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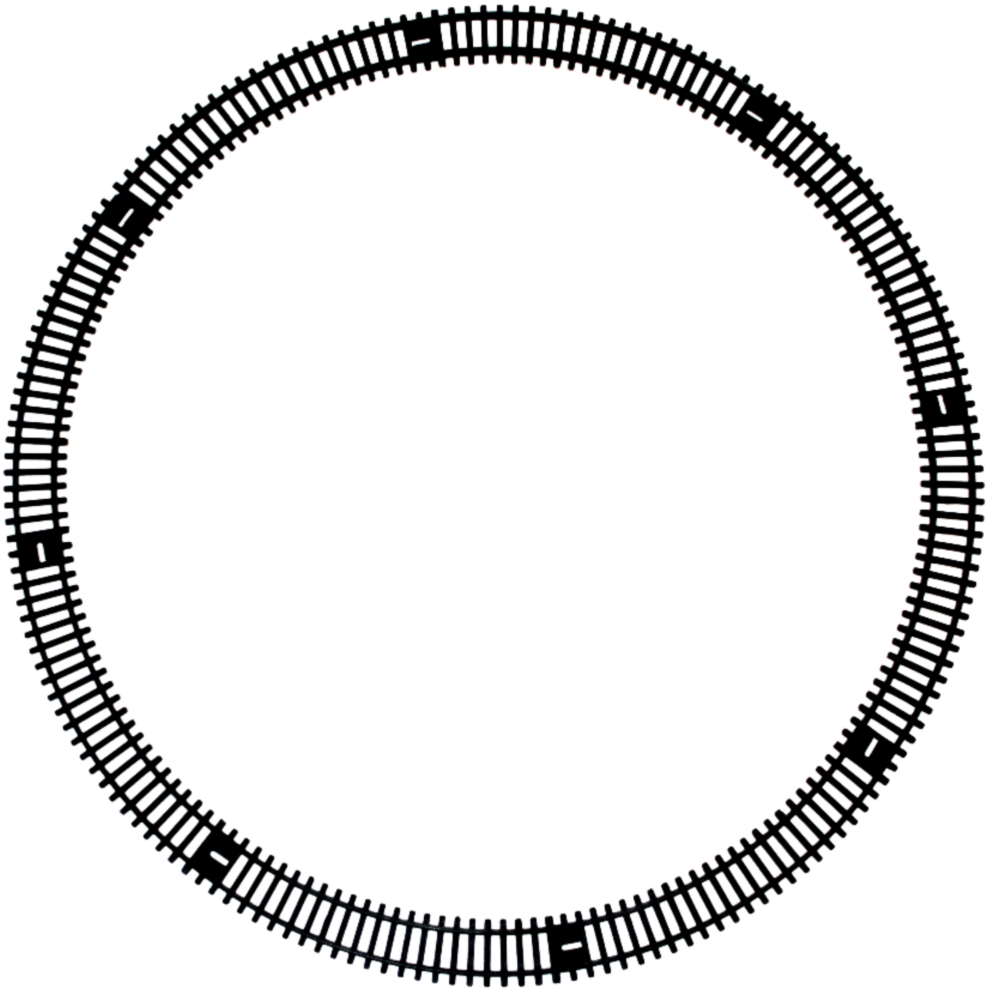


Value of Rail

The contribution of rail in Australia

A report commissioned by the Australasian Railway Association (ARA)
November 2017

Executive Summary

The Value of Rail Report has been commissioned by the Australasian Railway Association (ARA), the peak body for rail in Australia, representing all sectors of the rail industry.

Australia's population growth rate – around 1.5% a year – is among the highest in OECD countries and since the year 2000, our population has grown by more than 25%. This growth, projected into the future, has startling consequences: Australia's population is forecast to double by 2070 reaching almost 45 million people. This means that, on average, the population will increase by 370,000 people every year for the next 50 years. To put this into perspective, by around 2035 it will be as if another NSW has been added to Australia, by around 2045 it will be as if the entire population of Greece has been added to Australia's population and by 2065 it will be as if the population of the Netherlands has been added to Australia's population.

This growth in population won't be evenly spread. The majority of this increase will occur in our major cities. In fact, Sydney and Melbourne will add the largest number of people to their current residents. Both Sydney and Melbourne will add approximately 3 million people each by around 2060. This is roughly equivalent to adding the population of Brisbane and Adelaide to both of these cities.

The challenge of accommodating this growth in population is exacerbated by the fact that our cities can't continue to grow in geographic size forever. Natural boundaries, preferences of residents and commuting challenges will work together to limit the growth of the footprint of our largest cities. This means that there will almost certainly be a major increase in the density of our cities: more people living closer together.

Larger, more populous and more dense cities create significant challenges for achieving quick, convenient and affordable transport. Projections indicate that, with current vehicle technology and ownership trends, the stock of private motor vehicles will grow from around 14.8 million today to around 28 million by 2050. More vehicles will be accompanied by more travel and more congestion. Over the period to 2050 it's likely that travel in private motor vehicles will increase by 40% and congestion costs will increase by far more than this.

A similar, but more extreme, story is seen in freight with growth likely to follow along the path of GDP rather than population: a potential 88% increase in kilometres travelled by 2050 and an increase in vehicle stock of some 2.5 million trucks and light commercial vehicles.

To manage these challenges Australia will have to significantly develop its transport infrastructure with rail in a central role. Currently, rail is a significant industry in its own right and makes a large contribution to the Australian economy of around $26 billion a year (1.6% of GDP) and 140,000 jobs. Rail is also an efficient, environmentally and socially beneficial mode of transport. Rail has lower emissions than road transport, is safer and can help reduce congestion in our cities.

Significant investments are being made into Australia's rail infrastructure, with projects such as Inland Rail and movements towards metro operations in Sydney and Melbourne underway. In some sense these investments are making up for a prolonged period of underinvestment in rail infrastructure. Looking to the future, rail will continue to have a central role as a focus for investment in transport infrastructure.

Sustained investment in transport infrastructure (and rail more specifically) will not only allow us to manage the challenges posed by population and economic growth but will allow us to develop a better integrated and prosperous society.

This report quantifies the current value of rail to the Australian economy in terms of its contribution to GDP and employment as well as its broader contribution to society through benefits such as reduced emissions, greater safety and reduced congestion. The key challenges facing transport in Australia are explored in more detail and areas of focus for Government and industry are identified in order to ensure that rail continues to generate value for the Australian economy and society. The main findings of this report are:

Key findings

The value of rail to the economy

- The rail industry directly contributes $13.3 billion in value add and employed 53,490 FTE workers in 2016.

- The total contribution of the rail industry to GDP (direct and indirect) was $26 billion and 142,288 FTE workers – making up to 1.6% of the Australian economy.

- These employment figures are conservative. Employment in the industry has likely grown in recent years due to the increase in large rail projects. This trend will continue with projects such as Inland Rail employing additional workers in the order of tens of thousands of people. Forecasts of employment in the industry suggest growth of around 19.4% within the next ten years - potentially bringing total employment to around 170,000 by 2027.

	Wages	Gross Operating Surplus	GDP	Employment
Direct Contribution	$6.7billion	$6.6 billion	$13.3 billion	53,490 FTE
Indirect Contribution	$7.1 billion	$5.7 billion	$12.8 billion	88,798 FTE
Total	**$13.8 billion**	**$12.3 billion**	**$26.1 billion**	**142,288 FTE**

Rolling stock manufacturing
3,972 FTE

Railway construction and other services
8,923 FTE

Freight Rail
13,480 FTE

Passenger Rail
27,435 FTE

- Regional employment is a focus for the industry – more than half of rail freight workers are outside the eight major cities, and just under half of rail manufacturing jobs exist in regional areas.

- Rail enables exports from mining, manufacturing and agriculture. Around $2.8 billion was spent by industry to transport goods by rail in 2013-14.

The value of rail to society

- Rail imposes fewer costs on the community in terms of accidents, congestion and emissions than road. These costs are not factored into transport prices.
- Each passenger journey made by rail instead of road generates benefits for society of between $3.88 and $10.64 by reducing congestion, accident and carbon costs.
- There are also health, social inclusion and amenity benefits from using rail.
- Road freight produces 14 times greater accident costs than rail freight per tonne kilometre and 16 times as much carbon pollution as rail freight per tonne kilometre.
- Moving freight by rail instead of road generates benefits for society of around 1.45 cents per tonne kilometre. This means that, if all road freight moving between Sydney and Melbourne travelled by rail, this would generate social benefits of $111 million a year.

Carbon emissions are **40% higher** on road than rail for each km.

Road travel causes almost **eight times more** accident costs per kilometre than rail

Every road journey replaced by rail is estimated to reduce congestion costs by between **$2.46 and $9.22**.

Every train full of commuters reduces carbon emissions costs **by at least $16,640** per year

Train users obtain health benefits of **$6.62 per trip** from walking to the station

Every road journey replaced by rail can reduce time spent waiting in traffic by **7-27 minutes**

Road freight produces **16 times more carbon pollution** than rail freight per tonne kilometre

Moving a single container by rail instead of road can **save up to $344.79** in carbon costs for movements between Australia's major cities.

It is estimated that road freight crash costs were **14 times more per tonne kilometre for road.**

Moving nine tonnes of freight by rail instead of road between Melbourne and Brisbane **saves around $250 in accident** and emission costs

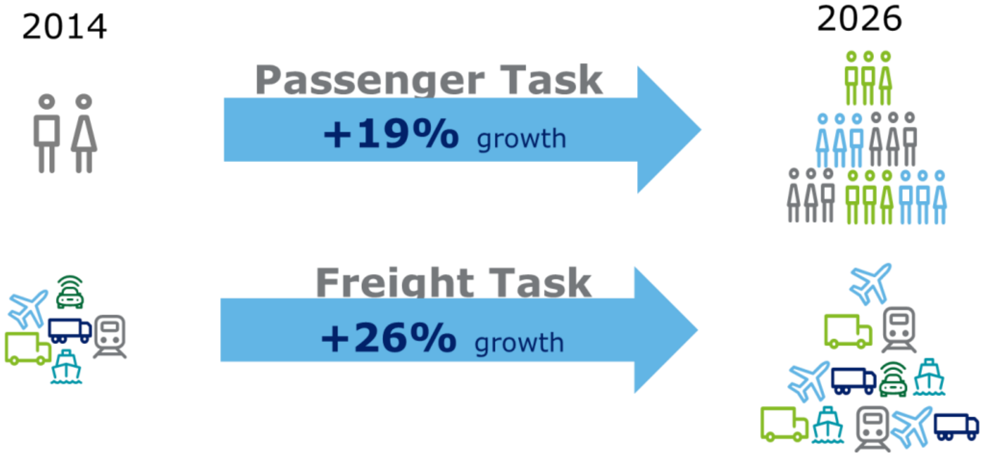
- A single train is estimated to be able to replace up to 800 cars during peak hour or around 110 trucks moving freight.

Case Studies

- Inland Rail will provide a modern rail line connecting Brisbane and Melbourne, benefits include:
  - An increase in GDP by $16 billion during construction and the first 50 years of its operation
  - The creation up to 16,000 new jobs at its peak
  - The elimination of around 200,000 truck movements and 15 serious crashes on roads per year
  - Encouragement of development of freight precincts in areas such as Parkes
- V/Line's Regional Rail Link improved services on the Geelong, Bendigo and Ballarat lines, benefits include:
  - Reduced travel times by rail which are similar (and sometimes better) than travel times by car
  - A roughly 60% increase in passengers on the Geelong and Ballarat lines
  - The enabling of population growth in areas such as Carline Springs
- Integration of rail modes in Sydney will enable a truly connected CBD to emerge:
  - A new metro line will connect with existing heavy rail enabling development in the Barangaroo area which is expected to provide 24,000 jobs and generate $2 billion per year to the NSW economy
  - Light rail will reduce the number of buses in the CBD by 180 in the morning peak hour, equivalent to the number of busses the use Elizabeth St every morning.
  - Dedicated interchanges between these rail modes are being constructed throughout the CBD, including at Central, Town Hall, Wynyard and Circular Quay
- Rail is a good option for some businesses in making short journeys from the port to nearby factories
  - In Sydney, Woolworths makes use of rail at its distribution centre in Yennora where it has 74,000 square-metres of dedicated storage space. The use of rail at Yennora is cost effective for Woolworths and is estimated to eliminate 30 trucks from Woolworths' fleet – reducing congestion for Sydney's residents.
  - Breville has made a significant investment in relocating to a new, purpose designed national distribution centre at Minto Intermodal Terminal. By using rail, Breville reduces inefficient road handling movements and generates benefits for its business and the residents of Sydney.

Challenges for the future of transport in Australia and how to address them

The transport task is growing: Australia's population is forecast to double by 2075, and passenger and freight growth are both expected to outstrip this. Our transport networks will need to keep pace with this growth in demand.



- There is forecast growth of 19% in the passenger task and 26% in the freight task over the period to 2026 (NTC 2016). Any modal shift towards rail will mean that growth rates in rail transport will be even higher.
- Technological change and policy which creates advantages for road transport are creating challenges for transport in Australia. New policy approaches will be needed to ensure we can meet the growing transport challenge.
- The upcoming stream of large infrastructure projects in road and rail will create constraints on skilled labour. We currently don't have a clear picture of the scale or specifics of skills that will be required to deliver these projects.
- The continued success of Australia's transport system and its ability to contribute to the economy and society is not guaranteed, and will require collaboration between industry and government to enable our transport networks to operate efficiently and allow the public to get the most out of the investments that are being made.

  – Government should continue to pursue improvements to planning decisions, procurement and regulation, including through road pricing reform.

  – Industry should pursue harmonisation of product designs and standards between jurisdictions and harness disruptive technologies with the potential to improve rail efficiency.

  – Government and industry should work together to improve customer experience, rail productivity and planning for the volumes and types of skilled workers required to deliver the ongoing stream of transport projects that will be required in the next 10-20 years.

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Glossary

Acronym	Full name
ABS	Australian Bureau of Statistics
BITRE	Bureau of Transport, Infrastructure and Regional Economics
COAG	Council of Australian Governments
CPI	Consumer Price Index
HC	Human Capital Approach
HVRR	Heavy Vehicle Road Reform
IPCC	Intergovernmental Panel on Climate Change
ITLS	Institute of Transport and Logistics Studies
KM	Kilometres
NTC	National Transport Commission
TIC	Transport and Infrastructure Council
TRESIS	Transport and Environmental Strategic Impact Simulator
VSL	Value of Statistical Life
WTP	Willingness to Pay Approach

1 Introduction

Deloitte Access Economics has been commissioned by the Australasian Railway Association to produce a report on the contribution of rail to the Australia economy. Rail is both an industry – employing people, generating exports and supporting the Australian economy - as well as a mode of transport which can generate benefits in terms of reductions in congestion, accidents and emissions when compared to other modes of transport.

This report builds on a previous report by Deloitte Access Economics on 'The True Value of Rail' that focussed on the benefits of rail in terms of reducing emissions, accidents and congestion when compared with road transport. This report takes a wider look at the contribution of rail to the Australian economy by considering its role as an industry, its contribution to reducing transport externalities and a number of case studies of how rail is currently contributing in Australia.

This report comes at an opportune moment. Australia is committing to significant investments in its rail network. Inland Rail has received Australian Government funding; Sydney and Melbourne are making the first steps on introducing metro style operation to their networks; Brisbane and Perth continue to grow their heavy rail network; and Canberra, Newcastle, Parramatta, Adelaide and the Gold Coast are investing in light rail. It is important to consider the broader benefits that this type of investment generates for the Australian economy and the long lived stream of benefits that Australian society will see from the investments that are currently being made.

This report encompasses the contribution of Rail to GDP, in Chapter 2. This looks at how rail, as an industry, fits in with the broader Australian economy, the employment it generates and its share of the national economy. For example, the rail industry directly employs people to work on stations and trains as well as in manufacturing. Rail acts as an input to other industries by supporting the movement of goods around Australia – enabling exports. Rail also acts as purchaser of output from other industries – fuel must be purchased to operate the locomotives, steel and concrete is required to construct track and IT systems are needed to efficiently operate the complex rail network. An important aspect of the rail industry, particularly in manufacturing, is that it provides a source of employment in regional centres.

The report also considers, in Chapter 3, the contribution of rail to our quality of life. In technical language rail reduces the negative externalities, costs borne by society, of undertaking the transport task in Australia. In practical terms this means that rail provides a transport option that is safer, less emissions intensive and also helps to reduce congestion. By reducing these costs rail has a strong and tangible role to play in the lives of all Australians. The more freight and passengers that are transported by rail, the greater these benefits are for society.

In Chapter 4 these benefits are put into context by looking at four areas of current activity in rail in Australia: Woolworths' use of rail, the development of Inland Rail, improvements to Victoria's regional rail network and the growing inter-relationship between heavy and light rail. These case studies show the range of ways that rail contributes to the Australian economy. Within these four case studies there can be found efficiencies in logistics networks, enabling growth of regional centres, reductions in transport externalities, improvements in the quality of life in our cities and direct economic activity through large infrastructure projects.

The report concludes with an overview of the challenges facing transport in Australia today and a brief view of where the rail industry could head in the near future and identifies three key areas for focus for policy makers:

- Transport strategies and investment decisions should be driven by independent assessments of costs and benefits.
- The Australian Government should actively pursue road pricing reform.
- A skills and projects review should be undertaken to ensure that Australia has the necessary amount and type of skilled workers required to deliver the ongoing stream of projects that will be required.

Total contribution
of the rail industry in 2016:

$26 Billion in GDP

142,288 workers

Around **half** of rail freight and manufacturing workers are employed outside the eight major cities

2 The value of rail to the economy

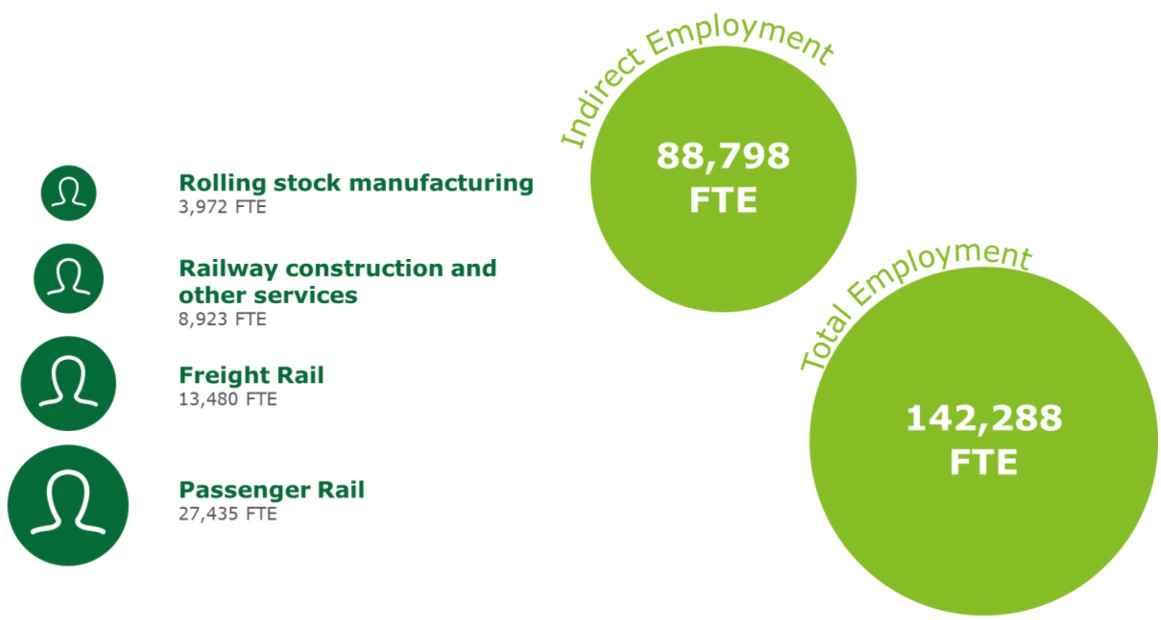
Each year Australia's rail network moves millions of Australians and helps facilitate billions of dollars in Australian exports. This activity generates billions of dollars in value added to the Australian economy and supports thousands of jobs. This chapter outlines the economic contribution of rail to Australia, precisely quantifies this contribution and discusses further the role that rail transport and manufacturing play in Australia's modern economy.

Figure 2.1 Economic contribution of Australia's rail industry

	Wages	Gross Operating Surplus	GDP
Direct Contribution	$6.7billion	$6.6 billion	$13.3 billion
Indirect Contribution	$7.1 billion	$5.7 billion	$12.8 billion
Total	**$13.8 billion**	**$12.3 billion**	**$26.1 billion**

Source: DAE

Figure 2.2 Employment contribution of Australian rail industry



Source: DAE

These employment figures are conservative. Employment in the industry has likely grown in recent years due to the increase in large rail projects. This trend will continue with projects such as Inland Rail employing additional workers in the order of tens of thousands of people. Forecasts of employment in the industry suggest growth of around 19.4% within the next ten years - potentially bringing total employment to around 170,000 by 2027.

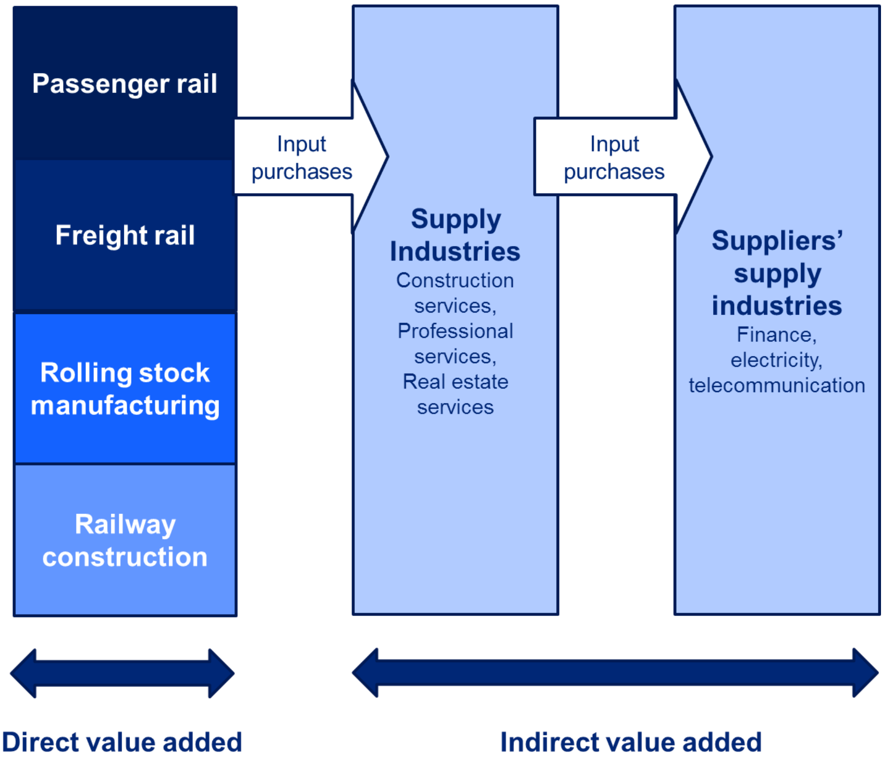
2.2 Overall economic contribution

Economic contribution studies provide an estimate of the size of an industry in the economy at a given point in time though two measures:

- directly, through the industry's operations; and
- indirectly, as the impact of its economic activities filters through the economy.

An economic contribution study provides a snapshot of an industry's interlinkages with the wider economy by bringing together the direct and indirect contribution of the industry. An economic contribution study is undertaken using Input-Output (IO) modelling. The chart below provides a description of how the flows between inputs and outputs are taken into account for the rail industry.

Figure 2.3 Economic contribution analysis



Source: DAE

The **direct contribution**, measured through direct value added, is calculated using the income approach to Gross Domestic Product (GDP) which sums returns to capital and returns to labour. Returns to capital are calculated through Gross Operating Surplus (GOS), which is industry output less the cost of intermediate goods and labour expense. GOS is similar to profit but ignores interest, taxes, depreciation, and amortization. Returns to labour are calculated through wages. Together they give the industry valued added.

The **indirect contribution** considers the demand generated in upstream industries as they produce inputs to the rail industry. It calculates the value added in these supply industries as a result of the rail industry's activity. For instance a rail operator might purchase telecommunications equipment to facilitate communications between employees on the rail network. This would increase demand for telecommunications equipment manufacturers, who would, in turn, demand plastics, metals and other inputs to make the equipment. The indirect contribution estimates how much each industry would have to increase production and calculates the valued added by each industry at each stage of production.

This approach is consistent with the framework used by the Australian Bureau of Statistics in compiling the Australian National Accounts.

2.3 Methodology

The analysis chiefly relies on the ABS 2013-14 Input-Output (IO) tables. IO tables show an industry's compensation to employees, gross operating surplus and an industry's purchase of intermediate goods by industry.

The first task in estimating the economic contribution of the rail industry is to define the scope of the rail industry. Defining the industry is complex as there are a number of Input-Output Industry Groups (IOIGs) with rail-related activities. However, for many of these industries, rail activities only make up a proportion of the entirety of the industry's value added.

Seven IOIGs were identified as rail-related using the Australian and New Zealand Standard Industrial Classification (ANZSIC). Of these industries, there are two core rail industries: **Railway Rolling Stock Manufacturing** (IOIG 2303) and **Rail Transport** (IOIG 4701). These two IOIGs are entirely part of the rail industry. The other five industries were partially included as rail industries based on the extent to which they interact with the two core industries. For instance, the Rental and Hiring Services IOIG is, for the most part, not rail related; however, the industry group includes railway stock leasing activities. Roughly 1% of the industry is estimated to interact with the Railway Rolling Stock Manufacturing or Rail Transport industries, so 1% of the Rental and Hiring Services industry was counted as part of the rail industry and the other 99% was treated as non-rail in the modelling. The full list of industries included in the definition of the rail industry is included in the table below.

Table 2.2 IO industries comprising of the Rail Industry

Code	Input-Output Industry Groups	Rail-related activity	Inclusion
2303	Railway Rolling Stock Manufacturing	Rolling stock manufacturing	Total
4701	Rail Transport	Freight and passenger rail services	Total
301	Forestry and Logging	Railway sleeper hewing	Partial
2004	Plaster and Concrete Product Manufacturing	Concrete railway sleeper manufacturing	Partial
3101	Heavy and Civil Engineering Construction	Railway permanent way construction and repair, subway construction and railway bridge construction	Partial
4801	Water, Pipeline and Other Transport	Scenic railway operations	Partial
5201	Transport Support services and storage	Rail freight forwarding, railway container terminal operation, railway station operation and railway stock leasing	Partial
6601	Rental and Hiring Services	Railway stock leasing	Partial

2.4 National contribution

The direct contribution of the rail sector is the total value added of the industry. Value added gives the difference between the value of the industry's products and the cost of the inputs to make the products. Value added is composed of the returns to labour (wages) and the return to capital (Gross Operating Surplus, or GOS). The analysis also provides the number of Full Time-Equivalent (FTE) jobs supported by the industry.

In order to produce its goods and services, the rail industry must purchase intermediate inputs. The indirect contribution stems from the economic activity produced as a result of the purchase of inputs. It calculates the amount of gross output that must be generated in order to produce the inputs and value added and employment associated with this output.

Table 2.3, below, outlines the economic contribution of the rail industry. In 2016, the rail industry had a direct economic contribution of $13.3 billion. Of this, $6.7 billion was in the form of wages to workers and $6.6 billion accrued as GOS to owners of capital. Furthermore, the rail industry directly employed an estimated 53,490 FTE workers.

Through its purchase of intermediate goods, the rail industry generates output in upstream industries. The industry's economic activity created $12.8 billion in indirect value added: $7.1 billion in labour income and $5.7 billion in GOS. In total this supported an estimated 88,798 FTE workers.

The total contribution of the rail industry to the Australian economy in 2016 was therefore $26 billion, supporting 142,288 FTE employees. This represents around 1.6% of the Australian economy and 1.4% of FTE employment.

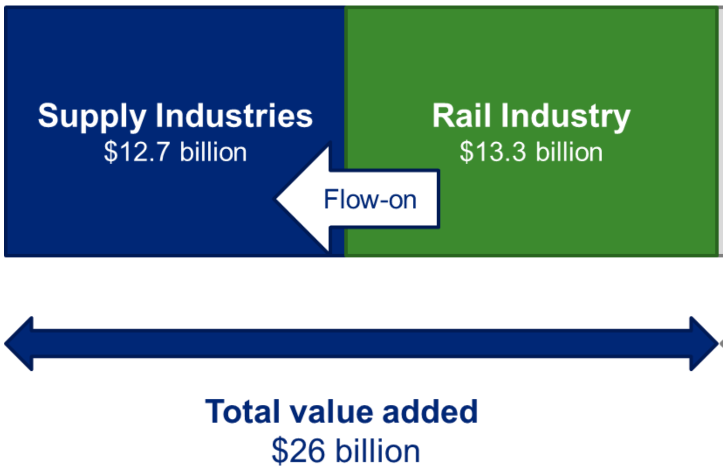
Table 2.3 Economic contribution of rail industry, 2016 ($million)

	Direct	Indirect	Total Contribution
Wages	6,744	7,065	13,809
GOS	6,574	5,697	12,271
Value Added	**13,318**	**12,762**	**26,080**
Employment	53,490	88,798	142,288

The rail industry has a relatively large ratio of indirect to direct employment. This reflects the capital intensiveness of the key subsectors that make up the rail industry. Railway Rolling Stock Manufacturing, Rail Transport and Heavy and Civil Engineering Construction all have below average employment per dollar of production. Indirect employment captures the employment required to make capital inputs; thus, capital intensive industries tend to have lower direct employment, but higher indirect employment.

For instance, the Railway Rolling Stock Manufacturing IOIG spends six times more on intermediate inputs than wages, whereas the average across the entire economy is closer to two times, reflecting the IOIG's capital intensiveness. This means that the industry has a low level of employment relative to its output, employing 1.4 FTE workers for every million dollars of output. However a key input industry for rolling stock manufacturing is iron and steel manufacturing – this industry employs 2.9 FTE workers for every million dollars of output. The indirect employment from the rolling stock manufacturing industry reflects the employment in the more labour-intensive steel industry from the purchases of steel inputs.

Figure 2.4 Breaking of contribution of rail industry



Source: DAE

2.4.2 Contribution of freight rail

Rail plays a vital role in Australia's freight system. Freight rail excels in moving bulk commodities, such as grains, timber, steel and coal. In this way, rail facilitates a significant proportion of Australia's agricultural and mining exports, moving commodities from regional areas to coastal ports for export.

In 2013-14 Australian industries collectively spent $2.8 billion on rail freight[1]. The mining industry was the largest user of freight rail, spending $800 million on rail transport. Non-ferrous metal and iron and steel manufacturing together spent $480 million, while the wholesale and retail trade industry spent $230 million. Agricultural industries spent $55 million on freight rail. As these figures show, freight rail is a key input for many of Australian industries.

Rail is less competitive against road freight for non-bulk commodities. However, rail does have a strong presence in freight movements between the eastern states and Perth. Rail's competitiveness in moving freight increases with distance, reflecting the economies of scale that freight rail provides.

Freight rail employs around 13,500 FTE workers in Australia. A majority of rail freight workers are based in regional areas. Based on the 2011 ABS Census 58% of rail freight workers' place of work is outside of the eight capital cities.

2.4.3 Contribution of passenger rail

In addition to freight, the rail industry contributes to the Australian economy though passenger rail in urban and regional Australia. In 2013-14 rail completed around 17 billion kilometres of passenger travel each year – resulting in around 900 million passenger trips. Rail is especially important to urban areas in peak times, where road transport becomes increasingly constrained. For instance, 46% of commutes from home to the work in the Sydney CBD are made via rail (BITRE, 2016a).

The input output analysis indicates that, in 2013-14 households consumed $5.7 billion in rail transport. Passenger rail employs around 27,400 FTE individuals in Australia. In contrast to freight, the clear majority of these workers (87%) are based on the eight capital cities, reflecting the fact that the majority of passenger rail movements occur in metropolitan areas.

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[1] The ABS IO tables do not distinguish between passenger and freight rail. It was assumed that all spending by industry (rather than consumers) on rail transport is freight-related as movement of employees via rail is negligible economic activity.

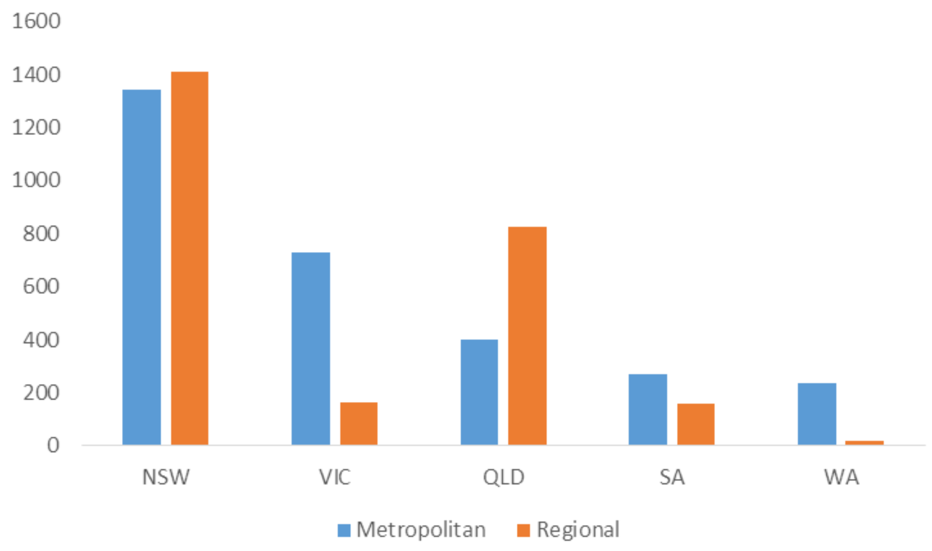
2.5 Rail Manufacturing

Rail manufacturing is an important component of Australia's rail industry, where it works as part of the global rail supply chain. Most rail manufacturing and maintenance equipment supply companies are small enterprises with a turnover less than 10m a year (ARA, n.d.)

The rolling stock manufacturing industry has a revenue of just over $3 billion and a value added of $825 million. This supports around 4,000 FTE workers.

Rail manufacturing has a strong regional presence – a significant proportion of activity occurs in regional cities and towns. According to the 2011 ABS census, 46% of Railway Rolling Stock Manufacturing and Repair Services employment is outside of the eight capital cities. 13% of rail maintenance and manufacturing firms are headquartered in regional Australia. Chart 2.2 shows the distribution of rail manufacturing jobs in regional and urban Australia.

Chart 2.1 Distribution of metropolitan versus regional rolling stock manufacturing jobs for five largest states, 2011



Source: ABS 2011 Census, DAE

Rail manufacturing is a key employer in Newcastle, Parramatta (in Western Sydney) and Maryborough[2]. During the 2011 Census, these three Statistical Areas represent 18% of all rail rolling stock manufacturing jobs in Australia. Other significant employment centres include North Adelaide, Melbourne, Brisbane and Ballarat.

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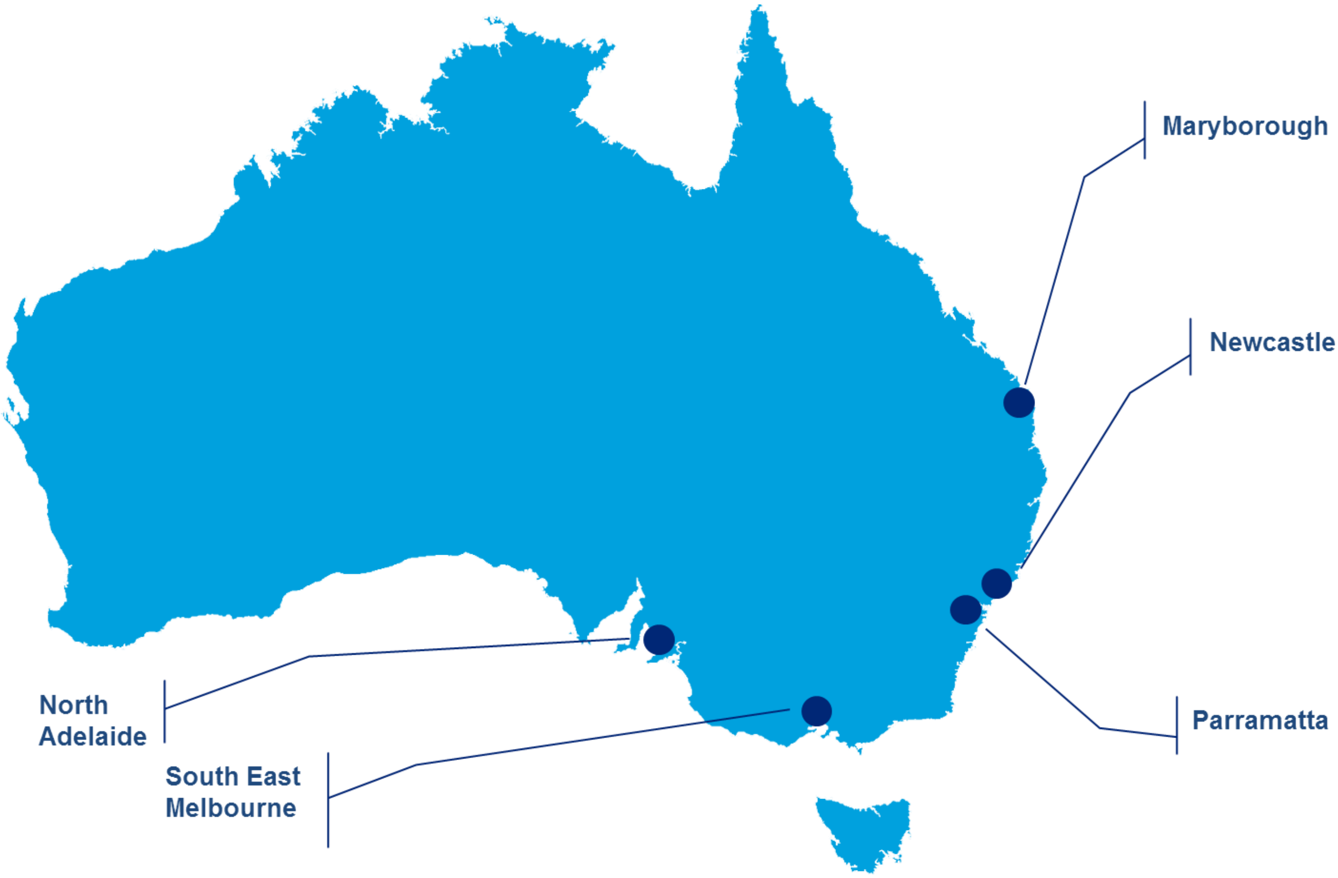
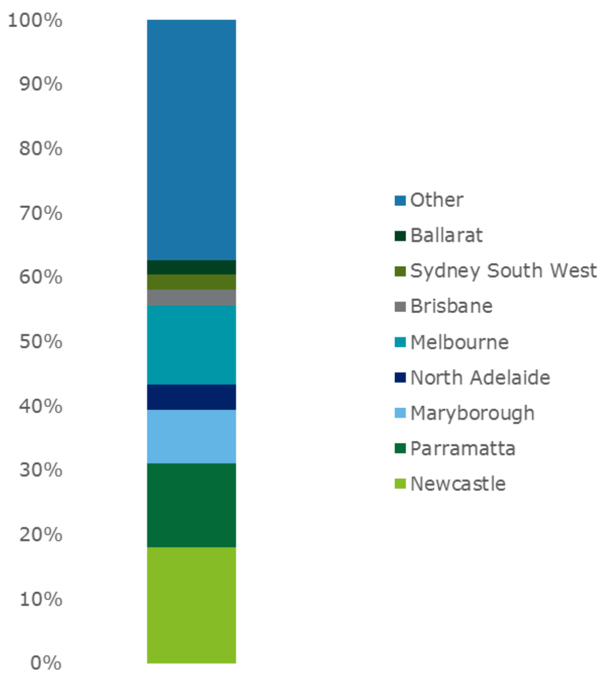
[2] Since the 2011 Census, Bombardier Transportation closed its Maryborough factory in December 2015, leaving Downer Rail the main rail presence in the area.

Figure 2.5 Locations of five largest rail manufacturing hubs by employment



Source: ABS 2011 Census, DAE

Figure 2.6 Share of employment in major rail manufacturing hubs



Road generates over **40% more carbon pollution** than rail travel per kilometre travelled

Road travel causes almost **eight times more accident costs** per kilometre travelled

Moving one person from road to rail can create **congestion cost savings of up to $9** in our largest cities

Moving nine tonnes of freight by rail instead of road between Melbourne and Brisbane saves around **$250 in accident and emission costs**

3 The value of rail to society

Both road and rail transport generate costs to society that are not reflected in the prices travellers pay. These costs, known as externalities, must be borne by society. Not reflecting these costs in prices means that travellers do not make correct transport decisions in the sense that they over utilise transport modes with relatively higher external costs compared to what would be socially optimal.

Importantly, rail transport generates less external costs than road transport. Modelling indicates that a passenger journey made by rail instead of road transport reduces costs relating to congestion, carbon pollution and crashes by around $3.88 in Brisbane and up to around $10.64 in Sydney. Moving freight by rail instead of road reduces external costs by around $1.45 per tonne kilometre. This means that replacing a 9 tonne freight movement between Melbourne and Brisbane avoids external costs by around $249.

External costs have tangible effects on the lives of Australians and the economy. Congestion increases travel times and costs thereby reducing people's leisure time and economic productivity. Carbon pollution creates social costs to be borne by current and future generations who will face the dual costs of climate change and the need to reduce emissions. Vehicle accidents lead to numerous fatalities and injuries per year, creating pain and grief to the victims and their families and affecting the economy by reduced ability to work and the need for care.

Rail transport is used to move passengers and various types of freight. In a number of markets, rail has a strong comparative advantage. Rail is the preferred transport mode for many bulk commodities and long-distance haulage tasks (in some instances, rail networks are used almost solely for the transportation of minerals). For other tasks such as passenger transport (for example, metropolitan public transport and intra-state services) and other freight tasks (for example, containerised freight, intra-city freight and grain), rail faces strong competition from transport by road.

Current mode choices are distorted because the prices travellers and freight operators face do not reflect the true costs generated by road and rail transport. There are mainly two reasons for this:

- Some costs are not captured in market prices, thereby disadvantaging rail transport (that is, road transport is under-priced); and
- The existence of price distortions because of cross subsidisation between different classes of road users.

These market distortions generate higher congestion, accident and environmental costs compared to what would be achieved if transport was priced according to the full range of costs it creates. In this sense, increasing the use of rail transport can contribute positively to the economy and society by reducing external costs transport such as accidents, congestion and emissions.

Rail's advantage in terms of lower externality costs should be considered when determining pricing and investment decisions. The following costs and benefits are commonly captured in Cost-Benefit Analyses of road and rail projects in Australia, in addition to the costs of implementing and operating a project (Transport and Infrastructure Council, 2016; Transport for NSW, 2016):

- Crash costs;
- Travel time savings;
- Travel time reliability improvements;
- Vehicle operating costs of road users;
- Road damage costs; and

- Environmental externalities (including air pollution, greenhouse gas emission, noise, water pollution; urban separation, nature and landscape and upstream / downstream).

These categories can generally be divided into user benefits (such as travel time savings), and externalities. The purpose of this section is to quantify and compare the external costs arising from road and rail travel. The major external costs related to these modes are crash costs, congestion costs and environmental externalities. As a result, this study quantifies the following costs of road and rail transport:

- Carbon emission costs;
- Congestion costs (time and vehicle operating costs); and
- Crash costs.

The following Section 3.1 presents external costs arising from passenger transport. It compares congestion costs, carbon emission costs and crash costs arising from road and rail transport in four major Australian cities and calculates the potential savings in these costs from moving passengers by rail instead of road. In addition, it provides a discussion on rail benefits related to health benefits, social inclusion and amenity benefits, including a case study on the potential value of health benefits from rail use in Sydney. Section 3.2 focuses on externalities related to freight. It quantifies the value of avoided congestion, crash and carbon emission costs from moving freight by rail instead of road and discusses the current pricing of heavy vehicles in Australia with respect to its ability to recover external costs.

3.1 Passenger transport

The largest difference in costs imposed by road and rail that are not reflected in market prices is through congestion, followed by crash costs. Carbon emission costs can also be significantly reduced by using rail compared to road as shown in this section. Further benefits from rail use include health benefits and improved social inclusion.

3.1.1 Carbon emissions

Greenhouse gases emitted from burning fuel to power road vehicles and trains impose a cost on society through its impact on the climate. Both road and rail generate costs from emitting greenhouse gases but the use of rail generates lower emissions per passenger journey than road.

In Australia, most passenger trips are made by private motorised vehicles. In 2015-16, passengers travelled 324 billion km using private vehicles. The majority of this was made by car, accounting for 280 billion kilometres. The remainder was made by commercial vehicles which contribute around 10% to the total road passenger task (BITRE, 2016a) and motorcycles. In comparison, rail passenger transport accounted for 16 billion kilometres travelled (BITRE, 2016a).

Car travel caused 43 million tonnes of greenhouse gases (measured in CO_2 equivalent) in 2015-16. This figure does not include emissions from non-commercial use of light vehicles and motorcycles.[3] Motorcycles caused around 0.4 billion tonnes of CO_2 equivalent emissions in 2015-16. There are no estimates on CO_2 emissions available for private use of commercial vehicles. Emissions from rail were notably less compared to road because of its lower emission intensity and total transport task. It is estimated that rail generated only 1.8 million tonnes of CO_2 equivalent in 2015-16 (BITRE, 2009a; 2016a).[4]

Adjusting for total distance travelled and number of trips, emissions from road users were around 0.16 kilograms of CO_2 equivalent per passenger kilometre travelled in 2015-16. In comparison, rail emissions were 0.11 kilograms of CO_2 equivalent per passenger kilometre. This means that every kilometre travelled by car or motorcycle rather than by rail resulted in an additional 0.05 kg of CO_2 equivalent emitted. These calculations are set out in Table 3.1.

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[3] Private use of light commercial vehicles are not neither reported separately from freight activities in BITRE (2016a) not in the National Greenhouse Gas Inventory (Department of the Environment and Energy, n.d.) and hence are excluded.
[4] This is estimated based on the emission intensity of rail passenger transport in 2006-07 BITRE (2009a) and the total passenger rail task in 2015-16 reported in BITRE (2016a).

Table 3.1 Greenhouse gas emissions from passenger transport in 2015-16

	Total emissions (Million tonnes of CO_2 equivalent)	Total distance travelled (Billions of passenger km)	Emissions/km travelled (Kilograms of CO_2 equivalent per passenger km)
Cars	43.2	279.1	0.15
Rail	1.8 [(a)]	16.1 [(b)]	0.11
Difference			**0.05**

Notes: Figures do not add due to rounding. (a) Sum of electric and non-electric. (b) Sum of passenger km for urban heavy, non-urban and urban light rail. Source: BITRE (2009a; 2016) and Deloitte Access Economics calculations.

Road passenger travel generates more than 40 per cent more carbon pollution than rail travel for each kilometre travelled.

Converting carbon emissions into a dollar value requires a unit cost of CO_2 equivalent. The unit cost captures the value of damages occurring from now into the distant future as a result of a one tonne increase in emissions of carbon (IPCC, 2014). There are a number of complexities that make it difficult to estimate the social cost of greenhouse gas emissions, the most significant of which is that the effect that today's emissions will have from now into the distant future.

In this report, a cost of $59.53 per tonne of CO_2 equivalent (2015-16 prices) is assumed to convert emissions into a dollar value, consistent with national transport appraisal guidelines (Austroads, 2012). At this price, every kilometre of travel moved from road to rail transport results in a reduction in carbon pollution costs of 0.27 cents.

This reduction can be put in context by estimating the congestion cost of an average commute trip within the four largest Australian cities. Table 3.2 shows the potential reduction in carbon costs if an average trip made by car was moved onto rail.

Table 3.2 Avoided carbon costs of one commuting trip made by rail instead of road, 2015-16 prices

City	Average trip (km)	Potential cost saving (cents)
Sydney	15.0	4.06
Melbourne	14.6	3.95
Brisbane	14.9	4.03
Perth	14.9	4.03

Source: Distances were sourced from BITRE (2015a) using 2011 ABS' Census Journey to Work data.

Every rail journey that replaces a car trip reduces carbon emission costs by around 4 cents.

Based on this per journey cost, it is estimated that carbon emission costs could be reduced by between $9,488 and $9,748 per year (depending on the city) if 1,000 commuters switched from road to rail.

Note that these results are based on the 2007 energy mix used to power rail transport, due to the lack of more updated passenger rail emission intensity data. However, then and now, rail transport is predominantly powered by diesel fuel. In 2015-16, 86% of energy used by rail was generated from diesel fuel, while the remainder was from electricity (BITRE, 2016a). Currently, the electricity used to power trains is predominantly generated from coal fired power plants, so the emissions from rail transport could be significantly reduced by increased electrification of rail networks and substitution into less emissions intensive sources of electricity. Appendix A considers the effective of alternative carbon emissions pricing on these calculations.

3.1.2 Congestion

As Australia's cities continue to grow and the pressure on the road network increases, avoiding or reducing congestion is one of the largest benefits that can be achieved from moving passengers by rail. This section quantifies the potential reductions in congestion costs from moving passengers by rail instead of road. In general, decreased congestion leads to faster travel times and lower carbon emission costs.

Congestion occurs when infrastructure is used above capacity at which point free flow of traffic is prevented. This is a greater issue for road rather than rail systems and is more likely to occur in densely populated areas.

Once the capacity of a road is reached, each additional user imposes a cost on existing road users in terms of increased travel time, travel time uncertainty and reduced driving amenity. Congestion also increases fuel consumption and consequently air pollution and greenhouse gas emissions, imposing additional costs to road users and society overall. Congestion is caused by under-pricing access to roads at peak times and places and an undersupply of the infrastructure necessary to accommodate demand.

Rail is less subject to congestion. While increased passenger numbers can cause crowding on trains, thereby reducing the amenity of the trip for the passenger, this does not impose travel time and other costs that arise from road congestion. Centralised scheduling of train services makes it easier to avoid congestion on the train lines. However, growing demand for passenger train services in urban areas as well as the need to share the infrastructure with freight services makes coordination increasingly difficult, thereby exacerbating the risk and severity of delays.

Quantifying the congestion costs from an additional road user is challenging and depends on a number of factors, including:

- Origin and destination of commuter journeys;
- Time of day that journeys are made;
- Capacity and layout of the road network;
- Location of railway stations;
- Frequency of rail services; and
- Available alternative modes such as buses, walking or cycling.

These factors differ from city to city and over time. As such, congestion costs are best estimated using models that simulates the transport network and its use in a particular city or locality.

This report uses two such models: the Metropolitan Scanner for Transport and Infrastructure (MetroScan-TI) and the Transport and Environmental Strategy Impact Simulator (TRESIS), developed at the Institute of Transport and Logistics Studies at the University of Sydney. MetroScan-TI is the successor model of TRESIS, which was used for the previous edition of this study (Australasian Railway Association, 2011). Compared to TRESIS, MetroScan-TI uses updated parameter values and inputs, more granular geographic detail and additional models related to non-work trips. It uses detailed behavioural data (gathered through experiments, surveys and data) and data on road networks, public transport options and demographic information. Further detail for both models is provided in Appendix B.

Regression analysis was used to determine the effect of moving a single person from road to rail transport as described in Appendix C. This can be modelled by estimating the decrease in train fares equivalent to moving only a single commuter from road to rail.

Table 3.3 shows the reduction in travel time for road users from reduced congestion that can potentially be achieved by shifting one car trip onto rail in Australia's four largest cities. These results mean that, for example, in Sydney, a single commuter trip moved from road to rail reduces the total travel time for road users by 27 minutes. This is equivalent to only a fraction of a second per road user.

Table 3.3 Avoided travel time per commuter trip switching from road to rail in 2015-16

City	Avoided travel time for existing road users (minutes)
Sydney	27.30
Melbourne	21.34
Brisbane	7.29
Perth	12.09

Notes: MetroScan-TI; TRESIS; Access Economics estimates; BITRE (2015b).

Every road journey replaced by rail potentially reduces travel time for remaining road users by between around 7 and 27 minutes.

More intuitive estimates can be made by considering larger passenger volumes. For example, if a Sydneysider's daily commute to and from work was moved from road to rail, the time saving for other road users would be 3 days and 18 hours. If this was extended to 1,000 people, the time saving would be in the order of 10 years and 3 months.

Avoided congestion costs in terms of travel time savings are anticipated to increase in the future as congestion increases. For example, forecast reduction in travel time from replacing one road trip to rail in Sydney are presented in Table 3.4.

Table 3.4 Forecast of avoided travel time per commuter trip switching from road to rail in Sydney

Year	Reduction in travel time (minutes)
2016	27.30
2017	27.58
2018	27.85
2019	28.13
2020	28.41
2021	28.70
2022	28.98

Source: MetroScan-TI, TRESIS, Deloitte Access Economics calculations.

Reduced travel times as a result of improved congestion also reduces CO_2 emissions. The Transport for NSW (2016) appraisal guidelines estimate that idling engines emit around 4.6 kilograms of CO_2 per hour. This rate can be applied to the amount of avoided travel time to estimate avoided CO_2 emissions per avoided commuter trip (Table 3.5).

Table 3.5 Avoided CO_2 emissions from congestion per avoided car trip in 2015-16

City	Reduction in CO_2 emissions (kg)
Sydney	2.1
Melbourne	1.6
Brisbane	0.6
Perth	0.9

Source: MetroScan-TI, Access Economics estimates, Transport for NSW (2016).

Converting these avoided congestion benefits from travel time (in minutes) and carbon emissions (in CO_2 equivalent) has been undertaken using the opportunity cost of travel time (that could otherwise be used for other purposes) and the cost per tonne of CO_2 ($59.53 in 2015-16 prices) as described above.

The value of travel time savings is estimated using the standard Australian approach for economic appraisals of transport initiatives. That is, 129.8% of Average Weekly Earnings (AWE) are used to estimate the value of time for business travel (to reflect foregone productivity) and 40% of AWE is used to capture people's willingness-to-pay to reduce travel time for commuting and leisure trips (Transport and Infrastructure Council, 2016). Assuming 10% of trips are made for business purposes, the value of travel time savings per trip is estimated in Table 3.6.

Table 3.6 Value of travel time savings, in 2015-16 prices

Trip purpose	Value per trip
Private (commuting and other)	$16.32
Business	$52.96
All purposes (weighted average)[a]	**$19.98**

Notes: (a) Assuming that 10% of trips are made for business purposes based on Sydney data (Transport for NSW, 2016). Source: Transport and Infrastructure Council (2016)

These congestion cost components can be added to estimate total avoided congestion costs per commuter switching from road to rail, as set out in Table 3.7. These results indicate that if 1,000 commuters switched their mode of transport from road to rail, this would reduce costs from congestion by between approximately $600,000 and $2.2 million per year (depending on the city). A sensitivity analysis of these estimates is included in Appendix A.

Table 3.7 Avoided congestion costs per trip switching from road to rail, in 2015-16 prices

City	Travel time ($)	Carbon emissions ($)	Total ($)
Sydney	$9.09	$0.12	**$9.22**
Melbourne	$7.11	$0.10	**$7.21**
Brisbane	$2.43	$0.03	**$2.46**
Perth	$4.03	$0.06	**$4.08**

Every road journey replaced by rail is estimated to reduce congestion costs by between $2.46 and $9.22.

3.1.3 Crashes

In Australia, every year a high number of road crashes lead to pain and grief for victims and their families. In addition, they generate large costs for the society as a whole due to medical care, disability care, support services and the cost of emergency services. These costs are predominantly covered by tax revenue and as a result are borne by the community at large. There are also losses in productivity from death or disablement, quality of life and damage to property.

Some of these costs are incurred by those making travel decisions. This is done through insurance, road user charges and perceived costs, that is, the amount that individuals are willing-to-pay to prevent the risk of becoming involved in an accident. However, in general, much of the cost is borne by society and people directly affected by an accident.

There are notably more road accidents each year than there are rail accidents as shown in Table 3.8 and Table 3.9. In 2010-11, road crashes in Australia were responsible for 1,277 fatalities and 34,082 injuries on roads, while there were only 33 rail fatalities and 66 injuries. The number of road fatalities per year has remained fairly stable since then, causing 1,241 fatalities in 2016-17 (BITRE, 2017). Note that rail fatalities in 2011 include suspected suicide and trespass occurrences, while these were excluded from statistics in the years following 2011-12. For example, rail crashes led to 7 fatalities in 2012-13, the latest year for which data is available.

Table 3.8 presents the number of fatalities and injuries from road crashes in 2010-11 and 2014-15 to 2016-17, while Table 3.9 shows the fatalities and injuries from rail accidents for three years over the period from 2010-11 to 2012-13.

Table 3.8 Number of fatalities and injuries for road transport

	2010-11	2014-15	2015-16	2016-17
Fatalities (number of people)	1,277	1,205	1,258	1,241
Hospitalised injuries (number of people)	34,082	36,283	n/a	n/a

Source: BITRE (2016a); BITRE (2017); Flinders University (2017).

Table 3.9 Number of fatalities and injuries for rail transport

	2010-11	2011-12	2012-13
Fatalities (number of people)[(a)]	33	20	7
Hospitalised injuries (number of people)[(a)]	66	n/a	n/a

Note: (a) Suspected suicide and trespass occurrences are excluded for rail crashes in 2012-13, but included in rail crashes in 2010-11 and 2011-12.
Source: BITRE (2016a).

Some cost items associated with accidents are similar for road and rail (such as the cost of a loss of life) while others, such as property costs, differ substantially. Accident costs are taken from two BITRE studies which estimate rail crash costs for 1999 and road crash costs for 2006 (BTRE 2002; BITRE 2009b). The two studies adopt slightly different methodologies because generally less detailed data is available on rail accidents.[5] While these reports are dated, there is a lack of publicly available data on accident cost changes. [6] Also, accident reporting is highly inconsistent across states and hence it is difficult to collate a consistent data set of crash statistics at the national level. Hence, this report is based on the two BITRE studies, assuming that the cost of road and rail accidents have grown in line with the Consumer Price Index (CPI).

Using the human capital approach, BITRE (2009b) estimates that the total social cost of road accidents in 2006 was $17.85 billion (in 2005-06 prices). Of the road accidents, passenger vehicle crashes made up around $17.2 billion of costs. Rail accidents cost are estimated to be $143 million in 1999 (in 1998-99 prices) (BTRE, 2002). Rail costs were not split by passenger and freight. Laird (2005) suggests a 30% share for freight, which would imply an accident cost of around $100 million for rail passenger transport.

The cost per passenger km travelled in 2006 was 8.4 cents for road and 0.87 cents for rail in 1999. Converted to 2015-16 prices using CPI inflation, the cost per km for road was 10.62 cents and 1.39 cents for rail. Road transport therefore generates 9.23 cents of additional crash costs per km than rail.

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[5] BITRE may have further developed its methodology in the period between these two reports. Changes made between the costing of road accidents in 1996 and 2006 account for around 1 per cent of total 2006 costs (BITRE, 2009b).
[6] This is unlikely to be a problematic assumption as it is the relative accident costs between road and rail which are of most interest and, as similar treatments are required for both road and rail accidents, it is unlikely that the cost relativity has changed significantly.

Table 3.10 Crash costs from road and rail passenger transport in Australia

Unit	Road	Rail
Total cost ($ million)[(a)]	$17,249 M	$100 M
km travelled (billion)[(a)]	206 B	12 B
Cost per km ($) (in original prices)[(b)]	$0.08	$0.01
Cost per km ($) (in 2015-16 prices)	$0.11	$0.01
Avoided crash costs from using rail instead of road ($ per km)		**$0.09**

Note: (a) Values refer to 2005-06 for road and 1989-99 for rail, (b) These figures are expressed in 2005-06 prices for road and 1989-99 prices for rail.
Source: Access Economics calculations based on BITRE (2009b) and BTRE (2002).

Road travel causes almost eight times more accident costs per kilometre travelled than rail transport.

The magnitude in the difference in accident costs between road and rail can be illustrated by examining the cost for an average commute trip in Australia's four largest cities. Table 3.11 shows the potential reduction in accident costs if an average commuter trip made by car was moved onto rail.

Table 3.11 Accident costs per trip, in 2015-16 prices

City	Average trip distance (km)	Potential cost saving ($)
Sydney	15.0	$1.38
Melbourne	14.6	$1.35
Brisbane	14.9	$1.38
Perth	14.9	$1.38

Source: Deloitte Access Economics calculation based on BTRE (2002); BITRE (2009b) and BITRE (2015a).

Every rail journey that replaces a car trip reduces accident costs by around $1.40.

These results indicate that if 1,000 commuters switch from road to rail, this would reduce accident costs by between $323,000 and $332,000 per year (depending on the city).

In Australia, crash costs are typically estimated using the hybrid human capital approach or the willingness to pay (WTP) approach (Transport and Infrastructure Council, 2016). The hybrid human capital approach seeks to capture the loss of economic value through foregone income and productivity as well as the resources needed due to the damages caused including hospital and repair costs. The WTP approach seeks to capture people's willingness to pay to avoid fatalities, major and minor injuries, known as the value of risk reductions or value of statistical life (VSL).

The most recent WTP values of avoided fatalities and injuries related to road crashes were estimated by Hensher *et al.* (2009) using data from New South Wales road users. This study estimated a VSL in Australia of around $6 million. This estimate is considerably higher than the $2.4 million used in the BITRE (2009b) analysis. The study by Hensher *et al.* (2009) still represents the most recent WTP value for fatalities in the Australian context and hence is still reflected crash cost parameter values used in the current transport appraisal guidelines (Transport and Infrastructure Council, 2016; Transport for NSW, 2016).

Tooth (2010) has applied the VSL values estimated by Hensher *et al.* (2009) to update the value of road crash costs estimated in BITRE (2009b). Incorporating this estimate of VSL into BITRE's framework results in an estimate of road accident costs of around $28 billion in 2006.

For the purpose of this study, Deloitte Access Economics estimates the road and rail crash costs for Australia in 2014-15 using integrated WTP values as published in the Transport and Infrastructure Council (2016). No statistics on road related injuries are publicly available for more recent years.

Table 3.12 Road related crash costs in 2014-15, in 2015-16 prices

State	Number of fatal **crashes and number of injuries** in 2014-15	Crash cost ($/**fatal crash/injury**)	Total costs ($)
Fatal crashes[(a)]			
NSW	320	$8.8 M	$2.43 B
VIC	230	$8.9 M	$2.04 B
QLD	210	$8.4 M	$1.75 B
SA	81	$8.2 M	$0.81 B
WA	149	$8.5 M	$1.41 B
TAS	35	$8.2 M	$0.25 B
NT	35	$9.3 M	$0.34 B
ACT	8	$9.8 M	$0.11 B
Australia	**1,068**		**$9.15 B**
Number of hospitalised injuries			
Australia	**38,417**[(b)]	**203,666**[(c)]	**$7.82 B**
Total road crash costs in 2014-15			**$16.97 B**

Source: BITRE (2017); Flinders University (2017); Transport and Infrastructure Council (2016); Victorian Government (2017); Deloitte Access Economics Assumption. (a) Includes crashes with heavy vehicle involvement. (b) Based on Flinders University (2017), assuming 2,000 hospitalised injuries were underreported in 2014-15 as estimated by Flinders University (2017). (c) Injury crash costs includes hospitalised injuries. Excludes minor injuries and property damage only road crashes. Cost per injury rate was calculated using a weighted average of the integrated willingness-to-pay values of serious and hospitalised injuries in urban and non-urban settings reported in Transport and Infrastructure Council, 2016. Assumption of portion of urban crashes based on BITRE (2015c) and portion of serious injuries based Australian Institute of Health and Welfare (2015).

Costs related to road fatal and injury crashes are estimated to be 17.0 billion in 2014-15. This estimation does not include costs related to property damage crashes only and minor injuries due to the lack of data. Table 3.13 shows that rail crash costs are only a fraction of road crash costs. In 2010-11, costs related to rail fatalities and injuries were only $274 million (including suspected suicide and trespass occurrences).

Table 3.13 Rail related crash costs, in 2015-16 prices

	2010-11	**2012-13**
Fatalities (number of people)[(a)]	$264 M	$56 M
Injuries (number of people)[(b)]	$10 M	n/a
Total crash costs	**$274 M**	**$56 M**

Source: Transport and Infrastructure Council (2016); BITRE (2016a); Deloitte Access Economics Assumption. (a) Fatality costs are based on the value of statistical life as published in Transport and Infrastructure Council (2016). (b) In the absence of more granular data on the type of injuries related to rail accidents, a cost per injury of $148,079 has been assumed. This is in line with the average cost per road injury used in Table 3.13 and assumes 28% serious injuries, 36% hospitalised injuries and 36 minor injuries of all reported rail related injuries.

3.1.4 Health benefits

An emerging area of research examines the health benefits from public transport use, drawing on findings from public health research that has identified the benefits of physical activity and its impacts on reductions of morbidity and mortality (Mulley, 2016). The benefits associated with the active travel required to reach public transport and then the final destination (access and egress) are still neglected in health and transport research. As a result, these benefits are largely ignored by transport economists, or, worse, walking time to and from public transport and interchange are considered a disutility (Mulley, 2016).

Existing research using data from Australia and other countries shows that there is a correlation between public transport use and physical activity. For example, using data from Australian public transport users, Barr *et al.* (2016) find that public transport accessibility was positively correlated with walking at recommended levels. This was also the case for people who are not otherwise vigorously active.

While the quantification of health benefits of public transport users is an emerging area, health benefits from walking and cycling are widely acknowledged and regularly included in economic assessments of active transport projects in Australia. Health benefits from active travel are derived from a reduction in the risks of cardiovascular disease, Type 2 diabetes, some cancers and osteoporosis (Transport and Infrastructure Council, 2016). Other health benefits include reduced obesity, high blood pressure and high cholesterol and mental health benefits.

There are several studies that estimate the monetary value of health benefits from walking or cycling. The Transport for NSW (2016) guidelines summarise the unit values of walking benefits from existing studies finding a range of between $0.41 and $2.29 per kilometre (in 2015-16 prices). One reason for the differences are that some values reflect reduced mortality and morbidity, while others only capture mortality. The Australian transport appraisal guidelines recommend to use a value of $2.93 per kilometre (in 2015-16 prices) (Transport and Infrastructure Council, 2016) based on a study by Genter *et al.* (2008). This unit value captures the value people place on reduced morbidity and mortality using a willingness-to-pay approach and the value of the reduction in health care related expenditure. The value excludes productivity benefits because Genter *et al.* (2008) found insufficient evidence on the causality between active transport and reduced sick days.

The monetary value for health benefits related to walking recommended by the Australian transport appraisal 2016 guidelines is used in this study to quantify the health benefits from walking to access and egress rail stations in Sydney. Health benefits are estimated by multiplying the annual total distance walked by train users with the unit value of health benefits. As shown in Table 3.14, train users in Sydney walked 301 million kilometres in 2016 based on the MetroScan-TI model, generating $881 million in health benefits, equivalent to a benefit of $6.62 per train user.

Table 3.14 Health benefits from rail use in 2016 in Sydney, in 2015-16 prices

Walking task (in km)	Unit value ($/km)	Total health benefits	Health benefits per train trip
301 M	$2.93	$881 M	$6.62

Source: Transport and Infrastructure Council (2016); MetroScan-TI.

Based on information for Sydney, every rail journey generates around $6.62 in health benefits from walking.

3.1.5 Social inclusion

Transport infrastructure is fundamental to ensure social inclusion by lowering barriers that make it difficult for people to participate fully in society. Mobility is a key aspect of social inclusion as, without it, individuals are likely to have difficulty accessing employment, education, health services other public services, amenities and participating in social activities.

Rail services (and public transport in general) have the ability to enhance social inclusion. It provides an affordable way for most demographic groups to access jobs and services. In this sense, it provides a notable advantage compared to individual motorised transport which requires large costs related to vehicle ownership, registration, insurance and licensing and which is not accessible to very young and elderly people. The UK Department for Transport and other studies identify the following main groups as key groups as potentially benefiting from local public transport provision, such as (Mott MacDonald, 2013):

- People on low incomes and unemployed people, including people working part time and those claiming state benefits;
- People living in remote areas, such as rural areas or urban peripheries;
- Disabled people, including people with mobility limitations, sensory disabilities and people with mental wellbeing disabilities;
- Older people, including retired people (aged 60/65 and over) and, potentially, older working aged people (aged over 55);
- Younger people and children, including younger adults aged 16-24; and
- Single parents.

Depending on the group, public transport services potentially lead to a series of benefits including (Mott MacDonald, 2013):

- Access to employment;
- Access to education;
- Access to health services;
- Access to shops, other public services and amenities;
- Improvements in health (direct and indirect benefit);
- Reduced risk of social and economic exclusion; and
- Increased opportunities for socio economic mobility for children from low income families.

Until recently, there has been little focus on quantifying the value of social inclusion from public transport in Australia. This has reflected the difficulty in estimating the value from significantly expanded transport services. Stanley *et al.* (2011) estimates the effects of public transport schemes in Australia on social inclusion. The approach is based on a series of face-to-face interviews across Melbourne with 443 adults. The results of the survey indicate that those at higher risk of social exclusion make fewer journeys per day. At the average level of household income, the willingness to pay for an additional journey, among those included in the survey, is up to $20.00 (in 2010 prices). This valuation declines as income increases because individuals with higher incomes tend to already make a large number of trips while individuals with lower incomes make a small number of trips and so stand to benefit significantly from increased mobility.

3.1.6 Amenity benefits

Transport infrastructure is an essential component of any city, and it does impact on the look and feel of the city. The amenity of infrastructure is not easily quantifiable, but it does have an impact on the liveability of the city and the satisfaction of residents in the area.

Different modes of transport have different impacts on local amenity, and light rail in particular brings many amenity benefits over road alternatives such as buses.

For passengers, light rail offers increased amenity through a reduction in noise whilst travelling, light rail can be up to 15 decibels quieter than buses (Tourism and Transport Forum, 2010), and increased comfort when on board. Light rail has wider aisles, multiple doors to improve accessibility and smoother trips for passengers than buses, and this is a benefit for passengers.

Beyond passenger amenity, light rail offers amenity improvement in the local area. Aside from being a quieter option than road transport, it also helps to reduce air pollution, improving the experience of those moving around the city. Light rail also creates more room for pedestrians and cyclists than buses and road alternatives allow for, given its dedicated lane arrangement and timetable predictability (Transport for NSW, 2012b). And because it can carry so many people, light rail often attracts investment along the route, further improving the desirability of the area (Tourism and Transport Forum, 2010).

Light rail removes buses from the roads, limiting congestion, noise and pollution, all of which detract from public amenity. Studies from the USA have found that light rail commuters think that light rail enhances the liveability of a city (Brown and Werner, 2009).

3.1.7 Summary on passenger transport

Costs created by passenger travel but not included in prices derive from a number of different areas including: carbon emissions, congestion, accidents, health, social inclusion, land use and funding arrangements.

Some of these are amenable to quantification in dollar terms which allows the estimation of total external costs as shown in Table 3.15.

Table 3.15 Total costs per average commuter trip, in 2015-16 prices

City	Carbon emissions	Congestion	Accidents	Total
Sydney	$0.04	$9.22	$1.38	**$10.64**
Melbourne	$0.04	$7.21	$1.35	**$8.59**
Brisbane	$0.04	$2.46	$1.38	**$3.88**
Perth	$0.04	$4.08	$1.38	**$5.50**

Each passenger journey made by rail instead of road reduces congestion, accident and carbon costs by between $3.88 and $10.64.

3.2 Freight transport

3.2.1 Carbon emissions

Rail plays a larger role in freight transport than it does in passenger transport, accounting for over half of land based freight, when measured in tonne kilometres. In 2014-15, the rail freight task moved 402 billion tonne kilometres, almost double than the road freight task of 211 billion tonne kilometres (BITRE, 2016a). The road task has grown to 219.1 between 2014-15 and 2015-16, while there is no comparable data available for the rail task. Even though road moves less goods, it generated nine times as much CO_2 equivalent emission as rail freight in 2014-15 (29.4 million tonnes of CO_2 equivalent for road compared to 3.5 million tonnes for rail) (BITRE, 2009a; BITRE, 2016a). The difference in the carbon emission intensity of road and rail freight is estimated to be 0.13 kilograms of CO_2 equivalent per tonne kilometre travelled (see Table 3.16).

Table 3.16 Carbon emissions of freight in 2014-15

	Total emissions (millions of CO_2 equivalent)	Total distance travelled (billion tonne km)	Emissions/tonne km travelled (Kilograms of CO_2 equivalent per tonne km)
Road			
Light commercial vehicles	10.3	4.9	2.97
Rigid trucks	7.4	36.7	0.20
Articulate trucks	11.7	169.5	0.07
Total road	**29.4**	**211.2**	**0.14**
Rail[(a)]			
Total rail	**3.5**[(b)]	**401.6**[(c)]	**0.01**
Difference			**0.13**

Notes: (a) Estimate includes emission from power generation for electric rail. (b) Sum of electric and non-electric. (c) Sum of passenger km for urban heavy, non-urban and urban light rail. Source: BITRE (2009a; 2016a) and Access Economics calculations.

Road freight produces 16 times as much carbon pollution as rail freight per tonne kilometre.

Carbon emissions from rail and road freight can be converted to a monetary value by applying a carbon price in line with the passenger analysis undertaken in Section 3.1.1. A price of $59.53 per tonne of CO_2 equivalent is used (in 2015-16 prices) in line with the unit cost of carbon recommended by the national transport appraisal guidelines (Austroads, 2012). While these guidelines are superseded, this unit value is still the basis of carbon emission cost values of transport activities recommended in current guidelines. This assumption is also in line with the average carbon price used by the Australian Treasury (2011) to conduct carbon emission modelling to inform policy making as discussed in Section 3.1.

Every tonne kilometre of freight moved from road to rail results in a reduction in carbon pollution costs of around 0.78 cents.

These results are based on the current energy mix used for road, while for rail transport, 2007 assumptions were adopted from BITRE (2009a). In Australia, rail transport is predominantly powered by diesel fuel and to a lesser extent by electricity. The emissions from rail transport could therefore be reduced by increased electrification of rail networks and substitution into less emissions intensive sources of electricity.

To put this figure into context we can look at the overall effect if a single container, weighing 9 tonnes, was moved by rail transport instead of road transport between some Australian cities. The total costs saved for various city combinations are given in Table 3.17.

Table 3.17 Example carbon cost savings for intercity freight, in 2015-16 prices

City	Sydney	Melbourne	Brisbane
Sydney			
Melbourne	$66.61		
Brisbane	$68.99	$133.78	
Perth	$290.48	$243.58	$344.79

Notes: Distances are taken from BITRE (2016a), rail emissions from BITRE (2009a) and freight task from BITRE (2016a); assumption of 9 tonne per vehicle.

3.2.2 Crashes

It is estimated that crash costs related to freight were 0.58 cents per tonne km in 2006 (BITRE, 2009b) for road and 0.04 cents per tonne km for rail in 1999 (BTRE, 2002). The calculation of these costs follows the same approach as set out for passenger transport related accidents (see Section 3.1.3). In 2015-16 prices, these costs would be 0.73 cents for road and 0.06 cents for rail. This means that the accident cost associated with road freight transport is more than ten times that for rail freight on a per tonne km basis. These calculations are set out in Table 3.18.

Table 3.18 Accident costs from freight transport in Australia

Unit	Road	Rail
Total cost ($ million)[(a)]	$999.20	$100.10
Tonnes km (billion)[(a)]	173.3	106.2
Cost per tonne km (cents) (in original prices)[(b)]	0.58	0.04
Cost per tonne km (cents) (in 2015-16 prices)	0.73	0.06
Difference (cents per km)		**0.67**
Tonnes kilometre (billion) in 2014-15	211.2	401.6
Total crash costs in 2014-15	**$1,549 M**	**$256 M**

Note: (a) Values refer to 2005-06 for road and 1989-99 for rail, (b) These figures are based expressed in 2005-06 prices for road and 1989-99 prices for rail. Source: Access Economics calculations based on BITRE (2009b) and BTRE (2002).

Every tonne kilometre of freight moved from road to rail results in a reduction in accident costs of around 0.67 cents.

To put this figure into context we can look at the overall effect if a single container, weighing around 9 tonnes and being transported between some Australian cities, was moved by rail transport instead of road transport. The total accident cost saved for various city combinations is given in Table 3.19.

Table 3.19 Example of avoided crash costs for intercity freight moved by rail instead of road, in 2015-16 prices

City	Sydney	Melbourne	Brisbane
Sydney			
Melbourne	$57.42		
Brisbane	$59.47	$115.33	
Perth	$250.41	$209.98	$297.23

Notes: Distances are taken from BITRE (2016a), assumption of 9 tonne of freight.

As discussed in Section 3.1.3, Tooth (2010) makes use of new estimates of the value of statistical life in Australia (Hensher *et al.*, 2009) to update BITRE (2002; 2009b) estimates of total accident cost. These updated calculations do not provide enough detailed information to update the BITRE estimates for the purposes of this paper. Rough calculations indicate that the revised difference in freight accident costs based on these updated figures would be around 0.82 cents per kilometre; a 39% increase above the BITRE based estimates. This gives an indication of the sensitivity of the above results to the VSL.

3.2.3 Infrastructure provision

Heavy commercial vehicle operators are required to pay a registration fee and fuel excise to help recover the cost of building, maintaining and operating the road network. If these fees do not accurately reflect the costs caused by each vehicle type, this distorts transport decisions by disadvantaging the use of certain type of vehicles and rail.

In practice, prices faced by individual users do not necessarily reflect the actual costs incurred by freight activities. For example, the Productivity Commission (2006) found that B-Doubles under recover the costs that they generate when compared to other classes of trucks. This cost is borne by the smaller rigid and articulated trucks. As such, the price signal sent to operators may not be correct, distorting the choice between using rail or road to transport freight.

The fact, the largest road vehicles receive the cross subsidisation from smaller vehicles is critical as these larger vehicles are the closest substitutes for rail transport.

The current basis for calculating heavy vehicle charges is to apportion the expected expenditure on roads. This is based on the average of seven years of budget data and is updated annually. This total cost is then apportioned across vehicle classes based on average:

- Vehicle kilometres travelled;
- Equivalent Standard Axle kilometres travelled, which is a measure of deep pavement wear;
- Passenger Car Unit kilometres travelled, which is a measure of relative road space requirements based on the size of the vehicle;
- Average Gross Mass kilometres travelled, which is a measure of the mass impacts on the road pavement in general; and
- Heavy vehicle kilometres travelled, which is a measure of the relative amount of heavy vehicle travel.

The principle of this pricing system is that, on average, each class of heavy vehicle pays its own share of allocated road expenditure, minimising under and over-recovery. This only ensures that costs are recovered on average in each vehicle class and so the pricing structure might not be the most efficient possible.

Another difficulty with the current pricing structure is that it is based on current expenditure needs, not future needs. Heavy vehicles today are paying for road damage that occurred in the past rather than paying to repair the damage they are causing today. Since heavy vehicle use has been growing steadily, road charges today are not sufficiently high to recover the actual cost of today's road use.

Pressure for ongoing reform was boosted by the Harper Competition Policy Review (Harper *et al.* 2015), which recommended that governments should introduce cost-reflective road pricing supported by new technologies, with pricing subject to independent oversight and revenues used for road construction, maintenance and safety.

In its response to the Harper Review (Harper *et al.* 2015), the Australian Government supported their recommendations on road transport and committed to accelerate work with states and territories on heavy vehicle road reform and investigate the benefits, costs and potential next steps of options to introduce cost reflective road pricing for all vehicles. In particular, the Department has established the Heavy Vehicle Road Reform (HVRR) Road Map – endorsed by the Transport and Infrastructure Council (TIC) in 2015. HVRR aims to create a market for the provision and use of heavy vehicle infrastructure, with clear links between the needs of users, the charges they pay and the services they receive. The timelines for this involve complete transition to the provision of roads as an economic service by around 2023.

The current round of reform seeks to enhance productivity by linking prices paid by users to maintenance and access incentives for road providers and consists of two components. The first is road charging, where heavy vehicles would directly pay for their use of road networks. The second component is the pathway through which these charges are directed back to road funding. By linking the charges for road use to the revenue of road providers, the reforms aim to provide greater funding certainty by ensuring that any maintenance cost increases would be offset by appropriate revenue streams.

3.2.4 Summary on freight transport

The carbon pollution and crash costs quantified above lend themselves to adding together to give an estimation of total cost that could be avoided by moving freight by rail instead of road. These are presented in Table 3.20. It can be seen that moving one tonne by rail instead of road results in external costs savings of 1.45 cent per tonne kilometre.

Table 3.20 Reduction of freight external costs from using rail instead of road, in 2015-16 prices

City	Avoided costs (cents)
Carbon emissions	0.78
Accidents	0.67
Total external costs savings (cents per tonne km)	**1.45**

This can be put into context by considering some of Australia's intercity freight trips assuming a 9 tonne heavy vehicle interstate trip.

Table 3.21 Example total costs for intercity freight, in 2015-16 prices

City	Sydney	Melbourne	Brisbane
Sydney			
Melbourne	$124.03		
Brisbane	$128.46	$249.10	
Perth	$540.89	$453.56	$642.02

Inland Rail will...

Increase GDP by **$16 billion** during construction and first 50 years of operation

Create up to **16,000 new jobs** at its peak

Eliminate **15 serious crashes** on the roads per year

Reduce carbon emissions by **750,000 tonnes**

Encourage development of freight precincts in areas such as Parkes

4 The value of rail in practice

This section of the report puts the benefits of trail transport identified above into context by looking at four areas of current activity in rail in Australia:

- the development of Inland Rail;
- extensions of the Victorian commuter network;
- the growing inter-relationship between rail modes in Sydney; and
- Woolworths' use of rail;

These case studies show the range of ways that rail contributes to the Australian economy. Within these four case studies there can be found efficiencies in logistics networks, enabling growth of regional centres, reductions in transport externalities, improvements in the quality of life in our cities and direct economic activity through large infrastructure projects.

4.1 Inland Rail

The Inland Rail project is a national scale transport initiative. Once built, the railway will run west of the ranges through Victoria, NSW and Queensland, bypassing Sydney to connect Melbourne and Brisbane. This connection will make rail competitive with road and will take strain off the road network. It will further connect regional Australia to global markets, and has been dubbed a 'once-in-a-generation' project by the Australian Government (ARTC, 2017).

There is a real need for Inland Rail, it has been developed to address a number of existing weaknesses in the transport network. Currently the only freight rail line connecting Melbourne and Brisbane goes through Sydney. This route has a number of obstacles to efficient train operations, including that it is longer than the road alternative, requires trains to negotiate the busy Sydney urban passenger network, track curvature lowers average train speed and tunnels prevent double stacking. As a result, 74% of eastern corridor freight is carried by road (ARTC, 2015). These trucks cause congestion on Sydney roads, and produce far greater carbon emissions than trains do (ARTC, 2015).

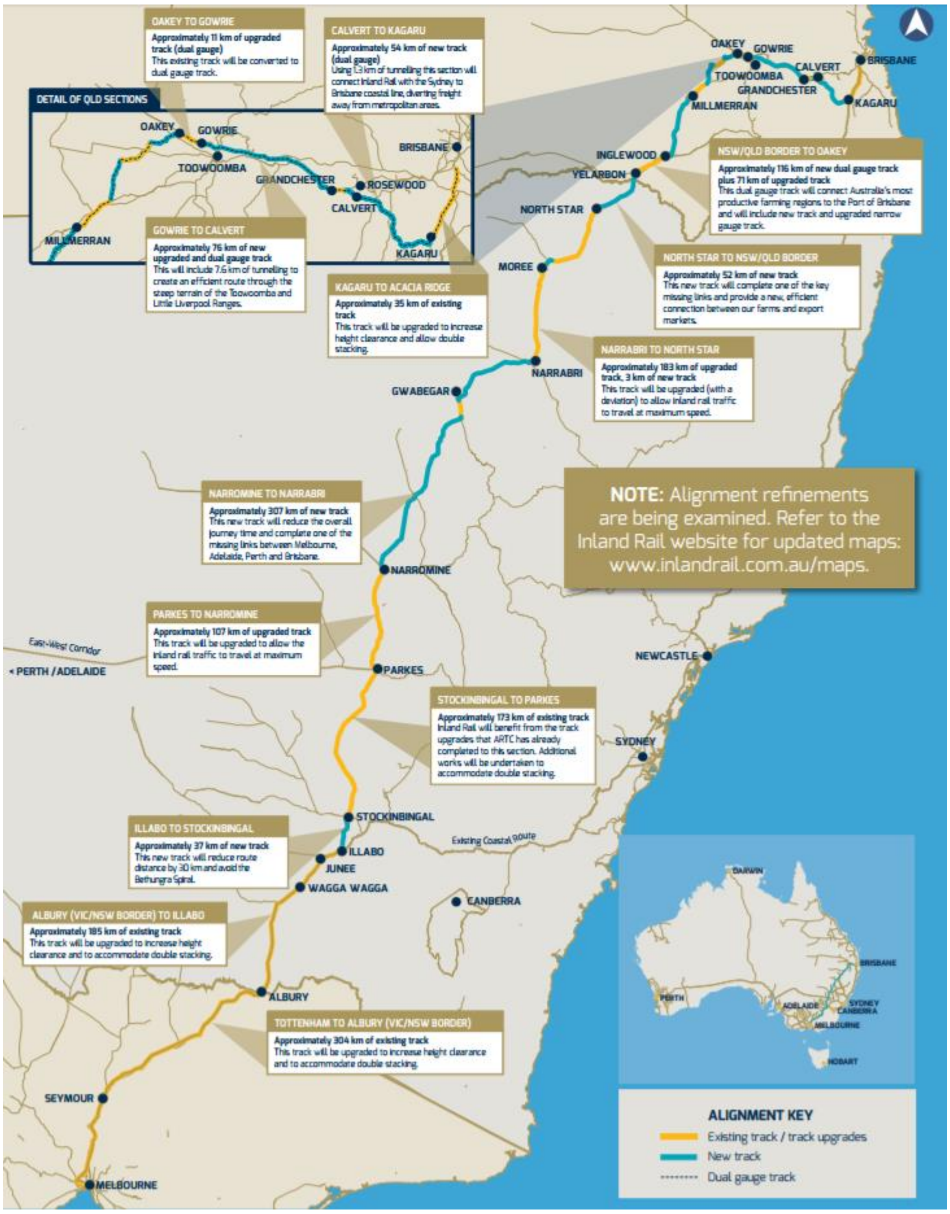
These problems will only intensify in the future as the freight task grows. By 2030, it is estimated that 32 million tonnes of freight will need to be moved between Melbourne and Brisbane annually, the equivalent of 1.2 million B-Double truckloads (ARTC, 2015). The current road infrastructure will not be able to support this growth without significantly increasing congestion in cities and on major highways which would likely mean more accidents on the road.

Other options were suggested to address these problems (such as national highway road upgrades, or upgrades to the existing coastal railway), however Inland Rail was eventually selected as the best solution for a number of reasons. These include its ability to provide dedicated freight capacity, avoid urban areas, foster growth in regional areas, and optimise environmental outcomes (ARTC, 2015).

The merits of Inland Rail has been under investigation for almost ten years, but in the 2017 Australian budget the Government announced its commitment to the full delivery of the project – promising $8.4 billion to build the railway (Minister for Infrastructure and Transport, 2017).

The project will take ten years to deliver and is scheduled to be operational in 2025. It will be built in sections: upgrading existing track as well as constructing missing track to link existing components together. The end result will be a double-stacked railway (freight containers will be able to be stacked on top of each other so twice the number of containers can be moved) that runs from Melbourne to Brisbane, bypassing Sydney, at speeds of up to 115km/h with trains almost 2km long. The route is shown in Figure 4.1.

Figure 4.1 Inland Rail route



Source: ARTC (2015)

The project is expected to deliver significant benefits, both for the transport network and for regional development. It has been estimated that it will increase GDP by $16 billion during construction and the first 50 years of its operation, and will create up to 16,000 new jobs at its peak (ARTC, 2015). In the business case assembled for Inland Rail, the benefit cost ratio estimated was 2.62:1 – meaning that for every dollar spent on the rail, $2.62 will be delivered in economic benefits (ARTC, 2015).

Inland Rail will improve connectivity in both freight and passenger transport systems. For freight, it connects Brisbane to Melbourne, and also to Adelaide and Perth through the intermodal terminal at Parkes in NSW. For passengers, it removes freight from the passenger network – particularly in Sydney. At present, almost one third of freight moving through Sydney is not destined for Sydney, just passing through on the way to Melbourne or Brisbane, and one freight train takes four passenger train slots as it moves through the network (Sexton, 2015).

BITRE calculates the 'sweet spot' (the point where trains become more efficient than road at moving freight at a distance of around 1,000km (BITRE, 2016). The Inland Rail development will exceed this sweet spot by a considerable margin, covering approximately 1,700km. This means that Inland Rail will make rail competitive, and likely preferable, to road for moving freight along the east coast of Australia. This, combined with the fact that the new route will by 30% faster than the current rail option (which takes between 32-34 hours), is predicted to tip the modal share of freight in favour of rail. While today the road/rail split along the Melbourne to Brisbane route is 74/26, it has been forecasted that Inland Rail will shift this to 38/62 in rail's favour (ARTC, 2015).

This shift of freight towards rail will improve safety on the roads by removing around 200,000 truck movements off the road each year– the Inland Rail business case estimates there will be 15 fewer serious crashes per year as a result of Inland Rail (ARTC, 2015). It will also help to offset the increasing congestion on urban roads and major highways by getting trucks off the roads. It will also help to improve environmental sustainability in the transport system. Carbon emissions are expected to be reduced by 750,000 tonnes as a result of the move away from trucks to trains.

Additionally, having an alternative north-south rail link makes the network less vulnerable to disruptions such as natural disasters. If one line is affected, activities can be shifted to the other line while repairs take place. This improves the reliability of the transport network, ensuring that freight gets to its destination on time.

In addition to the benefits Inland Rail will bring for the transport system, it will also have a significant impact on regional development. Most notably, it will give regional areas greater access to ports and global markets. Currently, the rail network bypasses some of Australia's most productive agricultural, and to a lesser extent mineral production, regions – particularly in Northern NSW and Southern Queensland.

Beyond the connectivity improvements, there will be many regional towns that benefit from the development of Inland Rail, Parkes in NSW provides a useful example. Parkes is a regional centre in Central Western NSW with a population of approximately 15,000. It is a transport and logistics centre because it is at the intersection of major east-west and north-south freight routes. Over 80% of Australia's population is within 12 hours drive of Parkes, and there is a 600 hectare site set to be developed into a 24/7 logistics hub (Parkes Shire Council, 2017). Currently, the transport and logistics industry makes up around 8% of the shire's $1b GRP and employs around 7% of workforce in the shire (Parkes Shire Council, 2017).

Inland Rail will pass through Parkes, turning it into a "National Logistics Hub" (Parkes Shire Council, 2017). While many regional communities will benefit from the project, Parkes will be the town where freight is transferred from the north-south railway to the east-west railway. This means that any freight moving between Brisbane or Sydney and Melbourne, Adelaide, Perth or the Northern Territory will pass through Parkes.

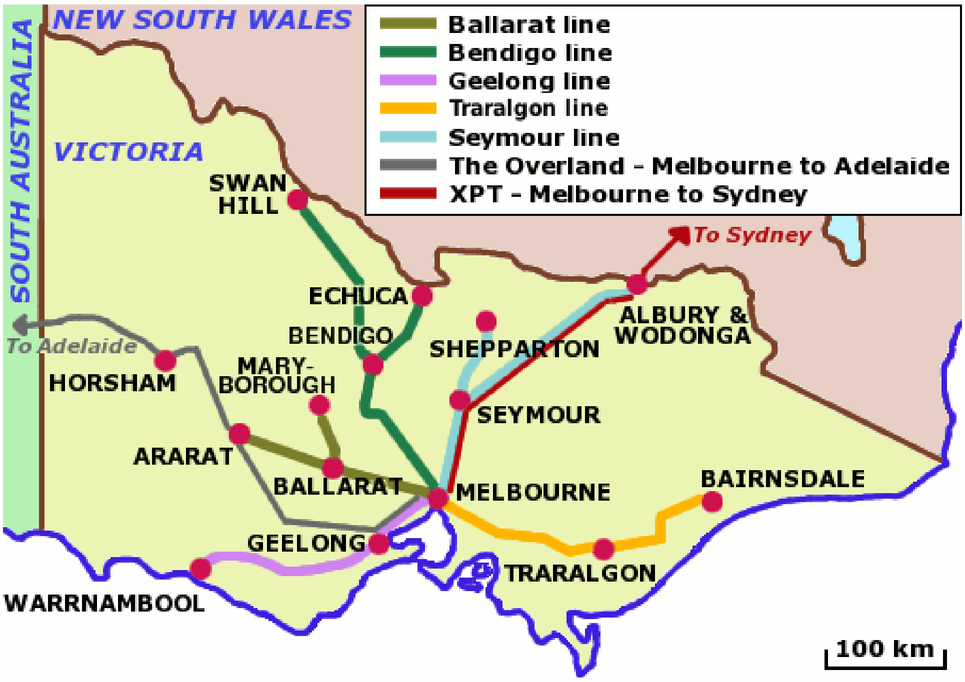
This presents a major opportunity for Parkes – particularly in freight handling, maintenance facilities, intermodal hubs, and large grain terminals. The Inland Rail is set to generate significant benefits for regional NSW, and while there are no specific estimates available for Parkes, the Department of Industry estimates that the impact of Inland Rail on the Central West region as a whole will be around $216 million over 60 years, and almost 500 new jobs will be created in the construction phase (Department of Industry, 2016).

Inland Rail is a large nation building project which will address many transport problems such as congestion and growth of the freight task. Construction is only beginning, but estimated benefits are significant and wide reaching, ranging from improved connectivity in the freight network and improved resilience of the transport system, to job creation and regional development.

4.2 V/Line

V/Line is a government owned corporation that operates regional passenger train services in Victoria. It operates services to the regional cities of Ballarat, Bendigo, Geelong, Seymour and Traralgon, and services out past these cities into more rural areas. Figure 4.2 shows a map of the train lines run by V/Line. In addition, V/Line manages and maintains all non-interstate rural rail track in Victoria.

Figure 4.2 Map of V/Line services



Source: Travel Victoria (2017)

V/Line is an important system for Victorians who live in regional areas and use its services to get around Victoria, and particularly into and out of Melbourne. Currently, V/Line operates 90 stations, 41 locomotives, 133 locomotive hauled carriages and 177 VLocity carriages (self-contained diesel passenger carriages that do not need a locomotive), and in 2015/16 there were 16.3 million passenger trips made on V/Line services (V/Line, 2016).

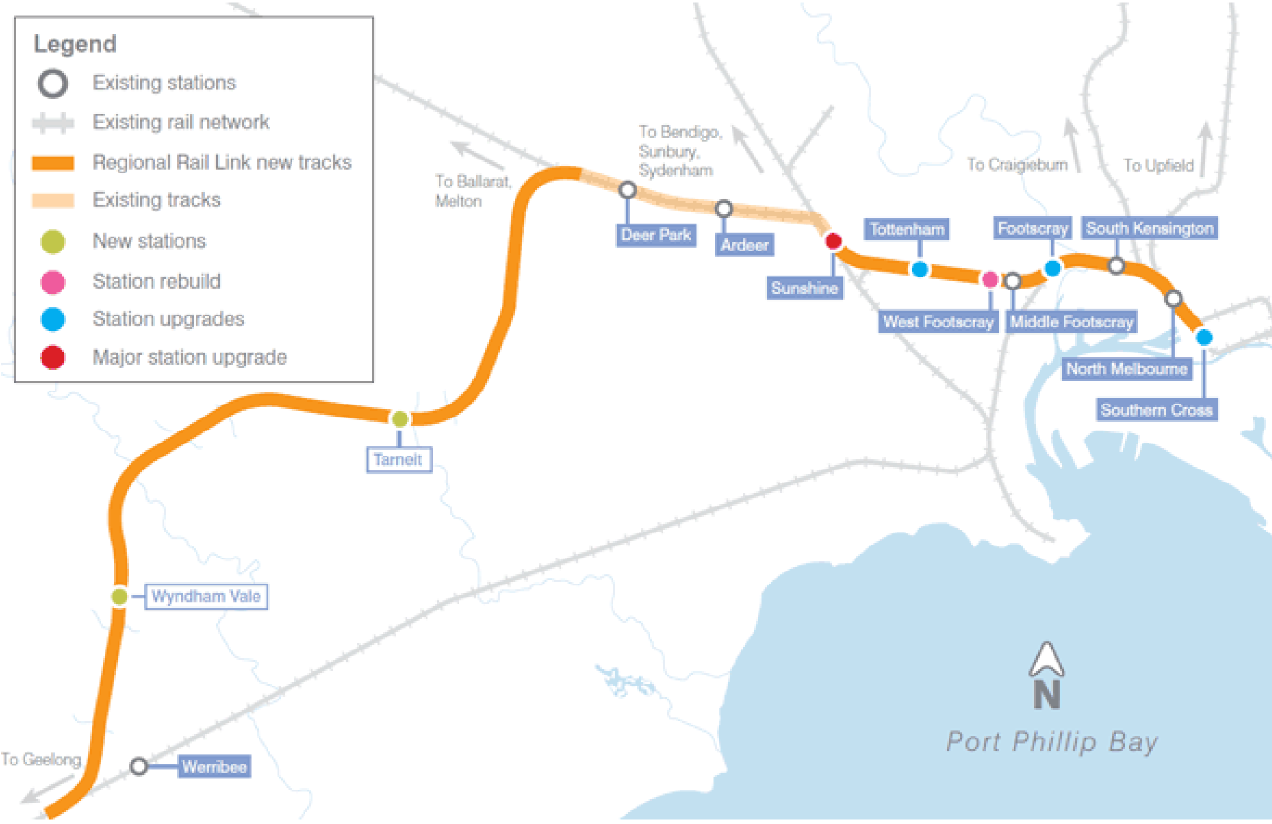
There have been a number of significant projects over the years to upgrade the quality of service that Victorians living in regional areas receive, including the *Regional Fast Rail project (2000-2006)* which involved a series of track and rolling stock upgrades to reduce travel times and enhance service frequency and safety on a number of regional lines. These investments have been driven partly by the finite supply of housing in Melbourne meaning commuters look for property outside the city, and the emphasis that recent governments have placed on regional rail development (consultation with V/Line, 2017). As a result, V/Line is transforming from a regional service to a commuter one (particularly along the Geelong corridor).

Perhaps the most significant of these projects is the *Regional Rail Link.* This project, completed in June 2015, separated V/Line services on the Geelong, Bendigo and Ballarat lines from the electrified metropolitan train lines in order to reduce delays on the regional lines.

Previously, as V/Line trains approached the Melbourne metro area they would merge onto the metro tracks. This meant that in many cases the V/Line services would be delayed, waiting for metro trains (which took precedence) to pass. As a result, catching the train from a regional city such as Geelong to Melbourne was not always as fast or reliable as driving. Driving is also not an ideal method of commuting, Melbourne has some of the worst congestion in Australia during peak hours (second only to Sydney) (Austroads 2016).

Building a separate rail track for the regional trains has meant that travelling to regional centres such as Geelong, Ballarat and Bendigo by train has become much faster and has enabled growth in both metro and V/Line services as the two are no longer competing for space on the tracks. Figure 4.3 below shows the Regional Rail Link addition to the V/Line network.

Figure 4.3 Map of the Regional Rail Link



Source: Department of Economic Development, Jobs, Transport and Resources (2016a)

The $3.65 billion project involved 90km of new track, two new stations (Tarneit and Wyndham Vale), upgrades to five existing stations, as well as various other upgrades such as the removal of level crossings (DEDJTR, 2016a). It took five and a half years to complete the project, and the new rail line was opened in June 2015.

The end result of the project is that passengers travelling on the Bendigo, Ballarat and Geelong lines are now using a different rail track to the metro passengers, and as a result their trips are much faster. Today, to get from Geelong to Southern Cross Station (in central Melbourne) takes 1 hour, from Ballarat to Southern Cross Station takes 1 hour 20 minutes, and from Bendigo to Southern Cross takes 1 hour 50 minutes (V/Line, 2017a). Without traffic, these travel times are very similar to driving, and when there is traffic (for example in peak hour) travel by train is faster than travel by road.

The result of the Regional Rail Link has been unprecedented growth on the Geelong and Ballarat lines. In 2015-16 there were 6.74 million passenger journeys taken on the Geelong line, 2.5 million more than the previous year. Further, while growth on the Geelong line averaged 2.1% a year between 2011-12 and 2014-15, in the first year that the new rail link opened patronage on the Geelong line grew by 59.0%. Similar growth was observed on the Ballarat line, annual growth from 2014-15 to 2015-16 was 12.8% with 3.79 million passenger trips completed, when annual growth had averaged 4.2% for the previous four years.

The rail link has enabled people living in regional cities to commute to Melbourne by train when previously they either had to drive or work locally. It has also enabled regional development. Many suburbs which either did not have a train station or did not have easy access to one now have a train station in close proximity with the ability to get commuters to the Melbourne CBD quickly. For example, a train station opened in Caroline Springs, a suburb in West Melbourne 25km from the CBD, in January 2017. This new station enabled significant growth in the suburb as Melbourne CBD workers can reliably commute from the suburb, where before Caroline Springs residents either had to drive (a less reliable commuting option) or drive to a station in a nearby suburb. Since January, Caroline Springs has become one of the busiest stations on the Ballarat line

(V/Line, 2017b). Similarly, Wyndham Vale was essentially farm land before the project and is now the second busiest station in the entire V/Line network (second only to Southern Cross) (consultation with V/Line, 2017).

Almost all the services along these lines are fully utilised, V/Line publishes statistics on average seats used at the busiest point on a train service, and, in peak hours, almost all services average above 90% capacity – particularly on the Geelong line (V/Line, 2017b). As V/Line adds more services, this new capacity is filled– implying that there is still more demand for these rail services (Consultation with V/Line, 2017).

Geelong, Ballarat, and Bendigo are all significant growth areas, with populations forecast to grow in all three of the cities by at least 34% over the next 20 years (.idcommunity, 2017). That equates to an additional 162,000 extra people living in these centres, and the Regional Rail Link better connects them to the rest of Victoria. It gives them the option to work locally or to work in Melbourne with ease.

The Regional Rail Link is the first step in part of a broader plan, the *Regional Network Development Plan* which is aiming for '20, 40, 5'. That is, services every 20 minutes to Ballarat, Geelong, Bendigo, Seymour and Traralgon during peak, every 40 minutes out of peak, and 5 services to the line extremities (past the regional cities) every day (DEDJTR, 2016b).

Other projects required to achieve this goal which are currently under discussion include an upgrade to the Ballarat line to duplicate the track in order to increase capacity, the purchase of new, higher capacity regional trains, and further investment on the eastern corridor towards Gippsland (DEDJTR, 2016c).

The Regional Rail Link was one of Australia's largest infrastructure projects in recent times (DEDJTR, 2016a) and is delivering generational change for public transport users in Victoria. It separated regional and metropolitan trains in order to increase capacity on both lines, and it has enhanced reliability and punctuality for commuters. The result has been strong growth in the use of V/Line services as regional centres grow. The project has won numerous awards for its construction and sustainable design and has improved access for regional Victorians to health and education, and helped to improve the road network by taking cars off the road and removing level crossings (DEDJTR, 2016a).

4.3 Rail modes working together

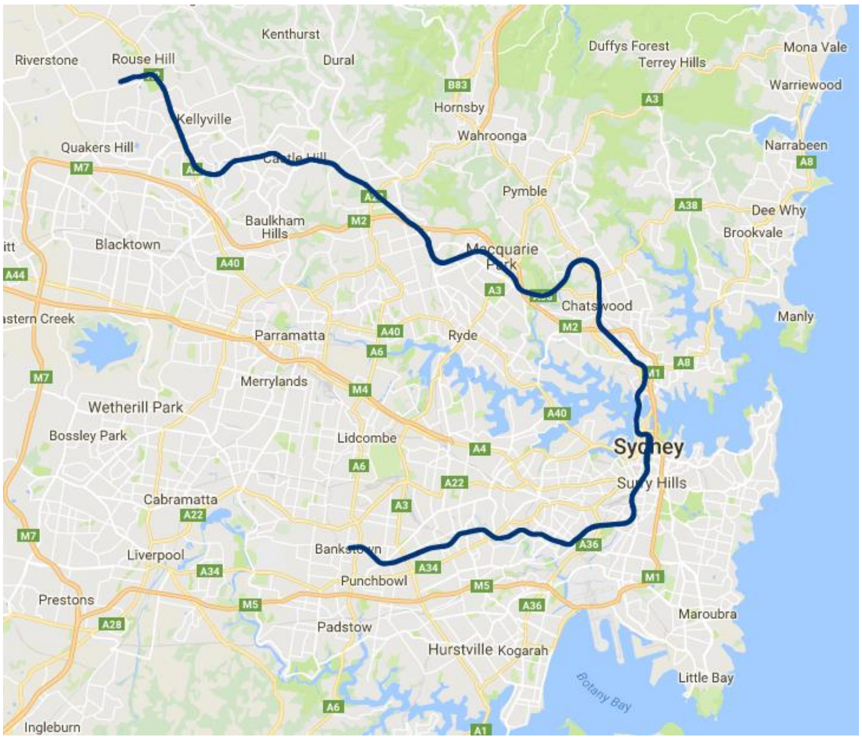
Sydney is Australia's largest city, home to 5 million people as of 2017 (ABS, 2017b). It is growing quickly with another million people expected to live and work in Sydney over the next decade (Transport for NSW, 2016). Every day, more than 23 million journeys are made across Sydney (Bureau of Transport Statistics, 2014), and by 2031 trips to the city are expected to have increased by 25%, and trips within the city by one third.

This growth is posing a transport challenge in Sydney: the current rail network will not be able to support this growth. Existing heavy rail is reaching capacity in the CBD, and it is not easy to build additional stations. The existing heavy rail network is effective at getting suburban commuters into the CBD, but is insufficient to move people within the CBD.

A range of transport options were considered to improve connectivity in Sydney, such as regulatory, governance and better-use reforms, road and bus alternatives, or increased frequency of existing trains. However, it was determined that investment in new rail options was the only approach that could provide a system able to satisfy long-term demand and encourage growth in public transport patronage and mode share (Transport for NSW, 2016).

Therefore, the NSW Government announced the development of the Sydney Metro, a heavy rail project specifically designed for commuters. It involves 66 kilometres of train line running from Rouse Hill to Chatswood, under the harbour, and out to Bankstown. The route is shown in Figure 4.4 below.

Figure 4.4 Sydney Metro route map



Source: Sydney Metro (2016)

New stations will be built at Crows Nest, Victoria Cross (in North Sydney), Barangaroo, Pitt Street and Waterloo, and upgrades to Martin Place and Central stations. The decision to build a metro-style line through the CBD means that new stations can be added to already densely built up areas within the CBD. Construction of Sydney Metro also involves a new harbour crossing, a second tunnel 40 metres below the harbour, creating significant new capacity to get people into the city. The metro is being completed in stages and is expected to be operational by 2024 (Sydney Metro, 2016).

The Sydney Metro is expected to cost approximately $12 billion with a BCR of 1.53, meaning it is expected to deliver over $18 billion in value (Transport for NSW, 2016). The new train line will support growth in rail patronage from 168,000 to 288,000 trips in the morning peak hour (or a 60% increase in total rail network capacity), reduce travel time for commuters, reduce traffic and bus congestion across Sydney Harbour and into the CBD, and improves the resilience of the network by providing a separate train line (Transport for NSW, 2016).

The metro will overlap heavily with the existing heavy rail network extensively, particularly in the CBD. Barangaroo is an area of significant new development – it has been forecasted that when complete (in 2024) it will provide space for 24,000 jobs and generate $2 billion per year to the NSW economy (Barangaroo Delivery Authority, 2015). Building a station there will allow the precinct to grow and enable people working there to get into and out of the CBD quickly. It will also take some strain off existing stations in the area such as Wynyard (one of the busiest stations in the Sydney network (Transport for NSW, 2014)). Similarly, the new station at Pitt Street will take strain off the existing heavy rail network and accommodate the expected growth in train patronage. The Martin Place station will be redeveloped as an interchange between the existing train lines and the metro.

The Sydney Metro will provide a new backbone to the CBD transport network, and add new stations to accommodate growth without disrupting existing heavy rail operations which are already at or approaching capacity.

At the same time, light rail in the CBD is being constructed. Currently most movement within the CBD is done by bus, but this is less than ideal given the significant congestion in the CBD and the smaller capacity of buses than rail. The light rail project involves expanding Sydney's existing light rail network further into the city centre, and integrating the light rail with heavy rail and bus timetables. The light rail will run from Circular Quay up George St (a major north south road connection) out to Central Station. It will then extend out past the Sydney Cricket Ground to the University of New South Wales (UNSW). The route map is shown in Figure 4.5 below.

Figure 4.5 Planned light rail extension Sydney

Source: Transport for NSW (2012b)

The light rail will significantly improve access not only to the CBD for commuters in the South East (suburbs such as Kingsford and Randwick), but also for Sydney residents attending events at the sporting and entertainment facilities at Moore Park and attending UNSW. Construction is underway and the light rail is expected to open for use in 2019.

The light rail will reduce the number of buses in the CBD by 180 in the morning peak hour, and is forecasted to be have 97% of services running with three minutes of the timetable. This is significantly more reliable than the current bus network in the CBD, where just 19-34% of buses run within this window. The light rail project is estimated to have a cost of around $1.2 billion with a benefit cost ratio (BCR) of 1.4 meaning that it is expected to deliver $1.40 in benefits for every $1 spent (Transport for NSW, 2016).

The areas being served by the light rail are high commuting corridors but they present particular transport challenges. These areas tend to have geographical challenges and are not as densely used as core CBD areas; as a result, neither a metro or heavy rail solution would be suitable. Light rail is a good solution, almost a hybrid between buses and heavy rail. Each light rail vehicle can carry 450 people – the equivalent of nine buses (Transport for NSW, 2016), and will not get caught in traffic congestion the way that buses do.

However, it does not require the significant infrastructure or take as much space as heavy rail, so is ideal for the dense CBD where space is strongly contested.

Dedicated heavy/light rail interchanges are being constructed throughout the CBD, including at Central, Town Hall, Wynyard and Circular Quay (Transport for NSW, 2013). This will ensure that people can easily switch between the two with minimal difficulty, and be able to get around the CBD more quickly.

The combination of existing heavy rail, the Sydney Metro, and the light rail will maximise the capacity of the transport network in the CBD. The Sydney Metro will bring large volumes of commuters into the city through a dedicated tunnel network – ensuring that the road above and existing train network is unaffected. In the CBD, light rail will allow people to get around easily and quickly, without getting caught in traffic congestion.

It is critical that light and heavy rail are used in conjunction to achieve maximum impact on the Sydney CBD. The current network is under strain – Sydney has the worst road congestion of any city in Australia (Austroads, 2016), and many train lines are at capacity (Transport for NSW, 2012a). The Sydney Metro is a necessary upgrade to get people into the city in the future, but by coupling it with light rail in the CBD, it ensures that people can move around the CBD once in. The coupling also means that fewer heavy rail train stations are necessary because people can switch to light rail once they get close to their destination. Similarly, getting people efficiently around the CBD is not enough on its own, to ensure an effective transport network heavy rail is needed to get the vast numbers of people who live in other parts of the city into the CBD.

4.4 Short Haul Freight

The increasing levels of congestion seen in our major cities combined with the growing size of the freight task mean that rail is a good option for some businesses in making fairly short journeys from the port to nearby factories. Two particular examples, discussed below, are Woolworths and Breville which both use rail for transport from the port to their distribution centres in Sydney.

4.4.1 Woolworths

Woolworths is one of the most significant freight movers in Australia. In addition to its supermarket network, Woolworths also owns and distributes freight for Big W, BWS, Dan Murphys, Wine Market and Cellarmasters. All up, the business employs over 205,000 people and serves over 900 million customers monthly.

This equates to a significant freight task: Woolworths generates 20 million cartons of product each week, distributed in part by 3,000 truck movements daily (Victoria University, 2014). But, for a number of reasons, Woolworths is making greater use of moving goods by rail where possible. Woolworths is particularly making greater use of rail along the eastern corridor (Melbourne-Sydney-Brisbane), but is also actively engaging with rail on the corridors from the Northern Territory to Western Australia.

Woolworths' decision to make greater use of rail is partly commercially driven – increasing use of rail will allow Woolworths to reduce the cost of transport. By focussing on rail Woolworths is able to control all cost elements of the logistics movement and improve container utilisation. Also using rail allows Woolworths greater operational control and strategic influence over the way that freight is moved.

In addition to the corporate advantages of using rail, Woolworths is dedicated to using rail because of the social and community benefits of doing so. In Woolworths' 2020 social strategy, it has set a target of reducing carbon emissions by 10 per cent (compared with 2015 levels), and rail is a key part of achieving that goal – as discussed in Chapter 3, road freight produces 16 times as much carbon pollution as rail freight per tonne kilometre. Similarly, in its Transport Strategy, it has included key outcomes such as improving safety, decreasing the impact of its supply chain on the environment and community, and reducing costs to the consumer. Rail is able to contribute to all these goals. It is a safer option than road, it produces less carbon emissions, it is less disruptive to the community by virtue of existing in dedicated passages rather than adding to congestion on roads used by the public, and for particular tasks, it is a more cost-effective way of moving freight than road. Woolworths also considers that, following significant work by the ARTC on the national rail network and investments by state Governments, there is increasing confidence in rail infrastructure and its reliability.

A prime example of how and why Woolworths use rail is in Sydney, where Woolworths makes use of rail at its distribution centre in Yennora. Figure 4.6 shows the location of the distribution centre, located in the Western suburbs of Sydney between Granville and Liverpool.

Figure 4.6 Yennora distribution centre, Woolworths

Source: Google Maps

The Yennora terminal was originally developed as a central wool warehouse facility for NSW but has been gradually redeveloped into an integrated multi-user intermodal terminal/warehouse facility and is owned by Stockland with rail services provided by Qube.

The Yennora facility (shown in Figure 4.7 below) is part of the Yennora intermodal logistics area. It is one of the largest distribution centres of its kind in the southern hemisphere, with over 300,000 square-metres of warehousing and 700,000 square-metres of dedicated container hardstand (Stockland, 2016). The facility is able to store in excess of 5,000 full and 9,000 empty containers. Woolworths has 74,000 square-metres of dedicated storage space at the Yennora.

Figure 4.7 Yennora Intermodal Terminal

Source: Qube (2017)

This 70 hectare site operates as an intermodal rail terminal, with seven kilometres of rail sidings connected to the Main Southern Rail Line. Rail for Woolworths is effective here because there is easy access to the rail line and port, which means that rail can act as a shuttle through the congested inner west of Sydney and get the goods to Yennora. From there they can be more easily distributed to Woolworths' facilities around the state – though approximately 80% of the freight passing through Yennora is for metropolitan areas. For a food retailer such as Woolworths, this ability to avoid congestion is particularly valuable given the time of day sensitivities it faces when delivering food.

Victoria University has quantified the benefits that rail has brought to Woolworths through this Yennora terminal: "the total fleet requirement [has been reduced] by an estimated 30 vehicles, allowing vehicles to perform 3–3.5 trips per day to the 1–1.5 trips per day achievable operating directly from Port Botany" (Vitoria University, 2012). That is, by moving freight from Port Botany to Yennora, the road distribution network in metropolitan Sydney has become significantly more efficient which creates benefits for both Woolworths and Sydney's residents.

This is just one example of how rail has helped to improve Woolworths' freight operations, and demonstrates their ongoing commitment to using rail more.

4.4.2 Minto intermodal terminal

Minto, a suburb in the south of Sydney has an intermodal terminal that has drawn in a number of businesses to relocate and take advantage of the benefits of rail freight in metropolitan areas.

The Minto intermodal terminal opened in 2002 and is located 57km from Port Botany. It is based on a 12 hectare plot adjacent to a rail freight line with convenient access to the M5, M7 and Hume Highway for road deliveries.

Figure 4.8 Minto intermodal terminal

Qube Logistics operates the terminal and port rail shuttles. A key feature of the facility is on-site warehousing which has direct links to customers including a Cargill grain storage facility and Breville's national distribution centre. Each week there are 23 services to the port, carrying goods such as grain, malt, paper and electronic appliances, with future plans to expand capacity into nearby Culverston Road (an expansion of approximately 29 hectares).

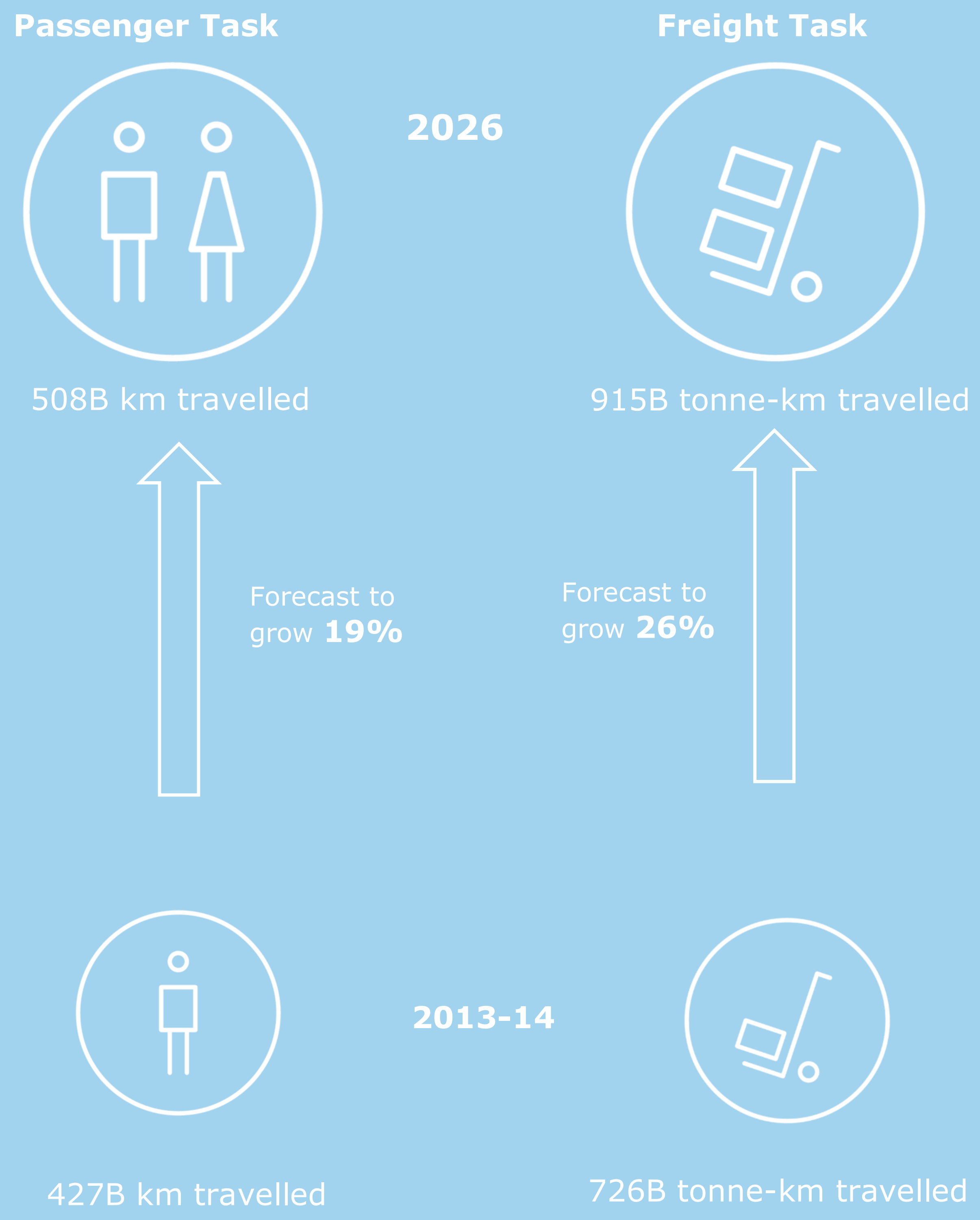
A number of businesses nearby receive significant benefits from this rail link, including Breville – a home appliance company. Breville has made a significant investment in its supply chain, recently relocating to a new, purpose designed national distribution centre at Minto. The new distribution centre replaces two outdated warehouses at Botany totalling over 23,000 square-metres with a new 15,000 square-metre distribution centre on a 4 hectare site incorporating its own 5000 square-metre container storage park in Minto.

A key attraction of the Minto site for Breville was its close proximity to an intermodal rail container terminal. According to Breville's Logistics Manager, Stuart Roche, "Being able to transport containers from Port Botany directly to the new Minto distribution centre by rail eliminates a lot of time and unnecessary handling and transport costs associated with receiving containers by road transport'" (Breville, 2017).

“We have a private link road to the intermodal terminal, so our trucks don’t even have to go out onto the main road anymore, with the travel time between the sites typically less than five minutes. This means we have quicker access to stock, and have been able to significantly cut back on road transport, which is a win for us, the environment and the people who travel on our busy roads in Sydney every day.”

Rail works well in this location for a number of reasons. Firstly, the scale of the operation means that the cost per unit is lower on rail than road, and for the businesses operating nearby (supplying large scale goods such as grain and malt) this is a significant advantage. Similarly, transferring goods from scarce port land to an offsite location saves space and cost for suppliers (Department of Infrastructure and Regional Development, 2016). In addition, the terminal’s location in Sydney is surrounded by roads which are frequently heavily congested, such as the M5, which makes rail a faster option for moving freight, even over a short distance (BITRE, 2016c).

There are also wider community benefits. Minto is in metropolitan Sydney, so having rail move freight rather than vast numbers of trucks limits congestion on the roads. Further, rail is a safer option, particularly in built-up areas where there are so many drivers and pedestrians on and around the roads. And as established earlier in this report, there are also significant environmental benefits associated with using rail over road.



Passenger Task
Freight Task
2026
508B km travelled
915B tonne-km travelled
Forecast to grow 19%
Forecast to grow 26%
2013-14
427B km travelled
726B tonne-km travelled

5 Challenges facing transport in Australia

Transport is critical to all economic activity in Australia and to the standard of living of all Australians. Goods must be moved along the supply chain efficiently, workers must get to work and home again safely, quickly and reliably and holidays, sports and recreation all rely on being able to move with ease around our country. Previous sections of this report identified the current contribution that rail is making to transport in Australia through direct economic benefits and also through social benefits such as reducing congestion, emissions and accidents.

Transport in Australia is currently facing a number of challenges which will shape the future of the industry as well as affecting the performance of the Australian economy and the quality of life of Australia's people. These challenges include a growing passenger and freight task, resource constraints in delivering projects and technological change. Rail will play a central role in addressing these challenges, particularly given its ability to move large numbers of people and large volumes of freight efficiently.

If Australia is to meet these challenges than rail transport will need to be a key component of our response – in turn, the rail industry will need to adapt to its changing environment. This chapter outlines the state of the transport system in Australia today, the challenges it faces, and the role for rail looking to the future.

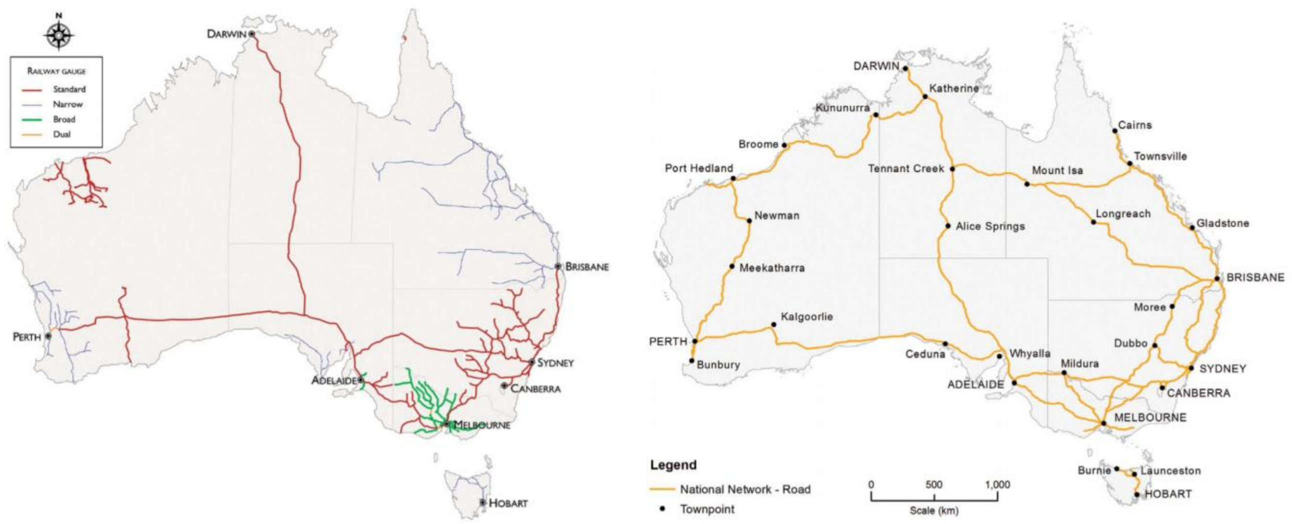
5.1 Transport in Australia Today

Road and rail complete the majority of the transport task in Australia, together accounting for over 80% of both the passenger and freight transport tasks. Australia's road and rail transport network is vast. There are over 40,000km of rail track in Australia (NTC, 2016), and over 870,000km of road (BITRE, 2016). The majority of both the road and rail networks are used by both passengers and freight, with only small portions dedicated to particular services. Figure 5.1 below shows the major components of the national rail and road networks (for rail this includes both freight corridors and passenger networks).

Figure 5.1 National rail and road networks

a. Australia's rail network

b. Australia's national road network



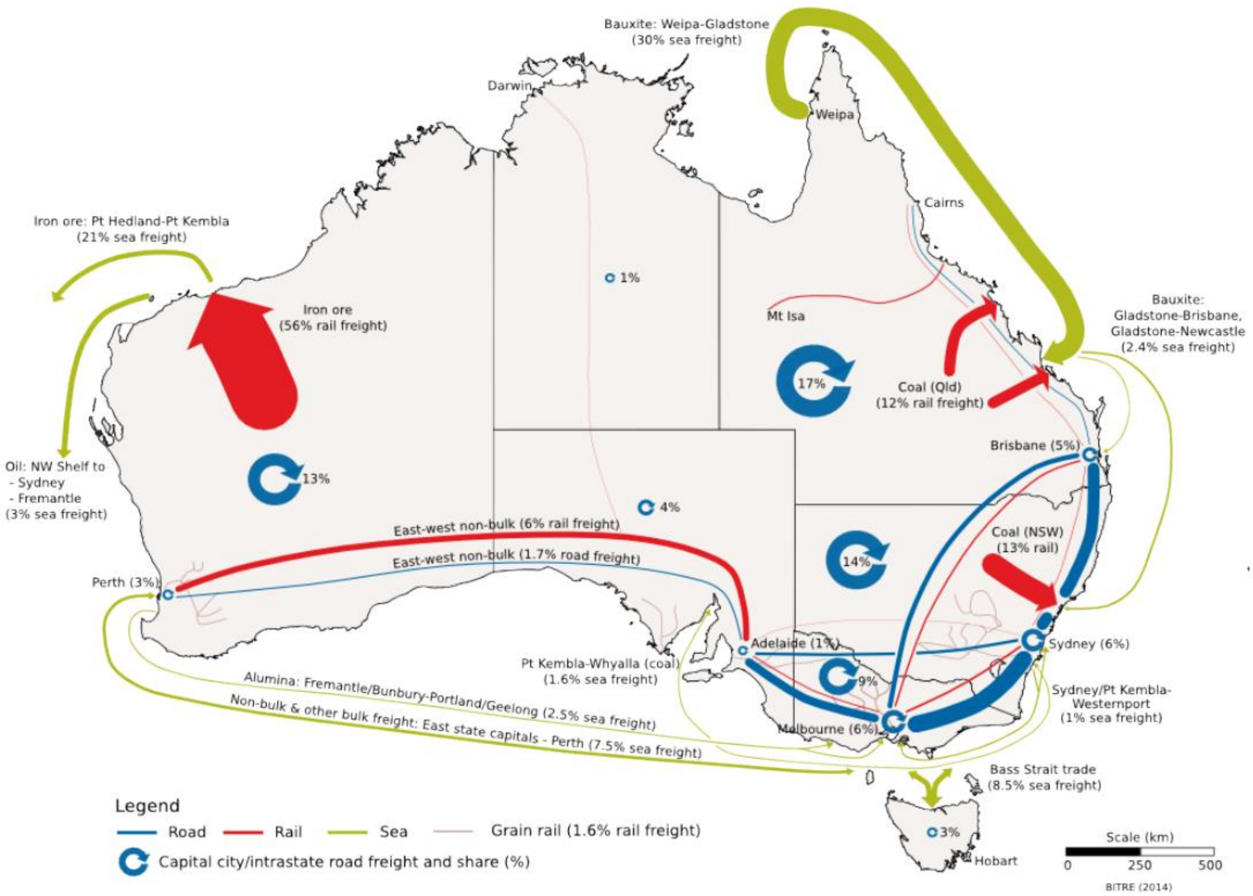
Source: BITRE (2016)

The road and rail networks are similar in their structure, although the pattern of rail regional rail networks feeding into ports and regional road connecting population centres is clear. For road, major interstate highways connect Sydney to Melbourne (Hume Highway), Sydney to Brisbane (Pacific Highway), and Melbourne to Brisbane (Newell Highway). As Figure 5.2 shows, these are the most heavily used freight routes. There are also major highways that connect other large cities across Australia, for example the Stuart Highway which connects Adelaide and Darwin, although these are less heavily trafficked than the east coast highways.

The road network is complemented by the national rail network, which plays a significant role in both distributing freight and moving passengers. The rail network can be broken into three categories:

- interstate railways (carrying passengers and freight) – examples include Perth to Adelaide, Sydney to Darwin, and Adelaide to Melbourne;
- intrastate railways (carrying freight or passengers) – examples include the Goonyella system in Queensland which connects mines to the port, and the intercity network for passengers north of Brisbane; and
- metropolitan passenger networks (carrying passengers) – in Sydney, Melbourne, Brisbane, and Adelaide.
- Light rail networks in Melbourne, Sydney, Adelaide and the Gold Coast.

Figure 5.2 Major freight movements in Australia



Source: NTC (2016) and BITRE (2014)

Table 5.1 below shows the breakdown of transport mode use by task. Some of the relative strengths of road and rail transport are clear in the shares shown. Road excels in passenger transport where around 80% of passenger trips are completed on the road network – although this does mask the fact that rail has a higher mode share in journey to work (around 16% in Sydney and 12% in Melbourne). In contrast, over half of all freight in Australia is moved via rail.

Table 5.1 Share of transport network use, by mode

Mode	Share of passenger trips	Share of freight task*
Road	79%	30.4%
Rail	3.7%	50.3%
Air	17.2%	0.1%
Sea	0.1%	14.5%

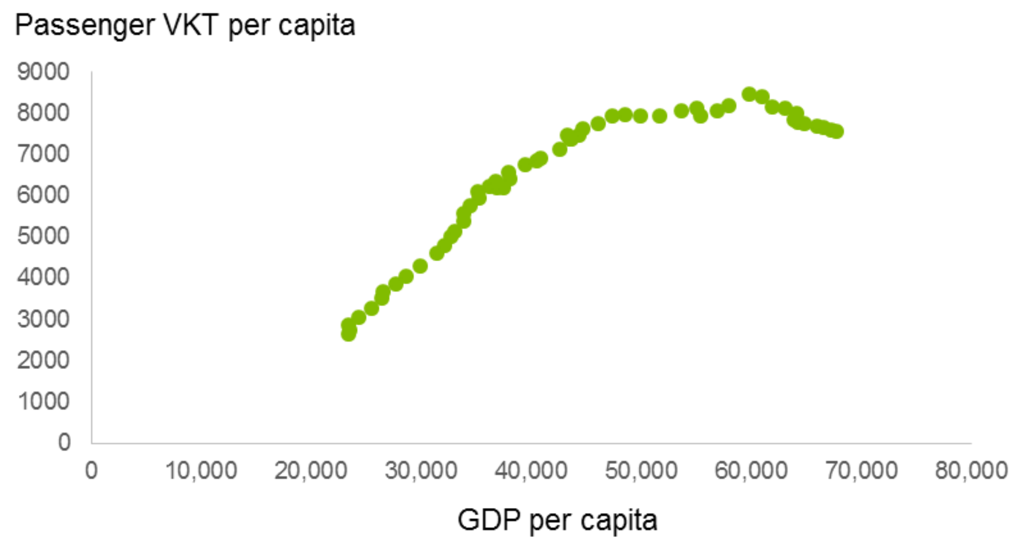
*The remaining 4.7% of freight is distributed through pipelines

Source: National Transport Commission (2016)

The modal splits shown above don't fully reflect the complexity of the transport task. In particular, road and rail do not always compete for share of the freight task, in many cases they are used together in an integrated fashion. Road is typically used for time sensitive commodities (such as fresh food and fuel) and non-bulk freight, while rail is used for non-time sensitive, bulk commodities (such as iron ore, coal, and grain) (NTC, 2016). Where road and rail compete, rail has an increasing advantage as distances increase.

In 2013-14 passengers collectively travelled 427 billion kilometres, and this is growing. Patronage on all heavy and light rail systems (expect Perth) grew in 2015-16, and nationally, Australians made 682 million journeys on trains (BITRE, 2017a). The passenger task has grown 8% in the 10 years to 2016 and is forecast to grow another 19% by 2026 (NTC, 2016). Over time the number of passenger kilometres travelled by road has been steadily increasing, however a number of factors such as the growth in domestic air travel, increasing fuel costs, congestion and daily travel preferences has meant that passenger travel per capita on road has been falling over the last few years, this is shown in the chart below.

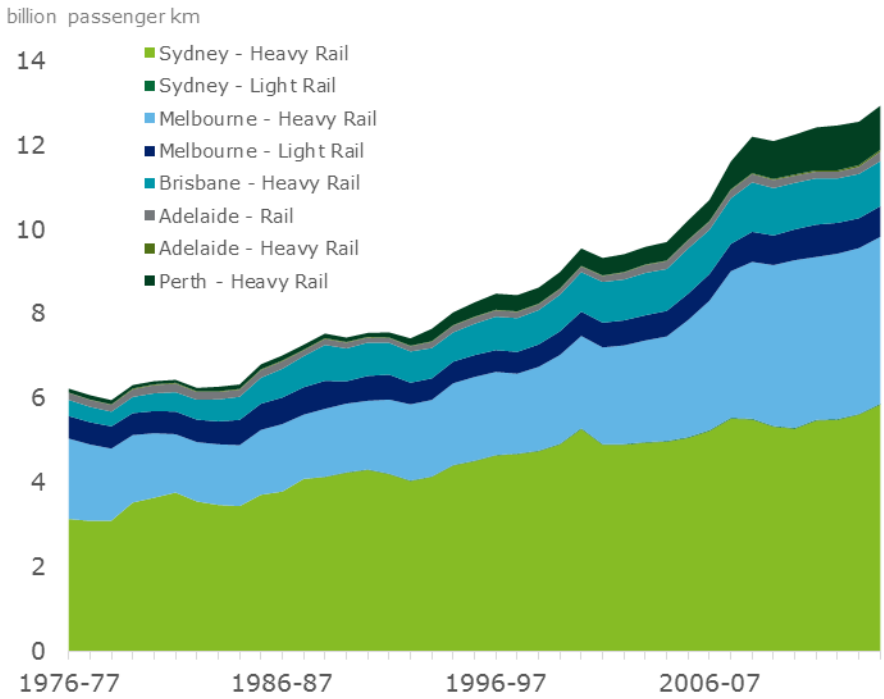
Figure 5.3 Relationship of per capita Australian urban car travel to per capita income levels



Source: DAE based on BITRE data

There has been strong growth in passenger travel by rail with average annual growth rates of around 2.9% a year over the past 10 years. Growth has been particularly strong in the heavy rail networks in Perth, Adelaide and Melbourne with growth averaging around 9%, 11% and 4.7% a year respectively, the overall growth in rail passenger travel is shown in the chart below.

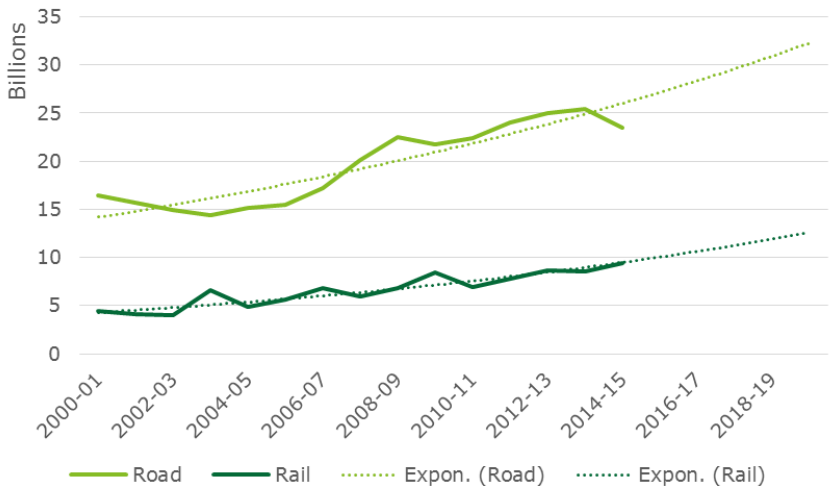
Figure 5.4 Growth in passenger rail travel in Australia



As a result of the sustained economic growth in Australia over recent years, the freight task has been growing even more quickly than the passenger task. In 2013-14 domestic freight moved totalled 726 billion tonne-kilometres, 50% larger than the task in 2006. Rail plays a more significant part in moving freight than moving passengers, so has become increasingly important in completing the nation’s transport task over the last decade. In 2015-16 rail moved more than 1.3 billion tonnes and 413 billion net tonne kilometres of freight around Australia (BITRE, 2017a).

Bearing in mind the modal split in Table 5.1, government has to decide how to allocate funding between road and rail. Chart 5.1 shows total levels of government investment in road and rail infrastructure over time, with a simple projection based on spending level trends for how funding will develop in the future. Chart 5.2 shows how the split between road and rail funding has evolved over the years since 2000. Road expenditure has dominated rail investment by government every year, but rail’s share has been growing. In 2000-01, rail’s share of government investment was 21%, by 2014-15 this had increased to 29%.

Chart 5.1 Total government expenditure on road and rail, constant 2014-15 prices



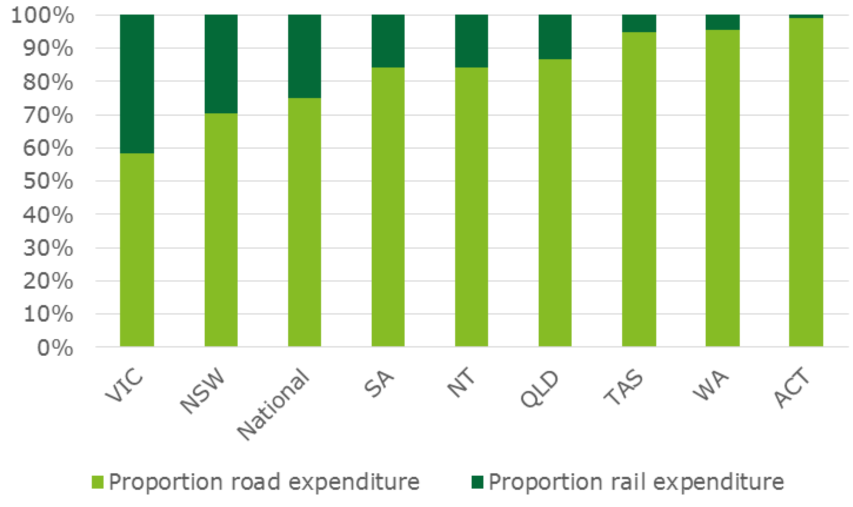
Source: BITRE (2016); Note: The expenditure forecast is a simple projection based on trend line spending, this method is used by Infrastructure Australia in forecasting expenditure.

Chart 5.2 Split between rail and road expenditure, total government expenditure, constant 2014-15 prices

Source: BITRE (2016)

Chart 5.3 shows this split at a state level, with government expenditure averaged over the period 2000-01 to 2014-15. Victoria was the state most evenly spending between road and rail, with rail receiving an average of 42% of the road/rail budget, followed by New South Wales (30%). The ACT and Western Australia spent the least (proportionately) on rail, averaging 1% and 4% spend on rail respectively.

Chart 5.3 Split by state, rail and road expenditure, average 2000 to 2015



Source: BITRE (2016)

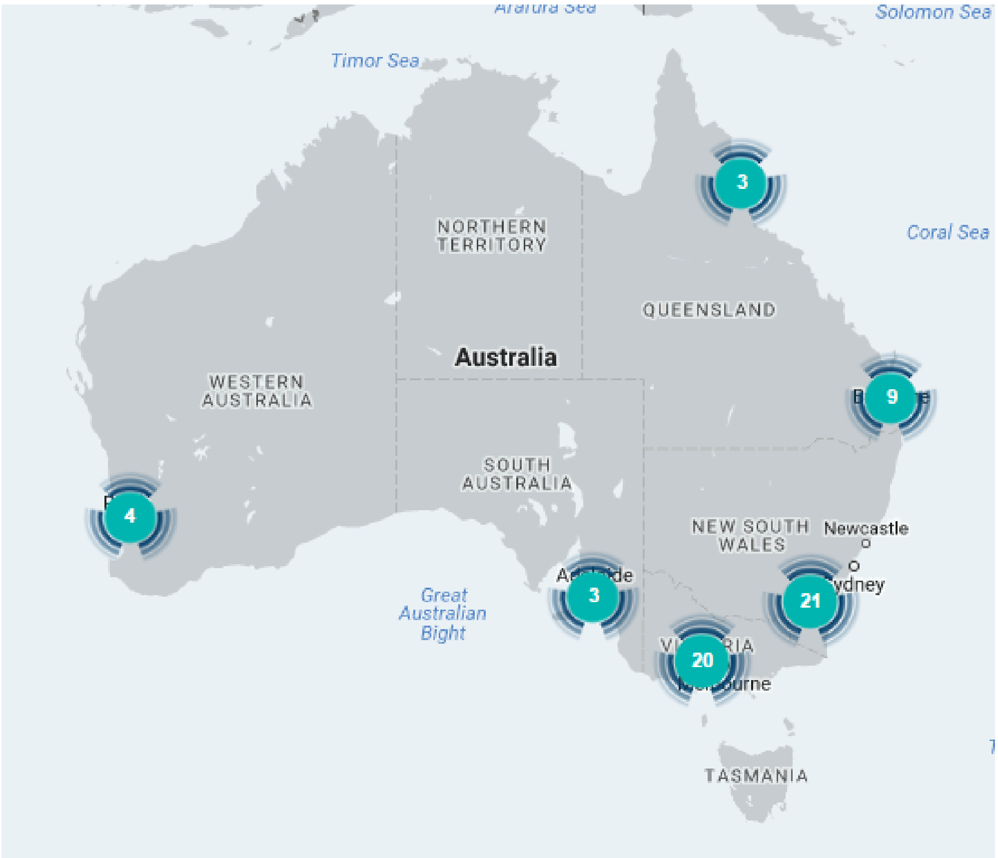
In addition to the existing transport network, a number of new projects are currently under construction around Australia. New road and rail systems are currently being built to increase the capacity of the network, and to fill gaps to better connect the network. Major rail projects include:

- a range of regional rail freight upgrades in Victoria to meet increasing demand for freight (on the North East, Gippsland, Geelong, and Murray Basin lines);
- Metronet projects in Western Australia to help ease congestion and improve connectivity across Perth
- Development of light rail projects in Canberra, Sydney, Parramatta, Adelaide and South East Queensland;
- Early stage development of the Melbourne Airport Link project;
- Development of metro style rail options in Sydney and Melbourne;
- the construction of the Moorebank Intermodal Terminal in Sydney (a rail port shuttle between Port Botany and the Moorebank precinct) to address urban congestion and improve national freight connectivity; and
- the development of the Inland Rail project (a freight corridor connecting Melbourne, Sydney, and Brisbane).

There are also significant road upgrades and new highways under construction nationally. Some of the largest include NorthConnex and WestConnex in Sydney, upgrades underway for the Hume, Pacific, and M1 highways and the Monash freeway in Victoria, the Perth airport gateway and the Northlink in Western Australia.

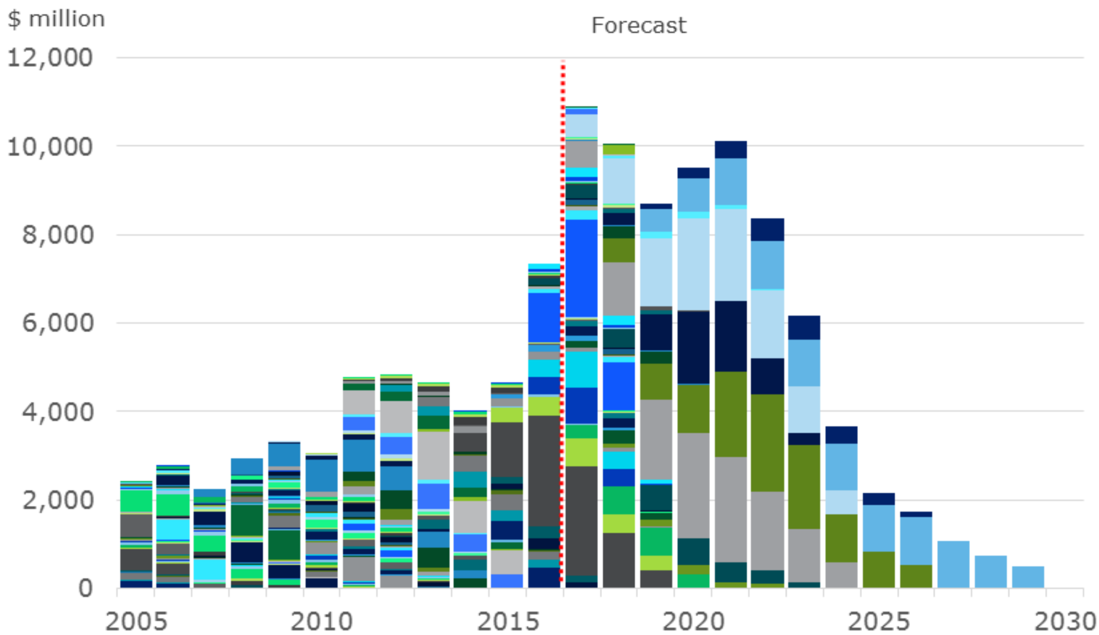
Infrastructure Partnerships Australia identifies 60 road and rail projects over $100 million in value, shown on the map below, that are announced, under procurement or commencing work. Focussing in on the rail projects alone, the chart below shows how expenditure on rail projects is likely to progress over the coming years. Each colour shows a different rail project that is completed, underway or committed. The data shows that spending on rail infrastructure for each of the next 6 or so years is likely to be higher than spending in any historical year in the dataset. These projects are being completed in order to accommodate an expected increase in both passenger and freight movements.

Figure 5.5 Significant road and rail projects around Australia (>$100 million)



Source: Australia and New Zealand Infrastructure pipeline (2017)

Figure 5.6 Estimated expenditure on major rail projects (2005-2030)



Source: Deloitte Access Economics

Note: Expenditure is based on an assumed split of total project budget over construction life

5.2 The transport challenge in Australia

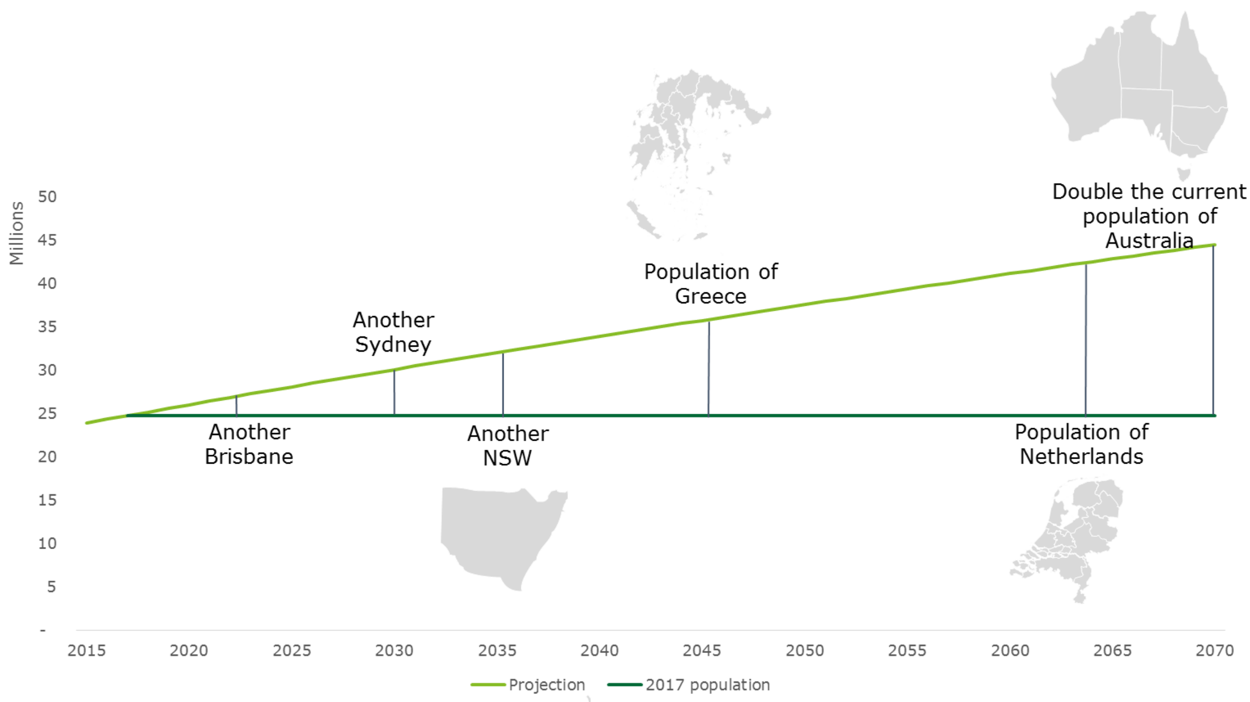
There are a number of key challenges facing transport in Australia both now and looking ahead. The key challenges are planning for growth in both passenger and freight transport, resource constraints in completing the pipeline of transport projects, the need for modal neutrality in policy making and adjusting to technological change. Each issue is discussed further below.

5.2.1 Population and economic growth

Demand for transport is fundamentally driven by growth in population and growth in economic activity. Looking at population, Australia is one of the fastest growing developed countries in the world, for example, in 2014 Australia had the third highest population growth rate in OECD, this high growth rate is expected to continue into the future with Australia's population forecast double by 2070, and by 2053 both Sydney and Melbourne are predicted to have almost 8 million people apiece (ABS, 2013a).

All these people will use the transport network to get around, so as this population growth accelerates, the burden on the transport system will increase. All modes of transport will feel this increased pressure, whether that be in the form of increased congestion of the roads, or timetable changes and crowded trains. Transport infrastructure will need to be upgraded in order to accommodate this demand.

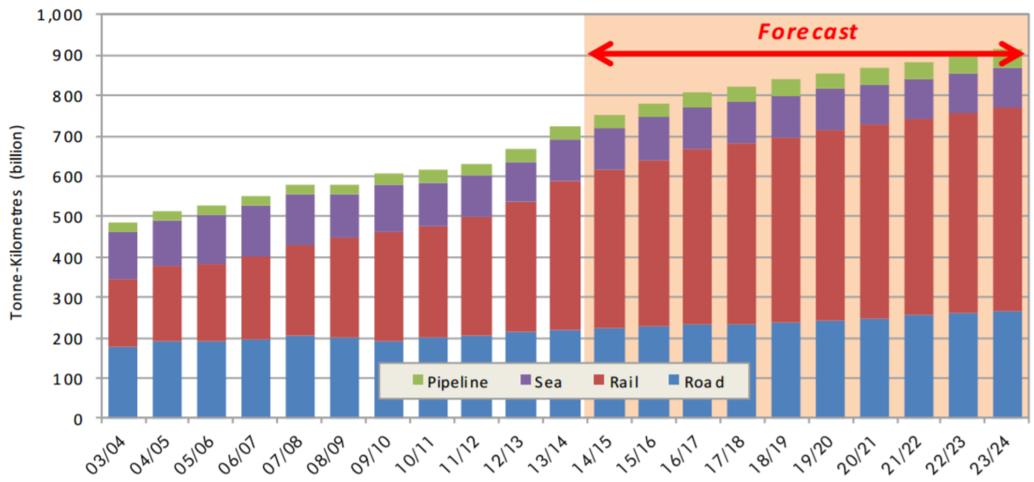
Chart 5.4 Australian population forecasts to 2070



Source: ABS (2013b)

Australia has not had a recession in 26 years (ABS, 2017a), and with economic growth comes growth in the freight task as businesses and manufacturers grow and trade more. Therefore, not only is the transport network facing growth on the passenger side, but also the freight side. The freight task is expected to grow 26% by 2026, and much of this increase will be moved by rail, as shown in Chart 5.5.

Chart 5.5 Expected growth in the freight task



Source: NTC (2016)

Further, the nature of freight is changing. Goods are increasingly consolidated at distribution centres in Asia, and then shipped straight to the final destination (BRinternational, 2015). For example, BCR, a major freight and logistics company in Australia, now offers 'origin warehousing' and 'buyer's consolidation'. These services allow businesses to consolidate shipments from several suppliers into a single container before it is shipped to them (BCR, 2014). In this way, the shipping process is made more efficient and affordable for businesses, and in light of this, the demand for freight will likely increase further.

5.2.2 Resource constraints

The volume of work underway to upgrade the transport system (particularly in metropolitan areas) is beginning to create a resource constraint – there is increasing competition for the skilled labour required to complete the range of projects that are currently underway. Both Sydney and Melbourne are developing new train lines, the Inland Rail connecting Melbourne and Brisbane is in early stages of development, and road projects (such as the Ipswich Motorway capacity upgrade in Queensland and upgrades to the Perth major east-west and southern freight corridor) are numerous.

This current wave of construction is, to some extent, making up for decades of underinvestment, and supply of labour and materials cannot keep up with demand. These capacity constraints are exacerbated by a lack of coordination in investment decisions between the states. This lack of coordination means that there is not a smooth demand profile for particular skills. This tends to increase costs and delivery risks for these large projects. Achieving coordination between the Commonwealth, the states, and in some cases local government is difficult. Each level of government has its own set of priorities and has only muted incentives to change their plans to accommodate other states.

This wave of construction has also meant that the existing network is put under strain while parts are closed for upgrade. For instance, in Sydney, the WestConnex project has meant access to existing motorways (such as the M4 and M5) has been limited for the last two years, and access will continue to be disrupted until the project's completion in 2023 (WestConnex, 2017). These disruptions cause congestion, slow down travel times, and detract from the efficiency of the network.

Importantly, it is unlikely that this wave of construction is just a phase – population growth compounded with economic growth means that the transport network will never be complete and that disruptive additions to the transport network will, increasingly, become part of the normal way of life. Our transport networks will need to be constantly upgraded and refreshed, and the challenge for Australia will be to find a way to minimise the disruptions to the network and make these upgrades in the most cost effective manner.

Beyond these labour and materials constraints, there are other constraints in upgrading our transport networks. For instance, there is increasingly limited available land for new transport projects in urban areas. Going forward, Australia will need to learn to make more efficient use of existing infrastructure rather than funding new projects. Additionally, tunnelling will need to be more frequently used to address capacity constraints. While it is more expensive than building above ground, the density of Australian cities is increasing and land is increasingly valuable – tunnelling will need to be adopted more broadly in order to overcome these capacity constraints. This will be an adjustment to thinking, and will require innovation in project planning and delivery as well as effective use of technology.

5.2.3 Modal neutrality

From a policy perspective, modal neutrality when making investment decisions between road and rail is important because it allows resources to be distributed in the most efficient manner possible. However, road and rail projects are often developed independently, and other factors such as politics can enter the decision making process.

A challenge for rail is that many of the benefits of investing in rail can take a long time to materialise. This can disadvantage rail - particularly if decisions are being made for political reasons. Short term election cycles can mean that there is an incentive to deviate from long term investment decision making processes, and in some cases too much funding may be direct to projects which are not the best solution to the transport projects.

Where modal neutrality is not maintained, the transport system is not built in an integrated manner. This creates challenges in the future because the transport network has not been built for the long term, and renewed investment is needed. Discrete parts of the network, built from a number of smaller projects, do not run together as well as they could in a system where long term, network wide planning was implemented.

The challenge of making mode neutral investments is made harder by the lack of a level playing field between road and rail in terms of charging and cost recovery. This issue is particularly prominent in freight where most rail freight networks operate at or near full cost recovery while road freight networks tend to receive some cross-subsidy from passenger travel. Going further, many of the externalities caused by road are not accurately priced (for instance congestion, accidents, and greenhouse gas emissions). Addressing these issues requires significant policy changes across the full spectrum of rail and road pricing regulation which is a challenge, particularly given it would fundamentally shift how Australians use the transport system.

Public-private partnerships (PPP) are one method used by other countries as a way to make rail as viable as road, however outside of toll roads they have not been a popular choice in Australia. Government and private sector working together can be a good way to deliver transport megaprojects on time and in budget, but the coordination required makes running these jobs challenging.

5.2.4 Technological change

While technological change opens up many opportunities, it also presents challenges. These challenges have been faced by many industries in Australia and are now being particularly felt in transport. Perhaps the most significant challenge is adapting to autonomous driving technology. For rail, driverless technology offers the potential to achieve greater efficiency for operations. For example, autonomous freight rail could operate more safely and could use less fuel to complete the freight task (by optimising breaking behaviour) in passenger rail autonomous vehicles could vastly increase capacity on urban rail networks by reducing the need for head-way between trains. Implementing driverless technology in rail is challenging as it requires improvements to signalling and communications infrastructure to a point where the trains can make the transition to driverless.

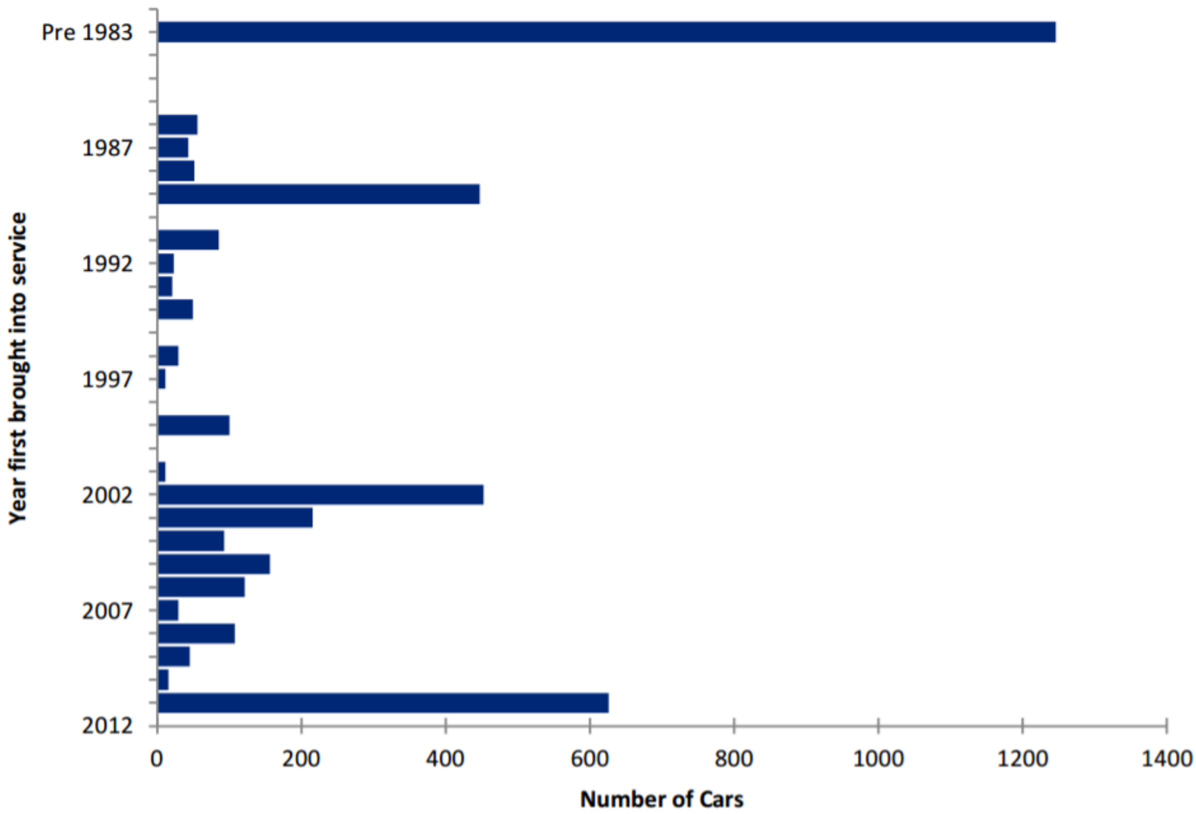
Autonomous driving technology in road has the potential to vastly alter the nature of passenger and freight travel. How and when this happens will have big implications for mode share and travel patterns which are extremely difficult to anticipate. For instance, if rail is able to effectively use autonomous driving technology, and consequently becomes able to move freight more quickly and at a lower cost, road may experience a decrease in mode share. Conversely, if rail is slow to adapt, road’s share of the freight task could increase. This uncertainty makes planning very difficult.

5.3 Challenges facing rail manufacturing in Australia

In addition to challenges in the general transport industry in Australia, the rail manufacturing sector faces particular challenges. The rail manufacturing sector incorporates construction of rail rolling stock, supply chains in the industry are complicated by the fact that trains in Australia are often derived from a mix of Australian and international components. Australian manufacturing tends to focus on carriages, maintenance and assembly with locomotives usually manufactured overseas. For instance, Downer no longer manufactures locomotives in Australia; rather the manufacturer uses locomotives manufactured in North America by Electro-Motive- Diesel (EMD) and Progress Rail Services (PRS).

The key challenge facing the rail manufacturing industry in Australia is that it is marked by a high level of volatility in demand and profit (DAE 2013). This is related to the resource constraints issue identified for transport more broadly, above. Rail operators tend to place discrete, large orders of new stock, often waiting years between new purchases. Manufacturers, therefore, face considerable uncertainty over when the next major project will come.

Chart 5.6 Introduction of cars in current fleet, 1983 to 2012



Source: DAE (2013)

The volatility in production reduces the incentive for suppliers to invest in new more, efficient plants. New technology and capital will depreciate in value over time. Without a steady pipeline of new work, there is a good chance that any investment will simply be written off in seven to ten years' time before any substantial new orders arrive.

The manufacturing industry is further hampered by the large variety of passenger rolling stock used in Australia – a legacy of the nation's colonial past where each colony was independently run. There are at least 36 different classes of trains used in Australia (DAE 2013), resulting in a host of different gauges, power systems and fitouts. There are certainly benefits to variations in design to fit different contexts – the seating requirements of a long distance fleet, for instance, is necessarily different from that of a metropolitan train. However, this heterogeneity carries considerable costs. UK estimates suggest that heterogeneous specifications add 5% to 10% onto the cost base of rolling stock.

Given these issues facing train suppliers, there is a case for implementing a more coordinated approach to rolling stock purchases. Procurement programs could have a longer-term focus to smooth out production. Jurisdictions could potentially realign orders to avoid lulls in production. Where the benefits outweigh the costs, jurisdictions could harmonise rolling stock orders and engage in joint-procurement, thereby creating a greater economies of scale in the rolling stock industry (DAE, 2013).

This volatility of orders makes maintaining skilled workers difficult. Manufacturing firms can invest in building up skilled workers over the course of a project only to be forced to downsize their workforce at the project conclusion if a new order is not placed. Long term unemployment can contribute to skill degradation as the unemployed worker is not as actively refreshing their knowledge of the industry. This issue is exacerbated by the fact that rail manufacturing often has to compete with the mining sector which employs individuals with a similar skills range. Rail has a difficult time matching the high salaries offered to engineers and other professional in the mining sector (ARA, 2012). Employers report a fear of investing in upskilling workers only to have them poached by the more lucrative paying industries.

A 2017 survey of the rail industry by the Rail Industry Reference Committee (Rail IRC, 2017) found that 84% of rail industry employers experienced a skill shortage in the past year. A shortage of qualified personal, aging workforce, cost of qualification, remuneration and the need for shift work were all reported to be factors in the shortage.

5.4 Rail's role in the future of transport in Australia

Rail will play an important role in addressing Australia's future transport challenges. Particular areas where rail will contribute are in completing the urban commuter transport task and the freight transport task, reducing the fuel intensity of transport, creating accessible urban centres and in providing skilled work for Australians.

As the population grows (particularly in metropolitan areas), rail will be the backbone of commuter transport in dense urban areas. Even in a world of autonomous vehicles, the sheer volume of people that fit on a train means that rail will remain the most efficient way to move large volumes of people into and out of CBDs and around crowded cities. Further, with increasing road capacity constraints and congestion, rail will play a greater role in urban transport more generally. Rail network capacity can be more easily expanded by using longer trains and smarter operational procedures to help accommodate growth in the passenger transport task.

The freight task in Australia is forecast to grow 26% by 2026 (NTA, 2016), and rail will be crucial in managing that growth. There will always be a need for road to get freight to the delivery destination, but rail will be increasingly needed for long haul movements. The Inland Rail project is the final step in creating a nationally connected rail freight network, and, as such, after its completion, rail will be able to more quickly move freight around the country (particularly along the east coast). This should enable better integration between road and rail, and allow each mode to focus on its strengths. Further, as more intermodal terminals are constructed, rail will be increasingly able to assist in managing congestion for port related traffic in metropolitan areas.

Rail also uses less fuel to complete the transport task, which may become increasingly important in the face of emissions constraints and increasing fuel scarcity. According to the US Department of Energy, fuel use per passenger is far lower on trains than in cars. On average, rail achieves an average of 89 passenger kilometres per gasoline-gallon equivalents (GGEs) – meaning that it takes almost 90 kilometres for a passenger to use the equivalent of one gallon of gasoline, while for cars it is just 61 kilometres (US Department of Energy, 2017). Similarly, in the UK it is estimated that rail uses between 1.65 and 1.9 Mega Joules (MJ) of energy per passenger kilometre travelled while cars used 2.1 MJ (Banister, 2014).

Another key role for rail in the future will be helping to create accessible and interesting urban centres. For longer distance travel, rail can move people more quickly than road, and so rail can expand the commuter radius (the distance that people will travel for work). Slightly faster rail would mean that places such as Newcastle and Wollongong would be within commuting distance of Sydney, Ballarat within commuting distance of Melbourne, and the Sunshine Coast within easy reach of Brisbane. These regional links to existing CBDs could help with housing affordability and regional development as those regions become viable living options for city workers.

Rail station development will be key to creating connected and lively urban areas. Currently, Australian rail stations are transport oriented flow through areas, but in other parts of the world they are lively recreational and retail hubs. Although improving, currently decisions about station and over station development in Australia are made somewhat in isolation from urban planning decisions, however in countries like Japan, Hong Kong, and the UK the development of recreational and retail precincts are fully integrated into station design.

Finally, the rail industry will continue to provide skilled work in Australia. There are currently a large number of rail projects underway, and beyond that there is a sustainable pipeline of rail projects looking into the future. This presents workers with the ability to develop and apply their skills overtime without needing to retrain for new industries when the rail network is 'completed'.

The transport system is facing a number of challenges, and rail will play a critical role in addressing these. Investment in rail is important for building a strong transport network and capitalising on the economic and population growth which is forecasted in Australia. Rail's contribution to the economy is already significant, as profiled in Chapter 2, and it will grow.

5.5 Ensuring rail can address Australia's transport challenges

The picture painted above of continued success of Australia's rail transport system and its ability to contribute to the economy and society is by no means guaranteed. The challenges of population, resource constraints, modal neutrality and technological change facing transport will need to be addressed by industry and government working together to provide an environment where rail can contribute to its full potential.

To get the most out of our transport network into the future, industry and policy-makers will need to pursue reforms that enable our transport networks to operate efficiently and allow the public to get the most out of the investments that are being made. Although there are a broad range of initiatives that need to be pursued, some areas for focus are set out below and grouped by whether they are best pursued by government, industry or a combination of the two. These areas for focus are based on consultations with industry experts and the evidence developed in previous sections of this report.

5.5.1 Government

In the area of rail transport, government's core responsibilities are in the areas of planning, procurement and regulation. Steady improvements can be made in all three of these areas to help ensure that rail can meet Australia's future transport challenges.

In the area of planning, government can focus on enhancing its future plans and ensuring that investment decisions are driven by considering costs and benefits rather than politics. Significant efforts have been made in this direction with independent infrastructure advisory bodies being established in most Australian jurisdictions, however, there still remains a long way to go to ensure that this process is embedded in decision making. The election cycle creates an incentive for politicians to favour large, visible transport projects. This can be at the expense of mundane but effective investments, such as signalling upgrades. Furthermore, there is an incentive to value projects with short-term gains rather than long-term gains. As noted by the Productivity Commission's (2014) report into public infrastructure, under the current arrangements, "there are numerous examples of poor value for money arising from inadequate project selection".

Once investment decisions have been made there is then a need to execute project procurement in a coordinated and efficient manner. For example, a nationally consistent tender process could be established to significantly reduce the administrative burden and cost of tendering for projects. A redesigned tender process could also focus on improved information provision and efficiency. Deloitte Access Economics (2015) has previously investigated the benefits of improved tendering processes and identified that these could save Government around $2.5 billion over the period to 2030.

An area of focus for regulatory reform could be in transport pricing. There is scope for ensuring that road usage is charged in a manner that accurately captures the cost of road infrastructure provision and, further, the negative externalities of road usage, such as congestion, vehicle emission and accidents. The current charging arrangement can lead to poor incentives, resulting in socially undesirable outcomes. For example, trucks may be used on routes where trains would be preferred if trucks were charged for the full costs created by their use of the road network. Similarly, drivers may choose routes or times of travel that cause congestion for other road users because pricing does not consider the effect of their decisions on others. The Heavy Vehicle Road Reform, currently being pursued by Australian Governments, is a first step towards addressing these long standing pricing inequities between road and rail travel.

5.5.2 Industry

Industry is best placed to focus on the systems and execution of rail transport strategies including in the design of equipment and the use of technology.

In terms of equipment, while government improves procurement processes, the rail industry could focus on harmonisation of equipment and standards to make it easier for government to undertaken its procurement. The Australian rail industry currently draws on non-standardised product designs which leads to increased costs during procurement and difficulty in easily identifying and replacing parts. Efficiencies in executing investment decisions could also be pursued through continued harmonisation of standards between jurisdictions in areas such as safety, environment and engineering.

Turning to the use of technology, it is likely that the rail industry will begin to experience significant digital disruption in the coming decade with the introduction of driverless cars and a range of new transport technology. The rail industry will need to embrace this disruption and adapt to new areas of competition. An integral part of this adaptation will be to introduce disruptive technology into rail itself. For example, significant improvements in signalling and vehicle automation can be achieved using technology that already exists. Introduction of this technology will lower costs and improve the efficiency of rail which will generate benefits for the Australian economy and society, such as more reliable train services and less congestion on roads.

5.5.3 Government and industry together

There are a range of areas where neither government nor industry can make significant improvements alone, but by working together, can help ensure that rail can address Australia's transport challenges. Areas for focus include improving customer experience, making rail more productive and managing the upcoming stream of projects.

Customer experience depends on pricing, payment systems, on-board experience and infrastructure functionality (among a range of other factors). It is therefore best improved by government and industry working together. By being truly customer focussed the rail industry will be able to grow patronage and therefore grow the industry and the benefits it generates for the economy and society. One channel that could be pursued for improving customer experience could be to make better use of data gathered by industry and government to analyse commuter and customer behaviours and responses. This data analysis could be used to inform ongoing improvements to the way services are provided.

Rail productivity is another area that is best addressed by government and industry working together. Rail productivity can be increased by upgrades to infrastructure and rolling stock, and improvements in regulation and day-to-day operations. Often productivity improvements require a combination of these factors. For example, introduction of locomotives capable of heavier hauls could enhance productivity in some rail freight movements, but before industry can invest government needs to invest in improved infrastructure. In turn, to make these decisions, government first requires certainty from industry on future plans and requirements. By coordinating, government and industry can align their incentives to implement mutually beneficial rail productivity improvements.

An important task for both the rail industry and government is ensuring that Australia has the necessary type and number of skilled workers to deliver the ongoing stream of projects that will be required. This report has identified the scale of investment in road and rail projects that is currently taking place as well as the likely need for ongoing investment to keep pace with growth in the population and the economy. This pipeline of work is being committed to with no clear picture of the workforce required to complete it. For example, at some point in the next 15 years there may be significant work on a metro line in both Melbourne and Sydney. Both projects will compete for the same labour and it is unclear whether the available labour pool in Australia could meet these needs. This is further complicated by the interaction with road projects that will be undertaken at the same time.

A review of these skills and the ability of the labour pool to provide them is required. This review could be conducted by government, but would need significant input from industry about the specific projects and skills expected to be needed in the future. Any such review should take into account both road and rail transport and should clearly identify how skills requirements will develop over the next 10-20 years during the delivery of the range of mega-projects currently underway in Australia.

References

ABS 2017a, *5206.0 – Australian National Accounts: National Income, Expenditure and Product, Mar 2017*, available at: http://www.abs.gov.au/ausstats/abs@.nsf/mf/5206.0

ABS 2017b, *3218.0 – Regional Population Growth, Australia, 2015-16,* available at: http://www.abs.gov.au/ausstats/abs@.nsf/MediaRealesesByCatalogue/28F51C010D29BFC9CA2575A0002126CC

ABS 2013a, *Australia's population projected to double by 2075,* available at: http://www.abs.gov.au/ausstats/abs@.nsf/lookup/3222.0Media%20Release12012%20(base)%20to%202101

ABS 2013b, *3222.0 – Population Projections, Australia, 2012 (Base) to 2101*, available at: http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3222.02012%20(base)%20to%202101?OpenDocument

ARA 2012, *The shortage of engineering and related employment skill,* available at: https://ara.net.au/sites/default/files/Shortage-of-engineering-and-related-employment-skills%20(1).pdf

ARA n.d., *Australian Suppliers*, available at: https://ara.net.au/sites/default/files/u1/ARA_Australian-Rail-Suppliers-REDUCED.pdf

Australian Rail Track Corporation 2017, *Inland rail,* available at: https://inlandrail.artc.com.au/

Australian Rail Track Corporation 2015, *Summary of the 2015 Business Case,* available at: https://inlandrail.artc.com.au/documents

Australian Rail Track Corporation 2015b, *2015-2024 Sydney Metropolitan Freight Strategy,* available at: http://www.artc.com.au/uploads/2015-Sydney-Metro-Strategy-Final.pdf

Australian Treasury 2011, *Strong growth, low pollution: modelling a carbon price, Canberra ACT,* available at: http://carbonpricemodelling.treasury.gov.au/content/default.asp.

Australasian Railway Association 2011, *The true value of rail,* prepared by Deloitte Access Economics, Sydney, available at: https://www.deloitteaccesseconomics.com.au/uploads/File/20110603%20-%20The%20True%20Value%20of%20Rail%20(Final).pdf.

Austroads 2012, *Guide to Project Evaluation Part 4: Project Evaluation Data, Sydney,* available at: https://www.onlinepublications.austroads.com.au/items/AGPE04-12.

Austroads 2016, *Congestion and reliability review,* available at: https://www.onlinepublications.austroads.com.au/items/AP-R534-16

Banister, D 2014*, Sustainable transport and public policy,* available at: http://www.gci.org.uk/Documents/E6-40-04-021.pdf

Barangaroo Delivery Authority 2015, *Overview,* available at: http://www.barangaroo.com/discover-barangaroo/overview.aspx

Barr, A., Rebecca B., Julie A. S., Jan S., Neville O., David D., Lukar T., Lauren K., and Anne K. (2016), *Associations of public transport accessibility with walking, obesity, metabolic syndrome and diabetes.* Journal of Transport & Health, Volume 3, Issue 2, Pages 141-153, available at: http://www.sciencedirect.com/science/article/pii/S2214140516000086.

BCR 2014, *How to reduce your freight costs using buyer's consolidation,* available at: http://logistics.bcr.com.au/blog/how-to-reduce-your-freight-costs-using-buyers-consolidation

BRinternational 2015, *China value added services logistics,* available at: http://www.brint.com.au/warehousing-distribution/china-value-added-services.

Brown B, and Werner C 2009, *Before and After a New Light Rail Stop,* Journal of the American Planning Association, Vol.75, No.1.

Bureau of Transport Statistics 2014, *Travel Forecasts 2011-2046,* available at: http://www.bts.nsw.gov.au/Publications/TransFigures/TransFigures/default.aspx

Bureau of Transport Statistics 2013, *Public Transport Users in Sydney,* available at: http://www.bts.nsw.gov.au/Publications/TransFigures/TransFigures/default.aspx

Bureau of Transport, Infrastructure and Regional Economics (BITRE) 2017, *Australian Road Deaths Database*, Canberra ACT, available at: https://bitre.gov.au/statistics/safety/fatal_road_crash_database.aspx

Bureau of Transport, Infrastructure and Regional Economics (BITRE) 2017a, *Trainline 5 Statistical Report 2017.*

Bureau of Transport, Infrastructure and Regional Economics (BITRE) 2016, *Yearbook 2016 Australian infrastructure statistics,* Canberra ACT, available at: https://bitre.gov.au/publications/2016/yearbook_2016.aspx.

Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2016a, *Trainline 4*, available at: https://bitre.gov.au/publications/2016/files/train_004.pdf

Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2016b, *A dozen facts about transport in Australia,* available at: https://bitre.gov.au/publications/2016/files/is_075.pdf

Bureau of Transport, Infrastructure and Regional Economics (BITRE) 2016c, *Why short-haul intermodal rail services succeed,* available at: https://bitre.gov.au/publications/2016/files/rr_139.pdf

Bureau of Transport, Infrastructure and Regional Economics (BITRE) 2015a, *Australia's commuting distance: cities and regions.* Information Sheet 73, Canberra ACT, available at: https://bitre.gov.au/publications/2015/is_073.aspx.

Bureau of Transport, Infrastructure and Regional Economics (BITRE) 2015b, *Traffic and congestion cost trends for Australian capital cities,* Information Sheet 74, Canberra ACT, available at: https://bitre.gov.au/publications/2015/is_074.aspx.

Bureau of Transport, Infrastructure and Regional Economics (BITRE) 2015c, *Road trauma Australia 2015 statistical summary,* Statistical report, Canberra ACT, available at:

Bureau of Transport, Infrastructure and Regional Economics (BITRE) 2014, *Freightline 1—Australia freight transport overview,* Canberra ACT, available at: https://bitre.gov.au/publications/2014/freightline_01.aspx

Bureau of Transport, Infrastructure and Regional Economics (BITRE) 2013, *Public transport use in Australia's capital cities: Modelling and forecasting,* available at: https://bitre.gov.au/publications/2013/files/report_129.pdf

Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2009a, *Greenhouse gas emissions from Australian transport: projections to 2020, Working Paper 73,* Canberra ACT, available at: https://bitre.gov.au/publications/2009/files/wp_073.pdf.

Bureau of Infrastructure, Transport and Regional Economics (BITRE) 2009b, *Cost of road crashes in Australia 2006,* Research Report 118, Canberra ACT, available at: https://bitre.gov.au/publications/2010/report_118.aspx.

Bureau of Transport, Infrastructure and Regional Economics (BITRE) 2002, *Rail accident costs in Australia,* Report 108, Canberra ACT, available at: https://bitre.gov.au/publications/2003/report_108.aspx.

Champion Post 2015, *The Melbourne to Brisbane Inland Rail project in track for 2018,* available at: http://www.parkeschampionpost.com.au/story/4310267/inland-rail-project-well-on-track/

CRA International (CRAI) 2008, *Value of CityRail externalities and optimal government subsidy,* available at: https://www.ipart.nsw.gov.au/files/sharedassets/website/trimholdingbay/crai_report_-_cityrail_externalities_-_6_june_2008.pdf.

Deloitte Access Economics 2015, *Economic benefits of better procurement practices.*

Deloitte Access Economics 2011, *The true value of rail.*

Dematic 2017, *Breville,* available at: http://www.dematic.com/en-au/news-and-downloads/literature/case-studies/featured-case-studies/breville/

Department of Economic Development, Jobs, Transport and Resources 2016a, *Regional Rail Link,* available at: http://economicdevelopment.vic.gov.au/transport/rail-and-roads/public-transport/regional-rail-link

Department of Economic Development, Jobs, Transport and Resources 2016b, *Regional Network Development Plan,* available at: http://economicdevelopment.vic.gov.au/transport/rail-and-roads/public-transport/regional-network-development-plan

Department of Economic Development, Jobs, Transport and Resources 2016c, *Connecting Regional Victoria – Victoria's Regional Network Development Plan,* available at: http://economicdevelopment.vic.gov.au/__data/assets/pdf_file/0018/1308123/Regional-Network-Development-Plan.pdf

Department of the Environment and Energy 2016, *National Greenhouse Gas Inventory - Kyoto Protocol classifications,* Canberra ACT, available at: http://ageis.climatechange.gov.au/#.

Department of the Environment and Energy n.d., *Australian Greenhouse Emissions Information System, Australian Government,* Canberra, available at: http://ageis.climatechange.gov.au/

Department of Industry 2016, *Inland rail – Central Wes NSW regional economic analysis on the potential impact of the proposed inland rail,* available at: http://www.rdacentralwest.org.au/wp-content/uploads/2016/09/RDACW-Inland-Rail-Report_web.pdf

Department of Industry, Innovation and Science 2012, *On Track to 2040,* available at: https://industry.gov.au/industry/IndustryInitiatives/AustralianIndustryParticipation/SupplierAdvocates/Documents/OnTrackTo2040-Roadmap.pdf

Department of Infrastructure and Regional Development 2016, *Australian Logistic Council Dialogue,* available at: http://www.austlogistics.com.au/wp-content/uploads/2016/04/Dolman-presentation-April-2016-ALC-Dialogue.pdf

Flinders University 2017, *Hospitalised Injury,* Flinders University, Adelaide, available at: https://bitre.gov.au/publications/ongoing/hospitalised-injury.aspx

Fully Loaded 2011, *We Can't Stand Still On Freight Productivity: Woolworths,* available at: https://www.fullyloaded.com.au/industry-news/1109/we-cant-stand-still-on-freight-productivity-woolworths

Genter, J.A., Donovan, S. and Petrenas, B. 2008, *Valuing the health benefits of active transport modes,* Research Report 359, prepared for the NZ Transport Agency, available at: https://www.nzta.govt.nz/resources/research/reports/359/

Harper, I. Anderson, P., McCluskey, S. and O'Bryan M. QC 2015*, Competition Policy Review – Final Report,* Commonwealth of Australia, Canberra, available at: http://competitionpolicyreview.gov.au/files/2015/03/Competition-policy-review-report_online.pdf

Hensher, D.A., Stopher, P.R., Bullock, P. and Ton, T, 2004, *TRESIS (Transport and Environmental Strategy Impact Simulator): Application to a Case Study in NE Sydney,* Transportation Research Record 1898, pp. 114-123.

Hensher, D.A., 2008, *Climate change, enhanced greenhouse gas emissions and passenger transport- what can we do to make a difference?* Transportation Research D, Vol. 13 (2), pp. 95-111.

Hensher, D. A., Rose, J. M., de Dios Ortúzar, J., Rizzi, L. I., 2009, *Estimating the willingness to pay and value of risk reduction for car occupants in the road environment,* Transportation Research Part A, Vol. 4, pp.692-707.

.idcommunity 2017, *City of Greater Geelong population forecast,* available at: http://forecast.id.com.au/geelong

.idcommunity 2017a, *City of Ballarat population forecast,* available at: http://forecast.id.com.au/ballarat

.idcommunity 2017b, *City of Greater Bendigo population forecast,* available at: http://forecast.id.com.au/bendigo/home

Infrastructure Australia 2015, *Population Estimates and Projections,* available at: http://infrastructureaustralia.gov.au/policy-publications/publications/files/Background-paper-on-demographic-projections.pdf

Infrastructure Australia 2014, *Spend more, waste more. Australia's road in 2014: moving beyond gambling,* available at: http://www.ycat.org.au/wp-content/uploads/2014/07/Draft-IA-Roads-Report.pdf

Infrastructure Partnerships Australia 2017*, Infrastructure Pipeline,* available at: http://infrastructurepipeline.org/

Institute of Health and Welfare and Flinders University 2015, *Trends in serious injury due to road vehicle traffic crashes,* Australia 2001 to 2010, Injury Research and Statistics Series no. 89, Cat. no. INJCAT 165. Canberra, available at: http://www.aihw.gov.au/WorkArea/DownloadAsset.aspx?id=60129554604

Intergovernmental Panel on Climate Change (IPCC) 2014, *CLIMATE CHANGE 2014 Mitigation of Climate Change,* presentation by Michael Hanemann, IPCC, Geneva, available at https://unfccc.int/files/methods/other_methodological_issues/application/pdf/wg_iii.pdf

Laird, P. 2005, *Revised Land Freight External Costs in Australia,* Paper presented to the 28th Australasian Transport Research Forum, Sydney.

LECG 2009, *Value of Sydney bus externalities and optimal government subsidy,* available at: https://www.ipart.nsw.gov.au/files/sharedassets/website/trimholdingbay/consultancy_report_-_lecg_draft_report_on_value_of_sydney_bus_externalities_and_optimal_government_subsidy_-_12_may_2009.pdf.

Minister for Infrastructure and Transport 2017, *$20 billion investment in rail,* available at: http://minister.infrastructure.gov.au/chester/releases/2017/may/budget-infra_03-2017.aspx

Moorebank Intermodal Company 2017, Construction begins on Moorebank Logistics Park, available at: http://www.micl.com.au/

Mott MacDonald 2013, *Valuing the social impacts of public transport – Final report, prepared for the Department of Transport,* available at: http://www.socialvalueuk.org/app/uploads/2016/07/DfT-final-report.pdf

Mulley, C. 2016, *Editorial - Public transport and health: Publicising the evidence,* Journal of Transport & Health, Volume 3, Issue 2, Pages 131-132, available at: http://www.sciencedirect.com/science/article/pii/S2214140516301487?via%3Dihub#bib1

National Transport Commission (NTC) 2006, *Productivity Commission Inquiry into Freight Infrastructure Pricing Submission,* National Transport Commission, Melbourne, available at: https://www.ntc.gov.au/Media/Reports/(45CD509B-695A-5123-A0D2-D7E68F6ADC4D).pdf

National Transport Commission 2016, *Who moves What Where – Freight and Passenger Transport in Australia,* available at: https://www.ntc.gov.au/Media/Reports/(D62E6EFC-36C7-48B1-66A7-DDEF3B04CCAE).pdf

Parkes Shire Council 2017, *The National Logistics Hub*, available at: http://www.parkes.nsw.gov.au/business-investment/investment-opportunities/national-logistics-hub/

Productivity Commission 2006, *Inquiry into Road and Rail Freight Infrastructure Pricing, Report no. 41,* Productivity Commission, Canberra, available at: http://www.pc.gov.au/inquiries/completed/freight/report/freight.pdf

Rail Express 2012, *Qube to acquire Macarthur Intermodal,* available at: https://www.railexpress.com.au/qube-to-acquire-macarthur-intermodal/

Rail IRC 2017, *Skills Forecast*, available at: http://www.australianindustrystandards.org.au/wp-content/uploads/2017/03/Rail-Key-Findings-Paper-2017V1.0.pdf

Qube 2017, *Facilities,* available at: http://www.qube.com.au/logistics/facilities/new-south-wales

Sexton, D 2015*, Parks Mayor: Inland Rail crucial to intermodal success,* available at: https://www.railexpress.com.au/parkes-mayor-inland-rail-crucial-to-intermodal-success/

Stanley, J., Hensher, D., Stanley, J., Currie, G., Greene, W., Vella-Brodrick, D. 2011, *Social Exclusion and the Value of Mobility,* Journal of Transport Economics and Policy (JTEP), Volume 45, Number 2, May 2011 , pp. 197-222(26).

Stockland 2016), *Yennora Distribution Centre, Yennora,* available at: https://www.stockland.com.au/investor-centre/our-portfolio/logistics/yennora-distribution-centre

Sydney Metro 2016, *Sydney Metro city and southwest Final Business Case,* available at: https://www.sydneymetro.info/sites/default/files/Sydney%20Metro%20CSW%20Business%20Case%20Summary.pdf

Sydney Trains 2017, *Waratah,* available at: http://www.sydneytrains.info/about/fleet/a_sets

Tooth, R. 2010, *The cost of road crashes: A review of key issues.* Published by LECG and the Australasian Railway Association, available at: http://www.econ.mq.edu.au/Econ_docs/research_seminars/2011_research_seminars/Tooth_Accidents_180311.pdf

Transport and Infrastructure Council 2016, *Australian Transport Assessment and Planning Guidelines (2016),* PV2 Road Parameter Values, Commonwealth of Australia, Canberra, available at: https://atap.gov.au/parameter-values/road-transport/index.aspx.

Transport for NSW 2016, *Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives Transport Economic Appraisal Guidelines, Transport for NSW, Sydney,* available at: https://www.transport.nsw.gov.au/sites/default/files/b2b/publications/principles-and-guidelines-for-economic-appraisal-of-transport-investment.pdf.

Transport for NSW 2014, *Train Statistics 2014,* available at: http://www.bts.nsw.gov.au/Publications/Search-publications/default.aspx?dfaction=search&dfdtitle=train&df263_4

Transport for NSW 2013, *CBD and South East Light Rail Project,* available at: http://data.sydneylightrail.transport.nsw.gov.au/s3fs-public/SLR_CSELR_Project_Update_April_2013.pdf

Transport for NSW 2012a, *Sydney's rail future – Modernising Sydney's trains*, available at: http://www.transport.nsw.gov.au/sites/default/files/b2b/publications/sydneys-rail-future.pdf

Transport for NSW 2012b, *Sydney's light rail future – Expanding public transport, revitalising our city,* available at: https://www.transport.nsw.gov.au/sites/default/files/media/documents/2017/sydneys-light-rail-future.pdf

Transport and Infrastructure Council 2015, *National Key Freight Routes Map,* available at: http://transportinfrastructurecouncil.gov.au/publications/freight_route_maps.aspx

Travel Victoria 2017, *Regional passenger train services,* available at: https://www.travelvictoria.com.au/victoria/trains/

US Department of Energy 2017, *Average per-passenger fuel economy of various travel modes,* available at: https://www.afdc.energy.gov/data/10311

VicRoads 2017, *Crash data base,* Victorian Government, Melbourne, available at: https://www.data.vic.gov.au/data/dataset/crash-stats-data-extract

Victoria University 2014, *Food Australia Map,* available at: https://fial.com.au/system/files/knowledge_repository/Food%20Australia%20Map%20Warehousing%20Overview.pdf

V/Line 2017a, *Train and coach timetables,* available at: https://www.vline.com.au/Timetables/Train-coach-timetables

V/Line 2017b, *Performance and capacity,* available at: https://www.vline.com.au/About-V-Line/Performance

V/Line 2016, *Annual Report 2015-16,* available at: https://corporate.vline.com.au/getattachment/6ad41cbe-17f6-489c-9fac-d65a1a627131/Annual-Report-2015-16

WestConnex 2017, *WestConnex,* available at: https://www.westconnex.com.au/

Woolworths Group 2017, *People Planet Prosperity – Corporate Responsibility Strategy 2020,* available at: https://www.woolworthsgroup.com.au/icms_docs/186036_woolworths-group-corporate-responsibility-strategy-2020.pdf

Woolworths 2011, *National Land Freight Strategy Discussion Paper,* available at: http://infrastructureaustralia.gov.au/policy-publications/submissions/nlfs/files/110509_WOW_SUBMISSION_National_Freight_Strategy_Discussion_Paper.pdf

Appendix A – Sensitivity analysis

The price of carbon has bearing of the emissions externalities benefit from rail calculated in Chapter 3. However, there are a number of factors that make pricing carbon challenging. For example, the effect of today's emissions will happen from now into the distant future. Further challenges include that the magnitude of effects are highly uncertain, impacts are felt globally and they depend on the trajectory of emissions over time (that is, the damages depend on the level of greenhouse gas concentration already in the atmosphere).

For these reasons, the assumed carbon cost of $59.53 per tonne is not necessarily representative of the true cost of carbon emissions. Table A.1 therefore uses a range of carbon costs to derive unit values of avoided carbon emissions from replacing road by rail transport.

Table A.1 Avoided carbon costs from using rail instead of road transport at different carbon prices, in 2015-16 prices

Carbon price ($/tonne)	Avoided emissions cost (cents/passenger km)
20.00	0.09
59.53	0.27
50.00	0.23
75.00	0.34
100.00	0.45

The cost of congestion is also difficult to assess. Different values for travel time savings significantly alter the values calculated. Table A.2 sets out a sensitivity analysis for the value of time, using plus and minus 20% of the parameter values set. This accounts for the uncertainty of the correct value of travel time which is difficult to measure empirically.

Table A.2 Avoided congestion costs sensitivity analysis, in 2015-16 prices

City	Core estimate	VTTS +20%	VTTS -20%
Sydney	$9.09	$10.91	$7.27
Melbourne	$7.11	$8.53	$5.69
Brisbane	$2.43	$2.91	$1.94
Perth	$4.03	$4.83	$3.22

Table A.3 presents a range of other carbon prices to calculate potential carbon emission cost savings from using rail for freight instead of road.

Table A.3 Carbon emissions costs at different carbon prices, in 2015-16 prices

Carbon price ($/tonne)	Emissions cost (c/tonne km)
20.00	0.26
59.53	0.78
50.00	0.65
75.00	0.98
100.00	1.30

Appendix B – Transport modelling

B.1. Overview

Transport modelling was undertaken by the Institute of Transport and Logistics Studies at the University of Sydney Business School using their in-house land use and transport models. The outputs used for this study are based on two different model versions. For Brisbane, Perth and Melbourne, the study relies on the outputs generated in 2011 using the TRESIS model. For Sydney, the study uses a combination of outputs generated by TRESIS and MetroScan-TI. MetroScan-TI was developed from the TRESIS model, however, it uses updated parameter values and inputs, includes a model related to private trips and includes a higher granularity of regions. The following Section describes the TRESIS model, while Section A.3 presents MetroScan-TI.

B.2. Tresis

The Transport and Environmental Strategic Impact Simulator (TRESIS) is a microsimulation package, developed at the Institute of Transport and Logistics Studies (ITLS), part of the University of Sydney. It is designed as a policy advisory tool to evaluate, at a strategic level, the effect of policy instruments on urban passenger travel behaviour and the environment. Versions of TRESIS can be applied to Canberra, Sydney, Melbourne, Brisbane, Adelaide, and Perth.

As an integrated model of many aspects of household decision-making such as location of home and work as well as vehicle stock, TRESIS offers users the ability to analyse and evaluate a variety of land use, transport, and environmental policy strategies or scenarios for urban areas.

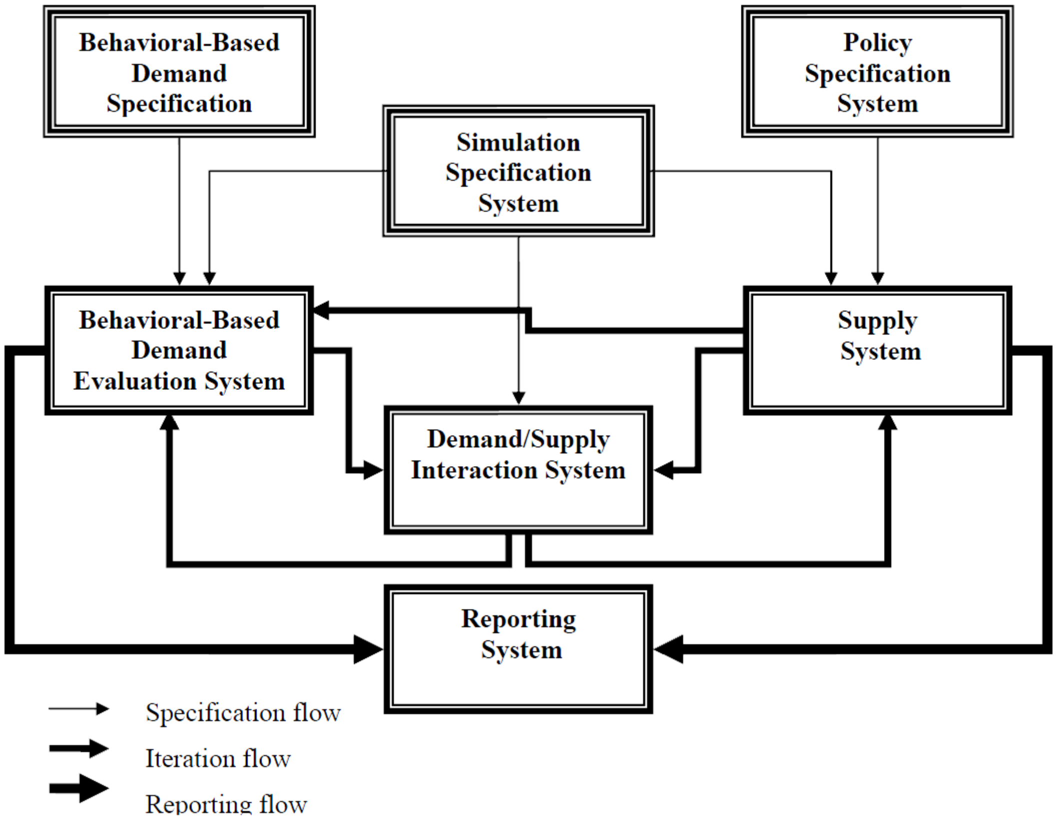
The behavioural engine of TRESIS encompasses key household, individual, and vehicle-related decisions; in particular:

- Residential location of households;
- Type of dwelling;
- Location of employment;
- Household's number and type of vehicles;
- Modes of transport; and
- Time of travel.

From this, a range of economic and environmental impacts are estimated on a year by year basis. The results of a base case scenario are used as references to compare with those of the policies and projects to be tested. The system generates a number of performance indicators to evaluate these effects in terms of economic, social, environmental and energy impacts.

TRESIS is structured around seven key systems, set out in Figure A.1.

Figure B.1 TRESIS' component systems



Source: Hensher (2004)

Simulation specification system

This system provides a means for users of TRESIS to control factors such as:

- the types, sources, and locations of input and output from TRESIS;
- the heuristic rule for accommodating the temporal adjustment process;
- the number of future years to be simulated from the present year; and
- the specification to control the calibration and iteration process of TRESIS run.

The heuristic rule for accommodating the temporal adjustment process needs to be clarified. The model system in TRESIS is static and hence produces an instantaneous fully adjusted response to a policy application. In reality, choice responses take time to fully adjust, with the amount of time varying by specific decision. We expect that it would take longer for the full effect of the change in residential location to occur and much less time for departure time and even choice of transport mode. TRESIS allows users to impose a discount factor that establishes the amount of a change in choice probability that is likely to be taken up in the first year of a policy. It removes the rest of the change and uses the new one-year adjustment as the starting position for the next year.

Behavioural demand specification system

This system provides the household characteristics data and model formulation for the behavioural demand evaluation system of TRESIS. It contains a module for constructing a synthetic household database as well as a suite of utility expressions representing the behavioural system of choice models for individuals and households. These models are based on mixtures of revealed and stated preference data. Each synthetic household carries a weight that represents its contribution to the total population of households. Through time TRESIS carries forward the base year weights or, alternatively, modifies the weights to represent the changing composition of households in the population.

Households adjust their residential location in response to changes in the transport system and for other reasons. Consequently any one of a number of strategies can influence the probability of a household both living in a particular location and the type of dwelling they choose to occupy. At any point in time there will be a total demand for dwelling types in each residential location. Excess demand will result in an increase in location rents and dwelling prices; excess supply will result in a reduction in the respective rents and prices. In TRESIS, dwelling prices are used to clear both the market for dwelling types and location.

Disequilibrium is allowed for when an injection of new dwellings creates excess supply given the number of households. Any additional dwellings will be left vacant in the particular year as an indication that property developers may have created too much stock at that time. In future years as households grow the take up rate increases without creating increases in dwelling prices until the market is cleared.

Supply system
This system contains four key databases:

- Transport network database (with different levels of service for each time of day for each of six main modes of transport including drive alone, ride share, train, bus, light rail and busway)
- Land-use zone database (with attributes such as number of different dwelling types and associated prices, number of jobs, etc.);
- Automobile technology or vehicle database (number of different vehicle types and associated performance and energy indicators); and
- Policy and environment parameters database (carbon contents in petrol, diesel, CNG and electric vehicles and others).

Key attributes (such as travel times for different times of the day, demand level and associated prices of housing) of transport network and zone databases are updated dynamically at run time during the calibration process to reflect the impact of the demand system on the supply system. In return, the newly updated attributes of the supply system will have an impact on the behavioural demand evaluation system. The iterative control process is handled by the demand/supply interaction system.

Policy specification system
A rich array of policy instruments is supported in TRESIS, such as new public transport, new toll roads, congestion pricing, gas guzzler or greenhouse gas taxes, changing residential densities, introducing designated bus lanes, implementing fare changes, altering parking policy, introducing more flexible work practices, and the introduction of more fuel efficient vehicles.

The policy specification system employs a graphical and map-based (Map Objects) user interface to translate a single or mixture of policy instruments into changes in the supply system.

Behavioural demand evaluation system
Given the input from the behavioural demand specification system and the supply system, the characteristics of each synthetic household are used to derive the full set of behavioural choice probabilities for the set of travel, location and vehicle choices and predictions of vehicle use.

Demand/Supply interaction system
This system contains three key procedures to control or equilibrate the three different types of interactions between demand and supply. The key mechanism for driving these three procedures is the level of interaction between demand and supply. The three procedures are:

- Equilibration in the residential location and dwelling type market involves establishing total demand for different dwelling types in each residential location calculated at any point in time. Excess demand will result in an increase in location rents and dwelling prices. In TRESIS, prices for different dwelling types are used to clear the markets for dwelling types and locations, in the absence of data on location rents.
- For equilibration in the automobile market: a vehicle price relative model is used to determine the demand for new vehicles each year. This model controls the relativities of vehicle prices by vintage via given exogenous new vehicle prices. A vehicle scrappage model is used only to identify the loss of

used vehicles consequent on vintage and used vehicle prices, where the latter are fixed by new vehicle prices in a given year. The supply of new vehicles is determined as the difference between the total household demand for vehicles and the supply of used vehicles after application of the scrappage model based on used vehicle prices.
- For equilibration in the travel market: households might adjust their route choices between origin and destination, or trip timing and/or mode choice in response to changes in the transport system, particularly the travel time and cost values between different origins and destinations. In other words, different households can have different choices in responding to changes in different levels of service at different times of day.

Output

TRESIS provides a comprehensive set of outputs representing performance indicators such as impacts on greenhouse gas emissions, accessibility, equity, air quality and household consumer surplus. The output is in the format of summary tables cross-tabulated by household types, household incomes and residential zones and in more detailed format by origin and destination, by different times of day and by different simulation years.

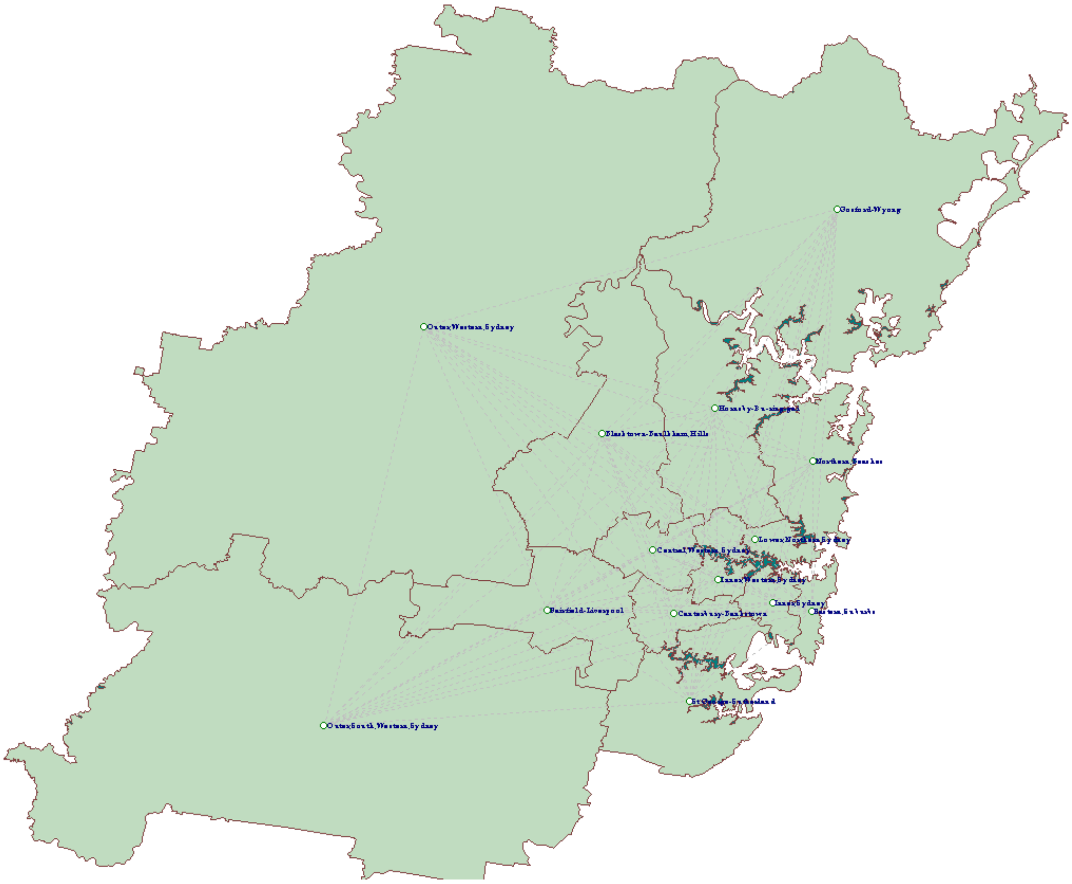
It contains a set of choice models for:

- commuting — includes choice of working hours, departure time, mode of transport and workplace location;
- automobile choice — type of vehicle and number of vehicles per household;
- residential — location and dwelling type; and
- automobile use — annual vehicle and kilometres travelled by the household and the spatial composition of this travel.

This input is combined to create a model where households select their home and work locations as well as their transport decisions, including whether to own a car or not. TRESIS has been used to analyse diverse situations including the benefits that could flow from increased bus use in Melbourne (Stanley 2007), an improved road connection in north east Sydney (Hensher *et al.*, 2004) and from congestion pricing on Sydney's roads (Hensher, 2008).

One key advantage of TRESIS is that it allows modelling to be targeted to each major Australian city. This report focuses on congestion costs for Sydney, Melbourne, Perth and Brisbane. Each city is represented by a number of regions with each region having road, rail and bus links to other regions. Sydney, for example, is made up of 14 regions, as is shown in Figure A.2.

Figure B.2 TRESIS regions in Sydney



Source: TRESIS

B.3. MetroScan-TI

MetroScan-TI is the successor model of TRESIS. Compared to TRESIS, it has updated parameter values, inputs, more granular geographic detail and additional models related to non-work trips. In particular, MetroScan-TI seamlessly integrates the latest releases of Economic Development Research Group's TREDIS and the TRESIS models. MetroScan-TI uses integrated passenger, freight, land-use and economic models that have rich feedback between location and travel related decisions, using detailed behavioural data.

The main outputs of used for this study are:

- Number of business and commuting trips made by rail in Sydney (2016-2022);
- Number of business and commuting trips made by car in Sydney (2016-2022); and
- Total kilometres walked by train users in Sydney.

These outputs were provided for an average weekday and then annualised with a factor of 248.

Appendix C – Approach to estimate congestion cost

The outputs used from TRESIS and MetroScan-TI to estimate rail transport externalities were:

- Total travel time; and
- Annual number of journeys by each mode.

Both models also provide information on carbon emissions. To estimate congestion costs for Melbourne, Perth and Brisbane, this study uses a 2011 model run from TRESIS (these costs were adjusted for the purpose of this report to reflect increases in congestion costs since 2011). The 2017 version of the MetroScan-TI model and previous TRESIS modelling results were used to generate congestion cost estimates for Sydney.

Following an approach developed for the NSW government (CRAI 2008, LECG 2009), this study measures congestion costs in terms of the increase in travel time and carbon emissions imposed by an extra road user on all existing road users.

Generally, we can say that travel time is an increasing function of journeys by both road and rail. Considering congestion, there should be a quadratic relationship between the number of journeys and total travel time; this is because each additional road user will generate congestion externalities which increase the average travel time for all other road users. In contrast, the relationship between total travel time and the number of train journeys should be linear as the central organisation of the train system should be able to manage additional journeys.

This leads to the following functional form for a relationship between the number of journeys and total travel time:

$$\text{Total travel time} = \beta_1\text{*(rail journeys)} + \beta_2\text{*(road journeys)} + \beta_3\text{*(road journeys)}^2$$

This parameterisation allows the identification of average journey time for the different modes of transport. For rail, the average journey time is given by β_1 while for road the average journey time is:

$$(\beta_2\text{*(road journeys)} + \beta_3\text{*(road journeys)}^2)/\text{(road journeys)}$$

Here, average road travel time depends on the number of road journeys, this reflects the congestion externality.

Using output from TRESIS on how people change their transportation decisions when the train fare is increased or decreased, the parameters (β_1, β_2 and β_3) can be extracted using ordinary least squares regression.

Once these parameters have been extracted, we can then carry out the thought experiment of moving one person from road to rail transport

$$\text{Total travel time}_{\text{base}} = \beta_1\text{*(rail journeys)} + \beta_2\text{*(road journeys)} + \beta_3\text{*(road journeys)}^2$$
$$\text{Total travel time}_{\text{experiment}} = \beta_1\text{*(rail journeys+1)} + \beta_2\text{*(road journeys-1)} + \beta_3\text{*(road journeys-1)}^2$$

We can then find the different in total travel time

$$\text{Total travel time}_{\text{experiment}} - \text{Total travel time}_{\text{base}}$$

This difference is made up of three components, the increase in rail travel time for the passenger that has been shifted, the decrease in their road travel time and the decrease in other people's road travel times. We can identify these three components as:

Average increase due to own shift to rail = β_1

Average decrease due to own shift from road = $-(\beta_2 * x + \beta_3 * x^2)/x$

This leaves an amount which is unaccounted for, the externality on other road users.

This approach gives the following results presented in Table C.1.

Table C.1 Congestion externality modelling results - 2011 models

City	β_1	β_2	β_3
Sydney	56.56	54.26	4.27×10^{-8}
Melbourne	71.69	32.59	3.68×10^{-8}
Brisbane	67.22	26.53	2.89×10^{-8}
Perth	57.94	21.94	4.59×10^{-8}

Note: All coefficients are statistically significant at the 1% level of significance.

Based on these coefficients, the change in travel time for existing road users were calculated for the 2011 study (refer to first column of Table C.2). For the purpose of this report, it was estimated that these costs have increased in line with BIITRE estimates on congestion costs in major Australian cities. BITRE (2015b) estimates that congestion costs have increased by 25% in Melbourne, 24% in Brisbane and 31% in Perth between 2011 and 2016.

Table C.2 Change in travel time for existing road users (minutes)

City	2011 estimates	2016 estimates
Melbourne	-17.10	-21.3
Brisbane	-5.90	-7.3
Perth	-9.20	-12.1

Source: MetroScan-TI, Deloitte Access Economics calculations.

The MetroScan-TI model provided updated 2016 and forecast rail and car trips enabling to estimate travel time savings due to reduced congestion related to one traveller switching from road to rail. The results are presented in Table C.3, together with the 2011 value calculated for the Australasian Railway Association (2011) report using a similar approach.

Table C.3 Change in travel time for existing road users in Sydney (minutes)

City	Reduction in travel time
2011	22.50
2016	27.30
2017	27.58
2018	27.85
2019	28.13
2020	28.41
2021	28.70
2022	28.98

Source: MetroScan-TI, TRESIS, Deloitte Access Economics calculations.

Limitation of our work

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