

Trains not Planes: Why Australia needs an Ultra High Speed Rail Network.

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Abstract

This paper discusses an Ultra High Speed Rail (UHSR) network for eastern Australia. This network is composed of five lines with a total length of 5000km as shown in Figure 1: Sydney to Melbourne via Canberra, Sydney to Brisbane via the Gold Coast, Sydney to Adelaide via Parkes, Melbourne to Brisbane via Parkes and Melbourne to Adelaide.

UHSR is the most efficient form of transport for connecting the major urban areas to regional areas and both passengers and goods can be transport at these high speeds. Currently a typical rail journey between Brisbane and Melbourne takes over 19 hours to complete without any stops. UHSR will take under 5 hours even with stopping at the rural centres shown in Figure 1.

UHSR has a number of advantages for both passenger and freight movement:

- Rapid transport routes to 44 regional towns in NSW, Qld, SA and Vic as well as the ACT.
- A network of 5000km of track including 20% tunnelling and stations at a cost of \$B160, which is manageable over a 15 - 25 year construction cycle.
- This construction period allows a flexible pace of implementation to moderate the 'boom and bust' cycles in other areas of the economy, such as the housing, manufacturing and mining sectors.
- Enables economic development in the regions of these States and Territories.
- Assists in developing industry particularly for high value goods for distribution for import and export.
- Would provide Jobs throughout the four States and territory for both construction and longer term employment for maintenance and operation.
- Encourages tourism into the regions.
- Has the lowest emissions of the major transport modes, including air and road travel.
- Uses less land space than roads for the volume of goods or passengers transported.
- Uses renewable energy sources situated along the track and can supply excess to the grid.
- Provides a comfortable environment for passenger travel that is quicker than air transport once delays in security and required boarding times are taken into account.
- Removes trucks from the road system that contribute to road accident statistics, traffic congestion, road maintenance costs, carbon emissions and air pollution.

The building of a UHSR network will cause disruption to the long haul trucking industry. It is replaced, however, with shorter haul loads around each regional centre. It is essential that there is a just transition for truck drivers as many own their own rigs, having mortgaged them against their house. Short haul requires different trucks from long haul. Consequently there needs to be a mechanism to assist drivers with this change. Long haulage drivers should be given priority for this assistance.

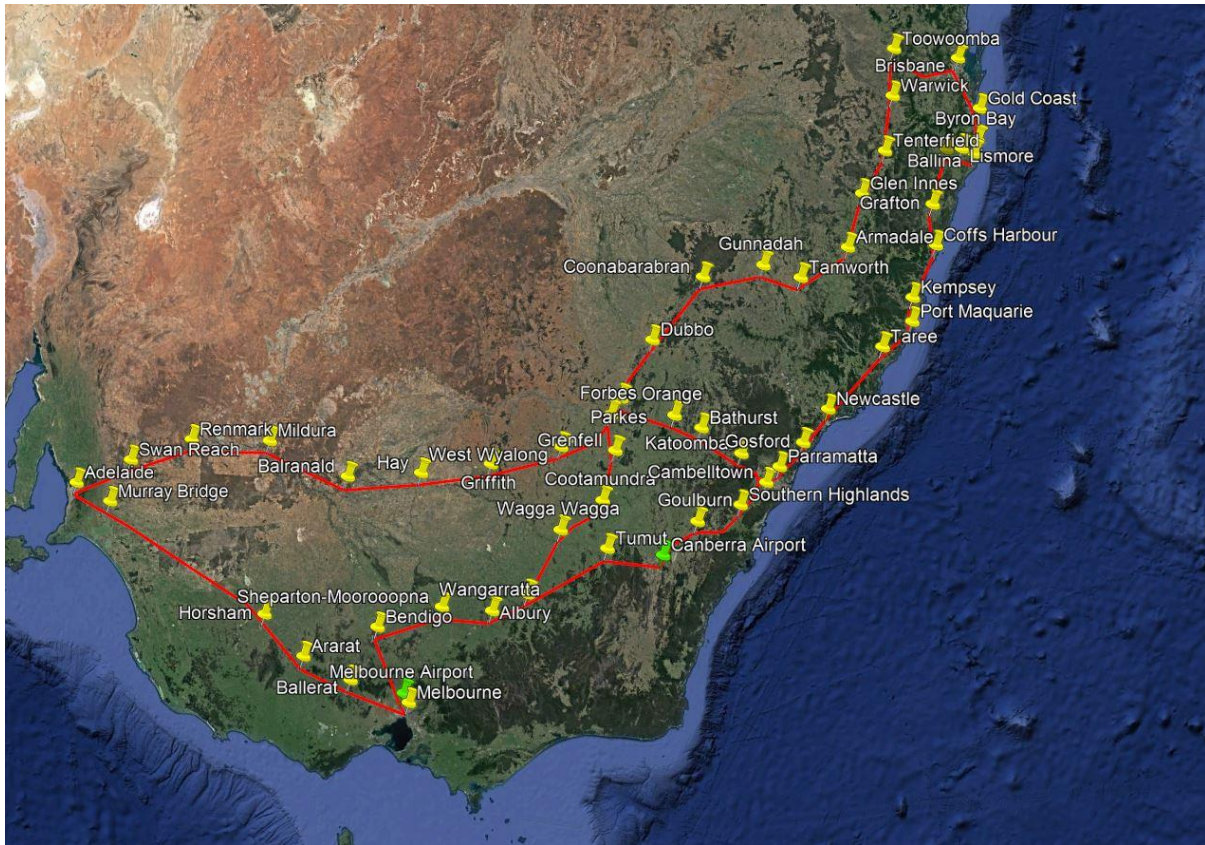


Figure 1 Proposed UHSR network for eastern Australia

Introduction

An Ultra High Speed Rail (UHSR) network is central to sustainable economic growth in Australia. It provides an integrated system of transport for passengers and goods that is currently lacking and takes advantage of being the fastest, most economic, least polluting mode of transport between 200 km and 1200km for passengers and longer distances for freight.

Australia is the only continent (apart from Antarctica) that does not have a high speed rail system. This limits interactions between rural and urban areas of the continent. Current rail speeds are a maximum of 125km/hr whereas UHSR is currently 400km/hr. Introducing such high speed trains reduces the time between Brisbane and Melbourne from 19.8 hours to under 4.8 hours with intermediate stops via an inland route.

High speed rail has operated in Europe, Japan and China for many decades. Over this time the average operational speeds have increased as the technology has developed, from 220km/hr to 320km/hr and a new train service between Shanghai and Beijing will operate between 350km/hr and 400km/hr.¹ The higher speeds can be considered as UHSR is also being introduced in Europe in the next five years at speeds of 400km/hr.

High speed rail acts as both competition and complimentary to other transport systems, especially in high volume and high demand markets. As such it can revitalise local, regional and national transport networks. By linking regional areas to international hubs it can influence the socioeconomic and political development of regions in which it operates. As it can cover a wider area in a much shorter time than other forms of transport, it provides more efficient and effective mobility for people and goods which, combined with good telecommunications, can integrate regional society and economies nationally. This mechanism provides more options for sustaining transport growth from economic demand while mitigating negative impacts on the environment and society through less land use, reduced energy consumption, emissions and traffic accidents.

This paper discusses an ultra high speed rail network for eastern Australia that can then be extended Brisbane, and Darwin from Adelaide or Toowoomba, and Perth from Adelaide

What is Ultra High Speed Rail

The definitions that are normally used for discussing High Speed rail are currently the following. The definition changes as the highest commercial speeds increase:

Ultra-High Speed Rail (UHSR) - Speeds >350km/hr. Systems coming into operation from this year (2019) in Europe and China will operate at 380-420km/hr. Commercial speeds are currently 350km/hr.

High Speed Rail (HSR) - Speeds between 200km/hr and 350km/hr. This includes older high speed rail systems and modern outer suburb rail systems across Europe. The lower speed of 200km/hr is suitable for orbital rail networks in outer Western Sydney and in the urban fringes other Australian metropolitan areas.

¹ <http://shanghaiist.com/2017/06/26/fuxing-bullet-train/>

Conventional Rail (CR) - Speeds <200km/hr. Most systems worldwide operate at 120km/hr and below for passenger and freight. The Metro system in Sydney is being designed to operate at 80km/hr similar to the wider rail network. Similar speeds are used in other Australian States.

Note the speed of a system is limited by the frequency of stops and keeping acceleration or deceleration within prescribed limits² ensure a comfortable ride.

Fit for purpose

A transport system is a physical network that can move people and freight from a point of origin to a destination. It involves multiple modes that can involve rail, road, water and air. To have an efficient network, sensible combinations of these modes are required that can transport the volume and intensity of people and bulk or non-bulky goods across the network. Each mode of transport has different spatial scales providing the most efficient movement of goods and people. Optimum choice of technologies would allow efficient transport use for urban, suburban, interurban and interregional geographies.

Modern transport systems all have elements of advanced technology that increase the efficient use of the networks or extend the networks. In this context, advanced just means additional to conventional systems. These additions need not be to the whole system but to sub-systems that increase efficiency of the whole. Such advance systems can be to the physical infrastructure, transport vehicles, the work force, supporting facilities and equipment including sensor and decision software that form intelligent transport systems and which will become increasingly important in the foreseeable future.

Advanced transport systems are required to demonstrate their performance across a spectrum of current and prospective needs and expectations. These include social, environmental, economic, operational and technological benefits of a system and would allow comparison of alternative choices of transport for a particular region.

Because of the complexity of interactions between all elements in this system, the benefits are often not equally dispersed through society. Figure 2 is one extreme where a top down approach by Government to decision making occurs. In this approach government decisions are based primarily on economic advantage to investors and infrastructure companies and low immediate cost to Government. People are seen and discussed only as consumers or customers. Social and environment benefit or costs are monetised to make an economic judgement and where social and environments costs tend to end up as externalities. This invariably means the cost comes back on the public purse or directly as a personal cost. An example of the former is the increased health costs for Western Sydney being imposed on the community from a Western Sydney Airport. An example of the latter are the road tolls. The outcome is efficiency for large business interests (only as long as congestion is avoided) and increased inequality for the people (mainly as a result of being time poor from extensive commuting).

² Acceleration or deceleration below 1.3m/s² to ensure a comfortable ride. Often the acceleration is limited even further to 0.6m/s².

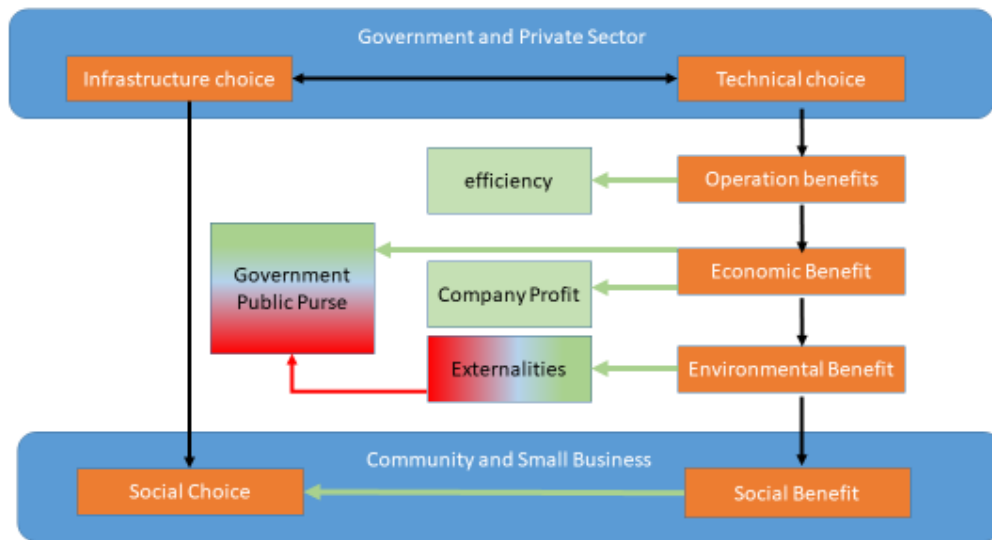


Figure 2 Top down approach to decision making

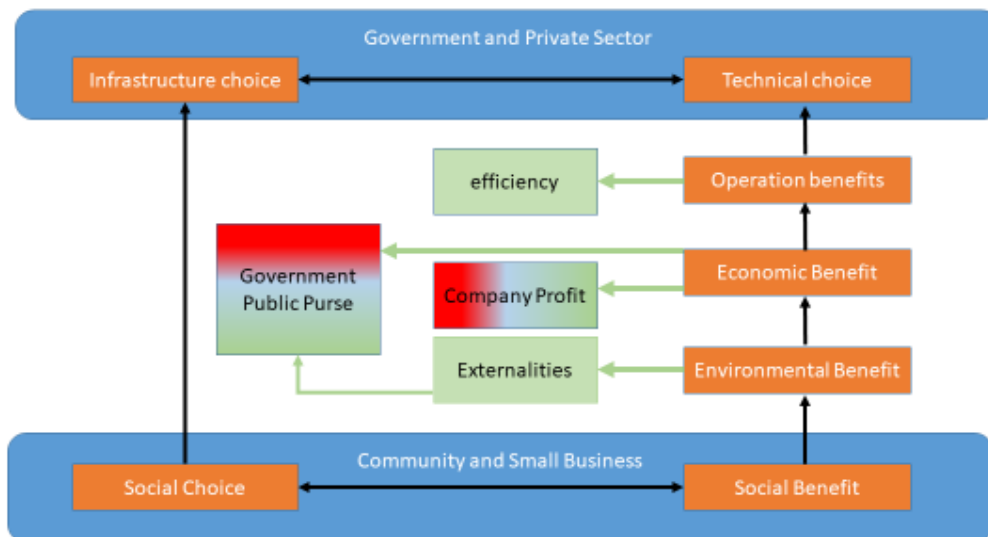


Figure 3 Bottom up approach to decision making

At the other extreme, shown in Figure 3, the decision making is driven from a bottom up approach. In this approach the social and environmental benefits of the technology are considered more equitably with economic benefit. Clearly the economic cost still has to be manageable. The outcome tends to

be more equitable for the population but the immediate cost to government is higher. There may be a short term cost to companies, although this depends on how the government structures its contracts and risks in building the infrastructure.

Technological advance usually does bring some social disruption that people get comfortable with over time. The technological choice, however, should produce a more robust and equitable society. As a consequence, the choice of technologies for infrastructure lies between these two extremes and based on evidence rather than ideology.

It is therefore important that the social, environmental, economic, operational and technological benefits and opportunities as well as their impacts are seen as being fit for purpose over at least a 40 year lifespan³ and in combination with seamless multimodal transport options for the community.

Externalities

Externalities are costs to society which are not borne by the development company or operator of the infrastructure. They mainly arise from environmental damage and accidents which impact on human health and well-being or impact on the environment and climate.

Externality costs are lower for rail than other forms of transport as shown in Figure 4, which compares accidents, noise, air pollution, climate change and upstream and downstream processes involved in operation.⁴

Cars and trucks contribute most to accidents per thousand kilometres. Rail is the safest form of transport.

Noise, particularly at night, causes sleep deprivation which has been shown to affect the ability of children to learn and increases violence in adults.⁵ UHSR does cause some noise but this is largely dissipated by fences along the rail corridor in urban areas. Higher levels of noise occur from air transport and from trucks.

Air pollution causes lung cancer and asthma and other respiratory disease. Greenhouse gas emissions are a contributor to climate change. UHSR does not generate air pollution as it is electrically powered which can be generated from renewable sources such as wind or solar. Any pollution tends to be associated in manufacture of rolling stock or in the construction of the infrastructure.

Aircraft and vehicles contribute most to climate change. Both energy consumption and CO₂ equivalent production is lower for trains than other modes as is shown in Figure 5 for a 600km trip.⁴ UHSR can source its energy from renewable energy aligned along the track and reduced power consumption

³ Physical infrastructure such as road and rail is built to last at least 40 years. Typical total replacement of rolling stock and signal technology occurs over a 40 year period. This period is also the period over which newer mass products completely replace older technology.

⁴ UIC High Speed Rail: Fast track to sustainable mobility, 2018, International Union of Railways, https://uic.org/IMG/pdf/uic_high_speed_2018_ph08_web.pdf.

⁵ Maria Klante, Jan Spilski, Jochen Mayerl, Ulrich Möhler, Thomas Lachmann and Kirstin Bergström, Effects of Aircraft Noise, on Reading and Quality of Life in Primary School Children in Germany: Results From the NORAH Study, Environment and Behavior, 1 –35, 2016, Sage Publications. DOI: 10.1177/0013916516642580

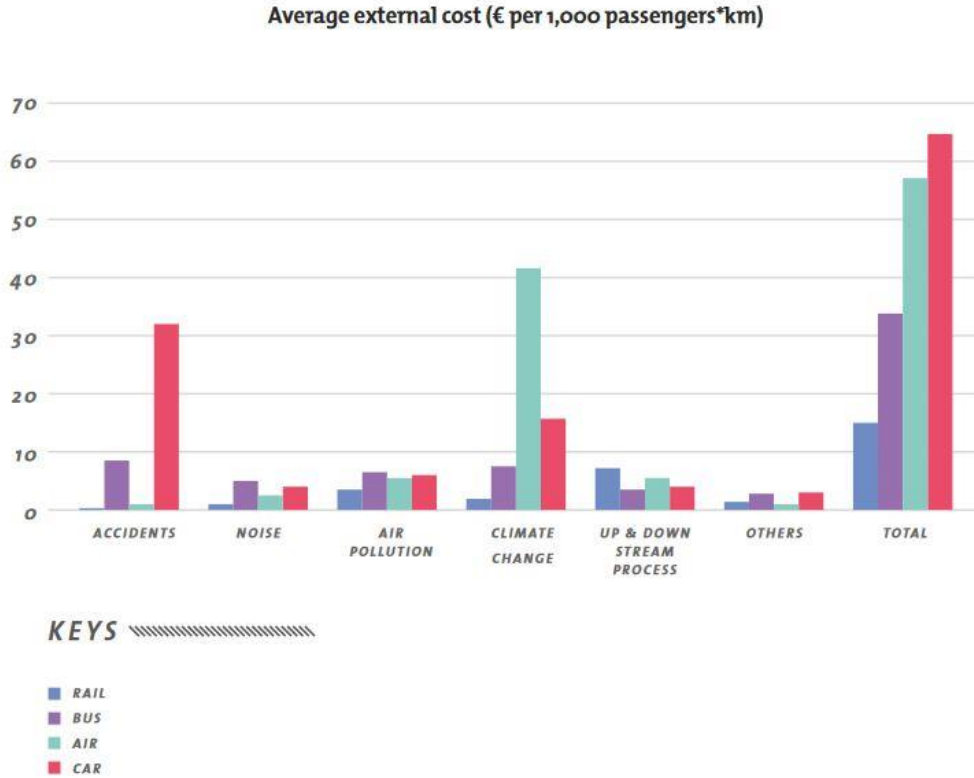


Figure 4 Externality Costs for different modes of transport⁴

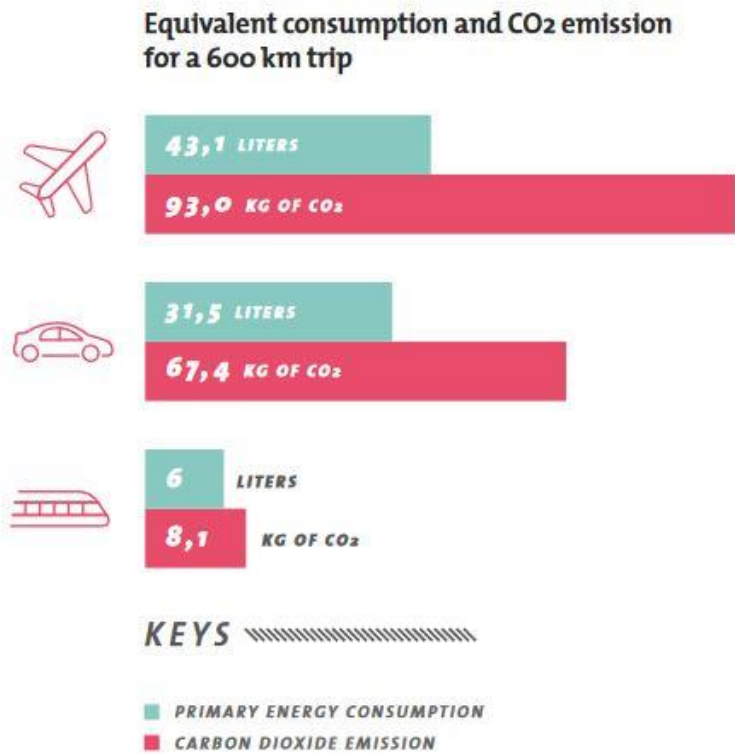


Figure 5 Energy consumption and CO₂ equivalent emissions²

with reciprocal braking as it supplies more electricity back to the grid while undergoing braking. Less power consumption also implies less emissions if sourced from fossil fuels.

Operating principles of UHSR

All high speed trains operate on principles of tilt trains which have operated in Japan and Europe since the 1970s. They now operate on newly built tracks for UHSR. This is due to their ability to tilt to minimise g-forces associated with turning on track at higher speeds. As a result, the trains are interoperable on a range of tracks - from conventional to purpose built UHSR track - and offer a more comfortable ride.

In order to operate at high speed, the existing conventional track has to be reconstructed or replaced. This involves levelling of horizontal and longitudinal slopes, increasing the radii of curved segments, partially reconstructing tunnels, and other infrastructure.

The track gauge (standard gauge is 1435mm) affects the lateral behaviour of a vehicle and hence on the comfort of passengers. The track cant (how high one rail is above the other) in a curve is safe if it is no more than 180mm. Steep cant transitions⁶ can lead to derailment and also impact on ride comfort.⁷

Figure 6 shows the difference between conventional trains and tilt trains. When trains enter a curve, passengers experience a centrifugal force and this can be reduced by angling the track in a cant or by a tilt of the vehicle. This tilt allows higher speeds to be achieved without discomfort. Passive tilting relies on natural forces around the centre of gravity and is suitable for lower speeds. Active tilt has an additional tilt to reduce the overall acceleration on passengers and is used in UHSR rolling stock.⁷

⁶ Moving from one level of cant to another. For example a curve would have a higher rail on the outside curve. When the rail goes from a right hand curve to a left hand curve, the level of cant changes. Such transitions should not occur quickly if derailment is to be avoided.

⁷ Milan Janic, Advanced Transport Systems, Springer Verlag, London, 2014

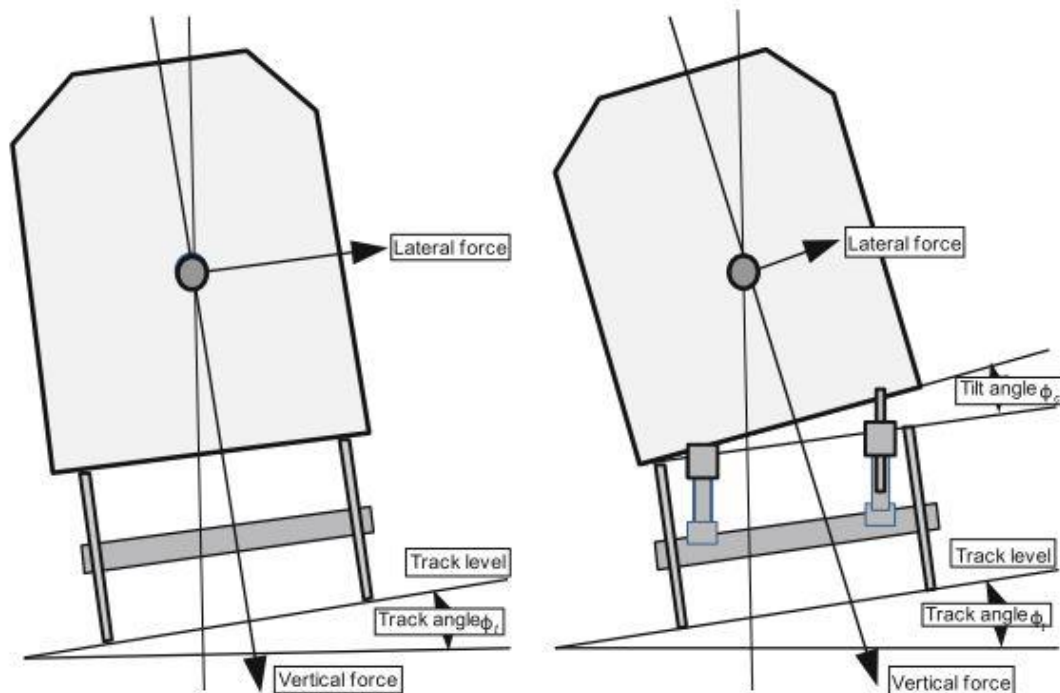


Figure 6 Principles of a tilt train⁸

Most high speed trains use electrical energy from a catenary wire above the train accessed by a pantograph on top of the train. A pantograph can be raised or lowered to contact the catenary wires supplying the electrical power for the train. Having trains with multiple pantographs increases their interoperability as each can use different DC or AC voltages. This is necessary in Europe where different countries have different electrical voltages.

Noise at high speed is a problem and is mainly due to rolling noise as speed increases. Measurements have shown that the ETR480 and ETR500 tilt trains operated in Europe generate noise of 90.5dBA and 88.0dBA while passing at speeds of 250km/hr. This is less than technical specifications for interoperability (TSI) limits at higher speed.⁹ The noise experienced by the local population is lower than these due to noise barriers near noise sensitive areas and the distance to the rail lines from these barriers (>25m).

The safe operations of high speed trains relies on scheduling that ensures safe distances between trains and obeys speed limits on sections of the line. The dependence on these is likely to change as more sensors are added for semiautomatic and automatic control of the train.

High speed trains do not cause congestion on exclusively operated lines. On lines with mixed traffic they can cause delays to lower prioritised traffic using the same lines. This is no different from conventional systems where freight is often given a lower priority than passenger trains particularly during peak transport times. This will be discussed in more detail below when assessing the proposed UHSR network.

⁸ Persson, R. (2007). *Tilting trains: Description and analysis of the present situation*, Literature study ISBN 978-91-7178-608-1. Stockholm: Royal Institute of Technology.

⁹ Poisson, F., Gautier, P.E., Letourneaux, F. (2008). *Noise sources for high speed trains: A review of results in the TGV case*. In B. Schulte-Werning et al. (Eds.), *Noise and vibration*

Market Passenger Share and modal switching

The development of UHSR between cities leads to a modal shift away from roads leading to a lowering of road congestion. It is estimated that a single train with a capacity of 440 seats and half full can replace about 190 cars. In Western Sydney only about 9% of cars carry more than the driver.¹⁰ Hence any change in congestion may not be obvious in metropolitan areas due to the high levels of commuter traffic swamping any signal of change of transport mode.

The market share of the modal split between rail and air in France is shown in Figure 7. HSR takes in excess of 75% of the market when distance times of less than 2.5 hours duration and then drops consistently as travel times get longer.

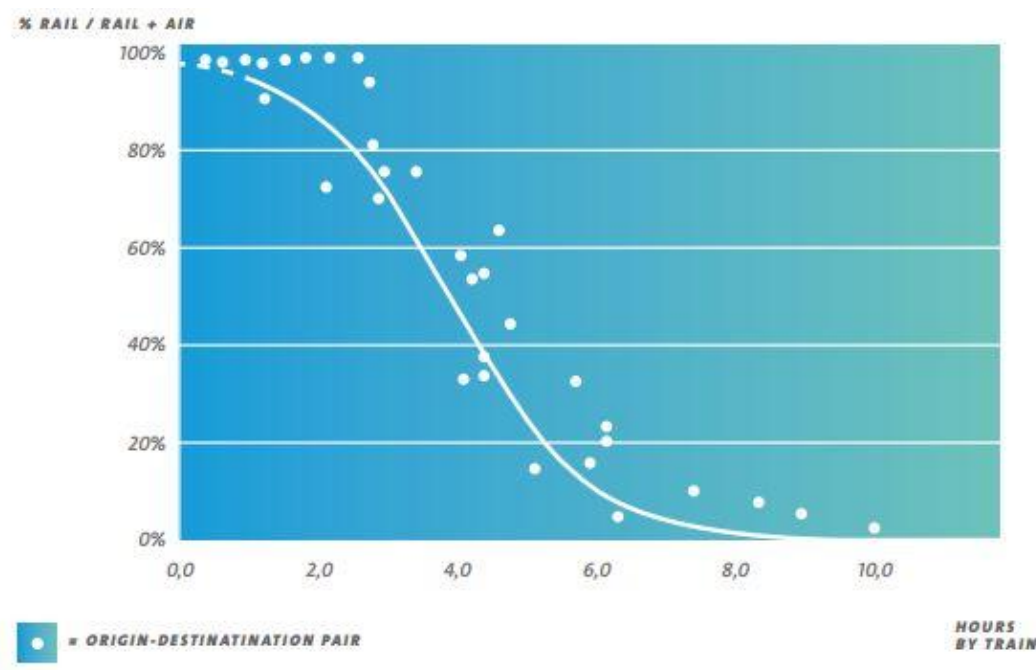


Figure 7 Market share of HSR and Air travel in France¹¹

The global market share of different modes of transport is shown in Figure 8. At distances under 200-300km the use of private car dominates travel modes. It offers a full door to door trip in privacy with full choice of departure or arrival times, the choice of route and no constraints linked to tickets or reservations.

¹⁰ Passenger in cars obtained from 2016 census data, ABS 2016 census.

¹¹ UIC High Speed Rail: Fast track to sustainable mobility, 2018, International Union of Railways, https://uic.org/IMG/pdf/uic_high_speed_2018_ph08_web.pdf, p59

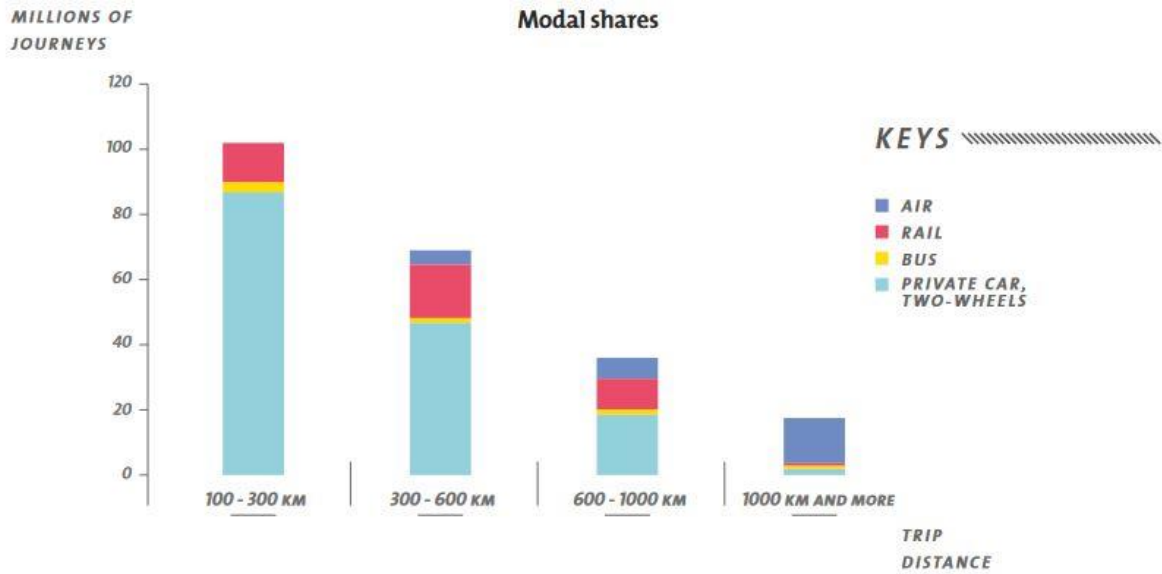
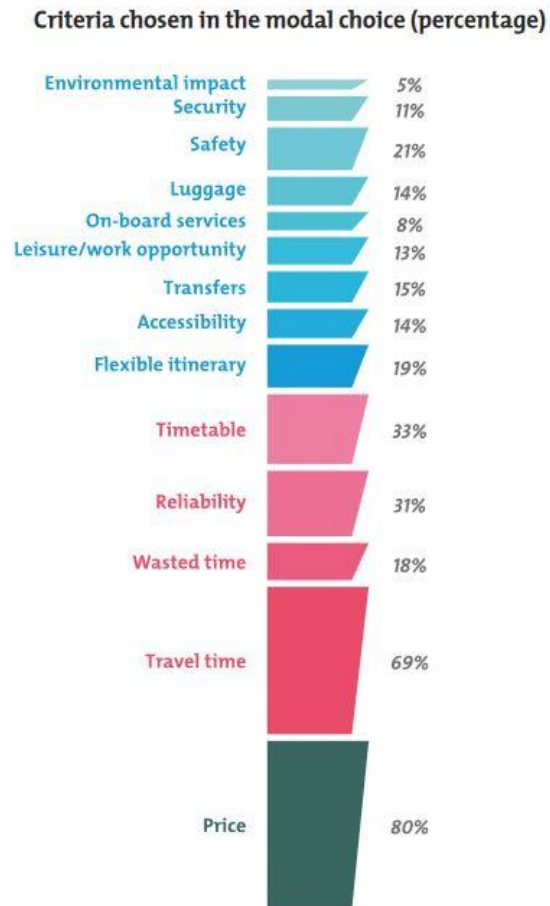


Figure 8 Modal market share of HSR⁷



At longer distances rail is preferred over air as long as the journey time is not excessive for the reasons found in the survey in Figure 9. With ultra-high speeds being achieved 50% of trips are made by rail for distances of under 1600km where there is a direct connection.

The advantage of UHSR is highlighted in surveys of modal choice as shown in Figure 9. The survey asked more than 2000 people in three European countries. Price was a determining factor but travel times, reliability and a dependable timetable were all important. UHSR gives flexibility to travel arrangements whilst providing a safe environment where both leisure and work can occur.

Figure 9 Choice of transport mode ⁷

The Proposed network

Figure 1 shows the proposed routes for five lines connecting Adelaide, Brisbane, Canberra, Melbourne and Sydney. It connects 47 regional towns and 8 metropolitan stations in capital cities. Figure 10 shows the same routes but also displays the major Ports and International Ports relative to the UHSR network. It shows that the ports and major international airports, where the majority of imports and exports to Eastern Australia occur, are well positioned to take advantage of UHSR freight as well as passengers.

Parkes is at the crossroads of the inland route between Melbourne and Brisbane, and between Adelaide and Sydney. Because it is the centre of agriculture in the west of NSW as well as being an intermodal location for rail and road, it is a natural centre for placing a freight airport for import and export of freight from this country.

The UHSR network for eastern Australia could be extended by additional lines from Brisbane via Roma and Emerald to Mount Isa and then Darwin or from Adelaide to Darwin to include Port Pirie and Port Augusta.



Figure 10 The UHSR network relative to major ports and International Airports

Cost

The current average costs of construction of 1km of new high speed dual line in Europe (2017) is €15-40 million/km (\$23-63 million/km) according to Union Internationale des Chemins de fer (UIC).⁷ The higher figure is for tunnelling in unstable strata. This includes signalling and catenary overhead line

infrastructure but not stations and rolling stock. It would suggest that a network linking Sydney, Melbourne, Adelaide, Canberra and Brisbane over 4900km of double track should cost in the region of \$B160. A detailed breakdown is given in Table 1 and assumes 20% of each distance involves tunnelling through strata giving an average cost of \$M31.6 per km of double track. The exchange rate has been taken as 1.58 Euros to the dollar. It is also assumed that each station would cost approximately \$M50 which includes additional rails, platforms signalling and access. The building of a line between Melbourne and Sydney to Brisbane, a distance of 1660km, should cost in the region of \$B55 based on 2017 costs. The Department of Infrastructure report uses a unit cost of \$M65.0 per km¹² in their estimates while the Beyond Zero emissions report use \$M43.2 per km.¹³ A question arises as to why overseas UHSR construction costs are considerably lower per kilometre than estimates being produced by government and private bodies. Aurecon suggest an international competitive rate of \$M35 per km is more appropriate. This is 10% more than in Table 1.¹⁴ The difference reflects the development costs associated with design and geological data on strata for proposed rail corridors which was not included in the estimates given here. Another difference is the assumption about the degree of tunnels used. In the Department of Infrastructure paper, phase 2, the tunnelling between Sydney and Melbourne was assumed to be 29% with 69km of tunnelling in Sydney. In this paper 20% has been assumed.

Table 1 Cost of building the basic infrastructure for a High Speed Network in Australia. These costs do not include freight marshalling yards or the rolling stock but does include stations.

Rail Distance	Distance (km)	Cost of double track (\$billion)	No Stations	Cost of Stations (\$billion)	Total Cost (\$billion)
Brisbane Melbourne via Parkes	1688	53.34	18	0.900	54.24
Brisbane - Sydney via Gold Coast	845	26.70	12	0.600	27.30
Sydney to Adelaide via Parkes	1258	39.75	10	0.500	40.25
Sydney to Albury via Canberra	506	15.99	4	0.200	16.19
Adelaide to Melbourne	664	20.98	4	0.200	21.18
Capital Stations			7	0.350	0.35
Total	4961	156.77	55	2.75	159.52

¹² Dept. of Infrastructure and Transport, High Speed Rail Study Phase 2 Report, 2012.

¹³ Zero Carbon Australia High Speed Rail, Beyond Zero Emissions Melbourne Energy Institute, The University of Melbourne German Aerospace Centre, 2014, high-speed-rail-bze-report-2014.pdf.

¹⁴ Aurecon, The Potential Impacts of High Speed Passenger Rail to Eastern Australia, Discussion Paper: Australasian Railway Association (ARA), 30 October 2014. Downloaded as 14-10-27 REPORT-The-Potential-Impacts-of-High-Speed-Rail-to-Eastern-Australia.pdf on 24 October 2018.

Construction

There are a number of processes involved in the construction of such a network: financing, initial design, consultation, buying and negotiating land use, final design and construction. Figure 11 is a Gantt chart of this process.



Figure 11 Timescale for the delivery of the full network

Currency-issuing governments are able to fund infrastructure without resorting to public-private partnerships and without resorting to debt. There is no financial constraint on their activities, but there is a real resource constraint (labour, materials, technical capacity etc). Consequently, to ensure price stability, that is, to avoid high inflation, these real resources must be available, or made available (through training and investment programs). If these real resources are currently under-utilised, for example, unemployed labour or excess capacity in steel production, then an expansion of government activity to build infrastructure will not be inflationary. Moreover, such an expansion is an important counter-cyclical fiscal strategy, boosting economic activity during business cycle downturns and restraining such activity during boom periods.

This situation describes the Federal Government and is the reason why HSR needs direct Commonwealth funding. State governments are in a different situation (as they do not issue the currency) and this is one of the reasons why they often resort to other methods to fund their infrastructure. Some of these methods, such as public-private partnerships, are susceptible to corruption.^{15,16}

The five lines are split into a number of sections that relate to development in each State in order that passenger and freight services can be started as soon as practicable. For example, Brisbane to Ballina and Brisbane to Warwick enable both passenger services from northern NSW and the Gold Coast to Brisbane, as well as freight from the farming communities to the west and south west of Brisbane, fast access to Brisbane Airport and docks. Similarly with the other capital cities.

¹⁵ Cameron K Murray, Paul Frijters, *Game of Mates: How favours bleed the nation*, ISBN 978-0-6480611-0-6, 2017.

¹⁶ Bent Flyvbjerg, *Survival of the Unfittest: why the worst infrastructure gets built—and what we can do about it*, *Oxford Review of Economic Policy*, Volume 25, Number 3, 2009, pp.344–367.

If it is assumed that there are four engineering teams working on this development (associated with each State), then preliminary design of each sub-route can be completed in a year. Consultation of these routes is required as part of the planning process and can be started midway through the preliminary design process and would take about two years in total. Similarly the acquisition of land for stations and negotiation for the route with land holders can also be started during the period of consultation and would be expected to take about two years in total. The final design and route would take a further year.

The construction phase as shown in Figure 11 assumes an average rate of construction of 0.5km per day (this is less than half the rate of construction in China¹⁷). The slowest part of construction is likely to be in tunnelling as tunnel boring machines advance according to the type of strata. The longer the tunnel the slower the average rate of progress.¹⁸ Consequently the Sydney to Parkes section might take longer. In Figure 11 the additional time for the Sydney to Parkes, Albury to Canberra and Adelaide to Mildura sections is shown as a grid in yellow. The construction times were assessed from an average rate of 1m/hr for these tunnel lengths of 40km and 50km. Faster average rates can occur with shorter tunnel sections.¹⁸ The assessment of the best route through these terrains is part of the preliminary design. Even with the expected delay for long tunnels the whole network could be built in 12-13 years.

Thus, a complete network of 4900km could be built within 15 years at \$B11.6 per annum including project development costs at 10% of construction costs (or \$B6.7 per annum over 25 years). This concept will move passengers and freight between major centres and rural areas on the east coast at high speed.

UHSR Passenger Services

International passenger numbers coming to Australia and freight through the international airports is shown in Table 2. Both are expected to grow. While inbound passengers are likely to head initially to capital cities, the availability of a fast train network will increase tourism especially to the regional centres. The non-bulky and priority freight being containerised for airflight is readily transported by UHSR without significant repackaging. The expected increase in perishable exports would make a case for a dedicated international airport at Parkes where three intermodal modes come together – road, rail and air. It is also situated at the centre of a large agricultural area where perishable goods distribution is an issue for efficient export.

Daily domestic air passenger trips between city pairs is shown in Table 3. The figures include those using international carriers as well as domestic carriers. Column 3 represents the market share of these passengers that would switch to UHSR, assuming the train speeds were 400km/hr, based on reference 7. Column 4 is the number of passengers who will switch modes between the cities.

A similar estimate for road users is based on Tourism Australia Research estimates for the number of people going interstate and intrastate on daily and overnight visits. The data was estimated as a ratio for the number of passengers to capital cities and the number arriving by car or other transport. The city pairs were then estimated in the same proportion as the city pair flights. The market share was based on the principle that about 50% of car trips were holiday or family visits and consequently are unlikely to change the mode of transport. Those that may change were determined by the time taken

¹⁷ Tom de Castella and Kathryn Westcott, HS2: 20 reasons why it can take 20 years to build a railway, BBC News Magazine, 29 January 2013.

¹⁸ Nick Barton, Optimum advance for long distance TBM drives, Feedback, TunnelTalk.com, 2014, Optimum advance for long distance TBM drives.pdf, downloaded 12/02/2019.

to drive - the longer the drive the higher the chance of a change of mode. Below 3 hours, a car is probably the most effective form of transport and so was set at a 1% change. Above 17 hours, it was assumed that 50% would change mode. A log relationship was used to fit the data between these extremes.

Table 2 Passengers and Freight at International Airports¹⁹

Airport	Passengers per day			Freight per day (tonnes)		
	Inbound	Outbound	% change from 2017	Inbound	Outbound	%change form 2017
Adelaide	1 520	1 460	2.7	44.1	47.1	8.5
Brisbane	8 577	9 049	7.0	181.5	224.5	8.1
Canberra	125	157	16.4	0.1	0.0	-
Gold Coast	1 278	1 362	-9.8	10.8	2.4	-
Melbourne	15 725	15 992	9.8	416.8	490.0	4.3
Sydney	22 425	22 828	2.3	872.2	661.1	8.3

¹⁹ Bureau of Infrastructure, Transport and Regional Economics (BITRE), September 2018 International Airline Activity - Monthly Publications, Downloaded as .International_airline_activity_1809_Tables.xlsx, 20190103

Table 3 Domestic passengers between City pairs

City Pair	No of Air Passengers per day ^a	Market Share ^b	Number of Rail Passengers	Number of road visitors ^c	market Share ^d	Number of Rail Passengers
Adelaide - Brisbane	2348	0.2	470	3889	0.49	1898
Adelaide - Canberra	521	0.65	339	967	0.38	370
Adelaide - Gold Coast	603	0.25	151	840	0.50	420
Adelaide - Melbourne	6815	0.95	6474	13240	0.24	3171
Adelaide - Sydney	5229	0.7	3660	11071	0.39	4269
Brisbane - Canberra	1695	0.75	1271	2980	0.35	1029
Brisbane - Melbourne	9745	0.5	4872	18193	0.44	8050
Brisbane - Sydney	13118	0.95	12462	26203	0.27	7165
Canberra - Melbourne	3152	0.95	2994	6506	0.18	1182
Canberra - Sydney	2608	0.95	2478	5878	0.01	59
Gold Coast - Melbourne	5604	0.45	2522	9375	0.46	4281
Gold Coast - Sydney	7539	0.95	7162	13644	0.30	4107
Melbourne - Sydney	25345	0.95	24077	54394	0.28	15252

a) Data extracted from domestic airline city pair data to June 2018, BITRE, Domestic_airlines_YE Jun_2018.xlsx. b) Estimated using market share in ref 7. c) Data from Tourism Australia Research, estimates for the year ending June 2018 from the national visitor survey, NVS Web Tables - YE June 2018.xlsx. d) Assumed that a maximum of 50% of people would transfer mode if journey time by road was more than 17hours and 1% would transfer mode if the journey time was less than 3hours. A log relationship was used for mode transfer between these times.

Table 4 Estimated number of daily passengers and number of train sets required

UHSR line	Passengers	No. of Trains per day. 485 passengers	No. of Trains per day. 750 passengers	No 485 passenger Train Sets per day	No 750 passenger Train sets per day
Adelaide Canberra via Melbourne	14530	30	20	5	3
Melbourne to Sydney via Canberra	41866	87	56	9	6
Adelaide - Sydney via Parkes	10868	23	15	4	3
Melbourne to Gold Coast via Parkes	22664	47	31	9	6
Sydney to Gold Coast	30896	64	42	8	5
Total	120824	251	164	35	23

The proposed Australian UHSR network can be broken into five lines as indicated in Table 4. A passenger going to Canberra from Adelaide would go via Melbourne as the shortest route. Similarly those going to Brisbane from Melbourne would go via Parkes as would those going to Brisbane from Adelaide. The number of passengers per day is estimated from Table 3 for the five routes.

A typical train would have a capacity of between 450 and 750 passengers depending on how four classes of passengers – executive, business, premium and standard – are integrated into the passenger sets. The numbers of trains required per day, also given in Table 4, show that on the Melbourne to Sydney route trains would be required every 15 minutes to 30 minutes depending on the passengers per train set. Other lines would require a lower frequency of service. The number of operating train sets required to deliver this service are also shown in Table 4. It is assumed that there would be a turnaround time of 1 hour at terminal stations.

The travel times between city pairs for air and UHSR are compared in Table 5 below. The flight times are the scheduled flight times from gate closure to opening the arrival gate. The airport pre-flight waiting time is assumed to be 1.5 hours which corresponds to opening of the flight for luggage. While the minimum pre-flight waiting time is 0.5hours, the majority of passengers allow longer. The UHSR travel time assumes a commercial speed of 400km/hr and takes account of comfortable acceleration and deceleration with an assumed stop of 1 minute at intermediate stations. A direct train without stops would be faster. For example, Adelaide to Melbourne would be 11 minutes faster than shown in Table 5.

Table 5 Approximate travel time between city pairs for air and UHSR

City Pair	Flight Time hr : min	Airport Pre-flight waiting time hr : min	Total Airport to airport flight time hr : min	UHSR travel time hr : min
Adelaide - Brisbane	2:35	1:30	4:05	5:37
Adelaide -Canberra	1:25	1:30	2:55	3:39
Adelaide- Gold Coast	2:30	1:30	4:00	5:57
Adelaide - Melbourne	1:20	1:30	2:50	1:53
Adelaide - Sydney	1:55	1:30	3:25	3:48
Brisbane - Canberra	1:50	1:30	3:20	3:38
Brisbane - Gold Coast				0:20
Brisbane - Melbourne	2:25	1:30	3:55	4:48
Brisbane - Sydney	1:35	1:30	3:05	2:49
Canberra – Gold Coast	1:28	1:30	2:58	3:18
Canberra - Melbourne	1:09	1:30	2:40	1:32
Canberra - Sydney	0:40	1:30	2:10	0:49
Gold Coast - Melbourne	2:05	1:30	3:35	5:08
Gold Coast - Sydney	1:35	1:30	3:05	2:35
Melbourne - Sydney	1:25	1:30	2:55	2:29

Many of the UHSR journeys are similar or less than current travel times. For example, Sydney to Melbourne and Sydney to Brisbane will take about 2.5 hours similar to the current air travel time once waiting time at the airports are taken into account.

UHSR Freight Services

A significant proportion of fast freight can be integrated into this rail network. Table 6 shows a comparison of characteristics between air, rail and road cargo. International air freight is forecast to increase and can be readily transferred and distributed along the eastern seaboard without the need for long distance road transport or a second airport in Western Sydney. This in turn will reduce truck accidents, the damage it causes on the road infrastructure, air pollution and carbon emissions.

The use of the ultra, high speed rail network for freight can transform the way freight is transferred around Eastern Australia, not just high priority and perishable goods. Automated systems can increase the efficiency of loading. For example, automated loading and unloading can reduce the time taken to load and simultaneously unload an 8 car train to between 20 and 50 mins²⁰.

Table 6 Comparison of modal freight

	Air Cargo	Rail Cargo ^a	Truck Cargo
Intercontinental	++	+	-
Intracontinental	+	++	+
Short distance	-	+	++
Door to door flexibility	-	-	++
Security	+	++	+
Low environmental emissions		++	+
Low congestion	+	++	-
Maximum tonnage	<150	<300 ^a	<60 (B-double)
Current maximum commercial speed (Km/hr)	850	350	110
Loading and unloading	Automatic loading or unloading	Automatic simultaneous loading and unloading	Manual and automatic loading and unloading
Palette (L,W,H mm)	3175 x 2440 x 2440	3170 x 2440 x 2900	1165 x 1165 x --
Container (L,W,H mm)	3175 x 2440 x 3000	3180 x 2440 x 2440	

a) Based on Siemens new freight systems.

²⁰ Gediehn, A., High Speed cargo via rail; technical innovation on rolling stock, Siemens Specific Seminar 2, Industrie Sektor Mobility/ IL CP, Zaragoza 13 April 2010,

At speeds of 350-400km/hr international freight can be in the major city distribution centres within 5 hours allowing for loading and unloading times. Similar times would exist for export of perishables.

Table 7 shows the time for travel between major ports and airports to Parkes travelling at 350km/hr. The introduction of 400km/hr train sets in the near future in China, Europe and Japan will see an increase in freight at these higher speeds as well.

Table 7 Transit times to Parkes

Port and Airport	Distance to Parkes	Travel time (hr : min)
Adelaide	954	2:53
Brisbane	938	2:55
Melbourne	750	2:26
Sydney	304	1:02

Table 8 below shows the amount of goods loaded and unloaded at the major ports. It includes import and exports and redistribution of goods to other Australian ports. The large figure for goods loaded at Newcastle is due to the large amount of coal exported from this port. The others involve materials and containers that are transported in bulk, for example fuel or gas, or arrive in containers at the dock. Both are mainly transhipped by road rather than rail. For example, some 470 B-double trucks per day are needed at Port Botany container terminals. This equates to about 80% of container traffic being on roads and 20% on rail. A further 160 fuel B-double tankers access Port Botany daily which may rise to 220 per day by 2030.²¹ There are about 14 people killed per month from heavy truck crashes in Australia.²²

Much of the containerised materials including some bulk materials can be split into container systems suitable for both air and UHSR transport. Bulk materials such as grains can be split into intermediate bulk containers that would fit in air and HSR compartments as well as 20 TEU (Twenty foot equivalent unit) containers. This process can lead to development of niche markets for materials where currently they are mixed for transport in bulk and command a low price.

Splitting loads at port can be more effective than transport to another depot where it is then transhipped. The tagging system for containers can be targeted to their destinations via a UHSR network. For example, a washing machine order from Korea for the *Good Guys* can be packaged from individual stores in Korea and loaded in UHSR ready containers in 20 TUE containers for shipping. At the port, they can be unpacked from the containers and sent to the appropriate UHSR destination where stores are located. This process can be made automatic and has a number of advantages at the

²¹ Rebecca Franks, Vopak's plan could see 92,000 tankers a year accessing Sydney's port by 2032, April 4, 2017, Sothern Courier, Daily Telegraph.

²² Fatal Heavy Vehicle Crashes Australia—Quarterly Bulletins – September 2018, The Bureau of Infrastructure, Transport and Regional Economics (BITRE), accessed Jan 3 2019.

Port. Border control inspections and biohazard inspections can be done as packages are unloaded from 20 TEU containers at the port. It reduces the risk of biohazards getting into the wider Australian environment and provides point coverage for the detection of illicit materials.

Table 8 Tonnages and containers exchanged from ports.²³ Note that containers at Newcastle and Port Kembla are excluded by contract between the NSW Government and Port Botany, this is seen by many as anticompertitive and smacks of political ineptitude/corruption²⁴

Port	Loaded 2015-16	Unloaded 2015-16	Containers exchanged 2015-16
	Million tonnes	Million tonnes	20TEU
Sydney	6.1	20.4	2323722
Melbourne	13.3	19.8	2638536
Brisbane	13.5	16.1	1147173
Adelaide	6.7	6.8	389684
Newcastle	455.6	22.6	
Port Kembla	12.5	1.5	

There were important differences in the past between passenger and freight. High speed rail has concentrated on reducing energy consumption to increase speed whereas freight has concentrated on the weight to axil weight ratio to increase the weight of freight carried for a given system. The effect of these biases is to portray freight as not being compatible with UHSR.

As an example, the amount of freight projected to be transported between Brisbane and Melbourne is 32 Million tonnes per annum by 2030.²⁵ Table 10 shows the difference between using conventional rail and UHSR to move the equivalent yearly tonnage. The tonnage for inland rail is based on an 1800m train double stacked with four 20 TEU equivalent containers per railcar. The tonnage for the UHSR is based on developments for moving freight by Siemens for the proposed Europe/Russia/China high speed freight line running at 350km/hr.²⁶ While 146 trains per day seems a lot, it represents a train every 10 minutes which is within both the capacity and safety constraints.

²³ Bureau of Infrastructure, Transport and Regional Economics (BITRE), 2017, *Yearbook 2017: Australian Infrastructure Statistics, Statistical Report*, BITRE, Canberra ACT

²⁴ Jenny Wiggins, Sale of NSW ports included 'anti-competitive and illegal' deeds: ACCC, Financial Review, Dec 10, 2018.

²⁵ ARTC, The case for Inland Rail, *The_Case_for_Inland_Rail.pdf* downloaded from www.inlandrail.com.au, 27 September 2018.

²⁶ K.Barrow, RZD develops plans for high-speed rail freight, *Railway Journal*, 18 Oct 2017, downloaded 4 June 2018 as RZD develops plans for high-speed rail freight.pdf.

Table 10 Comparison of moving 32 million tonnes per annum of freight between Melbourne and Brisbane

	Inland Rail	UHSR
Time taken Brisbane to Melbourne (hrs)	19.8	4.5
Freight weight per train (tonnes)	17700	300
Trains per day in each direction	2.5	146

It is not suggested that this frequency of service is actually enacted but that it is feasible, and will transport not only perishable goods and priority goods for next day delivery and can be extended for speciality goods or products. This ability allows new products to be developed for overseas markets. For example, export of grain is achieved by putting the harvest in silos and then onto conventional rail. It does not have to be done like this. Particular farms can specialise in specific types of harvest (heirloom, certain genetic characteristics, organic etc) that can be placed into intermediate bulk

containers to be transported to specialised markets around the world. This is far different from mixing the harvest and a slow train coming.

UHSR offers a huge benefit in the time saved in transporting freight. This is particularly important for perishable goods. The times given in Table 10 do not account for loading and unloading times. Automatic loading of a UHSR train using roll-on – roll off containers or standard air pallets would take approximately 30 minutes. The time taken to load an 1800m train depends on how many loading units there are. A single loading system would take in the order of 9 hours but can be reduced by having several loading units along the length of the train.

Typical freight terminal layouts are shown in Figure 12. These layouts, while suitable for loading by crane for conventional rail are inefficient for UHSR as they do not lend themselves to automation.

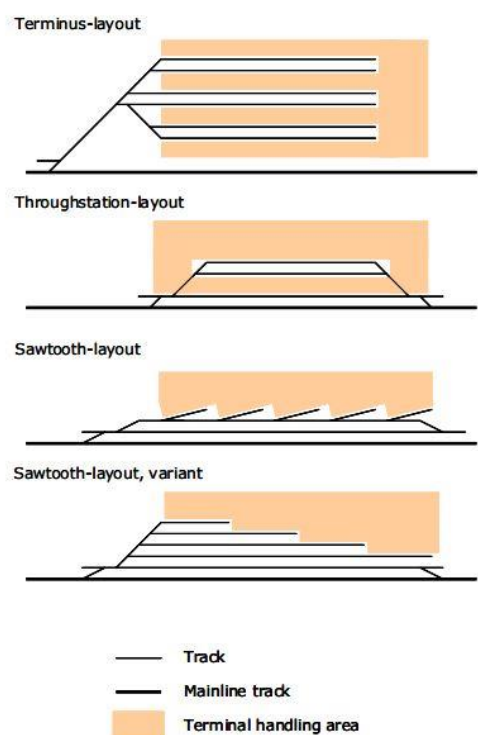


Figure 12 Typical Freight Termini layouts

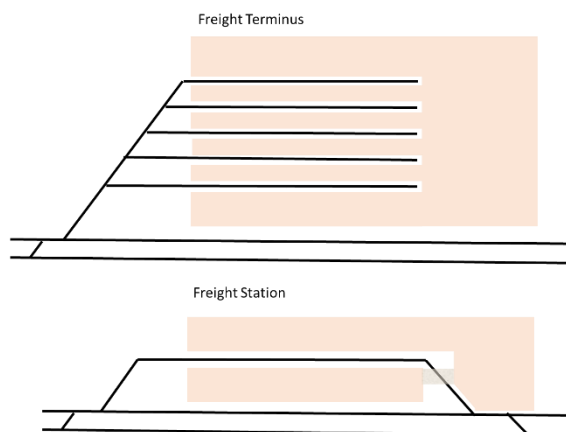


Figure 13 Efficient Layouts for Automation

The two layouts shown schematically in Figure 13 allow for simultaneous loading and unloading of roll-on roll-off containers or containers that can be loaded or unloaded into aircraft through automated horizontal transfer technology as shown in Figure 14.

There are a number of advantages in using this technology:

- A UHSR train can be loaded and unloaded simultaneously reducing dwell times at termini or at through stations.
- The smaller containers used for air freight and for UHSR enable more efficient targeting of goods between pickup and

delivery. The ability to tag individual containers with the same rail destinations but for different physical locations allow for loading onto trucks to their local destinations.

- The transfer from 20 TUE or 40 TEU containers at Ports will increase efficiency. Packing in the smaller containers with the TUE containers allows automation at the Ports as the smaller containers should already be tagged for their destinations allowing groupings of smaller containers onto rail for similar destinations.
- The transfer at ports can also assist Border Security for discovery of illicit imports and exports. It also assists in biosecurity in limiting the import of invasive species to port areas which normally have an urban buffer between the port and the larger environment.
- Utilising the rail system more effectively reduces road maintenance costs due to less use of trucks.
- Utilising the rail system more effectively reduces the number of crashes involving trucks on the road. 154 people died from 136 fatal crashes involving heavy trucks last year.²⁷ These are a major component of serious road accidents as well as being responsible for long delays in commuter traffic on metropolitan roads.
- UHSR would cause a shift in modal transport away from long distance road haulage to short haul hub and spoke around each of the regional centres. The need for long haul road transport would decline being replaced by larger short haul requirements. A just transition is required for long haulage truck drivers as many own their own rigs and have bought them against mortgaging their houses. Short haul requires different vehicles equipped with automatic loading and unloading facilities. The transition will require assistance for truck drivers to make the change.

²⁷ https://bitre.gov.au/publications/ongoing/fatal_heavy_vehicle_crashes_quarterly.aspx

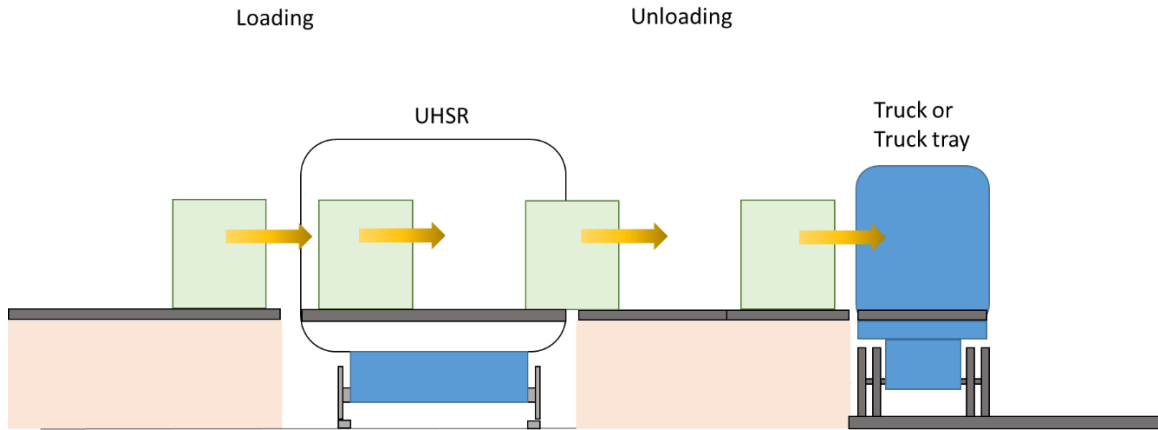


Figure 14 Automated Horizontal Transfer

Unless the freight train speeds match the UHSR speed, there is potential for delay in the transportation of freight. The left hand side of Figure 15 shows the overlap between passenger trains (blue) travelling at 400 km/hr and freight trains (orange) travelling at 300km/hr. It is assumed that the passenger and freight travel 600 km between the ends of the line. The passenger service is every hour (the first 2 are shown). The freight services depart 18 minutes after the passenger service and then every 18 minutes. The third and fourth freight services cannot get to their destination before being overtaken by the second passenger service. If passenger services are given priority over freight, which is normally what occurs, the third and fourth trains either have to be cancelled or placed in a siding to wait while the passenger service passes.

The right hand side is a more efficient solution. Two intermediate freight stations, located say at 130km and 400km along the line, allow targeted freight to be automatically unloaded (or loaded) at these stations with a minimal delay. Here 30 minutes has been used corresponding to simultaneous loading and unloading of a train. Note that even with this type of delay the freight arrives at the final destination before the third passenger train arrives.

The ability to target destinations in this way make the delivery and pickup of goods at intermediate stations much more efficient than conventional freight.

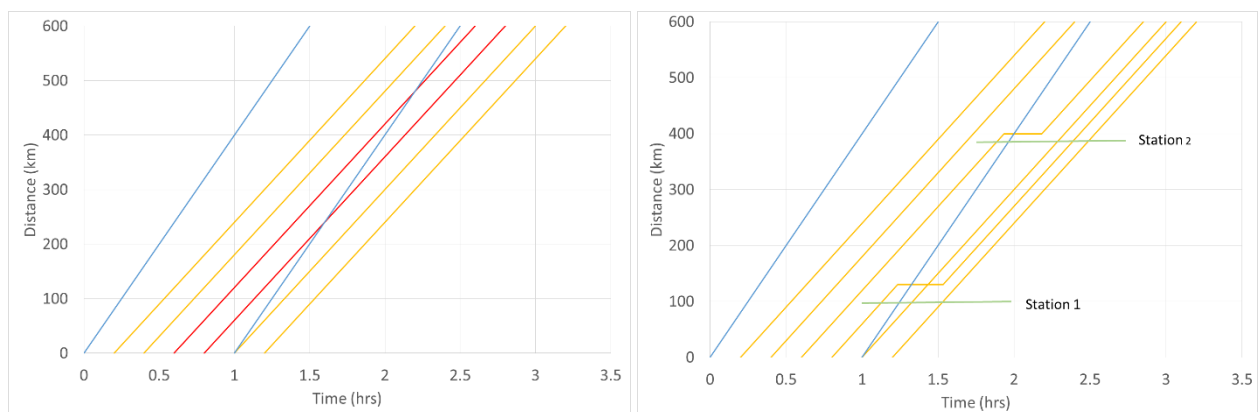


Figure 15 Effect of Mixed traffic at different speed.

Impact on Rural Communities

There are a number of benefits for Australia for building a UHSR network of five lines capable of average speeds exceeding 400km/hr and which were not considered in the *Joint Study on Aviation Capacity in the Sydney Region*.²⁸ These benefits can be enhanced by parallel development of solar power or other renewable energy source to supply the energy for the trains and ultrafast Internet optical fibre along the rail corridor to develop jobs based on renewable energy, computer technologies and communication.

The building of the UHSR train track requires specialised steel products. Steel makes up 20-25% of high speed train sets, mainly for the wheels, axles, bearings and motors. Steel is also used in rail tracks, sleepers and catenary. The network length of some 6000km would require in the order of 270 kilotonnes of steel for bridges and viaducts, 460 kilotonnes for rails and catenary poles and 560 kilotonnes for reinforced concrete.²⁹ This would revitalise steel making in Whyalla, Port Kembla and Western Sydney. It could also aid recycling of steel and iron (it does not have to go to China and back). These products could also be exported for similar projects in Southeast Asia. This strategy also reduces the footprint of pollution emission.

A second industrial outcome is the development of a solar manufacturing industry in Australia. Australia has the minerals and the expertise in this area. Recent research at UNSW has produced photovoltaic cells that have set a world record in efficiency and is regarded as a world leader in solar engineering. According to Prof. Martin Green, Australia's research in photovoltaics has already generated flow-on benefits of more than \$8 billion to the country. Gains in efficiency alone, made possible by UNSW's PERC cells, are forecast to save \$750 million in domestic electricity generation in the next decade. PERC cells were invented at UNSW and are now becoming the commercial standard globally.³⁰

The rail corridor can be used to generate solar power. A single set of 1kW panels along the rail corridor would generate between 2.5 GWH and 6.3GWH daily depending on the season. This is enough to power between 25 and 63 trains daily along each of the five routes.³¹ Four rows of panels is probably the maximum number of panels that would easily fit along the rail easement. The estimate is conservative because the panels can be linked in a way that does not require as much rectification as domestic systems, hereby increasing the efficiency. The development of a solar power manufacturing industry in this country has the benefit of moving to a low carbon economy while requiring a mix of

²⁸ Joint study on aviation capacity in the Sydney Region, Australian Department of Infrastructure and Transport, 2012.

²⁹ Based on quantities for 600km of track. Environmental Case Study: high speed rail, Worldsteel Association, updated 2015, https://www.worldsteel.org/en/dam/jcr:3ecb07b6-ca04-469e-8f77-b3d27cbb8f7d/Rail%2520case%2520study_2015_vfinal.pdf, downloaded January 2019.

³⁰ Wilson Da Silva, Milestone in solar cell efficiency by UNSW engineers, UNSW newsroom, 17 May 2016.

³¹ The power estimates are based on 320W commercial panels containing 72 solar cells. The number of trains are based on Table 6 extrapolated to 400km/hr trains from Piotr Lukaszewicz, Evert Andersson, Green Train energy consumption Estimations on high-speed rail operations, KTH Railway Group Stockholm 2009, downloaded from <http://www.gronataget.se/upload/PublikaDokument/GT%20Energy%20consumption%20slutl.pdf>.

skill sets – from trades to professionals, and has the potential for high exports while maintaining high employment.

The five UHSR lines would invigorate 47 towns/cities as shown in Table 11. These centres would become viable growth centres relieving some of the pressure on Sydney and Melbourne. In their analysis, Aurecon,³² highlighted the advantage of becoming a UHSR city compared to one that did not have a UHSR rail (Figure 16) for a number of overseas cities. This study was based on an earlier UIC study³³ that looked at the benefits both qualitatively and quantitatively of cities and towns being connected to HSR (UHSR in the context here) rail. Generally there was an economic lift to industry, retail and shopping, office and conventions, hotels, residential construction and entertainment. This resulted in a positive cultural change to the cities “image” both within the region and more broadly. It led to new industry associated with zero emission technology. It also led to use of the HSR link to capitalise on their further development. Additionally it led to new land use in the immediate vicinity of the rail link from agriculture to industry, offices, retail and services and CBD renewal.

Table 11 Towns enhanced by the UHSR lines

UHSR line	Towns
Adelaide Canberra via Melbourne	Adelaide, Murray Bridge, Horsham, Ararat, Ballarat, Melbourne, Melbourne Airport, Bendigo, Shepparton, Wangaratta, Albury, Tumut, Canberra
Melbourne to Sydney via Canberra	Melbourne, Melbourne Airport, Bendigo, Shepparton, Wangaratta, Albury, Tumut, Canberra, Goulburn, Southern Highlands, Campbelltown, Parramatta, Sydney
Adelaide to Sydney via Parkes	Adelaide, Swan Reach, Renmark, Mildura, Balranald, Hay, Griffith, West Wyalong, Forbes, Parkes, Orange, Bathurst, Katoomba, Parramatta, Sydney
Melbourne to Gold Coast via Parkes	Melbourne, Melbourne Airport, Bendigo, Shepparton, Wangaratta, Albury, Wagga Wagga, Cootamundra, Grenfell, Forbes, Parkes, Dubbo, Coonabarabran, Gunnedah, Tamworth, Armadale, Glen Innis, Tenterfield, Warwick, Toowoomba, Brisbane, Gold Coast
Sydney to Brisbane	Sydney, Parramatta, Gosford, Newcastle, Taree, Port Macquarie, Kempsey, Coffs Harbour, Grafton, Casino, Lismore, Ballina, Byron Bay, Gold Coast, Brisbane.

³² Aurecon, The Potential Impacts of High Speed Passenger Rail to Eastern Australia, Discussion Paper: Australasian Railway Association (ARA), 30 October 2014. Downloaded as 14-10-27 REPORT-The-Potential-Impacts-of-High-Speed-Rail-to-Eastern-Australia.pdf on 24 October 2018.

³³ UIC, High Speed Rail as a tool for regional development, International Union of Railways, August 2011

This change was not limited to one country but was seen across many different cultures. The growth also occurred over wider sectors compared with cities that did not receive HSR.

A similar pattern is seen with the positive benefits to the people in those communities. A time series analysis of before and after (8 years of HSR) also showed benefits to the population, commuters, students, GDP, employment, land values and use (Figure 17). These potential positive impacts can accrue for each of the 47 communities connected to this UHSR network. The data suggests that each town/city reflected on what opportunities were best for them leaving it to the community to develop rather than try to achieve all possible positive impacts or have imposed by State or Federal Government.

In the funding model discussed above any increase in the value of developable lands associated with UHSR stations should be captured by Government or communities and not by real estate agents or developers who purchase land for speculation purposes. Building these five UHSR lines would allow new infrastructure to be developed that is in keeping with a low emission future. It would allow for the transfer of much of the domestic passenger and freight traffic away from road and air transport, both of which are major contributors to carbon emissions and fundamentally detrimental to the planet and human survival. the transfer of much of the domestic passenger and freight traffic away from road and air transport, both of which are major contributors to carbon emissions and fundamentally detrimental to the planet and human survival.



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Figure 16 Economic advantages of UHSR cities over non UHSR cities

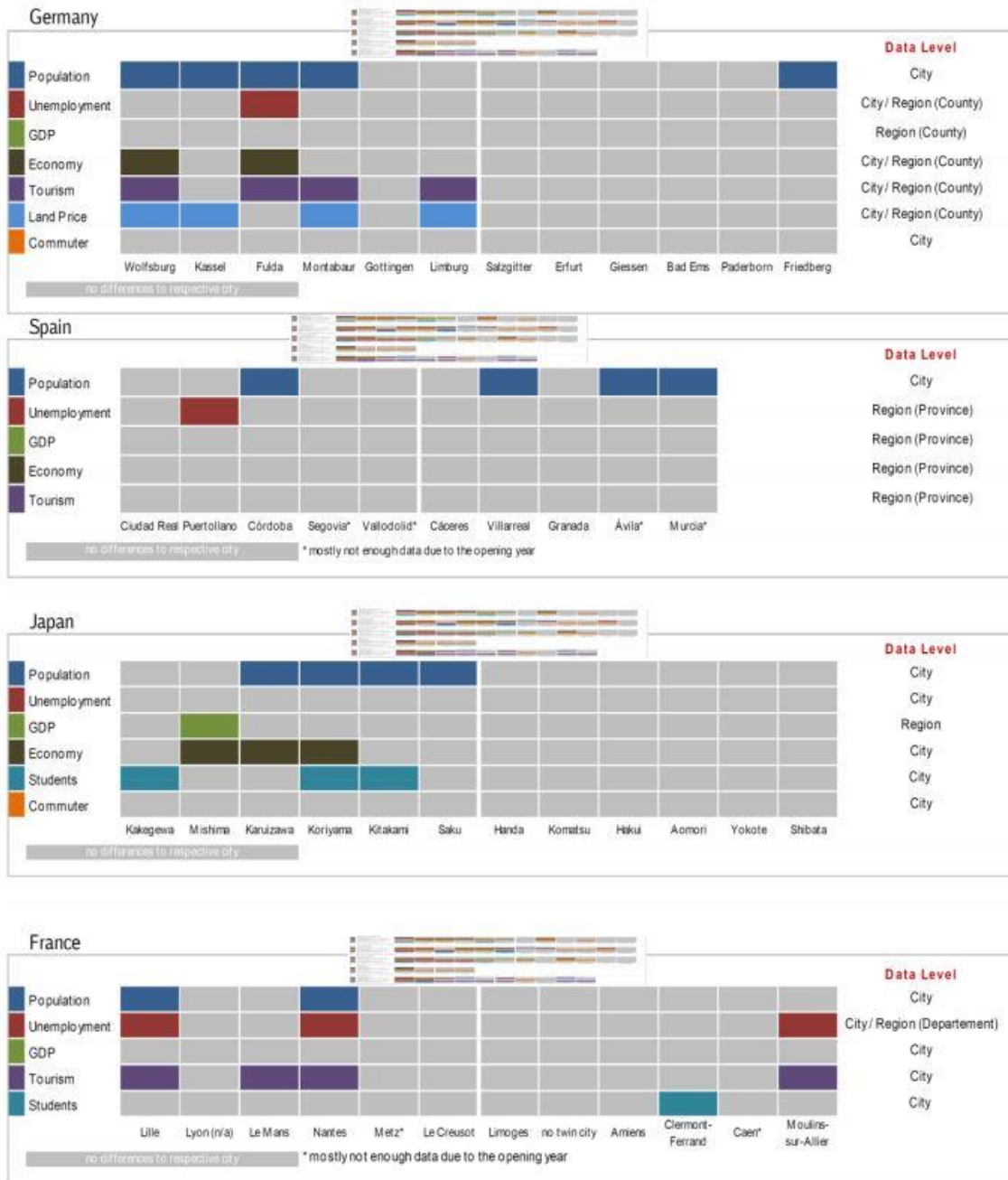


Figure 17 Social benefits of UHSR

Conclusion

The proposed UHSR services 69.2% of Australia’s population. While the majority is in the greater metropolitan areas, 11.7 % are in regional areas of the four states. This regional estimate is based on ABS Local government area data, ³⁴ and only uses the immediate LGA around the proposed stations. In practice the benefits of USHR would extend beyond the immediate local area and involve populations from neighbouring areas. The population serviced by UHSR is shown in Figure 18. The inset shows the proportions against the total population of Australia as it was estimated by the ABS at the end of June 2017. UHSR would service 86% of the NSW population, 80% of the Victorian population, 65% of the Queensland population, 80% of the South Australian population and 100% of the ACT population. The higher regional passenger demand comes from the Melbourne, Canberra, Sydney to Brisbane routes. This is largely driven by population density.

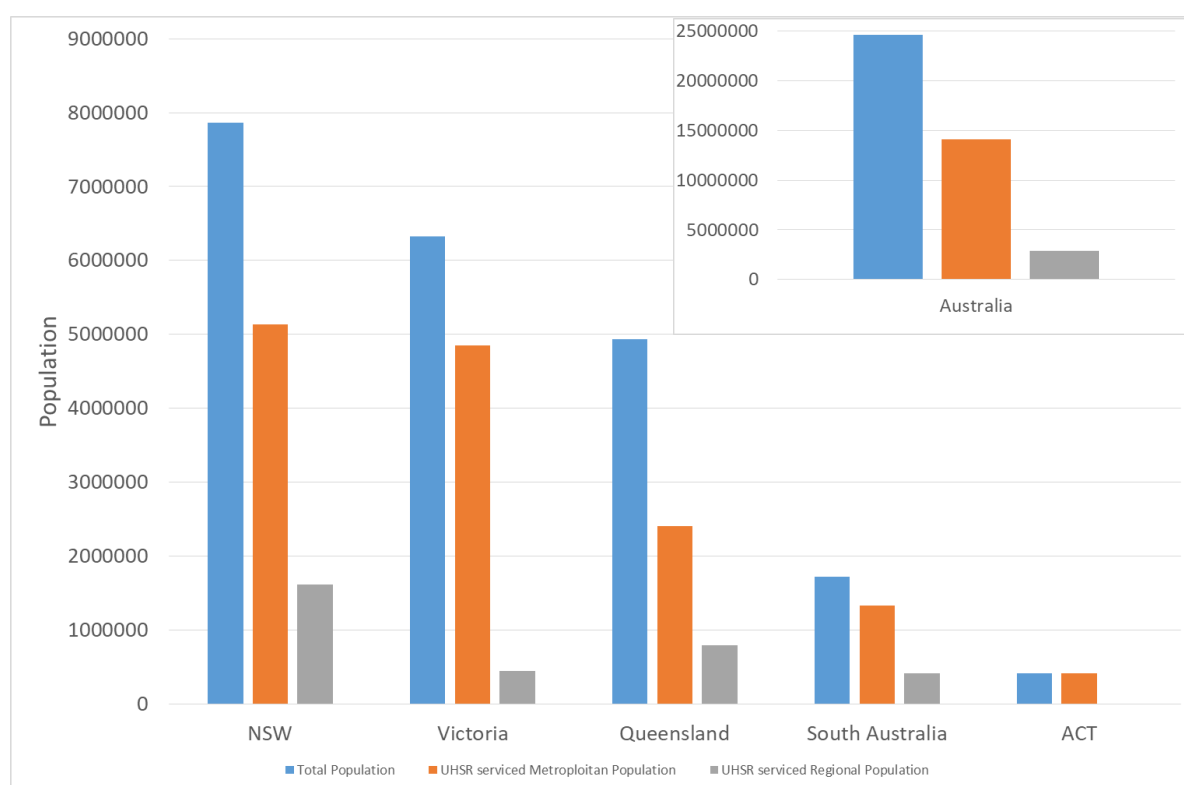


Figure 18 Population serviced by the proposed UHSR network

While the regional population in Victoria and South Australia seems low compared to the other states, a map of land use, shown in Figure 19, indicates that the routes across Victoria to Adelaide and the route from Adelaide to Parkes would go through prime cropping land with some grazing and native vegetation. The inland route from Melbourne to Brisbane would go through prime cropping land. This offers an opportunity for the agricultural industry to change to same day delivery for specialised crops such as heirloom, genetically modified or organic seed, vegetables and fruit. It also provides an

³⁴ ABS population statistics, DATA BY REGION, 2011-17, Released at 11:30 am (Canberra time) 9 November 2018, POPULATION AND PEOPLE, Local Government Area, 2011-2017, 14100ds0002_2011-17.xls, downloaded 30/01/2019.

opportunity for the agricultural industry to change their business model from bulk delivery to individually packed and labelled products that will command higher prices on the market. Such commodities can be exported and would be in demand worldwide.

All routes, therefore, have a capacity to service both the passenger and freight needs of the Australian population. UHSR provides an alternative to air travel that would be affordable and competitive to air fares, while providing better comfort, safety and reliability and ensuring low contributions to climate change. It also provides a far better freight service that is reliable, allows different levels of delivery service, such as same day, next day or within four days etc., giving much more service flexibility. A large advantage for agriculture is the ability to package individual farm products and benefit in the same way as wine from an individual vineyard which can command a premium price. Such an efficient rail system will also significantly reduce road damage costs and accidents as well as air pollution and carbon emissions.



Figure 19 Land use in South Eastern Australia³⁵

Most infrastructure projects in Australia seem to over run their budgets by 50% or more mainly due to political corruption rather than other reasons.³⁶ Even if this was to occur, the cost would push the completion to an extra five years at the same level of financing of \$B11.55 per annum.

Apart from rethinking the packaging and delivery of agricultural products, there are opportunities for other new industries. The UHSR network requires energy. This can come from two different types of sources - electricity generated by renewables and hydrogen. Australia is at the forefront of solar technology and the development of high purity hydrogen from ammonia.

³⁵ <https://nationalmap.gov.au/#share=s-ruZN2lnpCJPwtFlpoFgjvVTs4Bx>, accessed 30/01/2019.

³⁶ Cameron K Murray, Paul Frijtersm Game of Mates: How favours bleed the nation, ISBN 978-0-6480611-0-6, 2017.

Solar and wind power sources can be built along the UHSR network. Solar in particular can use the rail corridor to generate electricity and can be designed to supply electricity to the grid. Use of Australian expertise in developing solar panel manufacturing processes here has an economic impact that goes far beyond Australia's domestic needs.

The use of hydrogen as a power source has been delayed because of the lack of ability to store hydrogen in bulk. Ammonia is a way around this and the CSIRO technology combination with hydrogen fuel cell technology, while needing to be proven for a mass market, is another industrial market that can be developed. It also has an economic impact beyond Australia's domestic need.

The ability to deploy optical fibre along the routes and the need for signalling and control technology opens up an industrial area in computer technology. There will be a need for the development of software and application technologies. There is also a need to develop hardware technologies including prefabrication of chips used in processors. Doing this overcomes one of the national security problems with using Chinese (or indeed American) designed and fabricated chips.

There are also advantages for older industries as well, for example in the manufacture of steel. UHSR requires exact tolerances in the composition of rails and other components in rolling stock. The ability to prefabricate concrete sections of rail can assist in transforming the cement manufacturing process and delivery to site.

With any of these industrial manufacturing processes comes a spectrum of job type: from the professional to the trades to general administration. This is particularly important as the employment participation rate in the regional centres serviced by UHSR is only 54% on average.

UHSR would support the development and enhancement of regional tourism and hence the local hotel, accommodation and restaurant industries would benefit. The Aurecon study showed a consistent gain in these industries for towns/cities that had a UHSR station overseas and there is no reason to suppose Australia would be any different.

It is easy to foresee that the building of a UHSR network as described above would result in a massive boost to the Australian economy that would be difficult to achieve in any other way.

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