The Potential Impacts of High Speed Passenger Rail to Eastern Australia

Discussion Paper

Australasian Railway Association (ARA)
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Note to Reader

The cost figures for different International projects are not strictly comparable for a number of reasons including: outlays of projects costs may be at different points in time, accounting conventions may be different; cost estimates are in different foreign currencies with varying inflation and fluctuating exchange rates. Most cost data was converted to 2012 but others were left in the year as provided. In general the rolling stock is excluded from the per km unit costs.
Executive Summary

Aurecon undertook desk-top research to support this discussion paper by the Australasian Railway Association (ARA) which looks at a range of issues relating to high speed rail in Australia including demographic trends, the international experience of high speed rail; international construction costs and the potential economic impact of high speed rail.

This discussion paper should be considered high-level and the information and assertions outlined on the range of issues would require further detailed analysis and testing if they were to be considered further.

According to the Australian Bureau of Statistics (ABS), by 2061 (less than 2 generations) Australia’s current population of 22.7million will have grown to between 36.8 to 48.3 million and 40 years later could reach between 42.4 and 70.1 million.

This rapid growth is likely to be felt most by the east-coast Capital Cities where, the ABS has speculated, the greatest increase will be felt. Their projection is that –

- 83% of Victoria’s population will live in Melbourne compared with 75% in 2012,
- 74% of New South Wales population (the largest total population gain) will live in Sydney in 2061 up from 64% in 2012, and
- 52% of Queensland’s population (up from 48% in 2012) will reside in Brisbane in 2061.

If we “do nothing”, within 2 generations we could see the emergence of Australian “MegaCities”.

We hold that Australia must decide whether it is prepared to see a sociological shift away from the present Australian lifestyle of suburbanisation or invest in solutions to position and redefine regional living as an alternative.

High Speed Rail (HSR) provides a demonstrated alternative to this imposed aggregation. Europe, Japan, and China have seen the emergence of “Domicile Cities” – places to live and sleep, but not necessarily work. A recent UIC (International Union of Railways, see http://www.uic.org/) study evaluated this phenomenon and hit upon the issue that HSR had a direct positive impact in a cultural change between “Sleeping Cities” and “Working Cities”. HSR cities benefited from a distinct positive enhancement in “Image” - the image, self-image, and self-worth of a city - and change it in a positive way.

Apart from the HSR infrastructure itself, it was evidenced that HSR development directly stimulated other development - such as green energy, high-tech power plants and the production of solar panels. Fulda in Germany or Kakegawa in Japan are noted examples – where there was a direct city benefit from the image of HSR itself in that it is seen to convey modernity, innovation, “green”. Other cities such as Nantes, Le Mans, Le Creusot or Vendome (France),
Valladolid, Segovia or Cordoba (Spain) as well as Montabaur, Kassel or Fulda (Germany) capitalised upon their connection to the HSR network as a stimulus to initiate urban and economic development. Examples include formerly agricultural areas which are now attractive for industry, offices, services or retailers. CBD renewal was also highlighted by converting existing areas in a city centre after connection to the HSR.

It has thus been demonstrated that –

- **HSR influences the image of a city or changes it in a positive way**
- **HSR has the tendency to stimulate a change or redevelopment in land use**
- **HSR stimulates economic investment in brand new industries**

There is a clear positive distinction between HSR cities and non-HSR cities in the same country in terms of benefits in the areas of industry, retail/shopping, offices, hotels, residential areas and entertainment.

Australian HSR has been under serious investigation since the early 1980s. These studies have indicated that a high-speed rail service between the major eastern capital cities could be beneficial – if not viable. The most recent 2013 study proposed a price tag in the order of $114 billion and a route in excess of 1700km. A more recent 2014 study (the Zero Carbon Australia High Speed Rail report published in April 2014) contemplates a development cost of approximately $80 billion.

Notwithstanding the cost of HSR development, which we consider a little further on, countries all over the world are making the investment decision and are reaping the benefits. A notable example is China, where in the 1990s the country was suffering rapid urbanisation and the associated costs arising from massive population shifts into the major cities. This was evidenced by problems such as air quality, water, and lack of infrastructure such as roads, leading to consumable shortages. In short, Chinese *MegaCities* were choking and straining to provide for their rapidly growing populations. The population was forced to suffer road congestion and a marked degradation in the city’s standard of living. As these cities competed for economic growth, it soon became evident that they were self-limited in terms of growth unless they could find a solution to the *MegaCity* itself.
China’s HSR has been widely hailed as the stimulus for an economic revolution – a carefully considered strategy to introduce bullet train (HSR) services to connect the MegaCities of Beijing, Shang-Hai, and Guangzhou with surrounding secondary cities. This centrally planned and initiated strategy has served to stimulate the development of second and third tier cities and eliminate or minimise the loss of quality of life of the rapidly growing urban population.

To truly appreciate the impact which HSR can have upon a population and its culture, one must consider Japan’s Shinkansen – an idea which started in 1939. From the very start, the service received significant passenger acceptance, and by 1970’s Osaka World Expo had grown well beyond a novelty into an accepted service.

The Shinkansen has proven itself to be a resounding success not the least of which for passenger safety. In fact Japan’s demonstration of the benefits of HSR is recognised as the spur for HSR development around the world, specifically in Europe. France’s TGV, which began operations in 1981, and Germany’s Inter-City Express ICE which commenced operations in 1991 were modelled largely on the Shinkansen service.

In this paper we consider and reveal the possible impacts – the pros and cons of HSR on eastern Australia including operating high speed freight trains - adding HSR Freight as a viable add-on to Australia’s HSR Passenger.

We hold that HSR is a topic which must be debated now if Australia is to be in a position to effectively and proactively manage Australian’s projected population growth, and at the same time manage the increasing freight tasks. We propose that the Australian Government should consider the establishment of a High Speed Rail Development Office with a clear mandate and strict deadline to define and specify the best and most effective HSR solution for Australia. We suggest that the Government must consider the greater benefits to the community which HSR can yield and formalise its commitment to HSR.

We suggest that innovative financing – perhaps linked to the introduction of investment bonds specifically for the development of the project targeted toward the small, private-sector investor be considered.

We strongly suggest that the proposed High Speed Rail Development Office consider and seek to understand why overseas HSR construction costs are generally significantly lower per kilometre than estimates previously considered for Australia.

<table>
<thead>
<tr>
<th>Country</th>
<th>Unit Cost per km (AU$m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia Dept. of Infrastructure &amp; Transport Report</td>
<td>$65.0m</td>
</tr>
<tr>
<td>Australia Beyond Zero Emissions Report</td>
<td>$43.2m</td>
</tr>
<tr>
<td>China (350km/h HSR weighted cost per line)</td>
<td>AU $16.84m to AU $32.97m</td>
</tr>
<tr>
<td>Japan</td>
<td>AU$32.1m to AU$69m</td>
</tr>
<tr>
<td>Europe</td>
<td>AU$27.8m to AU$43.3m</td>
</tr>
<tr>
<td>USA (California HSR)</td>
<td>$57.8m</td>
</tr>
</tbody>
</table>
We hold that there are significant opportunities to leverage on overseas construction methodologies and approaches, potentially resulting in significant savings.

We suggest that the opportunity to leverage overseas construction methodologies and approaches be considered so as to benefit from significant cost savings. Within such a philosophy we propose that internationally competitive rates of say AU$35 m per km might be considered for the Australian HSR with the total project delivered for approximately AU$63 billion¹.

Notwithstanding the outcomes of these considerations, we strongly advocate that proactive land use policies must be adopted to preserve and utilise high-speed rail alignments and that the Government formalise its commitment to high speed rail and open the project to the market.

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¹ This estimate is based on international benchmarking. Further analysis will be required to confirm HSR delivery costs in Australia.
2 **Australia is at a decision point in its economic development**

2.1 **Australian Capital City Population Growth**

Within 50 years, Australia will either have followed the path of many Asian countries and adopted a philosophy of greater population aggregation, or actively encouraged population spread into Australian regional centres.

It is highly likely that population aggregation will be the “do nothing” outcome.

By way of context, the Australian Bureau of Statistics (Cat: 3220) defined Australia’s population at 30-Jun-2012 as 22.7 million. Their reasonable projection is that this will increase to between 36.8 to 48.3 million by 2061, and reach between 42.4 and 70.1 million by 2101.

If growth continues as it has, this will be felt most in the east coast capital cities. By 2061, it is projected that –

- 83% of Victoria’s population will live in Melbourne compared with 75% in 2012,
- 74% of New South Wales population (the largest total population gain) will live in Sydney in 2061 up from 64% in 2012, and
- 52% of Queensland’s population (up from 48% in 2012) will reside in Brisbane in 2061.

Not surprisingly, such massive population growth - with the total Australian population more than doubling in less than 2 generations, centred largely upon capital cities - will have a significant impact in how those capital cities are governed and operated. Infrastructure investment in such “MegaCities” will require new thinking, investment in different infrastructure, and a completely new way of life for many of Australia’s population – not simply more of the same on a larger scale.

**Put simply, Australia must decide whether it intends to see investment gravitate toward the development of Australian MegaCities and thereby see a sociological shift away from the present Australian lifestyle of suburbanisation or invest in transport solutions that position regional centres as an alternative to city living and employment**

**MegaCities** impose a quite different investment strategy than rural and regional urbanisation. In short, concentrating populations into geographically small, densely populated areas necessitates more significant community infrastructure (energy, water, etc) as well as imposing a quite different lifestyle upon the population.

2.2 **Australian High Speed Rail (HSR) to better manage Population Aggregation**

High Speed Rail (HSR) offers an alternative path to imposed regionalisation – by facilitating Capital City growth not at the cost of MegaCity aggregation. HSR brings clear and significant economic benefits to the communities it serves - not only in terms of lower cost of travel but also in reduced environmental impact of that travel.

Recent and ongoing research demonstrates that HSR uses much less energy per kilometre than auto or air travel.

HSR in Australia has been under serious investigation since the early 1980s. Various studies and recommendations have asserted that a high-speed rail service between the major eastern capital cities could be viable. In 2013 the Australian Government released Phase 2 of a study
on the implementation of high-speed rail on the east coast of Australia, linking Melbourne, Canberra, Sydney, Brisbane and regional centres in between. With a price tag in the order of $114 billion and a route in excess of 1700km, the proposal is indeed significant. A more recent study, the Zero Carbon Australia High Speed Rail report published in April 2014, proposes to reduce the development cost to approximately $80 billion. Regardless of the total project price, it must be highlighted that the total figure would not be invested at once; rather high-speed rail is a staged project that would be rolled out and therefore invested in over many years.

A significant portion of the research underpinning recent HSR reports focussed on the diversion of passengers from the airline industry as the largest income stream underpinning the potential viability of the proposed high speed rail in Australia. Very little attention was given to other revenue sources such as high speed freight. The volume of freight moved in Australia is growing steadily and has been predicted to double by 2030 from 2010 levels. Road-based trucks carry up to 95% of freight between Melbourne and Sydney and Sydney and Brisbane. With growing freight volumes on Australian roads, this will be an ever bigger problem suggesting options for using the high speed rail for freight should be examined.

In this paper we investigate the possible impacts – the pros and cons of HSR on eastern Australia including operating high speed freight trains.

2.3 We propose

We propose to highlight the opportunities to be had, the niche markets to target, the benefits which are likely to be achieved in terms of additional revenue stream to Australia’s HSR. We also seek to add value to the economics of the Australian HSR debate by adding HSR Freight as a viable add-on to Australia’s HSR Passenger. Various forms of integration between HSR passenger and freight are explored.

HSR is a topic which must be debated now if Australia is to be in a position to effectively and proactively manage Australian’s projected population growth, and at the same time manage the increasing freight tasks. This debate must contemplate a “proactive governance” position – that a wise investment now, is far better than a reactive investment in the future. We hold that Australia cannot wait until 2065 to make a decision on HSR – when, it is projected, individual trips down Australia’s East Coast would double from current levels to 355 million per annum.

We propose that the Australian Government should consider the establishment of a High Speed Rail Development Office to determine the best and most effective HSR solution for Australia. We suggest that the Government must consider the greater benefits to the community which HSR can yield and formalise its commitment to HSR.

We suggest that innovative financing – perhaps linked to the introduction of investment bonds specifically for the development of the project targeted toward the small, private-sector investor be considered.

We strongly suggest that the proposed High Speed Rail Development Office consider and seek to understand why overseas HSR construction costs are generally significantly lower per kilometre than estimates previously considered for Australia. We suggest that the opportunity to leverage overseas construction methodologies and approaches be considered so as to benefit from significant cost savings. Within such a philosophy we propose that internationally competitive rates of say AU$35m per km might be considered for the Australian HSR with the total project delivered for approximately AU$63billion1.

Notwithstanding the outcomes of these considerations, we strongly advocate that proactive land use policies must be adopted to preserve and utilise high-speed rail alignments and that the Government formalise its commitment to high speed rail and open the project to the market.

1 We strongly suggest that the proposed High Speed Rail Development Office consider and seek to understand why overseas HSR construction costs are generally significantly lower per kilometre than estimates previously considered for Australia. We suggest that the opportunity to leverage overseas construction methodologies and approaches be considered so as to benefit from significant cost savings. Within such a philosophy we propose that internationally competitive rates of say AU$35m per km might be considered for the Australian HSR with the total project delivered for approximately AU$63billion.
3 Lessons to be learned

3.1 The Emergence of Chinese *MegaCities*

The Asian development of *MegaCities* is fuelled out of a desire of the population to move to middle-class areas, access labour markets, access more and better social services, and improve their social standing.

But *MegaCities* come at a price – from high levels of traffic congestion (including the loss of productivity from a workforce “parked” on the motorway), pollution, crime, and diminished quality of life. Many Asian cities, having previously embraced the *MegaCity* social philosophy are now looking to transportation technology to provide a means by which they can capitalise on the benefits of being a *MegaCity* without requiring their population to live within their boundaries.

By way of example, in the 1990s the average speed of Chinese passenger rail was well below 60 km/h. Significant investment had been put towards improving this efficiency with only short-term or limited geographic improvement. It was evident that the existing service was a victim of its own success with predominantly commuter, short-haul, all-stops, slow-speed, though reliable services.

In the 1990s China was suffering rapid urbanisation and the associated costs arising from massive population shifts into the major cities. This was evidenced by problems such as air quality, water, and lack of infrastructure such as roads, leading to consumable shortages. In short, Chinese *MegaCities* were straining to provide for their rapidly growing populations. The population was also forced to suffer road congestion and a marked degradation in the city’s standard of living. As these cities competed for economic growth, it soon became evident that they were self-limited in terms of growth unless they could find a solution to the *MegaCity* itself.

3.2 The Regional Impacts of HSR to China

Improving transport infrastructure links with nearby cities was soon identified to be the best strategy for mitigating the *MegaCity* challenge. HSR allows individuals to provide economic
value to the MegaCity without the MegaCity having to house and service them. Consequently, the cities of Tianjin, Nanjing, and Shaoguan (located between 100 and 750 km from China’s MegaCities of Beijing, Shanghai, and Guangzhou) were identified as joint beneficiaries of the economic growth being enjoyed by their MegaCity neighbours.

In 2006 China’s Ministry of Railway (MOR) announced its ambitious plan to introduce “Bullet Train Services” – a strategy which accepted that the existing services were providing good service to their commuter passengers but couldn’t be expected to solve the more complex problem of decentralising China’s population out of its Megacities.

The first Bullet Train line began operations in April 2007 providing services up to 200–250 km/h. Coinciding with the 2008 Beijing Olympic Games, in August 2008 another HSR commenced operations between Beijing and Tianjin. This reached an even more impressive operating speed of around 350 km/h and heralded the services to come. By the end of 2010, China’s HSR network covered 8,358 km with plans in place to increase this to 12,000 kms by 2020 and in doing so, connect each regional centre with a population of 200,000 or more by HSR or expressway.

HSR is widely regarded as one of the most significant technological breakthroughs in passenger transportation of the 20th century. The MOR’s strategy to introduce bullet train (HSR) services to connect the MegaCities of Beijing, Shang-Hai, and Guangzhou with surrounding secondary cities was carefully (and centrally) planned and initiated so as to stimulate the development of these second and third tier cities and eliminate or minimise the loss of quality of life of the rapidly growing urban population.

The World Bank Working Paper High-Speed Rail: The Fast Track to Economic Development? (No. 55856) states that HSR has a distinct time advantage over air travel for journeys of up to 3 hours or 750 km. Shorter journeys, perhaps up to 100 km still compete with the private vehicle – but this edge is diminished as congestion grows. Hence, there is a “sweet spot” – a point not too close, and not too far – where HSR can provide a vital link between the MegaCity and the “Domicile City” (the place where people live, raise their families, but not necessarily work). In China the emergence of these Domicile Cities has been seen to be especially well accepted; with public transport usage well established, and private vehicle ownership and use low.

Figure 1 - Planned dedicated high-speed passenger line network 2020, Ministry of Railways China, Mid to Long-Range Network Plan (MLRNP)
Some firms and government offices are even relocating to the *Domicile Cities* to be closer to their workforce and thus capitalising on lower rents and greater workforce productivity – as opposed to how it was previously with workers coming to the *MegaCity* to be closer to their employer.

The growth of Domicile Cities has also led to a significant shift in real estate wealth – with these developing cities able to capitalise on a growth in individual home demand, and economic development of relocated firms.

The detailed criteria by which the MOR selected which cities would be connected have not been publicly disclosed. It is clear that many regional cities were keen to embrace the concept. An example is Tianjin (specifically the Baodi district of Tianjin) which expected to get a high-speed rail station – and didn’t.

Opportunistic property developers incorrectly identified the boom to come. At one count, the district has 3,000 unfinished villas, at least one empty shopping village, and an abandoned recreational centre.

3.3 The Japanese “Bullet Train”

Despite its technological “edge”, HSR is not a 21st century concept. In fact Japan can look back to 1939 and point to the *Dangan Ressha* (bullet train) Project as perhaps the precursor to today’s modern HSR.

Just 67 years after the country opened its first railway line in 1872 between Shinbashi in Tokyo and Yokohama to the south in Kanagawa Prefecture, Japan developed aspirations of a HSR to boost rail passenger travel between Japan’s burgeoning MegaCities.

With the onset of global war, the *Dangan Ressha* was abandoned although part of it subsequently lived on with some of the alignment’s unfinished tunnels and partially constructed infrastructure being ultimately incorporated into the *Shinkansen*.

Unlike much of Japan’s existing rail network (1067mm gauge), the *Shinkansen* was built to Standard Gauge (1435mm) and against strong opposition from those who argued that rail transport was old technology. Design/development of the *Shinkansen* began in earnest in 1957 against the backdrop of Japan’s post-war emergence as an economic and
manufacturing nation. After 7 years of dedicated and persistent development, the Tōkaidō Shinkansen commenced operations in 1964.

From the very start, the service has received significant passenger acceptance which has given rise to substantial passenger growth. By the 1970 Osaka World Expo the service had increased to 16 trains, and later grew to include Osaka and Okayama in 1972 and to Hakata in 1975.

The service has also improved with the inclusion of dining cars; a typical service offered by United States' inter-city passenger trains.

As might be expected of any new technology, the Shinkansen suffered its fair share of issues including complaints of noise and vibration from adjoining properties. A wide ranging number of closures were effected in the period 1974 to 1982 to solve such issues as rail wear, noise, and vibration – both to the adjoining properties and passengers.

Notwithstanding such issues, the Shinkansen has proven itself to be a resounding success not the least of which for passenger safety. In fact Japan’s demonstration of the benefits of HSR is recognised as the spur for HSR development around the world, specifically in Europe. France’s TGV, which began operations in 1981, and Germany’s Inter-City Express ICE which commenced operations in 1991 were modelled largely on the Shinkansen service.

Something of a HSR technology race began between Europe and Japan when the TGV debuted with a top speed of 270 km/h against the Shinkansen’s 210 km/h. Not to be outdone, Japan worked to increase HSR train speed to meet the TGV and now both the Tōhoku Shinkansen and the TGV match top speeds of 320 km/h.

3.4 The Implications of HSR on regional and urban development in Europe

The UIC (International Union of Railways, see - http://www.uic.org/) undertook a very comprehensive study in 20112 to evaluate the implications of HSR on regional and urban development, in Japan, France, Germany, Italy and Spain. The study did not question impacts on mobility and modal choices because they were already well assessed but rather considered the positive effects on the regional and urban development assessed qualitatively and quantitatively. The study attempted to analyse and illustrate the non-traffic related impacts of HSR for the first time in a worldwide extensive sample. The overall analysis approach took into consideration worldwide benchmarks comparing the situation of small and medium-sized cities and regions before and after being connected to HSR. Apart from the detailed quantitative investigation, the study served as a basis for discussion including all pros and cons regarding the impacts when considering HSR examples.

The UIC study is in itself a complex and specific piece of work, and we are not proposing to review it here. In summary though, the study did reveal that HSR had a direct positive impact in a cultural change between “Sleeping Cities” and “Working Cities”. Further, HSR cities benefited from a distinct positive enhancement in “Image” - the image, self-image, and self-worth of a city - and change it in a positive way.

It was evidenced that this often led to the development of new economic structures directly stimulated by the connection to HSR – such as green energy, high-tech power plants and the production of solar panels. Fulda in Germany or Kakegawa in Japan are noted examples of this change. It was found that cities with HSR benefit from the image of HSR itself because this transport mode conveys modernity, innovation, “green”.

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2 High Speed Rail as a tool for regional development, International Union of Railways, August 2011
Cities such as Nantes, Le Mans, Le Creusot or Vendome (France), Valladolid, Segovia or Cordoba (Spain) as well as Montabaur, Kassel or Fulda (Germany) have capitalised upon their connection to the HSR network as a stimulus to initiate development.

This is also evident in changes in land use – firstly where land use around a HSR station has a totally new use and user market. Examples include formerly agricultural areas which are now attractive for industry, offices, services or retailers. CBD renewal was also highlighted by converting existing areas in a city centre after connection to the HSR.

“In Cordoba for example, the construction of a railway tunnel brought space for a new quarter in the city centre. Metz, Ciudad Real or Koriyama are examples for changes to existing spaces such as for example unused freight yards, idle railway equipment or unused urban areas, which were converted to new uses. This has been observed for all the countries except for Italy, where there is generally not enough space to make great changes in the historical city centres of the investigated cities. Developments in the areas of industry, retail/shopping, offices, hotels, residential areas and entertainment were qualitatively assessed for HSR cities/towns and their twin (non-HSR equivalents). Some of the qualitative outcomes from the study include:

- **HSR can influence the image of a city or change it in a positive way.** The image might change through the development of new economic structures stimulated by the HSR link.

- **HSR has the tendency to stimulate a change in land use** in cities connected to HSR and especially in the surrounding area of the stations.

- In the case of a change in the surrounding area, the qualitative results show a truly visible development in the case of HSR cities.

- Although a generally improved development can be stated for the HSR cities in comparison to the twin cities, development differs between the HSR cities.

As can be seen from the material overleaf, there is a clear positive distinction between **HSR cities** (shown on the left hand half of the chart for each city) and **non-HSR cities** (shown on the right hand side of the chart) in terms of benefits in the areas of industry, retail/shopping, offices, hotels, residential areas and entertainment.
Figure 3 - Qualitative Results (HSR Cities on LHS, non-HSR on RHS)

Some of the quantitative outcomes from the study show a better development in HSR cases than in non HSR cases, demonstrated through a comparison of time series data for each considered impact up to eight years after the commissioning of HSR. These impacts are in the areas of population, commuter, students, GDP, employment/unemployment, real estate/land prices, and land use.

As can be seen from material overleaf, there is a clear positive distinction between HSR cities (shown on the left hand half of the chart for each city) and non-HSR cities.
Figure 4 - Quantitative Results (HSR Cities on LHS, non-HSR on RHS)

Whilst it is tempting to seek to apply the impacts from one country across all as a generalisation, a particular caveat must be considered with respect to the different countries, and in particular the specific HSR cities, which have considered the opportunities presented by HSR. For example some cities have embraced tourist related opportunities, whilst others have followed a commuter-focus.

Notwithstanding the obvious cultural and economic differences between this study and Australia, we hold that it is not unreasonable to assume that cities/towns to be serviced by HSR in Australia will show the same positive differential benefits as a result of HSR.
The Implications of HSR on regional and urban Australia

As has been noted previously, evidence provides that HSR presents a competitive advantage over airline travel for journeys of up to about 3 hours or 750 km particularly where airports are located on the outskirts of, and linked to, city centres.

This is particularly the case in Australia where airport to airport travel only constitutes a portion of the total journey – one has to also consider the journey from and to the airport as part of the total journey.

As a typically CBD to CBD service, research provides that HSR best services journeys up to 250-500km.

Beyond just the journey time, HSR also provides a tangible reduction in congestion on short-haul routes thus also freeing up capacity at airports for longer, and more lucrative long-distance airline travel. The corollary of this is that finite airport capacity is given over and made available to long-distance airline travel, with similar congestion reduction seen in the road links between the airport and the final destination.

This might be evidenced as a benefit to government in terms of airline/airport congestion and the cost of new airport infrastructure, and a distinct benefit to Local and State Governments by reducing road congestion and hence putting off investment in public road infrastructure servicing the airports.

*The World Bank Working Paper High-Speed Rail: The Fast Track to Economic Development? (No. 55856)* states that in Japan, around 50% of the initial patronage transferred from conventional rail with the remaining 50% transferring from other modes or being newly generated. The report notes the severe impact on short-haul air services with a significant number of short-distance air routes being terminated and airlines forsaking up to 70% of their market share on these routes to HSR.

A similar outcome was reported in France (with around 20% of patronage on the Paris-Lyon TGV route coming from the airlines) and Germany (with around 15% coming from previously air travellers). The general summation is that HSR is likely to command up to 80% of the modal share (road, conventional rail, airlines) for journeys of around and up to 500 km, reducing to 20% of around and up to 1,000 km.

In Australia’s case, noting that travel time would be under the 3 hour threshold, it can be assumed that up to 80 % of air travellers between Sydney – Canberra, Melbourne – Sydney and Sydney – Brisbane would transfer to HSR.

For the year ending June 2014, the Bureau of Infrastructure, Transport and Regional Economics (BITRE) reported the following passenger and aircraft movements between the relevant HSR cities.

<table>
<thead>
<tr>
<th>Route</th>
<th>Passengers (y/ending June 2014)</th>
<th>Aircraft trips</th>
<th>Potential HSR modal shift</th>
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<tr>
<td></td>
<td></td>
<td></td>
<td>50%</td>
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<td>Melbourne – Sydney</td>
<td>8.28 million</td>
<td>54 829</td>
<td>4.15 million</td>
</tr>
<tr>
<td>Brisbane – Sydney</td>
<td>4.5 million</td>
<td>32 260</td>
<td>2.25 million</td>
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<tr>
<td>Canberra – Sydney</td>
<td>1 million</td>
<td>19 104</td>
<td>0.5 million</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>13.78 million</strong></td>
<td><strong>77 153</strong></td>
<td><strong>6.9 million</strong></td>
</tr>
</tbody>
</table>
Conservatively, if HSR were to precipitate a modal shift of just 50% of the 2014 aviation patronage, it might be seen that 6.9 million customers would choose to travel by HSR instead of air on the three inter-city routes.

Were this to grow to a modal shift of 80% of 2014 air travellers on the three routes, it can be estimated that in excess of 11 million aviation passengers would choose to travel by HSR instead of air.

The MegaCities – Domicile Cities relationship mentioned in 2.2 provides that the Chinese HSR experience might give rise to regional centres who are in the 150-250km radius from the major city evolving as Domicile Cities.

When mapped against the major cities on the East Coast Australian HSR alignment, this might suggest that there are a discrete number group of regional centres which could be the beneficiaries of HSR by adopting and applying a Domicile City position with respect to the major cities on the route.

The map above seeks to graphically demonstrate this relationship and point toward the synergistic relationship these cities might share.
5 The High Speed Rail Investment Decision

Europe, the United States, and China are following the wisdom of High Speed Rail (HSR) development by investing heavily in their HSR networks.

Another notable example is Saudi Arabia who are developing one of the world’s most ambitious HSR Links, the Haramain High Speed Rail project also known as the "Western Railway" or "Mecca-Medina high speed railway". This 320kmh project will cover 449 kilometres and provide high-speed inter-city rail transport when services are scheduled to commence by the end of 2015.

We hold that Australian investment in High Speed Passenger Rail will go a long way toward strengthening and growing Australia’s regional economies. Whilst acknowledging this, the most recent Chinese Experience highlights a number of caveats – not the least of which developers trying to get in front of the game.

Whilst China provides an excellent recent example, to best understand the sociological shift which HSR can initiate over a long period, we suggest that it’s also valuable to consider where it all began - the concept of the “bullet train” which was born in 1964 with Japan’s Shinkansen.

We propose that Australia can learn a lot from the Japanese, European, and Chinese HSR Experience and extrapolate them to Australia.

We propose that HSR is fundamental in reshaping Australia’s economic vitality on the East Coast – it will provide cost-effective transportation options that link major commerce centres and domicile cities as per the Chinese example above.

Shadow Minister for Transport and Infrastructure Anthony Albanese MP stated in The Guardian on 18 April 2014 that, “High-speed rail would revolutionise interstate travel, and would also be an economic game-changer.” Studies have shown that for every $1 spent on HSR on the first section between Sydney and Melbourne, the project would return $2.15 in economic benefit to our nation.

We propose that HSR is a sensible stimulus for Government and private sector spending and will revitalise regional communities serviced by HSR.

Transportation can have a significant impact on rural growth. This is evidenced over the last two decades in countries where HSR has been constructed. Rural areas with HSR links demonstrate a higher economic growth than those without. HSR has also precipitated the re-population and revitalisation of formerly dying towns with long-distance commuters working in the big cities but retaining a rural lifestyle or more recently, sparking a shift where businesses relocate to regional areas to reap the benefits of lower rents and improved workforce productivity.

HSR development will however also present unavoidable environmental and social impacts due to displacement, loss or disruption of land for land owners, farmlands, commercial or industrial businesses - but the benefits far outweigh the loss.

We argue that such a valuable transportation asset provides a far more efficient use of land, and that high capacity rail transport provides safer and more effective social benefits than additional, bigger and faster roads.

The benefits of HSR through broader labour market and job creation, increased mobility, passenger convenience with fast and easy access, will stimulate the Australian east-coast regional economy (linking cities together into integrated regions that can then function as a single stronger economy) far more effectively than larger and potentially more congested roads would.
HSR will –

- create entirely new industries,
- expand visitor markets and tourism while increasing visitor spending,
- be the catalyst for mixed-use real estate around stations,
- reduce dependence on fossil fuels, and
- provide long-term environmental benefits of improved air quality through reduced carbon emissions of automobile and air traffic.

- It will foster the positive aspects of urban sprawl, and circumvent the population aggregation as mentioned previously.

HSR will necessitate a paradigm shift in regional planning by Domicile Cities so as to provide a distinct and tangible benefit to families who seek more affordable housing and living conditions especially for new and young people entering the economic market.
6 HSR Investigations in Australia

6.1 Australian Department of Infrastructure and Transport Report

The Australian Department of Infrastructure and Transport Report, High Speed Rail Study Phase 2 has included in the capital cost all the physical infrastructure components (land, earthworks, structures, track, equipment and facilities), as well as the design, program and construction management. These cost components were developed from Australian unit costs to ensure the robustness of the estimates.

How much benchmarking was done against international HSR systems to verify the construction costs is not known and could be challenged. The estimated cost of constructing the identified HSR alignment in its entirety would be about $114 billion (in 2012 terms), comprising $64 billion between Brisbane and Sydney and $50 billion between Sydney, Canberra and Melbourne.

The more detailed alignment options and preferred selections are described in detail in Phase 2 Chapter 4 “Alignment and Station Locations”. In total, the preferred alignment includes 144 kilometres of tunnel along the route, representing 29% of the total cost of construction, almost half of which (67 km) is to tunnel in and out of Sydney. It is stated in this report that the cost estimate reflects current and proven HSR system technology and takes account of a range of manufacturers’ delivered costs for existing HSR systems.

It is understood that the capital costs have been risk adjusted to reflect uncertainty, principally around the scope of the major construction, engineering and operational elements of a future HSR program. In total, the risk adjustment process increased capital costs by about 10.8% or $12.3 billion. The following Table ES-6 is extracted from the report and illustrates the construction cost of the total HSR line of $114 billion at a statistical confidence level of P50.

<table>
<thead>
<tr>
<th>Project development</th>
<th>Sydney-Canberra</th>
<th>Canberra Junction-Melbourne</th>
<th>Newcastle-Sydney</th>
<th>Brisbane-Gold Coast</th>
<th>Gold Coast Junction-Newcastle</th>
<th>Total HSR system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction</td>
<td>2.2</td>
<td>2.5</td>
<td>1.7</td>
<td>1.0</td>
<td>3.1</td>
<td>10.4</td>
</tr>
<tr>
<td>Construction</td>
<td>20.8</td>
<td>24.4</td>
<td>17.2</td>
<td>10.0</td>
<td>31.2</td>
<td>103.6</td>
</tr>
<tr>
<td>Total capital costs</td>
<td>23.0</td>
<td>26.9</td>
<td>18.9</td>
<td>11.0</td>
<td>34.3</td>
<td>114.0</td>
</tr>
</tbody>
</table>

Rolling Stock is excluded and is acquired by entering into a finance lease arrangement.

The following Table ES-7, also extracted from the report, further indicates the cost per km for each section and the average cost for the whole system of $65 million per km. (2012 $billion)
The report states that the preferred HSR alignment has been designed first and foremost to meet market needs (in terms of journey times and reliability), while also being environmentally and economically sustainable. Tunnelling has been adopted where no dedicated surface route could be created without unacceptable dislocation and/or environmental costs.

Tunnels make up 144 kilometres (eight per cent) of the preferred alignment and are the most significant construction cost element (29 per cent of total construction costs). Access to and from Sydney would require the most tunnelling (67 kilometres) compared to Brisbane (five kilometres), Melbourne (eight kilometres) and Canberra (four kilometres).

The HSR system would adopt internationally proven and available technology for train sets and associated systems (such as train control and power supply systems), which would cost less than if an Australian “customised” design were specified. Extracted from the report is Table 7.9 showing the costs of civil works for the alignment which adds up to $85 billion and a unit cost per km of AU $501m. If stations of $7.5b are included, the unit cost per km increases to AU $54.3m.

(The report continues.)
6.2 “Beyond Zero Emissions” High Speed Rail Report

Beyond Zero Emissions, the German Aerospace Centre and the University of Melbourne developed and released its own high speed rail report; Zero Carbon Australia Transport: High Speed Rail. It acknowledges the work that was done on the Dept. of Infrastructure and Transport report referred to above. It recognises the long-term economic, social, health and environmental benefits and expresses an urgency to reach a decision, “There is a debate to be had about the details, the timing, and the cost, but the decision to start, and to invest in this proposal is essential and urgent”.

In the cost analysis, it is understood that infrastructure costs are significantly affected by the particular landscape of each section which may require different earthworks requirements, tunnels, bridges and other infrastructure. International benchmarking was done with a greater focus at a sub-component level i.e. civil works, track, signalling, electrification, auxiliary buildings, rolling stock, operational costs, and management. International unit prices have been normalised to 2012 Australian dollars to be comparative to the government report.

The following Tables 5.2 and 5.3 consist of the data extracted from the Beyond Zero Emissions’ report and have been best matched to the format of the above Tables ES6 and ES7.

Table 5.2

<table>
<thead>
<tr>
<th>Management &amp; Contingency</th>
<th>Sydney Central to Canberra</th>
<th>Canberra (Gunning) to Melbourne (South Cross)</th>
<th>Newcastle to Sydney</th>
<th>Brisbane to Gold Coast</th>
<th>Gold Coast to Newcastle</th>
<th>Total HSR System</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3,089</td>
<td>4,670</td>
<td>2,070</td>
<td>1,081</td>
<td>5,356</td>
<td>16,266</td>
</tr>
<tr>
<td>Construction Cost</td>
<td>11,657</td>
<td>17,624</td>
<td>7,811</td>
<td>4,081</td>
<td>20,212</td>
<td>61,385</td>
</tr>
<tr>
<td>Total Capital Cost ($b)</td>
<td>14,746</td>
<td>22,294</td>
<td>9,881</td>
<td>5,162</td>
<td>25,568</td>
<td>77,651</td>
</tr>
</tbody>
</table>

(Excludes Rolling Stock component)

Table 5.3

<table>
<thead>
<tr>
<th>Built Track Length (km)</th>
<th>Total Capital Cost ($b)</th>
<th>Cost per Km ($m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sydney to Melbourne</td>
<td>942</td>
<td>37,040</td>
</tr>
<tr>
<td>Sydney - Canberra</td>
<td>310</td>
<td>14,746</td>
</tr>
<tr>
<td>Canberra - Melbourne</td>
<td>633</td>
<td>22,294</td>
</tr>
<tr>
<td>Brisbane to Sydney</td>
<td>857</td>
<td>40,611</td>
</tr>
<tr>
<td>Sydney - Newcastle</td>
<td>159</td>
<td>9,881</td>
</tr>
<tr>
<td>Brisbane – Gold Coast</td>
<td>74.8</td>
<td>5,162</td>
</tr>
<tr>
<td>Gold Coast - Newcastle</td>
<td>622</td>
<td>25,568</td>
</tr>
<tr>
<td>Total</td>
<td>1,799</td>
<td>77,651</td>
</tr>
</tbody>
</table>
(Excludes Rolling Stock component)

The most important value provided by this report is that it has established a capital investment cost, which is far less than the previous government report.

This immediately opens the debate and speculation as to whether HSR can be constructed at an even lower cost than what the Beyond Zero Emissions report has developed by -

- Advancing the designs to achieve a greater level of confidence in the cost estimate, and
- Investigating, in greater depth, the international construction industry and embracing the competitive benefits that it can offer Australia.
7 HSR Capital Investment

7.1 Introduction

The approach of optimising the HSR for the best economic outcome for a country is currently being applied worldwide. Still today, some countries find the HSR economics the greatest impediment for not pursuing or getting involved in HSR. Australia, being one of these countries, commenced with their investigations in 1980 and 34 years later are still debating its viability.

The following is a high-level overview of the capital investment necessary to support HSR.

7.2 HSR Cost Projections

HSR development has a large initial capital cost and the proposed HSR from Melbourne to Brisbane would be one of the largest infrastructure programs ever undertaken in Australia. For competitive and cost efficient delivery of the project, the government may have to look at the global market for financial/construction advice and competitive bidding where projects of this nature have been successfully executed and operated for many years.

The government has commissioned and published an exhaustive number of documents on HSR over the past years that have reported large cost difference. The latest report from Beyond Zero Emissions, the German Aerospace Centre and the University of Melbourne, confirms the large cost variation. They have revised the cost of the project down from $114 billion (an estimate given by the Dept. of Infrastructure and Transport report last year) to $84bn (2012 terms). This is a generous reduction of $30bn for the planned 1748 km rail line.

This construction cost differentiation most likely confirms that the project concept/feasibility design of the project has not been adequately advanced so as to allow a greater accuracy of the cost estimate.

The Productivity Commission, in its recent report (“Public Infrastructure, Productivity Commission Inquiry Report, No. 71, 27 May 2014”) published on 14 July 2014, believe that,

> “it is essential to reform governance and institutional arrangements for public infrastructure to promote better decision making in project selection, funding, financing and the delivery of services from new and existing infrastructure”.

It provides that a lack of data prevents our policymakers from accurately estimating construction costs and benchmarking our projects against overseas equivalents.

The HSR is a significantly large project with major public and private funding requirements. Innovative funding techniques such as transit-oriented developments and value capture have been successfully used to fund HSR construction in Asia. We recommend that a similar approach is undertaken in Australia. This would reduce or potentially eliminate construction funding requirements from the Federal and State governments.

7.3 Construction Economics

Internationally a large amount of HSR projects have been constructed over the past 20+ years and each country has a costing structure which is commensurate to the country’s construction industry’s ability to construct and deliver the major HSR infrastructure elements at a cost effective level with a perceived value for money to the respective governments. Total cost of ownership of HSR systems is proven to be generally lower than the total costs of competing alternatives (new highway or air capacity).
We hold that there are many overseas investors interested in investing in HSR in Australia. Chinese, Japanese and Korean investors are prime targets for Australian HSR funding, having already funded HSR in their countries, leaving them looking to invest elsewhere.

China represents the largest and fastest rail expansion programme in the world.

China plans to almost double the size of its high-speed rail network for 2014/15 with a spend of £60bn (AU$110bn)

**If the economics work in China, it could work here in Australia considering all the different local factors of each country which may impact on the cost structure.**

The Japanese systems often more expensive than their counterparts but this is due to the infrastructure being more comprehensive because they have their own dedicated elevated (viaduct) gateway, no traffic crossing and disaster monitoring systems. With the Japanese currently having negative interest rates, an interest rate of 1%, as a finance rate, is almost double what they receive now and could thus be an enticing proposition to Japanese financiers.

Despite Australia’s projections and predictions, we can’t accurately forecast how much it will cost to build a HSR network. As a result, the general response to HSR in Australia has been one of uncertainty and a reluctance to push ahead with the project. The fear of constructability risks, cost overruns and the cost of new rail lines versus restoring existing rail lines are only some of the major factors driving this hesitance.

Table 6.1 below indicates the cost differences of new lines, extensions and restoring of existing lines:

![Comparative per-route kilometre costs of urban passenger rail](image)

**Table 6.1**
7.4 International Trends: HSR construction costs

A brief look at some of the international HSR construction unit costs are listed overleaf -

7.4.1 China

By the end of 2013, China Railway had constructed a network of approximately 10,000 route-km of high-speed railways. The network has been built at a relatively low unit cost compared with similar projects in other countries.

This note considers China's HSR construction unit costs and some of the key cost components.

The Beijing–Tianjin HSR was the first of a new generation of HSR opened in August 2008 with a maximum speed of 350 km/h. Since 2008 the 350km/h lines have grown almost exponentially as indicated in the Table 6.1 below.

Table 6.1

<table>
<thead>
<tr>
<th>Year</th>
<th>Cumulative operational length (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>200km/h Mixed</td>
</tr>
<tr>
<td>2009</td>
<td>200km/h PDL</td>
</tr>
<tr>
<td>2010</td>
<td>250km/h</td>
</tr>
<tr>
<td>2011</td>
<td>350km/h</td>
</tr>
</tbody>
</table>

Table 6.1 (Source: High-Speed Railways in China: A Look at Construction Costs- World Bank, Beijing - Released July 2014)

These lines are all passenger dedicated lines and were newly built as green-field projects.

An analysis of the unit costs per km of about 27 Chinese HSR lines (> 6000km) currently in operation showed varied amounts (between AU $16.84m to AU$32.97m)( 0.179 RMB), however the weighted cost per line for the 350km/h HSR lines was RMB 129m (AU$23.11m).

We must acknowledge that this data is only available in aggregate form and expenditures were incurred over different years, so costs may not be directly comparable, however this provides a useful range of benchmarking values for comparison with Australian costs for new HSR projects.
These unit costs include costs of preparation, land acquisition, construction of railway and regular stations, contingencies, rolling stock and interest during construction. The exclusion of preparation costs, rolling stock and interest during construction reduces the unit cost further down to 82% of the above unit costs.

The standard cost factors influencing China’s price would be the design elements such as type of track (ballast-less track is used on all 350km/h lines), topography and geology along the alignment, land acquisition costs (these would be high in dense urban areas), use of viaducts instead of embankments, the construction of major bridges across wide rivers, and the quantum and size of stations.

The high end of AU$32.97 per km refers to projects that had exceptions such as:

- Shi-Zheng Railway with 69% of the track on Viaduct. (Viaduct @ AU $ 11.65m per km for double track line);
- Beijing - Tianjin rail line with two mega stations; and
- Shanghai - Hangzhou with several major bridges and a high cost of land in densely populated areas.

China’s HSR and its corresponding rail transportation equipment industry have become a symbol of the rapid economic development and the ongoing industrial transformation and upgrading of this ambitious resurgent nation. China and its entrepreneurs are now reaching out to the international marketplace. China boasts high quality HSR technology and has transformed its name into a powerful brand in exploiting overseas markets.

China is increasing efforts to export its HSR technology to the rest of the world eg:

- Chinese companies were involved in the construction of a HSR line in Turkey, Ankara-Istanbul that was completed in July 2014.
- China also intends to take the initiative in building a 3,000 km network to connect Kunming, Yunnan province, with Singapore by passing through Laos and Thailand.
- Chinese officials expressed strong interest in the 350 km HSR project between Malaysia and Singapore.
- China’s rail equipment and technology played a role in Brazil with the World Cup. They are further strengthening their role by offering their technology solution, construction ability, and experience in railroad construction.
- The Mombasa-Nairobi HSR in East Africa is also the first new railway for 100 years in Kenya. It is totally contracted to and organised by Chinese enterprises, and is the first project that fully adopts Chinese standards.

The completion of the HSR in Turkey signals the successful entry of China’s HSR technology and equipment into Turkey, a country whose entry threshold is higher in that it adopts European technology standards. This first success will no doubt create favourable conditions for China to enter other international railway markets such as Australia.

Chinese companies boast that they can build railway lines faster than Japanese companies and for about half the cost.
Even if we consider China’s high end unit cost per km of AUS32.97, it proves to be a very compelling cost for the Australian market which currently is estimated at a unit cost of AUS$43.2 per km (Beyond Zero Emissions 2012 $ value). For the Australian HSR line, a cost reduction of almost $18.4 billion on the total project cost could be achievable if a similar technology solution, construction, regime and cost structure as the Chinese was adopted here in Australia.

7.4.2 Japan

The Japanese systems, as stated earlier, are often more expensive than their counterparts but this is due to the infrastructure being more comprehensive because they have their own dedicated elevated (viaduct) gateway, no traffic crossing and disaster monitoring systems.

Some major reasons for the higher civil engineering costs than the European HSR costs are:

- **Tunnels**: Due to high mountains in Japan the ratio of tunnel sections to the total length of rail tend to be high. The total length of tunnels on the existing four Shinkansen lines is 30.8% of the total rail length. Tunnelling was ± 35% of the total infrastructure cost.

- **Elevated Track (Viaducts)**: Frequent earthquakes, heavy rain and deep weak ground on the plains do not suit the economic banking method and few sections can use it, hence elevated track is used which is up to four times the cost of banking. Viaduct was ± 49% of the infrastructure cost.

- **High environmental costs** especially the cost of sound barriers.

- **Multiple Stations**: Short Station to Station distances (30km to 40km)

- **High land prices**. Japanese land prices apparently the highest in the world

Construction costs for the four Shinkansen lines is extracted from a working paper “UCTC No. 103 - A Review and Evaluation of the Shinkansen Train – University of California”, and shown in Table 6.2 below.

**Table 6.2**

<table>
<thead>
<tr>
<th>Shinkansen Lines</th>
<th>Route (km)</th>
<th>Construction Cost @ construction date (US$) billion</th>
<th>Escalated to 2012 (US$) billion</th>
<th>Costs 2012 (AU$) billion</th>
<th>Unit Cost per km AU$ m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tokaido</td>
<td>515</td>
<td>0.92 (1964)</td>
<td>3.68</td>
<td>4.1</td>
<td>7.96</td>
</tr>
<tr>
<td>Sanyo</td>
<td>554</td>
<td>2.95 (1972)</td>
<td>11.2</td>
<td>13.6</td>
<td>24.6</td>
</tr>
<tr>
<td>Tohoku</td>
<td>496</td>
<td>11.02 (1982)</td>
<td>14.3</td>
<td>15.9</td>
<td>32.1</td>
</tr>
<tr>
<td>Joetsu</td>
<td>270</td>
<td>6.69 (1982)</td>
<td>8.7</td>
<td>9.7</td>
<td>35.9</td>
</tr>
</tbody>
</table>

Exclusions are unknown

The unit costs in the Table 6.2 may have certain cost items excluded which have not been indicated in the working paper referred to above (eg: cost items such as land cost which are ± 25% of the total construction costs).

The costs are not immediately comparable with Table 6.3 below which indicates unit costs per km to be much higher for the Japan Shinkansen than Table 6.2 in the order of AU$ 53m to AU$ 69 per km which highlights, in this instance, the danger of comparing costs without having the detail available that show which costs have been excluded or included.
For the purpose of this exercise the unit costs for Tokaido and Sanyo have been ignored due to the date of construction and the maturity of the technology at the time. The costs in Table 6.3 have also been used as the comparable high end unit cost per km in Table 6.4.

### Table 6.3

<table>
<thead>
<tr>
<th>Country</th>
<th>Cost per km (€ millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AVE Madrid-Lerida, Spain</td>
<td>20</td>
</tr>
<tr>
<td>TGV Atlantique, France</td>
<td>20</td>
</tr>
<tr>
<td>TGV Mediterrane, France</td>
<td>20</td>
</tr>
<tr>
<td>ICE Frankfurt-Cologne, Germany</td>
<td>20</td>
</tr>
<tr>
<td>Shinkansen-Thoku, Japan</td>
<td>30</td>
</tr>
<tr>
<td>Shinkansen-Joetsu, Japan</td>
<td>30</td>
</tr>
<tr>
<td>TGV Korea, Korea</td>
<td>30</td>
</tr>
<tr>
<td>Naples-Rome and Florence-Turin, Italy</td>
<td>30</td>
</tr>
<tr>
<td>Shinkansen-Hokuriku, Japan</td>
<td>30</td>
</tr>
<tr>
<td>TGV Taiwan, Taiwan</td>
<td>30</td>
</tr>
<tr>
<td>HSL Zuid, Netherlands</td>
<td>30</td>
</tr>
<tr>
<td>Channel Tunnel Rail, UK</td>
<td>30</td>
</tr>
</tbody>
</table>

Source: Commission for Integrated Transport 2004, High-speed Rail: international comparisons, London. Inclusions and exclusion in these unit costs were not provided.

#### 7.4.2.1 Japan’s “Beyond Border Interests”

Japan is extending its interest beyond borders. At a railway conference and exhibition held in Kuala Lumpur this year (2014), Masaki Ogata, Vice Chairman of East Japan Railway Co., touted the technology that has made the Shinkansen bullet train a proud feature of Japanese manufacturing. Ogata intends that JR East is to win the bid for construction of the Malaysian HSR that will cover about 350 kilometers in 90 minutes and connect Kuala Lumpur and Singapore. The line is expected to begin operations in 2020.

A Japanese consortium has already progressed with groundwork ahead of bidding for this HSR project. Four major companies – the East Japan Railway Company (JR-East), Sumitomo Corporation, Hitachi and Mitsubishi Heavy Industries – intend to offer the efficiency and reliability of Japan’s Shinkansen bullet train system.

Total expected construction costs (excl. Rolling Stock) for the Malaysian HSR are estimated at US$12 billion (AU$13.3b) which provides a unit rate of ± AU$38m per km.

Historically Japan has exported its Shinkansen technology minimally. However, it is now focused on becoming a competitive player in the international market and wants to gain a firmer position in the international bidding process. Japanese companies are now publicising various other services they can provide, such as operations support, maintenance and inspection.

“It’s high time for us to make an all-Japan effort to pitch the Shinkansen system to overseas markets,” Mr Masafumi Shukuri, chairman of the International High-Speed Rail Association, said in a recent interview.
Japan’s Shinkansen indicates a safety record that is free of any fatal operational accidents during a half-century of operation.

The current market competition between Japan and China could be beneficial to an Australia HSR project.

7.4.3 Europe

The cost of HSR construction in Europe, having design speed of 300 km/h and above is estimated to be of the order of US$25m to US$39m (± AU$27.8m – AU$43.3m) per km for completed works. The upper level unit cost of AU$43.3 is very similar to the Beyond Zero Emissions AU$43.2 estimate provided.

7.4.3.1 France

Europe was introduced to high-speed rail when the LGV Sud-Est from Paris to Lyon opened in 1981 and TGV started passenger service. Since then, France has continued to build an extensive network, with lines extending in every direction from Paris. France has the second largest high-speed network in Europe, with 2,037 km of operative HSR lines in December 2011.

France is pushing ahead with the extension of its high-speed rail network. The biggest of the three projects currently under way is the new line between Tours and Bordeaux halfway down the Atlantic coast. There are 302 km of direct track to lay, plus another 38 km of connections to existing track. The project cost is estimated at USA $10.6bn (AU$11.8bn). The unit rate is averaged at AU$34.6m per km.

Based on D.P. Crozet (International Transport Forum, December 2013) the unit cost for four HSR lines under construction in France in 2013 ranged between US$24.8m and US$35.2m (± AU$27.6 – AU$39.1). The four lines are shown in Table 4.5 below:

Table 4.5

<table>
<thead>
<tr>
<th></th>
<th>East Strasbourg</th>
<th>BPL Brittany</th>
<th>CNM Nimes-Montpellier</th>
<th>Sud Europe Atlantique</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cost (Euro m)</td>
<td>2,000</td>
<td>3,300</td>
<td>1,800</td>
<td>7,800</td>
<td>14,900</td>
</tr>
<tr>
<td>Length (km)</td>
<td>106</td>
<td>182</td>
<td>80</td>
<td>303</td>
<td>671</td>
</tr>
<tr>
<td>Cost/km (Euro m)</td>
<td>18.9</td>
<td>18.1</td>
<td>22.5</td>
<td>25.7</td>
<td>22.2</td>
</tr>
<tr>
<td>(US $ m)</td>
<td>25.9</td>
<td>24.8</td>
<td>30.8</td>
<td>35.2</td>
<td>30.4</td>
</tr>
<tr>
<td>(AU $ m)</td>
<td>28.8</td>
<td>27.6</td>
<td>34.2</td>
<td>39.1</td>
<td>33.8</td>
</tr>
</tbody>
</table>

(Cost breakdown not available –assumption made that Rolling Stock is excluded)

AUS$33.8m per km is significantly lower than the Beyond Zero Emissions of AU$43.2 estimate provided.

7.4.3.2 Germany

Construction on first German high-speed lines began shortly after that of the French LGVs but Inter City Express (ICE) trains were only deployed ten years after the TGV network was established. The ICE network is more tightly integrated with more than twice the population density.
density of France. The third generation of the ICE reached a speed of 363 km/h (226 mph) during trial runs, and is certified for 330 km/h (205 mph) in regular service.

The two new HSR projects that are currently under construction are:

- The Erfurt–Leipzig/Halle HSR, 300km/h and 123km long. To be commissioned in 2015. The total cost of the Erfurt–Leipzig/Halle HSR is expected to amount to more than €2.6 billion (AU$4.8b). This amounts to a unit rate of about AU$39.04m per km.

- The Nuremberg–Erfurt HSR, 300km/h and 190km long. To be commissioned in 2017. The total cost of the Nuremberg–Erfurt HSR project is estimated to be €5.1 billion (AU$9.42b) calculating at a unit cost of AU$ 49.59m per km.

7.4.3.3 Italy

The earliest high-speed train deployed in Europe was the Italian “Direttissima”, the Florence–Rome high-speed railway (254 km) in 1978. The Italian high-speed railway network consists of 1342 km of lines, which allow speeds of up to 300 km/h.

- The Milan–Bologna segment (182km) opened on 13 December 2008, its construction cost was about 6.9 billion euro at a unit cost of AU $54.5million per km (2008 costs).

- The Rome to Napoli segment (206km) opened in 2006; its unit construction cost was AU$44.0m per km (2011 costs).

- The Torino-Milan (125km) was completed in 2006; its unit construction cost was AU$99.6m per km (2011 costs).

7.4.3.4 Spain

The Alta Velocidad Española (AVE) high-speed rail system in Spain has been in service since 1992, when the Madrid–Sevilla (Seville) route started running. Six other lines have been opened since, including the 621-kilometre long Madrid–Barcelona line. The Madrid–Alicante line completed in June 2013 brings the total length of the network to 3,100 kilometres which makes it the most extensive HSR network in Europe. According to the UIC, Spain has the third largest network in the world, behind only Japan and China.

- In 2013 Spain opened a new 165km HSR link between Albacete and Alicante, built at a cost of €1.9bn (AU$3.5b). The unit rate being AU$21.27m per km.

- Completion of the Cordoba to Malaga line (154km) was Dec 2008 at a unit construction cost of US$23.1million (AU$25.7m) per km, (2008 cost)

- Completion of the Madrid to Barcelona- Figueras line (749km) was February 2008 as a unit construction cost of US$24.3m (AU$27.0m) per km.

7.4.3.5 Britain

On 4 June 2014, at the opening of the British parliament for 2014-15, the government confirmed its commitment to a controversial high-speed link known as HS2.

The British government is budgeting £17 billion to £21 billion (US$28 billion to US$35 billion) (AU$31.1b to AU$38.8b), including contingency funds, to lay 225 km of track from London to Birmingham. There is no clarity in the inclusions and exclusions of this budget amount and therefore calculating a unit cost per km would not be feasible for comparison at this stage until further information comes available.
7.4.4 Saudi Arabia

The Haramain High Speed Rail project also known as the "Western Railway" or "Mecca-Medina high speed railway", is a 449.2 km high-speed inter-city rail transport system under construction in Saudi Arabia. The line is planned for completion at the end of 2015. The double-track line will be electrified and the design speed is 360 km per hour, with 35 Talgo 350 trains planned to run at 330 km/h. Five "aesthetically iconic stations" are planned for the line.

The total construction costs were awarded between 2009 and 2011 as following:

- Civil Works – US $1.8bn (AU$2bn)
- Stations – US $2.49bn (AU$2.76bn)
- Railway Systems & Rolling Stock – US$9.4bn (AU$10.4bn)

A total of US $ 13.69bn (AU$15.2bn) for the 449.2km rail line which calculates at ± AU $33.87m per km. **The exclusion of rolling stock would reduce the cost to an estimated US $31.7 per km.**

This unit cost is significantly lower than the Australian Unit Cost indicated in the above reports.

We further note from the Civil Works package that China Railway Construction Corporation (CRCC) is part of the consortia.

7.4.5 USA - California

In contrast to the likes of Spain, China and Germany etc, HSR has thus far received little support in the US, where a host of factors - economic, political and cultural - have held back any attempts to bring modern rail technology to the regional transport market.

California's high-speed project has however kicked off preparatory work for a line that is intended to stretch from San Francisco to Burbank (680km) and extended further to San Diego via Los Angeles.

**The HSR construction cost (excluding land, rolling stock and interest during construction) is estimated to US$52million (AU$57.8million) per km in California (California HSR Authority, Draft Business Plan 201).**
7.5 Summary of Construction Costs

Table 6.4 provides a summary of construction costs for HSR projects referred to above.

Table 6.4

<table>
<thead>
<tr>
<th>Country</th>
<th>Unit Cost per km (AU$)million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia Dept. of Infrastructure &amp; Transport Report</td>
<td>$65.0m</td>
</tr>
<tr>
<td>Australia Beyond Zero Emissions Report</td>
<td>$43.2m</td>
</tr>
<tr>
<td>China (350km/h HSR weighted cost per line)</td>
<td>AU $16.84m to AU $32.97m</td>
</tr>
<tr>
<td>Japan</td>
<td>AU$ 32.1m to AU$ 69m</td>
</tr>
<tr>
<td>Europe</td>
<td>AU$27.8m to AU$ 43.3m</td>
</tr>
<tr>
<td>USA (California HSR)</td>
<td>$57.8m</td>
</tr>
<tr>
<td>Malaysia (Kuala Lumpur to Singapore HSR)</td>
<td>$38.0m</td>
</tr>
<tr>
<td>Saudi Arabia (Mecca-Medina HSR)</td>
<td>$31.7m</td>
</tr>
</tbody>
</table>

(Construction costs - exclude Rolling Stock)

Overseas HSR construction costs are generally significantly lower per km than estimates contained in recent studies for HSR in Australia. This would imply that there are significant opportunities to leverage on overseas construction methodologies and approaches, potentially resulting in significant savings.

With more international competitive rates of say AU$35m per km, HSR should be able to be delivered in Australia for approximately AU$63billion\(^1\), representing an AU$15billion saving to the Beyond Zero Emissions proposal.
Although the costs in the previous table are at best approximate, consideration must be given to various factors that may lead to the lower HSR unit costs as achieved by some of the countries. The following factors would have an important impact on the low unit rate:

- Rapid capacity building in the construction industry to deliver high volumes of HSR in a short period.
- Capacity building of rail construction material and equipment suppliers
- Innovative techniques adopted to take advantage of very high passenger volumes
- Standardisation of design of various construction elements (bridges, tunnels, viaducts, signalling etc)
- Low manufacturing costs (e.g., China’s Slab Track is 1/3 the price of German Slab Track)
- Development of competitive local sources for construction (e.g., earthworks, bridges, tunnels, EMU trains etc)
- Advanced mechanization in construction and manufacturing
- Tunnel construction technology developed to achieve low costs per km. (subject to labour cost & geology)
- Constructing viaducts vs high embankments
- Ability for contractors to amortize capital investment in high-cost construction equipment over a number of projects
- Low labour cost
- Low interest cost
- Low cost of land acquisition and relocation costs

Australia must explore international markets and adopt, where possible, the above various low cost impact factors in developing a more feasible and bankable HSR project.

The large differentiation in unit costs per km confirms that there are great opportunities for the East Coast Australia (Melbourne to Brisbane) HSR project and the early engagement and involvement of selected international advisors, contractors, equipment and service providers would ideally be the next step to take.
8 High Speed Passenger Rail and High Speed Freight Rail

Any measures to introduce freight on the HSR passenger network will have to be done with careful consideration of the impact on the viability of the passenger services.

Research undertaken for the European Community (EC) in 2006 reviewed the effectiveness of HSR and its competitiveness with air travel on eight European routes, including London-Paris (distance approximately 500 kilometres), Madrid-Barcelona (distance approximately 620 kilometres) and Paris-Marseille (distance approximately 780 kilometres). This data suggested that the main determinant of market share, as long as HSR had a competitive service frequency, was the rail journey time.

It is therefore important that any modification as a result of introducing freight of some kind to the HSR network takes this important element into account.

Operating different types of services with vastly different axle loads, service patterns and speeds on the same rail infrastructure is known to reduce the overall efficiency of the rail infrastructure. Operating passenger and freight trains on the same rail infrastructure for example often results in conflicting objectives having to be dealt with at the design and operational phases. Freight rail demands high axle load capability and long passing loops to cater for the often (relatively) slower and longer freight trains. Passenger rail on the other hand demand a smooth ride for their generally light weight trains, the ability to stop at heavily populated areas and much higher speeds than their freight counterparts.

8.1 Technical Considerations

8.1.1 Speed Differential

One of the main differences between operating passenger and freight services on the same rail infrastructure is the speed differential between the two types of services.

Freight rail services tend to operate at slower speeds than passenger rail services. With HSR passenger services the differential is potentially even greater.

Operating any rail service at slower speed inherently takes up more capacity, as illustrated in the diagram overleaf.

With time showing on the X-axis, and distance (eg. between two stations) on the Y-axis, one can clearly see that many more fast trains (blue) can operate on the same section as slow trains (red). Figure 2 overleaf demonstrates 12 fast trains (shown in blue) able to operate in one hour block between two stations.

If these fast trains were replaced by all slow trains (shown in red), then only six trains are able to operate in one hour, between these two same stations – hence, effectively halving capacity.
The impact on capacity is even more pronounced when we combine these fast and slow services. Figure 6 below illustrates the impact when (a) inserting a slow train in a fast train schedule, as well as (b) inserting a fast train in a slow train schedule.

Either way, the impact is significant with 9 to 11 trains in this illustration being replaced by one or two faster or slower trains.

Building railway lines that are able to operate both passenger high speed trains and slow freight trains may appear to be a valuable option as it gives two sources of revenue for a capital intensive high speed rail project.

However allowing for mixed passenger-freight traffic on a high speed line with different speeds, poses problems including additional safety constraints, operating challenges of timetabling, extra cost of cab-based signalling systems for freight trains, reduced allowances on cants and gradients, larger curve radii, track wear from heavy haulage due to higher axle loads etc.
Freight services have to date generally not been included in the HSR service planning. International experience demonstrates that the only freight carried on dedicated HSR networks is transported in vehicles similar to high speed passenger rolling stock.

**The challenge for HSR is therefore to design a high speed freight rail service to minimise the impact on capacity. Key to this is designing a freight service that can operate at a similar high speed than the HSR Passenger services.**

### 8.1.2 Axle Load Differential

Another key difference between operating passenger and freight services on the same rail infrastructure is the different axle load of the two services. Freight rail services tend to operate at much higher axle loads to enhance carrying capacity and thus freight transport economics. Passenger rail services tend to focus on lowering axle loads to enhance energy efficiency, with HSR passenger services tending to push the boundaries in terms of low axle loads.

In Japan for example, technology improvements have resulted in a 40% energy consumption improvement from their Series 0 high speed rolling stock (1964 – 2008), to their more recent Series E2 high speed rolling stock (2002). Weight of the train and consequential axle load reduction from 16 to 13 tonnes was one of the key contributors to this efficiency improvement.

![Reduction of train operation energy](image)

**Figure 7 - HSR Operating Energy Reductions (Japan)**

**The challenge for HSR is therefore to design a high speed freight rail service that limits axle loads yet provides an efficient freight service. This implies a focus on niche freight markets, such as postal, time sensitive light weight consumer goods, and perishables.**

### 8.1.3 Ride Comfort

Operating trains at high speed requires higher standards of track geometry, and this is accentuated when combined with passenger services. HSR trains are relatively insensitive to grades however are quite sensitive to the lateral accelerations produced by operation through horizontal curves. Lateral forces experienced by passengers in curves increase significantly (by a factor of the square of the velocity) as curving speeds increase.
As a result, HSR passenger lines require a specific and demanding set of parameters governing track geometry and track type. The geometry needs to maintain the comfort of passengers while enabling the train to travel at the required high speed. This is ensured by restricting the degree of horizontal and vertical curvature of the track, i.e. by curves with large radii, and limiting how much vertical acceleration/deceleration is permitted.

Freight rail is much more sensitive to grades as it significantly impacts on the energy requirements to move the weight of the train (including its payload) up the incline. Freight is also less demanding when it comes to ride comfort; horizontal curve limits are predominately for safety, stability and rail/wheel wear. Other than the vertical curves and grades, the demanding set of parameters governing track geometry and track type will suit HSR freight services.

8.1.4 Reliability

International benchmarking experience suggests that 99.7% of planned journeys are achievable on a closed HSR system, as demonstrated for the Taiwan HSR, which has services that achieve departures within one minute of the timetabled schedule, and within five minutes on arrival. Conversely, where HSR services share infrastructure with conventional passenger and freight trains, the benchmarking experience indicate that the service availability diminishes considerably due to a variety of operational, reliability and maintenance factors.

The conclusion drawn in many high speed rail studies is that, if operating high speed passenger trains is the main target; freight access to high-speed infrastructure needs to be carefully managed so that it does not disproportionately reduce the capacity, increase the cost, or the value of the HSR infrastructure.

‘Light freight’ trains carrying items such as high value, parcel-type goods may have great potential, although there may be some additional cost involved to cater for these services, the benefits would far out way these costs. HSR alignment geometry tends to be based on a design speed which allows for future technological improvements in rolling stock and permanent way construction practice. In Australia, the HSR basic geometry for urban and regional areas, as adopted in recent studies, is summarised in Table 1 below. This however is not cast in concrete as geometry and track design has some flexibility to accommodate required functional, operational and performance variables.

Table 1 - HSR Basis Geometric Standards

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Urban</th>
<th>Rural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desirable / minimum horizontal curves</td>
<td>3,075m / 2,840m</td>
<td>7,900m / 7,285m</td>
</tr>
<tr>
<td>Maximum vertical grades</td>
<td>3.5% if grade length &lt; 6km</td>
<td>2.5% if grade length &gt; 6km</td>
</tr>
<tr>
<td>Acceleration</td>
<td>0.6 m/s/s</td>
<td></td>
</tr>
<tr>
<td>Braking</td>
<td>1.3 m/s/s</td>
<td></td>
</tr>
</tbody>
</table>

The greatest challenge to conventional freight rail use of the HSR alignment are the steep maximum vertical grades, the relative low axle loads and the requirement to operate at speeds in sync with the high speed passenger service to minimise the capacity consumption impact.

The challenge is to design freight services to operate with the design specifications for high speed passenger rail. It is acknowledged that not all freight will be able to be transported by high speed freight rail. A niche market should be identified not too dissimilar to SNCF’s TGV
postal services (La Poste) in France, operating at 270 km/h. These services are reported to be quite successful. By 2017, the volume of mail moving by rail is expected to grow in excess of 30% of the capacity of the current TGV service, with La Poste aiming to become ‘a major operator’ in the intermodal sector.

In July 2009 the Eurocarex association was formed to support the development of high speed rail in Europe on a wider scale\(^3\). By 2012 however, progress stalled on this initiative, due mainly to lack of funding.

\[\textbf{The challenge for HSR is therefore to design the high speed rail alignment such that high speed freight rail services are not adversely impacted. This effectively translates to flatter grades, which will come at a cost through increased earthworks. Flatter grades however will provide for lower energy costs for the HSR Passenger services also.}\]

\(^3\)\url{http://www.eurocarex.com/index.php}

Figure 8 - TGV La Poste
8.2 Integration of High Speed Passenger and High Speed Freight

High-speed freight services can be scheduled either together with high speed passenger traffic services or in a separate system. There are advantages and disadvantages to both systems.

New passenger rolling stock often are fixed multiple unit train sets, making it practically impossible to attach existing express parcel or mail vans to them. In addition, new passenger train sets themselves are normally not intended to carry larger amounts of freight, if any at all, and subsequently do not provide any space for this or only very small compartments. These issues can be overcome here in Australia in the early, custom design of the train sets.

8.2.1 Integration Options

Notwithstanding the limitations described above, Figure 9 below shows different ways of coordinating high-speed freight and passenger traffic should one wish to pursue this avenue.

**Figure 9 - Integration Options**

**Option A** represents the highest level of integration: The freight is transported in the same train as the passengers, however in a customised carriage dedicated to freight. Freight traffic is as good as fully integrated with passenger traffic in regards to timetables, networks, stops, vehicle circulation etc. Loading and unloading along the way is only possible at passenger stations and naturally only at those where the train stops to let passengers on and off.

With **Option B**, passengers and freight are transported in separate trains that can be multiple-coupled. This makes express freight traffic more independent of passenger traffic. Passenger and freight trains can for example travel coupled together on shared stretches, yet have different starting points and destinations. When necessary, the trains can be switched between different passenger trains which give greater opportunities for creating direct connections.

In the same way, the freight trains can be used together with passenger trains during the day and as pure express freight trains at night, which increases rolling stock utilisation.

The ability to multiple-couple the rolling stock can naturally also be exploited to join several freight units together.

With **Option C**, passenger and express freight traffic are coordinated only in regards to timetables. This is advantageous if the trains for some reason cannot or may not be multiple-coupled and the track network suffers from capacity problems. Running the freight trains “in the
shadow” of the passenger trains (or vice versa) reduces the capacity needed for the additional trains.

Other advantages are that stops for loading and unloading need not be made at the same time as passengers board or leave the trains, and that the freight trains do not necessarily need to stop at the same stations as the passenger trains (this is important, for example, if goods terminals are located where passenger trains do not stop). It should, however, be pointed out that stopping times and/or stopping patterns between the passenger and freight trains make it difficult to coordinate the train’s positions over greater distances. In contrast to B, an extra driver for the freight train is also needed with Option C.

Option D shows a pure express freight train that operates fully independently of passenger traffic, i.e. the system is completely separate from passenger traffic. This option requires additional network capacity. This is the configuration adopted by the TGV’s La Poste service.

8.3 The Market Potential for High Speed Freight Rail

8.3.1 Freight Data

As mentioned previously, the volume of freight moved in Australia is growing steadily and has been predicted to double by 2030 from 2010 levels. Road-based trucks carry up to 95% of freight between Melbourne and Sydney and Sydney and Brisbane.

With growing freight volumes on Australian roads, this will be an ever bigger problem suggesting all options for using the high speed rail for freight should be examined.

Various publications have been used to determine the overall freight task between Brisbane, Sydney, Canberra and Melbourne. The most recent reliable road freight data appears to be “Research Report 121, Road freight estimates and forecasts in Australia”, published in September 2010 by the Bureau of Infrastructure, Transport and Regional Economics (BITRE). Rail freight data was obtained from BITRE’s Trainline 1 report published in 2012. Air freight data was obtained from more historical origin destination data combined with more recent airport specific freight volumes.

8.3.2 HSR Freight Target Market

The HSR Freight market will most likely have to focus on high value products and time sensitive products – a market is currently dominated by air - but significant other freight suitable for HSR is currently going by road.

Some of this other road freight likely to be attracted to HSR freight is part of the total road freight market on the east coast of Australia. Total road freight between Melbourne and Sydney is currently 45Mt p.a., and the total road freight between Brisbane and Sydney currently 31Mt p.a. To understand the potential to HSR Freight, the following % of the different commodities have been assumed:

- 5% general freight
- 40% of cold food
- 15% food
- 0% Steel / metal
- 0% furniture

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4 Domestic Air Cargo Industry in Australia, Occasional Paper 87, Bureau of Transport Economics, Canberra, 1987
- 50% parcels
- 0% cars
- 5% unknowns
- 5% others

Very little current rail freight is likely to go to HSR freight due to the fact that most if not all is not time sensitive, is generally more bulky or not valuable enough.

8.3.3 HSR Freight Market Potential

The assumed shift to HSR (from air freight) is 50%, translating into 22,000 tonnes between Melbourne and Sydney, and 18,000 tonnes between Brisbane and Sydney. The reasoning behind this is that a competitive response is expected from the airline industry.

The largest freight market potential for HSR Freight is in the road freight business. Based on the %’s shown above, this can potentially add up to 5.9m tonnes on the Melbourne - Sydney corridor, and 4MT on the Sydney - Brisbane corridor.

The total HSR Freight potential (mainly ex road, but also 50% of the air market) is then 6Mt p.a. (between Melbourne and Sydney) and 4.1Mt p.a. (between Brisbane and Sydney)

The level of HSR freight integration is likely to limit HSR freight potential to substantially less than the 6Mt p.a. (between Melbourne and Sydney) and 4.1Mt p.a. (between Brisbane and Sydney). This is due to the shared arrangement between HSR freight and HSR passenger services and is also depending on the integration option chosen.

8.4 HSR Freight Carriage Method

It is recommended that a standard method of transport be adopted for the transport of freight on the HSR network, whichever integration method is adopted. To minimise the interruption to HSR Passenger services through speedy loading and unloading, a method similar to that used in the airline industry is recommended. The standard air freight containers leans itself well for this purpose.

The larger AA2/AAP sized air freight containers are ideally suited for use in dedicated HSR freight cars or trains. Their sizing allow up to five AA2/AAP sized air freight containers to be transported in each HSR freight car.

The maximum capacity of these type of containers is 10.6 cubic metres, and 4.9 tonnes payload. Based on the average density of products expected to be transported in these containers, actual payloads are likely to range between 1.33 tonnes and 4.9 tonnes, with an average in the order of 2.36 tonnes. This translates into a freight payload per HSR car of between 6.6 tonnes and 24.5 tonnes, and an average of 11.8 tonnes.

Using the Freight Field Survey, 26th Australia Transport Research Paper, as a basis of calculating the weighted average density of the expected product mix

![Figure 10 - Standard AA2/AAP Air Freight Container](Image)
8.4.1 Option A – Dedicated Freight Car

For the purpose of this assessment, the Beyond Zero Emissions HSR Passenger timetable was used to assess various integration options with potential HSR freight. The Beyond Zero Emission HSR Passenger report contained a notional timetable between major centres on the East Coast of Australia. The number of services where an additional dedicated freight car could be attached is summarised in the table below:

<table>
<thead>
<tr>
<th>Number of services per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum (assuming 25% of HS passenger trains have a dedicated freight car)</td>
</tr>
<tr>
<td>Melbourne - Sydney</td>
</tr>
<tr>
<td>Sydney - Melbourne</td>
</tr>
<tr>
<td>Brisbane - Sydney</td>
</tr>
<tr>
<td>Sydney - Brisbane</td>
</tr>
</tbody>
</table>

This would translate into freight volumes on the main corridors as follows:

<table>
<thead>
<tr>
<th>Freight p.a. (based on average payload)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min</td>
</tr>
<tr>
<td>Melbourne - Sydney</td>
</tr>
<tr>
<td>Sydney - Melbourne</td>
</tr>
<tr>
<td>Brisbane - Sydney</td>
</tr>
<tr>
<td>Sydney - Brisbane</td>
</tr>
</tbody>
</table>

These freight volumes only represent between 1.9% and 7.7% of the potential freight volumes that could be considered for HSR freight.
8.4.2 Option B – Multi-Coupled Train

Option B allows multiple freight specific cars be coupled together, and attached to the scheduled HS passenger train. The potential freight volumes are therefore a multiple of the freight volumes estimated under the Option A scenario, in direct correlation to the number of freight cars.

Assuming each HS freight train consists of only three dedicated freight cars, freight volumes on the main corridors would be as follows:

<table>
<thead>
<tr>
<th>Corridor</th>
<th>Minimum (assuming 25% of HS passenger trains have a dedicated freight coupled train)</th>
<th>Average (assuming 50% of HS passenger trains have a dedicated freight coupled train)</th>
<th>Maximum (assuming every HS passenger train has a dedicated freight coupled train)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melbourne - Sydney</td>
<td>180,553</td>
<td>348,210</td>
<td>696,420</td>
</tr>
<tr>
<td>Sydney - Melbourne</td>
<td>180,553</td>
<td>348,210</td>
<td>696,420</td>
</tr>
<tr>
<td>Brisbane - Sydney</td>
<td>116,070</td>
<td>232,140</td>
<td>464,280</td>
</tr>
<tr>
<td>Sydney - Brisbane</td>
<td>116,070</td>
<td>232,140</td>
<td>464,280</td>
</tr>
</tbody>
</table>

These freight volumes represent between 5.6% and 23.1% of the potential freight volumes that could be considered for HSR freight.
8.4.3 Option C – Shadow Freight Train

The operation of a shadow HS freight train is complicated by the stopping times and/or stopping patterns between the passenger and freight trains. Notwithstanding, this option is worthwhile considering since the potential is significant. Assuming that up to 50% of the proposed HS passenger services can be used to ‘shadow’ HS freight services, then we are looking at potentially running up to 27 ‘shadow’ HS freight services per day, as follows:

<table>
<thead>
<tr>
<th>Number of ‘shadow’ HS freight services per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melbourne - Sydney</td>
</tr>
<tr>
<td>Sydney - Melbourne</td>
</tr>
<tr>
<td>Brisbane - Sydney</td>
</tr>
<tr>
<td>Sydney - Brisbane</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Freight p.a. (based on average payload)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melbourne - Sydney</td>
</tr>
<tr>
<td>Sydney - Melbourne</td>
</tr>
<tr>
<td>Brisbane - Sydney</td>
</tr>
<tr>
<td>Sydney - Brisbane</td>
</tr>
</tbody>
</table>

These freight volumes represent approximately 23% of the potential freight volumes that could be considered for HSR freight.

The theoretical maximum freight volumes using this scenario, involving shadowing every HS passenger train, and assuming maximum payload per HS freight car of 24.5 tonnes, is 5.7m tonnes on the Melbourne – Sydney corridor, and 3.9m tonnes on the Sydney – Brisbane corridor., or almost 100% of the freight market potential.

This scenario is not deemed realistic due to the complexities associated with operating shadow trains, and the likely load factor being much less that the theoretical maximum 24.5 tonnes per HS freight car.
8.4.4 Option D – Fully Independent Freight Train

This option involves the operation of fully independent HS freight services, and will therefore require additional network capacity. Assuming the timetable for HS passenger services is generally constrained, and that only a few additional train paths may be made available for HS freight services, then this option may be limited in its potential. However, for every path found, the length of the HS freight train could potentially be maximised compared with the other options discussed above.

Assuming that between four and six train paths per day can be found between the major centres, dedicated HS freight, and that each dedicated HS freight train comprises nine cars, then freight volumes can add up to a reasonable number:

<table>
<thead>
<tr>
<th>Number of dedicated HS freight services per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melbourne - Sydney</td>
</tr>
<tr>
<td>Sydney - Melbourne</td>
</tr>
<tr>
<td>Brisbane - Sydney</td>
</tr>
<tr>
<td>Sydney - Brisbane</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Freight p.a. (based on average payload, nine car HS freight trains)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Melbourne - Sydney</td>
</tr>
<tr>
<td>Sydney - Melbourne</td>
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<tr>
<td>Brisbane - Sydney</td>
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<tr>
<td>Sydney - Brisbane</td>
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</tbody>
</table>

These freight volumes represent approximately 8% of the potential freight volumes that could be considered for HSR freight.
8.5 Making High Speed Freight Rail a part of High Speed Rail

Whilst the previous high level assessment indicates the potential HS freight market in tonnes, the expected revenue able to be derived will need to be determined to assess the financial viability of implementing HS freight rail services. Further studies are therefore recommended to understand the current road and air freight prices customers are being charged, and the likely prices HS rail freight will need to charge to attract this business.

Section 8.4 above indicates the ‘shadow’ HS rail freight service to have the greatest potential for market penetration, at 23% of the target market. This option is not without its complexities, and it is therefore recommended that further studies be conducted to assess the potential for the operation of HS rail freight services.

It is noted that The Korea Railroad Research Institute are studying the implementation of fast rail freight services on their existing high speed rail network through the Cargo Train express project.

We propose that the opportunity exists for closer cooperation in this endeavour.
9  About the Authors

Ken Devencorn  
Rail Infrastructure and Operations

Ken has over 25 years’ experience in business and project management. He has occupied a number of senior positions within the Queensland public and private sectors over the past 20 years and built a strong reputation for delivery complex and difficult projects on time and on budget. He was the General Manager of Airtrain, the Brisbane Airport Rail Link (Queensland’s first private sector passenger rail service) during project development and delivery, and prior to that a formative member of the Queensland Rail Network Access Unit, later to become the Network Access Group. He has extensive experience with asset valuation (DORC/ORC), competition reform and competitive access, and Rail Accreditation including corridor sub-lease. He has provided extensive Due Diligence advice to a variety of rail, and supply chain clients over the past 10 years.

Alex Pey  
Rail Economics

Alex provides expert advice on rail infrastructure and operations planning for clients globally. He has a long history in railway accounting and railway economics. He has an expert understanding of rail planning and logistics chains. Alex has considerable experience in planning, designing and costing rail logistics supply chains. Prior to joining Aurecon in 2008, Alex was with Queensland Rail (QR) for 25 years performing a number of senior roles involving strategic infrastructure planning (including developing QR’s first Rail Infrastructure Master Plan for Central Queensland Coal Region, regulation and policy, commercial and technical.

Brian Jacobs  
Rail Engineering

Brian has 36 years’ work experience in senior management positions as professional engineer in a diversity of industries such as the rail industry (last 21 years in Heavy Haul and Passenger Rail), property construction & development, timber, steel & concrete design, and the manufacturing environment, which has provided a diversity of skills that complement the attributes required to perform at all management levels. He’s business exposure has provided a broad knowledge base in business in general and has developed the leadership and strategic management skills to manage various delivery teams and large multi-disciplinary projects.
Aurecon provides engineering, management and specialist technical services for public and private sector clients globally. With an office network extending across 27 countries, Aurecon has been involved in projects in over 80 countries across Africa, Asia Pacific, the Middle East and the Americas and employs around 7,500 people throughout 12 industry groups. We seek to foster human achievement in all aspects of our work. We operate a client centric business model that gives us the agility to deliver the full range of our services globally. We create best teams for our key clients, develop strong client relationships and deliver market leading solutions. Our clients benefit from our collaborative business model as it nurtures the development of market leading expertise across their industries. Our technical professionals develop business advantage for our clients based on deep understanding of the industries in which they operate.

Aurecon provides world-class engineering, management and specialist technical services to government and private sector clients across a wide variety of industries.