Australian Government

Department of Infrastructure and Regional Development

Bureau of Infrastructure, Transport and Regional Economics

AUSTRALASIAN RAILWAY ASSOCIATION

STATISTICAL REPORT

Rail

bitre

Trainline 4

Bureau of Infrastructure, Transport and Regional Economics
and
Australasian Railway Association

Trainline 4

Statistical Report

Department of Infrastructure and Regional Development
Canberra, Australia

ISSN: 1440-9569
ISBN: 978-1-925401-97-4
November 2016/INFRA3061

An appropriate citation for this report is:

Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2016, *Trainline 4, Statistical Report,* 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 Regional Development
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 statistical report is a further development of the previous rail freight performance publications series *Trainlines 1–3*. These publications are collaborations between BITRE and the Australasian Railway Association (ARA).

Trainline 4 provides an overview of freight, urban and non-urban passenger rail. The report analyses traffic levels, the provision of infrastructure and rolling stock, and railway performance. *Trainline 4* also has two case studies: one on the newly opened Roy Hill railway in the Pilbara region of Western Australia, and one on rollingstock manufacturing and maintenance in Australia, with a focus on Bombardier and UGL Ltd. The case studies are for informative purposes only, they do not assess or rate the three companies against their competitors, nor do they claim the companies are superior to their competitors.

We acknowledge the assistance of those organisations which (voluntarily) provided data about the Australian railway industry and provided answers to follow up questions. We also acknowledge the assistance and cooperation of Roy Hill Holdings, Bombardier, and UGL Ltd. in the preparation of this edition's case studies.

This report was written by Rodney Avery, with contributions from Peter Kain.

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

Danny Broad
Chief Executive Officer
Australasian Railway Association

November 2016

At a glance

Railway task

- Patronage on all urban heavy and light rail passenger networks grew in 2014–15, including Perth which had experienced a previous minor decline and Melbourne's light rail network. Reported patronage on Sydney's light rail system almost doubled, compared to the previous financial year.
- Sydney continues to have Australia's busiest urban heavy rail passenger network, with approximately 292 million passenger journeys in 2014–15. Nationwide heavy rail urban patronage for 2014–15 was approximately 644 million.
- Based on aggregated 'above rail' provided data, in 2014–15 intermodal and bulk tonnages each grew by 11 per cent respectively compared to the previous financial year. Overall Australian railways carried more than 1.2 billion tonnes of freight. Bulk movements continued to dominate, accounting for approximately 98 per cent of the total rail freight task.
- Operations have commenced on Australia's fourth and newly built 'greenfield' Pilbara iron ore rail operation – Roy Hill Holdings.
- Iron-ore movements in Western Australia accounted for approximately 62 per cent of national rail freight tonnages. The opening of the Roy Hill line may increase this dominance further. Combined bulk movements in Queensland and New South Wales—principally coal—accounted for almost 29 per cent of total tonnages.
- According to 'below rail' provided data, intermodal designated tonnages grew on some sectors of the interstate network while bulk tonnages decreased. This reflects a change in the composition of some intermodal designated trains, where they now carry steel products.
- Management of rail safety is progressively moving to a single national authority. Some of the greatest assessed rail safety risks extend beyond trackside and include (management of) crew fatigue when driving by road to and from rail locations.

Railway networks

- Australia's operational heavy railway network is approximately 33 300 route-kilometres, with approximately 10 per cent of it being electrified. Thirty kilometres of new rail lines were opened in 2016, including the Petrie– Kippa-Ring extension in Queensland and a coal spur line in New South Wales.
- Australia has approximately 291 route kilometres of operational light rail/tramway.

- Melbourne has Australia's largest heavy and light suburban (excluding inter-urban) passenger rail networks at approximately 460 route kilometres and 250 route kilometres, respectively.
- The principal iron ore railways are in Western Australia's Pilbara region (2 642 route kilometres). The principal coal networks are Aurizon's central Queensland systems (1 838 route kilometres) and the New South Wales Hunter Valley Coal network (approximately 785 route kilometres). Grain flows run from agricultural hinterlands to ports and for domestic processing. There are approximately 5 100 route kilometres of operational railway that are largely or exclusively used for grain haulage.

Railway performance

- Assessed frequency of urban heavy rail services in all Australian capital cities that operate urban heavy rail services is largely unchanged compared to the findings in *Trainline 3*.
- Most cities exceeded their urban heavy and light rail punctuality targets, while non-urban (heavy) rail punctuality results were poorer.
- Scheduled intermodal freight train transit times on all corridors are largely unchanged, except for eastbound trains on the Perth-Melbourne corridor, whose average scheduled transit times have increased by six hours, due largely to an 'outlier' train with a long dwell en route, which affects the average.

Contents

List of figures

List of tables

CHAPTER 1

Australia’s railway industry

Trainline is a compendium of Australia’s rail industry. It provides a broad range of data and analysis of the industry[1].

This compendium provides insights and an understanding of the railway industry. Australia’s railways are evolving, with changes both outside and within the industry. These changes include:

Urban patronage. The introduction of frequent urban railway services with high average speeds, good bus, cycling, and parking links to high amenity stations has generated very strong patronage growth in some Australian cities. Of the urban networks, Perth’s patronage has grown at the fastest rate in the last decade.

Resurgence of light rail. In addition to Melbourne’s extensive light rail network, Sydney and the Gold Coast’s light rail networks are expanding, as is patronage on those lines. Early construction has commenced on the ACT’s light rail network.

Regional and inter-urban passenger service. Regional passenger services, specifically in Victoria, have been upgraded both in rollingstock and infrastructure within the last decade leading to a doubling of traffic.

Logistics. Interlinked chains of international and domestic production and distribution have revolutionised the production and consumption of manufactured and processed goods. Logistics systems for bulk commodities have also broadened, such as with containerised grain, ores in containers and barging of bulk commodities from rail heads to Cape-size vessels anchored in deep off-shore waters.

Commodity flows. Australia produces around 40 per cent of the world’s iron ore exports, with virtually all of this being conveyed by railway from mine to port. The East Turner River valley railway corridor in the Pilbara is the world’s third-busiest. The last decade has seen a tripling of these exports, enabled by new and expanded railways. Over the same period, coal exports have risen by 45 per cent, again being enabled by new or expanded railway networks.

Technology. Railway operations have embraced leading-edge technology, such as the world’s heaviest wagon axle loads and development of remotely-controlled iron ore trains, in-cab software that advise drivers on optimal running to maximise efficiency and fuel conservation, and shifts towards predictive and real time maintenance.

The following chapters give an overview and data on railway transport tasks performed; characteristics of the railways and train operators’ rolling stock that runs; aspects of railway performance, including safety, environment and reliability; and two case studies, one on Roy Hill Holding’s Pilbara operations and one on rollingstock manufacturing, design, and maintenance in Australia

1 As a statistical report, the industry analysis does not consider operational, technical or regulatory aspects. Discussion of these aspects can be found in BTRE (2006). Note also, information on railway infrastructure investment levels will be provided in BITRE’s 2016 issue of the *Australian Infrastructure Statistics Yearbook.*

CHAPTER 2
Rail traffic

This chapter presents and profiles the Australian railway industry's principal tasks. It discusses the major freight commodities moved and markets served. It also considers the passenger task—urban, regional, and long-distance.

Overview

The railway industry performs vital freight and passenger transport tasks. Railways excel in transporting large volumes of both freight and passengers. In Australia, this primarily involves moving bulk commodities (for export) and urban passenger transportation.

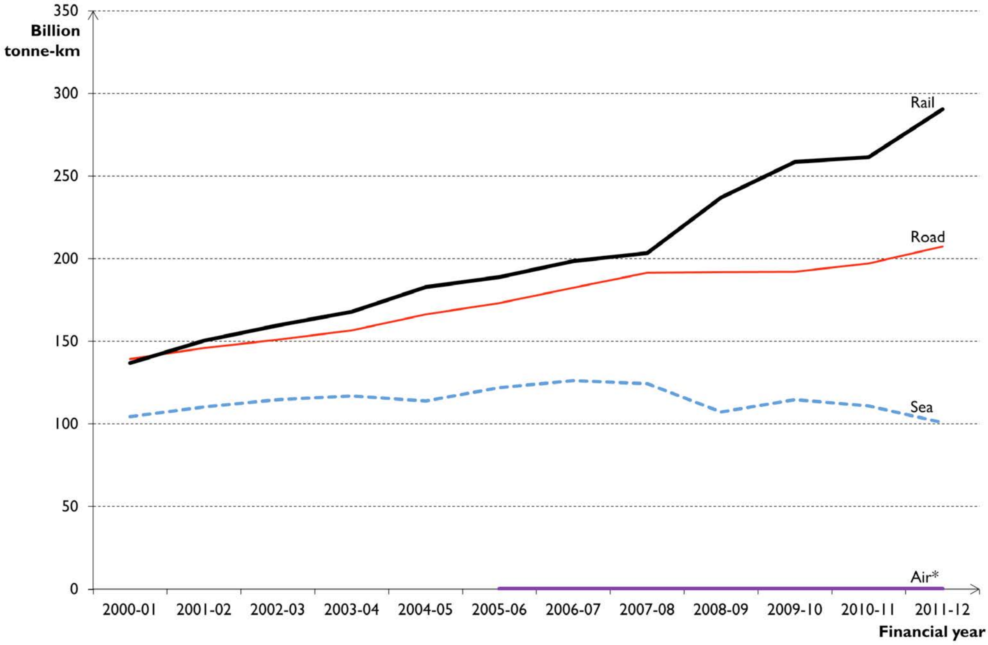
Weekday commuting to central city areas is the key passenger rail task. The surge in rail patronage in Perth since 2006 illustrates the growth in some commuter services (BITRE 2012, p. 55). Similarly, strategic investments in track and trains on some of regional Victoria's railway corridors have brought exceptionally strong patronage growth. (BITRE 2014, p.68)

Rail transport's role in the Australian economy has increased sharply in recent years; see Figure 1. Rail now accounts for almost one-half of Australian freight transport activity, up from approximately 36 per cent at the turn of the century. Rail freight transport's strong position is primarily founded upon the transportation of iron ore and coal to ports for export. These two commodities account for over 80 per cent of Australia's rail freight tonne-kilometres (BITRE 2014a, p.3).

Rail is also often central to moving other bulk commodities, such as grains, sugar, and timber, especially to sea ports. Rail and road compete strongly for long-distance non-bulk freight, but as distances increase rail transport's competitiveness increases. Rail's mode share of non-bulk freight is highest between the eastern states and Perth (the East–West Corridor)[2].

2 BITRE 2009 (*Road and rail freight: competitors or complements?*) assesses the circumstances for rail and road competition, particularly in non-bulk freight. See, also, *Freightline 1* (BITRE 2014a, and other issues in the series) for contextual material on rail and road freight.

Figure 1 Estimated Australian freight volumes by transport mode

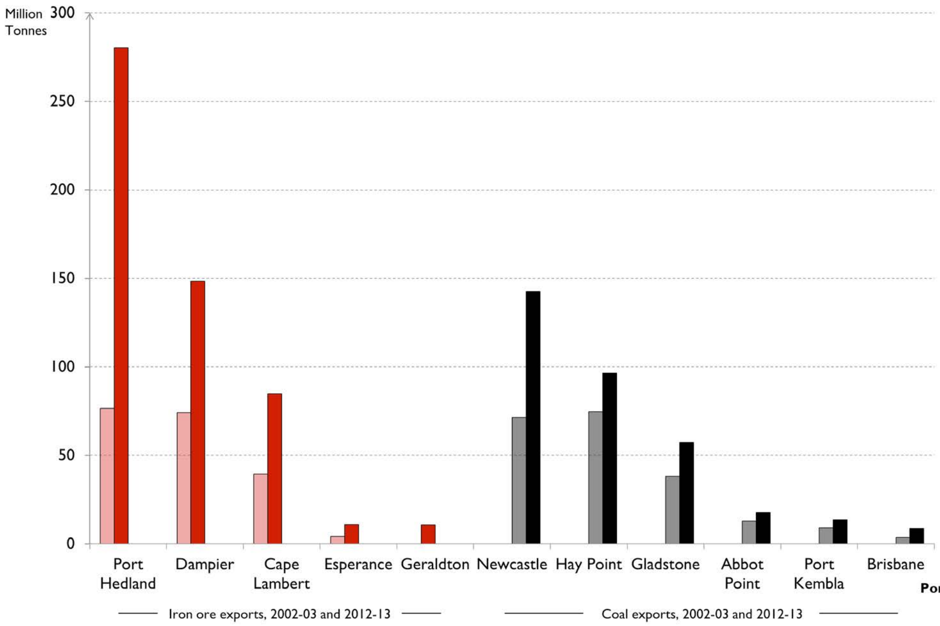


* Not available prior to 2005–06

Source: Figure produced using data from BITRE 2014a, (Table 1, p.2).

As Figure 1 shows, the recovery of rail's freight market share rose sharply, particularly since the 2007–08 financial year. This rise was driven by growth in commodity exports, with three times the volume of iron ore production in 2012 relative to 2002 and black coal production rising by 45 per cent in the decade to 2012–13.

Figure 2 Exports of iron ore and coal from major Australian ports



Source: BITRE 2013, p. 14.

The growth in commodity exports has been achieved through the expansion of ports, terminals, processing, mines and railways. The railways enable Port Hedland to be the world's largest bulk export port. Newcastle is the world's largest coal export port. The East Turner River valley in the Pilbara has the third-busiest rail corridor in the world—it may become the busiest corridor in coming years[3]. The corridor also carries the world's heaviest rail wagon payloads.

Rail's non-bulk freight performance is weaker, but there are strong performing areas. Rail accounts for the majority of inter-capital origin–destination non-bulk freight on the East–West corridor. According to the latest published estimates, rail has approximately 30 per cent market share of non-bulk freight travelling between Brisbane and Melbourne (BITRE 2014a, p.3). Rail also performs a key role in some regional freight flows, mainly between inland terminals and ports. Griffith (New South Wales) to Melbourne is one example.

National rail freight task, tonnes

The estimated total national rail freight task is presented using data provided by above-rail train operators (Table 1) for the 2014–15 financial year. The freight task is measured in tonnes. The figures presented are conventional net tonnes, excluding tare (non-payload) weight of the vehicle. Total tonnages grew, both intermodal and bulk. Based on the above rail operator provided data, all

3 The 653 km Datong–Qinhuangduo railway in China is the busiest freight railway in the world (440 million tonnes), followed by the Union Pacific–BNSF joint railways from the Powder River coal basin in the USA (400 million tonnes in 2011). Unless there is very strong traffic growth on those railways, the additional logistics capacity in the Pilbara will result in the East Turner having the busiest railway corridor in the world.

tonnages – total, intermodal, and bulk grew by 11 per cent. Much of the increase in bulk tonnages was due to increased iron ore tonnages carried – from 727 052 005 to 764 235 855 million tonnes.

The largest rail freight flows in Australia are bulk freight. According to above-rail operator provided data, the total rail freight task was approximately 1.23 billion net tonnes in 2014–15, of which approximately 1.20 billion tonnes (approximately 98 per cent) was bulk freight and 24.27 million tonnes was intermodal freight (See Box 1 for a definition of bulk freight and intermodal freight).

It is important to note tonnage data is not distance-weighted. The intermodal task would be a higher proportion of the total freight task if net tonne-kilometres were measured[4]. This is because the largest intermodal flows travel comparatively long distances; reflecting the market in which intermodal rail is most competitive against road transport.

Table 1 National rail freight task, thousand net tonnes

Year	Bulk	Intermodal	Total
2007–08	642 826	19 519	662 345
2008–09	705 039	17 481	722 520
2009–10	798 763	16 521	815 284
2010–11	–	–	–
2011–12	–	–	–
2012–13	1 012 997	27 559	1 040 556
2013–14	1 089 566	21 891	1 111 457
2014–15	1 210 949	24 272	1 235 221

Notes: Bulk tonnages for the 2013–14 year have been adjusted due to one operator providing a revised estimate.
The table excludes traffic data for some of the smaller train operators, such as Southern Shorthaul Railroad and Sydney Rail Services.
Data for 2010–11 and 2011–12 are not available.

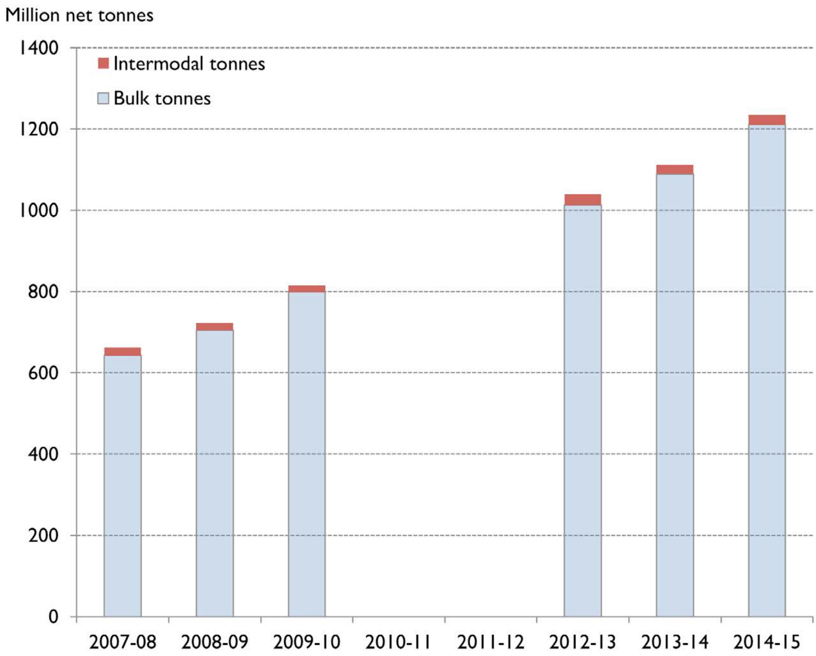
Sources: BITRE estimates; BITRE 2012a; BITRE 2014; BITRE 2015; 2014–15 data was provided by Pacific National, Aurizon, Fortescue Metals Group, BHP Billiton, Rio Tinto, Freightliner, Genesee & Wyoming Australia, SCT Logistics, TasRail, QUBE Holdings, and Watco.

Bulk rail traffic is almost entirely intrastate, although there is some cross border rail traffic from southern New South Wales to Melbourne. The biggest bulk haulage task is in the Pilbara region of Western Australia, which represents approximately 61 per cent of Australia's total rail freight task by tonnages. Other sizeable intrastate bulk flows are in Queensland (approximately 21 per cent of the total rail freight task) and New South Wales (approximately eight per cent of the total rail freight task), where there are large coal movements in both states.

Combined bulk and intermodal rail freight transport has grown since 2007–08 (Figure 3). Most of this growth has been in bulk commodity transport, which itself has been driven by the mining resources sector.

4 In 2009–10, for example, the bulk task accounted for 98 per cent of net tonnes and 89 per cent of net tonne kilometres (BITRE 2012a, p.26).

Figure 3 National rail freight task, 2007–08 to 2014–15



Note: The chart excludes traffic data for some of the smaller train operators, such as Southern Shorthaul Railroad and Sydney Rail Services.

Data for 2010–11 and 2011–12 are not available.

Sources: BITRE 2012a p.29; BITRE 2014 pp 7-8; BITRE 2015, pp 6-7; Data provided by Pacific National, Aurizon, Fortescue Metals Group, BHP Billiton, Rio Tinto, Freightliner, Genesee & Wyoming Australia, Watco, SCT Logistics, TasRail; BITRE estimates.

Trainline uses specific definitions for bulk and non-bulk freight. In principle, 'bulk' freight generally involves large quantities of homogenous product that is conveyed in wagons; non-bulk freight is generally perceived as any containerised or unitised freight, generally placed or lifted into transport holds. However, 'non-bulk' freight is not always containerised. Conversely bulk commodities are often conveyed in containers. In this report, 'bulk' is used to refer to anything not considered 'intermodal', so 'bulk' includes steel, which may, in other contexts, be classified as non-bulk. 'Intermodal' is defined by the classification of train as used for infrastructure charging. Box 1 provides more insight into these definitions.

Box 1 Defining 'intermodal' and other trains

Trainline reports 'intermodal', 'steel' and 'bulk' freight movement statistics. The definition *Trainline* uses for intermodal freight is 'market-based'. Defining the traffic in terms of the market served (such as relatively high priority goods for which road freight is a strong competing mode) can be clearer than when defined in terms of the type of goods (notably, non-bulk) conveyed or the type of wagon used. Where data for 'intermodal' trains is reported, such trains are defined as trains with axle loads up to and including 21 tonnes and a maximum speed of up to 115 kilometres per hour. In terms of ARTC infrastructure charges, intermodal designated trains now include mixed trains that carry both intermodal and steel products. Because these trains carry steel products, they are subject to 80 kilometres per hour speed restrictions. These mixed trains complicate measuring tonnages for ARTC as they weigh whole trains, not components of a train.

Wagon types may not reflect the traditional perception of 'intermodal' as meaning 'more than one mode' and may not reflect a situation where the goods can be readily transferred across modes. 'Intermodal' traffic consists of wagons conveying containers on flat (or well) wagons as well as by louvre (or box) wagons. Further, the goods themselves may be bulk goods (such as grains or hay) as well as non-bulk (such as palletised tinned dog food). However, the type of train operated is unambiguous.

The defining feature of an intermodal train is the infrastructure charge rather than the way the goods are conveyed. 'Container' can be used to define the 'intermodal' activity but it does not convey the market within which rail is competing. For instance, containers can be used to classify goods movements but the goods within the container may include 'bulk' items such as steel, grain or minerals. When compiling data presented in this report, train operators have classified containerised bulk goods trains (such as ores, grains, steel and mineral sands) as bulk.

National freight task, by operator

Some publicly available data can be used to determine national rail freight activity. The two largest rail freight operators, Aurizon and Pacific National (formerly part of the Asciano group that was split into three separate businesses in August 2016), provide quarterly train-operator traffic data[5] to the Australian Stock Exchange (ASX). That material forms the basis of the data presented in Table 2, with more details provided in Appendix C.

5 Aurizon's traffic data here refer to its own train haulages; the company also provides third-party access to its tracks (particularly Pacific National trains), which the company reports through its Aurizon Network subsidiary.

Table 2 ASX train operator traffic trends (billion net tonne-kilometres)

	Pacific National				Aurizon				Combined
Period	Coal	Other bulk	Intermodal (including steel)	Total	Coal	Iron ore	Other bulk and non-bulk	Total	Total
2007–08	12.7	2.8	25.9	41.4	42.8	-	18.4	61.2	102.6
2008–09	13.9	3.6	22.5	40.0	43.5	-	18.5	62.0	102.0
2009–10	18.1	3.4	22.2	43.7	45.3	-	18.9	64.2	107.9
2010–11	18.3	4.0	21.8	44.2	40.9	-	18.9	59.8	104.0
2011–12	20.0	5.6	23.0	48.6	41.9	6.7	14.3	62.9	111.5
2012–13	24.0	6.0	22.7	52.7	43.6	10.3	13.2	67.1	119.8
2013–14	29.2	5.1	21.5	55.8	49.2	12.2	12.5	73.9	129.7
2014–15	30.9	5.1	23.8	59.8	49.1	10.4	12.9	72.4	132.2
2015–16	31.8	4.4	22.4	58.6	49.7	9.6	12.3	71.6	130.2

Note: Data sources and (where published) a breakdown of information into quarters and half-years are presented in Appendix C. Aurizons 'other bulk and non-bulk' totals for the years prior to 2011–12 include iron ore.

The tonne-kilometre data present one perspective of each operator's traffic task. The measure is preferable to tonnes hauled (which can be unrepresentative of the task when short haulage lengths are involved).

Coal continues to dominate for both operators, representing approximately 54 percent of Pacific National's tonne-kilometres and almost 69 percent of Aurizon's tonne-kilometres. When comparing the coal operations, Pacific National hauled approximately 43.5 per cent of the total 2015–16 coal tonnage but just 39 per cent of the total tonne-kilometres. Pacific National dominates coal haulage in the Hunter Valley, where the haulage length to the port (and power stations) is less than the average lengths in the Queensland coal fields, where Aurizon dominates. Pacific National's average coal haulage length in 2015–16 was approximately 201 km, compared to 241 km for Aurizon [6].

Pacific National's steel traffic is incorporated into its intermodal operations. Pacific National hauls steel products across the interstate network, connecting the steel-making facilities in Port Kembla (Bluescope) and Whyalla (Arrium) to the mainland capital cities and the Long Island (Hastings) processing plant. That traffic was 2.8 million tonnes in 2015–16, which is approximately the same as the previous financial year.

Traffic volumes reflect rail's competitiveness with other transport modes (particularly for intermodal traffic) and prevailing economic conditions. Variations in individual commodity flows arise from international demand for commodities as well as train operators winning or losing major contracts.

6 Stock Exchange reports provide the following data for 2015–16: Pacific National's total coal ntk and tonnage were approximately 31.8 billion and 0.158 billion respectively, implying an average haul length of approximately 201 km (ntk is divided by tonnes). Equivalent figures for Aurizon's total coal ntk and tonnages were 49.7 billion and 0.206 billion, respectively, implying an average haul length of approximately 241 km.

Table 3 Train operator traffic trends (TEUs (000))

Period	Pacific National	Aurizon	Combined
2014–15	771.5	372.0	1143.5
2015–16	799.1	372.6	1171.7

Source: Asciano 2016, p.17; Aurizon 2016, p.14.

In addition to measuring freight transport by tonnes and net tonne kilometres, transport by twenty foot equivalent (TEU) units of shipping containers provides another measure. This measure shows freight activity by volume rather than weight. As Table 3, above, shows, Aurizon's TEU measure of traffic remained approximately constant over the two financial years, while Pacific National's grew by approximately 3.5 per cent. Combined TEUs grew by approximately 2.5 per cent.

Box 2 Further freight rail operator traffic data resources

No single data source covers the entire Australian network. Data sources are train operator data, and track/infrastructure manager data.

The principal published train operator data are those presented above (Table 2) for Pacific National and Aurizon. Those sources also provide financial information, including revenue by commodities hauled.

There is limited information on the other freight train operators (Qube Holdings, SCT Logistics [and subsidiary, Specialised Bulk Rail], Queensland Rail, Freightliner Australia, Southern Shorthaul Railroad, Crawfords Freightlines, Glencore Rail, Genesee & Wyoming Australia, Watco and the Pilbara railways [BHP Billiton, Rio Tinto including its Weipa operations, Fortescue[7]). TasRail provides information on tonnages of some commodities that it transports, such as logs and minerals. (TasRail 2015, pp.18–25)

Genesee & Wyoming must file reports with the USA's Securities and Exchange Commission (SEC; see the references for the web link). The filings provide information on revenue and costs for the Australian subsidiary; and insights into traffic trends.

Some one-off studies provide traffic flows data. For example, a Port of Brisbane study (Port of Brisbane, with the Queensland Transport and Logistics Council 2013, pp.31–33) cites intrastate and interstate domestic container rail movements, by direction, whether containers are full or empty, and the origin and destination terminals of the containers.

Figure 64 illustrates the primary railway infrastructure managers. Below-rail data sources from these managers include:

- Aurizon Network's aggregated traffic data and train numbers for each of its five Queensland coal systems, together with other freight and passenger services operating over its network (Aurizon Network 2015 n.d; Aurizon 2015; Aurizon 2015a-d);

7 Fortescue (2014, p.11) illustrates the mining traffic data that can be inferred as being essentially railed ore. The "ore shipped—Fortescue mined ore" tonnage will correspond to ore that has been mined at Fortescue mines; the third-party ore is ore that is shipped via Fortescue's berths at Port Hedland but will have been brought to the port by road.

Box 2 *Further freight rail operator traffic data resources continued*

- ARTC's aggregated Hunter Valley network quarterly coal tonnage throughput (ARTC n.d.);
- ARTC's aggregated annual network tonnages are reported in its annual reports; and
- disaggregated tonnage data for each of Brookfield's lines (Brookfield Rail n.d. and Brookfield Rail n.d.(a); Brookfield Rail 2014 for selected 2013 grain line tonnages).

Traffic data and projections can also be provided to the infrastructure managers' economic regulators, which may then publish that material[8].

While explicit traffic data are not generally available for Pilbara railways or for east coast coal ports, the export iron ore and coal from those ports is generally moved to the ports by rail. Discussion and data sources for each of those ports can be found in *Australia's Bulk Ports* (BITRE 2013). BITRE's *Freightline* series (being published a series of reports) also presents freight flows by commodity. (BITRE 2014(a) and BITRE 2014(b), BITRE 2016) BITRE's forthcoming *Future key commodity freight through Australian ports to 2033–34* will also include relevant information.

An informal source of east-west rail activity at Gheringhap in Victoria is on Graham Elliott's web site: http://ghaploop.railpage.org.au/ and in the BITRE report on that data source. (BTRE 2007)

Interstate network traffic

This section reports interstate traffic flows by line segment based on 'below rail' (track infrastructure manager) provided data. It only includes tonnages on the interstate network that the ARTC and Brookfield Rail manages. Table 4 and Table 5 show intermodal and total gross tonnes by line segment, with line segments ordered from north to south and east to west. Figure 4, Figure 6, Figure 7 and Figure 8 also show the data. There are three factors to note when reviewing the tonnages. Where tonnage does not move along the entire length of a segment, it has been weighted by the proportion of the line segment travelled. Tonnages are calculated as gross. Empty wagons and locomotive weights are therefore included. Coal traffic is excluded. This is because that traffic is not in a form that is amenable to comparison with other commodities. In particular, while coal generally does not move on the interstate network, large coal volumes briefly traverse the network near Newcastle and in the New South Wales Southern Highlands. In those locations, coal tonnages are higher than all other commodities carried.

Interstate intermodal traffic

Table 4 and Table 5 present intermodal and total tonnage levels on line segments of the interstate network.

8 Aurizon's economic regulator is the Queensland Competition Authority (http://www.qca.org.au/Rail); ARTC's is the ACCC (https://www.accc.gov.au/regulated-infrastructure/rail); Brookfield Rail's is the Economic Regulation Authority [WA] (http://www.erawa.com.au/rail/rail-access).

Table 4 Gross tonnes by line segment, North–South corridor

Line segment, by direction of freight	Million gross tonnes					
	Intermodal			Total		
	2012–13	2013–14	2014–15	2012–13	2013–14	2014–15
Acacia Ridge to Casino	1.91	1.84	2.00	2.47	2.38	2.37
Casino to Acacia Ridge	2.25	2.24	2.79	3.57	3.47	3.43
Acacia Ridge – Casino	4.15	4.08	4.79	6.04	5.85	5.80
Casino to Maitland	1.91	1.83	2.03	2.96	2.86	2.86
Maitland to Casino	2.25	2.24	2.80	4.11	4.00	3.97
Casino–Maitland	4.16	4.08	4.83	7.07	6.86	6.82
Macarthur to Tahmoor	2.73	2.66	2.96	6.74	7.22	8.04
Tahmoor to Macarthur	3.26	3.21	3.46	7.84	8.36	10.87
Macarthur–Tahmoor	5.99	5.88	6.42	14.59	15.58	18.92
Tahmoor to Moss Vale	2.74	2.67	2.96	7.51	8.03	8.87
Moss Vale to Tahmoor	3.26	3.22	3.47	10.51	11.19	13.72
Tahmoor – Moss Vale	6.00	5.89	6.44	18.02	19.22	22.59
Moss Vale to Marulan	2.74	2.67	2.96	9.30	9.18	9.64
Marulan to Moss vale	3.26	3.22	3.47	14.72	13.88	15.44
Moss Vale – Marulan	6.00	5.89	6.44	24.02	23.06	25.08
Marulan to Goulburn	2.84	2.74	3.01	8.17	7.85	7.64
Goulburn to Marulan	3.37	3.31	3.53	11.25	9.85	9.40
Marulan–Goulburn	6.20	6.06	6.53	19.42	17.71	17.05
Goulburn to Cootamundra	2.84	2.74	3.01	6.97	6.57	6.31
Cootamundra to Goulburn	3.37	3.32	3.53	10.49	9.04	8.75
Goulburn–Cootamundra	6.20	6.06	6.53	17.46	15.62	15.05
Cootamundra to Junee	2.15	2.07	2.14	7.50	5.80	5.20
Junee to Cootamundra	2.39	2.39	2.29	8.32	6.21	5.76
Cootamundra–Junee	4.55	4.45	4.43	15.82	12.00	10.96
Junee to Albury	2.16	2.07	2.14	7.50	7.06	5.95
Albury to Junee	2.39	2.38	2.29	6.21	6.22	6.01
Junee–Albury	4.45	4.45	4.43	13.70	13.28	11.96
Albury to Tottenham	2.15	2.05	2.12	6.38	6.64	5.68
Tottenham to Albury	2.36	2.34	2.24	4.95	5.13	4.48
Albury–Tottenham	4.51	4.38	4.36	11.32	11.77	10.17

Note: The ARTC has revised its tonnages calculation methodology. As such, tonnages shown for the 2012–13 and 2013–14 financial years are revised and may differ from what was reported in Trainline 3.

Sources: Data provided by ARTC and Brookfield Rail.

Table 5 Gross tonnes by line segment, East–West corridor

Line segment, by direction of freight	Million gross tonnes					
	Intermodal			Total		
	2012–13	2013–14	2014–15	2012–13	2013–14	2014–15
Cootamundra to Parkes	0.72	0.69	0.87	3.21	2.80	2.71
Parkes to Cootamundra	1.01	0.95	1.25	5.91	4.75	4.12
Cootamundra–Parkes	1.72	1.64	2.12	9.12	7.55	6.83
Parkes to Broken Hill	1.72	1.65	1.86	4.31	3.54	3.74
Broken Hill to Parkes	1.32	1.23	1.47	3.02	2.83	3.00
Parkes – Broken Hill	3.04	2.88	3.34	7.33	6.37	6.74
Broken Hill to Crystal Brook	1.71	1.65	1.86	4.03	4.52	4.77
Crystal Brook to Broken Hill	1.29	1.21	1.46	2.87	2.93	3.24
Broken Hill – Crystal Brook	3.01	2.86	3.32	6.90	7.45	8.01
Tottenham to Dimboola	4.13	4.08	3.84	7.10	1.06	5.94
Dimboola to Tottenham	3.44	3.40	3.14	8.57	5.53	6.72
Tottenham–Dimboola	7.57	7.48	6.98	15.67	15.58	12.66
Dimboola to Tailem Bend	4.15	4.09	3.86	5.91	5.72	4.81
Tailem Bend to Dimboola	3.46	3.41	3.16	4.57	4.41	3.84
Dimboola – Tailem Bend	7.61	7.51	7.01	10.48	10.12	8.75
Tailem Bend to Dry Creek	4.18	4.13	3.89	5.98	5.77	4.87
Dry Creek to Tailem Bend	3.48	3.44	3.19	4.61	4.44	3.88
Tailem Bend – Dry Creek	7.67	7.56	7.08	10.59	10.21	8.75
Dry Creek to Crystal Brook	5.09	5.13	5.30	7.81	8.16	7.52
Crystal Brook to Dry Creek	3.88	3.85	4.07	10.64	11.45	9.38
Dry Creek – Crystal Brook	8.98	8.97	9.37	18.46	19.60	16.90
Crystal Brook to Port Augusta	6.82	6.75	6.64	10.02	9.72	8.92
Port Augusta to Crystal Brook	5.18	5.01	5.01	10.93	10.34	8.13
Crystal Brook – Port Augusta	12.00	11.76	11.65	20.95	20.06	17.06
Port Augusta to Tarcoola	6.99	6.93	6.93	9.82	10.46	9.35
Tarcoola to Port Augusta	5.26	5.13	5.07	11.62	14.42	11.28
Port Augusta – Tarcoola	12.25	12.06	12.00	21.43	24.88	20.63
Tarcoola to Kalgoorlie	5.73	5.56	5.58	6.70	6.47	6.28
Kalgoorlie to Tarcoola	4.40	4.26	4.24	5.22	4.93	4.95
Tarcoola – Kalgoorlie	10.13	9.82	9.81	11.92	11.40	11.23
West Kalgoorlie to Koolyanobbing East	5.43	5.10	4.96	11.12	13.73	15.89
Koolyanobbing East to West Kalgoorlie	4.03	3.74	3.61	20.68	21.71	22.12
West Kalgoorlie – Koolyanobbing East	9.46	8.84	8.58	31.80	35.44	38.01
Koolyanobbing East to West Merredin	5.43	5.10	4.96	8.50	11.46	13.39
West Merredin to Koolyanobbing East	4.03	3.74	3.61	6.88	7.53	7.70
Koolyanobbing East – West Merredin	9.46	8.84	8.58	15.38	18.99	21.09
West Merredin to Avon	5.43	5.10	4.96	9.73	13.46	15.75
Avon to West Merredin	4.03	3.74	3.61	7.79	7.79	8.05
West Merredin – Avon	9.46	8.84	8.58	11.60	21.24	23.81

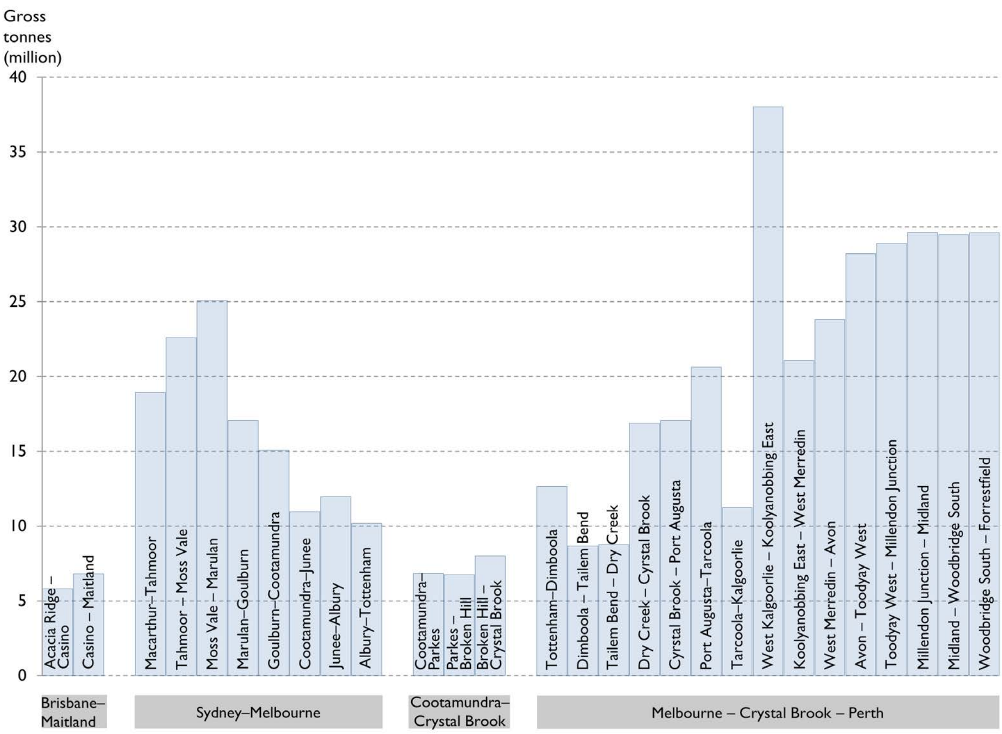
(continued)

Table 5 Gross tonnes by line segment, East–West corridor *(continued)*

Line segment, by direction of freight	Million gross tonnes					
	Intermodal			Total		
	2012–13	2013–14	2014–15	2012–13	2013–14	2014–15
Avon to Toodyay West	5.43	5.10	4.96	14.49	16.70	19.27
Toodyay West to Avon	4.03	3.74	3.61	8.42	8.54	8.93
Avon – Toodyay West	9.46	8.84	8.58	22.91	25.25	28.20
Toodyay West to Millendon Junction	5.43	5.10	4.96	14.94	17.15	19.86
Millendon Junction to Toodyay West	4.03	3.74	3.61	8.56	8.63	9.05
Toodyay West – Milledon Junction	9.46	8.84	8.58	23.51	25.78	28.91
Milledon Junction to Midland	5.43	5.10	4.96	15.38	17.68	20.40
Midland to Millendon Junction	4.03	3.74	3.61	8.69	8.77	9.21
Millendon Junction – Midland	9.46	8.84	8.58	24.07	26.45	29.62
Midland to Woodbridge South	5.44	5.11	4.97	15.31	17.67	20.32
Woodbridge South to Midland	4.04	3.74	3.62	8.61	8.72	9.14
Midland – Woodbridge South	9.48	8.85	8.59	23.92	26.38	29.46
Woodbridge South to Forrestfield	5.44	5.11	4.97	15.38	17.74	20.40
Forrestfield to Woodbridge South	4.05	3.74	3.62	8.68	8.79	9.21
Woodbridge South – Forrestfield	9.48	8.85	8.59	24.06	26.52	29.61

Source: Data provided by ARTC and Brookfield Rail.

Figure 4 Gross tonnes on the interstate network, by line segment, 2014–15



Source: Data provided by ARTC and Brookfield Rail.

The following specific flows explain variations in intermodal traffic:

- Changing intermodal train composition. ARTC provided intermodal tonnages are calculated from intermodal designated trains that operate on its network, not on the actual products each intermodal designated train carries. Some Pacific National intermodal designated trains now carry steel products, differing from the earlier practice where steel products were carried on steel designated trains only. This shift to merged but still intermodal designated trains inflates comparative intermodal tonnages.
- Intermodal traffic on the North–South segment between Sydney (Macarthur) and Cootamundra West includes diverging/converging traffic at Cootamundra West from the East–West Corridor (via Broken Hill).
- Regional intermodal traffic (exports heading for the Port of Melbourne) joins the network at Junee from terminals in the Riverina district and at Ettamogah (Albury), as well as traffic from Junee to Sydney.
- Changes in some regional intermodal traffic flows from Junee, whereby they now travel to Sydney instead of Melbourne.
- Some intermodal rail traffic originates/terminates in terminals at Parkes/Goobang for the East–West Corridor (via Broken Hill). SCT Logistics, for example, operates one intermodal train a week each direction between Goobang and Perth.
- Intermodal traffic flows between Melbourne and western Victoria (originally at Horsham but subsequently Dooen).
- Higher intermodal traffic volumes west of Crystal Brook, where the separate Melbourne/Adelaide and Sydney/Parkes flows merge. Intermodal flows fall to the west of Tarcoola; the junction with the Darwin line.

Further discussion on some of these intermodal flows can be found in the section on maritime container flows.

According to ARTC's data, when comparing 2014–15 to the previous financial year, intermodal tonnages on parts of the North-South corridor appear to have increased but this is due to the merging of some intermodal and steel trains into combined but still intermodal designated trains, whose tonnages ARTC's calculations capture due to the intermodal designation of those trains.

Between Cootamundra West and Crystal Brook, intermodal tonnages increased by 18 per cent. This increase is partially due to the two Adelaide-Brisbane (and return) trains per week that now travel via Parkes, Broken Hill and Crystal Brook instead of the previous route via Melbourne. While this route change was noted in Trainline 3, according to the ARTC the full flow on effects of the route change is reflected in the 2014–15 financial year calculations.

Between Tottenham and Dry Creek (Adelaide) intermodal tonnages decreased by 6.5 per cent but increased by 4.5 per cent between Dry Creek and Crystal Brook. The re-routing of the Adelaide-Brisbane trains may partially explain these changes. Poorer economic conditions in Perth following the end of the construction phase of the state's mining boom may explain the declines on other segments of the east-west corridors.

Figure 5 Combined intermodal-steel train consist

Note: The image above shows an intermodal designated Pacific National Melbourne-Wollongong train at Chiltern in Victoria. While the train is intermodal designated, it consists of intermodal and steel product freight. The steel can be seen at the rear of the train.

Source: Photo courtesy of Rodney Avery.

"Other" traffic on the interstate network

There are significant non-intermodal freight flows, classified as "other" in Figure 6, Figure 7 and Figure 8. Steel is moved along the length of the East–West corridor between New South Wales (Newcastle and Port Kembla) and South Australia and Western Australia (Port Augusta, Whyalla and Perth). There are also steel movements on the North–South corridor, primarily between Port Kembla and the interstate capitals.

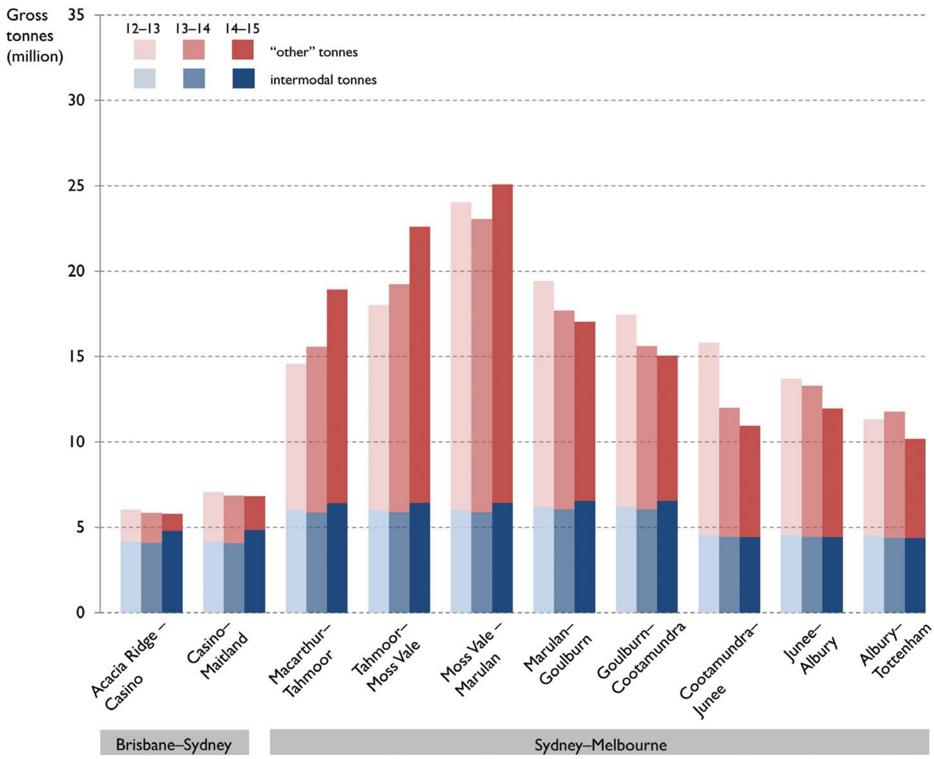
Other significant non-intermodal freight flows are as follows:

- **Grain movements**[9] generally join the network from a web of branch and secondary lines, connecting agricultural hinterlands to the port. Movements on the interstate network are heaviest close to Perth and in New South Wales.
- **Aggregate, sand and limestone** quarries in the southern New South Wales Tablelands are an important contributor to tonnages between Macarthur and Goulburn. The exhaustion of quarries in Western Sydney has resulted in expansion of mining activity in the Southern Tablelands.
- **Iron Ore** from Mount Walton and the Yilgarn Region in Western Australia contributes a major proportion of tonnages hauled on the West Kalgoorlie – Forrestfield line segment. Iron ore is railed in two directions. It moves east from Koolyanobbing, via Kalgoorlie, to Esperance Port. It also moves west from the Mount Walton mine to Kwinana. According to advice from Brookfield Rail, there was an increase in iron ore train pathways utilised, which contributed to increased 'other' tonnages between West Kalgoorlie and Forrestfield.

9 Grain can also be transported in containers. When this is the case, grain is classified as intermodal.

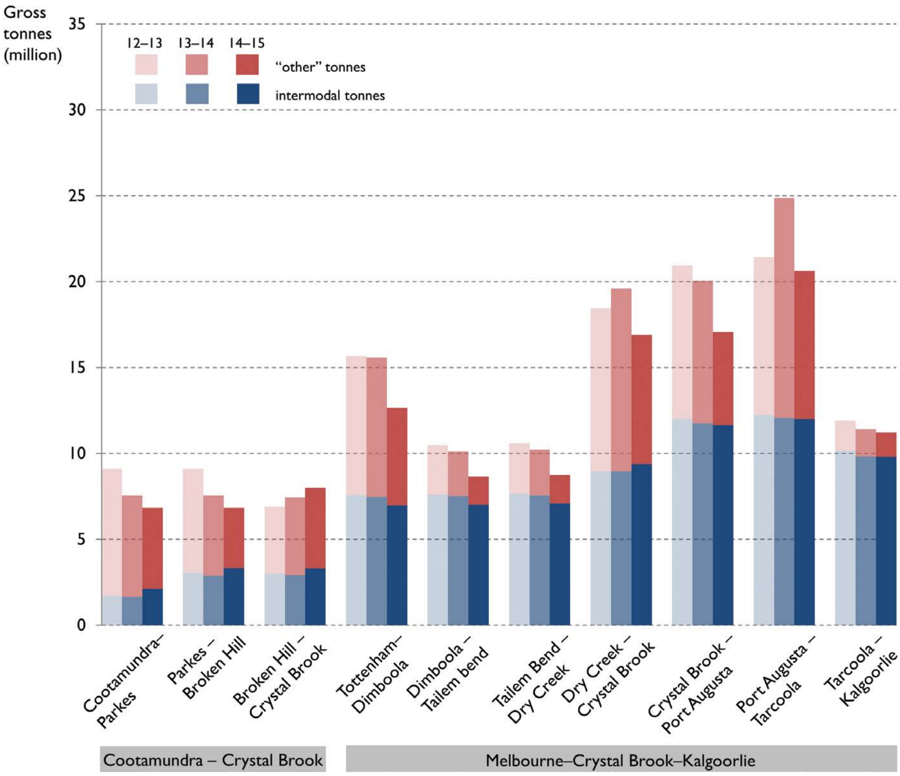
- **Port Augusta-Tarcoola** traffic flows also rose sharply over the three financial year periods. According to the ARTC, this increase was due to Arrium iron ore traffic that entered the ARTC network at Tarcoola and proceeded to Whyalla.
- **'Other'** tonnages declined in most, but not all sectors in 2014/15 compared to the previous financial year. According to advice from the ARTC, these declines can be attributed to the shift of much of the steel tonnages from the 'other' category to intermodal (where tonnages have correspondingly increased) and reduced grain freight in western Victoria, which affects 'other' tonnages between Tottenham and Dimboola.

Figure 6 Gross tonnage on the North–South corridor, by line segment, 2012–13 to 2014–15



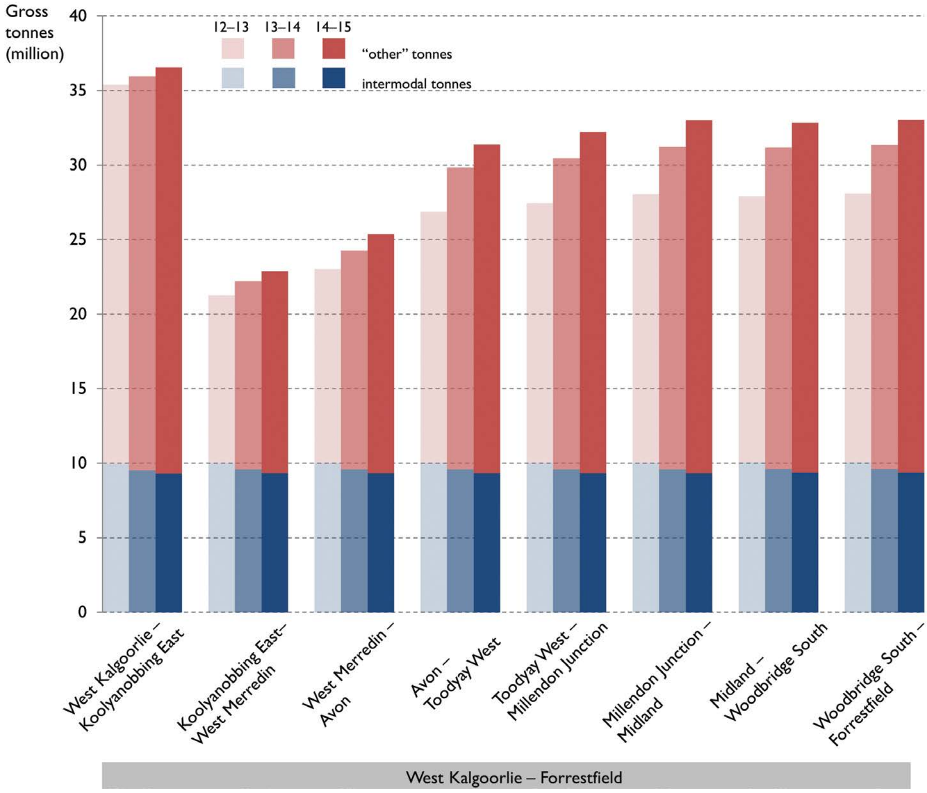
Source: Data provided by ARTC.

Figure 7 Gross tonnage on the East–West corridor, by line segment, 2012–13 to 2014–15



Source: Data provided by ARTC.

Figure 8 Gross tonnage on the East–West corridor, by line segment, 2012–13 to 2014–15

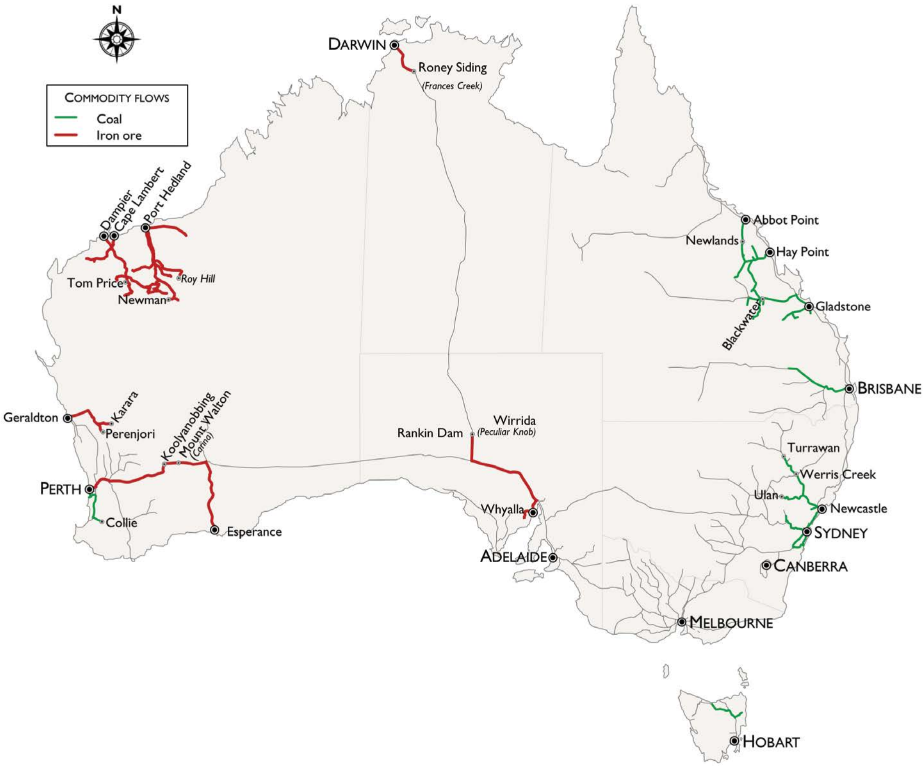


Source: Data provided by Brookfield Rail.

Rail freight traffic, by commodity

This section analyses rail freight traffic by commodity or market. Iron ore, coal, grain and non-bulk freight traffic are analysed. Iron ore and coal are the rail industry's two largest bulk freight flows.

Figure 9 Principal iron ore and coal flows, 2016



Iron ore traffic

The majority of Australia's iron ore is exported[10] almost all of which is transported to port by rail[11]. The largest flows are in the Pilbara region of Western Australia, which accounts for over 94 per cent of Australia's iron ore exports (BITRE, 2014b). The integrated railways of the Pilbara region, by infrastructure owner (Figure 10), are:

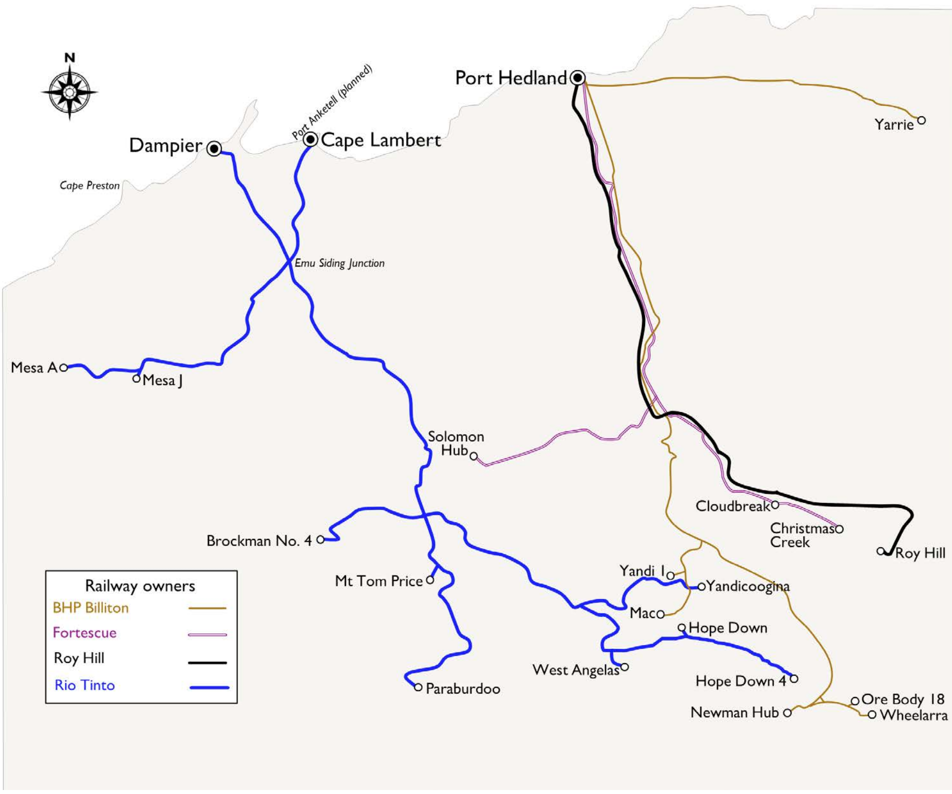
- **Rio Tinto:** The Robe River to Cape Lambert and the former Hamersley Iron's network to Port Dampier. As of 2012, trains on the Hamersley railway were approximately 2.4 kilometres long and had a capacity of 26 000 tonnes (BITRE 2013, p.31).

10 There are two domestic manufacturers of steel, Arrium and BlueScope Steel, with a blast furnace in each of Whyalla and Port Kembla, respectively. Between them they used approximately 6.5 million tonnes of iron ore in 2011–12. Arrium sources its iron ore mostly from the Middleback Ranges in South Australia. BlueScope Steel uses iron ore from Mount Newman (Western Australia) and Savage River (Tasmania) See BITRE 2014b.

11 Rail has an estimated 86 per cent of the domestic iron ore freight task, with road having an estimated 2 per cent. Where iron ore is used in domestic manufacturing, coastal shipping is used to shift iron ore between ports (representing an estimated 12 per cent of the domestic iron ore freight task). See BITRE 2014b.

- **BHP Billiton:** The Goldsworthy line (to Yarrie) and the Newman line run to Port Hedland. Each train on the Newman line can carry approximately 37 000 tonnes (BITRE 2013, p.27). The Goldsworthy (to Yarrie) line ceased operations 2014 but remains mothballed.
- **Fortescue Metals Group:** The Fortescue Hamersley line from Solomon Hub and the Christmas Creek line run to Port Hedland. Trains on these lines can haul approximately 33 000 tonnes each (BITRE 2013, p.27).
- **Roy Hill Holdings:** The recently opened 344 route kilometre railway from Roy Hill to Port Hedland. These trains typically haul 232 ore cars, with a payload of more than 32 000 tonnes of ore. Rail operations started in December 2015.

Figure 10 Pilbara iron ore railways, by infrastructure owner, 2016



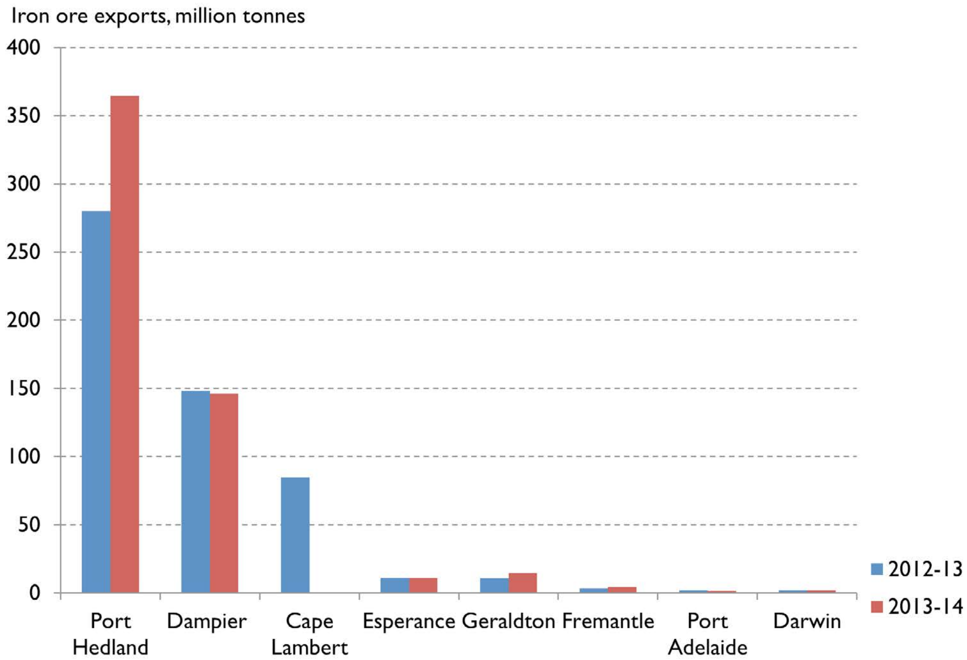
The scale of the task means rail is the most efficient means for transporting iron ore from mine to port. Tonnages exported, by principal port, provide an indicator of tonnages hauled by the iron ore railways. See Table 6, and Figure 2 (p.5).

Table 6 Iron ore exports, million tonnes, 2013–14

Port Hedland	Dampier	Cape Lambert (Port Walcott)	Esperance	Geraldton	Fremantle (Perth)	Port Adelaide	Darwin
364.3	146.1	N/A	11.2	14.3	4.5	1.5	1.8

Figure 11, below, shows a comparison of iron ore exports between the latest available reporting periods.

Figure 11 Iron ore exports by financial year



Note: Cape Lambert iron ore facilities lie within the administrative area of Port Walcott. The data for Port Walcott is not available for the reporting period. The 2013–14 is the latest period for which data is available.

Sources: Ports Australia 2015, Ports Australia 2014, BITRE 2014c.

Coal traffic

Similar to iron ore, rail is the best transport option from mine to port. Most of Australia's coal is extracted in Queensland and New South Wales. Queensland coal is predominantly metallurgical (used in steel-making) while the New South Wales coal is predominantly thermal (typically used in electricity generation)[12].

12 Further overview of coal attributes is provided in BITRE 2013 (p.9).

Figure 12 Pacific National Hunter Valley Coal Train

Note: The image above shows a Pacific National Hunter Valley coal train.
Source: Photo courtesy of Pacific National.

Australia's principal rail coal haulage is from these two states—see Figure 9. The Central Queensland Coal Network, using narrow gauge track, is managed by Aurizon and is divided into five coal systems. The ARTC largely manages the New South Wales standard-gauge Hunter Valley system. The systems are:

- **Newlands (Queensland).** This system runs through the northern end of the Bowen Basin, to the port at Abbot Point. The line services mines at Collinsville, Sonoma, and Newlands. It was recently linked to the Goonyella Rail Corridor (Aurizon 2015). The Newlands System now also includes the Goonyella to Abbot Point (GAP) link between the Newlands and Goonyella Systems, enabling coal to be delivered to either south to Mackay ports or north to Abbot Point. Up to now, all GAP coal traffic has only travelled north to Abbot Point.
- **Goonyella (Queensland).** Goonyella is an electrified system that also services the Bowen Basin coal region. It primarily serves the terminals at Hay Point and Dalrymple Bay. (Aurizon 2015a). The maximum train load is 10 000 tonnes, with a 2 100 metre maximum train length (BITRE 2013, p.53).
- **Blackwater (Queensland).** This system services the Bowen Basin coal region. It delivers coal to the export terminals at the Port of Gladstone. It also services domestic users such as the Stanwell and Gladstone power stations, Cement Australia and Comalco refinery (Aurizon 2015b). The system consists of mostly electrified duplicated lines that extend west from Rockhampton.

- **Moura (Queensland).** This system is approximately 242 route kilometres and services the Boundary Hill, Dawson, Callide, and Baralaba mines. It is single track with passing loops and is linked to the Gladstone power stations, Comalco refinery, Queensland Alumina Limited, Cement Australia and the R G Tanna and Barney Point coal terminals at the Port of Gladstone (Aurizon 2015c). The average train payload servicing the two coal terminals at the Port of Gladstone, is approximately 4 200 tonnes. (BITRE 2013, p.63)
- **Hunter Valley (New South Wales).** Coal is transported to three coal-loading terminals in Newcastle. The previous average for coal trains was between 6 000 and 7 000 tonnes each (BITRE 2013, p.42). According to the ARTC, however, the current average is approximately 8 000 tonnes, as part of the Hunter Valley Strategy. In 2016, the Idemitsu coal mine at Boggabri opened its rail spur connection to the Hunter Valley Network. This means the mine now sends its coal to the port of Newcastle by rail, in place of its previous reliance on road transport.

Table 7 Major systems coal traffic, Queensland and New South Wales 2015–16

	Queensland				NSW
	Blackwater	Goonyella	Moura	Newlands	Hunter Valley
Net tonnes (m)	64.13	61.75	12.05	28.10	159.5
Net tonne-kilometres (b)	22.62	25.08	1.96	7.30	n/a

Note: Queensland tonnages include both Aurizon and Pacific National. The Newlands system total includes GAP.
Hunter Valley tonnages are also available through the web site of the Hunter Valley Coal Chain Coordinator (https://www.hvccc.com.au/DailyPlanning/Pages/SummaryPerformanceReports.aspx)

Sources: Aurizon 2016a p.9, ARTC n.d. (multiple issues).

In addition to the major coal systems, other significant railway coal tonnages include haulages from:

- the West Moreton coal fields in southern Queensland (with approximately 8.1 million tonnes hauled by Aurizon in 2013–14), using Queensland Rail infrastructure (BITRE 2015);
- the Southern mine region at Wongawilli Colliery, New South Wales;
- the Metropolitan Colliery, near Helensburgh, New South Wales;
- the Tahmoor colliery, near Picton, New South Wales;
- the Western coal region, near Lithgow, New South Wales; and
- Fingal, in Tasmania, by TasRail.

Aurizon and Pacific National dominate coal haulage, with involvement also by Freightliner Australia and Southern Shorthaul Railroad[13]. Aurizon is the main coal train operator in Queensland. In the Hunter Valley in New South Wales, it has approximately 25 per cent market share[14].

In 2014, Pacific National estimated that it undertook around 72 per cent of the South Eastern Australia coal haulage (Asciano 2014, p.27). It also hauls coal in Queensland and the company estimates that it has 30 per cent of the coal haulage market measured by net-tonne-kilometres in the state (Asciano 2014, p.27). Pacific National has not published a revised update since 2014.

13 Freightliner Australia operate coal trains in the Hunter Valley on behalf of Glencore; Southern Shorthaul Railroad operate coal trains in New South Wales on behalf of Centennial Coal.

14 Aurizon provides fact sheets of each coal system in which it operates—see http://www.aurizon.com.au/ourservices/coal.

Table 8 shows the tonnes and net-tonne kilometres hauled by the two main operators in 2014–15 and 2015–16.

Table 8 Coal haulage by principal train operators

	Aurizon		Pacific National	
	2014–15	2015–16	2014–15	2015–16
Tonnes (million)	211.2	206.8	162.8	158.8
Net tonne kilometres (billion)	49.2	49.7	30.9	31.8

Sources: Asciano 2016, p.17; Aurizon 2016, p.14; BITRE 2015, p.23.

Approximately 90 per cent of coal extracted in Queensland and 73 per cent in New South Wales is exported. Coal extracted in Tasmania is used domestically. Table 9 shows the most recent data of coal tonnages exported.

Table 9 Coal exports, by principal ports, (million tonnes), 2013–14

Newcastle	Hay Point	Gladstone	Abbot Point	Port Kembla	Brisbane
155.5	108.3	69.6	22.9	13.3	8.1

Source: Ports Australia, 2014a.

Box 3 Further resources

BITRE (2013, *Australia's bulk ports*) includes a profile of the major coal ports as well as the landside logistics and production processes between the mine and the port facilities. Each port profile provides relevant material for additional landside traffic data and rail/terminal handling performances.

BITRE (2016, *Freightline 4—Australian coal freight transport*) provides information on Australian coal transport supply chains and freight movements in 2014–15.

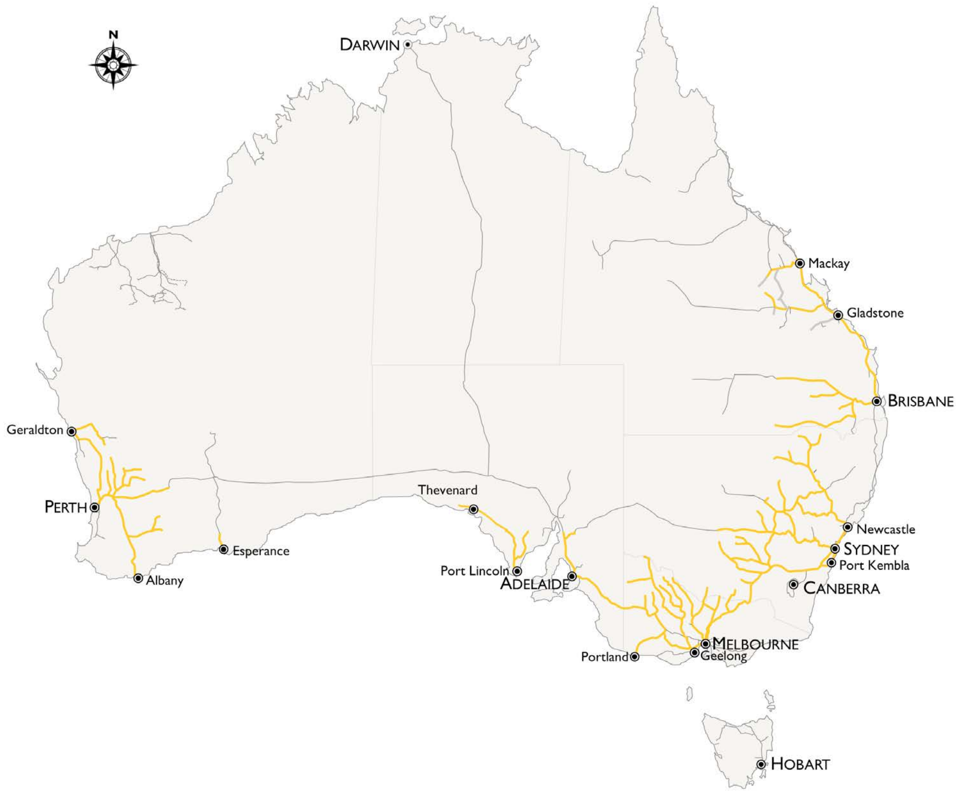
BITRE (forthcoming, *Future key commodity freight through Australian ports to 2033–34*) includes forecasts of coal movements through ports.

Grain traffic

A major role for Australia's railways is hauling agricultural produce from rural areas to ports for export and, to a lesser extent, domestic consumption. Grain harvests are primarily cereal grains, but also pulses, chickpeas, oilseed and oats. Average annual grain production between the years 2010–15 (wheat, coarse grains, pulses and oilseeds) was 45 million tonnes, 33 per cent more than average annual production levels for 2005–10. Approximately 73 per cent of the harvest over the five years 2010–15 was exported (Grain Growers 2016, p.2) According to the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), approximately 85 per cent of Australian wheat produced in 2012–13 was exported, at a value of $6.3 billion. (ABARES 2015, pp.4, 13)

Figure 13 shows grain flows by rail. This traffic largely uses branch lines which are dedicated to grain haulage, which connect with main lines. In September 2016, there was an estimated 5 100 route-kilometres of operational railway track that was largely or exclusively provided for grain haulage.

Figure 13 Australian grain railway flows



Notes: The railway network referred to here uses a broad definition that is based around cereals, such as soft and hard grains, but also including other agricultural food products such as pulses (or "legumes") and chickpeas. (or "chick peas") Traditional soft grains include barley, oats, rye and soft white wheat; hard grains include sorghum/millet, durum wheat, hard white wheat and spelt. Pulses include lentils. Rice and oilseed are also included.

The map shows grain flows along the railway lines that are designated as operating in September 2015. Some railways—notably in south-west Western Australia and in central New South Wales—are not shown, having been classified as closed to traffic.

As discussed in BITRE 2013 (pp.109–10), eighteen major ports regularly export grain[15].

Rail has traditionally dominated grain transport over long distances, while road transport becomes more competitive over shorter distances, as illustrated in Table 10. Australian wheat that is exported is most likely to travel by rail from receival sites in the hinterland to the seaports. (ABARES 2015, p.13)

15 These rail ports are, in decreasing order of 2011–12 grain exports, Fremantle, Albany, Geraldton, Melbourne, Newcastle, Esperance, Port Adelaide, Port Lincoln, Port Kembla, Geelong, Brisbane, Portland, Port Giles, Sydney, Wallaroo, Gladstone, Mackay, Thevenard. See BITRE 2013, p.110. Note, also, the opening in 2014 of a bulk grain export facility at Bunbury (without rail connection) and a new grain terminal in Newcastle (Newcastle Agri-Terminal).

Table 10 Rail market characteristics, by State

	Queensland	NSW	Victoria	SA	WA
Median bin distance to port (km)	303	412	273	130	207
Rail's mode share to port	46	85	53	50	60

Note: The South Australian include the two Mallee lines in South Australia that are currently non-operational but not closed.

Sources: Australian Export Grains Innovation Centre 2014 (p.17) See also rail and road receivals at WA ports, presented in ACIL Tasman (2009, pp.18–19).

AEGIC (2014, p.33) illustrates the rail transport costs for wheat, by state and grain handling company, within the overall export logistics supply chain. For a 200 km rail haul, these represent around one-third of the post-farm-gate prices through to the export vessel. As a major supply chain cost, therefore, the choice of mode can play a major role in the overall costs.

By way of comparison, according to the AEGIC, more than 95 percent of export grain transport in Canada, a key Australian competitor, is moved by rail, but transport distances are considerably longer (typically 1300–1800 kilometres). Most Canadian grain is exported through two ports in British Columbia. In contrast, Australia has more grain handling ports and grain growing areas are closer to the coast which translates to shorter transport distances (approximately 100–400 kilometres) and which degrades rail's advantage over road[16].

Grain traffic trends

While rail transport has offered a traditional advantage to the bulk transport of grain over long distances, with the advantage growing as tonne kilometres grow, and depending on topography[17], this advantage is not absolute and has been partially eroded by other factors that have improved road transport's competitiveness[18]. These include:

- Poor track infrastructure, which reduces rail's efficiency due to lighter maximum loads and slower speeds and, in some cases, upgrade costs that are not viable;
- Improved roads and road transport services;
- Increased containerisation of grain at the expense of the use of rail hoppers;
- Changes to the logistics flow, such as the introduction of fewer but larger grain storage facilities;
- Deregulation of grain export marketing, which has seen smaller shipments of grain being moved on diverse pathways for a broader range of bulk handlers and export marketers;
- Rail industry restructuring, funding and ownership changes; and
- Increased domestic grain consumption of wheat produced in New South Wales, for which road transport is better suited.

Despite the increased competition of road transport, the ARTC has increased maximum grain train axle loads from 19 tonnes to 23 tonnages and increased maximum train lengths from 850 metres to 1000 metres on the 100 kilometre Narrabri-Moree line in north western

16 For more information, see The puck stops here! Canada challenges Australia's grain supply chains, (AEGIC, 2015)
17 Most wheat producing areas in New South Wales are west of the Great Dividing Range, while the main ports through which grain is exported is Newcastle and Port Kembla. Rail transport is more suited to moving the product over the Range to the ports. (ABARES, 2015, pp.15–16)
18 *Trainline 3* discusses in detail these changes and challenges to grain transport by rail. (See BITRE, 2015)

New South Wales as part of a six-month trial that commenced in May 2016, with the aim of reducing grain handlers' transport costs. This followed a 12-month review and risk assessment process that included the running of Australia's largest grain train in December 2015. (Track and Signal, July–September 2016, p.30)

According to ABARES, export by containerisation is more prevalent in Australia's eastern states than Western Australia because there is a greater supply of empty shipping containers for (discounted) 'back filling', it is more suited for niche market grain varieties (of which the eastern states produce more than Western Australia), and some destination ports are not equipped for bulk handling. (ABARES, 2015, pp.13–14).

Despite the challenges to rail's grain transport competitiveness, the Victorian government is investing in its north western rail network. The investment, known as the Murray Basin Rail Project, is aimed at mode shift from road to rail, including grain transport. Central to the project will be conversion of the rail network from broad to standard gauge and increasing axle loads to 21-tonnes. Gauge standardisation will boost port access for the Murray Basin rail network. Post gauge standardisation, trains originating from the Murray Basin will also have direct access to the deep sea Port of Portland which has standard gauge access only, in addition to the Port of Geelong, which has both broad and standard gauge access[19]. The option of two ports is anticipated to stimulate competition between the two ports and the deeper water at Portland means rail freight originating from the Murray Basin region can be exported on larger bulk carriers. Work has commenced on the project.

Box 4 Further reading on railway grain handling

Overviews:

- A comprehensive overview of (essentially-cereal) grain flows can be found in the report *The cost of Australia's bulk grain export supply chains.* An information paper; and its Postscript Version 2014.1; both documents were published by the Australian Export Grains Innovation Centre.
- A review of trends in containerised grain exports can be found in the article written by Mark Fitzgerald "Container exports open market opportunities", (*Grain Business,* July 2014).

Queensland reports:

- Transport, Housing and Local Government Committee (Queensland), *Rail freight use by the agriculture and livestock industries,* Report No. 45.
- Port of Brisbane 2013, *Import/export logistics chain study. Summary report.* This study presents a snapshot of railed grain through the Port of Brisbane, with rail heads at Thallon, The Gums, Meandarra, Miles, Talwood, Dalby West and Malu being cited. The railed tonnage of wheat (86 per cent by rail), sorghum (13 per cent by rail) and pulse (1 per cent by rail) are presented; maize and cottonseed do not move by rail. (p.30)

19 For more information, see Public Transport Victoria 2015.

New South Wales reports:

- *New South Wales Grain Freight Review* (by Department of Infrastructure, Transport, Regional Development and Local Government, 2009). The report assesses the case for retention and investment in grain railways.
- Independent Pricing and Regulatory Tribunal (IPART) 2012, *Review of access pricing on the NSW grain line network. Transport—Final report.* The report includes 2010–11 forecast volumes by grain branch line, which provides some indication of grain volumes by line (pp.10–11).
- Pollard 2012, "Moving NSW wheat: the post deregulation experience", *Railway Digest,* presents a review of the logistics changes to wheat haulage in New South Wales.

Victorian reports:

- Department of Infrastructure (Victoria) 2007, *Victorian rail freight network review.*
- Department of Transport 2011, Grain logistics taskforce report, and Victorian Government response to Grain Logistics Taskforce Report. November 2012,

South Australian reports:

- Department of Transport & Urban Planning 2003, *Eyre Peninsula grain transport. Summary report.* The report considers the case for the retention (and joint-funding by interested parties) of grain railways on Eyre Peninsula.

West Australian reports:

- Strategic Design and Development 2009, Report prepared for Freight and Logistics Council of WA on behalf of the Strategic Grain Network Committee,
- Department of Infrastructure, Transport, Regional Development and Local Government 2009, *WA grain freight review*.
- Economics and Industry Standing Committee, Western Australia Parliament Legislative Assembly 2014, *Inquiry into the management of Western Australia's freight rail network.* This inquiry considered a range of aspects of the lease of rail infrastructure.

National reports:

- House of Representatives Standing Committee on Transport and Regional Services 2007, *Inquiry into the integration of regional rail and road networks and their interface with ports.*
- ABARES 2015, *Australia's what supply chains Infrastructure issues and implications.* This report assesses Australian grain transport infrastructure modalities and challenges, including the comparative benefits of rail and road transport, port access constraints, and the fitness of rail and road networks to manage grain transport. The report mainly focuses on a comparison of Western Australia and New South Wales.

Non-bulk and short-haul rail freight traffic

Non-bulk and short-haul (a distance that is shorter than that which intermodal rail transport is usually considered viable) rail freight movements are mostly containerised, although SCT Logistics, (for example) typically uses louvre wagons for their palletised traffic.

(See Box 1 for further discussion of defining non-bulk rail freight.) Short-haul traffic is often considered to be uncompetitive with road freight, due to the relative short distances over which the freight is moved, however, it can be successful. To succeed, short-haul rail traffic needs:

- minimised road drayage costs between the hinterland and intermodal terminal;
- low line haul and high road haul costs; and
- a convergence of parties who encourage short haul and viable hinterland terminals (BITRE 2016a, pp v-vi)[20].

Apart from rail container movements between domestic intermodal terminals, rail services also undertake maritime tasks (for import, export and Bass Strait traffic) that can be classified as follows:

- Landbridge movements, from one port to another. Container movements from around Hobart, to the Port of Burnie (for export or transfers to and from the mainland), and between Adelaide and the Port of Melbourne are primary examples.
- Regional export movements, from inland terminals to the port. This traffic includes agricultural commodities, such as sugar, cotton, grains, livestock, and logs.
- Urban import and export movements. These are short-haul container movements, linking the port terminal with urban logistics centres (where boxes are de-stuffed, stored or distributed to local businesses around the terminals). Empty containers are also shifted by these local rail services.
- Export maritime activities are generally based around single commodities and/or a single company's logistics-based hub.

The following discussion focuses on port rail flows to or from capital cities and urban shuttles, while noting other, non-capital city flows can operate. (An examples is Mt Isa – Townsville.)

Rail (and road) volumes of containers through the primary capital city ports are presented in BITRE's regular *Waterline* series. (BITRE 2014d, tables 1.1–1.6, includes TEU[21] rail volumes through the ports for each of those cities.)

Landbridge and regional movements

The maps that follow show the long-distance maritime railway services linking city ports.

Port of Brisbane—Fisherman Islands

Figure 14 presents the rail container flows between Queensland intermodal terminals and the Port of Brisbane (Fisherman Islands).

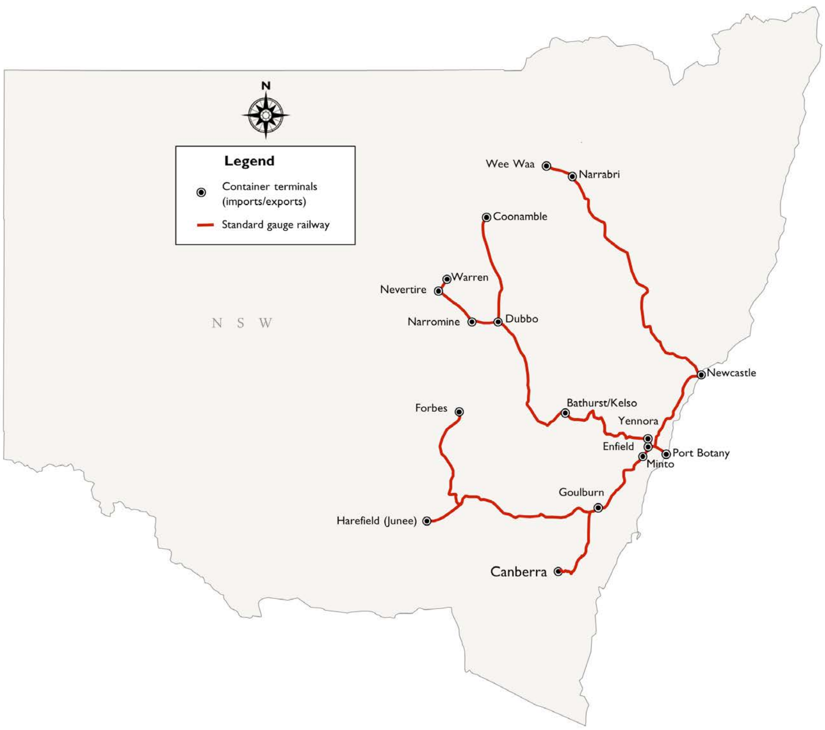
20 BITRE 2016a (Why short-haul intermodal rail services succeed), provides an in depth discussion on the (potential) viability of short-haul rail transport in Australia.
21 TEU: Twenty-foot equivalent unit.

Figure 14 Rail container operations serving the Port of Brisbane (Fisherman Islands)

The Port of Brisbane used to manage export traffic, including seasonal cotton, from Dalby and Goondiwindi, but this ceased in late 2009 and September 2014 respectively. This was due to the inability of rail to transport anything higher than 8'6" high containers due to the Toowoomba Range tunnel profile. This made rail transport from these centres unviable and the traffic has switched to road transport. According to an 18 August 2016 Queensland government media statement, Queensland Rail is investing $32.4 million in the Toowoomba Range Clearance Upgrade project, which will increase clearances to accommodate 9'6" containers. Containers are still moved to/from northern destinations to the Port of Brisbane.

Sydney Ports—Port Botany

Figure 15 Rail container operations serving Sydney Ports—Port Botany



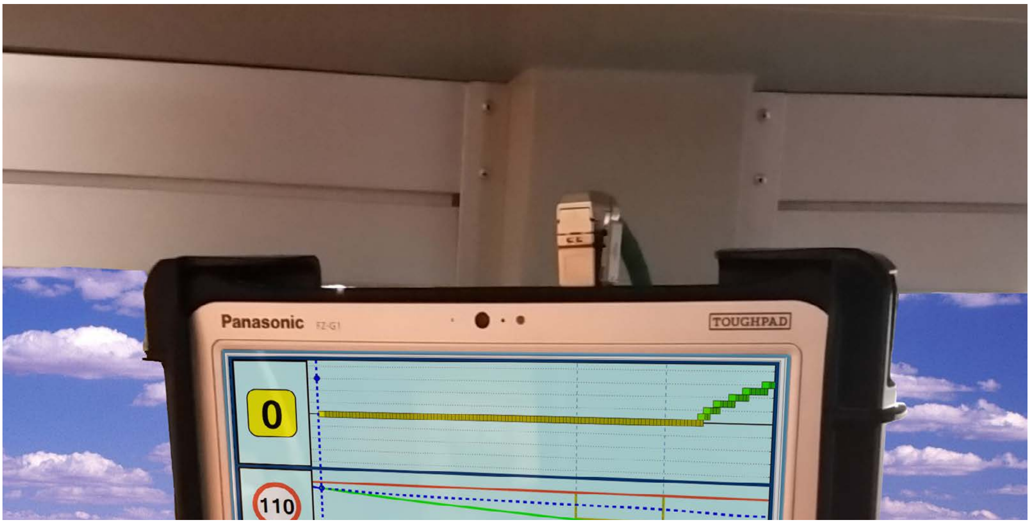
Regional services are based on export container traffic, with train movements to the hinterland conveying empty boxes for filling. Rail moves a range of containerised commodities, primarily agricultural, to Port Botany. These commodities include:

- specialised grain, conveyed from Forbes, Narrabri, Dubbo, Coonamble and Narromine;
- Qube Holding's intermodal terminal at Harefield (near Junee) ships containerised grain and cardboard (from Visy's plant at Tumut);
- chick peas from Narrabri;
- cotton from Warren, Nevertire, Wee Waa and Narrabri;
- logs from Bathurst/Kelso and Newcastle (Sandgate);
- logs from Goulburn to Port Botany and Port Kembla (commenced in 2016);
- refrigerated meat from Dubbo;
- aluminium ingots and various agricultural produce from Newcastle; and
- scrap metal from Canberra (currently suspended, pending the opening of a new Canberra terminal).

Port of Melbourne

The major regional container export flows through the Port of Melbourne are shown in Figure 16. Rail container flows through the port that originate or are destined for Tasmania are not shown. It is possible some of the Bass Strait traffic moves by rail along the North–South rail corridor.

Figure 16 Rail container operations serving the Port of Melbourne



The non-urban movements can be categorised into landbridge, western and eastern Victoria flows, and southern New South Wales flows.

Landbridging. There is a landbridge movement of containers between Adelaide and the Port of Melbourne. Some of the trains operate to the stevedore rail sidings at the dock (notably, to Patrick's Appleton Dock) while other train movements are to South Dynon intermodal terminal (with the containers then being conveyed to the stevedore container stacks by road vehicles). In recent years there has been a shift from hubbing Adelaide's container movements through Melbourne (for direct sailings to and from foreign-destination ports) to shipping through Adelaide with hubbing in Singapore (in particular). As a result, there are fewer landbridge trains.

Intrastate Victoria. These are:

- Wakefield Transport, at Merbein (Mildura), with logistics operations in a range of containerised agricultural and mining exports;
- Westvic Container Export Services, at Warrnambool, with agricultural and other diverse export (and domestic) traffic;
- Wimmera Container Line, at Dooen (near Horsham), especially with grain exports (for Wimmera Grain Company);
- Containerised paper is shifted to Qube Holding's Victoria Dock in the Port of Melbourne from Maryvale in the Latrobe Valley;
- Milk products from Mooroopna (Shepparton), hauled by Qube Holdings; and
- Faba beans, chick peas and other pulses from Donald, hauled by Pacific National.

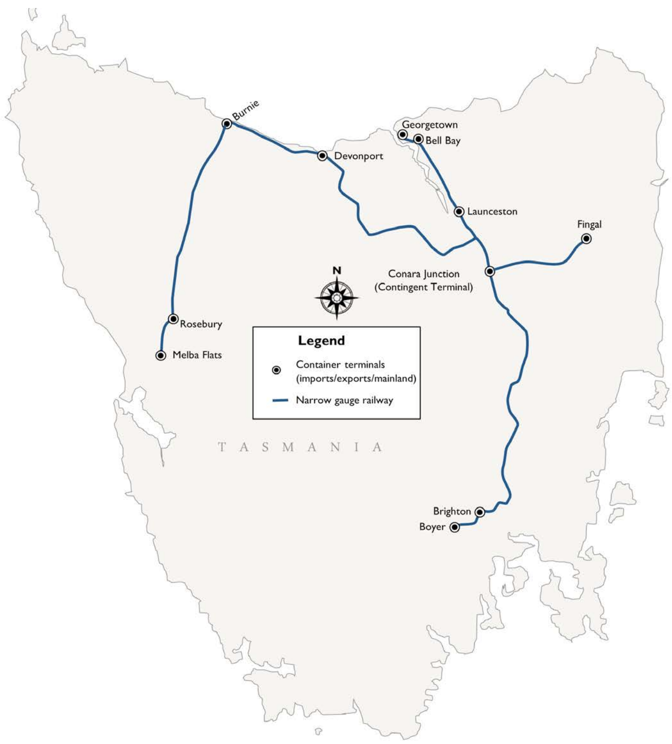
Southern New South Wales. Export flows to the Port of Melbourne, including:

- containerised rice from Deniliquin;
- containerised grains (such as wheat, barley, sorghum) from Tocumwal; and
- containerised wine for export from Griffith and Leeton (including the Wumbulgal terminal near Griffith that opened in June 2015); and
- inbound and outbound products through Ettamogah Rail Hub (near Albury), including products of the Mars Petcare company.

Tasmania

Tasmania has a growing freight system, with a new terminal opened at Georgetown (Belly Bay) in September 2015 and the Devonport terminal re-opened in March 2015. In early 2016, as part of a tripartite infrastructure optimisation project between TasRail, TasPorts and the Toll Group, work to upgrade the Burnie Freight Terminal was completed. The upgrade has provided multiple rail roads and a new container hardstand. This facility compliments the already existing bulk handling, storage and export facility. The Conara Junction terminal was re-opened in May 2015 as a contingent terminal only.

Figure 17 Rail container operations serving Tasmanian ports



Rail traffic terminals in Tasmania include:

- George Town: A multi modal-terminal with container storage area handling containerised general freight, metal ingots and bulk log freight;
- Devonport: A freight terminal handling containerised general freight;
- Burnie: An upgraded multi-modal freight terminal, which handles containerised general freight, bulk metal concentrates, paper products, and metal ingots;
- Launceston: A freight terminal handling containerised general freight;
- Brighton: A multi-modal freight terminal with container hardstand and storage area that handles containerised general freight, bulk log freight, and metal ingots; and
- Conara Junction: A contingent freight terminal handling bauxite and containerised general freight.

TasRail also hauls zinc ingots, containerised metal concentrate, bulk cement, coal, sugar, recycled metal, glass bottles, fish food, fertiliser, construction materials, consumer goods, groceries and aluminium ingots.

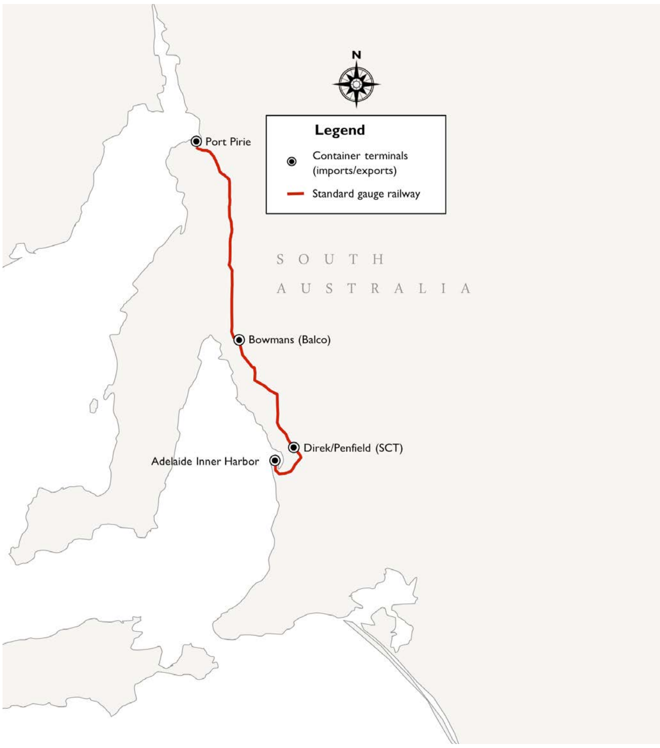
Figure 18 Rail container operations in Tasmania

Note: The image above shows a TasRail general container service heading northbound at Tea Tree on the South Line.
Source: Photo courtesy of TasRail.

Port Adelaide—Outer Harbor

There are regional maritime container traffic flows to Inner Harbor (Port Adelaide)—see Figure 19. While purpose-built containers are also used for haulage of mineral sands (such as from Kanandah, near Broken Hill, to Port Flat), these movements lie outside this analysis.

Figure 19 Rail container operations serving Port Adelaide—Inner Harbor



Regional trains operate between the Bowmans Intermodal Terminal (operated by Balco Australia) and Outer Harbor. The terminal is used for the export of agricultural products such as oaten hay, grain and pulses, seed, wine and pork bellies. The terminal also handles imported containerised bait tuna. The facility is also used as a consolidation point for a range of commodities, a task that would otherwise be done at the port. The terminal is served by rail services that convey containers to both Outer Harbor and the Port of Melbourne. Some Bowmans container trains also serve the Nyrstar lead smelter at Port Pirie. Containerised lead is collected for export through Outer Harbor.

Port of Fremantle—Inner Harbour

Figure 20 Rail container operations serving Kwinana

The primary regional container export flows are lead from Leonora and nickel products from a nickel smelter south of Kalgoorlie.

Short-haul urban maritime container movements

Short-haul urban shuttle trains provide a rail link from sea ports to surrounding intermodal (distribution) centres. These services are advantageous by virtue of the fact they reduce road congestion into and out of the ports and connecting arterial roads. There are several flows of short-haul urban maritime container movements. These are:

- Yennora – Port Botany (approximately 40 km, Figure 15);
- Minto – Port Botany (approximately 55 km, Figure 15);
- Enfield – Port Botany (approximately 18 kilometres, Figure 15);
- Direk/Penfield – Outer Harbor, Port Adelaide (approximately 25 km, Figure 19);
- Altona-West Swanston Dock (approximately 24 kilometres); and
- Kewdale/Forrestfield – Fremantle (Inner Harbour) (approximately 24 km, Figure 20).

In July 2016, partners DP World and SCT Logistics commenced weekly port shuttle trains following a previous trial of the service (*Railway Digest,* September 2016, p.26). Salta Properties also opened an intermodal terminal with rail infrastructure at Altona in Melbourne in May 2014. There is an intention to operate shuttle trains between the terminal and the Port of Melbourne, along with shuttle trains between Somerton and Dandenong South to the Port of Melbourne but this has been shelved until the Victorian government leases the Port of Melbourne (*The Age,* 2015) (Figure 16).

The Yennora and Minto operations handle imports and exports. The terminals conduct logistics activities for imported goods, including storage, consolidation and deconsolidation, and onwards road distribution to nearby warehouses. Exports include empty container transfers to the port.

On 30 August 2016 Aurizon started running freight shuttles between its leased Enfield intermodal facility in western Sydney and the Port of Botany, concurrently with it signing a five-year contract with K&S Freighters to move up to 20 000 TEU per annum. According to advice from Aurizon, K&S Freighters will be a foundation customer for the shuttle service, which moves imported goods from the port to Enfield. Aurizon will consequently lengthen its trains (within permitted limits) and increase double stacking on its east-west services in fulfilment of its contract. Aurizon currently operates six services per week but expects this to increase. (*Railway Gazette,* 31 August 2016)

The short-haul movement between the SCT Logistics terminal at Direk (Penfield) and Outer Harbor involves the export of wine.

The Western Australian Government subsidises container movement shuttle trains between intermodal facilities at Forrestfield/Kewdale and the Inner Harbour at Fremantle. SCT Logistics operates the train services on behalf of Intermodal Link Services (a part of the Intermodal Group). These operate between the Forrestfield Intermodal Terminal and the North Quay Rail Terminal at the port. Two trains of up to 600 metres operate daily in each direction. Goods are transferred from international and coastal shipping and include bulk goods, food and beverages, and construction equipment.

Box 5 Further resources on non-bulk freight activity

There is a range of regular and one-off studies that can facilitate understanding port-rail freight flows. The ongoing and recent publications include:

BITRE's *Waterline* series presents quarterly data on rail traffic volumes through the mainland State capital city ports (where traffic is measured in TEU, Twenty-foot Equivalent Unit containers).

Each *Waterline* issue also presents port maps, which show principal rail lines within port precincts and summarises each of the regional and short-haul rail services operating between the hinterland and the port (BITRE 2014d, Appendix A).

Fremantle Ports publish longer-run data on rail TEU volumes through the Fremantle Ports (2014, p.5). Fremantle Ports (2012) analyses rail and road TEU movements between the hinterland and the port.

Port of Brisbane provides survey data on rail and road container movements through the port. This is summarised (Port of Brisbane 2013, pp.10, 26).

Port of Melbourne, et. al., (2010), provides survey data on hinterland container freight task (presented in the number of TEU) through the Port of Melbourne (pp.48, 74–75, 102).

Rail TEU traffic volumes are reported by the Sydney Ports Corporation in its annual report, as part of its "Port Botany Landside Improvement Strategy" (See, for example, p.28, of Sydney Ports Corporation 2013).

Monthly and annual rail (and road) volumes through Port Botany are presented in chart format on the NSW Ports website (NSW Ports 2016).

Urban rail passenger traffic

Each of the mainland state capital cities operate urban passenger rail services. These services enable the mass movement of passengers to and from capital city centres. Urban passenger rail services provide an alternative to private cars which minimises road congestion. These services also provide transport for those without cars.

Table 11 Urban rail patronage, 2014–15[a]

	Brisbane[b]	Sydney[c]	Melbourne[d]	Adelaide	Perth	Gold Coast
Patronage – heavy rail	51.6	291.9	227.5	10.9	64.2	
Patronage – light rail		6.1	182.1	8.9		6.28

Notes: a Methodologies for calculating patronage vary between cities.

b Brisbane does not include the seperately administered Airtrain line.

c According to the data source (see below), Sydney data from 2013–14 onwards is for Sydney Trains patronage only. There are two urban heavy rail operators in Sydney: Sydney Trains and NSW TrainLink, both of which were formed on 1 July 2013. Sydney Trains is the main operator, while TrainLink provides additional express services using interurban trains that stop at a small number of Sydney suburban stations ('shared stations'). The following example illustrates. A patron travelling from Parramatta to Sydney Central can board either a Sydney Trains train, or a TrainLink train from Lithgow. The TrainLink train would be more attractive as it operates mostly express to Sydney Central. Future reporting may be able to include the TrainLink component of urban heavy rail patronage following the replacement of paper tickets with Opal cards.

d Melbourne's light rail patronage includes the CBD free travel zone which commenced on 1 January 2015. Patronage data are those reported by operators. For some cities, data differ to those reported in BITRE 2014e. This is because BITRE 2014e adjusts data where necessary to allow comparison across networks.

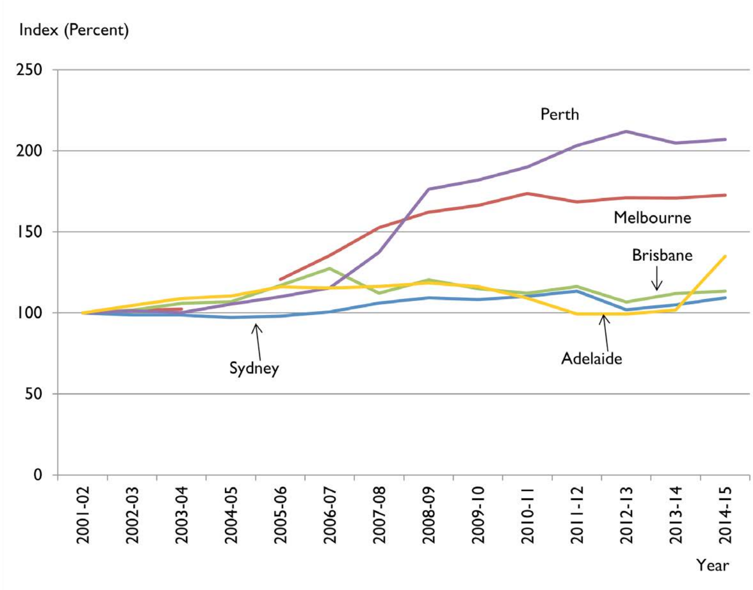
Sources: Public Transport Authority of Western Australia 2015 p.48; Public Transport Victoria 2015a p.26; Department of Planning, Transport and Infrastructure 2015, p.79; Queensland Rail 2015, p.31; Data provided by Sydney Trains.

Figure 21 shows, urban passenger traffic in Perth grew strongly over the last decade but declined in 2013–14. In 2014–15, however, overall patronage increased again, by 1.2 per cent. According to advice from Transperth, the previous decline occurred with full fare paying passengers. The Joondalup line experienced the strongest growth, at 1.2 per cent, while the 'heritage' lines of Armadale and Fremantle experienced declines of 1.2 per cent and 0.7 per cent respectively. Patronage on the Mandurah line grew by 0.2 per cent. Growth on the Joondalup line may be due to the 2014 Clarkson-Butler extension and urban growth between Joondalup and Butler.[22] (Public Transport Authority of Western Australia, 2015)

Metro Trains Melbourne has revised downwards its 2013–14 patronage figures to 225.7 million. Based on this revision, its 2014–15 patronage grew slightly – to 227.5 million. Melbourne's light rail patronage also grew slightly, after a previous decline, but it includes free travel in the CBD zone, which began on 1 January 2015.

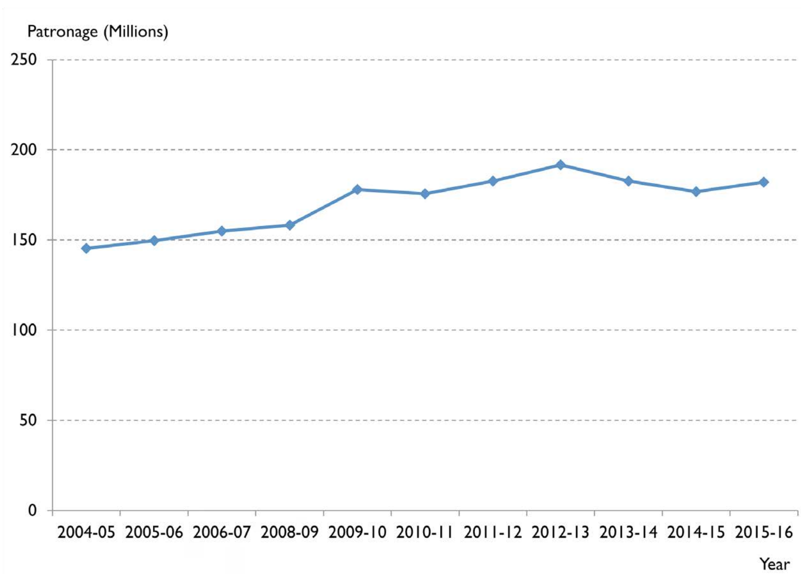
22 While the line continues beyond Joondalup and now terminates at Butler, the line is still referred to as Joondalup.

Figure 21 Index of urban heavy railway patronage in Australian cities



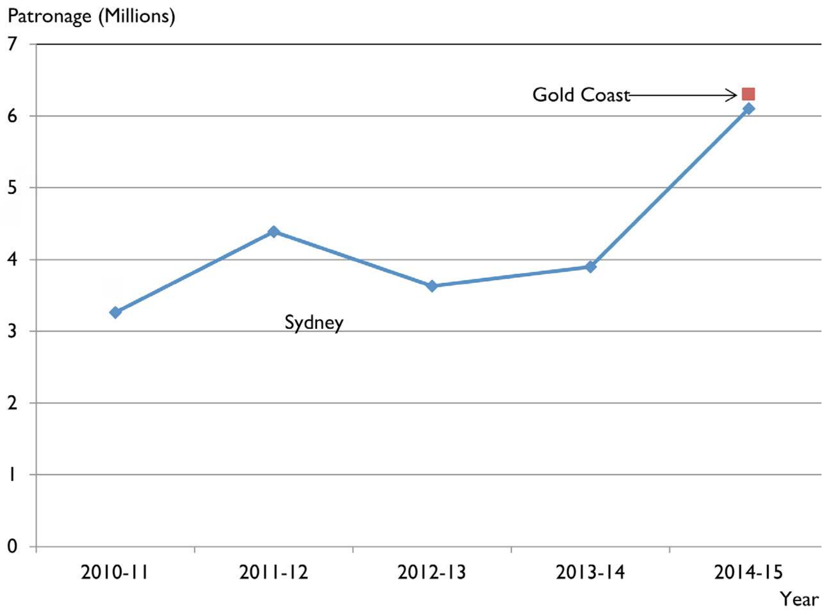
Sources: Index based on patronage data from: BITRE 2012; Public Transport Victoria 2015a p.26; Public Transport Authority of Western Australia 2015 p.44; Department of Planning, Transport and Infrastructure 2015 p.79; Queensland Rail 2015 p.31; Transport for NSW 2015, p.33.

Figure 22 Melbourne light rail patronage



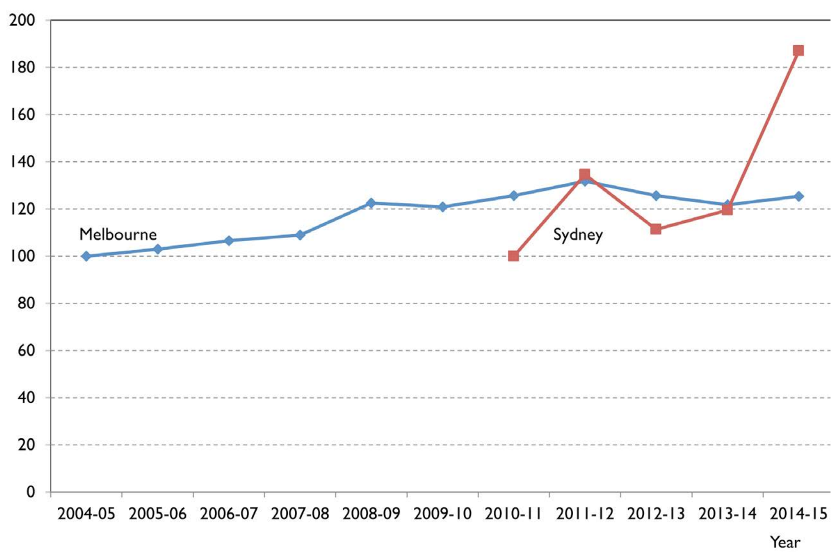
Sources: Public Transport Victoria 2015a p.27.

Figure 23 Sydney and Gold Coast light rail patronage



Sources: Transport for NSW 2015, p.36; Department of Transport and Main Roads 2015, p.195.

Figure 24 Index of light rail patronage Melbourne and Sydney



Note: The index does not include Adelaide due to a patronage methodology change by the South Australian Department of Planning, Transport and Infrastructure, which would not show a 'like for like' comparison. It does not include the Gold Coast because 2014–15 is the base index year from which future calculations will be made.

Source: Public Transport Victoria 2015a p.27; Transport for NSW 2015 p.36..

National (external) and local (network-specific) factors explain heavy and light rail patronage trends. The former includes economic activity (influencing employment and disposable income) and fuel prices. The fuel price influence can be seen in the 2006–2008 period when fuel prices increased significantly. Conversely, an increase in disposable income and decrease in the cost of motor vehicles ownership and operation may encourage a degree of switching away from public transport. Another factor that affects mode choice is the non-financial relative generalised cost of rail travel. This cost includes quality of service, in-vehicle travel times, network scale and the standards of rollingstock and other infrastructure amenity.

Specific local factors that will have some bearing on the city travel trends are as follows:

Brisbane. Fares increased by 15 per cent per annum from January 2010. The annual fare increases were halved to 7.5 per cent for January 2013 and 2014 (Translink 2012, p.68). Correspondingly, patronage declined sharply from 2011–12, although it is beyond the scope of this publication to assess whether demand decreased because of the fare increases, investments in other transport modes, such as busways, both or combinations of known and unknown variables. The new electronic stored-value "Go Card" was introduced at that time and included cheaper off-peak travel discounts. In 2015 it was decided to keep fares at the 2014 level for the year.

Sydney experienced strong population and employment growth between the census years 2001 and 2006. However, that growth was strongest in outer areas, where radially-focused public transport offers a weaker alternative to car transport (BITRE 2012, p.18). The growth in these areas was accompanied by significant expansions in the road network, with the M5 East Freeway and Westlink M7 opening in 2001 and 2005, respectively (BITRE 2012b, p.296).

Melbourne. The strongest rate of patronage growth in Melbourne was between 2005–06 and 2008–09. Figure 21 shows the heavy rail trend and Figure 22 shows light rail. This growth corresponded with a rapid growth in employment in inner Melbourne during those periods[23]. Being serviced by relatively good heavy and light-rail (and other public transport modes), further inner Melbourne employment growth may encourage public transport patronage. Note, the 2006 figures exclude Commonwealth Games patronage.

Adelaide's heavy rail patronage has continued to increase following previous declines that occurred during the period of infrastructure enhancement and the Rail Revitalisation Programme renewal works. The works required extended periods of line closures from 2008. Patronage is expected to increase once the Seaford, Tonsley and Belair lines become fully operational. According to the South Australian Department of Planning, Transport and Infrastructure annual reports, light rail patronage almost doubled in the last financial year. According to advice from the Department, however, reporting of free travel has historically only included Seniors free travel, however given advances in technology that now enable more accurate data capture, all free travel has been included in the reporting for 2014–15. Free travel includes, but is not limited to, travel within the Adelaide CBD, and transport for special events such as new year's eve. It is therefore not feasible to make comparisons to previous years.

Perth. Much of the surge in Perth's patronage in 2006–07 reflects the opening of the Mandurah line. The two new lines built from central Perth to Butler and Mandurah provide relatively

23 Between 2006 and 2008, the City of Melbourne Local Government Area (LGA) gained 50 400 jobs. That employment growth represents seven per cent per annum, compared with 3 per cent per annum growth experienced from 2002–2006 (BITRE 2011, p.122).

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 rail systems.

Unlike the other Australian capital cities with urban heavy rail services, Transperth, the city's urban rail service provider, charges for car parking at its stations. The current fee is $2.00 per day. Patrons can pay for parking seamlessly when arriving at the station using their SmartRider cards or by cash at vending machines. While this pay parking may be seen as a disincentive for rail travel, it can be argued that it encourages rail travel as the daily fee is low, particularly in comparison to parking fees in the Perth CBD, and it discourages non-travellers from using the car parks, which in turn maximises available car parking spaces for train travellers.

Commuting traffic

Urban passenger rail services are largely aligned to service weekday commuter demand to and from city centres. The task is strongly skewed to morning and afternoon peak period travel. In each of the five cities discussed, rail has a higher mode-share for peak period commuting than at other periods, particularly for home–CBD travel; see Table 12. In Sydney, rail has the highest journey-to-work mode share for city-centre commuting, where around 46 per cent of workers use the train (Mees and Dodson 2011, p.7). However, despite the relatively high employment density of city centres, most jobs are located outside each centre. Thus, because rail offers poorer accessibility in non-CBD areas, its overall journey-to-work mode shares are relatively low (Table 12).

Table 12 Urban rail journey-to-work mode shares, 2011

	Brisbane	Sydney	Melbourne	Adelaide	Perth
Heavy rail (%)	7.6	16.0	11.7	2.5	7.7
Light rail (%)	–	0.1	3.6	0.5	–

Notes: Cities refer to greater metropolitan areas. For the 2011 census, ABS replaced its previous geographical definition system, the Australian Standard Geographical Classification, with the Australian Statistical Geography Standard. This led to some changes in the boundaries of greater metropolitan areas.

Mode shares defined as persons who caught a train/tram for all or part of their journey to work. Calculations exclude census respondents who did not specify travel mode, worked at home or did not go to work.

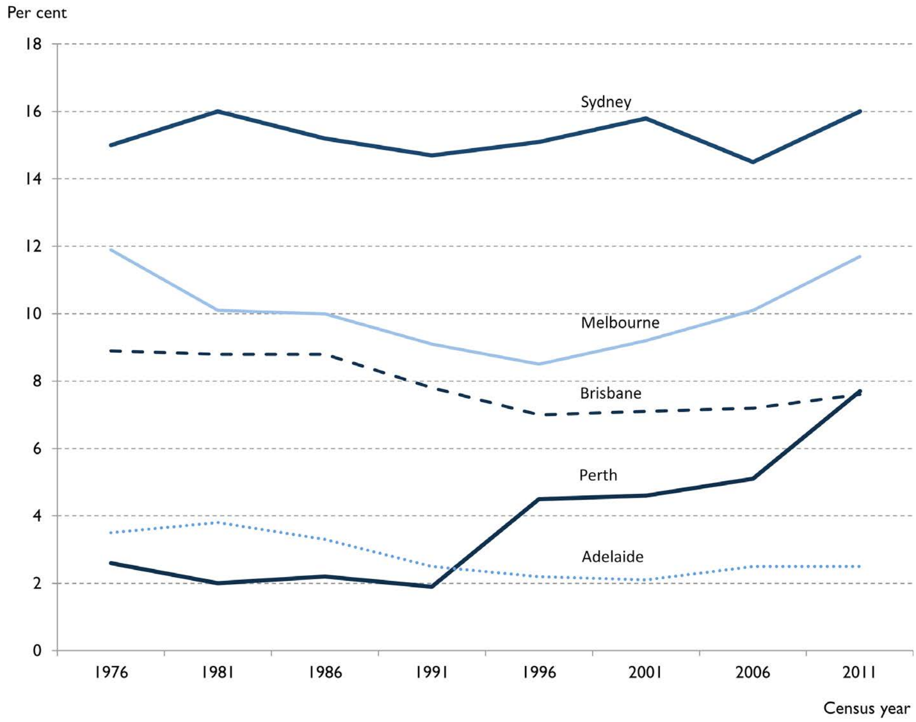
Tram/light rail census data includes respondents who: caught a tram/light rail; caught a train and tram/light rail; caught a bus and tram/light rail. The tram/light rail data is therefore an underestimate because it does not include all possibilities, for example, car and tram/light rail.

Source: ABS 2011.

Following long-term declines in urban rail patronage for all cities from the mid-1970s, ridership began recovering in the 1990s.[24] Figure 25 shows the journey-to-work mode share data for heavy rail, derived from the census, since 1976. The journey to work data from 2001 closely resembles total patronage trends over the last decade (Figure 21).

24 For an analysis of public transport mode share trends, see Mees & Groenhart, 2012.

Figure 25 Journey-to-work mode share, urban heavy rail



Note: Cities refer to greater metropolitan areas. For the 2011 census, ABS replaced its previous geographical definition system, the Australian Standard Geographical Classification, with the Australian Statistical Geography Standard. This led to some changes in the boundaries of greater metropolitan areas.

Sources: ABS 2011; Mees and Groenhart 2012.

Box 6 Further reading

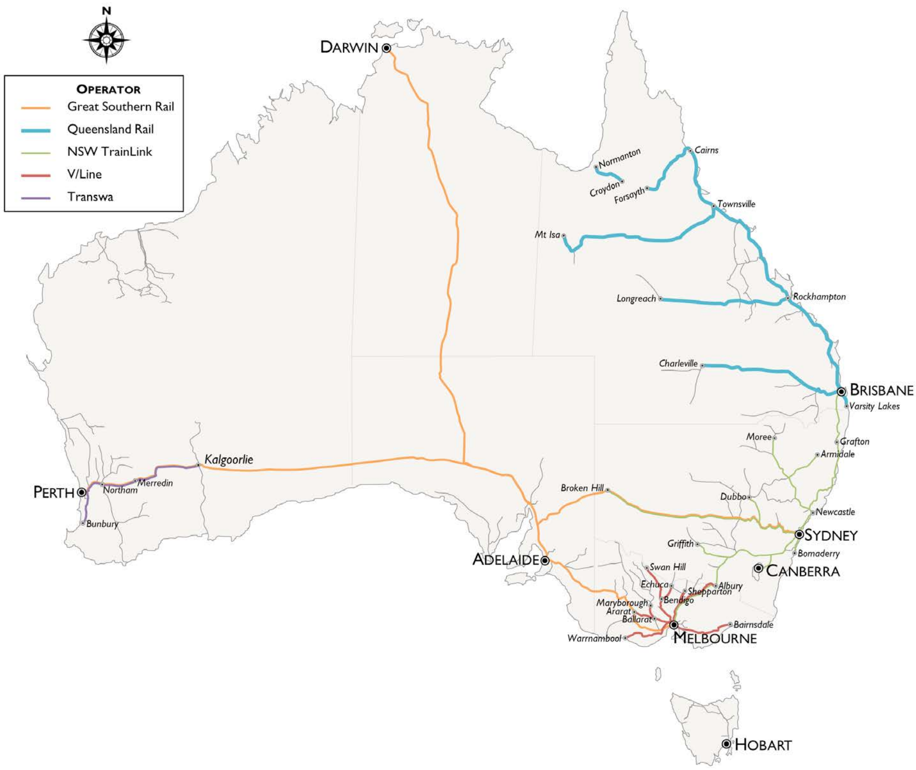
For further information on urban passenger trends, see BITRE information sheets: *Urban transport: updated passenger trends—Information Sheet 59* (BITRE 2014f); and *Long-term trends in urban passenger transport—Information Sheet 60* (BITRE 2014g).

BITRE 2012, *Understanding Australia's urban railways* presents an overview of Australia's passenger and freight railway systems.

Non-urban passenger traffic

Australia's railways provide a limited range of services in the inter-city, regional and long-distance passenger markets. Coverage of these services is presented in Figure 26.

Figure 26 Non-urban passenger services, by operator



Non-urban passenger traffic, broadly described as day-return (under four-hour) and long-distance (over four hours) travel, can be further classified by the primary travel markets served:

- "inter-urban" or "regional" travel, such as Sydney–Newcastle (now truncated), Sydney–Wollongong/Bomaderry, Melbourne–Ballarat and Perth–Bunbury. Such services could include daily commuting or day-return business or leisure travel;
- long-distance connections between cities (such as Brisbane–Sydney) and regional centres, such as Sydney–Canberra and Perth–Kalgoorlie;
- heritage railway travel, for nostalgia and leisure purposes; and
- tourist-focused services such as the Kuranda Scenic Railway (Queensland Rail), and Adelaide–Darwin (The Ghan) (Great Southern Rail).

The scale of an operator's passenger task is largely determined by the function of their railway. Table 13 shows the latest financial year patronage statistics by operator. Railways with a large commuter task have higher patronage than those which cater largely to long-distance travel. For NSW TrainLink, for example, only a small percentage of patronage is regional travel. The majority of passengers use inter-city services on the Newcastle and Central Coast, Blue Mountains, Southern Highlands and South Coast lines.

Table 13 Non-urban rail patronage, by operator, 2014–15

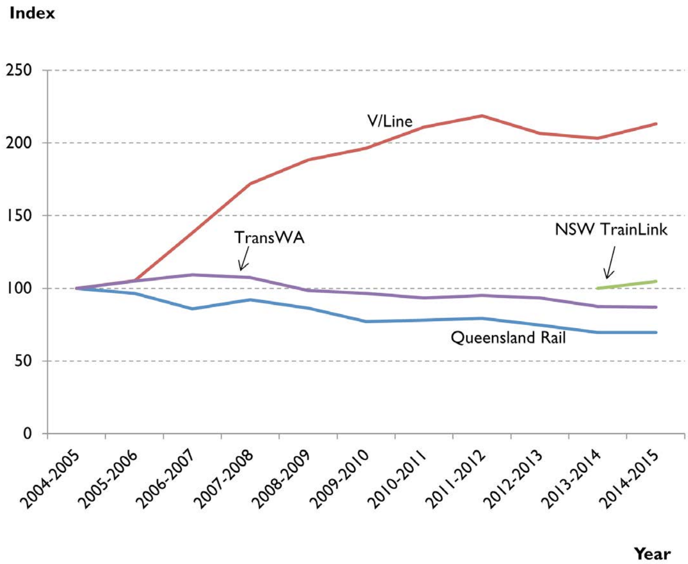
	Queensland Rail[a]	NSW TrainLink		V/Line	TransWA
		Regional	Inter-city		
Patronage (thousands)	700	1 224	34 545	13 631	218

Notes: [a] Data exlude patronage on services delivered under the "TransLink" brand. Patronage data by line are not available for the Gold Coast and Sunshine Coast TransLink lines.

Sources: NSW Trains 2015 p.12; Public Transport Authority of Western Australia 2015, p.65; Queensland Rail 2015, p.39; V/Line 2015, pp.10-11.

Similar to urban patronage, non-urban patronage is influenced by broad, macroeconomic factors and local, network specific factors. Figure 27 shows patronage trends by operator. The index for NSW TrainLink is truncated to 2012–13 due to the patronage data revision.

Figure 27 Index of non-urban rail patronage, by operator



Notes: The NSW Trainlink index is the sum of regional and inter-city boardings. There is no New South Wales data presented for the periods prior to 2012–13 due to the formation of TrainLink on 1 July 2013, which merged regional and inter-city services under one operator. Including previous years' data would not be comparing 'like for like'.

Queensland Rail data exclude services under the TransLink brand on the Sunshine Coast and Gold Coast lines.

Sources: NSW Trains 2016 p.12; Public Transport Authority of Western Australia 2015, p.65; Queensland Rail 2015 p.39; V/Line 2015, pp.10-11; historical annual reports.

Some noteworthy trends are:

Queensland Rail non-urban rail travel has steadied at "more than 700,000 passengers", after a trend of decline commencing in 2005–06 (Queensland Rail 2015). Long-distance and scenic railway services are vulnerable to reductions in discretionary spending because they rely on leisure travel and tourism (including foreign tourism which may be influenced by changes in the value of the Australian dollar). According to the Queensland Rail 2013–14 annual report, approximately half of its non-urban patronage for the financial year was on the Kuranda Scenic Railway (Queensland Rail 2014).

NSW TrainLink. It is not yet possible to assess meaningful NSW TrainLink patronage trends due to the formation of TrainLink on 1 July 2013, which merged the former inter-urban and regional/long distance services. According to the NSW Trains (TrainLink) 2014–15 annual report, overall patronage increased by 4.7 percent. Intercity patronage increased by 5.1 per cent, while regional (rail) patronage declined by 0.4 per cent. The annual report claims Intercity patronage growth was due to population increases in the service area along with better patronage calculation methodology following the introduction of the Opal card. It attributes the decline in regional rail patronage to competition from other transport modes.

V/Line patronage has more than doubled over the last decade. This follows major upgrades between 2003 and 2006 under the Regional Fast Rail programme. (BITRE 2014e (pp.61–70) reviews the upgrades.) The programme reduced scheduled transit times and increased frequencies. Other contributory factors include a fare reduction of 20 per cent in March 2007, central Melbourne employment growth, and strong population growth along the rail corridors (BITRE 2014e, p.69). In 2014–15 patronage grew by almost five percent (V/Line 2015). Between 2010–11 and 2014–15, the Geelong corridor experienced growth of more than 22 percent, the highest of any corridor. The Seymour line, which was not included in the Regional Fast Rail programme, had the second highest five-year growth, at more than 21 percent (V/Line 2015). Previous years' overall declines can be attributed to the completion of the Sunbury Electrification Project that transferred some V/Line passengers to Melbourne Metro services and line closures due to Regional Rail Link works (BITRE, 2014e, p.68, V/Line, 2014, p.22).

TransWA patronage continued its decline since 2006–07 although the rate of decline eased in 2014–15 to approximately 0.5 percent, compared to the previous financial year (Public Transport Authority of Western Australia, 2015). Despite the overall decline, patronage on the *Prospector* and *Avonlink* services increased. The *Australind,* which accounts for almost half of TransWA's total patronage, continued its decline. *Australind* patronage was down by approximately five percent compared to the previous financial year. According to advice from TransWA, while patronage on the *Avonlink* increased, the number of services also increased and patronage per service declined.

There are three probable factors that have contributed to the *Australind's* decline. They are cancelled services due to maintenance issues, upgraded road conditions between Bunbury and Perth, and Bunbury residents who, since the opening of the Mandurah-Perth line, now commute to Perth daily by driving to and parking their cars at Mandurah station, from where they continue their journey to Perth by rail on the faster Mandurah-Perth rail service. The previous decline in *Prospector* patronage was due to a carriage fire, which reduced supply capacity.

Data for Great Southern Rail, services (Sydney–Perth Indian Pacific; Melbourne–Adelaide The Overland; Adelaide–Darwin The Ghan). The Indian Pacific and Ghan services are heavily and increasingly premium level tourist services with a large proportion of its patrons being foreign tourists. As such, it can be assumed the strength of the Australian tourism industry influences patronage on these trains. The *Overland* is a twice weekly service with a lesser tourism focus

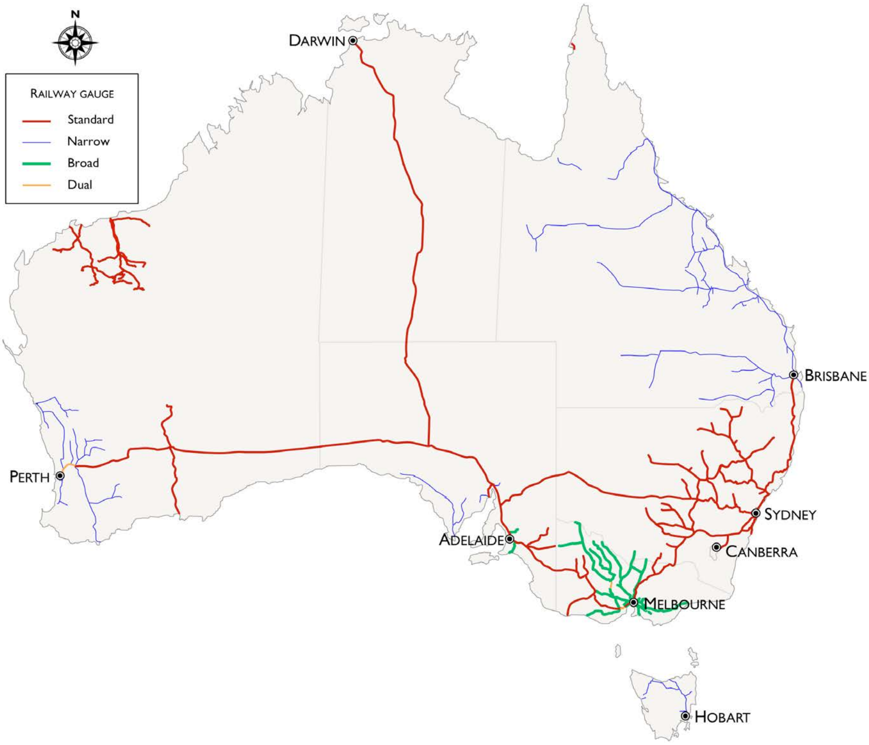
CHAPTER 3

Infrastructure and rolling stock provision

Railway network

Australia's railway network was constructed by the previous colonies (then states) as separate networks with different gauges. The networks mostly radiated from the state (previously colonial) capitals, with cross-border links coming only after intrastate (intra-colonial) lines were well developed and met at the borders. The exception is Queensland, whose early railways consisted of a network of disparate railways that connected inland areas with coastal ports. These railways were eventually linked, forming the current Queensland network. While aspects of the break of gauge legacy remains (Figure 28), interstate trains now operate across a continuous 1 435 mm 'standard' gauge.

Figure 28 Railway network, by track gauge, August 2016



Notes: The lines shown here are the railways that are open for traffic at August 2015. The BHP Goldsworthy line is shown but it has been mothballed since 2014.

Broad ("Irish") gauge is 1 600 mm; standard ("Stephenson") gauge is 1 435; narrow ("Cape") gauge is 1 067 mm.

Table 14 shows route kilometres of electrified and non-electrified railways in each jurisdiction. Queensland, Western Australia and New South Wales have similar-sized networks. Most of the network is single-tracked (approximately 89 per cent) although with some exceptions, such as most urban networks, the Sydney–Melbourne line (of which around three-quarters is now double-track) and the East Turner River corridor through the Chichester Range in East Pilbara (with some BHP Billiton double track and some Fortescue double track).

Table 14 Estimate of route kilometres of open (operational) heavy railway in 2016, by jurisdiction, gauge and electrification

State or Territory	ACT	NT	NSW	Qld	SA	Tas	VIC	WA	Total
Route kilometres by gauge									
Broad			73		253		2 921		3 247
Narrow		3		8 164	561	808	16	2 970	12 522
Standard	6	1 690	7 093	117	2 561		1 222	4 558	17 247
Other			1	4		7	30		42
Dual				36	22		32	207	297
Total	6	1 693	7 167	8321	3 397	815	4 221	7 735	33 355
Route kilometres by electrical system									
1 500V DC			641				375		1 016
25 kV AC				2 138	44			171	2 353
33 kV AC			8						8
Total			649	2 138	44		375	171	3 377

Notes: V denotes volts, kV denotes kilovolts, and Hz denotes hertz. DC denotes 'direct current' and AC denotes 'alternating current'.

Data may not add to totals due to rounding.

Does not include urban light rail and tramways; the extensive Queensland sugar tramways are excluded.

Queensland figures include the 19 kilometres of standard gauge railway at the Rio Tinto bauxite mine at Weipa and the 13 kilometre Moreton Bay Rail Link that opened in 2016.

The NSW figures include the 11 kilometre Boggabri coal mine rail spur, which opened in 2016.

The WA figures include the Roy Hill Holdings 344 kilometre Pilbara line that opened in December 2015.

The reduction in the SA standard gauge figures denote changes to the Mallee and Leigh Creek lines, which became non-operational in 2015.

Source: BITRE estimates; data provided by Aurizon; Rio Tinto Alcan, and Tasrail; Avery (2013) p.144.

Queensland has the longest length of electrified railways, principally due to the electrified line between Rockhampton and Brisbane and a number of coal lines in Central Queensland. Elsewhere, overhead power systems have been installed on lines with relatively-intensive urban and selected intercity passenger services. Around 10 per cent of the Australian network route-kilometres are electrified. Appendix D provides an overview of the network in terms of infrastructure manager and of management structure (that is, whether the manager is vertically-integrated or vertically-separated).

New railways

900 route-kilometres of freight track and 102 route-kilometres of passenger (heavy and light-rail) track have been opened since 2010.

Table 15 Railways opened from 2010

Traffic	Location	State	Length (km)	Project	Infrastructure builder
Iron ore	Mesa K – Waramboo (Mesa A)	WA	49	Mesa A	Rio Tinto
	Cloudbreak – Christmas Creek	WA	50	Christmas Creek extension	Fortescue Metals Group
	Tilley Siding (Morawa) – Karara	WA	85	Karara Rail Spur	Karara Mining Ltd
	Solomon Junction – Solomon	WA	130	Solomon extension	Fortescue Metals Group
	Hope Downs 4 railway	WA	53	Hope Downs extension	Hope Downs Joint Venture (Hancock – Rio Tinto)
	Roy Hill–Port Hedland	WA	344	Roy Hill	Roy Hill Holdings
Coal	Cameby Downs Loop	Queensland	7	Cameby Downs Loop	Queensland Rail
	Goonyella–Newlands	Queensland	68	Northern missing link	Aurizon
	Middlemount Rail Spur	Queensland	16	Middlemount Rail Spur	Macarthur Coal
	Maules Creek-Werris Creek line	NSW	20	Maules Creek	Whitehaven
	Aldoga-Wiggins Island	Queensland	13	Wiggins Island Coal Export Terminal	Aurizon
	Moranbah-Caval Ridge	Queensland	12	Caval Ridge Spur	Billiton Mitsubishi Alliance
	Boggabri East	NSW	11	Boggabri Rail Spur	Idemitsu
Intermodal	Sefton–Macarthur	NSW	36	Southern Sydney Freight Line	ARTC
Inter-Urban passenger	Deer Park–West Werribee	Vic	27	Tarneit (Regional Rail Link)	V/Line
Urban passenger	Darra–Springfield	Qld	10	Springfield branch	Queensland Rail
	Glenfield–Leppington	NSW	12	Leppington line	RailCorp
	Epping – South Morang	Vic	4	South Morang Extension (re-opening)	V/Line
	Noarlunga–Seaford	SA	6	Noarlunga Line extension	Department of Planning, Transport and Infrastructure
	Clarkson–Butler	WA	8	Joondalup Line extension	Transperth (Public Transport Authority)
	Petrie – Kippa–Ring	Qld	13	Moreton Bay Railway	Queensland Rail
Urban passenger light rail	Griffith University – Broadbeach	Qld	13	Gold Coast Light Rail	Queensland and Australian governments; Gold Coast City Council, GoldLinQ
	Lilyfield – Dulwich Hill	NSW	6	Inner West Light Rail extension	Transport for NSW
	North Terrace – Entertainment Centre	SA	3	Port Road Light Rail Extension	Department of Planning, Transport and Infrastructure

Notes: The Epping – South Morang project was a line re–opening, using right-of-way from a railway that was closed in 1959. A list of network additions since 1970 is at Appendix B.

Source: BITRE estimates, data provided by Aurizon and Gracosway.

Expansion of the mining industry in the Pilbara region of Western Australia has provided the source of much of the recent rail infrastructure expansion and subsequent rail freight task. Development of iron ore mines in the Pilbara region has led to the construction of a network of railways linking mines with ports at Dampier, Cape Lambert (Port Walcott) and Port Hedland. BHP Billiton's network in the region began with the opening of the 208 kilometre Goldsworthy–Port Hedland Railway in 1965. Rio Tinto's line between Tom Price and Dampier opened in 1966. The third largest mining company in the region is Fortescue Metals Group, which opened a railway between Cloudbreak Mine and Port Hedland in 2008. In 2015, Roy Hill Holdings added 344 route kilometres of standard gauge single line railway to the network connecting the newly developed Roy Hill Mine to the port facility in Boodarie Industrial Estate south of Port Hedland. The operation uses Roy Hill's two new berths, SP1 and SP2, at Stanley Point within the port. BITRE 2013 (p.21) presents a map of the railway, berthing stockpile facilities at Port Hedland (inner harbour). Enhancements to track and train specifications mean trains in the region are amongst the longest and heaviest in the world, with scope for additional axle load increases. Following construction of the Roy Hill line, there is currently an estimated 2 639 route kilometres of railway in the Pilbara region.

Since 2009, 110 kilometres of railway have been constructed for coal haulage. Coal exports, centred on Queensland's Bowen, Galilee and Surat Basins and the Hunter Valley network in New South Wales, rely on the railway network for moving coal to ports. New lines and additional capacity have enabled the substantial expansion of exports. Such new lines and additional capacity include the Goonyella–Newlands railway in Queensland, part of the Goonyella to Abbot Point Expansion ("GAPE") project; and the Wiggins Island Rail Project (WIRP), which was completed in December 2015. Other projects have included substantial Commonwealth investment in the interstate network, with new signalling, passing loops and passing lanes, re-railing, re-sleepering and re-ballasting. The Northern Sydney Freight Corridor Program, currently underway, will ease congestion through northern Sydney. There have also been renewal and capacity-enhancing projects on urban passenger networks. Sydney's rail clearways programme enhanced the network's capacity and reliability through targeted works on key bottlenecks. Adelaide's urban passenger network has undergone extensive track renewal and the Seaford line has been electrified.

Table 16 lists railways that are being constructed in 2016, with 28 route-kilometres being built.

Table 16 Heavy and Light Railways under construction, 2016

Traffic	Location	State	Length (km)	Project	Infrastructure builder
Urban passenger	Epping–Cudgegong Road	NSW	23	North West Rail Link	Transport for NSW
Urban passenger light rail	CBD and South East Light Rail	NSW	12[a]	CBD and South Est Light Rail	Transport for NSW
Urban passenger light rail	Gold Coast	Qld	7	Gold Coast Light Rail, Stage 2	Queensland TMR
Urban passenger light rail	Canberra	ACT	12	Capital Metro	ACT Government

Note: [a] Transport for NSW estimate that 5 kilometres of construction will be completed by the end of 2016.

The two urban passenger railways that are under construction are Sydney Metro Northwest (Epping-Cudgegong Road) and expansion of Sydney's existing light rail system.

Infrastructure activities extend beyond new railway construction, however, with a range of enhancement projects across the country. This includes the Victorian level crossing removal project and Victoria's Murray Basin Rail Project.

Dedicated commodity networks

As discussed in Chapter 2, the primary railway traffic flows are iron ore, coal, grains, intermodal, and urban passengers. Major parts of the Australian railway network are dedicated to serving individual commodity flows.

Iron ore and coal networks

The iron ore and coal networks are illustrated in Figure 9. The iron ore railway networks in the Pilbara region were built by mining companies exclusively to serve the iron ore mines, as was the Karara (Western Australia) spur line and the Middleback railways (near Whyalla) in South Australia. As bespoke developments, these lines were generally built to very high standards in order to accommodate the large traffic flows envisaged. On many of the lines there has been extensive subsequent capacity expansion (signalling, track and train capacity).

Coal lines were developed in eastern Australia, generally being grafted onto the existing mixed-traffic network. While the track standards are high and include some electrified systems in Queensland, they are generally of a lower standard than the purpose-built iron ore lines.

Grain railways

Grain railways usually feed into secondary or main lines. (The map of grain haulage is shown in Figure 13.) By contrast with iron ore and many coal railways, the grain lines are generally built to lower technical and operational standards, they are in a relatively poor condition and they carry variable seasonal traffic.

The technical and operational diversity of the grain lines, mostly reflecting the varying importance (levels) of different branch traffic flows, has led to the classification of lines according to their technical standard (and, thus weight-bearing capability or train speed), their economic importance, or to their viability. The respective categories across the states[25] are outlined here.

Queensland

The "network capabilities" of railways in Queensland are classified according to the maximum permitted axle loads on a given section of track. BTRE 2006 (p.305) shows the prevailing axle loads that were current in 2005. Network information packs for access seekers provide details about track standards and permitted axle loads and train speeds[26]. Often the axle-load limits are 15 tonnes. It has been noted that rail cannot be used to haul containerised grain due to these load limits (Transport, Housing and Local Government Committee [Queensland] 2014, p.24).

25 Most of South Australia's railways have been closed and the remaining four lines have not been classified.

26 An illustration of this information can be seen with the "Information pack" for South Western Queensland (Queensland Rail) [Network Access], undated.

New South Wales

The New South Wales government's grain railways are categorised by class of track. Mainline tracks can be at the highest physical condition and technical standard of "Class 1". The grain railways are either Class 3 (45 per cent of the route-km) (the lowest standard, Class 5 (55 per cent of the route-kilometres[27]). The axle load limits on these two classes of line is 19 tonnes. This compares with 25 tonnes on Class 1 lines and 21 tonnes on Class 2 lines.

Victoria

Switchpoint¸ the 2007 review of the State's rail network, established a classification of different railways (Department of Infrastructure 2007). The classification attached descending priority for track rehabilitation (or upgrading) from a high-priority Platinum, Gold, Silver, and Bronze to restore the railway infrastructure to the original track condition classification (which was generally Class 4 or, at a lower standard, Class 5). Note, however, that while these lines are of different operating standards, they are all suitable for 19 tonne axle load grain trains.

The Victorian government is also investing in grain and other bulk transport by rail as part of the Murray Basin Rail Project. The project involves standardising the rail line gauges that serve the Murray Basin in north western Victoria, and increasing axle loads from 19 to 21 tonnes. Gauge standardisation will enable the port at Portland (which only has a standard gauge rail connection, to compete with the dual gauge ports of Melbourne and Geelong. The project is expected to cost $416 million (Department of Economic Development, Jobs, Transport and Resources, 2015).

Western Australia

Grain railways in Western Australia are classified by their viability and competitiveness. Tier 1 lines are considered to be competitive with road transport and are perceived to remain competitive given probable future cost increases. Tier 2 railways are currently cost competitive with road, given prevailing rail access prices and train operating costs. Tier 3 lines are regarded as unviable as rail volumes are low and trains are uncompetitive with road transport. The lines are also typified by low (16-tonne) axle loads, with low-standard track structure. (Strategic Design and Development 2009, p.8). In 2014, a parliamentary inquiry was undertaken to investigate aspects of the Western Australian freight rail network, including the provision of Tier 3 railways; see the Economics and Industry Standing Committee of the WA Parliament Legislative Assembly (2014).

Urban heavy-rail passenger networks

Australia's urban heavy rail networks are extensive, even if the network coverage is not dense (see Table 17). The networks are radial, reflecting the historical development of Australian cities, with lines branching from dense Central Business Districts (CBDs) into the surrounding, low density suburbs[28].

27 New South Wales Grain Freight Review 2009, p.59.
28 Maps of these systems are provided in BITRE (2012).

Table 17 Network characteristics of heavy urban passenger railways, 2016

	Sydney	Melbourne	Brisbane	Adelaide	Perth
Operator	Sydney Trains	Metro Trains Melbourne	Queensland Rail	Adelaide Metro	Transperth
Ownership	Public	Private (government franchise)	Public	Public	Public
Dedicated metropolitan passenger lines (km)	190	232	103	126	179
Shared metropolitan freight/passenger lines (km)	162	171	140	–	1
Total metropolitan route length (km)	352	403	243	126	180
Electrified metropolitan route length (km)	352	373	243	44	180
Metropolitan stations (number)	178	218	144	86	70
Average distance between stations (km)	1.9	1.8	1.7	1.4	2.6
Metropolitan passenger route length under construction (km)	23	–	–	–	–
Passenger network gauge	Standard	Broad	Narrow	Broad	Narrow

Notes: Distances are route kilometres.

Metropolitan networks are defined by passenger operator boundaries with the exception of Queensland Rail. Brisbane's metropolitan network is defined here as being bounded by Caboolture, Shorncliffe, Domestic Airport, Doomben, Cleveland, Beenleigh, Rosewood, Springfield Central and Ferny Grove. The number of Brisbane stations and track distance includes the six new stations on the 13 kilometre Moreton Bay rail extension. The Perth station numbers exclude the Aubin Grove station on the Mandurah line, which is currently under construction.

Does not include track dedicated to urban freight only.

Sources: BITRE estimates; Public Transport Authority of Western Australia 2015, p.40; Data provided by Adelaide Metro.

There are a number of characteristics and trends that make each system distinctive:

Network expansion. Perth's system has developed over the last 20 years from a small network to a route-kilometre length that is just shy of metropolitan Sydney. New lines from Perth to Joondalup / Currambine / Butler (41 km), and Mandurah (70 km), and the Thornlie branch (three km) have transformed long-distance urban transport within the city. (See Appendix B for dates of railway openings.)

Network form. Perth's system is also distinctive relative to the other Australian networks due to the nature of the new railways. Table 17 shows Perth's network is almost 45 per cent longer than Adelaide's, but has 16 fewer stations. This station spacing provides for significantly higher average train speeds on Perth's Mandurah line and, to a lesser extent, the Butler line (see Figure 43). With fewer stations, good station access is inherent to station design through rail-bus interchanges, extensive park-and-ride facilities and encouragement of (nearby) Transit Oriented Development (TOD).

Shared networks. Brisbane, Melbourne, Adelaide and Perth use a different track gauge to the interstate network. This has separated urban passenger trains from interstate and some intrastate freight trains operating on the standard gauge, although there is some track sharing between urban and intrastate freight trains on the same gauge. Examples of shared track include the north coast intermodal freight and coal from the Toowoomba region into the Port of Brisbane and steel products between Melbourne and Long Island (via the Frankston suburban line). Sydney's network is standard gauge throughout. It therefore shares capacity with trains travelling on the interstate North–South and East–West (via Lithgow) corridors, as well as intrastate freight. The Southern Sydney Freight Line, however, provides a dedicated southern access to Sydney freight yards, which has eliminated the previous southern Sydney curfew on freight trains operations during peak passenger commuting periods.

Electrification. Electrified services commenced in Sydney and Melbourne[29] from the early inter-war period using Direct Current (DC) traction power. Cites that electrified their networks later use more advanced Alternating Current (AC) traction. Perth and Brisbane electrified their networks relatively recently—Brisbane from the late 1970s and Perth from the early 1990s. In Adelaide, the Rail Revitalisation Programme includes track enhancements and system electrification. Electric train operation commenced on the Seaford and Tonsley lines in 2014.[30]

Urban light rail passenger networks

The technological and operational differences between tramways, light rail and heavy rail are increasingly blurred.[31] This report will refer to Australia's light rail operations with an understanding that the networks, in particular in Melbourne, share characteristics with tramways. It should also be noted former heavy rail corridors form parts of the network in Melbourne, Sydney and Adelaide.

By route kilometres, Melbourne has the world's largest light rail network. Single route operations are on the Gold Coast in Queensland and in Sydney and Adelaide (see Table 18).

Table 18 Network characteristics of light railways 2016

	Gold Coast	Sydney	Melbourne	Adelaide
Total route length (km)	13	12.8	250	15
Segregated right of way	largely segregated	largely segregated	20% segregated	largely segregated
Routes (no.)	1	1	24	1
Number of stops (no.)	16	23	1 763	29

Sources: Currie and Burke 2013; Yarra Trams 2016.

Melbourne's network is distinct, with only a small proportion of the network being segregated from road traffic, and with close spacing between stops. Some parts of the network share the close-stop and on-road feature of buses whereas in other parts it more closely resembles the limited-stop, segregated railway. These characteristics mean Melbourne's average speed is significantly lower than other cities.

Sydney and Adelaide once had significant tramway systems prior to the middle of the 20th century. Adelaide's single remaining line runs between the Adelaide Entertainment Centre and Glenelg, via

29 Only Melbourne's Frankston–Stony Point line remains un-electrified.
30 It is not intended to electrify the line between Goodwood Junction and Belair.
31 Tramways generally have short spacing between stations and operate on roads, often sharing a right-of-way way with traffic. Light rail is considered to largely have its own right-of-way with more widely spaced stations. Melbourne's extensive system, in particular, illustrates the flexibility of light rail and its consequent definitional blurring. Melbourne's light rail vehicles operate on former heavy rail lines to St Kilda and Port Melbourne, but most of the network shares right-of-way with road traffic.

the CBD. The majority of the route length is in a segregated light rail corridor between the edge of the CBD and Glenelg, using a former heavy-rail corridor.

Sydney's light rail line, between Central Railway Station and Dulwich Hill station, runs along a former freight heavy rail corridor, with a small segment of on-road (largely segregated) operation between Haymarket and Central Railway Station. Sydney's light rail network is being expanded by 12 kilometres, with 19 stops. The extension will travel from Central Station to Circular Quay and through Surry Hills to Moore Park, Kensington, Kingsford and Randwick. Services are expected to commence in 2019.

The Gold Coast light railway, which opened in July 2014, runs between the Gold Coast University Hospital and Broadbeach. The line has been placed along roads but the space is generally not shared with road traffic. The line runs along a dense retail corridor (Currie and Burke 2013, p.12). Average station spacing is the highest of the Australian cities. In August 2015, the Queensland Government announced it would extend the network 7.3 kilometres from the Gold Coast University Hospital terminus to Helensvale heavy rail station.

Non-urban passenger network

The non-urban passenger services are not stand-alone networks. Typically, the non-urban services share track with urban passenger and freight trains, although the June 2015 opening of the Regional Rail Link has reduced this in Victoria. (The coverage of the non-urban passenger operations services, by principal operator, is presented in Figure 26.) Key network characteristics of the regional passenger services, including heritage railways, are presented in Table 19.

Table 19 Network coverage of non-urban passenger rail services

	Queensland Rail	NSW TrainLink	V/Line	TransWA	Great Southern Rail	Heritage operators
Electrified route kilometres	741	449	–	–	–	1
Total route kilometres	4 617	4 275	1 655	836	7 243	555 (approx)

Notes: Queensland Rail route length includes the Gympie North – Brisbane and Brisbane – Varsity Lakes services.

Diesel services may run on electrified track. Where non-urban electrified and diesel services share electrified track (such as Rockhampton–Brisbane), the route is defined as electrified. Where non-urban diesel services share track with electrified urban trains (such as V/Line services on Melbourne's metropolitan network), the route is defined as not electrified.

Source: BITRE estimates.

Train operator equipment stock (excluding freight wagons)

Locomotives

In July 2016, there was an estimated 2050 operational locomotives in Australia. This excludes locomotives in storage or available for hire. Data presented here use the age of the locomotive since built new, or the age since rebuilt, whichever is the lower period.[32] The age of the fleet reflects a range of different underlying influences on rolling stock investment.

Figure 30 shows approximately 50 per cent of Australia's fleet was aged approximately 16 years or under in mid-2016, compared to approximately 14 years or under the previous year and 11 years or under the year before that. There are several points of qualification for this apparent ageing, however.

BITRE has revised its age analysis estimates due to new data sources becoming available. Thus, the analysis in this report does not compare 'like for like' with that in previous reports.

The analysis is for locomotives that almost perform freight duties only. There has been considerable investment in new passenger rollingstock such as V/Line's expanding DMU VLocity fleet. This rollingstock, by virtue of being DMUs, is excluded from the age analysis and particularly effects the broad gauge analysis due to the lesser freight task on that gauge compared to the standard and narrow gauges and the growing dominance of DMUs on the broad gauge for passenger services.

While approximately 50 per cent of the locomotive fleet is aged 16 years of under, there is little variation in this figure for locomotives aged 8–16 years. For example, approximately 43 per cent of the fleet is aged eight years or younger. This can be seen in Figure 29, below, which shows a flattening in the line denoting the cumulative age of the locomotive fleet for locomotives aged 8–16 years. The status of the locomotive fleet is also highly fluid, with locomotives frequently becoming operational or going into storage. Of the locomotives that are aged 16 or under, approximately 70 per cent operate on the standard gauge.

What the table and figures below also do not show is the degree of and type of locomotive usage. Newer locomotives tend to be assigned primary 'frontline' duties such as hauling intermodal trains across the continent or hauling coal or iron ore trains, while older locomotives tend to be assigned lesser secondary duties such as providing additional motive power behind newer locomotives and doing yard duties. BITRE is currently unable to measure the degree of locomotive usage. While the large NR class locomotive fleet, which is the mainstay of Pacific National's intermodal services, is now 20 years old, they have been progressively upgraded, including with new engines. They are now arguably new locomotives.

Care is also needed when comparing locomotive ages by gauge, particularly between the broad and standard gauges, where there is considerable re-gauging of the previous Victorian government owned locomotives, such as the G, T, and N classes. For example, six of the previous all broad gauge N class locomotives have been converted to standard gauge for the Melbourne–Albury V/Line passenger services.

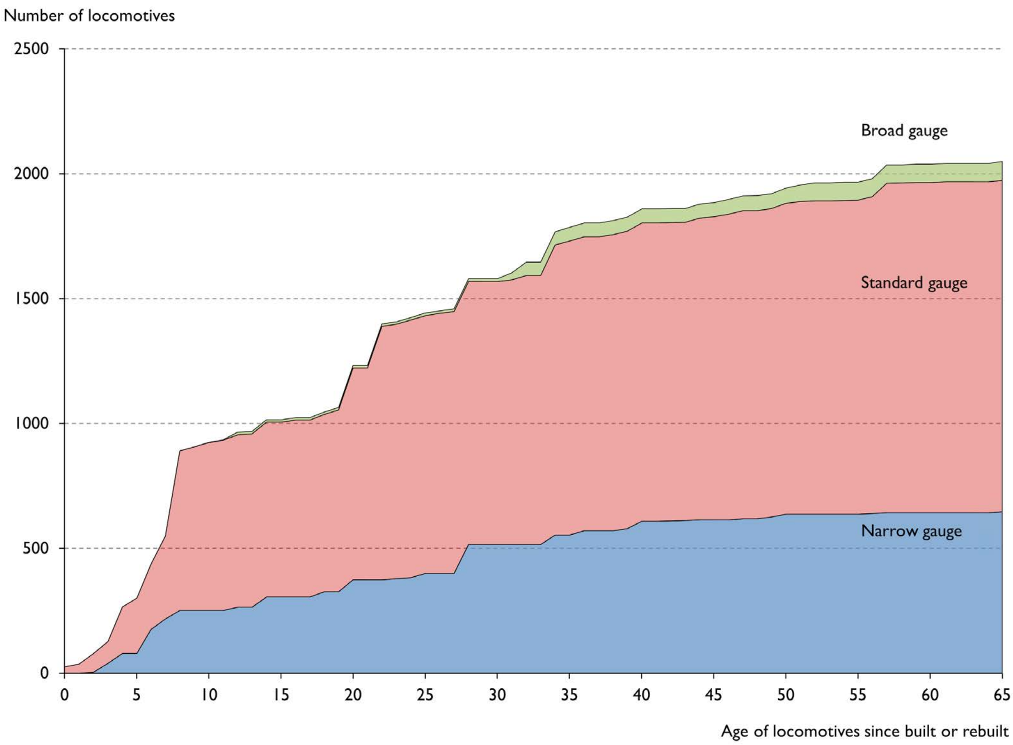
32 Rebuilt locomotives can attain the same (or better) performance and longevity characteristics as a new locomotive.

Table 20 Locomotive ages

Age range (years)	Narrow Gauge	Standard Gauge	Broad Gauge	Total
0–5	80	221	0	301
6–10	171	452	1	624
11–15	54	27	9	90
16–20	70	148	0	218
21–25	25	184	0	209
26–30	115	22	0	137
31–35	39	122	46	207
36–40	55	15	0	70
41–45	5	23	0	28
46–50	23	30	5	58
51+	9	84	15	108
Total	646	1 328	76	2 050

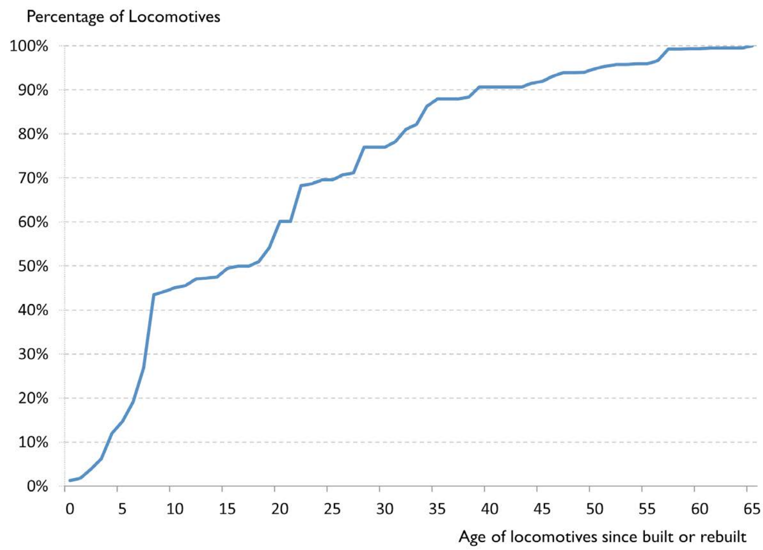
Source: Data provided by Aurizon, BHP Billiton, Pacific National, Fortesque Metals Group, Genessee and Wyoming Australia, Rio Tinto, SCT, Tasrail, Queensland Rail; Clark 2015; Railpage 2016.

Figure 29 Cumulative locomotive age profile, by number of locomotives



Sources: BITRE analysis of data from Aurizon, BHP Billiton, Pacific National, Fortesque Metals Group, Genessee and Wyoming Australia, Rio Tinto, SCT, Tasrail, Queensland Rail; Clark 2015; Railpage 2016.

Figure 30 Cumulative locomotive age profile, per cent



Source: BITRE analysis of data from Aurizon, BHP Billiton, Pacific National, Fortesque Metals Group, Genessee and Wyoming Australia, Rio Tinto, SCT, Tasrail, Queensland Rail; Clark 2015; Railpage 2016.

Box 7 Further resources

The monthly magazine *Railway Digest* compiles a list of current and recently completed rolling stock contracts and deliveries of locomotives, wagons, permanent-way vehicles and passenger stock. This list is published regularly in the magazine. Railpage.com.au also provides regularly updated and historical details of locomotives by gauge, operational status, and current operator.

Urban passenger rolling stock

The levels of rolling stock networks require are a function factors that include the following:

- traffic levels;
- the network size and length of individual lines;
- the range of 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 services (with faster operations requiring fewer train sets).

Passenger heavy rail stock

Urban heavy rail rolling stock is generally modern, with the last of the 1970s stock undergoing replacement. Most current rolling stock is air-conditioned, with Sydney's remaining, non-air-conditioned, S-Set trains used on low patronage lines and for stand-by services. (See Table 21.)

Most train services are provided by "multiple-unit" stock permanently-coupled carriages. Sydney's fleet generally run as four car units, coupled into eight car trains. Elsewhere, most stock is the three-car EMU, generally being paired as six-car trains. Adelaide's rolling stock, with large numbers of one and two-car units, enables Adelaide Metro to cater for modest traffic levels with a broad range of configurations. There are also some two car operations in Perth.

Table 21 Heavy rail rolling stock

	Brisbane	Sydney	Melbourne	Adelaide	Perth
Vehicles (no.)	633	1 619[a]	1 308	130	288[b]
Air-conditioned vehicles (no.)	633	1 427	1 308	130	288[b]
Carriage format	Single-deck	Double-deck	Single-deck	Single-deck	Single-deck
Multiple-unit format	211 three-car	248 four-car 78 eight car	436 three-car	30 one-car; 20 two-car; 20 three-car;	48 two-car; 64 three-car
Common train formations	EMUs coupled as six-car sets	EMUs coupled as eight-car sets	EMUs coupled as six-car sets	DMU, up to four-car; EMUs, normally as three-car sets, can couple as six car sets	EMUs coupled as six-car sets on new lines

Notes: a Sydney's remaining S-set rollingstock will be retained until at least 2019 for stand-by services.
b Transperth is expanding its heavy rail rolling stock. The figure quoted above was current as at April 2016.

Sources: Sydney Trains 2016; advice from Sydney Trains; VicSig 2016; advice from Queensland Rail; advice from Public Transport Authority WA; advice from Adelaide Metro.

Sydney is the only system to use double-deck carriages, which it began introducing in 1964 to increase passenger capacity on the existing network. It can take double deck trains longer, however, to disembark passengers due to passengers from the upper and lower decks meeting at the carriage doors, which can create bottlenecks and increase station stopping times. In August 2016, NSW TrainLink signed a $2.3 billion contract for the construction and maintenance of 512 EMU cars, to serve its intercity operations. The EMUs will be designed and built in South Korea, with UGL Ltd. support. The trains are expected to enter service between 2019–2022. (*Railway Gazette International* September 2016, p.17)

In February 2016, Queensland Rail received the first of 75 New Generation Rollingstock (QNGR) six car set EMUs for use in south east Queensland. The QNGR fleet is expected to begin entering revenue service in mid-2016. While replacing existing ageing EMU sets, the QNGR fleet is expected to increase capacity by approximately 30 per cent. (*Railway Digest* April 2016 pp.30-31)

Light rail

Melbourne's light rail fleet is much larger and more varied than the other cities; see Table 22. Melbourne's older rolling stock, such as the Z and A classes, introduced between 1975 and 1984 and 1984–1986, respectively, are comparatively short and have low passenger capacity.

Over the past 30 years, there has been a progression towards longer, higher capacity vehicles, using vehicle articulation rather than the coupling of vehicles (as had been the practice with Adelaide's now-heritage H-class trams). Melbourne's E class FLEXITY tram, introduced from 2013, is more than twice the length of the earlier Z and A classes. Similarly, rolling stock introduced in the last decade in other cities is all over 30 metres in length. The new trams introduced are a mix of imported and locally built vehicles. Bombardier manufactures the Australian built vehicles at its Dandenong plant in Victoria. These vehicles are used in Melbourne and Adelaide.

Since publication of *Trainline 3*, Melbourne's fleet has reduced by one car. Yarra Trams withdrew eight Z class trams, which was largely offset by the introduction of seven E class trams. As at February 2016, there were also 17 E class trams under construction.

Figure 31 Yarra Trams E Class FLEXITY Tram

Source: Photo courtesy of Bombardier.

Table 22 Light rail rolling stock

City	Vehicle type	Length (metres)	No. vehicles
Gold Coast	Flexity 2	43	14
Sydney	Urbos 3	33	10
Sydney total			10
Melbourne	A1 class	15	27
	A2 class	15	42
	B1 class	23.5	2
	B2 class	23.6	129
	C class	23	36
	C2 class	32.5	5
	D1 class	20	38
	D2 Class (Combino)	29.9	21
	E Class	33.5	33
	Z1 class	16	15
	Z2 class	16	1
	Z3 class	16.6	114
	W6 class	14.2	3
	W7 class	14.2	1
	SW6 class	14.2	6
Melbourne total			473
Adelaide	100 Flexity Classic	30	15
	200 Citadis	32	6
Adelaide total			21

Note: Fleet numbers are based on rollingstock in service.
Adelaide retains two heritage H class trams for tourist trips and special events.

Sources: Bombardier 2016; Currie and Burke 2013; VicSig 2016a; Transport Enthusiasts Society of South Australia 2016; Council of Tramway Museums of Australasia 2016; Track Record 2016.

Non-urban passenger rolling stock

Like urban rail rolling stock, and reflecting historical acquisitions, the composition of the non-urban passenger stock is a function of:

- traffic levels;
- service frequency;
- the size of the network and the length of individual lines;
- 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 services (with faster operations requiring fewer train sets).

There are a wide range of non-urban passenger services in Australia. Thus, rolling stock, designed for individual markets and service types, vary considerably. Table 23 shows the number of individual vehicles/cars, by type and operator.

Table 23 Non-urban passenger rolling stock, by vehicle type and operator

	Queensland Rail	NSW TrainLink	V/Line	TransWA
Electric multiple unit cars (no.)	150	445	–	–
Diesel multiple unit cars (no.)	27	65	220	14
Locomotives (no.)	23	19	41	–
Carriages (no.)	60	60	133	–
Total cars/vehicles	260	589	394	14

Notes: Rolling stock may also be used in urban operations, electric multiple units in intercity operations, for example, often act as limited-stop urban trains once they enter the metropolitan network.

The above lists individual vehicles rather than sets.

V/Line diesel multiple unit totals are as current on 15 April 2016.

Great Southern Rail's trains are hauled by Pacific National, using Pacific National locomotives on a 'hook and pull' basis.

Sources: VicSig 2016b; Sydney Trains 2016; NSW TrainLink 2016; Public Transport Authority of Western Australia 2015 p.54; Data provided by Queensland Rail, V/Line 2015a p8.

Locomotive hauled trains are primarily used for long-distance routes although V/Line uses them on some commuter route services, such as Melbourne-Bacchus Marsh. Some Queensland Rail long-distance services are locomotive hauled, although the diesel tilt train is now used on all Brisbane-Cairns services. V/Line's N class locomotives haul long distance trains on both the broad and standard gauges. New South Wales uses both XPT trains and Xplorer DMUs on its long distance services. While the XPTs are capable of travelling at 160km/h, track conditions such as tight curves restrict their ability to travel at such speeds across much of its network.

Figure 32 Prospector Train

Note: This image shows a TransWA *Prospector* passenger train crossing the Great Eastern Highway at Bodallin in Western Australia.

Source: Photograph courtesy of TransWA.

Medium-distance regional/commuter services are generally operated with DMUs. VLocity DMUs, that are capable of travelling at 160km/h, are used on Victoria's Regional Fast Rail services. TransWA uses DMUs for all rail services. The Perth–Kalgoorlie Prospector DMU is also capable of travelling at 160km/h. On board facilities, such as buffet, are provided depending on the length of the service. All DMUs are air-conditioned and generally seat two either side of a central aisle.[33]

NSW TrainLink and Queensland Rail have large electric multiple unit (EMU) fleets, which are largely used for intercity/commuter services. New South Wales, uses its EMU fleet for Wickham (Newcastle)–Sydney, Sydney–Lithgow and Sydney–Kiama (via Wollongong) services. Much of Queensland Rail's EMUs are used on the Sunshine Coast and Gold Coast lines.

A unique passenger rolling stock for Australia is Queensland Rail's fleet of tilt train (fixed-formation) sets. Queensland Rail has a fleet of electric tilt trains, used on Rockhampton–Brisbane services, and diesel tilt trains used on the Cairns–Brisbane services. (BITRE 2014e, p.60 and pp.161–162, discusses the nature of the tilt-train services and the principles of tilt trains.)

33 NSW TrainLink's Hunter and Endeavour trains seat five across.

CHAPTER 4
Railway performance

Network indicators

Safety

Table 24 shows the normalised[34] rate of train safety occurrences, by category of event until 2012[35]. Collisions with infrastructure and running line derailments are the most common form of accident. These are followed by collisions with a person (not at a level crossing) and collisions with vehicles at level crossings.

34 Normalisation means, in this context, to transform measurements so that they can be compared in a meaningful way. In the context of the railway statistics cited here, the occurrences are reported relative to the level of railway activity that is undertaken. Clearly, the likelihood of any safety-related occurrence will rise, cet. par., with the level of activity (usage) of the network. In this case, the occurrences are factored relative to the number of train kilometres operated.

35 ATSB has not published new train safety data as shown in Tables 23 and 24 since *Trainline 2* was published.

Table 24 Normalised occurrence rate, per million train kilometres travelled

Year	Period	Running line derailments	Collisions with trains	Collisions with rolling stock	Collisions with person (not level crossings)	Collisions with vehicle (not level crossings)	Collisions with infrastructure	Collisions with vehicle (level crossings)	Collisions with person (level crossings)
2002	Jul–Dec	1.37	0.08	0.06	0.29	0.24	0.27	0.41	0.07
2003	Jan–Jun	1.09	0.12	0.00	0.19	0.07	0.39	0.34	0.03
	Jul–Dec	0.78	0.09	0.03	0.28	0.16	0.43	0.50	0.11
2004	Jan–Jun	0.99	0.06	0.02	0.20	0.16	0.40	0.30	0.03
	Jul–Dec	0.96	0.01	0.08	0.26	0.15	0.55	0.37	0.04
2005	Jan–Jun	0.80	0.14	0.04	0.21	0.10	0.43	0.40	0.04
	Jul–Dec	0.75	0.08	0.04	0.27	0.08	0.70	0.39	0.04
2006	Jan–Jun	0.60	0.05	0.07	0.27	0.05	0.51	0.40	0.06
	Jul–Dec	0.70	0.15	0.05	0.24	0.12	0.69	0.47	0.04
2007	Jan–Jun	0.75	0.07	0.01	0.25	0.06	0.58	0.35	0.06
	Jul–Dec	0.83	0.11	0.03	0.21	0.06	0.51	0.27	0.04
2008	Jan–Jun	0.83	0.11	0.08	0.21	0.08	0.88	0.34	0.04
	Jul–Dec	0.55	0.11	0.03	0.31	0.02	0.79	0.29	0.01
2009	Jan–Jun	0.92	0.11	0.01	0.23	0.04	0.63	0.29	0.07
	Jul–Dec	0.78	0.09	0.08	0.37	0.05	0.65	0.24	0.05
2010	Jan–Jun	0.69	0.13	0.06	0.28	0.07	0.75	0.24	0.07
	Jul–Dec	0.85	0.04	0,01	0.27	0.06	0.57	0.27	0.02
2011	Jan–Jun	0.91	0.06	0.05	0.33	0.06	0.51	0.24	0.03
	Jul–Dec	0.68	0.08	0.01	0.26	0.08	0.52	0.27	0.09
2012	Jan–Jun	0.78	0.06	0.01	0.23	0.03	0.73	0.22	0.04

Notes: Data excludes light rail and trams.
Occurences did not necessarily result in fatality or injury.
Source: ATSB 2012.

The ATSB (2012, p.43) notes important differences in the collection and reporting of safety occurrences between jurisdictions. For a detailed description of these differences see (ATSB, 2012, pages 43–45). Fatalities are presented in Table 25. The ATSB has not published any further data since 2011–12.

Table 25 Railway fatalities, by year (number)

Year	2002–03	2003–04	2004–05	2005–06	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12
Fatalities	42	29	30	43	44	34	32	26	26	44

Notes: Data exclude light rail and trams.
Fatality data include collisions at level crossings.
Suicides are excluded from New South Wales data.
Source: ATSB 2012.

Since 2012, it has not been possible to report standardised findings. This is due to the various state based rail safety regulators and the emergence and expansion of the Office of the National Rail Safety Regulator (ONRSR), each of which has their own definitions and counting methodologies.

In 2015, Western Australia came under ONRSR responsibility and Queensland is expected to follow suit after its State Parliament passes the required legislation. Following this, the ONRSR will have complete national responsibility and standard nationwide rail safety reporting should follow.

ONRSR, which, in 2014–15, had regulatory safety oversight for South Australia, New South Wales, Tasmania, Northern Territory, Victoria and the Australian Capital Territory, stated in its *Annual Safety Report 2014 to 2015* there were 78 notified fatalities on railways which the *Rail Safety National Law* (2012) regulates. These fatalities were:

- 75 acts of suspected suicide or trespass, of which three occurred at level crossings;
- Two passenger fatalities (one of whom fell from the platform and one who was caught between the train and platform); and
- One public fatality involving a trip and fall.

There were no injury related workplace fatalities arising from railway-related hazards.

Regarding non-fatal injuries, 537 people were reported to have received serious injuries on rail premises, of which more than 75 per cent were fall related. Of the remaining injuries, approximately nine per cent were assaults. Approximately 80 per cent of reported serious injuries occurred on the Sydney and Melbourne urban passenger rail networks. (ONRSR 2015, p.8)

It is not feasible to compare ONRSR's 2014–15 data to the previous financial year as the Regulator's scope included fewer state jurisdictions in the previous financial year.

In Western Australia, where the Department of Transport administered rail safety implementation during the financial year, there were 0.83 serious rail accidents per million train kilometres. ((Department of Transport (Western Australia) 2015, p.144) The Department of Transport defined a 'serious' rail accident as:

'A 'serious' rail accident is one consistent with a Category A notifiable occurrence as set out in the

Rail Safety Regulations 2011. That is:

- an accident or incident that causes the death, serious injury or significant property damage;
- a running line derailment;
- running line collision between rolling stock;
- a collision at a road or pedestrian level crossing between rolling stock and either a road vehicle or a person;
- a fire or explosion on or in a rail infrastructure or rolling stock that affects the safety or railway operations or that endangers one or more people;
- a suspected terrorist attack or threat of attack; or
- any accident or incident that is likely to generate intense public interest or concern.' (Department of Transport (Western Australia) 2015, p.144)

In Queensland, where the Department of Transport and Main Roads administered rail safety during the 2014–15 financial year, there were 75 Category A notifiable occurrences during that financial year, excluding suicides, assaults or natural causes. (Department of Transport and Main Roads 2015a, p.23)

The department defines a Category A notifiable occurrence as

- 'an accident or incident that caused significant property damage, serious injury or death;
- a running line derailment;
- running line collision between rolling stock;
- a collision at a railway crossing between rolling stock and either a road vehicle or a person;
- a fire or explosion on or in rail infrastructure or rolling stock that affects the safe carrying out of the railway operations or has endangered one more persons;
- a suspected terrorist attack or an act or event suspected to be a terrorist attack; or
- an accident or incident involving an inadequacy in the safety management system for the railway operations that could have caused significant property damage, serious injury or death.'

Safety is a risk that affects both the public and those who work in the rail industry. Rail operators have stringent safety policies and legal requirements they embed and foster in their workplace cultures and practices, such as Pacific National's *Home Safely Every Day,* and Aurizon's *ZEROHarm* campaigns. Metro Trains (Melbourne) has had considerable success promoting safety to the public via social media with its Dumb Ways to Die app, which is targeted at the children and youth demographic. The app includes the song *Dumb Ways to Die,* games and a pledge app users make to be safe around trains.

Interestingly, rail industry safety risks extend beyond immediate rail locations and operations. According to a Pacific National presentation given at the 2016 ARA Heavy Haul Rail Conference, the company's greatest identified safety risk is actually that of train crews driving by road to and from trains and train depots (such as for crew changes), particularly at night and in rural locations. In mitigating this risk, Pacific National has installed fatigue monitoring equipment in train crews' road vehicles that monitor and respond in real time to signs of drivers falling asleep while driving. According to a presentation Aurizon gave at the same conference, the company takes a pro-active approach to safety by analysing past injuries to identify specific risks they need to manage.

Environmental performance

The measurement of the rail industry's emissions is complicated by the need to allocate upstream emissions from power generation sources to downstream energy uses, such as powering electric trains. Emissions data are therefore an approximation.

Changing requirements, such as higher performance and, for passenger rail, air-conditioning and on-board electronics, may increase emissions intensity. Table 26 shows a revised carbon dioxide equivalent emissions estimation of the rail industry since 2005. This has not been updated since publication of *Trainline 3* mainly due to the Commonwealth Department of Industry, Innovation and Science not having released any new data on detailed national fuel consumption. According to the current estimation, emissions have increased by approximately 20 per cent since 2005. The commodities boom and the ensuing increased rail transport of bulk materials is likely to be a cause of the higher level of emissions, as is the increased passenger task.

The emissions intensity of rolling stock and locomotive fuel efficiency also affects the industry's performance. Manufacturers and operators focus on maximising energy efficiency in such ways as Aurizon using regenerative braking on its electrified Central Queensland coal network, which provides 17 per cent of the operator's energy needs on the electrified Goonyella and Blackwater lines (Aurizon 2016b) and in cab real time driver assist systems such as UGL Ltd.'s EcoRun that advise drivers on optimal settings for their trains, such as how much power to use, when to brake or decelerate along given sections of track and according to the specifics of a given train, and how much fuel they have saved. UGL Ltd. estimates EcoRun can provide fuel savings of between 4–15 per cent, depending on train type.

Figure 33 EcoRun

Note: The image above shows a simulation of EcoRun in operation.
Source: Photo courtesy of UGL Ltd.

Table 26 Rail industry's full fuel cycle carbon dioxide equivalent emissions, annual billion grams

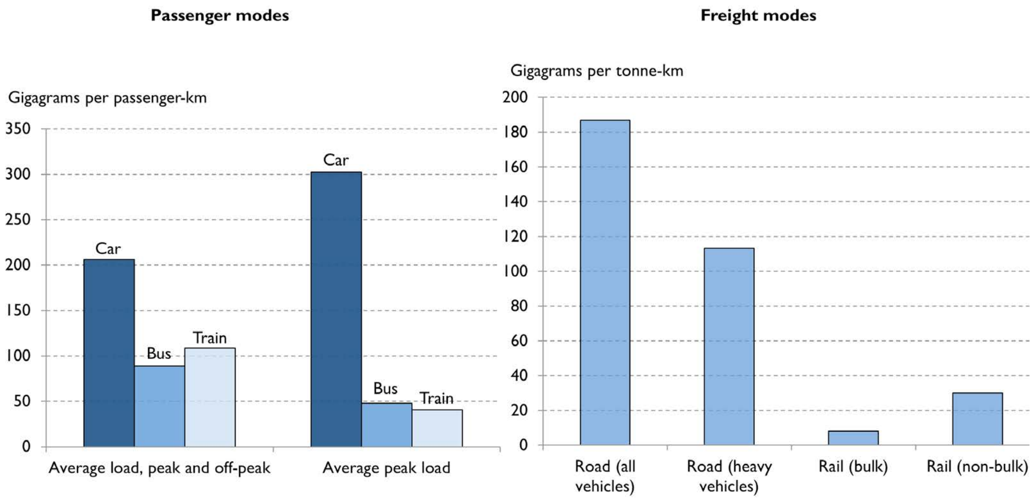
2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
4583	4592	4869	5023	5097	5163	5230	5373	5507	5 686

Note: Preliminary/provisional estimate.
Source: BITRE estimates.

The emissions intensity of freight rail is low relative to road freight vehicles. (Figure 34).

Urban passenger rail transport creates less relative pollution than cars, especially during peak period travel. Over the full day, the gap in average emissions intensity is less substantial, however, since off-peak rail travel generally has much lower average occupancy levels and road vehicles are less subject to congestion.

Figure 34 Estimated emissions intensity of passenger and freight modes, 2007, carbon dioxide equivalent



Notes: "Average load (peak and off-peak)" is the national average occupancy, by mode, over the day, for all passenger travel (both urban and non-urban). For buses, if intensity estimates were restricted solely to urban use, then average values would be substantially higher.

"Road (all vehicles)" is the average across all rigid and articulated trucks as well as light commercial vehicles.

"Road (heavy vehicles)" is the average across rigid and articulated trucks.

"Rail (bulk)" is the average for private, dedicated bulk railways. Bulk traffic on railways shared by non-bulk trains would likely have a higher emissions intensity.

Source: BITRE estimates.

Interstate network indicators

This section considers indicators of the interstate network, namely the railways between the state capitals (and, additionally, Darwin).

Access revenue yield indicator (ARTC)

The access revenue yield data provided by ARTC is the revenue per '000 GTK that a reference superfreighter train generates for ARTC in specific line segments.

Access revenue is the infrastructure manager's income derived from train operators using the railway. The ARTC's access charge has two components: a flagfall charge, which is a reservation charge for booking a train path on a given line segment, invariant with tonnage; and a variable charge, which varies directly with the train operator's gross tonne kilometres. Thus, as tonnage on a train rises, the average access charge per tonne declines.

This access charging regime encourages train operators to operate longer trains. Longer trains enable infrastructure managers to increase tonnage throughput, as there is a limit to the number of trains that can operate over the network. However, longer trains require trackage that can accommodate the trains' lengths. Consequently, interstate network infrastructure has been upgraded to take longer trains.

The indicator presented below is an index of the maximum access yield for the interstate network managed by ARTC, based on ARTC data and analysis. The indicator measures the changes (relative to the base year) in the maximum access revenue yield per gross tonne kilometre. Changes in this composite indicator may reflect changes in:

- real access charges (higher charges will increase the indicator);
- train operators' use of existing capacity (heavier/longer trains will lower the indicator); or
- enhancements in rail infrastructure and train operators' uptake of those enhancements (more uptake of improvements, through heavier trains, will lower the indicator).

As shown in Table 27, the average yield increased on all corridor segments from the 2013–14 to 2014–15 financial years. Average yields on all corridor segments except Albury–Tottenham are at record highs since the 2006–07 financial year.

Table 27 Index of real maximum access revenue yield, interstate network (2009–10 = 100)

	2006–07	2007–08	2008–09	2009–10	2010–11	2011–12	2012–13	2013–14	2014–15
North–South corridor									
Acacia Ridge – Border Loop				100.00	99.36	101.41	100.64	100.14	101.50
Border Loop – Newcastle	101.79	97.92	100.60	100.00	99.36	101.41	100.64	100.14	101.50
Macarthur–Albury	96.07	97.95	100.62	100.00	99.38	101.43	100.64	100.15	101.53
Albury–Tottenham	108.72	105.72	100.62	100.00	99.38	101.43	100.64	100.15	101.53
East–West corridor									
Melbourne–Adelaide	97.55	94.94	100.60	100.00	99.38	101.44	100.65	100.16	101.52
Adelaide–Kalgoorlie	92.68	90.23	100.60	100.00	99.36	101.42	100.64	100.13	101.51
Cootamundra–Parkes	93.41	97.98	100.60	100.00	99.38	101.44	100.66	100.16	101.52
Parkes – Broken Hill	95.68	97.91	100.60	100.00	99.37	101.43	100.65	100.14	101.50
Broken Hill – Crystal Brook	85.35	82.95	100.60	100.00	99.37	101.43	100.65	100.14	101.50

Note: The 2013–14 figures are revised and differ from what was published in *Trainline 3*.
Source: Data provided by ARTC.

Interstate network utilisation

Train frequency on the interstate network

The numbers of scheduled weekly intermodal trains that originated and terminated in the given city pairs are shown in Table 28. These origins and destinations are those of trains, and not those of goods on the trains. For example, Brisbane–Melbourne trains will often dwell in Sydney where goods are loaded and unloaded[36]. Caution is also needed when comparing train numbers. Train numbers can decline when average train sizes increase.

36 Pacific National trains dwell at Chullora. Aurizon trains dwell south of Sydney, Enfield.

There have been increases and decreases in the number of scheduled intermodal designated trains on the North–South corridor. The number of Sydney–Brisbane and reverse trains has more than doubled, while the number of Melbourne–Brisbane (and reverse) trains has declined. The Melbourne–Brisbane decline is due to the cessation of Pacific National's MB2/BM2 trains. The MB2/BM2 trains had an ARTC intermodal designation, but they also carried steel products. While there continues to be only one weekly Sydney–Melbourne intermodal train and no Melbourne–Sydney intermodal trains, the number of Wollongong–Melbourne and Melbourne–Wollongong trains has increased from two to seven and one to seven per week respectively, compared to 2015. All of these trains except one are designated intermodal and all travel via Sydney where they load and unload intermodal freight. These trains serve as mixed intermodal and steel trains.

On the East–West corridor, the number of scheduled intermodal trains operating between Melbourne and Perth has decreased slightly, while the number of scheduled intermodal trains operating between Melbourne and Adelaide has stabilised after previous declines that were due to a decline in the landbridge task between Melbourne and Adelaide. The number of scheduled intermodal trains operating between Sydney and Perth has decreased slightly. Excluded from the Sydney–Perth and Perth–Sydney train numbers are the SCT Goobang (Parkes)–Perth (and return) services, of which there is one train per direction each week. SCT bridges the gap between Goobang and Sydney by road transport, as part of its integrated logistics services.

Table 28 Number of weekly intermodal designated train services, by city pair

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
North–South corridor										
Brisbane to Sydney	1	1	1	1	1	2	2	2	2	5
Sydney to Brisbane	0	0	0	0	0	0	0	0	2	5
Sydney to Melbourne	6	3	0	2	2	3	2	2	1	1
Melbourne to Sydney	6	3	0	2	2	3	2	2	0	0
Brisbane to Melbourne	18	16	17	15	15	15	15	15	16	12
Melbourne to Brisbane	18	17	17	15	15	15	16	16	16	12
Brisbane to Adelaide	5	5	3	3	3	2	2	2	2	2
Adelaide to Brisbane	5	4	3	3	3	2	2	2	2	2
East–West corridor										
Melbourne to Adelaide	17	17	17	11	12	9	9	8	6	6
Adelaide to Melbourne	17	17	17	11	12	9	9	9	6	6
Melbourne to Perth	15	16	15	18	19	20	20	20	20	18
Perth to Melbourne	15	16	15	17	19	20	20	20	20	19
Sydney to Perth	8	8	7	7	7	8	9	10	8	7
Perth to Sydney	8	8	7	7	7	8	9	10	9	7
Adelaide to Perth	0	2	2	0	0	0	0	0	0	0
Perth to Adelaide	0	2	2	0	0	0	0	0	0	0
Central corridor										
Adelaide to Darwin		5	7	7	6	7	6	6	6	6
Darwin to Adelaide		5	6	6	6	7	6	6	6	6

Sources: Working timetables of infrastructure managers (ARTC, Sydney Trains, Brookfield Rail and Genesee & Wyoming Australia).

Weekly trains by interstate line segment

Table 29 presents the total number of scheduled weekly interstate intermodal and steel trains on each line segment. This is an indicator of the intensity of the usage of the interstate network. Table 29 differs from Table 28 because it includes all trains that travel along a given corridor, including those that continue on to another corridor and steel designated trains. A train travelling from Melbourne to Perth, for example, will be counted on all line segments on that route. Table 28 also includes interstate trains that do not travel from capital city to capital city, such as the Melbourne–Griffith (MC and CM) trains.

The most intensive use of the network by interstate trains continues to be on the Crystal Brook–Port Augusta segment, even though there are six fewer trains per week than in 2015. This segment is used by interstate intermodal trains travelling to and from Perth; intermodal trains between Adelaide and Darwin; and steel trains from Newcastle and Port Kembla to Port Augusta, Whyalla and Perth. The reduction in the number of trains operating between Sydney and Parkes via Lithgow is due to Pacific National re-routing five of its Newcastle–Whyalla steel trains via Cootamundra West.

The Sydney–Cootamundra and Cootamundra–Melbourne line segments remain the busiest on the North–South corridor. In addition to intermodal and steel trains, these segments are also used extensively by passenger and bulk commodity (mostly grain) trains.

The distinction between intermodal and steel trains has become blurred. Pacific National has consolidated some of its steel and intermodal traffic into single trains for efficiency's sake. The latest ARTC working timetable (March 2016) now lists some trains previously annotated as steel trains as intermodal. The Wollongong–Melbourne and Wollongong–Brisbane trains are cases in point. For example, the Melbourne–Wollongong and Wollongong–Melbourne trains, which are traditionally steel trains, now carry intermodal freight also and travel via Sydney, rather than directly via Robertson.

Table 29 Total weekly interstate intermodal and steel trains, by line segment

Line segment	2006	2010	2015	2016
North–South corridor				
1. Brisbane–Sydney	63	49	42	48
2. Sydney–Melbourne				
Sydney–Cootamundra	84	68	58	60
Cootamundra–Melbourne	63	53	49	49
East–West corridor				
3. Sydney–Crystal Brook via Broken Hill				
Sydney–Parkes via Lithgow	6	9	11	6
Cootamundra–Parkes	21	20	20	22
Parkes–Crystal Brook	27	29	33	30
4. Melbourne – Crystal Brook				
Melbourne–Adelaide	78	71	59	55
Adelaide – Crystal Brook	51	57	64	60
5. Crystal Brook – Perth				
Crystal Brook – Port Augusta	67	86	90	84
Port Augusta – Tarcoola	60	71	77	69
Tarcoola–Perth	60	59	65	57

Sources: Working timetables of infrastructure managers (ARTC, Sydney Trains, Brookfield Rail, and Genesee & Wyoming Australia).

Train flow patterns on the interstate network

Train flow indicators based on scheduled running times provide information about the flow of trains across the network.

Table 30 only provides information about intermodal designated scheduled services, which share the line with other trains such as bulk goods trains, steel designated trains and passenger trains. Changes to the nature and scale of these other trains' operations may influence intermodal train flow patterns in the infrastructure managers' path planning. It is beyond the scope of this publication to assess what influence other trains' operations may have on intermodal train flow patterns. It should be noted; the train flow patterns are based on scheduled times. Actual times for individual trains may differ due to operational circumstances.

Table 30 Scheduled inter-capital intermodal train flow patterns

Line segment/ direction	Number of weekly intermodal services		Average speed		Average number of stops		Average scheduled transit time (mins)		Average dwell time (mins)		Percentage dwell time (per cent)		Dwell time per stop	
Year	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
North-South corridor														
Brisbane to Sydney	16	17	57	54	8	7	1 027	1 072	117	164	11%	15%	15	22
Sydney to Brisbane	16	17	55	55	7	6	1 067	1 060	156	153	15%	14%	23	24
Sydney to Melbourne	13	13	68	66	3	2	853	872	62	74	7%	9%	23	31
Melbourne to Sydney	12	12	71	72	2	2	808	801	31	22	4%	3%	13	11
Brisbane to Melbourne	12	12	58	59	11	10	2 001	1 971	304	277	15%	14%	27	27
Melbourne to Brisbane	12	12	62	62	10	9	1 892	1 885	216	214	11%	11%	22	25
East-West corridor														
Melbourne to Adelaide	26	24	63	67	3	3	789	749	96	63	12%	8%	28	19
Adelaide to Melbourne	26	25	58	58	5	6	855	861	153	149	18%	17%	28	27
Adelaide to Perth	20	18	66	66	14	14	2 422	2 400	359	355	15%	15%	26	26
Perth to Adelaide	20	19	58	57	18	18	2 765	2 802	680	731	25%	26%	38	40
Cootamundra to Crystal Brook	4	3	67	64	4	4	1 147	1 192	278	321	22%	27%	69	74
Crystal Brook to Cootamundra	9	7	56	66	5	5	1 357	1 152	342	321	25%	28%	68	66
Brisbane to Adelaide	2	2	52	52	15	14	3 230	3 230	921	911	29%	28%	61	63
Adelaide to Brisbane	2	2	51	51	16	16	3 292	3 292	986	963	25%	29%	73	60
Central corridor														
Tarcoola to Darwin	6	6	71	75	4	4	1 897	1 796	225	209	12%	12%	56	55
Darwin to Tarcoola	6	6	70	70	4	4	1 939	1 926	222	208	11%	11%	56	52

Note: The number of services excludes trains that do not run the entire line segment. Cootamundra to Crystal Brook, for example, excludes Sydney to Perth trains that run via Lithgow (five trains).
The Brisbane–Adelaide and Adelaide–Brisbane figures for 2015 have been revised since publication of Trainline 3.

Sources: Working timetables of infrastructure managers (ARTC, Sydney Trains, Brookfield Rail and Genesee & Wyoming Australia).

(a) Dwell time and number of stops

Dwell time indicators show the time trains are scheduled to spend dwelling (stationary) in railway yards and passing loops. Reasons for dwelling include:

- operational—such as changing train crews or refuelling;
- loading and unloading freight at intermediate destinations; and
- track capacity and traffic—trains may need to wait in passing loops and sidings for others to pass or overtake.

North–South corridor

Compared to 2015, the average number of stops in 2016 is largely unchanged.

Sydney is a major market served by the Brisbane–Melbourne and Brisbane–Adelaide trains, where freight is loaded and unloaded. This increases the corridors' average dwell times. Aurizon trains dwell at Enfield. This stop is an important revenue generating activity and therefore enhances the economic viability of Aurizon's rail services. Some dwell times are therefore of the train operators' volition, while some are externally imposed. It is important to consider this when measuring dwell and travel times to assess rail transport's performance.

Average dwell times on the North-South corridor in 2016 have fluctuated by segment compared to 2015. The biggest change has occurred with Brisbane to Sydney trains, whose average dwell time has increased by 47 minutes. A contributing factor to this increase is two trains which dwell at Wallarobba and Stroud Road crossing loops for 159 and 165 minutes respectively, which contrasts to the average dwell per stop for all trains on the corridor of 22 minutes.

East–West corridor

Assessing traffic flows on the East-West corridor is more complex because it consists of several intersecting lines that, for Perth bound trains, intersect at Crystal Brook Junction in South Australia. For Sydney–Perth trains, calculations do not include Sydney–Cootamundra (part of the North-South corridor) and the alternative Sydney–Parkes via Lithgow route.

Similar to the North-South corridor, the average number of stops on the East-West corridor is also largely unchanged, as is average dwell times, except for Melbourne–Adelaide, where average dwell times have decreased by approximately 34 per cent.

Operators stop at intermediate destinations to load and unload freight. Adelaide is the largest intermediate city on the corridor. Pacific National operates a terminal at Islington, SCT Logistics operate from their terminal in Bolivar and Aurizon uses a terminal at Port Flat. Another significant intermediate terminal is at Goobang (Parkes) in New South Wales.

Two other significant operational dwell locations are at Cook and Spencer Junction (Port Augusta) in South Australia. Both locations are used for crew rest breaks, crew changes and the refuelling of some trains. The longest scheduled stop for a train at Spencer Junction in 2016 was more than 19 hours.

Central corridor

Dwell times and the number of stops on the central corridor in 2016 were largely unchanged from 2015. Genesee & Wyoming Australia owns the integrated Darwin–Tarcoola railway. Their Adelaide–Darwin (and return) trains generally include the following characteristics:

- Trains originate/terminate at the intermodal terminals at Berrimah (Darwin) and the Islington freight terminal (Adelaide);
- Trains stop at intermodal terminals in Katherine, Tenant Creek and Alice Springs; and
- Operational stops at Tarcoola and Spencer Junction are common.

(b) Average speed

Average train speed is a measure of a train's in motion speed plus its dwell time. The measure can be used to assess physical railway performance, both train and infrastructure. As with other train pattern indicators, average speed is partly determined by train operator factors such as locomotive power and whether the operator picks up and drops off freight en route. Prevailing speeds also reflect a range of infrastructure-based factors, including the number of stops, track alignment, and track condition.

Table 30 shows that average scheduled speeds have remained largely unchanged on all corridors compared to 2015. The reduced average dwell time on the Melbourne-Adelaide corridor is reflected in average speeds on the same corridor, which have increased by four kilometres per hour.

Track indicators for the interstate network

The indicators in this section provide information on infrastructure quality and freight train flow patterns on the interstate network.

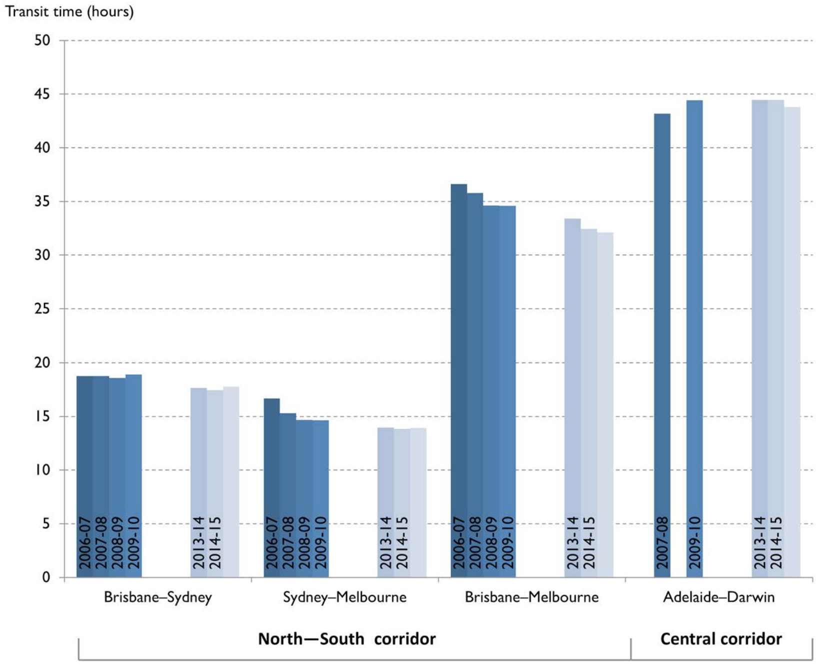
Scheduled intermodal transit time

The scheduled intermodal transit time indicator is the average timetabled transit. Figure 35 and Figure 36 present the average scheduled intermodal transit time for trains on eight city pairs, for the North–South, Central and East–West corridors respectively. These data are presented in Table 30.

Scheduled transit times are influenced by factors including line speed; the number of stops en route; the number and type of other trains on the line (particularly when the route has single track or in shared urban networks); operator-dependent factors such as time spent in intermediate cities; and, for Sydney–Perth trains, the route used.

After earlier decreases in the North-South corridor, mostly between 2006–2010, average scheduled transit times have largely stabilised. Compared to the previous financial year, average scheduled transit times on all corridors were roughly the same in 2015–16, except for the Melbourne–Perth corridor, where average scheduled transit times increased by 1.5 hours. This increase occurred with eastbound trains, whose average scheduled transit times increased by approximately six hours. The eastbound train with a 19-hour layover at Spencer Junction was a major reason for this increase.

Figure 35 Average scheduled transit times, North–South and Central corridors, 2006–07 to 2015–16

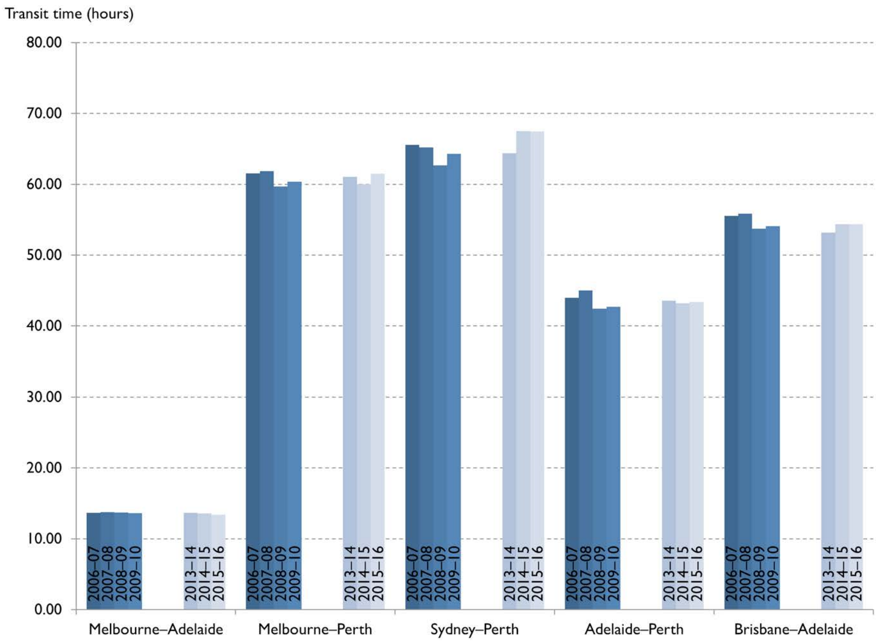


Notes: Calculations include all intermodal designated trains on a given line segment. The Sydney–Melbourne calculations, for example, include Brisbane–Melbourne trains.

For 2005–06 to 2009–10, BITRE calculated average scheduled transit times from infrastructure managers (ARTC, RailCorp and Brookfield Rail) working timetables that were current for the last week of June each year. In 2013–14, ARTC timetables effective from 6 April 2014 to 21 June 2014 were used. For the Central corridor, ARTC timetables were used in conjunction with Genesee & Wyoming Australia's timetable, effective as of 30 April. In 2014–15, ARTC timetables effective from 19 April 2015 were used. For the Central corridor, ARTC timetables were used in conjunction with Genesee & Wyoming Australia's timetable, effective as of April 2015. For 2015–16, ARTC's March 2016, John Holland's January 2016, Sydney Trains March 2016, Genesee & Wyoming Australia's April 2016 and Brookfield Rail's April 2016 timetables were used.

Sources: Infrastructure managers' working timetables (ARTC, Sydney Trains, Brookfield Rail, and Genesee & Wyoming Australia).

Figure 36 Average scheduled transit times, East–West corridors, 2006–07 to 2015–16



Notes: Calculations include all trains on a given line segment. The Melbourne–Adelaide calculations therefore include Melbourne–Perth trains.

Calculations for west bound Sydney–Perth trains are based on a combination of the two routes these trains take: via Cootamundra and via Lithgow.

For 2005–06 to 2009–10, BITRE calculated average scheduled transit times from infrastructure managers (ARTC, RailCorp and Brookfield Rail) working timetables that were current for the last week of June each year.

In 2013–14, ARTC timetables effective from 6 April 2014 to 21 June 2014 were used. Brookfield Rail provided their timetable used in the week beginning 6 April 2014. In 2014–15, ARTC timetables effective from 19 April 2015 were used. Brookfield Rail provided their timetable used in the week beginning 6 April 2015 and Sydney Trains provided their timetable used in the week beginning 20 April 2015.

For 2015–16, ARTC's March 2016, John Holland's January 2016, Sydney Trains March 2016 and Brookfield Rail's April 2016 timetables were used.

The Sydney–Perth calculations are revised for the years 2013–14 to 2015–16.

Sources: Infrastructure managers' working timetables (ARTC, Sydney Trains, Brookfield Rail and Genesee & Wyoming Australia).

Train reliability on the interstate network

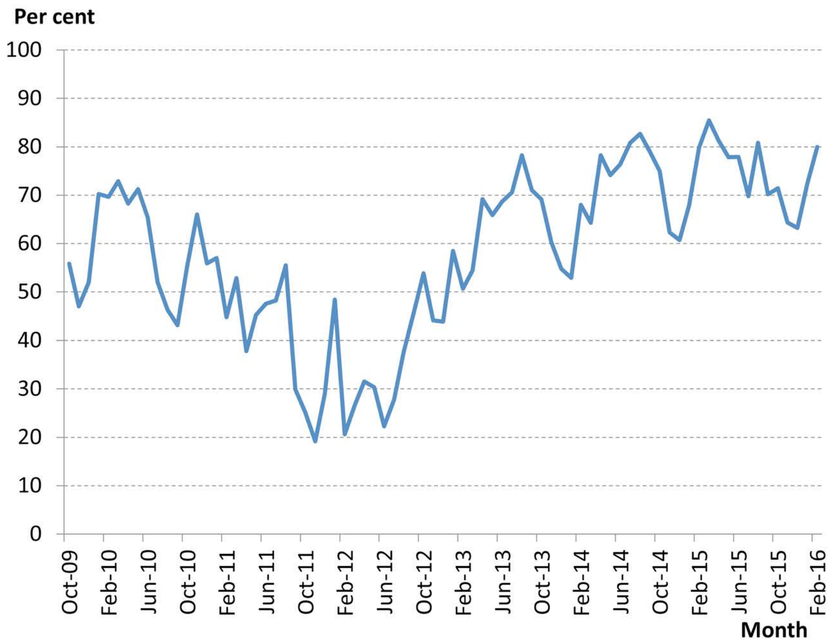
The ARTC publishes performance indicators relating to key service quality areas including reliability. Detailed information regarding reliability by city pair is available on the ARTC website.

Train and track issues can affect reliability. Problems for train operators include mechanical issues with rolling stock, delays at terminals, flow on problems from other operators' delays, and problems beyond operators' control such as trespassers and vandalism. These problems can cause significant delays across the network and trains entering the network late. This requires infrastructure managers to allocate train paths without compromising their obligations to other operators.

Infrastructure issues can also impact reliability. Track quality problems can result in (temporary) speed restrictions and track closures. Signalling failures can also cause delays. Infrastructure maintenance and renewal, as well as weather conditions, are important aspects in infrastructure reliability. Flooding in the New South Wales Central Coast in April 2015, for example, caused a temporary complete closure of both the Hunter Valley and North Coast lines.

Figure 37 and Figure 38 show the percentage of intermodal trains that left the ARTC network within 30 minutes of schedule. The data are collected monthly and is subject to significant variation due to the impact of individual events.

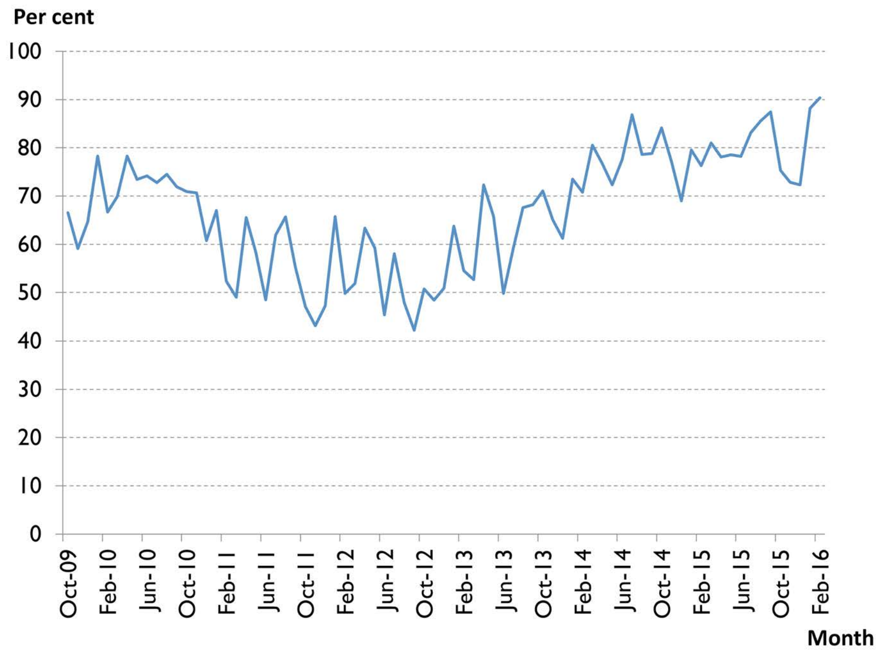
Figure 37 North–South corridor, percentage of intermodal trains exiting the network within 30 minutes of schedule



Source: Data provided by ARTC.

Reliability on the North–South corridor (Brisbane–Islington Junction, Botany/Macarthur/Unanderra–Melbourne) decreased from early 2011 to mid-2012. During this period, the track between Sydney and Melbourne was subject to many temporary speed restrictions and increased maintenance activity due to reported rough-riding and mud holes (ATSB 2013, p.5). In December 2011, the ARTC commenced the "Ballast Rehabilitation Programme", to replace fouled ballast and improve track drainage on the corridor. Temporary speed restrictions have been progressively removed and reliability improved from mid-2012. Since June 2013, approximately 72 percent of intermodal trains on average exited the network within 30 minutes of schedule.

Figure 38 East-West corridor, percentage of intermodal trains exiting the network within 30 minutes of schedule



Source: Data provided by ARTC.

Reliability on the East–West corridor (Cootamundra West/Parkes–Kalgoorlie and Melbourne–Kalgoorlie) has remained approximately stable, but generally improved since February 2014. There was a small decline from August 2011 to early 2013. During this period, high track utilisation, due to the commencement of iron ore services, meant unhealthy trains [37] on the Crystal Brook–Tarcoola section had limited opportunities to recover. Reliability has since improved due to the installation of Centralised Train Control (CTC) signalling. Since October 2014, average reliability has been approximately 80 percent. February 2016 was a record high, with approximately 90 percent of intermodal trains exiting the network within 30 minutes of schedule.

Permitted train lengths on the interstate network

Permitted train lengths are important to track capacity. On Australia's mostly single track this is often determined by the length of passing loops. Since the mid-1990s in particular, infrastructure managers built longer crossing loops and passing lanes (approximately 6–8 kilometres in length) across the interstate network. Track alignment and gradients can also determine permitted train lengths.

37 ARTC defines a "healthy" service as one which: (a)presents to the network within tolerance (on time within tolerance), is configured to operate to its schedule and operates in a way that it is able to maintain its schedule; (b) or is running late only due to causes within the network, but only when the root cause is outside the rail operator's control; (c) or is running within tolerance, regardless of previous delays (ARTC 2014).

Permitted unrestricted train lengths on the interstate network are as follows:

- 1 500 metres on Brisbane–Sydney;
- 1 500 metres, on Melbourne–Adelaide (1 800 metres restricted); and
- 1 800 metres on Sydney–Melbourne, Cootamundra–Crystal Brook, Adelaide–Kalgoorlie, Tarcoola–Darwin.

The 'unrestricted' train length is the maximum length operators can operate any scheduled service without reference to the infrastructure manager. The length is shorter than the standard loop length on the line segment. The 'restricted' train length is the maximum train length permitted on the line segment. Under restricted access terms, trains that exceed the prevailing loop length can be operated by ensuring trains that have to be passed can be accommodated within the prevailing loop length.

Since 2007–08, passing loops have been constructed on the Cootamundra–Parkes section and additional passing lanes added on the single track sections between Junee and Melbourne to allow the operation of unrestricted 1 800 metre trains.

Double stacking capability on the interstate network

Double-stacking containers on wagons is also important to track capacity. In Australia, double-stacking involves stacking one hi-cube (9 feet 6 inch, or 2.896 metres high) container on top of another in a low-floor (well) wagon. The top of the stack must be no higher than 6.5 metres above the top of the rail, and mass limits must not be exceeded. Double-stacking is permitted west of Parkes and west of Adelaide.

Clearances on the North–South corridor are restricted to single-stacking of hi-cube containers. The increasingly prevalent higher maxicube (10 feet 6 inch, or 3.20 metre) containers must be conveyed in low-floor well wagons.

The central corridor line can accommodate double-stacked containers and road freight vehicles (for the transport of oil) 'piggybacked' on rail flat wagons.

Track quality of the interstate network

The maintenance and standards of railway infrastructure are important to trains operating performances. The permitted track speed and the smoothness of the wagons' ride are strongly influenced by the infrastructure quality, the maintenance regime and the underlying economic life of the infrastructure.

Figures 24 to 27 illustrate engineers' physical measures of average track condition by line segment. These indicators use a 'track quality index' (TQI). A lower the index number denotes a higher track quality.

The composition of the index varies between infrastructure managers, reflecting both differences in priority and different operational environments across the network. Therefore, these index numbers should not be used to compare track conditions across line segments managed by different infrastructure managers. However, relative changes in TQIs can meaningfully be compared. Box 8 provides details of how these indices are calculated for each track manager.

Box 8 Calculating track quality indices

For safety, maintenance, planning and regulatory reasons, infrastructure managers regularly measure the condition of their track. Managers measure the extent to which the railway track deviated from the 'designated' (or 'true') alignment. Infrastructure managers can report a global indicator of track condition on a given line segment. The ARTC produced a 'track quality index' (TQI) as part of their Access Undertaking agreement with the Australian Competition and Consumer Commission. The TQI is a statistical measure calculated from the standard deviations of a number of different track geometry parameters. The TQI for a given line segment is taken as the average of the individual TQI sample readings. The parameters that are measured include rail placement, vertical and horizontal alignment, and twist.

Infrastructure managers regularly operate a train with a 'track geometry measuring car'. The carriage is equipped to measure and record a range of different geometric parameters. There is a variety of track geometry measuring cars in Australia and hence a variety means of measuring and analysing the parameters that make up the TQI. Further, track quality is reported as a composite measure of the different geometric parameters. This composite measure can differ between systems depending on the parameters used.

The following are the track quality measurements and indicators for the national network.

The ARTC's and Genesee & Wyoming Australia's TQIs, standardised across both networks, consists of:

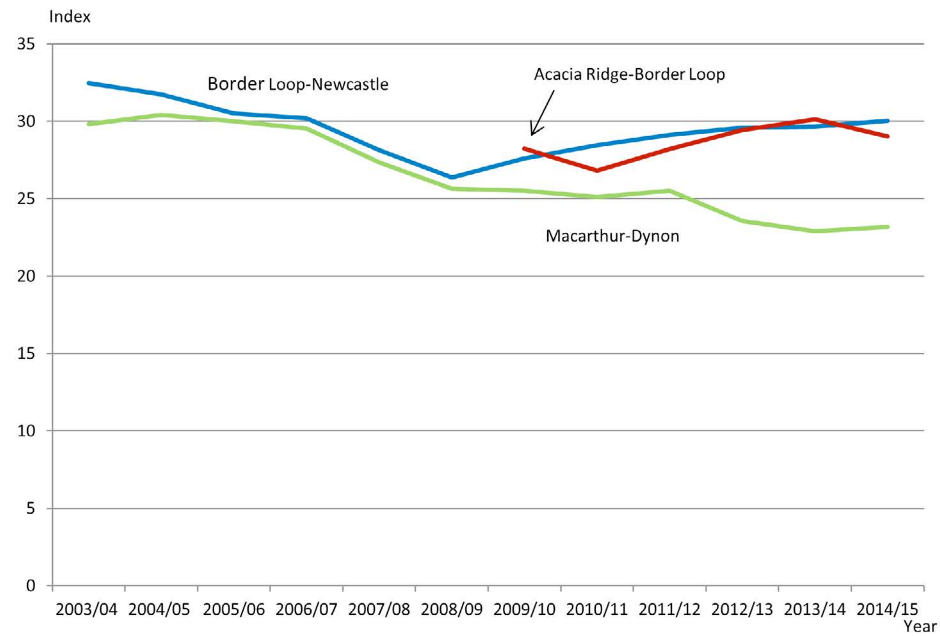
- gauge;
- twist (short), measured over two metres;
- vertical irregularities ('top'), deviation over a 20 metre inertial reading (average of left and right rail); and
- horizontal line irregularities ('versine'), 5/10 metre chord emulation (average of left and right rail).

These are based on average of Standard Deviations over 100 metre sections.

The charts show trends in track condition for given line segments. The rate of track quality decline is influenced by such factors as the quality of renewal material and work, the level and type of track usage, climatic and local geographical factors, and the skill and timeliness of ongoing maintenance work.

As the figures below show, ARTC's TQI has fluctuated by line segment. The index for the Macarthur–Dynon corridor has trended down, the index for the Cootamundra West–Crystal Brook corridor is increasing after an earlier sharp decline, while the index for other corridors is either largely unchanged or is increasing. Genesee & Wyoming Australia's TQI has remained relatively stable or has fluctuated significantly but without long term trends of change (Katherine–Union Reef corridor). The break in the Katherine–Union Reef and Union Reef Darwin corridors in the first half of 2012 is due to the Edith Bridge derailment.

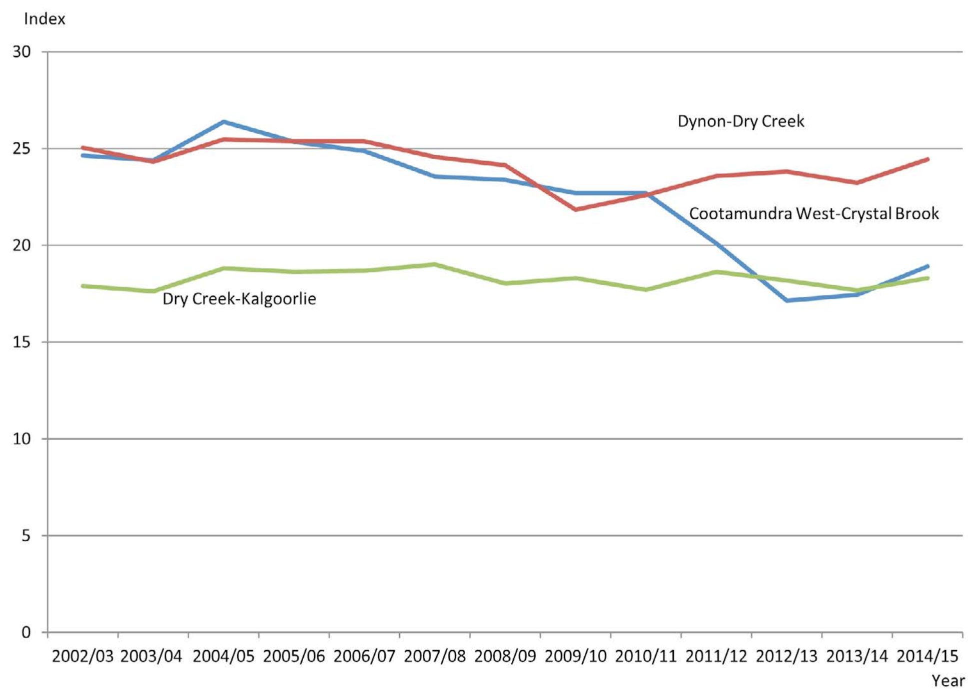
Figure 39 ARTC track quality index, North–South corridor



Note: Lower indices indicate higher track quality.

Source: Data Provided by ARTC.

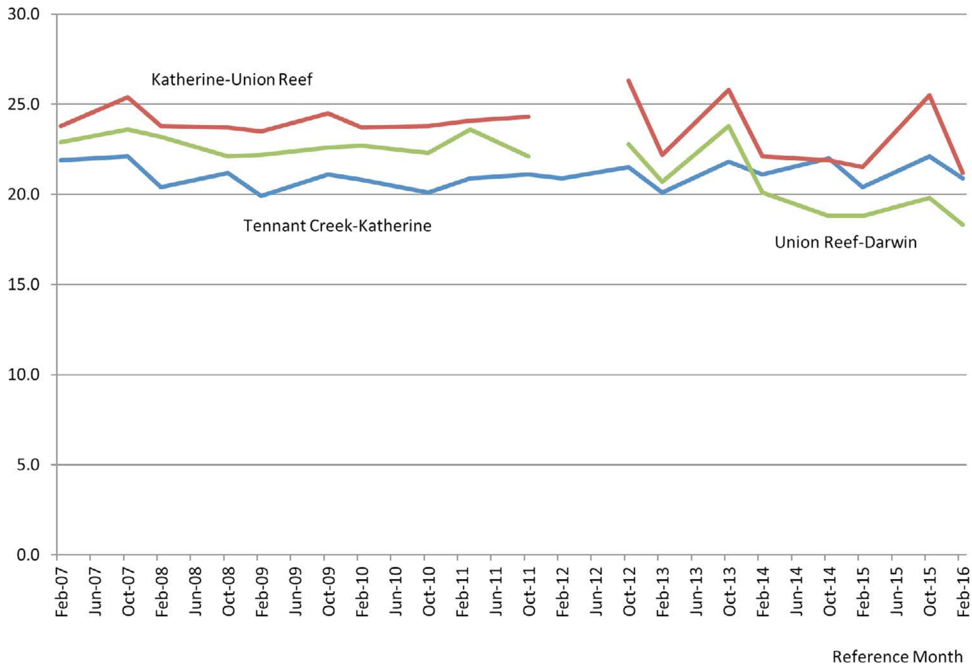
Figure 40 ARTC track quality index, East-West corridor



Note: Lower indices indicate higher track quality.

Source: Data Provided by ARTC.

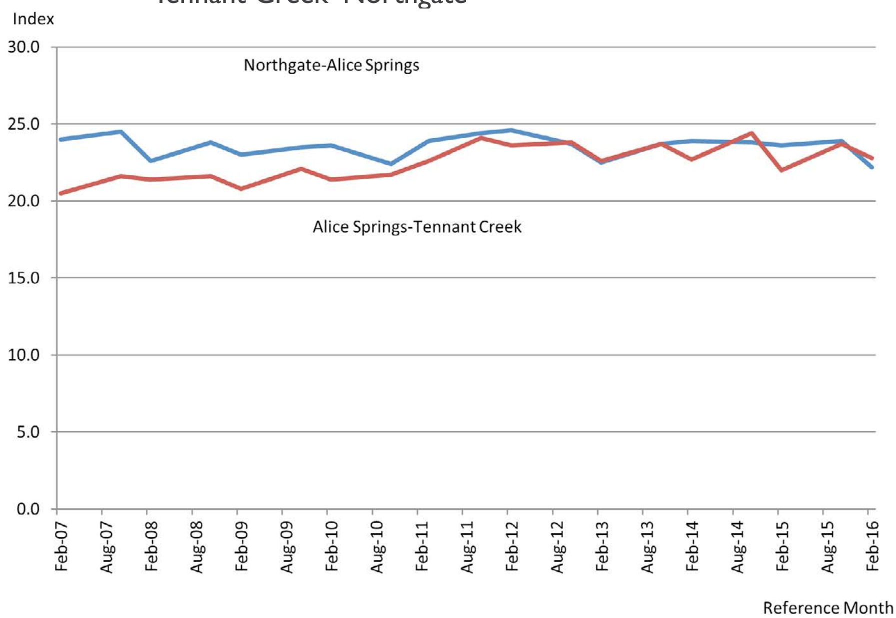
Figure 41 Genesee & Wyoming Australia track quality index, Darwin-Tennant Creek



Note: Lower indices indicate higher track quality.

Source: Data Provided by Genesee & Wyoming Australia.

Figure 42 Genesee & Wyoming Australia Track Quality Index, Tennant Creek–Northgate



Note: Northgate is the start of the Genesee & Wyoming Australia track. It is located shortly north of Tarcoola, where it separates from the ARTC track.
Lower indices indicate higher track quality.

Source: Data Provided by Genesee & Wyoming Australia.

Passenger train indicators

(a) Punctuality

Punctuality is important to rail's competitiveness. The International Transport Forum (2010, p.5) notes poor punctuality not only worsens the transport "experience" but can affect the commercial (work) and personal activities of those that depend on reliable transport services.

Urban rail punctuality

For infrequent services, in particular, customers rely on timetables. Punctuality is therefore part of a journey's perceived time. Punctuality is less significant for frequent "turn up and go" services[38]. Real-time information at railway stations, light rail stops, online and through smart phone applications are playing a growing trip planning role.

Measures of punctuality are largely determined by the definitions of "on time", which varies between operators. The punctuality of operators is presented in Table 31. In 2014–15, most operators met their punctuality targets.

Table 31 Urban rail punctuality, on time performance, 2014–15

	Sydney[a,b]	Melbourne	Perth	Brisbane	Adelaide
Heavy rail punctuality (%)	93.9	92.7	95.02	97.24	91.5
Heavy rail target (%)	92	92.5	95	95	95
Heavy rail measure	Arriving within 5 minutes of schedule at peak times	Arriving no later than 4 minutes 59 seconds late.	Arriving within 4 minutes of schedule	Arriving within 3 minutes 59 seconds of scheduled time	Arriving no more than 5 minutes 59 seconds after scheduled time.
Light rail punctuality (%)	–	83	–	–	99.1
Light rail target (%)	–	82.9	–	–	93
Light rail measure	–	Arriving no earlier than 59 seconds before and no later than 4 minutes 59 seconds after scheduled time.	–	–	Arriving no more than 5 minutes 59 seconds after scheduled time.

Notes: a Sydney and Gold Coast light rail operators do not publish timetables as they operate on a 'turn up and go' basis.
b Sydney heavy rail is "suburban lines". It does not include inter-city services that also use the Sydney suburban network. Skipped stops are not counted as being punctual.

Sources: Public Transport Victoria 2015a, p.26; Public Transport Authority of Western Australia 2015, p.116; Advice from Department of Planning, Transport and Infrastructure; Sydney Trains 2015; Queensland Rail 2015a.

38 The light rail operators in Sydney and the Gold Coast, for example, do not publish timetables.

Non-urban rail punctuality

Table 32 shows operators' punctuality targets and results. Punctuality targets are generally higher for markets which are likely to have a higher value-of-time. For example, trains which service interurban commuter corridors, such as NSW TrainLink's intercity services and V/line have targets of 92 per cent. In contrast, QR Travel, which operates numerous long-distance services, have a punctuality target of only 75 per cent.

The punctuality results indicate long-distance services are generally less punctual than shorter distance services. Of note is TransWA's *Prospector*. While its recorded punctuality increased from 77 to 84 percent, the target decreased from 90 to 80 percent. According to page 54 of the Western Australia Public Transport Authority 2013–14 Annual Report: *"On the basis of historical data, the Prospector goal was adjusted in 2013–14 from 90 per cent of services to 80 per cent, to reflect a more achievable target."* (Public Transport Authority of Western Australia 2014). QR Traveltrain's target measurement has also increased, from 10 minutes to 15 minutes.

Table 32 Non-urban rail punctuality, on time performance, 2014–15

	Service type	Punctuality 2014–15 (%)	Punctuality target (%)	Measurement
Queensland Rail	QR Traveltrain	85.09	75	Arriving within 15 minutes
NSW TrainLink	Intercity	87.4	>92	Arriving within 6 minutes
	Regional & interstate	77.4	>78	Arriving within 10 minutes
V/Line	All	95.7	92	Arriving within 5 minutes on commuter services, 10 minutes on long services
TransWA	Australind	93	90	Arriving within 10 minutes
	Prospector	65	80	Arriving within 15 minutes
	MerredinLink	84	95	Arriving within 10 minutes
	AvonLink	96	95	Arriving within 10 minutes

Note: For intercity Queensland Rail services on the TransLink network, see Chapter 3 – Urban passenger rail – Reliability.

Sources: V/Line 2016a; V/Line 2015, p.9; NSW Trains 2015, p.11; Queensland Rail 2015a; advice from Queensland Rail; Public Transport Authority of Western Australia 2015, p.56.

(b) Service attributes

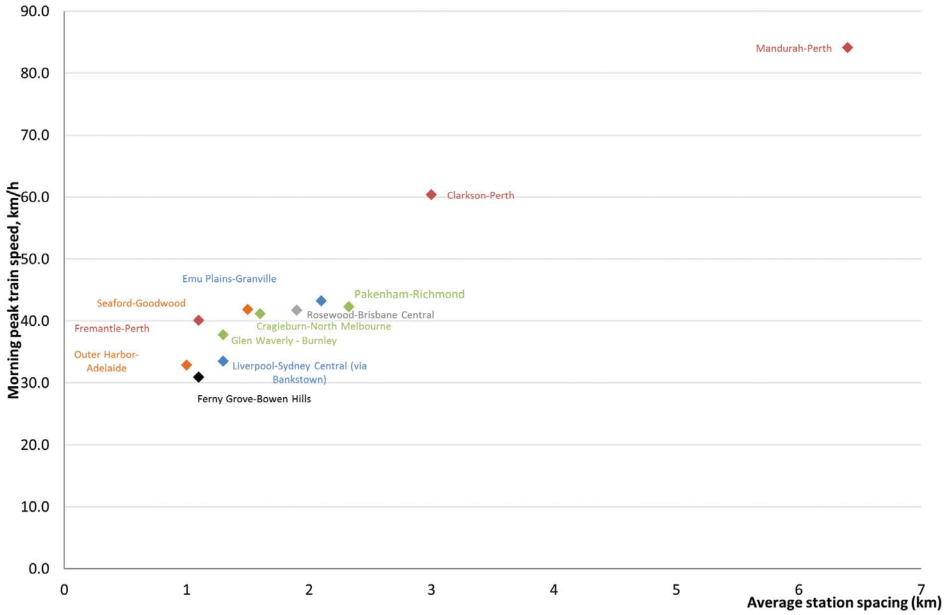
Train speeds

Australia's older passenger lines have relatively short station spacing. Mees and Dodson (2011) observed that Australian lines were often built as a way of supporting urban expansion with consequent short distances between stations[39]. A consequence of this, however, is the regular stops cause slower speeds.

In contrast, newer lines, such as Mandurah–Perth and, to a lesser extent, Clarkson–Butler have wider station spacing, which allows higher average speeds. In addition to speed, wider station spacing allows for simpler train schedules because there is little need for express services. Figure 43 shows stopping services. Express services help overcome short station spacing.

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

Figure 43 Station spacing and illustrative train speeds



Source: Derived from operator timetables, June 2016.

Wide station spacing reduces the capacity for patrons to access railway stations by walking. Integration of the railway with other modes of transport, such as the provision of feeder bus or tram services and park and ride facilities therefore becomes crucial[40].

40 While the Perth–Mandurah line is, by virtue of its operator, an urban system, its distance (70 kilometres) is comparable to the Melbourne–Geelong service, which V/Line operates as an inter-urban service. Similar to the Melbourne–Geelong line also, the Perth–Mandurah line does not follow a continuous urban area but also traverses lightly urbanised and non-urbanised areas between urban centres.

Figure 44 Mandurah Railway Station

Note: The image above shows Mandurah Railway Station. The Mandurah line was opened in 2007. The station is not located in the centre of Mandurah, but is served by frequent feeder bus services and has a commuter car park, as can be seen in the right of the image.

Source: Photograph courtesy of Rodney Avery.

Average scheduled light rail speeds also generally correlate to stop spacing (see Table 32). Caution is needed when comparing Melbourne with other networks due to the wide variation in speeds that exist in that city. Currie and Burke (2013) analysed designated stop spacing and average speeds by line on Melbourne's network. Designated stop spacing varies from 100 metres on the East Brunswick–St Kilda Beach line to 317 metres on the Bundoora RMIT–Water Front City Docklands line. Across the entire Melbourne network, average stop spacing is 254 metres.

Table 33 Light rail station spacing and speeds

	Gold Coast	Sydney	Melbourne	Adelaide
Average station spacing (metres)	812	556	254	535
Average scheduled speed (km/h)	23	21.3	16	17.3

Note: Sydney, Adelaide and Gold Coast average speeds derived from scheduled transit time and route kilometres.

Sources: Currie and Burke 2013; BITRE analysis.

Speeds depend largely on a light railway's function and its operating environment. A line designed to operate in a dense pedestrianised zone has lower speeds than vehicles operating in a segregated corridor. Sometimes a single line will have a mix of functions. Sydney's light rail, for example, operates largely on a segregated line. Between Haymarket and Central Station, however, it travels "on-road" (albeit largely separated from vehicles) through areas of significant pedestrian activity near Paddy's Market and George Street.

Frequency

The graphs below show urban heavy rail service frequency as measured from arrival at the point of destination from the point of departure ('end of line') and from major centres and junctions. All cities provide express and all stops services, to varying degrees.

Frequency is important to service quality and, therefore, mode choice. Frequency is also closely connected to passengers' overall travel times. It determines how long passengers wait for a train and how closely the train departure (or arrival) time is to the passenger's preferred time. Passengers' perceptions of service frequency are therefore closely related to their perception of total journey times (including waiting time, in-vehicle journey time and transfer time).

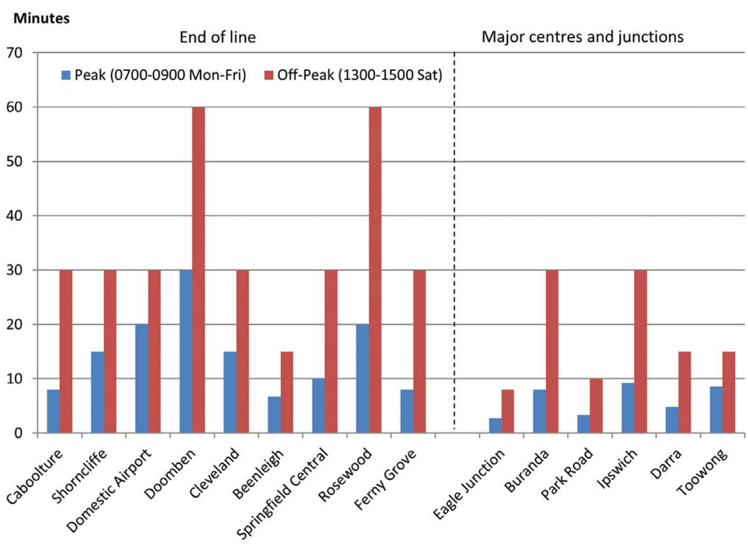
Frequency is also important in integrating rail services both with other rail lines and other transport modes. Services may have coordinated arrival and departure times for passenger interchanges between services. However, the scale of large urban networks can make coordination unfeasible. In these cases, frequency is crucial in reducing passengers' interchange waiting times. Major centres and junction stations generally have high frequencies due to service densification. As the graphs below show, all Australian capital cities with urban heavy rail services have higher service frequency during peak periods.

Timetable analysis shows service frequency in 2016 is largely the same as the previous year.

Brisbane heavy rail

Queensland Rail operates all-stops and express trains. Figure 45 illustrates average times between trains for arrivals at Brisbane Central in peak and off-peak times, from stations that are at the end of lines or at major centres and junctions.

Figure 45 Average time between trains for services arriving at Brisbane Central



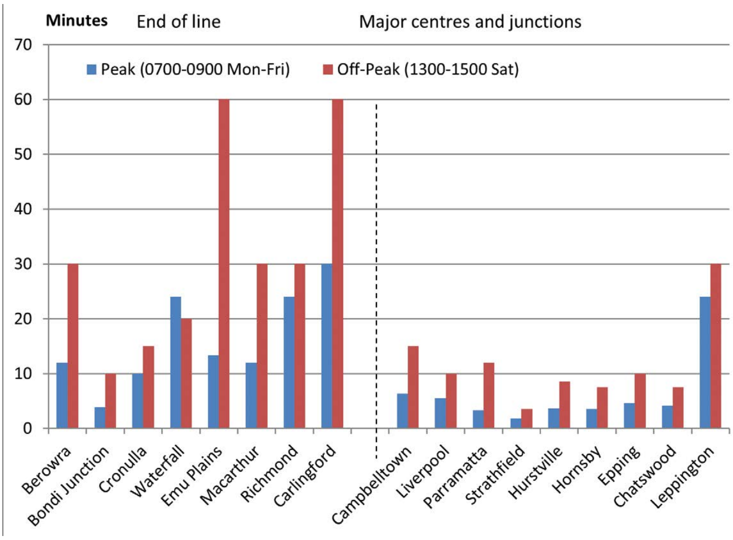
Source: Translink, 2016.

Sydney heavy rail

Sydney Trains frequency depends on the time of day, service demand and varying network capacity constraints. It is not practical to measure average peak hour wait times from points of origin ('end of line') due to the wide discrepancy between lines across the network. The Bondi Junction line has the most services, at an average arrival at Sydney Central every four minutes, while the Carlingford line has an average arrival of every 30 minutes; see Figure 46. There is less discrepancy in peak hour wait times at major centres and junctions. The average wait time is six minutes.

Off-peak service frequencies similarly vary significantly across the network from both points of origin and major centres and junctions.

Figure 46 Average time between trains for services arriving at Sydney Central



Source: Sydney Trains 2016a.

Figure 46 includes a number of stations listed in The New South Wales Government's Transport Master Plan as being "Regional Cities" (Parramatta and Liverpool) and "Major Centres" (Hornsby, Chatswood, Bondi Junction Hurstville, Campbelltown, Macarthur).[41] These locations are significant transport interchanges and destinations. Frequencies through these locations provide an important indicator of the value of the network in providing transport services other than radial-based commuting.

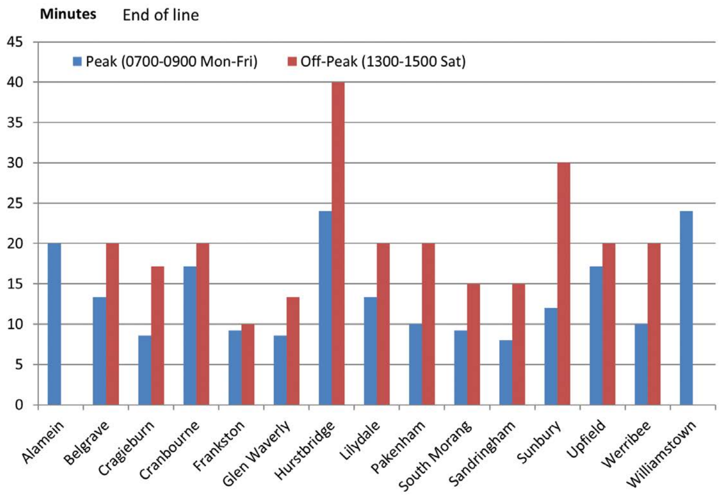
Melbourne heavy rail

Peak frequencies similarly vary considerably across services, with smaller branch lines generally running fewer trains. For 'end of line' services, Alamein and Williamstown have the fewest through running peak time services, at intervals of 20 and 24 minutes respectively. Average off peak services vary from 10 minutes on the Frankston line to 40 minutes on the Hurstbridge line. The

41 The full list of "Regional Cities" is: Paramatta, Liverpool, Penrith. Major centres are: Hornsby, Dee Why, Brookvale, Chatswood, Bondi Junction, Burwood, Bankstown, Kogarah, Hurstville, Cambelltown, Macarthur, Blacktown, Castle Hill.

Alamein and Williamstown lines have no direct services to Flinders Street station in the off peak period shown. Rather, shuttle trains run to Camberwell and Newport stations respectively, where passengers change trains for onward travel.

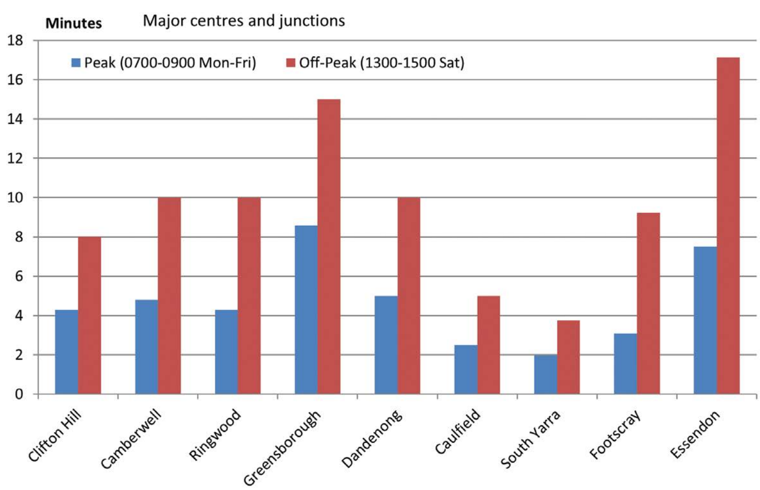
Figure 47 Average time between trains for services arriving at Flinders Street from end of line



Source: Public Transport Victoria 2016.

There is less variation between peak hour service frequency at major centres and junctions. South Yarra is the busiest, with an average departure every two minutes. This is because it is one of Melbourne's busiest junctions, with converged trains from Cranbourne, Pakenham, Frankston and Sandringham passing through the station. During off peak periods, service frequency at the major centres and junctions as shown in the graph is approximately half that of peak hour services.

Figure 48 Average time between trains arriving at Flinders Street Station from major centres and junctions

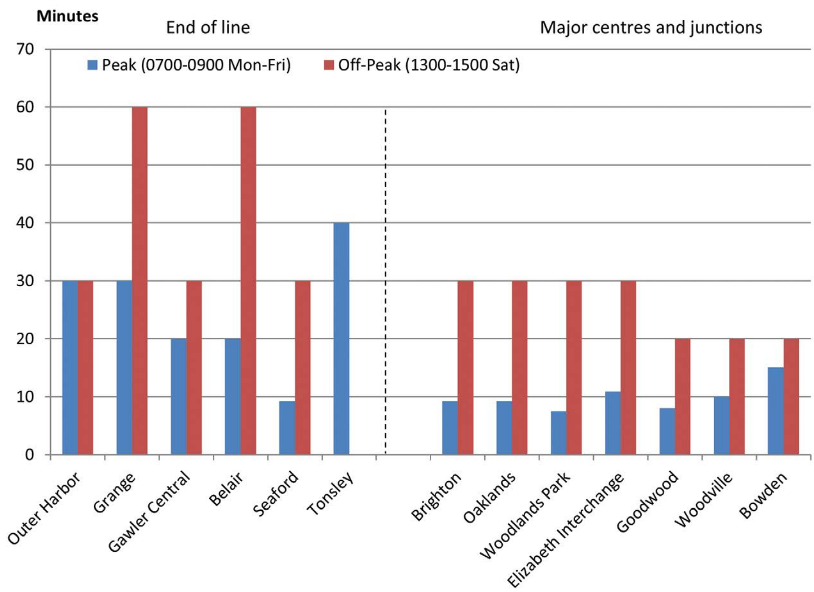


Source: Public Transport Victoria 2016.

Adelaide heavy rail

While average frequencies are relatively consistent across the Adelaide network for both 'end of line' services and trains departing from major centres and junctions, they are comparatively long. Service patterns are strongly geared to the peak-period commuting task to Adelaide Railway Station. Average times between trains in peak periods are often less than one-half of those in off-peak periods. Adelaide's lower service levels reflect its modest ridership compared to the other networks.

Figure 49 Average time between trains for services arriving at Adelaide Railway Station



Note: The Tonsley line does not run services on the weekend.
Source: Adelaide Metro 2016a.

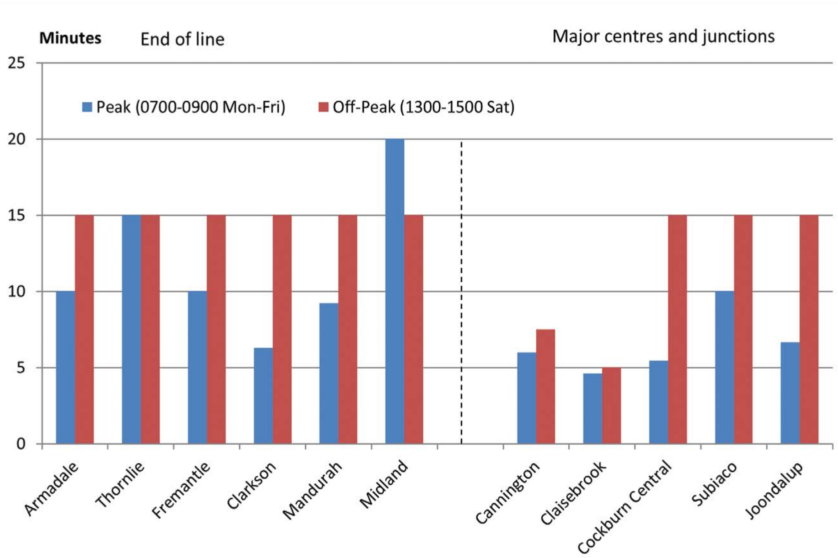
Perth heavy rail

Transperth's trains mostly stop at all stations. Transperth's focus on maintaining low dwell times and long distances between stations on its Mandurah and Joondalup lines enables relatively high average line speeds; see Figure 43. Consequently, there are no express services on these two lines, unlike the city's 'heritage' lines that are spread over large areas but with closer station spacing.

A notable aspect of Transperth's rail services is that each 'end of line' service has a train departing, on average, every 15 minutes during the assessed off peak periods (eight services each). The difference in service levels between major centres and junctions and 'end of line' services is less significant than in Brisbane, Sydney and Melbourne. This is partly due to the lack of express services. Having only two junctions outside the city centre reduces the service densification seen in other cities where lines merge, such as South Yarra in Melbourne.

All 'end of line' service frequencies have remained largely unchanged, except for the Midland line, which, according to timetable analysis and comparison, now runs six peak hour services compared to 12 as reported in *Trainline 3.* Of those previous 12 services, approximately half ran express. According to the latest available timetable, these express services no longer run, hence the reduction. Major centre and junctions service frequencies are unchanged for the peak and off peak periods, except for Claisebrook which has had a peak period reduction flowing on from the Midland line reduction.

Figure 50 Average time between trains for services arriving at Perth Central



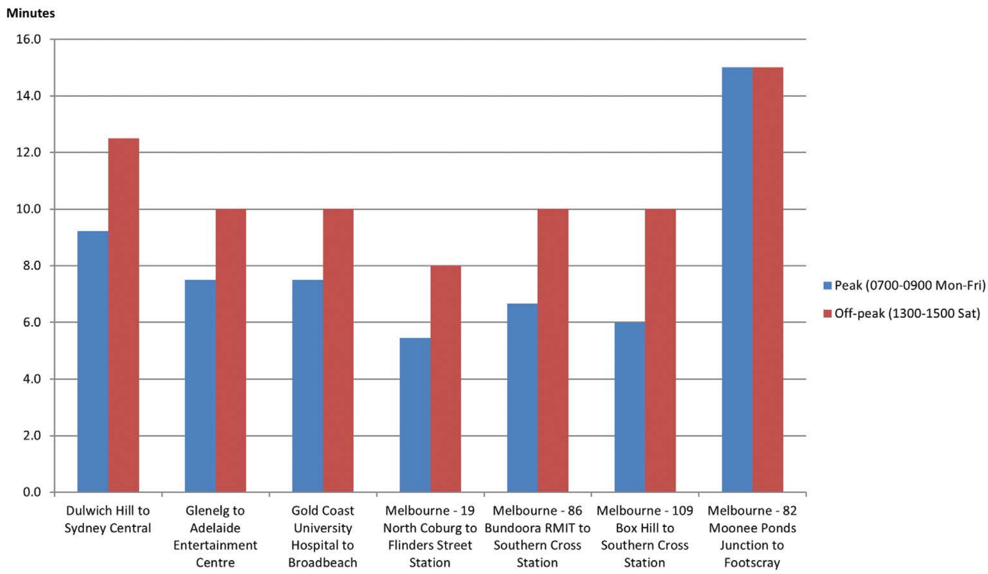
Source: Transperth 2016.

Light rail

Light rail frequencies in Australia vary across networks (see Figure 51). Average off peak waiting times are 15 minutes or less. In peak periods, waiting times are generally about eight minutes. Care should be taken when comparing the single route Sydney, Gold Coast and Adelaide operations with Melbourne. Many Melbourne routes share tracks, meaning a customer may be able to take more than one tram to his/her destination, thus increasing frequency.

The selected routes for Melbourne provide an indicator of transit times across the network's 24 routes. Routes 19 (Flinders Street Station to North Coburg) and 82 (Moonee Ponds Junction to Footscray) have the shortest and longest peak hour intervals on the network, respectively.

Figure 51 Average time between trams, by route and direction



Note: Sydney and Gold Coast operations do not run to timetables. Melbourne tram services have a separate timetable for Fridays. As such, calculated peak hour frequency as shown above is based on the published Monday–Thursday timetables. Peak hour calculations are based on peak hour directions of travel.

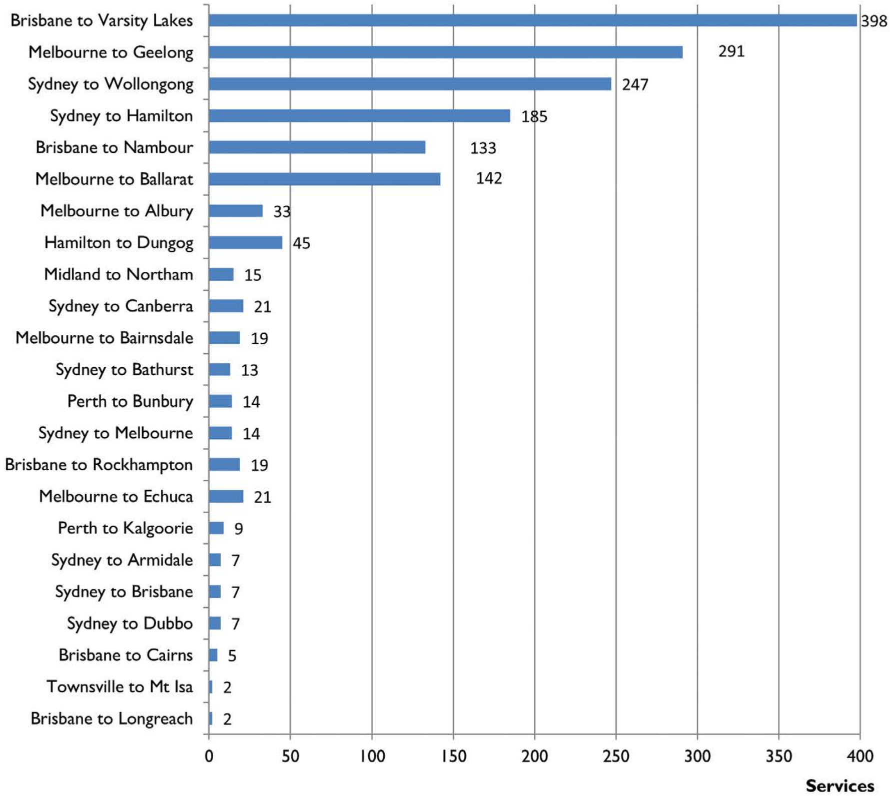
Sources: Transport for NSW 2016; G:link 2016; Public Transport Victoria 2016; Adelaide Metro 2016b.

Non-urban rail

Frequency is important for non-urban services because it determines how closely a train departure and arrival is to a passenger's preferred time. Service frequencies can also determine the amount of time a passenger waits for a train and, therefore, is closely aligned with perceptions of total travel time and its generalised cost.

Figure 52 shows services per week on selected non-urban routes. Frequencies align with the function of each railway, the distance of the corridor and the size of the populations they serve. Railways that serve inter-city and regional centre-capital city commuter markets generally have the highest service frequency.

Figure 52 Non-urban passenger rail services per week



Notes: Based on calculation of outbound 'down' services. Does not include return services.
The Sydney–Wollongong figures include truncated services that depart from Waterfall.
Services include trains that arrive at but do not terminate at destination, for example, NSW TrainLink services from Melbourne to Albury that continue on to Sydney.

Sources: NSW TrainLink 2016a; Queensland Rail 2016; Transwa 2016; Translink 2016; V/Line 2016.

An analysis of Census 2011 data by Bernard Salt (2013) found Sunshine Coast–Brisbane, Brisbane–Gold Coast, Newcastle–Sydney (via the Central Coast), Sydney–Wollongong, Melbourne–Geelong and Perth–Mandurah are among Australia's largest inter-city rail commuter corridors.

Victoria, in particular, has high levels of service between Melbourne and major regional cities, which increased further in June 2016. Frequency increases was one of the key upgrades in Victoria's Regional Fast Rail project. The programme increased weekly services between Melbourne and regional cities by the following levels: Geelong (+13%), Ballarat (+83%), Bendigo (+71%) and Traralgon (+59%) (BITRE, 2014e, p.65).

Frequencies are approximately similar except for the following:

- Brisbane–Varsity Lakes services have increased from 306 to 398 per week; and
- Melbourne–Ballarat services have increased from 132 to 142 per week.

Transit times—non-urban

Transit times are important for commuter travel in determining rail's competitiveness against other transport modes. Commuter travellers may consider comparative door-to-door transit times rather than the top speed of a service when making transport mode choices. For non-urban services, the value of transit time varies according to the market. Time rich tourist travellers are likely to value comfort ahead of time. The Indian Pacific, Ghan, and Kuranda Scenic Railway are cases in point. Conversely, the opposite would likely apply to commuters who are time poor. Rail travel also provides a social service to those who do not have access to other transport modes.

Table 33 shows the key characteristics of selected regional/commuter and long-distance services. The speed shown is an average over the length of the service, including stops.

Table 34 Key characteristics of selected non-urban passenger services

	Operator	Track gauge	Route length (km)	Electrified	Indicative transit time	Indicative average speed (km/h)	Stopping stations (no.)
Regional/commuter 3 hour 59 minutes or less							
Brisbane to Nambour	QR (TransLink)	Narrow	105	Yes	1h 57m	56	19
Brisbane to Varsity Lakes			89	Yes	1h 23m	64	12
Hamilton to Dungog	NSW TrainLink	Standard	81	No	1h 17m	63	14
Sydney to Hamilton			165	Yes	2h 35m	64	14
Sydney to Wollongong			82	Yes	1h 28m	56	8
Sydney to Bathurst			238	No	3h 43m	64	6
Melbourne to Ballarat	V/line	Broad	118	No	1h 6m	107	3
Melbourne to Ecucha			250	No	3h 23m	74	5
Melbourne to Bairnsdale			275	No	3h 44m	74	15
Melbourne to Geelong			81.5	No	55m	89	6
Melbourne to Albury		Standard	305	No	3h 58m	77	10
Midland to Northam	TransWA	Standard	102	No	1h 20m	80	1
Perth to Bunbury		Narrow	183	No	2h 30m	72	11
Long-distance 4 hours or more							
Townsville to Mount Isa	QR Travel	Narrow	977	No	20h 55m	47	8
Brisbane to Longreach			1 325	No	25h 5m	53	19
Brisbane to Cairns			1681	No	24h	72	26
Brisbane to Rockhampton (electric Tilt Train)			639	Yes	7h 45m	82	11
Sydney to Canberra	NSW TrainLink	Standard	330	No	4h 18m	77	9
Sydney to Dubbo			462	No	6h 27m	72	14
Sydney to Armadale			579	No	8h 6m	71	19
Sydney to Brisbane			987	No	14h 12m	70	21
Sydney to Melbourne			951	No	10h 58m	87	17
Perth to Kalgoorlie	TransWA	Standard	653	No	6h 50m	96	15
Adelaide to Darwin	GSR	Standard	2 971	No	53h 15m	56	3

Sources: Great Southern Rail 2016; NSW TrainLink 2016a; Queensland Rail 2016; Transwa 2016; V/Line 2016; Translink 2016; Rail Geelong 2016.

Average train speeds are a function of:

- The quality of the track, including condition, curves, level crossings and capacity;
- The standard of rolling stock, influenced by its power, propulsion, in-cab signalling and the existence of a tilting mechanism;
- Railway procedures, including crew changes, loading and unloading passengers/luggage and right-of-way priority relative to other trains;
- The station spacing and stopping pattern, determined largely by the function and policy objective of the service; and
- Deliberate extended stops en route for passengers to do off train tours (such as the Ghan stopping at Alice Springs for more than four hours.

The Brisbane–Nambour; Brisbane–Varsity Lakes; Sydney–Newcastle; and Sydney–Wollongong services have similar, relatively low average train speeds. These services are medium-distance, inter-city, commuter railways. The services stop at a large number of stations relative to distance travelled. This is because they function as limited-stop and stopping commuter trains in the peri-urban coastal regions and metropolitan areas of Brisbane and Sydney respectively. In addition, the Newcastle–Sydney and Sydney–Wollongong rail corridors are slow and circuitous due to the 'steam era' alignments through the mountainous terrain in which they operate.

V/Line's medium-distance regional services are relatively fast. The Victorian Government's Regional Fast Rail Project (completed by 2006) and the Regional Rail Link (opened in June 2015), included a number of measures that improved average speed:

- upgraded track condition and separation from suburban trains in metropolitan Melbourne;
- improved track alignment;
- upgrading or elimination of level crossings;
- improved signalling and communications; and
- enhanced rolling stock.

While the Regional Rail Link has enhanced the Regional Fast Rail Project for services between Melbourne and Bendigo, Ballarat, and Geelong, Melbourne–Traralgon services still lack a dedicated corridor through the more expansive south eastern suburbs of Melbourne.

There is a wide dispersion of transit times across V/Line services, caused by different stopping patterns that cater for different market segments. The Melbourne–Ballarat service cited above, for instance, is based on an express peak hour service with only three stopping stations. This contributes to a relatively high average speed. For more information on V/Line's Regional Fast Rail Project; see BITRE, *Improving regional passenger rail services,* 2014e.

Long-distance passenger trains in Australia generally have uncompetitive transit times compared to air and some road coach travel[42]. While NSW TrainLink's XPT trains can cruise at 160 kilometres per hour, their speed is restricted in much of New South Wales due to the tight curves that typify much of the state's railway alignment. Queensland Rail's Tilt Trains similarly have their speed restricted north of Rockhampton due to track conditions that do not allow 160 kilometres per hour travel.

42 Long-distance trains can provide services for centres along their route, thus acting as medium-distance services along numerous route segments. For example, the Sydney–Melbourne and Sydney–Canberra trains serve regional centres such as Goulburn and Moss Vale.

CHAPTER 5
Case Studies

Roy Hill

Background and History

Roy Hill is a newly built and recently commissioned mining operation located in the Pilbara region of Western Australia, in some of the world's most extreme conditions. The operation has an initial projected mine life of 17 years, with a likely extension of a further 12 years. The project is a collaboration between Hancock Prospecting Pty Ltd, which owns a 70 per cent equity interest, in partnership with Marubeni Corporation, POSCO, and China Steel Corporation, which collectively own the remaining 30 per cent equity interest. Ninety per cent of the mine's product is sold under long term contract, with the balance being sold into the spot market. Most product is sold to its customer shareholders in Japan, South Korea, and Taiwan, with the balance going to China.

Mining commenced in May 2014, as construction of the mine and associated infrastructure, including a 344 kilometre railway linking the mine sites to Port Hedland was still underway. The railway commenced revenue operations in December 2015. Given the entire railway, including its rollingstock, infrastructure and support facilities, was built anew, it is referred to as a 'greenfield' railway. As a greenfield railway, and due to the need for continuous and efficient operations, Roy Hill was able to build it to the world's highest and most modern standards, namely without inheriting existing infrastructure and rollingstock with its legacies that would require upgrading and modernisation. The cost of civil, track, signals and communications infrastructure was $1.91 billion and supporting rail facilities cost $61.7 million.

The railway includes custom built locomotives and rollingstock, track and rollingstock that is capable of carrying 42.8 tonne axle loads – the heaviest in the word, purpose built track inspection vehicles, modern train control, and 'smart' track inspection practices. The greenfields concept does not just apply to Roy Hill's rail operations, but the entire project. Being a greenfield railway, Roy Hill provides insight into the capabilities and efficiencies of a modern Australian railway and what this can achieve.

Roy Hill considers its railway to be critical to its operations. It is because of this criticality Roy Hill has invested heavily in rail operations reliability, which it says it achieves by carrying out regular inspections and maintenance, employing the best people in the world, and utilising the latest in rail operations technology.

Operations

Figure 53 Roy Hill train near Port Hedland

Note: The image above shows a loaded single rake Roy Hill train approaching the company's Port Rail Loop at Port Hedland.

Source: Photograph courtesy of Rodney Avery.

Roy Hill operates five trains per day from the mine to port. Each train is hauled by three locomotives, including one placed in the middle of the train for power distribution ('distributed power') to reduce the drawbar load on wagons towards the front of the train. For the first 30 kilometres from the mine site to port a further two manned locomotives are placed at the rear of the train to assist in the undulating terrain along that section of the track.

Each train is more than 2.7 kilometres long and has 232 tandem paired ore cars, which carry 138.4 tonnes of payload each; a total of more than 32,000 tonnes per train. Roy Hill has chosen this length in order to maximise the efficiency of its rail, mine and port operations. A train consists of two rakes. Upon arrival at the rail terminal yard at Boodarie South Industrial Estate south of Port Hedland, the two rakes are split, for the short onward leg to the Port Rail Loop and Stockyards where the ore is unloaded. This is for several reasons. The first is due to the trains operating with distributed power, which prevents the contents being dumped in such a consist. The second reason is to manage in train forces during the unload cycle. The third reason is to minimise cycle times. Following unloading, the first rake wagons can be shunted and maintained while the second rake is being unloaded. This minimises turnaround times. The rakes are also routinely rotated to minimise the drawbar load on individual wagons. Wagons towards the front of the train draw a much greater trailing load than wagons towards the rear, which places additional strain on those wagons. Rake rotation and distributed motive power minimises the rate of wear this additional strain would otherwise cause.

Roy Hill employs 50 full time drivers. Current crewing is a driver and assistant but this will become driver only operations as the railway's train control evolves.

Infrastructure

Figure 54 Roy Hill railway

Source: Photograph courtesy of Rodney Avery.

Roy Hill is able to achieve 42.8 tonne axle loads due to the qualities of the ore cars, which can carry such weights and the track infrastructure. Such infrastructure qualities include rail and sleeper quality, below track formations, close sleeper spacing, ballast quality, bridge capacities, and Flash Butt welding between rail joints (which, unlike other welding methods, provides consistent strength that is almost equal to that of the parent rail).

The railway consists more than 54,000 tonnes of rail, made by the Nippon Steel and Sumitomo Metal Corporation in Japan and 612,000 concrete sleepers, made in Thailand by Italian Thai DPC Ltd. The railway has four passing loops, each approximately 3.2 kilometres long, that are specifically located to optimise cycle times and maximise efficiency.

Motive Power

Roy Hill has 21 RHA class ES44ACI GE Evolution Series locomotives, manufactured by General Electric Company, in the United States of America. Details of the locomotive are as follows:

- Weight – 196tonnes
- Length – 23.165m
- Width – 3.142m
- Tractive Power – 4345hp

- Engine – V12 4 stroke, turbo charged and intercooled EPA Tier 2 NYAB CCBII ECP Brakes
- Fuel Monitor – GE Accufuel System (Consist Manager/Monitor)
- GE Locotrol –
  - Dual Mode Distributed Power
  - Tower Control
  - Remote Control
  - Auto Equipment Start Stop
  - Tetra Digital Radio System
  - Remote Monitoring using WiMax
  - Anslado Cab Based Signalling

While a North American design, Roy Hill's locomotives have been adapted for Pilbara conditions and requirements. These include:

- Larger radiator capacity;
- Greater oil capacity;
- Gear ratio for heavy haul;
- Traction motor blower air flow for additional cooling of the traction motors; and
- Cab design for driver only operations (one driver).

While currently crewed, the locomotives are capable of being upgraded to driverless operations.

Figure 55 Roy Hill RHA Class locomotive undergoing pre-delivery trials

Note: The image above shows Roy Hill's newly built RHA class locomotives undergoing pre-delivery trials in highly contrasting winter conditions in the United States of America.

Source: Photograph courtesy of Roy Hill Holdings.

Other Rollingstock

Roy Hill has a fleet of 1,196 wagons. The wagons were built by China Southern Rail in Zhuzhou, China. While the bogies routinely carry 42.8 tonne axle loads they are designed to carry 45 tonne axle loads. Given such heavy loads, loading accuracy is crucial and the tolerance for wear on the wheel seat has to be tightly controlled. Roy Hill will trial bearings capable of increased axle loads of 45 tonnes with the potential for future increases, subject to consideration of the overall rail infrastructure, such as the track and bridges. In addition to the ore cars Roy Hill has:

- 12 fuel tank cars, each with a capacity of 98,000 litres;
- 5 flat top cars for transporting rail materials such as rail and sleepers;
- 10 ballast cars with remote control doors;
- 1 ballast plough; and
- 10 side dump cars for carrying flood rock and rock armour.

Figure 56 Ore wagons at the newly built Port Stockyard Facility

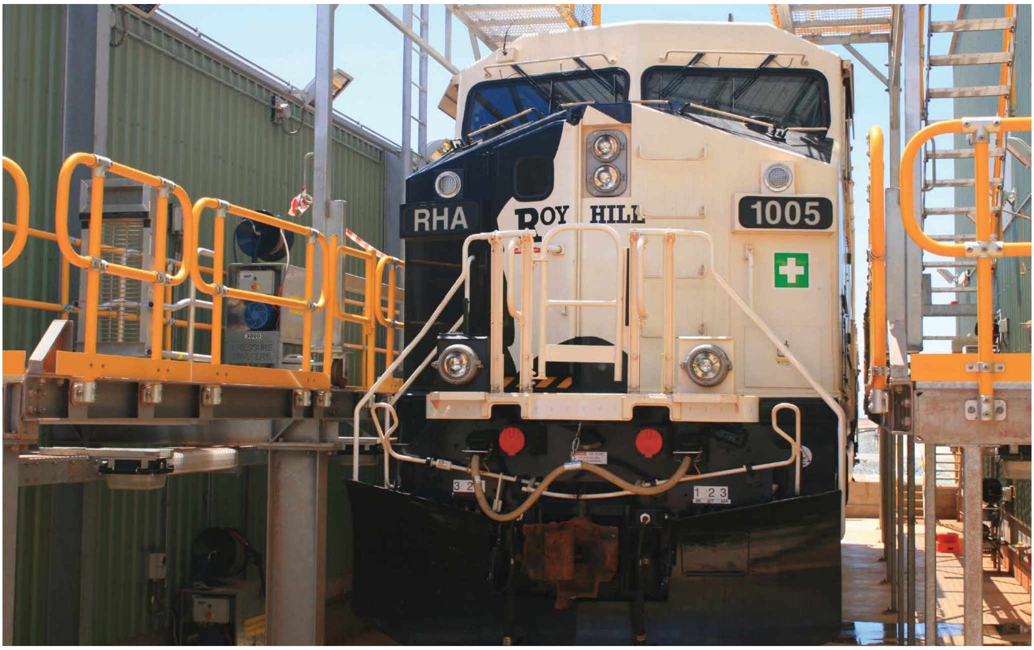
Note: The image above shows stabled ore wagons at the company's port stockyard facility at the Boodarie Industrial Estate near Port Hedland.

Source: Photograph courtesy of Rodney Avery.

Roy Hill maintains its motive power and other rollingstock fleet at purpose built facilities at the Boodarie South Industrial Estate. The wagon fleet undergo a workshop maintenance activity every two years where all wheelsets are removed and re-profiled, brake blocks are replaced and the ECP brake system tested. The locomotive fleet have a scheduled maintenance activity at 184 days where wheelsets are machined, oils and filters are changed, all mechanical and electrical systems are checked and the brake and traction systems are tested. Roy Hill has an underfloor wheel lathe capable of machining locomotive and track machine wheelsets in-situ and single wagon wheelsets.

The workshop also has a 32t crane, set of 50t jacks, a single axle drop table and two shunting vehicles which give Roy Hill all the rolling stock maintenance capability required to undertake any task up to and including engine changes.

Figure 57 Pre-service wash



Note: The image above shows an RHA Class locomotive undergoing a pre-service wash at the Boodarie Industrial Estate Rolling Stock Workshops.

Source: Photograph courtesy of Rodney Avery.

Maintenance

Roy Hill uses the manufacturer's recommendations for scheduled activities along with a predictive, condition monitoring based maintenance program in conjunction a with and reliability centred maintenance strategy for improvements. This maximises the life of assets, reduces maintenance costs, reduces the risk of derailment, and accurately predicts and plans maintenance tasks.

The on track maintenance fleet consists of a Track Measurement Vehicle, eight Land Cruiser hi-rail track inspection vehicles, two hi-rail excavators, two hi-rail ambulances, and two hi-rail tool trucks.

The track is inspected every seven days and two inspectors are on roster at any one time. Track inspectors use a Digital Track Notebook (DTN), a paperless system that records the results of manned track inspections. The DTN provides a calendar based inspection plan and it ensures fulfilment of regulatory compliance. The DTN also provides a full asset history that is available at any time.

The Track Measurement Vehicle (see image below), which has ground penetrating radar, track bed imaging, right of way video, and rail surface imaging assesses:

- Track geometry;
- Rail profile;

- Corrugation; and
- Ultrasonic Rail Flaw.

It also provides a ballast/formation profile.

Figure 58 Track Management Vehicle

Note: The image above shows Roy Hill's Track Management Vehicle.
Source: Photograph courtesy of Rodney Avery.

Track Measurement Vehicle outputs for geometry will feed into a VAMPIRE module of Roy Hill's Rail Track Condition Monitoring system (RTCM). VAMPIRE is a vehicle-track interaction simulation program that automatically predicts vehicle-track interaction from actual track geometry data. Data output is used to understand actual track geometry derailment risk based on lateral/vertical force parameters.

In addition to the Track Measurement Vehicle, Roy Hill has 3 no. Vehicle Track Interaction (V/TI) enabled locomotives. These V/TI locomotives have strategically placed accelerometers on axle, bogie and car bodies that assess track continuously whilst in operation. Any exceedances of set parameters result in near real time reporting to a central review application, dependant on 3G network coverage. This is supplemented by interface to the Whispir System that automatically text alerts Inspectors and key Wayside staff.

Non urgent V/TI results will in the future also be put through a "Clusters" module. The clusters module uses V/TI results of all magnitudes and assesses density, repetition and proximity to highlight areas that warrant further investigation. This analytical algorithm has proven extremely useful in the USA of highlighting risk areas where combinations of low magnitude issues may result in combined large magnitude impacts.

A further module of RTCM to be implemented is the Automated Maintenance Adviser (AMA). Once implemented, AMA will take information from multiple sources to be able to trend track condition and predict maintenance requirements based on deterioration modelling. Information from the Track Measurement Vehicle, V/TIs, Weighbridge, Track Inspectors (DTN), SAP and Maintenance Plant is used. By this collation and analysis of information AMA determines a recommendation for Wayside maintenance activities based on rules engines. Final outputs of AMA are reviewed and approved before being transferred to SAP. The AMA analysis is capable of grouping, prioritising and scheduling works based on principles of condition monitoring. AMA is also capable of "Sandbox" modelling to be able to understand how the asset may react to alternative maintenance strategies.

Final total output of the maintenance checks are used to recommend maintenance tasks and it is tracked electronically. Such tasks include rail grinding, rail and sleeper replacement, ballast renewal, and point asset maintenance.

Train Control

Roy Hill uses a Train Control System (TCS) that is a fully integrated system that support on track rail operations (train and infrastructure vehicle movements) and maintenance activities on the railway through TETRA and GPS supported systems, which generate and issue electronic movement authorities to vehicles in the field via on-board Human Machine Interface (HMI). The TCS also includes interfaces for the rail asset and train monitoring from a number of field devices including broken rail detection, stream flow monitoring, dragging equipment detectors and rolling stock monitoring equipment.

Remote Operations

Much of Roy Hill's rail operations are conducted from the company's Perth-based Remote Operations Centre. These operations do not happen in isolation, but as part of the company's vertically integrated end to end integration of its entire Pilbara operations. Loading and unloading of trains is conducted from the Remote Operations Centre. It takes approximately 160 minutes to load a train at the mine site. Unloading at Port Hedland occurs in 88 second cycles using a rotary car dumper that unloads two oar cars at a time.

Rail Manufacturing and Maintenance in Australia – Bombardier and UGL Ltd.

Background

This case study provides information about the manufacture and maintenance of rollingstock in Australia. It focuses on two companies: Bombardier Transportation and UGL Ltd. as examples.

The local manufacture of rollingstock faces strong overseas competition from such countries as China and the United States of America, which can offer cheaper up front products. There are, however, arguably some advantages to onshore built rollingstock, such as a local manufacturer's good understanding of Australian requirements, the creation of skilled employment and onward benefits to the local supply chain, wider economic benefits and security of local IP, as well as the ability to provide 'cradle to grave' services as part of an ongoing relationship between manufacturer and customer. For example, the bogies of Yarra Trams' E-Class trams, which Bombardier builds at its Dandenong plant, have been specifically designed to operate with Melbourne's unique track conditions. Australian requirements also vary considerably throughout the country, due to such elements as climate differences, multiple gauges, and specialised customer requirements. This differs from a 'one size fits all' model which some overseas manufacturers may provide. It is also arguable that an overseas manufacturer will, despite an Australian customer's specific requirements, still be influenced, however subtly, by the local (overseas) environment in which they operate.

Manufacturing (Bombardier)

Bombardier's rollingstock manufacturing focus in Australia is on heavy and light rail passenger vehicles. They build, for instance, Victoria's growing VLocity DMU fleet and Yarra Trams FLEXITY E-Class trams. Dominating Bombardier's current manufacturing activities in Victoria is V/Line's expanding fleet of VLocity DMUs, which first entered service in 2005. Currently 199 cars have been built, of which one has been scrapped. In service, there are 54 three car sets, five three car sets are in testing and commissioning and seven three car sets are under construction.

Bombardier is also heavily involved in the design and engineering of rail vehicles for use in Australia, which are built both locally and overseas. They do this design at their 'Centre of Excellence for Industrial Design and Engineering' in Brisbane and Melbourne. A good example of adapting global best practice to local requirements is the Gold Coast Light Rail vehicles which were designed locally and are the only trams in the world to be been fitted with surf board racks to complement the Queensland aesthetic.

Rollingstock construction projects for which Bombardier has been contracted include:

Vehicle	Fleet Size (Cars)	Contract Awarded
Melbourne FLEXITY Swift (E-Class) trams	70	2010, 2015
VLocity DMU	199	2001, 2015
Adelaide A-City EMU	66	2011
Adelaide FLEXITY trams (Built in Germany)	15	2004
Queensland SMU 260 and IMU 16 (Joint venture with EDI Downer)	202	2004, 2006, 2008
Perth A Series EMU (Joint venture with EDI Downer)	96	2011
Perth B Series EMU (Joint venture with EDI Downer)	204	2011
Gold Coast Light Rail (FLEXITY 2)		
(Local design, built in Germany)	18	2011, 2016
Queensland New Generation Rollingstock (Built in India)	450	2014

Note: This table refers to construction only, Maintenance contracts appear under the maintenance section.

Figure 59 V/Line VLocity DMU

Note: The image above shows a V/Line VLocity DMU.
Source: Photograph courtesy of Bombardier.

Manufacturing (UGL Ltd.)

UGL Ltd. has a history of building both passenger and freight rollingstock – approximately 11,000 to date. It built, for instance Sydney Trains' Oscar (H set) passenger trains, which came into service between 2006–2012 and TrainLink's 14 Hunter class passenger trains, which entered service in 2006. It has also built much of Australia's recent generation freight locomotive fleet. This included 120 NR class locomotives for the then National Rail Corporation (now Pacific National), which progressively entered service from 1996. Introduction of the NR class locomotive was a major milestone for Australian freight rail transport, as it represented a new nation focused (rather than state focused) approach to rail freight transport, with a modern locomotive that could operate nationwide on the interstate standard gauge network. UGL Ltd. has recently finished a complete overhaul of the remaining NR class fleet.

Passenger rollingstock construction projects for which UGL Ltd. has been contracted are shown in Table 34.

Table 35 UGL passenger rollingstock construction projects

Vehicle	Fleet Size (Cars)	Manufactured
NSW K Set EMU	160	1981–1985
NSW C Set EMU	56	1986
NSW Tangara EMU	453	1988–1995
NSW Oscar EMU	220	2006–2012
WA Prospector DMU	7	2007
NSW Hunter Rail Cars	14	2006–2007
Hong Kong Phase 3 and 4 Light Rail (Built in China to UGL specifications/design)	42	2003–2008
NSW New Intercity Fleet EMU (To be built in South Korea, based on a UGL design, with UGL engineering oversight)	520	To enter service from 2019

Note: this table refers to construction only, Maintenance contracts appear below, under the maintenance section.

With regards to locomotives, UGL Ltd.'s more recent focus has been the C44ACi family of locomotives of which 160 have been built to date. These locomotives are designed jointly by UGL Ltd. in Australia and General Electric in the United States of America, but all are built in Australia. The C44ACi base model design is ideally suited to operate in both heavy haul applications and high speed freight operations across the Australian Defined Interstate Rail Network. Customers can order additional requirements from a selection of standard options to suit their specific operations. Such options include but are not limited to three position selectable fuel load, operator cab inclusions, electronic controlled pneumatic braking (ECP), distributed power (DP), EcoRun and high adhesion software such as direct excitation adhesion control (DEAC) software. The C44ACi locomotive design incorporates GE alternating current (AC) Traction Technology, which has been used extensively throughout North America, in Australia and other international applications. AC traction is a major innovation in heavy haul diesel locomotives, allowing up to 20% greater haulage capability and higher speeds over more traditional direct current (DC) traction technology. Other significant advantages of AC propulsion over DC propulsion include:

- Higher starting and continuous tractive effort;
- Improvement in braking effort (with dynamic braking);
- Greater adhesion;
- Enhanced slow speed control;
- Improvement in traction motor overhaul cycles; and
- Reduced maintenance.

The C44ACi locomotive achieves greater fuel efficiency through various means, such as the Bosch electronic fuel injection system and auxiliaries driven by AC motors.

Specific locomotives in the C44ACi class family include but are not limited to the 93 class, CF class and MRL class. It has also built the 3700 horsepower Powerhaul Series Locomotive 2011, which is designed specifically for the Queensland and Western Australian narrow gauge networks.

Figure 60 C44ACi Class locomotive construction

Note: The image above shows a C44ACi class locomotive under construction at UGL Ltd.'s Broadmeadow plant.
Source: Photograph courtesy of Rodney Avery.

Maintenance (Bombardier)

Under what it designates 'services', Bombardier conducts fleet maintenance (including cleaning), operations maintenance, vehicle refurbishment and modernisation, and material management. Current maintenance contracts which Bombardier has includes:

- Melbourne FLEXITY Swift (E-Class);
- VLocity DMU;
- V/Line classic fleet (including N-Class locomotives, Sprinter DMUs and locomotive hauled passenger carriages;
- Adelaide FLEXITY trams;
- Adelaide 3000 and 4000 class DMUs;
- Queensland SMU and IMU 16;
- Perth A and B series EMUs;
- Gold Coast Light Rail FLEXITY 2 vehicles; and
- Queensland New Generation Rollingstock.

Figure 61 V/Line fleet maintenance

Note: The image above shows an array of V/Line's passenger fleet undergoing maintenance in Melbourne.
Source: Photograph courtesy of Bombardier.

Maintenance (UGL Ltd.)

In like manner to Bombardier, UGL Ltd. provides 'cradle to grave' maintenance of both the assets it builds and assets it has not built. To maximise efficiency, its maintenance is trending towards a proactive and predictive approach, whose aim is to minimise the time a given asset is out of service. Maintenance contracts it has for assets it has not built include:

- Heavy maintenance, CCO and supply chain services for 1050 EMU cars for Sydney Trains at Auburn (as part of a joint venture with Unipart);
- NSW TrainLink's New Intercity Fleet (which will commence entering service in 2019);
- Metro Trains Melbourne, as part of a joint venture; and
- Refurbishment of Sydney Trains' Tangara fleet.

Figure 62 C44ACi Class locomotive maintenance

Note: The image above shows a Freightliner CF (C44ACi) class locomotive undergoing maintenance at UGL Ltd.'s Broadmeadow plant.

Source: Photograph courtesy of Rodney Avery.

APPENDIX A

Significant railway events

Date	Event	Description
30 July 1991	National Rail Corporation (Agreement) Act	Agreement between Federal Government and states of Queensland, NSW, Victoria and WA for National Rail Corporation to take over operation of interstate rail services from states
3 April 1993	Commencement of National Rail third-party access	National Rail began third-party access freight operations on interstate track
1995	Port of Brisbane	Connection of Port of Brisbane to standard gauge network, opening in 1997
1995	Trans Australia Railway	Traffic on Trans Australia Railway disrupted for six weeks due to flooding
June 1995	Melbourne–Adelaide gauge standardisation	Completion of standardisation of Melbourne–Adelaide broad gauge with new standard gauge line via North Geelong – Cressy – Ararat (bypassing former main line through Ballarat)
July 1995	First private train on national network	SCT commenced first private train service on national network, Melbourne–Perth
June 1996	TNT (Toll) trains commenced	TNT (later Toll) began operating freight trains between Melbourne and Perth
1 July 1996	Vertical separation in NSW	State Rail Authority split, with Rail Access Corporation managing infrastructure, Rail Services Australia undertaking track maintenance, FreightCorp operating freight trains and residual State Rail Authority operating passenger trains
1 July 1996	National Rail Safety agreement	Inter-governmental Agreement to legislate terms for national safety and accreditation processes
26 October 1996	NR class locomotives enter service	The first of 120 of National Rail's new 4000 hp locomotives entered service
May 1997	Patrick Rail operations	Patrick Corporation commences land bridging container train service between Port Adelaide and the Port of Melbourne
30 October 1997	Privatisation of AN's passenger business	Great Southern Railway consortium purchased Australian National Railways' passenger business ("Pax Rail") for $16 million, effective from 7 November 1998
14 November 1997	Privatisation of AN's Tasmanian network	Australian Transport Network purchased Australian National Railways' Tasmanian operations ("Tasrail") for $22 million, effective from 14 November 1997
31 October 1997	Privatisation of AN's SA intrastate network	Genesee & Wyoming purchased Australian National Railways' SA intrastate network ("SA Rail") for $57.4 million, effective from 31 October 1997

(continued)

Date	Event	Description
1 July 1998	Vertical separation of Commonwealth railway infrastructure	ARTC commenced management of Australian National's infrastructure (assets of AN's Track Access Unit) following incorporation of ARTC on 25 February 1998
February 1999	V/Line freight service sold and track leased	V/Line freight business sold and intrastate country track leased for 45 years to Rail America for $163 million trading as Freight Australia
August 1999	Victorian franchising	Victorian passenger rail and tram services franchised to National Express, Connex and Yarra Trams
1 July 1999	Lease of Victorian interstate rail network	The Australian Rail Track Corporation is given 15 year lease of Victorian interstate rail network from SA border through Melbourne to Albury
2 December 1999	Glenbrook accident	Train collision at Glenbrook, NSW
November 2000	NSW rail industry restructure	Merger of Rail Services Australia and Rail Access Corporation in NSW into Rail Infrastructure Corporation
18 December 2000	Privatisation of Westrail	Consortium of Wesfarmers and Genesee & Wyoming purchased Westrail for $585 million
May 2001	Opening of intermodal terminal	Bowports, in conjunction with FreightCorp, developed an intermodal terminal at Minto, with port shuttle trains commencing in May 2001
30 January 2002	Sale of National Rail and FreightCorp	Consortium of Patrick Corporation and Toll Holdings purchased National Rail Corporation for and FreightCorp for $1.2 billion, forming Pacific National
17 December 2002	National Express abandons franchises	National Express walked away from its V/Line Passenger and Melbourne passenger contracts
31 January 2003	Waterfall accident	Passenger train derailment at Waterfall, NSW
27 March 2003	Bridge closure	Temporary closure, until 23 April, of Menangle Rail Bridge, on Sydney–Melbourne railway line. Interstate trains had to move along alternative circuitous routes
May 2003	Freight competition between Sydney and Melbourne	Freight Australia commenced a daily freight service between Sydney and Melbourne
1 January 2004	NSW RailCorp	Creation of Rail Corporation New South Wales (RailCorp) as the merged entity of the State Rail Authority of New South Wales and the metropolitan functions of the Rail Infrastructure Corporation
16 January 2004	Darwin line opened	First freight train arrived in Darwin
February 2004	Takeover of ATN-Tasrail	Pacific National purchased ATN-Tasrail
April 2004	QRN commences North–South intermodal service	QR National commences intermodal freight service between Brisbane, Sydney and Melbourne
1 September 2004	Takeover of Freight Australia	Pacific National purchased Freight Australia business and track lease for $285 million
5 September 2004	ARTC lease in NSW	ARTC commences 60 year lease of interstate rail network in NSW and management contract of country rail network
1 July 2005	QRN operating in Hunter Valley	QR National commences operating in Hunter Valley (Mount Arthur–Port Waratah)
September 2005	Tasmanian rail freight	Pacific National announced that it intended to withdraw most of its rail freight services in Tasmania leaving only two bulk haul operations
14 February 2006	Sale of WA and SA rail freight operations and track	In a complex sale worth $970 million, Queensland Rail purchased ARG's WA freight business; Babcock & Brown purchases ARG's WestNet infrastructure; and Genesee & Wyoming takes full control of ARG's SA operations

(continued)

Date	Event	Description
11 March 2006	Toll takeover of Patrick	ACCC approves Toll takeover of Patrick
March 2006	South Maitland Railway	30 km of the South Maitland Railway reopens to service the Austar Coal Mine in the Hunter Valley
17 August 2006	Linfox buys FCL	Linfox buys FCL, a major rail-based freight forwarding company
September 2006	Victorian regional fast trains commence	The start of the first Regional Fast Train service begins. Faster services are introduced from Geelong, Ararat/Ballarat, Bendigo and the Latrobe Valley
October 2006	End of Sydney–Perth coastal shipping service	Boomerang coastal shipping service, operating between Sydney and Perth since June, ended after financial failure
20 October 2006	SCT commence Parkes service	SCT Logistics commenced freight service between Parkes and Perth
November 2006	Sandgate Flyover	Opening of main line flyover of coal lines, to enable unimpeded movement of coal trains, between Hunter Valley and Kooragang Island
18 December 2006	Pacific National wins 7-year steel contract	PN wins a contract extension, with Bluescope and OnsSteel for 7 years, to shift steel products around the country
1 January 2007	Tasmanian government takes back rail infrastructure	Tasmanian government resumes financial responsibility for the State's commercial railways; day-to-day infrastructure management remains with Pacific National
3 January 2007	North–South Corridor upgrading	On this date the new Wagga Wagga bridge was opened The construction is a first major milestone in the $1.8 billion North–South Corridor upgrade
15 February 2007	ACCC approval of SCT acquisition	ACCC approved SCT Logistics' purchase of train assets (including 9 locomotives) from Pacific National, as part of Toll's takeover of Patrick
18 February 2007	CRT ceases Melbourne port shuttle	CRT ceased its Altona North–Port of Melbourne shuttle
15 March 2007	Tasrail funding	Australian Government announced $78 funding of remedial work on AusLink section of Tasmanian railway system with $40 million more from the Tasmanian Government and commitment by Pacific National to spend $38 million on locomotive and wagon upgrades
18 April 2007	ACCC approves Toll restructuring, formation of Asciano	ACCC approves Toll Holdings restructure, with new company Asciano, which will include the Pacific National and Patrick Portlink assets
18 April 2007	Toll restructuring	Toll announces split of Toll Holdings, with Asciano Ltd controlling the Patrick and Pacific National assets
4 May 2007	Re-acquisition of Victorian track lease	Victorian government bought back leased intrastate track from Pacific National giving control of the network to V/Line Passenger, the State's regional rail operator
October 2007	Lang Hancock Railway opens	58km Lang Hancock Railway opens between Hope Downs and existing Rio Tinto railway
November 2007	Asciano announces end of rail services in southern Australia	Asciano announces end of grain and intrastate intermodal services in Tasmania, Victoria and NSW, to take effect from early 2008
16 November 2007	QRN commences Melbourne–Perth service	QRN commences new thrice-weekly Melbourne–Perth service, incorporating the weekday P&O Melbourne–Adelaide train
23 December 2007	Opening of Mandurah railway in Perth	Opening of 70km Perth–Mandurah passenger railway

(continued)

Date	Event	Description
18 January 2008	Rail competition begins in Victoria	El Zorro begins broad gauge grain train competition in Victoria, the first in that State
March 2008	Opening of Lang Hancock Railway	Opening of 58km Lang Hancock Railway in the Pilbara, linking Hope Down iron ore deposits with Pilbara Rail network
March 2008	Pacific National begins withdrawal from Victoria	Pacific National begins withdrawal of freight services in Victoria, following earlier (Nov. 2007) announcement of closure of operations. El Zorro announces it will take over Warrnambool–Melbourne container operation
15 May 2008	Opening of Fortescue railway	Opening of Fortescue Metals Group's 260 km Cloudbreak railway in the Pilbara
13 June 2008	Cessation of Tasmanian train operations	Pacific National announced cessation of its Tasmanian train operations, later indicating it would sell the business
25 July 2008	Extension of double-stacking network	Commencement of standard double-stacking operations between Parkes and Perth following ARTC investment
5 August 2008	Pacific National wins Queensland coal haulage contracts	Asciano announces it has signed 10-year contracts with Rio Tinto and Xstrata for coal haulage in Queensland from early 2010
May–September 2008	Grain contracts awarded	GrainCorp, AWB, ABB sign contracts with train operators for grain haulage
15 September 2008	New Portland freight traffic	Commencement of movement of mineral sands between Portland and Melbourne
24 September 2008	Investment in Tasmanian tracks	Announcement by Tasmanian government of upgrading of its railway tracks
2 October 2008	Additional east–west train service	Pacific National adds a third "Express" freight train to its Melbourne–Perth service
27 October 2008	Pilbara railway access decision	The Treasurer, Mr Swan, announces that Fortescue Metals Group has the right to use Pilbara railways built by BHP-Billiton and Rio Tinto
November 2008	Closure of grain lines	NSW Government announces closure of 5 grain railways in the west of State
November 2008	Construction of Southern Sydney Freight Line	Construction of the 36 km Southern Sydney Freight Line commenced
6 November 2008	Darwin railway operator in administration	FreightLink placed in administration
26 November 2008	Suspension of railway construction	Suspension of work on Fortescue's Cloudbreak–Christmas Creek railway
1 December 2008	Gauge conversion	End of Albury–Wodonga–Seymour broad gauge services marked the commencement of conversion of railway to standard gauge
12 December 2008	Infrastructure investment announcement	Australian Government announces $1.2 billion funding for ARTC for rail projects on interstate and Hunter Valley networks
23 February 2009	Chatswood–Epping	Opening of Sydney's Chatswood–Epping passenger line
3 March 2009	Extra Parkes–Perth service	SCT Logistics commenced second freight service between Parkes and Perth
23 March 2009 8 April 2009	Grade separation in Melbourne	Opening of Melbourne's Footscray Road rail underpass, as part of Dynon Port Rail Link; opening of Tottenham–Dynon rail link
5 May 2009	PN coal contract in Queensland	Asciano wins 9-year coal-haulage contract with Macarthur Coal (3.7 million tonnes pa)

(continued)

Date	Event	Description
15 May 2009–23 June 2009	Temporary mainline closure in Tasmania	Following a derailment, Tasmanian railway was closed to enable significant track renewal task to be brought forward and expedited
29 May 2009	GrainCorp trains	GrainCorp commences train operations in NSW, taking grain trains from NSW government
2 June 2009	QR above-rail privatisation	Queensland Premier announced plan to part-privatise QR, namely, the freight businesses (but not passenger services); and to explore the sale or lease of the regional intrastate infrastructure to ARTC
23 June 2009	Announcement that Tasmanian railways will be nationalised	Asciano agrees the transfer of Tasmanian train operations to Tasmanian government, effective from 30 November 2009
30 June 2009	New train operator	Freightliner Australia, a subsidiary of a major UK freight operator, commenced operating in Australia
June 2009	GrainCorp trains	GrainCorp takes over 18 48-class locomotives and 180 wagons from NSW government; grain trains to be run by Pacific National
22 July 2009	Asciano contract	Asciano signed 10-year contract with Xstrata Coal for moving coal in Hunter Valley
22 August 2009	Mildura railway	Completion of upgrade of Mildura railway
October 2009	ARTC lease	ARTC commenced lease of the Benalla–Oaklands railway, from V/Line
30 Nov 2009	Formation of TasRail	Tasmanian government took control of railways, from Asciano, establishing TasRail on 1 December
December 2009	Track upgrade	Completion of concrete sleepering of the Cootamundra–Parkes line
17 January 2010	ARTC track	ARTC commenced a 60-year lease of the Brisbane–NSW border standard gauge track
22 February 2010	Rio Tinto line opens	Opening of 49-kilometre Rio Tinto railway in Pilbara, between Pannawonica and Mesa A
May 2010	Goonyella-Newlands	Commencement of construction of 69 km Northern Missing Link railway linking the Goonyella and Newlands coal systems in Queensland
May 2010	Asciano wins contract from Toll	Toll and Asciano signed a five-year contract for intermodal and car transport
May 2010	Interstate track re-railing	Commonwealth announced programme to re-rail interstate track, Cootamundra–Parkes, Broken Hill–Whyalla, Albury–Melbourne–Geelong, Kalgoorlie–Koolyanobbing
9 June 2010	Freightlink sold	Genesee & Wyoming Australia buys Freightlink, the Darwin line operator. The transaction is expected to take 3 months for completion
30 June 2010	Camellia closed	Asciano closed its Patrick-subsidiary Camellia intermodal terminal in Sydney, along with its Dubbo and Port Botany services
1 July 2010	QR split	QR split into passenger train and non-coal intrastate infrastructure (Queensland Rail); and freight train and coal infrastructure network (QR National)
October 2010	SBR	Commencement of Specialised Bulk Rail services between siding west of Cairn Hill and Outer Harbour (Adelaide). SBR is a subsidiary of SCT Logistics. The service is for IMX Resources

(continued)

Date	Event	Description
22 November 2010	QR National float	QR National was floated, while leaving around 25–40 percent of the shares with the Government
January 2011	Widespread flooding	Severe flooding in eastern Australia, especially in Queensland, where train services and coal exports were severely disrupted
January 2011	New Fortescue line	Fortescue commenced commissioning of new 50 km railway between Cloudbreak and Christmas Creek, WA
February 2011	Cyclone Yasi disruption	Cyclone Yasi crossed the north Queensland coast around Cairns, causing disruption to freight, notably coal exports
Late February 2011	Trans Australia Railway	Flooding cut the Trans Australia Railway for a number of days
26 June 2011	V/Line services to Albury–Wodonga	Resumption of V/Line passenger services to Albury–Wodonga, following conversion of broad gauge track between Albury and Seymour
20 July 2011	Roy Hill Holdings	Roy Hill Holdings received permission to build 342 km Roy Hill–Port Hedland railway
19 December 2011	Northern Missing Link	Opening of 68 km "Northern Missing Link", Newlands – North Goonyella, Queensland
27 December 2011 to 29 February 2012	Darwin Line cut	The Darwin line was broken near Katherine after flood waters washed away part of the track/bridge work. Goods between Darwin and Katherine were conveyed by road during this period
15 January 2012	NSW regional rail	John Holland took over management of NSW's Country Regional Network from ARTC, under contract from NSW Government
15 January 2012	Karara railway	QR National commenced contract with Karara Mining to haul iron ore over new railway, to Geraldton
30 January–27 February 2012	Port Botany works	DP World's Port Botany rail yards were closed to enable expansion of the rail facilities
April 2012	South Morang	Opening of Epping – South Morang railway in Melbourne
7 June 2012	Sale of Independent Railways	Qube announced that it was purchasing Independent Railways of Australia, including the Macarthur Intermodal Shipping Terminal at Minto, Sydney
5 August 2012	ARTC lease in Sydney	Enfield West – Port Botany section (19 km) of Metropolitan Freight Network leased by NSW to ARTC until 2064
14 September 2012	Trans Australian Railway	Centenary of the commencement of construction of the Trans Australian Railway
14 November 2012	MidWest Rail Upgrade	Formal completion of $550 million upgrade of the Morawa–Mullewa–Geraldton Port railway, including installing dual-gauge sleepers
1 December 2012	Aurizon	QR National changed its name to Aurizon
1 December 2012	Fortescue Hamersley Line	First train on the Fortescue Hamersley Line in the Pilbara, serving the Firetail iron ore deposits at Solomon
December 2012	Geraldton upgrade	Completion of substantial track upgrade and capacity expansion of tracks into Geraldton
21 January 2013	Southern Sydney Freight Line	Formal opening of the Southern Sydney Freight Line
29 January–February 2013	Queensland coal disruptions	Queensland's Blackwater and Moura coal systems disrupted by Cyclone Oswald
21 April 2013	Hope Down 4	Opening of Hope Down 4 railway in the Pilbara
June 2013	El Zorro	South–east Australian train operator, El Zorro, ceased operations

(continued)

Date	Event	Description
1 July 2013	Sydney Trains/NSW Trains	Establishment of Sydney Trains and NSW Trains, from CityRail and RailCorp
October 2013	Roy Hill Railway	Commencement of construction of Roy Hill Railway
1 December 2013	Springfield Railway	Opening of the Springfield urban railway in Brisbane
2 December 2013	Enfield Staging Facility	First train to use the Enfield Staging Facility in Sydney
23 February 2014	Seaford Railway and Adelaide electrification	Opening of the Seaford urban railway extension from Noarlunga, coinciding with first public operation of electric trains in the city on the Adelaide–Seaford line
2 May 2014	Tonsley Railway electrification	The Tonsley railway electrification was commissioned
22 June 2014	Hobart/Brighton Hub	Intermodal freight services shifted from Hobart to Brighton Hub (to the north of the city), leading to closure of the Hobart–Bridgewater Junction line
27 July 2014	Regional Rail Link	V/Line regional passenger services commenced using new dedicated tracks between Sunshine and Melbourne Southern Cross railway stations, as part of the Regional Rail Link project
5 August 2014	Port Botany Terminal	Opening of the Hutchison rail terminal at Port Botany
21 September 2014	Butler Railway, Perth	Opening of the 9 km Butler urban railway extension from Clarkson
12 November 2014	North Quay Rail Terminal, Fremantle	Opening of extended North Quay Rail Terminal at Fremantle's Inner Harbour
25 December 2014	Newcastle Station Closure	Heavy rail line from Wickham to Newcastle closed
8 February 2015	South West Rail Link	Opening of Sydney's South West Rail Link, between Glenfield and Leppington
23 February 2015	Canberra freight	Resumption of rail freight services on Canberra railway, with containerised scrap metal being shifted by Espee Railroad Services to Port Botany for export
25 March 2015	Sale of Freightliner	Genesee & Wyoming completed its acquisition of 94 per cent of Freightliner Group
30 March 2015	Great Southern Rail	Allegro Funds acquired Great Southern Rail from Serco
21 May 2015	Viterra	Grain handling group Viterra announced it would no longer be using rail to transport grain on the Pinaroo and Loxton lines in SA
21 June 2015	Regional Rail Link	Opening of the Wyndham Vale – Tarneit section of the Regional Rail Link in Victoria
August 2015	Murray Basin Rail Project	Victorian government commits to implementing the project, following the release of the project's business case. The project involves standardising the rail gauge and increasing axle load capacities in the state's Murray Basin region. Associated critical maintenance works commence in October
October 2015	Sydney CBD and South East Light Rail	Major construction works commence
December 2015	Wiggins Island Rail Project	Completion of (Stage One) of Wiggins Island Rail Project
10 December 2015	Roy Hill Holdings	First shipment loaded, using ore transported on the newly opened rail link from the mine sites to Port Hedland
June 2016	Norhtern Sydney Freight Corridor Programme	Epping to Thornleigh Thrid Track line opened
2 July 2016	New Melbourne port shuttle service	SCT Logistics and DP World commence weekly shuttle services from Altona to West Swanston terminal

(continued)

Date	Event	Description
12 July 2016	ACT Light Rail	Construction commences on ACT Light Rail. Initial work involves construction of the Mitchell depot and maintenance centre
19 August 2016	Asciano Acquisition	Asciano acquisition complete, with business split into three distinct businesses – Patrick, Pacific National, and Bulk and Automotive Port Services (BAPS)
30 August 2016	Aurizon shuttle trains	Aurizon commences freight shuttle trains between Port of Botany and Enfield Intermodal Terminal
3 October 2016	Petrie – Kippa–Ring line	Petrie – Kippa–Ring line officially opened

APPENDIX B

Significant network route additions from 1970

Opened	Route additions	Jurisdiction	Gauge	Route km	Project/market
1970	Midland–Forrestfield Forrestfield – Kenwick Junction	WA	Narrow	8.0 10.0	Urban freight
	Kenwick Junction – Kenwick	WA	Narrow	1.0	Urban freight
	Bunbury Power House – Bunbury Inner Harbour	WA	Narrow	1.5	Urban freight
	Broken Hill – SA/NSW border SA/NSW border – Peterborough Peterborough – Port Pirie	SA/NSW	Standard	48.7 253.8 114.4	Interstate standardisation
	Blackwater–Laleham	Qld	Narrow	41.1	Coal
1971	Hay Point – Yukan Yukan–Goonyella Goonyella Mine Balloon Loop	Qld	Narrow	30.2 196.9 5.1	Coal
1972	Shay Gap – Goldsworthy	WA	Standard	65.0	Iron ore
	Tom Price – Paraburdoo	WA	Standard	110.0	Iron ore
	Kooragang Junction Triangle Loop	NSW	Standard	0.9	Coal
	Coppabella – Peak Downs Peak Downs Mine Balloon Loop	Qld	Narrow	42.6 5.6	Coal
	Cape Lambert – Pannawonica (Mesa J)	WA	Standard	203	Iron ore
	Spencer Junction – Whyalla	SA	Standard	74.0	Steel
	East Swanson Dock	VIC	Broad	1.4	Urban freight
1973	Longreach Junction – Coldwater Creek Longreach Junction – Longreach	TAS	Narrow	27.0 2.8	Mixed freight
	Redmine–Kambala	WA	Standard	8.0	Mixed freight
	Taurus–Koorilgah	Qld	Narrow	5.9	Coal
	Cockburn South – Kwinana	WA	Narrow	12.0	Urban freight
	West Kalgoorlie – Kambalda	WA	Standard	54.0	Gauge standardisation

(continued)

Opened	Route additions	Jurisdiction	Gauge	Route km	Project/market
1974	Leonora–Kalgoorlie Kambalda–Esperance	WA	Standard	259.0 332.3	Gauge standardisation
	Bell Bay Wharf – Longreach Junction	TAS	Narrow	17.8	Freight
	Coldwater Creek Junction – East Tamar Junction	TAS	Narrow	12.5	Freight
	Peak Downs – Saraji Saraji Mine Balloon Loop	Qld	Narrow	21.1 5.5	Coal
	Cobarra Balloon Loop Junction – Greenvale	Qld	Narrow	216.5	Nickel ore
1975	Callemondah Yard – Powerhouse Loop – Fork at Callemondah	Qld	Narrow	3.6	Coal
	Boorgoon Mine Balloon Loop	Qld	Narrow	4.2	Coal
	Box Flat – Swanbank Powerhouse	Qld	Narrow	4.6	Coal
1975–1988	Bottom Points – Clarence	NSW	Narrow	7.0	Heritage passenger
1976	Pt Stanvac – Christie Downs	SA	Broad	2.9	Urban passenger
	Pinjarra East – Pinjarra South	WA	Narrow	1.1	Passenger and freight
	Dongara–Eneabba – South Mine	WA	Narrow	93.5	Mineral sands
	Osborne Power Station – Container Terminal	SA	Broad	4.2	Port–intermodal
	Flynn – Phosphate Hill	Qld	Narrow	66.1	Phosphate
1978	Kenwick Junction – Canning Vale	WA	Narrow	5.0	Urban freight
	Picton Junction – Picton East – Point V	WA	Narrow	5.1	Freight
	Christie Downs – Noarlunga Centre	SA	Broad	1.3	Urban passenger
	Whittingham Junction – Mount Thorley Balloon Loop	NSW	Standard	14.8	Coal
	Roma Street – South Brisbane	Qld	Narrow	1.8	Urban passenger
1979	Norwich Park Mine Balloon Loop	Qld	Narrow	5.4	Coal
	Bondi Junction – Erskineville Junction	NSW	Standard	10.1	Urban passenger
	Saraji – Norwich Park	Qld	Narrow	43.2	Coal
	Port Botany – Botany ANL (now Patrick) Terminal – Port Botany	NSW	Standard	0.8 1.4	Port–intermodal
1980	Alice Springs – Kulgera Kulgera – SA/NT border SA/NT border – Tarcoola	NT/SA	Standard	256.0 15.7 562.5	Interstate
	Vales Point Balloon Loop – Vales Point Junction	NSW	Standard	2.7	Coal
	Golding – Callemondah Yard	Qld	Narrow	8.5	Coal
	Fork at Gladstone	Qld	Narrow	0.5	Port
	Fisherman Islands – Ampol Refinery Junction	Qld	Narrow	3.0	Port
	Fisherman Islands Balloon Loop	Qld	Narrow	1.7	Port
	Gregory Mine – Burngrove Gregory Mine balloon loop and fork	Qld	Narrow	61.1 7.6	Coal

(continued)

Opened	Route additions	Jurisdiction	Gauge	Route km	Project/market
1981	Tahmoor Colliery Junction – Tahmoor Colliery Balloon Loop	NSW	Standard	1.3	Coal
	Kwinana CBH	WA	Narrow	8.0	Grain/port
	Boonal (Yarrabee)	Qld	Narrow	3.5	Coal
	Inner Harbour Balloon Loop	NSW	Standard	2.0	Port
1982	Container Terminal – Outer Harbor	SA	Broad	1.3	Port
	Dry Creek North Junction – Dry Creek East Junction	SA	Broad	0.5	Port
	Lota–Thornside	Qld	Narrow	1.9	Re-opening/ urban passenger
	Elura Mine – Elura (CSA) Junction	NSW	Standard	33.6	Ore
	Glanville – Grand Junction Road Container Terminal – Glanville Container Terminal – Outer Harbor Dry Creek North – Dry Creek East Junction Cavan – Dry Creek East Junction Dry Creek – Gillman Junction Gillman Junction – Port Adelaide Junction Port Adelaide Flat – Gillman Junction	SA	Standard	2.7 10.9 1.3 0.5 1.1 4.7 2.4 3.1	Interstate standardisation
	Saxonvale Junction – Saxonvale Balloon Loop (Bulga Mine)	NSW	Standard	8.0	Coal
	Ulan Junction – Ulan Balloon Loop Sandy Hollow – Ulan	NSW	Standard	2.0 105.2	Coal
	German Creek – Gregory Mine Junction	Qld	Narrow	36.1	Coal
	Snowtown–Kadina Kadina–Wallaroo	SA	Standard	74.4 9.9	Gauge conversion (dual gauge)
	Crystal Brook East Fork	SA	Standard	1.2	Interstate standardisation
	Crystal Brook – Salisbury–Islington	SA	Standard	189.1	Interstate standardisation

(continued)

Opened	Route additions	Jurisdiction	Gauge	Route km	Project/market
1983	Hamilton–Worsley Worsley North – Worsley East	WA	Narrow	11.0 1.0	Alumina/rural freight
	Norwich Park – German Creek Fork at German Creek	Qld	Narrow	21.7 1.3	Coal
	Oaky Creek Mine Balloon Loop Fork at Oaky Creek Mine balloon Loop	Qld	Narrow	6.1 0.5	Coal
	Riverside Mine Balloon Loop Riverside–Goonyella	Qld	Narrow	7.4 5.2	Coal
	Teralba Colliery Junction – Teralba Colliery Balloon Loop	NSW	Standard	3	Coal
	Watonga – Blair Athol Mine Blair Athol Balloon loop	Qld	Narrow	108.2 6.9	Coal
	Drayton Junction – Drayton Balloon Loop	NSW	Standard	8.0	Coal
	Curragh–Saggitarius	Qld	Narrow	14.0	
	Moss Vale Triangle Loop	NSW	Standard	0.4	Mainline/rural freight
	Abbot Point – Kaili	Qld	Narrow	16.0	Coal
	Annandale – Boundary Hill Mine	Qld	Narrow	5.6	Coal
	Torrens Bridge Junction – Mile End Junction Mile End Junction – Mile End Goods Yard	SA	Standard	0.9 2.3	Interstate standardisation
1984	Collinsville – Newlands Mine	Qld	Narrow	75.6	Coal
	Canning Vale – Cockburn South	WA	Narrow	13.0	Urban freight
	Cockburn North – Cockburn East	WA	Narrow	1.0	Urban freight
	Kooragang Island Balloon Loop	NSW	Standard	5.0	Coal
1981–1985	Flagstaff – Flinders Street (City Loop)	Victoria	Broad	3.0	Urban passenger
1985	Altona – Laverton Junction	Victoria	Broad	4.6	Freight/ passenger
	Ulan–Gulgong	NSW	Standard	23.8	Coal
1986	Blair Athol Mine – Claremont	Qld	Narrow	22.0	Coal
	Fork at Rocklands	Qld	Narrow	0.8	Coal
	Roma Street – South Brisbane	Qld	Standard	1.8	Interstate passenger
	Melbourne Yard – Webb Dock	VIC	Broad	7.8	Port
1987	Wellington Point – Cleveland	Qld	Narrow	4.4	Urban passenger
	East Hills – Glenfield	NSW	Standard	8.3	Urban passenger
1987–1988	Blue Cow – Perisher – Bullocks Flat	NSW	Standard	8.5	Rural passenger
1989	Hellyer Mine – Moory Junction	TAS	Narrow	11.5	Zinc ore
1989	Jimblebar – Jimblebar Junction	WA	Standard	32.0	Iron ore
1990	Glenlee Triangle Fork	NSW	Standard	0.3	Mainline Freight
	Mount McLaren Balloon Loop	Qld	Narrow	1.0	Coal
	Yarrowlea–Ebenezer	Qld	Narrow	8.4	Coal

(continued)

Opened	Route additions	Jurisdiction	Gauge	Route km	Project/market
1991	Camberwell Balloon Loop – Camberwell junction	NSW	Standard	4.0	Coal
	Rosella – Brockman 2	WA	Standard	44.0	Iron ore
	Thornton Junction – Bloomfield Colliery Balloon Loop	NSW	Standard	7.5	Coal
1992	Gidgy Junction – Yandicoogina	WA	Standard	32.0	Iron ore
	Stanwell Power House Balloon Loop	Qld	Narrow	5.1	Coal
	Eraring Junction – Eraring Balloon Loop	NSW	Standard	1.8	Coal
	Gordonstone Junction – Gordonstone Balloon Loop	Qld	Narrow	12.8	Coal
	Joondalup–Perth	WA	Narrow	26	Urban passenger
1993	Currambine–Joondalup	WA	Narrow	3.0	Urban passenger
	Shay Gap – Yarrie	WA	Standard	32.0	Iron ore
	Riverside – North Goonyella	Qld	Narrow	18.8	Coal
	Point "V" – Bowen Junction	Qld	Narrow	0.9	Coal
	Mackay – Point "X"	Qld	Narrow	4.3	Coal
	Gunnedah Junction – Gunnedah Balloon Loop	NSW	Standard	2.0	Coal
1994	Marandoo–Rosella	WA	Standard	59.0	Iron ore
	Moura Mine Balloon Loop	Qld	Narrow	5.6	Coal
	Owanyilla Balloon Loop	Qld	Narrow	0.2	Coal
1995	Apamurra–Monarto	SA	Standard	34.4	Gauge conversion
	Fork at Blackwater	Qld	Narrow	0.6	Coal
	Tottenham Junction – VIC/SA border (via Cressy) VIC/SA border – Goodwood – Mile End Goods	SA/Vic	Standard/ dual	520 309.0	Interstate standardisation
	Hopetoun–Murtoa	VIC	Standard	111.3	Gauge conversion
	Rainbow–Dimboola	VIC	Standard	64.0	Gauge conversion
	Yaapeet–Rainbow	VIC	Standard	17.0	Gauge conversion
	Maroona–Portland	VIC	Standard	171.0	Gauge conversion
	Dartbrook Junction – Dartbrook Balloon Loop	NSW	Standard	4.0	Coal
	Stratford Balloon Loop – Stratford Junction	NSW	Standard	3.2	Coal

(continued)

Opened	Route additions	Jurisdiction	Gauge	Route km	Project/market
1996	Islington Workshops – Kilburn Junction	SA	Standard	0.3	Interstate standardisation
	Fork at Coppabella	Qld	Narrow	1.4	Coal
	Ewington Branch	WA	Narrow	3.0	Coal
	Burton Mine Balloon Loop	Qld	Narrow	5.0	Coal
	Beenleigh–Helensvale	Qld	Narrow	28.0	Urban passenger
	Maryborough–Ararat	VIC	Standard	81	Gauge conversion
	Dunolly–Maryborough	VIC	Standard	15	Gauge conversion (dual)
	Loxton–Tookayerta Tookayerta – Tailem Bend	SA	Standard	8.1 151.2	Gauge conversion
	Granville Triangle Loop	NSW	Standard	0.9	Urban passenger
	Mount Owen Balloon Loop – Glennies Creek Junction	NSW	Standard	6.5	Coal
	Liddell Junction – Ravensworth Washery Balloon Loop	NSW	Standard	3.0	Coal
1997	Mackenzie – Ensham Mine Balloon Loop	Qld	Narrow	14.9	Coal
	South Walker Branch	Qld	Narrow	2.3	Coal
	Aldoga – East End	Qld	Narrow	11.9	Coal
	Fishermans Landing – Mount Miller	Qld	Narrow	8.3	Coal/port
	Fisherman Islands – Dutton Park	Qld	Narrow/ Standard	20.4	Urban freight (dual gauge)
	Helensvale–Nerang	Qld	Narrow	7.7	Urban passenger
1998	Arriga Junction – Arriga Junction Fork – Arriga	Qld	Narrow	4.1	Rural freight
	Nerang–Robina	Qld	Narrow	9.5	Urban passenger
	Moranbah North Balloon Loop	Qld	Narrow	7.3	Coal
	Pinnaroo – Tailem Bend	SA	Standard	144.5	Gauge conversion
	Olympic Park Flemington – Goods Junction	NSW	Standard	3.9	Urban passenger
1999	Macarthur Junction – Macarthur Balloon Loop	Qld	Narrow	5.1	Coal
	Yandi–Marandoo	WA	Standard	147.0	Iron ore
	Parkes Y-Link	NSW	Standard	0.4	Rural freight
	Mount Thorley Junction – Wambo Balloon Loop	NSW	Standard	16.0	Coal
2000	Sydney Central – Turrella (Airport line)	NSW	Standard	7.3	Urban passenger
2001	Brisbane Airport – Eagle Junction	Qld	Narrow	8.5	Urban passenger
2002	Mindi–South Walker	Qld	Narrow	8.7	Coal
2003	Hail Creek – South Walker	Qld	Narrow	46.7	Coal
2004	Darwin – Alice Springs	NT	Standard	1 418	Interstate
	Mt Millar – Comalco Balloon Loop	Qld	Narrow	2.4	Coal
	Clarkson–Currambine	WA	Narrow	4.0	Urban passenger
2005	Beckenham–Thornlie	WA	Narrow	3.0	Urban passenger

(continued)

Opened	Route additions	Jurisdiction	Gauge	Route km	Project/market
2006	South Maitland Railway	NSW	Standard	30.0	Coal (re-opened line)
	Kinrola–Rolleston	Qld	Narrow	110.0	Coal
2007	Hancock Junction – Hope Downs	WA	Standard	58.0	Iron ore
	Perth–Mandurah	WA	Narrow	70.0	Urban passenger
2008	Port Hedland – Cloudbreak Mine	WA	Standard	260.0	Iron ore
	Port River Rail Bridge	SA	Standard	0.3	Port
2009	Lake Vermont – Dysart	Qld	Narrow	18.0	Coal
	Chatswood–Epping	NSW	Standard	15	Urban passenger
	Robina – Varsity Lakes	Qld	Narrow	4.1	Urban passenger
	Oaklands–Benalla	NSW	Standard	125	Gauge conversion
2010	Cameby Downs Loop	Qld	Narrow	7.0	Coal
	Brooklyn Triangle	VIC	Standard	0.5	Interstate
	Mesa K – Warramboo (Mesa A)	WA	Standard	49.0	Iron ore
	Darra–Richlands	Qld	Narrow	4.5	Urban passenger
2011	Cloudbreak Mine – Christmas Creek	WA	Standard	50.0	Iron ore
	Newlands – North Goonyella	Qld	Narrow	69.0	Coal
	Middlemount Rail Spur	Qld	Narrow	16.5	Coal
2012	Brockman 2 – Brockman 4	WA	Standard	41.0	Iron ore
	Tilley Siding (Morawa) – Karara	WA	Narrow	79	Iron ore
	Solomon Junction – Solomon	WA	Standard	130.0	Iron ore
	South Morang – Epping	VIC	Broad	3.5	Urban passenger (re-opened line)
2012–13	Sefton–Macarthur (Southern Sydney Freight Line)	NSW	Standard	36	Interstate freight
2013	Hope Downs 4 railway	WA	Standard	53.0	Iron ore
	Richlands–Springfield	Qld	Narrow	9.5	Urban passenger
2014	Noarlunga–Seaford	SA	Broad	5.7	Urban passenger
	Clarkson–Butler	WA	Narrow	8.0	Urban passenger
2015	Glenfield–Leppington	NSW	Standard	12	Urban passenger
	Deer Park – West Werribee (Regional Rail Link)	VIC	Broad	27	Inter-urban passenger
	Roy Hill	WA	Standard	344	Iron ore
2016	Boggabri Coal Mine Expansion	NSW	Standard	17	Coal
	Petrie–Kippa–Ring	Qld	Narrow	13	Urban passenger

Note: Does not include light rail/tramways. Does not include the Roy Hill–Port Hedland Railway that was due for opening in late 2015 but had not yet opened at the time of writing.

Sources: Quinlan and Newland 2000; BITRE 2015; Data provided by Aurizon.

APPENDIX C

Train operator traffic

Table 36 ASX train operator traffic trends (billion net tonne-kilometres)

	Asciano				Aurizon				
Period	Coal	Other bulk	Intermodal (including steel)	Total	Coal	Iron ore	Bulk	Non-bulk —plus residual bulk from 2011–12	Total
Sep–07	3.0	0.7	6.7	10.4	–	–	–	–	–
Dec–07	3.1	0.6	6.7	10.5	–	–	–	–	–
1HY–08	6.2	1.4	13.4	21.0	–	–	–	–	–
Mar–08	3.1	0.7	6.0	9.8	–	–	–	–	–
Jun–08	3.4	0.7	6.5	10.6	–	–	–	–	–
2HY–08	6.5	1.4	12.5	20.4	–	–	–	–	–
Full year 2007–08	12.7	2.8	25.9	41.4	42.8	–	13.6	4.8	61.2
Sep–08	3.4	0.8	6.7	10.8	–	–	–	–	–
Dec–08	3.5	0.8	5.9	10.2	–	–	–	–	–
1HY–09	6.9	1.6	12.6	21.1	–	–	–	–	–
Mar–09	3.3	1.0	4.8	9.1	–	–	–	–	–
Jun–09	3.7	1.1	5.1	9.8	–	–	–	–	–
2HY–09	7.0	2.0	9.9	18.9	–	–	–	–	–
Full year 2008–09	13.9	3.6	22.5	40.0	43.5	–	14.3	4.2	62.0
Sep–09	4.2	0.9	5.7	10.8	–	–	–	–	–
Dec–09	4.2	0.8	5.9	10.9	–	–	–	–	–
1HY–10	8.4	1.7	11.6	21.7	–	–	–	–	–
Mar–10	4.4	0.8	5.3	10.5	–	–	–	–	–
Jun–10	5.2	0.9	5.4	11.5	–	–	–	–	–
2HY–10	9.7	1.7	10.7	22.0	–	–	–	–	–
Full year 2009–10	18.1	3.4	22.2	43.7	45.3	–	15.2	3.7	64.2
Sep–10	5.3	0.9	5.7	11.9	–	–	–	–	–
Dec–10	4.2	0.8	5.6	10.6	–	–	–	–	–
1HY–11	9.6	1.6	11.3	22.5	22.6	–	–	10	32.6
Mar–11	4.1	1.2	5.0	10.3	–	–	–	–	–
Jun–11	4.6	1.2	5.5	11.4	–	–	–	–	–
2HY–11	8.7	2.4	10.5	21.6	18.3	–	–	8.9	27.2
Full year 2010–11	18.3	4.0	21.8	44.2	40.9	–	–	18.9	59.8

(continued)

Period	Asciano				Aurizon				
	Coal	Other bulk	Intermodal (including steel)	Total	Coal	Iron ore	Bulk	Non-bulk —plus residual bulk from 2011–12	Total
Sep–11	4.9	1.3	5.8	12.0	–	–	–	–	–
Dec–11	4.8	1.4	5.9	12.0	–	–	–	–	–
1HY–12	9.6	2.7	11.7	24.0	22	–	9.9	–	31.9
Mar–12	4.7	1.4	5.6	11.8	–	–	–	–	–
Jun–12	5.7	1.6	5.7	12.9	–	–	–	–	–
2HY–12	10.3	3.0	11.3	24.6	19.9	–	–	11.1	31.0
Full year 2011–12	20.0	5.6	23.0	48.6	41.9	6.7	–	14.3	62.9
Sep–12	5.3	1.6	5.8	12.7	–	–	–	–	–
Dec–12	6.1	1.3	6.0	13.4	–	–	–	–	–
1HY–13	11.5	2.9	11.7	26.1	21.9	4.8	–	6.8	33.5
Mar–13	6.0	1.5	5.4	12.9	–	–	–	–	–
Jun–13	6.6	1.6	5.5	13.7	–	–	–	–	–
2HY–13	12.6	3.1	10.9	26.6	–	–	–	–	–
Full year 2012–13	24.0	6.0	22.7	52.7	43.6	10.3	–	13.2	67.1
Sep–13	7.1	1.3	5.6	14.0	12.4	3	–	3.3	18.7
Dec–13	7.4	1.2	5.6	14.3	13.1	3.1	–	3.3	19.5
1HY–14	14.5	2.5	11.2	28.2	25.5	6.1	–	6.6	38.2
Mar–14	7.3	1.4	5.1	13.8	11.4	3	–	3	17.4
Jun–14	7.4	1.3	5.1	13.8	12.3	3.1	–	2.9	18.3
2HY–14	14.7	2.7	10.2	27.6	23.7	6.1	–	5.9	35.7
Full year 2013–14	29.2	5.1	21.5	55.8	49.2	12.2	–	12.5	73.9
Sep–14	7.4	1.1	5.5	14	12.6	2.8		3.5	18.9
Dec–14	7.8	1.3	5.7	14.8	12.6	2.5		3.3	18.4
1HY–15	15.2	2.4	11.2	28.8	25.2	5.3		6.8	37.3
Mar–15	7.6	1.4	5.0	14	11.5	2.4		2.9	16.8
Jun–15	8.1	1.3	4.7	14.1	12.4	2.7		3.2	18.3
2HY–15	15.7	2.7	9.7	28.1	23.9	5.1		6.1	35.1
Full year 2014–15	30.9	5.1	20.9	56.9	49.1	10.4		12.9	72.4
Sep–15		–	–	–		–	–	–	–
Dec–15		–	–	–		–	–	–	–
1HY–16	16.2	2.3	10.2	28.7	25.0	5.0	–	6.5	36.5
Mar–16		–	–	–		–	–	–	–
Jun–16		–	–	–		–	–	–	–
2HY–16	15.6	2.1	9.4	27.1	24.7	4.6	–	5.8	35.1
Full year 2015–2016	31.8	4.4	19.6	55.8	49.7	9.6	–	12.3	71.6

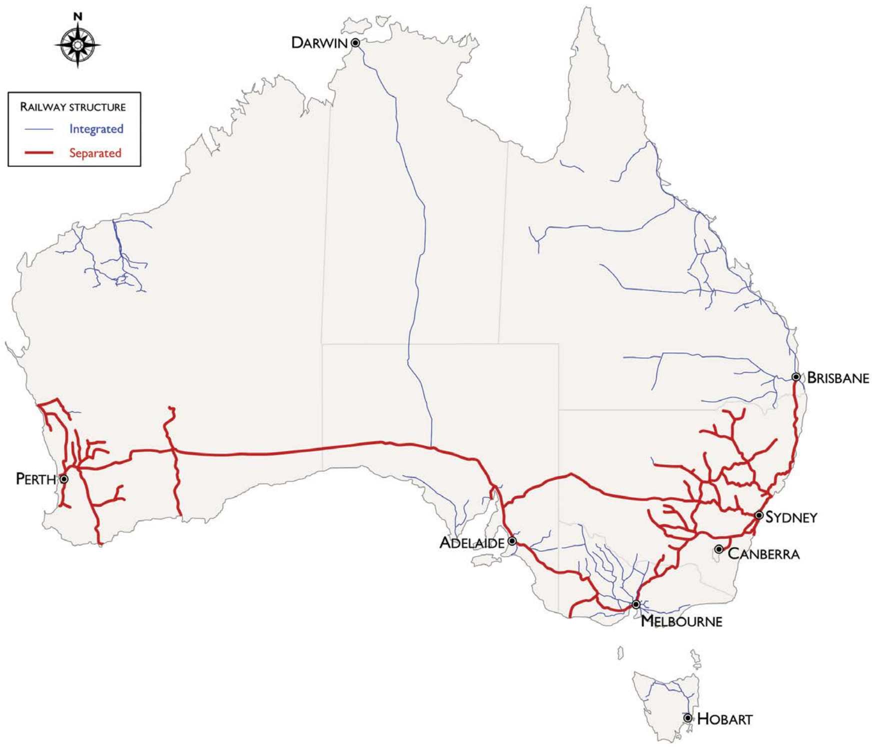
Sources: QR National 2010, pp.98–99; Asciano web site (Australian Stock Exchange [ASX] Announcements – no longer publised, following August 2016 division of Asciano. Saved copies available from BITRE); Aurizon website (ASX Announcements).

APPENDIX D
Industry Structure

The industry structure consists of both vertically–separated and vertically-integrated railways.

In vertically-separated railways, the railway infrastructure manager does not operate revenue-earning trains; the "open access" manager sells track access to train operators. Integrated railways manage the network's infrastructure and access and also operate trains on the track. Integrated railway owners may provide "third-party access" to (other) train operators.

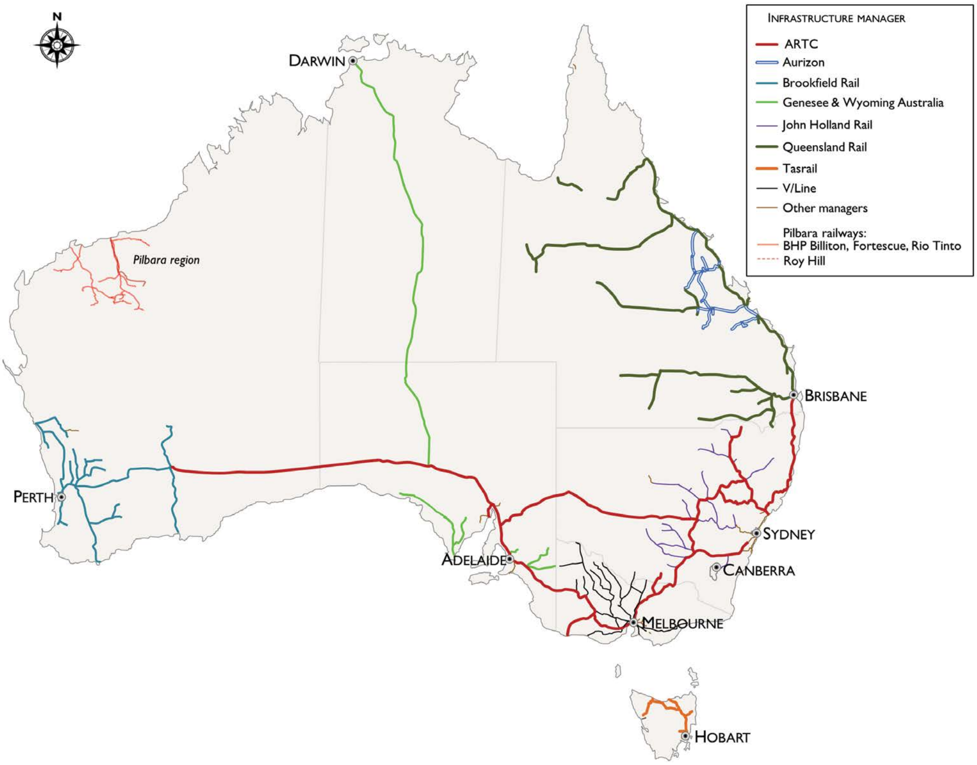
Figure 63 Australian rail industry structure



Infrastructure management

Australia's infrastructure managers are diverse in structure and operation. Figure 64 presents Australia's railway system by network manager.

Figure 64 Australian railways, by network manager, 2016



Note: The lines shown here are the railways that were open for traffic at July 2016.
The BHP Goldsworthy line in the Pilbara is shown on the map but it was mothballed in 2014.

The pattern of the network management can be described thus, by traffic type:

- **Interstate.** The interstate network is managed by the ARTC and Brookfield Rail infrastructure managers. The Tarcoola–Darwin line is owned (long-leased) as an integrated railway company, by Genesee & Wyoming Australia. Sydney-Perth trains which travel via Lithgow use John Holland Rail managed track between Marrangaroo (Lithgow) and Parkes.
- **Iron ore—Pilbara.** These lines have integrated infrastructure management and train operation, with lines owned by BHP Billiton, Rio Tinto, Fortescue Metals Group and Roy Hill.
- **Coal.** Coal railways in Queensland have an integrated structure. Aurizon manages infrastructure and operates trains in Central Queensland and uses Queensland Rail infrastructure elsewhere. Third-party access is provided to these lines. Coal railways in New South Wales have a vertically-separated structure, with the ARTC managing the Hunter Valley coal network and with some coal trains also operating over rail infrastructure managed by John Holland Rail or RailCorp.

- **Mixed.** Tasmania's network of mixed bulk and non-bulk traffic is vertically-integrated, with TasRail managing the system and operating the trains.
- **Grain.** Grain railways are vertically integrated in Queensland (Queensland Rail), and South Australia (Genesee & Wyoming) and separated in New South Wales (ARTC, John Holland Rail and RailCorp), Victoria (V/Line) and Western Australia (Brookfield Rail).
- **Passenger.** Urban systems have integrated management structures.

Table 37 Principal infrastructure managers of Australian railways, 2016

Infrastructure manager	Structure	Primary usage
Interstate		
Australian Rail Track Corporation (ARTC)	Separated	Intermodal, grain, ores, steel, passenger
Brookfield Rail	Separated	Intermodal, grain, ores, steel, passenger
Genesee & Wyoming Australia (GWA)	Integrated	Intermodal, ores, passenger
Intrastate		
Aurizon	Integrated	Coal
Queensland Rail	Integrated and Separated	Passenger (integrated), grain, coal, cattle, ores, intermodal (separated)
John Holland	Separated	Intermodal, grain, ores, cotton, passenger
ARTC (New South Wales regional and Hunter Valley)	Separated	Intermodal, coal, grain, cotton, passenger
V/Line	Integrated (passenger); Separated (freight)	Passenger, grains, mineral sands, intermodal
ARTC (Portland, Benalla–Yarrawonga)	Separated	Grain, mineral sands
TasRail	Integrated	Intermodal, coal, ores, timber
GWA (intrastate South Australia)	Integrated	Grain, gypsum, ores
Brookfield Rail (intrastate Western Australia)	Separated	Grain, ores
BHP Billiton	Integrated	Iron ore
Rio Tinto	Integrated	Iron ore
Fortescue Metals Group	Integrated	Iron ore
Roy Hill Holdings	Integrated	Iron ore
MTM (Metro Trains Melbourne)	Separated	Passenger, freight, steel
Sydney Trains	Separated	Passenger, freight
Urban		
Queensland Rail (Brisbane, Gold Coast)	Integrated	Passenger
Airtrain CityLink Limited	Integrated	Passenger
Sydney Trains	Integrated	Passenger
MTM (Metro Trains Melbourne)	Integrated	Passenger
Adelaide Metro (Department of Planning, Transport and Infrastructure)	Integrated	Passenger
Transperth	Integrated	Passenger

Note: There are a number of other, smaller, infrastructure managers, including heritage railways, totalling approxiametly 555 route-kilometres.

Above rail operators

Train operation is undertaken by numerous organisations.

- **Heavy rail urban passenger** operators are largely integrated organisations, that is, they manage the tracks on which their trains run. Most are publically-owned entities, with the exception of Metro Trains Melbourne, which is a privately owned joint venture that operates trains and manages the network on behalf of the Victorian Government under a franchise agreement.
- **Non-urban passenger** services are largely government operated with a few exceptions, including Great Southern Rail, which operates the long-distance Ghan, Indian Pacific and Overland trains.
- **Heritage passenger railways.** Around 40 heritage volunteer-based organisations manage and operate railways, totalling approximately 500 route-kilometres.
- **National rail freight operators.** Two largest national rail freight train operators are Aurizon and Pacific National. The companies' core activity is coal haulage in Queensland and New South Wales, with other important ancillary bulk-haulage activities. Both companies also operate intermodal services on the open access interstate network.
- **Regional rail freight operators.** Genesee & Wyoming Australia is a major train operator in South Australia and the Northern Territory. Other significant players include Southern Shorthaul Railroad and Freightliner Australia (a subsidiary of Genesee & Wyoming Australia). TasRail provides the rail freight services in Tasmania while Watco WA Rail is contracted by CBH to provide grain haulage in Western Australia.
- **Logistics companies**—notably SCT Logistics, and Qube Holdings—operate intermodal services for their own logistics chains. They also operate a small number of bulk services. SCT Logistics has a diverse portfolio of rail and road activities, including intercity intermodal operations. Qube Holdings also has a diverse intermodal and bulk portfolio, with a primary focus on local and regional port-based operations. Fletcher International is a new player in the rail transport industry. It provides agricultural products rail services from Dubbo to Port Botany in New South Wales. (Other logistics companies—such as Toll, Sadliers Logistics and Ettamogah Rail Hub—use rail freight operators to undertake their rail haulage.)
- **Mining companies,** such as Rio Tinto, BHP Billiton, Fortescue Metals Group and Karara Mining operate trains on their own railways.

Table 38 Principal train operators in Australia, 2016

Train operator	Infrastructure network used	Primary tasks
Freight		
Aurizon	Aurizon, Queensland Rail, ARTC, Brookfield, Sydney Trains	Coal, iron ore, intermodal, minerals cattle, grain, mixed bulk
Pacific National	Aurizon, Queensland Rail, ARTC, V/Line, John Holland, Sydney Trains, Brookfield, GWA, MTM Melbourne	Coal, ores, intermodal, steel, grain, mixed bulk
Genesee & Wyoming Australia (GWA)	GWA, ARTC	Intermodal, ores
SCT Logistics/Specialised Bulk Rail	ARTC, Brookfield Rail,	Intermodal, grain, iron ore
Qube Holdings	ARTC, Brookfield Rail, V/Line, Sydney Trains, John Holland	
MTM Melbourne	Intermodal, grain, mixed bulk	
Watco	Brookfield	Grain
Southern Shorthaul Railroad	ARTC, Sydney Trains, John Holland	Coal, grain, intermodal, infrastructure works
Freightliner Australia	ARTC, Sydney Trains, John Holland	Coal, grain, cotton
TasRail	TasRail	Intermodal, coal, ores, timber
Rio Tinto	Rio Tinto	Iron ore
BHP Billiton	BHP Billiton	Iron ore
Fortescue Metals Group	Fortescue Metals Group	Iron ore
Roy Hill Holdings	Roy Hill Holdings	Iron Ore
Non-urban passenger		
Queensland Rail	Queensland Rail	Passenger
NSW TrainLink (long distance, interstate, intrastate, and inter-urban)	Sydney Trains, ARTC, John Holland, V/Line, Queensland Rail	Passenger
V/Line	V/Line, ARTC, MTM Melbourne	Passenger
TransWA	Transperth, Brookfield Rail	Passenger
Great Southern Railway	Sydney Trains, John Holland, ARTC, Brookfield Rail, GWA	Passenger
Heavy urban rail passenger		
Queensland Rail	Queensland Rail, AirTrain CityLink Limited	Passenger
Sydney Trains	Sydney Trains	Passenger
MTM Melbourne	MTM Melbourne	Passenger
Adelaide Metro (Department of Planning, Transport and Infrastructure)	Adelaide Metro (Department of Planning, Transport and Infrastructure)	Passenger
Transperth	Transperth	Passenger
Light urban rail passenger		
GoldLinQ	GoldLinQ	Passenger
Transdev	Transport for NSW	Passenger
Yarra trams	Yarra trams (Keolis Downer EDI Rail)	Passenger
Adelaide Metro (Department of Planning, Transport and Infrastructure)	Adelaide Metro (Department of Planning, Transport and Infrastructure)	Passenger

APPENDIX E

Urban historical rail infrastructure construction

The railways included in the calculations conform to the urban area used in the BITRE report, Understanding Australia's urban railways. This means, for example, that BITRE includes railways from eras that pre-date the urbanisation of the surrounding area. For example, Sydney's Richmond line is included. The line was constructed in the 1860s but only in recent years has become regarded as part of Sydney. Similarly, Sydney's South-West (Leppington) line opened in 2015, as a vanguard to later urban development.

Data presented are for railway route kilometres, that is, the length of the railway corridor. Thus, for instance, the route length does not change if a single-line railway is duplicated.

Data presented are for passenger and freight railways.

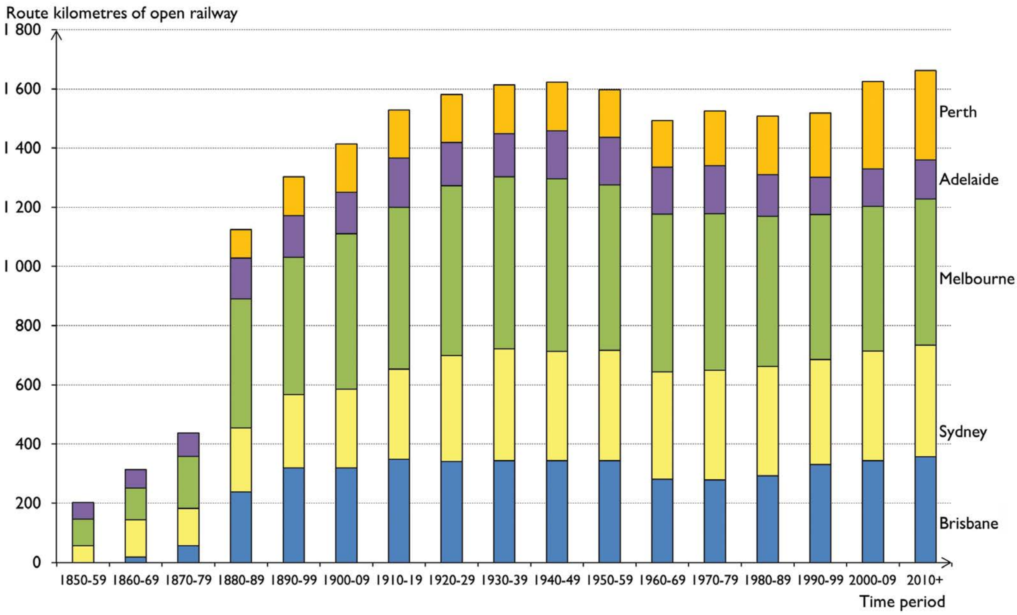
Data presented are for "heavy" railways. This means that light-rail and tram route lengths are not included. This is a relevant consideration when heavy-rail routes are converted to light-rail routes. Key routes where this happened were:

- one of the two Glenelg railways in Adelaide in the 1920s;
- Melbourne's St Kilda and Port Melbourne railways in the 1980s; and
- Sydney's Metropolitan Goods freight railway to form the Dulwich Hill—Inner West Light Rail—Line, between 1997 and 2014.

Generally, in recent decades, new railways have involved extensions of existing railway corridors or new branch lines in outer urban areas. There have been notable exceptions, such as:

- the opening of Perth's 70 kilometre Mandurah railway in 2007, which provided a major addition to the city's railway network, with a completely new railway corridor to Perth Central Station;
- Sydney's 10 kilometre Eastern Suburbs line was also a new railway corridor through to the city's Central Station, opening in 1979;
- Sydney's 11 kilometre Airport Line provided a new corridor into Sydney Central.

Figure 65 Historical urban rail infrastructure distances



References

ABARES – see Australian Bureau of Agricultural and Resource Economics and Sciences

Adelaide Metro, 2016, Train Timetables, <https://www.adelaidemetro.com.au/timetables/trains>

Adelaide Metro, 2016a, Tram Timetable, <https://www.adelaidemetro.com.au/routes/Tram>

ARTC – See Australian Rail Track Corporation

Asciano 2014, Financial year 2014 Full year financial results, < http://www.asx.com.au/asxpdf/20140821/pdf/42rm8b0nfbhzfn.pdf>

Asciano 2014a, Investor briefing—presentation, 19 June 2014, <http://asciano.com.au/investors/announcements/802/download>

Asciano 2016, Financial Year 2016 Full Year Financial Results, < http://www.asx.com.au/asxpdf/20160816/pdf/439bgg00xgsqd0.pdf>

ATSB—see Australian Transport Safety Bureau

Aurizon Network n.d., web site, Aurizon Network, Reports and QCA, <http://www.aurizon.com.au/network/reports-and-qca>

Aurizon n.d., Australian Stock Exchange announcements, <http://www.aurizon.com.au/Investors-site/Pages/Financial-Results.aspx>

Aurizon 2015, Newlands system information pack < http://www.aurizon.com.au/Downloads/Aurizon%20Newlands%20Rail%20Corridor.pdf>

Aurizon 2015a, Goonyella system information pack, < http://www.aurizon.com.au/~/media/aurizon/files/what%20we%20do/network/network%20downloads/cqcn%20info%20packs/goonyella%20system%20information%20pack%20-%20issue%206_6.ashx >

Aurizon 2015b, Blackwater system information pack, < http://www.aurizon.com.au/Downloads/Blackwater%20System%20Information%20Pack%20-%20Issue%205.6.pdf>

Aurizon 2015c, Moura system information pack, < http://www.aurizon.com.au/Downloads/Moura%20System%20Information%20Pack%20-%20Issue%206.0.pdf>

Aurizon 2016, 15/16 Annual Report p.14, < https://www.aurizon.com.au/~/media/aurizon/files/investors/documents%20and%20webcasts/2016/full%20year%20results/annual%20report%202016.ashx>

Aurizon 2016a, Aurizon Network Public Quarterly Performance Report 4th Quarter 2015-2016 April-June 2016, <http://www.aurizon.com.au/~/media/aurizon/files/what%20we%20do/network/network%20downloads/reports%20and%20qca/aurizon%20network%20public%20quarterly%20report%20-%204th%20quarter%20april%20-%20june%202016.ashx>

Aurizon 2016b, Heavy Haul Operations at Aurizon – Integrated Solutions for Efficiency presentation at 2016 ARA Heavy Haul Rail Conference

Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), 2015, *Australia's what supply chains Infrastructure issues and implications* <http://data.daff.gov.au/data/warehouse/9aaw/2015/awscfd9aaw20150305/AustWheatSC_InfrstrctIssuesImplctns_20150305_V1.1.0.pdf>

Australian Bureau of Statistics 2011, *Census of population and housing – journey to work,* <http://www.abs.gov.au/census>

Australian Export Grains Innovation Centre 2014, *The cost of Australia's bulk grain export supply chains.* An information paper, <Online version no longer available>

Australian Export Grains Innovation Centre 2014a, *The cost of Australia's bulk grain export supply chains.* Postscript Version 2014.1, <Online version no longer available>

Australian Export Grains Innovation Centre 2015, *The puck stops here! Canada challenges Australia's grain supply chains,* <Online version no longer available>

Australian Rail Track Corporation n.d., Network key performance indicators <artc.com.au> (search 'Hunter Valley performance results')

Australian Rail Track Corporation n.d (a). web site, Performance Indicators 'Reliability, <http://www.artc.com.au/customers/access-interstate/performance-indicators/reporting/library/Reliability.pdf?0315>

Australian Rail Track Corporation, 2014. Performance indicators 2007 interstate access undertaking – reliability, Adelaide, <https://www.artc.com.au/library/Reliability.pdf?260416>

Australian Transport Safety Bureau 2012, *Australian Rail Safety Occurrence Data,* < https://www.atsb.gov.au/media/3602413/rr2012001.pdf>

Australian Transport Safety Bureau 2013, Canberra, *Safety of rail operations on the interstate rail line between Melbourne and Sydney* <https://www.atsb.gov.au/media/4182477/ri-2011-015_final.pdf>

Avery, Rodney, *Great Rail Journeys of Australia,* Acacia Press, Brisbane, 2013

BITRE—see Bureau of Infrastructure, Transport and Regional Economics

BTRE—see Bureau of Transport and Regional Economics

Bombardier 2016, FLEXITY 2 *Light Rail System – Gold Coast, Australia* < http://www.bombardier.com/en/transportation/projects/project.flexity2-gold-coast-australia.html?f-region=all&f-country=fr&f-segment=all&f-name=all>

Brookfield Rail n.d., Net tonnes per route section, <http://www.brookfieldrail.com/assets/br_files/Communications%20Material/Brookfield%20Rail%20Net%20Tonnes%20per%20Route%20Section.pdf>

Brookfield Rail n.d. (a), web site, Brookfield Rail. Gross tonnes per route section, 2010–2012, <http://www.brookfieldrail.com/assets/br_files/Communications%20Material/Brookfield%20Rail%20Gross%20Tonnes%20per%20Route%20Section.pdf>

Brookfield Rail 2014, Grain freight rail network. Fact sheet. <http://www.brookfieldrail.com/assets/br_files/Resources/140603%20BR%20Grain%20Frieght%20Rail%20Fact%20Sheet%20FINAL.pdf>

Bureau of Transport and Regional Economics 2006, *Optimising harmonisation in the Australian railway industry, Report 114,* <www.bitre.gov.au/publications/2006/files/report_114.pdf>

Bureau of Infrastructure, Transport and Regional Economics 2009, *Road and rail freight: competitors or complements? Information sheet 34,* <http://www.bitre.gov.au/publications/2009/files/is_034.pdf>

Bureau of Infrastructure, Transport and Regional Economics 2011, *Population growth, jobs growth and commuting flows in Melbourne,* Research report 125 <http://www.bitre.gov.au/publications/2011/report_125.aspx>

Bureau of Infrastructure, Transport and Regional Economics 2012, *Understanding Australia's urban railways,* Research report 131, <http://www.bitre.gov.au/publications/2012/files/report_131.pdf>

Bureau of Infrastructure, Transport and Regional Economics 2012a, *TrainLine 1,* Statistical report, <http://www.bitre.gov.au/publications/2012/train_001.aspx>

Bureau of Infrastructure, Transport and Regional Economics 2012b, *Population growth, jobs growth and commuting flows in Sydney,* Research report 132, <http://www.bitre.gov.au/publications/2012/report_132.aspx>

Bureau of Infrastructure, Transport and Regional Economics 2013, *Australia's bulk ports,* Research Report 135, <http://www.bitre.gov.au/publications/2013/files/report_135.pdf>

Bureau of Infrastructure, Transport and Regional Economics 2014, *Trainline 2,* <http://bitre.gov.au/publications/2014/files/trainline_002.pdf>

Bureau of Infrastructure, Transport and Regional Economics 2014a, *Freightline 1—Australian Freight Transport Overview.* <http://www.bitre.gov.au/publications/2014/files/Freightline_01.pdf>, Canberra

Bureau of Infrastructure, Transport and Regional Economics 2014b, *Freightline 2—Australian Iron Ore Freight Transport,* <http://www.bitre.gov.au/publications/2014/files/Freightline_02.pdf>, Canberra

Bureau of Infrastructure, Transport and Regional Economics 2014c, *Australian Sea Freight*

Bureau of Infrastructure, Transport and Regional Economics 2014d, Freightline series. <http://www.bitre.gov.au/publications/publications.aspx?query=s:"freight"&link-search=true>, Canberra

Bureau of Infrastructure, Transport and Regional Economics 2014e, *Waterline,* <http://www.bitre.gov.au/publications/2014/files/water_054.pdf>

Bureau of Infrastructure, Transport and Regional Economics 2014f, *Improving regional passenger rail services,* Research report 137, <http://www.bitre.gov.au/publications/2014/files/report_137_Regional_Rail.pdf>

Bureau of Infrastructure, Transport and Regional Economics 2014g, *Urban transport: updated passenger trends,* Information Sheet 59 < http://bitre.gov.au/publications/2014/files/is_059.pdf>

Bureau of Infrastructure, Transport and Regional Economics 2014fh *Long-term trends in urban passenger transport*—Information Sheet 60, Canberra < https://bitre.gov.au/publications/2014/files/is_060.pdf>

Bureau of Infrastructure, Transport and Regional Economics 2015, *Trainline 3,* <http://bitre.gov.au/publications/2015/files/trainline_003.pdf>

Bureau of Infrastructure, Transport and Regional Economics 2016, *Freightline 4,* <http://bitre.gov.au/publications/2016/Freightline_04.aspx>

Bureau of Infrastructure, Transport and Regional Economics 2016a, *Why short-haul intermodal rail services succeed* <http://bitre.gov.au/publications/2016/files/rr_139.pdf>

Bureau of Transport and Regional Economics 2006, *Optimising harmonisation in the Australian railway industry,* Report 114, <https://bitre.gov.au/publications/2006/report_114.aspx>

Bureau of Transport and Regional Economics 2007, *Filling a gap in rail data: an investigation of the Gheringhap Loop train sightings* <http://www.bitre.gov.au/publications/2007/files/ip_057.pdf>

Clark, Peter, 2015, *An Australian Locomotive Guide Second Edition,* Rosenberg Publishing Pty. Ltd., Kenthurst

Council of Tramway Museums of Australasia 2016, <http://www.cotma.org.au/documents/adelaide_2012/Randall%20Barry%20&%20Peter%20Haskard%20-%20Adelaide's%20new%20electric%20trains.pdf>

Currie, G and Burke, M 2013, *Light Rail in Australia - Performance and Prospects.* Australasian Transport Research Forum. <http://www.atrf.info/papers/2013/2013_currie_burke.pdf>

Department of Economic Development, Jobs, Transport and Resources, 2015 <http://economicdevelopment.vic.gov.au/__data/assets/pdf_file/0009/1191429/Murray-Basin-Rail-Project-Summary-Brochure.pdf>

Department of Infrastructure [Victoria] 2007, *Victorian rail freight network review. Switchpoint: the template for rail freight to revive and thrive!* <http://www.railfreightalliance.com/wp-content/uploads/2014/06/Switchpoint-Fischer-Report.pdf>

Department of Infrastructure, Transport, Regional Development and Local Government 2009, *WA grain freight review,* <http://investment.infrastructure.gov.au/publications/reports/pdf/WA_Grain_Freight_Review_report.pdf>

Department of Infrastructure, Transport, Regional Development and Local Government 2009a, *New South Wales grain freight review,* <http://investment.infrastructure.gov.au/publications/reports/pdf/NSW_Grain_Freight_Review_Final_report.pdf>

Department of Planning, Transport and Infrastructure 2015, *Annual report 2014–15,* < http://dpti.sa.gov.au/__data/assets/pdf_file/0006/251691/DPTI_Annual_Report_2014-15_without_financial_statements_reduced_3_Feb.pdf>

Department of Transport & Urban Planning 2003, *Eyre Peninsula grain transport. Summary report.* <http://www.docstoc.com/docs/96905487/Grain-production-will-continue-to-increase-on-Eyre-Peninsula>

Department of Transport (Victoria) 2011, *Grain Logistics Taskforce Report,* <http://www.transport.vic.gov.au/__data/assets/pdf_file/0015/57120/Grain-Logistics-Taskforce-Report.pdf>

Department of Transport (Western Australia) 2015 *2014-15 Annual Report,* <http://www.transport.wa.gov.au/mediaFiles/about-us/ABOUT_US_P_Annual_Report_2014_15.pdf>

Department of Transport and Main Roads 2015 *2014 Annual Report 2015,* p.195 < https://publications.qld.gov.au/dataset/ce305b65-95f9-4c18-b474-eeea4f65502a/resource/129334d5-b9ac-445e-b652-cbbae8d4b7a0/download/transportandmainroadsannualreport201415onlinered.pdf>

Department of Transport and Main Roads 2015a *Rail Safety Regulator's Report 2014-2015,* <http://www.tmr.qld.gov.au/Safety/Rail-safety/Safety-reports>

Economics and Industry Standing Committee, WA Parliament Legislative Assembly, 2014, *Inquiry into the management of Western Australia's freight rail network.* <http://www.parliament.wa.gov.au/publications/tabledpapers.nsf/displaypaper/3912300ad02cbe5f14cd9d0848257d74000d77af/$file/2300.pdf>

Fitzgerald, M 2014, "Container exports open market opportunities", *Grain business,* July, pp.22–24, <http://www.glencoregrain.com.au/uploads/Magazine/Glencore_026_GBM_Winter_2014_FINAL_LR.pdf>

Fortescue 2014, ASX announcement, 20 August 2014, <http://fmgl.com.au/UserDir/AsxAnnouncement/20140820%20annual%20results785.pdf>

Fremantle Ports 2012, *Fremantle Port landside container study,* <http://www.fremantleports.com.au/SiteCollectionDocuments/Fremantle%20Port%20Container%20Movement%20Study%202012%20full%20version.pdf>

Fremantle Ports 2014, *Truck productivity study,* <http://www.fremantleports.com.au/SiteCollectionDocuments/Fremantle%20Ports%20Truck%20Productivity%20Study.pdf>

G:link 2016, All Stations, <http://ridetheg.com.au/stations/>

Grain Growers 2016, *State of the Australian Grains Industry 2016,* < http://www.graingrowers.com.au/media-centre/media-releases/685-new-report-reveals-a-largely-positive-story-of-the-australian-grains-industry>

Great Southern Rail 2016, <http://www.greatsouthernrail.com.au/fares_and_timetables/timetables/the_ghan_timetable_20162017/>

House of Representatives Standing Committee on Transport and Regional Services 2007, *Inquiry into the integration of regional rail and road networks and their interface with ports* <http://www.aph.gov.au/parliamentary_business/committees/house_of_representatives_committees.html?url=trs/networks/report/fullreport.pdf>

Hunter Valley Coal Chain Coordinator < https://www.hvccc.com.au/DailyPlanning/Throughput%20Reports/Monthly%20Performance%20Report%202015-08-31%20NM.pdf>

Independent Pricing and Regulatory Tribunal 2012, *Review of access pricing on the NSW grain line network. Transport—Final Report,* <http://www.ipart.nsw.gov.au/files/0e7ce937-257b-4cbf-be52-a0d700fae160/Final_Report_-_Review_of_access_pricing_on_the_NSW_grain_line_network_-_April_2012.pdf>

International Transport Forum 2010, *Improving Reliability on Surface Transport Networks,* Paris, OECD

Mees, P and Dodson, J 2011, Public transport network planning in Australia: assessing current practice in Australia's five largest cities, Griffith Univerity, Brisbane

Mees, P and Groenhart, L 2012, *Transport policy at the crossroads: travel to work in Australian capital cities 1976–2011,* RMIT, Melbourne

New South Wales Grain Freight Review 2009, <http://investment.infrastructure.gov.au/publications/reports/pdf/NSW_Grain_Freight_Review_Final_report.pdf>

NSW Ports 2016, < http://www.nswportsbotany.com.au/trade/trade-results/>

NSW Trains 2015, *2014-15 Annual Report Volume 1,* <http://www.transport.nsw.gov.au/sites/default/files/b2b/nswtrains/publications/NSW-Trains-2014–15-Annual-Report-Volume-1.pdf>

NSW TrainLink 2016, Our fleet, <http://www.nswtrainlink.info/your_journey/on_board/fleet>

NSW TrainLink 2016a, <http://www.nswtrainlink.info/timetables>

Office of the National Rail Safety Regulator 2015, *Rail Safety Report 2014–2015* < http://www.onrsr.com.au/__data/assets/pdf_file/0013/13270/Rail-Safety-Report-2014-2015.pdf>

Polaris Metals 2014, <http://polarismetals.com.au/>

Pollard N 2012, "Moving NSW wheat: the post deregulation experience. Part one", *Railway Digest,* July, pp.34–43; and "Moving NSW wheat: the post deregulation experience. Part two", *Railway Digest,* August, pp.28–33

Port of Brisbane 2013, *Import/export logistics chain study. Summary report,* <http://www.qtlc.com.au/wp-content/uploads/2013/10/IMEX-Study.pdf>

Port of Melbourne, Victorian Department of Transport, Essential Services Commission 2010, *Port of Melbourne and Dynon Rail Terminals 2009 Container Logistics Chain Study.* Full Report <http://www.portofmelbourne.com/~/media/Files/publications/container-study/container-study-full-2009.ashx>

Ports Australia 2014, Iron ore exports <http://www.portsaustralia.com.au/aus-ports-industry/trade-statistics/?id=10&period=13>

Ports Australia 2014a, Coal Exports <http://www.portsaustralia.com.au/aus-ports-industry/trade-statistics/?id=9&period=14>

Ports Australia 2015, Iron Ore Exports < http://www.portsaustralia.com.au/aus-ports-industry/trade-statistics/?id=10&period=14>

Public Transport Authority of Western Australia 2014, *Annual Report 2013–14,* < http://www.pta.wa.gov.au/portals/0/annualreports/2014/docs/annual-report-sections-1-2.pdf>

Public Transport Authority of Western Australia 2015, *Annual Report 2014-15,* <http://www.pta.wa.gov.au/Portals/15/annualreports/2015/pdfs/PTA%20Annual_Report_2014-15_Full_Report.pdf>

Public Transport Victoria 2015, *Murray Basin Project* < http://ptv.vic.gov.au/assets/PTV/PTV%20docs/Projects/Murray-Basin-Rail-Project-Summary-Brochure.pdf>

Public Transport Victoria 2015a, *Annual Report 2014–15,* <http://ptv.vic.gov.au/assets/PTV/PTV%20docs/AnnualReport/PTV_Annual_Report_2014-2015.pdf>

Public Transport Victoria 2016, Timetables, <http://ptv.vic.gov.au/timetables/standard>

QR National 2010, QR National share offer document, Brisbane

Queensland Rail [QR Network Access], Information pack. South Western system, (no longer available online)

Queensland Rail 2014, *Annual and Financial Report 2013–2014,* < http://www.queenslandrail.com.au/about%20us/Documents/QueenslandRail_AnnualFinancialReport_2013-14_FINAL.pdf>

Queensland Rail 2015, *Annual and Financial Report 2014–2015,* <http://www.queenslandrail.com.au/about%20us/Documents/Queensland%20Rail%20FY2014-15%20Annual%20and%20Financial%20Report%20-%20FINAL.pdf>

Queensland Rail 2015a, *Service punctuality and reliability,* <https://www.queenslandrail.com.au/about%20us/Pages/Servicepunctualityandreliability.aspx>

Queensland Rail 2016, <http://jp.translink.com.au/travel-information/network-information/trains/all-timetables>, and <http://www.queenslandrailtravel.com.au/plan-your-trip/Rail%20Information/Timetables>

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

Rail Geelong 2016, <http://www.railgeelong.com/lineguide/geelong/diagram/page-1>

Railpage 2016, www.railpage.com.au

Railway Digest April 2016

Railway Digest September 2016

Railway Gazette 31 August 2016, <http://www.railwaygazette.com/news/freight/single-view/view/aurizon-launches-sydney-port-shuttle.html>

Railway Gazette International, September 2016

Salt, B 2013, "GFC to blame as city-flickers play follow the jobs" *The Australian,* 18 July 2013

Securities and Exchange Commission (USA), web site for Genesee & Wyoming filings, <http://www.sec.gov/cgi-bin/browse-edgar?action=getcompany&CIK=0001012620&owner=include&count=40&hidefilings=0>

Strategic Design and Development 2009, *Report prepared for Freight and Logistics Council of Western Australia on behalf of the Strategic Grain Network Committee,* <www.transport.wa.gov.au/mediaFiles/rail-freight/freight_Strategic_Grain_Network_Report.pdf>

Sydney Ports Corporation 2013, *Annual report 2012–13,* <http://www.sydneyports.com.au/__data/assets/pdf_file/0010/30025/D13_38682_Sydney_Ports_Annual_Report_2012_13_Final_v1.0_23_October_2013.pdf>

Sydney Trains 2015, Our Performance, <http://www.sydneytrains.info/about/our_performance/otr_year.jsp>

Sydney Trains 2016 Our Fleet, <http://www.sydneytrains.info/about/fleet/>

Sydney Trains 2016a, Timetables <http://www.sydneytrains.info/timetables/#landingPoint>

TasRail 2015, *Annual report 2014–2015,* <http://www.tasrail.com.au/client-assets/downloads/annual_reports/2014-2015_Annual_Report_(with_financials).pdf>

The Age, 2015 <http://www.theage.com.au/victoria/labor-puts-brakes-on-port-rail-project-that-would-take-3500-trucks-off-road-20150916-gjo7c3.html>

Track and Signal, July-September 2016

Track Record 2016, <http://trackrecordfl.com/sydney-light-rail-fleet-list/4587820796>

TransLink 2012, *Annual report 2011–12,* < https://publications.qld.gov.au/dataset/65792fcb-b904-4bdc-960e-230594b661c1/resource/f571ba84-620a-4724-84e1-88a0e7443a7b/download/201112annualreport.pdf>

Translink 2016, <http://jp.translink.com.au/travel-information/network-information/trains/all-timetables>

Transperth 2016, <http://www.transperth.wa.gov.au/Timetables>

Transport Enthusiasts Society of South Australia 2016, <http://www.users.on.net/~wisp/TESSA/AdelaideTrams.html>

Transport for NSW 2015, *Annual report 2014–15,* <http://www.transport.nsw.gov.au/sites/default/files/b2b/publications/annual_reports/tfnsw-annual-report-2014-15-volume-1.pdf>

Transport for NSW 2016, Light Rail Services, <http://www.transportnsw.info/sites/en/maps-and-timetables/light-rail.page>

Transport, Housing and Local Government Committee (Queensland) 2014, *Rail freight use by the agriculture and livestock industries,* Report No. 45, < http://www.parliament.qld.gov.au/documents/committees/THLGC/2014/INQ-RAIL/rpt_rail_16June2014.pdf>

Transwa 2016, <https://www.transwa.wa.gov.au/Bookings/Timetables>

VicSig 2016, Suburban rolling stock, <http://www.vicsig.net/index.php?page=suburban&section=rollingstock>

VicSig 2016a, Trams, <http://www.vicsig.net/index.php?page=trams&section=rollingstock>

VicSig 2016b, Passenger <http://vicsig.net/index.php?page=passenger>

V/Line 2014, *Annual Report 2013–2014,* <https://corporate.vline.com.au/getattachment/f6019517-0ddf-40ac-abfc-a9cdb149c57e/Annual-Report-2013-14>

V/Line 2015, *Annual Report 2014–2015,* <https://corporate.vline.com.au/getattachment/cc310c6b-b9a2-4d13-bfdb-83de0c6f60ba/Annual-Report-2014-15>

V/Line 2015a, <http://www.vline.com.au/about/ourcompany/fleet/intro.html> (link no longer available)

V/Line 2016a, <https://www.vline.com.au/About-V-Line/Performance>

V/Line 2016, <https://www.vline.com.au/Timetables/Train-coach-timetables/>

Yarra Trams 2016, Facts and Figures, <http://www.yarratrams.com.au/about-us/who-we-are/facts-figures/>

www.bitre.gov.au

ISBN: 978-1-925401-97-4