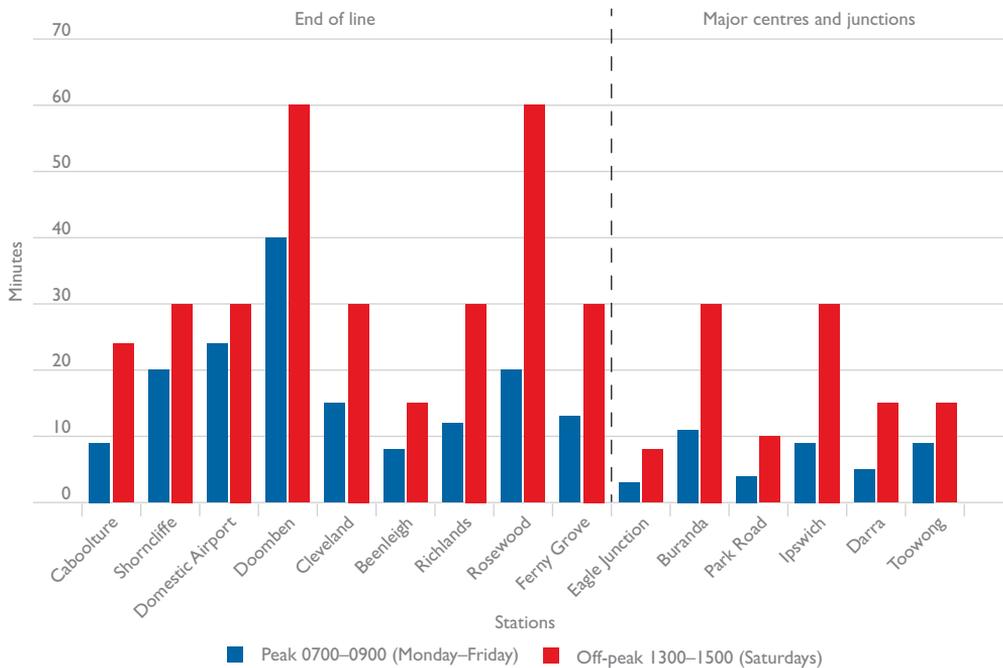
Note   The average time between trains was calculated using TransLink timetables in October 2011.

As shown in Figure 17, railway stations that are located at junctions generally have higher train frequencies. The relatively low-time intervals for Caboolture–Brisbane and Beenleigh–Brisbane trains also reflect the stations' dual roles as urban and inter-urban stations (for Sunshine Coast and Gold Coast services respectively).

As with Sydney and Melbourne, the operations are strongly geared towards commuting, with extended, 30-minute intervals in the off-peak (Saturday daytime).

Station facilities

Bus interchanges and bicycle storage are common at large stations in Brisbane. The "Busway" system parallels much of the inner-city rail network and there are interchanges between the networks at Roma Street, South Brisbane, South Bank, Park Road and Buranda.

Parking is often provided for the commuter market at outer-suburban stations. As with Sydney station parking (page 29), the aim of providing station car parks is to improve access to the rail system in dispersed areas where there is a strong reliance on cars. In addition, there are a number of "rail bus" services which are designed to improve the catchment of the network by acting as feeder routes.

Patronage

Patterns

The Queensland Rail system (urban and inter-urban), carries around 60 million passengers per annum. Rail represented about 6 per cent of total passenger kilometres travelled in Brisbane in 2008.[105]

Patronage data are not available on a line-by-line basis. Data for the privately-owned (PPP) Airtrain line to the international and domestic airports indicate that that line carried around 1.9 million passengers in 2008–09 (an increase of 0.25 million over 2007–08).[106]

Trends

The network recorded significant traffic growth in the last decade, facilitated by the extensions to the inter-urban Gold Coast line, the opening of the Airport line and higher oil prices (that is, higher car-operating costs) during 2006–08.

Conversely, from 2009–10, there has been a marked decline in patronage (Figure 4). In part this has arisen from rising real fares: the government has announced that it will increase fares by 15 per cent per annum each January from 2010 until 2014. The 2010–11 patronage level was also affected in January by flooding in the city; a related response was to then provide free services for an eight-day period, during which passenger numbers were not counted. Finally, the introduction of the electronic "go card" has improved patronage estimation; this has led to a reduction in patronage level estimates as the previous methodology had involved a degree of double-counting.[107]

---

105 Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2009, p.8.
106 The Advertiser, 2009, p.95.
107 Queensland Rail Limited, 2011a; TransLink Transit Authority, 2011a, pp.60, 67; TransLink Transit Authority, 2011c, p.4

Perth

Summary

Perth's urban passenger rail system is operated by Transperth, the brand name through which the Public Transport Authority of Western Australia provides services in the Perth metropolitan region.

Perth has a network based around a long north–south spine, an east–west corridor and a south-east line. The network has almost tripled in size (route-km) in the last twenty years and has been electrified. Network capacity will need to be addressed to cater for future city growth but the network does not suffer the route-intertwining that blights Sydney and that provides operational challenges in Brisbane and Melbourne.[108]

As noted earlier, a distinctive feature of the network is the relatively few stations; in particular, on the new lines the stations are generally widely-spaced. Partly arising from this, as well as a focus on low station dwell times, train speeds are relatively high. The long distances between stations are offset by good road and bus accessibility as well as large station park-and-ride facilities, notably on the newer Clarkson and Mandurah lines.

As with the other networks, service levels cater for commuting. A distinctive feature of the operations, however, is the maximum 15-minute interval between trains at all off-peak times (apart from the very extremes of the operating period). That is, the urban railway is focused on all aspects of journey purpose, not just the commuting task.

In his research, Gaymer (2010, p.12) has noted that improving public transport can "attract strong demand from certain [traveller] segments". This would appear to be the case in Perth. The city has undoubtedly enhanced its train operations, in network coverage and service standards (modern carriages, electrification, service frequency, linkages to other modes). As noted above, the dividend from the good service quality has been strong patronage growth, even on the long-established railway lines. The Transperth operations and patronage trends provide a strong contrast to the other networks.

---

108 Perth's transport policy is guided by the Public Transport Plan for Perth 2031. Department of Transport Western Australia, 2011.

Figure 18   Perth's passenger rail network
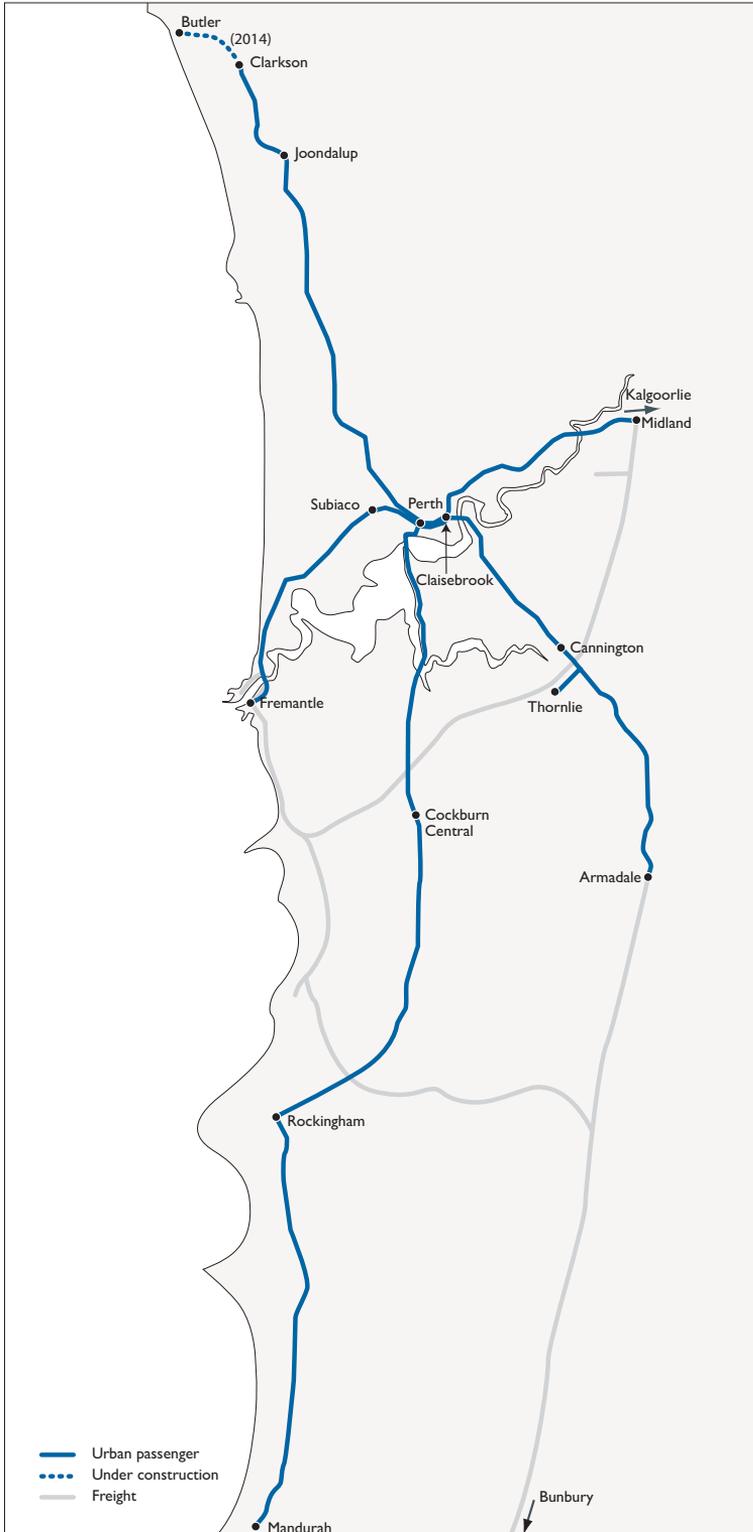
Network

Perth's urban passenger railway operator is the publicly owned Transperth, the brand name through which the Public Transport Authority of Western Australia provides services. Transperth's network consists of narrow-gauge track centred on Perth station: the Clarkson, Mandurah, Midland, Fremantle and Armadale lines, with a short spur to Thornlie from the latter line. The network alignment follows the 120 km north–south length of the Perth Metropolitan Area. In operational terms, Clarkson services in the north operate through to Mandurah in the south of the city. Similarly, Midland services on the eastern side of the city operate through to Fremantle on the western edge of the city.

Perth's metropolitan rail system has benefitted from strong investment since 1990, notably with electrification in 1991 and, from 1993, the construction of a new north–south rail corridor of more than 100 km, between Clarkson and Mandurah. Thus, from a tiny operation of around 66 route-kilometres in 1990, the system has expanded to 169 route-kilometres. The network expansion was facilitated by building roadways with wide central reservations within which the railways could be built.

Network activities from 1990

Table 10 is a list of major Perth railway projects which have increased the network's capacity and coverage. Inevitably, ancillary projects such as new rolling stock depots, were required, with additional depots being built at Nowergup and Mandurah.

Table 10   **Major Perth railway constructions since 1990**

Project/line	Date of completion	Route length (km)
Network electrification	1991	network
Joondalup line opened, Perth–Joondalup	1992	26
Joondalup line extension, Joondalup–Currambine	1993	3
Joondalup line extension, Currambine–Clarkson	2004	4
Thornlie line opened, Beckenham–Thornlie	2005	3
Mandurah line opened, Perth–Mandurah	2007	70

In 1991, electrification of the-then existing lines (Fremantle, Armadale and Midland) was completed. The newly electrified system became fully operational in September 1991 with new rolling stock replacing the diesel fleet as overhead electrical systems were activated.

The network was extended with the 1992 opening of the Joondalup line on the northern side of the city. The line was built in the central reservation of the Mitchell Freeway, with later extensions to Currambine (1993) and Clarkson (2004). Similarly, the central reservation of the Kwinana Freeway was used for most of the alignment of the Mandurah line on the southern side of the city. The Perth–Mandurah line was opened in December 2007. A costly but crucial element of this alignment involved constructing a 774 metre tunnel from the south side of the city into Perth station.

Network extensions currently under construction

The Clarkson (Joondalup) line is being extended to the new suburb of Butler, a distance of 7.5 km.[109] The project is due for completion in 2014 and is designed to serve the growing population in Perth's northern suburbs. The extension is shown in the map at Figure 18.

The Perth City Link project is under construction. The project will provide additional Perth station track and platform capacity. However, the primary objective of the project is to restore the land continuity between the central Perth and Northbridge districts by placing the Fremantle line into a 600 metre tunnel. Annex C sets out the government's network development plans and aspirations.

Service quality

The commencement of electrified services in 1991 led to the withdrawal of the system's fleet, consisting of 20, two-car Diesel Multiple Unit (DMU) train sets. The oldest of the current fleet are the 48 two-car EMU 'A-series' train sets introduced at that time.[110]

In conjunction with patronage growth, new line openings and service improvements, the all-air-conditioned rollingstock has been augmented by a fleet of 46 three-car 'B-series' trains, delivered between 2004 and 2011.[111] A further 15 three-car trains have been ordered, for delivery between 2013 and 2016.

Average time between trains

Transperth runs all-station trains but relatively few express trains. With Transperth's focus on keeping train dwell times low at stations, and with relatively long distances between stations, it means that average line speeds are relatively high: trains spend a relatively small proportion of their time at stations or slowing down to enter/depart stations. As a consequence of these high speeds, Transperth finds it has little need to provide express services.

A further characteristic of the Perth services that distinguishes it from the other operations is high service frequency in peak and off-peak periods. Figure 19 compares train frequencies from stations located at the end of lines with stations at major centres and junctions.

---

109 Public Transport Authority of Western Australia, n.d.b
110 Public Transport Authority of Western Australia, n.d.a
111 Clark, 2005

Figure 19   Average time between trains for services arriving at Perth Central
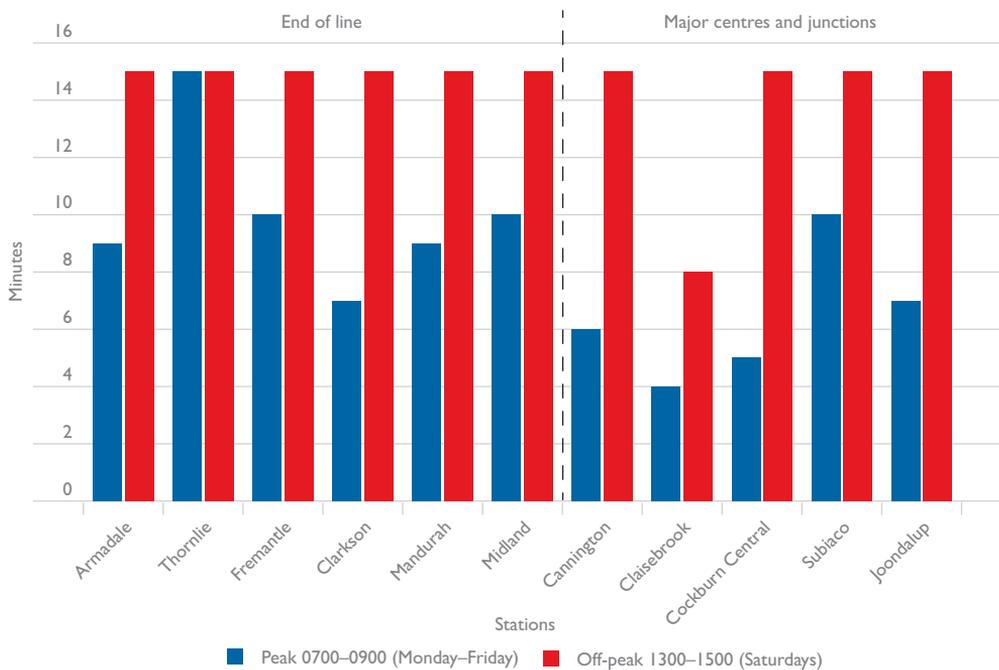
Note: The average time between trains was calculated using Transperth timetables in October 2011.

There are two notable aspects of the services. First, service standards are fairly consistent across the network, both across and within lines. The difference in service levels between major centres and junctions and stations which are located at the end of railway lines is far less significant than the difference in Sydney, Melbourne and Brisbane. Part of the reason for this consistency arises from the low number of express services and the absence of inter-urban services. In addition, the low number of railway junctions—with only two junctions outside of the city centre—reduces the type of "service densification" that can be seen when operations merge at junction stations in Melbourne, Brisbane and Sydney.

The second notable aspect of the Transperth services is that, except at the extreme ends of the operating day, the maximum time between trains is 15 minutes—even in off-peak periods. That is, the system is not focused entirely on the commuting task. Currie and Loader (2009, p.8) suggest that when one mode has an average headway of 15 minutes and the other a headway of 10 minutes or better, then this facilitates high transfer rates. Perth's Mandurah line has attracted patronage in line with, or greater than, forecasts.

Station facilities

Transperth has an ongoing programme to enhance station access. As noted earlier (page 5), on the new lines the stations are widely spaced, enabling fast journey times; catchment areas around the stations are large through ensuring good road and bus links and station facilities. This is particularly important in the context that the relatively long distances between stations results in a relatively low proportion of residents being within walking distance of the station.

Two core aspects are addressed:

- **Bus connections.** There is emphasis on good complementary bus connections at stations. Bus routes interface directly with stations. Rail/bus transfers are encouraged by interchanges that shelter passengers from the weather, minimise walking distance and provide walkways over busy roads where appropriate.

- **Station car parking.** Transperth's other focus is on ensuring ease of car access to stations with adequate complementary free or low-cost park-and-ride facilities. The current station investment programme includes $50 million expenditure on the Car Park Expansion Project.[112] The investment will add 3 000 parking bays at stations on the Clarkson and Mandurah lines. The car parks will be a mixture of pay and free parking. It is notable that the new Butler extension will include 950 spaces at the terminus.

In the absence of high-density urban settlement, that ease of access—to attract patrons from a wide catchment area—is critical to attracting healthy patronage levels; the station access patterns reflect the success of those road, bus, car and station initiatives. While access patterns vary across stations, it is apparent that some major stations have attracted considerable patronage through a wide catchment area and relatively little walk-based patronage. Thus, a 2008 survey found that around one-third of commuters using Mandurah were arriving by bus and two-thirds by car. At Murdoch, around 60 per cent were arriving by bus and one-third by car; walking was a negligible access mode.[113] Patronage can be attracted by ensuring good network (road and bus) links and services and station facilities. Other research reinforces the need for those good links so as to attract patrons; a BITRE (2010, pp.146–47) analysis shows that the opening of the Mandurah line did not materially affect the percentage of jobs within a short distance (0.5–2.0 km) of a railway station or bus stop.

Patronage

Patterns

As with other Australian cities, Perth's urban railways fulfil an important role in the commuting task, particularly links to Perth's central city area. This area contains 18 per cent of metropolitan-area jobs. Over 60 percent of peak hour travel to Perth CBD is by public transport. Rail's contribution to that task has increased in the last 20 years: in 1990, the rail services were 10 per cent of public transport trips; this had risen to 34 per cent in 2004–05 and to 44 per cent in 2010.[114] [115]

---

112 Public Transport Authority of Western Australia, n.d.c
113 Martinovich, 2009. The access mode figures here are a stark contrast with patterns elsewhere; in 2006 in Sydney, walking averaged around 47 per cent of station access mode, bus was 16 per cent and car was 35 per cent..
114 Department of Transport Western Australia, 2011, p.14
115 Public Transport Authority of Western Australia, 2011b

Trends

Perth's urban railway patronage has increased substantially. In 1992, rail patronage was 7 million.[116] With two major route expansions since that time, and complementary increases in the train fleet, this patronage level had risen to 59 million in 2010–11. That is, rail patronage stands at over eight times the level of 20 years ago. The opening of the Mandurah line in December 2007 provided the most recent major boost to patronage on the network—as is illustrated in Figure 20. The growth in network patronage owes much to the opening of the Clarkson and Mandurah lines (Figure 21).

Patronage growth has *also* been achieved through substantial enhancements to service quality; the impact of these improvements on patronage should not be under-estimated. Patronage has clearly responded to the provision of electrified rolling stock and to major boosts in train frequency in peak- and off-peak periods. Thus, patronage on the lines existing in 1990 (Armadale [but now including the Thornlie spur], Fremantle and Midland) attracted 7 million passengers in 1992 but currently represent around 23 million boardings—a more than tripling of patronage.

Figure 20   Transperth railway patronage (million passengers per month)
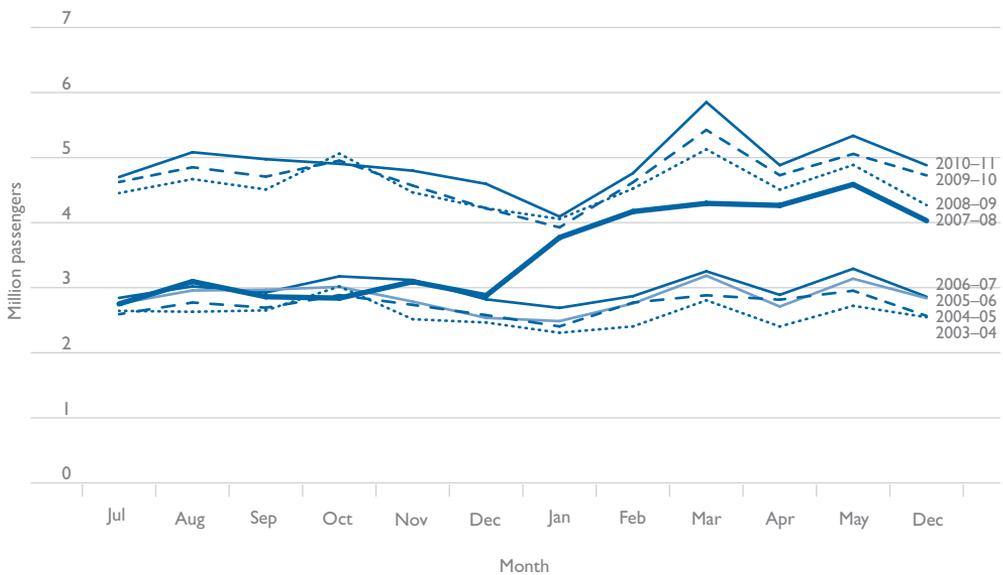
Source: Public Transport Authority of Western Australia, 2011b.

---

116 Muhammad et al., n.d., p.5

Figure 21   Transperth patronage, by line, 2010–11
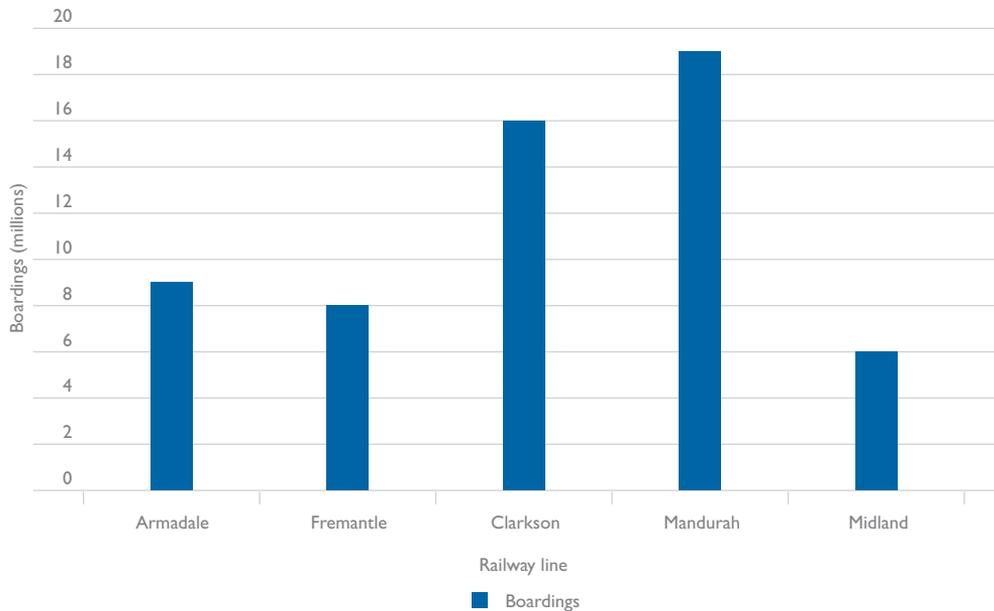
Source: Public Transport Authority of Western Australia, 2011b

A model for other cities?

Does Perth's rail revival offer a model for urban service provision? This is of great interest to policymakers because well-functioning and well-used urban railways are attributes that are essential for the success of a number of government policies—on the environment, on economic productivity and efficient transport—including congestion relief—and on the catchall urban "liveability". In that context, rail conduits can be important lifelines across our urban settlements, but are they used in a way that can help to deliver that suite of policies?

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. In addition, network integration with other modes of transport — well-connected feeder buses and ample car parking — expands network catchment and encourages rail-centred travel beyond the radial spines. Transperth sums up the ethos thus, "in low [urban] densities the 'masses' must be brought or come to the railways" via connecting lines.[117]

The importance of network integration should not be under-estimated. It is the basis for public transport planning in Perth and is reflected in infrastructure provision, passenger information, service coordination and ticketing. Ideally, when planning public transport, individual modes should not be considered in isolation but as part of a broader network.

117 Quoted in Mees & Dodson, 2011, p.17

Thus, while recognising that Transperth's system works on the radial, commuting strengths of urban railways, the crucial question is whether Transperth can use those same system attributes to attract significant levels of non-radial, non-commuting travel. If this traditionally car-reliant city does attract such patronage levels, then the city will have proven that public transport can indeed be a cornerstone of policies in city liveability, transport and environmental management. The challenge for policymakers beyond Perth would then be to identify whether such lessons and practices could be applied to their cities.

Adelaide

Summary

Adelaide's broad-gauge metropolitan rail network is managed by the Government of South Australia's Department of Planning, Transport and Infrastructure. The day-to-day running of the public transport network, including marketing and branding, is undertaken by the department using the "Adelaide Metro" brand name. Figure 22 provides a map of the city's passenger rail system, including the light rail operation.

Adelaide has a small radial network centred on Adelaide Railway Station. The network provides non-electrified urban rail services, a public transport task shared with buses and a light rail line. In practical train service terms, the network has not changed over the last two decades. Indeed, by the turn of this century the network infrastructure required extensive renewal and modernisation: track renewal, rather than the track capacity issue of other cities, was the immediate concern.

After a number of earlier abortive attempts at electrification, dating from the 1950s, steps are being taken to upgrade most of the system to overhead power supply. Coinciding with the infrastructure renewal and electrification programmes is a modest southern extension to the network.[118]

Current average times between trains reflect the strong focus on serving commuting; off-peak operations are relatively poor. For instance, 60-minute service gaps are typical on the Adelaide network compared with (at the other end of the spectrum) 15-minute (or less) service gaps in off-peak on the Perth network. The infrastructure renewal, enhancement and electrification will be accompanied by substantial service quality improvements with much improved (reduced) times between train services. Electrification of the system will be accompanied by expansion of the rolling stock fleet.

These service quality improvements will play an important part in attracting patrons. Short-term projections are for patronage to rise from the current plateau of around 11 million, to around 20 million.[119]

118 Adelaide's transport policy is guided by the "30 Year Plan for Greater Adelaide". South Australian Government, 2009 and the "Strategic Infrastructure Plan for South Australia". South Australian Government, 2005.
119 Williams, 2011, p.2

Figure 22   Adelaide's passenger rail network

Network

Adelaide has a (broad-gauge) heavy rail network and a (standard-gauge) light rail line. Both operations are managed by the government of South Australia's Department of Planning, Transport and Infrastructure; services operate under the Adelaide Metro brand. Adelaide's heavy rail network is not electrified and uses diesel-electric and diesel-hydraulic trains; the network consists of four main lines and two branch lines. Rail plays a relatively minor role in Adelaide's public transport system with bus services carrying the majority of passengers.

Much of the network is double-track, with exceptions including the single-track Belair, Grange and Tonsley lines and single track at the extremities of the Outer Harbor and Gawler lines.

There was little investment or renewal in Adelaide's network during the 1990s and early 2000s. However, this trend has recently changed with two short extensions to the light rail line, a programme of extensive renewal (enhancements and modernisation) of the heavy rail network, extension of the Noarlunga railway and electrification of that line and its Tonsley branch line.

Network activities from 1990

There were no significant changes to Adelaide's heavy-rail network that impacted on passenger operations during the period from 1990.[120] Infrastructure enhancements were undertaken, however. These included:

- the construction of a bridge over the Port River at Port Adelaide, shortening the freight route between Dry Creek and Lefevre Peninsula, including removing the passenger–freight interface on the Outer Harbor line. The bridge and associated new track opened in 2008.

- moving the Adelaide railcar depot from Adelaide Railway Station to a new depot at Dry Creek, opening in 2010.

- renewal of the Belair (2009) and Gawler (2012) railways. This included re-railing the track and inserting new concrete sleepers. The new sleepers will enable track gauge to be readily changed from the current broad gauge, to standard gauge.[121] [122]

A significant change to the Belair railway line occurred in 1995. Until that time, the line had been double-track. In that year, one of the two tracks was converted to standard gauge, as part of the interstate rail network; passing loops were built on the remaining urban broad gauge track.

---

120 There were some relatively minor passenger–line service closures from this time—Penfield 3 (in 1990) and G.M.H. (in 1992).

121 Department of Planning, Transport and Infrastructure South Australia, 2011c

122 Department of Planning, Transport and Infrastructure South Australia, 2011d

Network extensions

Apart from vital track renewal projects across the entire network, the major activity is a range of tasks being performed to electrify the Noarlunga/Tonsley line. Construction work is underway, with plans for electrified services to commence from 2013.

The first addition to Adelaide's urban rail network since 1978 is an extension of the Noarlunga line. The line is being extended by 5.5 km to Seaford. The extension (shown in Figure 22) is due to be opened in 2013, concurrent with the commencement of electrified services.[123]

Annex C sets out network development plans for Adelaide. Inevitably, such project lists are open-ended, with short- and long-term aspirations, so the list should not be seen as definitive.

Service quality

Adelaide has an operational air-conditioned diesel fleet of 99 railcars, introduced in stages between 1980 and 1996. The oldest units in the fleet (30 diesel-hydraulic railcars) will be retired as electrification of the Noarlunga/Tonsley line proceeds. Installation of electrification on other lines – announced in 2008 – has been suspended due to budgetary constraints. There will be 22 new Electric Multiple Unit (EMU) three-car trains delivered from 2012.[124]

---

123 Department of Planning, Transport and Infrastructure South Australia, 2011e
124 Department of Planning, Transport and Infrastructure South Australia, 2010b

Average time between trains

Adelaide Metro runs express and all-stops services on a radial network. Figure 23 compares train frequencies from the end of railway lines to major centres and junctions.

Figure 23   **Average time between trains for services arriving at Adelaide Railway Station**
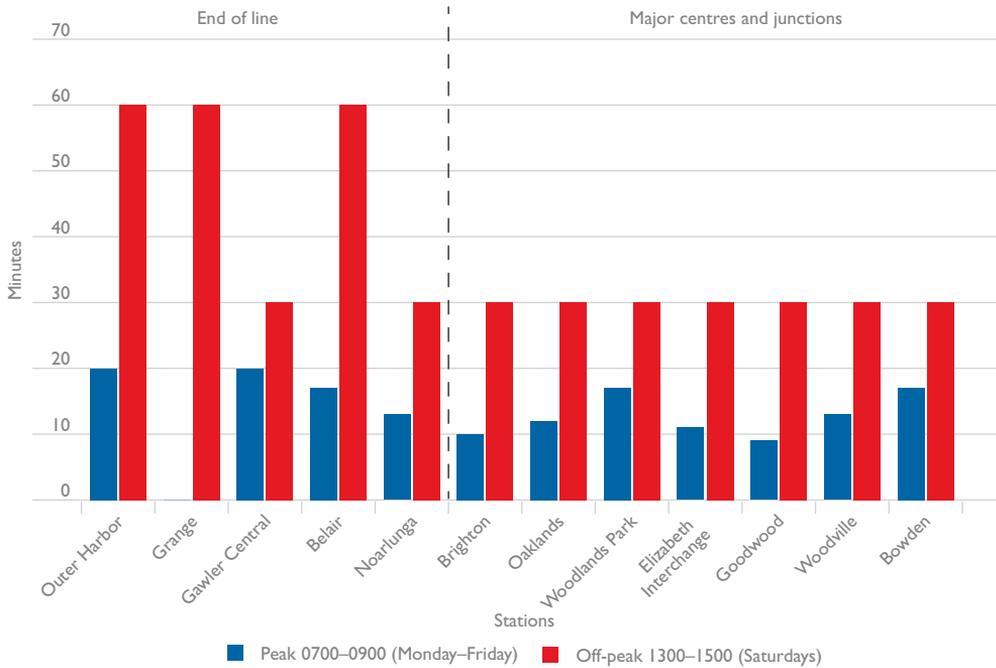
Note: The average time between trains was calculated using Adelaide Metro timetables in May 2012. At the time of writing, services on the Tonsley line had been replaced by buses – timed to connect with trains at Woodlands Park. In addition, weekday services on the Grange line were replaced by buses (until the late evening). Buses on the Grange line were timetabled for an interchange with trains at Woodville. The Grange line also operated a half hourly train shuttle service from Grange to Woodville. Replacement buses on the Tonsley and Grange lines were not included in Figure 23. Shuttle train services on the Grange line were not included because they were not coordinated with trains bound for Adelaide Central. Replacement buses on the Grange and Tonsley line were being used temporarily due to the redevelopment of the Adelaide Convention Centre.

While average time between trains is relatively consistent across the network, the average time is comparatively long. The commuting and off-peak service quality contrast with other cities, especially Perth, is stark. Current infrastructure enhancements, including track, signalling and rolling stock modernisation and expansion, will enable faster trains running with increased frequencies.

Current service patterns on the network are geared almost entirely to the peak-hour commuting task to Adelaide Railway Station. In most situations, average times between trains in peak periods are less than one-half those times in off-peak periods. Indeed, the Tonsley branch line has no weekend services.

The government recognises that the network can fulfil other tasks. It is recognised, for instance, that despite the relatively short distance between the station at Tonsley and a nearby university and hospital[125], the presence of two major roads, circuitous routes to the station and a large change in elevation means that the station has minimal patronage.[126] Faced with a similar issue on the Noarlunga line, the State government rebuilt Oaklands station in 2008, in part to improve links with nearby regional facilities, including Adelaide's largest shopping centre (Westfield Marion), which is around 500 metres from the station.

In 2007 the State government commenced a long-term plan to radically enhance these service standards. A range of State government commitments, with Federal funding, have been announced and commenced to address infrastructure renewal requirements as a reflection of "a fundamental change in South Australia's planning strategy".[127] Thus, in 2010, the State government released a complementary planning development strategy, the 30 year plan for greater Adelaide; this outlines the government's long-term planning goals and strategies. The government aims to: concentrate new housing in existing urban areas; locate housing and jobs in transit corridors; increase densities around railway stations and transport interchanges; create mixed use precincts; revitalise major activity centres and establish transit oriented developments.[128]

Core service quality improvements include a commitment of 15-minute service frequency to "most" stations and less than 10 minutes to "key nodes".[129] Electrification and track renewal will enable higher average speeds, facilitating the objective of reduced transit times. Thus, service quality should be enhanced dramatically as track, electrification and rolling stock investments come on-line from 2013.

Patronage

Patterns

Figure 24 illustrates Adelaide's rail patronage by line. Patronage is shared unevenly across the network with the two longest lines, Gawler and Noarlunga, sharing most of the passenger task. Belair is the least patronised line and its passenger numbers have fallen in recent years. However, it is important to note that patronage on the Belair line was adversely affected in 2009 by the suspension of services for track upgrades as part of the Rail Revitalisation Scheme. Similarly, the Outer Harbor line was closed, between Woodville and Outer Harbor, for four months in 2009 because of an upgrade of the Port Adelaide viaduct.

---

125 Flinders University of South Australia; Flinders Medical Centre.
126 The Darlington Transport Study includes a proposal for an extension of the Tonsley line to the university and medical centre. The proposal is for a 15 minute frequency tram/train weekday service. The Tonsley line would also be duplicated. Railway Digest, 2011a
127 Williams, 2011, p.1
128 South Australian Government, 2009
129 Williams, 2011, p.2

Figure 24   Adelaide railway patronage, by line*
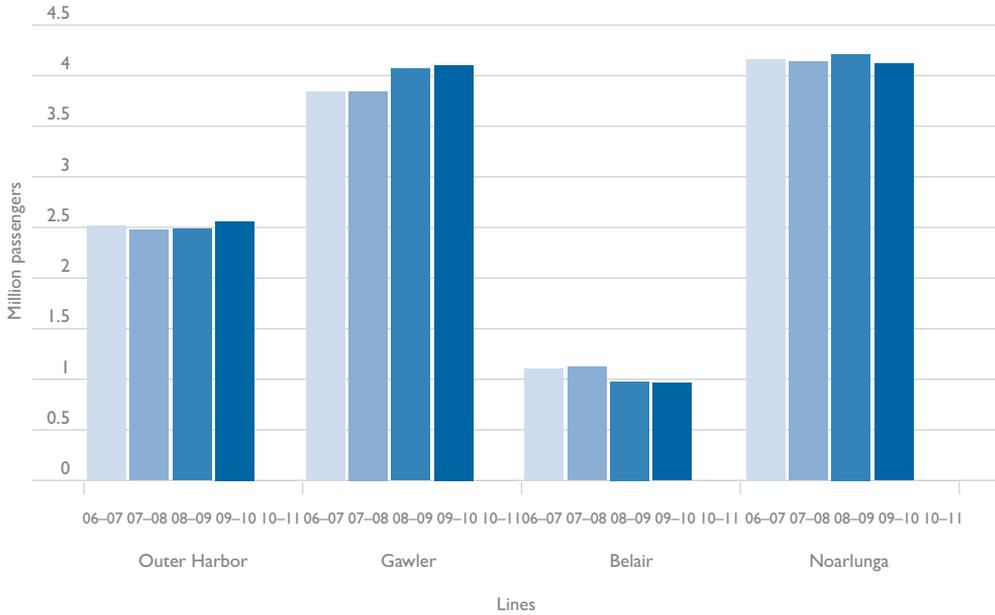
Note: * The Grange line patronage is included within Outer Harbor and the Tonsley line patronage is included within Noarlunga.

Source: TransAdelaide annual reports (various years)

Trends

Adelaide's rail system has the smallest traffic levels of the five capital city networks. Adelaide's rail patronage has languished in recent years (Figure 4). Train patronage in 1991–92 was 7 million; in 2010–11 it was around 9 million.[130] A driver for patronage growth would be activity in central Adelaide, such as employment, tertiary education enrolments and retailing. Important offsets would include increments to low-cost car parking provision. Data on the latter is not available but it seems that city-centre employment levels have not had the strong growth rate experienced in Melbourne.[131]

The State government has projected that its service quality improvements, underpinned by extensive infrastructure rehabilitation and enhancement, will deliver a 2016 train service plan that will attract 20 million passengers per annum, that is, more than doubling current ridership.[132]

---

130 Passenger Transport Board, 2001, p.19; Department of Planning, Transport and Infrastructure South Australia, 2011a, p.62.

131 Employment in the Adelaide Local Government Area declined between 1987 and 1997 by 7.7 per cent, from 96 713 to 89 276. Between 1997 and 2008 employment grew by 32.7 per cent, from 89 276 to 118 500. Adelaide City Council notes that the fastest growth rate was 9.7 per cent, between 2006 and 2008. Adelaide City Council, 2009.

132 Williams, 2011

CHAPTER 4
Metropolitan freight railways

The five cities examined in this report operate systems carrying passenger and freight trains. Much like the passenger railways examined above, the freight networks have different operational characteristics and perform a unique role in each city's transport task. This chapter reviews the characteristics and functions of the freight operations in the urban setting; the passenger–freight interface in each city; and notable recent developments and plans.

Table 11 provides a comparative framework setting out primary characteristics of urban freight rail operations.

Table 11   Urban freight operations

	Sydney	Melbourne	Brisbane	Perth	Adelaide
Route length					
Dedicated metropolitan freight route length (km)	33*	66	81	121	62
Dedicated passenger route length (km)	181	230	86	168	88
Shared metropolitan passenger/freight route length (km)	156	196	140	1	30
Total metropolitan route length (km)	370	492	301	290	180
Metropolitan freight lines under construction (route-km)	36*	-	-	-	-
Gauges					
Passenger lines (mm)	1 435	1 600	1 067	1 067	1 600
Interstate* freight lines (mm)	1 435	1 435	1 435	1 435	1 435
Intrastate freight lines (mm)	1 435	1 600	1 067	1 067	1 600
Freight carried					
	Domestic Transit Maritime	Domestic Landbridging Maritime	Domestic Maritime	Domestic Maritime	Domestic Transit Landbridging

Note: * Sydney's dedicated freight network length will be expanded by the opening of the 36 km Southern Sydney Freight Line in 2013.

Annex D sets out the principal freight facilities and Figure 25–Figure 29 provide network maps of freight operations and terminals in each city.

Networks

Metropolitan freight train operations in Brisbane, Melbourne, Adelaide and Perth are distinctly different from that in Sydney:

- There are two, largely separate, rail networks. There is a non-standard gauge (mostly) urban passenger network and there is a standard-gauge freight network—see Table 12.

- The standard gauge networks in these cities form part of the interstate rail network *and are not used by urban passenger trains.*

- The local narrow and broad gauge lines serve urban passenger and intrastate freight.

- With the exception of Perth, broad and narrow gauge freight trains share some track with metropolitan passenger services.

Table 12   Principal urban freight-only lines*

City	Line	Description	Freight gauge
Sydney	Metropolitan Goods Line**	Port Botany–Sefton Park Junction	Standard
Sydney	Southern Sydney Freight Line	Sefton Park Junction–Macarthur (under construction)	Standard
Melbourne	Tottenham–Dynon Goods Line	Tottenham–Southern Cross Station	Standard
Melbourne	Interstate North–South Corridor	Sunshine–Broadmeadows	Standard
Brisbane	Fisherman Islands Line	Park Road–Fisherman Islands	Dual (Standard, Narrow)
Brisbane	Interstate North–South Corridor	Clapham–Bromelton	Standard
Perth	Fremantle Goods Line	Midland–Fremantle	Dual (Standard, Narrow)
Adelaide	Interstate East–West Corridor	Belair–Direk	Standard
Adelaide	Dry Creek–Outer Harbor Link	Dry Creek South–Pelican Point	Dual (Broad, Standard)

Note: * Includes use by long-distance V/Line, CountryLink, transwa and Great Southern Railway passenger services.
         ** Also known as the Port Botany Line

Sydney's rail network is unique in being a single, standard gauge throughout (corresponding to the national interstate rail gauge). Interstate corridor capacity is shared between urban passenger and interstate/intrastate freight tasks. Sydney's dedicated freight network is relatively small (Table 11).

The function of the freight networks vary between cities (Table 11). The role of freight in the five cities can be divided into four principal tasks:

- **Domestic freight.** The five urban systems carry domestic intermodal freight and local bulk goods. Brisbane's narrow gauge network carries coal traffic for domestic consumption. Steel trains are common on the standard gauge of each system (and Melbourne's broad gauge).

- **Maritime.** The rail networks carry maritime freight, with international and Tasmanian origins/destinations. The Brisbane and Sydney networks carry coal for export. Each system has grain movements, principally for export. In Sydney, especially, those grain movements are made using containers. Melbourne's rail maritime freight task also includes domestic freight to or from Tasmania.

- **Land-bridging.** The land-bridging task essentially complements maritime activities. For example, the Port of Melbourne forms a remote terminal for some of Adelaide's international trade (offering better service frequency and origin/destination options than the South Australian port).

- **Transit.** Sydney and Adelaide, in particular, carry "transiting" freight between Brisbane and Melbourne, and Melbourne and Perth, respectively.

Freight and passenger rail interface

Parts of the metropolitan networks are used by both passenger and freight trains. The amount of shared track varies across the cities largely because of the historical development of each system. Much of the freight–passenger train segregation in Melbourne, Brisbane, Perth and Adelaide arises because the freight is moving on standard gauge while the urban passenger trains are operating on the local broad or narrow gauge.[133] As a proportion of the total metropolitan route length, Sydney and Brisbane have the most shared passenger–freight track at 42 per cent and 47 per cent of the network, respectively. In contrast, passenger and freight trains on Perth's rail system are separate (excepting a small section of shared track across the Fremantle rail bridge).

The interface between passenger and freight services can be challenging for managing capacity utilisation due to different operational characteristics of each train type. Passenger trains move relatively faster than freight trains but also stop more frequently. Freight trains will usually be significantly longer (and heavier) than passenger trains, using more track space and having slower acceleration. Passenger services are given priority access to track capacity. Thus, in a network that is already highly-utilised, it can be particularly difficult to find paths for freight trains. Nevertheless, shared track is common internationally and, provided traffic is well managed, can be an efficient use of infrastructure. Figure 25–Figure 29 illustrate each city's rail freight operations and terminals.

---

[133] Standard gauge track was introduced to Melbourne in 1962, to Brisbane in 1930, to Perth in 1969 and to Adelaide in 1983.

Figure 25   Sydney's freight operations and terminals
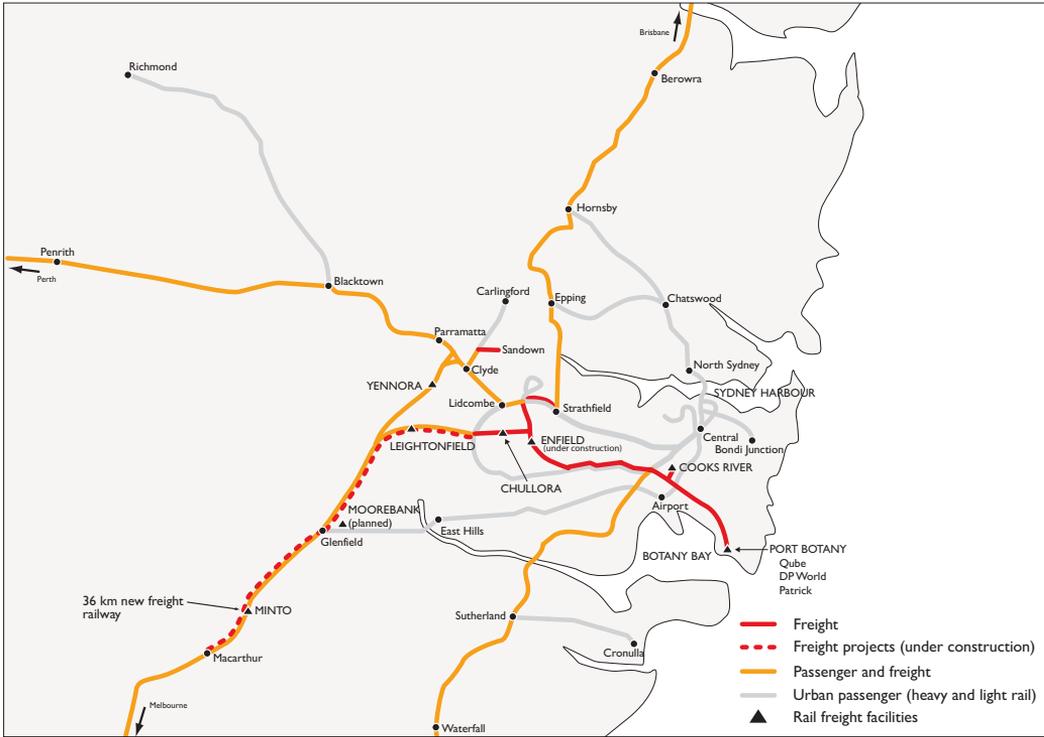
Figure 26   Melbourne's freight operations and terminals
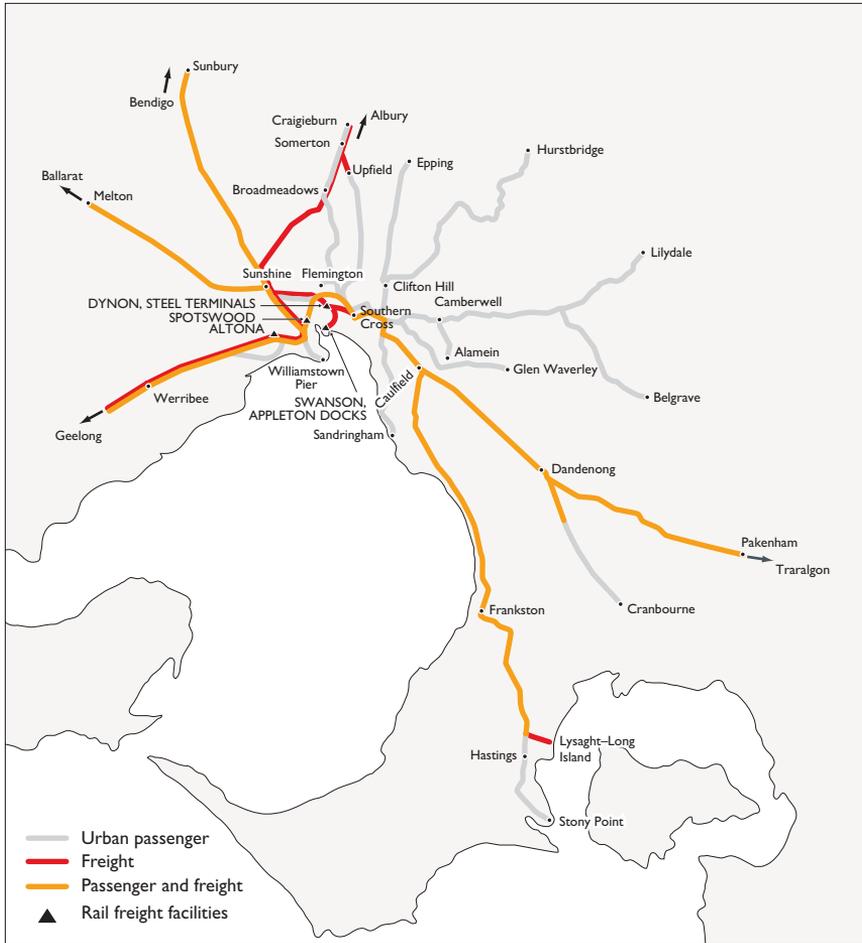
Figure 27   Brisbane's freight operations and terminals
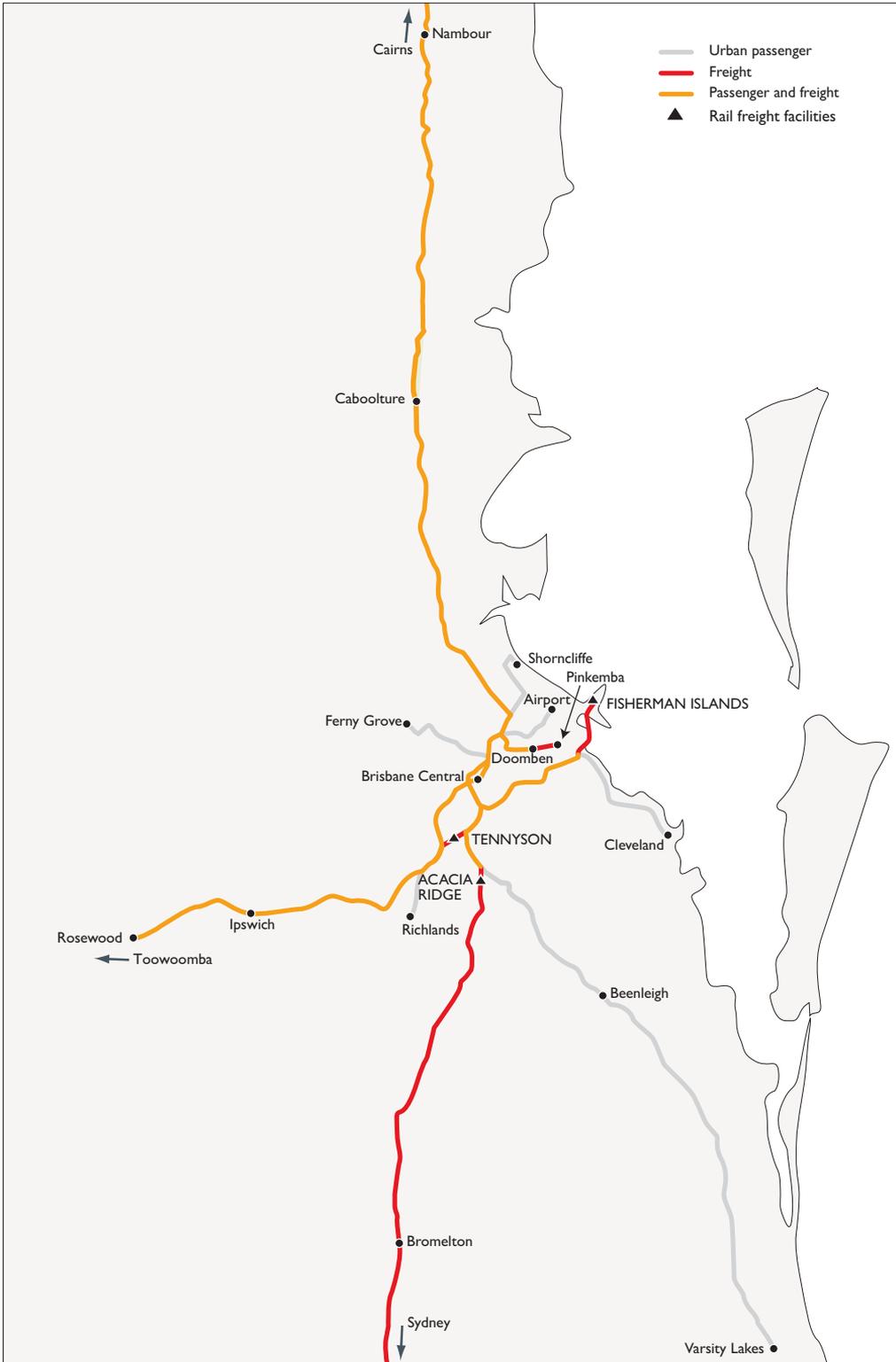
Figure 28   Perth's freight operations and terminals
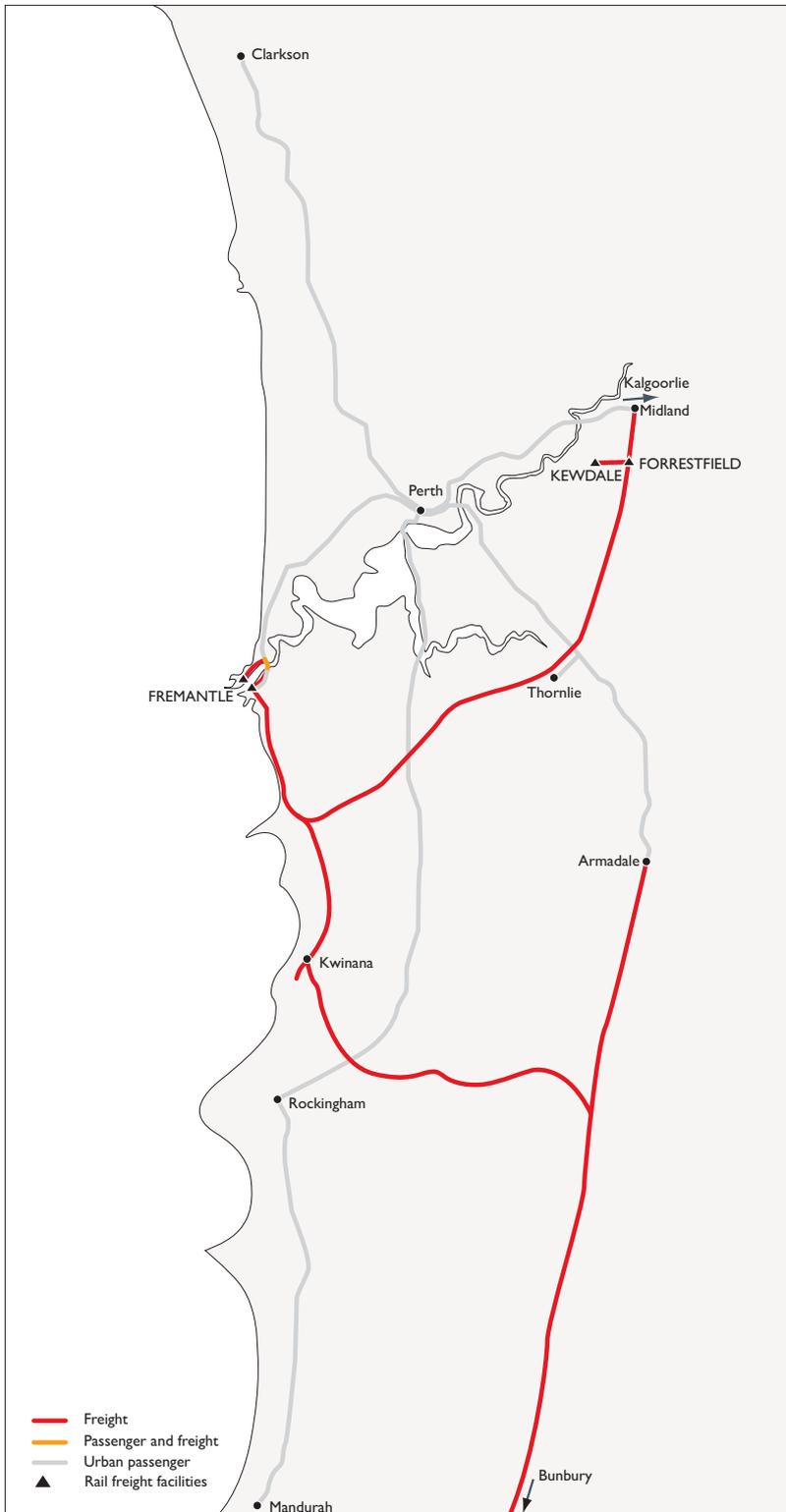
Figure 29   Adelaide's freight operations and terminals
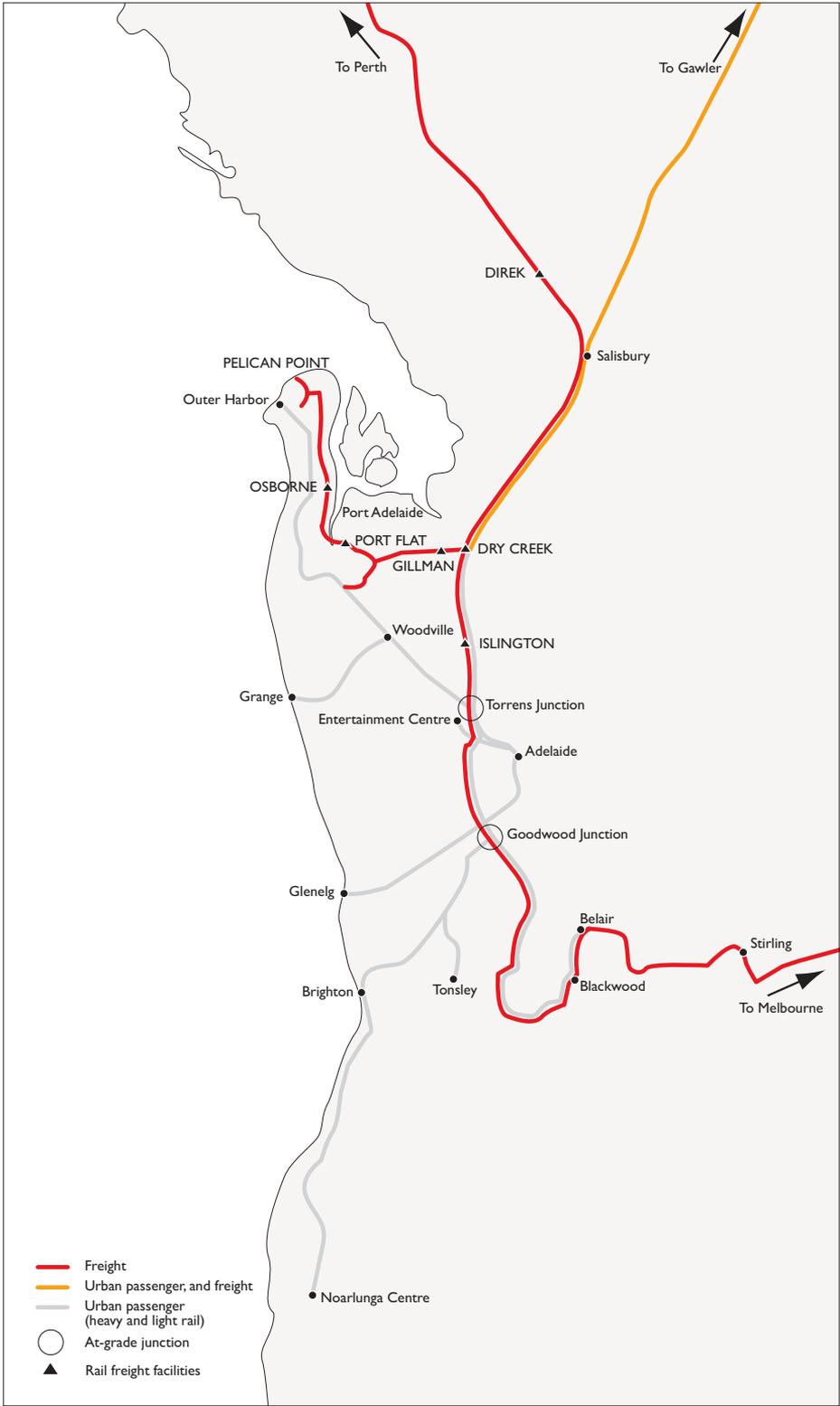
Sydney

Sydney's primary freight and passenger train services operate over the North–South and East–West (*via Lithgow*) interstate corridors. The interoperability of the interstate and urban system, reflecting historical developments, has contributed to the relatively small route length — 33 km — of dedicated freight network.

Freight and passenger trains intensively and extensively share a common rail (standard-gauge) network. The freight facilities are presented in the map at Figure 30. Important freight trackage in the city are the Metropolitan Goods Line and the (under construction) Southern Sydney Freight Line, linking the interstate network with freight facilities at Leightonfield, Minto, Chullora, Cooks River and Port Botany.

Figure 30 Sydney's rail freight corridors
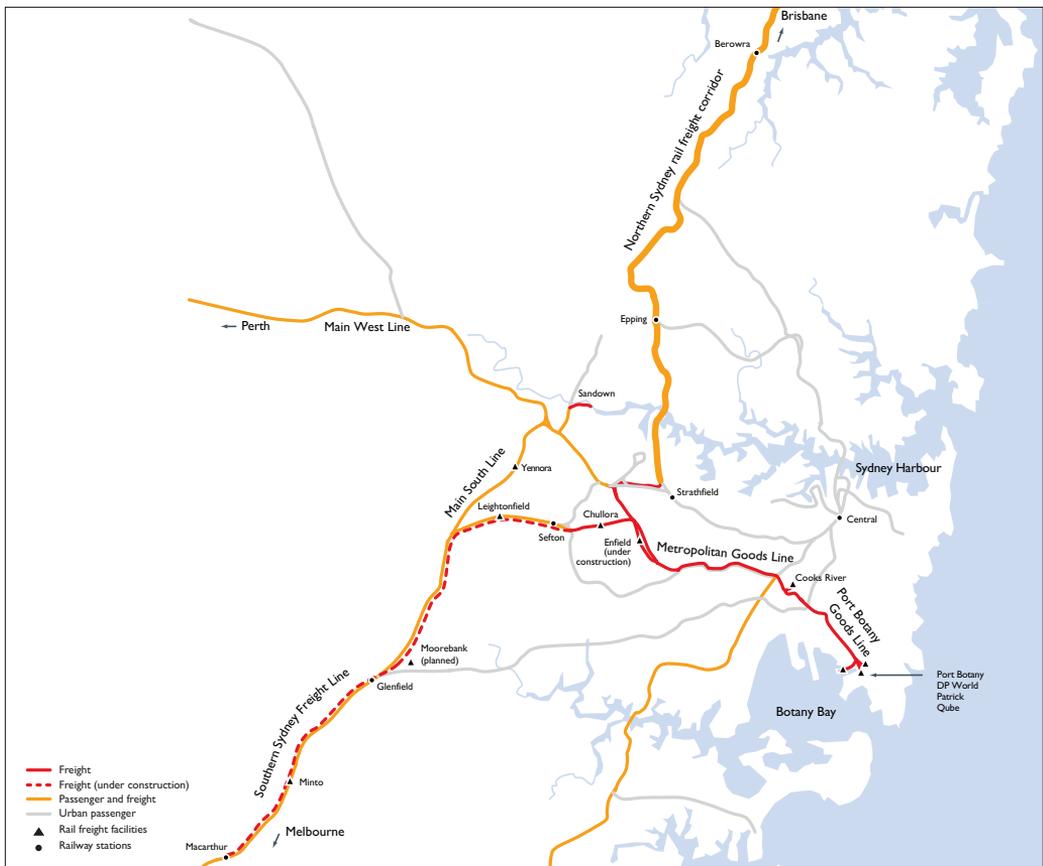
Source: Adapted from Schwandl, 2011, p.71

Table 13   Recent freight rail network changes in Sydney

Project	Date of completion	Route length (km)
Progressive closure of Rozelle goods line	1990s–2000s	7
Opening of Minto intermodal terminal	2001	-

Table 13 lists some notable recent developments for Sydney's freight rail network.

• The Rozelle goods line was progressively closed to freight over two decades. The original line was between Dulwich Hill – White Bay – Darling Harbour goods yard. The Darling Harbour branch saw little traffic in the 1980s and the section closed with the redevelopment of the area into a tourist precinct. Most of the Darling Harbour branch was converted into Sydney's light rail line (Lilyfield–Central Station). In the 2000s, traffic between Rozelle goods yard and Dulwich Hill ceased with the closure of White Bay/Glebe Island as Port of Sydney progressively shifted activities away from the Harbour. In 2010 the NSW government announced it would convert the line into an extension of Sydney's light rail operation.

• Construction of Minto intermodal terminal commenced in 2000. Shuttle runs of 600 metre-length trains between the terminal and Port Botany began in 2001.

Table 14   Freight projects in Sydney

Project	Date of completion	Route length (km)
Port Botany Line Upgrade [Metropolitan Goods Line] Stages 1 and 2	2013	-
Southern Sydney Freight Line	2012	36
Enfield intermodal terminal	2013	-
Moorebank intermodal terminal	Ongoing	-
Northern Sydney Freight Corridor Program	2016	-

Table 14 lists the significant projects that are underway in Sydney; these focus on terminal provision and provision of capacity for freight trains on the North–South corridor in the Sydney region. The perspectives of these developments are as follows:

• **Port Botany Line Upgrade (Stage 1)** [Metropolitan Goods Line]. Stage 1 of the project focuses on track reconfiguration and upgrades at Port Botany rail yard. Stage 2 works includes signal control separation from RailCorp to the ARTC's Junee control centre, Enfield staging roads and further work at Port Botany. Two kilometres of track at Mascot will be duplicated.[134]

• **Southern Sydney Freight Line.** This new line, currently under construction, will remove the curfews for trains entering or leaving the southern side of Sydney. The Macarthur–Sefton Park Junction line will connect with the existing dedicated Metropolitan Goods Line (Sefton Junction–Port Botany). Thus the line links the North–South Corridor with freight terminals at Port Botany, Chullora and Enfield. The principal achievement of the project will be that passenger and freight networks will effectively operate independently in southern Sydney. Figure 31 shows a freight train running on suburban tracks through Minto railway station.

---

134 Australian Rail Track Corporation (ARTC), 2010, p.24

- **Enfield Intermodal Logistics Centre.** The Enfield rail terminal is under construction, with expected completion in 2013. The terminal will principally provide for shuttle trains between the terminal and Port Botany, relieving road congestion in the vicinity of the port.

- **Moorebank.** In April 2012, the Australian Government announced its intention to call for tenders from the private sector to design, build and operate an intermodal terminal at Moorebank. The facility will be located on the southern side of the city, adjacent to the Southern Sydney Freight Line. The terminal will cater for shuttle trains between the terminal and Port Botany; and domestic interstate container traffic.[135] At an adjoining site, the Sydney Intermodal Terminal Alliance, SIMTA, is seeking approval to develop a range of freight facilities, including an intermodal terminal, warehousing and container storage.

- **Northern Sydney Freight Corridor Program.** This capacity enhancement program aims to decrease freight congestion shared with the urban/inter-urban passenger trains between Newcastle and Strathfield (in suburban Sydney). According to the Transport Construction Authority NSW, the main problems on the line are "a shortage of holding loops [for the freight trains], several steep inclines, junctions causing delays at critical locations, and passenger services restricting freight services in metropolitan Sydney". The program's primary aims are to improve capacity on the passenger system and allow 24 hour access for freight trains.[136] The Commonwealth and NSW governments have signed an intergovernmental agreement to commence work on the program. The agreed package of works includes a rail underpass at North Strathfield, a third track between Epping and Pennant Hills, new passing loops near Gosford and a (recently completed) holding track at Hexham.[137] Construction commenced in February 2012.[138]

Figure 31   Freight train moving through CityRail station

Source: Photograph courtesy of Colin Butcher.

Freight trains in metropolitan Sydney are subject to a curfew, in order to ensure that freight trains do not impede passenger train schedules on shared corridors. To give passenger trains priority and to ensure service punctuality, freight trains generally do not run in Sydney during the morning and afternoon peak. Figure 32 and Figure 33 illustrate the number of scheduled freight trains passing southbound and northbound *through* Macarthur over two time periods

135 Department of Finance and Deregulation, 2012
136 Transport Construction Authority NSW, 2011b
137 Albanese, 2011
138 Transport Construction Authority NSW, 2011b

(Monday–Friday and the weekend), as at January 2012.[139] Figures 34 and 35 illustrate the number of freight trains running southbound and northbound through Berowra—the northern extremity of metropolitan passenger services.

Figure 32   Southbound freight trains through Macarthur
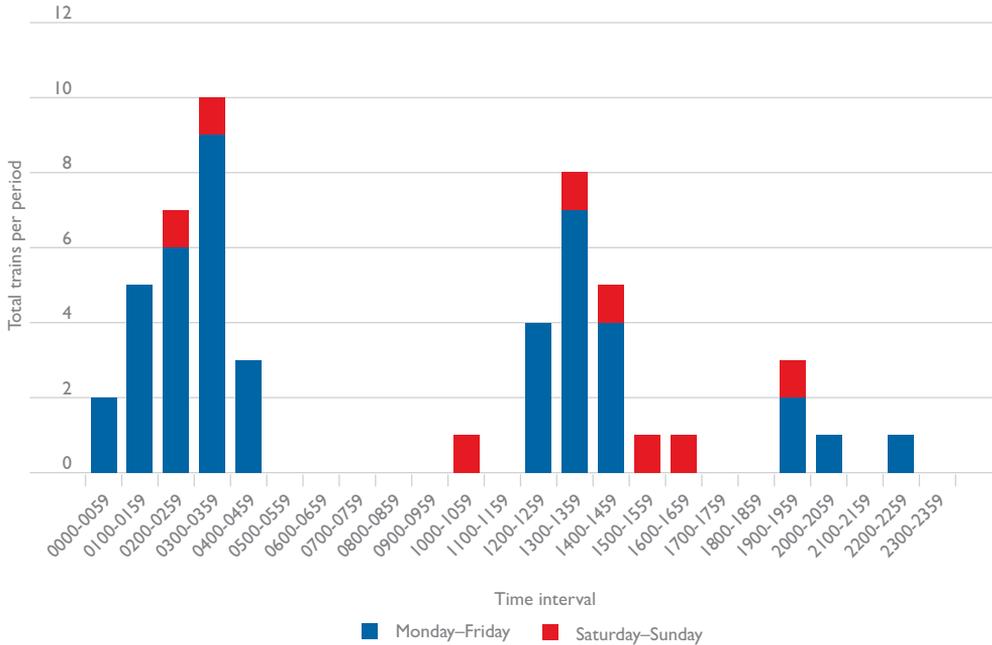
Figure 33   Northbound freight trains through Macarthur
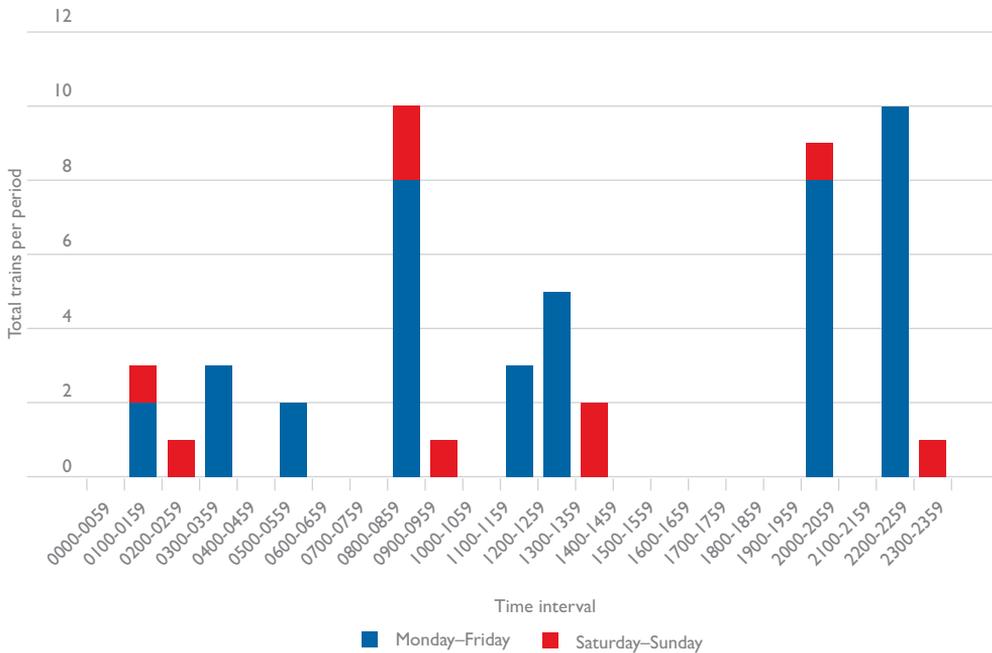
139 These trains operate on shared passenger/freight lines and will switch to the Southern Sydney Freight Line upon completion. There are other freight trains using the shared tracks that, *in principle*, would be subject to the curfew on the southern side of Sydney, notably Minto–Port Botany shuttles and Leightonfield–Glenlee shuttles.

Figure 34   Southbound freight trains through Berowra
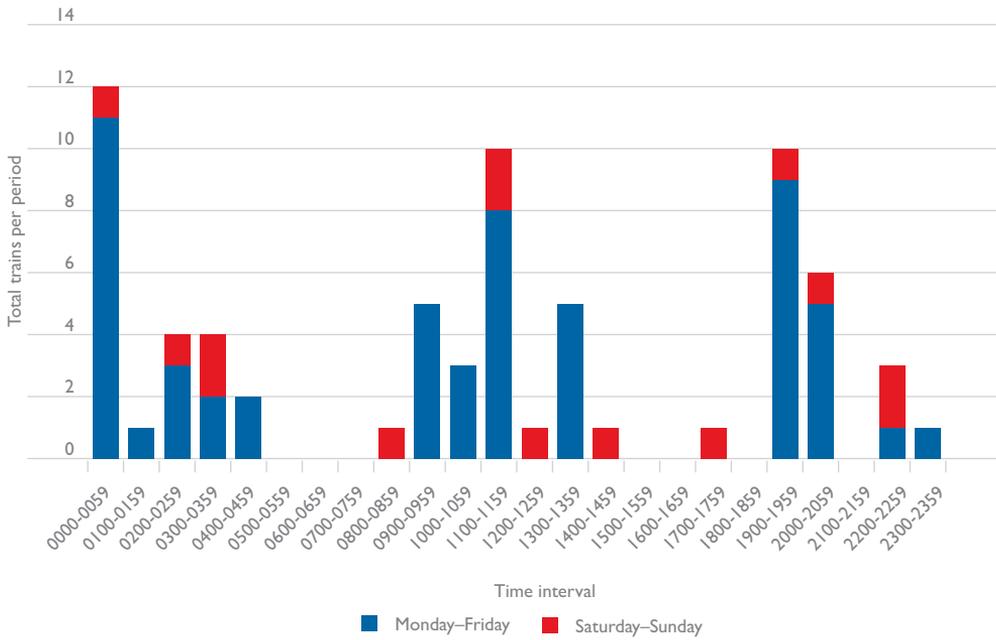
Figure 35   Northbound freight trains through Berowra
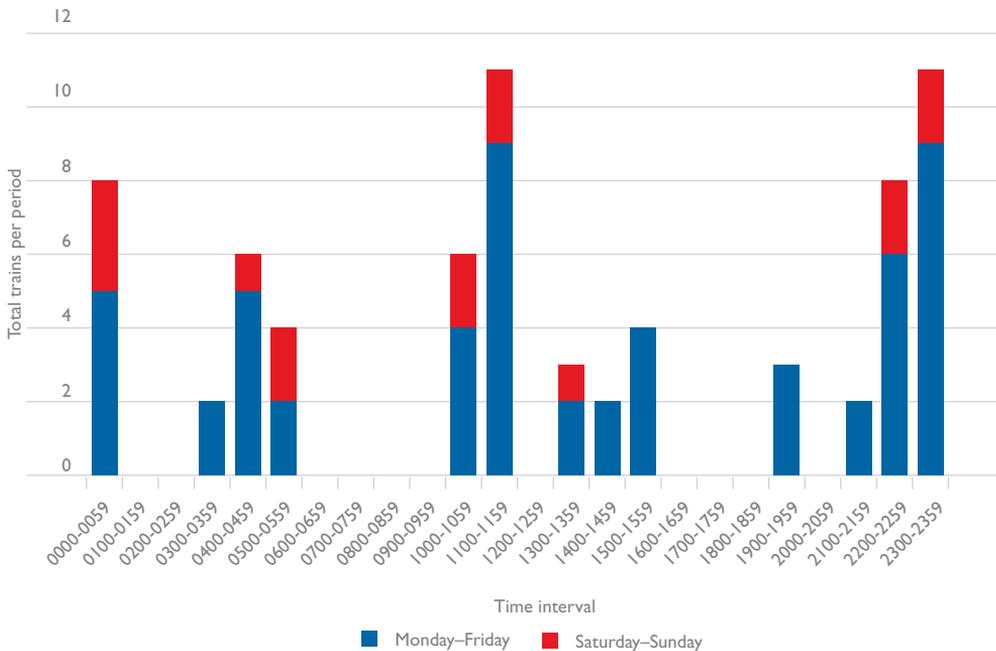
The scheduled operations through Berowra illustrate the type of freight traffic, which is diverse. Of the 140 scheduled trains to pass through Berowra weekly (in the January 2012 timetable), 96 are intermodal trains (68.6 per cent), 30 are coal (21.4 per cent) and 14 are "other bulk" (10 per cent). The latter will include containerised cotton traffic moving from the north to Port Botany.

Melbourne

Melbourne's broad gauge passenger network is largely separated from interstate standard gauge freight movements; the dedicated, and un-electrified, freight network in the city is relatively large (66 km route length). Urban and non-urban passenger trains share some tracks with broad gauge freight trains. Melbourne's freight operations and terminals are illustrated in Figure 26.

A notable freight operation on Melbourne's urban (broad gauge) network is the steel train between the Melbourne Steel Terminal and Long Island (near Hastings, on the east side of Melbourne).

Table 15   Recent freight rail projects in Melbourne

Project	Date of completion	Route length (km)
Melbourne–Adelaide gauge standardisation*	June 1995	-
Dynon Port Rail link and Tottenham–Dynon link	April 2009	-
Brooklyn Triangle	August 2010	-
Port of Melbourne rail access improvement	October 2010	-

Note: The Melbourne–Adelaide gauge standardisation included switching the main line from a hilly route via Ballarat to a longer, but flatter, route via North Geelong.

Table 15 lists recent significant projects on Melbourne's freight rail network. Aspects of these projects are:

• The Melbourne–Adelaide rail line was converted to standard gauge to become part of the interstate rail network, including new and converted standard gauge track between Geelong and Melbourne. The project, completed in 1995, was part of the Australian government's One Nation infrastructure program.

• Additional track capacity was provided between Tottenham Yard and Dynon in 2009, with the duplication of the standard gauge line. In addition, a bridge was constructed at Footscray Road; the grade separation eliminated a level crossing and enhanced rail access to the Port of Melbourne.

• The Brooklyn–Sunshine Triangle was completed in 2010; the short new link provides a direct link between the North–South and East–West corridors in inner Melbourne.

• The Port of Melbourne rail access improvement project provided direct dual gauge access between the Port of Melbourne and Dynon terminal as well as broad gauge access between the Port and east Melbourne.[140] In addition, the dual gauge track between Sims Street Junction and the port was duplicated.[141] The new infrastructure is now being used by 50 scheduled train movements per week. The trains include: 12 paper trains between Maryvale and Westgate Ports and return, 28 steel trains between the E gate steel terminal and Hastings and return, and 10 shunt moves of sugar wagons between the operations tracks near South Dynon and the receival plant at North Dynon.[142]

---

140 Railway Digest, 2011b
141 Albanese, 2010
142 Railway Digest, 2011b

Interstate track enhancement through Melbourne (Albury–Melbourne–Geelong) in 2012 will involve replacing light-weight 47 kg/metre rail with 60 kg/metre rail, enabling heavier wagon loads and higher train speeds.

Brisbane

As a proportion of the metropolitan network, Brisbane has the most shared passenger/freight track in Australia. Much of the shared narrow gauge track is on the Rosewood/Ipswich and Caboolture lines. The Rosewood/Ipswich line includes bulk freight, such as coal trains from the West Moreton Coal system. The Caboolture line includes intermodal freight traffic for the main Cairns–Brisbane North Coast Line. Urban freight operations and terminals in Brisbane are illustrated in Figure 27.

Brisbane also has the second longest dedicated freight network at 81 km. Much of this route length is the interstate line between Acacia Ridge and Bromelton, the northern end of the Brisbane–Melbourne north–south corridor.

Table 16   Recent freight rail projects in Brisbane

Project	Date of completion	Route length (km)
Connection of Port of Brisbane (Fisherman Islands) to standard gauge	1997	29
Queensland Border to Acacia Ridge Track Upgrade	2010	49
Corinda–Darra additional freight track	2010	6

Source: Australian Government, 2011

Table 16 lists some recent freight projects in Brisbane.

• The Port of Brisbane was connected to the standard gauge network under the Australian government's One Nation program. The project included a dual gauge track between the Acacia Ridge freight terminal and the Port at Fisherman Islands.

• The track between Bromelton and Acacia Ridge was upgraded and converted from standard to dual gauge (standard and narrow) in 2010. The project was part of the Australian government's Nation Building–Economic Stimulus Plan. The upgrade replaced timber sleepers with more durable concrete sleepers. The narrow gauge access to Bromelton aims to assist in the development of the area as an intermodal logistics hub.

• An additional non–electrified track was constructed between Corinda and Darra. The track is used by trains travelling between the West Moreton coal and grain systems and the Port.

The Cross River Rail project—providing additional urban passenger train capacity (page 46)—has implications for freight operations. The completion of the project would increase track capacity on the north–south rail line across central Brisbane, enhancing freight service flexibility across the city.

Perth

Perth has an extensive dedicated freight operation, focused on the Midland–Fremantle Goods Line, linking freight terminals at Forrestfield/Kewdale and the port at Fremantle. With the exception of the Fremantle rail bridge, freight and passenger trains run on separate tracks. The freight facilities are summarised in Annex D and a network map of freight lines and terminals is shown in Figure 28.

Perth's metropolitan freight network was privatised in 2000. It is exclusively controlled by Brookfield Infrastructure Partners and operated by Brookfield Rail. Brookfield Rail is an independent infrastructure provider, "responsible for access management, signalling and communication systems, train control and rail construction and maintenance".[143] Freight is transported by a number of operators who access the rail network via negotiation based on regulated policies and practices established under legislation.[144]

The narrow gauge Western Australian lines developed mainly for carrying grain and minerals and the standard gauge lines for heavy-haul and iron ore. Currently the network transports a wide range of commodities including grain, alumina, bauxite, iron ore and interstate freight.[145]

As a result of the Western Australian Metro Freight Network Review (2001–02), a number of projects were identified that would redress what was seen as an imbalance between road and rail haulage in the urban area. The Review resulted in investment projects and longer term plans.

Table 17   Recent freight rail projects in Perth

Project	Date of completion	Route length (km)
Victoria Quay track realignment	2005	-
North Quay rail loop and terminal, Fremantle	2006	-

Sources: Parliament of Australia, 2006; Fremantle Ports, 2006.

Table 17 lists some notable recent projects on Perth's metropolitan freight network.

• The North Quay rail loop project provided dual gauge (narrow and standard) access to the maritime terminal at Fremantle. In addition, stage 1 of a new rail terminal was constructed alongside the loop. Dual gauge was provided to enable local (narrow-gauge) and interstate (standard-gauge) trains to access the Quay.

• Other port freight investment has been undertaken so as to increase rail freight usage to the port and through the urban area. Such work includes realignment of the freight line adjacent to Victoria Quay, which was undertaken in 2005. The realignment created more space for cargo handling and improved the overall efficiency of the Port.

---

143 Brookfield Rail, 2011
144 Economic Regulation Authority, 2012
145 Brookfield Rail, 2011

The Australian and West Australian governments are planning a number of significant freight projects in Perth. Plans for rail include 'the construction of a crossing loop between North Quay and Cockburn Junction, the second stage of the North Quay rail terminal and the new intermodal facility in Kewdale/Forrestfield'.[146]

Adelaide

Adelaide has a dedicated freight network of 62 km, the core of which is the interstate standard gauge tracks. Adelaide's broad-gauge passenger network is largely separate from freight lines. The standard gauge interstate line runs adjacent to the broad gauge passenger tracks between Belair (in the Adelaide Hills) and Salisbury (on the northern edge of Adelaide).

Table 18   Recent freight rail projects in Adelaide

Project	Date of completion	Route length (km)
Adelaide–Melbourne gauge standardisation	June 1995	-
Outer Harbor – Dry Creek upgrade	2008	-
Adelaide Rail Freight Movements Study	2010	-

Table 18 lists notable activities in recent years on Adelaide's metropolitan freight network.

• In 1995 one of the tracks between Adelaide and Belair—on the Melbourne–Adelaide line—was converted to standard gauge as part of the gauge standardisation between the cities. Ancillary freight facilities at Outer Harbor were also provided.

• In 2008 an upgrade of the Outer Harbor – Dry Creek line was completed. The works included construction of a rail bridge over the Port River, upgrades to Lefevre Peninsula rail corridor and installation of "Bishop's Loop" at Wingfield.[147] The project removed the need for freight trains to use the Outer Harbor passenger line when accessing port facilities at Port Adelaide, Osborne and Pelican Point.[148]

• The "Adelaide Rail Freight Movements Study" was completed on behalf of the Commonwealth government in 2010. The study investigated the case for upgrading the existing interstate railway alignment through the Adelaide Hills, including options for constructing new alignments to the north and south of the city. The study found that "the capital outlay required to improve the existing rail line or construct a new line is far greater than the benefits derived from such an outlay".[149]

---

146 Department of Infrastructure and Transport, 2011. A number of plans have focused on improving the efficiency and competitiveness of rail operations at Kewdale and between the terminal and Fremantle. The construction of a southern rail terminal at Kewdale, potentially catering specifically for port related freight, has been proposed. The proposal includes the construction of a rail spur which would link the new terminal directly to the freight network. This could improve rail operations by avoiding the need to back shunt trains from Forrestfield. Department of Planning Western Australia, 2006, p.40.

147 Forbes, 2009

148 Department of Planning, Transport and Infrastructure South Australia, 2008a; Department of Planning, Transport and Infrastructure South Australia, 2008b.

149 GHD, 2010, p.44

There are two key interfaces between the interstate network and urban Adelaide system, these being at Goodwood Junction (where the Melbourne line crosses the Noarlunga Centre urban line) and Torrens Junction (where the Perth line crosses the Outer Harbor passenger line). These junctions are shown in Figure 29. In their respective 2012–13 budgets, the Commonwealth and South Australian governments announced funding for the grade separation of the standard gauge interstate network from the broad gauge passenger network, at these junctions.[150]

---

150 Department of Infrastructure and Transport, 2012

Conclusions: understanding our urban railways

Our railways fulfil important roles in moving people and freight to, around and through our major cities. The urban networks are also central to a range of policy objectives including the liveability of cities, productivity, alternative conduits to congested roads, social inclusion and the environment.

Thus, against this background, this report seeks to establish the existing and potential role of our urban railways. The following observations can be made:

1. **Rail has key strengths.** The urban rail systems have relative strengths in moving people over long distances, connecting suburbs with city centres and performing commuting and other mass–transit roles.

2. **Rail performs less well in non–radial and non–commuting movements: if rail is to fulfil a significant role in these tasks then high service quality and service integration is essential.** In this context, Perth, especially, encourages such travel by integrating rail with other modes. Transperth provides car parking; coordinated operations with bus services; transport interchanges at railway stations; integrated ticketing across modes; and customer information designed to facilitate mode change. In addition, railway service frequency is relatively high in the off-peak to encourage out-of-hours travel. Perth's system therefore offers more than a peak-hour alternative to the car. *The value of urban railways to the broad range of policy objectives is greatest when the network is also extensively used for non-radial, non-commuting tasks.*

3. **Rail's strengths in tapping transport markets are derived in part from historical legacies.** The networks have been bequeathed by the diverse transport and town planning decisions made by earlier generations. Sydney and Melbourne have the most extensive systems which were expanded from the late 19th century. The availability of established transport reserves between outer suburbs and the city centre provided a cost-effective basis for Perth to triple the size of its network in the last 20 years. A contrasting example is Adelaide's challenge in linking its largest non-CBD shopping centre (Westfield Marion) to the nearby Noarlunga railway; and linking major tertiary and medical facilities (Flinders University and Flinders Medical Centre) to the nearby Tonsley railway.

4. **The *existing* passenger task is mostly focused on radial corridors linking the city centre and the suburbs.** Sydney's rail system also caters well for non-radial links to some key urban centres, including commercial centres at Parramatta, Chatswood and North Sydney, event centres such as Olympic Park and residential developments such as Green Square.

5. **Service quality is often geared only to making the commuting role attractive.** The systems are typically geared at the commuting task, with poor service standards in off-peak.

6. **Experiences in Perth show that service quality improvements can dramatically improve patronage.** As illustrated by patronage patterns in Perth, service standards can strongly influence patronage. Traffic on the Armadale/Midland/Fremantle lines is more than three times the level recorded in 1992, with quality enhanced through maximum 15 minute intervals between services and new electrified trains.

7. **Exogenous factors—such as employment—are important drivers of patronage.** Melbourne and Brisbane, in particular, have benefitted in recent years from strong CBD employment, which has increased overall throughput to the respective city centres.

8. **Good station/mode interface is a crucial complementary requirement for broadening patronage catchment areas.** Improving station access by encouraging other modes (bus, car, bicycle and tram) expands the catchment area. Good linkages—good access roads, bicycle lanes and frequent bus services—facilitate that expansion. These linkages are complemented by station facilities (kiss-and-ride lanes, adequate free parking or low-cost paid parking, bicycle lockers and good bus interchanging). A ticketing system which encourages rather than penalises transfers can also help to expand network catchment.

9. **Train service quality can be made more attractive/competitive where the catchment areas can be broadened.** Perth's new lines are characterised by wide station spacing that leads to high average speeds, simple stopping patterns and high rolling stock utilisation. The new lines link regular-frequency rail services with good connections to bus services, and provide large car parks at stations with good road linkages. While this quality (high speed and frequency) is not costless, it makes public transport more competitive with road, attracting more patrons and fulfilling complementary policy objectives.

10. **Rail patronage is strongly influenced by competing road provision, car running costs and city-centre parking provision.** As has been experienced in the five cities during 2008–09, patronage is clearly influenced by the cost of using alternative modes, focused on rising petrol prices. Similarly, however, patronage is influenced by the provision of good quality roads, such as patronage losses on Sydney's East Hills line following the opening of a parallel motorway; conversely, rising congestion in cities encourages rail patronage. Provision of low-cost central city car parking is also an important consideration, albeit there is no time-series data on parking costs and parking provision to ascertain the extent to which this has influenced patronage.

11. **Urban railways also face capacity constraints.** Railways provide important alternative conduits to congested urban roads—but face their own capacity constraints that need to be addressed. Each railway system has its own corridor capacity challenges. Urban operations can be constrained by the sheer volume of passenger services through bottleneck locations; the Brisbane Cross River tunnel, the Melbourne Metro Tunnel and Victorian Regional Rail Link projects seek to address those bottlenecks.

12. **The passenger–freight shared use of the rail network is particularly challenging in Sydney.** For Sydney, the urban network directly shares rail conduits with the national interstate rail freight system. Freight trains absorb urban rail capacity but governments recognise that rail freight also shifts interstate, port and local freight movements away from roads.

ANNEX A
Explanatory notes

Sydney

- Sydney's metropolitan network is defined here as being bounded by Waterfall, Macarthur, Emu Plains, Richmond and Berowra; this corresponds to Sydney Trains' network boundaries.

- The non-metropolitan network is defined as the CityRail network that extends beyond the Sydney metropolitan boundaries. This is a far-flung network that encompasses the interurban operations to Wollongong/Bomaderry, Goulburn, Lithgow/Bathurst and Newcastle. Also included are the local CityRail services from Newcastle, notably to Scone and Dungog.

- Sydney's dedicated freight network is defined as being the Sandown Line, the Metropolitan Goods Line (Marrickville Junction – Campsie Junction – Chullora Junction – Sefton Park Junction and Flemington Junction – Chullora Junction), the Port Botany Goods Line (Marrickville Junction – Port Botany), and Strathfield Junction – Flemington Junction.

- Lines under construction in Sydney are the South West Rail Link and the Southern Sydney Freight Line.

- RailCorp measures Sydney's patronage data which is based on ticket sales, journey multipliers and travel-pass usage rates.

Melbourne

- Melbourne's metropolitan network is defined here as being bounded by Stony Point, Sandringham, Williamstown, Werribee, Melton, Sunbury, Flemington Racecourse, Craigieburn, Upfield, South Morang, Hurstbridge, Lilydale, Belgrave, Alamein, Glen Waverley, Pakenham and Cranbourne.

- Melbourne's dedicated freight network is defined as being bounded by Donnybrook in the north and Werribee in the south west. It also includes dual gauge freight lines between Newport, Tottenham and Dynon.

- The Regional Rail Link is under construction.

- The Victorian Department of Transport measures Melbourne's patronage figures as 'passenger boardings'.

Brisbane

- Brisbane's metropolitan network is defined here as being bounded by Caboolture, Shorncliffe, Domestic Airport, Doomben, Cleveland, Beenleigh, Rosewood, Richlands and Ferny Grove.

- Brisbane's non-metropolitan network is defined as the TransLink network that extends beyond the metropolitan network boundaries. This consists of the "Sunshine Coast" line (Gympie North – Caboolture) and the "Gold Coast" line (Beenleigh – Varsity Lakes).

- Brisbane's dedicated freight network is defined as the dual gauge line from Bromelton to Yeerongpilly Junction, where it joins the passenger network. The dedicated freight network also includes spur lines to Fisherman Islands, Swanbank, Ipswich Workshops and Ebenezer.

- Lines under construction are the Richlands to Springfield extension and the Petrie – Kippa-Ring railway.

- Queensland Rail has recently adopted TransLink's measurement of patronage. Patronage is defined as 'passenger trips'. Patronage data was taken from Queensland Rail and TransLink annual reports.

Perth

- Perth's metropolitan network is defined here as being bounded by Midland, Armadale, Thornlie, Mandurah, Fremantle and Clarkson.

- Perth's dedicated freight network is defined as being bounded by Midland, North Fremantle, Kwinana Loop, Alcoa and Mundijong Junction.

- The Clarkson to Butler extension is under construction.

- The Public Transport Authority of Western Australia measures Perth's patronage as 'total boardings'. This includes all fare paying boardings plus free travel and transfer between services.

Adelaide

- Adelaide's metropolitan network is defined here as being bounded by Belair, Tonsley, Noarlunga Centre, Grange, Outer Harbor and Gawler Central.

- Adelaide's dedicated freight network is defined as running between Belair and Dry Creek South Junction where it splits into two lines; one heads to Port Adelaide and Outer Harbor and the other, interstate line, continues north to Salisbury where it leaves Adelaide.

- The South Australian Government is electrifying the Noarlunga/Tonsley line. The Noarlunga–Seaford extension is under construction. Electrification of the Gawler, Outer Harbor and Grange Lines was suspended in the 2012–13 State budget.

- The South Australian Department of Planning, Transport and Infrastructure measures Adelaide's patronage as 'initial boardings'.

Patronage statistics

Patronage measurement systems can vary over time. By using a patronage index rather than a patronage level, we aim to present a robust measure of patronage trends. Nonetheless we note the following changes in measurement systems or descriptions:

The Victorian Department of Transport notes that the 'patronage estimates for the three metropolitan modes were estimated using a different methodology from 2004–05'.[151] This is represented by a gap in the series in Figure 4, albeit that the series retains 2001–02 as the base year.

Queensland Rail reports that it changed its patronage-estimation methodology to be consistent with the process used by TransLink to estimate rail patronage in 2010–11. This should not impact on data presented in this report: Figure 4 shows a patronage index, rather than patronage levels. We have uplifted the 2007–08 Queensland Rail index by the TransLink rail growth rate for each of the years 2008–09, 2009–10 and 2010–11. Thus, TransLink presents rail patronage of 51 million, 54.7 million, 52.3 million and 51 million for 2007–08, 2008–09, 2009–10 and 2010–11, respectively.[152] This is the equivalent of the index being inflated by 7.3 per cent in 2008–09, and deflated by 4.4 per cent and 2.5 per cent in 2009–10 and 2010–11, respectively.

In Adelaide, from 2009, patronage was affected by significant infrastructure works. The Belair line was closed for a number of months because of track and sleeper replacements. Buses replaced trains between Outer Harbor and Woodville for 26 weeks while level crossings and the Port Adelaide viaduct were upgraded. In addition, from 6 June 2010 to 31 March 2012 upgrading work on the Gawler line resulted in buses replacing trains from Mawson Interchange to Adelaide Railway Station.[153]

Dedicated passenger route length

'Dedicated Metropolitan passenger route length' refers to route kilometres of passenger only lines that are deemed to lie within the metropolitan network boundaries defined in this report.

Non-metropolitan passenger route length

'Non–metropolitan passenger route length' refers to route kilometres used by the relevant operator that lie outside the defined metropolitan boundaries.

Total metropolitan route length

'Total metropolitan route length' refers to the total metropolitan route kilometres which are used by the relevant transport authority of each city plus all dedicated metropolitan freight lines.

---

151 Department of Transport Victoria, 2011a
152 TransLink Transit Authority, 2011d
153 Department of Planning, Transport and Infrastructure South Australia, 2010c, p.75

Dedicated metropolitan freight route length

'Dedicated metropolitan freight route length' refers to the route length of dedicated freight lines that are deemed to lie within the defined metropolitan boundaries.

Shared metropolitan passenger route length

'Shared metropolitan passenger route length' refers to the route length of lines that are shared between passenger and freight trains and lie within the defined metropolitan boundaries.

Lines under construction

'Lines under construction' refers to new lines for which construction has commenced. It does not include planned lines or improvements to existing lines.

ANNEX B
Urban railway lines

Table 19   Urban railway lines in Australia

City	Main line	Line name	Exclusive links	Branch lines
Sydney	Brisbane–Sydney	Northern Line	Hornsby–Strathfield	Epping–Chatswood
		North Shore Line	(Newcastle) Berowra–Central	
	Sydney–Lithgow (Parkes)	Western Line	Central–Emu Plains (Lithgow)	Richmond
				Carlingford
				Olympic Park
		Inner West Line	Lidcombe–Cabramatta	
		Bankstown	Sydenham–Sefton	
		Airport & East Hills Line	Central–Glenfield	
		Eastern Suburbs & Illawarra Line	Bondi Junction–Waterfall (Wollongong)	Cronulla
	Sydney–Melbourne	South Line	Granville–Macarthur (Goulburn)	Leppington (under construction)
Melbourne		Werribee	Footscray–Werribee (Geelong)	Laverton Loop
				Williamstown
		Melton	Sunshine–Melton (Ballarat)	
		Sydenham/Sunbury	North Melbourne–Sunbury (Bendigo)	
		Craigieburn	City Loop–Craigieburn (Seymour)	Flemington Racecourse
				Upfield
		South Morang	City Loop– South Morang	Hurstbridge
		Pakenham	City Loop–Pakenham (Bairnsdale)	Sandringham
				Frankston/Stony Point
				Cranbourne
		Belgrave	Richmond–Belgrave	Glen Waverley
				Alamein
				Lilydale

(Continued)

Table 19   Urban railway lines in Australia (continued)

City	Main line	Line name	Exclusive links	Branch lines
Brisbane	Cairns–Brisbane	Caboolture Line	Roma Street–Caboolture (Gympie North)	Shorncliffe
				Doomben
				Airport
		Ferny Grove Line	Bowen Hills–Ferny Grove	
		Cleveland Line	Park Road–Cleveland	
		Beenleigh Line	Roma Street–Beenleigh (Varsity Lakes)	
		Rosewood Line	Roma Street–Rosewood	Darra–Richlands [Springfield]
Perth		Joondalup Line	Perth Central–Clarkson	
		Fremantle Line	Perth Central–Fremantle	
		Midland Line	Midland–Claisebrook	
		Armadale Line	Armadale–Perth Central	Thornlie
		Mandurah Line	Mandurah–Perth Central	
Adelaide		Belair Line	Belair–Adelaide Railway Station	
		Noarlunga Line	Goodwood–Noarlunga [Seaford]	Tonsley
		Outer Harbor Line	Adelaide Railway Station – Outer Harbor	Grange
		Gawler Line	Adelaide Railway Station – Gawler Central	

Urban railway network proposals

Table 20 Network proposals

City	Project	Line	Length (km)	Project description
Sydney	North West Rail Link	Epping–Rouse Hill	23	Double track railway—includes 15 km of twin-bored tunnel, at level track and 4 km of elevated track. Eight (new) stations, each with bus interchange and bicycle facilities. Park and ride facilities at four stations totalling 4000 spaces.
	Epping–Parramatta	Epping–Parramatta	14	New tracks, Epping–Carlingford and Rose Hill/Camellia–Parramatta; some use of the Carlingford tracks, which would be duplicated. Upgrading of 5 stations and one new station.
Melbourne	Melbourne Metro Tunnel	South Kensington–South Yarra	9	An 8 km rail tunnel, South Kensington–South Yarra. Five new stations: North Melbourne, Parkville, CBD North, CBD South, and the Domain. The proposal is designed to enhance network capacity.
	Cranbourne East rail extension	Cranbourne–Cranbourne East		A service extension of the Cranbourne line along existing disued track, to Cranbourne East.
	Avalon Airport rail link	Lara–Avalon Airport		A branch line from the existing Melbourne–Geelong railway to Avalon airport.
Brisbane	Cross River Rail	Yeerongpilly–Victoria Park	18	Includes a twin 10 km rail tunnel and four underground stations. The proposal is designed to enhance capacity in the network.
Perth	Butler extension	Butler–Yanchep	14	Extension of Northern Suburbs Railway from Butler (currently under construction). New stations at Alkimos, Eglinton and Yanchep.
	Airport link	Bayswater–Perth Airport	7	Stations at a new airport terminal and at existing domestic terminal.
	Light rail rapid transit	Perth–Mirrabooka–University of WA		Light rail network linking central Perth to Mirrabooka as well as Curtin University and the University of Western Australia.
Adelaide	Gauge conversion	Adelaide network		Gauge convertible sleepers are being installed across Adelaide's network, to allow for future track conversion from broad, to standard, gauge.

Sources: Transport for NSW, 2011b; Mckew, 2010; Wapling, 2011; Victorian Government, 2008; Department of Transport Victoria, 2011e; Queensland Government and Australian Government, 2011; Public Transport Authority of Western Australia, n.d.b; Department of Transport Western Australia, 2011; Department of Planning, Transport and Infrastructure South Australia, 2010a; Department of Planning, Transport and Infrastructure South Australia, 2011b.

ANNEX D

Principal urban rail freight facilities

Table 21   Principal urban rail freight facilities

City	Terminal location/ name	Principal activity	Operator Terminal	Principal train	Line	Comment
Sydney	Chullora	Domestic freight	Asciano	Asciano	Adjacent to Metropolitan Freight Line	
	Cooks River	Empty container park	Maritime Container Services	Independent Railways	Adjacent to Metropolitan Freight Line	
	Enfield Intermodal Logistics Centre	Port shuttle (import/ export containers)	Hutchison Port Holdings	na	Adjacent to Metropolitan Freight Line	To open in 2013
	Leightonfield (Villawood)	Port shuttle for Bluescope Steel products	ARTC	Qube Logistics	On Bankstown line, near North–South Corridor	
	Minto	Port shuttle (import/ export containers)	Macarthur Intermodal Shipping Terminal	Independent Railways	Adjacent to North–South Corridor	In June 2012, Qube bid to purchase the terminal and Independent Railways.
	Moorebank	Port shuttle/ domestic freight	Common-user	Proposed	Adjacent to North–South Corridor	In April 2012, the Australian government announced its intention to call tenders for the project.
	Port Botany	Port shuttle	DP World; Asciano; Hutchison	Qube Logistics Independent Railways	Maritime port	Hutchison terminal to open in 2013
	Yennora	Port shuttle; domestic freight	Qube; QR National	Qube; QR National	Adjacent to North–South Corridor	
Melbourne	Altona	Domestic freight	SCT Logistics	SCT Logistics	Adjacent to East–West Corridor	
	Altona North	Domestic freight	QR National	QR National	Adjacent to East–West Corridor	

(Continued)

Table 21   Principal urban rail freight facilities (continued)

City	Terminal location/ name	Principal activity	Operator Terminal	Principal train	Line	Comment
	Melbourne Steel Terminal	Domestic freight	Arrium	Asciano	Tottenham–Dynon Rail Link	
	North Dynon	Domestic & port	Qube Logistics; QR National	Qube Logistics; QR National	Tottenham–Dynon Rail Link	
	Port of Melbourne–Appleton Dock, berth F	Port break-bulk and dry-bulk handling	Emerald Group		Tottenham–Dynon Rail Link	Grain terminal
	Port of Melbourne–Appleton Dock, berths B,C,D	Port break-bulk and dry-bulk handling	Qube Logistics	Qube Logistics	Tottenham–Dynon Rail Link	
	South Dynon (Melbourne Freight Terminal)	Domestic & port	Asciano	Asciano	Tottenham–Dynon Rail Link	
	Spotswood	Domestic freight	Sadleirs Logistics	Asciano	Adjacent to East–West Corridor	
	Swanson Dock East	Port intermodal	Asciano	Asciano	Tottenham–Dynon Rail Link	
Brisbane	Acacia Ridge, Brisbane Multi-User Terminal, steel terminal	Domestic intermodal; steel	QR National; Bluescope	QR National Asciano	Brisbane–Melbourne main line; Cairns–Brisbane main line	Multiple terminal facilities
	Brisbane Multi Modal Terminal, Fisherman Islands	Port intermodal	Port of Brisbane		Maritime port	
	Fisherman Island	Port coal terminal	Queensland Bulk Handling	QR National	Fisherman Island freight line	
	Fisherman Islands	Port bulk grain		QR National	Fisherman Island freight line	
	Tennyson	Domestic intermodal	QRX	Asciano	Yeerongpilly–Corinda line	
Perth	Forrestfield	Domestic intermodal	QR National	QR National	Adjacent to East–West corridor	
	Forrestfield	Port intermodal	Intermodal Link Services	Asciano QR National	Adjacent to East–West corridor	
	Forrestfield	Domestic non-bulk	SCT Logistics	SCT Logistics	Adjacent to East–West corridor	
	Forrestfield	Domestic steel	Bluescope Steel	Asciano	Adjacent to East–West corridor	
	Fremantle Grain Terminal	Port bulk	CBH	QR National	Fremantle freight line	

(Continued)

Table 21   Principal urban rail freight facilities (continued)

City	Terminal location/ name	Principal activity	Operator Terminal	Principal train	Line	Comment
	Kewdale	Domestic intermodal	Asciano	Asciano	Adjacent to East–West corridor	
	Kewdale		Sadleirs Logistics	QR National	Adjacent to East–West corridor	
	North Quay Rail Terminal, Fremantle	Port	Intermodal Link Services	Asciano	Fremantle freight line	
Adelaide	Direk	Domestic intermodal; containerised iron ore	SCT Logistics	SCT Logistics/ Specialised Bulk Rail	Adjacent to East–West corridor	
	Dry Creek	Domestic intermodal	Genesee & Wyoming Australia	Genesee & Wyoming Australia; QR National	Adjacent to East–West corridor	
	Dry Creek South	Domestic freight (broad gauge)	Genesee & Wyoming Australia	Genesee & Wyoming Australia	Adjacent to East–West corridor	
	Gillman, Bluescope Steel	Domestic steel	Bluescope	Asciano	Outer Harbor– Dry Creek railway	
	Islington	Domestic intermodal	Asciano	Asciano	Adjacent to East–West corridor	
	Osborne	Domestic bulk (limestone)	Penrice Soda Products	Genesee & Wyoming Australia	Outer Harbor– Dry Creek railway	
	Pelican Point, Outer Harbor	Port landbridging	Qube (Mackenzie Intermodal)		Outer Harbor– Dry Creek railway	
	Pelican Point, Outer Harbor— Adelaide Container Terminal	Port intermodal	DP World	Qube; Asciano	Outer Harbor– Dry Creek railway	Berths 6, 7, served by dual-gauge
	Pelican Point, Outer Harbor	Port grain terminal	Viterra	Genesee & Wyoming Australia	Outer Harbor– Dry Creek railway	Grain terminal, berth 8
	Pelican Point, Outer Harbor	Iron ore terminal	Flinders Ports	Specialised Bulk Rail	Outer Harbor– Dry Creek railway	
	Port Flat, Gillman	Port intermodal	Kerry Logistics	Asciano	Maritime port	

Note: This list excludes operational freight facilities such as for refuelling and train marshalling. For instance, an important freight mashalling facility on the southern edge of Sydney is Glenlee, where QR National marshalls trains. Also excluded from the list are prospective terminals being considered by Qube Logistics at Moorebank (adjacent to the planned common-user terminal) and at Minto (on Qube's site, currently leased to PrixCar). Data relate to urban facilities so terminals such as Onesteel's terminal at Long Island are excluded. Other facilities, such as Acacia Ridge terminal, have multiple freight trans-shipment facilities, such as for paper, steel and containers.

ANNEX E

Average distance between stations, by line

Table 22   Distance between stations

City	Line	Distance between stations (km)	Station end-points
Sydney	City Circle	0.8	Central–Circular Quay–Central
Sydney	Carlingford	1.0	Clyde–Carlingford
Sydney	Eastern Suburbs	1.1	Central–Bondi Junction
Sydney	Airport Line	1.2	Central–Wolli Creek
Sydney	Bankstown	1.3	Central–Liverpool
Sydney	Cronulla	1.5	Sutherland–Cronulla
Sydney	North Shore	1.5	Central–Berowra
Sydney	Northern	1.5	Strathfield–Hornsby
Sydney	Olympic Park	1.5	Flemington–Olympic Park
Sydney	South Line	1.6	Central–Campbelltown
Sydney	Illawarra	1.8	Central–Waterfall
Sydney	Western	2.1	Granville–Emu Plains
Sydney	Richmond	2.4	Blacktown–Richmond
Sydney	East Hills Line	2.5	Wolli Creek–Macarthur
Sydney	Epping–Chatswood	2.6	Epping–Chatswood
Melbourne	Alamein	0.8	Camberwell–Alamein
Melbourne	South Morang	1.1	Flinders Street–South Morang
Melbourne	Sandringham	1.1	South Yarra–Sandringham
Melbourne	Upfield	1.2	North Melbourne–Upfield
Melbourne	Glen Waverley	1.3	Burnley–Glen Waverley
Melbourne	Williamstown	1.3	Footscray–Williamstown
Melbourne	Frankston	1.5	Caulfield–Frankston (including Southland station)
Melbourne	Craigieburn	1.6	Flinders Street–Craigieburn
Melbourne	Lilydale	1.6	Flinders Street–Lilydale
Melbourne	Hurstbridge	1.7	Clifton Hill–Hurstbridge
Melbourne	Belgrave	1.9	Ringwood–Belgrave

(Continued)

Table 22   Distance between stations (continued)

City	Line	Distance between stations (km)	Station end-points
Melbourne	Pakenham	2.2	Richmond–Pakenham
Melbourne	Werribee	2.6	Newport–Werribee
Melbourne	Stony Point	3.2	Frankston–Stony Point
Melbourne	Cranbourne	3.5	Dandenong–Cranbourne (including Lynbrook station)
Melbourne	Sunbury	4.2	North Melbourne–Sunbury
Melbourne	Melton	5.8	Sunshine–Melton
Brisbane	Doomben	0.7	Eagle Junction–Doomben
Brisbane	Ferny Grove	1.1	Bowen Hills–Ferny Grove
Brisbane	Shorncliffe	1.2	Central–Shorncliffe
Brisbane	Beenleigh	1.6	Yeerongpilly–Beenleigh
Brisbane	Cleveland	1.6	Central–Cleveland
Brisbane	Rosewood	1.9	Central–Rosewood
Brisbane	Caboolture	2.5	Northgate–Caboolture
Brisbane	Richlands (Springfield Central)	2.5	Darra–Richlands
Brisbane	Airport	2.8	Airport Junction–Domestic Terminal
Perth	Fremantle	1.1	Perth–Fremantle
Perth	Midland	1.1	Claisebrook–Midland
Perth	Armadale	1.5	Perth–Armadale
Perth	Thornlie	1.6	Beckenham–Thornlie
Perth	Joondalup (Clarkson/Butler)	3.0	Perth–Clarkson
Perth	Mandurah	6.4	Perth Underground–Mandurah
Adelaide	Outer Harbor	1.0	Adelaide Station–Outer Harbor
Adelaide	Tonsley	1.0	Woodlands Park–Tonsley
Adelaide	Grange	1.1	Woodville–Grange
Adelaide	Noarlunga (Seaford)	1.2	Goodwood–Noarlunga Centre
Adelaide	Belair	1.5	Adelaide Station–Belair
Adelaide	Gawler	1.5	Adelaide Station–Gawler Central

ANNEX F
Illustrative service speeds, by line

Sydney

Emu Plains–Granville, 36 km. Stopping train departs Emu Plains at 0737, arriving at Granville at 0816. Average speed 55.4 km/h.

Liverpool–Central (via Bankstown line), 35.7 km. Stopping train departs Liverpool at 0757, arriving at Central at 0904. Average speed 32.0 km/h.

Melbourne

Pakenham–Richmond, 54.5 km. Stopping train departs Pakenham at 0704, arriving at Richmond at 0809. Average speed 50.5 km/h.

South Morang–Flinders Street, 24.7 km. Stopping train departs South Morang at 0718, arriving at Flinders Street at 0803. Average speed 32.9 km/h.

Craigieburn–North Melbourne, 24.1 km. Stopping train departs Craigieburn at 0704, arriving at North Melbourne at 0741. Average speed 39.0 km/h.

Brisbane

Ferny Grove–Bowen Hills, 13.4 km. Stopping train departs Ferny Grove at 0716, arriving at Bowen Hills 0739. Average speed 35.0 km/h.

Rosewood–Central, 57.0 km. Stopping train departing Rosewood at 0730, arriving at Central 0850. Average speed 42.8 km/h.

Perth

Mandurah–Perth, 70.1 km. Stopping train departs Mandurah at 0703, arriving at Perth at 0752. Average speed 85.5 km/h.

Clarkson–Perth, 32.2 km. Stopping train departs Clarkson at 0705, arriving at Perth at 0741. Average speed 53.7 km/h.

Fremantle–Perth, 18.7 km. Stopping train departs Fremantle 0858, arriving at Perth at 0926. Average speed 38.3 km/h.

Adelaide

Noarlunga Centre–Goodwood. Fast train is not available. Noarlunga Centre to Keswick is 26.4 km. 0750 from Noarlunga Centre arrives at Keswick at 0834, i.e., 36 km/h. Express from Noarlunga Centre to Adelaide, departing 0739, arriving at Adelaide at 0812. 33 minutes. Average speed 54.9 km/h.

Outer Harbor–Adelaide, 21.9 km. Stopping train departs Outer Harbor at 0828, arriving at Adelaide 0908. Average speed, 32.7 km/h.

ANNEX G

Capital costs on recent urban railway projects

Table 23 Capital costs

Project (year)	Project description	City	Length (km)	Cost (millions)
Line construction				
Olympic Park line (1998)	Loop rail line and Olympic Park station.	Sydney	4	98
Light rail extension (2000)	Dual track extension from Wentworth Park to Lilyfield.	Sydney	3	20
Airport Rail Link (2000)	Mostly tunnelled dual track railway with 5 new stations.	Sydney	7	900
Epping–Chatswood (2009)	Tunnelled dual track railway with 3 new stations and upgrades to Epping and Chatswood stations.	Sydney	15	2 346
Mandurah line (2007)	Double-track railway partly along medium strip of Kwinana freeway. Includes 11 stations; 5 200 car bays; 770 metre tunnel; 594 metre cut and cover tunnel; and 18 bridges and structures.	Perth	70	1 300
Robina–Varsity Lakes (2009)	Double-track extension including a 300 metre tunnelled section; 3 road bridges; 3 km of new roads; and a new station at Varsity Lakes.	Gold Coast	4	324
Darra–Richlands (2010)	A 'transport corridor' which includes a dual track railway; new station at Richlands with a bus interchange and car parking; 4 km duplication of Centenary highway; 6 km shared use pathway; 6 road bridges; 4 rail bridges; and 3 pedestrian bridges.	Brisbane	5	800
Victoria Square–City West light rail (2008)	Light rail on dedicated corridor with 5 new stops.	Adelaide	2	31
City West– Entertainment Centre light rail (2010)	Double-track light rail on dedicated corridor. Includes 4 new light rail stops and 400 park and ride bays at the Adelaide Entertainment Centre.	Adelaide	3	100
Epping–South Morang (2012)	An extension from Epping to South Morang. Included duplication of existing track between Keon Park and Epping.	Melbourne	4	498

(Continued)

Table 23   Capital costs (continued)

Project (year)	Project description	City	Length (km)	Cost (millions)
Electrification				
Dandenong–Cranbourne (1995)	Electrification included all wiring and power transmission works as well as an upgrade of Cranbourne station and a new station at Merinda Park.	Melbourne	14	27
St Albans–Sydenham (2002)	Extension of the electrified rail line included associated wiring works; new stations at Watergardens and Keilor Plains; and an upgrade of St Albans station.	Melbourne	5	44
Broadmeadows–Craigieburn (2007)	Works included track upgrades; overhead wiring; signalling changes; upgrade of Craigieburn station; extension of parking facilities; and a new station at Roxburgh Park.	Melbourne	10	115
Dapto–Kiama (2001)	Works included overhead wiring; power transmission system; substations; bridge and tunnel clearance works; and alterations to platforms to accommodate longer trains.	Sydney	24	45
Duplication				
Mitchelton–Keperra (2008)	Duplication of track and upgrades to Oxford Park and Grovely stations including an expansion of car parking.	Brisbane	3	46
Clifton Hill–Westgarth (2009)	Duplication of track and construction of rail bridge over Merri Creek.	Melbourne	1	49
Cronulla branch line (2010)	Duplication of track and station upgrades at Sutherland, Kirrawee, Woolooware and Cronulla. The work also involved bridge renewals and extensions.	Sydney	7	350

Sources: Olympic Co-ordination Authority, 2002; Martin, 2011; State Rail Authority of New South Wales, 2000; Audit Office of New South Wales, 2010; Public Transport Authority of Western Australia, 2008; Queensland Rail Limited, n.d.c; Queensland Rail Limited, n.d.a; Department of Planning, Transport and Infrastructure South Australia, 2010c; Mulder, 2012; Victorian Auditor General, 1996; Department of Transport Victoria, 2002; Department of Transport Victoria, 2007; Rail Infrastructure Corporation NSW, 2001; Queensland Rail Limited, n.d.d; Victorian Auditor General, 2010; RailCorp, 2011

Abbreviations

ABS	Australian Bureau of Statistics
ARTC	Australian Rail Track Corporation
ATRF	Australasian Transport Research Forum
BART	Bay Area Rapid Transit (San Francisco)
BITRE	Bureau of Infrastructure, Transport and Regional Economics
BTS	Bureau of Transport Statistics (New South Wales)
CBH	Co-operative Bulk Handling Limited
DB Regio	Deutsche Bahn Regio (German regional railway)
DMU	Diesel Multiple Unit
DPTI	Department of Planning, Transport and Infrastructure (South Australia)
DP World	Dubai Ports World
EMU	Electric Multiple Unit
ITF	International Transport Forum
km	kilometre
NSW	New South Wales
OECD	Organisation for Economic Co-operation and Development
OSCAR	Outer Suburban Carriage
QLD	Queensland
QRX	Queensland Railfast Express
RER	Réseau Express Régional (regional express network)
SA	South Australia
S-Bahn	Stadtschnellbahn (surface railway)
SSFL	Southern Sydney Freight Line
TCA	Transport Construction Authority (New South Wales)
TOD	Transit Oriented Development
U-Bahn	Untergrundbahn (underground railway)
WA	Western Australia

References

Adelaide City Council, 2009. *Adelaide city census of land use and employment 2008.* Adelaide: Adelaide City Council.

Albanese, A., 2010. *Melbourne's 'Missing Link' rail project completed.* [Online] Available at: http://www.minister.infrastructure.gov.au/aa/releases/2010/October/AA458_2010.aspx [Accessed 12 January 2012].

Albanese, A., 2011. *Northern Sydney freight corridor locked in.* [Online] Available at: http://www.minister.infrastructure.gov.au/aa/releases/2011/December/AA231_2011.aspx [Accessed 16 December 2011].

Audit Office of New South Wales, 2010. *'Transport Infrastructure Development Corporation': the Auditor General's report to parliament.* Audit. Sydney: Audit Office of New South Wales.

Audit Office of New South Wales, 2011. *New South Wales Auditor-General's Report. Financial Audit. Volume Eight 2011. Focusing on transport and ports.* Sydney: Audit Office of New South Wales. http://www.audit.nsw.gov.au/ArticleDocuments/228/01_Volume_Eight_2011_Full_Report2.pdf.aspx?Embed=Y.

Australian Bureau of Statistics, 2006. *Census of population and housing.* [Online] Available at: http://www.abs.gov.au/census [Accessed 22 November 2011].

Australian Bureau of Statistics, 2011. *Regional population growth, Australia, 2009–10.* [Online] Available at: http://www.abs.gov.au/ausstats/abs@.nsf/mf/3218.0/ [Accessed March 2012].

Australian Government, 2011. *Nation Building: Economic Stimulus Plan.* [Online] Available at: http://www.economicstimulusplan.gov.au/theplan-infocus/if_190310_artc.aspx [Accessed 10 January 2012].

Australian Rail Track Corporation (ARTC), 2010. *Annual report 2009–10.* Adelaide: ARTC.

Blake, X., Milthorpe & Frank, 2010. Analysis of journey to work travel patterns in Sydney. In *ATRF.* Canberra, 2010. Australasian Transport Research Forum.

Brookfield Rail, 2011. *About Brookfield Rail.* [Online] Available at: http://www.brookfieldrail.com/AboutBrookFieldRail/AboutBrookFieldRail.html [Accessed 2 May 2012].

Brown, G., McKellar, R., Johnstone, P. & Igglesden, D., 1999. Perth's parking policy: managing parking as an element of the urban transport system. In *ATRF.* Perth, 1999. Australasian Transport Research Forum.

Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2009. *Urban passenger transport: how people move about Australian cities: Information sheet 31.* Canberra: Department of Infrastructure and Transport BITRE.

Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2010. *Population growth, jobs growth and commuting flows in Perth: Report 119*. Canberra: Department of Infrastructure and Transport BITRE.

Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2011a. *Australian infrastructure statistics yearbook 2011*. Canberra: Department of Infrastructure and Transport BITRE.

Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2011b. *Rail profile database*. Internal database. Canberra.

Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2011c. *Population growth, jobs growth and commuting flows in Melbourne: Report 125*. Canberra: Department of Infrastructure and Transport BITRE.

Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2012. *Traffic Growth in Australia: Report 127*. Canberra: Department of Infrastructure and Transport BITRE.

Bureau of Infrastructure, Transport and Regional Economics (BITRE), forthcoming, a. *Population growth, jobs growth and commuting flows in Sydney*. Canberra: Department of Infrastructure and Transport BITRE.

Bureau of Infrastructure, Transport and Regional Economics (BITRE), forthcoming, b. *Public transport use in Australia's capital cities: Modelling and forecasting*. Canberra: Department of Infrastructure and Transport BITRE.

Bureau of Transport Statistics NSW, 2011. *2009/10 Household Travel Survey. Summary report 2011 release*. Sydney: NSW Government Bureau of Transport Statistics NSW.

CityRail, 2011a. *CityRail fleet*. [Online] Available at: http://www.cityrail.info/about/fleet/a_sets [Accessed 7 September 2011].

CityRail, 2011b. *Our customers*. [Online] Available at: http://www.cityrail.info/about/our_performance/ [Accessed 20 December 2011].

CityRail, n.d.a. *Rail clearways program*. [Online] Available at: http://www.cityrail.info/news/projects/clearways/ [Accessed 24 August 2011].

CityRail, n.d.b. *Network map*. [Online] Available at: http://www.cityrail.info/stations/network_map [Accessed 13 March 2012].

Clark, P., 2005. Perth's three–car B set EMUs,. *Railway Digest*, March. pp.32–33.

Coxon, S., Burns, K. & de Bono, A., 2011. An examination of three approaches to metro rolling stock design to ameliorate extended dwell times due to passenger growth and associated crowding. In *ATRF*. Adelaide, 2011. Australasian Transport Research Forum.

Currie, G. & Loader, C., 2009. Exploring bus transfer behaviour in metropolitan Melbourne. In *ATRF*. Auckland, 2009. Australasian Transport Research Forum. www.patrec.org/web_docs/atrf/papers/2009/1715_paper11-Currie.pdf.

Department of Finance and Deregulation, 2012. *Moorebank intermodal terminal project*. [Online] Available at: http://www.finance.gov.au/property/property/moorebank-intermodal-freight-terminal/index.html [Accessed 12 January 2012].

Department of Infrastructure and Transport, 2011. *Perth urban transport and freight corridor upgrade.* [Online] Available at: http://www.nationbuildingprogram.gov.au/projects/ProjectDetails. aspx?Project_id=wan008 [Accessed 12 January 2012].

Department of Infrastructure and Transport, 2012. *Budget 2012–13.* [Online] Available at: http://www.infrastructure.gov.au/department/statements/2012_2013/index.aspx [Accessed 9 May 2012].

Department of Planning Western Australia, 2006. *Kewdale–Hazelmere integrated masterplan.* Perth: Western Australian Government.

Department of Planning, Transport and Infrastructure South Australia, 2008a. *Port river expressway.* [Online] Available at: http://infrastructure.sa.gov.au/port_river_expressway/ content/about_the_project [Accessed 28 August 2011].

Department of Planning, Transport and Infrastructure South Australia, 2008b. *LeFevre Peninsula.* [Online] Available at: http://www.infrastructure.sa.gov.au/lefevre_peninsula [Accessed 28 September 2011].

Department of Planning, Transport and Infrastructure South Australia, 2010a. *Coast to coast light rail.* [Online] Available at: http://www.infrastructure.sa.gov.au/coast_to_coast_lightrail [Accessed 21 September 2011].

Department of Planning, Transport and Infrastructure South Australia, 2010b. *New trains and trams.* [Online] Available at: http://www.infrastructure.sa.gov.au/RR/rail_revitalisation/new_ trains_and_trams [Accessed 21 September 2011].

Department of Planning, Transport and Infrastructure South Australia, 2010c. *Annual report 2009–10.* Adelaide: Government of South Australia.

Department of Planning, Transport and Infrastructure South Australia, 2011a. *Annual report 2010–11.* Adelaide: Government of South Australia.

Department of Planning, Transport and Infrastructure South Australia, 2011b. *Rail Revitalisation.* [Online] Available at: http://www.infrastructure.sa.gov.au/RR [Accessed 15 September 2011].

Department of Planning, Transport and Infrastructure South Australia, 2011c. *Noarlunga rail revitalisation.* [Online] Available at: http://www.infrastructure.sa.gov.au/RR/rail_revitalisation/ noarlunga_line_renewal [Accessed 21 December 2011].

Department of Planning, Transport and Infrastructure South Australia, 2011d. *Gawler rail revitalisation.* [Online] Available at: http://www.infrastructure.sa.gov.au/RR/rail_revitalisation/ gawler_rail_revitalisation [Accessed 21 December 2011].

Department of Planning, Transport and Infrastructure South Australia, 2011e. *Seaford rail extension.* [Online] Available at: http://www.infrastructure.sa.gov.au/seaford [Accessed 21 December 2011].

Department of Transport and Main Roads Queensland, 2011. *Moreton Bay rail link.* [Online] Available at: http://www.tmr.qld.gov.au/moretonbayrail [Accessed 17 December 2011 2011].

Department of Transport Victoria, 2002. *Annual Report 2001–02.* Melbourne: Victorian Government.

Department of Transport Victoria, 2007. *Annual Report 2006–07*. Melbourne: Victorian Government.

Department of Transport Victoria, 2008. *Transport Demand Information Atlas for Victoria. Volume 1: Melbourne 2008*. Melbourne: Victorian Government.

Department of Transport Victoria, 2011a. *Track Record 48*. Melbourne: Victorian Government.

Department of Transport Victoria, 2011b. *South Morang rail extension project*. [Online] Available at: http://www.transport.vic.gov.au/projects/pt/smrep [Accessed 19 August 2011].

Department of Transport Victoria, 2011c. *Sunbury electrification project*. [Online] Available at: http://www.transport.vic.gov.au/projects/pt/sunbury [Accessed 21 December 2011].

Department of Transport Victoria, 2011d. *Regional Rail Link*. [Online] Available at: http://www.transport.vic.gov.au/projects/pt/rrl [Accessed 7 August 2011].

Department of Transport Victoria, 2011e. *Avalon Airport Rail Link*. [Online] Available at: http://www.transport.vic.gov.au/projects/pt/avalon-airport-rail-link [Accessed 21 December 2011].

Department of Transport Victoria, n.d. *New trains*. [Online] Available at: http://www.transport.vic.gov.au/projects/pt/new-trains [Accessed 23 August 2011].

Department of Transport Western Australia, 2011. *Public transport for Perth in 2031. Mapping out the future for Perth's public transport network*. Perth: Government of Western Australia.

Economic Regulation Authority, 2012. *Rail Access*. [Online] Available at: http://www.erawa.com.au/1/170/48/rail_access.pm [Accessed 2 May 2012].

Editor, Table Talk, 2011. Australian Timetable News. *Table Talk*, October. p.5.

Emerson, S., 2012. *Panel delivers rail capacity options*. [Online] Available at: http://www.scottemerson.com.au/ [Accessed 20 June 2012].

Forbes, M., 2009. Port River expressway: Dry Creek to Outer Harbor resignalling. Adelaide, 2009. Institution of Railway Signal Engineers (IRSE).

Fremantle Ports, 2006. *2005–06 Annual Report*. Perth: Fremantle Ports.

Gaymer, S., 2010. Quantifying the impact of attitudes on shift towards sustainable modes. In *ATRF*. Canberra, 2010. Australasian Transport Research Forum.

GHD, 2010. *Adelaide rail freight movements study*. Canberra: Australian Government Department of Infrastructure, Transport, Regional Development and Local Government.

Independent Pricing and Regulatory Tribunal, 2009. *Review of CityRail fares, 2009–12. Final determination*. Sydney: IPART. http://www.google.com/url?q=http://www.ipart.nsw.gov.au/files/Fact%2520Sheet%2520-%2520Review%2520of%2520CityRail%2520fares%25202009%2520-%25202012%2520-%2520Final%2520Determination%2520-%252016%2520December-%25202008%2520-%2520WEBSITE%2520DOCUMENT.PDF&sa=.

Independent Pricing and Regulatory Tribunal, 2011. *CityRail and metropolitan and outer metropolitan bus services: prices and services report 2011*. Sydney: IPART.

Infrastructure Australia, 2011. *2011 Project Assessments.* [Online] Available at: http://www.infrastructureaustralia.gov.au/2011_coag/project_assessments.aspx [Accessed 10 September 2011].

International Transport Forum (ITF), 2010. *Improving reliability on surface transport networks.* Paris: OECD/ITF Organisation for Economic Co-operation and Development.

Jane's, 2011. *Jane's urban transport systems 2011–12.* Surrey: IHS Janes, IHS Global Limited.

Kerr, J., 2003. Motorway takes toll on rail trips. *Sydney Morning Herald*, 2 April. http://www.smh.com.au/articles/2003/04/01/1048962755880.html.

Laird, P.P.G., 1994. *Research Paper Number 12 1994. Rail and urban public transport: Commonwealth funding and policy issues.* Research Paper. Canberra: Department of the Parliamentary Library.

Ly, M., 2011. Adelaide suburban network. *Railway Digest*, June. pp.18–26.

Martin, S., 2011. Reviewing the last decade of public transport infrastructure projects in Australasia. In *ATRF*. Adelaide, 2011. Australasian Transport Research Forum. 28–30 September.

Martinovich, P., 2008. The challenge of expanding Perth's rail system. In *Presentation to the Railway Technical Society of Australasia, Western Australian Division.*, 2008. 24 April.

Martinovich, P., 2009. Application of a commuter railway to low density settlement. In *Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2009 Infrastructure Colloquium.* Canberra, 2009.

Mckew, M., 2010. *Epping to Parramatta rail link.* [Online] Available at: http://www.maxinemckew.com.au/2010/08/11/infrastructure-investment-to-move-sydney-forward/ [Accessed 18 November 2011].

Mees, P. & Dodson, J., 2011. *Public transport network planning in Australia: assessing current practice in Australia's five largest cities. Research Paper 34.* Brisbane: Griffith University.

Muhammad, I., Low, N. & Glover, L., n.d. *Mega projects in transport and development: background in Australian case studies. Perth urban railway.* Melbourne: Australasian Centre for the Governance and Management of Urban Transport, The University of Melbourne. www.abp.unimelb.edu.au/gamut/pdf/rail-background-report.pdf.

Mulder, T., 2012. *First trains to South Morang mark historic day for rail.* [Online] Available at: http://www.terrymulder.com.au/media-releases/first-trains-to-south-morang-mark-historic-day-for-rail [Accessed 15 May 2012].

NSW Department of Planning and Infrastructure, 2005. *Metropolitan Strategy: City of Cities.* Sydney: NSW Government NSW Department of Planning and Infrastructure.

NSW Department of Planning and Infrastructure, 2011. *The growth centres.* [Online] Available at: http://www.gcc.nsw.gov.au/the+growth+centres-5.html [Accessed 21 December 2011].

NSW Government, 2010. *Metropolitan Plan for Sydney 2036.* [Online] Available at: http://www.metroplansydney.nsw.gov.au/ [Accessed 28 November 2011].

NSW Government, 2011. *NSW 2021: A plan to make NSW number one.* [Online] Available at: http://2021.nsw.gov.au/ [Accessed 15 November 2011].

Olympic Co-ordination Authority, 2002. *A report on the financial contribution by the New South Wales Government to the Sydney 2000 games*. Audit. Sydney: Olympic Co-ordination Authority.

Organisation for Economic Co-operation and Development (OECD), 2011. *Redefining Urban: A new way to measure metropolitan areas in OECD countries*. Paris: OECD.

Parliament of Australia, 2006. *Standing Committee on Transport and Regional Services: Hansard*. Canberra: Australian Government House of Representatives.

Parliament of Victoria, 2008. *Local economic development in outer suburban Melbourne. Report of the Outer Suburban/Interface Services and Development Committee*. Melbourne: Parliament of Victoria. http://www.parliament.vic.gov.au/images/stories/committees/osisdv/Local_Economic_Development/Report/Report_Oct_08.pdf.

Passenger Transport Board South Australia, 2001. *Annual Report 2000–01*. Adelaide: Government of South Australia.

Passenger Transport Board South Australia, 2003. *Annual Report 2002–03*. Adelaide: Government of South Australia.

Public Transport Authority of Western Australia, 2008. *Annual Report 2007–08*. Perth: Western Australian Government.

Public Transport Authority of Western Australia, 2011a. *Annual report 2010–11*. Perth: Western Australian Government.

Public Transport Authority of Western Australia, 2011b. *Transperth patronage*. [Online] Available at: http://www.pta.wa.gov.au/NewsandMedia/TransperthPatronage/tabid/218/Default.aspx [Accessed November 2011].

Public Transport Authority of Western Australia, n.d.a. *Our fleet*. [Online] Available at: http://www.pta.wa.gov.au/OurSystem/OurFleet/tabid/64/Default.aspx [Accessed 12 August 2011].

Public Transport Authority of Western Australia, n.d.b. *Butler Extension Project*. [Online] Available at: http://www.pta.wa.gov.au/Projects/ButlerExtensionProject/tabid/245/Default.aspx [Accessed 11 November 2011].

Public Transport Authority of Western Australia, n.d.c. *Car park expansion project*. [Online] Available at: http://www.pta.wa.gov.au/Projects/CarParkExpansionProject/tabid/223/Default.aspx [Accessed 30 August 2011].

Queensland Government and Australian Government, 2011. *Cross River Rail. Reference design overview*. http://www.crossriverrail.qld.gov.au/images/stories/reference_design_overview/Pdf-crr-reference-design-overview-august-2011-complete.pdf.

Queensland Government, 2011. *Connecting SEQ 2031: An integrated regional transport plan for south east Queensland*. [Online] Queensland Government Available at: http://www.connectingseq.qld.gov.au/ [Accessed 28 November 2011].

Queensland Rail Limited, 2011a. *Annual report 2010–11*. Brisbane: Queensland Government.

Queensland Rail Limited, 2011b. *Keperra to Ferny Grove rail upgrade*. [Online] Available at: http://www.queenslandrail.com.au/NetworkServices/ConstructionUpgrades/MajorInfrastructure/

CurrentProjects/KeperratoFernyGrove/Pages/Introduction.aspx [Accessed 21 December 2011].

Queensland Rail Limited, n.d.a. *Darra to Springfield transport corridor–Stage 1.* [Online] Available at: http://www.queenslandrail.com.au/NetworkServices/ConstructionUpgrades/MajorInfrastructure/CompletedProjects/Pages/DarratoSpringfieldTransportCorridorStage1.aspx [Accessed 30 November 2011].

Queensland Rail Limited, n.d.b. *Fleet.* [Online] Available at: http://www.queenslandrail.com.au/RailServices/City/Fleet/Pages/Fleet.aspx [Accessed 17 August 2011].

Queensland Rail Limited, n.d.c. *Robina to Varsity Lakes rail extension.* [Online] Available at: http://www.queenslandrail.com.au/NetworkServices/ConstructionUpgrades/MajorInfrastructure/CompletedProjects/Pages/RobinaVarsity.aspx [Accessed 30 November 2011].

Queensland Rail Limited, n.d.d. *Mitchelton to Keperra duplication.* [Online] Available at: http://www.queenslandrail.com.au/NetworkServices/ConstructionUpgrades/MajorInfrastructure/CompletedProjects/Pages/MitcheltonKeperra.aspx [Accessed 30 November 2011].

Quinlan, H. & Newland, J., 2000. *Australian railway routes: 1854 to 2000.* Redfern: Australian Railway Historical Society New South Wales Division.

Rail Infrastructure Corporation NSW, 2001. *Annual Report 2000–01.* Sydney: NSW Government.

RailCorp, 2010. *Annual Report 2009–10.* Sydney: NSW Government RailCorp.

RailCorp, 2011. *Annual report 2010–11.* Sydney: NSW Government RailCorp.

RailCorp, n.d. *Rolling stock public-private partnership.* [Online] Available at: http://www.railcorp.info/about_railcorp/rollingstock_public_private_partnership [Accessed 7 September 2011].

Railway Digest, 2011a. Transport study includes rail to Flinders University. *Railway Digest,* January. p.20.

Railway Digest, 2011b. Port of Melbourne Rail Access Improvement Project paying dividends. *Railway Digest,* February. p.17.

Schwandl, R., 2011. *Urban Rail Down Under: Metropolitan Railways and Trams in Australia and New Zealand.* Berlin: Robert Schwandl Publishing.

Semler, C. & Hale, C., 2010. Rail station access—an assessment of options. In *ATRF.* Canberra, 2010. Australasian Transport Research Forum. railcrc.net.au/sites/default/files/managed/files/r1-123_final_report_final.pdf.

South Australian Government, 2005. *Strategic infrastructure plan for South Australia.* [Online] Available at: http://www.dpti.sa.gov.au/infrastructure/strategic_infrastructure_plan/sa_strategic_infrastructure_plan [Accessed 28 November 2011].

South Australian Government, 2009. *30 year plan for greater Adelaide.* [Online] Available at: http://www.dplg.sa.gov.au/plan4adelaide/html/plan.cfm [Accessed 28 November 2011].

State Rail Authority of New South Wales, 2000. *Annual Report 1999–2000.* Sydney: NSW Government.

The Advertiser, 2009. Airtrain just keeps on rising. 4 September.

TransLink Transit Authority, 2011a. *Annual report, 2010–11*. Brisbane: Queensland Government.

TransLink Transit Authority, 2011b. *TransLink's Tracker 2010–2011 Q1*. Queensland Government. http://www.google.com/url?q=http://translink.com.au/resources/about-translink/reporting-and-publications/2010-11-quarterly-report-jul-to-sep.pdf&sa=U&ei=poDhTtquBcyaiQfzrZi2BQ&ved=0CCMQFjAG&usg=AFQjCNGBCQkAkirWudoh-oZ9cr9wyzdACQ.

TransLink Transit Authority, 2011c. *TransLink tracker, 2010–2011 Q4*. Brisbane: Queensland Government. http://translink.com.au/resources/about-translink/reporting-and-publications/2010-11-quarterly-report-apr-to-jun.pdf.

TransLink Transit Authority, 2011d. *Train patronage correction*. Brisbane: Queensland Government TransLink Transit Authority.

Transport Construction Authority NSW, 2011b. *Northern Sydney freight corridor program*. [Online] Available at: http://www.tca.nsw.gov.au/Our-Projects/Current-Projects/Northern-Sydney-Freight-Corridor-Program/Project-profile/Project-profile/default.aspx [Accessed 15 2011 December].

Transport for NSW, 2011a. *Rail options for the Sydney Greater Metropolitan area*. Sydney: NSW Government.

Transport for NSW, 2011b. *North west rail link*. [Online] Available at: http://northwestrail.com.au/ [Accessed 15 December 2011].

Transport for NSW, 2012a. *Sydney's Rail Future: Modernising Sydney's Trains*. Sydney: NSW Government Transport for NSW.

Transport for NSW, 2012b. *New car parks and interchanges for commuters*. [Online] Available at: http://www.transport.nsw.gov.au/news/getting-on-with-the-job [Accessed 15 June 2012].

VicSig, 2011. *Melbourne rollingstock*. [Online] Available at: http://www.vicsig.net/index.php?page=suburban&section=rollingstock [Accessed 9 August 2011].

Victorian Auditor General, 1996. *Building Better Cities: A joint government approach to urban development*. Audit. Melbourne: Victorian Audit Office.

Victorian Auditor General, 2010. *Management of major rail projects*. Audit. Melbourne: Victorian Audit Office.

Victorian Government, 2008. *Victorian Transport Plan 2008*. [Online] Available at: http://www.transport.vic.gov.au/research/planning/the-victorian-transport-plan [Accessed 28 November 2011].

Wapling, A., 2011. Melbourne Metro Rail Tunnel – providing confidence through a robust busniess case. In *AusRAIL*. Brisbane, 2011. Aurecon.

Williams, M., 2011. 2016 train services, the transport foundation of the '30 year plan for greater Adelaide'. In *The Institution of Railway Signal Engineers (IRSE), Australian Section Incorporated, Technical Meeting*. Adelaide, 2011. http://www.irse.org.au/knowledge/technical-paper-abstracts/doc_download/751-2016-train-services-the-transport-foundation-for-the-30-year-plan-for-greater-adelaide.

Xu, M., Milthorpe, F. & Tsang, K., 2011. Detailed analysis of the travel patterns of rail users in Sydney. In *ATRF*. Adelaide, 2011. Australasian Transport Research Forum.

www.bitre.gov.au