ARUP-TMG

EAST COAST VERY HIGH SPEED TRAIN SCOPING STUDY

Phase 1 - Preliminary Study

Final Report

November 2001



INTERNATIONAL

INDEPENDENT CONSULTANTS IN RAILWAY TRANSPORT

26th November, 2001

Job No 01152

High Speed Train Branch
Department of Transport and Regional Services
Level 1, 15 Mort St,
Civic,
Canberra, ACT

Attention: Dr Judith Winternitz
Assistant Secretary

Dear Dr Winternitz

East Coast High Speed Train Scoping Study – Stage 1 Preliminary Study

As leader of the Arup –TMG team, I am pleased to submit to you the Final Report of the preliminary study for this project. The study provides a broad reaching review of the issues involved in the creation of a high-speed rail system between the major cities on the East Coast of Australia

We trust that it will assist the HSTB and the Government in their further consideration of these issues. We would welcome the opportunity to continue to assist your team in such consideration.

We would like to express our appreciation of the working relationships we have enjoyed with you and your team at HSTB.

Yours sincerely,
TMG International Pty Limited

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Study Director

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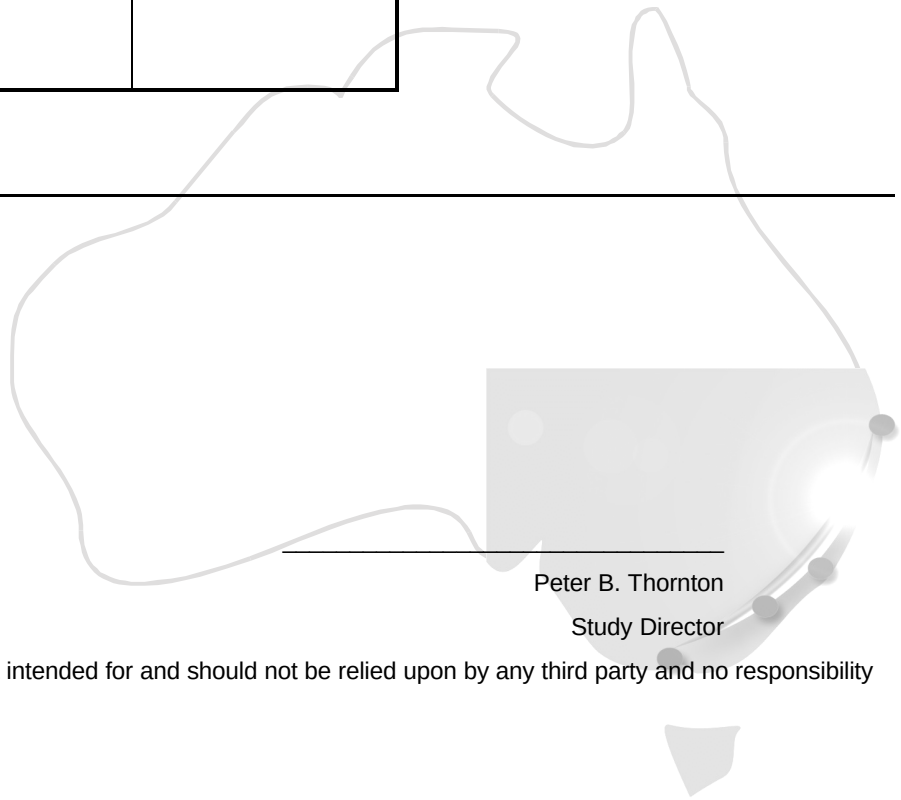
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This report takes into account the particular instructions and requirements of our Client. It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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EXECUTIVE SUMMARY

EX.1 Introduction



Very high speed railways on Australia's East Coast have been under consideration for over fifteen years. To date these have been brought forward by the private sector for consideration by governments None have proven commercially viable without significant public sector funding contribution and /or other forms of financial concession.

This study, commissioned by the Commonwealth Government, is the first step in developing the Commonwealth's own view on very high speed trains (VHSTs). It examines the issue from the perspective of the "national interest".

The study is broad and considers policy issues; international VHST systems; potential corridors; technology options; potential demand; national interest economics; regional development potential; financing and operating possibilities; capital and operating costs; and benefit to users, non-users and the Australian public at large.

In this study, VHST means train technologies and systems which can operate in the range from 250 km/h to 500 km/h.

The study aims to provide a realistic first assessment of the viability of an EC VHST by considering what role it might play in the future transport task in the East Coast corridor of Australia which stretches nearly 2000 km from Brisbane to Melbourne.

EX.2 Creating VHST Networks



VHSTs have been in operation since 1964, when the Tokaido Shinkansen commenced operations in Japan. That system has subsequently been extended to serve Japan's extremities. In Europe, VHST development commenced with France's Lignes a Grande Vitesse (LGV) system. German, Italy and Sweden have all developed national technologies and high speed rail systems. Today, a massive program of building high speed railways is under way in Europe. High speed rail projects are also under construction in Asia. In the USA consideration is being given to a large number of possible VHST projects.

Given the huge costs involved, it is relevant to consider the reasons why nations are investing in VHST systems. Overwhelmingly, it has been possible to identify simple but powerful national goals which a VHST system helps to satisfy. In almost all cases, the initial development has been to expand transportation capacity in corridors where existing rail and other modes are reaching saturation. National and regional development has also been an objective. In Japan, the Shinkansen is seen as a spine on which urban and regional development is supported. In Germany it is seen as an instrument of building national unity. Similarly, European unity is being promoted by building VHST links between countries. In all cases, Governments have had substantial involvement in financing the VHST systems.

To date in Australia, a common, powerful vision of the role of a VHST in the East Coast of Australia has not been held by the Governments which would be involved.

EX.3 Policy and Strategy Framework



The lack of such a common vision in Australia is, in part, a reflection of the fact that five governmental jurisdictions would need to be involved in an EC VHST. Furthermore, there are policy issues in relation to rail systems that go to the core of Australia's federal system of government.

All five Governments would need to be totally committed to a project of the scale of an EC VHST and would need to contribute political, administrative and financial support. All five Governments would need to be involved in establishment of an entity adequately resourced to create an EC VHST. The entity and the project would need their own policy framework as none exists at present at any level of government.

In addition to such policy addressing the transport and development aspects of a VHST, there are environmental policies which would provide a context for development and operation of a VHST system. Other environmental policies define national goals and objectives which a VHST could help to deliver.

EX.4 VHST Technologies



VHST technologies were originally developed to address national needs though most European technologies are now being marketed globally. Japanese technology has been more domestically focused though it is now being exported to Taiwan. In all cases, significant government contracts and/or research funding have underpinned the development of such national technologies.

Two forms of technology are possible candidates for an EC VHST. In the 250 km/h to 350 km/h range there are several manufacturers producing steel wheel on steel rail (SWSR) VHSTs. For speeds between 350 km/h and 500 km/h there are two MagLev technologies, one German and one Japanese. These MagLev systems are totally incompatible, being based on entirely different engineering principles. Only the German Transrapid MagLev is close to being in revenue service.

SWSR technology has been characterized by competing views about the most economical means of achieving fast travel. One view held that expensive new straight alignments and powerful trains were necessary while the other favoured sophisticated tilting suspension on the rolling stock to enable faster times to be achieved on existing tracks or on less straight and less expensive new track. Such polarization has now largely disappeared, with all manufacturers being able to offer VHST products with any desired combination of power, speed and tilting capability.

A MagLev system would be closed, meaning that no other technology could operate on its infrastructure. Furthermore, there is no competitive industry at present for the supply of MagLev systems and possibly not for there maintenance. A SWSR VHST system, on the other hand, could operate on existing rail infrastructure or enable other rail operators to operate on its infrastructure. There is a substantial industry established to supply both VHST rolling stock and to build and maintain VHST infrastructure.

There are no emerging technologies which appear even remotely likely to challenge either SWSR VHST or MagLev VHST technology in terms of their passenger moving capabilities in the foreseeable future.

EX.5 The East Coast Corridor



If the VHST is to be created and funded as a public transport enterprise, it will need to relate effectively to the centres of population throughout the East Coast corridor. That is, there is a balance to be reached in terms of providing a service to people in the corridor and achieving minimum point-to-point travel times. Thus, current and future patterns of settlement are key determinants regarding corridor selection.

Environmental constraints will also be powerful determinants in corridor selection.

To achieve minimum transit times, a VHST alignment would need to be as straight as is practical. However, the topography of the East Coast corridor is such that the straightest routes encounter the most difficult terrain and bypass the existing centres of population. Consequently, any alignment will be longer than is optimal for capital city to capital city travel.

In each of the longest sectors there are two broad corridor options. Between Canberra and Melbourne there is an inland route via Albury-Wodonga and a so-called coastal route via the Monaro and Gippsland. Similarly, between Newcastle and Brisbane there is an inland route via the New England or a coastal route via the Gold Coast.

Immediately north and south of Sydney there are also options. To the south, possible routes are via Sutherland and Wollongong or via Campbelltown and Bowral. To the north, the existing route via Hornsby could be followed and a postulated route in tunnel under the Hawkesbury River has been examined, principally to assess the effect of a major route shortening.

EX.6 Preliminary Corridor Analysis



Three key planning parameters drive corridor selection and preferences: population size and distribution, cost, and environmental issues. However, it is demand and cost effective engineering that will initially drive provision of any form of EC VHST, with environmental considerations forming the basis for comparison of otherwise similar corridors.

In broad terms:

- Canberra to Melbourne – the inland corridor appears likely to be less costly to develop and less likely to have significant environmental issues;
- Newcastle to Brisbane – the coastal corridor appears more likely to connect with growing centres of population, to be less costly to develop, and to be manageable in terms of environmental issues;
- South of Sydney – corridors via Campbelltown and via Wollongong both address significant areas of population. Via Campbelltown would appear to involve lesser cost and lesser environmental issues;
- North of Sydney - environmental and terrain constraints make all corridors extremely expensive. Of the two considered, the existing corridor is likely to be the less expensive and more likely to be acceptable environmentally;
- Metropolitan entries and exits are crucial to all forms of VHST and need to be resolved if optimal time performance is to be achieved.

EX.7 Operating Performance and Transit Times



Modeling was undertaken, using TMG's MTRAIN simulation software, to determine the potential performance of trains of maximum speeds of 250 km/h, 350 km/h, and 500 km/h over indicative alignments in the nominated corridors.

For comparison purposes, the travel times of the existing 160 km/h XPT are about 10 hours 30 minutes between Melbourne and Sydney and 14 hours 15 minutes between Brisbane and Sydney.

For a limited stops VHST, the estimated intercapital transit times were found to be of the order of:

	Existing Air	250 km/h	350 km/h	500 km/h
Melbourne to/from Sydney	1.4	5.1 - 5.6	4.1 – 4.5	3.2 – 3.5
Brisbane to/from Sydney	1.5	5.5 – 5.6	4.4 – 4.6	3.4 – 3.6

Clearly, no VHST can match air on a terminus to terminus performance. Taking into account other components of overall travel time such as terminus access, gate waiting time and the like and then deducting a 20 minute "comfort bonus" in favour of VHST, even the 500 km/h VHST cannot match air for these intercapital journeys.

However, the real issue is not so much whether VHST could match inter-capital air travel times but whether it is able, as a result of its service characteristics and stopping patterns, to capture a unique and sustainable market in its corridor.

EX.8 Project Costs



Indicative costs for the construction of VHST infrastructure were estimated from a range of sources including Arup-TMG's database and published sources. A benchmarking analysis of international projects was conducted to determine the relative cost of an EC VHST as compared to similar VHST projects around the world. Costs for an EC VHST from Melbourne to Brisbane were assessed to range from about $32 billion to $59 billion for systems in the 250 km/h to 500 km/h range. These costs are for a full double track EC VHST and are in the lower half of international costs on a per kilometre basis. It is considered that lower implementation costs might ultimately be achievable through measures such as partial use of single track where traffic density permits. For this level of assessment variability on infrastructure costs should be assumed to be in the range –10% to +30%.

Rolling stock pricing was based on actual tender data where available or from authoritative sources. The cost of a notional 400-seat trainset of maximum speed of 250 km/h to 500 km/h was assessed to range from $40 million to $100 million.

Operating costs were estimated using a "bottom up" approach and benchmarked against international data, adjusted on a parity price basis. Operating costs in the 250 km/h to 500 km/h technology range were assessed to average about 6-7 cents per passenger-kilometre at startup, increasing as the business increases in scale.

EX.9 Financing, Creating and Operating an EC VHST



There are a variety of methods by which a VHST could be financed and created. The most common international model has been that government has effectively been the financier, developer, long term owner and generally the operator of the service and the system. This confers the ability to call competitive tenders for all aspects of the project and the service. In some notable cases - the Japanese rail system in particular - the government owned operation has been privatised. Ultimate control of the infrastructure assets has generally remained in public hands. A range of public private partnership financing arrangements are also possible with risks being allocated to the party best able to manage them. A key issue in determining the private sector's ability to participate in financing is the capacity of the project to generate adequate cashflows to service its debt and equity.

A project of the scale of an EC VHST would take between 10 and 20 years to create, provided that adequate construction phase funding were available and that the Australian infrastructure industry had adequate resources to apply to it. In practical terms, an EC VHST would be constructed in stages, with each stage preferably being operable as a VHST service upon completion.

A key issue would be the creation of the organization to operate the VHST service, long-term operations and maintenance being the core business of a VHST system. Globally, the private sector is increasingly taking over government transport businesses. Nevertheless, if governments are to be major investors in an EC VHST, it would be appropriate that they retain a close participation in all activities and phases of creating and operating the system.

EX.10 Demand for an EC VHST



A preliminary assessment of demand for an EC VHST was conducted, involving three key steps: estimating the inscope base travel market in 2001; projecting the inscope base travel market to 2051; and forecasting diversion to VHST from other modes and induced travel.

The inscope area covered a region from Melbourne to north of Brisbane and up to about 300 km from the coast. Total travel in 2001 is estimated at 158 million trips, comprising 17 million business trips and 141 million non-business. Sydney-Melbourne (6.7 million trips) and Sydney-Canberra (5.4 million trips) are the largest flows. The number of air trips in 2001 within the inscope market is estimated at 11.1 million.

Growth in air travel has been double that of road in the past decade. The number of trips on trunk intercapital air routes has doubled over that period, though trip numbers on regional air routes have been more volatile with some declining and some growing.

The base market is projected to double over the next 20 years and to double again by 2051. Air travel in particular is forecast to increase its share of both the business and non-business markets. A general shift to air is forecast on the basis of higher income levels, even with adjustment for an increase in fares.

Diversion to VHST was estimated on the basis of comparison of overall service level offered by a VHST to that of potential donor nodes. Ten diversion models were applied to 1240 separate travel markets. Demand, passenger-kilometres travelled, and revenue were estimated for 52 possible route combinations for 250 km/h, 350 km/h and 500 km/h technologies.

By 2051, the total inscope market is forecast to grow to 522 million trips p.a. assuming current population trends. VHST trips are forecast to be from 59 million p.a. to 75 million p.a. for the 250 km/h to 500 km/h VHSTs over the full corridor. By 2051, VHST is forecast to divert between 36% and 43% of trips and acquire 57% to 63% of its revenue at the expense of the air travel mode.

The demand assessment showed the performance of each VHST technology for the corridor as a whole and for its component sectors. Key findings related to network effects, by which a complete Brisbane to Melbourne service could generate up to 25% more demand than the sum of separate Brisbane to Sydney and Sydney to Melbourne routes. For the Sydney-Canberra and Canberra – Melbourne sectors, the network effect of having the full route in place is a 92% increase.

A large proportion of potential demand is shown to exist in the regions adjacent to Brisbane, Sydney and Melbourne. Forecast changes in distribution of population are not shown to have significant effect on total travel, with absolute population appearing to be more important in determining demand for an EC VHST.

EX.11 Defining the National Interest



An EC VHST has often been referred to as a project of national interest. Underlying this seems to be the notion that it is somehow more important than other projects or worthy of special consideration and financial support by governments. The notion of national interest projects has a long history in Australia. The most recent project of similar scale was the Snowy Mountains Scheme. Such projects, including an EC VHST, are not national interest goals in themselves. They achieve such status by being the means to deliver a high level strategic goal or set of goals. Examples of such goals are found in the Commonwealth Government's key objectives for the rail industry: a competitive economy, industrial development, better accessibility, improved safety and environmental sustainability. National goals are often set throughout the political process. For example, in Japan, the further development of VHST is seen as reinforcing the key economic axis of the nation.

The conventional means of evaluating the relative worth of projects to the nation is by cost benefit analysis. This is based on the premise that equivalent impacts are equal no matter whom they affect. It also involves decisions about the present worth of future costs and benefits through the selection of discount rates. High discount rates tend to devalue future benefits and costs relative to more immediate ones. It is argued that the use of high discount rates effectively mitigates against public investments, whose very aim is to change the present and to create a new future. Obviously, if an EC VHST could demonstrate its worth at "normal" levels of discount rates and also be clearly a means to satisfy national strategic goals, which may not be satisfied without it, it could be an economically attractive proposition for government investment. Alternatively, it may be appropriate to apply lower discount rates in assessing the worth of the project on the basis that the national interest benefits are keenly sought and can be supported through the political process.

There is a body of evidence to suggest that economic benefits beyond those of merely an effective transport mode can accompany development of a VHST but that these do not eventuate in the absence of a supportive policy framework.

EX.12 Regional Development Impacts



Regional Australia in the East Coast corridor is generally enthusiastic about a VHST and it is widely held that such a project would be of significant economic benefit to those locations it serves. Equally, there are fears about not being served and consequent negative effects on regional and local economies.

The evidence from international experience is not so clear-cut about the benefits. Recent OECD research into this issue reported that:

> *"…a clear objective for an infrastructure project concerning regional development, including the context and specific strategic needs of the region is necessary. Further, these objectives should also include their relationship to other policies, sectors and tiers of government and the impacts of the project should be evaluated against these broader objectives."*

This suggests that a VHST is a component of stimulating economic growth but that other factors are also relevant. Examples of such factors are economic stability and strength in the local community, coordinated planning for development, and a strong and educated workforce.

Nevertheless, there are well documented examples of development being stimulated around VHST stations, increased tourism in regional centres, increases in service industries, and relocation of businesses to regional areas consequent on VHST construction.

There are also examples of negative effects on regions. In one case, the VHST sufficiently changed accessibility to influence a corporation to shift back to the major cities leaving their staff to commute.

Regional development is most likely to result from a VHST project when it is accompanied by supportive policy and positive actions by governments.

EX.13 East Coast Metropolitan and Regional Economic Development



An assessment is made of the possible effects that an EC VHST might have on the regions through which it could pass. As noted in Clause EX.11, such effects are not necessarily a direct outcome of a VHST and would require supportive policy and actions to bring them about.

Some examples drawn from the assessment are:

- A VHST might strengthen transport linkages and reinforce growth in South East Queensland and beyond into Northern NSW;
- The Hunter region would enjoy significantly improved travel times to Sydney and may develop a long distance commuting market;
- Sydney's role as a global city could be enhanced and could benefit from improved links to the regions and to the other capital cities;
- The ACT region could benefit by the linkage of its concentration of highly educated workforce and research facilities to the commercial opportunities in Sydney and day tourism to the ACT could also be enhanced;
- The Riverina and North East Victoria regions may enjoy some increased tourism and, for those regions closer to Melbourne, the possibilities of long distance commuting and better access to high quality social infrastructure in Melbourne may be benefits. A VHST would not affect the other major economic drivers such as agriculture in this region (nor in other regions); and
- Melbourne's benefits may come principally from its enhanced connectivity to the ACT and to Sydney. Benefits could include increased tourism as well as better access for skilled workers who may commute from longer distances.

EX.14 Evaluation of an EC VHST System



An EC VHST is forecast to capture a significant part of the future transport task in the East Coast corridor. Its market share comes principally from a reduction air travel in the corridor. For example, by 2021, after a notional ten years of operation, a 350 km/h EC VHST is forecast to generate 34 million trips per annum, of which 13 million will replace growth in air travel. By 2051 VHST is forecast to have 66 million trips double the trips by air.

The highest inter-capital flow would be between Sydney and Melbourne. The highest demand assessed for 2021 was 40 million trips over the full corridor, assuming 500 km/h technology and the shortest route options via Wollongong and the coastal routes north of Newcastle and south of Canberra. The heaviest individual corridor loading, however, would occur on the sectors immediately north and south of Sydney.

A VHST could generate a range of economic benefits such as passenger timesaving, air and road decongestion, reduced road accidents, and reduced greenhouse emissions. However, revenue and user benefits are of an order of magnitude greater than the benefits to the public at large, costs being dominated by infrastructure capital cost.

As an example, the following findings emerged from economic evaluation of 350 km/h technology, a discount rate of 7% being applied:

- No combination of costs and revenue delivers a positive net present value (NPV) on a simple cashflow financial assessment. The full Brisbane to Melbourne VHST project shows a financial internal rate of return (IRR) in the hands of governments of less than 2.5%.

- For the private sector to achieve a 15% hurdle rate on its investment it would be necessary that government fund around 80% of the full project and more than 85% of the Melbourne-Sydney and Sydney-Brisbane stages. This assumes that all surplus revenue would go to service private sector debt and equity.

- The full Brisbane-Melbourne VHST would yield an economic NPV in the range -$15 billion to +$73 billion (IRR from 4% to 14%). The NPV at 7% for the Brisbane-Sydney corridor ranges from - $13 billion to +$25.0 billion while that for Sydney-Melbourne ranges from -$11 billion to +$11 billion.

- Providing the system can be funded and put into service, revenues from the EC VHST service appear to be sufficient to cover operating costs.

At the macro level, the Brisbane-Sydney corridor appears to be the economically strongest service, apparently driven by the demand in the Newcastle-Sydney sector. However, the socio-demographic variables of this sector are such that its demand risk is high.

The full project has a significantly greater NPV than either of the parts, indicating that the more extensive travel possibilities and greater connectivity, especially in the Newcastle-Canberra corridor, increases revenue. In all corridors, users enjoy a significant multiple (approximately 2.5) on their fares, whereas the ratio of public benefits to publicly borne costs is in the range 0.12 to 0.25.

250 km/h technology is the most cost effective in generating demand in the short to medium range corridors (Newcastle to Canberra). The 350 km/h and 500 km/h are about equally cost effective in the longer range corridors in generating demand, revenue, and user benefits per dollar of capital invested. Taken across all sectors and stages, the 350 km/h technology appears to perform best on these indicators.

An EC VHST could have a significant impact on air services. An estimated 194,000 air traffic movements could be removed from Sydney Airport by 2021 of which 159,000 are estimated to be regional services to East Coast towns. An EC VHST could assist in avoiding the adverse environmental effects of airport expansion but would generate a set of different effects spread over a very long corridor, some of which may be regarded as adverse by the specific communities affected as are airport effects.

A VHST would reduce road vehicle-kilometres travelled in the corridor. However, benefits of alleviating traffic congestion may not be significant as the greatest amount of road traffic replaced would be outside metropolitan areas - on the NSW North Coast and between Albury-Wodonga and Shepparton in particular.

Corridors can be selected to avoid major environmental effects, at the national, state and regional level of policy and planning.

A VHST may assist in the satisfaction of some broad national strategic goals such as improved regional accessibility and connectivity, enhanced transport safety; reduced dependence on oil, and enhanced environmental sustainability.



EX.15 Is there a place for an EC VHST in Australia's Transport Future?





Very High Speed Trains for intercapital travel have been under consideration for over 15 years in Australia. Such is the level of interest that the private sector has been prepared to invest heavily and to compete vigorously for the right to build, own, and operate such a massive project.

Business interests, regional government and communities continue to lobby Governments in support of the concept and its image as a means of generating growth in regional East Coast Australia is untarnished.

The scale of an EC VHST must not be underestimated. An EC VHST linking Melbourne, Sydney, and Brisbane is on the same scale as all of the Japanese Shinkansen constructed to date or the whole of the German High Speed Rail program and greater in length than the proposed California High Speed Rail project.

It would be, on any set of measures, a project of national interest and impact on national and regional economies. Its cost and risks would be of such magnitude and its construction and operation of such scale that it could only be achieved through the leadership of Australia's Commonwealth and State Governments working in concert to the common purpose. Under such leadership, there would be many opportunities for private-public cooperation and partnerships to deliver and possibly operate elements of the project.

It has been shown that an EC VHST could capture a significant part of the future East Coast travel market and provide relief to the other modes. International experience indicates that economic growth in a VHST corridor can occur but requires more than just construction of the VHST to be realized. The project appears to have economic merit, if it can be funded. Nevertheless, there may be alternatives which are more affordable and which offer greater public benefits.

For these reasons an EC VHST could have a place in Australia's transport future. The securing of a place for an EC VHST in Australia's transport future would be dependent on whether or not it could become an integral part of a vision and action plan for a new paradigm of development, mobility, and transportation connectivity in the East Coast corridor.

An EC VHST will not achieve such status in the absence of political vision and leadership, long-term bipartisan political commitment, the full participation of all Governments and the collective will and skills of Australians.

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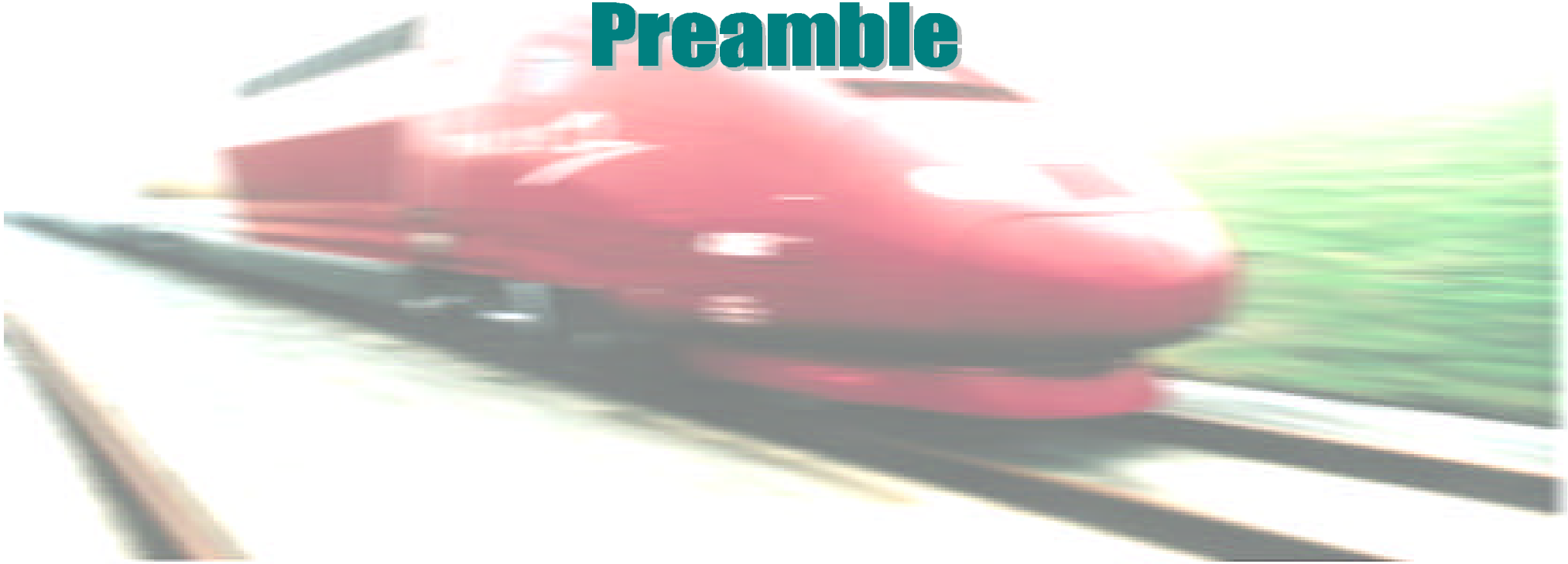


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PREAMBLE

P.1 Composition of this Report

Following is a resume of the content, purposes and inter-relationships of the sections and annexures of this report into Phase 1 of the East Coast Very High Speed Train Scoping Study. The report has been prepared to provide an overview of issues to be addressed in depth in the overall Study.

Section 1 - Background to the Study

This section sets out the history of the VHST concept in Australia, the Commonwealth's purposes in commissioning this Study, the general approach taken in the Study, and some of the broad issues relating to transportation over the Melbourne- Canberra- Sydney- Brisbane corridor.

Section 2 - Creating VHST Networks

This section sets out the policy backgrounds, the extent of public sector involvement in particular, and some of the outcomes of VHST services now operating in Europe and Japan. It also describes the status of various proposals for VHSTs in the USA.

It provides insights into the national interests that lead nations to invest in VHST systems and sets out the history of VHSTs in Australia with a brief resume of the 1990 VFT proposal and a detailed account of the policies and private sector responses relating to the Sydney-Canberra VHST proposal.

Section 3 - Policy and Strategy Framework

An East Coast VHST would be subject to five Australian governmental jurisdictions, each with significant legislative differences. This section assesses the intergovernmental arrangements which would be needed for public funding to such a project, its facilitation and implementation.

The section summarises national environmental policies and refers to the position of a VHST relative to the principles of Ecologically Sustainable Development and protection of bio-diversity in the rail corridor. It refers to the generation of greenhouse gases by a VHST, both in absolute terms and relative to other forms of transport, and describes its possible noise and vibration impacts.

Section 4 - VHST Technologies

This section records that all VHST systems brought into service to date have relied on SWSR (steel wheel steel rail) technology, with tilting bodies in many instances, and that supply of SWSR rolling stock is now fully internationalised and competitive. The only other feasible candidate VHST technology is MagLev, prototypes of which have been operated in Germany and Japan.

The performance characteristics of the different types of VHST rolling stock on tracks of varying gradients and curvatures are set out, with discussion of the characteristics of the rolling stock including energy demand, braking capacity, and passenger comfort.

Section 5 - The East Coast Transport Corridor

The existing and projected population patterns and environmental context of Eastern Australia are set out. The engineering and environmental constraints applying to the possible East Coast VHST routes are broadly compared to a statement of general planning requirements for such corridors.

Section 6 - Preliminary Corridor Analysis

The candidate corridors identified in section 5 are qualitatively assessed, in terms of cost, demographic and environmental issues, with the preferred routes over the stages where alternatives exist (Melbourne-Canberra, Canberra- Sydney, and Newcastle- Brisbane) being nominated.

Options and issues relating to the entry of the VHST service into Melbourne, Canberra, Sydney and Brisbane are described.

Section 7 - Operating Performance and Transit Times

This section sets out the bases and results of computer simulation of operation of a VHST between Melbourne, Sydney, and Brisbane and discusses the resulting journey times in relation to air travel.

Section 8 - Project Costs

A benchmarking analysis of published data from international sources together with specific "bottom up" analyses from the Australian context provides the basis of the indicative capital and operating costs, relative to a range of technologies, set out in this section.

Section 9 - Assessing the Demand for an EC VHST

This section describes the structure, data inputs and outputs of the demand forecasting model constructed for this study.

A total of 47 potential stations in all the corridors were identified. The model was applied to the range of VHST technologies and alignments within the corridors to forecast numbers of trips and revenues generated for two population growth scenarios to the year 2061.

The demand forecasts for alternative corridors are a key input to assessing the optimal corridor for a VHST. The model also predicts the overall base market for travel in the East Coast corridor and the impact a VHST would have on other modes of transport.

Section 10 - Financing, Creating and Operating an EC VHST

A discussion is presented of alternative delivery and financing models, with consideration of the possible mix of public and private participation and a review of financing arrangements adopted for recent major rail projects around the world. Possible public-private financing structures for an EC VHST are described as well as the practical limitations on the private sector's involvement.

The section discusses the time-scales and possible stages for implementation of the EC VHST, the form of entity required to be responsible for its operation, and the business development plan which might be required.

Section 11 – Defining the National Interest

This section discusses the approach to defining the national interest and sets out the criteria by which the consideration of national interest can augment the evaluation of projects by the conventional economic methodologies.

It cites other Australian projects which have made significant contributions, not quantifiable in strict economic terms, to the national interest and refers to the indirect and national interest type benefits expected of existing VHST systems in Europe and Japan.

It also sets out the approach taken in other nations to evaluating projects in the "national interest", with particular experience from recent studies in the USA cited.

Section 12 - Regional Development Impacts of VHST Systems

It is noted that the desire for improvement in transport links to major centres is such that the VHST concept is enthusiastically supported by all regions of Eastern Australia which could be included in such a route.

Experience in Europe and Japan is cited to address the regional impacts which could result from introduction of a VHST and the support from broader policies and other initiatives which might be required to ensure that such impacts are in fact beneficial.

Section 13 - Impacts of a VHST on East Coast Metropolitan and Regional Economic Development.

This section continues from general discussion of regional issues in section 12 to identify the particular impacts which an EC VHST **might** have on each of six regions of Eastern Australia through which it would pass and the nine regions lying on alternative corridors.

Economic development and infrastructure issues, drawn from official sources, are tabulated for each region with a qualitative assessment of the likely impact of a VHST on those issues.

General comparisons are then made with regard to the possible regional development impacts on the alternative corridors, those indications adding to the material presented in sections 5, 6 and 9 in determination of optimum routes over the three sections where alternatives exist.

Caution in interpreting these benefits as being other than predictive is emphasized.

Section 14 - Evaluation of an East Coast VHST

This section assesses the role that an EC VHST could play in the future East Coast transport task. It then examines the ways in which an EC VHST could be in the National Interest, adopting the approach described in section 11 and taking account of issues raised throughout the whole of the Study.

Taking the 350 km/h technology as an example, it looks at the viability of the project from a financing perspective, both in Government hands alone and with the involvement of the private sector. It then looks at the VHST from an economic perspective by assessment of a standard set of benefits to the community.

It provides qualitative assessment of a series of outcomes, such as effects on inter-regional connectivity, effects on air and road transportation in the corridor, and the distribution of benefits along the corridor, achievement of which might be seen by Government as being in the national interest.

Section 15 - Is there a Place for an EC VHST in Australia's Transport Future?

This section summarises the discussions of the previous 14 sections by setting out the context for an East Coast VHST service and the pros and cons in terms of the following major issues:

- The transport tasks which the VHST could perform,
- The market share which a VHST could attract, particularly in competition with air travel,
- Corridor selection in terms of regional development, environmental, and engineering issues,
- The selection of VHST technology,
- Its cost, financing, and involvement of the private sector,
- Operation of a VHST system and staging of its development, and
- National interest and government policy considerations.

Annexure 1- National Interest; Extending the Scope of Analysis

This annexure cites and discusses the outcomes of recent research in this field, that material having been summarised in section 11.

Annexure 2- Environmental Analysis

This annexure extends the discussion of sections 5 and 6 to identify particular environmental impacts along the candidate corridors.

Annexure 3- Australian Maps

The maps of this annexure can be read in conjunction with the discussions of sections 7, 8, 9, 10, 11, 13, and 14.

P.2 Abbreviations and Terminology

High Speed Train Systems

EC VHST	East Coast Very High Speed Train
ESD	Ecologically Sustainable Development
HSGT	(American) High Speed Ground Transportation
HSR	High speed rail (generically)
HST	(Victorian) High Speed Train
LGV and TGV	Lignes & Grande Vitesse and Trains & Grande Vitesse - the VHST network and trains of France
PAX	Passenger
VFT	Very Fast Train (the subject of a 1990 Australian Study)
VHST-	Very high speed train (generically)
XPT and Xplorer	Current NSW long-distance passenger trains.

VHST technologies-

MagLev	Magnetic Levitation
SWSR	Steel Wheel on Steel Rail

Rail Organisations

CountryLink	The NSW long-distance train operator.
JR Central	The operator of the Tokaido Shinkansen service in Japan.
QR	Queensland Rail
RIC	The NSW Rail Infrastructure Corporation
SNCF	The national railway operator of France
SRA	The NSW State Rail Authority

Australian Government Agencies

ABS	Australian Bureau of Statistics
BTE	Bureau of Transport Economics

DoI	Victorian Department of Infrastructure
DoTRS	Commonwealth Department of Transport and Regional Services
HSTB	High Speed Train Branch of the DoTRS.

P.3 Geographical Data

Figure 1.1 indicates the routes considered in this study for an EC VHST. The names of potential stations and the abbreviations used for these locations are also shown.

Geographical Regions are described in terms of Figure 1.1 as follows:

Brisbane Metropolitan region includes Brisbane and Brisbane Airport and Ipswich;

Darling Downs region includes Toowomba and Warwick;

Moreton region includes Robina, Gold Coast and Coolangatta;

New England region includes Tamworth, Armidale and Glen Innes;

Far North Coast region includes Grafton and Ballina (Casino, Lismore, and Byron Bay);

Mid North Coast region includes Taree, Port Macquarie and Coffs Harbour;

Hunter region includes Newcastle and Muswellbrook;

Central Coast region includes Gosford, Wyong/Warnervale;

Sydney Metropolitan region includes Hornsby, Chatswood, Strathfield, Sydney, Kingsford Smith Airport, Glenfield/Campbelltown and Sutherland;

Illawarra Region includes Wollongong, Kiama, Shellharbour, Shoalhaven and Wingecarribee;

Southern Highlands region includes Bowral and Moss Vale;

Capital Country region includes Goulburn and Yass;

Canberra region includes Canberra, Canberra Airport;



Figure 1.1 Locations

Riverina region includes Wagga Wagga and Albury/Wodonga;

Alpine region includes Bombala, Cooma and Monaro;

Gippsland Region includes Warragul, Traralgon, Sale and Orbost; and

Melbourne Metropolitan region includes Melbourne, Melbourne Airport and Dandenong.

P.4 Contributors

This study was commissioned by the High Speed Train Branch (HSTB), Department of Transport and Regional Services on behalf of the Commonwealth Government of Australia. The study was under the direction of the Assistant Secretary of the HSTB, Dr J. Winternitz.

Peter Thornton of TMG International Pty Limited directed and led the Arup-TMG team and its specialists. The team comprised:

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- Operations/Technologies: Alex Wardrop, Robert Yee, Melissa Yep (TMG);
- Infrastructure Planning and Costing: Rodd Staples, Graeme Krisanski and Mike Dickens (Arup);
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- Document editing and production; Rodd Staples (Arup), Peter Bishop, Greg Dobson and Tracy Winters (TMG), Katrina Smith (Arup).

P.5 Acknowledgments

Arup-TMG acknowledges the inputs made and information provided by officers of agencies of the Commonwealth, ACT, NSW, Victorian and Queensland Governments who participated in the various meetings held during the course of this study.

Arup-TMG would also like to acknowledge the information and assistance provided to Dr Neil Douglas for the demand model by the following people:

- David Gargett and David Mitchell of DoTRS, who provided travel data and advice regarding its use;
- Peter Hoss of DoTRS who provided Aviation Statistics and advice;
- Malcolm Emerson of NSW RTA who provided road traffic count data;
- Peter Allen and Ian Gallard of Countrylink, who provided patronage data for Countrylink services operating on the Brisbane - Melbourne corridor; and
- Michael Doggett of SRA who provided patronage data on Southern Highlands, Central Coast, and South Coast CityRail NSW services.

Photographs of Eurostar at Waterloo Station, Queensland Tilt train, and outback NSW are courtesy of Arup

Photographs of Transrapid trains are reproduced with the kind permission of Transrapid Australia.

All other photographs of VHSTs are courtesy of UIC http//www.uic.asso.fr.

Section 1

Introduction and Background



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SECTION 1

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1 INTRODUCTION AND BACKGROUND

1.1 Background to the study

The possibility of a contemporary high speed rail system operating in the eastern seaboard corridor of Australia has been actively promoted for at least 20 years. It was first seriously investigated in the form of a Very Fast Train, or VFT, for the Sydney-Canberra-Melbourne route by a private sector consortium, which could ultimately not demonstrate that the service could be delivered and operated without some significant form of Government financial support. A second consortium, Speedrail, proposed a more limited Sydney-Canberra service with the prospect of future extension over the East Coast corridor. After a competitive process against other technologies and business plans, Speedrail was accorded an opportunity by the Commonwealth Government to prove up its proposal. However, the private sector was again unable to demonstrate that a VHST service could be implemented without significant financial support from Government. A more detailed account may be found later in this report.

What was successfully shown in these processes was that:

- technically, there were several different forms of VHST which could be implemented in this corridor;
- there was considerable interest from the private sector to be involved in such a project; and
- the idea of VHSTs caught the imagination of the public, of the communities along proposed routes, and of politicians at all levels of government.

In view of these factors, and while rejecting the Speedrail offer, the Commonwealth Government announced its decision to investigate the matter of EC VHSTs for the first time from its own interest perspective.

1.2 The Commonwealth's objectives in this Study

Following its decision not to proceed with the Speedrail proposal, the Commonwealth announced on 13 December 2000 that it would conduct a Scoping Study *"to examine the options for an East Coast Very High Speed Train (VHST) network, linking Melbourne, Sydney and Brisbane, together with Canberra and major regional and coastal centre along the route".*

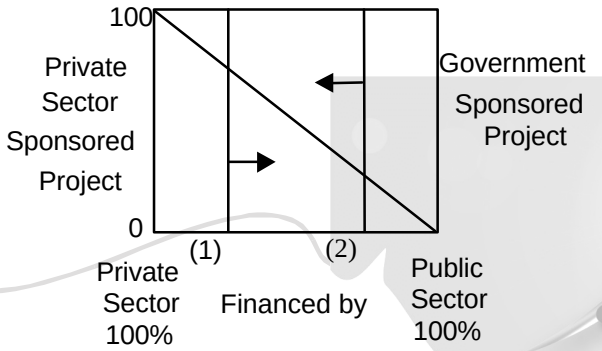
Up to this point, proposals for VHST services, and indeed other rail projects, have been brought to Government by the private sector for consideration. There have been some initial assertions that such projects could be financed by the private sector without recourse to public funding or concessions though, without exception, it has ultimately been shown that very significant public funding would be required for both capital development and operation. Consequently, it has become clear to Government that projects of this nature cannot be implemented without the active involvement of the public sector, both in facilitation and in financing.

Figure 1.1 illustrates this "seachange" of perspective. Transportation projects promoted as 100% financed by the private sector typically end up with significant public investment in them. In a sense, the job of the private sector is to "push" the project towards Government to reach a balance between the proportion of public/private funding such that private investors will participate. Clearly, the point can be reached where the balance between public and private funding means that the project is no longer a private sector project with some public sector support but is principally a public sector one. Under such conditions it becomes the job of Government to determine how it should involve the private sector, and what tasks and consequent risks it should outsource to the private sector.

On the other hand, the ongoing degree of public and industry interest in a VHST has now led the Government to consider the fundamental question:

"*Is there a place in Australia's transport strategy and policy for an East Coast VHST?"*

Figure 1.1: Project Financing Options



To address these two perspectives effectively means that Government needs to develop a view of its own. The objective of the Scoping Study is thus to "*provide the Commonwealth Government with an analysis of VHST potential, approaching the issue from a national benefit perspective and within a longer- term transport infrastructure context".*

The goals of the Scoping Study are to:

- To investigate at a broad and balanced level, and from a national interest point of view, the range of key economic and social factors involved in the construction and operation of an EC VHST network;
- To appropriately engage key stakeholders and potential partners (industry, other governments and the community); and
- To develop from (i) and (ii) a small number of practical scenarios for the possible construction and operation of an EC VHST network and to assess the costs, benefits and funding options for each scenario.

PHASE 1 of the Scoping Study, the subject of this report, is intended to provide an overview of all of the issues to be investigated in depth in the overall Scoping Study. It will serve as an information paper for decision makers in Government and its agencies and help to guide the more detailed studies which follow.

1.3 Approach to the scoping study

The Commonwealth Government has initiated this study and would be a major, if not the major funder, of an EC VHST. The Brief therefore requires that the study adopts the perspective of the "national interest".

The question, however, of what constitutes the "national Interest" is complex, the concept not being enshrined in Commonwealth policy and, indeed, there being no policy at all into which the provision of some form of VHST could tidily fit. Providing some framework for assessing whether or not an EC VHST has a place in Australia's transport future is then a core part of this study.

The methodology of this study is therefore structured to adopt this perspective by having four major "national interest" themes, as outlined in figure 1.2. This framework takes the scope of the brief as listed and rearranges it into these themes.

Policy Framework

This aspect of the study addresses the matters which any prudent investor, private or public, would consider before embarking on an enterprise of this scale – the why, what for, how, when and by whom questions of creating and operating a national business enterprise in VHS rail. The Commonwealth has after all been an owner of railway enterprises in the past, as well as other transport companies and infrastructure. The past decade has seen the Commonwealth progressively divest itself of such involvements. Why would it wish to become the majority owner of a high-speed rail system? If it does, how should such a business be set up? What are the lessons from other countries?

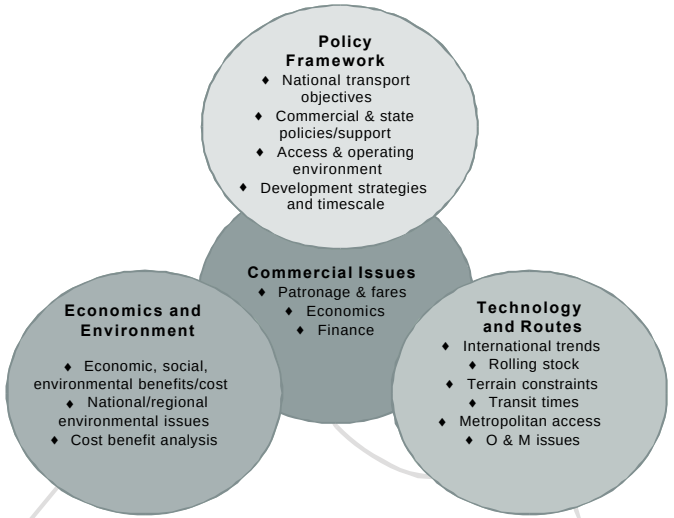


Figure 1.2: National Interest Themes

But more fundamentally still, what policy rationale is there for the Commonwealth (and the States) to embark on such a vast undertaking? Given the likely scale of cost it would be necessary for Government to have a clear view that such an enterprise would support the desired patterns of urbanization, national and regional economic development in this part of the Nation.

In short, Government must have a strong belief that an EC VHST, whether in part or in whole, will shape southeastern Australia according to what Government desires. While their reasons have differed, possession of such clarity of reason has underpinned the decisions of those nations who have chosen to publicly finance and build VHST systems.

Economics and Environment

The externality effects of high-speed rail are indicated below, and discussed in more detail later in this Report.

The manner in which a VHST is implemented and operated would affect the economy at national, regional and local levels and it is necessary that consideration be given to the identity of the likely winners from such investment, and who is likely to bear the costs. It has been found that other proposals of a similar scale deliver net benefits to users but non-users actually suffer net costs and this changed accessibility has in fact "sucked" investment out of regions rather than "pushing" it in. Government would need to have strong rationale for the selection of a particular corridor, based on an understanding of the benefits to be delivered by both the capital investment and the long-term operation in the chosen corridor.

Travel times depend largely upon the straightness of track, and hence cost of construction, and, as an EC VHST would, realistically, require significant public funding, the balance between the serving of regional centres and minimisation of travel times, between capital cities in particular, would again be a major consideration.

The environment and the effect of human activity on it represents an externality, involving issues ranging from the obligations of government under statute and international treaty to broader considerations of values ascribed by the community to discrete elements in the natural and physical world. There are already huge tracts of land such as Koscziusko National Park, which, terrain aside, preclude an EC VHST. While 50 years ago the Snowy Mountains Scheme was constructed within the heart of the now preserved region, community attitudes today are very different. Selection of a corridor for an ECVHST must from the outset seek to avoid conflict with incompatible land uses at the macro scale and, where conflict is inescapable, use design to reduce adverse effects to acceptable levels. The identification, at the macro level, of environmental assets over the entire 2000km corridor is a key task in this study since it will be influential in the broad selection of corridors which are at least in the realm of the possible rather than the improbable.

Commercial Issues

Even though an EC VHST may be justified on the basis of national economic planning policy it cannot be a significant financial burden to taxpayers. This perspective was well expressed by the California High Speed Rail Authority in its business plan of June 2000 for a 1124km high-speed rail network:

"*Rather than seeking to realize primarily social and political objectives that require substantial public subsidies to construct and operate, the mindset that drives the development of the high speed train system should focus on returning substantial financial, economic and environmental benefits for whatever public and private investments are made.*"

Implicit in this statement is that a VHST must deliver quantifiable benefits, whether or not measured in purely monetary terms, that meet the "hurdle" rates of its private and public sector investors, in addition to meeting policy objectives.

To have any chance of being economically, let alone financially successful, a VHST must attract and retain a viable commercial market. To do this over the intercapital corridors being considered, a VHST would need to both capture substantial proportions of travel from air, car, coach, & existing rail services and create travel behaviours which do not exist at present. An understanding of what range of patronage and hence revenues is within the realm of the possible is basic to understanding whether a VHST has any chance of being economically and commercially viable.

Creating a VHST will involve not only building massive infrastructure and constructing high technology vehicles to operate on it but also the creation of an ongoing transport business enterprise able to run the service and maintain its assets. Questions relevant to a broad understanding of such a business include:

- How the enterprise could be financed?
- Which elements could be in-sourced and which outsourced?
- What proportion of government/private sector funding is realistic?
- Who could be an operator of the service?
- Who could create and maintain the infrastructure?
- What type of regulatory framework would be appropriate?
- What are the likely responses of competing modes (notably air)?

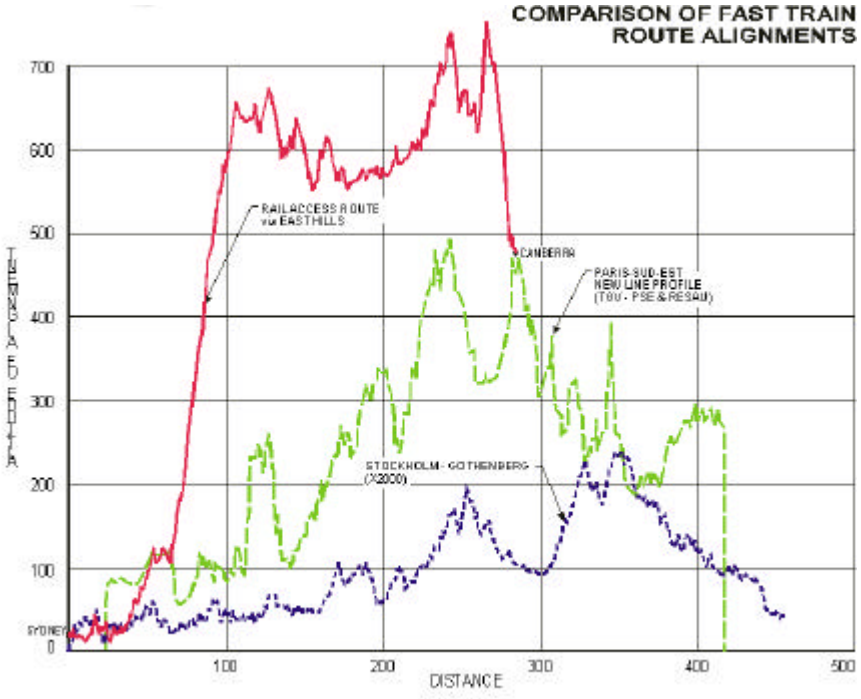
These issues are generally addressed in Sections 10 and 14 of this Report.

Technologies and Routes

One reality that is still not well understood is that the terrain of south eastern Australia is challenging for high-speed rail operation. A comparison of the profile of the Sydney - Canberra route to two European journeys of comparable length is shown in figure 1.3. Any land transport corridor between Sydney and Melbourne crosses the Great Dividing Range twice and, while seemingly innocuous, this represents a significant challenge for rail transportation.

Cars have the performance capacity to operate on most contemporarily designed road alignments to, and generally well beyond, the legally permitted maximum speed. Trains, however, are designed more closely to their intended operational regime and, in any event, must operate on much flatter grades and much greater horizontal curves.

Figure 1.3: Fast Trains Route Alignments



Train technologies, of whatever form, need to be assessed on the infrastructure alignments in which they are intended to operate to derive realistic travel times. Simulation modelling is essential to achieve this, simple approximations only serving to set false expectations and distort the fundamental business plan.

The sources of technologies, the industry trends in high-speed train design and manufacture, and the fact that there are several competitive suppliers of technologies needs to be understood.

The question of where any VHST should go to and through is fundamental and bears on such issues as regional development, patronage environmental impact and the costs of implementation and operation. There has already been considerable prior investigation of a number of VHST alignments in Eastern Australia, not only by the VFT, Speedrail Consortia and other private sector proponents but also by State Government agencies. In NSW, Rail Infrastructure Corporation (RIC) has undertaken studies to look at upgrading in the Sydney-Canberra and Sydney-Brisbane corridors. The Department of Infrastructure (DoI) in Victoria has undertaken its own study of a VHST to Sydney as well as proposing a program of regional fast trains to link regional centres to Melbourne. Notably, the Northeast corridor to Albury-Wodonga is not included in that program. Queensland Transport and Queensland Rail have been developing the SunGold High Speed rail strategy to link the Gold and Sunshine Coast regions to Brisbane.

The key technology and routing questions that are broadly addressed by this study then are:

- What corridors are feasible for an EC VHST?
- Where should the corridor go and which communities should it serve?
- What level(s) of service, i.e. travel time, frequency, accommodation could be realistically provided?
- How fast does a new ground transport system need be to capture a viable market?
- How exclusive should the corridor be? i.e. Is it for passengers only or should it cater for freight operations?
- How open should the technology be? I.e. fully compatible with existing rail infrastructure or completely stand-alone?
- How established should the technology be or how avant-garde?
- What opportunities would there be for major Australian content particularly in the high technology component?
- What would such a system cost the Australian nation as well as the participating travellers?
- What benefits, such as accessibility and energy efficiency, would accrue from the introduction of a new system?

1.4 East Coast Transport Corridor Realities

To fully appreciate the scale of an East Coast VHST, it is useful to understand some of the basics of the corridor, its dimensions and the current performance of rail against its fastest competitor, being air travel.

Figure 1.4 shows the corridors under consideration in this study, with more detailed maps being included in annexure 3. The rhumb line ("as the crow flies") distances from Melbourne to Sydney and from Sydney to Brisbane are about 730 and 770 km respectively though the terrain along both of the direct routes is mountainous and the current land transport links avoid the worst of this terrain.

The State Rail Authority of NSW (SRA) currently provides interstate long distance trains in both corridors.

Between Sydney and Melbourne, the service:

- Travels a distance of 963 km terminus to terminus, being 32% greater than the rhumb line distance,
- Has a scheduled travel time of 10hrs 30min
- Operates 2 trains per day each way
- Averages 92 km/h using XPT rolling stock with a maximum speed of 160 km/h

Between Sydney and Brisbane, the service:

- Travels a distance of 988 kms terminus to terminus, being 28% greater than the rhumb line distance,
- Has a scheduled travel time of 14hrs 16mins
- Operates 1 train per day each way
- Averages 69 km/h, using XPT rolling stock with a maximum speed of 160 km/h

A rail journey between Melbourne and Brisbane would occupy 35 hours, with a stopover of up to 10 hours in Sydney.

By contrast, air travel between Sydney and Brisbane and between Sydney and Melbourne reliably provides **door to door** travel time of around 3 to 3.5 hours, The following are based on average personal experiences of travel during the course of this study, for business purposes (i.e. no luggage to check in) and early morning flights (i.e. departure from home at 6:30 am) and an evening return.

Sydney - Brisbane

- Car to Airport 35 minutes
- Terminal Wait 20 minutes
- Gate to gate 90 minutes
- Terminal Transit & Wait 10 minutes
- Car to City Office 25 minutes

Total 180 minutes, or 3 hours door to door

The times for Sydney - Melbourne are basically the same:

- Car to Airport 35 minutes
- Terminal Wait 20 minutes
- Gate to gate 85 minutes
- Terminal Transit & Wait 10 minutes
- Car to City 35 minutes
- **Total 185 minutes, or 3 hours 05 minutes, door to door**

Day trips by air between these centres are therefore practical for business, the most time sensitive form of travel, and other purposes.

It is instructive to contrast the approximate populations and distances between the four Australian cities which would be connected by the EC VHST with Europe in regard to city pairs that have constructed VHST links. The distances are "as the crow flies ".

- Sydney (4 m) - Melbourne (3.5 m) 730 km
- Sydney (4 m) - Brisbane (1.5 m) 770 km
- Sydney (4 m) - Canberra (0.3 m) 250 km
- Paris (9.3 m) - Lyons (1.3 m) 390 km
- Madrid (4.6 m) - Seville (0.9 m) 390 km
- Brussels (1.6 m) -Paris (9.3 m) 320 km
- Berlin (3.5 m) - Hanover (0.5 m) 245 km

Whilst there are some parallels in terms of city pair populations, the reality is that by and large the populations are greater and the distances shorter in Europe. The densities of population in the linking corridors are far lower in Australia than they are in the successful VHST corridors of Japan and Europe.

These basic dimensions, together with the availability of serious mode competition, have always been and will remain the key issues in the commercial viability of any passenger rail service.

1.5 A Cautionary Note on Prices

Throughout the report reference is made to data involving prices in international currencies. Such prices have generally been converted to Australian dollars at current exchange rates, without adjustment for inflation or exchange rate movements in the case of costs incurred in earlier years.

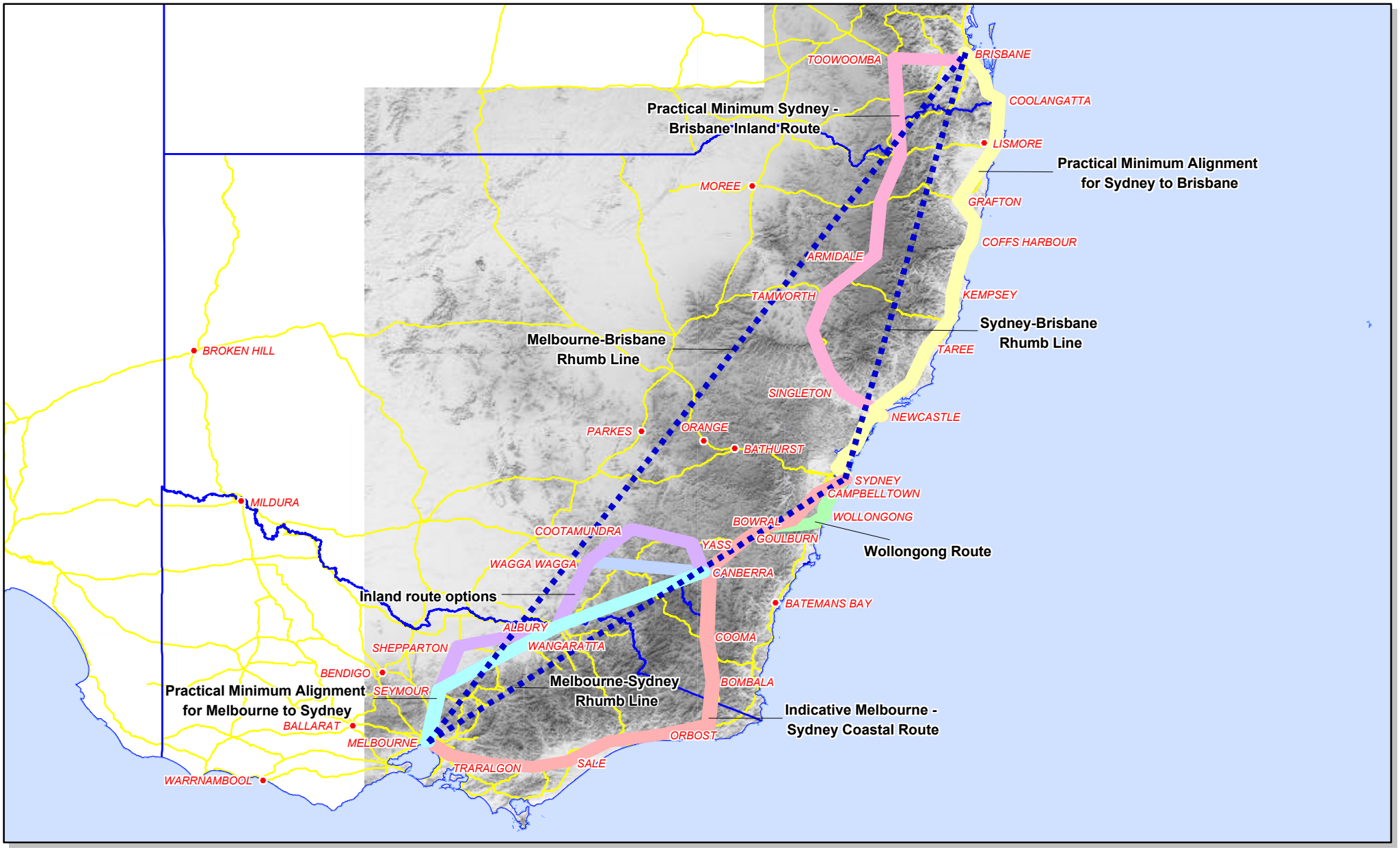
Price parity, being the relative cost of construction or operation in one country from another, is a further complication. Where practical, consideration has been given to this effect, as noted.

Inevitably, there will be some degree of error from these sources but in terms of the order of magnitude of costs involved in an EC VHST such international data is still informative and relevant to a preliminary assessment of a VHST.

1.6 Key Points

- Previous VHST offers have failed to demonstrate commercial viability without Government funding and/or financial concessions;
- The Sydney – Canberra VHST process showed the high level of interest from the private sector and the technical feasibility of a range of VHST technologies and systems;
- The Government now is approaching the issue of an EC VHST from the perspective of it being a national interest project;
- To go forward Governments must have a strong belief and clear view about the future development of the corridors in which an EC VHST would lie;
- Eastern seaboard corridors have well established air services which conveniently permit one day trips between the state capitals;
- The realities of population distribution, terrain and distances are fundamental but only population distribution can be changed; and
- International prices converted Australian currency may not be entirely equivalent but are considered a relevant guide to projects of this scale.





Major Centres in South East Australia

Figure 1.4

Section 2

Creating VHST Networks



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2 CREATING VHST NETWORKS



Photo courtesv UIC

In this section consideration is given to the reasons why VHST systems have been developed and the methods by which they have been created, it being noted that the scale of investment required and potential risks are such that this has only been possible as a result of actions by national governments.

This is followed by an assessment of the Sydney-Canberra VHST project as an indication of the issues related to creation of a VHST in Australia.

2.1 VHST in France

Thierry Mignaux, the SNCF Deputy MD for Operations, said at the 3rd World Congress on High Speed Rail in 1998 *"…it is impossible to overemphasize the importance of the compatibility between high speed lines and the existing network, which makes it possible for trains to penetrate deeply into cities and above all for a large proportion of the network to be served by high speed trains."*

This statement reflects the underlying railway strategy to which the development of France's Lignes a Grande Vitesse (LGV) is a response. France has a railway system of over 25,000 km of conventional track. To 1996 it had constructed more than 1280 km of high-speed lines and has recently added the 250km TGV Mediterranee at a cost of $3.6 billion.

TGV rolling stock, in various configurations, is operated on more than 6,000 km of track, illustrating its ability to operate in a variety of access and track conditions ranging from the dedicated high speed lines to lower standard lines in remoter parts of the country or in difficult terrain.

The outstanding benefits of this approach are that:

- existing stations can be served;
- TGVs can operate across a wide range of track speeds;
- development of routes can be staged; and
- access can readily be gained to existing terminals in major cities.

From a national development perspective, however, the genesis of the high-speed rail system lay in the saturation of both road and rail routes between Paris and Lyon. Rather than augment the existing railway, SNCF chose to build an entirely new rail alignment, dedicated to passenger trains, with geometry tuned to the operational performance of the TGV.

France had a history of development of high-speed trains both for electrified and non-electrified environments. Curiously, at the time the French Government reportedly (www.trainweb.org/tgvpages/history.html) *"favored more "modern " air-cushioned or MagLev trains, such as Bertin's Aerotrain. Steel wheel on steel rail was (wrongly) considered a dead end technology".*

The LGV/TGV was radical for its time *"combining very high speeds and steep grades that would allow a railway to follow the contours of existing terrain, like a gentle roller coaster. Instead of 1 or 2 percent grades which would be considered steep in normal applications, up to 4 percent would be feasible"*. (www.trainweb.org/tgvpages/history)

At a national level there were also the following overarching imperatives[1]:

- creation of a VHST export technology; and
- reduction of dependency on imported oil, France having more nuclear generated power than any other European nation, via conversion of railways to electric traction and the use of energy efficient traction motors.

The process of creating the TGV has been one of an exclusive relationship between the French Government, SNCF and the private sector company, Alstom. Indeed, while the credit for the concept planning and design of the TGV is due to SNCF, the experience of manufacturing TGV rolling stock has been vested exclusively within one private sector organization, Alstom. This illustrates the extent to which the TGV, throughout its development, has been a "national" product funded and supported by the French Government. The "*TGV Handbook*"[2] reported *that "Alstom and SNCF, with*

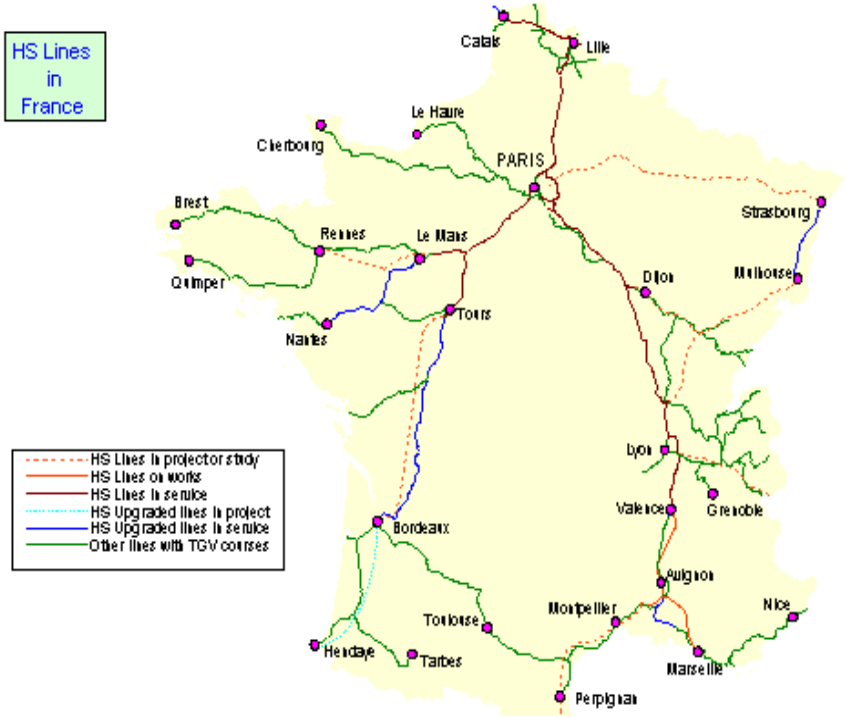
1. Najafi FT and Nassar FE " Comparison of High Speed Rail and MagLev Systems" Journal of transportation engineering July/August 1996

2. Perrin B; *TGV Handbook* 2nd edition

FF535 million support from the French Government, are developing a new generation TGV, TGV NG".

This train is designed to have a commercial speed of 320km/h with the objective of covering 1000km in 3 hours, that being the type of performance that would be required between Sydney and Melbourne or Brisbane.

Figure 2:1 High Speed Lines in France
© courtesy of UIC website:
www.uic.asso.fr/gv/common/maps.htm



With regard to export of technology, it is worth noting that France and Germany developed distinct VHST technologies at the same time. Within national boundaries, they utilised nationally developed technologies and, externally, French and German rolling stock industries are mostly in competition.

To date trains based on Alstom's TGV technology has been exported for operation on routes including:

- between London , Brussels and Paris – **Eurostar**;
- between Paris, Brussels, Amsterdam and Cologne – **Thalys**;
- in Spain – **AVE**; and
- in Korea for the Korean High Speed Train.

LGV/TGV technology was promoted heavily in the USA for the Florida high-speed rail project (FOX) and in Australia for Speedrail, neither of which projects has proceeded.

The extent of the LGV network is shown in figure 2.1.

While SNCF had investigated tilting trains as early as the 1960s, their outstanding success with the TGV/LGV concept meant that this technology was not pursued. However, the escalating cost of extending the TGV network into more difficult terrain and through areas of environmental sensitivity has renewed competition from such technologies.

This shift in policy is supported by the financial crisis in SNCF, indicated by statements that:

> *"France's' Government has had to take over FF125 billion (US$39.4 billion) of debts of the state owned railway" (The Economist February 21st 1998)*

> *"the French Government commissioned a review of the 1992 TGV Master Plan."* (www.trainweb.org/tgvpages/history)

The review recommended that, inter alia:

- the master plan be cut back from 4700 km of LGV to 3320 km;
- SNCF should consider tilting trains to achieve journey time reduction; and
- future TGV lines should be designed so that they can carry freight at night.

Regional governments saw tilt trains as a way of compensating for the cut-back of TGV alignment proposals. SNCF conducted tests using the Italian ETR 460 trains and has commenced development of the TGV Pendulaire, a VHS tilting train. The adoption of tilt technology by SNCF is entirely complementary to the philosophy of the TGV, and will enable the maximum travel timesaving to be achieved on routes that contain sections of both LGV and lower geometric standards. This will assist in extracting the maximum economic benefit from sunk cost assets.

As a direct outcome of this- *"French National Railways is set to introduce tilting TGV services on the Limousin route from Paris to Toulouse, following the signing of a finance agreement with the Government and local regions."*[3]

In summary, the creation of the LGV/TGV system in France has been a national project. The master plan for the TGV was prepared by the National Government, the railway infrastructure is now owned by a national organization- Reseau Ferre de France (RFF), and the system is operated by a national government business enterprise– SNCF. Its cost has been considerable and of the scale that only a national government could manage though, today, France is looking to more than the original TGV technology to achieve travel time efficiencies over its rail system.

2.2 VHST in Japan

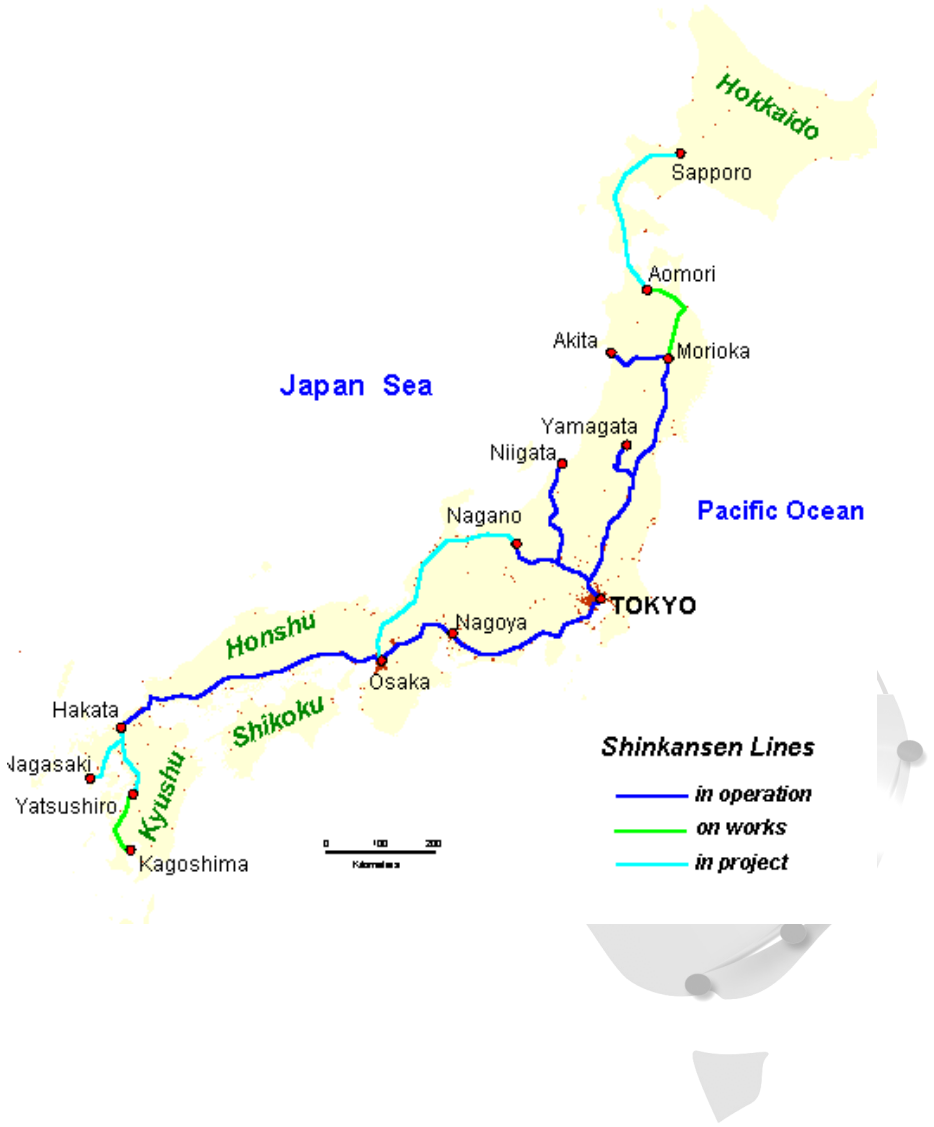
The Shinkansen commenced operation in 1964 on the classic Tokaido route between Tokyo and Osaka, 17 years before the first TGV in France. The strategic rational of the Japanese Government was founded on the following two priorities[4]:

- to reduce energy consumption and to lessen Japan's dependence on imported oil –the Shinkansen is powered by electric traction; and
- to create new development centres to reduce pressures on large cities by provision of a high capacity fast train for long distance work commuting.

The Japanese were not so interested in creating a new technology as in improving an existing one, to be able to economically change the patterns of settlement in the corridor between its two greatest cities while retaining the ability to access employment.

The Shinkansen was, until 1997, fully the creation of the Government through the Japanese National Railways (JNR) Today it is owned and operated by three privatized companies; JR Central, JR East and JR West. JR Central operates around 280 services each way per day over the 552.6 km between Tokyo and Osaka and carries 134 million passengers per annum.

Figure 2.2 High Speed Lines in Japan
© courtesy of UIC website:
www.uic.asso.fr/gv/common/maps.htm



[3] The Railway Gazette, July 2000
[4] Najafi FT and Nassar FE " Comparison of High Speed Rail and MagLev Sytems" Journal of transportation engineering July/August 1996

- In the 2001 Annual report of Central Japan Railway Company, its President Yoshiyuki Kasai wrote, *"As a railway operator we are guided by two basic management principles. We firstly take a broad long term view of our business development, as railway projects require massive investments and entail technological development programs with significant lead times the time frame for recovering investments is extremely long. Rather than emphasize short term profitability, we maintain a strategic stance. Our second management principle is to provide the highest possible level of quality in our daily services."*

JR Central has assets of over US$47 billion but also liabilities of US $38.7 billion, of which $28.8 billion is the inherited cost of the railway's infrastructure. Prior to privatization JNR is reported to have amassed debt of 37 trillion yen or about AUD$610 billion. [5]

After 37 years of development the Shinkansen system extends over 2154 km, being about 200 km longer than the distance from Melbourne to Brisbane. It is relevant to note that, while private companies now operate the Shinkansen, the Government has retained control of the entity that constructs the alignments of the Shinkansen; the Japan Railway Construction Public Corporation.

JR Central is also developing a MagLev project, called the Chuo Shinkansen, of which project the President of JR Central has said:

- *"Construction of the 600km Chuo Shinkansen Line between Tokyo and Osaka could cost between Yen 5 trillion ($US45.9 billion) and Yen 6 trillion ($US55 billion)"*[6]
- *"As the existing Tokaido Shinkansen high speed line between Tokyo and Osaka approaches capacity, the MagLev line is a strategic national project that can only be financed by local, regional an national governments through taxes"*.

The rationale for initiating such a massive project is grounded in Japan's plans for the creation of a 21st Century national land use plan, aimed at delivery of:

- more decentralization;
- promotion of regional autonomy;
- transfer of capital region functions to outlying regions; and
- mutual regional exchanges.

Creation of a new Chuo national axis based on the increased accessibility by means of a 500 km/h MagLev line could potentially deliver these outcomes. This national axis will provided additional ground transportation in the same corridor as the Tokaido Shinkansen while addressing different cities between Tokyo and Osaka.

Other benefits of the Chuo Shinkansen are considered to be:

- a response to the problems of global warming, by virtue of its projected CO_2 emission performance compared to cars and planes; and
- relief of capacity limitations now facing the Tokaido Shinkasen and the need to diversify risk following the Great Hanshin/Awaji Earthquake, these factors having shown that *"the Tokaido Shinkansen is reaching a situation in which it cannot support the future of Japan on its own."*

In summary, the initial, ongoing and future development of VHST in Japan is closely linked to national policies to achieve desired regional land use and major city accessibility goals. While the private sector is now an integral part of the VHST system, the Government closely controls its development under the National Shinkansen Development Law.

2.3 VHST in Germany

The economic integration of Germany is now being driven on three fronts – western European, domestic German and eastern European. While Germany had been working in a ordered manner towards integration within the European Community, the opening of its borders to the east in 1989 was more dramatic and high-speed rail is seen as playing a major role in such integration.[7]

Germany has a long tradition in high-speed trains. In 1872, the Berlin to Hanover express operated at speeds up to 160 km/h. While development of modern VHSTs commenced in Germany about the same time as in France, its first VHST, the ICE (Inter-City Express), was not put into service until 1991, some ten years after the commencement of TGV services.

According to Najafi and Nassar, the driving priorities behind the German VHST development were quite different to those in France but no less nationalistic in their intent. These included initially:

- land bridging between Eastern and Western Europe;
- fast services for both passenger and freight trains; and

5 The Economist, Vol. 346, No. 8056 February 1998

6 KJ January 2001

7 Prof. D Zumkeller "High Speed Transport as a factor in East/West European Integration" Proc #rd World Congress on High Speed rail Berlin 1998

- creating an integrated capacity in internal mobility and crossbred trade.

To these were added the overarching task of supporting German reunification.

These objectives led the German Federal Government's rail owner and operator, Deutsche Bahn, to adopt different technical standards to those of the TGV, examples of those differences being:

- the significantly more expensive slab track construction;
- alignments to permit freight operation;
- tunnels to minimize grades; and
- signalling and communications to accommodate mixed traffic.

It is also relevant to note that the German system of planning for new infrastructure provided for extensive public consultation and public hearing, the legislative ability of the French Government to create the TGV system initially being much easier.

The manufacture of the VHSTs themselves also differed in Germany. While, like France, the design and specification for the rolling stock was prepared by the Government's rail owner and operator, the ICE trains have been manufactured by more than one private sector company viz. Siemens and Adtranz.

Germany, like France, is competing to export its ICE technology, that point being illustrated by the anecdote[8] that, when the first Thalys (TGV) train from Paris pulled into the station in Brussels, an ICE train was already standing at the adjoining platform.

In 1991 the German Federal Government agreed on investing DM 32 billion (or approximately AUD$30 billion) in German Unity rail projects and by 1997 had invested some DM 17 billion of that amount. In additional DM38 billion (or approximately AUD$36 billion) has been invested in modernization of rail in the eastern part of the new Germany.

Table 2.1 summarizes the nine German Unity projects.

Table 2.1 German Unity Rail Projects

Project name	New Time in hours	Length km	Project Cost DM billion
Lubeck/Hagenow Land to Stralsund	2 hours	242	1.587
Hamburg to Berlin	2.23 hours	270	3.805
Uelzen to Stendl	0.93 hours	113	0.921
Hanover to Berlin	1.77 hours	264	5.107
Helsmstedt to Berlin	1.65	163	2.394
Eichenberg - Halle	2.25	170	0.534
Bebra – Erfurt	0.98	104	1.955
Nuremberg-Berlin	2.65	514	14.46
Leipzig to Dresden	0.98	117	1.889

This total of 2010 km of upgrading and new construction for high-speed operations is about 100 km longer than the distance from Melbourne to Brisbane and is being delivered progressively over a fifteen year period to 2006.

Additionally, Germany is constructing links as a part of the European Union's Trans-European network scheme, two major elements of that network being:

- Nuremberg to Munich as a part of a north-south link into Italy – 171km, DM 3.87 billion; and
- Cologne to Rhine/Main as a link to Amsterdam, Brussels, and London –219 km, DM 8.79 billion.

It is evident from this scale of investment that Germany is completely committed to the further development of its SWSR VHST network though, concurrently, there has been development of MagLev and propulsion. As with SWSR ICE technology, MagLev development in Germany has been, from its outset in 1969, sponsored by the Federal Government in close partnership with major German industrial companies and the operator, Deutsche Bahn.

German MagLev technology is based on the simpler of the two forms of MagLev technology; electromagnetic systems (EMS) rather than the electrodynamics systems (EDS) on which Japanese MagLev is based. The two are entirely incompatible. Through an extensive program of testing, the German MagLev system, known under the trademark name "Transrapid", achieved Government approval for commercial operation in 1991.

[8] Hill T, personal comment, 2001

A full account of the history of Transrapid's development and technology may be found at www.transrapid.de.

In 1992 the Federal Government included the Berlin-Hamburg Transrapid project in the Federal Transportation master plan. Not withstanding this decision the German government also decided to upgrade the existing rail alignment of ICE operation at a cost of DM3.805 billion.

The planning for the project commenced in 1994 with the formation of a private-public organization - the MagLev Planning Company. The authority to proceed with the planning for the project was established under three acts of the German Federal Parliament:

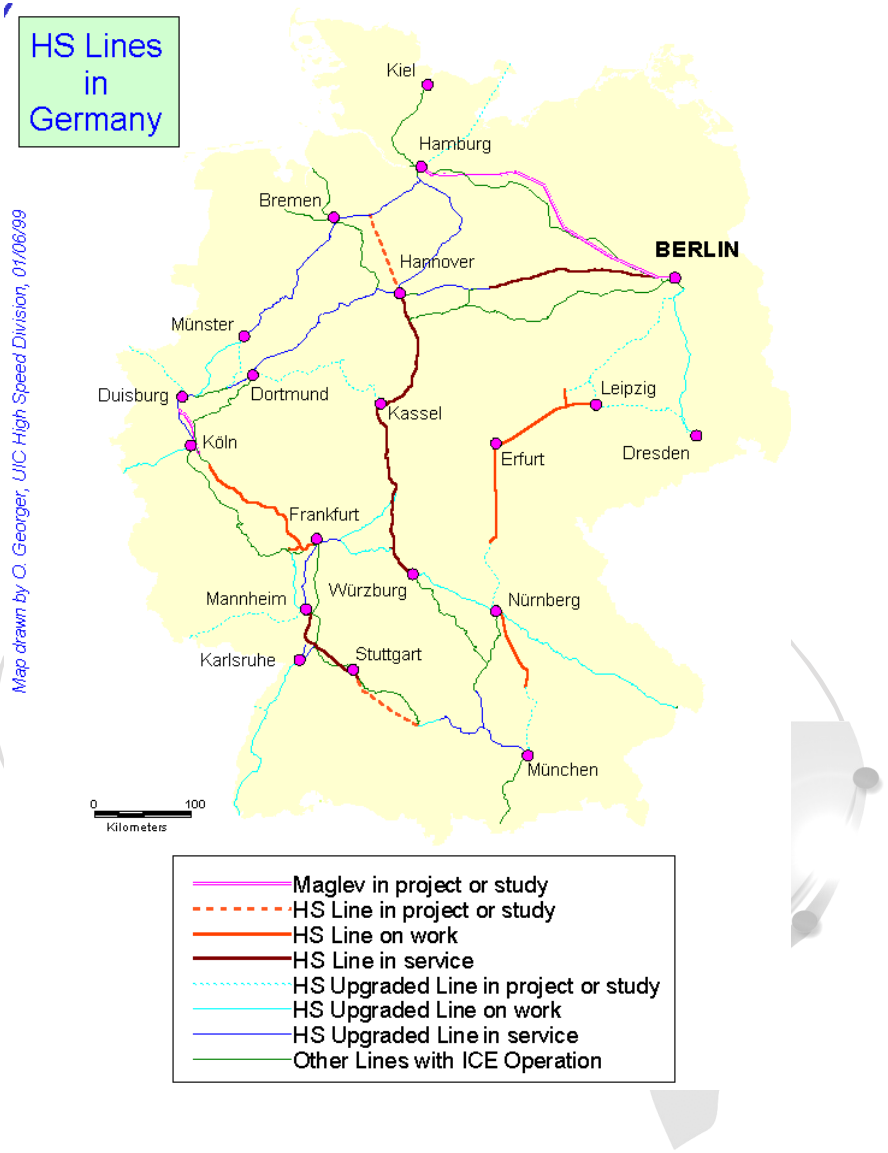
- Magnetic Levitation Service Planning Act (1994);
- Magnetic Levitation Service Requirement Act (1994); and
- General Magnetic Levitation Service Act (1996).

From a delivery perspective, however, the project was intended to be owned and operated by Deutsche Bahn. The fixed infrastructure of the project represented 63% of the project capital cost and was to be fully funded by Government. The operating system was to have been provided and financed by the private sector at a cost of DM 3.7 billion. This amount was to have been repaid by access charges set at a level to cover financing costs. The amount of at risk private capital was limited to DM $500 million.

The Transrapid project attracted enormous interest but, notwithstanding its considerable technical achievements, a large proportion of the interest was critical, if not unfavourable. Much of the criticism centred on the cost of the project as well as the fact that it would parallel an ICE service.

In February 2000 the German Government decided not to proceed with the project. Projected costs had exceeded an acceptable threshold, the project's commercial viability was seen as being unsupportable, and it was actively opposed by environmental groups in the German Parliament.

Figure 2.3 High Speed Lines in Germany
© courtesy of UIC website:
www.uic.asso.fr/gv/common/maps.htm



Notwithstanding this setback, Transrapid International, a private sector company owned by major German industrial interests, has been active in marketing this technology outside and inside Germany. Transrapid has recently achieved a major success in securing the Shanghai High speed Airport link project, which is now under construction.

Transrapid has also been strongly promoted for MagLev links in the USA, as discussed later in this section, and was selected in six of the seven shortlisted projects. Within Germany interest in has shifted to the construction of shorter more specialized links such as those to airports and regional VHST links.

In summary, Germany has had a national interest to create both an internal and external VHST network to bind itself together and to link it efficiently into both Western and Eastern Europe. The Government has made massive investments in both SWSR and MagLev technological development and German rolling stock companies have actively promoted both technologies in export markets.

2.4 VHST in Sweden and Italy

"Every country has its own solution to the need for trains to go faster. France has been able to build high-speed lines relatively inexpensively… "However, Sweden's terrain is far from easy. The construction of completely new lines with easy curvature and gradient would be ruinously expensive in Sweden."[9]

The approach adopted in Sweden to economically achieve better travel times was to develop rolling stock which could travel faster on existing alignments, the answer being the 200 km/h X-2000 tilt train developed by Swedish industry to the specification of Swedish State Railways (SJ).

Sweden bears some similarities to southeastern Australia in that it has relatively long distances between major cities and low population densities. Its two largest cities, Stockholm and Gothenburg, have about 1.54 and 0.75 million inhabitants respectively and are 394 km distant "as the crow flies" and its next largest city, Malmo is 507 km from Stockholm with a population of 0.5 million.

Sweden's X-2000 trains not only operate over lines upgraded for high speed services but over regional lines, the total route length being 3160 km.

Two other aspects of Sweden's rail system are relevant:

- the relative thinness of traffic and long distances means considerable parts of the system are single track; and
- the network is used by a variety of train types including for freight.

The X-2000 has been trialled in the USA and in Australia.

Sweden, therefore, sought to achieve economy of service improvement as well as creating a domestic and exportable HST technology.

Swedish development of tilting trains, however, was preceded by the development of Italian "Pendolino" tilting technology. Built by Fiat Ferroviara, the "Pendolino", as did the X-2000 later, allowed its operator, Italian State Railways (FS), to extract travel time saving from existing infrastructure. The "Pendolino" and/or aspects of its technology in various models have been exported to Finland, Switzerland, Spain, Germany and, most recently, Britain.

Notwithstanding its history of building high-speed railways and technologies, Italy is now embarking on the development of new VHST alignments. In 1991 the Government set up Treno Alta Velocita Spa (TAV) (www.en.tav.it) to plan and construct VHST projects in the critical corridors of:

- Milan-Naples;
- Turin-Milan-Venice; and
- Milan-Genoa.

The Turin-Milan-Naples component of the project is valued at more than 43,000 billion lire (~AUD$42 billion), involves construction of over 896 km of alignment and is due for completion in 2006.

The underlying objective of the Italian Government is to make the rail network competitive, at both the national and the European level, specific objectives being:

- improvement in the rail transport service;
- reorganization to achieve separation of flows;
- freeing up of local lines for regional traffic;
- increasing capacity, efficiency and safety on congested corridors;
- achievement of significant travel time savings; and
- preservation of Italy's environmental and cultural heritage.

9 D. Haydock "High Speed rail In Europe" 1995 pub Platform 5 Publishing Ltd.

TAV was originally set up as 40% public and 60% privately owned company though it is now effectively the Government's agency for overseeing delivery of the project, being owned 100% by FS. It appears from TAV's web site that private sector contracting consortia *"were assigned upon private negotiation full responsibility for executive planning and implementation of the high speed lines"*. However, in the future such arrangements will comply with new national and European legislation, appearing to make competitive tendering mandatory. It is of note that contracting arrangements include specific anti-Mafia provisions.

On its dealings with many agencies of regional and local governments, TAV says, "*Dialogue and cooperation with the central and local institutions is an essential requirement for construction of large-scale public works. The projects for the new high speed lines and urban railway junctions therefore have to undergo precise authorization procedures so as to ensure the best possible integration of the new infrastructure in the territory and thereby meet the needs of the parties involved in its implementation.*"

Funding for the project is 40% from the Government and 60% raised by FS through capital markets for the new lines and 100% by the Government for the urban junction works. The lines will be made available to operators including FS'sTrenitalia on the basis of an access charge.

In summary, VHST infrastructure is being implemented under the sponsorship of Italy's national government which will also be one, if not the major, service provider.

2.5 VHST in Spain

Spain has faced many challenges in upgrading its rail system to VHST standards. Foremost amongst these have been[10]:

- the gauge of the existing railway network was 1668 mm, rather than the European standard gauge of 1435 mm;
- until the 1980s, 79% of the system was single track and even 160 km/h operation was not possible; and
- the topography of Spain between Madrid and the cities of the coast is very rugged in comparison to the terrain in northern Europe.

The motivation to upgrade came from a number of sources:

- Spain's entry into the European Common Market in 1983;
- the objective to link into the high speed lines in France, and thence to the remainder of Europe;
- capacity problems on the Madrid to Seville route, which links several major Spanish cities; and
- the stimulus of the Seville Universal Exposition of 1992.

The Madrid to Seville project is 471 km in length and was completed in five years. While this was a very creditable performance, cost more than doubled from that originally estimated though the cost per kilometre was still much lower than was being achieved on the German VHST projects. In terms of technology, the initial Spanish approach has been distinctive by its use of international tendering leading to:

- adoption of basic TGV rolling stock and modification for the harsher operating conditions of Spain; and
- use of German technology for the infrastructure.

The Spanish VHST or Alta Velocidad Espanola (AVE) system is also distinctive, being designed to permit operation of both passenger and freight services and operation of different types of VHST rolling stock, including the Spanish built TALGO 200 tilting trains. This flexibility is possible by virtue of the lines operating at well below capacity.[11]

Spain is now constructing the Madrid to Barcelona leg of its VHST system, that line being of 796 km length and costing about PTAS 1.09 trillion or AUD$12.4 billion. It will have connections north to the French border and linkage around Madrid of the two lines is also in the planning phase.

For this project, two types of 350 km/h rolling stock are to be procured, the Siemens IC E350E and the Adtranz-Talgo 350 trainsets, 20% of train manufacture to be in Spain. These will be the fastest trains in revenue service anywhere. The cost of the rolling stock is PTAS 123 billion or about AUD$1.5 billion.

While the technology and infrastructure continue to be delivered by the private sector, ownership and operation remains in the hands of the Spanish Government's railway company RENFE.

In summary Spain's national government through its operator RENFE has been the instigator of the development of its VHST system. Implementation has been by the

[10] B.Cross & D Haydock "Spanish High Speed Lines" in "High Speed Rail in Europe" 1995 Platform 5 Publishing

[11] UIC "High Speed Rail Development Madrid – Andulusia" 1997

private sector. Spain has also shown a willingness to adopt the best technology from a variety of suppliers and to integrate it into their system.

2.6 VHST in Taiwan and Korea

Both Taiwan and Korea are currently constructing high-speed rail projects

The Taiwanese project links its two largest cities, Taipei and Kaoshiung, the rationale adopted by Government focussing on two key aspects of policy:

- relieving congestion on existing intercity modes in the densely populated West Taiwan Corridor which contains 14 cities and 77 townships; and
- boosting economic productivity by stimulating regional development.

Other benefits considered to be obtainable are land efficiency; pollution prevention; energy efficiency; safety; high capacity and all weather performance.

The project is estimated to cost US$13 billion for a 345 km VHST link. The project is significant for the fact that more than 300 km of the route will be either on viaduct of in tunnel; indicative of the difficult terrain through which it passes. Transit time between Taipei and Kaoshiung is estimated to be 90 minutes. Daily patronage is estimated at 171,000 – equivalent to 62.5 million per annum.

The project is being delivered by the private sector through a 35-year concession. The project is to be financed 25% by Government and the remainder via concessionaire (30% equity/70% debt).

The rolling stock contract was in itself a demonstration of both international cooperation and competition. Initially it appeared that the VHSTs would be supplied by European companies – Alstom and Siemens having formed a consortium to build Eurotrain which combined the technologies of both the TGV and the ICE.

However, in the end a consortium of Japanese companies – builders of Shinkansen technology – were successful. This project will be the first export of Shinkansen technology. This was despite the Eurotrain having been members of the successful concessionaire's consortium and which is the subject of a lawsuit.

The Korean VHST project links Korea's two largest cities, Seoul and Pusan. The corridor containing these cities contains 71% of the country's 45 million people; 66% of all rail passengers; and 70% of all freight. The rationale for the project is grounded in policy to:

- alleviate congestion on existing land transport links – road and rail;
- socio-economic benefits of increased passenger and freight growth, travel time savings and reduced traffic accidents; and
- socio-cultural benefits including regional growth; diffusion of information into regional Korea; and stimulated tourism particularly in regional areas.

The project is 412 km in length and is estimate to cost 18.44 trillion won (about AUD$32 billion) with a transit time of 1.93 hours. As in Taiwan, the Korean VHST project passes through very mountainous terrain and requires many tunnels and viaducts leading to a very high cost per kilometre.

It proposed to open the project progressively in stages for revenue service. The project is forecast to carry up to 500,000 passengers per day. The VHST rolling stock and systems technology is technology is based exclusively on the TGV and is being supplied by Alstom.

The project is said to be six years behind schedule and to have incurred major cost overruns (www.ktx.or.kr).

2.7 The European VHST Master Plan

At its inception and for at least a decade after VHST transport was entirely confined within national boundaries. France and then Germany and Italy developed VHST systems according their national needs and on the basis of national manufacturing technology. Sweden and Spain followed on with similar localized technologies. While for the most part the rail systems nations of Europe at least had a common gauge, there were nonetheless differences between their electric traction power and safe working systems. However, there was also a well-established tradition of Trans European Express train services across Europe and even continuous rail services links via ferries to Britain.

Today Europe is focussing on creating a high-speed rail network between member countries of the European Union and its neighbours. VHST is seen as one of the keys which can help bind Europe together According to the International Union of Railways[12] "*The European Union has recognized the importance of this network for society and for the European Economy. At the European Council meeting in Essen* (circa 1997), *the Heads of State and Government confirmed that the 14 transport*

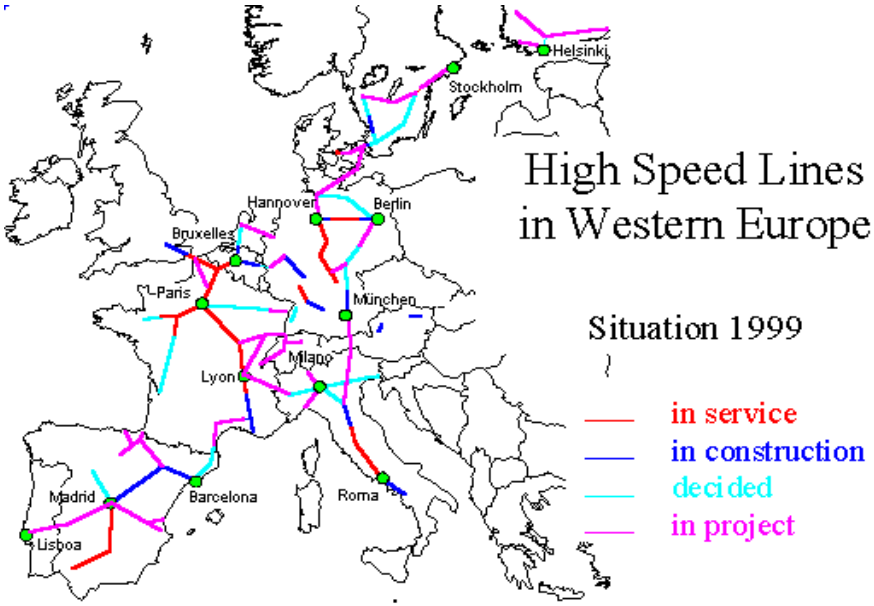
[12] UIC; 1998; *Trans European high speed network – the field of railway excellence*

projects were a top priority: 9 of these concern rail transport and 8 concern key links in the Trans –European high speed network,". At the date of that publication, which was released at the High Speed Rail Conference in Berlin in 1998, the following major VHST projects linking Europe together were in progress either in planning, delivery. or opened recently:

- United Kingdom – Channel Tunnel rail link London to Folkestone Belgium – Paris to Brussels Thalys services;
- Belgium– Brussels to Cologne and Amsterdam (PKBA) Thalys services;
- Netherlands High Speed Project to the Belgium border;
- France – TGV Est to German border; TGV Nord to Lille and the Channel Tunnel;
- Spain – Madrid to Barcelona and the French Border;

Figure 2.4 High Speed Lines in Western Europe

© courtesy of UIC website:
www.uic.asso.fr/gv/common/maps.htm



- Scandinavia – Sweden to Denmark;
- Italy – direct Pendolino train services from Rome to Paris and TGV services from Paris to Milan; and
- Cisalpino services between Switzerland and Italy.

Thus UIC states that *" the European High speed rail network is taking shape. At present, high-speed trains run on more than 14,000 km of line in Europe, approximately 2500 of which are new lines dedicated to high-speed operations. The Trans – European high speed network master plan involves some 12,500 km of new lines and 14,000 km of upgraded lines costing a total of approximately 210 billion ECU."* This amounts to almost $400 billion Australian.

The technical and commercial challenges now faced by European railway operators then are to:

- respond appropriately to socio-economic and environmental policy;
- develop effective use of capital markets via public/private partnerships;
- create VHST operations that are commercially sound;
- achieve full interoperability – in every regard from train operation to sales and ticketing – between national systems;
- sharpen competition;
- maximize return on investment and optimize operating economics; and
- achieve information sharing between operators particularly in terms of research.

UIC[13] noted that *"not only should the construction of new lines be encouraged but there potential of existing lines should be exploited to the full, in particular by using tilt body technology, which is a means of bringing about progress more rapidly and in a more distributed fashion throughout Europe."*

This latter point is relevant to consideration of an EC VHST in that, like Europe, Australia has a very large sunk investment in railway corridors. Extracting maximum performance from that asset needs to be achieved to the maximum practical extent possible commensurate with the overarching policy and commercial goals. before investing in competing infrastructure.

The relevance of VHST as a unifying force in economic and social terms in Europe has been acknowledged by the adoption by the European Union bodies of a draft master plan for VHST and the inclusion of that plan in the Maastricht Treaty as a Trans-European network (UIC, ~1997). In this regard, not withstanding the enormous cost, creation of such a unified system is part of the policy.

[13] UIC; 1998; *Trans European high speed network – the field of railway excellence*

2.8 VHST in the USA

In the USA, investigation into various forms of VHST systems, in US terminology HSGT, has been ongoing for more than a decade in recent times but Congressional interest in HSGT dates back at least to 1965, with the passage of the High Speed Ground Transportation Act.

Under this Act the Federal Railroad Administration amongst other initiatives introduced new technology on the Washington-New York-Boston Northeast corridor. It also commenced an R&D program into advanced HSGT technologies including MagLev.

While the introduction of new technology rolling stock demonstrated the potential of HSGT it also showed the neglect in infrastructure that had occurred. To date and over a 25 year program, more than US$6.6 billion has been invested in infrastructure upgrading particularly in the corridor between Washington and New York.

Federal HSGT emphasis in the 1980s shifted to studies of potential HSGT corridors and the interest of the State Governments in HSGT also increased: "*By 1986, at least six States had formed high-speed rail entities, and ultimately Florida, Ohio, Texas, California, and Nevada awarded franchises to private-sector consortia to build and operate intercity high-speed rail or MagLev systems. For a variety of reasons, none of these proposals has yet led to construction.*"

Interstate HSGT given further support under the Intermodal Surface Transportation Act (ISTEA) of 1991.

In 1997 a report was submitted to the US Congress examining the economics of high-speed ground transportation (HSGT in highly populated corridors throughout the United States. The intention of the report was *"to draw nationwide-not corridor-specific-conclusions from projections of the likely investment needs, operating performance, and benefits of HSGT in a set of illustrative corridors in several regions."*[14]

The report noted that this study could not substitute for *"the more detailed, State- and privately-sponsored analyses of specific corridors that would be prerequisite to HSGT implementation."*

Parallel with interest in SWSR HSGT was an ongoing interest in MagLev systems. FRA[15] reported that:

> *"In the late 1980s, Congress sought further information on MagLev, requesting FRA to assess the potential for MagLev technology and systems in the United States. Accordingly, FRA submitted a preliminary MagLev report to Congress in June 1990. In 1991, the National MagLev Initiative (NMI) was launched, with an initial appropriation of $12 million. The NMI was a cooperative effort among the Department of Transportation, the U.S. Army Corps of Engineers, and the Department of Energy, directed at system concepts for MagLev development, market analysis, and safety issues"*

FRA[16] also reported that:

> *"The Rail Safety Improvement Act of 1988 extended the statutory definition of "railroad" in the Federal Railroad Safety Act of 1920 to include "all forms of non-highway ground transportation that runs on rails or electromagnetic guideways," including "high-speed ground transportation systems that connect metropolitan areas, without regard to whether they use new technologies not associated with traditional railroads.""*

In its 1997 study and the earlier 1996 study, FRA considered a range of HSGT technologies. These were a spectrum of 90- 150 mph (160-270 km/h) HSGT's termed "Accelerail", new HSR represented by ICE and TGV and MagLev for which the German Transrapid was taken as representative.

The corridors investigated as shown in figure 2.5 and are:

- **California North/South** (San Diego-Los Angeles-San Francisco Bay Area);
- **California South** (San Diego-Los Angeles);
- **Chicago Hub Network** (Chicago to Detroit, St Louis, and Milwaukee);
- **Chicago-Detroit Chicago-St Louis;**
- **Florida** (Tampa-Orlando-Miami);
- **Northeast Corridor (NEC)** (Boston-New York-Washington);
- **Pacific Northwest** (Eugene-Portland-Seattle-Vancouver, B.C.);
- **Texas Triangle** (Fort Worth-Dallas-Houston-San Antonio);

[14] Federal Railroad Administration " High Speed Ground Transportation for America"

[15] ibid

[16] ibid

- **Empire Corridor:** New York-Buffalo (treated as an extension of the NEC); and
- **Southeast Corridor:** Washington-Richmond-Charlotte (treated as an extension of the NEC).

A key finding was that none of these corridors was commercially feasible in that it covered both its capital and operating costs but could be self sustaining once the infrastructure is in place.

FRA[17] reported that:

> *"Although the projections of system performance do not meet the traditional private sector criteria of "commercial feasibility", they may provide a basis for private/public partnerships depending on the size of investment required, detailed cash flow and other analyses, the financing capabilities of the prospective partners, and the impetus afforded the partner's by each projects perceived costs and benefits."*

FRA went on to state, however, that:

"Each illustrative corridor would have one or more HSGT technology that would meet the threshold conditions for partnership potential."

In 1998 the US President signed into law the Transport Equity Act for the 21st Century which had a major focus on safety but also supported two HSGT programs being:

- Magnetic Levitation Transportation Technology Deployment Program to fund nationally significant projects that will demonstrate the feasibility and safety of transportation systems employing magnetic levitation Under this program the Transportation Secretary is empowered to "*select one or more projects to receive assistance for preconstruction planning activities. Upon completion of preconstruction planning activities for all selected projects, the Secretary will select one project to receive financial assistance for final design, engineering, and construction activities"*
- High Speed Rail Development by which the existing high speed rail development program was reauthorized for the period 1998-2001 at a total of $40 million for corridor planning and $100 million for technology improvements. This program has supported the incremental development of high-speed rail in corridors around the country.

Under the former program the qualifications for consideration for Federal funding are stated to be to:

- exhibit partnership potential;
- be able to be constructed with available Federal and non-Federal funding;
- result in an operating transportation system in revenue service;
- be undertaken through a public-private partnership;
- satisfy applicable statewide and metropolitan planning requirements;
- be approved by the Secretary based on a State application;
- be carried out as a technology transfer project to the extent non-US MagLev technology is employed; and
- involve materials at least 70% of which are manufactured in the United States.

Issues of national importance such as contribution to reducing congestion, non-Federal financial support, job creation are considered relevant to the decision in determining which project to fund for final design and implementation. Two MagLev projects have been selected for final evaluation:

- Pittsburgh, Pennsylvania

  A 72 km (45 mile) project linking Pittsburgh Airport to Pittsburgh and its eastern suburbs. The project would be the first stage of a system that would eventually provide high-speed intercity service to Cleveland on the west and Philadelphia on the east.

- Baltimore, Maryland to Washington DC

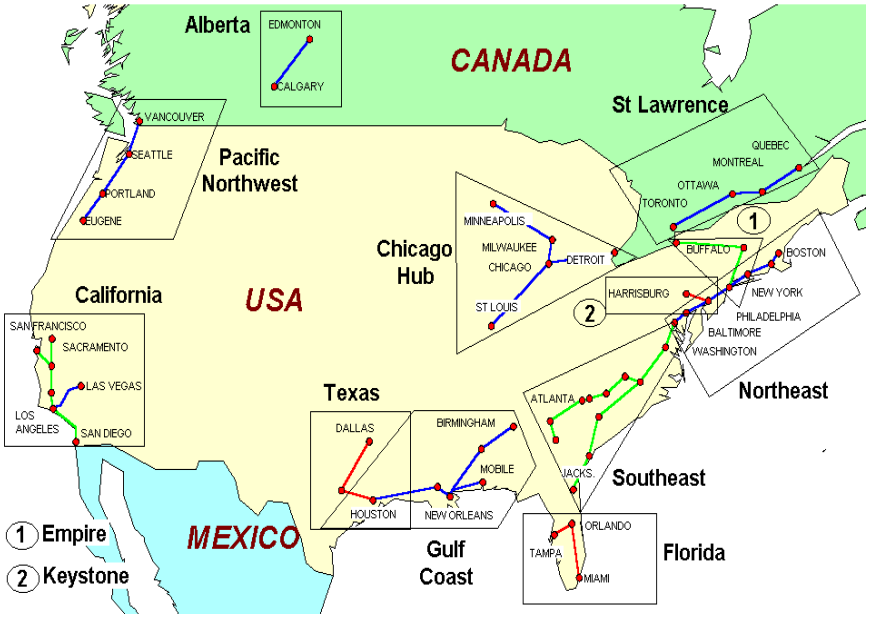
  A 64 km (40 mile) project linking Camden Yard in Baltimore (a sports complex and center for recreation and tourism) and Baltimore-Washington International (BWI) The project is visualized as the initial stage of a high-speed MagLev system that would serve the entire northeast corridor between Boston and Charlotte, NC. In the event the Baltimore-Washington area wins their bid for the 2012 Olympic designation the system would provide rapid transportation between the sports venues in both cities and the airport.

Federal funding of US$14.2 million has been provided to develop final business plans. It is relevant to note that in both cases the route length is relatively short and is similar to those now being studied in Germany for MagLev rather than the intercity routes of several hundreds of kilometres for which some proposals were made.

Many SWSR HSGT proposals are also current as indicated in figure 2.5, those of Florida and California being particularly interesting.

[17] ibid

Figure 2.5: High Speed Projects in North America
© courtesy of UIC website:
www.uic.asso.fr/gv/common/maps.htm



A full chronology of the attempts to develop a VHST system in Florida may be found at www.dot.state.fl.us/FHSRauthority/history.htm. It has a 25-year history, which in 1996, led to a private sector consortium FOX being awarded public-private partnership mandate to develop the project.

According to the Department of Transport in Florida:

"The FOX consortium was made up of Fluor Daniel, Odebrecht Contractors, Bombardier and GEC Alsthom. The Fox proposal was to build new grade separated, fully dedicated high-speed rail system connecting Miami, Orlando and Tampa. System capital cost was estimated at $6.1 billion with year 2010 ridership projected at 8.5 million per year. FOX proposed to finance the system with mostly debt financing with bonds fully repaid from net system revenues and the State's annual contribution of $70 million. In addition, $350 million in equity funding was to be provided from the four FOX partner companies."

In 1997 the Governor of Florida announced that the project had been terminated, citing that, given the level of Government funding required, there were other more pressing funding requirements. Florida remains interested in HSGT and in 2001 enacted the Florida High Speed Rail Act.

The State of California has recently release a detailed business plan for development of HSGT in the State, which may be found at www.cahighspeedrail.ca.gov.

Salient parameters of the California High-Speed Rail proposals are:

- a system comprising 1124 route kilometres;
- an estimated delivery cost of AUD $49 billion;
- a projected 32.1 million riders p.a.;
- it serves a population of 50 million linking the major cities of San Diego, Los Angeles and San Francisco;
- it is a Government sponsored and funded project;
- it is linked to Los Angeles International Airport;
- it would have a 16 year delivery time; and
- the business plan is based on the adoption of 350 km/h SWSR technology, however, MagLev technology is not ruled out at this stage.

The strategic objectives for an HSGT system in California were cited by the California Intercity High Speed Rail Commission as including:

- retaining California's competitive edge;
- enhancing mobility and connectivity of the many secondary centres in the corridor;
- achieving transportation stability through diversity of mode and by bypassing congested freeways;
- providing access to city centres in order to strengthen then economically;
- supporting the growth in population; and
- enhancing the image of the State – HSGT technology is seen as consistent with California's reputation as an international high tech centre.

The California High Speed rail project is now moving into the environmental assessment phase as requires under State and Federal legislation.

In summary, the USA is now very active in developing HSGT technology and operating systems in its highly populated transport corridors. While it currently would need to import the HSGT technology components from either Japan or from Europe, the Federal Government's funding requirements are intended to lead to a domestic HSGT technology capability.

2.9 VHST in Australia

Background

The notion of high-speed rail in eastern Australia was canvassed as early as 1981, though its real impetus commenced in 1984 when a private sector consortium developed and put a proposal to Government to build, own and operate a VHST system between Sydney and Melbourne via Canberra. This proposal, known as the Very Fast Train (VFT) was the brainchild of an eminent scientist and CSIRO head, Dr Paul Wild who assembled a consortium of major Australian and international companies. The consortium developed its proposal over a number of years and, in doing so, raised community interest and expectations in respect of the possibility of a VHST on the East Coast of Australia.

At that time there were two well established technologies– the TGV, as put into service by SNCF in France, and the Shinkansen of the Japan National Railway though other countries, Germany, Sweden and Italy in particular, were developing technologies including tilting body and MagLev trains. The VFT Consortium adopted the French TGV technology.

In its publication "VFT Focus for the future – A progress report October 1989" the Consortium said:

> *"Although the VFT project will be financially independent of the public sector, government cooperation is needed for it to proceed. Its environmental impacts would in any event be subject to scrutiny, but the project is so large that other issues including economic, social and industrial impacts are of interest to governments and the community. Although no financial support is sought, specific government action to assist the project is required in the facilitation of acquisition of both public and private land for the route."*

It went on to say:

> *"...the VFT Consortium believes that planning for development along the route, and its contribution to financing, are integral to the project."*

The Consortium also said, however:

> *"If it cannot be made adequately profitable, the VFT will not go ahead. Either way it will not be a burden on the taxpayer."*

Notwithstanding the significant amount spent (reportedly more than $18.9 million in 1989) on investigating and developing its proposal, the VFT Consortium was ultimately unable to demonstrate that the project would be commercially viable in the absence of significant financial concessions or contributions from Government.

The concessions proposed by the Consortium primarily related to taxation and land development and, following the Government's rejection of those proposals in 1991 and in the face of other commercial imperatives at the time, the VFT Consortium abandoned its pursuit of the project.

The Sydney – Canberra VHST Project

In 1993 interests which had been associated with the VFT, with the significant addition of the TGV rolling stock manufacturer, Alstom, as a major stakeholder, formed the Speedrail Consortium to address the shorter Sydney to Canberra corridor.

As with the VFT Consortium before it, Speedrail attracted considerable interest and support, particularly in the communities along its corridor and in the ACT.

Speedrail was also able to attract funding support from the Commonwealth, NSW and ACT Governments to conduct further major feasibility studies and, in July 1995, Speedrail reported that *"The overall finding of the study is that Speedrail's Sydney to Canberra link is commercially financible."*

Other commercial interests, however, disputed the commercial viability of the Speedrail proposition, which required construction of about 200 km of costly dedicated high-speed rail alignment. The manufacturer of the X-2000 high-speed train in service in Sweden, ABB, sponsored trials by the SRA of this train type on NSW routes including Sydney to Canberra.

The concept behind tilting trains is to allow faster travel around curves to minimize the need for new very straight alignment construction and to extract minimum transit times from existing rail alignments. Tilting trains, which at that time had maximum speed capabilities of 200-220 km/h, achieve this from sophisticated car-body suspension which reduces the unacceptable lateral accelerations that would otherwise be experienced by passengers. The trials showed that, as had been found in Italy, Germany, Spain and Sweden, significant time savings could be achieved though travel times still did not approach the level at which such a service would be competitive with air travel. Other interests, notably the MagLev train builder, Transrapid, focussed on achieving absolute minimum travel time.

Following sustained promotion by Speedrail and an evaluation of the possibility of improving passenger rail services between Sydney and Canberra by the Very High Speed Train Secretariat (formed by the Commonwealth, NSW and ACT

Governments), the Prime Minister announced in December 1996 that the three Governments would proceed with a competitive tender process and seek expressions of interest from the private sector to create this service. The basis of any further Commonwealth involvement was to be no net cost to the taxpayer and the proving up by a preferred tenderer of commercial viability of the project.



Bids by the Private sector

Expressions of interest were called by the Governments in 1996. At least six consortia were formed. Each consortium was associated with a particular rolling technology which in turn was associated with a particular country's railway system. These were:

- Speedrail – Alstom TGV 300km/h electric train – France;
- Transrapid – MagLev train – Germany;
- Talgo – Talgo Electric or diesel hauled passive tilt train – Spain;
- Capital Rail – ADtranz X2000 derivative 250km/h electric active tilt train– Sweden;
- InterCapital Express – Siemens IC-D 200km/h diesel/electric tilt train– Germany; and
- Fiat Ferroviare – Pendolino Active Tilting Train – Italy.

No consortia emerged based on Japanese VHST rolling stock although Japanese interests monitored the process.

The Final Offers



Following the calling of Expressions of Interest, the consortia representing the Talgo and Pendolino, both tilting train technologies, did not proceed and the remaining four, Speedrail, Transrapid, Capital Rail and InterCapital Express, went on to lodge Expressions of Interest. All four were shortlisted and in October 1997 were invited to submit a final offer. The Brief issued to the shortlisted consortia stated that it was

"in response to private sector interest and approaches to the Governments to design, construct, finance, operate and maintain a very high speed train service between Sydney and Canberra".

Implicit in this is that the Government had not initiated the project but that Government was providing the opportunity to the private sector to demonstrate that it could deliver, as had been claimed, a viable VHST service.

Some particular terms of the Brief which illustrate the Government's position were:

- risk to Government

  "the successful Proponent will establish a project vehicle to a): finance the project and protect the Governments and Agencies from financial and operational risk"

- financial involvement of Government

  "there be no net cost to taxpayers"

- service performance

  "subject to other criteria the Governments will prefer fully operational VHST services between Sydney and Canberra which have shorter travel and service times to those which have longer travel and service times"

- ongoing liability of Government

  "Proponents should particularly note that the Governments will not favour the acceptance of ongoing liability in respect of the Project"

- VHST technology

  "The Governments have no prior preference regarding the technology to be used for the VHST system provided it can be clearly demonstrated by the Proponent that the VHST System to be delivered and operated at acceptable risk to the Governments and in compliance with the other requirements of this Invitation."

- system extension

  "Proponents must describe how their technology and service being proposed is suitable for extension to other centres"

Nature of the Tender

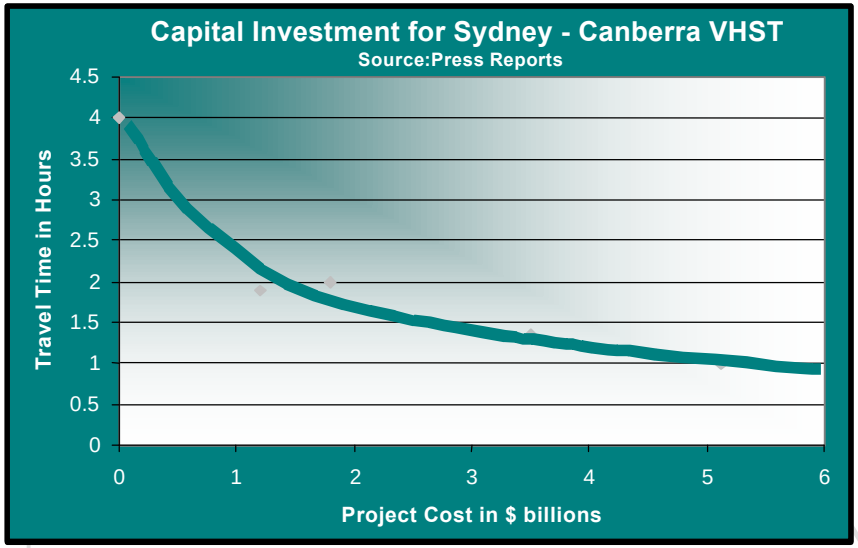
While Sydney-Canberra project was called as a competitive tender, it had many differences from most other tenders called by Government, including those called on a "build own operate, transfer" (BOOT) basis. These differences mainly arose from the fact that a railway, in terms of its technology and service parameters, is a far more complex entity than, say, a tollway and understanding of the needs for creation of an entity to operate a VHST is relevant to determining any future approach.

The documents to which the bidders responded were not prescriptive in terms of technologies or other fundamental matters but were intended to be basically performance specifications. Despite this intention however the document still tended to focus on the technology and the infrastructure in a traditional public infrastructure tender manner rather than focusing on the central issue of creating a viable business. Indirectly, Government did in fact express a view on the question of technology by its criteria concerning service performance.

Offers to Government

All of these offers were made "Commercial in Confidence". However, the very considerable interest in the public and in the press led to significant speculation as to their relative merits, and, from those reports, it is possible to understand the differences in approach.

Figure 2.6: Cost/Transit Time Relationship



Most press and public attention focussed on the faster, more expensive proposals, both of which would have required construction of dedicated alignment for their particular engineering characteristics over most, or all in the case of Transrapid, of the route. These two offers captured the imagination of politicians, the press and the public to a far greater extent than did the slower but far less costly offers which proposed major upgrades of the existing corridor and non-dedicated alignments.

The tenders offered four entirely different commercial regimes to government, differing markedly in cost, staging, service, and transit times proposed. The two faster proposals required that all infrastructure be in place from the outset while the slower proposals had the capacity to reduce time by further investment as the business became established.

Transrapid sought to maximize its market share by proposing a route via Wollongong.

The two slower proposals attempted to use as much of the existing alignment as possible, shared with other rail traffic, but adopted tilt-train technology to minimise travel times over those sections of existing track, and one proponent used a diesel-powered train that would have avoided the need for electrification of the corridor.

The most basic inference that can be drawn from the offers put forward by the four consortia is shown in figure 2.6. This shows clearly that cost of reducing transit time in this corridor increases exponentially.

Selection of a preferred Tenderer

On 4 August 1998, the Prime Minister announced that the Speedrail consortium had been selected to proceed to the proving up phase of the project. The Prime Minister said at the time:

> "*Our national transport vision is one free of State boundaries and differences where passengers and freight can move at lightning speed in complete safety."*

Speedrail prepared and submitted its "proved up bid" on 19 November 1999 and embarked upon an intense process of lobbying support for its proposal, further raising the profile of high speed rail particular in regional Australia along its corridor.

Decision of the Commonwealth

Following a thorough evaluation of this offer by the three governments, the Minister for Transport and Regional Services announced on 13 December 2000 that:

> *"The Government has also decided to terminate the Sydney-Canberra Very High Speed Train tender process on the grounds that we are not convinced that the Speedrail Consortium's bid meet the no net cost to government criterion. Speedrail had been invited to prove up its bid after being recognized as the consortium that had come closest to meeting the tender requirements, but as a substantial up front subsidy would be required to make the project viable it has not been accepted."*

Thus, like its predecessor, the VFT, Speedrail was unable, in the end, to convince the Government that it merited both special treatment and a major capital investment by Government. The Government's required contribution to the capital cost, which by then was quoted at $4.8 billion, was reportedly in excess of $1billion.

Implications for an East Coast VHST

If Government had been actively seeking the creation of this project for reasons of its own and in recognition that it could not be delivered in the absence of major funding from Government it might have included a clause in the Brief which stated *"subject to other criteria the Governments will prefer the creation of a demonstrably commercially viable VHST operation between Sydney and Canberra which requires the lowest capital contribution and operating subsidy from Government".* This would have focussed the competition more on the creation of a business and less on the matter of rolling stock selection".

The Sydney to Canberra VHST project also provides a highly contemporary example of the issues faced by Governments in planning, engineering and operating an EC VHST. All of the bidders pointed to the need for deep and active involvement of governments in the planning and delivery processes.

These include, inter alia:

- knowing whether or not the project is wanted and why;
- making choices about where a VHST should go and which communities would benefit and/or might incur costs;
- actively providing train paths on existing alignments, where they control the infrastructure/and or operate commuter services into and out of cities;
- being prepared to fund aspects of the project or works associated with the project;
- streamlining the approvals processes; and
- using powers at law or of negotiation to acquire necessary land.

In the Sydney to Canberra project, Governments always faced significant risk. Had no proponent been selected to proceed to the proving-up stage, a great expectation in the public would not have been met and there existed the possibility that the private sector, having just put four firm offers on the table, would see the Government as simply not interested in high speed passenger rail. This would have been intensified by that fact that Government had been presented with such a wide choice of VHST business plans for this corridor.

On the other hand, by selecting a preferred proponent there remained the risk that its business plan would not, as proved to be the case, meet the test of 'no net cost to Government' in the way that Government ultimately interpreted it. Of course, had it not interpreted it that way and Government proceeded to invest sums of up to 40% of the capital cost in the project, the other bidders would have been disenfranchised and the Government certainly exposed to criticism and possibly legal action. If the Government chose poorly and allowed a project to be implemented that proved non- viable commercially, it would face having a huge piece of public infrastructure as a "white elephant". At the level of Government funding said to have been needed by the Speedrail project, the Government, not the private sector, would effectively have been the leading equity participant and, as such, it would have needed to be fully committed and involved in the creation of the infrastructure and operation of the business at the top level of management.

Beyond the matter of Government funding of the infrastructure, Government support would also have been needed in the project's operating phase. If the project proved commercially unviable under private sector operational management the choices for Government would have been to:

- effectively nationalize the project and assume full responsibility for its finances – in effect what the New Zealand government has had to do with Air New Zealand; or
- allow the private sector processes of dealing with financially non viable businesses to operate, with the VHST service ceasing altogether as has effectively happened in the case of the Ansett group;

It is also clear from the Sydney to Canberra process that governments at all levels will need to be totally committed to a common goal in regard to the creation of a project even of that scale let alone one of the scale of the full EC VHST.

Such commonality of purpose was not in place for the Sydney to Canberra VHST project.

In fact, the reverse seemed to be the case with support being expressed for one or other of the proponents based not on the matter of their fundamental commercial viability as a package but on such technical details, such as their route, effect on commuter transport systems and their technology. However, notwithstanding such support, the NSW and the ACT Governments had made it clear to the Commonwealth during the process that they were not prepared and/or able to contribute financially to the project.

The press releases during the 4 years of the process showed clearly that many politicians at all levels of Government, supporters in industry, and the public were captivated by the "sizzle" of VHSTs but were not prepared to face up to the realities of how these were to be achieved or what it ultimately meant for Government in terms of risk and commitment. That in itself is a testimony to the effectiveness of the VHST proponents lobbying and publicity.

When it became increasingly clear that, whatever the technical merits of the Speedrail proposal (which were considerable), its particular proposal could not be delivered without massive government funding, its supporters increasingly spoke of its nation building potential and extendibility to link the East Coast major cities.

The experience of the Sydney to Canberra project is that the following are tasks which are fundamental to achieving any future VHST:

- achieving commonality of purpose between the States and the Commonwealth;
- recognizing that creating and financing the project will require contributions, whether in cash or in kind, from all levels of Government, and
- finding the compelling national interest reason for Governments to pursue it.

2.10 Key Points

- Countries that have created VHST systems have had simple but powerful national goals which VHSTs have been considered to support.
- Such countries have been prepared to fund the enormous costs involved because of the belief in their visions about how national development and transport are interrelated. Others have sought to extract maximum performance from what they already had.
- No VHST been fully viable on a strictly commercial basis though some have been successful in covering operating costs.
- While European nations and Japan have developed VHSTs for the internal national purposes the European nations have been far more active in exporting their technologies and system than have the Japanese.
- MagLev technology has been developed in both Germany and in Japan. The German Transrapid technology has been actively promoted around the world as an export technology though the Japanese technology has not been similarly offered.
- In Europe the VHST network is seen as a key to unifying the countries of the European Union.
- In Japan it is seen as the transport spine by which development is supported.

- In Europe VHST systems, services and technologies now transcend national boundaries.
- In Japan, VHST services are now provided by private sector companies. However they carry the debts of the system creation on their balance sheets.
- Sweden, Spain and Italy have all build VHST systems using both national and imported technologies - all have been active in linking to the European network.
- Interest in the USA in VHSTs is high, with both SWSR and MagLev technologies being investigated in depth for high population density corridors across the country.
- In Australia, VHSTs have been promoted heavily and at considerable expense by the private sector as commercially viable solutions to transport problems.
- No project has successfully shown that it can be achieved without upfront Government funding, which in some cases could be as much as 40% of the projected capital cost.
- Australian decision-makers and governments have not held a common, underlying powerful vision of and commitment to VHST as a national project and asset.



Section 3

Policy and Strategy Framework



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3 POLICY AND STRATEGY FRAMEWORK

3.1 Overview

Two major factors that would be influential on the planning, design, construction and operation of an EC VHST are considered in this section.

The first of these is the question of the existence of policy and a legislative framework within which the Commonwealth, in concert with the other governments of the East Coast corridor, could give effect to a VHST project. The existence and availability of such policy and legislation would in itself be a reflection that an EC VHST, in part or in toto, was a strategic objective of the Nation and could indicate Governments' collective view on satisfying the types of national interest objectives identified in section 11.

The second is the policy and legislation providing for the achievement of the strategic objectives of environmental sustainability, as well as setting more specific environment goals and outcomes. Such legislation will be broad in its influence on the planning, design, construction and operation of a VHST, particularly in the selection of routes and technologies.



3.2 Commonwealth and States VHST Policies

3.2.1 Background

The scale and complexity of development of an EC VHST network would require Commonwealth, State, Territory and local governments to commit jointly to its success. This would need to be founded on a belief that an EC VHST would, in some particularly special manner, be in the national interest as well as meeting other socio-economic goals. Such belief would need to be accompanied by a willingness to address the jurisdictional and policy issues affecting its development.

An EC VHST would be an unusual undertaking as it would involve development of infrastructure on land within five jurisdictions along a route of about 1900 km with all the associated land acquisition, ownership, planning and environmental policies and other considerations relevant to each of the jurisdictions. To add to that complexity, the EC VHST would be an integrated system of track infrastructure, stations, rolling stock, electrical systems, communications, signalling and operations controls.

No government currently has a policy framework that could promote and sponsor the development of an EC VHST, though, on the other hand, no government is hostile to the concept. Collectively, current policy positions are essentially based on a sense that there may be some potential for VHST technology but that potential, in an Australian context, is uncertain and yet to be adequately defined.

Heavily counterbalancing that mild interest is the lack of immediate, compelling imperatives to justify the substantial government commitments that an EC VHST would require. Within current policy horizons there is no immediately apparent need for an EC VHST system so that governments are under no real pressure, either from a public policy or a public perception viewpoint, to promote and develop this new transport mode.

As noted in Section 2 of this study, countries that have created VHST systems have had simple but powerful national goals to which VHST development was integral. Those countries have been prepared to fund the enormous costs of VHST development because of their commitment and belief in their visions about the interrelationships between transport and national development.

Governments in Australia have consistently made substantial investments in the development of transport and communications networks that are strategically important to the economic and social well being of the society. In the second half of the 19th century investment focused on the development of colonial rail systems and, in the latter part of the 20th century, the focus has been on the development of national road and airport networks and the national telecommunications system.

Investment in strategically important national infrastructure has been based on the desire of governments to have infrastructure that ensures the efficient movement of people, freight, and information and that is commensurate with prevailing community expectations.

The development of an EC VHST as an additional piece of strategic infrastructure would not alter the need for governments to ensure that existing strategic infrastructure continues to be maintained and upgraded to keep abreast of technological change, market demand, and community expectations, albeit that the telecommunications systems and airports are commercially operated. The critical policy issue is whether development of an EC VHST system would be justified as an additional but complementary piece of infrastructure that would meet broader strategic national goals.

To date, Governments have tended to react to private sector VHST proposals rather than initiating such development. There has been no attempt at any level of government to comprehensively identify and evaluate the long term strategic objectives that could justify an EC VHST, though the commissioning of this study is in itself an indication of the Commonwealth's desire to understand the full range of issues relevant to such development.

3.2.2 Policies to develop an EC VHST

Development of an EC VHST network would raise policy issues that go to the core of Australia's federal system of government, being dependent on the collective political, financial and administrative support of the Commonwealth, New South Wales, Victoria, Queensland and the Australian Capital Territory Governments.

Despite the scale and complexity of an EC VHST, it would be possible to satisfactorily resolve those challenges if the Commonwealth took the leading role in project facilitation and the States and the ACT gave total commitment by implementing policies and committing the necessary finances and resources.

There would need to be complete commonality of purpose to achieve the project in whatever form or stages it may take. To achieve this, the Governments would need to make firm commitments to each other in relation to funding the project's development and irrevocable commitments to meet their obligations in respect of all elements of its implementation and operation.

There would also need to be definition of the private sector's role in that process, whether this is in the form of build/own/operate/transfer (BOOT) arrangements, simply at the level of manufacture and construction, or any arrangement in between those extremes.

For the Governments to reach the point of commitment it would be necessary that they form a view about the national interest in dedicating a substantial proportion of national resources to a single endeavour on a scale that is seldom seen. Governments would need to address, from their individual perspectives, the policy implications of diverting significant government funding and human resources to support the development of an EC VHST in preference to other activities.

There are numerous examples where the Commonwealth, State and Territory Governments, on both project and ongoing bases, work together to achieve particular outcomes. Examples are in education, health, pipelines, and the national road building programs and the need for the specially developed framework required for implementation of an EC VHST would represent an extension, albeit on an unprecedented scale, of such processes.

The Commonwealth has limited experience in the development of land transport infrastructure at the project planning and implementation level. The States would be critical to the success of an EC VHST project facilitation and development by virtue of their specific jurisdictional responsibilities, administrative structures and processes, experience and specialist resources to facilitate a project of the scale envisaged.

There are constitutional constraints on the Commonwealth's involvement in the development and operation of railways in States and there are overlaps between the Commonwealth and States in terms of their respective jurisdictional responsibilities. These issues would need to be resolved to avoid uncertainty and disputes between government agencies and, potentially, legal challenges mounted by those opposed to the project or its effects on their interests. There are examples of agreements between governments in respect of overlapping responsibilities, such as environmental approvals.

An EC VHST would also be dependent on access to State infrastructure assets, principally to existing rail networks in the vicinity of the capital cities. This is a critical issue for States, particularly where there are potential conflicts between VHST services and existing commuter services in Sydney, Melbourne and Brisbane.

As with the Commonwealth, the States and ACT would individually need to identify and consider a range of first order and other policy issues and to develop their individual views. These would need to be "brought to the table" with those of the Commonwealth to achieve agreement on how governments will facilitate and develop an EC VHST.

Local government would principally be affected by an EC VHST through its roles in local land use planning, provision of services, and local stakeholder issues.

While the project planning approvals process would be a Commonwealth, State and ACT matter, local land use planning would also need to be considered in terms of the consequential impacts that the corridor and station locations would have on existing local land use strategies. As an example; location of an EC VHST station in a town centre may conflict with an existing planning strategy but a greenfield station development may affect local amenity by diverting investment away from existing settled areas.

Local government would thus need to be closely involved in much of the planning for an EC VHST due to its obligations to represent local communities, to plan for development and to provide a range of urban infrastructure and services. These requirements and impacts are likely to be on such a scale that local government authorities may not have the financial and other resources to effectively participate in these processes without assistance from the Commonwealth and States.

3.2.3 Policies affecting EC VHST decision making

Prior to committing to an EC VHST, Governments would need to consider fundamental policy issues and, while there is no relevant policy framework existing, there are project development policy models that provide an indication of the types of issues that would need to be fully evaluated.

The Commonwealth's Strategic Investment Coordination Criteria (Invest Australia) provide such an example, giving prospective investors an outline of the types of high level policy issues that the Commonwealth wants addressed in any application for investment incentives and which would form the basis of any government decision to provide such incentives.

The criteria are that the investment:

- would not be likely to occur without the incentive;
- provides significant net economic benefits such as employment, research and development, technology transfer, industry development and further investment;
- complements Australia's areas of competitive advantage;
- is viable in the long term without subsidy; and
- that the incentive:
  - is open to foreign and domestic investors;
  - takes into account assistance from other Commonwealth and Sate programs; and
  - is consistent with international obligations.

The last criterion is not relevant to an EC VHST though, in varying degrees, the others would be applicable in its policy context. As discussed in detail in section 10, an EC VHST would only be developed with financial support of Government and that investment could take a variety of forms. It may, however, be possible for at least a part of the project to operate in the long term without subsidy and under the control of private sector investors, as discussed in Sections 10 and 14.

Apart from consideration of financial issues, the aspect most focussed on by Governments would be measurement and understanding of the net economic, social, and environmental benefits that an EC VHST could bring, as discussed elsewhere in this study.

3.3 Government facilitation and project development

Assuming that the Governments reach consensus and make the commitment to cooperate across their jurisdictions to develop and bring into operation an EC VHST, then there would be a wide range of project facilitation, development and operational issues to be resolved.

As with other major government projects, facilitation and development of an EC VHST would tend to be supported by its own policy framework which would be based on adaptation of relevant, existing policies together with the development of a whole range of project specific policies. The fundamental difference is that there is no direct precedent for a single project of this scale and complexity.

3.3.1 EC VHST facilitation

The intergovernmental agreement and complementary legislation required to give certainty to the development of an EC VHST would need to include a set of principles for facilitation of the project, issues to be addressed including:

- establishment of a special purpose entity empowered and resourced to facilitate and deliver the EC VHST;
- project facilitation and implementation processes;
- cross-jurisdictional issues;
- enforceability;
- timing and project staging;
- financial and other resource commitments;
- funding mechanisms including private sector investment;
- allocation of financial and other risks;
- the type and ownership of the entity(ies) to facilitate, develop, own and operate the EC VHST system in parts or in stages;
- planning, environmental and regulatory approval mechanisms;
- land acquisition, ownership and management; and
- dispute resolution.

3.3.2 EC VHST project development

Early establishment of an adequately empowered and resourced entity responsible for facilitation and delivery of an EC VHST would be essential, such an entity requiring the legal and financial capacity for resolution of policy and financial issues related to project definition and planning, risk management, design, tendering, contracting and commissioning.

The nature of this task is such that the entity would need to be:

- a public authority, jointly responsible to the Commonwealth, States and the ACT; or
- a public corporation, wholly or at least majority owned by the Commonwealth with the States and ACT as equity participants.

This would not preclude the involvement of the private sector in the development and operation of an EC VHST though a major issue would be determination of those elements of the project to which the private sector's resources and expertise could best be directed.

The following provides an indication of the range of matters for which the facilitation and delivery entity would be responsible:

- project facilitation:
  - organisational arrangements;
  - project management planning;
  - risk management planning;
  - liaison and consultation with government agencies across all jurisdictions;
  - concept and preliminary planning and design; and
  - community and stakeholder consultation.
- technology:
  - VHST and other system technology selection;
  - operating performance and technical standards (infrastructure, rolling stock, stations, other infrastructure – signalling, power and train operating systems); and
  - service quality (transit times, maximum speed, service frequency).
- corridor:
  - route selection;
  - corridor preservation;
  - station locations;
  - land acquisition processes for corridor, stations, and associated development; and
  - native title.
- infrastructure:
  - track, bridge and other structures standards;
  - electrical systems including power supply; and
  - interfaces with existing rail systems.
- operations:
  - establishment/selection of the operating entity(ies) for the VHST system, if vertically integrated, or individual or groups of system components including infrastructure, trains, operating systems, stations, maintenance facilities, land management and related land development;
  - access to existing rail networks; and

  - rail safety, standards and other regulatory requirements for infrastructure, rolling stock, systems and operations.
- transport planning:
  - transport integration; and
  - existing rail network, road network (including bus) and air network.
- planning and environment:
  - environmental issues – noise and vibration, native vegetation, fauna, threatened species, air quality/pollution; and
  - heritage – Indigenous, European.
- project delivery:
  - environmental assessment;
  - environmental and planning approval processes;
  - project scoping, staging and programming;
  - tendering;
  - design and construction;
  - contract administration;
  - community consultation; and
  - system commissioning.

The range and complexity of activities required for facilitation of an EC VHST, either in total or in stages, would be extensive though it would be possible to attract people with the skills necessary to carry it forward. Their success would be largely determined by the adequacy of the policy settings put in place by governments, the clarity of their mandate, and the adequacy of resources provided from the outset.

At the time of signature of an EC VHST intergovernmental agreement, there would be a number of specific policy positions which had not been finalised and implementation details that would still need be resolved in accordance with the terms of the agreement. Resolution of such matters would be a major task for the project implementation entity in consultation with the relevant agencies of all participating governments.

3.4 National environmental policies

3.4.1 Ecologically sustainable development

In the past decade, the principles of Ecologically Sustainable Development (ESD) have become fundamental drivers of State and Federal Government environmental legislation and policy. Annexure 2 contains a review of the key National and State Government legislation and policy that promotes and/or requires the consideration of ESD in strategic planning and development and assessment of projects such as the EC VHST. This review clearly demonstrates that there is 'black' letter law and policy which embodies the principles of ESD and directs that such principles underwrite strategic and environmental planning, particularly at the state level.

The key legislation at the Commonwealth level is the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The principles of ESD as set out in section 3 of this Act are:

- decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equity considerations;
- if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- the principle of inter-generational equity—that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations;
- the conservation of biological diversity and ecological integrity should be a fundamental consideration in decision-making; and
- improved valuation, pricing and incentive mechanisms should be promoted.

These principles are also reflected in a number of pieces of relevant state legislation such as the NSW *Environmental Planning and Assessment Act 1979* and the Victorian *Planning and Environment Act 1987*. The application of these principles to the planning for and development and operation of energy-intensive transport projects presents challenges for decision-makers to 'justify' projects such as a VHST as compatible with ESD principles. At best, an EC VHST may be seen as being relatively better in ESD terms than some competing forms of high-speed long distance transport because its better energy consumption characteristics (see section 3.4.4).

To date, there is a relatively limited experience in the meaningful integration of the ESD principles in the planning for and development of major transport projects.

Examples are the development of policies that are aimed at integrating transport and land use planning such as NSW's draft State Environmental Planning Policy on 'Integration of Land Use and Transport' or the Victorian Department of Infrastructure's consideration of environmental issues and their impact in the development of the new Melbourne metropolitan strategy. At the project-specific level, several State governments are moving towards the implementation of 'net gain/no net loss' policies in relation to the impact on native vegetation and fauna habitat of major road and other projects.

3.4.2 Environmental Assessment

The EPBC Act has substantially altered the roles of the Commonwealth, States and Territories in relation to environmental impact assessment (EIA) of proposed developments and the protection and conservation of Australia's biodiversity.

The EPBC Act provides that the Commonwealth's EIA process will be triggered by proposed activities that may have a significant impact on matters of national environmental significance identified in the EPBC Act, namely:

- World Heritage properties;
- Ramsar listed wetlands;
- listed threatened species and communities;
- listed migratory species;
- protection of the environment from nuclear actions, and
- the marine environment.

As indicated in sections 5 and 6, consideration of the first four above-mentioned matters of environmental significance would influence the approach to and actual identification of candidate corridors for a VHST system, regardless of the VHST technology to be used. It could therefore be reasonably assumed that the Commonwealth EIA procedures would apply to a VHST project, either directly or through the use of accredited processes under State and Territory EIA processes.

Another way in which the Commonwealth could play a significant role in the planning for and assessment of an EC VHST system would be pursuant to the provisions of section 146 of the EPBC Act. Under these provisions, the Commonwealth Environment Minister may agree to conduct a strategic assessment of actions that may be carried out under a proposed policy, program or plan. This provision is intended to allow for the early assessment of the cumulative impacts of relevant actions under that policy, program or plan. The outcomes of a strategic assessment may be taken into account in deciding the appropriate assessment approach for a particular action. For example, if the relevant environmental impacts have been assessed during a strategic assessment, the Minister could decide that an individual action may be assessed on preliminary documentation rather than by environmental impact statement.

Given the overall scope of an EC VHST and the diversity of environmental and socio-economic contexts that may be affected, undertaking a strategic assessment may be an appropriate means of comprehensively documenting and assessing the likely relationship of an EC VHST to ESD principles as well as providing a framework for subsequent more detailed EIA of specific elements of an EC VHST network under State and Territory processes.

3.4.3 Biodiversity

As stated in the National Strategy on Biodiversity, biological diversity is the variety of all life forms - the different plants, animals and microorganisms, the genes they contain, and the ecosystems of which they form a part. It is not static, but constantly changing; it is increased by genetic change and evolutionary processes and reduced by processes such as habitat degradation, population decline, and extinction. The concept emphasises the interrelatedness of the biological world. It covers the terrestrial, marine and other aquatic environments.

For the purpose of this Strategy, biological diversity is considered at three levels:

- genetic diversity - the variety of genetic information contained in all of the individual plants, animals and microorganisms that inhabit the earth. Genetic diversity occurs within and between the populations of organisms that comprise individual species as well as among species;
- species diversity - the variety of species on the earth; and
- ecosystem diversity - the variety of habitats, biotic communities and ecological processes.

The key elements of this Strategy have been given effect by the EPBC Act as well as through State biodiversity policies. Protection of Australia's biodiversity would be a key influence in corridor location, particularly in terms of any proposed significant loss of native vegetation in either a contiguous, specific-area basis or on a scattered but cumulative basis.

3.4.4 Energy usage

Energy usage is a key sustainability issue for VHST projects, even though VHST is claimed to be more energy efficient per passenger km than aviation, its main direct competitor. As noted in section 4, even SWSR VHST technologies consume

significant amounts of electrical energy which, in south-eastern Australia, is generated largely from fossil fuels.

Improving technology has increased the energy efficiency of all types of transport vehicles, rail technology in particular, with improvements in hauling power and the length of trains. The Sustainable Energy Task Force report[1] identified that one of the primary challenges to energy use in the transport sector was growth in intercapital transport, particularly the high rate of air passenger growth and declining growth of rail passenger use.

The following table provides a comparison of the current non-urban passenger fuel use. This is calculated in terms of energy consumption (petajoules) per passenger km, where energy consumption is estimated for a full cycle basis (ie. energy consumed in the production of fuel or electricity). This does not take into account the fuel used in manufacture of vehicles and infrastructure associated with the transport.[2]

Table 3.1 Non-urban Passenger Fuel Use
(PJ/billion passenger km)

Transport Mode	Fuel Use
Buses	0.46
Rail	1.77
Private Motor Vehicles	2.35
Air	3.10

Source: ACIL, 2000

Buses are the most efficient non-urban passenger mode, followed by rail, though the difference widens for poorly patronised passenger trains where a large of amount of energy is expended for little passenger transport benefit.

Non-VHST rail transport currently has relatively good fuel efficiency in comparison with other modes as a result of the following:

- Lower resistance (steel wheels on tracks have less resistance than rubber tyres on roads);
- Less overall air drag (higher passenger load capacities per trip); and
- Easier track gradients over long distances.[3]

Growth in the total transport task is characterised by high rates of growth in modes, particularly air transport, that are comparatively more energy intensive in performance (passenger km travelled) than the slower modal options. Private motor vehicles and air travel dominate the total passenger task in Australia with growth in air passenger km outstripping growth in any other mode, although air travel is the least energy efficient mode. On most inter-capital corridors, air is now the dominant model.[4]

International studies have identified that VHSTs are significantly more energy efficient than automobile and air travel. The Shinkansen in Japan was identified as being 4.5 times more energy efficient than automobile travel and 5 times more efficient than air travel; and the TGV in France was 2.5 times more efficient than the automobile and 4 times more efficient than air travel (Institute of Transport Studies 1996).

The Speedrail consortium (Sydney-Canberra VHST) claimed a significant decrease in energy consumption per passenger, using less than half the energy per passenger than cars and one quarter that of aircraft.[5]

However, there may be implications for the extra energy needs required for a VHST in the Australian context. The relatively long distances between the capital cities imply significant energy requirements (electricity) to power a VHST using conventional technology. This electricity requirement may have significant implications for the existing energy grid outside of the metropolitan areas.

3.4.5 Greenhouse Gas Emissions

The amount of greenhouse gas emissions from transport systems in Australia is roughly in proportion to the fuel consumed. Comparison across transport modes needs to consider differences in emissions for the fuel and energy used, types of greenhouse gas emissions, and relative improvements in transport technology.

Table 3.2 provides estimates of the amount of greenhouse gas emitted per passenger km for each transport mode and the amount of greenhouse gas emitted from rail transport with respect to the total transport sector.

1 The Institution of Engineers Australia; 1999; The Sustainable Energy Task Force Report
2 ACIL Consulting; 2000; Rail in Sustainable Transport. A Report to the Rail Group of the Standing Committee on Transport
3 ibid
4 The Institution of Engineers Australia; 1999; op. cit.
5 ACIL Consulting; 2000; op. cit.

Table 3.2 Greenhouse Gas Emissions

(Grams per passenger km)

Transport Mode	Emissions
Rail	150
Bus	75
Private Motor-Vehicle	225
Air	220-240

Source: ACIL, 2000

As with energy consumption, buses are the lowest emitter of greenhouse gas for non-urban passenger modes, followed by rail and then similar emissions between car and air.

European studies estimate that VHSTs operate at a comparative 42g of CO_2 emissions per passenger km.[6]

Table 3.3 provides the level of greenhouse gas emissions from rail transport as a percentage of the total transport sector emissions.

Table 3.3 Rail Greenhouse Gas Emissions
(percentage of total transport sector 1994)

Greenhouse Emission	% of Total Transport Sector
Carbon Dioxide (CO_2)	2.3%
Oxides of Nitrogen (NO_X)	5.5%
Carbon Monoxide (CO)	0.13%
Non-Methane Volatile Organic Compounds (NMVOC)	0.003%

Source: ABS 1997 (Cat. No. 4605.0)

Most greenhouse emissions in the transport sector currently come from road transport, which accounts for 79% of the total non-urban passenger task. Existing rail accounted for only 2.1 % of the total non-urban passenger task, but the use of diesel powered trains accounts for a relatively higher proportion of oxides of nitrogen..[7]

Between 1988 and 1994, CO_2-e emissions from rail decreased by 17.6% and other CO_2-e emissions also decreased for rail transport during this period. For the same period, CO_2-e emissions from road and air travel increased 11.4% and 36.1% respectively.[8]

All existing VHSTs are powered by electricity and dedicated electric train systems offer zero direct emission of CO_2; though the source of electricity generation determines the overall air pollution and greenhouse gas emission characteristics of the system.

Coal has higher CO_2 emission factor than fuel oil and natural gas.[9] but, while the latter fuels are currently the predominant energy sources for the Australian transport sector (air, road, sea and long-distance rail), it is likely that a VHST would be primarily powered by coal-sourced electricity.

3.4.6 Noise and vibration

There are potentially significant noise and vibration impacts on human and natural environments from the operation of a VHST.

From a community perspective, railway noise has been identified as significantly less annoying than road traffic noise. Rail noise differs from highway noise, as it is a punctuated event, which occurs for a few moments when the train passes whereas highway noise is a continuous drone.[10]

In Australia, estimates of noise emissions by transport mode have identified that rail noise (passenger and freight) operates at an ambient noise output of between 57-62 dB (A), LA_{eq} 24, and maximum noise outputs at between 75-92 dB (A), LA_{max}. The ambient noise level is relatively lower than other transport modes, however the maximum noise outputs are relatively higher than road transport.

VHSTs are likely to produce significant noise levels. Studies have calculated that, in order to maintain 55dB(A) background ambient noise level at 180mph (288 kph), a 480ft (146m) wide corridor is required (Institute of Transportation Studies 1996). In Australia, 55dB(A) is the ambient noise level (adjusted for intensity and duration of noise events) often defined as the threshold of noise impact and noise annoyance.

6 ACIL Consulting; 2000; op. cit.

7 Australian Bureau of Statistics; 1997; Catalogue No. 4605.0
8 ibid
9 ibid
10 Institute of Transport Studies; 1996; (title required)

Studies of noise impacts from VHSTs (Institute of Transportation Studies 1996) have also demonstrated that:

- Noise levels decrease exponentially, rather than linearly, with increase in distance from the source; and
- Geometric spreading has much more effect on the noise levels at high speed than the changes in speed.

Control of noise and vibration is a State government matter and generally. there are inconsistent levels set between Australia's States and Territories for noise and vibration from trains. As examples; in Queensland, the guidelines for rail noise are an ambient noise level of 65dB(A) with a maximum 87dB(A) for a single event while New South Wales nominates ambient levels of 60dB(A) and a maximum of 85dB(A).

Draft noise and vibration guidelines were developed for the proposed Sydney to Canberra VHST project.[11] These were developed in relation to residential, commercial and sensitive land uses such as schools and hospitals. The guidelines nominated noise criteria for land use categories for different times of the day, nighttime levels (2200-0700) for residential areas of L_{Aeq} 50dB(A) and L_{Amax} of 82dB(A) for example.

The guidelines stated that 'where it can be demonstrated that target noise levels are not feasible or reasonable to achieve within the project planning, design and implementation (for justifiable reasons), then the criteria should be approached as closely as possible, with the aim of adopting broader supporting strategies to achieve the overall objective of not unreasonably affecting the acoustic amenity of the community'.[12]

Sleep disturbance was also nominated as a community impact that would require particular attention in the planning and assessment of a VHST project. In terms of emitted noise criteria, the guidelines set an allowable limit for a VHST speed of 300 kph of 98dB(A). The guidelines also proposed vibration criteria for human exposure and building damage.

While noise levels for a MagLev VHST are claimed to be lower than for SWSR VHST systems, the noise levels associated with the operation of MagLev technology are still in excess of 80dB(A) for speeds above 300 kph. This suggests that substantial noise attenuation could be required in the vicinity of nominated land uses along a VHST route, regardless of the VHST technology used.

Harmonised noise and vibration guidelines for all jurisdictions, reflecting best practice, would need to be formulated as part of the planning for an EC VHST system. Another policy issue for governments would be the extent to which there could be exemptions for a VHST to prevailing approaches to transport noise guidelines.

3.4.7 Waste

There is little literature on the waste generated by various transport modes, including rail and VHST in particular.

The major wastes generated from existing conventional rail include:

- rolling stock;
- waste infrastructure (rail lines and wiring); and
- waste oil.[13]

Urban rail infrastructure (including rolling stock) is typically maintained for up to 30 years or more, with one or two refurbishments and partial upgrades. In comparison, buses and trucks revert to a less intense use after 10-15 years and commercial aircraft are exported before the end of their lifespan. Most rolling stock is scrapped for subsequent recycling.[14]

A higher percentage of waste from lubricating and other non-fuel oil recycled in the automotive industry (60-90%) than in rail (40%) which is recovered and recycled by the rail authorities.[15]

3.4.8 Resource Use

The impacts of the VHST project on the natural resources required to construct the project will also need to be considered. It is likely that the VHST project would require significant demands on natural resources for construction.

The key resource issues are likely to involve:

- dimensions and scale of the project;

[11] Vipac Engineers and Scientists; 1999; *Sydney to Canberra Very High Speed Train (VHST) Project – VHST Guidelines for noise and vibration emissions: Revised Guidelines. Report No. 240970-11, July 1999.*

[12] ibid

[13] Australian Bureau of Statistics; 1997; op. cit.

[14] ACIL Consulting; 2000; op. cit.

[15] Australian Bureau of Statistics; 1997; op. cit.

- materials used in the rail infrastructure (including sleepers, tracks, bridges and rolling stock);
- maintenance requirements;
- flexibility in design (use of modular components); and
- demands on natural resources and energy.

The use of locally based and accredited natural and recycled materials is also key to determining the sustainable use of natural resources.

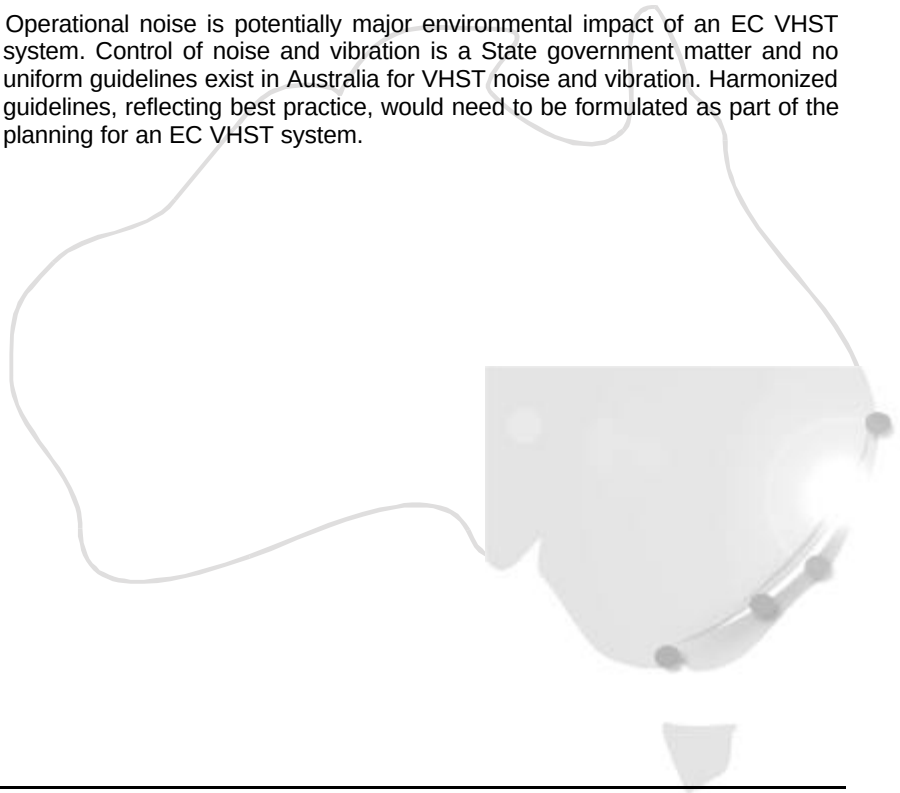
3.5 Key Points

VHST Policy

- No government currently has a policy framework for VHST.
- An EC VHST would be subject to the laws of five jurisdictions, consequently development of an EC VHST raises policy issues that go to the core of Australia's federal system of government.
- The Commonwealth, NSW, Victoria, Queensland and the ACT must give total commitment and cooperation politically, financially and administratively to ensure success.
- Local government would need to be closely involved but has the least financial and other capacity to be effective in that involvement.
- Development of an EC VHST would need to be supported by its own policy framework based on existing and project specific policies.
- Ultimately, success would be dependent on the prevailing policy settings and a clear mandate being given to an adequately resourced entity charged with the task of developing an EC VHST.

Environmental Policy

- ESD principles, as set out in the Commonwealth's *Environment Protection and Biodiveristy Conservation Act 1999*, would need to underlie planning for and assessment and implementation of an EC VHST.
- Justification of an EC VHST would be a challenge from an ESD perspective because of the energy-intensive nature of such a system.
- With the operation of the EPBC Act, the Commonwealth Government has a strengthened role in environmental impact assessment where proposed activities such as an EC VHST may impact on matters of national environmental significance.
- Whether or not, the EPBC Act would be triggered by specific aspects of an EC VHST proposal, there is arguably a valid role for Commonwealth involvement in environmental impact assessment of such a proposal, possibly through the strategic assessment provisions of this Act.
- Protection of Australia's biodiversity would be a key influence in corridor location, particularly in terms of any proposed significant loss of native vegetation in either a contiguous, specific-area basis or on a scattered but cumulative basis.
- VHST systems, while more energy efficient on a per passenger kilometer basis than competing long distance air or road transport, are still an energy intensive form of passenger transport.
- While not contributing directly to air pollution and the generation of greenhouse gas emissions at the point of operation, an EC VHST system, because of its significant use of electricity generated from carbon-producing fossil fuels, would indirectly contribute to such emissions.
- Operational noise is potentially major environmental impact of an EC VHST system. Control of noise and vibration is a State government matter and no uniform guidelines exist in Australia for VHST noise and vibration. Harmonized guidelines, reflecting best practice, would need to be formulated as part of the planning for an EC VHST system.



Section 4

VHST Technologies



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4 VHST TECHNOLOGIES

4.1 Technology Development

High-speed ground transport systems, principally railways but also MagLev guideways, are being developed primarily in Europe and Japan. However, there has been interest in North America and Asia and, of course, Australia. So far, SWSR railways have been the only high-speed technology which has been commercially applied to maximum speeds up to and now exceeding 300 km/h. MagLev guideway technology has been extensively tested in Germany and Japan to maximum speeds in excess of 500 km/h (as has the French TGV rail technology). To date no high-speed MagLev system has been placed in commercial service (although a number of low speed systems were placed in service in the 1980s). However, a project in Shanghai to construct a 30 km link to its airport was announced in January 2001. This system, using the German Transrapid technology, is proposed to operate at an average speed of 250km/hr.

High-speed railway research and development has generally been promoted by national railway companies, such as those of Japan, Spain, France, Germany, Italy, Sweden and UK. These rail companies have been actively looking at the means to make their systems operate more effectively and more competitively. In recent times only limited development has occurred in North America. The high cost of technological development of high-speed railways and MagLev systems has meant that research and development has generally been undertaken by very large global industrial concerns, often with significant government underwriting. As such those technologies have become associated with particular countries and are now marketed globally as national symbols.

The rolling stock industry has now broken beyond national markets. Consequently the industry has become highly competitive and, in some cases, loss making. Some countries no longer have a dominant internal supplier and are selecting from suppliers globally. There has been a highly significant shakeout in the VHS train manufacturing business. Some significant players have exited the industry while others have merged and or been taken over to form yet larger enterprises. These industry changes are important to any decision about the technology for an EC VHST. The state of the industry needs to be understood, as does the nature of the rolling stock that the industry is now producing and intends to produce in the future.

An important question is how open different technologies are. The more generic a technology is, the more its application can be competitively tendered and the more it will be accessible to Australian manufacturing and construction industries. However, there is a concern that more advanced technologies, particularly such as MagLev, will not be openly available – at least not in the key advanced technology components of levitation systems, traction power and vehicles. Clearly, this is yet to be tested and whether this is a real issue or not is ultimately for Governments to decide in the light of relevant policy on the importation of high technology equipment. It can be argued that there is no expectation that large passenger aircraft should be fully manufactured or even assembled in Australia. Australian industry has been awarded contracts to manufacture components of such aircraft – for example, tail plane elevators for the B777 were manufactured by Hawker de Havilland at Bankstown, NSW under contract to Boeing. However, Australia has a long established rolling stock manufacturing industry and potentially many other skills that could create the high-tech componentry of any form of VHST. The issue may be one of whether it is more economically efficient to manufacture the rolling stock in places where there are already established production facilities.

The two leading candidate MagLev technologies – the German and the Japanese – are fundamentally different systems and completely technologically incompatible. Equally, certain technological choices will bar alternative competing technologies if a unified system is desired. Thus it is not possible to have a part VHST rail solution and a part MagLev solution in the same corridor. Once committed to say, MagLev, the whole of the VHST operation in that corridor will need to be MagLev. It is conceivable, however, that if a SWSR system were to be implemented then at some later date the corridor could be retrofitted, upgraded or augmented to MagLev. This serves to emphasise the important of the physical alignment.

Known high-speed ground transport technologies embrace a spectrum of performance and exclusivity. Superficially, this embraces travel time (which is more important than raw maximum speed), alignment geometry, compatibility with other rail operations, carrying capacity, energy consumption and line capacity. There will also be an operating speed above which even SWSR high-speed rail services absolutely require exclusive corridors.

The compatibility of different technologies with existing rail systems is also of significance because this will affect the ease of entry of new technology transportation into central Brisbane, Sydney, Canberra and Melbourne. MagLev, being a totally different technology, is compatible only with the physical corridor. SWSR technologies on the other hand have been designed to be fully compatible provided the rail gauge and power systems are suitable.

The latter is a relevant consideration – VHST technologies are more than the rolling stock or vehicles. A VHST technology is a complete system encompassing the alignment, the track (or guideway), the safety and control system, the propulsion systems and the vehicles themselves.

4.2 International Trends

A history of the development of contemporary VHST technologies is shown in Figure 4.1. What this shows is that up until the 1990's VHST technologies were essentially developed on a national basis to the specifications of the national railway operator. Thus, VHST solutions in France and Germany were different to those in Sweden and Italy and driven principally by considerations of affordability – in short, the cost associated with building dedicated VHST alignments. Spain, which had developed a distinctive VHST technology in the form of the Talgo passive tilting train, also has developed railways based on TGV technology.

In the past 5 years alone, however, there has been a number of significant changes in the VHST manufacturing industry. These changes are significant as they affect not only what can be supplied but also who can supply it.

In the EOI phase for the Sydney-Canberra project there were at least the following competent providers of proven technology: ABB Daimler Benz (Adtranz), GEC-Alsthom, Siemens, Fiat Ferroviaria, Talgo and Transrapid. The Japanese manufacturers, while competent, did not express interest with either conventional VHST's or MagLev, nor did any North American company. Ultimately, Fiat and Talgo did not proceed. Since then, inter alia, events such as the following have occurred:

- ABB sold its 50% of Adtranz to Daimler Chrysler who later on sold it 100% to Bombardier Transportation of Canada;
- GEC – Alsthom – now just Alstom – acquired Fiat Ferroviaria;



- Siemens and Alstom have collaborated on the Taiwanese VHST to produce a hybrid trainset though this project has ultimately gone to Japanese Shinkansen technology;
- Adtranz and Talgo have collaborated on producing a 350kph tilting train for Spain;
- Siemens and Alstom are collaborating on the AGV for European markets
- Bombardier and Alstom have collaborated on the Acela VHST rolling stock for the NE corridor in the USA; and
- The Hamburg – Berlin magnetic levitation project has been halted by the German Government.

The US Federal government has initiated a serious interest in MagLev projects by funding studies in seven US cities and by allocating an amount of US $950 million as a contribution for one high speed MagLev to be selected by the Secretary for Transportation. Other developments include:

- Transrapid have a contract to install a MagLev link to Shanghai's airport;
- MagLev projects are being investigated in Europe and in the USA – the focus of such links has moved from long distance to regional or special purpose corridors of lengths of the order of 20 – 50 km.



- In the USA, Transrapid has been selected for consideration ahead of competing US technologies principally due to being in full scale test status operation already;

- The Japanese Chuo Shinkansen MagLev project remains in ongoing prototype testing with no commitment to build it;
- The distinction between very fast trains and tilt trains has become blurred with all manufacturers designing and building trains that have the features of both high-speed and tilt so they are effective on a range of track conditions; and
- Manufacturers are increasingly moving to standard "platforms" capable of incorporating a range of performance features desired by the operator.

4.3 Suppliers of VHST Technology

While there has been a shift in the technology, the main change has been the restructuring of the industry so that each of the major manufacturers of VHST technology is now able to offer operators a broad range of VHST technology products – from 160km/hr to 350 km/hr, with and without tilting capability in the case of SWSR technologies, and up to 500 km/hour in the case of magnetic levitation technology. This restructuring is illustrated in Figure 4.2. Over 50% of world rolling stock manufacturing capacity is held in 3 firms – Bombardier (incorporating Adtranz), Siemens and Alstom (incorporating Fiat Ferroviare). Bombardier alone claims to control about 25% of the US$25 billion per annum world market for rolling stock (Railway Gazette, August 2001). Such restructuring of the industry not only has led to better profitability but also competitive product lines across a spectrum of potential operator needs.

The result of this restructuring for operators of VHST systems is that they are no longer confined to a particular manufacturer for a given type of VHST. All manufacturers now have the capacity to deliver virtually any combination of maximum speed and tilting capability. The key trend in SWSR rolling stock technologies has been the integration of the fundamental characteristics of maximum speed, acceleration, braking, multiple power systems, onboard power, bogie suspension, and tilting capacity. Today, and in the future, manufacturers will supply rolling stock to suit the operator's specification that, in turn, will have been developed to respond to the particular geography, railway operating environment and commercial conditions in which it will operate.

4.4 Commercially Available Technologies

It is assumed for the purposes of this study that commercially available and implementable technologies for an EC VHST presently are:

- Steel wheel on steel rail technologies with or with out tilting capability as exemplified by the TGV, ICE3, Adtranz Talgo 350 and other rolling stock products in the range 160km/h to 350 km/h; and
- MagLev technology as exemplified by Transrapid in the 500km/hr range.

These are the only technologies that are currently real candidates for implementation. SWSR has the benefit of its established technology position, massive installed presence throughout the world and the benefit of yet further VHST investment throughout Europe, Asia and the USA. Transrapid MagLev has been licensed to operate commercially in its country of origin, has its first commercial application under construction and is actively marketing for other opportunities for which it is commercially suitable. Recent studies in the USA to select a MagLev technology for implementation concluded that Transrapid had at least a 4-year start on any local US MagLev technology. It remains to be seen whether the Transrapid system will be an enduring technology in the way SWSR has proven to be and the means in which further development of its technology can occur.

4.5 Performance Characteristics of VHSTs

As discussed above there has been plenty of development of very high-speed train technologies over the last two to three decades. Moreover, the serious work has been concentrated in Japan and Europe. The key factors have been:

- Reductions in travel time;
- Coping with a wide variety of terrain and land use; and
- Increasing the energy density of rolling stock.

4.5.1 Travel Time Reduction

Prior to the serious assault on travel times, lead by the Japanese in their development of the Shinkansen, travel time reductions were incremental through progressive development of classic train technology plus local improvements to existing railway alignments. The best examples of this approach would be the conversion of the steam age railways between London and Scotland along the west and east coasts of England and Scotland to high speed electrified railways. However, even today, these two corridors remain complex joint-use railways, catering for a broad spectrum of train services ranging from freight, through commuter and regional passenger services to long distance high-speed passenger services. They will soon host the next generation of high-speed passenger services in the form of Virgin Rail's 240 km/h Pendolino (tilting) trains.

The continuation in the reduction in travel times in Japan and Europe has basically lead to the development of specific railways over which is run specific rolling stock. In the Japanese case, the Shinkansen were entirely new railways, built to standard gauge (ie 1435 mm between the gauge faces of railway track), rather than the

prevailing narrow gauge (1067 mm). The original maximum permitted speed was 210 km/h in revenue service. Over the intervening three decades this maximum service speed has risen to 270 km/h. Over the same period of time the fastest commercial (ie between termini and inclusive of regular stops) speeds have risen from 163 km/h to 243 km/h. There have certainly been faster runs as the Japanese Railways (JR) and its successors developed new rolling stock but the speeds and times that matter are those achieved in every day operations.

In the European case, standard gauge railways and the in-town termini already existed. The issue was how to improve the line haul operations between termini. The French, Italian, German, Spanish and Belgian railways have all developed new very high speed mainlines to complement their existing railway networks. In the cases of the French and Spanish Railways, specific mainlines (eg LGV Mediteranee and Nord in France and the Madrid – Sevilla AVE in Spain) largely run from terminus to terminus. However the more obvious configuration of very high speed lines is for them to augment the existing network by either bypassing bottlenecks or creating new links. The pay-off in France has been for 270-300 km/h trains to achieve commercial speeds as high as 256 km/h in general operation.

4.5.2 Terrain and Land Use

The most obvious requirement for a very high speed railway is that it possesses as favourable alignment over as much of its terminus-to-terminus length as possible. By and large, the designers of new very high speed railways have imposed demanding geometric standards on their lines. Thus on the Shinkansen, the minimum plain track radius of curvature has been progressively increased from 2500 metres to 4000 metres. Unfortunately neither the level of superelevation (applied cant) nor the level of cant deficiency is known. On the French Lignes a Grande Vitesse (LGV) there has been a similar widening of the minimum radius of curvature to 3500-4000 metres together with high levels of superelevation and low levels of cant deficiency. The Spanish Alta Velocita Espanola (AVE) lines have been designed with 4000 metres radius curvature, plus a different mix of superelevation and cant deficiency, for a maximum speed of 300 km/h. However the practicalities of crossing the Sierra Morena between Cordoba and Puertollano, on the Madrid – Sevilla AVE, saw the minimum radius reduced to 2300 metres and the maximum permitted speed reduced to 250 km/h.

To achieve these horizontal alignments many very high speed railways have had to adopt expensive modes of construction including extensive tunnelling and bridging. The French Paris-Sud-Est (PSE) and Atlantique LGVs have largely avoided the constructional excesses of other railways through being able to pick favourable country though which to run. However, the latest extension of the PSE LGV to Marseilles has included significant tunnels and bridges. Furthermore, the French practice has been to accept short sharp grades, eg as steep as 3.5% (ie 1 in 28.5) but for no more than 4-5 kilometres in length, in order to avoid extensive tunnelling and/or bridging while keeping the general grading under 1.5% (ie 1 in 67).

At the other extreme, the Shinkansen have largely been kept to maximum gradients of 1.5 –2.0% but at the fearsome expense of substantial tunnelling and bridging. For example, while the 515 km New Tokaido Line between Tokyo and Osaka largely avoided tunnelling it included many viaducts. However, the 550 km new Sanyo Line between Osaka and Hakata has 58% of its length on viaduct and 35% of its length in tunnel. As another example, the 270 km Joetsu Line between Omiya (on the outskirts of Tokyo) and Niigata has 39% of its length in tunnel. One last example is the Madrid – Sevilla AVE on which the ruling gradient is 1.25% (ie 1 in 80) and has one extended run at a constant gradient for over 18 km.

Finally, looking at the German Neubaustrecke and the Italian Direttissima, both sets of lines have been built for 250-300 km/h maximum permitted speeds. The German lines were built to very exacting standards of 1.25% (ie 1 in 80) maximum grades and 7000 metres radius curves (easable to 5100 metres). The Italian lines were built to slightly less exacting standards of 1.5% maximum grades and 5450 metres. In the case of the Italian lines, tunnel cross-sections have also been documented. Thus the Italians have nominated 82 square metres as the cross-section for a double track tunnel to allow two 300 km/h to pass each other without creating too great a shock wave. By way of contrast, it is understood that the tunnels on the LGV Mediteranee have been built with 100 square metres cross-sections.

Figure 4.3 shows the vertical and horizontal alignments and speed limit profile for the Sevilla – Madrid AVE. The important features to note are:

- The constrained curvature and speed limits of no more than 250 km/h along the Guadalquivir River valley between Sevilla and Cordoba;
- The extended climb at no more than 250 km/h from Cordoba, through Villanueva and Brazatortas to Puertollano with curvature, and speed limits (215 km/h maximum), constrained around Adamuz;
- The improvement in curvature and speed limits beyond Puertollano with the prevailing speed limit increasing to 270 km/h; and
- The very limited extent of 290-300 km/h operation.

Thus well over half the Sevilla – Madrid AVE is constrained to 250 km/h or less. As compared to train performance in France, these factors constrain trains with only one to three stops over the 471 kilometres route between Sevilla and Madrid to commercial speeds of 188-195 km/h in both directions. This is approximately three-quarters of the best TGV or Shinkansen commercial speeds.

4.5.3 Energy Density

It is clear that trains have to be powerful enough so that they are capable of travelling at close to their maximum permitted speeds throughout their very high speed routes. The trend has thus been to move quickly from diesel to electric traction and to eschew DC electrification (eg at 750V, 1500V and/or 3000V) for high voltage AC electrification (at 15kV 16 Hz to 25kV 50-60 Hz) in order to develop the requisite installed power.

The high speed railways of Britain passed through 160 km/h to 200 km/h relying upon diesel traction with installed powers of 2500 - 3500 kW. However the higher speeds of 225-240 km/h now being sought in Britain can only be delivered by electric traction with installed powers of 5000 - 6000 kW. In all cases head end power (ie locomotives or power cars) was adopted.

The 210 km/h head end powered Swedish X-2000 tilt train has an installed power of 3300 kW for 318 tonnes. This power was expected to increase to 5000 kW if the train was upgraded to 240 km/h for service in the US Northeast Corridor between Boston, New York and Washington. The 250 km/h high powered multiple unit (ie distributed power) tilt trains of Italy and Switzerland have an installed power of approximately 6000 kW to propel 417 tonne trains.

The original 270 km/h PSE TGVs needed an installed power of 6450 kW to propel 418 tonnes trains. The 300 km/h Atlantique TGVs needed an installed power of 8800 kW to propel 484 tonnes trains. However, these trains were configured for a flatter alignment than was the PSE LGV. Therefore, the 300 km/h TGV Reseau needed an installed power of 8800 kW to propel 416 tonnes trains in order to run over the PSE LGV. Such power ratings have been adopted for German ICE power cars, Italian ETR500 power cars and Spanish AVE power cars, all of which may run in revenue service at 280-300 km/h for trains at least as heavy as the TGV Reseau. Finally, the 300 km/h Eurostar needed an installed power of 12200 kW to propel 816 tonnes. In all cases, these ratings are continuous ratings. Short-term ratings achieved during acceleration can be 20 to 40% higher. For more details refer to Table 4.2.

A different picture emerges on the Japanese Shinkansen. The Japanese trains were built from the outset to be crowd-shifters. Accommodation levels have always been consistently higher than in European trains. For example, contemporary Shinkansen consists can accommodate over 1300 passengers in a 392-397 metres train compared to 770 seats in a 394 metres Eurostar train. Consequently, train power has always been high in order to propel quite heavy trains. However, Shinkansen trains have been progressively lightened as their maximum permitted speeds have been raised. Thus:

- 210 km/h Series 0 trains weighing 970 tonnes with an installed power of 11840 kW;
- 285 km/h Series 700 trains weighing 708 tonnes with an installed power of 13200 kW; and
- 300 km/h Series 500 trains weighing 688 tonnes with an installed power of 17600 kW.

Thus increased speed and reduced travel time can only be achieved through a progressive increase in the installed power of trains and/or a systematic reduction in train weight. At the beginning of the very high speed era trains had power-to-weight ratios of just over 10 kW/tonne for maximum permitted speeds of 210 km/h. Nowadays power-to-weight ratios are over 20 kW/tonne for maximum permitted speeds of 300 km/h. It is quite likely that power-to-weight ratios will exceed 30 kW/tonne for maximum permitted speeds of 350 km/h. For more details refer to Table 4.2.

The development of magnetic levitation trains, as an alternative to classic trains, in order to reach maximum service speeds of 500 km/h or higher can only be achieved through a considerable increase in installed power. The indications are that the German Transrapid technology would require over 150 kW/tonne to reach 500 km/h with commercial payloads, ie 250-300 passengers. It is expected that the alternative Japanese Chuo Shinkansen MagLev technology would be no less energy intensive.

4.6 VHST System Requirements

As should be clear from the previous section, VHST technologies form a system. That is, they are composed of various components which all have to fit together before the full benefits of a VHST system are delivered. The obvious components to be addressed are:

- Rolling stock;
- Alignment;
- Operations and control; and
- The system openness.

Known high speed ground transport technologies embrace a spectrum of performance and exclusivity. Superficially this embraces travel time (which is more important than raw maximum speed), alignment geometry, compatibility with other rail operations, carrying capacity, energy consumption and line capacity. There will probably be a maximum speed above which high speed rail services absolutely require exclusive corridors, as much because of the loss of line capacity through

handling trains of disparate travel times as from different trains' impacts on the track structure and other infrastructure items. However before those issues are reached the compatibility of different technologies with existing rail services have to be understood because this will affect the ease of entry of new technology transportation into central Brisbane, Sydney, Canberra and Melbourne.

Very high speed railway alignment standards must be understood. As observed previously very high speed railways are generally very demanding of their alignments. While they perform best with flat grades and large curve radii there is always some latitude. Certainly very high speed trains can tolerate gradients as steep as 3.5% provided they are short and straight. However, most high speed railways do not have to deal with steep and sustained climbs. Yet this will be a requirement in any corridor exiting Sydney to the north or the south, Melbourne to the north and Brisbane south via an inland route.

Similarly, there are peculiar Australian environmental issues which could affect the development of a very high speed railway system. Australian corridors may not be subject to snow and blizzard but they will certainly be subject to flood, fire and drought. They will often be unsupported by other infrastructure, such as electricity supply, because of the low settlement density outside the major conurbations. This lack of settlement can be a virtue in that it could ease corridor selection but it also means that major national parks and wilderness areas have to be negotiated.

4.6.1 Rolling Stock

The most obvious characteristic of any train is its performance, ie how fast can it travel and what travel times can it deliver in regular operations. This study has to examine a spectrum of VHST capabilities and performance. Therefore germane issues include:

- The energy source and power rating for a train;
- Feasible levels of acceleration and deceleration and the dependence upon adhesion;
- The tractive configuration, ie head end versus distributed power;
- The maximum permitted speed;
- Factors affecting passenger comfort; and
- The boundary between classic railway operation and magnetic levitation (MagLev).

Tables 4.2 and 4.3 summarise the characteristics of European and Japanese very high speed rolling stock from which the following observations are drawn.

Energy Source and Power Rating

Trains can be self-contained or they can be dependent upon external sources of energy. Most trains operating outside Australian conurbations are diesel powered. There is a minimum of supporting infrastructure, save for the need to have fuel storage and refuelling points strategically located around the railway network. By way of contrast, classic railway electrification requires:

- The means of delivery, via overhead wires at either 1500V DC or 25kV AC in Australia, from which trains collect current (up to 6000 A for DC and 900 A for AC) via sliding pantographs;
- The means of distribution, via traction substations of varying complexity (eg transformer and rectifier for DC or transformer only for AC) and capacity (eg typically 1.5 – 5 MW for DC and up to 25 MVA for AC); and
- The means of supply, via a suitably dimensioned high voltage transmission network (eg 3 phase, 33kV for DC to 3 phase, 66-132kV for AC).

A MagLev system does not need to deliver power directly to its trains. On the other hand it has to deliver it to its guideway in quantities substantially greater than would be required by a classic railway. Therefore, the means of distribution and supply are highly pertinent.

Thus, there is substantially more infrastructure associated with electrification than with dieselisation. On the other hand, there are definite limits to the level of energy which can be supplied to a diesel powered train. It is unlikely that a feasible diesel powered VHST could exceed an installed power train, for traction, of approximately 6000 kW and such power would have to be divided between at least two power cars or under every passenger car. It is possible VHSTs could be gas turbine powered but there have been no recent attempts to build such trains because of their high fuel consumption and high exhaust temperatures.

On the other hand, high powers can be installed on VHSTs under electrification. The continuous rating of VHSTs has reached almost 18000 kW in the case of the Series 500 Shinkansen trains in Japan. Furthermore, the short term rating for electrically powered trains can be up to 40% higher. However, there is probably a realistic limit to the level of current (ie 900-1000 A) which can be delivered to trains under 25kV AC (which is probably the highest practicable supply voltage). Therefore the highest rating of a classic train probably could not exceed 22000-25000 kW.

Since the MagLev system is not constrained by a delivery system, much higher powers can be applied to its trains which could, perhaps, be thought of as projectiles because the propulsion comes from, and is controlled at, the guideway. However, the power required to propel a MagLev train still has to reflect the

realities of train weight and maximum speed. Therefore, individual MagLev trains could easily command a peak power requirement of 40,000 kW per train during acceleration on level tangent guideway, i.e. without taking into account terrain.

Feasible Levels of Acceleration and Deceleration

It is desirable that trains have as high levels of acceleration and deceleration as possible to keep travel times as low as possible. Provided a train can readily reach its cruise speed it should be able to maintain that speed for long distances, subject to intervening alignment constraints (discussed further below). Therefore, high rates of acceleration and deceleration reduce the travel time losses of making stops. They also provide the means by which trains may surmount steep grades.

In classic trains the sustainable levels of acceleration and deceleration are ultimately governed by the levels of adhesion which can be reliably maintained between wheel and rail. Trains with modern traction systems are able to command very high levels of adhesion at low speed. For example, modern freight locomotives can now regularly achieve 35% adhesion, ie 35% of the weight upon driving wheels can be exerted as a tractive force, when starting a train. However, the level of adhesion rapidly reduces as train speed increases or as adhesive conditions between wheel and rail deteriorate. VHSTs, such as TGVs, probably cannot command any higher level of adhesion than 10% at speed. This limits their sustained rates of acceleration to no more than 0.5 m/s^2 since there is no more than 17 tonnes of power car weight per traction motor available for adhesion.

There is another factor governing deceleration of classic trains. Whereas acceleration is dependent upon the level of power which can be applied to its traction motors, deceleration is dependent upon a combination of the amount of power which can be generated by its traction motors plus the amount of heat which can be dissipated by friction braking. The total energy which has to be dissipated, one way or another, during deceleration could be as much a 50% higher than the peak power demanded during acceleration. Furthermore, the total energy which has to be dissipated during deceleration will be proportional to the speed from which deceleration commences. Hence braking power must rise in step with the maximum permitted speed. However, the pay off is that sustained deceleration can be as high as 0.9 m/s^2.

MagLev trains are unconstrained by levels of adhesion since their performance is governed by the forward and backwards thrust which can be generated by the guideway. Therefore higher levels of acceleration and deceleration are sustainable by MagLev systems. However, MagLev systems pay for performance in the form of considerably higher installed powers, over and above just the increase in power requirements required to meet their higher maximum permitted speeds.

Tractive Configuration

Throughout the developmental history of railways there has been a choice between head end and distributed power for traction. Head end power, ie locomotives or power cars, is more economical in terms of equipment than distributed power (vide the comparisons between European and VHSTs where European trains largely adopt head end power whereas Japanese trains exclusively adopt distributed power). However head end power can limit the maximum acceleration rate which can be achieved by high speed trains. The ultimate expression of distributed power is in MagLev trains where each unit is a traction unit, in that it reacts against the guideway for propulsion.

Distributed power, because of its greater redundancy, also is more forgiving of equipment failures so that trains with distributed power will be more reliable in service.

Ultimately the choice between traction configurations will be determined by the technology and the cost. However in the context of ever developing a very high speed rail corridor in southeastern Australia, infrastructure costs are most likely to dominate total system costs so that cost differences between different rolling stock configurations will be a minor consideration.

Maximum Permitted Speed

The maximum permitted speed that different trains can achieve in revenue service will depend upon the installed power, the geometric characteristics of the alignment over which a train is run and the train's ability to collect its traction energy. Classic trains have been driven over 500 km/h under experimental conditions but no train has yet entered service with a maximum service speed greater than 300 km/h. However, SNCF demonstrated a "tweaked-up" TGV-Reseau on the newly opened LGV Mediteranee travelling considerable distances at 350 km/h thereby demonstrating the practicality of 350 km/h running.

From a general review of European rolling stock it seems that the practical limit of diesel traction is 200 km/h. This is because of the problem of installing sufficient power to travel much faster over general terrain.

Electrically powered trains are constrained by their power supply and its means of delivery. The most glaring example is the performance of the 300 km/h Eurostar train when supplied by 750V DC where it is limited to 160 km/h. Various TGV trains must operate over the SNCF's original 1500V DC electrification. Inevitably trains running under 1500V DC are limited to less than half the installed power that is achievable under 25kV AC with a consequential reduction in the maximum achievable speed (probably no more than 200 km/h). In the case of 3000V DC electrification, trains may still be underated compared to their 15/25kV AC performance. On the one hand, trains running in Belgium under 3000V DC are

limited to 220 km/h. On the other hand, trains in Italy are permitted to run up to 250 km/h or 300 km/h.

Realistically, if trains aspire to very high speeds they must collect their traction energy at a high voltage to reduce the levels of current that must be drawn. However, the indications are that there has been a plateau in the levels of power which can be installed in very high speed trains. Since TGV trains can be run in multiple it is likely that the current maximum continuous rating of a twin-unit TGV-Reseau would be 17.6 MW (with a short term rating of 24.6 MW). The most powerful Japanese Shinkansen train has a similar continuous rating. Thus, this is likely to be the limit of deliverable power to a single train.

The only way in which higher powers could be delivered to trains would be to limit train size. Thus, the proposed TGV-Nouvelle Generation would probably have to be run as a single unit. If a hypothetical 500 km/h TGV ("X") where postulated it would probably need at least 40% more power than a TGV-NG, provided the requisite levels of current could be delivered to it.

MagLev is not constrained by matters of power delivery because power is only delivered to the guideway and not onwards to the train. Therefore, much higher levels of power would be practicable. However, the very high powers per train (eg peak power demands of 40 MW for a four-unit train and approaching 60 MW for an eight-unit train) would challenge a MagLev's distribution and supply system. The Japanese have reported overheating problems in delivering such power levels to their MagLev guideway.

Irrespective of the actual traction mode, any electrified EC HVST corridor would have to be served by a dedicated high voltage transmission line because of the thinness of the general electricity supply network. This had already been recognised in the Sydney- Canberra corridor studies and bids.

Factors Affecting Passenger Comfort

The principal issues affecting passenger comfort are:

- The ambience in which train passengers expect to travel;
- The space available per passenger and therefore the total accommodation levels of very high speed trains; and
- The longitudinal, lateral and vertical forces to which passengers would be subjected during a typical journey.

The most obvious characteristic of train travel is that passengers are free to roam around the train. In fact, they are encouraged to access restaurant cars for food and drink as an alternative to being served in-seat by a trolley service. This will influence the amount of space to be set aside per passenger and the levels of forces to which passengers should be subjected throughout a typical journey.

Clearly European accommodation standards (eg 1.15-1.42 m^2 per passenger) are more generous than Japanese ones (typically 1.01 m^2 per passenger) although not overly so. The indications from current Australian long distance rolling stock, such as XPTs and Xplorers, suggest that Australian accommodation levels could be 20% more generous (ie 1.35-1.40 m^2 per passenger) than those on TGVs.

It is equally important that passengers are not subjected to forces that detract from the ambience they expect from train travel. Therefore:

- Longitudinal acceleration should not exceed 1.0 m/s^2 and preferably should be lower;
- Lateral acceleration should not exceed 1.5 m/s^2 and preferably should be lower; and
- Vertical acceleration should not exceed 0.4 m/s^2 and preferably should be lower.

Longitudinal acceleration will be determined by train performance. VHST types operate at 0.5 m/s^2 or less. However, MagLev trains are capable of much higher levels of acceleration and deceleration so they may have to be constrained to levels that are comfortable for ambulatory passengers.

Lateral acceleration during motion, and superelevation when stationary, are important comfort factors because they can unbalance ambulatory passengers. Therefore uncompensated cant deficiency should not exceed 150 mm and superelevation should not exceed 180 mm. If a train has a tilting body higher levels of actual cant deficiency are possible because the body tilt can compensate for a considerable proportion of the cant deficiency.

Vertical acceleration arises when a train runs along a vertical curve linking adjacent constant gradients. When a train crests a rise, passengers tend to be lifted out of their seats. When a train bottoms a sag, passengers tend to be squashed into their seats. Therefore, vertical curves need to be of large radii, for example, 25000 metres, or more, for 300 km/h running.

Such considerations of the forces acting upon passengers are independent of the type of train and/or its mode of traction. They therefore should apply equally to classic and MagLev trains.

Boundary between Classic Railways and MagLev

The advantage of classic railways for very high speed operation is that they can revert to existing railway infrastructure when entering or passing through conurbations. Thus, they do not expressly need new corridors although they may need the infrastructure in existing corridors to be augmented. MagLev inherently needs exclusive infrastructure. Thus, it is at a disadvantage when entering or passing through conurbations.

The distinction between the infrastructure needs of classic railways and MagLevs is less clear cut outside conurbations. An obvious determinant will be the comparative cost of infrastructure and the consequential travel time returns. It seems that there is no overwhelming advantage for MagLev over classic railways up to 350 km/h in that comparable travel times could be delivered by either mode. On the other hand, it is currently quite likely that MagLev is a more viable mode for speeds of 500 km/h or more because classic railways will not be able to achieve the requisite energy density to sustain such speeds. There remains a gray area in the 350-450 km/h range where either classic railways or MagLevs could deliver. However neither classic railways nor MagLevs have yet demonstrated any commercial viability above 350 km/h. Furthermore, MagLev has yet to demonstrate sustainable regular commercial operations in a normal transportation setting.

4.6.2 Alignment

Train performance can be greatly affected by the gradient, curvature and speed limit characteristics of a railway alignment.

Gradients

The steepness of a railway will gradually tell on any kind of train, classic or MagLev. Up to a certain gradient, trains can still accelerate to their maximum permitted speed so that such gradients may not greatly affect trains cruising at close to their maximum permitted speeds. Thereafter, as gradients become steeper, trains cannot accelerate to their maximum permitted speed from a standing start but they can surmount them without too much loss of speed if they approach these gradients at close to their maximum permitted speed. This is the key to the design of the LGV PSE alignment: the prevailing gradient is no steeper than 1.5% on which TGVs can cruise at their maximum permitted speed; but short stretches of railway (say 4 kilometres in length) as steep as 3.5% can be breasted without too much loss of speed (say dropping from 270 km/h to 220 km/h).

However, if gradients become even steeper there is a risk that if a train must stop on such a gradient if will then not be able to make a standing start. This is even more critical if the train has experienced a traction failure where, for example, if half of a TGV's power cars shut down. An EC VHST will be a lonely place for a train to break down because of the sparse settlement en route. Therefore it will be imperative that trains can limp home under part power. Hence absolute gradients must not exceed the level at which a partly failed train can make a standing start.

If gradients become even steeper then even healthy trains will not be able to make a standing start if they have to stop on them. Figure 4.4 illustrates the relationship between train performance in the form of the balancing speed (ie the speed at which no acceleration is possible on a gradient) on a continuous gradient versus increasing levels of gradient (in percentage form). For example, a range of different TGV-type trains with their moderate levels of acceleration (but not maximum permitted speed) can only balance at 150-180 km/h on a 3.5% gradient. Furthermore, TGV-type trains rapidly fail after 4% gradients because of their dependence upon head end power and traction. On the other hand, multiple unit trains, such as "ICT" and "AIM2" can theoretically tolerate much higher gradients because power and tractive effort is distributed throughout these trains.

As a general rule, an EC VHST should be designed with a prevailing ruling gradient of nor more than 1.5%. However short sections, preferably no more than 4 kilometres in length, could be steepened to 3.5% if there was a significant alignment cost saving. However, such an alignment could not be shared with low power-to-weight freight trains if this was a design consideration. On the other hand, a sharable alignment could possibly tolerate short lengths of 2.5%.

Because MagLevs are clearly more gradient tolerant than classic railways prevailing gradients can certainly be made steeper. The Japanese experience suggests that 4% gradients are readily applicable. They could be steepened to 5-6% but probably not as much as 10%, as sometimes claimed, because MagLevs would not be able to accelerate from a standing start, on the basis of published MagLev performance data.

Curvature

Curvature, in itself, is not a significant drag on train performance. However, curvature determines the speeds at which trains may comfortably travel. Nevertheless, curvature is an important consideration in alignment location because it controls whether or not physical obstacles, such as hills or valleys or the built environment, such as found in conurbations, can be bypassed. Planners need options if they are to economically plan very high speed alignments. Typically, very high speed railways need large radius curves in order to allow trains to run at their free speed. To some extent, superelevation can be applied to curves and trains can be allowed to run at a cant deficiency to reduce curve radii. However there are limits.

Superelevation can be applied to the point at which it is uncomfortable for passengers if a train stops on a superelevated curve. The maximum French level of 180 mm of superelevation is uncomfortable because passengers have difficulty

in keeping their footing if walking through a stationary train. On the other hand, the NSW Rail Infrastructure Corporation (RIC) has experienced difficulty in maintaining 140 mm of superelevation on mixed traffic railways with high levels of freight traffic, whereas it can reliably maintain 125 mm of superelevation.

Trains can run at quite high levels of cant deficiency without risk of overturning. However passengers have difficulty in adjusting to high levels on uncompensated cant deficiency. Uncompensated cant deficiency applies in the opposite sense to superelevation. It also leads to the train applying high lateral forces to the outside rail on a curve unless smart bogie design is applied to be kind to the track, for example by making the bogie axles steerable through curves. For a variety of reasons it would therefore be desirable not to exceed 150 mm of cant deficiency. If the rolling stock incorporates tilting bodies, either passively as in the Talgo design or actively in the ABB/Fiat/SIG, etc form, then higher levels of actual cant deficiency can be tolerated because a significant portion of its affect on the passenger can be compensated. Under these circumstances up to 300 mm of cant deficiency can be applied provided at least 55-60% can be compensated by body tilt.

Speed Limits

Speed limits can thus be determined by the combination of radius of curvature, applied superelevation and actual cant deficiency which may include a proportion compensated by train body tilt. Figure 4.5 shows the impact of different superelevation and cant deficiency settings on the maximum permitted speed around curves of varying radii. The tested settings were:

- loco hauled E_a = 125 mm, D_m = 90 mm;
- XPT E_a = 125 mm, D_m = 110 mm;
- low tilt E_a = 125 mm, D_m = 110 mm, U_t = 135;
- high tilt E_a = 140 mm, D_m = 130 mm, U_t = 170;
- low TGV E_a = 150 mm, D_m = 60 mm;
- high TGV E_a = 180 mm, D_m = 120 mm;
- low MagLev E_a = 180 mm, D_m = 110 mm; and
- high MagLev E_a = 410 mm, D_m = 265 mm

where E_a is superelevation, D_m is uncompensated cant deficiency and U_t is compensated cant deficiency. These different settings have been gleaned from track design standards and actual applications. For example, the Spanish AVE lines limit superelevation to 150 mm but appear to accept cant deficiencies up to 120 mm. The high MagLev values are inferred from stated minimum curvature for various set speeds.

From the designer's viewpoint it would be desirable to be able to keep train speed as high as possible while being able to adopt as low a radius as possible in difficult terrain in order to mitigate expenditure on bridging and tunnelling. In this context, tilting body trains should be seen as infrastructure extenders rather than as specific rolling stock variants. This is especially so since body tilt can be applied to any type of classic train at a price. However the designer should still aspire to as wide a curve radius as possible where the terrain permits to ease the track maintenance burden which comes with high levels of superelevation and cant deficiency. Finally the high levels of superelevation and cant deficiency inferred for MagLev could be highly uncomfortable for passengers, particularly if a train stops on a curve, which it will inevitably do so. However bringing MagLev alignment standards back towards those of classic railways will also complicate alignment design, especially in conurbations where MagLevs must acquire rights of way, which are grade separated from other modes of transport.

4.6.3 Operations and Control

This is primarily an issue for classic railways because they are open systems capable of being shared by different type of trains. A very high speed railway along the East Coast of Australia would be a huge enterprise for a comparatively small train flow, as postulated in previous studies and proposals. Hence single track alignments were commonly postulated under privately-sponsored schemes. However, the closing speeds of very high speed trains, the safe separation distances required between following and opposing trains and the temporal separation required between trains running in opposing directions suggest that once train flows reach two per hour in each direction then a double track alignment would be required. Once a double track railway is proposed it has a considerable excess of capacity over demand if postulated VHST flows peak at 2-3 per hour in each direction and 1 per hour in each direction otherwise.

Hence, as an example, the UK Channel Tunnel Rail Link is mandated to accommodate a range of different train flows, ie international Eurostar passenger trains, a variety of different interurban commuter trains in and out of peak periods and fast freight trains in quiet periods.

There is thus no intrinsic reason why an EC VHST cannot similarly have multiple train users provided there are rigorous rules for joint use, such as:

- All trains must conform to minimum running gear maintenance standards compatible with the maintenance of a high quality very high speed track;
- All trains must conform to the loading gauge of the very high speed railway (most likely dictated by the vertical clearances required for 25kVac electrification);

- All trains must be able to observe the commands of a common signalling system incorporating automatic train protection to mandate safe separation between all trains;
- Single-office train control and a single communications system must be enforced over all very high speed sections of the railway;
- There must be a seamless hand over of traffic between a very high speed railway and an adjoining metropolitan or interurban railway system upon entry into a conurbation (ie Brisbane/Gold Coast, Newcastle/Central Coast/Sydney North, Sydney South/Southern Highlands/South Coast, Melbourne North and/or Melbourne East); and
- There must be sufficient provision of freight train and slower passenger train refuging facilities throughout the very high speed railway and adjoining interurban railways such that slower trains can be easily refuged five minutes before the passage of higher speed trains.

At this stage it is not possible to be prescriptive on whether common traction systems (eg 25kV AC electrification) need to be applied to cohabiting train types. However, electric haulage of freight trains potentially could offer faster transit times and easier cohabitation, as well as being more environmentally friendly than diesel haulage.

A double track VHST must be signalled for symmetrical bi-directional use of each running line for operational flexibility in the event of traffic convergences and/or train failures.

It is quite likely that the increased density of train traffic and disparity between travel times within metropolitan and interurban railway networks will mean that joint use infrastructure will have to be either triple or quadruple track. Such multiple track, if properly configured (ie with parallel running tracks in each direction) will offer greater levels of line capacity and/or operational ease than pairs of independent double track railways. However, the presence of established conurbations will limit the opportunity for the alignment of such railways to be straightened and grade-separated sufficiently for very high speed running. It is quite likely that very high speed trains will be constrained to a maximum of 180-200 km/h in metropolitan areas and 200-250 km/h in interurban areas.

4.6.4 System Openness

SWSR Railways

The openness of a system, railway or otherwise, relates to whether there can be many different competent suppliers for its components and the degree to which different users may make use of it. In this context, a classic railway is a highly open system. There is a broad base of engineering experience in railway design and construction In Australia. There may not be any current experience in building very high speed railways but there is a readily accessible knowledge base via the overseas associates of Australian firms.

Similarly, rolling stock can be readily sourced from a number of European, North American and Japanese suppliers. As discussed above, these suppliers are able to meet a wide range of performance specifications for standard gauge rolling stock. Such specifications would embrace:

- The traction mode, although it is likely that a serious very high speed railway would be electrically powered;
- The body suspension which may include passive or active tilt; and
- The maximum permitted speed, likely to be as high as 350 km/h.

If the specifications for an Australian train were close to the specification of an established design there would be economies of supply of existing assembly lines. However, it is not clear whether the environmental conditions under which a train would operate in Australia could be directly met by overseas designs. This has certainly been the case for air-conditioning systems and diesel traction systems for Australian railways.

MagLev

On the other hand, a MagLev system will necessarily be a closed system with a limited number of suppliers. There are currently two systems which have been technically developed and demonstrated to run at speeds up to 500 km/h:

- The German Transrapid system, sponsored by Thyssen and Siemens; and
- The Japanese Chuo Shinkansen system, cooperatively developed by a range of major Japanese heavy engineering concerns.

These two systems are fundamentally technically different. The German system has its train straddling a wide beamway, supported and guided by magnetic attraction. The Japanese system has its train running in a wide trough, supported and guided by magnetic repulsion. There would be no operational synergy between either system nor would there be any with any existing ground transportation system already in place in Australia. At best, a MagLev system could share existing transport corridors but only if it was a good tenant and did not obstruct the operations of the corridor it was sharing. Inherently it would have to be grade separated from all existing parallel and transverse railways and highways.

Choosing a MagLev system would commit Australia to that system for at least a northern or a southern corridor out of Sydney if not to both corridors. It would

possibly confer an advantage to the promoters of that system over anyone else, at least until that system was out of patent protection in regard to supply of componentry and maintenance. While the guideway structure could and would most likely be designed in Australia, the equipment for the guideway, the supply of all traction supply and operational control plant and all the rolling stock would possibly be supplied from overseas. In this regard it is relevant to note that for the MagLev projects under consideration in the USA, the local content is required to be 70%. For the Atlanta to Chattanooga MagLev project, Transrapid proposed to supply the vehicles, propulsion and operating systems which amounted to about 25% of the project cost but about 100% of the high technology component.

All operational procedures would have to be developed from scratch because there is currently no operational commercial experience for a system of this scale.

4.7 Application to Australian conditions

4.7.1 Southeastern Australia Appreciation

Australia does not have the dominating mountain ranges of some other countries. However, its montane geography significantly impedes the development of low cost ground transport infrastructure because the principal trade routes between its major East Coast conurbations must traverse the foothills that reach out east and west of the Divide, even if they do not have to cross the Divide itself. Melbourne, Sydney and Brisbane all lie on the coastal strip to the east of the Great Dividing Range and are connected by a coastal highway but not a continuous coastal railway. There is a significant escarpment between this coastal strip and the immediate hinterland of southeastern Australia. Because of this Canberra, which lies somewhat inland, lies at a significant elevation even though it is still east of the Divide. While Canberra has direct highway connections to Melbourne and Sydney (and a direct railway to Sydney) it does not lie along the direct highway and railway connections between Melbourne and Sydney.

4.7.2 Level of Service Imperatives

Current Situation

Another challenge to be met is determining what level of service could or should be offered within a high-speed ground transport corridor. There are travel time, level of service, capacity and pricing benchmarks from existing transport modes plying between the four identified conurbations. Existing highway and railway passenger services offer 10.5-hour transits between central Melbourne and central Sydney and 13.5 hour transits between central Sydney and central Brisbane. Comparable air transit times would be roughly 2.5 hours.

Highway (ie bus) and railway service frequencies are around 2-4 services per day in each direction. Comparable air service frequencies are around 20-30 services per day in each direction. Bus capacities would be of the order of 50 passengers with multiple departures at key times of the day. Train capacities would be of the order of 250-300 passengers with single departures. Plane capacities would be of the order of 150-250 passengers with daylong multiple departures.

There is a broad spectrum of prices across all modes. While different carriers may quote bargain prices they still have to obtain a fare yield which at least covers direct operating costs. Fare yields would place bus slightly cheaper than rail and rail somewhat cheaper than air. However making ground transport significantly faster than it is now must inevitably move its costs towards those of air assuming that it has to be financially self-sufficient. On the other hand, Governments may choose different pricing policies to meet non-transportation objectives.

Future Situation

A VHST would have to serve a number of different travel needs:

- Direct connections between the major conurbations of Melbourne, Canberra, Sydney and Brisbane, including possible access to major airports and to the edges of each conurbation because of the vast areas of Australian cities compared to their more compact European counterparts;
- Direct connections between each conurbation and its regional hinterland, for example:
  - Melbourne – Northeastern Victoria;
  - Sydney – Southern Highlands, South Coast and Central Coast;
  - Brisbane – Gold Coast and Far NSW North Coast;
  - Coolangatta and the Qld Gold Coast; and
  - Direct regional linkages with access to the rural areas which trade with regional centres, eg Northeastern Victoria from Seymour, through Shepparton or Benalla to Albury/Wodonga; Wagga Wagga and the Riverina, Cootamundra and Yass to the Central West of NSW, Canberra and the Monaro, Goulburn and the Southern Highlands, the NSW Central Coast, Taree, Port Macquarie, Coffs Harbour, Grafton, Lismore/Ballina and the NSW Lower, Mid and Upper North Coasts.
  -

These travel needs suggest that a very high speed rail corridor will probably need in-town termini, suburban edge and/or airport stations and then regional stations roughly 100 kilometres apart. Then there would have to be a layered level of service, eg a limited-stops “express” shadowed by an all-stops “local” to meet the different travel demands. Furthermore, Melbourne, Sydney and Brisbane each

support suburban and interurban train services (up to 160 kilometres out of each capital city) which would fill in the gaps between very high speed stations. There would thus be a need to coordinate very high speed train services and suburban and interurban train services to provide as wide as possible rail-based public transport market. However, a VHST service should not be developed as an alternative interurban train service because this would be a very poor use of a technology which only comes into its own when its non-metropolitan stops lie at least 50 kilometres apart and ideally 100 kilometres, or more, apart.

4.7.3 Rolling Stock for Further Consideration in this Study

Table 4.4 summarises a range of actual and hypothetical trains with which train performance and alignment issues were explored in this study via train performance simulation. The existing speed and three additional speed steps were considered, as were alternative train types within each step:

- 160 km/h — current diesel trains in either multiple unit (MU) distributed power form (ie "VH16") or head-end fixed formation (FF) form ("XPT");
- 250 km/h — lower speed electric trains in multiple unit form (ie "AIM2") or fixed formation form (ie "XNEC");
- 300-350 km/h — high-speed electric trains in fixed formation form (ie 300 km/h "TGVR" and 350 km/h "TGVM"). No Japanese Shinkansen train performance information was available to test the multiple unit form; and
- 500 km/h — ultra high-speed electric trains in either classic form (ie "TGVX") or as a MagLev ("GMGL").

The different train types, identified for convenience by their MTRAIN train performance simulation, are:

- "VH16" — a proposed 160 km/h diesel multiple unit railcar with long distance seating accommodation;
- "XPT" — the existing 160 km/h Countrylink fixed formation train with long distance seating accommodation;
- "XNEC" — an uprated, 250 km/h version of the Swedish X2000 fixed formation tilting train, as tendered by Adtranz for the US Northeast Corridor;
- "AIM2" — a proposed 250 km/h electric multiple unit tilting train with long distance seating accommodation, offered by Adtranz in the Sydney – Canberra Expression of Interest;
- "TGVR" — the standard 300 km/h French TGV Reseau, offered by Alstom in the Sydney – Canberra Expression of Interest;
- "TGVM" — an uprated 350 km/h version of the TGV Reseau, as recently demonstrated on the LGV Mediterranee;
- "TGVX" — a hypothetical uprated 500 km/h version of the TGV Reseau with traction as proposed for the TGV-Nouvelle Generation; and
- "GMGL" — the 500 km/h German Transrapid multiple unit MagLev train, as offered in Australia and US with long distance seating accommodation.

Figure 4.8 presents the accelerative effort (m/s^2) versus speed (km/h) characteristics of these train types in a common format.

4.7.4 The Spectrum of VHST Train Performance

A range of different type of trains was introduced in the previous section to provide placeholders along a train performance spectrum. These placeholders were chosen to address the options open to Government about how it could invest in improved intercity passenger rail service, if at all, ie:

- A "Do Nothing" case of continuing with non-urban passenger railway services at the current level of a 160km/h maximum;
- A "Do Something" case of 250km/h technology which introduces significant travel time improvement and allows for joint passenger and freight movements in a single corridor;
- A "Do More" case which takes classic rail to its current commercial boundaries of 300/350km/h technology but with some uncertainty as to whether independent rail corridors are then required for passenger and freight rail; and
- A "Do Much" case which adopts 500km/h MagLev as the only technology which potentially could challenge air transit times between adjacent conurbations.

The first step in refining the technology choice was to undertake a performance play off over a 100 kilometre sector, unconstrained by gradient, curvature or speed limit. The MTRAIN train performance simulation model was used to calculate travel time, maximum attainable speed, average speed, total energy consumption and specific energy consumption for the ten previously introduced train types. Table 4.5 summarises these simulation results. Figure 4.9 graphically compares the speed versus distance behaviour of each candidate train. Figure 4.10 graphically compares the time versus distance behaviour of each train.

There are diminishing returns in travel time reduction as the trains run to higher maximum permitted speeds. The steps from 160 km/h, through to 250 km/h showed travel times falling fairly consistently with the increase in maximum permitted speed. Specific energy consumption was moderate, but only as compared to the performance of metropolitan trains which have to stop 60 times more often. Multiple unit trains, ie those with distributed power, performed marginally better than fixed formation trains with head end power. The step from 250 km/h to 300/350 km/h showed progressively diminishing travel time savings. In part this could be because only fixed formation trains were being tested (in the absence of performance information on multiple unit Shinkansen trains). Not surprisingly specific energy consumption was also rising. The performance of a hypothetical 500 km/h TGV was disappointing because its travel time reduction was much less than the increase in its maximum speed (and the consequential increase in the difficulty of preparing its infrastructure). The travel time performance of the MagLev train was better in both travel time reduction and energy consumption terms but still there were diminishing travel time savings.

An obvious observation is that average start-to-stop speeds drift quite quickly away from the maximum permitted speeds of the different train types. Since realistic timetables must incorporate some time margin to absorb unforeseen delays to ensure a high probability of on-time arrivals, actual average speeds will be somewhat less, for example from 5% to 10% less, depending upon whose timekeeping standards are adopted. Moreover, intermediate stops absorb further time. The realistic durations of intermediate station stops can range between 1 and 5 minutes depending upon the numbers of passengers boarding and alighting and any inter-service dependencies, for example connections with feeder transport services.

From a performance and risk basis, candidate trains should have distributed power to deliver the requisite travel times and to be able to get home under partial failure conditions over long lonely railway corridors. Thus the candidate trains to test the very high speed rail corridor development scenarios were:

- a 160 km/h diesel multiple unit train ("VH16") to test a "Do Nothing" case of at best the development of a better freight railway over which good regional passenger rail services could run;
- a 250 km/h electric multiple unit train ("AIM2") to test a "Do Something" case in which significant travel time savings would be achievable on a suitably aligned railway which could still be jointly used by passenger and freight rail services. It would quite likely deliver travel times comparable to the Sevilla - Madrid AVE because it could make better use of constrained alignments where the capital cost of straightening a railway to the ultimate becomes too high;
- a 350 km/h fixed formation ("TGVM") or multiple unit train to test a "Do More" case in which travel times could potentially be halved from the "Do Nothing" case. A high quality alignment would be absolutely necessary but the adoption of tilting body rolling stock would be able to stretch an alignment to get better travel time savings per unit construction cost; and
- a 500 km/h (intrinsically multiple unit) MagLev train ("GMGL") to test a "Do Much" case in which it might be possible to match suburb-to-remote-city air travel times. There is a considerable risk in adopting this mode because of its infrastructure cost and because there is no operational experience in long distance line haul operations for this transport mode. Furthermore, while MagLevs may be able to match Melbourne – Sydney or Sydney – Brisbane air travel times they will certainly not be able to match Melbourne – Brisbane air travel time so that not all of the air market is competitively open to it.

4.8 Future High Speed Transportation Technologies

4.8.1 Overview

Any form of public transport infrastructure is a very long-term investment. Such systems generally have asset lives that are:

- Virtually unlimited in terms of the corridor provision;
- At least 50 – 100 years in terms of the fixed infrastructure e.g. bridges stations and the like; and
- Around 25 years in terms of operating systems and rolling stock.

More particularly the installation of transport systems has a life of thousands of years in terms of its influence on the patterns of urban settlement and development. For example, the pattern of Roman roads in Britain still defines the road structure in many places, which in turn has defined cities and regional urban centres.

The selection of one mode or another therefore will have a profound influence on how well regions and even countries operate. In this regard the choice of a technology for an EC VHST is an important one.

That choice needs to be of a technology that will be sustainable, operable, expandable extendable and maintainable for at least the time needed for it to recover its costs and, hopefully, beyond. It would be most unfortunate if the choice of technology proves to be a "blind alley" that many other projects have been. More particularly any alternative transport mode need to be a realistic option to either of the established technologies – air and rail and of the emerging MagLev technologies in terms of speed and of passenger carrying capacity.

In this regard it is relevant to note that while both Germany and Japan have invested heavily in magnetic levitation systems, both also have monumental sunk costs in their SWSR rail system and both continue to invest in the further development of these. So do many other nations who are developing their passenger systems. More specifically Europe is developing its system to linking countries in the European Union based on SWSR technology. This seems to say that this is a technology that may have seemed at the end of its technological development but have proven not to be.

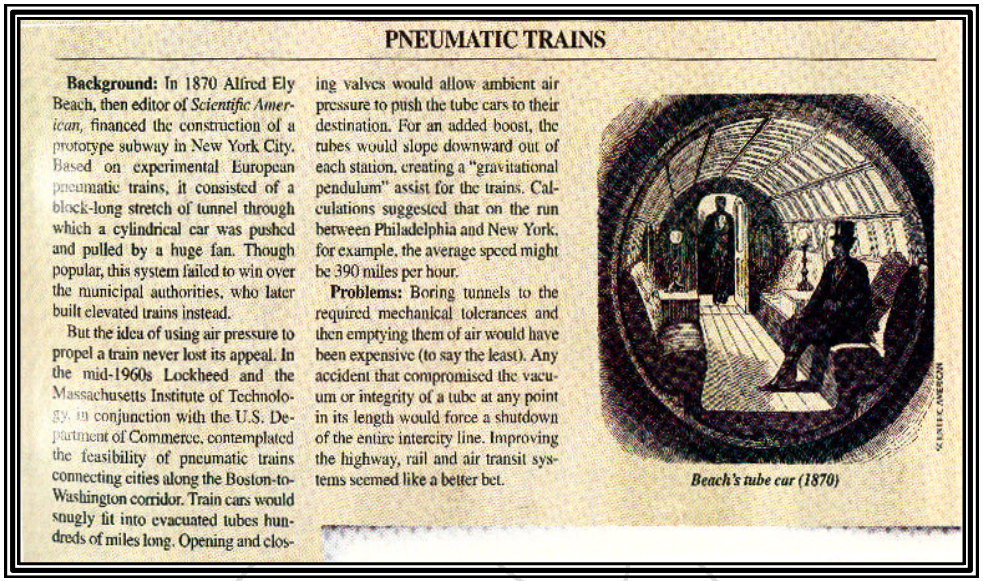
It is not too difficult to find examples of transport technologies that seem to hold the promise of the future but for one reason or another just did not get there. An article on this topic may be found at www.sciam.com entitled *"13 Vehicles that Went Nowhere"*

The articled describes vehicles, such as:

- The flying car;
- Rocket belt;
- Pneumatic trains;
- Atomic powered cars and planes; and
- Airships/Zeppelins.

The pneumatic train, a prototype of which was built in the 1870's in New York consisted of a circular tunnel through which a tubular vehicular was pushed by air pressure. The idea was revived in the sixties as a possibility for the Boston to Washington Corridor, where the system was calculated to be capable of 390 miles per hour (>600 km/hr).

Zeppelins fell from favour as a result of falling public image due to some major disasters, but also that aircraft could produce vastly quicker travel times. However, they are re-emerging not as passenger transport but as long distance freight/equipment transporters.



PNEUMATIC TRAINS

Background: In 1870 Alfred Ely Beach, then editor of *Scientific American,* financed the construction of a prototype subway in New York City. Based on experimental European pneumatic trains, it consisted of a block-long stretch of tunnel through which a cylindrical car was pushed and pulled by a huge fan. Though popular, this system failed to win over the municipal authorities, who later built elevated trains instead.

But the idea of using air pressure to propel a train never lost its appeal. In the mid-1960s Lockheed and the Massachusetts Institute of Technology, in conjunction with the U.S. Department of Commerce, contemplated the feasibility of pneumatic trains connecting cities along the Boston-to-Washington corridor. Train cars would snugly fit into evacuated tubes hundreds of miles long. Opening and closing valves would allow ambient air pressure to push the tube cars to their destination. For an added boost, the tubes would slope downward out of each station, creating a "gravitational pendulum" assist for the trains. Calculations suggested that on the run between Philadelphia and New York, for example, the average speed might be 390 miles per hour.

Problems: Boring tunnels to the required mechanical tolerances and then emptying them of air would have been expensive (to say the least). Any accident that compromised the vacuum or integrity of a tube at any point in its length would force a shutdown of the entire intercity line. Improving the highway, rail and air transit systems seemed like a better bet.

Beach's tube car (1870)

Reproduced with permission from Scientific American

4.8.2 Futuristic Technologies

Even a brief search on the Internet reveals a plethora of alternative and futuristic transport systems. This review looks at some alternative modes of high-speed intercity transport systems and considers them in terms of their disruptive nature relative to conventional high-speed rail. A technology is considered disruptive if it competes more effectively along one or more of the following four dimensions; cost, convenience, functionality and reliability. For example, the steam engine displaced the horse drawn cart because of its inherent functionality and long term reliability and economic benefit. Similarly, the combustion engine and production line revolutionized transportation by virtue of the modern automobile's convenience and relative cost.

In respect to high speed intercity transport, four technologies have been identified as potentially disruptive; magnetic levitation with linear induction (MagLev), evacuated tube transport (ETT), dual mode systems and Personal/Group Rapid Transit (PRT/GRT). MagLev is already a working technology in two specific forms and of one these, Transrapid, is already a commercial technology. Other technologies are somewhere between the "drawing board" and prototype development.

Advanced Magnetic Levitation

Already identified earlier in this report, MagLev holds the greatest potential to change present day rail paradigms due to its advanced stage research and development.

This study has already noted and accepted Transrapid MagLev technology as capable of being implemented. While now in full-scale testing, the Japan VHST MagLev system is not yet suitable for commercial implementation. The distinction between Transrapid and the Japanese MagLev's and the technologies that follow is that the latter utilize magnetic levitation as a secondary technology that supplements the overall system, rather than being its primary focus.

Additional to the German and Japanese systems are those MagLev systems being considered in the USA. A comprehensive account of current developments can be found at http:// faculty.Washington.edu/~jbs/itrans/MagLevq.htm. These range from being American versions of either the Transrapid or Japanese systems to yet more esoteric forms capable of even higher speeds.

ETT

The effects of air resistance, aerodynamic noise and magnetic drag ultimately constrain the magnitude of increase in maximum speed from conventional rail to MagLev. Evacuated Tube Transport (ETT)is an extension of MagLev that counters these limitations through operation in airtight and low-pressure tubes. This theoretically enables maximum velocities in the thousands of kilometres per hour. Advocates of ETT even propose high-speed undersea transcontinental travel at speeds equivalent or greater than aircraft, though at a fraction the energy spend. Realistically, ETT raises serious concerns over the numerous and unique O&M issues, initial capital investment and cost/time for R&D and commercialization.



One current attempt to apply this technology, which clearly harks back to the pneumatic train of the 1800's, as described above, is the Swiss Metro. This *technology "plans to use the same type of train as Transrapid but increase its speed by sucking the air out of the tunnel to create an atmosphere similar to that an airplane encounters at 45,000 feet. By building the 661 km network in tunnels , the designers neatly sidestep the political nightmare of trying to obtain a right of way in already crowded urban areas*" [1]

While the prospect of travelling in such a confined space seems instinctively unattractive it is probably little different to what many travellers endure on urban metros and is possibly little different to an overnight flight.

Moreover, placing such infrastructure in tunnels may be increasingly regarded as strategically attractive.

Dual Mode

Although not strictly a high-speed long haul transport alternative, dual mode potentially offers the capability to capture and divert large portions of the existing intercity 'car' travel. Dual mode vehicles can be driven manually on existing infrastructure and moved automatically on dedicated guideways. This technology marries the convenience of private transport with the scale economies of public systems, and in theory seems to be the "Holy Grail" of transportation technologies.

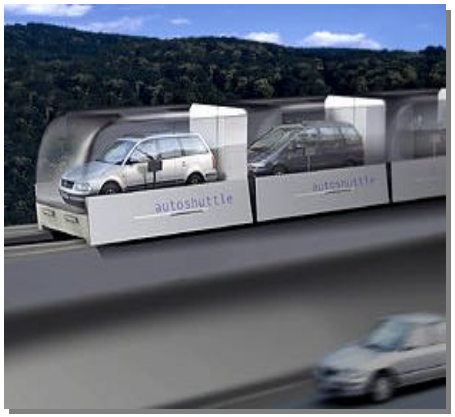
Perhaps indicative of its potential, there are numerous sources promoting their dual mode systems, ranging from existing automobiles being transported on

[1] Time Magazine 16 June 1997 Vol 149 No 24

platforms/shuttles to specialised electric powered vehicles that interface seamlessly with the guideways. One common feature is the utilization of MagLev technologies for the guideway propulsion. The American HiLoMag (High-Speed Low-Speed MagLev) system for example proposes speeds up to 320 km/h between cities and 100 km/h within built-up areas.

New Generation Aircraft

It is estimated that commercial air travel in the US will double in volume over the next twenty-five years. Part of this growth will stem from local area travel, as opposed to international and coast to coast journeys. The commercial imperative faced by aircraft manufacturers and service providers is the threat of short-medium distance ground transport alternatives. In this regard, there are two general implications for future short-medium range air travel.



Incremental increases in aircraft speed will return only diminishing benefits because of the distances involved. Larger craft, such as Airbus Industrie's 550 seat A380 will economically increase the capacity of current intercity routes. With scale cost savings in operation together with increased patronage, operators will be able to aggressively compete against high-speed ground transport on ticket price. However, non- travel times will be likely to increase due to longer time to load such aircraft. Furthermore, if ground access to airports increases in congestion overall travel time could further increase such that the in-vehicle time becomes less than 30% of the current point to point transit times in the eastern seaboard corridor of Australia.

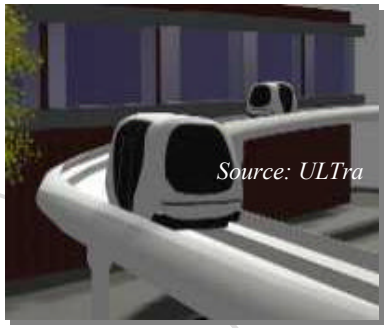
On the other hand, various aviation industry pundits cite the rise of smaller aircraft and more direct point-to-point routes of tomorrow. The emergence of smaller, more flexible aircraft is the result. This move is particularly driven by the USA with its huge aviation market in which the hub and spoke approach to operations leads to many regional cities not having convenient direct services. However, the Australian regional air market was already set up this way and regional Australia has endured many changes in equipment over the past 15 years as operators attempt to match the market. Many towns in the East Coast have suffered significant downgrading of their air services, as the national and regional air services market has become increasingly competitive. This is both in equipment type and service frequency.

PRT/GRT

Perhaps the greatest numbers of transport technologies in development are in the form of personal rapid transit. This is fundamentally a inner and outer city innovation. Although similar in concept to dual mode, it utilizes small-medium capacity vehicles running on dedicated guideways. There are literally dozens of this type of transport system proposal including one developed by one of Australia's leading technology firms, Bishop Engineering.

A more esoteric version of this form is the Unitran high-speed string transport system. A outline of Unitran can be found at www.unitran.ru/en/a_p_en.htm.

Unitran claims its system is capable of operating over distances of up to several thousand kilometres at speeds of up 500 km/hr. A search of the Internet reveals many other such personalized small vehicle systems.



Although PRT/GRT has been around since the 1970's, it is only since the recent advances in magnetic levitation technology that the possibility of connecting regional centres via PRT/GRT has become more feasible. Nevertheless, there is not much evidence yet to suggestion they are serious competitors for high capacity line haul VHST systems

Airtrain

One technology further that deserves a mention is the Airtrain concept. This hybrid train and plane vehicle runs on fixed overhead line at low speeds and becomes airborne at speeds in excess of 300km/hr. It remains within 300 mm of the guideway during 'flight' through proximity feedback controls. Because it is within a constant distance of the dedicated guideway the vehicle can be powered electrically through a pantograph. It is claimed that such a system would be cheaper and quicker to build than MagLev because the fundamental technologies already exist in commercial operation.

4.8.3 Evaluation

The disruptive technology evaluation framework can be used to evaluate the potential of these various technologies. If current VHST's such as the French TGV and Japanese Shinkansen are used as the benchmark, then the above technologies can be qualitatively evaluated against them. It is acknowledged that this framework is a superficial analysis of the actual dimensions that ultimately

comprise the suitability of a future technology. It deliberately omits difficult-to-qualify parameters such as political and societal considerations. Furthermore, it does not attempt to weigh or rank dimensions against each other.

Cost

This includes all obvious financial considerations such as capital cost including infrastructure, vehicles, research and development, final user cost as well as non financial elements such as environmental and opportunity costs.

Convenience

An important factor in the utilization of transportation modes is the overall door to door travel time including transfer and in-transit times, together with mobility at the end destination.

Functionality

The physical characteristics of the technology come into consideration here, such as use of existing infrastructure, geographic constraints, vehicle performance (V_{max}, V_{avg}), capacity, energy consumption, noise emissions and the like.

Reliability

This dimension is concerned with absolute levels of mandatory elements such as safety, availability and maintenance requirements. Any likely disruptive transportation technology should maintain at the minimum, if not increase, one or more reliability elements.

Table 4.1. Futuristic Technologies versus existing VHS Rail

	Relative to existing VHS rail				
	Advanced MagLev	ETT	Dual Mode	PRT/GRT	New Generation Aircraft
Cost – Financial	✗	✗✗	✗✗	✓	✓
Cost – non-financial	✓	✓	✓	✓	✗
Convenience	●	●	✓✓	✓	●
Functionality	✓	✓✓	✓	✗	●
Reliability	✗	✗	●	✗	●
OVERALL	●	●	✓✓	✓	●

4.8.4 Legend

No Change ● Better ✓ Worse or not proven ✗

4.8.5 Conclusion

The functional and environmental benefits offered by Advanced MagLev and Evacuated Tube Technologies do not seem to outweigh as yet the financial and operational hurdles they would face in reality. The compromise between functionality/performance and financial cost remains the prohibitive force in this regard. Conversely, future aircraft technologies, particularly over short-medium distances, seem to address economic issues without satisfying environmental concerns.

Dual mode and PRT technologies appear to sufficiently deliver a net positive benefit for users, though they face barriers in terms of engineering. For example, they rely on mass adoption of electrically powered vehicles and leaps in operational/control technologies respectively, before they become even remotely commercially feasible. Yet even then their potential to displace existing high speed, mass volume and middle distance technologies is at least highly questionable and, more likely seriously doubtful. That is, the solution provided does not necessarily address the problem or is inappropriate to address it. One

possible technology might come close because it could utilize the existing transport asset. This is the application of guidance systems on freeways to ordinary motor vehicles. Under this system when travelling on major intercity routes each vehicle would be under the control of a guidance system. This would operate it to the maximum permissible or achievable road speed and control it to be separated from other vehicles. This would require onboard intelligence as well as inroad guidance systems. Such systems are currently being developed. However, the logistics of having every registered vehicle fitted with the required systems are immense. Even then, the speed of such a system is most unlikely to approach that of a VHST.

In the short to medium term, no potentially available transport technology is even close as a suitable substitute to the only commercial MagLev system, Transrapid, and current high-speed SWSR train systems, particularly where there are already established SWSR networks and systems. The long-term situation hinges on economically improving the technology specific shortcomings in all of the more futuristic systems mentioned above.

4.9 Key Points

- There is a small number of substantial European, North American and Japanese industrial enterprises, each capable of delivering a broad spectrum of VHST technology;
- SWSR technology can readily deliver 250-350 km/h travel but it has to be electrically powered because of the high energy requirements;
- Two MagLev technologies have been demonstrated to at least 500 km/h but have, as yet, no established history of true commercial application;
- One MagLev technology - the German Transrapid system - is now being installed for a commercial application;
- SWSR technology can deliver commercial speeds of at least 350 km/h under favourable alignment conditions;
- In adverse terrain conditions, as may be found in parts of East Coast Australia, SWSR commercial speeds could fall to 180 km/h
- To deliver cost and time effective VHST systems in East Coast Australia will require an integrated approach to alignment design and rolling stock performance specification.
- Tilting body technology is now part of the mainstream of SWSR technology and should be seen as a cost effective means of reducing infrastructure costs in challenging terrain;
- Failure tolerant VHST technology needs to be selected for any East Coast Australia corridor because of its length, terrain and sparse settlement;
- Multiple use, for example by freight as well as passenger trains, of VHST corridors should be seriously investigated in East Coast Australia;
- While there is no shortage of alternative transport technologies, none has yet emerged which can deliver the travel times offered by SWSR or MagLev technologies in a demonstrably realistic manner.

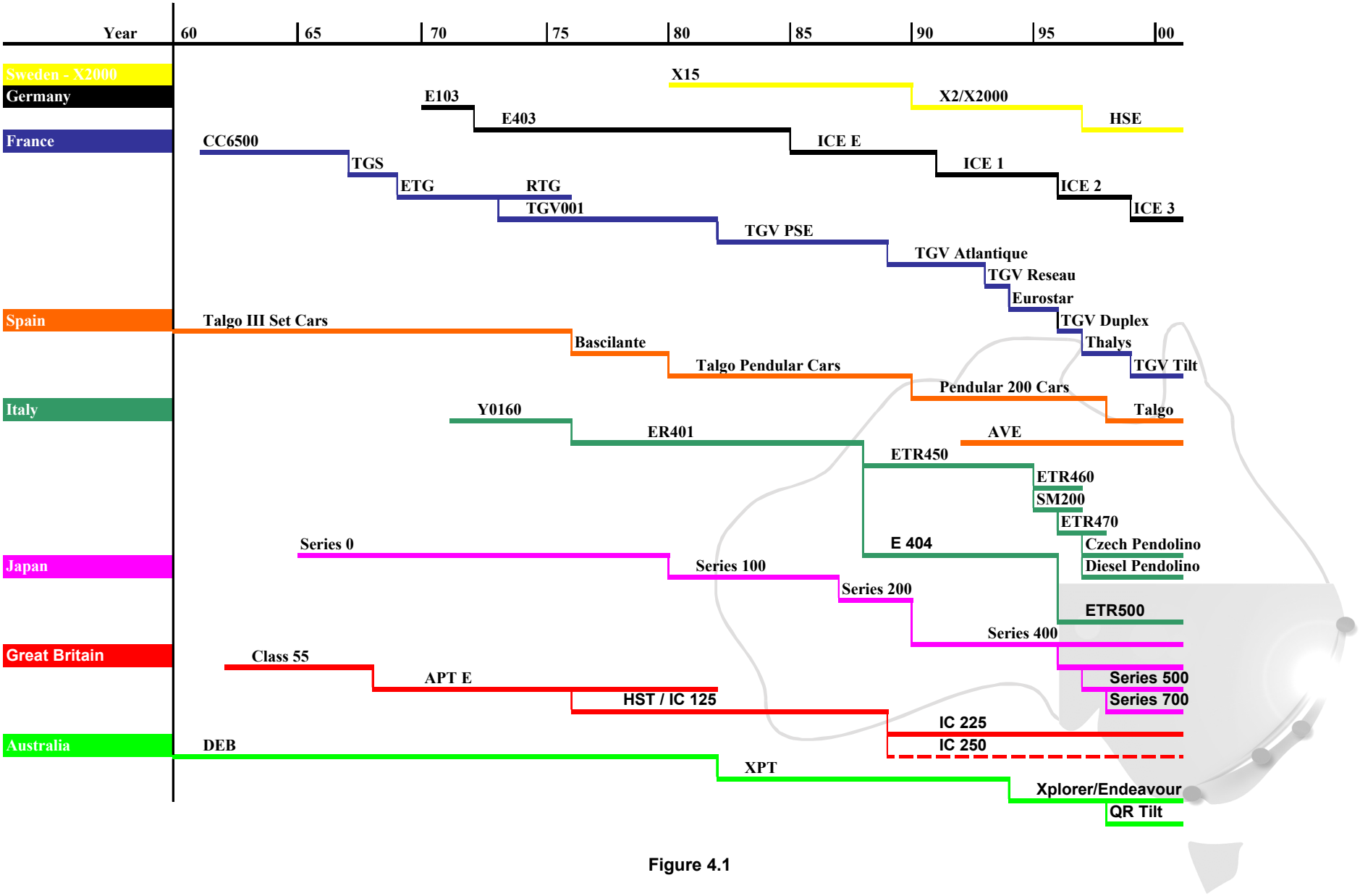

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CC6500
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RTG
TGV001
TGV PSE
TGV Atlantique
TGV Reseau
Eurostar
TGV Duplex
Thalys
TGV Tilt
Talgo III Set Cars
Bascilante
Talgo Pendular Cars
Pendular 200 Cars
Talgo
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ER401
ETR450
ETR460
SM200
ETR470
Czech Pendolino
Diesel Pendolino
E 404
ETR500
Series 0
Series 100
Series 200
Series 400
Series 500
Series 700
Class 55
APT E
HST / IC 125
IC 225
IC 250
DEB
XPT
Xplorer/Endeavour
QR Tilt

Figure 4.1

Figure 4.2

Manufacturer	Principal Country(ies) of Manufacture	Selected Trains	Power System	Tilting Suspension	Passenger Capacity	Train Length	Commissioning Date	In Service in:	Train Sets in service
Alstom incorporating Fiat Ferroviare	France	TGV Thalys	DC/AC	No	377	200	1996	FR/Bel/Ned	17
		TGV Duplex	DC/AC	No	545	200	1996	France	30
		TGV Reseau	DC/AC	No	377	200	1993	France	90
		TGV Eurostar	DC/AC	No	794	394	1994	Britain/France	38
		TGV AVE	DC/AC	No	329	200	1992	Spain	34
		TGV Atlantique	DC/AC	No	485	237	1989	France	105
		TGV SE	DC/AC	No	368	200	1981	France/Switz	109
		TGV Korea	AC	No	935	388	2001	Korea	46
		Pendolino ETR460	AC	Yes	478	237	1992	Italy/France	25
	Italy/France	Pendolino WMCL	DC	Yes	296	217	2001	Britain	53
		Pendolino Alaris	AC	Yes	81	160	1999	Spain	10
		Pendolino S220	AC	Yes	262	159	1995	Finland	25
		Pendolino ETR 470	AC	Yes	473	237	1996	Switz/Italy/France	9
Bombardier Adtranz		ETR 500	AC/DC	No	590	328	1996	Italy	60
		Acela Express	AC/Diesel	No	304	203	n/a	USA	n/a
	Germany	EMU Signatur	AC	Yes	240	109	1997	Norway	22
	Britain	ICN	AC	Yes	557	189	n/a	Switz	n/a
	Canada	ICE TD (1)	Diesel/AC	Yes	195	107	2000	Germany	20
	United States	Voyager	Diesel/AC/Yes	n/a	188	93	n/a	Britain	78
	Germany	Regina Widebody	n/a	Yes	180	53	n/a	Sweden	35
		X2000	AC	Yes	329	165	1996	HongKong/China	n/a
		Contessa	n/a	n/a	237	79	n/a	Denmark/Sweden	n/a
	Australia	Endeavour	Diesel	No	n/a	n/a	n/a	Australia	n/a
		Electrostar	DC	No	242	80	n/a	Britain	n/a
		Turbostar	Diesel	No	130	n/a	n/a	Britain	n/a
Kawasaki Heavy Industries, Hitachi and others	Japan	500	AC	No	1324	400	1997	Japan West	9
		200	AC	No	n/a		1982	Japan East	66
		700	AC	No	1323	400	1999	Japan Central-Wes	42
		E2	AC	No	624	200	1997	Japan East	29
		E3	AC	No	n/a	120	1997	Japan East	19
		E1	AC	No	1200	300	1994	Japan East	6
		E4	AC	No	1640	400	1997	Japan East	19
		400	AC	No	n/a	120	1992	Japan East	12
Siemens/Adtranz/Bombardier	Germany	ICE 3	AC/DC	No	415	200	1999	Europe wide	54
Siemens + Adtranz		ICE 2	AC	No	399	205	1997	Germany	44
Siemens		Venturio	AC/Diesel	Yes/No	n/a	n/a	In development	n/a	n/a
Siemens/Fiat/Bombardier		ICE T	AC	Yes	361	185	1998	Germany	43
Siemens + Fiat		CPA Class 4000	AC	Yes	301	150	1999	Portugal	10
		470	AC	Yes	475	230	1996	Italy	9
		ICE TD	Diesel	Yes	195	98	2000	Germany	20
		610	Diesel	Yes	136	n/a	1992	Germany	20
Talgo	Spain	XXI	Diesel/AC	Yes	400	200			
		I-250	AC	n/a	237	102		Spain	
		350	AC	Yes	400	200	2001	Spain	n/a
JR Central	Japan	Maglev - MLX01	Linear Induction	No	80	77	Trial	Yamanashi Test Line	
ThyssenKrupp and Siemens	Germany	Transrapid	Linear Induction	No	562	120	2004	China - Shanghai	3

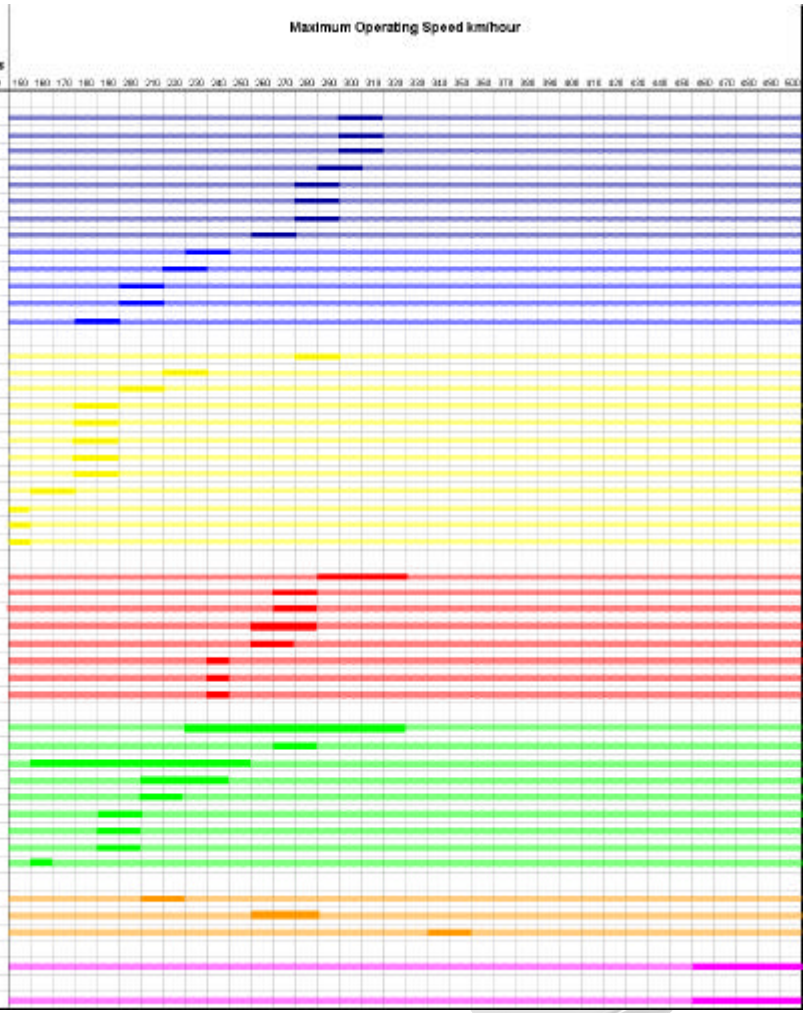


Table 4.2 - European Very High Speed Train Rolling Stock Comparisons

Railway	LCR	SJ	SNCF				DB	FS		RENFE
Train	Eurostar	X2000	TGV-PSE	TGV-A	TGV-R	TGV-NG	ICE2/1	ETR460	ETR500	AVE100
Configuration	P+18T+P	P+3T+D	P+8T+P	P+10T+P	P+8T+P	P+8T+P	P+6T+D	6M+3T	P+11T+P	P+8T+P
Length (m)	394/343	115/97	200/150	238/187	200/150	200/150	205/185	237	328/287	200/150
Width (m)	2.81	3.08	2.81	2.90	2.90	2.90	3.02	2.80	2.85	2.90
Laden wt (t)	816	271	418	484	416	418	416	417	602	416
Seats	770	216	368	485	377	377	394	456	581	329
Pax area (m^2)	1.25	1.38	1.15	1.12	1.15	1.15	1.42	1.46	1.41	1.32
Wt/pax (kg)	1060	1255	1136	998	1103	1109	1056	914	1036	1264
V_{Max} (km/h)	300	210	270	300	300	350	280	250	300	300
V_{Bal} (km/h)	-	-	-	-	-	-	-	-	-	-
Init acc (m/s^2)	-	-	-	-	-	-	-	-	-	-
Motors-no	12	4	12	8	8	12	4	12	8	8
-size (kW)	1020	815	537	1100	1100	1100	1250	490	1100	1100
-type	AC	DC	DC	AC	AC	AC	AC	AC	AC	AC
Cont rating (kW)	12200	3260	6450	8800	8800	13200	5000	5880	8800	8800
P/W (kW/t)	15.0	12.0	15.4	18.2	21.2	31.6	12.0	14.1	14.6	21.2
Cons (Wh/tkm)	-	-	-	-	-	-	-	-	-	-

Table 4.3 - Japanese Shinkansen Rolling Stock Comparisons

Company	JR			JR-E		JR-C/JR-W	
Series	0	100	300	200	E1	500	700
Configuration	16M	12M+4T	10M+6T	12M	6M+6T	16M	12M+4T
Length (m)	392	395	395	300	300	397	397
Width (m)	3.38	3.38	3.38	3.38	3.38	3.38	3.38
Laden wt (t)	970	925	710	697	692	688	708
Seats	1340	1321	1323	885	1235	1324	1323
Pax area (m^2)	0.99	1.01	1.01	1.15	0.82	1.01	1.01
Wt/pax (kg)	724	700	537	788	560	520	535
V_{Max} (km/h)	220	220	270	275	240	300	285
V_{Bal} (km/h)	235	276	296	-	-	365	338
Init acc (m/s^2)	0.37	0.44	0.44	-	-	0.53	0.54
Motors-no	64	48	40	48	24	64	48
-size (kW)	185	230	300	230	410	275	275
-type	DC	AC	AC	DC	AC	AC	AC
Cont rating (kW)	11840	11040	12000	11040	9840	17600	13200
P/W (kW/t)	12.2	11.9	16.9	15.8	14.2	25.6	18.6
Cons (Wh/tkm)	46.4	39.4	57.9	-	-	-	-

Table 4.4 - Actual and Hypothetical (Very) High Speed Train Rolling Stock Comparisons for MTRAIN Simulation

MTRAIN code	VH16	XPT	XNEC	AIM2	TGVR	TGVM	TGVX	GMGL
Type	MU	FF	FF	MU	FF	FF	FF	MU
Configuration	4M	P+7T+P	P+4T+D	4M	P+8T+P	P+8T+P	P+8T+P	4M
Length (m)	101	204/169	143/125	104	200/150	200/150	200/150	104
Width (m)	2.92	2.92	2.92	2.92	2.90	2.90	2.90	3.70
Laden wt (t)	252	450	340	196	416	416	424	253
Seats	210	409	287	210	377	377	377	272
Pax area (m^2)	1.40	1.21	1.27	1.45	1.15	1.15	1.15	1.41
Wt/pax (kg)	1200	1100	1185	933	1103	1103	1125	930
V_{Max} (km/h)	160	160	250	250	300	350	500	500
V_{Bal} (km/h)	-	-	-	-	-	-	-	-
Init acc (m/s^2)	-	-	-	-	-	-	-	-
Motors-no	4	2	4	12	8	8	12	-
-size (kW)	559	1492	1400	480	1100	1540	1540	-
-type	Diesel	Diesel	AC	AC	AC	AC	AC	AC
Cont rating (kW)	2236	2700 nett	5600	5800	8800	12300	18450	40000
P/W (kW/t)	8.9	6.0	16.5	29.6	21.2	29.6	43.5	158.1
Cons (/|Wh/tkm)	22.1 /	8.6 /	59.3 Wh	-	63.0	75.0 Wh	123.1 Wh	112.8 Wh

Table 4.5 - Train Performance Comparisons over a Hypothetical 100 Kilometres Level Tangent 500 km/h Route

MTRAIN Code	Train Type	Train Consist	Energy Source	Max Speed (km/h)	Gross Weight (t)	Travel Time (min)	Total Energy Consumption		Average Speed (km/h)	Specific Energy Consumption	
							(l)	(kWh)		(l/1000tkm)	(Wh/tkm)
VH16	MU	4M	Diesel	160	252	40.0	556.0	-	150.2	22.1	-
XPT	FF	P+7T+P	Diesel	160	450	40.6	388.3	-	147.8	8.6	-
XNEC	FF	P+4T+D	Electric	250	340	26.3	-	2016	228.1	-	59.3
AIM2	MU	4M	Electric	250	196	26.0	-	?	231.3	-	?
TGVR	FF	P+8T+P	Electric	300	419	23.0	-	2639	260.5	-	63.0
TGVM	FF	P+8T+P	Electric	350	419	20.6	-	3143	291.2	-	75.0
TGVX	FF	P+8T+P	Electric	500	424	17.7	-	5221	339.9	-	123.1
GMGL	MU	4M	Electric	500	253	15.1	-	2853	396.5	-	112.8

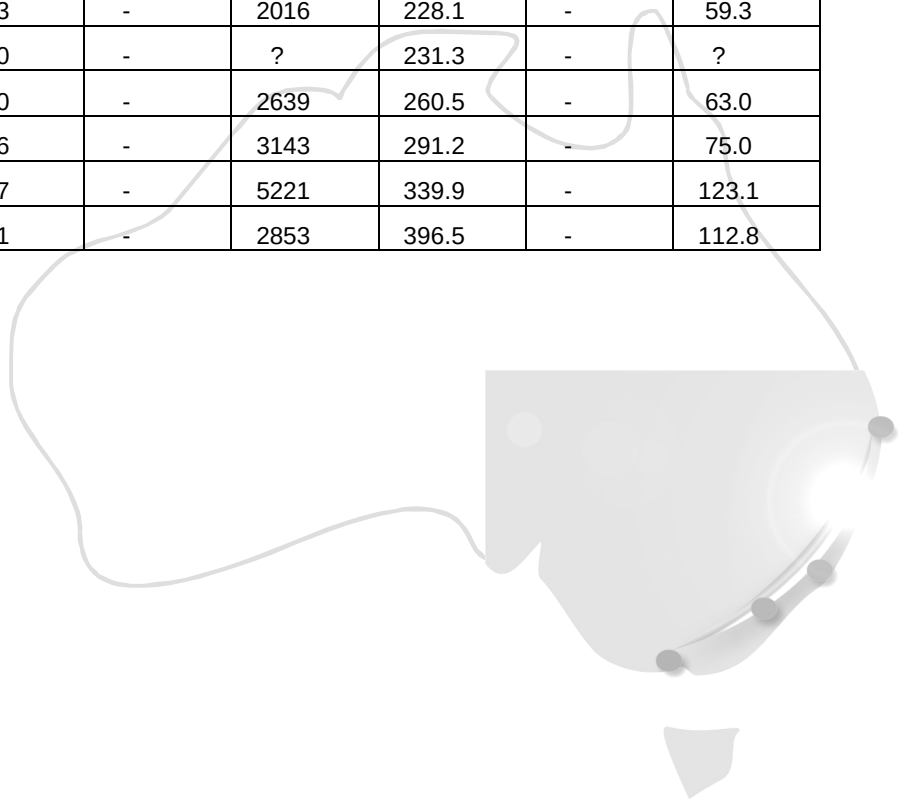


Figure 4.3: **A Vertical Profile of the Sevilla - Madrid AVE (High Speed Line) Exhibiting Similar Geographic Impediments to a Typical Inland Sydney - Canberra - Melbourne VHST Corridor**

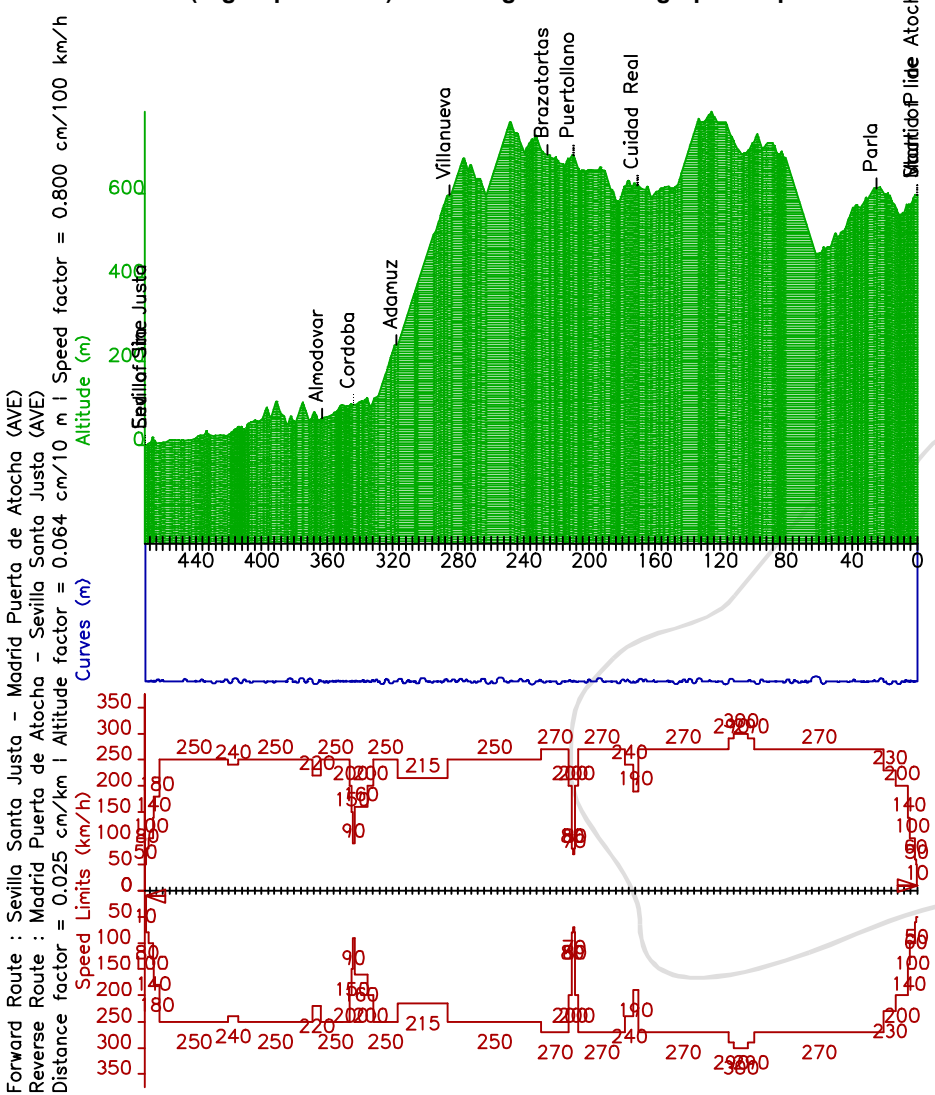


Figure 4.4: Maximum Speed for Different VHST Types

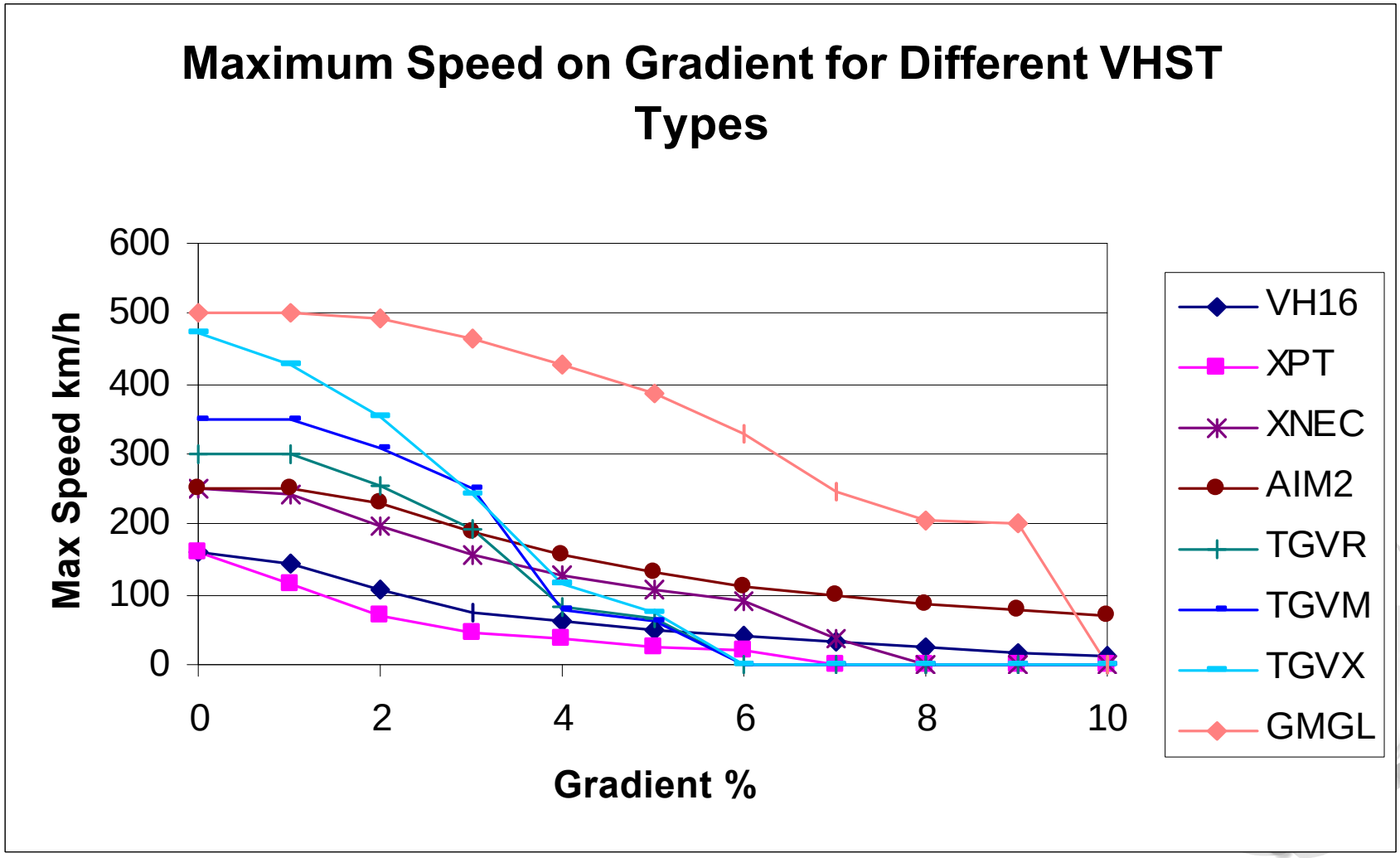


Figure 4.5: Speeds around curves for Different Types of Rolling Stock

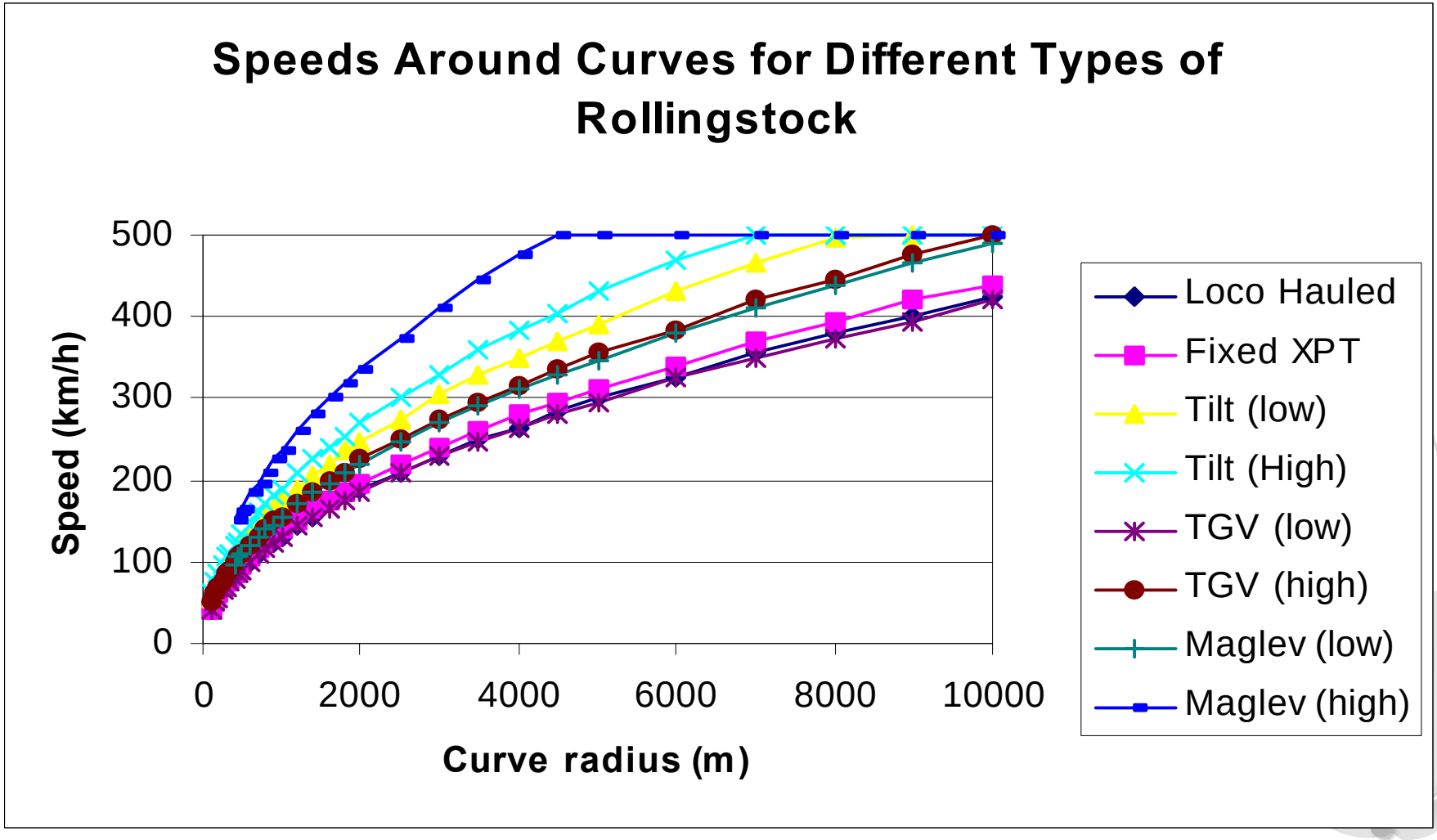


Figure 4.6: A Vertical Profile of a Typical Inland Sydney - Canberra - Melbourne VHST Corridor

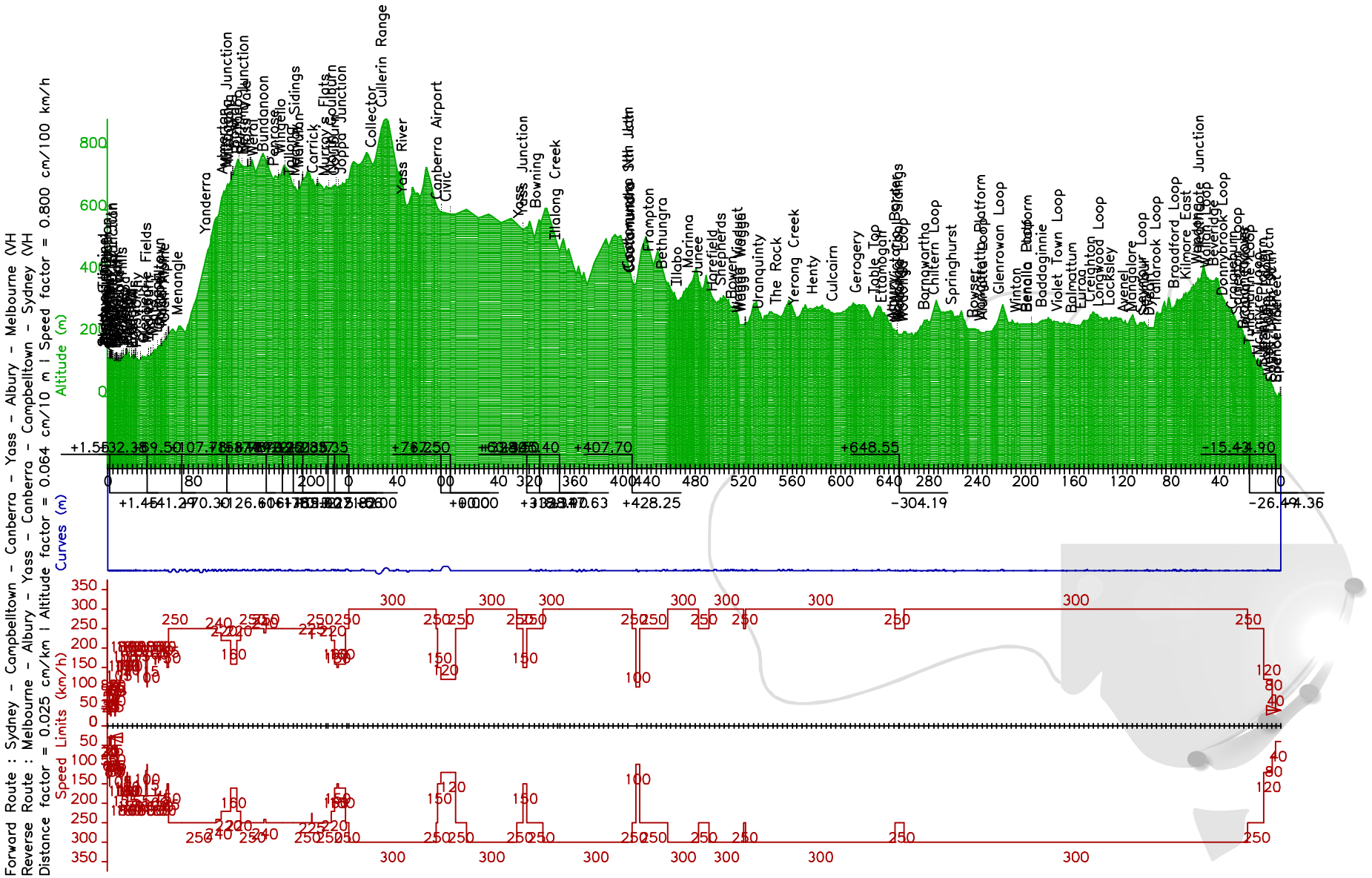


Figure 4.7: A Vertical Profile of a Typical Coastal Sydney - Newcastle - Gold Coast - Brisbane VHST Corridor

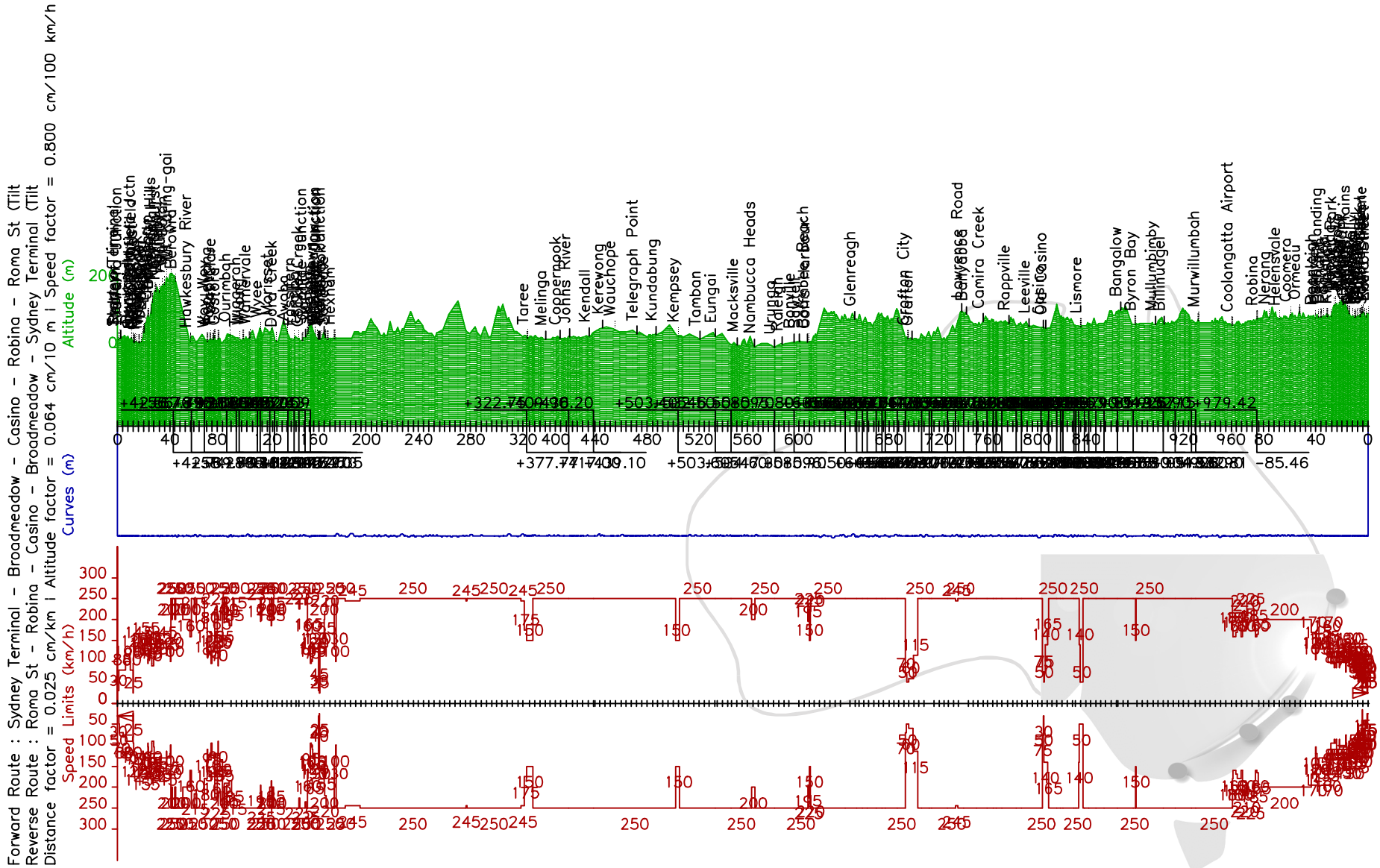


Figure 4.8: Train Performance for Different Types of Trains

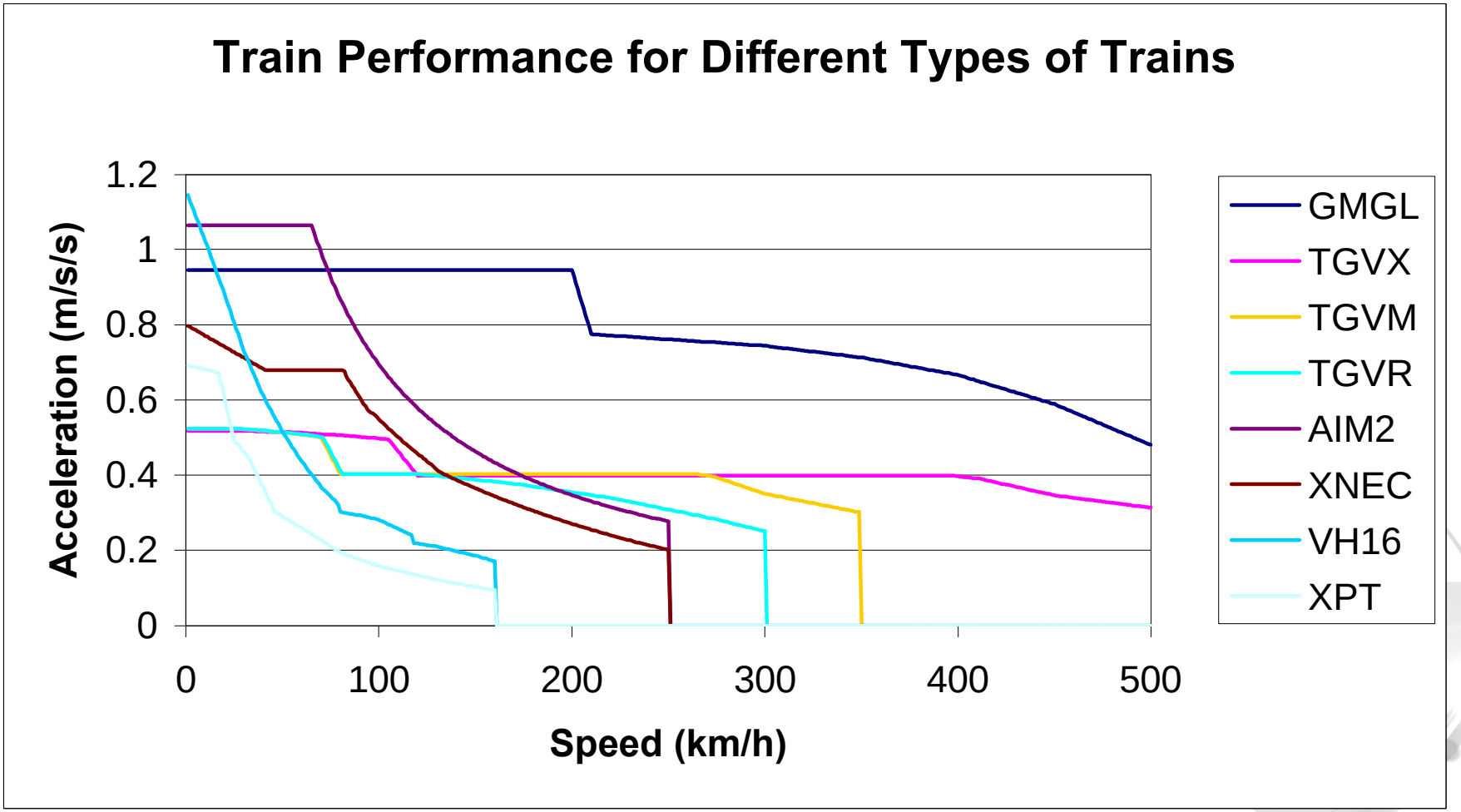


Figure 4.9: **Speed versus Distance Comparison between Different Trains Running over a Hypothetical 100 Kilometres Level Tangent 500 km/h Route**

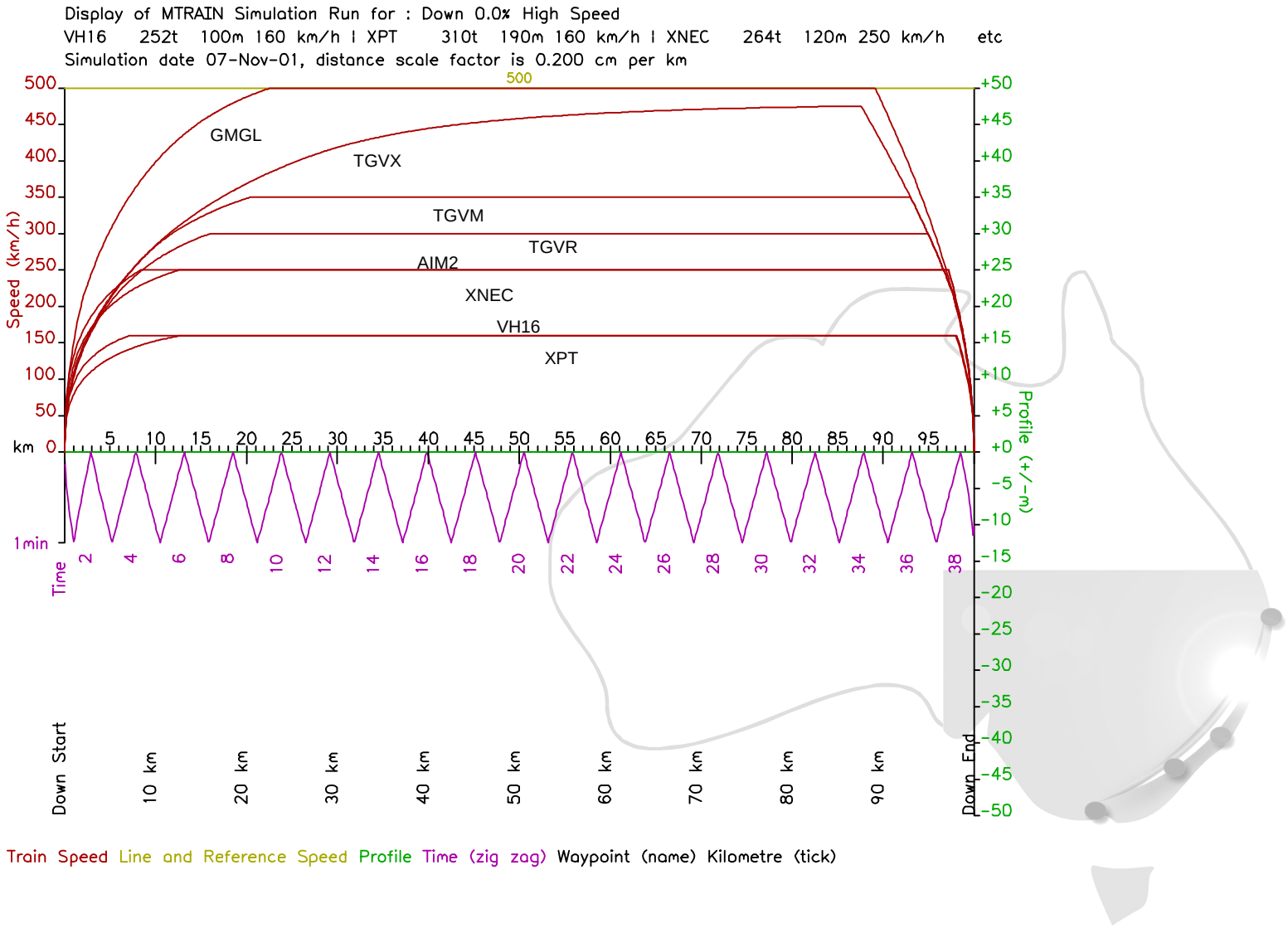
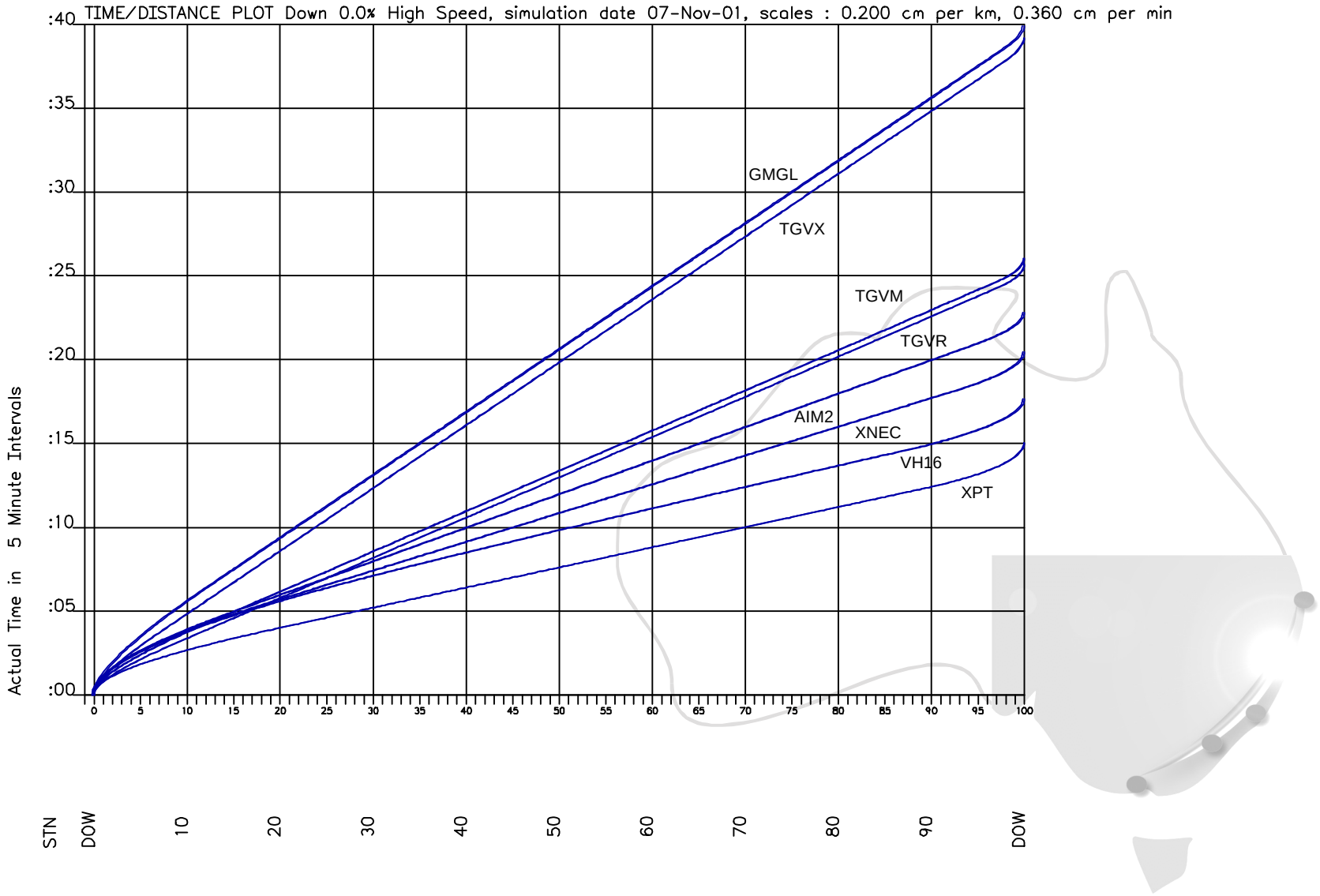


Figure 4.10: **Time versus Distance Comparison between Different Trains Running over a Hypothetical 100 Kilometres Level Tangent 500 km/h Route**



Section 5

The East Coast Transport Corridor



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5. THE EAST COAST TRANSPORT CORRIDOR

5.1 VHST Corridor Planning Principles

A key element in the development of any passenger transport system, be it air or ground-based, is the establishment of the corridor network, ie the linkages (direct and indirect) between points of major demand. The essential purpose of VHST systems is to provide a high speed transport system linking major areas of population that exhibit a strong demand for linkage.

For linear 'on the ground' infrastructure projects with defined end points, such as a VHST, the process of corridor development and selection usually moves progressively from the general to the particular. Early stages of corridor development involve a scanning of a large area between the end points to identify areas of greater or lesser suitability for the proposed infrastructure based on the functional requirements of the facility/service and the physical, environmental and socio-economic characteristics of the study area. In areas of greater suitability, alternative corridors are determined within which feasible options or alignments could be located. Based on a set of criteria that embrace cost, environmental, engineering, community and strategic considerations, an assessment is made of these alternative corridors to identify the most suitable corridor. Within the preferred corridor, one or more detailed alignments can be developed which represent the extent and nature of the actual 'on the ground' proposal. Further assessment can be undertaken of these alignments and sub-options for particular sections to arrive at a preferred/approved alignment.

For ground-based transport systems such as a VHST, a number of key principles contribute to the strategic planning of a network, those relating to corridor identification at the strategic level being discussed in Section 5.1.1 and 5.1.2.

5.1.1 Transport Planning

- providing the most direct linkage between determined end points (the rhumb line);
- linking areas of high passenger travel demand – this relates to the propensity of a given population to travel and the location of land uses or attractions that generate strong travel demands rather than just sheer population size; and
- the ability to integrate and provide an interchange with other transport modes.

5.1.2 Engineering Design/Operational Requirements

- ability to meet specified operational requirements, especially travel speeds and operational safety;
- vertical alignment - utilising flat or moderating topography as far as possible (generally maximum slope of 1%-2% for SWSR VHSTs) with limited areas with of slope in excess of 3%;
- horizontal alignment – VHSTs require wide radius curves, ideally a minimum of 3000-4000 metres. Curves with a smaller radius result in lower operational speeds for a VHST;
- reducing the extent of earthworks overall and, where earthworks are required, ensuring that a 'cut and fill' balance can be achieved within given sections of a corridor;
- reducing the extent and complexity of structures such as bridges and tunnels;
- ability to use existing rail corridors and other infrastructure such as stations; and
- avoiding areas with geotechnical difficulties or requiring expensive or unproven construction techniques.

5.1.3 Environmental Considerations

- avoiding areas of high conservation significance such as National Parks, RAMSAR wetlands and other areas with high biodiversity values (both terrestrial and aquatic environments);
- avoiding areas of high cultural heritage significance – both indigenous and non-indigenous;
- reducing the potential for noise and other adverse operational impacts on nearby communities;
- avoiding impacts on 'non footloose' strategic land uses such as energy and mineral deposits, forestry resources, and investment intensive land uses; and
- optimising land take to reduce strategic severance and circulation impacts.

These principles have been applied to the broad area between Melbourne, Canberra, Sydney and Brisbane to derive candidate corridors. For the purposes of this study, a VHST corridor has been established as a band approximately 40 km wide within which alternative routes and detailed alignments could be progressively established at later stages of planning.

5.2 Existing Broad Distribution of Population

The south-east corner of Australia between Brisbane and Melbourne contains over 75% of the national population. The majority (55%) of this population is located in the three State capital cities – Sydney, Melbourne and Brisbane with an additional 10% of population located in the urban areas of Canberra, Newcastle, the Gold Coast, and Wollongong. The remainder is located in the smaller cities and towns and rural areas. (See figure 5.1)

Australia is one of the most urbanized nations in the world with approximately 85% of the population living in urban areas with a population of 10,000 or more. The concentration of population is further evident with approximately 60% of the nation's population living in cities of 1 million or more – Sydney, Melbourne, Brisbane, Perth and Adelaide.

Coupled with this significant concentration of population in a few very large cities are the large distances between them, as indicated by the following 'as the crow flies' distances:

- 730km between Melbourne and Sydney;
- 770km between Sydney and Brisbane; and
- 1370km between Melbourne and Brisbane.

This combination of a few very large cities separated by relatively sparsely populated intervening areas and long distances has particular implications for the planning and provision of cost and time efficient long distance transport, especially VHST systems.

5.2.1 Population Dynamics

The two main dynamic processes driving settlement patterns in Australia and in south-east Australia in particular are:

- the continued spread of urbanization along the coastline – this process is particularly evident along the northern New South Wales coast and in the Gold Coast area of south-east Queensland; and
- the continuing concentration of population in the nation's five largest cities, with Sydney increasing its population dominance in both an absolute and relative sense.

Both of these processes have implications for the provision of long distance transport services between Melbourne and Brisbane.

Population Growth along the Coastline

This phenomenon is eliciting planning policy responses from governments, the most recent example being the NSW Government's Coastal Policy released in May 2001 which aimed at protecting areas of environmental significance and stemming uncoordinated urbanization right along the coastline.

Areas of rapid population growth such as the Far North Coast in New South Wales and the Gold Coast in Queensland are generally driven by lifestyle factors such as amenity for retirees, access to the coastline, and warmer climate rather than traditional economic factors such as a wider range of job opportunities.

Continuing Concentration of Population in the Five Largest Cities

The historical dominance of Australia's five major cities as locations of administrative, commercial, welfare and other services is arguably being challenged by the increasing internationalization of the Australian economy. This question was discussed in *Australia: State of the Environment 1996*[1] in the following way:

"The outcome of increased competition between cities depends on their ability to provide goods and services for the national and international marketplace. Success can be measured by the number of basic or export-oriented firms located in a city, the extent to which it is interlinked with national and global telecommunication networks (as distinct from local or regional ones), the number of people with key skills (human capital), and the number of multinational corporation offices. …Other indicators are the number of international firms based in the cities and the relative success of each city in attracting capital investment…."

On these criteria, Sydney is rapidly increasing its dominance in the nation's urban hierarchy. It is now Australia's pre-eminent international city in terms of the location of global corporations and communications networks. Melbourne is also an international city to a lesser extent. Both differ from other major Australian cities in terms of their concentration of export-oriented industries (other than raw or lightly processed rural and mineral commodities), innovative human capital and infrastructure supporting manufacture and producer service industries..[2] Brisbane, Perth, and Adelaide remain largely regional cities but ones whose global orientations are growing, particularly in the past decade.[3]

[1] State of the Environment Advisory Council, *Australia: State of the Environment 1996*
[2] Newton 1995, O'Connor and Stimson 1994, and in press
[3] State of the Environment Advisory Council, op. cit., 3-6 to 3-7

Population Projections

Population projections generally indicate that this broad pattern of population distribution and population dynamics will continue with marginal rather than significant changes likely such as the higher rate of population growth likely in the Gold Coast region than in metropolitan Brisbane.

5.3 Environmental Context

The environment of south-east Australia from Melbourne to Brisbane covers a wide range of natural ecosystems that have been significantly influenced by European settlement especially through the development of agriculture, forestry, mining and urbanisation. The fragility of many of these ecosystems is graphically illustrated by the devastating effects of land clearing and salinisation, the deterioration of water quality in inland and coastal waterways, and the number of flora and fauna species that are either threatened or endangered as a result of habitat loss.

The potential environmental impacts of a VHST system relate principally to:

- the development by means of land disturbance and clearing of a relatively narrow linear route which potentially results in the permanent loss of vegetation, indigenous cultural heritage items, and existing land uses; and
- the key operational impacts on the environment of noise, visual impact and changed access patterns at the regional and local levels.

Areas in East Coast Australia that could potentially be traversed by a VHST system embrace a range of environmental characteristics and sensitivities. Based on the range of environmental impacts associated with VHST development internationally, the actual potential impacts of VHST development and operation would depend on the characteristics of the receiving environment. The extent to which areas of high environmental value can be avoided in relation to alignment development and the opportunity to mitigate operational impacts such as noise in densely populated areas would assist in reducing overall adverse environmental impact of VHST development.

The various combinations of terrain, geology, vegetation and hydrology in south-east Australia result in extensive mountainous areas of high ecological value. This is reflected in the almost continuous chain of large areas of land under statutory protection, generally under State legislation, for their conservation or natural resource (forestry) values from the outskirts of metropolitan Melbourne to the south of Brisbane (See figures 5.2 and 5.3). This protection is generally further reinforced through complementary land use planning controls which usually prevent transport infrastructure 'as of right', ie a zoning amendment would be required.

In contrast to the mountainous, vegetated areas with high diversity of flora and fauna habitats are the foothills and plains areas that have been largely cleared for agricultural development with only remnant areas of ecological significance.

The need to prevent further loss of biodiversity throughout Australia is reflected in a range of statutory and policy initiatives generally aimed at achieving a 'no net loss' or 'a net gain' in terms of impacts on native vegetation and associated biodiversity.

Within Australia's large metropolitan areas, the extent of environmental change has generally been extensive so that areas remaining in a natural or quasi-natural state are of considerable value. However, the contemporary realities of major infrastructure development in metropolitan areas suggest that development options for metropolitan sections of a VHST would be either through:

- use of existing surface rail or other transport corridors; or
- development of new alignments in tunnels.

Metropolitan access issues are discussed in section 6.9.



Photo courtesy of UIC

5.4 Engineering Context

The East Coast of Australia, taken as that broad strip of Southeastern Australia running from Brisbane through Sydney and Canberra to Melbourne, presents significant challenges to the provision of ground transport of whatever speed. Brisbane, Sydney and Melbourne all lie on the coastal strip to the east of the Great Dividing Range and are connected by a coastal highway but not a continuous coastal railway. There is a significant escarpment between this coastal strip and the immediate hinterland.

The principal Sydney-Melbourne highway and railway connections (which still lie somewhat off the rhumb line between these cities because of the intervening mountain areas) cross the Divide twice. There is the existing choice of taking either coastal or inland highway and railway routes between Sydney and Brisbane (neither of which lie too far off the rhumb line between these cities). The Pacific Highway has to contend with a succession of major estuaries whereas the railway has to contend with two crossings of the Divide.

Those routes which have to cross the Divide must climb to 800 metres or so from sea level in NSW. The crossing in Queensland is then roughly 450 metres above sea level whereas that in Victoria is roughly 350 metres above sea level (directly north of Melbourne). Australia does not have the dominating mountain ranges of some other countries though its geography significantly impedes ground transport.

Between Melbourne and Sydney, the locations of the inland (Hume Highway) and coastal (Princes Highway) major road corridors reflect the heavy engineering impediments associated with a more direct corridor. A more direct link would require traversing highly undulating sections of the Divide for most of its length, requiring extremely high cost engineering solutions.

While Canberra has highway connections to Sydney and Melbourne (and a direct railway to Sydney), it does not lie along the direct highway and railway connections between Sydney and Melbourne. This reflects the historic selection of the national capital approximately mid-way between Melbourne and Sydney, nestled into the edge of the highest zone of the Divide, which makes access to it from the west and south extremely difficult.

Between Sydney and Newcastle, the relatively narrow band in which all major existing transport corridors lie reflects the extreme terrain difficulties associated with linking Sydney with the Central Coast, driven primarily by the Hawkesbury River valley and surrounding escarpments.

At present there is the choice of taking coastal or inland highway and railway routes between Newcastle and Brisbane, neither of which lie too far off the rhumb line between these cities. It can be anticipated that a VHST would generally also follow one of those corridors, even though the coastal route north of Newcastle has to contend with a succession of major estuaries while the inland routes involves two crossings of the Divide.

5.5 Derivation of Candidate VHST Corridors

5.5.1 Approach

The VHST corridor planning principles outlined in section 5.1 were applied to the study area to derive candidate corridors. Application of these principles included:

- defining potential stations/stopping points – this process involved nominating three levels of potential stopping points for an EC VHST, namely:
  - Tier 1 locations – Melbourne, Canberra, Sydney and Brisbane (which were derived from the Ministerial announcement of this study) between which there would be multiple direct services or services with limited intervening stops;
  - Tier 2 locations – major regional population concentrations and key suburban centers that could generate substantial passenger loads and would be served by multiple daily services. The locations in this category are:
    - Victoria
    - in an inland corridor – Melbourne Airport, Seymour, Benalla/Shepparton, Wangaratta, and Albury –Wodonga; and
    - in a Gippsland/coastal corridor – Dandenong, Warragul, Traralgon, and Sale.
    - Australian Capital Territory – no Tier 2 locations;
    - New South Wales
    - in an inland corridor north of Albury – Wagga Wagga, Goulburn, Campbelltown, Sydney Airport;
    - in a Gippsland/coastal corridor south of Canberra - Cooma, while north of Canberra – Goulburn and Wollongong;
    - in an inland corridor north of Sydney – Newcastle, Singleton, Tamworth, Armidale and Toowooomba; and
    - in a coastal Corridor north of Sydney – Gosford, Wyong, Newcastle, Taree, Kempsey, Coffs Harbour, Grafton, and Lismore.

- Queensland –Coolangatta Airport, Robina, and Brisbane Airport.

– Tier 3 locations – smaller regional centres of population and suburban centres which may be served by limited VHST services. The locations in this category are:
  - Victoria – Euroa;
  - ACT – no Tier 3 locations;
  - New South Wales – Cootamundra, Yass, Bowral; and
  - Queensland – Beenleigh.

- Key environmental attributes generally in the area between Melbourne and Brisbane, particularly areas of high environmental value; and
- Consideration of terrain categories/characteristics which would have positive or negative influences on VHST operations .

5.5.2 The Candidate Corridors

The choice of technology may offer some flexibility in terms of detailed route alignment though the strategic considerations of population distribution and physical & environmental constraints will most significantly affect route location.

On the basis of the preceding analyses, the following set of candidate corridors, as shown in figure 5.7, were derived:

Melbourne to Canberra

Between Melbourne and Canberra, there are two broad corridor options for a VHST; one via Gippsland and an Inland corridor via Albury/Wodonga.

Canberra to Sydney

Between Canberra and Sydney, there are two broad corridor options for a VHST – a Coastal corridor via Wollongong and Sutherland, and an Inland corridor via Campbelltown (in both cases, via Goulburn).

These two corridors are dictated largely by the availability of access points to the Sydney metropolitan area (in the south and south-west) and the possibility of accessing either the Southern Highlands (via Campbelltown) or Wollongong (via Sutherland). Beyond these regions, there are no major centres of population which would justify service by VHST, particularly given the mountainous terrain that exists.

Sydney to Newcastle

Northwards from Sydney towards Newcastle, it is reasonable to only nominate one potential corridor for a VHST as:

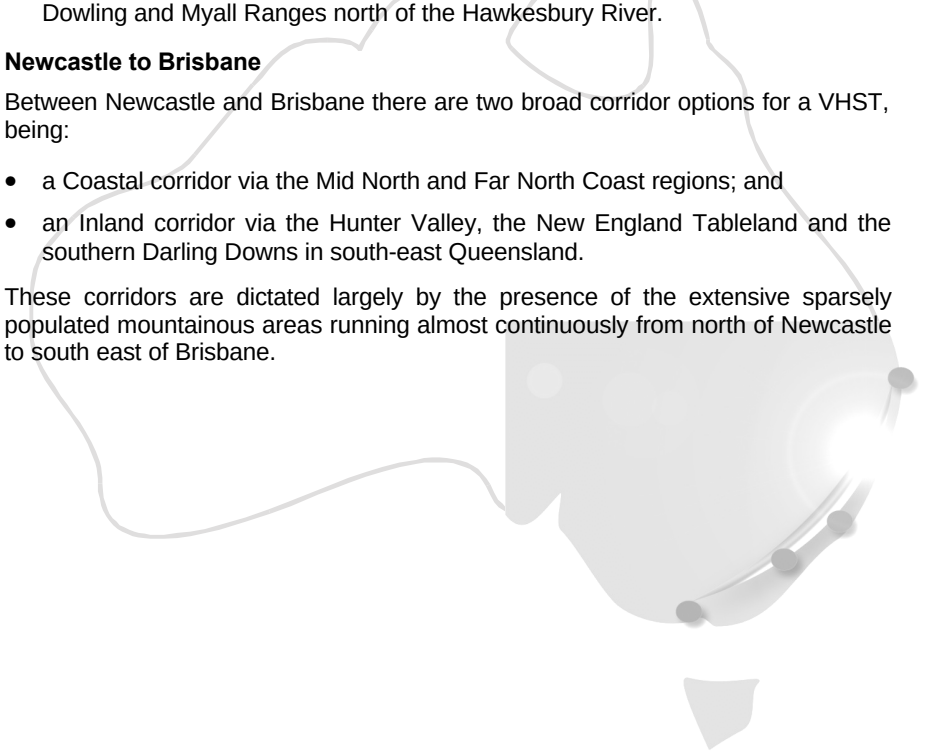
- the objective to find the most direct and operationally efficient corridor for a VHST between Central Sydney and Newcastle which is slightly to the north-east of central Sydney;
- the extent of heavily dissected terrain and related areas of high environmental value generally to the north and north-west of Sydney from less than 20 km north of the centre of Sydney to virtually the south western outskirts of Newcastle – the eastern extent of which is generally marked by the Sydney-Newcastle Freeway; and
- the substantial urban development that extends along the coast east of the Sydney-Newcastle Freeway from north of the Hawkebury River virtually to Newcastle with particular concentrations around Woy Woy, Gosford and Wyong. There are no major inland population centres west of the Judge Dowling and Myall Ranges north of the Hawkesbury River.

Newcastle to Brisbane

Between Newcastle and Brisbane there are two broad corridor options for a VHST, being:

- a Coastal corridor via the Mid North and Far North Coast regions; and
- an Inland corridor via the Hunter Valley, the New England Tableland and the southern Darling Downs in south-east Queensland.

These corridors are dictated largely by the presence of the extensive sparsely populated mountainous areas running almost continuously from north of Newcastle to south east of Brisbane.

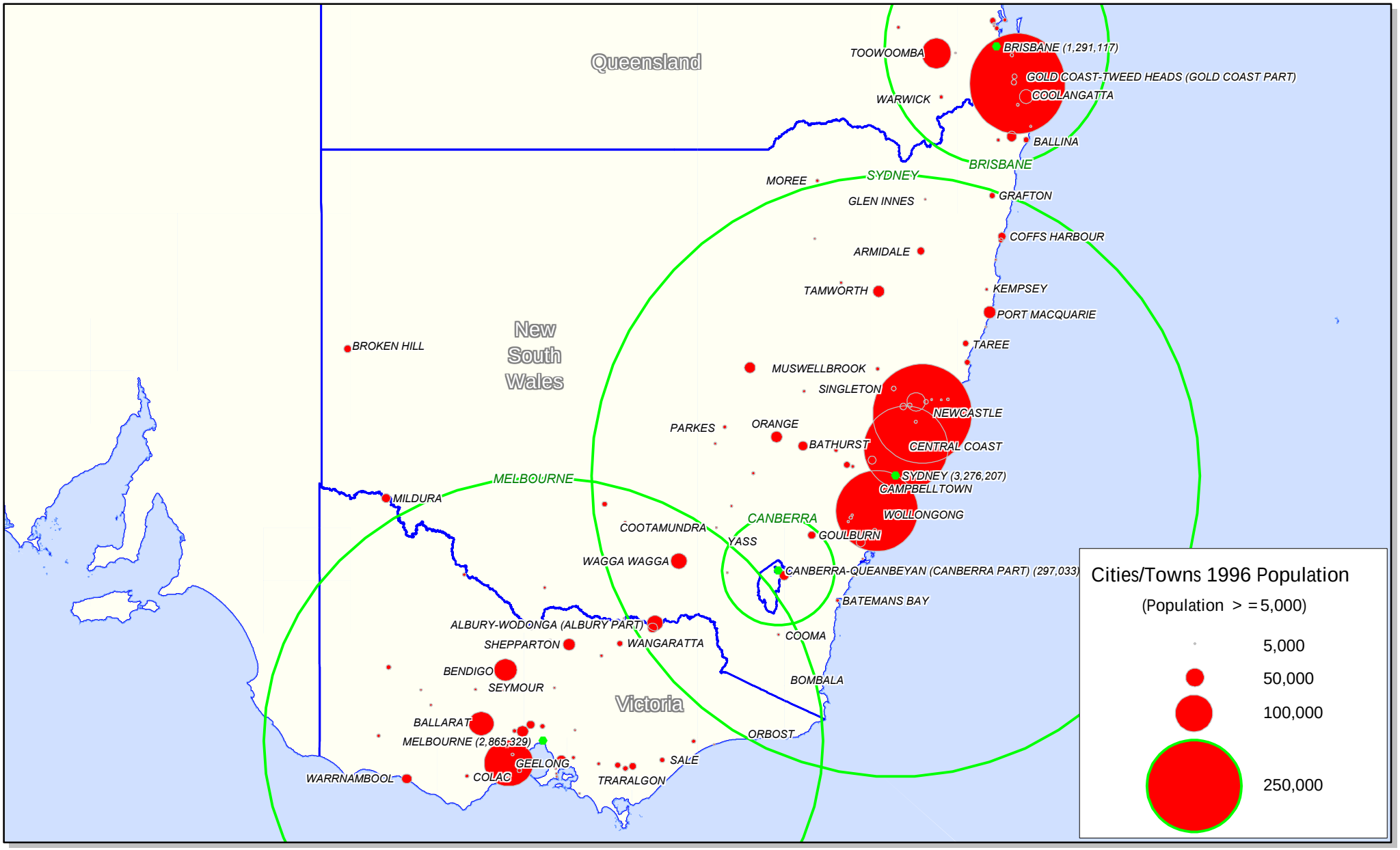


5.6 Key Points

The key conclusions that can be drawn in relation to VHST corridors in the East Coast study area are:

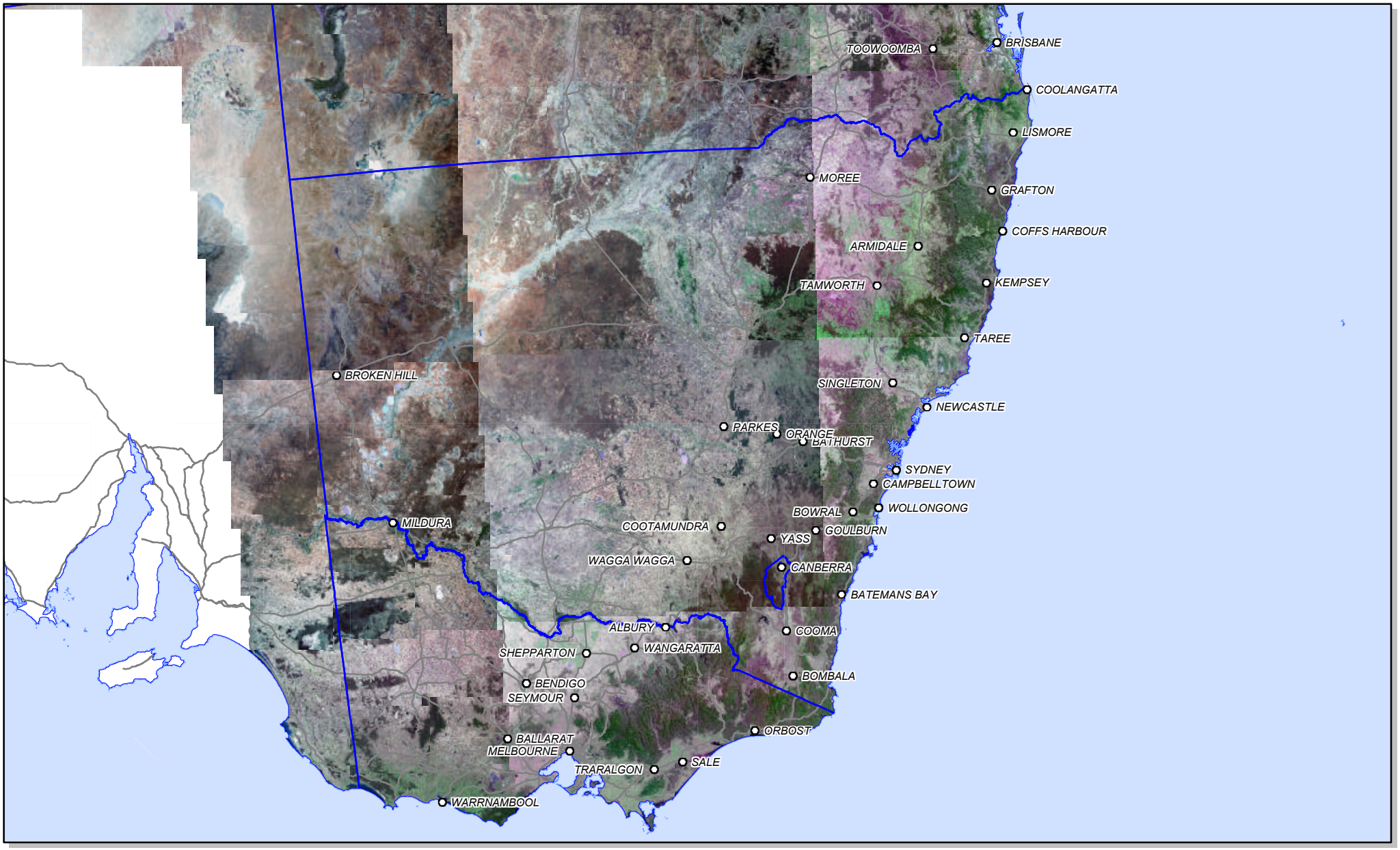
- There are a set of robust and 'universal' VHST corridor planning principles that can be derived from a combination of international experience in the planning for and operation of VHST systems and from Australian experience in the planning of linear infrastructure. These principles would essentially drive the VHST corridor (and subsequent alignment) planning process;
- The existing and future distribution of population in south-east Australia is the primary parameter for VHST planning;
- The current broad pattern of population distribution in south-east Australia, ie dominated by a few very large metropolitan areas and limited areas of non-metropolitan high population growth is unlikely to change significantly in the foreseeable future without significant changes to policy settings and economic activities;
- The optimum operation of a VHST system to achieve travel times competitive with air travel requires long sections of flat, straight alignments. The physical characteristics of south east Australia with extensive and continuous mountainous areas located close to the coastline dictate that for cost-effective VHST development, potential corridors are likely to be located away from these areas (regardless of their environmental attributes);
- Based on current policy settings with regard to biodiversity and environmental protection, large areas of south-east Australia are unlikely to be considered suitable for the location of a VHST system because of the absolute loss of areas of high conservation and cultural heritage value that would result and the related difficulties in achieving biodiversity 'net gain'; and
- The broad candidate corridors that emerge from the application of this process are:
  - between Melbourne and Canberra an 'inland' corridor via Albury/Wodonga and a 'coastal' corridor via Gippsland and the Monaro;
  - between Canberra and Sydney – an 'inland' corridor via Goulburn and the Macarthur/Campbelltown region and a 'coastal' corridor via Wollongong and Sutherland;
  - between Sydney and Newcastle – only a coastal corridor via Gosford/Wyong and lake Macquarie;
  - between Newcastle and Brisbane – an 'inland' corridor via the Hunter Valley, the New England region and the southern Darling Downs and a 'coastal' corridor via the Mid North and Far North Coast regions and the Gold Coast region.





Major Towns/Cities 1996 Population

Figure 5.1

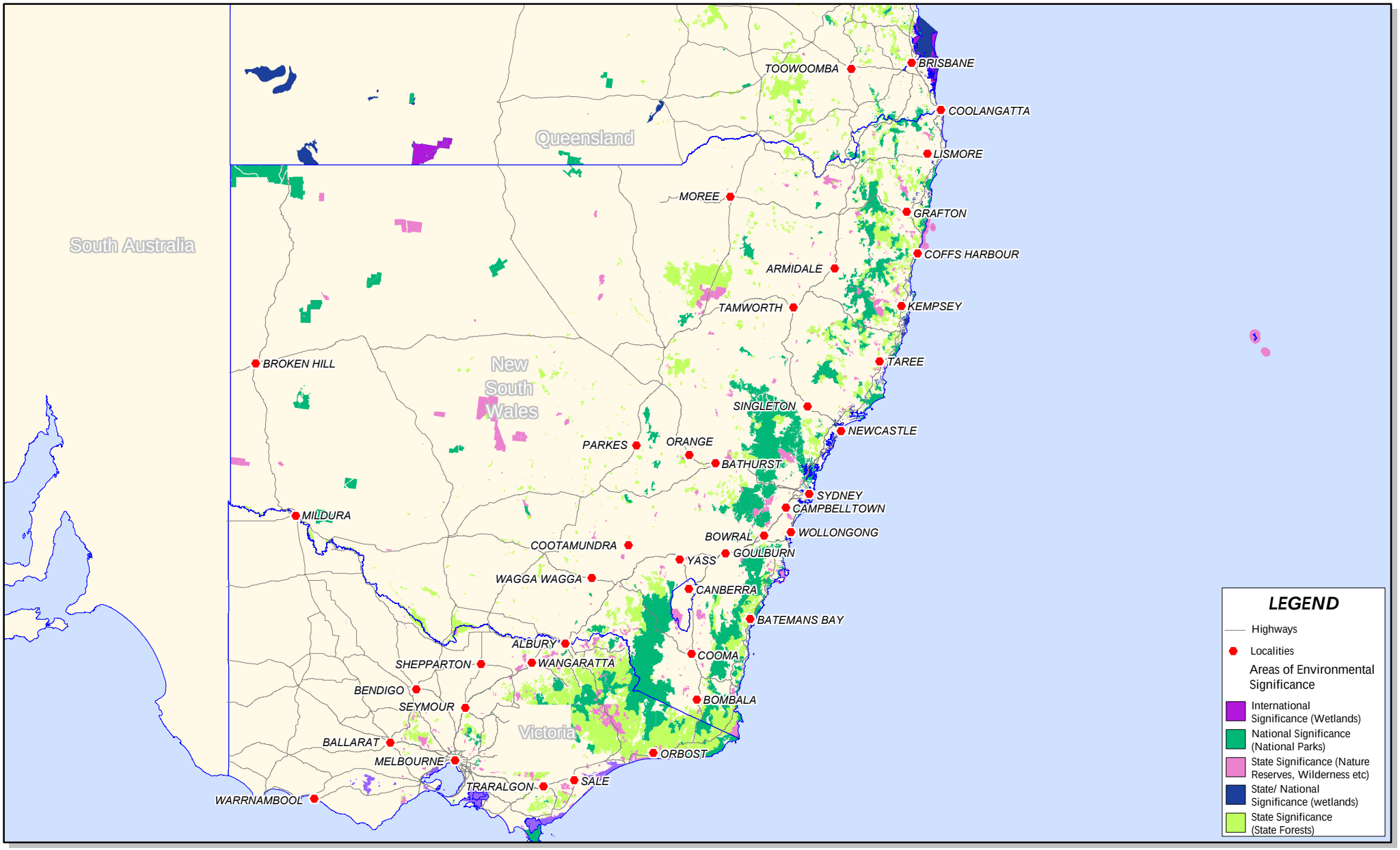


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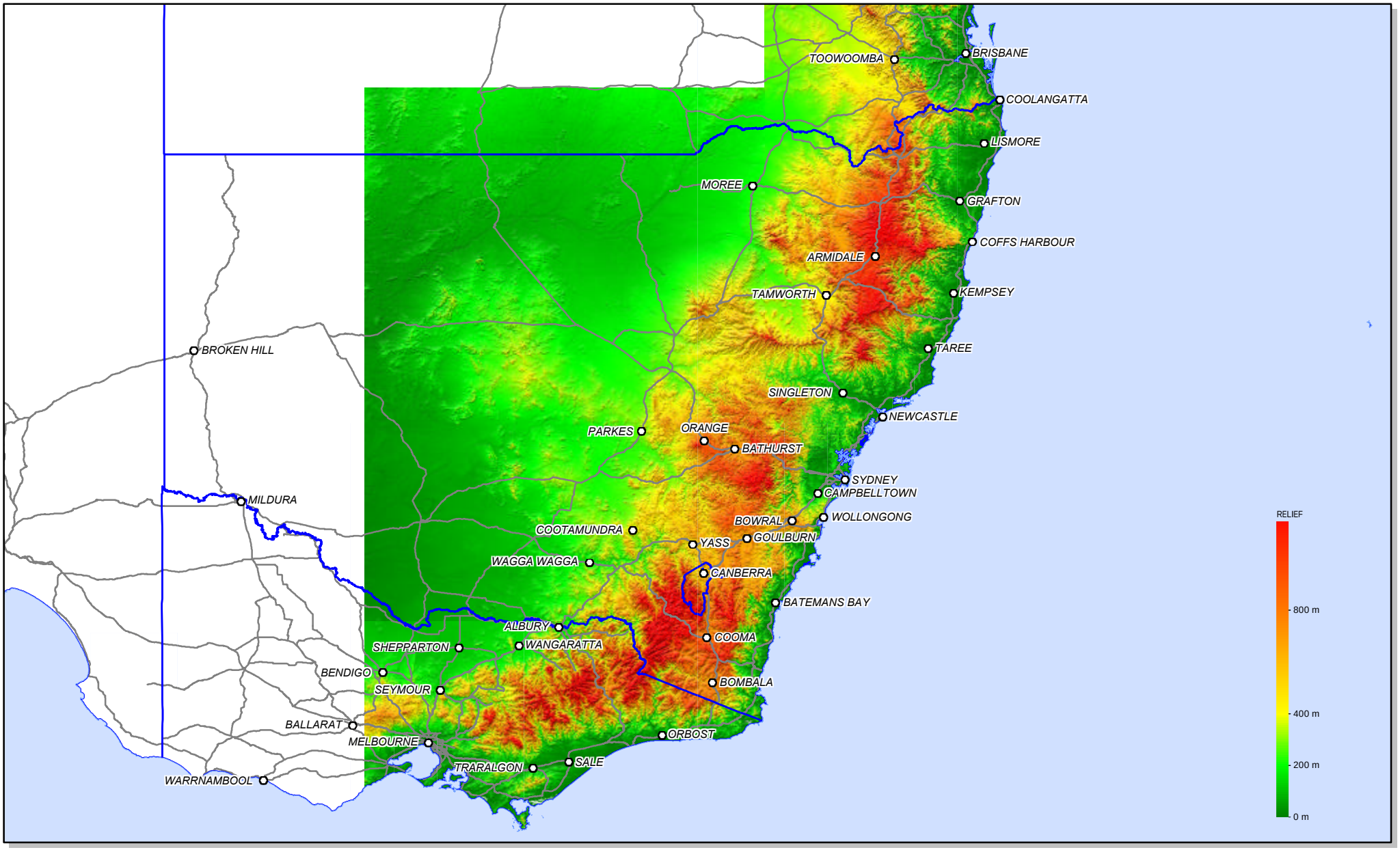
Satellite Image

Figure 5.2



Areas of Environmental Significance

Figure 5.3

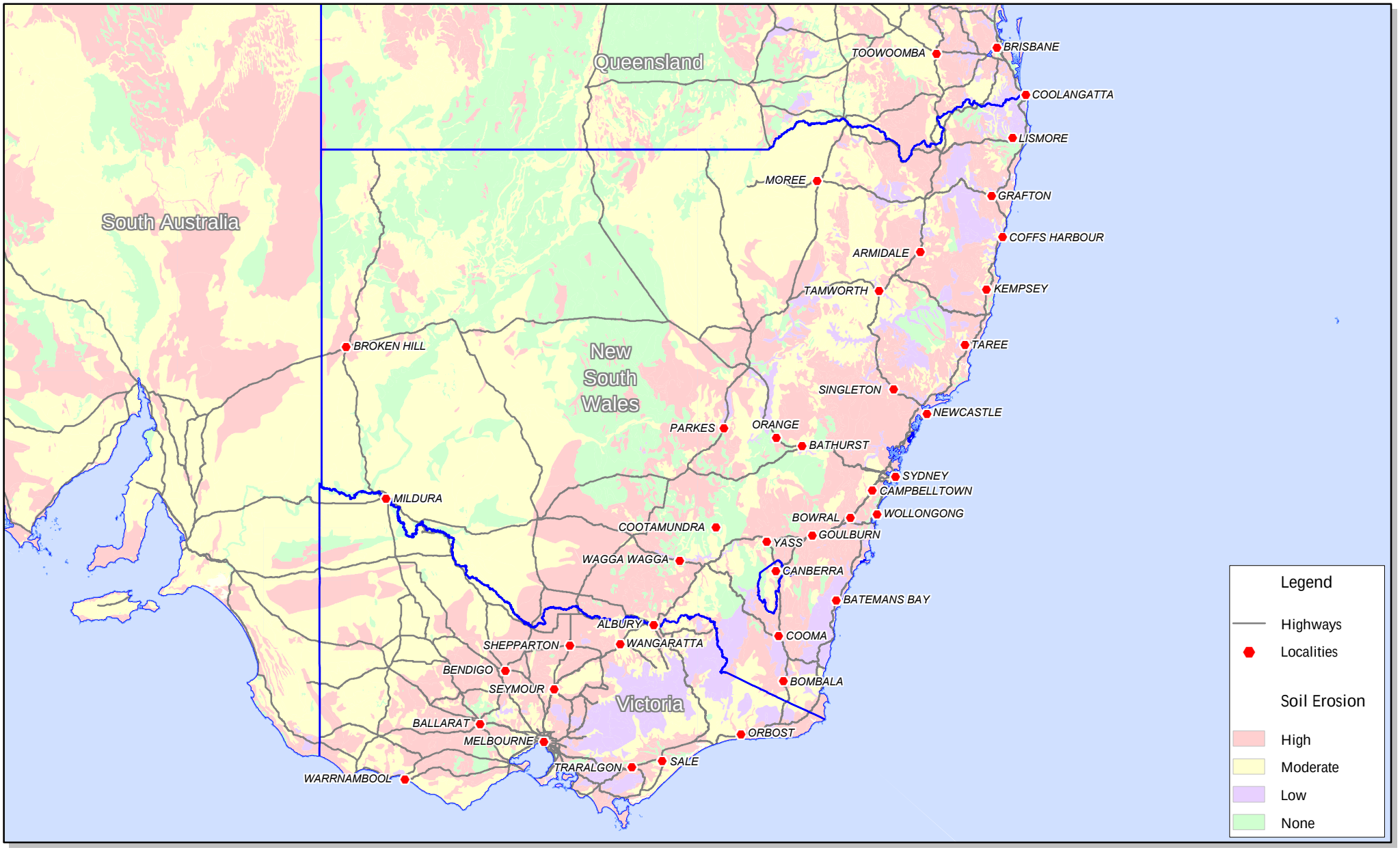


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Terrain Features

Figure 5.4

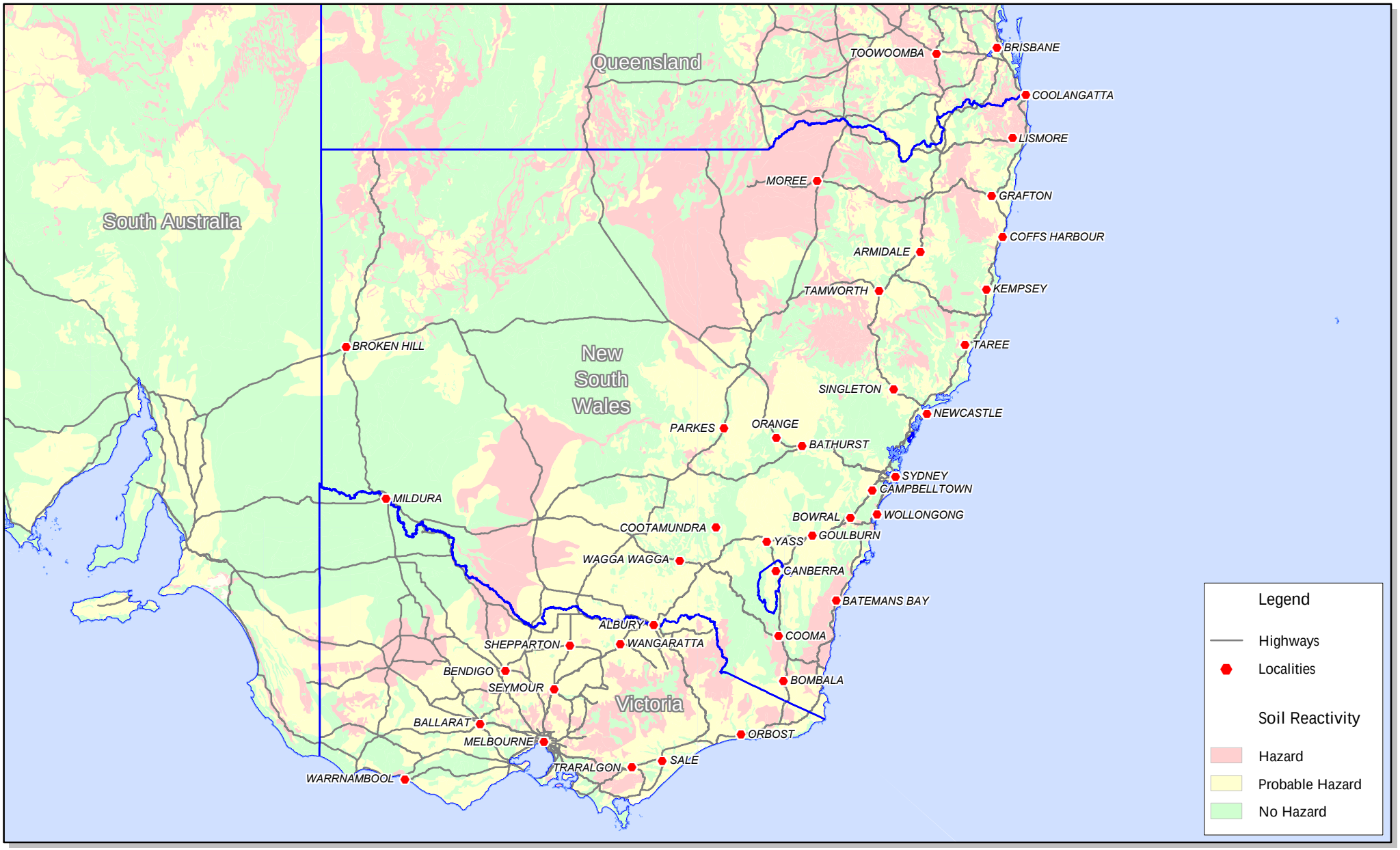


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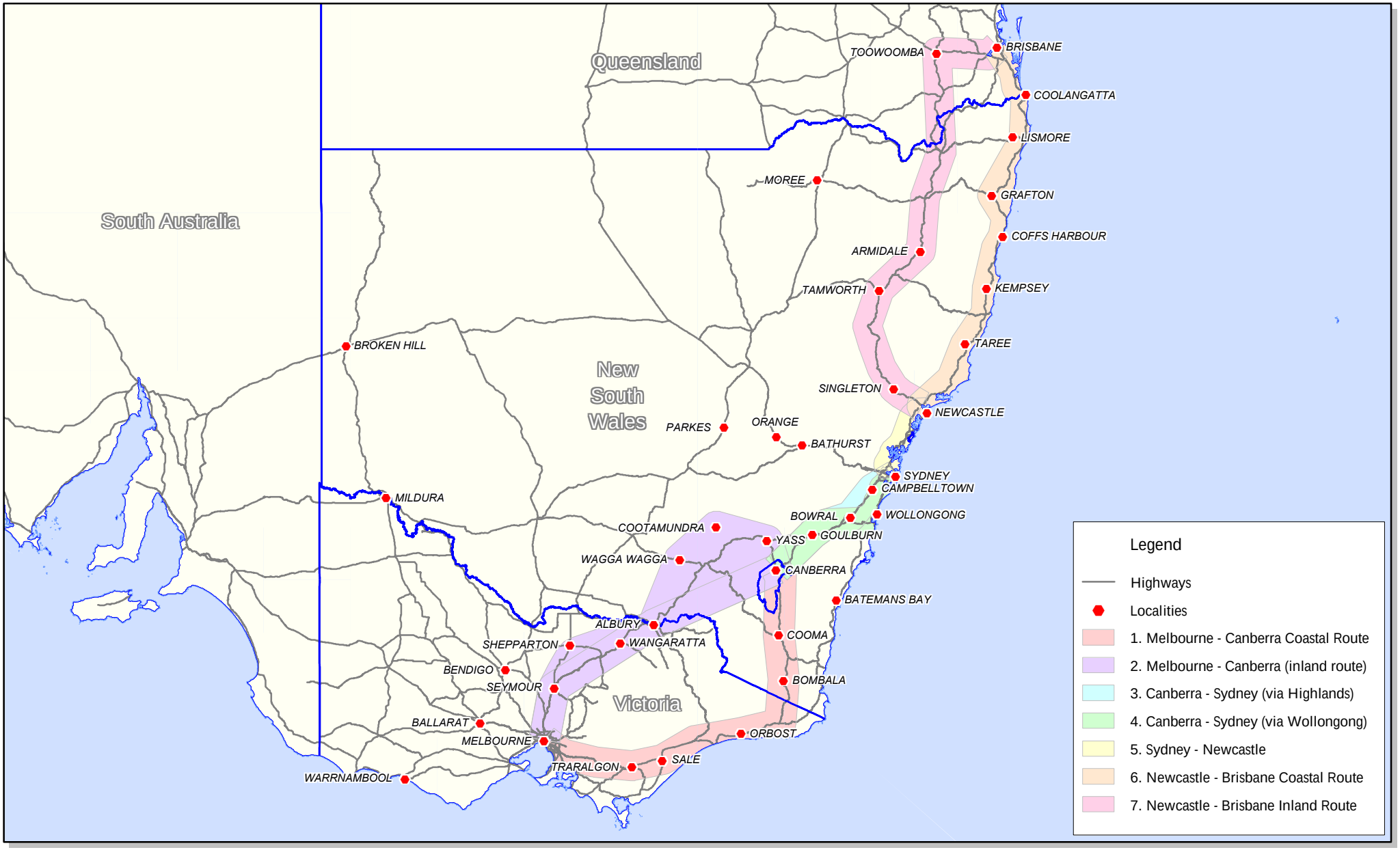
Soil Erosivity

Figure 5.5



Soil Reactivity

Figure 5.6



Candidate VHST Corridors

Figure 5.7

Section 6

Preliminary Corridor Analysis

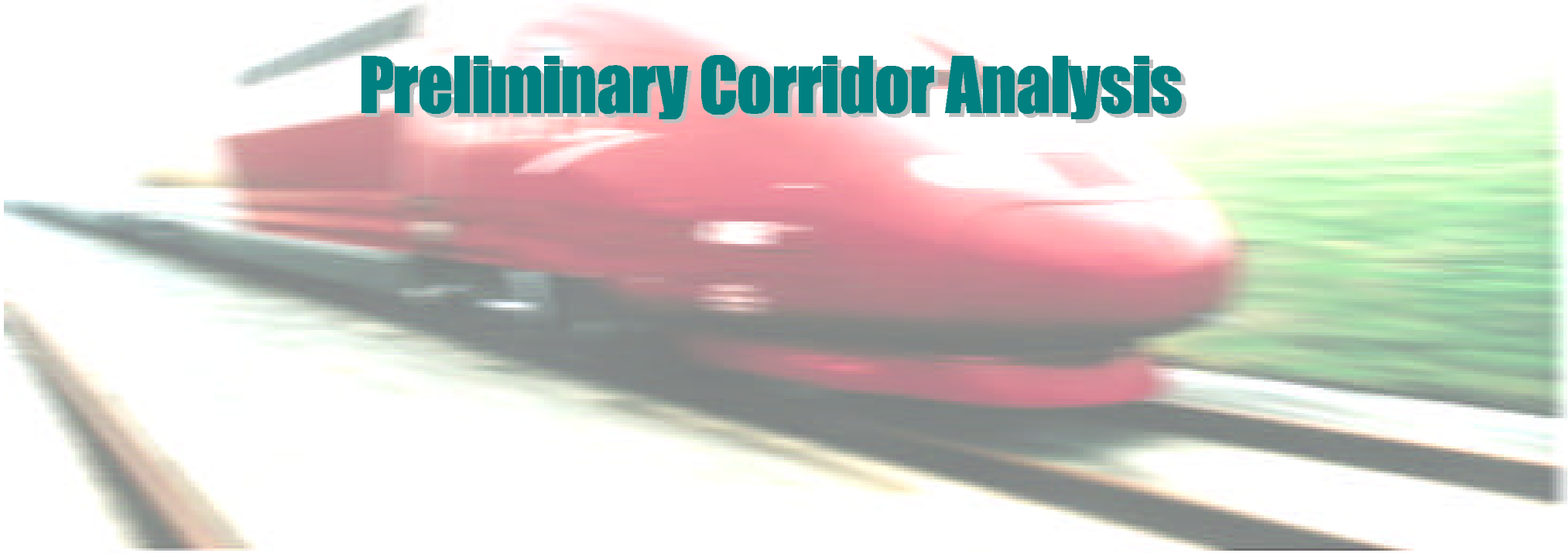
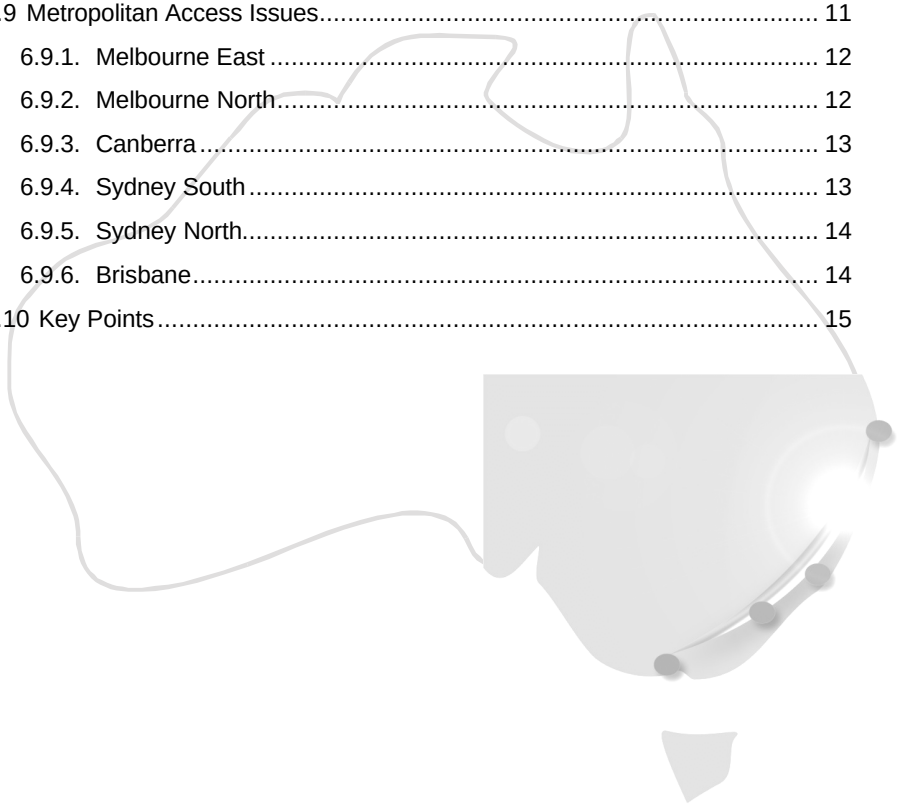


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6 PRELIMINARY CORRIDOR ANALYSIS

6.1 Comparison of Corridors

Having identified potential VHST corridors in section 5, this section addresses the key issues associated with each of the candidate corridors and compares them in terms of the framework provided in table 6.1. Given that a wide range of alignment options exists within any one corridor, the analysis at this point is presented at a broad level and there is an expectation that more detailed investigations would be undertaken with future studies. Particular issues associated with corridors into and out of the major metropolitan areas are also discussed.

The discussion is supported by a set of study wide maps (figures 6.1 to 6.14) and more detailed maps in annexure 3.

6.2 Melbourne to Canberra – Coastal Corridor

6.2.1. Corridor Definition

Exiting the metropolitan area

This corridor could commence at the Spencer Street Terminal which is strategically located at the western end of Melbourne's traditional central activities district (CAD) and immediately east of the developing Docklands area which will more than double the size of the existing CAD. Redevelopment proposals are currently under consideration for the Spencer Street Station by the Victorian Government.

Alternatively, a new terminal could be located in a more easterly location in central Melbourne, at Flinders Street Station for example.

Options for exiting the Melbourne metropolitan area in a south-easterly direction could be provided along the existing rail corridor through Caulfield, Dandenong, Berwick and Pakenham. Alternately, a new surface and/or underground corridor could be developed generally consistent with the Eastern Freeway and the yet to be developed Scoresby Transport Corridor, which runs from Ringwood to Frankston, some 2 km to the north-west of Dandenong.

Table 6.1 Assessment Matrix

Relative Performance / Planning Parameter	Strong/positive A	Moderate B	Weak/negative C
Likely engineering/ alignment issues – capital cost 1	Flat open country with no major geographic features. Limited number of major river crossings and floodplains.	Rolling terrain with short lengths of bridge, viaduct and tunnel.	Difficult terrain resulting in high earthworks, tunnels, viaducts and bridges.
Population distribution demographic issues 2	Large population centres with strong economy generating need for travel.	Scattered medium to small-sized cities. with areas of specific economic activity or growth, such as tourism.	Sparse regional development, reliant mainly on local economy. Low growth.
Environmental issues 3	Highly modified landscape, little intact natural vegetation, low biodiversity, few significant environmental constraints.	Modified environment with some large remnant areas of natural vegetation.	Largely intact natural environment, high biodiversity, significant environmental constraints.

Through West and East Gippsland

East of the extended Melbourne metropolitan area, the Coastal corridor would encompass the road and rail transport corridor through West Gippsland and towns such as Drouin and Warragul. Further eastwards, the corridor would cover most of the resource-rich Latrobe Valley and the related urban areas stretching some 25 to 30 km from Moe and Morwell to Traralgon (combined population 48,330). The Latrobe Valley, with its extensive brown coal resources, is the centre of the electricity generating industry in Victoria.

East of Traralgon, this corridor traverses generally flat to moderately undulating terrain used for dairying, grazing and other agricultural activities and encompasses the regional centre of Sale and nearby onshore facilities at Longford for the off-shore natural gas and oil resources. East of Sale, the corridor runs to the north of the Gippsland Lakes system (an internationally significant

wetland system (See section 6.2.2) and encompasses the largest towns in East Gippsland of Bairnsdale (population 10,888) and Orbost (population 2,149).

Through East Gippsland and the Monaro to Canberra

East of Orbost, in order to connect to Canberra as efficiently as possible, the Coastal corridor would turn northwards away from the coastal plain. This corridor is through increasingly dissected and heavily forested terrain protected in part by the Snowy River and Errinundra National Parks south of the Victorian/New South Wales border to higher land in the vicinity of Bombala.

North of Bombala, this corridor encompasses the Monaro Highway and crosses the Great Dividing Range just south of Cooma. This corridor would run directly northwards from Cooma generally to the east of the southern reaches of the Australian Capital Territory and the southern suburbs of Canberra and includes the urban area of Queanbeyan. This corridor terminates in the vicinity of Canberra Airport to link with the southern end of the Canberra to Sydney corridor.

6.2.2. Environmental Influences

From the eastern outskirts of the Melbourne metropolitan area, the environmental character of Western and Central Gippsland has been significantly influenced by land clearing for agriculture. The foothills of the Ranges which border the northern part of this corridor contain a number of relatively small State Parks and State Forests. The southern part of the corridor borders the Strezlecki Ranges which also have small areas similarly protected. East of Bairnsdale, there are almost continuous areas of State Forest (including old growth native forest) and a number of National Parks. The East Gippsland region represents some of the most ecologically diverse habitat in Australia and provides over a relatively short distance a full range of relatively intact ecosystems from the high alpine areas to the coastline. This ecological complexity adds to the significance of individual areas.

The EPBC data base indicated the possible presence of up to 40 threatened species, 21 migratory species and 19 marine protected species over various sections of this corridor.

East of Sale, the Gippsland Lakes are a Ramsar-listed wetland of international significance and many of the rivers traversed by the coastal corridor flow into this extensive lakes system.

North of Bombala to Cooma, the environmental character changes as the extent of native vegetation reduces and the impact of historical clearing of vegetation becomes the dominant environmental feature. As with other extensively cleared areas, there are still remnants of vegetation which have local habitat value but generally this area does not contain any large areas of environmental significance.

6.2.3. Key Engineering Elements

There are few major engineering impediments between Melbourne and the eastern edge of Gippsland, near Orbost. If this corridor generally followed the existing broad gauge rail and highway corridors, it would take the natural, easily graded, path avoiding the foothills of the Divide to the north and Mt Fatigue to the south. The biggest challenge would be exiting central Melbourne to the east because the existing multi-track broad gauge rail corridor (to Caulfield, thence Dandenong) is fully committed to suburban and interurban passenger traffic. Therefore, it is most likely that a new eastern exit, probably shared with some freeway alignments, would be needed.

Most of the major engineering features are located between Orbost, Bombala (in far southern NSW) and Cooma (the gateway to the NSW snowfields). A long sustained climb out of the Snowy River or Brodribb River valleys is unavoidable. The 1989 VFT proposal embraced 3.5% grades in this stretch of its coastal route. It is likely that there would be a need for significant sections of major construction works, such as bridging and tunnelling. Bombala, at 700 metres above sea level, is still not at the summit of the line. This would probably lie near Nimmitabel, at 1070 metres above sea level. If the corridor follows the Monaro Highway it would be following the most direct route. However it would still be a severely graded route if the former railway from Queanbeyan to Bombala is any guide, i.e. with ruling gradients lying between 2.0% and 2.5% and ruling curvature 240-400 metres radius.

The Canberra approach could pass along the eastern edge of the ACT and run direct to a major station site adjacent to Canberra Airport.

6.3 Melbourne to Canberra – Inland Corridor

6.3.1. Corridor Definition

Exiting the metropolitan area

This corridor commences at the Spencer Street Terminal strategically located at the western end of Melbourne's traditional CAD and immediately east of the developing Docklands area which will more than double the size of the existing CAD. Redevelopment proposals are currently under consideration for the Spencer Street Station by the Victorian Government.

Options for exiting the Melbourne metropolitan area in a northerly direction could be provided along several existing rail corridors or along the options being considered for the Airport Rail Link to provide a direct heavy rail link to Melbourne Airport. Two possibilities considered are:

- The Broadmeadows corridor. This runs mostly along the rail reserve of the existing Broadmeadows rail service. In order to provide a high-quality service new track may have to be constructed along part of the existing rail line within the current rail reservation. A new line would branch off the existing rail reserve in Broadmeadows and be located under the flight path reservation, which includes the Broadmeadows Valley Park; and
- The Albion corridor, which has recently been announced by the Victorian Government as the preferred corridor for possible development of an Airport Rail Link. This route would generally follow the existing St Albans line and the Broadmeadows interstate/freight line with a branch from Keilor East to Melbourne Airport. In the vicinity of Sunshine and Albion stations, the new tracks would need to be built below ground.

Craigieburn to Albury/Wodonga

From Craigieburn northwards, the Inland Corridor encompasses the current Melbourne to Sydney road and rail corridors (which parallel each other to varying degrees related mainly to town bypasses by the Hume Freeway) as well as areas approximately 10 km to the east and west. The Hume Freeway bypasses all the major towns between Craigieburn and Wodonga but still runs through the urban area of Albury just north of the NSW border. The railway runs through all these major towns (Seymour, Euroa, Benalla, Wangaratta and Wodonga) with varying levels of service provided by intrastate and interstate rail passenger services.

Albury to Canberra

From Albury to Canberra, there are two broad alternative corridors for a VHST system:

- generally along the existing rail corridor linking Wagga Wagga, Cootamundra and Yass and into Canberra from the north; and
- a significantly more direct and shorter corridor north-eastwards from Albury through the western foothills of the Australian Alps directly to Canberra.

These corridors are described below.

Corridor via Wagga Wagga, Cootamundra and Yass

This corridor encompasses the existing Melbourne-Sydney rail corridor north of Albury via Wagga Wagga, Cootamundra and Yass. North of Albury, this corridor also encompasses the Olympic Way – a major intrastate road link between Albury and Cowra. Wagga Wagga is the largest inland city in New South Wales (excluding Canberra) with a population of 42,847. It is also the location of a number of key services and facilities with regional and national roles such as Charles Sturt University, and Kapooka Army Base. Wagga Wagga is located on the Murrimbdigee River and is east of the Murrimbidgee Irrigation Area, one of Australia's major intensive agricultural regions. North of Wagga Wagga, this corridor includes the towns of Junee (population 3,683) and Cootamundra (population 5,880). This approach would facilitate a link to Canberra Airport without substantial disruption to existing and developing urban areas of Canberra's north-west and northern suburbs.

More direct north-easterly corridor from Albury

This corridor diverges from the existing intercapital rail and road network just to the north of Albury and would provide a significantly more direct and shorter corridor north-eastwards from Albury through the western foothills of the Australian Alps directly to Canberra. A VHST corridor within this corridor would have the advantage of a potentially shorter corridor than one via Wagga Wagga with resultant savings in travel times.

However, a new alignment would need to be identified over virtually all this segment with substantial lengths in tunnel to obtain optimum VHST performance given the dissected topography and related environmental values through much of this segment. Use of this segment would have the strategic disadvantage of not serving Wagga Wagga, as noted above the largest inland city in New South Wales and the location of a number of key educational, community services and defence facilities serving regional and national roles.

An approach to Canberra from the south-west would also be likely to require extensive lengths in tunnel under the central area of Canberra to link with Canberra Airport. Such a corridor may provide the opportunity for a VHST station in Civic/National Precinct as well as a station at the Airport.

6.3.2. Environmental Influences

Between the northern outskirts of the Melbourne and the Murray River, as a result of these areas being generally cleared for agriculture, there are relatively few large areas of environmental significance that have statutory protection. The King Lake National Park and associated State Forests are located in the Great Dividing Range to the east of the existing Melbourne to Sydney road and rail corridors. The eastern side of the VHST inland corridor skirts the foothills of the ranges and includes scattered areas of State Forest and State Parks. North of Wangaratta, the Chiltern-Ironbark State Park provides protection to an area of the threatened Ironbark forest.

The absence of large areas of environmental significance should not be taken to mean that there are no biodiversity values in largely cleared areas as there are usually many scattered small areas of remnant vegetation. These areas may provide important local habitat for a variety of threatened or endangered species and offer the potential for restoration and expansion through active or passive management.

A number of the generally north-west flowing rivers such as the Goulburn and the Ovens Rivers are designated as Heritage Rivers and also provide habitat for a number of endangered fish species.

North of the Murray River in New South Wales, similar environmental conditions prevail over the corridor via Wagga Wagga, Cootamundra and Yass. As with the section of this corridor south of the Murray River, as a result of these areas being generally cleared for agriculture, there are relatively few large areas of environmental significance that have statutory protection. The cleared nature of the land is, if anything, more pronounced than further south with pockets of associated soil erosion and land degradation.

The corridor sub-option that heads directly north east from Albury to Canberra would traverse extensive areas of high environmental significance including areas within the Kusciuszko and Brindabella National Parks and surrounding areas of State Forest.

Both corridor sub-options would cross the upper reaches of the Murrimbidgee River and several large water storages that regulate the flow of this river and tributaries such as the Tumut River.

6.3.3. Key Engineering Elements

This corridor has to cross the Divide twice. The first crossing would most likely be through the saddle at Heathcote Junction, 350 metres above sea level and 53 km from Melbourne. This is the natural path for the existing rail and highway corridors because it is significantly lower than the ridgeline of the Divide either side of it. To the north and south of Heathcote Junction, the terrain is relatively gently graded. Between the Divide and the Murray River (also the Victorian/NSW border) the corridor crosses Northeastern Victoria just to the west of the foothills of the Divide with few geographical impediments. The Murray River poses no engineering challenge, although it does have a wide floodplain lying below Wodonga.

North of Albury Wodonga there are fundamental route questions about how far off the Melbourne - Canberra rhumbline the corridor should be located. If the corridor takes a shorter alignment it misses various regional centres, the most important of which would be Wagga Wagga. It would also need to traverse the heavily broken country close to the Divide if it was to be positioned to the south of the Murrumbidgee River. In contrast, there are fewer engineering impediments for more northerly and westerly corridors via centres such as Wagga Wagga (being to the north of the Murrumbidgee River). The trade-off for fewer engineering impediments is that the corridor would then be significantly longer. Detailed alignment investigations would be needed to examine construction cost and travel time trade-offs.

The Canberra approach could be from the west to northwest and could pass by Civic en route to a major station site adjacent to Canberra Airport, on the other side of Mt Ainslie. The most significant influence on achieving a feasible corridor approaching Canberra from the west or north-west is the major extent of undulating terrain, characterised by the scale of the existing Burrinjuck Dam on the Murrumbidgee River. The more direct potential corridors into Canberra lie to the south of Lake Burrinjuck through the Brindabella Range. The more lengthy but less impeded corridor lies to the north and would pass close by Yass.

Table 6.2 Comparative Evaluation: Melbourne-Canberra

	Coastal	Inland Albury-Canberra (direct)	Inland Albury-Wagga Wagga-Yass-Canberra
Likely engineering capital cost	✷	✷✷	✷✷✷
Population distribution likely demand	✷	✷✷	✷✷✷
Environmental issues	✷	✷✷	✷✷✷

✷✷✷ most favoured ✷ least favoured

6.4 Canberra to Sydney via Campbelltown

6.4.1. Corridor Definition

The Canberra to Sydney corridor via Campbelltown leaves Canberra in the vicinity of Canberra Airport and encompasses the Canberra to Sydney road link (Federal Highway) to its junction with the Hume Freeway approximately 5 km south of Goulburn – a major regional service centre with a population of 21,293 people. This corridor traverses generally open and moderately undulating terrain which marks the Great Dividing Range and encompasses the western margins of Lake George. From Goulburn northwards, this corridor would encompass the dual carriageway Hume Freeway as well as sections of the Main Southern Railway which still has a more circuitous corridor than the intercapital highway.

The towns of the Southern Highlands within this corridor such as Moss Vale, Bowral, and Mittagong mark the outer extent of the commuter belt for the Sydney metropolitan area and are popular locations for 'ex-urban' residences. From Mittagong northwards, this corridor would skirt just to the west of the major water catchment areas for Sydney and Wollongong and enter the Sydney metropolitan area proper through the southern suburbs of the Campbelltown region.

Metropolitan entry to Sydney could be effected within this corridor along the Main Southern Railway to Campbelltown and then Glenfield (just south of Liverpool) where this line links with the East Hills suburban line. This line, in turn, links with the Airport Rail Link serving the International and Domestic Terminals at Sydney Airport. A direct run into the Sydney Central Terminal is then available from Sydney Airport.

6.4.2. Environmental Influences

North of Canberra to Goulburn, the corridor is extensively cleared and is located partly within the very upper reaches of the catchment of the westward-flowing Murrimbidgee River.

Lake George, located on the east side of the Federal Highway between Goulburn and Canberra, is one of only two large, shallow freshwater lakes in the uplands of NSW and is considered a wetland of national importance. It provides important refuge habitat for waterbirds during inland droughts and supports 201 species of birds, 31 mammal species, 29 species of reptiles and 12 amphibian species. It is a shallow lake with a small catchment and water levels fluctuate dramatically due to rainfall and evaporation.

North-east of Goulburn, the corridor includes the northern and western edges of the extensive Morton National Park (170 635 ha) which includes tracts of dissected sandstone country which marks the transition from the upland plateau into rainforest gullies and substantial waterfalls such as the Fitzroy and Belmore Falls down to the coastal plains of the Illawarra region.

This corridor then moves into the Southern Highlands with a number of protected areas of environmental significance to both the north (Tarlo River National Park, Nattai National Park) and to the east (Macquarie Pass National Park). The ecological complexity of the Southern Highlands is reflected in the EPBC data base which indicates the possible presence of 1 threatened ecological community, 47 threatened species, and 8 migratory species in the area between Goulburn and Bowral.

Water quality is a major issue in this section of the corridor as extensive areas to the east of the existing major transport/urban corridor are included in the water catchments areas for the Sydney metropolitan area managed by Sydney Catchment Authority.

The 630 ha Thirlmere Lakes National Park in the corridor north of Thirlmere contains five freshwater lakes and are among the last undisturbed systems near Sydney and form part of the Warragamba catchment area. From Picton north, the spread of metropolitan Sydney starts to influence the environmental character as the extent of cleared land increases and intact areas of native vegetation become more scattered before urban development in the vicinity of Campbelltown becomes the dominant environmental feature.

6.4.3. Key Engineering Elements

This corridor must cross the Divide once again before it enters Sydney. The crossing would most likely be to the north of Canberra at roughly 800 metres above sea level. The corridor would then drop down into the Southern Highlands, in the vicinity of Goulburn. There are no significant impediments to a corridor, save avoiding the Wollondilly River to the northeast, until the north edge of the Southern Highlands is reached near Mittagong.

The corridor has to fall 450-500 metres on a sustained gradient from the Southern Highlands to the Cumberland Plain and the Sydney Basin. Previous investigations suggest a feasible VHST corridor which is largely tunnel-free is achievable. In general, this corridor could parallel the Hume Freeway and avoid the National Park and water catchment areas to the east. It would most likely approach Sydney through Campbelltown, a sub-regional centre of Sydney.

6.5 Canberra to Sydney via Wollongong

6.5.1. Corridor Definition

This corridor is similar to the Canberra to Sydney corridor via Campbelltown to the vicinity of Moss Vale where it would diverge eastwards through heavily dissected terrain around the Macquarie Pass towards the coast and the major urban and industrial centre of Wollongong (population 219,761).

From Wollongong northwards, this corridor would be constrained in the east by the coast and would encompass inland a narrow and largely urbanized coastal plain and then extensive areas of heavily dissected terrain marked on the east by a significant escarpment.

Metropolitan entry to Sydney could be effected within this corridor via the metropolitan rail system north of the Royal National Park then via the Sutherland line to Wolli Creek station where this line links with the Airport Rail Link serving the International and Domestic Terminals at Sydney Airport. A direct run into the Sydney Central Terminal is then available from Sydney Airport.

6.5.2. Environmental Influences

The environmental influences on this corridor would be the same as those for the Canberra to Sydney corridor via Campbelltown up to the vicinity of Moss Vale.

A wetland of national importance, Wingecarribee Swamp, is located approximately 13 km east of Moss Vale. It is the oldest and largest high-altitude peat-forming swamp in Australia, with an average depth of 3 metres. The peat has taken about 15,000 years to form. The swamp also contains a number of rare flora and fauna species. The swamp is significant because of its natural, archaeological, cultural, scientific, and aesthetic values and a number of Aboriginal and European cultural sites have been found around the perimeter of the swamp.

From this point eastwards to the coast, there are extensive areas of environmental significance protected either by Morton and Macquarie Pass National Parks, Bungonia State Recreation Area or water catchments managed by Sydney Catchment Authority.

Another two wetlands of national importance are located in this region - the Budderoo National Park and Barren Grounds Nature Reserve Heath swamps - which are located approximately 15 km south-west of Robertson. These extensive heath swamps lie at the top of the Kangaroo River catchment. The heath swamps cover an extensive area and form a consolidated area of swamp which is undisturbed by rural or urban landuses.

The Illawarra Escarpment is complex in geological, hydrological and habitat terms and is a striking visual feature of this region. Between Bowral and Wollongong, the EPBC data base lists 46 threatened species and 16 migratory species.

At the foot of the escarpment, Lake Illawarra is located between Port Kembla and Shellharbour, on the Illawarra coastal plain approximately 8 m south of Wollongong. The lake has an area of 3,227 ha and is an estuarine lagoon. The shallow waters and saline conditions allow seagrasses which provide food for waterfowl. Aboriginal sites of archaeological significance occur near the lake including a burial ground, quarry and open middens. Some areas of the Lake are protected by the provisions of SEPP 14 Coastal Wetlands.

North of the urban area of Wollongong which stretches along the narrow coastal plain and the east of the protected water catchment areas managed by the Sydney Catchment Authority and Heathcote National Park is Royal National Park. This multi-use Park was established in 1879 and is the world's second oldest national park - after Yellowstone in the USA. The geology of Royal National Park is dominated by a sloping sandstone plateau rising from from sea level at Jibbon Point in the north to over 300 m at Bulgo in the park's southern corner. The plateau is split by the Hacking River system, which has been eroding the sandstone into deep gorges for at least 50 million years.

The western edge of the Royal National Park abuts the existing road and rail corridor (which links Sydney and Wollongong and the South Coast) for about 15 km and Sydney's outer southern suburbs. The northern edge of the Park abuts more suburban areas and from this point northward, the dominant environmental influence is urban development.

6.5.3. Key Engineering Elements

This corridor could share its exit from Canberra with that of the corridor via Campbelltown (discussed above) as far as at least Moss Vale, lying in the middle of the Southern Highlands. There is an existing railway between Moss Vale and Wollongong. However this railway is only moderately graded at no worse than 1.3% with curves down to 400 metres radius for the first 20 km from Moss Vale to Robertson. It is more heavily graded at 1.6% with curves down to 100 metres radius for a further 20 km from Robertson to Summit Tank. Finally it is severely graded at 3.3% and tightly curved (100 metres radius) for the remaining 20 km between Summit Tank and Unanderra, 5 km south of Wollongong. These poor geometric characteristics reflect the geographical impediment of the Illawarra Escarpment.

The most direct way of crossing the Illawarra Escarpment would be to construct a 40 km base tunnel, graded at 1.7%, between Moss Vale and Wollongong. A possible alternative, but considerably longer route, would be to continue north along the Campbelltown route to Wilton and intersect the uncompleted alignment of the Maldon - Dombarton Railway. This route offers a more favourably aligned corridor through a saddle in the Illawarra Escarpment above the Cordeaux River. However there would still be 12 km of 3.3% gradients from the Cordeaux Tunnel to Unanderra. In short, there are no easy ways of crossing the Illawarra Escarpment.

The route from Wollongong to Sydney then has to re-cross the Illawarra Escarpment. The geographic impediments of this section of the escarpment are similar to those further to the south with major tunnels (at least 10 km in length) required to climb from Wollongong to the outskirts of Sydney at Waterfall. The difficulties associated with the geometric impediments are compounded by the presence of relatively unstable ground conditions in the north Wollongong and Illawarra Escarpment region. The corridor could enter the main edge of metropolitan Sydney at Sutherland.

Table 6.3 Comparative Evaluation: Canberra-Sydney

	via Campbelltown	via Wollongong
Likely engineering capital cost	✷✷✷	✷
Population distribution likely demand	✷	✷✷
Environmental issues	✷✷	✷

✷✷✷ most favoured ✷ least favoured

6.6 Sydney to Newcastle

6.6.1. Corridor Definition

From a Central Sydney terminal, a 20 km wide corridor could encompass several feasible options for a northwards VHST exit from/entry to central Sydney. These options could include:

- use of existing surface and underground rail corridors via the Main Western Line to Strathfield then diverting to the Main Northern Line to Hornsby or via the North Shore Line also to Hornsby; and
- development of a new alignment which would need to be largely in tunnel because of the extent of high density urban development and high environmental and amenity values of Sydney Harbour and the North Shore area of inner Sydney.

North of the Hawkesbury River, this corridor would encompass the existing Sydney to Newcastle road and rail links. The Sydney to Newcastle Freeway (F3) runs largely along new alignment from Hornsby northwards which bypasses the urban development while the railway follows a more circuitous route through the centres of the major suburban centres and to the west of Lake Macquarie.

There would be several options for entry to and exit from Newcastle depending on where a major VHST station were to be located. Options include eastwards near the traditional commercial and civic centre of Newcastle or a more strategic location westwards near Hexham in the vicinity of the junction of the F3 Freeway, the New England Highway and the Main Northern Railway via the Hunter Valley.

6.6.2. Environmental Influences

From Central Sydney to Hornsby, the dominant environmental influence is urban development interspersed with the Lane Cove National Park, the southern fingers of the Ku-ring-gai Chase National Park and, to the east, Garigal National Park which protects the upper reaches of Middle Harbour.

Ku-ring-gai Chase National Park protects extensive areas of heavily dissected sandstone country on the southern side of Broken Bay where the Hawkesbury River discharges into the South Pacific Ocean. The Park contains a variety of vegetation types including heathland, eucalypt forests and woodlands, rainforests and mangroves.

On the northern side of the Hawkesbury River are the Brisbane Waters and Dharug National Parks. The Brisbane Waters National Park, through which the Sydney to Newcastle railway runs, contains sandstone landscapes rich in

Aboriginal art and rainforest areas. The Dharug National Park, located to the west of the Sydney to Newcastle Freeway, contains 16 km of the convict-built Old Great North Road that once connected Sydney and Newcastle.

To the west of Newcastle is Hexham Swamp, part of the Hunter River estuary complex and situated less than 5 km from the mouth of the Hunter River on the outskirts of Newcastle. The swamp lies on the western side of the river and covers an area of 3,200 hectares. Hexham Swamp is dominated by freshwater wetlands but also contains some small areas of estuarine wetlands. It is protected by the provisions of SEPP 14 Coastal Wetlands.

On the northern side of the Hunter River estuary close to the centre of Newcastle is the Ramsar-listed Kooragang Nature Reserve. Part of the Ramsar site is subject to flooding and tidal influences. Kooragang Nature Reserve supports a variety of wetland types, including mangrove forest, saltmarsh, saline and freshwater pasture, casuarina forest, brackish and freshwater swamp, mudflats, sandy beaches and rock training walls. Rainforest remnants also occur in Kooragang Nature Reserve. Kooragang Nature Reserve is important as a feeding and roosting site for seasonally migrating shorebirds, including the bar-tailed godwit, greenshank, terek sandpiper and eastern curlew. In total 190 species of birds have been recorded at Kooragang Nature Reserve representing 25% of species known in Australia.

6.6.3. Key Engineering Elements

To exit Sydney, this corridor must cross the Parramatta River/Sydney Harbour, climb over the northern rim of the Sydney Basin, cross the Hawkesbury River and traverse well-preserved National Parks until it can approach Gosford, the southern focus of the Central Coast, by skirting Brisbane Water.

If it follows the Main Northern Railway corridor through Strathfield and Hornsby, it has a long and sustained climb (eg with gradients as severe as 2.5%) from Meadowbank, on the Parramatta River, to Mt Kuring-gai (over 200 metres above sea level). It would then have to fall at gradients up to 1.7% on a proposed 200-250 km/h tunnel alignment (roughly 15 km) under National Park to cross the Hawkesbury River adjacent to Brooklyn. Once across the very deep Hawkesbury River it would have to cross Mullet Creek and tunnel under National Park again to approach Woy Woy more directly than the existing railway. The railway and local roads are then sandwiched between Brisbane Water and National Park en route to Gosford.

Alternatively, a shorter exit from Sydney directly north to Chatswood, linked to a very long (possibly 35-40 km) tunnel under National Park and the Hawkesbury River, is possible to link more directly with the Central Coast.

In either case, the presence of the Hawkesbury River to the north of Sydney presents one of the most significant regions of engineering impediments on the entire south-east coast of Australia. The presence of high, steep sided gorges right to the water's edge would most likely necessitate significant lengths of tunnelling on both sides of the river.

North of Gosford, the corridor passes along the coastal strip, to the inland of Lake Macquarie. There are no significant watercourses to cross, nor are there long sustained climbs. However there are a series of short sharp summits to be surmounted before approaching Newcastle. At this stage the corridor could penetrate Newcastle as far east as Broadmeadow, or as far west as West Wallsend, before heading further north.

6.7 Newcastle to Brisbane – Coastal Corridor

6.7.1. Corridor Definition

The Coastal corridor would be defined on the east by the coastline and would run parallel to the coast for the full distance between Newcastle and Brisbane. This corridor would encompass the coastal Sydney to Brisbane transport corridor formed by the Pacific Highway and the North Coast Railway, which parallels the Highway to varying degrees over the whole length.

This corridor encompasses the larger towns and cities of Taree, Port Macquarie, Kempsey, Coffs Harbour, Grafton, Lismore and Tweed Heads in New South Wales, and in Queensland, Coolangatta and other parts of the Gold Coast before entering the southern suburbs of Brisbane. The North Coast includes some of the fastest growing areas in New South Wales and major tourist centres such as Port Macquarie, Coffs Harbour and Byron Bay.

North of the New South Wales/Queensland border, the corridor encompasses the Coolangatta Airport (which serves the rapidly-growing Gold Coast region) and the Robina regional centre. This corridor would most likely travel to a terminal in central Brisbane at Roma Street Station and could include a separate linkage to Brisbane Airport.

6.7.2. Environmental Influences

Between Newcastle and Brisbane, a number of National Parks and Reserves designated as part of the World Heritage Area of the Central Eastern Rainforest Reserve are traversed by the broad corridor. The Central Eastern Rainforest Reserve is fragmented, covering 8 groupings across two States including the Main Range, Focal Peak Group, the Shield Volcano Group, the Iluka Nature

Reserve, the Washpool and Gibraltar Range, the New England Group, the Hastings-Macleay Group and the Barrington Tops Area. The Central Eastern Rainforest Reserves have been recognised for their 'unique array of rainforests, exceptional biodiversity, and ancient species'.

Between Newcastle and Taree, the EPBC Act database has indicated the possible presence of 54 threatened species, 41 migratory species and 63 marine protected species. There are also extensive regions of Littoral Rainforest within this corridor section. A number of SEPP14 Wetland areas are also located within this corridor section. Other areas of environmental significance in this section of the corridor include the Myall Lakes National Park and the Wallingat National Park. This section of the corridor also encompasses large areas of State Forest.

The EPBC Act database has indicated the possible presence of 48 threatened species, 31 migratory species and 50 marine protected species within the corridor between Taree and Kempsey. Also located within this corridor section is the Lorne Flora Reserve, a virgin forest region containing moist and dry blackbutt, brush box, turpentine, flooded gum and coachwood rainforest. A number of national parks and extensive areas of State Forest are also encompassed by this section of the corridor. Large areas of SEPP14 Wetlands are located along the coastline, especially between Port Macquarie and Kempsey.

Between Kempsey and Coffs Harbour, the EPBC Act database indicates the possible presence of 60 threatened species, 31 migratory species and 65 marine protected species within the coastal corridor. Bongil Bongil National Park is located towards Coffs Harbour, and there are many State Forests and Nature Reserves located within this section of the corridor.

The corridor between Coffs Harbour and Grafton encompasses a number of state forests and nature reserves. The Yuraygir National Park is located along the coastline, along the eastern extent of the corridor. The EPBC Act database indicates the possible presence of 66 threatened species, 31 migratory species and 62 marine protected species within this section of the coastal corridor. Some SEPP14 Wetlands have also been identified within this section.

Between Grafton and Lismore, the corridor encompasses Bundjalung, Broadwater and Bungawalbin National Parks. A number of nature reserves, state forests and SEPP14 wetlands are also located within this section of the corridor. The EPBC Act database indicates the possible presence of 92 threatened species, 20 migratory species and 47 marine protected species within this section.

National Parks located within the Lismore to Coolangatta section of the corridor include Mount Warning National Park, Nightcap National Park, Mooball National Park, Goonengerry National Park and Mount Jerusalem National Park. There are also a number of nature reserves and one area of state forest identified within this section of the corridor.

A number of National Parks are located generally west of the urban areas along the Gold Coast within the Coolangatta to Brisbane section of the coastal corridor including Springbrook National Park, Tambourine National Park, and Venman Bushland National Park. There are also a few fragmented areas of state forest and nature reserve identified in this section of the corridor. The EPBC Act database indicates the possible presence of 72 threatened species, 28 migratory species, and 58 marine protected species within a 30km wide corridor between Coolangatta and Brisbane. There is a known koala habitat area in the Daisy Hill – Springwood region, which is registered on the National Estate database. The entire coastal strip is comprised of a chain of waterways (lakes, estuaries, wetlands and rivers). Significant waterways include Tweed River, Terranora Broadwater, Cobaki Broadwater, Currumbin Creek, Tallebudgera Creek, Swan Lake to Burleigh Waters coastal strip, Advancetown Lake, Nerang River, Mermaid Waters region to Broadbeach Waters region, Nerang River, Coomera River, Logan River, Albert River, Coombabah Lake, Tingalpa Reservoir, Moreton Bay, Brisbane River. A large area used as a Land Warfare Centre is also located in the Gold Coast hinterland.



6.7.3. Key Engineering Elements

A new corridor between Newcastle and Taree would most likely follow a relatively direct coastal route (the existing corridor runs further inland in order to avoid the low coastal range lying between Newcastle and Taree). Such a corridor could be relatively direct and would not have to reach any great altitude. However, it may be necessary to traverse a series of short sharp summits, some of which may have to be tunnelled. In general, it would be necessary to locate a new corridor to the west of the Pacific Highway to avoid significant wetlands and significant lengths of very soft ground conditions. The closeness of the foothills of the Divide north of Taree would force the corridor to share with the existing railway and the Pacific Highway. There are no significant summits to be surmounted but there are at least five major estuaries (the Manning, Hastings, Macleay, Nambucca and Bellingen Rivers) to cross. The corridor could swing inland from Coffs Harbour to pass through the regional centre of Grafton and to avoid the coastal range and wetlands before swinging back to the coast (possibly in the vicinity of Ballina). There is a sharp escarpment just north of Coffs Harbour and at least two major estuaries (the Clarence and Richmond Rivers) to cross. Further to the north, the corridor would probably need to be kept to the east of Mt Warning on the NSW/Queensland border because of the virtually impenetrable terrain to the west (which is a legacy of an ancient volcano). The McPherson Range then constrains the corridor to approach Brisbane to the west of the Gold Coast in tandem with the existing narrow gauge Gold Coast Railway and the Pacific Motorway. There are no significant gradients and only two major estuaries (the Tweed and Albert Rivers) to cross.

6.8 Newcastle to Brisbane – Inland Corridor

6.8.1. Corridor Definition

The Inland corridor encompasses the inland transport corridor between Sydney and Brisbane formed by the New England Highway and the Main North Railway which terminates at Tenterfield. From Newcastle, this corridor runs through the resource-rich Hunter Valley which is the location of a major proportion of the electricity generating capacity in New South Wales based on black coal resources which also form a major export industry through the Port of Newcastle. The lower Hunter Valley is also a major wine-producing region with the related tourism industry continuing to develop.

North of Singleton, this corridor encompasses the towns of Muswellbrook and Scone and the extensive grazing areas northwards to the New England Tablelands and the major regional centre of Tamworth (population 31,863). From Tamworth, this corridor heads northwards through the New England region and the city of Armidale (population 21,334) which is the location of the University of New England and other major educational institutions. North of Armidale, a number of smaller towns are located within this corridor such as Glen Innes and Tenterfield.

Once in Queensland, this corridor encompasses the fruit-growing region centred on Stanthorpe and grazing/grain agricultural areas northwards through Warwick (population 25,000) to the major Darling Downs city of Toowoomba (population 100,000). At Toowoomba, the corridor turns eastwards and heads to the Brisbane metropolitan area via Ipswich and the expanding western suburbs of Brisbane. Alternatively, at Warwick, an option known as the Cunningham Rail Link may be considered to traverse the Great Divide near Cunningham's Gap.

6.8.2. Environmental Influences

Between Newcastle and Brisbane, along the inland route, the number of areas of environmental significance increases as the corridor approaches the Queensland/NSW border.

Just outside Newcastle lies the Kooragang Nature Reserve and a number of associated SEPP14 Wetland areas, the Lower Hunter National Park is south of Singleton, and a few fragmented areas of State Forest. North of Muswellbrook lies the Towarri National Park. The Oxley Wild Rivers National Park is located south of Armidale. North of Glenn Innes lies the Butterleaf National Park, the Capoompeta National Park and the Washpool National Park. Just south of the Border lies the Basket Swamp National Park, the Boonoo Bonoo National Park, Maryland National Park and Bald Rock National Park. Between the border and Toowoomba lies the Girraween National Park and a few scattered Nature Reserves and small areas of State Forest.

Between Toowoomba and Brisbane, the northernmost edge of the corridor traverses part of the Ravensbourne National Park, and the D'Aguilar Range National Park, at Split Yard Creek. Two large and two small areas of State Forest are traversed by this section of the corridor. There are a few scattered Nature Reserves within this section of the corridor including White Rock Conservation Park and the Flagstone Creek Conservation Park.

6.8.3. Key Engineering Elements

This corridor would run inland via the Hunter Valley to avoid the foothills of the Divide reaching down from Barrington Tops (further to the north). It still has to cross the Divide (ie the Liverpool Range) at Ardglen (720 metres above sea level) before dropping back into the flood-prone Namoi River valley to reach Tamworth. It then must climb to the ridgeline of the Divide (i.e. over 1060 metres above sea

level) via the Moonbi Range to reach Armidale. It must continue to climb (as high as 1380 metres above sea level) to take the direct route through Glen Innes, Tenterfield and Wallangarra on the NSW/Queensland border. The gradients on the various climbs are sustained and as often as severe as 2.5%. The curvature of the existing railway is quite restrictive, ie often under 400 metres radius, so that a VHST corridor would definitely be alignment challenged.

The corridor would continue along the ridgeline of the Divide en route to Stanthorpe, Warwick and Toowoomba because of the steepness of terrain back towards the coast. There is the prospect of a crossing of the escarpment from Warwick, via Cunningham Gap, to Bromelton on the existing interstate standard gauge rail corridor to Brisbane. Such a corridor would involve substantial tunnelling, eg up to 13 km. On the other hand, if the major regional centre of Toowoomba is to be served the corridor must continue further north. It is then faced with a 400 metres fall through the Toowoomba Range to gain the comparatively easily graded and aligned narrow gauge rail corridor (apart from the Little Liverpool Range) from Helidon, through Ipswich, to Brisbane. There are plans for a favourable alignment, suitable for standard gauge, down the Toowoomba Range. However it too would involve substantial tunnelling (e.g. 9-10 km).

Table 6.4 Comparative Evaluation: Newcastle-Brisbane

	Coastal	Inland
Likely engineering capital cost	✷✷✷	✷✷
Population distribution likely demand	✷✷✷	✷
Environmental issues	✷	✷✷✷

✷✷✷ most favoured ✷ least favoured

6.9 Metropolitan Access Issues

Establishing the actual entry/exit corridors from each metropolitan area would be very important because these would be comparatively low speed portions of a VHST network (as observed in VHST systems in Japan, France, Germany and the UK). The time lost in a slow exit from, say, Sydney would be hard to recover from the long distance sectors if timings are tight. There is also the issue of connection and integration with each metropolitan area's public and private transport networks.

There are some key issues associated with the use of existing corridors in the metropolitan areas. These include:

- the potential that in weekday peak periods there is little, if any, available capacity within the corridor;
- the existing corridors are typically poorly aligned, and have a mixture of train types (including freight) and stopping patterns. These factors combine to limit travel speeds and result in relatively slow journeys into and out of the typically large metropolitan areas; and
- the extra reliability risks associated with sharing congested corridors with other operators.

Brisbane is closely coupled to the Gold and Sunshine Coasts to form the conurbation of south east Queensland. Sydney is coupled to the Central Coast and Lake Macquarie/Newcastle regions in the north, the Blue Mountains region to the west and the Southern Highlands, Wollongong/Port Kembla and South Coast regions to the south. Melbourne is coupled to the West Gippsland and Geelong regions to the east and west respectively. Canberra and Queanbeyan form a somewhat isolated conurbation to the south of, but functionally part of, greater Sydney. These four conurbations contain approximately 55-60% of Australia's entire population yet they lie in probably less than 10% of its area. These conurbations also contain some of the most sought after real estate in the country and are home to increasingly articulate and demanding communities. These communities have higher expectations and are increasingly demanding more environmentally friendly and sensitive infrastructure solutions (eg through noise attenuation and reduction in visual intrusion), both in corridors and through sympathetic station constructions.

It is becoming increasingly difficult to identify, acquire and protect new infrastructure corridors. For example, issues revolving around compensation for environmental impacts are raised at the beginning of every major corridor planning study and the approach to dealing with this issue is evolving and different in each state. The use of compensatory habitats or the adoption of a 'no

nett loss' approach are responses which are gaining some acceptance in cases where the effects of proposed infrastructure can not be satisfactorily mitigated.

These issues are compounded in the metropolitan approaches and point to an increasingly difficult future for any new corridor. As a result, maximum use needs to be made of any existing corridors, even if operating conditions and standards must be compromised. There will certainly be a need to consider shared rail or highway corridors that do not reduce the amenity of the landlord transportation mode. In this respect, once high-speed corridors have exited each conurbation some of the close-in environmental effects would be easier to handle.

As part of discussing this issue in more detail, it is critical to consider the long term growth of each metropolitan area and its transport systems. The location of the end destination, together with opportunities for integration with other transport services and the number and location of the approach stops needs to be considered.



6.9.1. Melbourne East

While there is a direct multi-track broad gauge railway eastern approach to Melbourne from Gippsland there is limited scope for a VHST standard gauge approach along the same corridor. It is highly likely that near-term broad gauge augmentation of the double track Dandenong Line to meet the demands of suburban and interurban train flows would take precedence over long term development of an EC VHST.

While there should still be room in the corridor from Gippsland through Dandenong towards Springvale to accommodate a parallel standard gauge railway, opportunities for penetration closer towards Melbourne become much harder as urban settlement closes in on the existing rail corridor. It would be difficult to obtain even a high speed corridor because of the presence of so many level crossings.

There might be a possibility of gaining access by dual-gauging existing track. However, this could impose an 80 km/h speed limit on all rail traffic under Department of Infrastructure's current design rules. In any case, an approach through Flinders Street station would make Spencer Street terminus very difficult to access. An alternative to using the existing corridors in the inner areas of Melbourne could be to leave the railway corridor and join the Scoresby and Eastern Freeway corridors. This would provide an approach to central Melbourne via Clifton Hill before tunnelling the last 5-6 km to a new underground station adjacent to the existing Spencer Street terminus.

A MagLev system, relying on technology which is not compatible with existing commuter or long distance rail tracks, would most likely require the development of new transport corridors or, where feasible, utilisation of sections of freeway corridors.

6.9.2. Melbourne North

Three potential corridors from Northeastern Victorian into central Melbourne provide the most obvious options for conventional VHST systems. These include:

- the broad gauge Broadmeadows Line;
- the mixed broad and standard gauge Independent Goods Line; or
- Melbourne Airport and thence back to the Independent Goods Line.

The Broadmeadows Line approach is unlikely to be feasible because of the narrowness of the corridor and the lack of opportunity to accommodate a new standard gauge railway within it. Any use of the Independent Goods Line would

probably have to be predicated on it being wholly converted to standard gauge. However, this is quite likely given the near-term gauge standardisation programme announced for Northeastern Victoria. Nevertheless, cohabitation with freight trains and the progressive rail infrastructure congestion from Albion, through Sunshine, Tottenham, West Footscray Junction and South Dynon Junction would mean a slow entry into Spencer Street terminus.

Diversion via Melbourne Airport would require the development of a new railway corridor from Craigieburn or Somerton across to Melbourne Airport then roughly due south to join the Independent Goods Line near McIntyre Crossing Loop. The preservation of an airport rail access to Melbourne Airport is currently subject to environmental review (for the Melbourne Airport Train Link) so the outcome of that review may influence whether or not an EC VHST could be routed via Melbourne Airport. Notwithstanding utilising the existing standard/dual gauge approach to Spencer Street terminus, there is still an outstanding issue on the scale of terminus facilities required for a very high speed railway. It is highly likely that Spencer Street would have to extended to accommodate very high speed railway requirements.

Beyond these three corridors, access for new technologies such as MagLev or faster/more direct access for conventional VHST technologies would require the development of a new corridor. Given the extent of existing development, this is likely to require substantial lengths of tunnelling.

6.9.3. Canberra

As the major destination on any VHST corridor between Melbourne and Sydney, the planning of access into and through Canberra would require significant consultation with the ACT Government. It is likely that any such access would, as a minimum, provide a service to Canberra Airport. If more attractive access is required to a VHST service then this could possibly include a station in the vicinity of Civic.

Figure 6.11 provides a summary of potential corridors that have initially been identified for access into and through Canberra.

For a broad inland corridor from Melbourne, the location of a corridor would principally be dependent on whether a Civic Station is required in addition to a station at Canberra Airport. In the event that a station is appropriate to service Civic, the corridor would need to enter Canberra from the west (i.e. south of Belconnen) and would require sections of tunneling to avoid both difficult terrain and urban environments. If direct access to Civic is not necessary, access to Canberra could be achieved through more northerly corridors, such as a corridor that principally follows the Barton Highway (i.e. between Belconnen and Gungahlin).

For a broad coastal corridor from the Melbourne, Canberra Airport lies on a direct north south corridor). In this instance, significant deviation would be required to provide a station in the Civic area.

For corridors from Canberra to Sydney, the exit from Canberra would be determined largely by the location of the corridor from Goulburn, which could be located to the east or west of Lake George. If to the west of Lake George, a corridor would be required directly north from Canberra Airport. If to the east of Lake George, the corridor would need to exit Canberra to the east (in the vicinity of Queanbeyan).

6.9.4. Sydney South

For conventional VHST technologies, there are no rail gauge issues in accessing Sydney from either the Southern Highlands (south-west) or the South Coast (south). However there are considerable rail congestion problems because of the levels of current and projected commuter train traffic on both potential corridors. Therefore, on one hand, the Main Southern Railway between Campbelltown and Glenfield and the East Hills Line between Glenfield and Wolli Creek Junction would have to be augmented to quadruple track to cater for all users (by allowing the separation of faster trains from slower trains). However once this level of infrastructure were in place VHSTs may be able to obtain a 150-200 km/h approach for up to two-thirds of the 48 km approach into central Sydney.

On the other hand, the Illawarra/South Coast Line would have to be substantially deviated (i.e. a new corridor) between Thirroul and Waterfall (reducing route length by almost 9 km) and triple or quadruple tracked the 10 km between Sutherland and Hurstville. There would also have to be feasible link between Goulburn and Wollongong. One possibility would be to complete the Maldon – Dombarton Railway since this would intersect the direct Goulburn – Campbelltown corridor. Multi-track infrastructure (not yet in place) would permit the systematic separation of faster trains from slower trains but the overall alignment would not be as fast as via East Hills because of the steep terrain on each side of the Georges River at Como. Once VHSTs reached Sydenham they would join the slow inner suburban approach to Sydney Terminal. This terminal station is currently substantially committed to interurban trains.

It is problematic as to whether enough platform tracks would be available for VHST services on top of existing users at Sydney Terminal. Thus the whole use of Sydney Terminal would have to be reviewed once there was a clearer picture of the demands of VHSTs entering Sydney from the south and north.

Beyond the existing corridors, access for new technologies such as MagLev or faster/more direct access for SWSR trains would require the development of a new corridor. From the south-west there may be some opportunity to utilise portions of the existing M5 Motorway corridor. From the south, there is opportunity to utilise a yet-to-be-developed reservation for a motorway from Sutherland to Sydney Airport. In either case, there are no continuous corridors available and there is an expectation that substantial lengths of tunnelling would be required to avoid developed areas and access Sydney Terminal (or further into the CBD).

6.9.5. Sydney North

The greatest obstacles for a northern rail exit from Sydney are crossing the Parramatta River/Sydney Harbour, climbing over the northern rim of the Sydney Basin and crossing the Hawkesbury River and its inlets. The existing route north is via Strathfield and the Main Northern Railway through Hornsby. This railway is already partially quadrupled and these works would have to be completed to allow the combined flow of very fast trains, conventional long distance trains, interurban and suburban trains and freight trains to flow efficiently. A new, probably underground, transit of Hornsby may be necessary, plus augmentation of the existing double track railway to triple or quadruple track as far as Mt Kuring-gai. Beyond this, a new in-tunnel passage to Brooklyn (as already envisaged for interurban traffic) would have to be completed. It may be possible to continue to use the existing Hawkesbury River Bridge but it is likely that this would have to be duplicated on traffic and speed limit grounds. Then a new direct double track railway would be required to Woy Woy and/or Gosford.

There is also a possibility of an alternative, substantially underground, route via Chatswood directly to Woy Woy. It could use the Sydney Harbour Bridge to cross Sydney Harbour/Parramatta River if Lanes 7 and 8 were returned to rail use. From Chatswood this route would have to run underground all the way through western Warringah, Kuring-gai Chase, under Broken Bay and up Brisbane Water (some 30-40 km).

6.9.6. Brisbane

From northern NSW there are two approaches to the greater Brisbane area worthy of consideration. The first and most obvious choice seeks to find a corridor through the difficult terrain north of Mooball in NSW and then through the Tweed Valley to Coolangatta Airport, where it would link into the proposed Robina to Coolangatta railway. This option would provide a stop for the Gold Coast at Robina, which is the designated Key Regional Centre for the City. It is also the hub through which other public transport services will integrate.

The other link to Brisbane would generally follow the New England Tableland to Stanthorpe and then travel onto Warwick. At Warwick there are two options: north to Toowoomba generally along the existing QR corridor, or alternatively at Warwick, follow an option known as the Cunningham Rail Link which traverses the Great Divide near Cunningham's Gap. This option would then join the existing standard gauge line at Bromelton near Beaudesert, or continue further north and join the Ipswich line or a new transport corridor (currently being assessed), to the south and west of Ipswich.

These inland options miss the rapidly growing Brisbane - Gold Coast corridor but could stimulate regional development in and around Toowoomba and possibly share a corridor currently being evaluated for high speed freight trains.

Closer to Brisbane, each of these options could join either the existing Gold Coast line or follow the Gateway Motorway in a new but parallel rail corridor. Following the Motorway provides the potential for a much better corridor and transit speed but it is not without problems. Previous rail corridor proposals along this alignment had met with significant local community opposition and have led to successive State Governments refusing to even consider such a scheme. There is private industry and public sector support for a freight corridor adjoining the Motorway and providing a much better link to the Port of Brisbane. This Motorway has a reasonable standard alignment and is the designated dangerous and heavy goods route east of the City Centre and to the Port. A dual track standard gauge railway following this Motorway would provide a good quality option for a VHST and for freight trains wishing to avoid the congested lines through Acacia Ridge and the southern suburbs and Morningside to the Port.

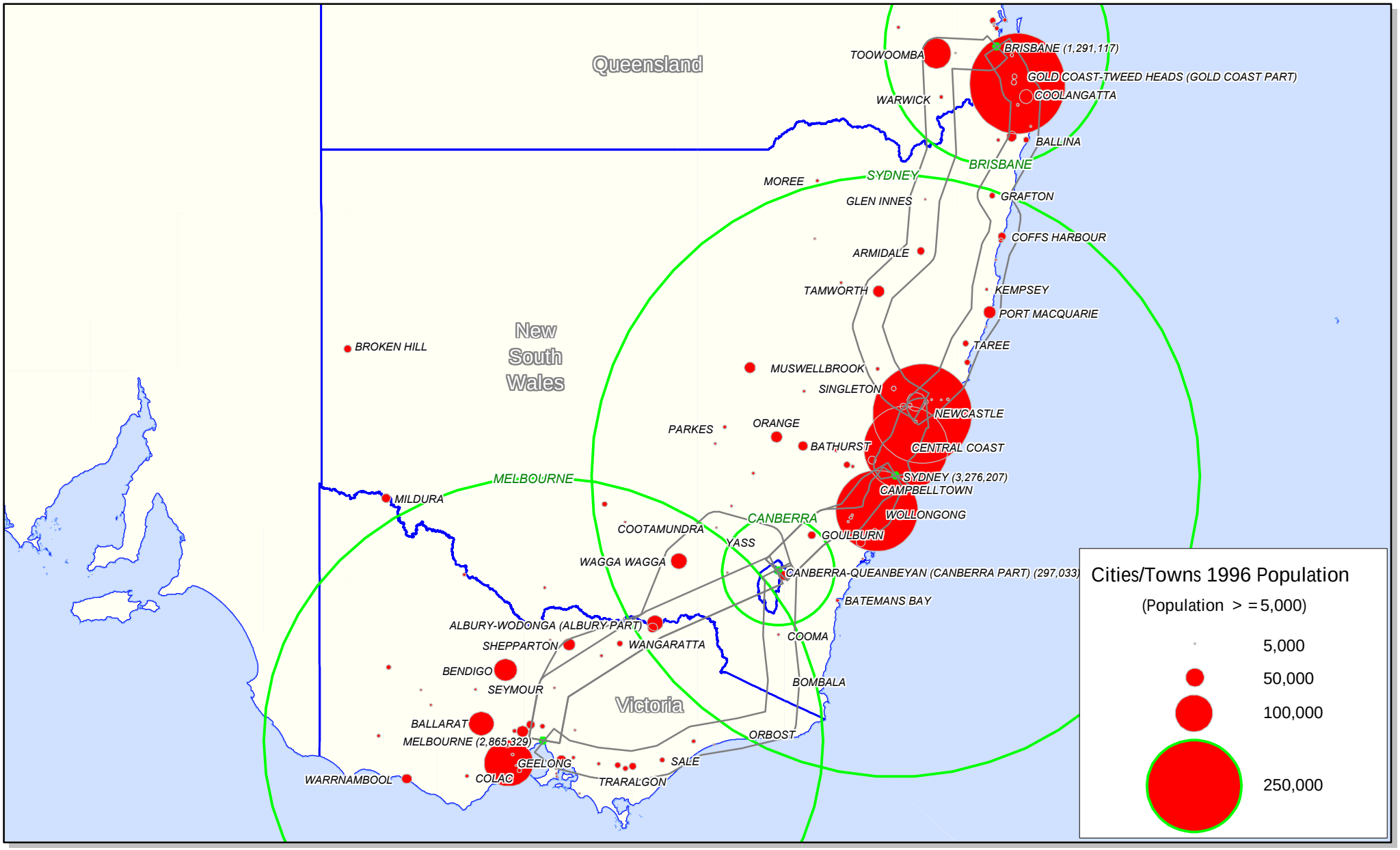
In the longer term, the Roma Street station area stands out as the most obvious terminus for an EC VHST. This is because of its current use by QR to service long distance (both inter and intrastate) and regional trains, together with the role it plays in the Brisbane suburban bus and train network. It is also an easy walk to much of the CBD and a number of accommodation options. International trends would also suggest that the Airport would be another end destination in Brisbane that is worth considering. However, connection to either or both of these options would represent a significant challenge, requiring tunnels under the Brisbane River and parts of the CBD.

6.10 Key Points

The key conclusions that can be drawn from this preliminary analysis of the 40 km wide candidate corridors are:

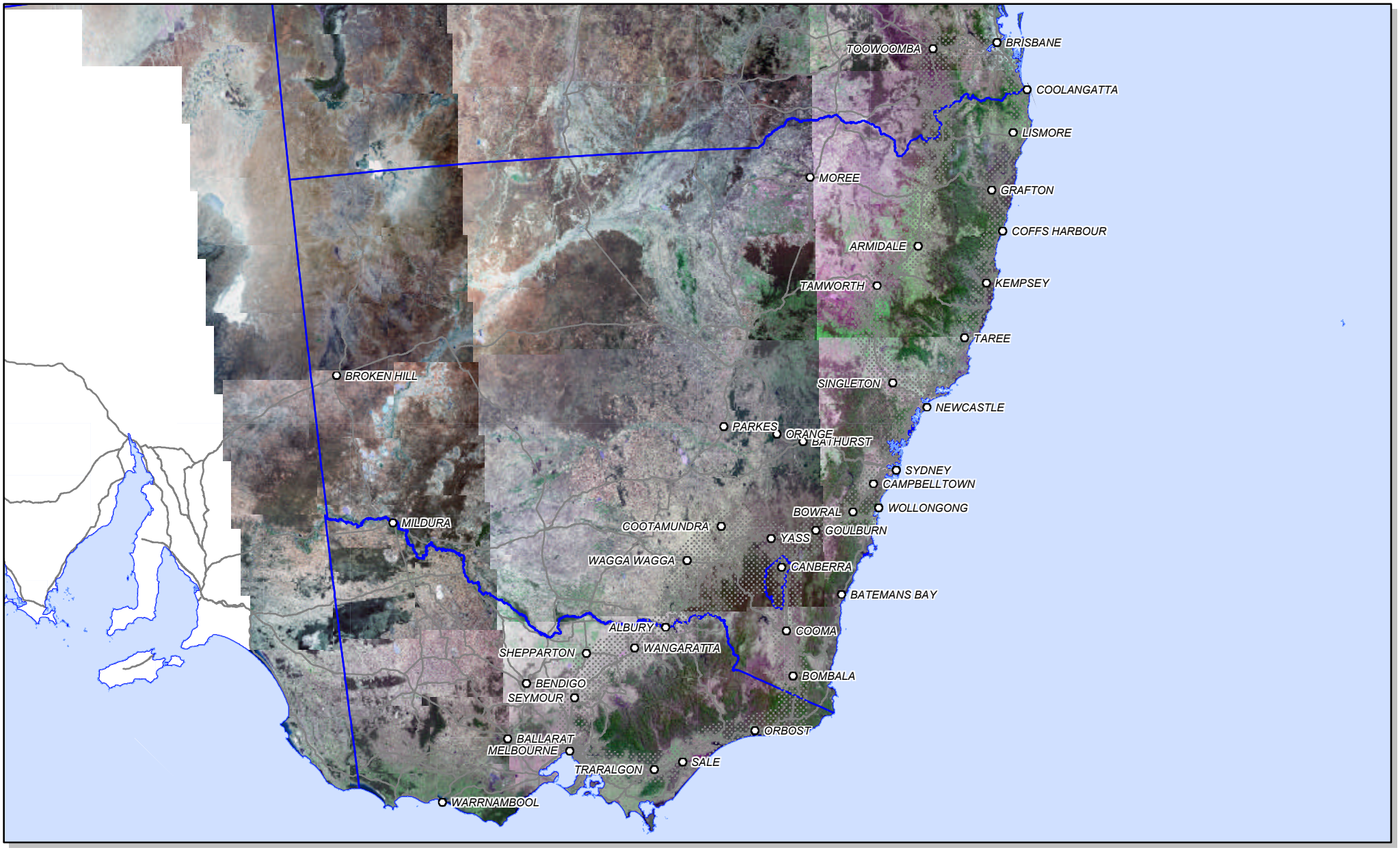
- The 'broadbrush' assessment of corridors is based on the relative performance of the corridors in relation to the three key planning parameters related to engineering/cost issues, population size and distribution, and environmental issues.
- For a corridor to warrant further detailed consideration, it firstly needs to demonstrate a strong performance (or the potential for) in relation to a large population with a strong economy generating a high level of patronage for a VHST system. Secondly, a corridor needs to perform well in relation to the key engineering issues that will influence cost-effective infrastructure provision and optimum VHST operation.
- Unless a corridor can demonstrate a strong performance in relation to these two parameters, there is not a strong argument for further detailed consideration regardless of how well it would perform in terms of environmental issues. In other words, patronage drives VHST provision.
- In terms of broadbrush comparative evaluation of a Melbourne to Canberra VHST link, an inland route via Albury/Wodonga, Wagga Wagga and Yass appears more favourable than a coastal route via Gippsland. At this stage, the patronage assessment is less definitive about this selection. The Gippsland route is penalised by a greater route length which increases capital costs, no significant strategic development benefits ahead of an inland route, and would traverse some of the areas of highest environmental significance over the whole study area. This preliminary assessment is consistent with the conclusion that was reached a decade ago in relation to the Very Fast Train proposal and more recently in a Pre-Feasibility Study on VHST undertaken by the Victorian Department of Infrastructure.
- In terms of broadbrush comparative evaluation, for a Canberra to Sydney VHST link, an inland corridor via Campbelltown appears to perform somewhat better than a corridor via Wollongong, particularly in relation to lower engineering costs and lower adverse environmental impacts.
- Between Sydney and Newcastle, there is no feasible option other than a corridor generally along the coast where the population concentrates now and in the future. However, there would be some significant engineering costs involved in optimising a VHST route particularly in the southern sections of this corridor and related environmental impacts on both the natural and social environments.
- In terms of broadbrush comparative evaluation, for a Newcastle to Brisbane VHST link, an inland corridor appears to provide a less robust intervening patronage base and would have higher engineering costs because of greater length and the need to cross the Great Dividing Range twice. Although an inland corridor would have substantially lower adverse environmental impacts than a coastal corridor, this aspect becomes somewhat academic if the operational feasibility for an inland corridor could not be sustained. A coastal corridor would connect areas with some of the highest population growth in Australia.
- Efficient metropolitan access is a key to the overall optimum performance of any VHST service. Each of the three major metropolitan areas would present substantial challenges in achieving cost effective VHST entry/exits.





Major Towns/Cities 1996 Population

Figure 6.1

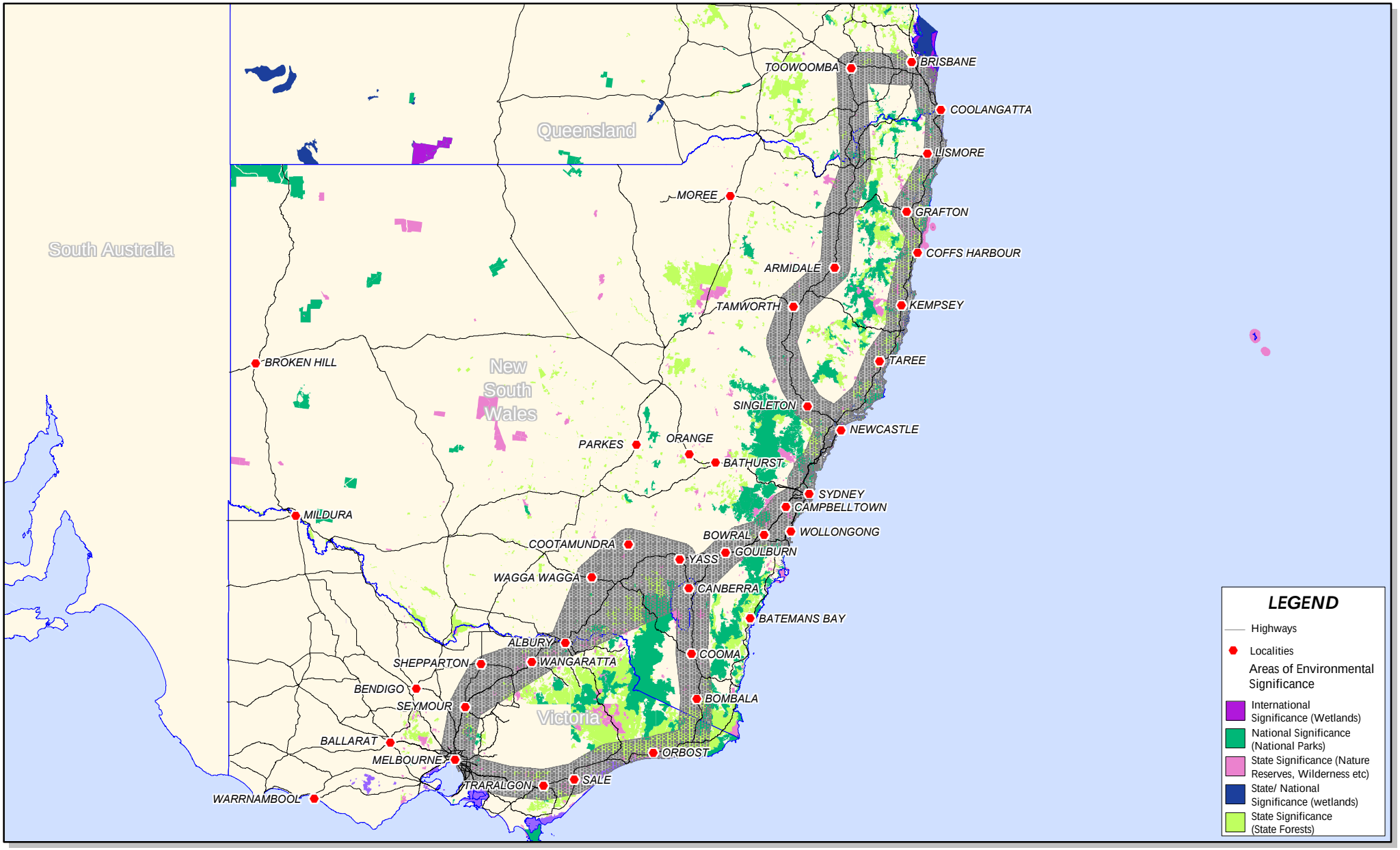


100 0 100 200
Kilometres

N

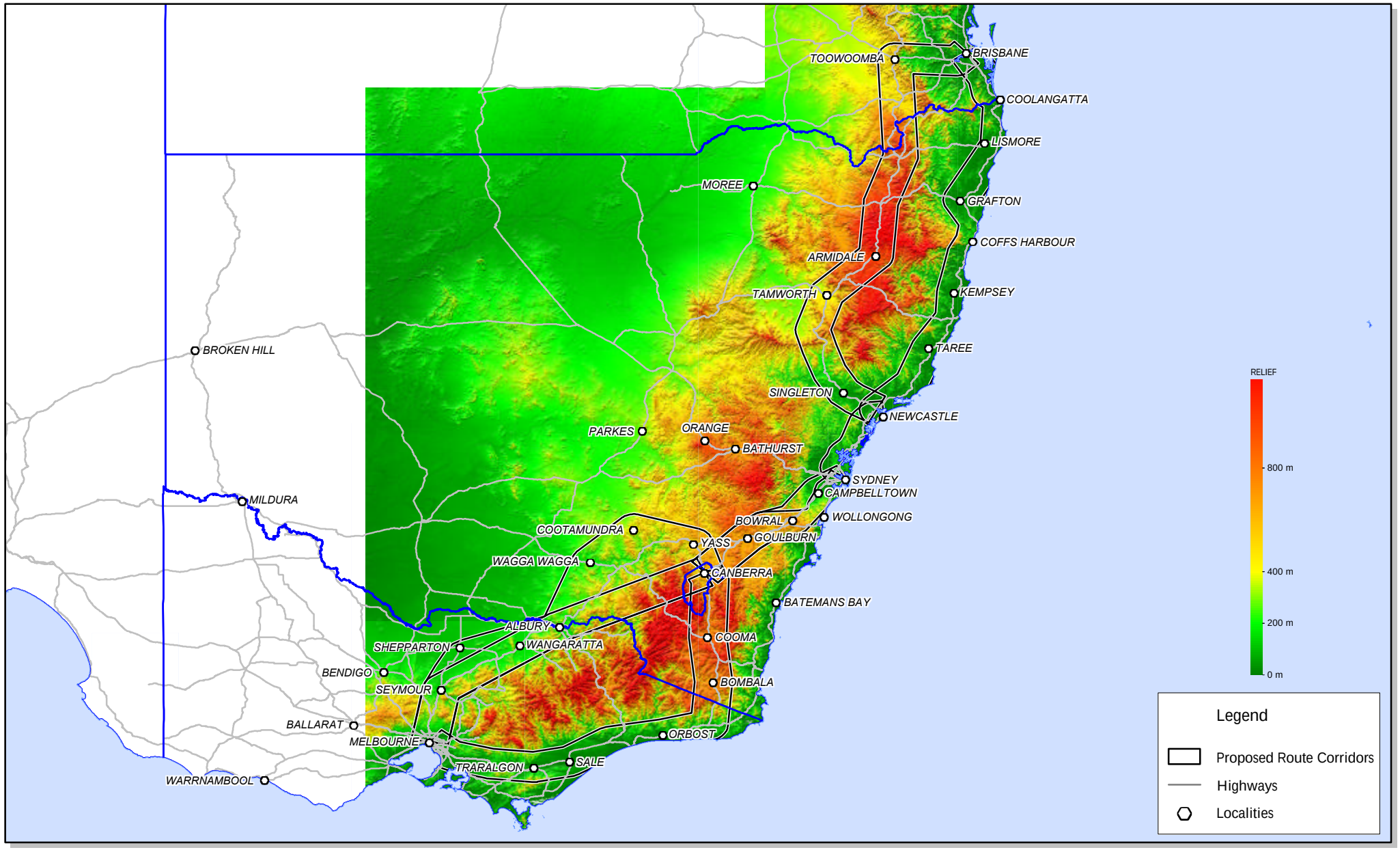
Candidate VHST Corridors with Satellite Image

Figure 6.2



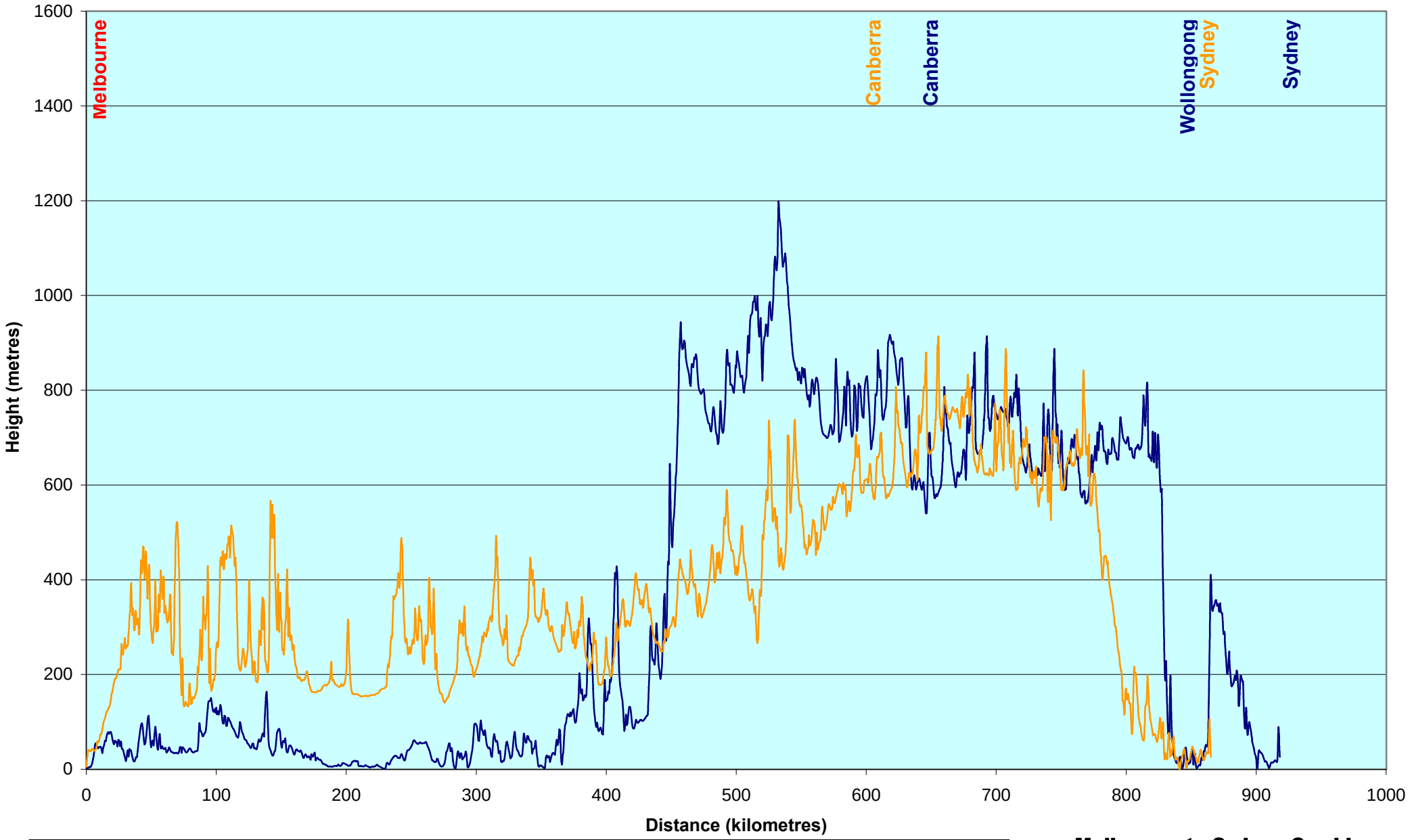
Candidate VHST Corridors with Areas of Environmental Significance

Figure 6.3

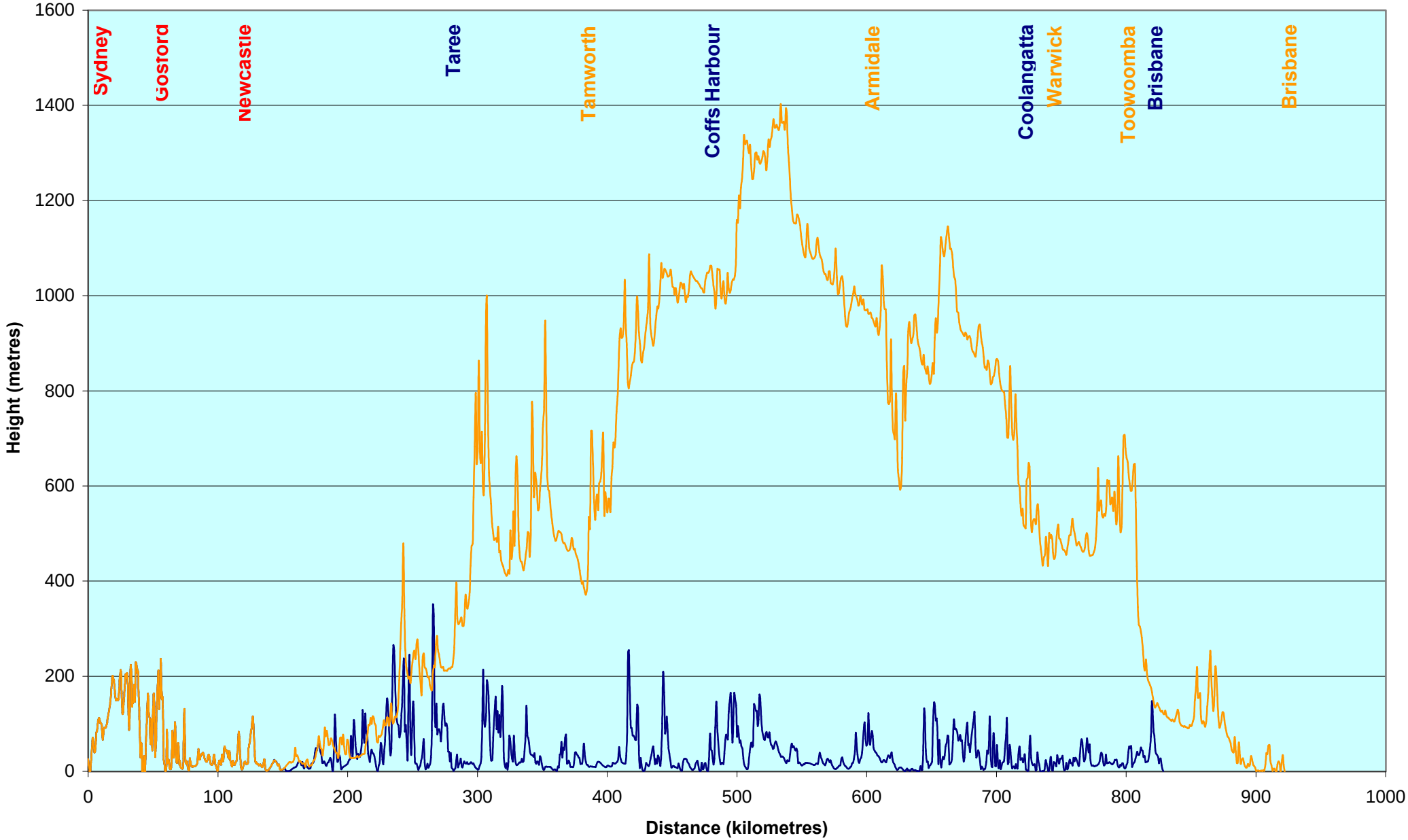


Candidate VHST Corridors with Terrain Features

Figure 6.4

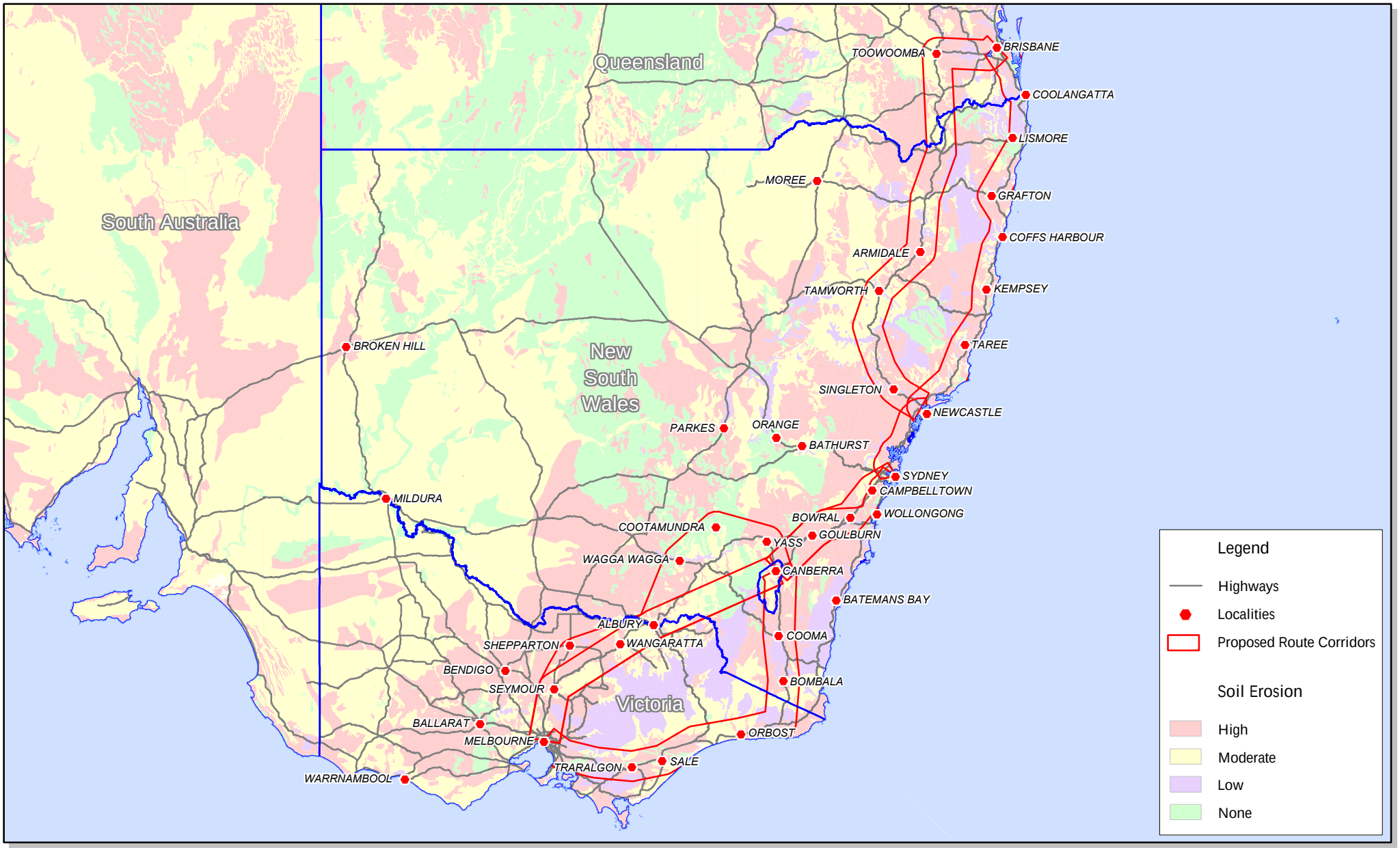


Melbourne to Sydney Corridor:
Terrain Profile Comparison
Figure 6.5



Sydney to Brisbane Corridor:
Terrain Profile Comparison

Figure 6.6



100 0 100 200
Kilometres

N

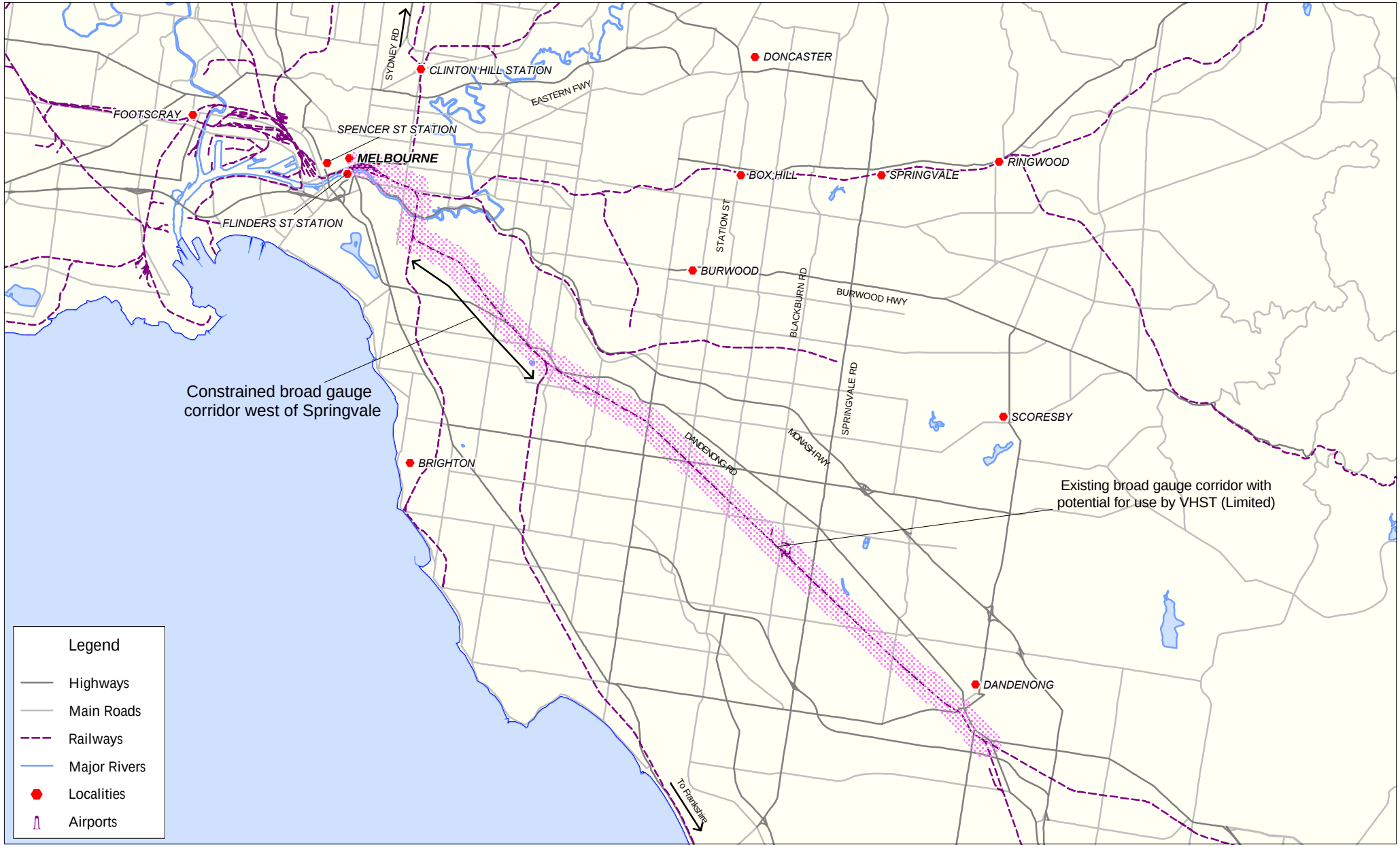
Candidate VHST Corridors with Soil Erosivity

Figure 6.7



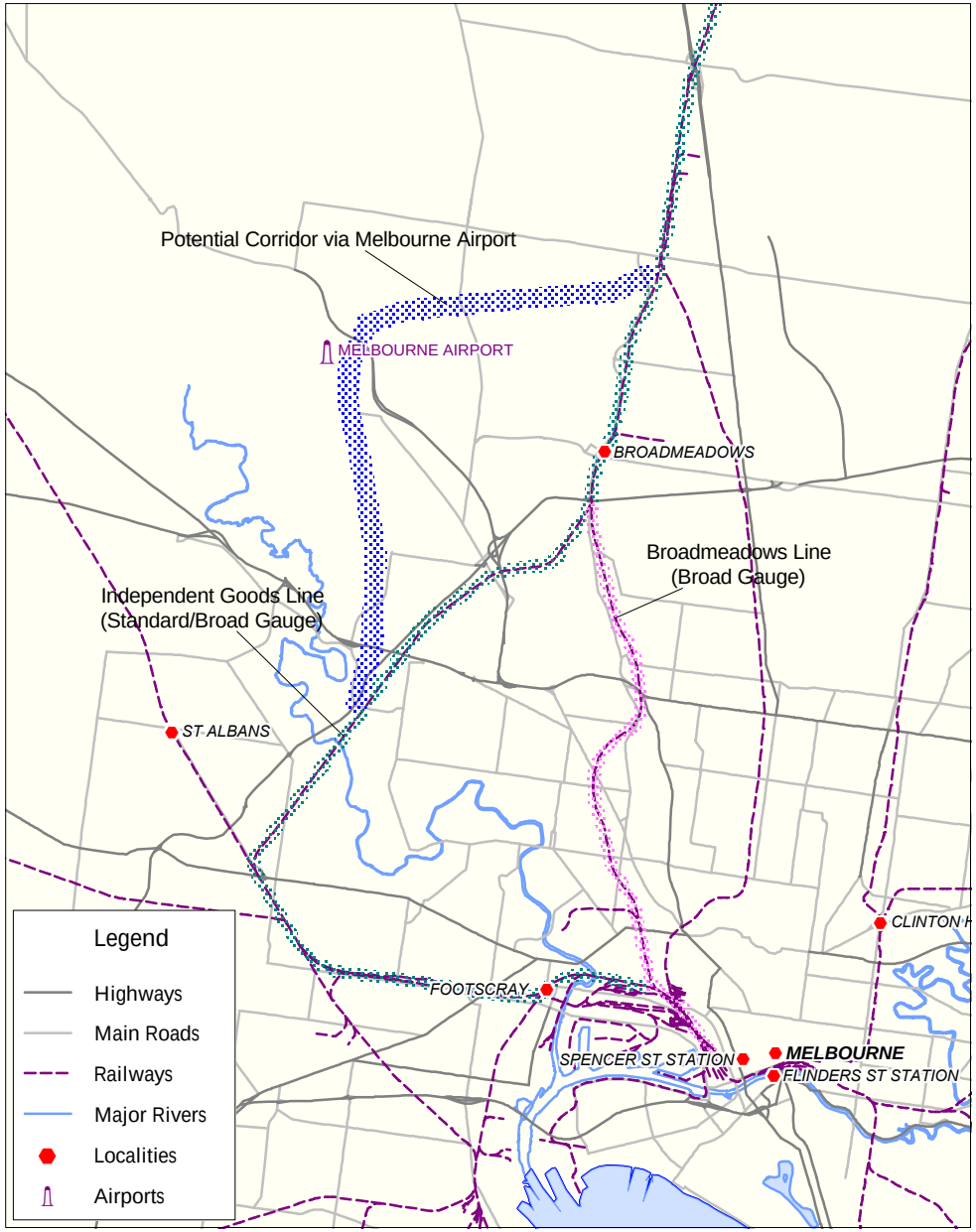
Candidate VHST Corridors with Soil Reactivity

Figure 6.8



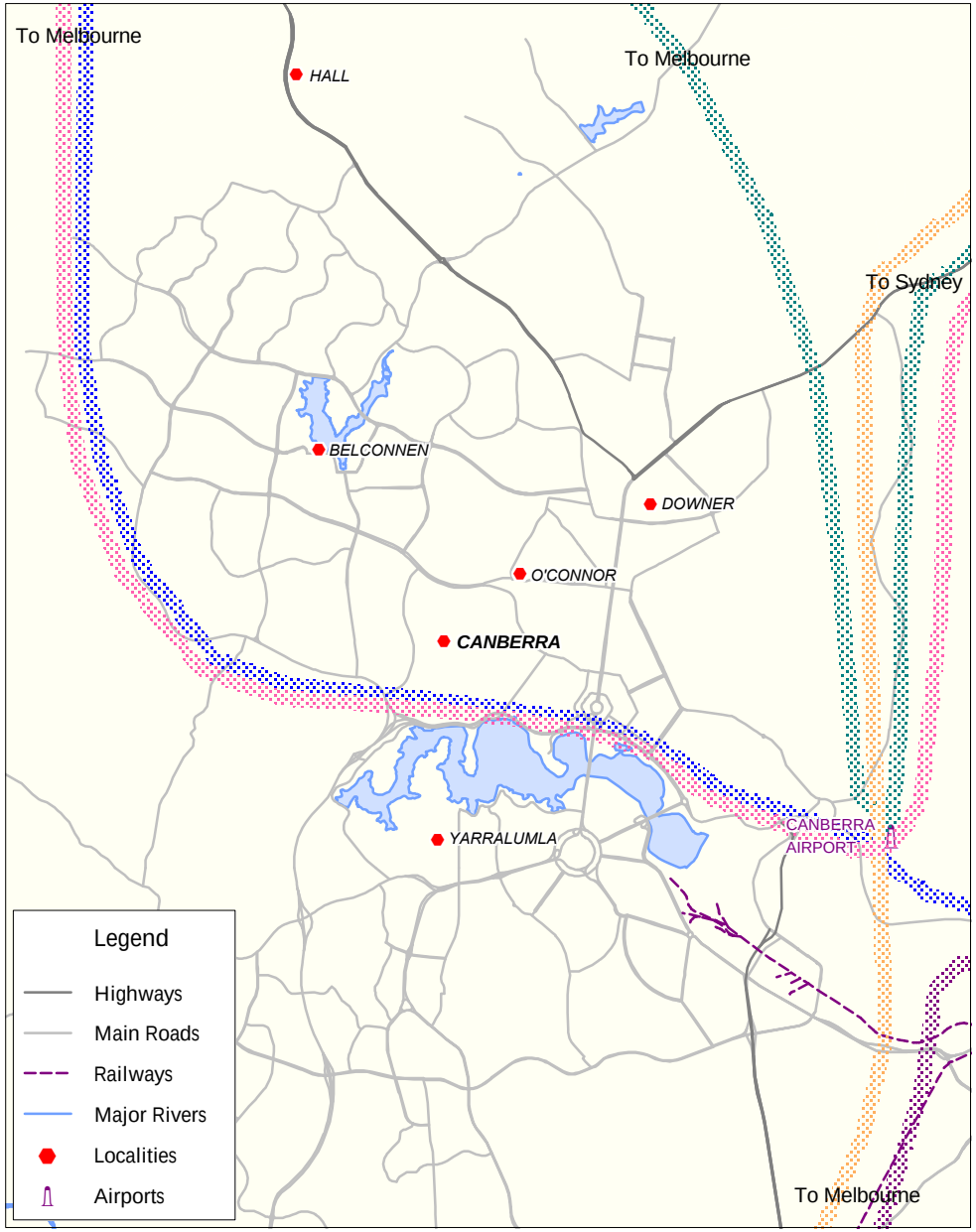
Melbourne South-East

Figure 6.9



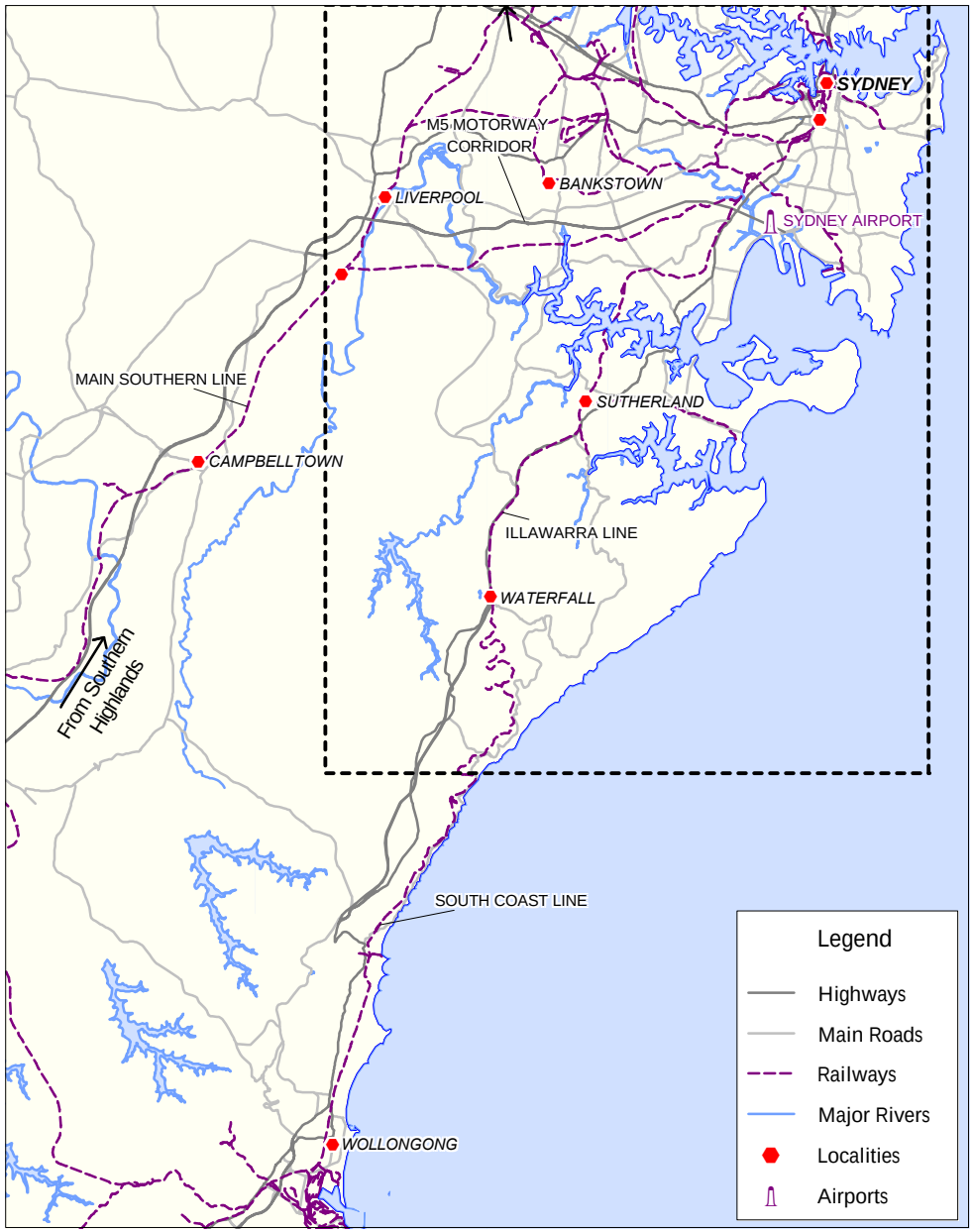
Melbourne North

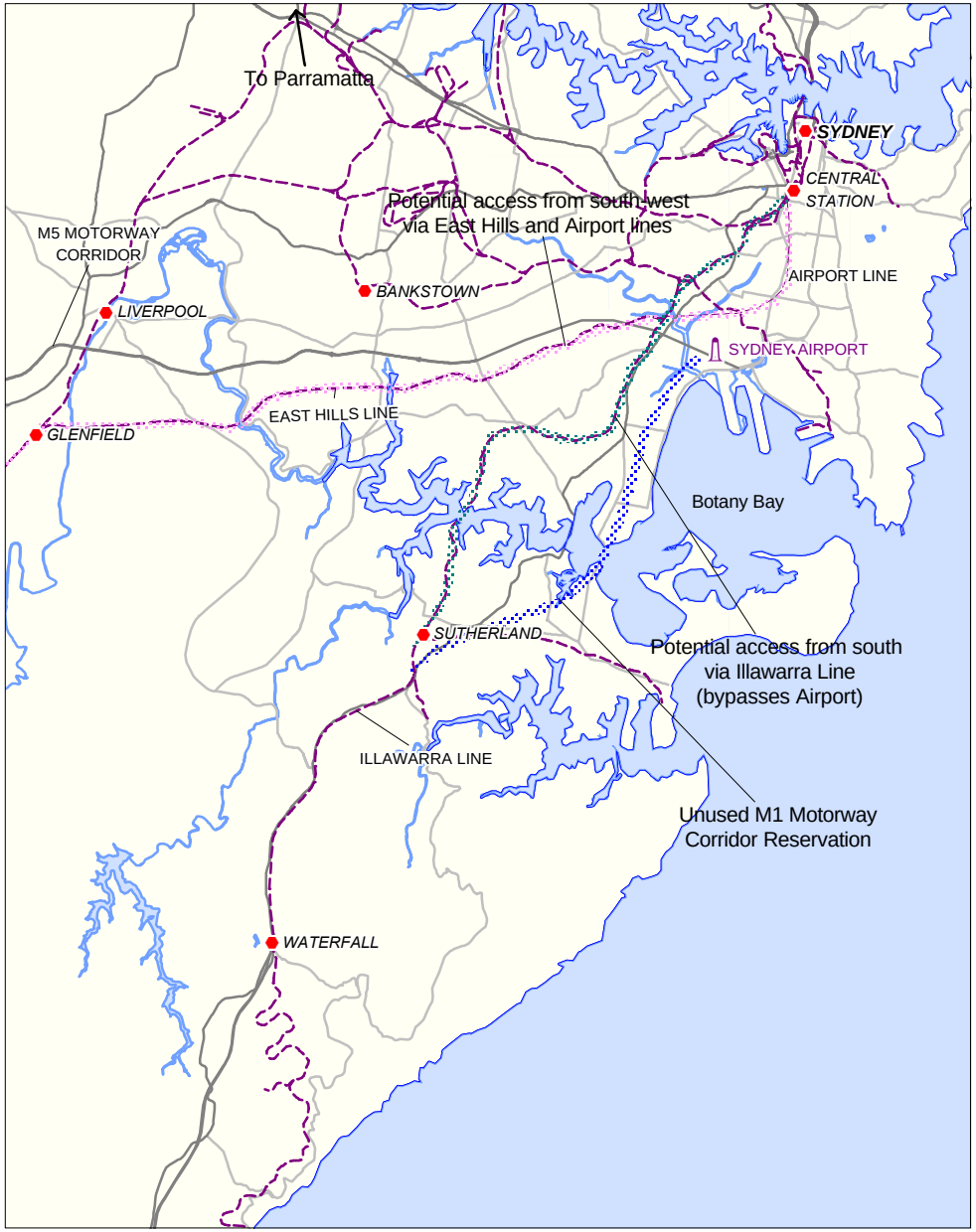
Figure 6.10



Canberra

Figure 6.11





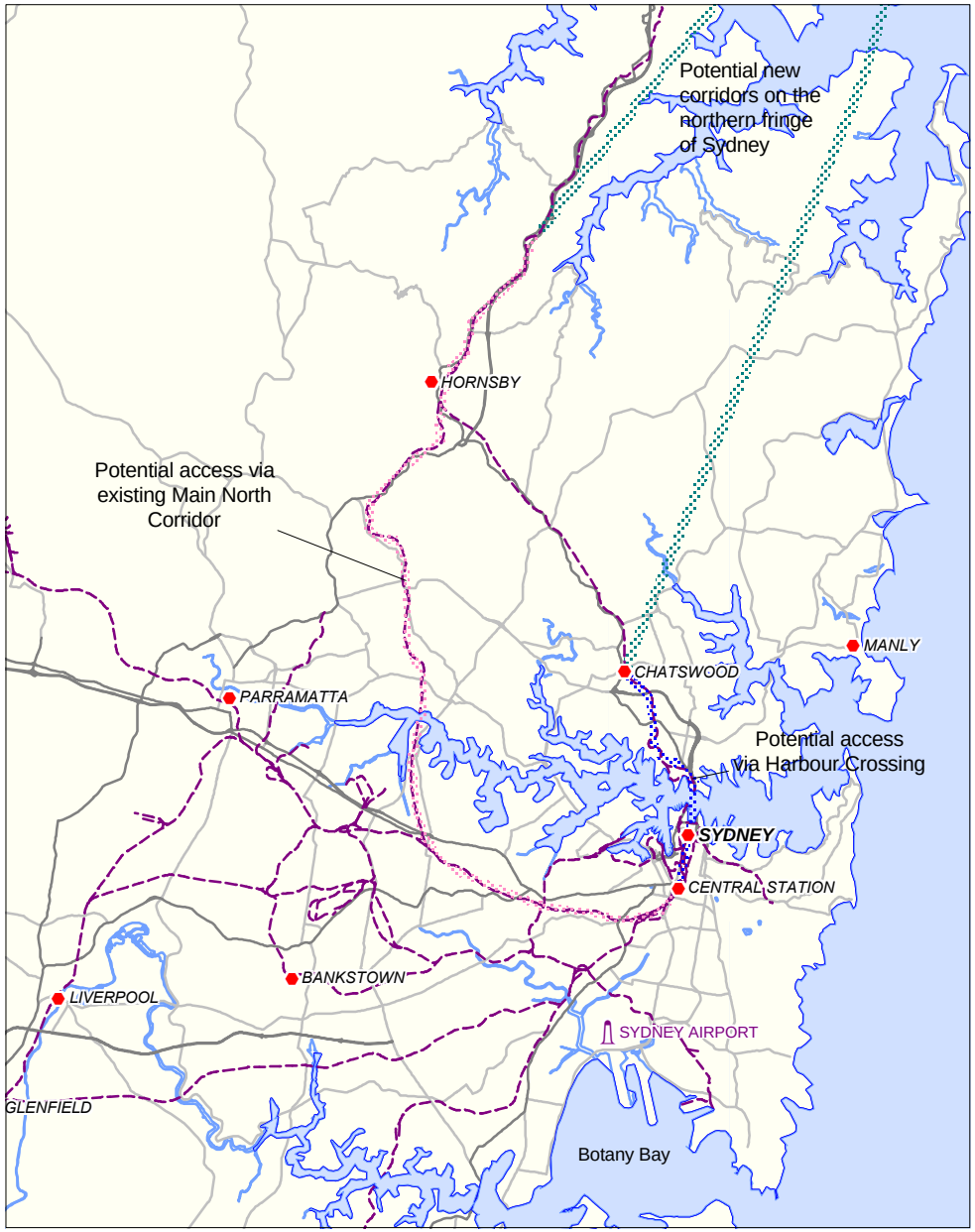
6 0 6 12
Kilometres

N

Sydney South

Figure 6.12



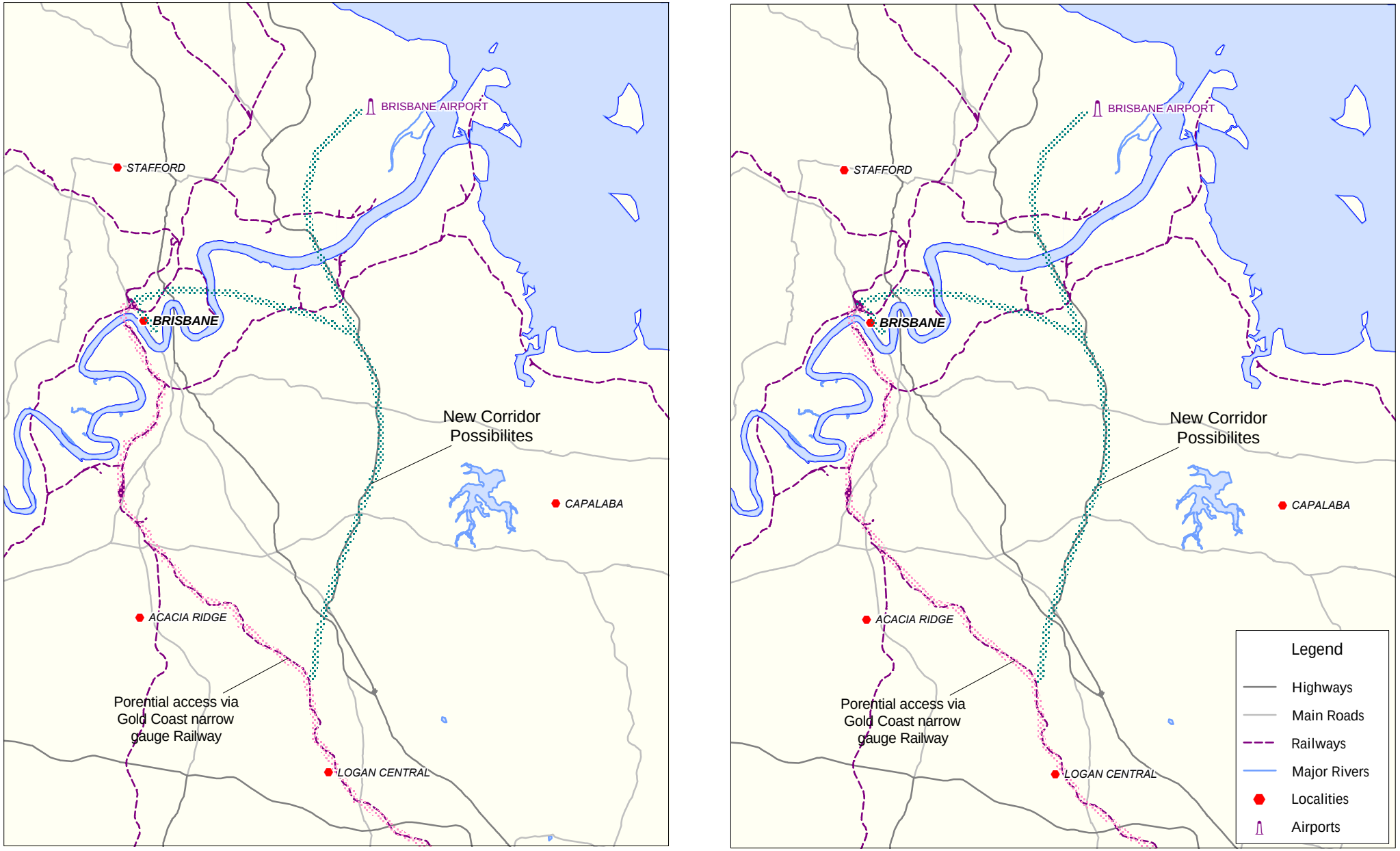


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Sydney North

Figure 6.13



Brisbane

Figure 6.14

Section 7

Operating Performance and Transit Times



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7 OPERATING PERFORMANCE AND TRANSIT TIMES

7.1 Introduction

In order to prepare realistic estimates of the transit times which could be offered by different trains along the train performance spectrum, simulations were conducted by means of the MTRAIN package with the representative 160 km/h, 250 km/h, 350 km/h and 500 km/h train technologies. No fully worked-up VHST alignment designs exist between Sydney and Melbourne or between Sydney and Brisbane. However, Arup-TMG and others have undertaken work under various commissions for Commonwealth, NSW or Queensland Government agencies to permit indicative alignments to be assembled for simulation of train performance.

Alignment profiles are needed in order to estimate travel times using train performance simulation. Such alignments may represent aspects of the most favoured corridors from the previous engineering and environmental assessment. However, their most useful purpose is to provide a basis for interpolation for all the route alternatives being considered for patronage estimation. The basis for interpolation was to take specifically simulated metropolitan entry/exit times plus generic average sectional speeds elsewhere.

Two alignments were chosen for train performance simulation to:

- benchmark train performance in typical East Coast Australia terrain;
- illustrate some of the metropolitan entry and exit issues;
- illustrate some of the coastal versus inland issues;
- cover the impact of terrain on competent high performance trains; and
- illustrate the pattern of settlement outside the major conurbations.

7.2 Preparing Alignments

The Sydney-Melbourne (see figure 6.6) and Sydney-Brisbane (see figure 6.7) corridors were considered separately. However, they exhibited similar en-route characteristics, as follows:

- a Sydney Exit which took each alignment from an in-town terminus (Sydney Terminal station) to the metropolitan limits;
- an Interurban Traverse, such as the Southern Highlands or the Central Coast, between metropolitan Sydney and rural NSW;
- a Line Haul leg through rural NSW and/or Victoria; and
- a Metropolitan Entry (to either Melbourne or Brisbane) similar in character to the Sydney Exit and finishing at a suitable terminus (i.e. Spencer Street and Roma Street respectively).

In this study, the Metropolitan entries and exits follow existing railway corridors because it was assumed that it would be highly unlikely that new railway corridors could be cut through established urban areas. This assumption requires testing in more detailed work. Thus, VHST operation is necessarily constrained by these corridors' geometric limitations, albeit on as favourable terms as possible. For example, tilt train speed limits, to a maximum of 200 km/h, were assumed, with reduced speeds on approach to the terminals at each end of each corridor.

It was assumed that speed limits could be higher on the respective Interurban Traverses on the grounds that there would be more scope to find a favourable alignment in the more sparsely populated areas outside the established metropolitan areas. The southern and northern Interurban Traverses out of Sydney had to pass through difficult terrain and extensive National Parkland. On the other hand, while there was no Interurban Traverse to the north of Melbourne there is one to the east of Melbourne on the Coastal route through Gippsland. There is an extensive traverse through the Gold Coast to the Qld/NSW border and there is also a transition from an Interurban Traverse to a Line Haul leg between the Southern Highlands and the ACT.

It was assumed that Line Haul legs could be operated at full line speed, subject to "all-stops" services having to stop periodically, i.e. roughly every 100 km. There was no opportunity to finesse alignment details during the construction of these simulation alignments. Therefore, adverse speed limits remain at various locations in the reported profiles as shown in section 6. However, for the purposes of estimating the most favourable travel times for each train performance level, most of these localised speed limits have been over-ridden. Similarly, some localities, for example Cootamundra to the south and Casino and Lismore to the north, were not bypassed. Thus the resulting simulation routes are probably somewhat longer than they might be under an alignment optimising exercise. Hence both the southern and northern alignments could be somewhat longer than the shortest practicable alignments.

7.3 Conducting the Simulations

The objectives of these train performance experiments were to obtain realistic, but optimistic, travel times for the different types of train and to illustrate the impacts of:

- actual horizontal and vertical alignments on travel times;
- imposed speed limits on travel times, especially in metropolitan areas;
- stopping patterns for limited-stops services serving only the major conurbations and all-stops services linking all major and minor centres; and
- speed limit relaxation outside conurbations.

So as not to penalise 350 km/h and 500 km/h trains, speed limits outside metropolitan and interurban areas were relaxed in two stages up to 500 km/h, without regard to the actual feasibility of doing so. The first stage was to maintain the few adverse speed limits where there were known geographic impediments, for example through Goulburn, Yass and Cootamundra. The second stage was to ignore these constraints altogether. Thus unconstrained transit speeds have been used throughout the remainder of travel time estimation to present the best possible picture of VHST performance.

7.4 Simulation Results

Table 7.1 summarises the non-Metropolitan Entry/Exit or Interurban Traverse average speeds for 160 km/h, 250 km/h, 350 km/h and 500 km/h trains running under limited-stops and all-stops service produced by MTRAIN train performance simulation when using the route profiles presented in figures 6.5 and 6.6. Limited-stops services were assumed to stop at metropolitan edge stations and then only major locations, such as Canberra on the Sydney-Melbourne corridor or Newcastle and Coolangatta on the Sydney-Brisbane corridor. All-stops services were assumed to stop at metropolitan edge stations thence at all regional stations, irrespective of whether they were major or minor stations. These regional stations had been placed roughly 100 km apart.

The outstanding feature of these bare average speeds (i.e. without any provision for recovery) was the similarity between northbound and southbound speeds irrespective of the vertical profiles of the different corridors. This suggests that each train type was well suited to its respective duty (i.e. maximum permitted speed) and was able to accommodate alignments conforming to the general objective of a predominant grading of no greater than 1.5%, albeit with some grades steeper than this but only over moderate distances. It is also apparent that over long distances each train type should be able to sustain speeds close to its maximum permitted speed under limited-stops running. However, the faster train types reduce their average speeds more quickly than the slower train types when they have to stop roughly every 100 km.

Table 7.1: Northbound (NB) and Southbound (SB) Average Speeds (km/h) for Trains of Different Maximum Permitted Speeds Running Limited-Stops (LS) or All-Stops (AS) over Non Metropolitan, etc Corridor Sectors

Corridor Sector	Dist (km)	Mode	160 km/h		250 km/h		350 km/h		500 km/h	
			NB	SB	NB	SB	NB	SB	NB	NB
NE Vic	670	LS	152	154	235	237	325	327	447	447
Riverina		AS	146	148	225	225	276	279	373	373
NSW Sth	228	LS	149	146	225	225	314	314	429	429
Highlnds		AS	145	142	218	218	275	269	361	361
NSW Nth	699	LS	148	148	219	219	302	302	437	437
Coast		AS	146	146	215	214	284	284	378	378

Full sectional travel time summaries were then able to be compiled using the specific travel times for Metropolitan Entries and Exits and Interurban Traverses, where applicable, plus Line Haul distances and their respective train specific average speeds. The Line Haul running times were sensitive to service stopping patterns. It was estimated that running all-stops would cost an additional 15-30 minutes over running limited-stops. The time penalty would be higher for the faster trains because they have to accelerate and decelerate further for each intermediate station stop than for the slower trains. All these times incorporated a 10% recovery time allowance. This is probably at the high end of world practice. However, it is unlikely that recovery time margins would be less than 5%, based on European experience such as on the British or French railways.

Finally, station stop times were added to the running times. It was assumed that there would be 3 intermediate stops under limited-stops running and 11 intermediate stops under all-stops running between Melbourne and Sydney. Similarly, It was assumed that there would be 5 intermediate stops under limited-stops running and 11 intermediate stops under all-stops running between Sydney and Brisbane. There are no dwell time standards for VHSTs. Therefore it was assumed that major stops would take two minutes and minor stops would take one minute for the purposes of this study.

Table 7.2 summarises the corridor sector limited-stops and all-stops running times for trains of different maximum permitted speeds calculated under the above conditions. The entire Melbourne - Canberra - Sydney - Brisbane corridor was

broken into ten sections for the patronage estimation purposes. These sections were included in table 7.2 to provide insight into the travel time performance of different corridor sectors and to discriminate between inland and coastal corridors, or parts thereof. The sections were further divided to identify different Metropolitan Entry/Exit, Interurban Traverse and Line Haul sectors.



Photo Courtesy of UIC

7.5 Summary Travel times

Table 7.3 consolidates the sectional times from table 7.2 to provide long haul travel time summaries for limited-stops and all-stops running for trains of different maximum permitted speeds. These travel time summaries apply to the inland Melbourne - Sydney and coastal Sydney - Brisbane corridors. They are for the corridors as costed and for which patronage estimates were produced. However these corridors may not necessarily be along the best and/or shortest alignments. Thus the prospective travel times for shortened corridors are also given to test the impact of route reduction. For example, it is estimated that the Melbourne - Sydney corridor could be reduced by up to 111 km if the corridor stays in the Hume corridor (rather than deviating via Shepparton) in Northeast Victoria and runs directly from Albury Wodonga to Canberra (bypassing Wagga Wagga, Cootamundra and Yass). At 894 km, this is still longer than the theoretical rhumbline distance of 730 km. There is less scope to reduce the more direct Sydney - Brisbane corridor, but it could be shortened by 19 km by cutting directly across Broken Bay. At 904 km this is still longer than the theoretical rhumbline distance of 770 km.

Table 7.2: Limited-Stops (LS) and All-Stops (AS) Sectional Travel Times (minutes) for Trains of Different Maximum Permitted Speeds Running between Melbourne, Canberra, Sydney and Brisbane via Inland and Coastal Route Alternatives

Sect	Corridor Sector	Dist	160 km/h		250 km/h		350 km/h		500 km/h	
		(km)	LS	AS	LS	AS	LS	AS	LS	AS
1	MEL exit North	37	30	30	29	29	29	29	24	24
	NE Vic	309	137	146	91	98	68	81	50	63
	Sth NSW	386	175	189	119	133	92	112	70	90
2	MEL exit East	26	26	26	26	26	26	26	21	21
	Gippsland	314	134	144	87	97	62	78	47	59
	Sth NSW	373	164	179	108	118	81	99	61	76
3	CNB-GLB	87	39	42	25	28	19	23	13	17
4	NSW Sth Highlands	150	69	72	47	50	36	43	27	34
	SDY entry Southwest	36	28	34	26	32	26	32	26	32
5	NSW Sth Coast	136	80	84	56	61	47	53	38	44
	SDY entry South	25	25	27	25	27	25	27	25	27
6	SDY Exit North	34	25	27	25	27	25	27	24	26
	Lower Cen Coast	43	22	25	18	21	18	21	18	21
7	SDY Exit Northeast	12	17	17	17	17	17	17	17	17
	Broken Bay	46	25	28	20	22	17	20	13	16
8	Upper Cen Coast	76	35	38	26	29	19	22	14	17
9	NSW New Eng	479	215	221	144	153	106	117	73	89
	Qld Darling Downs	287	130	135	91	96	69	74	54	62
	TWB-IPS	98	46	48	37	39	31	33	28	30
	BNE entry West	46	37	39	37	39	37	39	37	39
10	NSW Nth Coast	666	298	308	202	211	147	165	99	124
	Qld Gold Coast	64	38	40	32	34	32	34	30	32
	BNE Entry South	40	32	34	31	33	32	34	31	33

Table 7.3: Consolidated Limited-Stops (LS) and All-Stops (AS) Corridor Travel Times (minutes/hours) and Commercial Speeds (km/h) for Trains of Different Maximum Permitted Speeds

Corridor	Unit	160 km/h		250 km/h		350 km/h		500 km/h	
		LS	AS	LS	AS	LS	AS	LS	AS
MEL-SDY	Min	478	513	337	370	270	320	210	260
Inland	Hr	8.0	8.6	5.6	6.2	4.5	5.3	3.5	4.3
1005 km	Km/h	126	118	179	163	223	188	287	232
MEL-SDY	Min	429	462	305	337	247	293	193	240
Inland	Hr	7.2	7.7	5.1	5.6	4.1	4.9	3.2	4.0
894 km	Km/h	125	116	176	159	217	183	278	224
SDY-BNE	Min	450	472	334	355	273	303	216	253
Coastal	Hr	7.5	7.9	5.6	5.9	4.6	5.1	3.6	4.2
923 km	Km/h	123	117	166	156	203	183	256	219
SDY-BNE	Min	445	465	328	346	264	292	204	239
Coastal	Hr	7.4	7.8	5.5	5.8	4.4	4.9	3.4	4.0
904	Km/h	122	117	165	157	205	186	266	227

Thus the results for limited-stops trains were:

- 7.2 - 8.0 hours between Melbourne and Sydney and 7.4 - 7.5 hours between Sydney and Brisbane for 160 km/h trains;
- 5.1 - 5.6 hours between Melbourne and Sydney and 5.5 - 5.6 hours between Sydney and Brisbane for 250 km/h trains;
- 4.1 - 4.5 hours between Melbourne and Sydney and 4.4 - 4.6 hours between Sydney and Brisbane for 350 km/h trains; and
- 3.2 - 3.5 hours between Melbourne and Sydney and 3.4 - 3.6 hours between Sydney and Brisbane for 500 km/h trains.

These are impressive travel times results but they do represent the candidate train performances in their best light.

Tables 7.4 and 7.5 present the conditions for competitive travel between Sydney & Melbourne and Sydney & Brisbane respectively. It can be seen that, if the objective of an EC VHST is to be competitive with air services between those cities then the times offered are at least 45-60 minutes too long, even after train travel is allowed a comfort time bonus of, say, 20 minutes as compared to air. Even MagLev, the fastest mode, could not offer competitive limited-stops travel times over the routes and the scope for high speed traverses of the metropolitan entries and exits, the slowest portions of any train's journey, is limited by the physical and environmental constraints of the settlement patterns of the three cities.

Table 7.4: Conditions for Competitive Air and Rail Travel; Sydney toMelbourne

Travel times (minutes) assume leaving at 0630 for a morning business meeting with no en route problems			
Journey Stage	**Air**	**Rail**	
Car to airport/station	35	30	
Terminal wait	20	10	
Gate to gate	85	145	**190 best time for MagLev**
Terminal transit and wait	10	10	
Taxi to City	35	10	
Bare total	**185**	**205**	
Rail comfort bonus	-	-20	
Revised total	**185**	**185**	

Table 7.5: Conditions for Competitive Air and Rail Travel; Sydney to Brisbane

Travel times (minutes) assume leaving at 0630 for a morning business meeting with no en route problems			
Journey Stage	**Air**	**Rail**	
Car to airport/station	35	30	
Terminal wait	20	10	
Gate to gate	90	140	**200 best time for MagLev**
Terminal transit and wait	10	10	
Taxi to City	25	10	
Bare total	**180**	**200**	
Rail comfort bonus	-	-20	
Revised total	**180**	**180**	

7.6 Summary

In summary, for journeys between Sydney, Melbourne and Brisbane, air travel will retain a significant time advantage until such time as the ground access component becomes prohibitive. However, air services operate on very direct routes and do not, have mandatory stops, as for example in Canberra, enroute. Just stopping adds time but so also does the need to deviate from the straightest route. The issue then for a VHST is not so much whether it can compete "head to head with air but whether it can develop a unique and sustainable market from the populations and conurbations that lie along its route.

7.7 Key Points

- All types of trains can run close to their maximum performance over extended distances outside metropolitan and interurban areas;
- Metropolitan entry and exit corridor sections are critical because they are constrained by urban settlement while their transit times inflate long distance travel times out of proportion to their lengths;
- Route shortening outside metropolitan areas can only reduce travel times to a minor degree and possibly at the expense of reducing regional access to VHST services. Furthermore there is a practical limit to route shortening;
- Even allowing for a rail comfort bonus time, the quickest Melbourne-Sydney and Sydney-Brisbane door-to-door travel times by rail are still significantly longer than comparable air travel times; and
- Definitive travel time estimation will require rigorous route alignment investigation using the lessons learnt about train performance with respect to alignment geometry, using rational travel time versus construction cost trade-offs and using clear guidelines as to corridor purpose, regional access, etc.



Figure 7.1: Average Corridor Speed

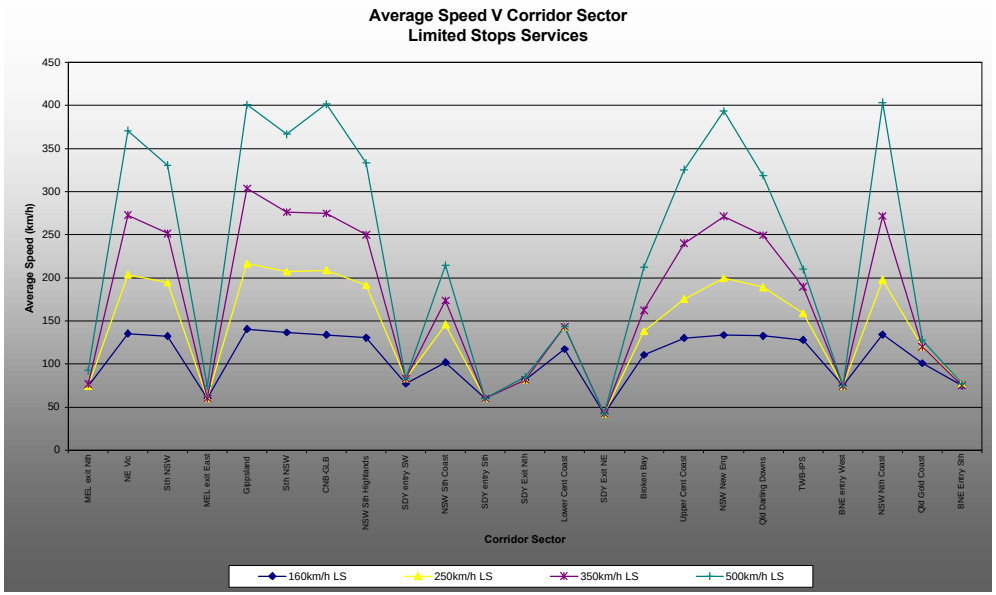
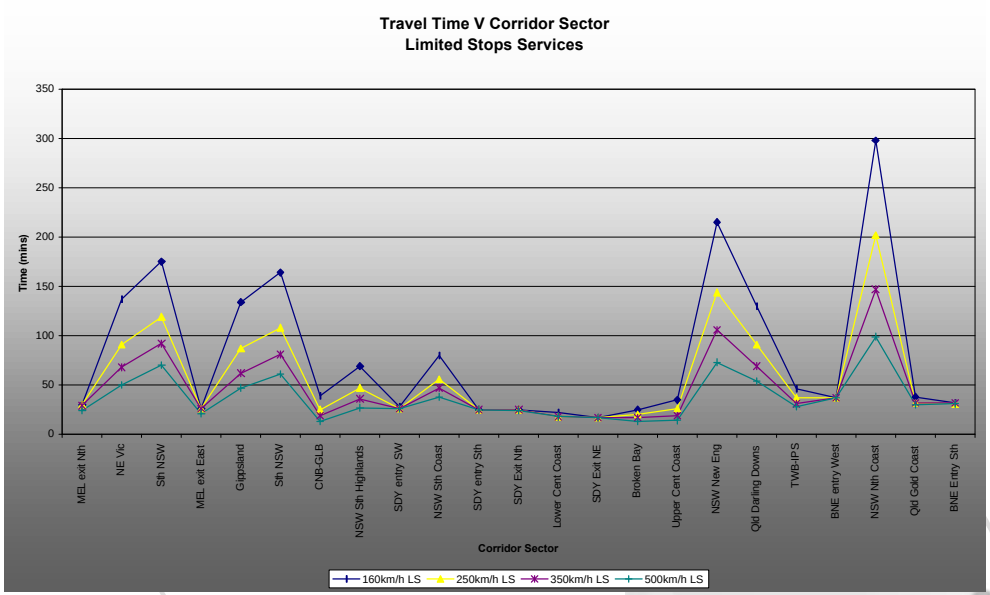


Figure 7.2: Corridor Travel Time



Section 8

Project Costs



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8 PROJECT COSTS

8.1 Infrastructure Capital Costs

8.1.1 International Benchmarking of Conventional VHST Project Costs

Given that there were no comparable VHST projects within Australia against which an East Coast VHST could be directly compared, a project-wide benchmarking analysis of the costs of SWSR systems was undertaken with a global focus. Costs were developed broadly on a per km basis using similar and relevant high-speed rail projects planned and completed around the world. Information on these projects was obtained from various sources including:

- published data in relevant rail trade magazines and technical journals;
- a database of cost information developed by Arup-TMG during the years of working in the rail industry;
- project summary information published by rail organisations; and
- public domain sources such as the Internet.

The data was adjusted for both escalation and for currency conversion and it was reviewed for industry cost equivalence on a materials and labour basis. Where noted herein costs were converted on a parity basis. The coverage of the cost information varied, depending on the source and type of project. For example, many of the European high speed rail projects do not include costs for rolling stock, since the project was an extension to an existing system and rolling stock was not considered on a project-specific basis.

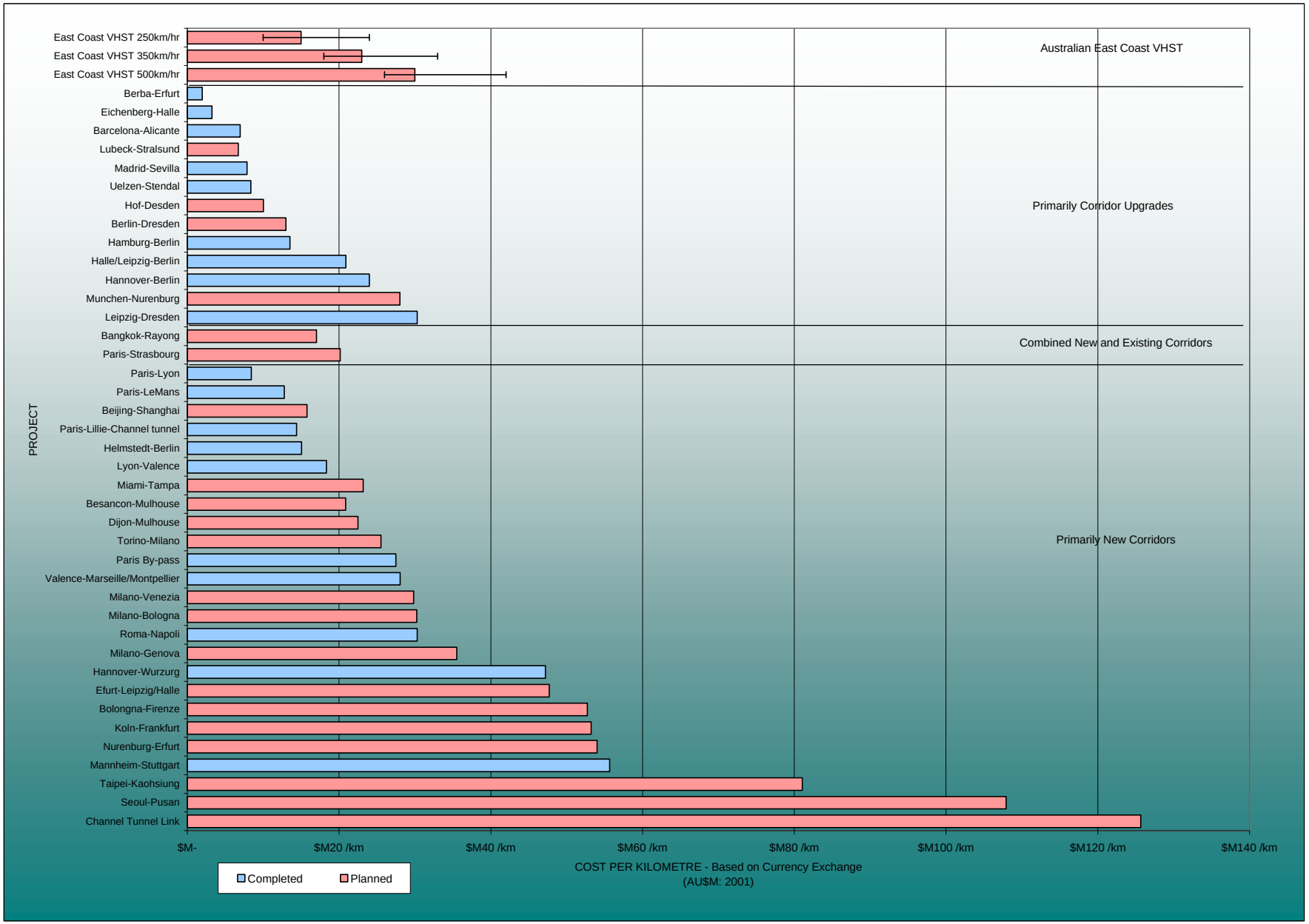
Figure 8.1 indicates the results of the benchmarking of high-speed international projects. Some general observations of the benchmarking, based on a review of available information, include:

- projects in excess of A$35 million per km typically included a significant length of tunnelling and/or viaduct (UK, Germany, Korea and Taiwan);
- for projects in the range A$25 to $35 million per km, project characteristics were more variable, ranging from combinations of tunnelling and upgrading of existing track through to a number of projects with similarities to the east coast corridor;
- projects less than A$25 million per km were more commonly upgrades of existing corridors (including realignments) or projects with relatively easy terrain;
- projects less than A$15 million per km were almost all upgrades of existing corridors with only minor realignments;
- TGV projects in France appeared to be lower in cost than high-speed projects in countries such as Germany and Italy. One possible reason for this could be a lower capital cost/higher maintenance cost approach in the design of the railways. For example, the initial German NBS railways were typically constructed using track slabs rather than ballast, and in certain corridors over more difficult terrain. Also, many of the earlier TGV projects were not under the same pressure for land and were built to far less stringent environmental constraints;
- whilst the out-turn costs of completed railways were recorded with some certainty, the projected cost of schemes under development were not likely to be as accurate. The out-turn cost of a large proportion of major civil engineering projects exceeds the original budget and this could increase the costs identified for a number of the rail projects used in the benchmarking;
- the costs are influenced by currency exchange. The gradual decline in the value of the Australian currency in the past two years has seen a major increase in these benchmarking results; and
- when reviewed on a parity basis the costs do reduce significantly particularly at the higher end. However, it does not alter the conclusion that the costs adopted for an EC VHST are well inside the international range and in fact in the bottom half of that range.

8.1.2 Application of Conventional VHST Costs to East Coast Corridor

On the basis of the international SWSR project costs, combined with input from rail corridor improvement estimates prepared by Arup-TMG on a limited number of rail projects in NSW (typically constrained to no more than 250 km/h alignments), a set of cost per km rates were derived taking into account:

- project development, management and approvals costs;
- civil engineering works, including major structures, earthworks and tunnelling;
- environmental mitigation measures, such as noise walls;
- rail systems including power, track, signalling and other safety measures;
- where relevant, amplification of existing rail corridors;



Benchmarking Against International VHST Projects

Figure 8.1

- where relevant, conversion of narrow or broad gauge corridors to dual gauge;
- a double track rail network throughout;
- rail stations, terminal and associated facilities; and
- construction contingencies.

These per km rates were prepared for a range of corridor categories including:

- the type of corridor to be used (existing standard gauge, narrow/broad gauge, amplified corridor, new corridor);
- the type of terrain in which the corridor is located and the subsequent need for minor, moderate or major civil engineering works (including, at the extreme, tunneling);
- the type of land use in which the corridor is to be developed, whether this be urban, rural residential, rural or environmentally sensitive (including the possible need for tunneling to avoid sensitive areas); and
- the type of technology (250 km/h or 350 km/h).

Given that specific alignment and route options are yet to be developed, these per kilometre rates were applied by developing a set of upper and lower range costs for each broad corridor. For SWSR technologies, variations between upper and lower costs for each broad category exist on the basis of:

- for the lower cost range:
  - minimal improvements are required in metropolitan corridors (e.g. creation of dual gauge track, amplification of corridor where capacity is known to be at its limit);
  - no new corridors in metropolitan areas (unless no existing corridors available); and
  - for all technologies within a new corridor band outside of metropolitan areas, a sensible route via the easiest terrain available (typically longer routes avoiding where possible major lengths of tunnelling and large earthworks).
- for the upper cost range:
  - significant improvements are required in metropolitan areas, typically (but not always) requiring new corridors; and
  - for all technologies within a new corridor band outside metropolitan areas, very direct routes focussed on achieving the best possible journey times rather than avoiding difficult terrain (typically shorter routes where possible lengths of tunnelling and large earthworks/structures are required).

8.1.3 International Benchmarking of MagLev Capital Costs

As no MagLev systems of significant scale have yet been placed into revenue service, there is only limited data on actual construction costs and experience of operations in a commercial environment. Of the two systems that are operational, only Transrapid is active in promoting MagLev technology. While there is reasonable data on the technical aspects of the Japanese MagLev systems there is no operating cost data available. Transrapid has been operating its test site for a number of years and has prepared detailed bids for a number of MagLev projects. Consequently, its operating cost data would appear to be the most reliable available in the public domain.

Tables 8.1 and 8.2 provide summaries of data obtained for projects in Europe, the USA and in China. Unfortunately, the data available is not completely consistent for all projects. However, the projects do cover a wide range of route lengths, as shown in figure 8.2.

In order to define a cost range for MagLev, capital cost estimates were based on project distances for sectors into and out of the major cities and intermediate sectors. Figure 8.3 is useful for showing that project costs reduce on a per-km basis as the length increases. This data is also useful for estimating costs for MagLev projects over relatively shorter distances and in more urbanized areas.

Figure 8.2 Project Costs for MagLev Systems

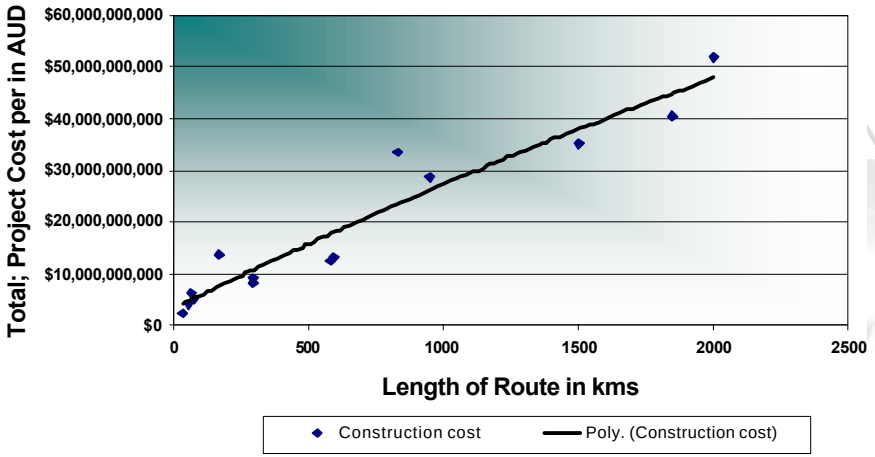


Table 8.1: European Transrapid MagLev Projects

Source: Transrapid International www.transrapid.de

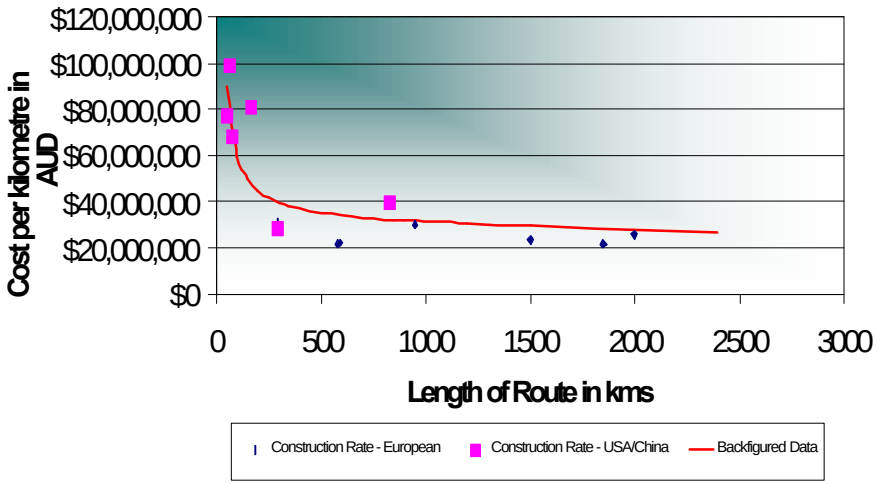
All Projects are from Berlin	X		1		2		3		4
Data	Rate		Warsaw	Moscow	Cracow	Kiev	Budapest	Thessalonika	Hamburg
Year			1996	1996	1996	1996	1998	1998	1996
Distances		km	580	1850	590	1500	950	2000	292.00
Transit Time		hours	1.72	4.75	1.83	4.10	2.75	6.33	1.00
Av Speed		km/hr	338	389	322	366	345	316	292
Max Speed		km/hr	500	500	500	500	500	500	450.00
Ridership per annum									11400000.00
Pax-kms		pax-km	3.20E+09	3.20E+10	3.50E+09	2.10E+10	1.08E+10	3.20E+10	2.60E+09
Cost		euros	6,500,000,000	21,000,000,000	6,800,000,000	18,200,000,000	14,800,000,000	27,000,000,000	*9,800,000,000 DM*
	0.52	AUD	$12,500,000,000	$40,384,615,385	$13,076,923,077	$35,000,000,000	$28,461,538,462	$51,923,076,923	$9,114,000,000
Fleet Cost		euros	390,000,000	1,260,000,000	408,000,000	1,092,000,000	900,000,000	1,620,000,000	588,000,000
(If not known assume 6%)	0.52	AUD	$750,000,000	$2,423,076,923	$784,615,385	$2,100,000,000	$1,730,769,231	$3,115,384,615	$558,600,000
Operating Cost per Annum		euros	n/a	n/a	n/a	n/a	$300,000,000		*250,000,000 DM*
	0.52	AUD					$576,923,077		$232,500,000
Fares		euros/km	n/a	n/a	n/a	n/a	$0.18		*0.274 DM*
	0.52	AUD	n/a	n/a	n/a	n/a	0.35		0.25
Revenues									*700,000,000 DM*
									$651,000,000
Private Sector % of Capital Cost			n/a	n/a	n/a	n/a	5.0%		39%
Annual Refinancing Costs		euros	n/a	n/a	n/a	n/a	$300,000,000		
	0.52	AUD	n/a	n/a	n/a	n/a	$576,923,077		
Parameters									
Construction Rate - European	AUD	$/km	$21,551,724	$21,829,522	$22,164,276	$23,333,333	$29,959,514	$25,961,538	$31,212,329
Operating Rate per passenger	AUD	$/pax	n/a	n/a	n/a	n/a	n/a	n/a	$20.39
Operating Rate per p-km	AUD	$/pax-km	0.00	0.00	0.00	0.00	0.05	0.00	0.09
Vehicles Rate	AUD	Veh Cost $/pax-km	0.23	0.08	0.22	0.10	0.16	0.10	0.21
Revenue per passenger	AUD	$/pax	n/a	n/a	n/a	n/a	n/a	n/a	$57.11

Table 8.2: MagLev Projects in the USA and China

Source: USDOT Federal Railroad Administration Website and Others

Data	X Rate	From To	1 Baltimore Washington	2 Pennsylvania HS Maglev	3 Atlanta Chattanooga	4 LAX March	5 Los Angeles San Francisco	6 Las Vegas Barstow	ShangHai Pudong
Year			2001	2001	2000	2000	1996	1998	2001
Technology			Transrapid	Transrapid	Transrapid	Transrapid		Transrapid	Transrapid
Distances		km	64	76	52	166	828	293.4	30
Transit Time		hours	0.33	0.47	0.38	0.97	2.05	0.80	0.12
Av Speed		km/hr	194	163	136	171	404	367	
Max Speed		km/hr					558	504	
Ridership per annum		pax	12,900,000	33,500,000	3,619,000	48,910,000	14,800,000	10,490,000	10,000,000
Pax-kms		pax-km	550,000,000						300,000,000
Construction cost		US$	$3,300,000,000	$2,700,000,000	$2,101,200,000	7,000,000,000	$17,300,000,000	$4,303,500,000	$1,200,000,000
	0.52	AUD	$6,346,153,846	$5,192,307,692	$4,040,769,231	13,461,538,462	$33,269,230,769	$8,275,961,538	$2,307,692,308
Fleet Cost		US$	$194,000,000	$162,000,000	$126,072,000	420,000,000	$1,000,000,000	$258,210,000	
(If not known assume 5%)	0.52	AUD	$373,076,923	$311,538,462	$242,446,154	807,692,308	$1,923,076,923	$435,576,923	
Operating Cost per Annum		US$	$29,709,000		$28,522,000	125,000,000	$261,800,000	$65,720,000	
	0.52	AUD	$57,132,692		$54,850,000	240,384,615	$503,461,538	$126,384,615	
Fares		US$/km	$0.41		$0.21	$0.18		$0.11	
	0.52	AUD	$0.79		$0.40	$0.34		$0.21	
Revenue		US$/km	$226,200,000		$39,000,000	$394,000,000	$914,900,000	$162,000,000	
	0.52	AUD	$435,000,000		$75,000,000	$757,692,308	$1,759,423,077	$311,538,462	
Private Sector % of Capital Cost			0.15						
Annual Refinancing Costs		US$							
	0.52	AUD							
Parameters									
Construction Rate - USA/China	AUD	$/km	$99,158,654	$68,319,838	$77,707,101	$81,289,483	$40,180,230	$28,207,095	$76,923,077
Operating Rate per passenger	AUD	$/pax	$4.43	$0.00	$15.16	$4.91	$34.02	$12.05	$0.00
Operating Rate per p-km	AUD	$/pax-km	0.10	n/a	n/a	0.32	n/a	n/a	n/a
Vehicles Rate	AUD	Veh Cost $ /pax-km	0.35	n/a	n/a	n/a	n/a	n/a	n/a
Revenue per passenger	AUD	$/pax	$33.72	$0.00	$20.72	$15.49	$118.88	$29.70	$0.00

Figure 8.3: Cost per Kilometre for MagLev Systems



The estimates initially made were based on currency exchange rates. When converted on a parity basis from US currency, costs for MagLev are about 30% less than those in figures 8.2 and 8.3. As there is a large amount of local content in MagLev's infrastructure, the costs in table 8.3 have been adjusted for this effect, making them more consistent with the infrastructure costs for the other technologies which could more easily be estimated from local construction rates. More detailed studies of the local construction cost rates for this type of construction would be needed to confirm this reduction for MagLev is in fact obtainable.

This gives a cost range of $55.8 billion to $58.6 billion or about $30 million per kilometre. Where very extensive tunnelling is required for all technologies, these costs have increased to account for creating the bare tunnel.

8.1.4 East Coast VHST Corridors Costs by Stages

Table 8.3 provides a summary of the indicative capital costs for each broad corridor, as derived from the analysis discussed above. These indicative costs are also summarised in figure 8.4 (total costs) and figure 8.5 (costs per kilometre).

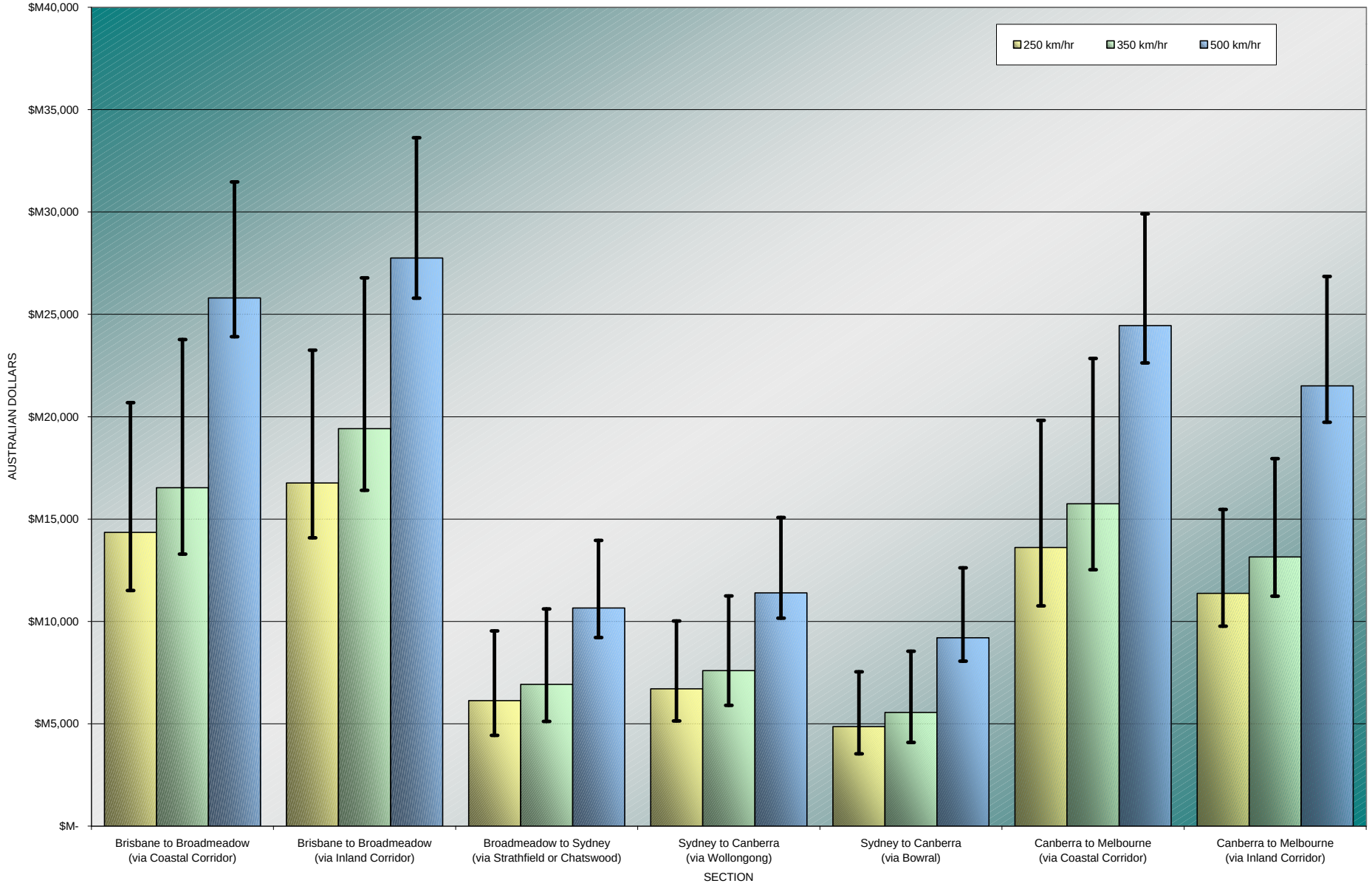
Table 8.3: Summary of Indicative Costs ($Billions)

Section	via	Seg. Label	Technology		
			250 km/h	350 km/h	500 km/h
Bris - New	Inland (New England)	1a	15.6-17.9	18.2-20.6	18.9
	Coastal (Gold Coast)	1b	12.7-15.9	14.8-18.3	19.6
New - Syd	Newcastle to Sydney	2	4.9-7.3	5.7-8.2	7-8.5
Syd - Can	Inland (Glenfield)	3a	3.9-5.8	4.5-6.6	11.4
	Coastal (Wollongong)	3b	5.7-7.77	6.6-8.6	12.3
Can - Mel	Inland (Albury)	4a	10.9-11.9	12.5 –13.8	17.8
	Coastal(Gippsland)	4b	12.0-15.3	13.9-17.6	18.2
Total ($B): 1b, 2, 3a, 4a			*32.5-41.0*	*37.5-46.8*	*55.8-58.6*

Notes:
1. Costs should be assumed to have an estimating accuracy of -10% to +30%;
2. The range on costs for 250 km/h and 350 km /h reflects different assumptions regarding extent of new construction as described previously. 500 km/h was assumed to have only one alignment except for Newcastle –Sydney;
3. Newcastle to Sydney range allows for a major route shortening option.

The indicative capital costs have been compared with previous estimates (where available) on the Sydney to Canberra VHST project and the earlier VFT project. Typically, the above indicative capital costs are significantly higher than those previously estimated.

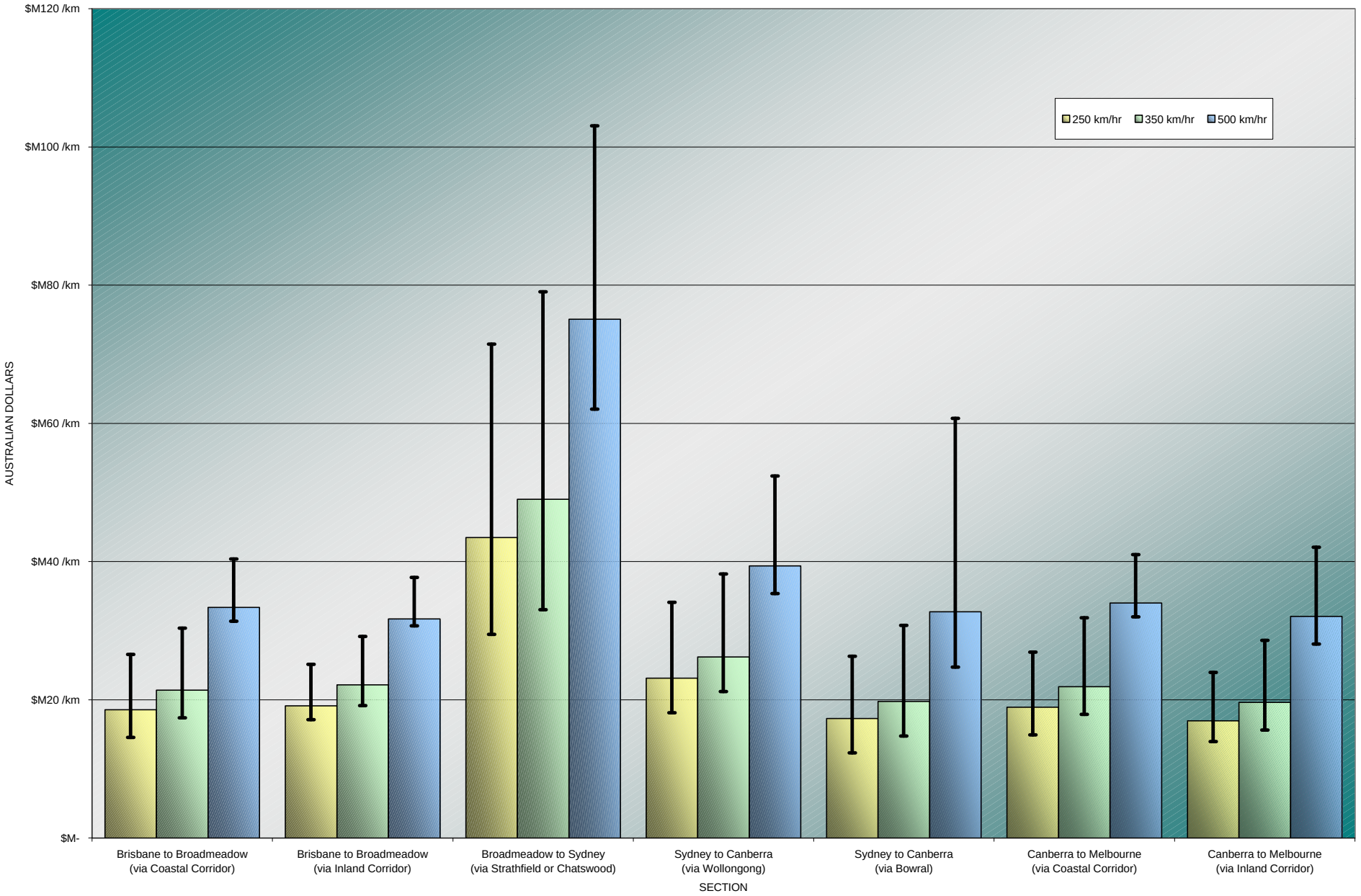
While a number of reasons may exist for these differences, a likely reason for discrepancies between the Sydney to Canberra VHST and this study is the common assumption in this study across all technologies that a double track corridor will be required. The Sydney to Canberra VHST proposals may have been based on a single track with only limited sections of double track and/or passing loops. Another reason for the discrepancy is the differing assumptions made in relation to metropolitan access. It is important also to note that this study is not attempting to identify a minimum commercially competitive infrastructure price but to assess a very large number of possibilities on a common basis.



Average Total Cost - Upper and Lower Range

Figure 8.4

Note: Cost range bar includes corridor range in Table 8.1 plus estimating accuracy of -10% to +30%



Average Cost per km - Upper and Lower Range

Figure 8.5

There is a reasonable expectation, from the prices quoted for the Sydney-Canberra project that scope exists to reduce these indicative costs as the project becomes more defined and more detailed operational planning can be undertaken to, for example:

- identify possible sections of single track corridor (expected to be significant particularly for the lower speed range technologies); and
- better define the realistic options for metropolitan access in terms of travel time, available capacity, and other physical constraints (such as gauge differences).

Table 8.3 also indicates the range in cost of the major corridor stages in the East Coast corridor - i.e. those stages that link the major cities of the East Coast. These are the logical complete stages in a total EC VHST system. However, their scale, even as individual projects, is so great that there may be logical sub-stages with which to commence. The issue of staging is considered further in sections 10 and 14. Staging needs to be considered in the context of an operable business and therefore the patronage available in that stage is a relevant consideration.

8.2 Rolling Stock Costs

An assessment of rolling stock costs has been made by reference to:

- Technical railway press – this source provides good coverage of actual contracts awarded particularly for VHST rolling stock in Europe;
- Internet sites – these sources have provided a considerable wealth of data about estimated costs.

The data derived from these sources is presented in table 8.4. A number of sources for each technology band are shown. It is evident that there is significant variation in the cost when calculated on a comparable i.e. per seat basis. Notably, the cost of the recently delivered *Acela* rolling stock for Amtrak's Washington – New York – Boston service is considerably above the others in its band.

The cost of the MagLev train sets is extremely high but was drawn from authoritative sources in which very detailed estimates were made. As at present the indications are that these trainsets would most likely be imported and they have been valued at exchange rates rather than parity pricing. In view of the variability, average costs on both a per-train set and a weighted cost per seat basis were calculated. From these, a notional cost for a 400 seat nominal train in each technology band was assumed as indicated below:

- 500 km/h - $100 million per trainset;
- 350 km/h - $47 million per trainset;
- 250 km/h - $40 million per trainset;

8.3 Operating and Maintenance Costs

Operating and maintenance costs have been assessed in two ways. Firstly, a top down approach by using data drawn from operating railways and estimates from other projects. Secondly, for the SWSR 350 km/h case, a bottom up approach using estimates of costs and quantities for items influencing operating costs. At this stage of definition of an EC VHST, both ways can only be regarded as indicative and should only be used to test the sensitivity of the viability of the project. Estimates have been made for both a SWSR system and a MagLev system. In the case of an SWSR system, no differentiation has been made for rolling stock type across the technology bands considered.

Estimates have been derived on the basis of cost per passenger-km and cost per train kilometre, as these appear on the data available to provide reasonably robust measures that account for the major variables operation. Estimates of operating cost have been made on the basis of parity pricing where these costs derive from international sources.

8.3.1 SWSR Systems

Cost Benchmarks – Top Down

The current long-distance operator in the East Coast corridors, SRA's Countrylink, had operating cost of 24-25 cents per passenger kilometre in 1988-89 but by 1997 had pulled these costs down to about 13.5 cents per passenger kilometre.

Table 8.4: Recent Contract or Quoted Prices for Rolling Stock

Name	Year	Source	Generic Type	Max. Speed	Train per order	Cars per set	Seats per Train	Cost in Millions (in US $ except Speedrail)	Assumed X-Rate	Cost in AUD	Cost per seat in AUD	Cost in AUD for nominal 400 Seats	Total Seats	Weighted Average for 400 seats	Adopted cost for Category
												400			
Pendolino Britannico	2001	Rail News July 2001	250 Electric Tilt	226	63	9	441	£594,000,000	$0.3634	$1,681,020,000	$71,921	$28,768,579			
Alstom Alaris	2001	Railway Gazette July 2001	250 Electric Tilt	250	20	4	236	ECV 228,000,000	$0.4600	$506,666,667	$107,345	$42,937,853			
Siemens ICE3	2000	Railway Gazette August 2	300 Electric	300	50	n/a	415	1,900,000,000 DM	0.95	$2,000,000,000	$96,386	$38,554,217			
Alstom/Bombardier Acela	2001	www.tgv.web.fr	Electric/Diesel	240	20	8	304	$611,000,000	$0.5200	$1,175,000,000	$193,257	$77,302,632			
					143		1396			$5,362,686,667	**Av. Cost/train**	***$40,890,720***	54923	$97,640	
													Weighted Av.Cost/Train	**$39,096,036**	**$40,000,000**
Speedrail 350	1999	Herald tribune	350 Electric Tilt	350	9	n/a	460	$500,000,000	$1.0000	$500,000,000	$123,457	$49,382,716			
Siemens ICE 350	2001	Railway GazetteMay 2001	350 Electric Tilt	350	16	8	404	123,000,000,000 pts	$0.0108	$1,302,966,102	$112,791	$46,116,556			
Talgo 350	2001	Railway GazetteMay 2001	350 Electric Tilt	350	16	14	318	incl above		incl above	incl above	incl above			
					254		3267			$1,802,966,102	**Av. Cost/train**	**$47,249,635**	15802	$115,560	
													Weighted Av.Cost/Train	**$46,223,974**	**$47,000,000**
Baltimore Washington Maglev	2001	www.bwmaglev.com	500 Maglev	500	6	3	312	$138,600,000	$0.5200	$266,538,462	$142,382	$56,952,663			
California Maglev Deployment	2001	www.calmaglev.org	500 Maglev	500	7	8	524	$619,400,000	$0.5200	$1,191,153,846	$324,742	$129,896,821			
California -Las Vegas Maglev	1998	www.ci.las-vegas.nv.us	500 Maglev	500	9	6	384	$415,800,000	$0.5200	$799,615,385	$231,370	$92,548,077			
Atlanta-Chattanooga Maglev	2001	www.acmaglev.com	500 Maglev	500	5	3	176	$136,900,000	$0.5200	$263,269,231	$299,170	$119,667,692			
					27		1396			$2,520,576,923	**Av. Cost/train**	***$99,766,348***	9876	$255,222	
													Weighted Av.Cost/Train	**$102,088,980**	**$100,000,000**

A review of data from the three Japanese railways that operate VHSTs is shown in table 8.5 and indicates that the three companies have very similar operating expenses – in the range of 15.0 to 16.7 cents per passenger kilometre.

Table 8.5: Operating cost data from Japan (1997)

Operating cost data from Japan.(1997)	Opex in Yen	Pax-km	yen per pax-km	Convert rate	Cents per pax-km
	millions	millions	millions	yen/cent	millions
JR West	810732	55974	14.48408	0.96	15.0
JR East	1897682	127314	14.90552	0.96	15.5
JR Central	780200	48672	16.02976	0.96	16.7

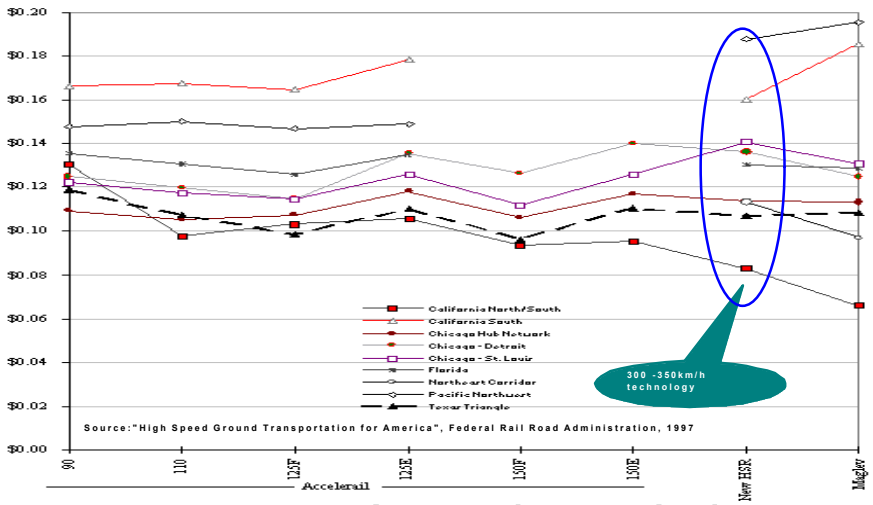
Source: 1997 Annual Reports

In the USA, the Federal Railroad Administration studied a large number of VHST projects across the USA examining a similar range of technologies and infrastructure options. Figure 8.6 is sourced from the FRA's study. In their study the FRA commented that, for most VHST systems, operating costs per passenger-mile lay in the range 10 to 14 cents (US). This is equivalent to about 7 to 10 cents (AUD) per passenger km, with the lower end of the range applying to corridors of 500km or more. However, as figure 8.6 shows, the range of costs broadens for the 350 km/h and 500 km/h technologies.

Estimates for VHST projects in California put operating costs for systems of a similar scale at as low as six cents per passenger kilometre (www.transitinfo.org/HSR/ex_sum.htm, 1996). More recently, the California High-Speed rail commission estimated an operating and maintenance cost of about four cents per passenger kilometre. This operating cost included traction power; train operations; rolling stock maintenance; station services; marketing and reservations; insurances; administration; and perway maintenance. However, the South Eastern High Speed Rail System in North Carolina estimated an operating cost of 11 cents (AUD) per passenger kilometre.

Obviously, there are significant organizational differences between the Japanese railway operators and any EC VHST operator – they are at least 20 times bigger operations for a start. Consequently these might reasonably be assumed to be an extreme upper bound. Countrylink is actually operating over exactly the same territory, as would an EC VHST. However, it operates diesel hauled trains and is a much smaller operation than an EC VHST would be. However, it has made huge changes in its cost structure. Countrylink's operating cost also reflects access charges.

Figure 8.6: Operating Costs per Passenger Mile



For the purpose of this study, an operating cost benchmark upwards of six cents per passenger kilometre appears a realistic "bottom end " noting that higher costs could be incurred.

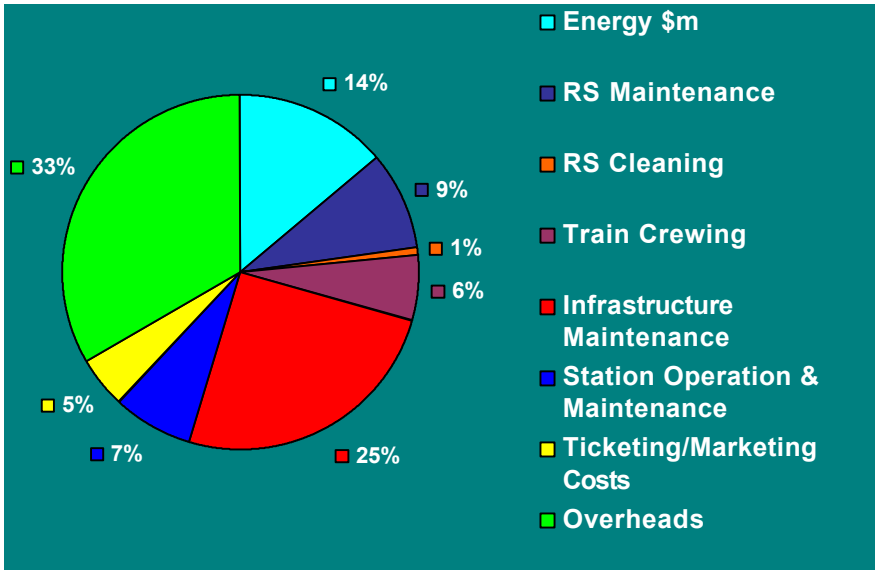
Bench marks for costs on a per train-km basis were derived from the same sources. In 1996 Arup-TMG estimated cost of $27-28 per train–km. The California High-Speed Rail Commission studies indicated a cost of about $17 per train-km with South East High Speed Rail indicating about $15 per train-km. In 2001 JR Central's costs per train-km were as low as $9 per train-km.

Cost Benchmarks – Bottom Up

As a part of the evaluation of an EC VHST, Arup-TMG made a bottom up estimate of operating costs which suggested that, at operational startup, the annual operating costs would be about $665 million for the full Melbourne to Brisbane via Sydney VHST system. This gives a cost of 6 cents per passenger kilometre and $17 per train kilometre.

The distribution of costs is shown in figure 8.7.

Figure 8.7: Estimated Operating Costs per Annum in Millions at Startup



The "bottom up" operating costs therefore accord reasonably well with the "top down" benchmarks assessing from other projects.

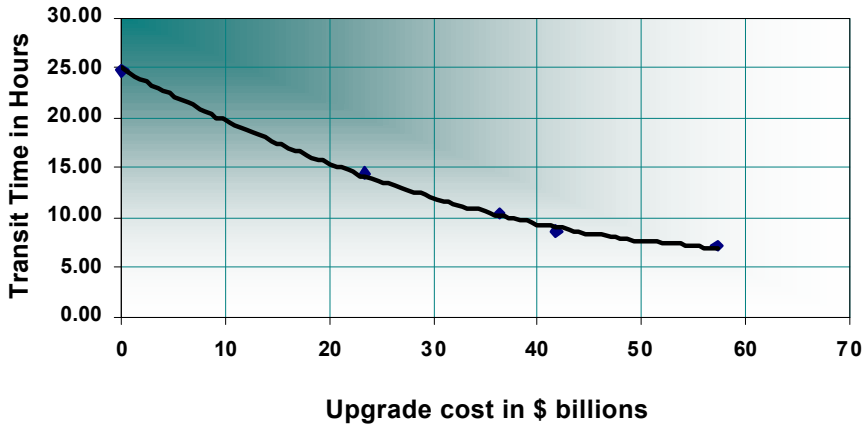
8.3.2 MagLev Systems

There have been no MagLev systems of any significant scale constructed and placed in to revenue service as yet. Data on operating costs per passenger-km is even sparser than for capital costs. Furthermore, such costs are very wide in range – from 4 cents per passenger-km cited by Transrapid in the studies for the European Union for a 950 km link from Berlin - Budapest and 9 cents for the Berlin – Hamburg project to 22 cents per passenger-km cited in a very detailed "bottom up" operating cost analysis for a proposed MagLev operation linking Chattanooga to Atlanta. This data places MagLev operating costs in a similar range to SWSR VHST operations. Consequently, for the purposes of this study operating costs have been assumed to be representative of either VHST system.

8.4 Incremental Cost of Faster VHSTs

Figure 8.8 shows the relationship between total Melbourne to Brisbane via Sydney transit time and investment in progressively faster forms of VHST. In all cases, including the existing, transit times have assumed no stopping time in Sydney. Additionally, the average cost for upgrading has been used. It is apparent that, as was the case in the Sydney – Canberra project the cost of travelling faster by ground transportation technologies increases exponentially. However, the marginal cost of going from a 250 km/h technology to a 350 km/h technology is in this case much less while it delivers a 20% reduction in transit time. As noted previously, costs for 500 km/h technology could reduce by up to 20% for local construction costs. However, the general relationship of technology, cost and transit time remains the same.

Figure 8.8: Transit Time vs Infrastructure Upgrade Cost
Melbourne to Brisbane via Sydney



8.5 Key Points

- As no VHST systems have been built in Australia, capital and operating costs have been benchmarked on international sources.
- For SWSR VHST systems local cost rates are able to be used to build up infrastructure pricing – for MagLev international rates adjusted for price parity have been used.
- The rates used take account of particular costly conditions such as urban environments and topographical constraints where tunnelling would be required. All costs are on the basis of full double track for all technologies.
- A range of cost from about $32 billion to $59 billion for the full Melbourne to Brisbane corridor was assessed. This is across the 250 km/h to 500 km/h technology spectrum and across a range of possible corridors and alignment options.
- Rolling stock costs were assessed from international sources and ranged from $40 million to $100 million for a notional 400 seat trainset.
- Operating and maintenance costs were assessed using a “bottom up” approach and benchmarked against international costs adjusted for parity. Costs or MagLev and SWSR systems were assessed to be very similar and about 7 cents per passenger-km.
- The trend in costs with speed is the classic curve of diminishing time saving benefits for increasing infrastructure costs.



Section 9

Demand



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9 DEMAND

9.1 Overview

9.1.1 Introduction

This section gives an overview of the methodology used to forecast demand for an EC VHST. It then presents the key demand and revenue forecasts resulting from use of the methodology.

The demand model is fully reliant on existing data sources. No market research surveys have been undertaken as part of this study to establish either the size of the travel market or the behavioural response of travellers to changes in transport service provision.

9.1.2 Forecasting Steps

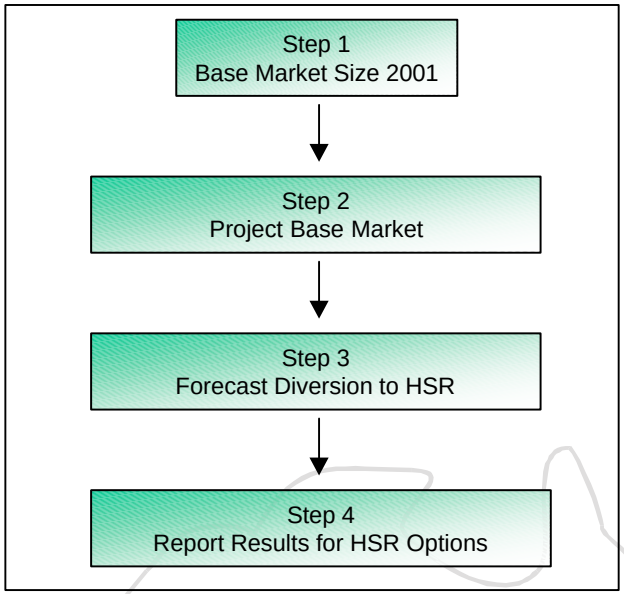
The forecasting methodology involved four steps (refer Figure 9.1).

Two models were developed:

- Base Market Model for 2001, and
- Base Market Projection and VHST Demand Forecasting Model

The two models enable demand, passenger km, revenue, user benefit and impacts on 'donor modes' to be forecast under a wide range of scenarios. Based on the forecasts, an initial evaluation of alternative route and technology options has been undertaken[1].

Figure 9.1: Forecasting Steps



9.1.3 Report Structure

Section 9.2 describes the process used to estimate the base 2001 travel market. Section 9.3 describes the method used to project the base market size. Section 9.4 describes the VHST demand forecasting model. Section 9.5 presents the base market size in 2001. Section 9.6 assesses the trend in market size. Section 9.7 projects the base market to the forecast years. Section 9.8 presents VHST demand forecasts by route, section and technology for 2021. Section 9.9 projects the VHST forecasts through the forecast years. Section 9.10 presents a profile of VHST demand. Section 9.10 assesses the source of VHST demand. Section 9.11 presents the market share VHST is forecast to achieve. Section 9.12 presents demand forecasts for selected VHST routes. Section 9.13 presents VHST demand and market share forecasts by flow. Section 9.14 presents line loadings and station usage forecasts. Section 9.15 provides sensitivity tests on key variables likely to affect VHST demand. Section 9.16 presents an assessment of the range in demand forecast. Section 9.17 presents an assessment of VHST service level in comparison to alternative modes. Section 9.18 benchmarks the forecasts against international experience.

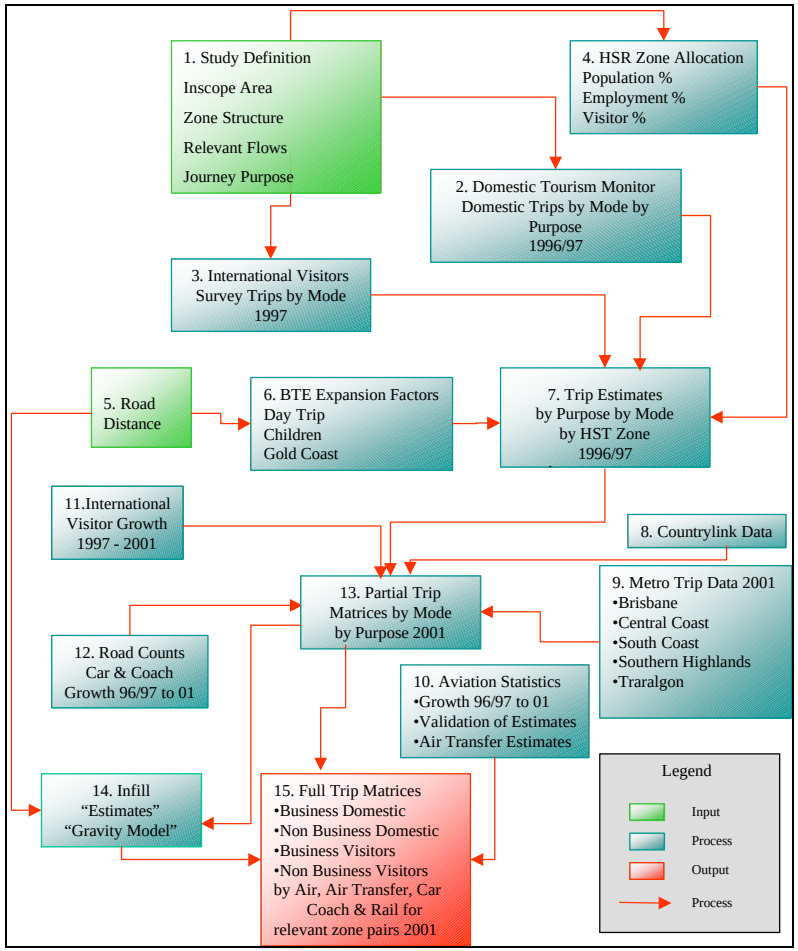
[1] The main demand model comprises two linked excel spreadsheets. One spreadsheet estimates the total market size in 2001. The second forecasts VHST demand for any selected year between 2001 and 2101 consequent on selected socio-economic scenarios and VHST and competitive service level.

9.2 Base Travel Market

9.2.1 Overview

The definition, process, and methodology used to estimate the base travel market is presented in Figure 9.2. Each box is described briefly below.

Figure 9.2: Base Travel Market Estimation



9.2.2 Study Definition

The demand model has been developed to assess alternative VHST routes and sectors (for example Brisbane to Sydney via an inland route north of Newcastle and via Hornsby south of Newcastle). Four sectors with two alternative routes each have been modelled.

Table 9.1: VHST Route Alternatives

Sector	Route Alignment	
Brisbane-Newcastle	Inland	Coastal
Newcastle-Sydney	Via Hornsby	Below Frenchs Forest
Sydney-Canberra	Via Bowral/Mittagong	Via Wollongong
Canberra-Melbourne	Inland	Coastal, via Gippsland

A potential catchment area for the EC VHST corridor was drawn around the prospective rail routes, comprising south east Queensland, NSW excluding north and central western areas and Victoria excluding north western areas.

The corridor was divided into 55 travel zones based on Domestic Tourism Monitor (DTM) travel zones[2]. Where necessary, DTM zones were subdivided to ensure that each potential VHST station had at least one assigned travel zone. A total of 47 potential VHST stations were included, as shown in Figure 9.3.[3]. The stations are representative rather than definitive, being set roughly 100 km apart excepting city outskirts where 'parkway' stations were included to cater for suburban passengers. Stations were defined as either main stations (red), stations (orange) or 'parkway' stations (blue). Express VHST services stop at main stations and 'Parkway' stations only (to pick or set down depending on direction)[4]. Stopping services served all stations on the route alternative. Station dwell times were set to be longer at main stations. The travel market was defined to include only relevant flows, an example of excluded travel being that between the Central West (Orange) and Sydney. Intra capital movements (eg Hornsby-Sydney) were also considered to be not relevant to the VHST.

Business trips (trips in the course of work but excluding commuting) trips tend to be of a different nature to leisure and commuting trips. For instance, the willingness to fares to save. travel time is higher. The model was therefore structured to forecast the size of the business and non-business travel markets separately.

2 Zones as used in the 1996/97 Domestic Tourism Survey (DTM).
3 Includes Brisbane Airport although not directly served (required interchange at Roma).
4 The term 'Parkway' is used loosely. Capital city stations were defined such that short distance trips between them were disallowed.

Figure 9.3: Inscope Study Area

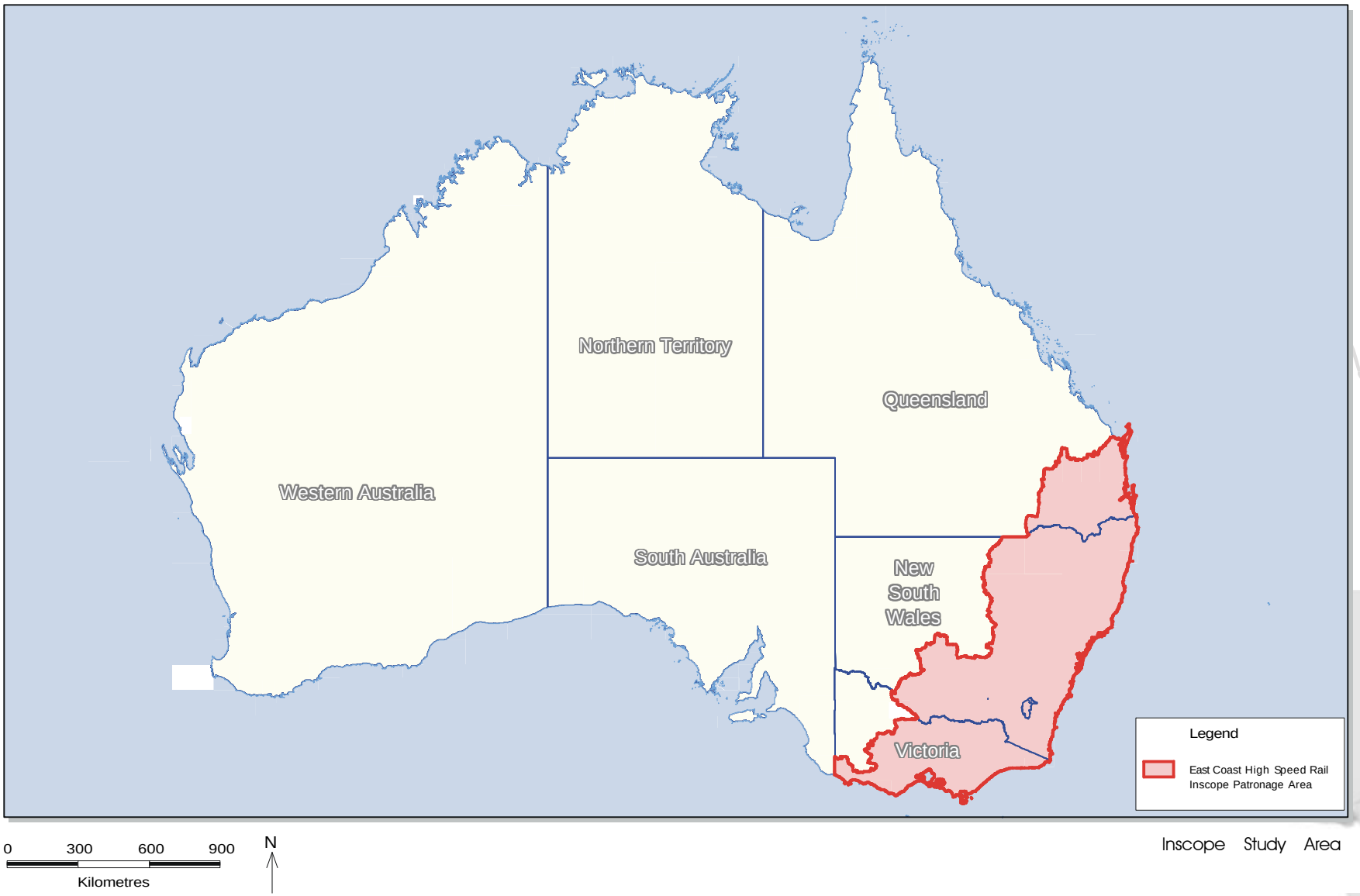


Figure 9.4: Study Zones

Zone No	Name
1	Maryborough
2	Sunshine Coast
3	Brisbane - Central/Metro
4	Brisbane - Beenleigh
5	Brisbane - Ipswich
6	Gold C -Robina
7	Gold C - Coolangatta
8	Darling Downs -Toowoomba
9	Darling Downs - Warwick
10	New England - Glen Innes
11	New England -Armidale
12	New England -Tamworth
13	Upper North - Ballina/Lismore/Casino
14	Mid North - Grafton
15	Mid North - Coffs Harbour
16	Lower North - Port Macquarie/Wauchope
17	Lower North -Taree
18	Hunter - Broadmeadow
19	Hunter - Muswellbrook
20	Central Coast - Wyong/Warnervale
21	Central Coast - Gosford
22	Sydney - Chatswood
23	Sydney - Hornsby
24	Sydney - Strathfield
25	Sydney - CBD
26	Sydney - Sutherland
27	Sydney - KSA
28	Sydney - Glenfield/Campbelltown

Zone No	Name
29	Blue Mountains
30	Central Western
31	Illawarra
32	SouthCoast
33	S. Tablelands - Bowral/Mittagong
34	S. Tablelands - Goulburn
35	ACT - Canberra Airport
36	ACT - Civic
37	Snowy - Cooma
38	Snowy - Bombala
39	S. Tablelands - Yass
40	Riverina - Cootamundra
41	Riverina - Wagga Wagga
42	Murray
43	Lakes - Orbost
44	Lakes - Sale
45	Gippsland - Traralgon
46	Gippsland - Warragul
47	Central Murray - Shepparton
48	Central Murray - Seymour
49	Melbourne - Dandenong
50	Melbourne - Airport
51	Melbourne - City/Metro
52	Gt Ocean Rd
53	Goldfields
54	Mornington Peninsula
55	High Country

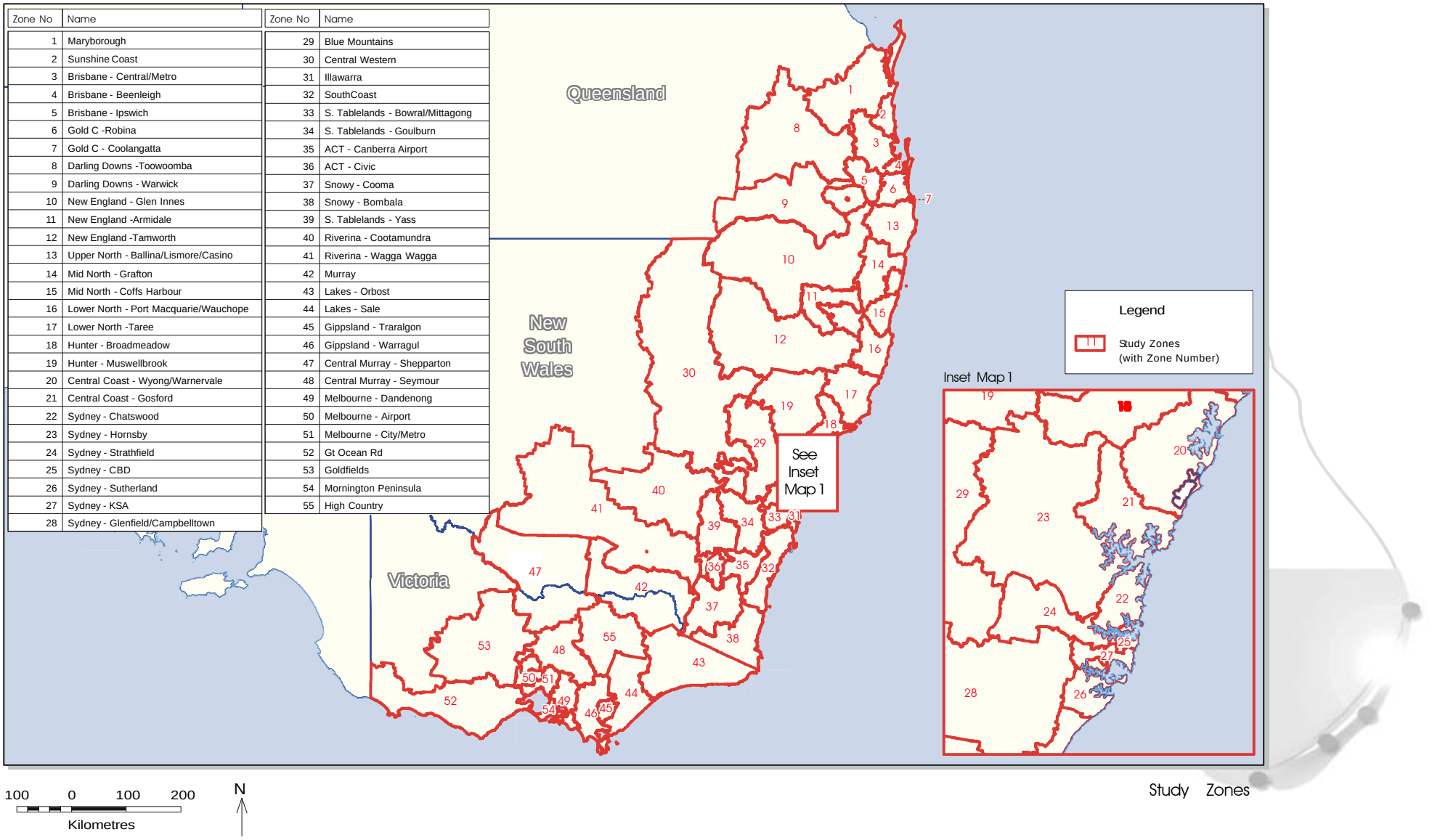
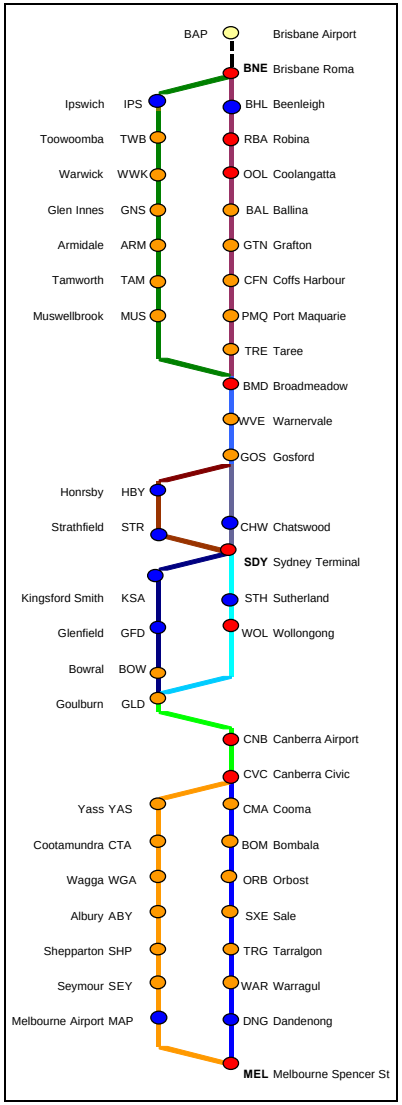


Figure 9.5: VHST Schematic



9.2.3 Domestic Tourism Monitor

The basis of the demand model was the 1996/97 Domestic Tourism Monitor (DTM). This is a market research survey of trips made by household members over a defined time period. The Bureau of Transport Economics (BTE) supplied the data to the study team which was then manipulated to provide estimate of the total number of business and non business single trips by air, car (including hire car), bus/coach and rail for 1996/97 for each DTM zone pair.

An important 'gap' in base demand is trips made within the corridor by non-corridor domestic residents. Typically these trips would be made on holiday or on business. An example might be a person who lives in Adelaide who takes a vacation on the Gold Coast and who makes a day trip to Brisbane. These trips are not included in the model excepting air transfer trips.

9.2.4 International Visitors Survey

An estimate of the trips made by overseas residents within the EC study area was based on the 1997 International Visitors Survey (IVS) provided by the BTE. The IVS provided an estimate of trips by air, car (including hire car) coach and rail trips between DTM zones in 1997. Global business and non-business shares were applied to derive business and non-business trip matrices.

9.2.5 VHST Zone Allocation

Domestic and international trips were provided by DTM zone pair. Trips were disaggregated to the 55 VHST zones according to the population and employment shares of the constituent VHST zones. Population and employment estimates for year 2001 produced by the study team (SGS) at a statistical local authority (SLA) level were used. SLA forecasts were aggregated up to the VHST zone level. For international visitors, judgement was used to allocate trips to VHST zones.

9.2.6 Road Distance

The DTM survey includes on trips that involved an overnight stay or longer. An estimate of day trips was produced that referenced road distances. A complete zone to zone road distance matrix was estimated by Arup that connected the 55 zones together.

9.2.7 BTE Expansion Factors

The BTE provided factors to expand the DTM trips to take account of day trips and children. The day trip factors were provided by mode, with dependence on distance. A lower factor was provided for non-business trips to the Gold Coast, with a lower proportion of day trips. The BTE also provided factors to take account of trips by children, who are not included in the DTM and IVS trips.

9.2.8 Trips Estimates by Purpose and Mode

The application of the socio-economic and BTE expansion factors to the DTM and IVS trips produced an estimate of total trips by mode by purpose for 1996/97.

9.2.9 Countrylink Data

Countrylink provided annual trip data for services between Brisbane and Melbourne. This data was used to estimate a supplementary trip estimate for year 2001. The Countrylink estimate was compared with the DTM estimate and substituted for the latter where the Countrylink data was judged more reliable.

9.2.10 Metro Trip Data

The DTM data was considered less reliable for trips under 150 km. For metro areas around Brisbane, Sydney and Melbourne, trip data was obtained to estimate trip estimates for rail and car. Data sources included Queensland Rail, Brisbane City Council, NSW SRA and National Express. Where unavailable, rail and car shares were assumed.

9.2.11 Aviation Statistics Data

Aviation Statistics (Avstats) data was supplied by the DoTRS for regular air services within the defined EC corridor. City pair Traffic on Board (TOB) data was provided by stages (the direct non-stop connection between two airports). The problem with this data is that it does not ascribe the origin or destination of the passengers just the flow. Data was provided for all flows for ten years by month (complete until March 2000). The DOTRS also provided total activity on a TOB basis including through traffic. For Brisbane, Sydney and Melbourne, international uplift and discharge airport totals were also provided.

The data was used to:

- determine a set of factors to growth the 1996/97 DTM data to 2001;
- validate the estimate air trip estimates and where necessary, develop appropriate zone flow factors; and
- estimate the number of air transfer trips.

Air transfers are trips made to/from EC airports to connect onto flights to destinations (or origins) outside the study area. Destinations may be domestic (eg Perth) or international.

9.2.12 International Visitor Growth

International visitor trips were growthed to 2001 by applying business and leisure factors based on annual visitor numbers to Australia. The figures were extrapolated to 2001 by application of regression equations. Section 9.11.4 presents the historical trend in business and non-business visitor numbers.

9.2.13 Road Counts

Road counts were obtained for twelve locations providing coverage of the inland and coastal corridors at important sections[5]. Data was obtained for as long a data series as possible, dating back to 1972 for some sites. The data was used to develop regression equations for car trip growth trips then develop factors to growth the DTM 96/97 car estimates from 1996/97 to 2001. The analysis also provided an impression of the past growth in car travel and a basis to gauge the forecast growth in future car usage.

9.2.14 Partial Trip Matrices

Where considered more reliable the DTM data was replaced by the Countrylink and Metro trip data and the Avstats data. The matrices were partial in that the DTM did not provide reliable estimates of trips within a DTM zone. Therefore there were no estimates of car and coach trips between HST zone pairs that were within the same DTM zone (for example Port Macquarie and Taree). The Countrylink data provided estimates for rail. The distances were considered too short for there to be any significant numbers of air trips.

[5] A map showing the road count locations is provided in section 5 with estimated historical trends in road volumes.

9.2.15 In-fill Estimates

The partial trip estimates for car and coach were used in conjunction with the road distance matrix to estimate a simple gravity model for car business, car non-business, coach business and coach leisure. The four models were then used to in-fill the trip matrices. .

9.2.16 Full Trip Matrices

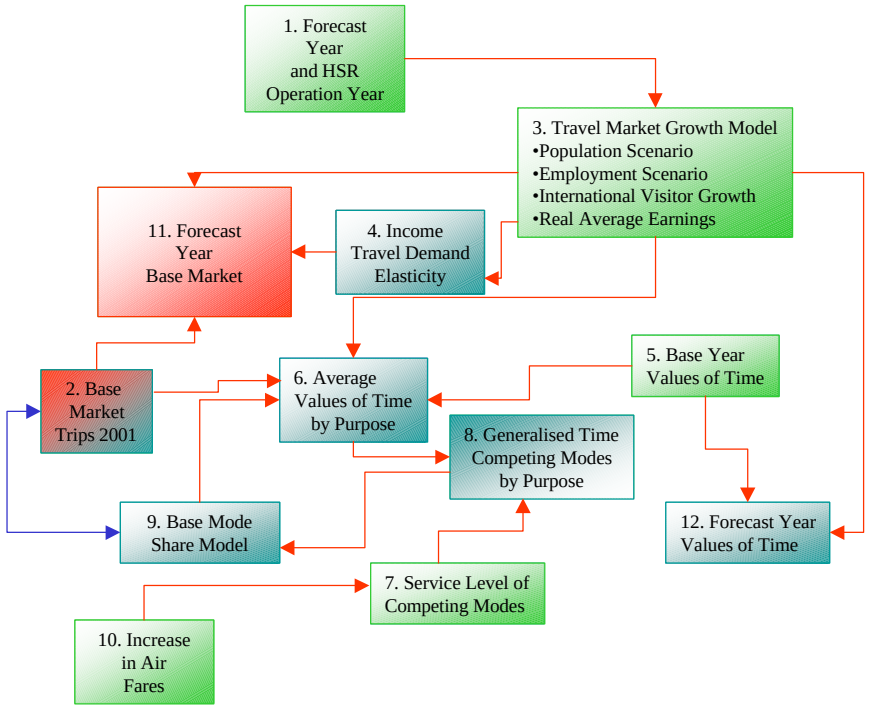
The study estimated trip matrices for business and non-business domestic trips, business and non-business international visitors by air, car, bus and rail for 2001. An estimate of air transfer trips by purpose was also estimated. Trips were aggregated by direction (for example trips from Sydney to Canberra were added to trips from Canberra to Sydney). For forecasting future year trips, the proportion of trips originating from each zone was also estimated for each flow by trip purpose. Non relevant flows were excluded. In total trips for 1,240 zone pairs were estimated.



9.3 Projecting the Base Market

The approach used to project the base travel market is shown in Figure 9.4.

Figure 9.6: Projecting the Base Market



9.3.1 Forecast Year

Forecasts can be produced for any year from 2001 to 2101. The commencement year for VHST operations can also be varied[6]. The reported forecasts assume the start year for VHST operations to be 2011. Forecasts are reported for 2011, 2021, 2031, 2041 and 2051. Most forecasts are reported for 2021.

9.3.2 Base Trips

The estimated trip matrices described in Section 9.2 were used.

9.3.3 Growth Model

Base 2001 trips are increased with population, employment and real average earnings. Different models were used for business trips, non-business trips and international visitors. For business trips, growth in the population at the trip origin and growth in employment at the trip destination are used. For non-business trips, population is used throughout. Five socio economic scenarios can be modelled.

The central demand forecasts were based on a trend or central population scenario. An alternative high growth scenario was also tested. The two scenarios were prepared by SGS Economics and Planning in association with NIEIR (National Economics).

Population growth scenarios, summarised in Table 9.2, are described in relation to national interest considerations in Section 11.7. Unless stated, forecasts refer to scenario A.

Table 9.2: Population and Employment Scenarios

Scenario	Description
A: Trend Population and Employment Growth	Absolute growth of population in the relevant parts of Victoria, New South Wales and Queensland are as forecast by the ABS (under its median assumptions) with employment forecast by SGS/NIEIR.
D: Higher Population Growth with Restricted Metropolitan Growth and Concentrated Urban Settlement Pattern.	The effects of a similar settlement policy as Scenario A combined with a much higher overall population growth (for Australia as a whole and the East Coast region in particular).

Under Scenario A (Trend Population and Employment Growth) the absolute growth of population in the relevant parts of Victoria, New South Wales and Queensland is that forecast by the ABS (under its median assumptions) with the employment implications as forecast by SGS/NIEIR as part of this study. Scenario A assumes that there is no impact of VHST on population or employment.

International visitors were projected by extrapolating past trends. The reported forecasts were damped to reach a maximum growth in 2051 potential in the central scenario[7]. Different parameters for business and leisure are included although the central growth rates are similar. For 2021, the central forecast is for a 217% increase in business trips and a 215% increase in non-business trips on 2001.

[6] The difference between the forecast year and the commencement year determine ramp up and long run effects.

[7] This assumption can be changed.

Domestic trips were increased with forecast real average earnings growth multiplied by the responsiveness of travel to changes in real average earnings. Forecast real average earnings growth is presented in Table 9.3. High central and low projections were produced. For the central projection, an annual growth of 1.75% p.a. between 2001 and 2021 was assumed declining to 1.25% between 2021-2031 and 1% between 2031 and 2051.

Table 9.3: Forecast Growth in Real Average Earnings

Scenario	2001- 2021	2021- 2031	2031- 2051	2051 onwards
High	2%	1.5%	1.25%	1%
Central	1.75%	1.25%	1%	0.8%
Low	1.25%	0.75%	0.5%	0.25%

PCIE assumptions

9.3.4 Income Travel Demand Elasticity

An income demand elasticity of 0.8 was used to determine the impact on business travel from increased real average earnings. Thus, a 10% increase in real average income produces an increase of 8% in business trips. For non-business trips, a proportionate response was assumed (elasticity of 1).

9.3.5 Base Year Values of Time

Values of travel time are a crucial determinant in the choice of travel mode. Value of time express the dollar or fare value of travel time. Values of time by purpose and mode were based on a review of recent studies[8].

Business travellers were assumed to value travel time about double that of non-business travellers. At $53/hr, air business users have the highest value of time. Car business travellers are assumed to value travel time at $30/hr with coach and rail travellers valuing travel time at $22/hr. Non business air travellers value travel time at $27/hr with car users valuing travel time at $11/hr. Coach and rail non business travellers are assumed to value travel time at $8/hr and $7/hr respectively. Metro trips (car and rail) which have a higher share of commuting trips have a $1 higher value of travel time than other non-business trips.

Table 9.4: Values of Travel Time - $/hr by mode by purpose in 2001

	Business	Non Business	
		Non Metro	Metro
Air	53	27	-
Car	30	11	12
Coach	22	8	-
Rail	22	7	8

Source: PCIE 2001

9.3.6 Average Values of Time

Average values of time for each zone pair for business and non business were estimated by weighting the individual mode values of time by the base mode shares. These values of time were then used in the calibration model. For forecast years, the average values of travel time were increased by the change in real average earnings.

9.3.7 Service Level of Competing Modes

Service level data for air, car, coach and existing rail was researched by Arup. Travel time, access and egress times, service frequency, and transfers were included with cost (including access/egress fares). For car and car access and egress to public transport by car or taxi, cost was expressed per trip by dividing by the average party size (1.2 for business and 1.75 for leisure).

[8] Long distance values were based on figures in 'Demand and Revenue Study - Sydney-Canberra High and Very High Speed Train Evaluation Project' (Table 11.6.3, page 98) - for VHST Secretariat June 1996 by PCIE. Metro trip values of time were based on two market research studies: 'Sydney-Newcastle Rail Upgrade Project - Demand Analysis' report to State Rail Operations development by PCIE, June 2000 and 'Sungold/CityWest - Market Research' report to Arup by PCIE, September 2000.

Table 9.5: Main Competing Service Level Attributes

Service Level Attribute	Car	Air	Rail	Coach
Cost	Distance based petrol cost + operating cost. Cost factored by party size.	Advertised 21 day advance economy fares. surcharge/ discount factors for business and non business trips	Estimated function of distance. Discount factors for business and non-business trips.	Estimated function of road distance. Discount factors for business and non-business trips.
Overnight Stay	Cost of overnight stay included.	n.a.	n.a.	n.a.
In-vehicle time	Drive time including stops and overnight stay.	Estimated according to type of aircraft (propeller or jet) and air distance functions.	Estimated from Countrylink and metro timetables.	Function of road distance and type of flow (capital or non-capital).
Transfers	n.a.	Direct or indirect service.	Number of transfers and estimated transfer time.	Services assumed to be direct.
Service Frequency	n.a.	Based on Avstats giving the number of services per day.	Estimated from Countrylink and metro timetables.	Capital and non-capital service frequencies assumed.
Access cost	n.a.	Function of access distance and access mode purpose.	Function of access distance to rail system and access profile by purpose.	Factor of Rail estimated rail access.
Access time	n.a.	Function of access distance and access mode purpose.	Function of access distance and access mode purpose.	Factor of Rail estimated rail access.
Comfort	Expressed as a function of travel time.	Expressed as a function of travel time.	Expressed as a function of travel time.	Expressed as a function of travel time.
Other aspects: Check in, baggage wait Reliability	Reliability estimates.	Assumed check in and baggage times. Service reliability assumptions.	Assumed check in and baggage times. Service reliability assumptions.	Assumed check in and baggage times. Service reliability assumptions.

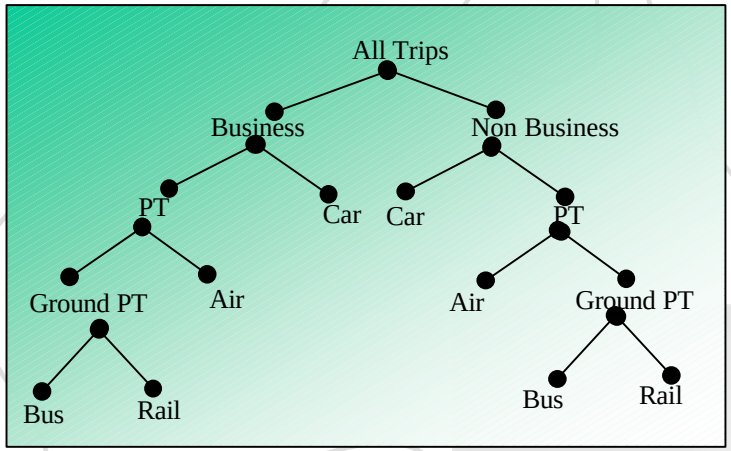
9.3.8 Generalised Time of Competing Modes

Frequency, transfers, access time, and comfort and the other service level attributes were weighted to express them in equivalent VHST travel time minutes. Different valuations for business and non-business travel were applied. Cost items were translated into HST travel time by application of the business and non-business average values of time. The total generalised time by car, air, coach and rail business and leisure trips was then calculated for each of the 1,240 individual geographic markets for each donor mode for business and non business trips. A total of 9,936 estimates were produced for each forecast year[9].

9.3.9 Base Mode Share Model

A base market model share sub-model was estimated and incorporated within the model to accommodate an anticipated shift to faster travel modes as real average incomes grow over time[10]. The sub-model was separately estimated for business and non-business trips and took an hierarchical form[11].

Figure 9.7: Base Mode Share Model Structure



9 1,240 flows for 4 modes (air, car, coach and existing rail) times 2 journey purposes (business and non-business) plus 16 flows for air transfers times 2 journey purposes.

10 The model is internally estimated and calibrated to the base market shares, service levels and values of time. Therefore changing the service level for 2001 or the base values of time changes the model parameter estimates thereby affecting the forecast year estimates.

11 Note that air transfer trips were not included in the model. Air transfer trips are assumed to grow with population and employment and real average incomes but not to be affected by changes in EC corridor ground transport service level.

At the lowest level, rail and coach are compared. The resultant composite cost for ground public transport is fed into the next level to compare ground public transport with air. A composite cost for public transport is then fed into the upper level and compared with car. All six models were successfully estimated with highly significant parameters.

To minimise forecasting errors for individual flows, the model applied the forecast change in share to the base share whilst ensuring that overall trips were constrained to the forecast growth resulting from the socio-economic factors. The estimated parameters were then used to forecast the impact of higher values of time in the forecast year on base market share.

9.3.10 Projected Increase in Air Fares

The base market model incorporates a 0.75% annual increase in real airfares to reflect higher labour cost operations resulting from increases in real average incomes. The increase in airfares is input into the service level of air used in future year base market shares. The model allows for variations in airfare increases.

9.3.11 Forecast Year Base Market Trips

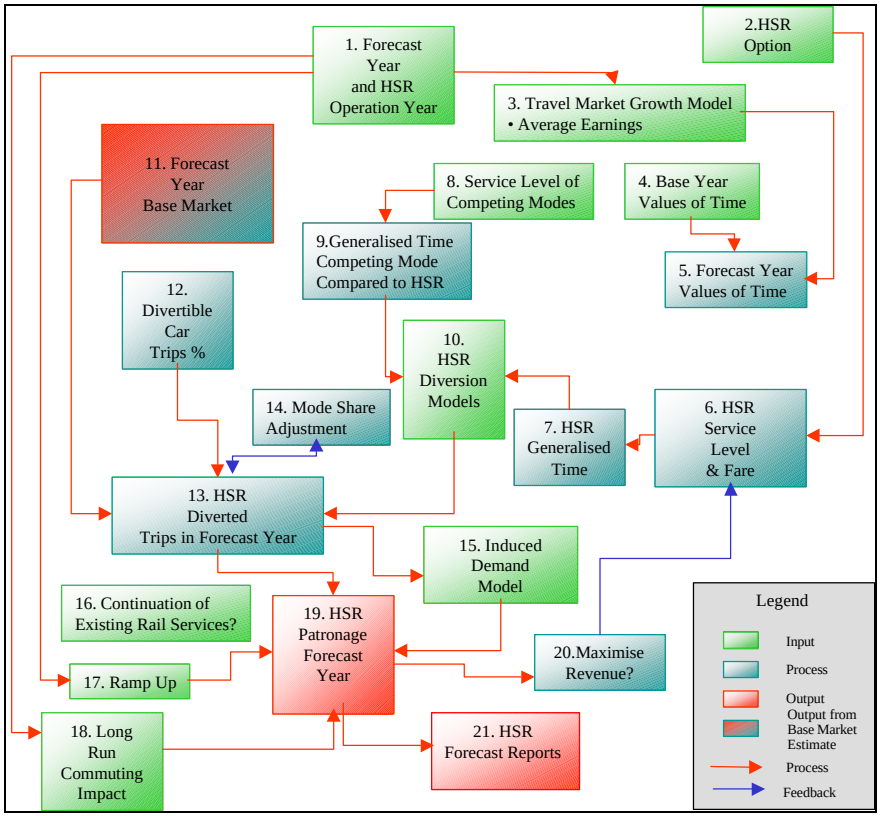
The output of the sub-model is base market trips by transport mode by trip purpose for the selected forecast year.



9.4 Forecasting VHST Demand

The VHST demand forecasting methodology model is shown in Figure 9.6. Each box is described briefly in the following sections.

Figure 9.8: Projecting the Base Market



9.4.1 Forecast Year

As selected in the projection of the base market.

9.4.2 VHST Option

Three VHST technology options that involve improved or new track and new rolling stock were evaluated:

Table 9.6: Rail Technology

Speed km/h	Description
500	VHST - Magnetic Levitation (MagLev)
350	VHST – TGV, ICE350, Adtranz-Talgo 350 type technology & track
250	VHST – 250 km/h train technology & track
160	Base- diesel powered trains on existing track

The three VHST technology options involve improved or new track and new rolling stock. Tilting capacity is assumed to be possible on the 250 km/h or 350 km/h VHSTs if desired. VHST was compared against a base 160 km/h rail option that maintains operating speed at current best October 2001 levels[12].

Inland and coastal routes north of Brisbane and south of Canberra were compared and alternative routes between Sydney and Canberra (via the Central Highlands or via Wollongong) and between Gosford and Sydney (via Hornsby and the Main North or via a new tunnel under Frenchs Forest to Chatswood). Four corridor sectors were evaluated: Brisbane-Newcastle; Newcastle-Sydney; Sydney-Canberra and Canberra-Melbourne. This enabled the study to assess the extent of any package effect of linking sectors together such as Canberra-Sydney with Canberra-Melbourne.

9.4.3 Increase in Real Incomes

The forecast increase in real income was used to increase values of time.

[12] The 160 km/h option follows the existing route (NSW coast, Hornsby, Central Highlands and inland via Albury to Melbourne). Frequency is improved to the same levels as the VHST options. A through Sydney service is assumed in the central scenario to enable comparison with the higher speed options.

9.4.4 Base Year Values of Time

The base year values of time were described in Section 9.3.5. In the diversion model, VHST is compared with each alternative model in a pairwise fashion. Mode specific values of time for the forecast year were used to convert fare and access cost into equivalent VHST travel time hours[13]. For example, to forecast diversion from air, the air business value of time was used to estimate the VHST generalised time.

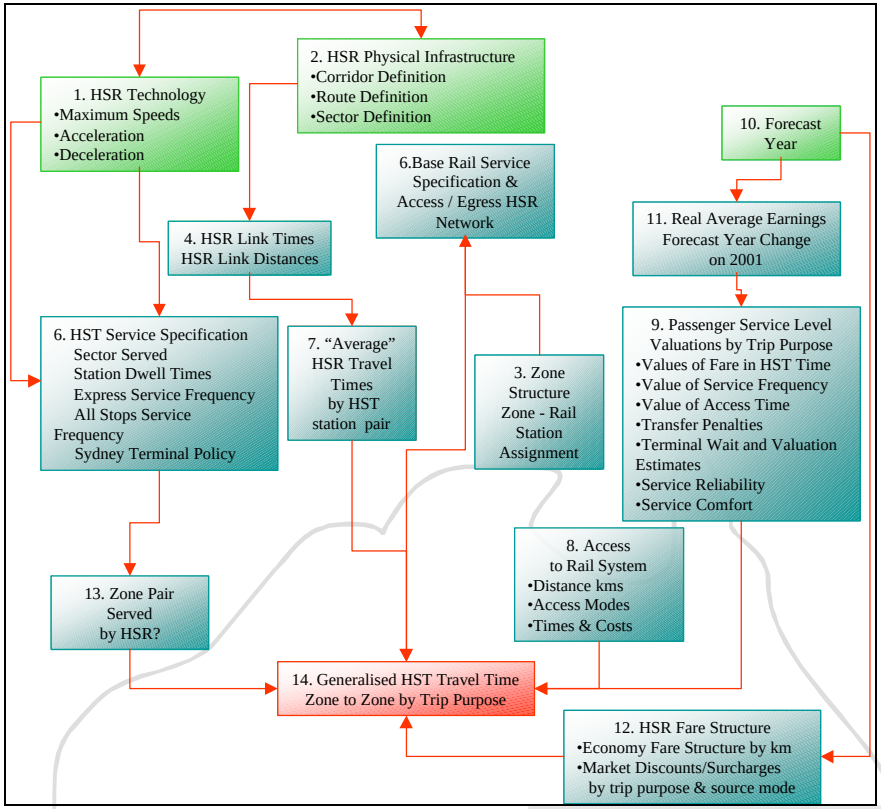
9.4.5 Forecast Values of Time

The base year values of time were increased in line with average income.

9.4.6 VHST Service Level and Fare

VHST was compared with each potential 'donor' mode in terms of overall service level. Ten diversion models were estimated - one for each donor mode and trip purpose. The models were applied to 1,240 individual geographic travel markets to forecast the percentage of trips VHST would attract. If, for example, VHST and air offer an equal service level, VHST attracts 50% of air business passengers.

Figure 9.9: VHST Service Level



VHST service level took account of route, technology and stopping pattern[14]. Fares, frequency, station dwell times, access time and cost, reliability and comfort were added to the VHST travel time to develop an overall measure of VHST service level. A generalised time measure was calculated that expressed all the individual journey components (including fare) in equivalent minutes on the VHST train. Comparable measures were estimated for air, car, coach and existing rail.

[13] As compared to the weighted average values of time used in the base market model.

[14] Express (state capital, ACT and Newcastle stops including parkway stops) and all stops service were assumed to alternate each hour with 16 services per day in each direction.

9.4.7 VHST Generalised Time

Ten sets of VHST generalised times were estimated. One for each potential source of demand for each of the 1,240 flows: business and non-business for air, car, coach and rail and air business and non-business transfers. The generalised times differed according to the value of travel time and different relative valuations of travel time components.

9.4.8 Service Level of Competing Modes

Service level of competing modes was described in Section 9.3.7.

9.4.9 Generalised Time of Competing Modes

Generalised times were estimated for each diversion mode inputting the same mode specific values of time as for VHST All time components were expressed ultimately in VHST in-vehicle hours including constants introduced to take account of any residual modal preferences. This ensured that the mode-purpose generalised times were directly comparable with VHST.

9.4.10 VHST Diversion Models

A set of diversion models, one for each mode and trip purpose, estimated the percentage of trips in each zone pair market that VHST would attract. Each diversion mode compared, pairwise, the generalised time of VHST versus that of the 'donor' mode. If the perceived generalised times are equal, for example, the VHST would attract 50% of the donor mode's passengers for that flow. The diversion models incorporated parameters governing the sensitivity of market share to generalised time. The parameters themselves were expressed as a function of distance to allow for variations in response to journeys of different lengths. For example, an hour's difference is inferred to be more important for a Sydney-Canberra trip than a Brisbane-Melbourne trip). For each donor mode and trip purpose, the estimated percentage diverting to VHST was estimated.

For non-business metro car trips, the diversion model was specified incrementally to reduce any tendency to overestimate diversion. Instead, the improvement in rail generalised time on the existing level of rail service was calculated with the diversion of car trips attributed to VHST.

9.4.11 Base Market in Forecast Year

The base market projection sub-model output trips by mode by purpose for the selected forecast year. Trips for each of the 1240 market pairs were multiplied by the forecast diversion proportion.

9.4.12 Divertible Car Trips

Only part of the car market was considered divertible. For some trips, such as sightseeing, the car may be an intrinsic part of the journey. Irrespective of VHST service level, diversion from car may be highly unlikely for these trips. For car business trips, 80% (short distance) to 90% (long distance) was assumed to be divertible. 70% (short) and 40% (long) of non-business car trips were assumed to be divertible.

Table 9.7: Divertible Car Percent

Percent of Total Car Market Divertible to VHST

Market	0 km	2000 km
Business	90%	80%
Non Business	70%	40%
Metro	35%	20%

Source: PCIE 2001

9.4.13 VHST Diverted Trip in Forecast Year

The percent diverting from each donor mode for business and non-business trip purposes were applied to the forecast year base trip forecast to determine the number of trips diverting to the VHST for each flow.

9.4.14 VHST Diversion Adjustment

The diversion model was adjusted to ensure that no diversion is forecast without any improvement offered by VHST on the service level of existing rail services. The number of trips forecast to divert to existing rail services (mainly Countrylink) was subtracted from the VHST diversion forecast. The adjustment was done individually for each of the ten diversion models.

9.4.15 Induced Demand

Induced demand - the number of totally new trips created by the introduction of a new travel option - is often controversial owing to a lack of substantive 'before and after' evidence from the past introduction of new services. However, there is a consensus in the belief that induced demand would contribute some additional trips to and EC VHST, based on a review of previous high speed rail demand studies undertaken in Australia and overseas.

In the model, induced demand was incorporated by applying a factor to trips diverted from air, car and coach. A factor of 15% was considered reasonable for business trips and 30% for non-business trips. The higher non-business factor is considered likely given the discretionary nature of leisure trips and the mandatory

nature of business trips. A small induced factor of 1% was applied to metro trips to allow for the separate application of a long distance commuting factor. The model allows the induced demand factors to be varied.

Table 9.8: Induced Demand Factors
Applied to Diverted Air, Car and Coach Trips

Market	Factor
Business	15%
Non Business	30%
Metro	1%

Source: PCIE 2001

9.4.16 Continuation of Existing Rail Services

The forecasts assume that Countrylink and other long distance rail services would continue in parallel with VHST. As a forecasting option, the impact of discontinuing existing long distance services can be tested. If services are continued, diversion is forecast conventionally. If discontinued, the percentage of existing rail trips unlikely to use a VHST because of higher fares and/or a worse service level is forecast. A demand elasticity is applied to those flows where generalised time to rail users is forecast to increase as a result of the substitution of VHST for conventional rail. Elasticities of -1.5 for business and -2 for non-business rail trips are used.

9.4.17 Ramp Up

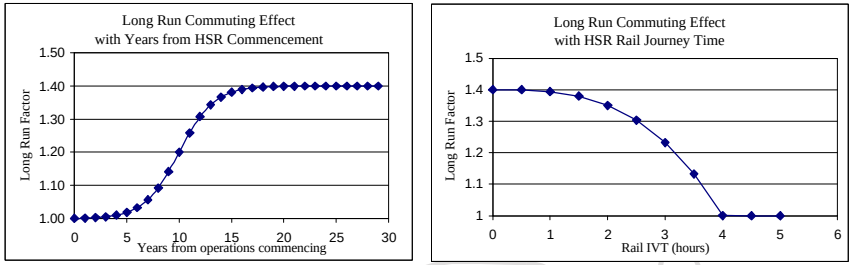
Ramp up is the delay in take up of demand and revenue attributable to marketing lags and a 'learning curve' amongst customers. Central ramp up factors of 70% in the first year, 90% in year 2 and 100% in year 3 were applied. The model allows the induced demand factors to be varied.

9.4.18 Long Distance Commuting

Evidence from the UK suggests that major improvements to rail services can have a marked long term impact on the distance people are willing to commute either daily or weekly. A long run effect 1.4 times the short run effect has been estimated. A long run commuting effect has been incorporated into the forecasting model for capital city flows (Brisbane, Sydney and Melbourne) to take account of this impact (applied to non-business trips only). Long distance 'commuting effects' are forecast to be strongest up to 2 hours from the capital cities of Brisbane, Sydney and Melbourne with a demand factor of just under 1.4 at 1 hours journey time. The long run commuting effect then declines rapidly to zero at 4 hours. The 'commuter belt' is therefore forecast to extend further with faster VHST technology.

The second aspect of the sub-model is the take-up rate. Up to five years from the commencement of VHST operations, the long run commuting effect is forecast to be negligible but to increase rapidly thereafter to reach the maximum effect 15 years after commencement of operations. The model allows the parameters to be varied.

Figure 9.10: Long Run 'Commuting' Effects
Applied to Diverted plus Induced Non Business Trips



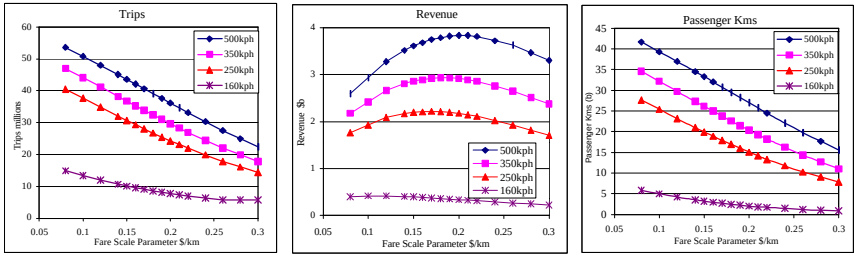
9.4.19 VHST Diverted Trips in Forecast Year

The forecast of VHST trips diverted from all donor modes by trip purpose for each flow for the forecast year taking into account ramp up and long run commuting effects.

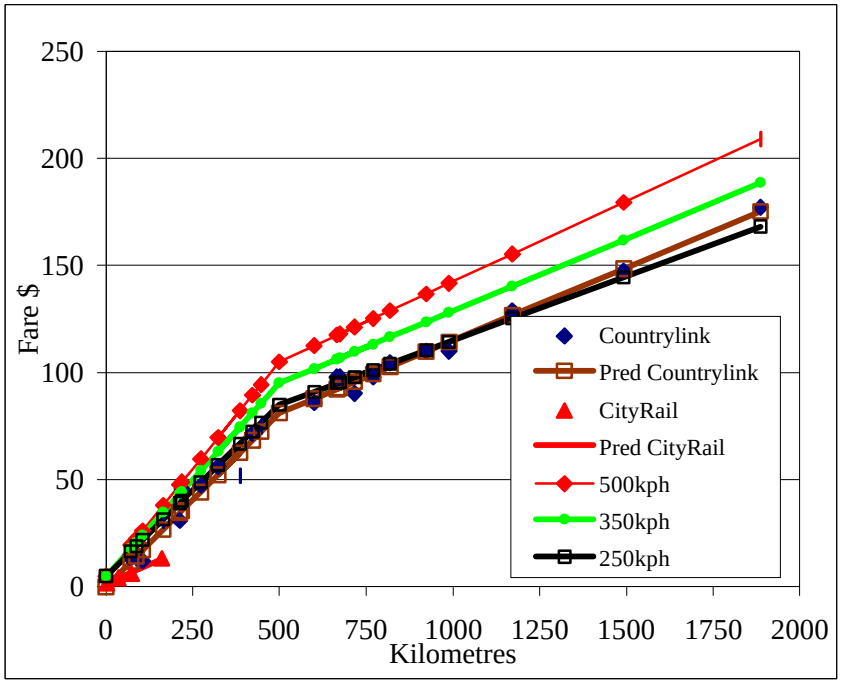
9.4.20 Maximum Revenue

For each VHST technology, the fare structure that would maximise revenue for the full corridor (Inland Brisbane-Newcastle, via Hornsby and Bowral and inland Canberra-Melbourne) in 2021 was determined. The revenue maximising fare structure was determined for each rail option to allow fare to increase with speed. The fare function was based on a flag fall fare of $5 with a distance factor of X cents per km with a distance taper introduced at 500kms.

Figure 9.11: Revenue Maximising Fare Structure on Revenue and Demand



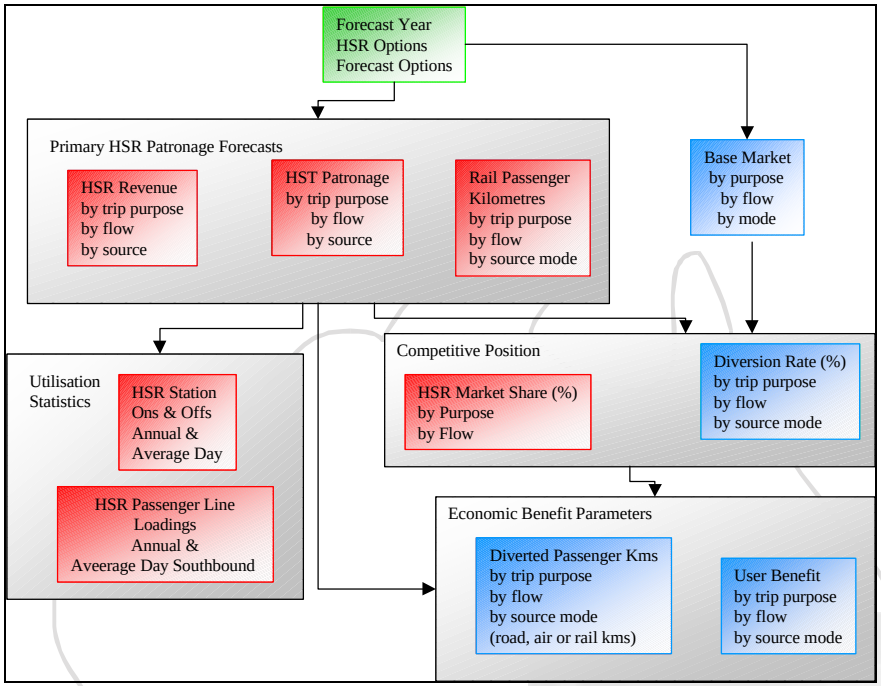
Rail Technology	Flag Fall	C/km	C/km >500 km
500	5	0.20	-0.125
350	5	0.18	-0.113
250	5	0.16	-0.1
160	5	0.10	-0.063
Countrylink	0	0.16	-0.094



9.4.21 VHST Forecast Reports

The demand model provides a range of outputs covering the base market, VHST demand, VHST utilisation statistics (such as ons and offs and line loadings), and the competitive position of VHST useful in economic benefit calculation (such as user benefit and diverted passenger km by mode).

Figure 9.12: Forecast Outputs



9.4.22 User Benefit

User benefit may be thought of as the difference between the fare the user is willing to pay and the fare actually paid. Generally, the higher the service level, the greater the willingness to pay. To maximise revenue, the VHST operator should set fares to extract as much benefit as possible from the user. The likelihood is however, that fares will not be set to internalise all benefit. Users will retain some residual benefit over and over the fare they pay.

Users of VHST may benefit from travel time reductions, more frequent services, more accessible services, greater comfort, reduced transfer connections (especially through Sydney) and fare reductions. In the demand forecast, these benefits were fully internalised by the fare structure set by the VHST operator.

The user benefit measures were calculated within the demand forecasting model. User benefit was calculated for business and non-business trips separately for each of the 1,240 individual geographic markets for each donor mode for business and non-business trips. A total of 9,872 user benefit estimates were produced for each forecast year[15].

Although the VHST can be considered as 'a new mode' it can also be as considered as an improvement on existing rail services. By referencing the existing rail service level, the maximum user benefit was constrained. The overall service level offered by VHST was then compared with the existing rail service level to estimate the net VHST user benefit. By referencing trip purpose and donor mode specific values of time and service level, VHST user the accuracy of the user benefit estimate was improved.

For an average passenger diverting to VHST, the benefit can be considered as half the total benefit. A user may be just unwilling to divert to rail at the existing (non VHST) service level. The benefit obtained is the full benefit of VHST compared to existing rail (100%). Another user may be indifferent to diverting to VHST at the VHST service level. User benefit for this passenger (over and above the fare paid) is zero. The average benefit is therefore half the change in benefit[16].

It should be noted, however, that as calculated user benefit requires accuracy in not only the estimate of VHST service level but also the base rail service level. Future work should therefore consider the base service level data as well as VHST if this approach is to continue to be used.



[15] 1,230 flows for 4 modes (air, car, coach and existing rail) times 2 journey purposes (business and non-business) plus 16 flows for air transfers times 2 journey purposes.

[16] Commonly referred to as the 'rule of a half'. The use of a half assumes a straight-line demand curve. If the demand curve is curved, average user benefit will differ from 50%.

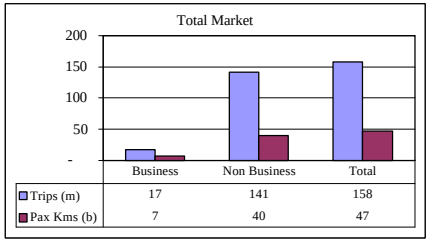
9.5 Base Market Size

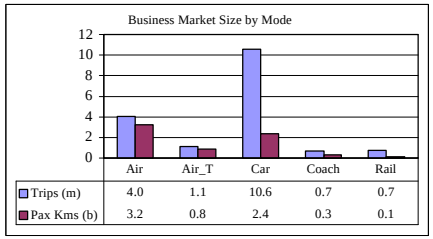
Section 9.5.1 describes the size and profile of the estimated East Coast travel market in 2001. Section 9.5.2 presents the size of key flows, such as Sydney-Melbourne. Section 9.5.3 presents market shares by key flow. Section 9.5.4 assesses the size of the international visitor market.

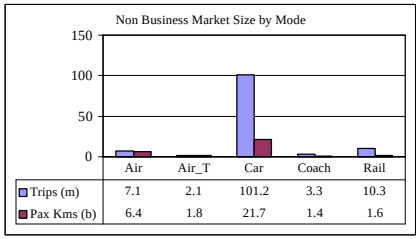
9.5.1 Base Market Size

The 2001 inscope travel market in is estimated at 158 million trips. Non-business travel predominates with 141 million trips. The business market is estimated at 17 million trips, one eighth the size. The annual distance travelled is estimated at 47 billion passenger km (bpk). Business trips tend to be longer than non-business trips: 412 km compared to 283kms. As a result, the business share of passenger km is higher (15%) than the trip share (12%).

Figure 9.13: Base Market Size 2001







Car dominates the shorter distance business market with air dominant over longer distances. Coach and rail are relatively lightly used for business travel with 4% and 1% of passenger km respectively. 10.6 million business trips are made by car over the whole inscope market compared to 4 million trips by air. At 3.2 billion, air business passenger km are four times higher than car reflecting a dominance at longer distances. An additional 1.1 million business air transfer trips are made. The average inscope business car trip is 220 km compared to 800 km by air (measured in road kilometres).

Car is used for seven out of ten non-business trips but accounts for only half of passenger km. Just over 100 million non-business trips are made by car, out of a total of 141 million trips. The total distance travelled is estimated at 22 billion passenger km, out of a total of 40 billion. The average inscope car trip is therefore around 220 km. 9 million trips are made by air, 7 million of which are wholly within the EC corridor plus 2 million air transfer trips. Air passenger km (measured in road distance) total 8.2 billion. The average air non-business trip is around 900 km, four times further than the average car trip. 10.3 million trips and 1.6 billion passenger km are made by rail. The average rail trip is around 150kms, reflecting the inclusion of shorter metro trips. Coach carries fewer trips than rail at 3 million but achieves a similar passenger km level of 1.4 billion reflecting an longer average trip of 330 km, twice that by rail.

9.5.2 Market Size by Aggregated Flow

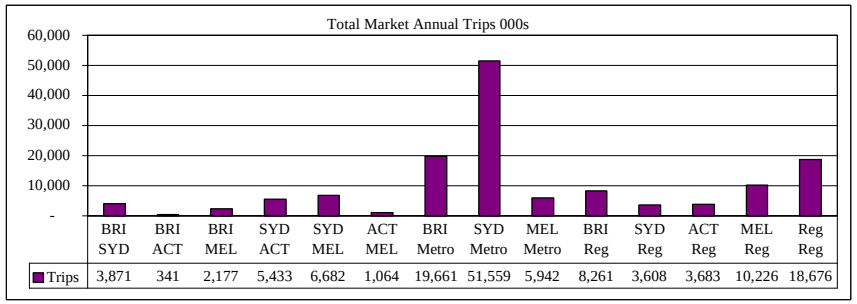
For reporting purposes, results have been aggregated into fourteen key flows:

- Six capital city market pairs (eg Brisbane-Sydney, Melbourne-ACT[17]).
- Three state capital-metro markets.
- Four capital-regional markets.
- An aggregation of all inter-regional trips[18] (eg Taree-Port Macquarie).

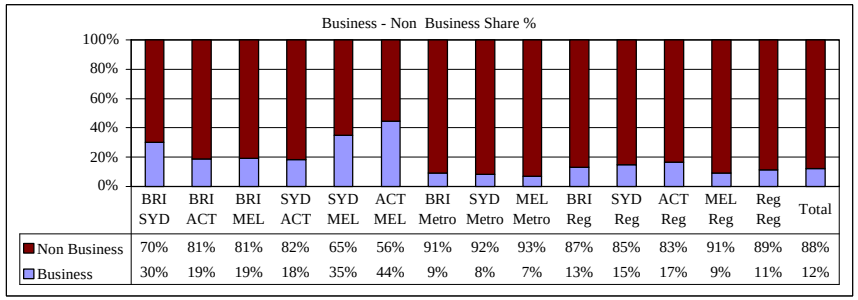
17 For demand study definitional purposes, ACT is referred to as a 'capital' but not a 'state capital'.

18 Inter-regional trips are trips between one regional centre and another such as Coffs Harbour and Taree. Any trips to or from a state capital or the ACT were excluded. Capitals were defined to also include zones served by the 'parkway' stations eg Hornsby.

Figure 9.14: Market Size by Aggregated Flow



	BRI SYD	BRI ACT	BRI MEL	SYD ACT	SYD MEL	ACT MEL	BRI Metro	SYD Metro	MEL Metro	BRI Reg	SYD Reg	ACT Reg	MEL Reg	Reg Reg
Trips	3,871	341	2,177	5,433	6,682	1,064	19,661	51,559	5,942	8,261	3,608	3,683	10,226	18,676



	BRI SYD	BRI ACT	BRI MEL	SYD ACT	SYD MEL	ACT MEL	BRI Metro	SYD Metro	MEL Metro	BRI Reg	SYD Reg	ACT Reg	MEL Reg	Reg Reg	Total
Non Business	70%	81%	81%	82%	65%	56%	91%	92%	93%	87%	85%	83%	91%	89%	88%
Business	30%	19%	19%	18%	35%	44%	9%	8%	7%	13%	15%	17%	9%	11%	12%

Sydney-Melbourne is the largest inter-capital market with 6.7 million trips pa. Sydney-ACT is the second largest with 5.4 million trips. At 1 million trips, Melbourne-ACT is estimated at one-fifth that of Sydney-ACT. Brisbane-ACT is the smallest inter-capital market with 340,000 trips although significant growth has occurred during the 1990s. Melbourne has the largest regional market at 10.2 million trips, principally due to high flows from Albury southwards[19]. Excluding the Gold Coast, 8.3 million trips are made between Brisbane and regional centres. The inter-regional market is estimated at 18.6 million trips, 12% of the total inscope market.

Metro travel, which includes many commuting trips, dominates the inscope market. Trips between the Central Coast, Central Highlands, Illawarra and Sydney account for more than 50 million trips, being over one third of the total market. Metro trips between Brisbane and the Gold Coast approach 20 million. A further 6 million metro trips are made on the eastern corridor out of Melbourne. Altogether, metro trips account for just under half the total inscope market.

Business travel has a higher share of the inter-capital market, reaching 44% for ACT-Melbourne. For Sydney-ACT and Brisbane-ACT, the business share reduces to just under 20%. Just over one third of the Sydney-Melbourne market is business travel, 10% more than that between Brisbane and Sydney with 30%.

Business travel is relatively less important on non-capital flows. For Brisbane-Regionals, the business share is 13%. For capital-metro trips, business travel falls below 10%.

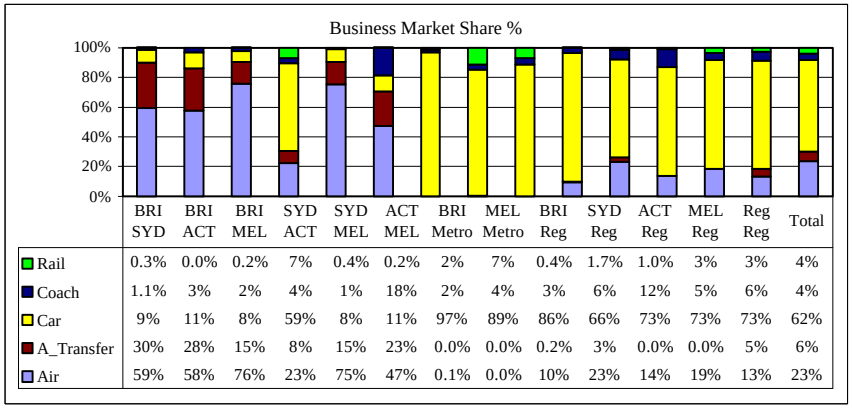
9.5.3 Market Share by Aggregated Flow

At 52%, Sydney-Melbourne has the highest air share of any inter-capital non-business market[20]. Car achieves a 34% share and air transfers 6%. Coach and rail have 4% shares. Air achieves a 34% share on the Brisbane-Melbourne, the longest inter-capital market excluding air transfers and 63% including transfers. Car share is estimated at 34% with coach and rail together carrying 3%. Air achieves a third of the Brisbane-ACT market, Melbourne-ACT 27% and Sydney-ACT 10%. Amongst non-capital flows, rail achieves an 8% share compared to 6% by air. Car's dominance of non-business travel stems from an 85% share of the metro market. Rail's 10 million non-business market is also bolstered by the inclusion of metro trips. Sydney achieves the highest metro rail share of 16%. Melbourne achieves a 6% share and Brisbane 3%. Car dominates the inter-regional market with eight out ten trips. For the remainder, rail with 8% achieves a higher share than either air with 6% and coach with 3%. An additional 2% of air transfer trips are made.

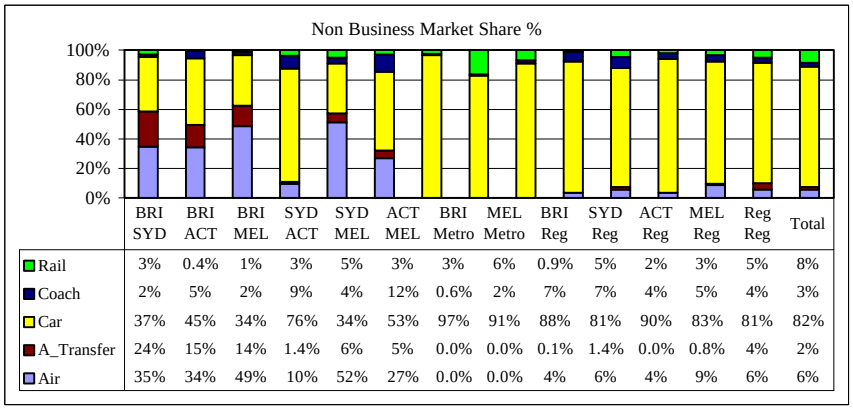
[19] Some of the trips between Shepparton / Seymour and Melbourne could be alternatively defined as metro trips.

[20] Note if air transfers are included in the total Brisbane-Melbourne air market air's share would be higher than that for Sydney-Melbourne.

Figure 9.15: Market Size by Aggregated Flow

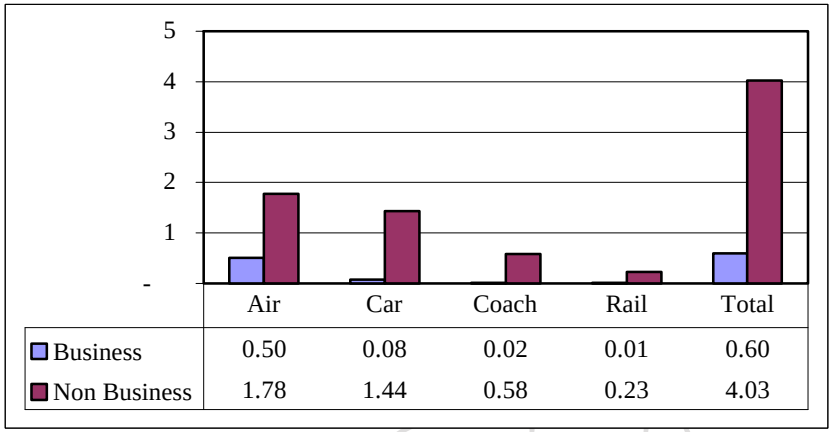


	BRI SYD	BRI ACT	BRI MEL	SYD ACT	SYD MEL	ACT MEL	BRI Metro	MEL Metro	BRI Reg	SYD Reg	ACT Reg	MEL Reg	Reg Reg	Total
Rail	0.3%	0.0%	0.2%	7%	0.4%	0.2%	2%	7%	0.4%	1.7%	1.0%	3%	3%	4%
Coach	1.1%	3%	2%	4%	1%	18%	2%	4%	3%	6%	12%	5%	6%	4%
Car	9%	11%	8%	59%	8%	11%	97%	89%	86%	66%	73%	73%	73%	62%
A_Transfer	30%	28%	15%	8%	15%	23%	0.0%	0.0%	0.2%	3%	0.0%	0.0%	5%	6%
Air	59%	58%	76%	23%	75%	47%	0.1%	0.0%	10%	23%	14%	19%	13%	23%



	BRI SYD	BRI ACT	BRI MEL	SYD ACT	SYD MEL	ACT MEL	BRI Metro	MEL Metro	BRI Reg	SYD Reg	ACT Reg	MEL Reg	Reg Reg	Total
Rail	3%	0.4%	1%	3%	5%	3%	3%	6%	0.9%	5%	2%	3%	5%	8%
Coach	2%	5%	2%	9%	4%	12%	0.6%	2%	7%	7%	4%	5%	4%	3%
Car	37%	45%	34%	76%	34%	53%	97%	91%	88%	81%	90%	83%	81%	82%
A_Transfer	24%	15%	14%	1.4%	6%	5%	0.0%	0.0%	0.1%	1.4%	0.0%	0.8%	4%	2%
Air	35%	34%	49%	10%	52%	27%	0.0%	0.0%	4%	6%	4%	9%	6%	6%

Figure 9.16: Size of Inscope International Visitor Market
Trips million in 2001



	Air	Car	Coach	Rail	Total
Business	0.50	0.08	0.02	0.01	0.60
Non Business	1.78	1.44	0.58	0.23	4.03

9.5.4 International Visitor Market

The total number of inscope trips made by international visitors within the EC corridor is estimated at 4.6 million, being 3.4% of the total inscope EC market[21]. 4 million visitor trips (85%) are non-business and 602,000 (15%) are business or conference related. Air dominates with 1.8 million non-business trips and 502,000 business trips. Car, including hire car, accounts for 1.5 million trips. Coach carries 600,000 trips, nearly three times the number of rail trips.

[21] International Visitors account for 6% when metro trips are excluded.

9.6 Trends in Market Growth

Data on the growth road volumes over a thirty-year period and air travel statistics during the 1990s were analysed to understand past growth in corridor demand and assess the future projections produced by the forecasting model. In addition, the growth in international visitors was over the 1990s was analysed as a basis for projecting future visitor numbers.

9.6.1 Road Traffic Counts

Road counts were obtained for twelve locations providing a coverage of the inland and coastal corridors at important sections. Data was obtained for as long a data series as possible, dating back to 1972 for some sites.

9.6.2 Trends in Road Traffic

Road traffic on the East Coast corridor grew strongly between 1970 and 2000. Growth rates were lower over the period 1995-2000 however. During the 1990s, growth in road traffic was strongest in the north of the EC corridor. Annual growth averaged 4.2% between Brisbane and the Gold Coast. Southwards, growth was stronger on the coast than inland. On the Pacific Highway at the Hunter River Bridge, north of Newcastle, traffic averaged 3.2% p.a. compared to 2.7% on the New England Highway between Newcastle and Musswellbrook.

Southwards, highway traffic growth rates tended to be lower. Between Sydney and Wollongong, growth averaged 1.2% p.a. between 1991 and 2000. Between Canberra and Melbourne, growth was higher inland than on the coast. At Ettamogah, on the Hume Highway, annual road traffic grew by 3.7%, which was more than twice the 1.7% growth experienced on the Princess Highway.

Figure 9.17: Trends in Road Traffic

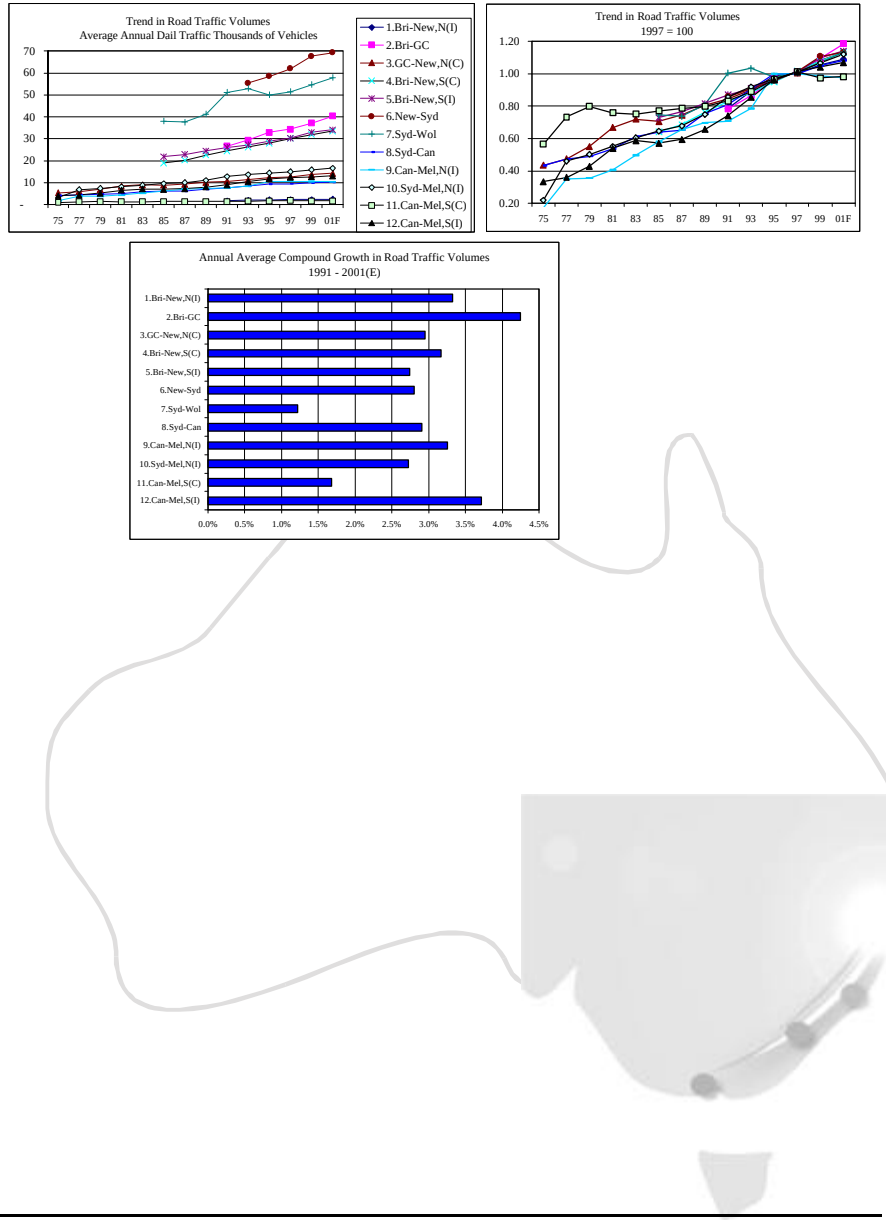
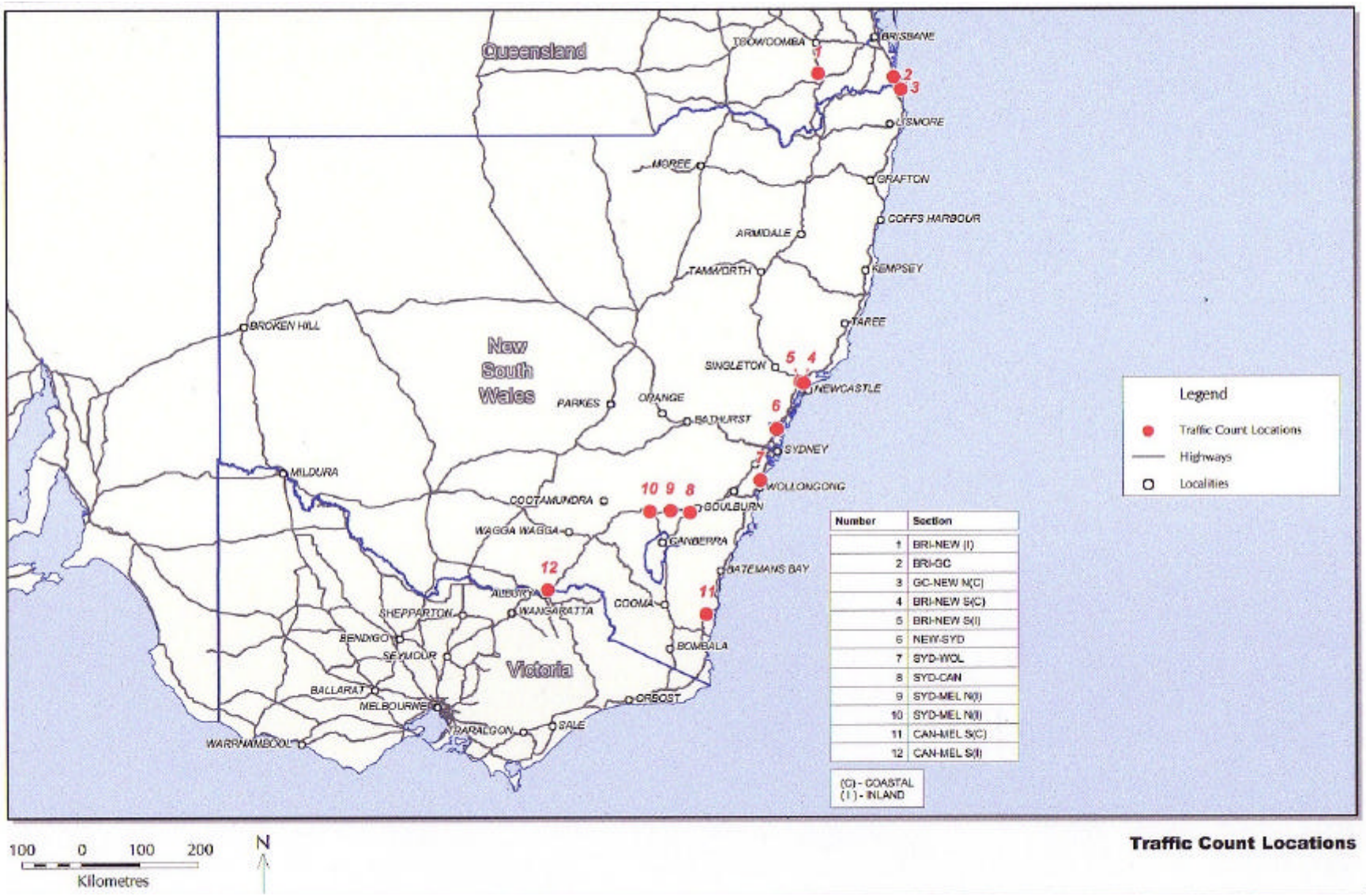


Figure: 9.18: Locations of Traffic Counts



9.6.3 Air Data

Aviation Statistics (Avstats) data was supplied by DOTRS for regular air services within the defined EC corridor. City pair Traffic on Board (TOB) data was provided by stages (the direct non-stop connection between two airports). Data was provided for all flows for ten years by month (complete until March 2000). The DOTRS also provided total activity on a TOB basis including through traffic. For Brisbane, Sydney and Melbourne, international uplift and discharge airport totals were also provided. Figure 9.17 shows the location of the airports within the EC corridor study area.

9.6.4 Trends in East Coast Air Traffic

Growth in air travel has been double that of road traffic during the 1990s. Growth has been greater on the larger inter-capital routes than on the smaller intra-regional routes.

Sydney is the largest airport, Melbourne second and Brisbane third. Canberra and Coolangatta are much smaller.

Domestic Terminals at Sydney, Melbourne and Brisbane experienced more growth during the 1990s than the International Terminals. Brisbane Domestic airport grew at the fastest rate averaging 8.2% a year. Growth was lowest at Melbourne International, averaging 5%. At Sydney, growth was 7.5% at Domestic and 5.7% at International. Large Regional Airports averaged 7.1% growth with small Regional Airports averaging 6.1%.

Growth was more rapid between 1990-1995 than 1995-2000. Sydney Domestic averaged 11.9% over 1990-1995 and 3.2% over 1995-2000. Coolangatta averaged 14.5% over 1990-1995 but declined at -1.3% over 1995-2000.

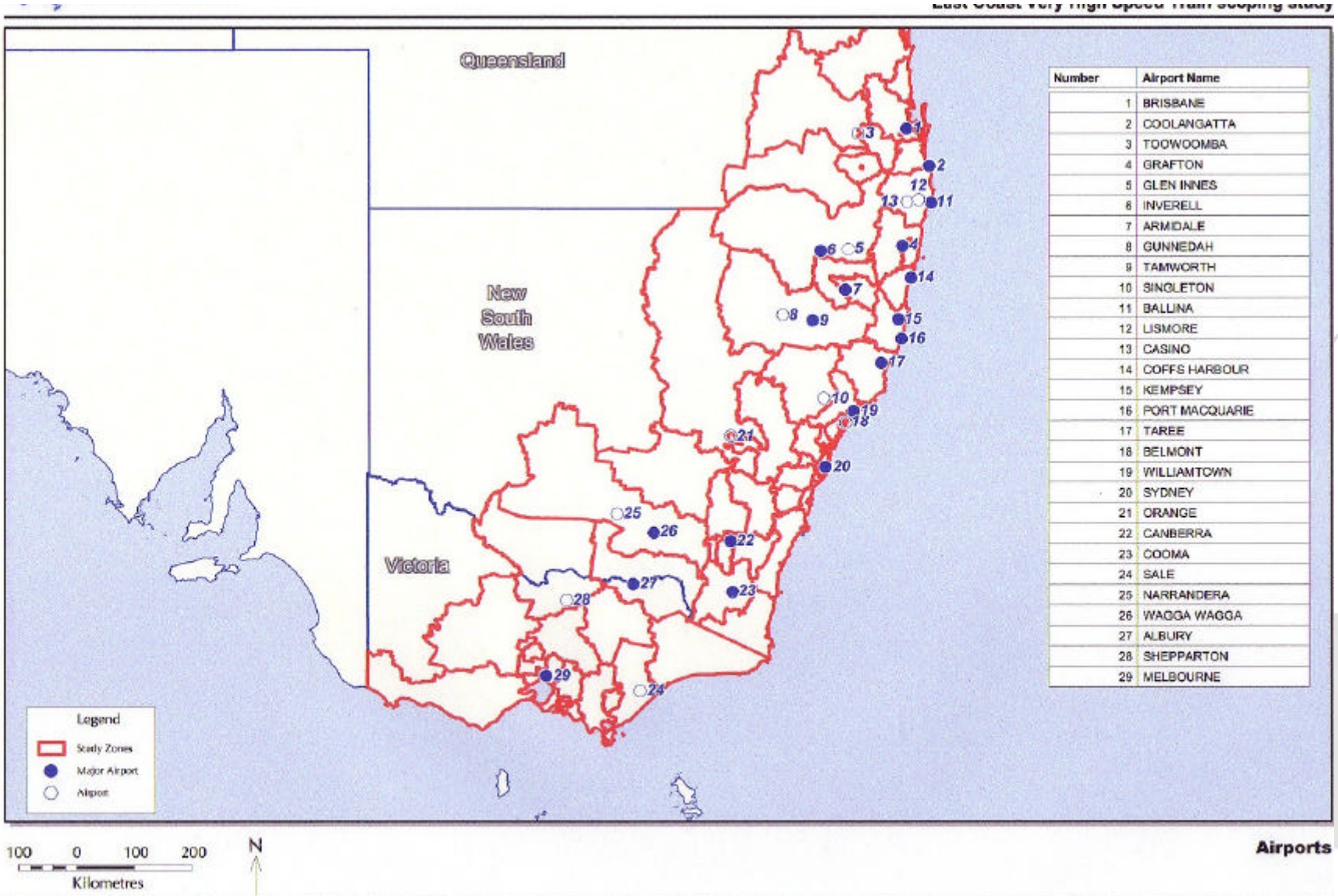
For the individual air markets (measured in 'Traffic on Board' (TOB) terms i.e. including transfer and through passenger trips) traffic on the Brisbane-Melbourne route more than tripled from just under 0.6 million to 2 million trips, an average annual growth of 12%. Sydney-Melbourne, the largest air market, more than doubled, achieving an average growth of 7.6% per year. Brisbane-Sydney also doubled from 1.7 million trips to 3.4 million trips. Brisbane-Canberra grew from virtually nothing to 280,000 trips. However, although still strong, growth rates have slackened during 1995 to 2000 compared to 1990 to 1995. Melbourne-Sydney grew by 5.6% between 1995 and 2000 compared to 11% a year between 1990 and 1995. Brisbane-Sydney grew by 4.7% a year between 1995 and 2000 compared to 10.4% between 1990 and 1995.

Capital-regional air routes have also experienced growth albeit at a slower rate than inter capital routes. Coffs Harbour-Sydney grew from 95,000 in 1990 to 174,000 in 2000, an increase of 6% a year whilst Newcastle Sydney grew from 115,000 to 148,000.

The trend on the smaller volume intra-regional air routes has been more volatile, reflecting marked changes in service levels. Some markets have experienced declines such as Glen Innes and Inverell toSydney, falling from 14,000 in 1990 to 10,000 in 2000. In some cases, direct routes have been established such as Newcastle-Coffs Harbour, Newcastle-Tamworth and Newcastle-Port Macquarie.

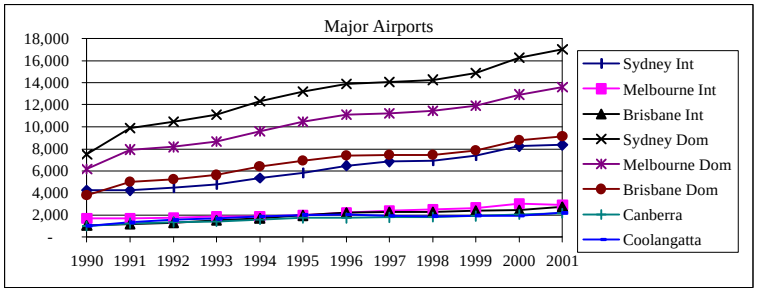


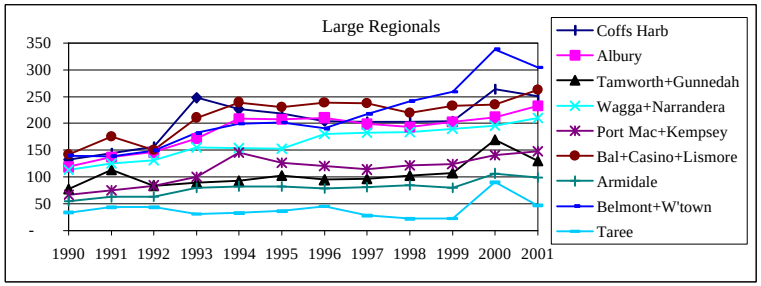
Figure 9.19: East Coast Corridor Airports

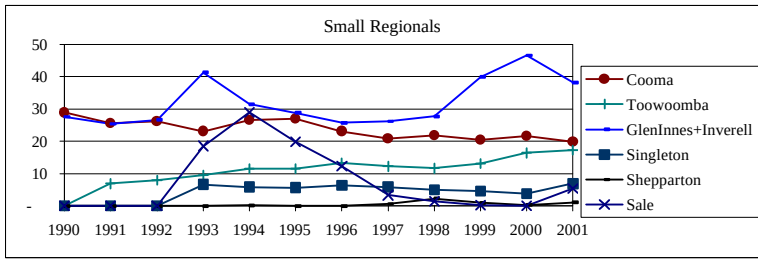


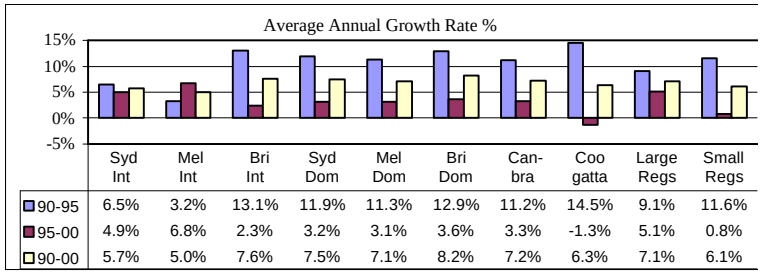
Number	Airport Name
1	BRISBANE
2	COOLANGATTA
3	TOOWOOMBA
4	GRAFTON
5	GLEN INNES
6	INVERELL
7	ARMIDALE
8	GUNNEDAH
9	TAMWORTH
10	SINGLETON
11	BALLINA
12	LISMORE
13	CASINO
14	COFFS HARBOUR
15	KEMPSEY
16	PORT MACQUARIE
17	TAREE
18	BELMONT
19	WILLIAMTOWN
20	SYDNEY
21	ORANGE
22	CANBERRA
23	COOMA
24	SALE
25	NARRANDERA
26	WAGGA WAGGA
27	ALBURY
28	SHEPPARTON
29	MELBOURNE

Figure 9.20: Trends in Airport Usage
Thousand Passenger Movements per year



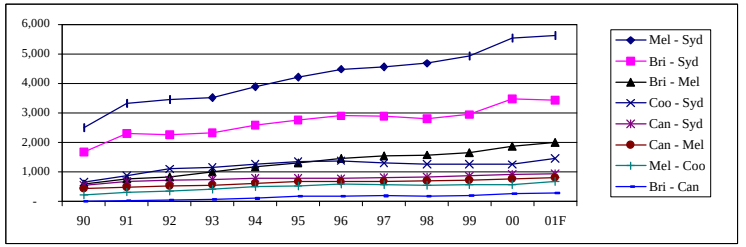


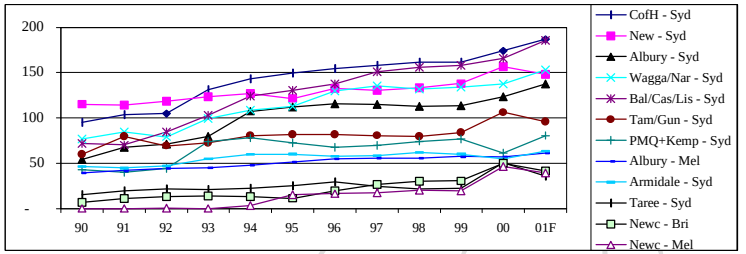


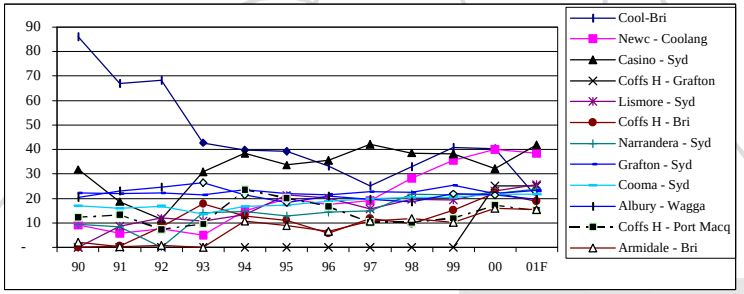


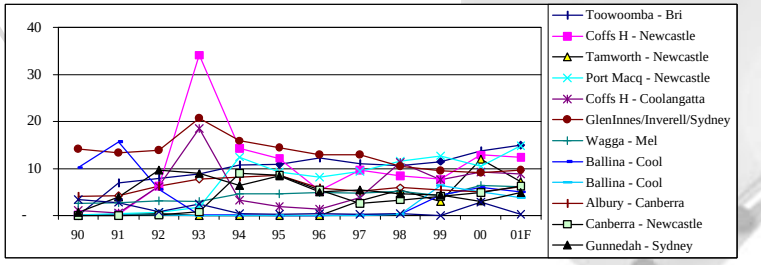
	Syd Int	Mel Int	Bri Int	Syd Dom	Mel Dom	Bri Dom	Can-bra	Coo gatta	Large Regs	Small Regs
90-95	6.5%	3.2%	13.1%	11.9%	11.3%	12.9%	11.2%	14.5%	9.1%	11.6%
95-00	4.9%	6.8%	2.3%	3.2%	3.1%	3.6%	3.3%	-1.3%	5.1%	0.8%
90-00	5.7%	5.0%	7.6%	7.5%	7.1%	8.2%	7.2%	6.3%	7.1%	6.1%

Figure 9.21: Trends in Air Market Usage







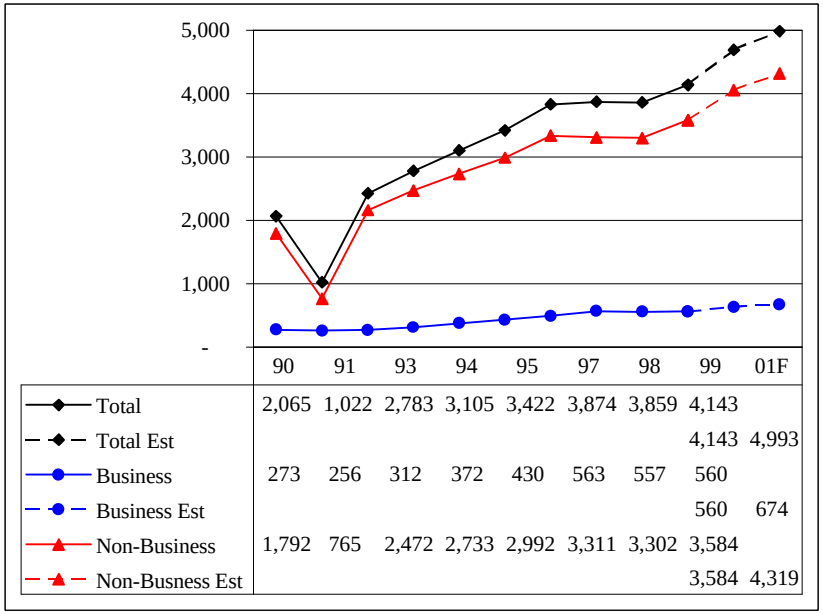


9.6.5 Growth in International Visitors

International visitor numbers have doubled from 2 million in 1990 to 4 million visits in 1998, an average annual increase of 9%. The annual growth rate has been greater for business than non-business visits. Business visits have increased from 263,000 in 1990 to 560,000 in 1998 (10% p.a.) compared to non-business visits that grew from 1.8 million to 3.3 million visits in 1998 (8% p.a.).

The inscope base market size in 2001 is estimated at 158 million trips. The non-business market dominates with 141 million trips, over 8 times the size of the business market, estimated at 17 million trips. Total passenger km are estimated at 47 billion with the business market accounting for 15%.

Figure 9.22: Growth in International Visitor Numbers
Thousand Visits per Year



	90	91	93	94	95	97	98	99	01F
Total	2,065	1,022	2,783	3,105	3,422	3,874	3,859	4,143	
Total Est								4,143	4,993
Business	273	256	312	372	430	563	557	560	
Business Est								560	674
Non-Business	1,792	765	2,472	2,733	2,992	3,311	3,302	3,584	
Non-Busness Est								3,584	4,319

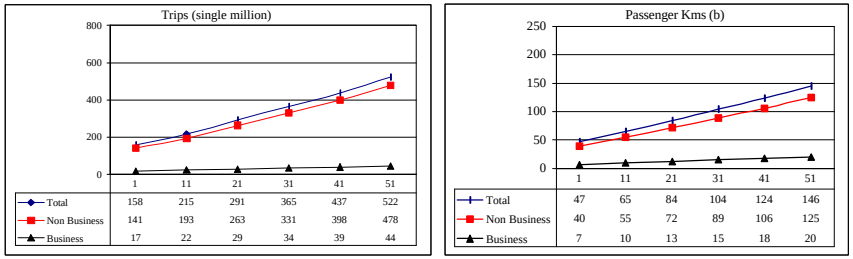
9.7 Projected Base Market

Data on the growth road volumes over a thirty-year period and air travel statistics during the 1990s were analysed to elucidate past growth in corridor demand and to set the base for the projections produced by the forecasting model. In addition, the growth in international visitors over the 1990s was analysed as a basis for projecting future visitor numbers.

9.7.1 Forecast Future Growth - Scenario A

The EC base inscope travel market is forecast to nearly double from 158 million trips in 2001 to 291 million trips in 2021 with the central trend population and employment scenarios (scenarios A). By 2051, the travel market is forecast to reach 522 million trips, 3.3 times the 2001-market size. The business travel market is forecast to grow from 17 million to 44 million trips and the non-business market from 141 million to 478 million trips. Passenger km are forecast to grow from 47 billion to 146 billion. Average Trip length is forecast to decline from 297 km to 280 km. Annually, the travel market is forecast to grow by 3% from 2001 to 2021 in trips and by 2.9% in passenger km.

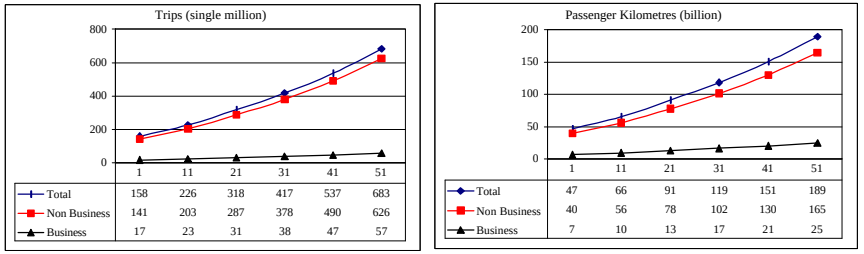
Figure 9.23: Total Market Growth - Scenario A



9.7.2 Total Market Growth - Scenario D

For comparison, the high population growth scenario (scenario D) results in the total base market inscope travel market increasing to 318 million trips in 2021 and 683 million trips in 2051. Passenger km increase to 78 billion in 2021 and 189 billion in 2051. The 'high growth' scenario results in a 31% larger travel market in 2051 than the central scenario.

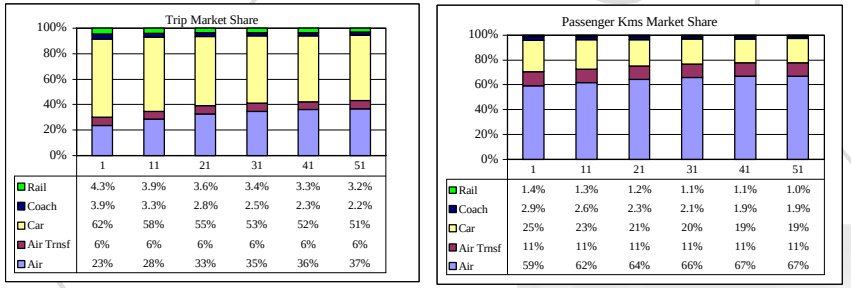
Figure 9.24: Total Market Growth - Scenario D



9.7.3 Projected Business Market Shares

Air's share of the business market is projected to rise from 23% in 2001 to 35% in 2031 and reach 37% by 2061. Air's dominance of the longer distance business market is reflected in an increase from 59% in 2001 to 66% in 2031 in the passenger km share. Car's share is forecast to decline from 62% to 55% in 2031 in terms of trips and from 25% to 19% in passenger km. Rail and coach shares are forecast to decline by a third and a half respectively over the 60-year horizon.

Figure 9.25: Business Market Share

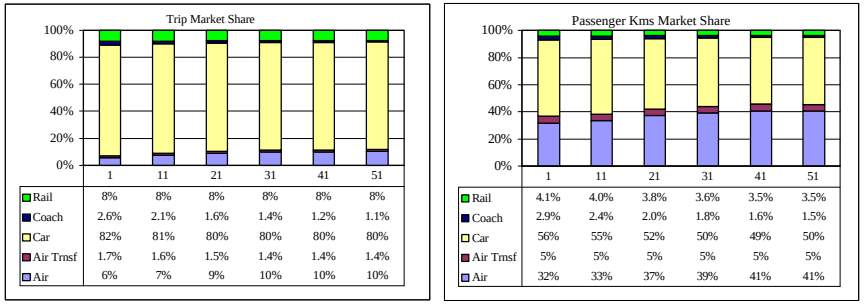


9.7.4 Projected Non-Business Market Shares

Air's share of the non-business market, in terms of trip numbers, is much lower than its share of the business market. Air's share is projected to rise from 6% in 2001 to 10% in 2031. Air has a much stronger position in the longer distance leisure market reflected in a 33% passenger km share. Air's share of passenger km is forecast to increase gradually to reach 39% in 2031. Car's share is largely forecast to retain its dominant position of 80% of trips, although its passenger km share is forecast to fall from 56% to 50% in 2031. Rail has a larger share the non-business market, due to the inclusion of metro 'commuting' trips. The current 2001

8% share is forecast to remain whereas the coach share of 2% is forecast to halve by 2051. Rail's share of passenger km is half the share of trips. Over the study period, rail's passenger kme share is forecast to decline by 15% compared to a halving of the coach share, rail's share being bolstered its stronger metro position.

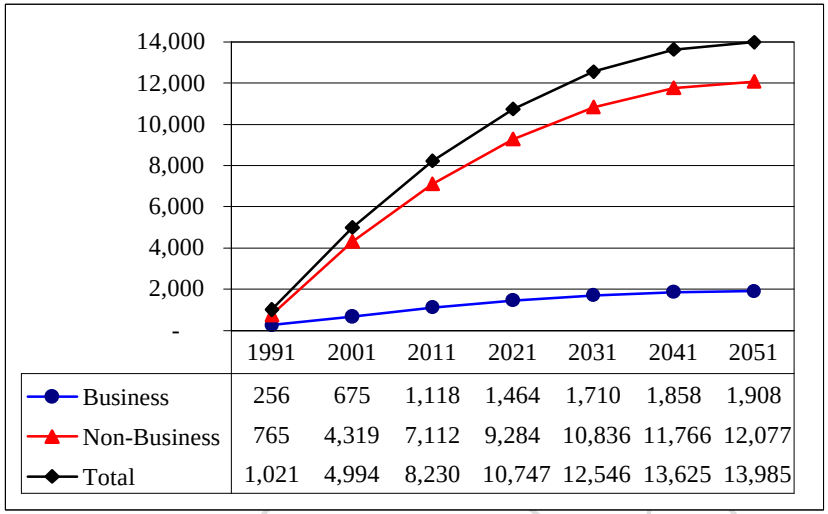
Figure 9.26: Non-Business Market Share



9.7.5 Projected International Visitor Market

The international visitor market is forecast to more than double from 1 million visits to 10.7 million visits in 2021, an annual increase of 4%. The international visitor market is forecast to peak in 2051 at 14 million visits, 2.8 times the number of visits in 2001. These growth rates were used to project the 2021 base international visitor East Coast market.

Figure 9.27: Projected International Visitor Market
Annual Visitors to Australia 000s



9.8 VHST Demand Forecasts by Route, Section and Technology

9.8.1 Introduction

A cross-sectional analysis was undertaken to compare VHST routes. Annual demand, passenger km[22], gross revenue[23], maximum load[24] and user benefit for 2021 were compared across the 52 possible route-section combinations for the three VHST technologies (250 km/h, 350 km/h and 500 km/h) and ten combinations for the base 160 km/h option[25]. The forecasts were produced for the central population and employment scenario assuming VHST operations commence in 2011 and that Countrylink services continue.

Table and graphs are provided at the end of this section. The following notation is used:

Sector start and finish stations: Brisbane (B), Newcastle (N), Sydney (S) and Melbourne (M).

Routes: Coastal (C), Inland (I), Hornsby (H), below Frenchs Forest (F)[26], Bowral (B) and Wollongong (W).

9.8.2 Corridor, Sector and Technology Comments

Demand increases with improved VHST technology and also increases step-like as the network is extended. In terms of technology, the increase in demand with faster VHST serfvices is amplified over longer corridors. The steepest jump in demand, revenue and user benefit is the initial increase from the 160 km/h base to 250 km/h. Further speed improvements increase demand but at a slower rate[27].

The highest demand is 39.7 million trips with 500 km/h VHST technology over the full corridor from Brisbane to Newcastle via the NSW coast; via new track under Frenchs Forest to Sydney; via Wollongong to Canberra and then via the coastal route to Melbourne.

Brisbane-Newcastle (coastal) generates the most trips, revenue and user benefit out of the four single sectors: Brisbane-Newcastle, Newcastle-Sydney, Sydney-Canberra and Canberra-Melbourne. Canberra-Melbourne (inland or coastal) generates the least trips and Newcastle-Sydney (Hornsby or below Frenchs Forest) the least revenue and user benefit.

Of the two sector options, Brisbane-Sydney (coastal) generates the most trips with Newcastle-Canberra (Hornsby, Bowral) generating the least number of new trips. Route is an important factor in ranking the sectors in terms of revenue and user benefit. The best routes for each of the two sector combinations are quite close: Brisbane-Sydney $1.43 billion, Newcastle-Canberra $1.42 billion and Sydney-Melbourne $1.43 billion for 50 km/h VHST. However, the route variation is greater. For example for Brisbane-Sydney, revenue is forecast at $1.43 billion via the coast and below Frenchs Forest compared to $1.07 billion via inland and Hornsby.

Of the three sector options, Brisbane-Canberra achieves a higher maximum demand, revenue and user benefit than Newcastle-Melbourne. Again however route is an important factor north of Canberra. A coastal route north of Newcastle maximises demand. A route below Frenchs Forest and a new Wollongong route would increase demand over the existing Hornsby and Bowral routes. South of Canberra the inland and coastal routes produce similar forecasts.

9.8.3 Coastal versus Inland

North of Newcastle, the coastal route serving the northern NSW coastal towns and the Gold Coast produces higher demand, revenue and user benefit than inland route via Armidale and Tamworth. For the full corridor with 350 km/h VHST (H,B,I) the northern coastal route is forecast to carry 32.4 million trips compared to 26.3 million inland, a difference of 6.1 million trips (23%). Gross revenue is $550 million higher (23%) with user benefit $330 million higher (9%).

South of Canberra, the inland and coastal routes produce similar demand forecasts.

22 Passenger km include distance travelled on existing rail services as part of VHST journeys.

23 Gross revenue includes ticket revenue from parts of VHST journeys made on existing rail services. Revenue is GST inclusive.

24 The highest number of passengers onboard the VHST at any point along the corridor counted over all southbound VHST services. The estimate was expressed in terms of the Annual Average Annual Daily (AADT) southbound load (annual/365).

25 There were a total of 166 route-sector-technology combinations: 52 for each of the three VHST technologies plus 10 for the 160 km/h base rail option (forecast only for the coastal, Hornsby, Bowral, Inland route).

26 This alignment was assessed purely to test the benefit of a fast exit/entry railway north from Sydney. It required a very long tunnel (>45 kilometres) under national parks and the Hawkesbury River

27 There are exceptions however for individual sections where, because of assumed higher fare structures and some residual infrastructure constraints, faster rail technology produces a slight decline in demand.

It is forecast that a 350 km/h VHST service via the Coastal-Hornsby-Bowral route and via either the coastal or inland rourte southrh of Canberra would generate between 32.4 and 32.8 million trips.

9.8.4 Brisbane-Newcastle Sector

Considered as a single VHST sector, a coastal VHST 350 km/h service between Brisbane and Newcastle generates 7.7 million trips compared to 6 million inland - a percentage difference of 28%. Gross revenue and passenger km are closer because of longer trips on the inland route. Gross revenue is $50 million higher on the coastal route (6%) with passenger km 0.1 billion higher (1%). User benefit is forecast to be higher via the inland route, a principal result of a lower existing rail service level on the inland route compared to the coastal route and therefore a bigger difference made by VHST to existing rail service levels. For the coastal route, 500 km/h VHST increases demand over 350 km/h by 0.6 million trips (8%). 350 km/h produces an increase of 0.5 million trips over 250 km/h (7%) and 250 km/h produces an increase of 4.8 million trips over the base 160 km/h option (200%).

9.8.5 Newcastle-Sydney Sector

An hourly 500 km/h VHST service between Newcastle and Sydney would generate 4.3 million trips via Hornsby and 5.4 million trips via the route below Frenchs Forest (26%). There is little demand difference between the VHST technologies for either route. For 500 km/h, revenue of $80 million via Hornsby and $100 million via Frenchs Forest, an increase of $20 million (25%). There is however a slight increase in revenue for 500 km/h VHST over 350 km/h and 250 km/h for the Frenchs Forest route.

The revenue increase of 500 km/h over 350 km/h (via Frenchs Forest) is $10 million (11%). The difference of 350 km/h over 250 km/h is forecast to be the same. For Hornsby, the revenue for all three technologies is the same. The passenger km and user benefit profiles are similar to the revenue profile. User benefit is slightly higher by the route below Frenchs Forest, as the new route augments existing SRA service levels.

There is no difference between the VHST technologies in terms of user benefit for the route below Frenchs Forest. For the Hornsby route, 500 km/h and 350 km/h do not produce an improvement on the base option (160 km/h with the same hourly frequency). All the benefit is captured by the VHST operator through fare increases (revenue increases by $25 million over the base option). User benefit remains at $20 million for all three options. However, 250 km/h does produce an improvement of $10 million on the base option.

9.8.6 Sydney -Canberra Sector

A Sydney-Canberra VHST service achieves the highest demand via Wollongong. At 6.7 million trips, demand is 75% more than the 3.8 million trips forecast to use a 350 km/h VHST via Bowral. Much of the increase in Wollongong demand is forecast to be metro trips between Wollongong and Sydney. As a result, the difference in revenue and user benefit is much smaller. For the 350 km/h VHST, revenue is forecast at $250 million via Wollongong and $200 million via Bowral, a difference of $50 million (25%). User benefit is forecast at $300 million and $260 million respectively.

For the Bowral route, a 500 km/h VHST is not forecast to produce more trips than a 350 km/h service. Revenue is forecast to be $20 million (11%) with user benefit increasing by $10 million (4%). These results reflect the increase in fare with 500 km/h. Demand and user benefit are suppressed by the fare increase with the revenue difference increased.

A 350 km/h servive produces an increase of 0.1 million trips over 250 km/h (3%), a revenue increase of $20 million(12.5%) and a user benefit increase of $10 million (4%) for the Bowral route. The increase of 250 km/h on the base option is marked. Trips increase by 2.1 million (131%), revenue by $120 million (300%) and user benefit by $190 million (380%).

For the Wollongong route, the technology options are closer. Trips are forecast at 6.7 million for both 500 and 350 km/h VHSTs. A slightly higher demand of 6.8 million trips is forecast for 250 km/h largely due to lower fares canceling out the speed differential. Revenue is forecast to be $20 million higher for 500 km/h over 350 km/h (9%) with 350 km/h revenue to be $30 million greater than 250 km/h revenue (15%). User benefit is $10 million higher for 500 km/h over 350 and $20 million higher for 350 km/h over 250 km/h.

9.8.7 Canberra-Melbourne Sector

A Canberra-Melbourne VHST service achieves similar demand via the inland or coastal route. For 500 km/h and 250 km/h VHST, the coastal and inland routes achieve the same demand. 2.8 million for 500 km/h and 2.5 million for 250 km/h. The coastal route is forecast to achieve a slightly higher demand forecast of 2.7 million trips compared to 2.6 million via the inland route. Revenue is forecast to be slightly higher via the coastal route. For 350 km/h, coastal revenue is $200 million compared to $190 million inland, a difference of $10 million (5%). User benefit is forecast to be $40 million higher via the coast for 500 km/h (14%), $50 million higher for 350 km/h (22%) and $50 million for 250 km/h VHST (26%).

Via the inland route, 500 km/h VHST demand is forecast at 2.8 million trips, 0.2 million higher than 350 km/h (8%) with 350 km/h VHST 0.1 million higher than 250 km/h (4%). The difference over the base option is not marked. Demand is 0.2 million higher (9%) for 250 km/h operation over the base option operating to the same hourly frequency and lower fares. Revenue is forecast at $230 million for 500 km/h, $40 million higher than 350 km/h (21%). 350 km/h VHST is $30 million higher than 250 km/h (19%) and 250 km/h is $70 million (78%). Thus although demand is not markedly higher for VHST over the base option, 9% for 250 km/h, passengers are willing to pay higher fares that widens the revenue difference to 78%. User benefit is forecast at $280 million for 500 km/h VHST, $230 million for 250 km/h and $190 million for 250 km/h and $130 million for the base option.

Via the coastal route, a 500 km/h VHST demand is forecast to achieve a demand of 2.8 million trips, 0.1 million higher than 350 km/h (4%) with 350 km/h VHST 0.2 million higher than 250 km/h (8%). Revenue is forecast at 230 million for 500 km/h, $40 million higher than 350 km/h with 350 km/h $30 million higher than 250 km/h. User benefit is forecast at $320 million for 500 km/h VHST, $280 million for 250 km/h and $240 million for 250 km/h.

9.8.8 Brisbane-Sydney Sector

Demand is higher via the coastal route north of Newcastle. A Coastal Brisbane-Sydney 350 km/h VHST service achieves a demand of 16.5 million trips via Frenchs Forest, 1.3 million trips more than via Hornsby (9%). Revenue is closer however, $1.16 billion compared to $1.13 billion (2.6%).

Via the inland route north of Newcastle, demand is forecast at 11.4 million trips (Hornsby), and revenue at $890 million, reductions of 25% and 21% respectively.

For the coastal Hornsby route, a demand of 16.1 million trips is forecast for 500 km/h VHST, 0.9 million more than 350 km/h (6%). 350 km/h VHST is forecast to obtain a demand of 15.2 million trips, 0.8 million more than 250 km/h (5.5%). A demand of 14.4 million trips is forecast for 250 km/h VHST, slightly more than double the base option (103%).

Revenues of $1.38 billion for 500 km/h, $1.13 billion for 350 km/h and $0.91 billion for 250 km/h are forecast for the coastal Hornsby route compared to $0.15 billion for the base option. In percentage terms, the increments are 22% for 500 km/h over 350 km/h and 24% for 350 km/h over 250 km/h. At over 500%, the increase from 250 km/h VHST over the base rail option is much more pronounced.

9.8.9 Sydney-Melbourne Sector

A Sydney-Melbourne 350 km/h VHST achieves the highest demand of 13.6 million trips via Wollongong then the coastal route to Melbourne. Revenue and user benefit are both greater via Bowral and the coast at $1.43 billion and $1.02 billion respectively. The difference between the coastal and inland routes south of Canberra is less than 10%. For the Bowral route with 350 km/h VHST, trips are forecast at 11.7 million compared to 11.2 million, an increase of 0.5 million via the coast (4.4%). Revenue is forecast at $1.08 billion compared to $0.99 billion, an increase of $90 million (9%).

Although the Wollongong route has higher demand than via Bowral, 13.6 million compared to 11.7 million (coastal south of Canberra) for 350 km/h VHST, revenue and user benefit are both greater via Bowral, $1.08 million compared to $0.99 for revenue and $1.55 million compared to $1.37 million for user benefit. The Wollongong route attracts a lot of metro trips compared to fewer but longer distance trips attracted by the Bowral route. As a result although trips are higher, the average revenue and user benefit is forecast to be high via Bowral.

For the Inland route via Hornsby, 500 km/h VHST is forecast to attract 12.7 million trips, 1.5 million more than 350 km/h VHST (13%). 350 km/h is forecast to attract 11.2 million trips 1.2 million more than 250 km/h (11.2%). 250 km/h VHST is forecast to attract 10 million trips 5.2 million more than the base option (108%). In terms of revenue, for the same route, 500 km/h VHST is forecast at $1.32 billion, $0.33 billion more than 350 km/h (33%) which is $0.23 billion (30%) more than 250 km/h. At $0.76 billion, 250 km/h is forecast at $0.56 billion more than the base option (280%).

9.8.10 Network Effects

The analysis suggests a significant network effect from providing complete VHST corridors. An analysis for the Coastal, Hornsby, Bowral and Inland route has undertaken for providing “complete” corridors for Brisbane-Sydney, Sydney-Melbourne and Brisbane-Melbourne for each VHST technology. The network effect is determined be comparing the sum of the individual sector patronage forecasts with the combined patronage forecast. For example, Brisbane-Sydney via the Coast and Hornsby for 250 km/h VHST, the patronage forecasts for the two component sectors are 7.2 million trips for Brisbane-Newcastle and 4.5 million trips for Newcastle-Sydney. The total is 11.7 million trips. This compares with a forecast of 14.4 million trips for a complete Brisbane-Sydney 250 km/h VHST corridor. The difference is 2.7 million trips. The network effect is therefore estimated at 23%.

The network effect is greatest for the Sydney-Melbourne corridor and increases with VHST speed. Providing a complete Sydney-Melbourne corridor increases

patronage by 92% for the 500 km/h option over the sum of the Sydney-Canberra and Canberra-Melbourne sections. For 250 km/h, the package effect is 61%. The package effect for Brisbane-Sydney is lower. Providing a complete Brisbane-Sydney service compared to the sum of the Brisbane-Newcastle and Newcastle-Sydney sectors increases patronage by 28% for 500 km/h VHST, 26% for 350 km/h and 23% for 250 km/h. A complete Brisbane-Melbourne corridor increases patronage by 25% compared to the addition of the separate Brisbane-Sydney and Sydney-Melbourne patronage forecasts. This result is dependent on the assumption of no change in train for passengers travelling through Sydney[28].

Table 9.9: Network Effect

Percent Increase from Full Corridor - Coastal, Hornsby, Bowral, Inland Route

	250kph	350kph	500kph
BRI-NEW + NEW-SYD	23%	26%	28%
SYD-CAN + CAN-MEL	61%	75%	92%
BRI-SYD + SYD-MEL	20%	23%	25%

Network Effect % = A&B / (A+B)
PCIE indicative forecasts

9.8.11 New Routes

'New' connections via Frenchs Forest between Gosford and Chatswood and via Wollongong and Canberra attract significant numbers of metro trips to VHST services. For longer trips, the two new routes do not always produce benefits however. Indeed, for some sectors the 'new' connections reduce passenger kilometers, gross revenue and user benefit for the whole route.

9.8.12 Maximum Load

The highest average daily (/365) southbound maximum load is 28,230 forecast for the 500 km/h VHST full corridor option (Coastal, Frenchs Forest, Wollongong, Coastal) between Sutherland and Wollongong. For 350 km/h and 250 km/h VHST the maximum load is 25,000 and 22,000 for the same option and location. For the base option, the maximum load is 8,280 between Gosford and Hornsby.

9.8.13 Caveats

Alterations to service level, fare and demand response may alter the findings. The forecasts are preliminary intended only as a guide.

Figure 9.28: Trips by Technology, Section and Route 2021

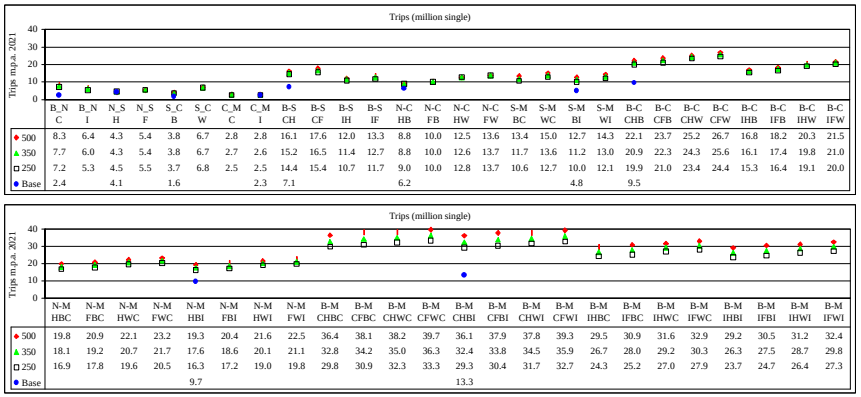
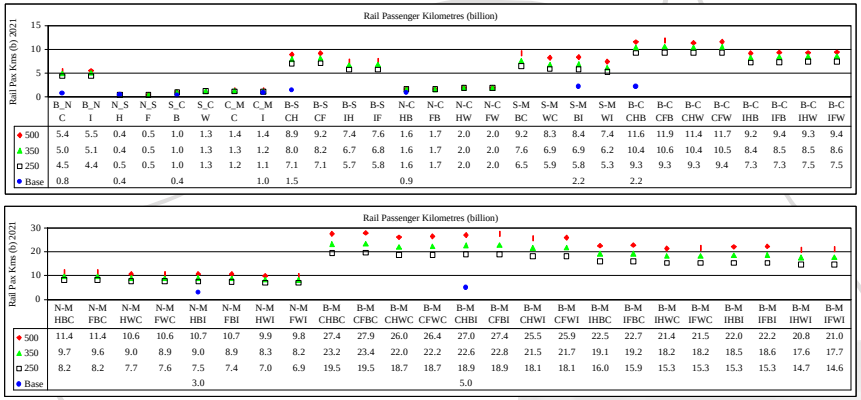


Figure 9.29: Passenger Kilometres by Technology, Section and Route 2021



28 The assumption of through Sydney running was relaxed in the sensitivity tests.

Figure 9.30: Gross Revenue by Technology, Section and Route 2021

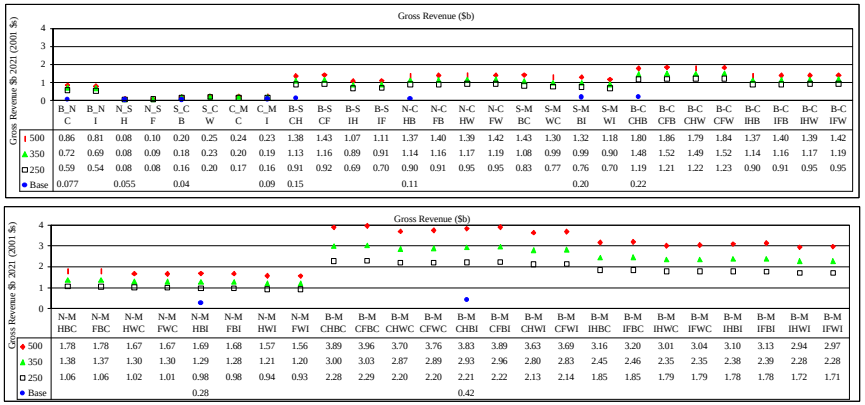


Figure 9.31: User Benefit by Technology, Section and Route 2021

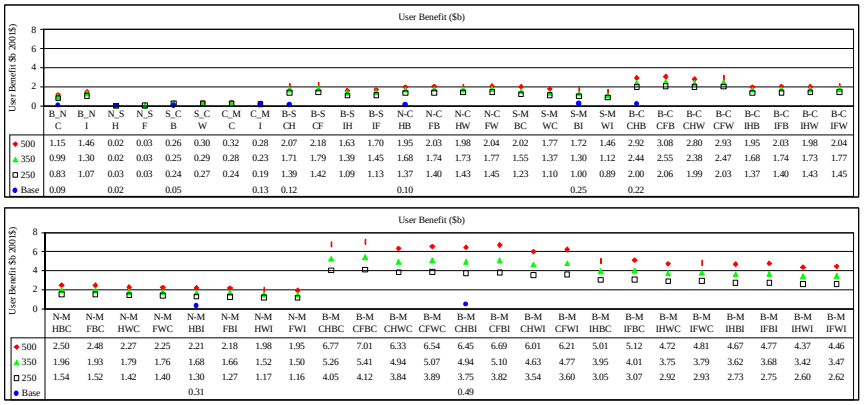


Table 9.10: Demand by technology, Section and Route 2021

500kph	BRI-NEW Coast	BRI-NEW Inland	NEW-SYD via Hrn	NEW-SYD via FF	SYD-CAN via Hrn via Bowral	SYD-CAN Via FF via Bowral	SYD-CAN via Hrn via Wollongong	SYD-CAN Via FF via Wollongong	CAN-MEL via Hrn via Bowral Coast	CAN-MEL via FF via Wollongong Coast	CAN-MEL via Hrn via Bowral Inland	CAN-MEL via FF via Wollongong Inland
Gross Trips m.p.a.												
BNE-NEW (Coastal)	8.27		16.1	17.6	22.1	23.7	25.2	26.7	36.4	38.1	38.2	39.7
BNE-NEW (Inland)		6.38	12.0	13.3	16.8	18.2	20.3	21.5	29.5	30.9	31.6	32.9
NEW-SYD			4.29	5.40	8.82	9.99	12.5	13.6	19.8	20.9	22.1	23.2
SYD-CAN					3.79		6.67		13.4		15.0	
CAN-MEL									2.83		2.81	
Gross Pax Kms b .p.a.												
BNE-NEW (Coastal)	5.44		8.92	9.19	11.56	11.87	11.41	11.66	27.4	27.9	26.0	26.4
BNE-NEW (Inland)		5.52	7.45	7.61	9.20	9.39	9.26	9.41	22.5	22.7	21.4	21.5
NEW-SYD			0.44	0.48	1.64	1.68	1.96	1.99	11.4	11.4	10.6	10.6
SYD-CAN					1.04		1.29		9.20		8.29	
CAN-MEL									1.43		1.37	
Gross Revenue $b.p.a.												
BNE-NEW (Coastal)	0.86		1.38	1.43	1.80	1.86	1.79	1.84	3.89	3.96	3.70	3.76
BNE-NEW (Inland)		0.81	1.07	1.11	1.37	1.40	1.39	1.42	3.16	3.20	3.01	3.04
NEW-SYD			0.08	0.10	0.33	0.34	0.39	0.40	1.78	1.78	1.67	1.67
SYD-CAN					0.20		0.25		1.43		1.30	
CAN-MEL									0.24		0.23	
Net User Benefit $b.p.a.												
BNE-NEW (Coastal)	1.15		2.07	2.18	2.92	3.08	2.80	2.93	6.77	7.01	6.33	6.54
BNE-NEW (Inland)		1.46	1.63	1.70	1.95	2.03	1.98	2.04	5.01	5.12	4.72	4.81
NEW-SYD			0.02	0.03	0.37	0.38	0.45	0.46	2.50	2.48	2.27	2.25
SYD-CAN					0.26		0.30		2.02		1.77	
CAN-MEL									0.32		0.28	
Max Load AADT S 000s												
BNE-NEW (Coastal)	8.43		16.41	18.46	18.95	21.18	18.11	20.21	24.89	27.37	28.01	28.23
BNE-NEW (Inland)		7.34	13.01	14.79	13.99	15.89	14.02	15.39	22.52	22.65	25.53	25.65
NEW-SYD			5.46	6.98	5.06	7.67	10.43	10.41	17.19	17.12	19.62	19.52
SYD-CAN					4.86		8.34		14.43		15.70	
CAN-MEL									3.31		3.42	

350 kph	BRI-NEW Coast	BRI-NEW Inland	NEW-SYD via Hrn	NEW-SYD via FF	SYD-CAN via Hrn via Bowral	SYD-CAN Via FF via Bowral	SYD-CAN via Hrn via Wollongong	SYD-CAN Via FF via Wollongong	CAN-MEL via Hrn via Bowral Coast	CAN-MEL via FF via Wollongong Coast	CAN-MEL via Hrn via Bowral Inland	CAN-MEL via FF via Wollongong Inland
Gross HSR Trips m.p.a.												
BNE-NEW (Coastal)	7.74		15.2	16.5	20.9	22.3	24.3	25.6	32.8	34.2	35.0	36.3
BNE-NEW (Inland)		6.01	11.4	12.7	16.1	17.4	19.8	21.0	26.7	28.0	29.2	30.3
NEW-SYD			4.34	5.44	8.83	9.99	12.61	13.69	18.1	19.2	20.7	21.7
SYD-CAN					3.76		6.74		11.7		13.6	
CAN-MEL									2.67		2.62	
Gross HSR Pax Kms b .p.a.												
BNE-NEW (Coastal)	4.96		7.99	8.16	10.40	10.60	10.37	10.53	23.2	23.4	22.0	22.2
BNE-NEW (Inland)		5.11	6.74	6.84	8.36	8.47	8.49	8.58	19.11	19.17	18.21	18.23
NEW-SYD			0.44	0.48	1.63	1.67	1.95	1.98	9.67	9.61	9.00	8.93
SYD-CAN					1.03		1.28		7.6		6.9	
CAN-MEL									1.3		1.2	
Gross HST Revenue $b.p.a.												
BNE-NEW (Coastal)	0.72		1.13	1.16	1.48	1.52	1.49	1.52	3.00	3.03	2.87	2.89
BNE-NEW (Inland)		0.69	0.89	0.91	1.14	1.16	1.17	1.19	2.45	2.46	2.35	2.35
NEW-SYD			0.08	0.09	0.30	0.31	0.36	0.36	1.38	1.37	1.30	1.30
SYD-CAN					0.18		0.23		1.08		0.99	
CAN-MEL									0.20		0.19	
Net User Benefit $b.p.a.												
BNE-NEW (Coastal)	0.99		1.71	1.79	2.44	2.55	2.38	2.47	5.26	5.41	4.94	5.07
BNE-NEW (Inland)		1.30	1.39	1.45	1.68	1.74	1.73	1.77	3.95	4.01	3.75	3.79
NEW-SYD			0.02	0.03	0.35	7.72	0.43	0.44	1.96	1.93	1.79	1.76
SYD-CAN					0.25		0.29		1.55		1.37	
CAN-MEL									0.28		0.23	
Max Load AADT S 000s												
BNE-NEW (Coastal)	7.69		15.17	17.03	17.44	19.44	16.77	18.70	22.23	24.43	24.94	25.03
BNE-NEW (Inland)		6.79	12.29	13.97	13.17	14.93	13.87	14.55	19.54	19.56	22.95	22.94
NEW-SYD			5.52	7.04	6.13	7.72	10.57	10.54	14.94	14.84	17.79	17.64
SYD-CAN					4.81		8.45		12.36		14.04	
CAN-MEL									3.10		3.18	

250 kph	BRI-NEW		NEW-SYD		SYD-CAN				CAN-MEL							
	Coast	Inland	via Hrn	via FF	via Hrn via Bowral	Via FF	via Hrn via Wollongong	Via FF	via Hrn via Bowral	via FF	via Hrn via Wollongong	Via FF	via Hrn via Bowral	via FF	via Hrn via Wollongong	via FF
									Coast				Inland			
Gross HSR Trips m.p.a.																
BNE-NEW (Coastal)	7.20		14.40	15.45	19.86	21.00	23.40	24.44	29.8	30.9	32.3	33.3	29.3	30.4	31.7	32.7
BNE-NEW (Inland)	5.33		10.72	11.73	15.33	16.39	19.07	20.04	24.3	25.2	27.0	27.9	23.7	24.7	26.4	27.3
NEW-SYD			4.55	5.50	9.02	10.01	12.84	13.75	16.9	17.8	19.6	20.5	16.3	17.2	19.0	19.8
SYD-CAN					3.73		6.76		10.6		12.7		10.0		12.1	
CAN-MEL									2.55				2.47			
Gross HSR Pax Kms b .p.a.																
BNE-NEW (Coastal)	4.45		7.09	7.13	9.26	9.33	9.32	9.35	19.5	19.5	18.7	18.7	18.9	18.9	18.1	18.1
BNE-NEW (Inland)	4.42		5.75	5.79	7.26	7.30	7.45	7.47	16.0	15.9	15.3	15.3	15.3	15.3	14.7	14.6
NEW-SYD			0.46	0.48	1.64	1.66	1.95	1.96	8.2	8.2	7.7	7.6	7.5	7.4	7.0	6.9
SYD-CAN					1.02		1.26		6.5		5.9		5.8		5.3	
CAN-MEL									1.2				1.1			
Gross HST Revenue $b.p.a.																
BNE-NEW (Coastal)	0.59		0.91	0.92	1.19	1.21	1.22	1.23	2.28	2.29	2.20	2.20	2.21	2.22	2.13	2.14
BNE-NEW (Inland)	0.54		0.69	0.70	0.90	0.91	0.95	0.95	1.85	1.85	1.79	1.79	1.78	1.78	1.72	1.71
NEW-SYD			0.08	0.08	0.27	0.28	0.33	0.33	1.06	1.06	1.02	1.01	0.98	0.98	0.94	0.93
SYD-CAN					0.16		0.20		0.83		0.77		0.76		0.70	
CAN-MEL									0.17				0.16			
Net User Benefit $b.p.a.																
BNE-NEW (Coastal)	0.83		1.39	1.42	2.00	2.06	1.99	2.03	4.05	4.12	3.84	3.89	3.75	3.82	3.54	3.60
BNE-NEW (Inland)	1.07		1.09	1.13	1.37	1.40	1.43	1.45	3.05	3.07	2.92	2.93	2.73	2.75	2.60	2.62
NEW-SYD			0.03	0.03	0.34	0.35	0.42	0.42	1.54	1.52	1.42	1.40	1.30	1.27	1.17	1.16
SYD-CAN					0.24		0.27		1.23		1.10		1.00		0.89	
CAN-MEL									0.24				0.19			
Max Load AADT S 000s																
BNE-NEW (Coastal)	6.89		14.15	15.59	16.14	17.72	15.61	17.13	20.06	21.76	22.31	22.32	19.95	21.67	21.52	21.54
BNE-NEW (Inland)	5.90		11.47	12.86	12.28	13.75	13.50	13.54	17.04	16.98	20.69	20.61	16.17	16.19	19.80	19.73
NEW-SYD			5.81	7.11	6.43	7.80	10.60	10.55	13.10	12.99	16.27	16.10	12.22	12.08	15.37	15.18
SYD-CAN					4.78		8.50		10.95		13.00		10.13		12.16	
CAN-MEL									2.94				2.99			

160kph Base Option	BRI-NEW		NEW-SYD		SYD-CAN				CAN-MEL							
	Coast	Inland	via Hrn	via FF	via Hrn via Bowral	Via FF	via Hrn via Wollongong	Via FF	via Hrn via Bowral	via FF	via Hrn via Wollongong	Via FF	via Hrn via Bowral	via FF	via Hrn via Wollongong	via FF
									Coast				Inland			
Gross HSR Trips m.p.a.																
BNE-NEW (Coastal)	2.4		7.1		9.5								13.3			
BNE-NEW (Inland)																
NEW-SYD			4.1		6.2								9.7			
SYD-CAN					1.6								4.8			
CAN-MEL														2.29		
Gross HSR Pax Kms b .p.a.																
BNE-NEW (Coastal)	0.8		1.5		2.2								5.0			
BNE-NEW (Inland)																
NEW-SYD			0.4		0.9								3.0			
SYD-CAN					0.4								2.2			
CAN-MEL														1.0		
Gross HST Revenue $b.p.a.																
BNE-NEW (Coastal)	0.08		0.15		0.22								0.42			
BNE-NEW (Inland)																
NEW-SYD			0.06		0.11								0.28			
SYD-CAN					0.04								0.20			
CAN-MEL														0.09		
Net User Benefit $b.p.a.																
BNE-NEW (Coastal)	0.09		0.12		0.22								0.49			
BNE-NEW (Inland)																
NEW-SYD			0.02		0.10								0.31			
SYD-CAN					0.05								0.25			
CAN-MEL														0.13		
Max Load AADT S 000s																
BNE-NEW (Coastal)	1.81		6.63		7.41								8.28			
BNE-NEW (Inland)																
NEW-SYD			5.24		5.63								5.89			
SYD-CAN					1.96								3.66			



9.9 VHST Demand by Technology and Year

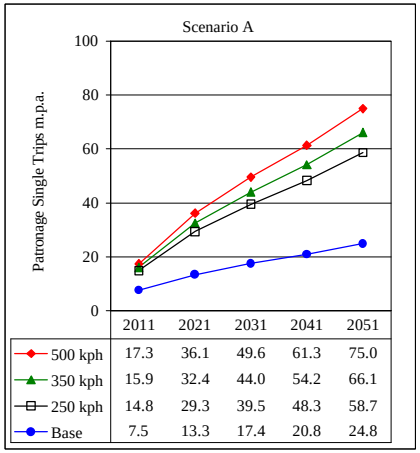
9.9.1 Introduction

Demand forecasts were produced for each technology for 2011, 2021, 2031, 2041 and 2051 for scenario A and scenario D using Brisbane-Melbourne via the coast, Hornsby, Central Highlands and inland from Canberra as an example. The evaluation includes ramp up for the start year 2011 and assumes that Countrylink services continue. The forecasts also assume that the maximum revenue fare structures are adopted. Forecasts of demand, gross revenue and passenger km are presented.

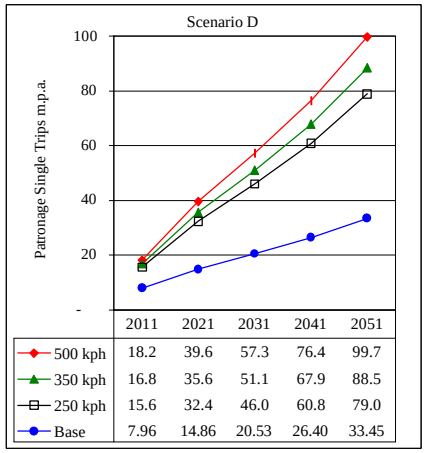
9.9.2 Demand

With no significant increase in speed but only frequency enhancements, comfort changes and fare revisions, the base rail option (160 km/h) achieves a demand of 7.5 million in 2011 under scenario A. Over the fifty-year period, trips increase triple to 24.8 million, an average annual increase of 2%.

Figure 9.32: VHST Demand by Forecast Year



	2011	2021	2031	2041	2051
500 kph	17.3	36.1	49.6	61.3	75.0
350 kph	15.9	32.4	44.0	54.2	66.1
250 kph	14.8	29.3	39.5	48.3	58.7
Base	7.5	13.3	17.4	20.8	24.8



	2011	2021	2031	2041	2051
500 kph	18.2	39.6	57.3	76.4	99.7
350 kph	16.8	35.6	51.1	67.9	88.5
250 kph	15.6	32.4	46.0	60.8	79.0
Base	7.96	14.86	20.53	26.40	33.45

250 km/h VHST operation over the corridor would increase demand to 14.8 million in 2011 under scenario A; a doubling over the base option. Ramp-up leads to a rapid increase over the first three years. By 2021, demand is forecast at 29.3 million trips, twice 2011 levels and representing an average increase of 7% a year. Growth is forecast double again by 2051, an annual average increase of 2.3% over the thirty year period.

350 km/h achieves a demand in 2011 to 15.9 million trips under scenario A, an increase of 1.1 million trips (7%) over 250 km/h. Demand is forecast to double by 2021 reaching 32.4 million trips and to double again by 2051 to reach 66.1 million trips. The annual rate of increase over the first ten years is forecast at 7.3%. The rate then falls to 2.4% over next thirty years.

500 km/h achieves 17.3 million trips in 2011 under scenario A, an increase of 1.4 million trips (9%) over 350 km/h. Demand is forecast to double by 2021 reaching 36.1 million trips then double again by 2051 to reach 75 million trips. The annual rate of increase over the first ten years is forecast at 7.6% and 2.5% over next thirty years.

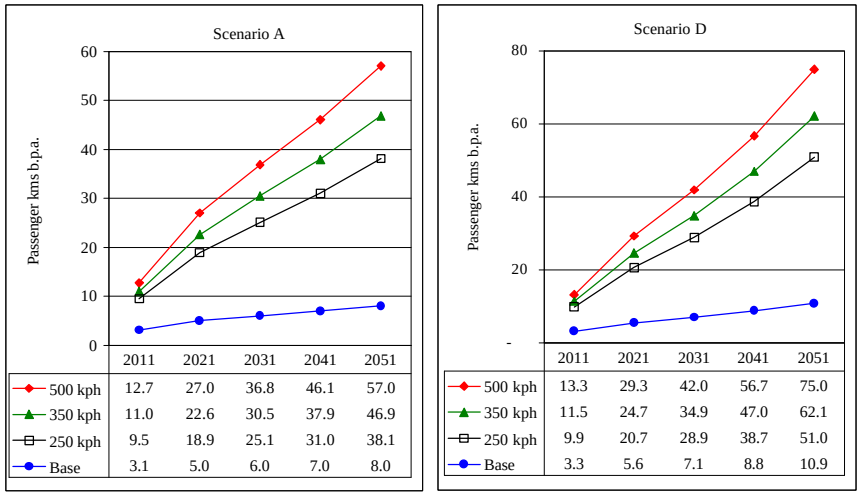
There is little difference between scenario D - the high population and employment growth scenario and the central (trend) scenario (A) in early years. However the difference becomes significant the longer the forecasting horizon is extended. For 500 km/h operation in 2031, demand is forecast at 57 million trips compared to 50 million trips in scenario A, an increase of 7 million trips 14%. By 2051, demand fall just short of 100 million in scenario D, an increase of 24.7 million over scenario A, or one third higher.

9.9.3 Passenger Kilometres

The difference between the rail technologies in distance travelled is wider than in terms of trips. VHST is becomes more competitive with air, the faster the technology and competition with air is more important at longer distances.

Passenger km with 500 km/h VHST is forecast at 12.7 billion in 2011, 1.7 billion greater than 350 km/h VHST. In percentage terms, the increase is 15.5% compared to a demand increase of 9%. Similarly the difference of 350 km/h over 250 km/h is 1.5 billion passenger-kilometres or 15.8% compared to a demand increase of 7%. 250 km/h is forecast to triple passenger km over the base option compared to a doubling of demand.

Figure 9.33: VHST Passenger Kilometres by Forecast Year



	2011	2021	2031	2041	2051
500 kph	12.7	27.0	36.8	46.1	57.0
350 kph	11.0	22.6	30.5	37.9	46.9
250 kph	9.5	18.9	25.1	31.0	38.1
Base	3.1	5.0	6.0	7.0	8.0

	2011	2021	2031	2041	2051
500 kph	13.3	29.3	42.0	56.7	75.0
350 kph	11.5	24.7	34.9	47.0	62.1
250 kph	9.9	20.7	28.9	38.7	51.0
Base	3.3	5.6	7.1	8.8	10.9

Scenario D increases passenger km over scenario A by around the same percentage as for trips. For 2031, for 500 km/h VHST, scenario D increases passenger km by 14% and by 32% in 2051.

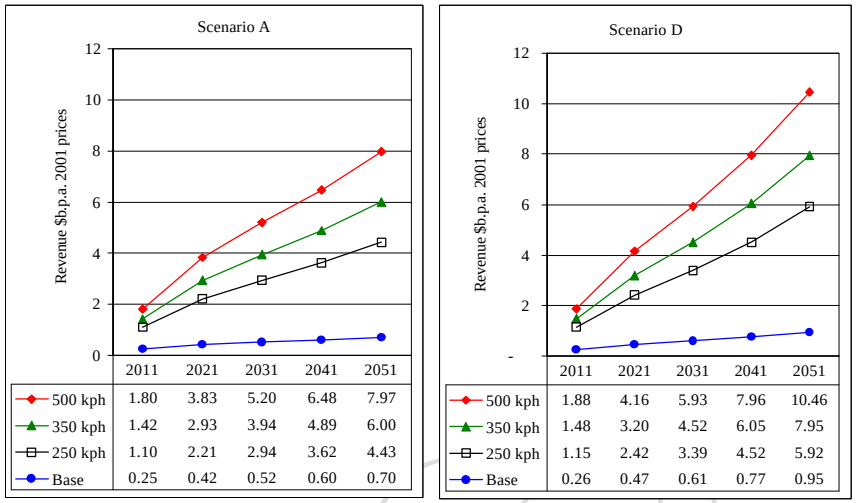
9.9.4 Gross Revenue

The revenue differences between rail technologies is widened by an increase in average fare the faster the VHST technology.

For 500 km/h VHST, revenue in 2011 is forecast at $1.8 billion rising fourfold to $7.97 billion in 2051, an average annual growth of just over 3.8%. The increase over 350 km/h VHST, is $380 million in 2011 a percentage increase of 21% compared to 9% in demand and 15.5% in passenger km.

350 km/h VHST increases revenue by $320 million over 250 km/h, a percentage increase of 29% with 250 km/h increasing revenue over the base option by $850 million, a percentage increase of 340%.

Figure 9.34: VHST Gross Revenue by Forecast Year



	2011	2021	2031	2041	2051
500 kph	1.80	3.83	5.20	6.48	7.97
350 kph	1.42	2.93	3.94	4.89	6.00
250 kph	1.10	2.21	2.94	3.62	4.43
Base	0.25	0.42	0.52	0.60	0.70

	2011	2021	2031	2041	2051
500 kph	1.88	4.16	5.93	7.96	10.46
350 kph	1.48	3.20	4.52	6.05	7.95
250 kph	1.15	2.42	3.39	4.52	5.92
Base	0.26	0.47	0.61	0.77	0.95

Scenario D increases revenue over scenario A by $730 million in 2031 for 500 km/h VHST or 14%, the same percentage increase as for trips and passenger km.

9.10 Source of VHST Demand

9.10.1 Introduction

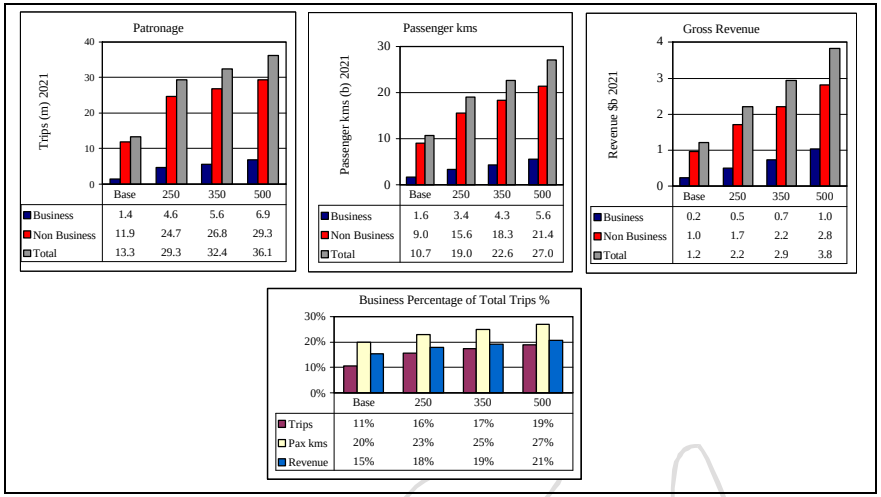
The composition of VHST demand has been assessed for each technology option using Brisbane-Newcastle via the coast, Newcastle-Sydney via Hornsby, Sydney-Canberra via the Central Highlands and Canberra-Melbourne via the 'inland' route as an example. The evaluation assumes that VHST services start in 2011 and that Countrylink services continue. The forecasts also assume that the maximum revenue fare structures are adopted. Composition of VHST demand is assessed in terms of demand, revenue and rail passenger km.

9.10.2 Business - Non Business Trips

With the base rail option, business travel is forecast at 1.4 million trips in 2021. The quicker journey times with VHST attract an increase in business use. 250 km/h VHST increases business trips to 4.6 million, 3.3 times the base option. 350 km/h increases business trips to 5.6 million, 22% above 250 km/h. 500 km/h VHST business trips are forecast at 6.9 million, 1.3 million 23% above 350 km/h VHST.

Non-business trips are forecast at 11.9 million for the base rail option. 250 km/h VHST more than doubles non-business trips to 24.7 million. The demand increase with 350 km/h is less pronounced than for business trips. Non-business trips increase to 26.8 million, an increase of 2.1 million trips on 250 km/h 8.5% (just over one third the of the business percentage increase). With 500 km/h VHST, non-business trips increase to 29.3 million, an increase of 9% on 350 km/h compared to a 23% increase in business trips.

Figure 9.35: Business - Non Business Profile



The differences between technology are more pronounced in revenue terms. 250 km/h operation is forecast to achieve a business revenue of $500 million in 2021, $300 million or 150% more than the base option. 350 km/h is forecast to increase revenue by 500 million over 250 km/h (29%) with 500 km/h producing a further increase of 300 million (43%) over 350 km/h The difference in non-business revenue is less marked however. With 500 km/h operations, non-business revenue is forecast at $2.8 billion compared to $2.2 billion with 350 km/h, an increase of 600 million or 27%.

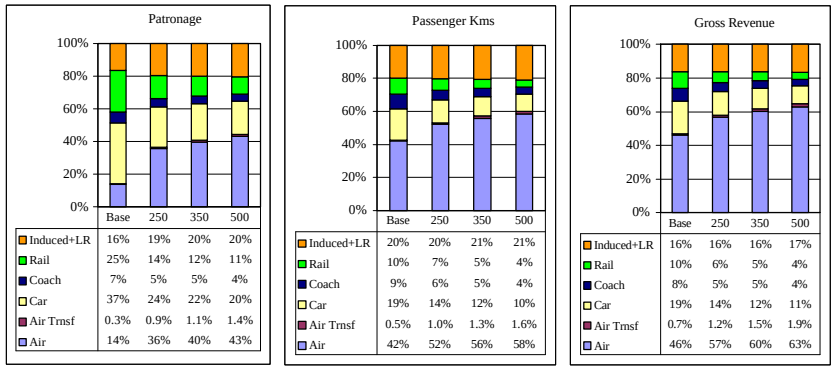
For the base rail option, business trips are forecast at 11% of total trips. With VHST, the business percentage increases to 16% with 250 km/h, 17% with 350 km/h an d 19% with 500 km/h. Longer business trips pushes up the passenger km business share to above 20% for the VHST options. For 500 km/h the passenger km share is forecast at 27%. The revenue shares lie between the passenger km and trip shares reflecting the distance taper built into the fare structure. For 250 km/h VHST, the business trips contribute 18% of gross revenue. The percentage rises slightly to 19% for 350 km/h and 21% with 500 km/h.

9.10.3 Analysis by Source Travel Mode

The source of VHST demand varies with technology. As speed increases, VHST becomes increasingly competitive with air. Consequently VHST demand has a higher share sourced from air. At the same time, the increase in a fare dampens demand from coach and rail.

For the base rail option, 32% of VHST ridership is from coach and existing rail with 16% induced, 37% from car and 14% from air. At 250 km/h, air's share increases to 37% with rail and coach falling to 14% and 5% respectively. At 350 km/h, diversion from air contributes 41% of VHST demand with rail and coach contributing 12% and 5% respectively, car 22% and induced and long run commuting effects contributing 20%. At 500 km/h air contributes 44% with rail and bus contributing 15%, car 20% and induced demand 20%. For all the options, air transfer trips contribute little to VHST demand (1.4% for 500 km/h operations).

Figure 9.36: Source Mode



Air contribution to VHST usage is greater when measured in terms of passenger km. For the base option, air contributes 42.5% with rail and coach contributing 19%, car 19% and induced demand 20%. At 250 km/h, air contributes just over half of VHST passenger km and nearly 60% at 500 km/h. Induced demand stays roughly constant at around one fifth of divert trips. Compensating for the increase in air share is a fall in rail and bus share from 19% combined with the base rail option to 8% with 500 km/h.

Gross revenue follows a slightly more exaggerated profile to passenger km. At 250 km/h air contributes 58% of total VHST revenue and 65% at 500 km/h. This is suggested to result from an ability of the VHST operator to charge higher fares to passengers diverting from air than those diverting from ground public transport and car. In reality this will depend on the ability to price discriminate effectively according to booking date, time of travel, facilities required and the like.



9.11 VHST Market Share

9.11.1 Introduction

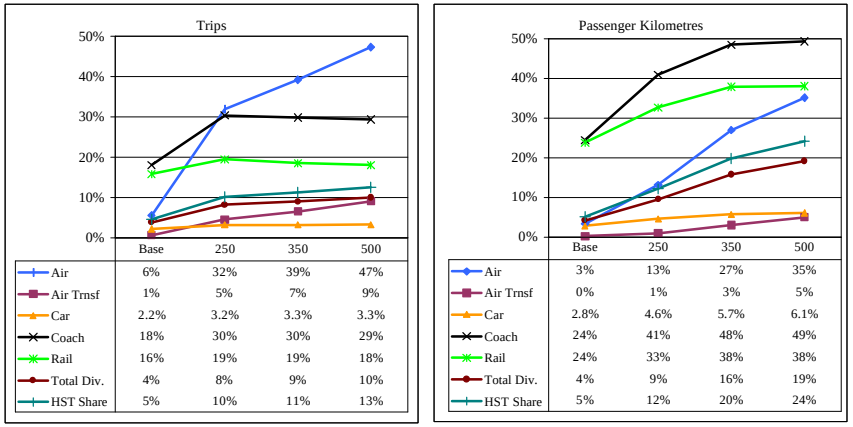
An analysis of the market share that VHST could achieve in 2021 was undertaken using the Coastal, Hornsby, Bowral, Inland route as an example. The evaluation assumes that VHST services start in 2011 and that Countrylink services continue. The forecasts also assume that the maximum revenue fare structures are adopted. To enable comparison, passenger km market shares were measured in road km rather than 'own' mode km. Market share in terms of trips and passenger km is presented.

9.11.2 Total Market

A 500 km/h VHST diverts 10% of existing inscope trips. VHST market share falls to 11% at 350 km/h, 10% with 250 km/h and would be only 5% with the base rail option. For the base option, the air market (O&D) is left largely unaffected with VHST achieving a 6% share. VHST share of the air market rises 32% with 250 km/h service, 39% with 350 km/h, and 47% with 500 km/h VHST.

VHST diverts 3% of the car market. With continuation of Countrylink services, the higher service frequency of existing metro rail services and the higher VHST fares, restricts VHST diversion to just under one fifth of the rail market[29]. Around 30% of the coach market is diverted. Including induced demand raises VHST share market share by around 25% to 13% for 500 km/h VHST.

Figure 9.37: VHST Total Market Share



	Base	250	350	500
Air	6%	32%	39%	47%
Air Trnsf	1%	5%	7%	9%
Car	2.2%	3.2%	3.3%	3.3%
Coach	18%	30%	30%	29%
Rail	16%	19%	19%	18%
Total Div.	4%	8%	9%	10%
HST Share	5%	10%	11%	13%

	Base	250	350	500
Air	3%	13%	27%	35%
Air Trnsf	0%	1%	3%	5%
Car	2.8%	4.6%	5.7%	6.1%
Coach	24%	41%	48%	49%
Rail	24%	33%	38%	38%
Total Div.	4%	9%	16%	19%
HST Share	5%	12%	20%	24%

9.11.3 Business Travel Market

The base option is too slow to achieve a significant business travel share. Of diverted trips, the base 160 km/h option achieves a 4% share. One fifth of coach and one quarter of rail business trips are forecast to divert with one third and one half of passenger km diverting respectively. However these markets are relatively small. Only 2% of car business trips are forecast to divert and 5% of car passenger km.

VHST achieves a higher share of the business travel market than the non-business market. With 250 km/h operations, VHST achieves a 15% trip share and 11% passenger share with induced demand included. Of diverted trips (excluding induced demand) 250 km/h VHST achieves a 13% trip share and 9% passenger km share. For 250 km/h, the passenger km business travel share is less than the trip share. This results from 250 km/h VHST failing to capture the longer distance business travel market; air is forecast to retain this market. One in four air business travellers are forecast to divert but only 8% of passenger km are diverted. Again, this results from 250 km/h VHST diverting shorter distance turbo-prop air business trips. Longer haul, jet air services are forecast to dominate 250 km/h VHST. Six percent of car trips and 10% of car passenger km are forecast to divert. Around over one third of coach and rail business travellers divert. A higher percentage of coach and rail passenger km divert. For rail, 58% of business travel km divert to VHST. For bus, the forecast is 49%.

[29] A cut off of 40kms was also imposed to restrict further the number of inner metro trips by VHST.

Figure 9.38: VHST Business Market Share

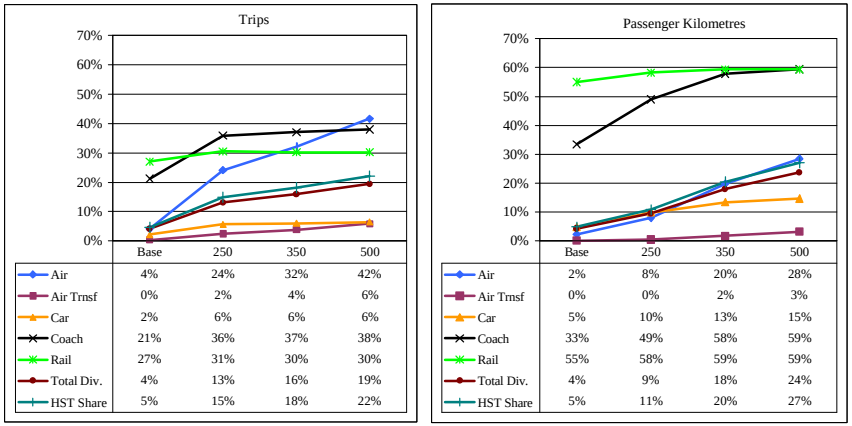
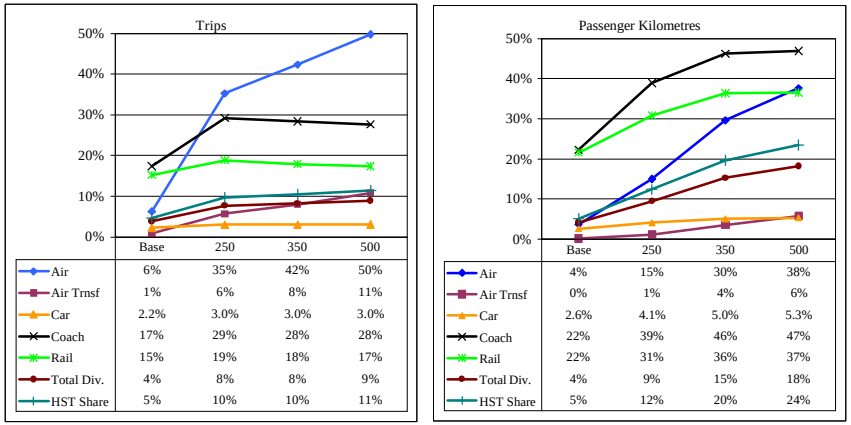


Figure 9.39: VHST Non-Business Market Share



For 350 km/h, VHST starts to become competitive with air. One third of air passengers are forecast to divert though, in terms of passenger km, diversion is lower at 20%. Air transfer diversion increases from 0% with 250 km/h to 2% measured in passenger km and doubles in terms of trips from 2% to 4%. Overall, 350 km/h VHST achieves an 18% trip and 20% passenger km share. 37% of coach and 30% of rail travellers divert. Diversion is higher at longer distances resulting in nearly six out of ten passenger km diverting. Car passenger km diverted increases by 3% points to 13% although trip diversion remains at 6%.

9.11.4 Non-Business Travel Market

The base option achieves a 5% non-business travel market share. Diversion from coach and rail is forecast to be lower than for business trips at 15% for rail and 17% for coach. Car diversion is forecast at 2.2% in trips and 2.6% in passenger km. 160 km/h is too slow for significant numbers of non-business air passengers to divert. The forecast is for 6% of trips and 4% of passenger km to divert.

250 km/h VHST is forecast to obtain a 10% share of non-business trips and 12% of passenger km. Significant numbers of non-business air travellers are forecast to divert:- 35% of trips and 15% of passenger km which compare with lower forecasts of 24% and 8% for business travel. Three percent of car passengers are forecast to divert and 4.1% of car passenger km.

350 km/h is forecast to achieve a 10% trip share and 20% passenger km with induced trips included. Of existing trips, VHST achieves overall diversion rates of 8% trips and 15% passenger km. A smaller percentage of non-business coach and rail users are forecast to divert. For coach 28% of trips and 46% of passenger km are forecast to divert. For rail the percentages are 18% and 36% respectively. The diversion rate from car is forecast to be half that of business trips and to be the same as 250 km/h VHST. The increase in fare compensating for the reduction in journey time. For air, 350 km/h increases diversion by 20% over 250 km/h in terms of trips and doubles the passenger km diversion rate. 350 km/h becomes more competitive with air over medium distances such as Sydney-Melbourne. Non-business diversion is forecast to be 50% higher in terms of passenger km and 30% higher in terms of trips than business diversion. 5% of car non-business passenger km and 3% of trips are forecast to divert. Trip diversion is forecast to be half that of business car travellers.

500 km/h VHST is achieve just under a quarter share of the non-business market measured in passenger km and an 11% trip share. One half of non-business air trips are forecast to divert with 38% of passenger km diverting. Diversion of car non-business trips is not forecast to increase on 350 km/h or 250 km/h VHST although passenger km increase to 5.3% from 5% with 350 km/h and 4.1% with 250 km/h. Diversion from coach and rail is forecast to be the same as 350 km/h.

9.12 VHST Demand for Selected Routes

9.12.1 Introduction

The impact of route was assessed on aggregated VHST flows using 350 km/h technology as an example. Five routes between Brisbane and Melbourne routes were assessed:

- IHBI: Brisbane-Newcastle Inland; Newcastle-Sydney via Hornsby; Sydney-Canberra via Central Highlands (Bowral) and Canberra-Melbourne Inland.
- IFWI: Brisbane-Newcastle Inland; Newcastle-Sydney via Frenchs Forest; Sydney-Canberra via Wollongong and Canberra-Melbourne Inland.
- CHBC: Brisbane-Newcastle Coastal; Newcastle-Sydney via Hornsby; Sydney-Canberra via Central Highlands (Bowral) and Canberra-Melbourne Coastal.
- CFWC: Brisbane-Newcastle Coastal; Newcastle-Sydney via Frenchs Forest; Sydney-Canberra via Wollongong and Canberra-Melbourne Coastal.
- CFWI: Brisbane-Newcastle Coastal; Newcastle-Sydney via Frenchs Forest; Sydney-Canberra via Wollongong and Canberra-Melbourne Inland.

The evaluation assumes that VHST services start in 2011 and that Countrylink services continue. The forecasts also assume that the maximum revenue fare structures are adopted. The impact on demand, passenger km, gross revenue and user benefit is presented. The analysis shows that route choice has different effects for the different market aggregations.

9.12.2 Demand

In terms of the capital city flows, the largest demand is Sydney-Melbourne. Demand is highest at 5.38 million with a coastal, Hornsby, Bowral and Coastal route. With an inland route south of Canberra, Sydney-Melbourne demand falls to 4.62 million, a difference of 0.76 million or 15%.

Brisbane-Sydney demand is higher via the coastal route and is highest via Hornsby with demand just exceeding 2 million trips. With a Frenchs Forest and route, demand is forecast at 1.8 million 12% lower. With an inland route north of Newcastle, demand falls under 1.5 million.

Brisbane-ACT demand is also highest with a coastal route north of Newcastle and a Wollongong route south of Sydney. Demand is also slightly higher with a Frenchs Forest route between Newcastle and Sydney. Demand just surpasses 300,000 trips with a coastal, Frenchs Forest and Bowral route. With a coastal, Hornsby and Bowral route, Brisbane-ACT demand is forecast at 290,000, 6% lower.

Brisbane-Melbourne demand approaches 1 million, one fifth of Sydney-Melbourne with a coastal, Frenchs Forest, Wollongong, Coastal route. There is little difference between the Hornsby-Bowral route and the Frenchs Forest-Wollongong route. South of Canberra, the inland route reduces demand by 9%. North of Newcastle, the inland route has a much more marked effect, reducing demand by 28%.

Sydney-ACT demand is 4% higher via Bowral than Wollongong, 3.18 million compared to 3.06 million.

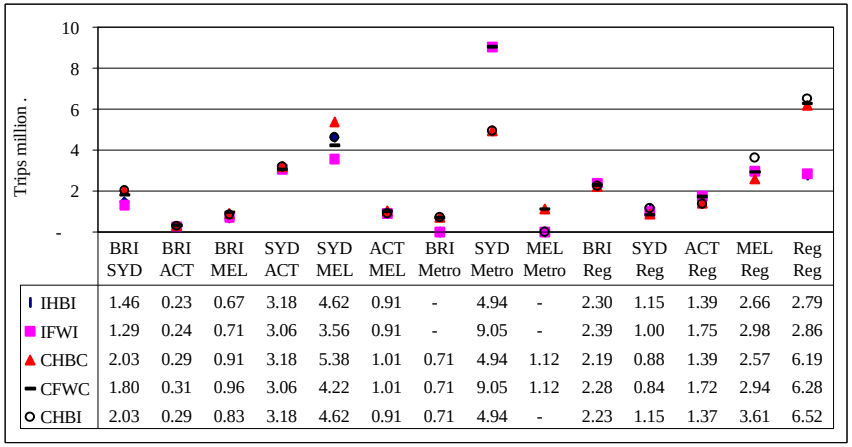
ACT-Melbourne demand is 11% higher via the coast at 1 million trips than inland (910,000).

A coastal route north of Newcastle is forecast to generate 0.71 million Brisbane-metro trips whereas there are no metro trips (as defined) on the inland route. Similarly, south of Canberra, the coastal route generates 1.12 million metro trips whereas there are no metro trips (as defined) on the inland route. For Sydney-metro trips, a new Frenchs Forest and Wollongong route is forecast to double metro trips to 9.05 million over a Hornsby and Central Highlands (Bowral) route.

Brisbane-Regional trips are higher with an inland rather than a coastal route. Trips are highest at 2.39 million trips with a Frenchs Forest and Wollongong route, 90,000 higher (5%) than via Hornsby and Bowral.

Sydney-Regional trips are higher via Hornsby and Bowral than via Frenchs Forest and Wollongong. The highest demand is 1.15 million with a coastal, Hornsby, Bowral, inland route. The same demand is also achieved with a coastal, Hornsby, Bowral and inland route. North of Sydney, the same demand is forecast for Sydney-Regionals via the coast or inland. South of Canberra, the inland route is forecast to increase trips by 0.27 million (30%) on the coastal route.

Figure 9.40: Demand - 2021 by Route - 350 km/h VHST



	BRI SYD	BRI ACT	BRI MEL	SYD ACT	SYD MEL	ACT MEL	BRI Metro	SYD Metro	MEL Metro	BRI Reg	SYD Reg	ACT Reg	MEL Reg	Reg Reg
IHBI	1.46	0.23	0.67	3.18	4.62	0.91	-	4.94	-	2.30	1.15	1.39	2.66	2.79
IFWI	1.29	0.24	0.71	3.06	3.56	0.91	-	9.05	-	2.39	1.00	1.75	2.98	2.86
CHBC	2.03	0.29	0.91	3.18	5.38	1.01	0.71	4.94	1.12	2.19	0.88	1.39	2.57	6.19
CFWC	1.80	0.31	0.96	3.06	4.22	1.01	0.71	9.05	1.12	2.28	0.84	1.72	2.94	6.28
CHBI	2.03	0.29	0.83	3.18	4.62	0.91	0.71	4.94	-	2.23	1.15	1.37	3.61	6.52

ACT-Regional trips are highest with a Frenchs Forest and Wollongong route reaching 1.75 million with an inland route north of Newcastle and south of Canberra. However, south of Canberra with a Hornsby and Bowral route, trips are slightly higher (2%) with an inland route.

Melbourne-Regional trips are highest with an inland route south of Canberra and are higher with a Hornsby-Wollongong route reaching 3.61 million. With a coastal route south of Canberra, regional trips fall to 2.57 million. This drop is in part due to the definition of the East Melbourne corridor as metro trips whilst Shepparton and Seymour are defined as Regional,

Regional-Regional demand is maximised at 6.52 million trips with a coastal, Hornsby, Bowral, inland route. Demand is reduced halved to 2.79 million with an inland route north of Newcastle. With an inland corridor, demand is lower with a Frenchs Forest-Bowral route but higher with a coastal corridor.

9.12.3 Passenger Kilometres

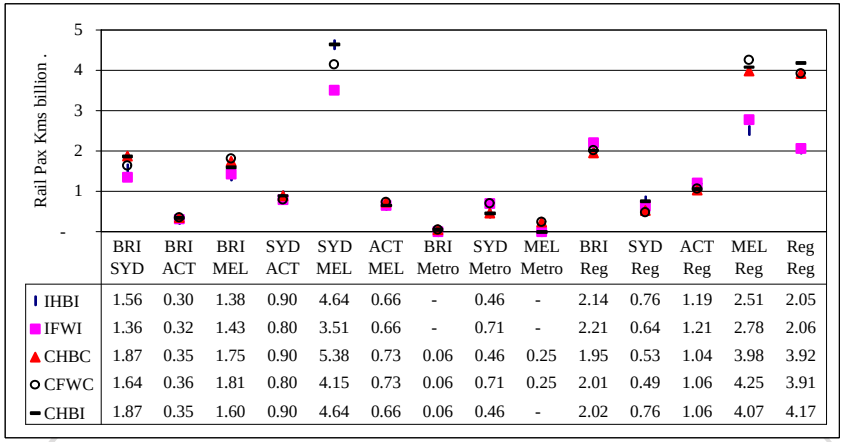
The passenger km profile reduces the importance of metro trips by virtue of their shorter distance. Of the capital flows, the coastal route generates greater passenger km between Brisbane and Sydney, ACT and Melbourne and is higher via Frenchs Forest and Wollongong.

Sydney-ACT and Sydney-Melbourne passenger km are higher via Bowral, 12.5% higher for ACT and 32% higher for Melbourne.

Passenger km for Brisbane-Regional flows are higher inland via Frenchs Forest and Bowral although the differences are not marked.

Sydney-Regional passenger km are higher via an inland throughout route at 0.76 billion. ACT-Regional passenger km are slightly higher with a Frenchs Forest-Wollongong route. Melbourne-Regional passenger km are higher with a coastal route reaching 4.25 million via Frenchs Forest and Wollongong. Regional-Regional capital passenger kiometres at 4.17 billion are highest with a coastal, Hornsby, Bowral and Inland route.

Figure 9.41: Passenger Kilometres - 2021 by Route - 350 km/h VHST



	BRI SYD	BRI ACT	BRI MEL	SYD ACT	SYD MEL	ACT MEL	BRI Metro	SYD Metro	MEL Metro	BRI Reg	SYD Reg	ACT Reg	MEL Reg	Reg Reg
IHBI	1.56	0.30	1.38	0.90	4.64	0.66	-	0.46	-	2.14	0.76	1.19	2.51	2.05
IFWI	1.36	0.32	1.43	0.80	3.51	0.66	-	0.71	-	2.21	0.64	1.21	2.78	2.06
CHBC	1.87	0.35	1.75	0.90	5.38	0.73	0.06	0.46	0.25	1.95	0.53	1.04	3.98	3.92
CFWC	1.64	0.36	1.81	0.80	4.15	0.73	0.06	0.71	0.25	2.01	0.49	1.06	4.25	3.91
CHBI	1.87	0.35	1.60	0.90	4.64	0.66	0.06	0.46	-	2.02	0.76	1.06	4.07	4.17

9.12.4 Gross Revenue

The revenue is similar to the passenger km profile. The important of metro trips is reduced compared because of the lower fares paid.

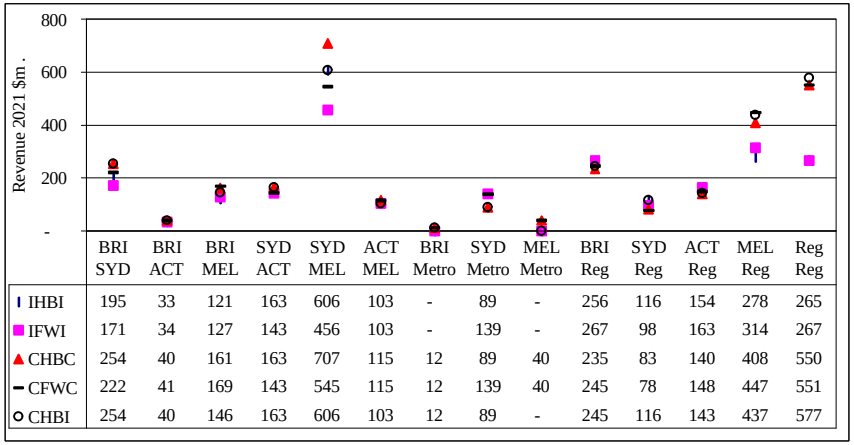
Of the capital flows, the coastal route north of Newcastle generates the greatest revenue for Brisbane-Sydney, Brisbane-ACT and Brisbane-Melbourne. For Brisbane-Sydney, the Hornsby route produces higher revenue at $254 million than Frenchs Forest. For Brisbane-ACT, the coastal route produces higher revenue at $41 million than the inland and Hornsby-Bowral increases revenue over Frenchs Forest-Wollongong.

Sydney-ACT and Sydney-Melbourne revenue is highest at $163 million and $707 million respectively via the coastal route. Sydney-ACT revenue is higher via Bowral. Sydney-Melbourne revenue is higher via Bowral and the coastal route.

Revenue for Brisbane-Regional flows is highest inland via Frenchs Forest and Wollongong at $267 million although the differences are not marked. Sydney-Regional revenue is highest at $116 million with an inland route via Hornsby and Bowral. ACT-Regional revenue is highest at $163 million with an inland route via Frenchs Forest and Wollongong although the differences are not great. Melbourne-Regional revenue is highest at $447 million with an inland route south of Canberra and is higher via Frenchs Forest and Wollongong.

Regional-Regional revenue is highest at $577 million with a coastal, Hornsby, Bowral and Inland route.

Figure 9.42: Gross Revenue - 2021 by Route - 350 km/h VHST



	BRI SYD	BRI ACT	BRI MEL	SYD ACT	SYD MEL	ACT MEL	BRI Metro	SYD Metro	MEL Metro	BRI Reg	SYD Reg	ACT Reg	MEL Reg	Reg Reg
IHBI	195	33	121	163	606	103	-	89	-	256	116	154	278	265
IFWI	171	34	127	143	456	103	-	139	-	267	98	163	314	267
CHBC	254	40	161	163	707	115	12	89	40	235	83	140	408	550
CFWC	222	41	169	143	545	115	12	139	40	245	78	148	447	551
CHBI	254	40	146	163	606	103	12	89	-	245	116	143	437	577

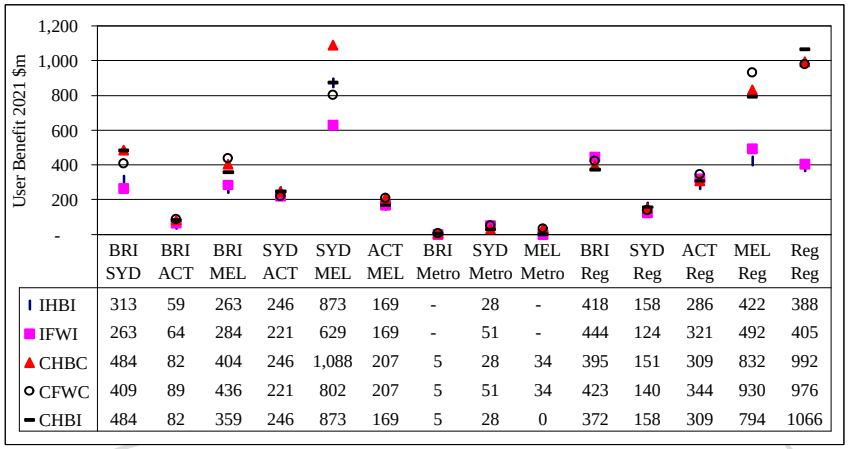
9.12.5 User Benefit

Of the capital flows, the coastal route generates greater user benefit between Brisbane and Sydney, ACT and Melbourne and is highest via Hornsby to Sydney but higher by Frenchs Forest and Wollongong to ACT and Melbourne.

Sydney-ACT and Sydney-Melbourne user benefit is higher via Bowral, 11% higher for ACT and 36% higher for Melbourne. User benefit for Brisbane-Regional flows is highest inland via Frenchs Forest and Wollongong. Sydney-Regional user benefit however is higher inland south of Canberra and is higher via Hornsby and Bowral. ACT-Regional user benefit is higher with a Wollongong-Frenchs Forecast coastal route. Melbourne-Regional user benefit is noticeably higher with a coastal route reaching $0.93 billion via Frenchs Forest and Wollongong. Regional-Regional user benefit reaches $1 billion with a coastal Hornsby-Bowral inland route.

User benefit also discounts the impact of metro trips because of a higher base rail service level. The Sydney Metro market remains the largest in terms of the increase in user benefit and is maximised by the Frenchs Forest-Wollongong alignment.

Figure 9.43: User Benefit - 2021 by Route - 350 km/h VHST



	BRI SYD	BRI ACT	BRI MEL	SYD ACT	SYD MEL	ACT MEL	BRI Metro	SYD Metro	MEL Metro	BRI Reg	SYD Reg	ACT Reg	MEL Reg	Reg Reg
IHBI	313	59	263	246	873	169	-	28	-	418	158	286	422	388
IFWI	263	64	284	221	629	169	-	51	-	444	124	321	492	405
CHBC	484	82	404	246	1,088	207	5	28	34	395	151	309	832	992
CFWC	409	89	436	221	802	207	5	51	34	423	140	344	930	976
CHBI	484	82	359	246	873	169	5	28	0	372	158	309	794	1066

9.13 VHST Demand and Market Shares by Flow

The size of flows was assessed for fourteen aggregated zone using for 350 km/h VHST for the full corridor following the coastal, Hornsby, Bowral, inland route. The evaluation assumes that VHST services start in 2011 and that Countrylink services continue. The forecasts also assume that the maximum revenue fare structures are adopted.

Section 9.13.1 presents the 14 zone system. Section 9.13.2 presents VHST demand for each of the 14 zone pairs. Section 9.13.3 presents the air share and 13.4 the overall VHST market share excluding induced demand and long run commuting effects.

9.13.1 Composition of 14 Zone Aggregation

For reporting purposes, the EC corridor was disaggregated into fourteen zones based on the TDM zones and VHST stations.

Table 9.11: Composition of 14 Zone System

Zone - Station	VHST Station	14 Zone #	14 Zone Name	Zone - Station	VHST Station	14 Zone #	14 Zone Name
Maryboro	BNE	1	BRI	Blue Mountains	SDT	6	Syd+CW
Sunshine	BNE	1	BRI	Central Western	SDT	6	Syd+CW
Brisbane	BNE	1	BRI	Illawarra	STH	7	Scoast
Brisbane	BHL	1	BRI	SouthCoast	WOL	7	Scoast
Brisbane	IPS	1	BRI	S. Tablelands	BOW	8	CHghlnds
Gold Coast	RBA	2	GoldCoast	S. Tablelands	GLD	8	Chighlnds
Gold Coast	OOL	2	GoldCoast	ACT	CNB	9	ACT
Darling Downs	TWB	3	N-Inlnd	ACT	CVC	9	ACT
Darling Downs	WWK	3	N-Inlnd	Snowy	CMA	10	Snowy
New England	GNS	3	N-Inlnd	Snowy	BOM	10	Snowy
New England	ARM	3	N-Inlnd	S. Tablelands	YAS	11	CTA-ABY
New England	TAM	3	N-Inlnd	Riverina	CTA	11	CTA-ABY
Upper North	BAL	4	N-Coast	Riverina	WGA	11	CTA-ABY
Mid North	GTN	4	N-Coast	Murray	ALB	11	CTA-ABY
Mid North	CFN	4	N-Coast	Lakes	ORB	12	Lake-Gip
Lower North	PMQ	4	N-Coast	Lakes	SXE	12	Lake-Gip
Lower North	TRE	4	N-Coast	Gippsland	TLG	12	Lake-Gip
Hunter	BMD	5	Ccoast	Gippsland	WGL	12	Lake-Gip
Hunter	MUS	3	N-Inlnd	Central Murray	SHP	13	SHPSEY
Central Coast	WVE	5	CCoast	Central Murray	SEY	13	SHPSEY
Central Coast	GOS	5	CCoast	Melbourne	DNG	14	Melbrne
Sydney	CWD	6	Syd+CW	Melbourne	MAP	14	Melbrne
Sydney	HBY	6	Syd+CW	Melbourne	MEL	14	Melbrne
Sydney	STR	6	Syd+CW	Gt Ocean Rd	MEL	14	Melbrne
Sydney	SDY	6	Syd+CW	Goldfields	MEL	14	Melbrne
Sydney	STH	6	Syd+CW	Mornington Pen	MEL	14	Melbrne
Sydney	KSA	6	Syd+CW	High Country	ALB	11	CTA-ABY
Sydney	GFD	6	Syd+CW	-		-	-

9.13.2 VHST Demand

The largest market is between the Central Coast and Sydney with 5 million trips. The second largest market is Sydney to Melbourne with 4.3 million trips with the third forecast to be Sydney-ACT with 3.1 million trips. Other large flows are Brisbane-Sydney with 1.9 million trips, North NSW Coast (north of Newcastle to Gold Coast) and Sydney with 2.1 million trips and Gold Coast-Sydney with 1.4 million trips. Melbourne-ACT is estimated at 0.9 million trips with Melbourne-Shepparton & Seymour combined estimated to be 0.1 million less at 0.8 million trips

Table 9.12: Zone Pair VHST Demand - 2021 Single Trips 000s
350 km/h Brisbane-Melbourne via Coast, Hornsby, Bowral and Inland

#	Zone	2	3	4	5	6	7	8	9	10	11	12	13	14	Total
1	Brisbane	705	126	567	724	2,031	70	25	291	340	243	38	95	831	6,087
2	GoldCoast		8	401	171	1,448	106	5	446	4	206	14	35	643	3,488
3	BRI-Inland		1	58	6	189	62	1	185	21	10	22	12	222	732
4	N-Coast			417	642	2,080	123	49	178	2	72	14	20	1,046	4,700
5	C.Coast				274	4,298	23	13	213	1	49	25	17	389	5,302
6	Syd&CW					-	-	327	3,184	15	781	57	300	4,622	9,285
7	S.Coast						-	-	-	-	2	-	-	1	3
8	C.High							5	155	-	82	1	3	66	313
9	ACT								-	-	165	7	22	905	1,100
10	Snowy									-	-	-		1	1
11	YassAlbury										24	-	1	519	544
12	Lake/Gipps											-	-	-	-
13	Shep-Sey												112	727	839
14	Melbourne													-	-
	Total	705	193	1,384	1,818	10,047	384	425	4,653	383	1,634	180	617	9,972	32,393

9.13.3 Air Share

VHST diverts 42% of the direct air market (ie excluding air transfers) achieving a dominance of the shorter distance and regional markets such as Sydney-ACT, ACT-Melbourne and Sydney-NSW Coast. However, air is forecast to remain dominant on the long distance denser market pairs. On Brisbane-Melbourne, VHST achieves an 11% share. On the Gold Coast-Melbourne route VHST diversion rises to 28%. For Brisbane-Sydney and Sydney-Melbourne, VHST diverts a third of the air market.

Table 9.13: VHST – Air Diversion to VHST - 2021
350 km/h VHST Brisbane-Melbourne via Coast, Hornsby, Bowral and Inland
excludes air transfers

#	Zone	3	4	5	6	7	8	9	10	11	12	13	14	All
1	Brisbane	26	7	89	33	12	39	47	75	59	8	46	13	29
2	GoldCoast	94	2	93	57	32	-	99	-	98	15	74	29	50
3	BRI-Inland	-	-	-	24	27	-	53	32	-	44	-	30	33
4	N-Coast	94	19	97	82	60	90	93	-	96	-	-	88	77
5	C.Coast		-	-	2	-	-	80	-	78	65	-	56	73
6	Syd&CW			-	-	-	-	71	2	67	11	99	35	42
7	S.Coast				-		-	-	-	-	-	-	-	20
8	C.High					-	-	-	-	88	18	-	82	78
9	ACT						-	-	-	-	-	-	60	68
10	Snowy							-	-	-	-	-	-	59
11	Yass/Albury								-	-	-	-	35	65
12	Lake/Gipps									-	-	-	-	14
13	Shep-Sey										-	-	-	74
14	Melbourne											-	-	34
	Overall	33	77	73	42	20	78	68	59	65	14	74	34	42

For Sydney-ACT, and Melbourne-ACT, VHST share reaches 72% and 59% respectively. It should be noted however, that only the 'first round' effect has been modelled. In the short term, air could react by reducing airfares to retain market share. In the long term, air frequency might be reduced to retain profitability on routes where abstraction is high further erode air's market position. The VHST is forecast to attract the majority of trips made between capital and non-capital flows. For example, on Sydney- NSW Coast flows (eg Port Macquarie), VHST attracts 84% of air passengers. This reflects a lower air service level served by smaller, less frequent turbo-prop aircraft rather than jet aircraft. Market growth over time could however see improvements in air service on that offered in 2001 that could suggest some overestimation in 'first round' diversion.

9.13.4 Overall Diversion to VHST

VHST is forecast to divert 10% of the base inscope market in 2021 (ie excluding induced demand and long run commuting effects). Diversion increases with distance excepting capital flows such as Brisbane-Melbourne where the superior air travel times retain air's dominant position and reduces VHST diversion to under 20%.

Table 9.14: Overall Diversion to VHST - 2021 - 350 km/h VHST
Brisbane-Melbourne via Coast, Hornsby, Bowral and Inland
Excludes Induced Demand and Long Run Effects %

#	Zone	2	3	4	5	6	7	8	9	10	11	12	13	14	All
1	Brisbane	1	1	9	60	23	16	30	36	73	41	13	48	15	7
2	GoldCoast	-	19	15	33	35	26	31	99	26	97	20	76	30	6
3	BRI-Inland		-	20	-	4	8	2	37	15	5	29	26	27	4
4	N-Coast			13	22	28	16	53	49	8	39	21	40	82	21
5	C.Coast				4	6	1	4	32	1	11	23	22	44	7
6	Syd&CW					-	-	13	26	1	21	11	69	30	11
7	S.Coast						-	-	-	-	1	-	1	-	1
8	C.High							2	13	-	16	6	25	28	13
9	ACT								-	-	14	8	21	42	26
10	Snowy									-	-	-	-	-	7
11	YassAlbury										5	-	30	5	12
12	Lake/Gipps											-	-	-	1
13	Shep-Sey												19	14	20
14	Melbourne													-	18
	Overall	6	4	21	7	11	1	13	26	7	12	1	20	18	10

On Sydney-Melbourne, VHST diverts 29% of the market, 7% points more than Brisbane-Sydney with 22%. On Sydney-ACT, VHST diverts 26% of the market with most non-business travellers continuing to drive. VHST achieves a higher share of 41% on ACT-Melbourne due to a higher base air share and lower car share that tends to favour VHST. VHST obtains a high share of trips to the Gold Coast capturing nearly the entire ACT market. Amongst non-capital flows, VHST share ranges from 16% north of Newcastle and the Central Coast to 41% for areas north of Newcastle and Shepparton / Seymour. The lack of a direct inland VHST service north of Newcastle suppresses VHST penetration. Similarly south of Canberra, the coastal shares are low due to the inland VHST route.



9.14 Line Loadings and Station Usage

9.14.1 Introduction

Southbound line loadings and station usage for 2011, 2021 and 2051 were produced using 350 km/h VHST as an example. The average annual daily (÷365) number of VHST boardings (ons) and alightings (offs) by station are presented with the passenger load departing each station[30]. It should be noted that the figures relate to the southbound direction only. The northbound direction has been assumed to be a mirror image.

The three routes were:

- IHBI: Brisbane-Newcastle Inland; Newcastle-Sydney via Hornsby; Sydney-Canberra via Central Highlands (Bowral) and Canberra-Melbourne Inland.
- CFWC: Brisbane-Newcastle Coastal; Newcastle-Sydney via Frenchs Forest; Sydney- Canberra via Wollongong and Canberra-Melbourne Coastal.
- CHBI: Brisbane-Newcastle Coastal; Newcastle-Sydney via Hornsby; Sydney-Canberra via Bowral and Canberra-Melbourne Inland.

The evaluation assumes VHST services commence in 2011 and that Countrylink services continue operation. The forecasts also assume that the maximum revenue fare structures are adopted and that ramp-up reduces 2011 demand.

9.14.2 Summary

For the southbound inland route, Brisbane has the highest boardings (ons) and Melbourne the highest alightings (offs). In 2011, Brisbane average daily ons are forecast at 3,620. Ons more than double to 7,760 in 2021 then increase by 2.3 times to reach 18,150 in 2051. Alightings at Melbourne are forecast at 5,920 in 2011 rising to 11,700 in 2021 and 21,580 in 2051. The maximum daily load is forecast to be between Glenfield and Bowral in 2011 and 2011 with loads of 9,000 and 18,770. In 2051, the maximum passenger load is forecast to be between Strathfield and Sydney with 38,300.

Table 9.15: Line Loadings and Station Usage Summary
Average Annual Daily Figures (/365)

		IHBI		CFWC		CHBI	
Year	Statistic	Total	Station	Total	Station	Total	Station
2011	Max Ons	3,620	BNE	5,320	SDY	3,910	BNE
	Max Offs	5,920	MEL	5,760	MEL	6,540	MEL
	Max Load	9,000	GFD	12,150	STH	10,740	GOS
	Total Ons	17,540	-	24,560	-	21,840	-
2021	Max Ons	7,760	BNE	10,550	SDY	8,210	BNE
	Max Offs	11,700	MEL	11,510	MEL	13,130	MEL
	Max Load	18,770	GFD	25,030	STH	22,200	GOS
	Total Ons	36,020	-	49,730	-	44,370	-
2051	Max Ons	18,150	BNE	19,910	SDY	19,100	BNE
	Max Offs	21,580	MEL	23,430	SDY	24,700	MEL
	Max Load	38,300	STR	54,270	GOS	50,050	GOS
	Total Ons	74,310	-	103,080	-	90,530	-

Note: figures rounded to nearest ten
Maximum load departing station

For the coastal route, the highest ons are at Sydney Central, which reflects high commuting from Wollongong. The highest offs are at Melbourne until 2051 when Sydney Central becomes highest in both ons and offs. In 2011, Sydney boardings are forecast at 5,320 rising to 10,500 in 2021 and 19,910 in 2051. Melbourne offs are forecast at 5,760 in 2011, 3% less than the inland route. Melbourne offs are forecast to increase to 11,510 in 2021. In 2051, the highest offs are forecast at Sydney 23,430. The maximum passenger load

With a coastal, Hornsby, Bowral and inland route, the highest ons are forecast at Brisbane and the highest offs at Melbourne. In 2011, Brisbane ons are forecast at 3,910, 8% higher than the inland throughout route. Brisbane ons increase to 8,210 in 2021 and 24,700 in 2051. Melbourne offs are forecast at 6,540 in 2011, 10% higher than the inland throughout route and 14% higher than the coastal throughout route. Melbourne ons double to 13,130 in 2021 and 24,700 in 2051. The maximum load is forecast to be between Gosford and Hornsby. In 2011, the maximum load is forecast at 21,840 reaching 44,370 in 2021 and 90,530 in 2051.

Comparing the three routes, the highest number of trips (total ons) is with the coastal throughout route largely due to the impact of Gold Coast, Wollongong and Traralgon commuting. In 2021, total ons are 38% higher than an inland throughout route. The maximum load is also highest with a coastal throughout route. Compared to an inland throughout route, maximum load is one third higher than an inland throughout route. For al three routes, the maximum load is forecast to be either entering or leaving Sydney.

[30] Note load relates to all trains: express and all stops.

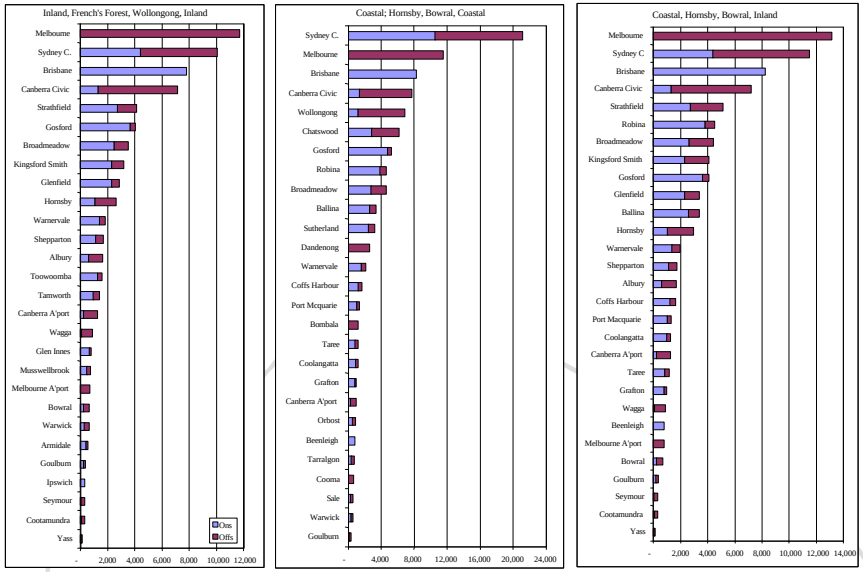
Central Brisbane, Melbourne and Sydney stations have the highest ons and offs. Parkway stations reduce the number using Sydney Central more than Brisbane and Melbourne. Both Brisbane and Melbourne are terminal VHST stations and as such have parkways on only one side. However in terms of station throughput (ons+offs) Sydney, is forecast to be the largest VHST station.

Southbound Station Throughputs

At 11,700 (23,400 both directions) in 2021, Melbourne is forecast to have the highest station southbound throughout (ons + offs) for the inland route. Sydney Central is second with just over 10,000 and Brisbane third with 7,800. Canberra Civic (city centre station) is fourth with 7,100. There is then a gap to Strathfield at 4,100, Gosford 3,990 and Broadmeadow (Newcastle) 3,480. Kingsford Smith is forecast to be the busiest airport station with 3,170. Glenfield and Hornsby Parkways have throughputs of 2,840 and 2,590 respectively. Warnervale/Wyong has a throughput of 1,780. Shepparton and Albury have throughputs of 1,780 and 1,650 respectively. The highest 'northern inland station' is Toowoomba with 1,560 followed by Tamworth with 1,390. Canberra Airport is forecast to be the second largest airport station with 1,220. Melbourne Airport throughput is forecast to be roughly half that of Canberra Airport at 650. Twelve of the 28 stations on the inland route are forecast to have a southbound throughput of under 1,000. The largest of these is Wagga with 860 then Glen Innes with 740. The lowest is Yass with 112 and Cootamundra with 290.

Sydney Central is forecast to have by fare the highest throughput with a coastal throughout route reaching 21,080 in 2021. Melbourne throughput is forecast to be around half that of Sydney Central at 11,510 (although 11% higher than the inland route). Sydney Central throughput is bolstered by Illawarra and south-coast commuting reflected in a throughput of 6,850 for Wollongong, the fifth largest station. Brisbane is forecast to be the third largest stations with 8,220, 6% higher than the inland throughout route. Canberra Civic remains fourth with 7,670, 8% higher than the inland throughout route. Chatswood Parkway is forecast to be sixth largest with a Frenchs Forest route with 6,110, one thousand more than Gosford with 5,190 with increases in throughout by 30% on the inland throughout route. Robina serving the Gold Coast with 4,570 is forecast to be 56% as large as Brisbane. Broadmeadow throughput is forecast to increase by just over 1,000 (30%) to reach 4,570 with a coastal route. Ballina serving Lismore, Casino and Byron Bay is forecast to be the largest of the north NSW coastal stations with 3,340. Sutherland Parkway serving southern Sydney is forecast to have a throughput 3,140, 11% higher than Glenfield Parkway with an inland throughout route. Dandenong Parkway is forecast to have a throughput of 2,590, one fifth that of Melbourne. Warnervale/Wyong is forecast to be the median station with a throughput of 2,120, 20% higher than with an inland throughout route via Hornsby and Bowral. Five stations are forecast to have a southbound throughput between 1,000 and 2,000: Coffs Harbour, Port Macquarie, Bombala (serving the south coast), Taree and Coolangatta. Five stations have throughputs between 600 and 1,000: Grafton, Canberra Airport, Beenleigh and Tarralgon. Cooma, Sale and Warwick and Goulburn are forecast to have the lowest throughputs of between 300 and 580 for southbound trains per day.

Figure 9.44: Average Daily Station Usage by Route – 2021
350 km/h VHST - Coastal, Hornsby, Bowral, Inland



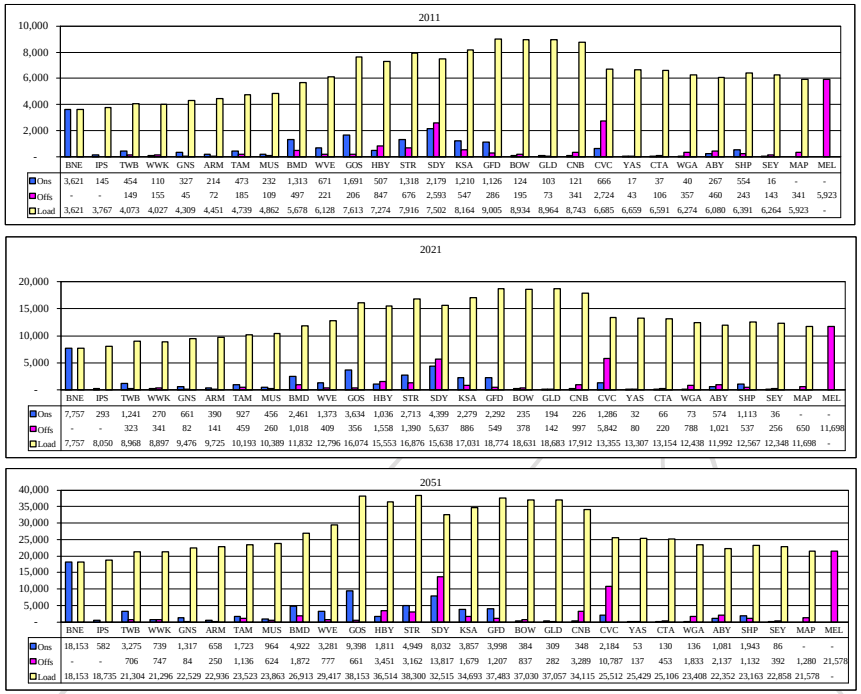
For the coastal, Hornsby, Bowral, Inland route, Melbourne regains the position of having the highest throughput of any single station. For 2021, a throughput of 13,130 is forecast, higher than for either the inland or coastal throughout routes. Sydney Central is second highest with 11,490, then Brisbane with 8,210 with Canberra Civic fourth with 7,120. For Brisbane, throughput is the forecast to be the same as the coastal throughput route and 6% higher than an inland throughout route whereas Canberra is forecast to be 6% lower than a coastal throughout route and roughly the same as an inland throughout route. Basically, in the north, a coastal route produces higher Brisbane usage and in the south an inland route produces a higher Canberra usage. Strathfield serving western Sydney is forecast to be the fifth largest station with 5,120 and Robina is forecast to be the sixth largest with 4,500. Broadmeadow, is forecast to have a station throughput of 4,390, 26% higher than an inland throughout corridor but 4% less than a coastal throughout corridor connected to Sydney via a new Frenchs Forest route.

Kingsford Smith is forecast to be the largest airport station with 4,090, Gosford ninth with 4,100 and Glenfield tenth with 3,360. Ballina is forecast to be the largest station on the north NSW coast with 3,350. Hornsby is forecast to have a throughput of just under 3,000. There is then a gap of 1,000 down to eight stations which have throughputs between 1,000 and 2,000:Warnervale, Shepparton, Albury, Coffs Harbour, Port Macquarie, Coolangatta, Canberra Airport and Taree. Five stations are forecast to have throughputs between 500 and 1,000: Grafton, Wagga, Beenleigh, Melbourne Airport and Bowral. Four stations are forecast to have southbound throughputs of under 500: Goulburn, Seymour, Cootamundra and Yass.

Projected Growth in Station and Train Passenger Loadings

Station throughput is forecast to double between 2011 and 2021 due to ramp up and market growth. Between 2021 and 2051, demand is forecast to double again. For the inland route in 2011, train loadings are forecast to be 4,000 between Brisbane and Newcastle with 85% boarding at Brisbane.

Figure 9.45: Average Daily Station Usage & Line Loading
Inland Route - 350 km/h VHST - Inland, Hornsby, Bowral, Inland

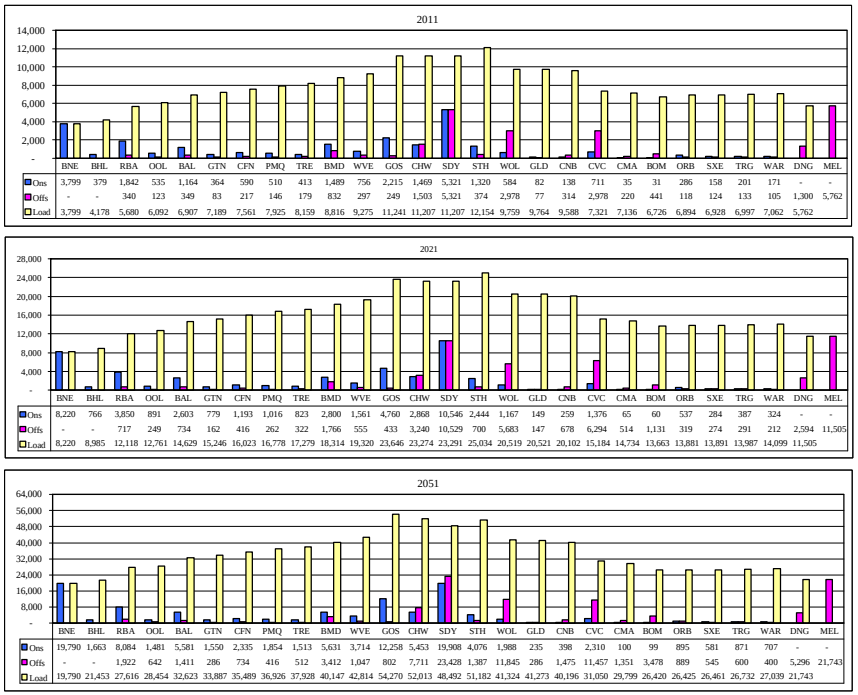


Between Brisbane and Muswellbrook, 715 passengers (13%) alight of a total of 5,576 who board. Train loadings build up after departing Broadmeadow (Newcastle) with the boarding of commuters at Broadmeadow, Warnervale/Wyong and Gosford. Train Loading reaches 7,600 departing Gosford. Loadings then reduce as Hornsby offs exceed ons. At Sydney Central 20% more board than alight (2,180 offs and 2,590 ons). Train Loading then increase to reach the route maximum of 9,000 departing Glenfield. Load is then constant with few boardings and alightings at the Central Highlands stations of Bowral/Mittagong and Goulburn. At Canberra Airport, offs exceed ons by nearly 3:1 and by 4:1 at Canberra Civic. Train loads are then roughly constant at 6,600 to Melbourne. The highest number of boardings south of Canberra is at Shepparton with 554. The highest offs (excepting Melbourne) is at Albury with 460. The loading is forecast to be similar in profile in 2021 and 2051 except for stronger growth in the NSW central coast area.

For the coastal throughout route in 2011, southbound train loadings gradually build up out of Brisbane reaching 5,680 departing Coolangatta, 7,560 at Coffs Harbour

and 8,160 departing Taree. For all stations ons exceed offs suggesting a stronger pull south towards Sydney than north towards Brisbane on the southeast Queensland and north NSW coast. The ratio of boardings to alightings at Broadmeadow is 1:1.8 (830 and 1,490 respectively). The ratio then increases to 2.5:1 at Warnervale/Wyong and 8.9:1 at Gosford. As a result train load reaches 11,240 departing Gosford to travel along the new Frenchs Forest route. At Chatswood and Sydney ons and offs balance at 1,500 and 5,300 respectively.

Figure 9.46: Average Daily Station Usage & Line Loading Coastal Route
350 km/h VHST - Coastal, Frenchs Forest, Wollongong, Coastal

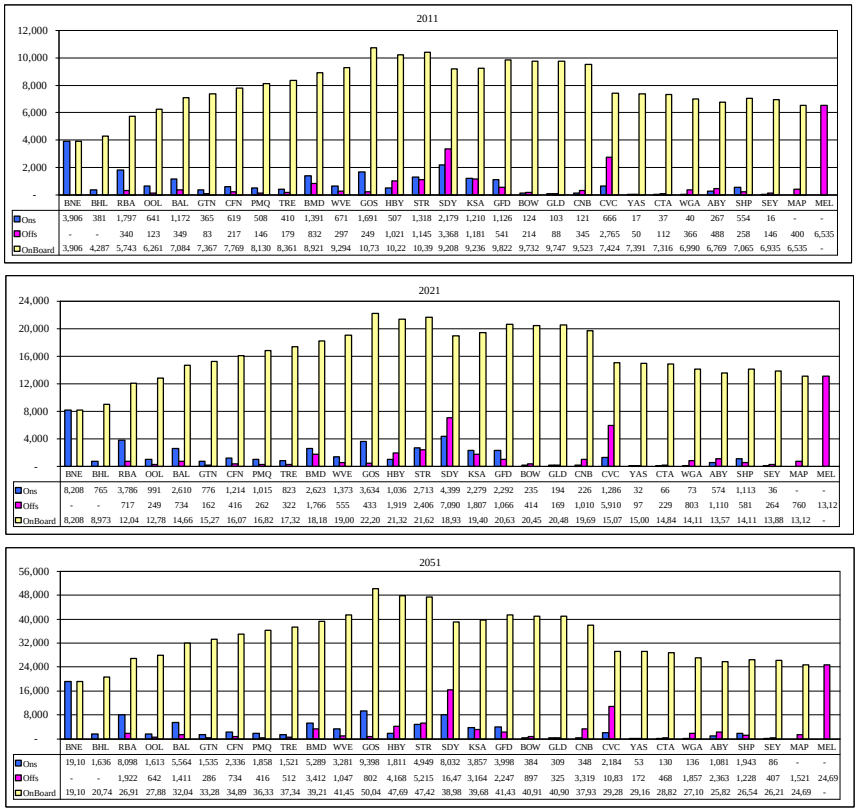


With an route via the Illawarra, loads reach a maximum departing Sutherland but decline at Wollongong with the alighting of 3,000 and boarding of 580 passengers. Passenger load is then flat until Canberra at 9,800. At Canberra, a total of 3,300 get off at the Airport and Civic stations combined with 850 getting on. Load is then flat at 7,000 until Dandenong when 1,300 get off. On the southern section, the highest number of ons is at Orbost with 290 with the highest number of alightings at Bombala with 440 (excluding Dandenong and Melbourne). The passenger load arriving Melbourne is forecast at just under 5,800. As with the inland route, the corridor profile in 2021 and 2051 is similar to 2011 apart from stronger growth in the central coast raising which results in Gosford- Chatswood becoming the highest loaded section in 2051.

For the coastal/inland route via Hornsby and Bowral, northern section loads in 2011 are similar to the coastal 'throughout' profile until Newcastle. Train loadings gradually build up out of Brisbane reaching 6,260 departing Coolangatta, 7,770 at Coffs Harbour and 8,360 departing Taree (3% higher than the coastal throughout route). For all stations ons exceed offs. The ratio of boardings to alightings at Broadmeadow is the slightly lower than for the coastal throughout route at 1:1.7 due to fewer ons (1,390) (offs are the same). Boardings are greater than alightings at Warnervale/Wyong and especially Gosford (1,690 compared to 250). As a result, passenger loads reach a corridor maximum of 10,700 departing Gosford. At Hornsby, offs exceed ons by two to one producing a decline in loadings. At Strathfield, the pattern is reversed with ons exceeding offs by 15%. At Sydney Central, 50% more alight than board (3,370 compared to 2,180).



Figure 9.47: Average Daily Station Usage & Line Loading
Coastal & Inland Route -50 km/h VHST - Coastal, Hornsby, Bowral, Inland



Loadings build up after departing Sydney to reach 9,800 departing Glenfield. Loads then remain flat until Canberra with few boarding or alighting at Central Highlands stations. At Canberra Airport, 350 alight and 120 board. At Canberra Civic, 2,770 get off and 670 get on. Loads fall on the southern sector averaging 7,400 until Melbourne. Within the southern sector, the highest boardings are at Shepparton at 550 and the highest alightings at Albury with 490. Arriving Melbourne the passenger loading is 6,500.

Figure 9.48: Line Loading - Inland, Hornsby, Bowral, Inland
Average Annual Daily Loading 2021 – 350 km/h VHST

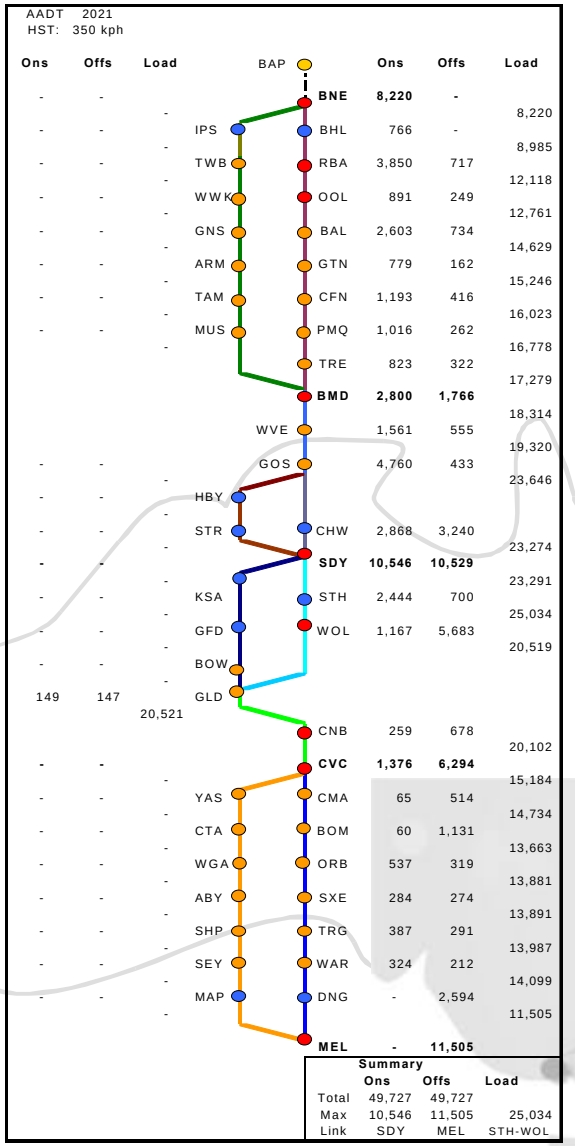


Figure 9.49: Line Loading and Station Usage
Inland, Hornsby, Bowral, Inland
Average Annual Daily Loading 2021 – 350 km/h VHST

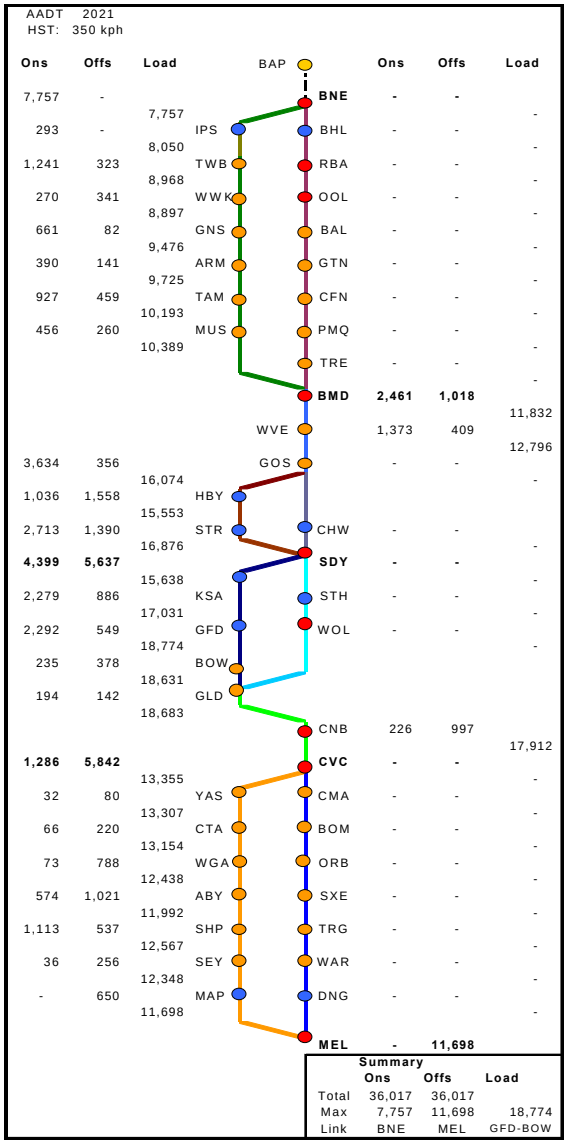
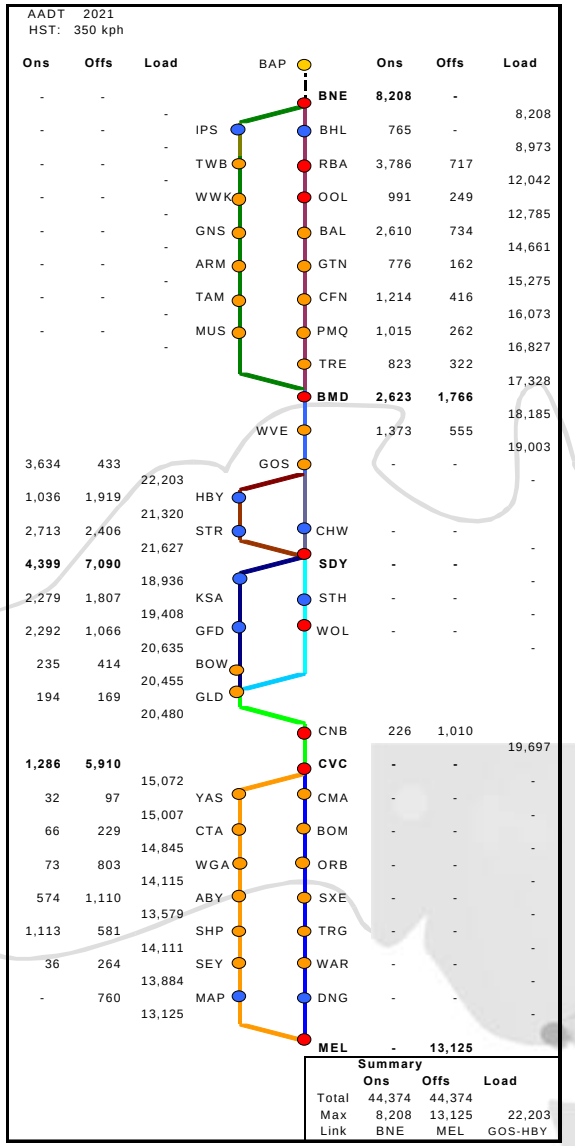


Figure 9.50: Line Loading and Station Usage
Coastal, Hornsby, Bowral, Inland
Average Annual Daily Loading 2021 – 350 km/h VHST



9.15 Sensitivity Tests

9.15.1 Introduction

Sensitivity tests were undertaken on selected variables and parameters. These tests are in addition to the variations in demand resulting from route and sector, VHST technology and population and employment scenario.

Twenty-six sensitivity tests were undertaken as described in Table 9.16.

Table 9.16: Sensitivity Test Description

#	Test	Description
1	No Countrylink	Countrylink and other long distance rail services are discontinued with VHST
2	Passengers Change Sydney	The central forecasts assume that a through service is provided allowing passengers to stay on the same VHST. The test enforces a transfer at Sydney Central.
3	High Induced Demand	Induced demand factor plus 10% points to result in factors of 40% non-business; 25% business and 10% metro (compared to 30%, 15% and 1%)
4	No Induced Demand	No induced demand
5	No Air Transfers Divert	No air transfer trips assumed to divert to VHST
6	High Long Run Commuting Effect	Maximum factor of 2 times diverted and induced for capital flows with 10 years to full effect and a fast take-up profile compared to a factor of 1.4 and 20 years with a medium take-up profile
7	No Long Run Commuting	No long run commuting effect included
8	+20% Int Vis. Growth	Additional 20% annual growth in international visitors per year
9	-20% Int. Vis. Growth	Reduction of 20% in annual growth in international visitors per year
10	No Int. Vis. Included	Exclusion of international visitors from VHST forecast
11	High Income Growth	2% real average income growth instead of 1.75%
12	Low Income Growth	1.25% real average income growth instead of 1.25%
13	High Income Demand Response	High total market response to real average incomes with elasticity of 1.4 instead of 0.8 for business and 1 for non-business
14	Low Income Demand Response	Low total market response to real average incomes with elasticity of 0.6 instead of 0.8 for business and 1 for non-business
15	Large Party Size	Large average group size of 1.5 for business and 2.25 for non-business instead of 1.2 and 1.75.
	Small Party Size	Small average group size of 1 for business and 1.4 for non-business instead of 1.2 and 1.75.
17	High Airfares	Business surcharge of 160% on Oct 2001 21 day advance economy fare instead of 130% and a non-business surcharge of 125% instead of 90%.
18	Low Airfares	Business surcharge of 100% on Oct 2001 21 day advance economy fare instead of 130% and a non-business surcharge of 75% instead of 90%.
19	High Car Cost	Double the car cost per km to 26c per car km from 13c
20	Low Car Cost	Half the car cost per km to 7.5c per car km from 13c
21	High Value of Time	25% higher base year values of time shown in Table 3.5
22	Low Value of Time	25% lower base year values of time shown in Table 3.5
23	High Mode Share Response	25% higher mode share sensitivity parameters
24	Low Mode Share Response	25% lower mode share sensitivity parameters
25	High VHST Frequency	32 (half hourly) Southbound departures per day instead of 16 (hourly).
26	Low VHST Frequency	Eight (two hourly) southbound departures per day instead of 16 (hourly).

9.15.2 Results

The forecasts are most sensitive to air fares with high airfares, VHST demand increases by 30%, passenger km by 49%, revenue by 46% and user benefit by 57%. With low airfares, VHST demand is reduced by 15%, passenger km and revenue by 23% and user benefit by 27%.

Demand is also forecast to be sensitive to whether a direct service is provided through Sydney. If passengers have to change trains at Sydney Central, demand is forecast to decline by 12%, revenue by 16% and user benefit by 23%.

VHST demand is also sensitive to income growth. With a higher growth in average real income (+14%), VHST demand increases by 10% and declines by 15% with a reduction of 30%. The impact on user benefit is roughly 1.75 times that on demand and revenue because of the impact of income on values of time. With higher income, time savings are valued more highly in dollar terms and correspondingly lower with lower income.

Similarly increasing the demand response to income by 40% for non-business and 75% for business travel produces a demand increase of 10% whilst a similar percentage reduction in response reduces demand by 15%.

Increasing the value of time has a different impact on demand and revenue from that on user benefit. With 25% higher values of time, demand declines by 4% as fewer air passengers are forecast to divert compensating for any increase in diversion from ground public transport and car. Passenger Km and revenue decline by 11% reflecting the reduction in air diversion at longer distances. However, user benefit increases by 7% reflecting the increased value of time savings. Lowering the values of time by 25% increases demand by 6% and revenue by 19% as air passengers are forecast to be more willing to accept the longer VHST travel time to achieve the fare reductions and access/egress savings. User benefit however declines by 7% reflecting the reduced valuation of travel time savings.

Discontinuing Countrylink and other long distance services increases VHST demand by 15%, VHST passenger km by 2% and revenue by 4% but leaves user benefit unaffected. The larger impact on trips than on revenue results from the low average Countrylink revenue yield with high numbers obtaining concessions. The neutral impact on VHST user benefit results from the diverting rail users deriving no excess benefit from VHST over and above the fare paid.

The increase in induced demand by one third for non-business travel and by two thirds for business travel and the inclusion of 10% for metro non-business travel results in a 7% increase in VHST demand. Removing all induced demand reduces VHST demand by 16%.

A high long run commuting effect increases demand by 15% but increases revenue and user benefit by 5% as a result of the impact being confined to shorter distance non-business trips that pay a lower average fare. Excluding the long run effect reduces trips by 4% and revenue by 1.3%.

High international growth increases demand by 2% with low growth reducing trips by 2%. Excluding international visitors altogether reduces demand and revenue by 14%. This test implies that one in seven VHST trips in 2021 are likely to be made by international visitors to Australia.

The variation in group size makes little impact on VHST demand. A large group size reduces VHST demand by 1%; a lower group size by 1% reflecting the impact on diversion from car.

Similarly VHST demand is not forecast to be significantly affected by car costs increasing by 1% with a doubling in car costs and declining by 1% with a halving in car costs.

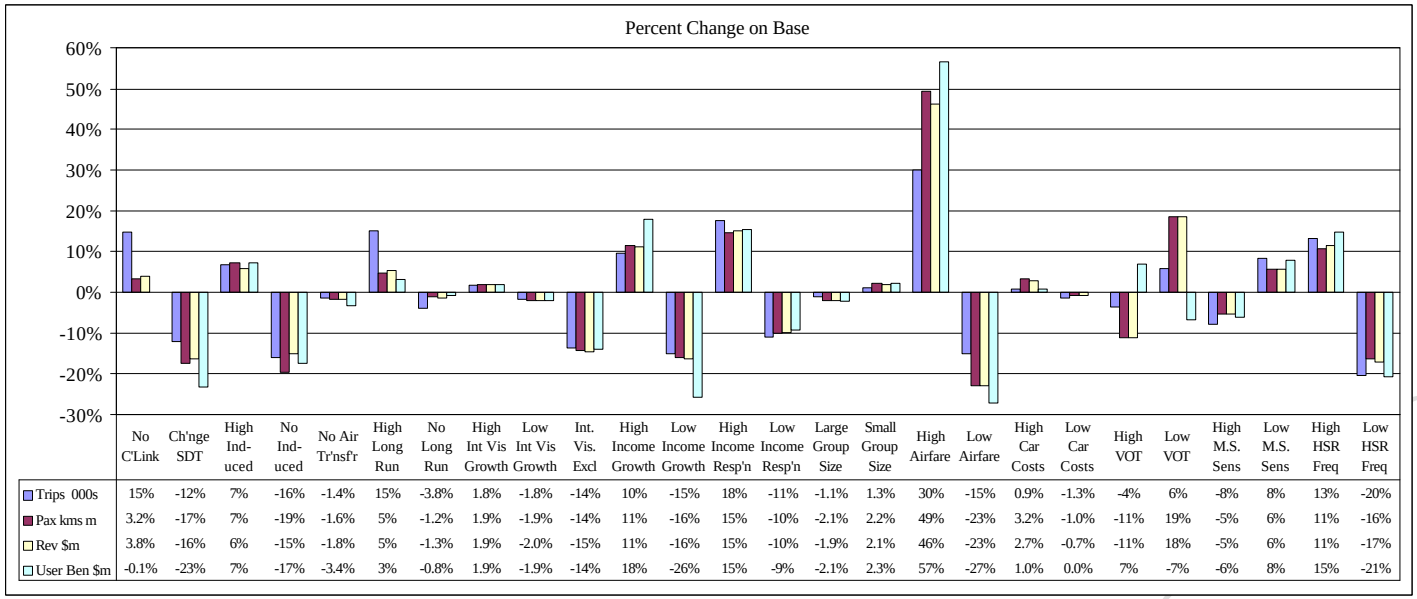
With a 25% increase in the sensitivity of mode share (diversion) to relative service level of VHST compared to the existing modes, VHST demand is forecast to decline by 8%. A reduction of 25% produces an 8% increase.

VHST demand is forecast to be moderately sensitive to VHST frequency. Doubling frequency from an hourly to half hourly service increases demand by 13% (a frequency elasticity of 0.13), revenue by 11% and user benefit by 15%. Halving frequency reduces demand by 20% (elasticity of 0.4). The impact of frequency is therefore asymmetrical. Reduction cost in revenue than increases in frequency gain in revenue.



Figure 9.51: Sensitivity Tests

350kph Coastal, Hornsby, Bowral, Inland Route 2021



Sensitivity Test	Trips 000s	Pax kms million	Revenue $m	User Benefit $m	Sensitivity Test	Trips 000s	Pax kms million	Revenue $m	User Benefit $m
1. No CountryLink	37,244	23,348	3,043	4,939	15. Large Party Size 1.5B: 2.25NB	32,035	22,149	2,874	4,840
2. Passenger Change Sydney	28,471	18,701	2,453	3,798	16. Small Party Size 1B; 1.4NB	32,800	23,109	2,992	5,060
3. High Induced Demand	34,569	24,287	3,107	5,302	17. Higher Airfares 160%B; 125%NB	42,074	33,766	4,284	7,739
4. No Induced Demand	27,203	18,209	2,491	4,083	18. Lower Airfares 100%B;75%NB	27,511	17,427	2,257	3,601
5. No Air Transfer Trips Divert	31,939	22,248	2,879	4,776	19. High Car Cost x 2	32,685	23,348	3,011	4,992
6. High Long Run Commuting	37,300	23,683	3,085	5,101	20. Low Car Cost x 0.5	31,961	22,397	2,910	4,946
7. No Long Run Commuting	31,166	22,349	2,892	4,905	21. High VOT + 25%	31,228	20,054	2,603	5,287
8.+20% Int. Visitors Growth	32,983	23,050	2,988	5,037	22. Low VOT -25%	34,319	26,832	3,471	4,616
9. -20% Int. Visitors Growth	31,803	22,181	2,873	4,852	23. High Mode Share Response x 1.25	29,892	21,416	2,776	4,644
10. No Int. Visitors Included	27,988	19,377	2,501	4,252	24. Low Mode Share Response x 0.75	35,095	23,913	3,096	5,329
11. High Real Av Income Growth	35,499	25,198	3,259	5,837	25. High HSR Frequency 32/Deps South	36,698	25,038	3,264	5,683
12. Low Real Av Income Growth	27,507	18,996	2,453	3,664	26. Low HSR Frequency 8/Deps South	25,808	18,937	2,427	3,919
13. High Income Demand Response	38,150	25,931	3,377	5,704					
14. Low Income Demand Response	28,826	20,326	2,643	4,483	Central Case Scenario	32,393	22,616	2,931	4,944

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9.16 Accuracy of Forecast Projection

9.16.1 Central, Low and High Demand Scenarios

Central, high and low revenue projections were developed using 350 km/h VHST an example for three corridor sectors Brisbane-Sydney, Sydney-Melbourne and Brisbane-Melbourne. The range in forecast was used in the financial and economic evaluations.

The VHST route used as an example was Brisbane-Newcastle coastal, Brisbane-Sydney via Hornsby and the Main North, Sydney- via the Central Highlands and Canberra-Melbourne via the Inland route. Forecasts were developed for 2011 (with ramp up), 2014 (ramp up impact ended), 2021 and 2051.

Table 9.17: Central, Low and High Demand Scenarios

Component	Low	Central	High
Population & Employment	Trend Growth Population and Employment (Scenario A)	Trend Growth population and employment (Scenario A)	High Growth Population and Employment (scenario D)
Real Income Growth	Low Income Growth 2001-2021: 1.25% p.a. 2021-2031: 0.75% p.a. 2031-2051: 0.50% p.a.	Central Income Growth 2001-2021: 1.55% p.a. 2021-2031: 1.25% p.a. 2031-2051: 1.00% p.a.	High Income Growth 2001-2021: 2.00% p.a. 2021-2031: 1.50% p.a. 2031-2051: 1.25% p.a.
International Tourism Growth	Low Growth 1.7% average annual compound growth 2001-2051	Central Growth 2% average annual compound growth 2001-2051	High Growth 2.2% average annual compound growth 2001-2051
Airfare Discounts and Surcharges On Oct 2001 21 Day Economy	Low Airfares 100% business surcharge 75% non-business discount on 21 economy airfare	Central Airfares 130% business 90% non business on 21 Day Economy Airfare	High Airfares 130% business 100% non business on 21 Day Economy Airfare
VHST Frequency	Services every 1½ Hours (12 each way per day)	Hourly Services (16 each way per day)	Services every 1hr 40 mins (24 each way per day)

The central scenario assumed trend population and employment trends (scenario A); medium tourism growth; central average real income growth[31]; current airfares and hourly VHST services (16 per day in each direction).

The high projection assumed high population and employment growth (scenario D), high real income growth, high tourism grow, an increase in air business fare surcharges and lower non-business airfare discounts and 24 VHST southbound trains per day.

The low projection assumed central population and employment growth (scenario A), low real income growth, low tourism grow, lower business airfare surcharges and higher non-business discounts and 12 VHST southbound trains per day.

9.16.2 Notional Probabilities of Forecast Occurring

Notional probabilities were assigned to the forecast range to provide an indication of the likelihood of the forecast occurring. The range covers 90% of the forecast outcomes. There remains a 10% chance that the forecast could be outside the range.

Table 9.18: Notional Probability

Chance % of a demand outcome above that forecast

Estimate	Probability
High	5%
Average of High and Central	20%
Central + 10%	40%
Central	50%
Central – 10%	60%
Average of Central and Low	80%
Low	95%

9.16.3 Forecast Range

Uncertainty increases the further out the forecast year. The Sydney-Melbourne corridor has a narrower range than Brisbane-Sydney after 2031 reflecting a greater uncertainty in demographics north of Sydney in later forecast years.

For 2011 for the full corridor, the most likely forecast is 16 million trips. With the notional probabilities, forecast accuracy at the 90% confidence level is estimated at ±19%. The range is suggested to be ±3.1 million trips. The forecast could lie between 13 million and 19 million trips.

[31] All projections assume an increase in real airfares of 0.75% a year.

Table 9.19: Accuracy of Demand Forecast

	2011	2021	2031	2051
± CV %				
BRI-SYD	20%	25%	38%	51%
SYD-MEL	20%	24%	30%	37%
BRI-MEL	19%	24%	35%	47%
± CV million				
BRI-SYD	1.5	3.8	8.2	17.2
SYD-MEL	1.1	2.7	4.3	7.4
BRI-MEL	3.1	7.8	15.5	30.9
Mean Forecast million				
BRI-SYD	7.4	15.2	21.4	33.7
SYD-MEL	5.6	11.2	14.1	19.9
BRI-MEL	16	32.4	44	66

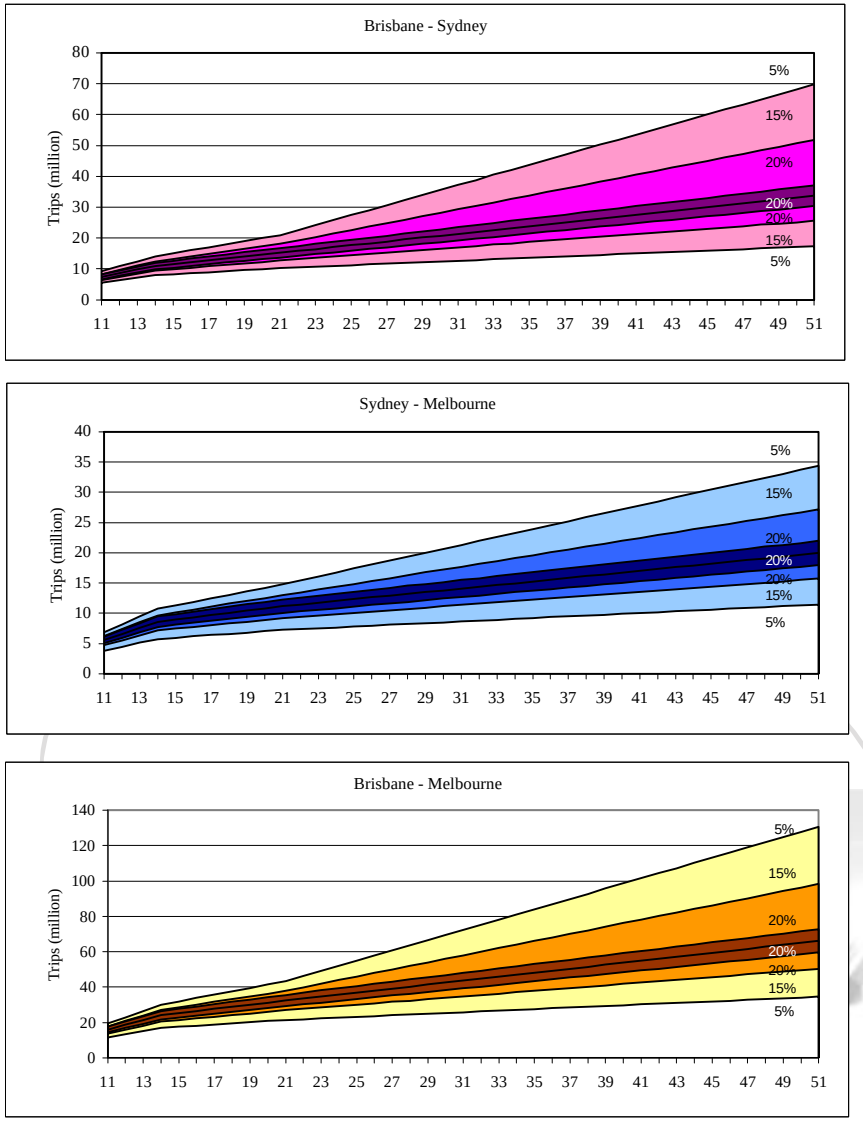
CV = Square error expressed as a ratio of the mean forecast.
Note the CV is assumed symmetrical – the forecasts suggest more upside than downside however.
PCIE Indicative forecasts.

For Brisbane Sydney, the 90% forecast range is from 6 million to 9 million trips in 2011, an accuracy of ±20%. For Sydney-Melbourne, the forecast range is 4.5 million to 7.8 million trips.

By 2021, the forecast range increases to ±25% for Brisbane-Sydney widening the forecast range to 11.4-19 million trips. For Sydney-Melbourne the range widens to 8.5-14 million trips whilst for Brisbane-Melbourne the demand range is from 24.6 million to 47.6 million trips.

By 2051, uncertainties in population, employment, real average incomes and tourism growth widen the forecast range for Brisbane-Sydney to ±51%. At ±37%, the range is suggested to be narrower for Sydney-Melbourne because of tighter population and employment projections. For the full corridor, the forecast range is estimated at ±47%. It should be noted however that forecast error in non-symmetrical. More upside opportunity is suggested than downside risk especially for Brisbane-Sydney.

Figure 9.52: Forecast Demand Range - Annual Trips Million



9.17 Service Level Comparison

9.17.1 Introduction

A comparison of the level of service potentially offered by VHST with that of existing travel modes was undertaken. The comparison was undertaken for fourteen example markets. The comparison was undertaken for 250 km/h VHST, 350 km/h and 500 km/h for the full corridor (Brisbane-Newcastle Coastal; Newcastle-Sydney via Hornsby; Sydney-Canberra via Bowral and Canberra-Melbourne Inland).

In the presentation, service level is described in terms of travel time, cost (primarily fare or car operating cost) and an overall measure of service level:- generalised time. Travel time is disaggregated into main mode time, access and egress time and a frequency time that measures the convenience of the timetable. Cost is presented on a per person single trip basis (½ return fare). Cost is split into main mode fare and 'other' mainly access and egress fares but also including any costs of overnight costs for car and takes account of party size for access costs and car operating costs.

Table 9.20: Example Markets

Code	Description	Code	Description
BRI-SYD	Brisbane CBD -Sydney CBD	SYD-ALB	Sydney CBD-Albury
ROB-HOR	Robina (Gold Coast)-Hornsby	ALB- MEL	Albury-Melbourne CBD
SYD-MEL	Sydney CBD-Melbourne CBD	BRI-NEW	Brisbane CBD-Newcastle CBD
GLF-MEL	Campbelltown-Melbourne CBD	BAL-NEW	Ballina-Newcastle CBD
SYD-ACT	Sydney CBD-Canberra CBD	PMQ-SYD	Port Macquarie-Sydney CBD
ACT-MEL	Canberra CBD-Melbourne CBD	BRI-MEL	Brisbane CBD-Melbourne CBD

9.17.2 Travel Time Comparison

Travel time components include:

- IVT: Invehicle Time: the scheduled time by the 'main' mode (eg VHST or air) and includes any transfer time.
- Access: Time spent accessing and egressing the main mode or any stop time for car.
- Frequency: A measure of the timetable convenience offered by the number of scheduled departures expressed in equivalent main mode time minutes.

For Brisbane-Sydney and Sydney-Melbourne city centre to city centre markets, VHST takes two thirds longer door to door than air. For Brisbane-Sydney, 500 km/h VHST takes 4.8hrs compared to 2.8hrs by air. For Sydney-Melbourne, 500 km/h VHST takes five hours compared to three hours. At 350 km/h, the VHST door to door time increases to 5.7hrs for Brisbane-Sydney and six hours for 350 km/h. At 250 km/h, the VHST time is 6.7hrs and 7hrs.

Incorporating the convenience of the timetable widens the travel time difference slightly by 12 mins on Brisbane-Sydney and by 18 mins on Sydney-Melbourne due to a more frequent air service level.

VHST offers significant travel time improvements on ground transport however for these two key markets. The car drive time including stops is estimated at 9.6hrs on Brisbane-Sydney and 9.2hrs on Sydney-Melbourne. The coach door to door time is estimated at 12.4hrs and 12hrs respectively with the existing rail time estimated at 14.1hrs and 11.8 hrs. The low existing rail frequency is estimated to add a further three hours to the travel time.

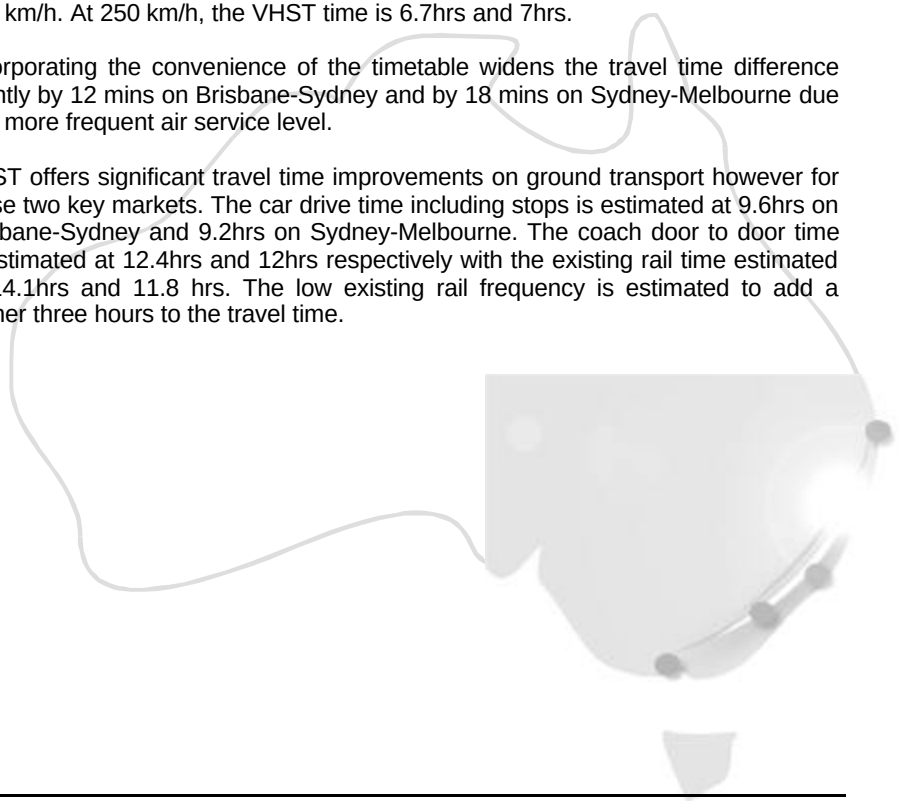
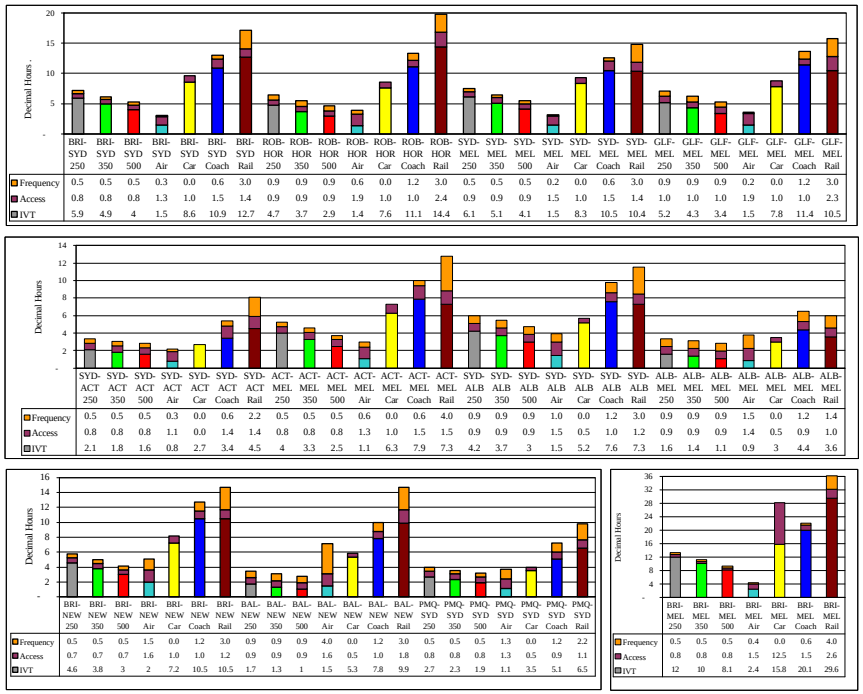


Figure 9.53: Travel Time Comparison



Parkway stations improve the service level of VHST relative to air by shortening the access time. Access and egress time for Robina (Gold Coast)-Hornsby is estimated to be one hour shorter than air. With Glenfield serving Campbelltown, the access time is 54 mins quicker than air.

VHST is competitive on Sydney-ACT and ACT-Melbourne. With 500 km/h, VHST can provide a station to station time of 1.6hrs compared to 0.8hrs by air. With 350 km/h, the VHST time increases to 1.8hrs and 2.1hrs with 250 km/h. A longer access and egress for air narrows the gap to half an hour for 500 km/h, about three quarters of an hour for 350 km/h and one hour for 250 km/h. A higher air frequency widens adds 12 mins to the VHST-air difference although this would narrow if air services were reduced with the introduction of VHST.

On ACT-Melbourne, VHST is slightly less competitive with air. Air time is estimated at 1.1hrs compared to 2.5hrs with 500 km/h VHST, 3.3hrs with 350 km/h VHST and 4hrs with 250 km/h VHST. Adding in access and egress narrows the difference but air retains a significant time advantage. Air door to door time increases to 2.4hrs compared to 3.3hrs with 500 km/h VHST, 4.1hrs with 350 km/h VHST and 4.8hrs with 250 km/h VHST. 500 km/h VHST is therefore just under one hour slower than air, with 350 km/h VHST 1¾ hours slower and 250 km/h VHST 2¾ hours slower. Again a higher frequency widens overall travel time difference in favour of air.

The door to door drive time is estimated at 2.7hrs on Sydney-ACT and 7.3hours on ACT-Melbourne including an hour stop time. On Sydney-ACT, 500 km/h VHST has a twenty minute advantage over car before inclusion of a half hour VHST service frequency that swings the advantage slightly in favour of car. On ACT-Melbourne, VHST has a definite travel time advantage over car. 500 km/h VHST at 3.3hrs is under half the 6.3hrs car drive time.

VHST provides a significant improvement on coach and rail times. The average coach time is estimated at slightly under 3½ hours on Sydney-ACT and just under eight hours on ACT-Melbourne. Existing rail times are 4½ hours and 7hours 20 mins.

For Sydney-Albury, the 500 km/h VHST station-station time at 3hrs is twice as long as air. Inclusion of access and frequency narrows the gap to 20% longer. On Albury-Melbourne, 500 km/h VHST has a one-hour advantage over air offering a total travel time of just under 3hours compared to 4hours for air. Both 350 km/h and 250 km/h are also quicker overall than air.

For Brisbane-Newcastle, at 5hours overall, 350 km/h VHST is comparable with air. 500 km/h VHST offers a time saving of just under one hour and 250 km/h takes 45 mins longer. Car travel time is estimated at twice that of 250 km/h VHST.

On Ballina-Newcastle, VHST has a definite travel time advantage over air, by providing a more frequent, direct and accessible service. Similarly, on Port Macquarie-Sydney, 500 km/h VHST although ¼ slower in terms of station-station time more than makes up the difference on air by being accessible and frequent. Overall, 500 km/h VHST is estimated to be just over half an hour faster than air. 350 km/h loses the advantage to be 50 minutes slower with 250 km/h VHST 1¼ hours slower.

Air is considerable quicker than VHST on Brisbane-Melbourne offering a total travel time of just over four hours. By comparison, 500 km/h VHST achieves an station-station time of just over eight hours and an overall travel time of 9.4hrs. 350 km/h VHST provides an overall travel time of 11.3hrs with 250 km/h achieving 13.3hrs. However, VHST provides a significant improvement on a car travel time of 28hrs (including overnight stop) and a coach time of over 22hrs and a rail time of 36 hours (including Sydney transfer time).

9.17.3 Travel Cost Comparison

Cost is presented on a 'per person single trip (½ return fare) fare basis'. Cost is split into main mode and 'other' costs. Other costs are mainly access and egress fares. For car any costs of overnight stays are included. VHST cost is the average fare paid by diverting passengers. In the model, different fare surcharges and discounts on the basic fare were applied to air, car, coach and rail markets. As a result, fares paid by air passengers were higher than the average shown. Fares paid by car, coach and rail users were lower. Fares are shown for 2001.

VHST fares increase with speed: 250 km/h fares are the lowest with 500 km/h the highest. Fares are also forecast to be higher for business than for non-business travel.

For Brisbane-Sydney, the average 350 km/h VHST business fare is $151, 40% higher than the non-business fare of $108. 500 km/h VHST fares are 12% higher with 250 km/h fares 12% lower than 350 km/h VHST fares. Access cost for city centre-city centre travel is forecast to be relatively small compared to VHST fares (2.5% for Brisbane-Sydney). The average 350 km/h VHST fare is forecast to be 60% that of the comparable air fare to maximise VHST revenue.

For Sydney-Melbourne, the 250 km/h VHST business fare is $143, the 350 km/h VHST fare is $161 and the 500 km/h fare is $179. Non-business fares are $105, $199 and $132 respectively. The 350 km/h business fare is set at 56% of the air business fare.

Figure 9.54: Business Travel Cost Comparison

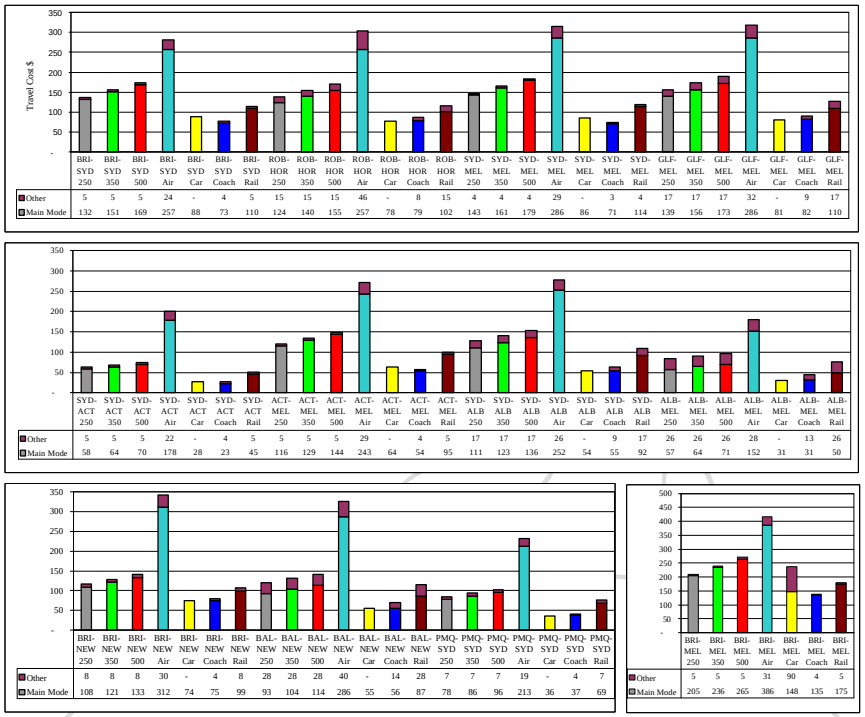
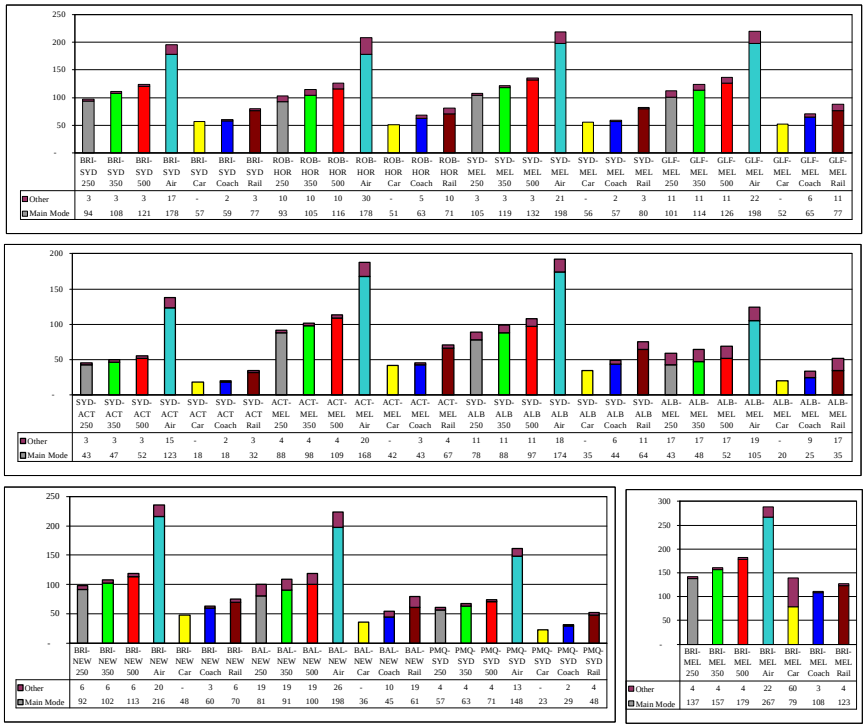


Figure 9.55: Non-Business Travel Cost Comparison



9.17.4 VHST Generalised Times

An overall measure of service level was estimated. The measure is referred to as 'generalised time'. Generalised time includes all time, cost and convenience components and is expressed in equivalent VHST hours. Cost components were translated into time by application of 'values of time' for each donor mode and trip purpose. There are therefore eight sets of VHST generalised times: air, car, coach and rail for business and non business trips. Six sets are presented. Coach and rail business travel, which are relatively small donor markets, are not presented.

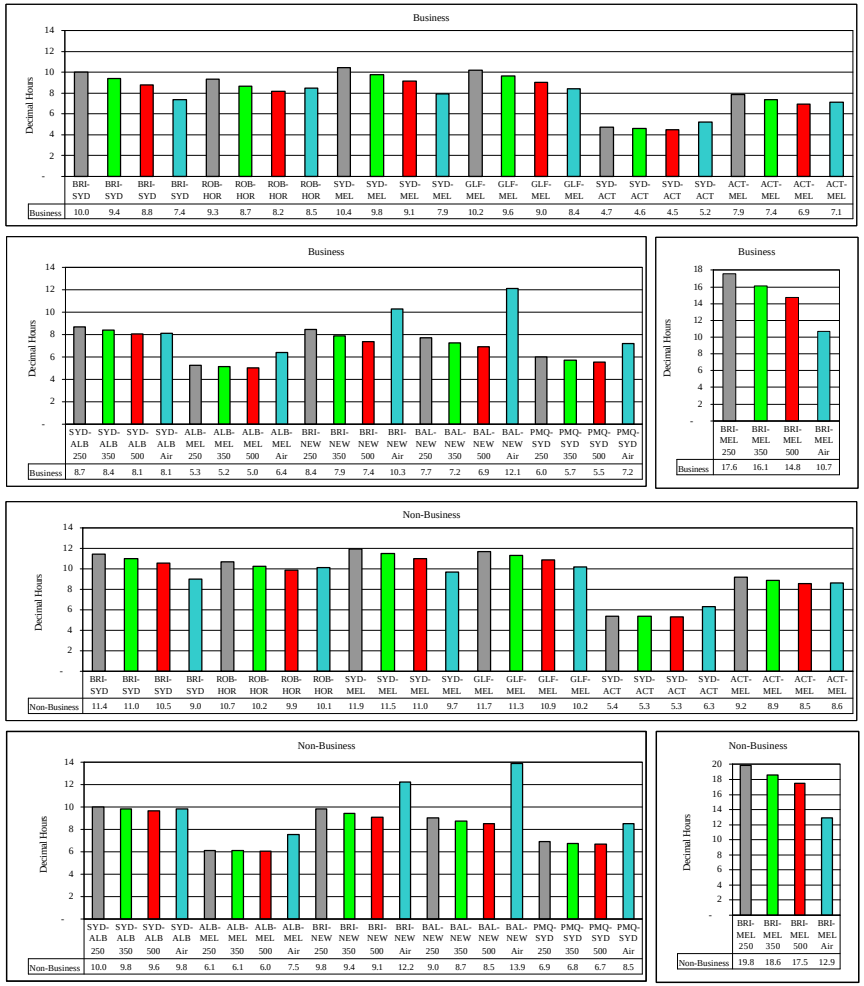
Relative travel comfort was taken into account by applying factors to the time spent on each mode. For car travel, the convenience of having the car at each end and as part of the journey was taken into account by deducting a 'constant'. The estimates relate to 2001. Increasing incomes will tend to reduce the cost component in future years offset for air by an increase in airfares of 0.75% p.a..

Air has an advantage over VHST on the key Brisbane-Sydney and Sydney-Melbourne city centre markets. For business travel, the generalised time measure for air is estimated at 7.4 hours, 1.4 hours less than 500 km/h VHST, 2 hours less than 350 km/h and 2.6hrs less than 250 km/h. For Sydney-Melbourne, air generalised time is estimated at 7.9hrs, 1.2hrs less than 500 km/h, 1.9hrs less than 250 km/h and 2.5hrs less than 250 km/h.

The generalised time for non-business travel is higher than for business reflecting a greater weight attached to the cost components. For Brisbane-Sydney, air generalised time is estimated at 9hrs, 1.5hrs shorter than 500 km/h VHST, 2 hours shorter than 350 km/h and 2.4hours shorter than 250 km/h.



Figure 9.56: VHST and Air Travel Generalised Time



For Robina-Hornsby, VHST access advantages and lower VHST fare compared to city centre stations are forecast to place 500 km/h VHST on an equal footing with air. For business travel, 500 km/h VHST and air have a generalised time of 8½ hours. 350 km/h VHST is 15 minutes longer with 250 km/h VHST one hour longer than air. For non-business travel, both 350 km/h VHST and air are estimated at around ten hours. 350 km/h is 15 minutes longer and 250 km/h VHST ¾ hour longer.

Similarly, Glenfield-Melbourne, narrows the overall generalised time advantage of air Sydney-Melbourne. Air however retains around a ¾ hour advantage on 500 km/h VHST and one hour advantage over 350 km/h VHST.

On Sydney-ACT, VHST has an advantage over air. The advantage is about ¾ hour on a 5 hour generalised time. 250 km/h, 350 km/h and 500 km/h VHST all hold roughly the same advantage. Increase in VHST speed is offset by higher VHST fares. For non-business travel, the VHST advantage increases to about one hour.

Air and 500 km/h VHST are broadly similar for the ACT-Melbourne market with generalised times of 6.9 hours and 7.1 hours respectively. 350 km/h is 20 minutes slower than air with 250 km/h ¾ hour slower.

For Sydney-Albury air and all three VHST technologies are forecast to be broadly comparable. For Albury-Melbourne, VHST has about a one hour advantage over air for business travel and 1½ hours advantage for non-business travel.

VHST has a decisive advantage for Brisbane-Newcastle, Ballina-Newcastle and Port Macquarie-Sydney. For non-business travel, VHST has three hour advantage for Brisbane-Newcastle, a 4½ hour advantage for Ballina-Newcastle and a 1¾ hour advantage for Port Macquarie-Sydney. By contrast, the differences by VHST technology are not as marked. The increase in VHST station-station time is offset by higher VHST fares.

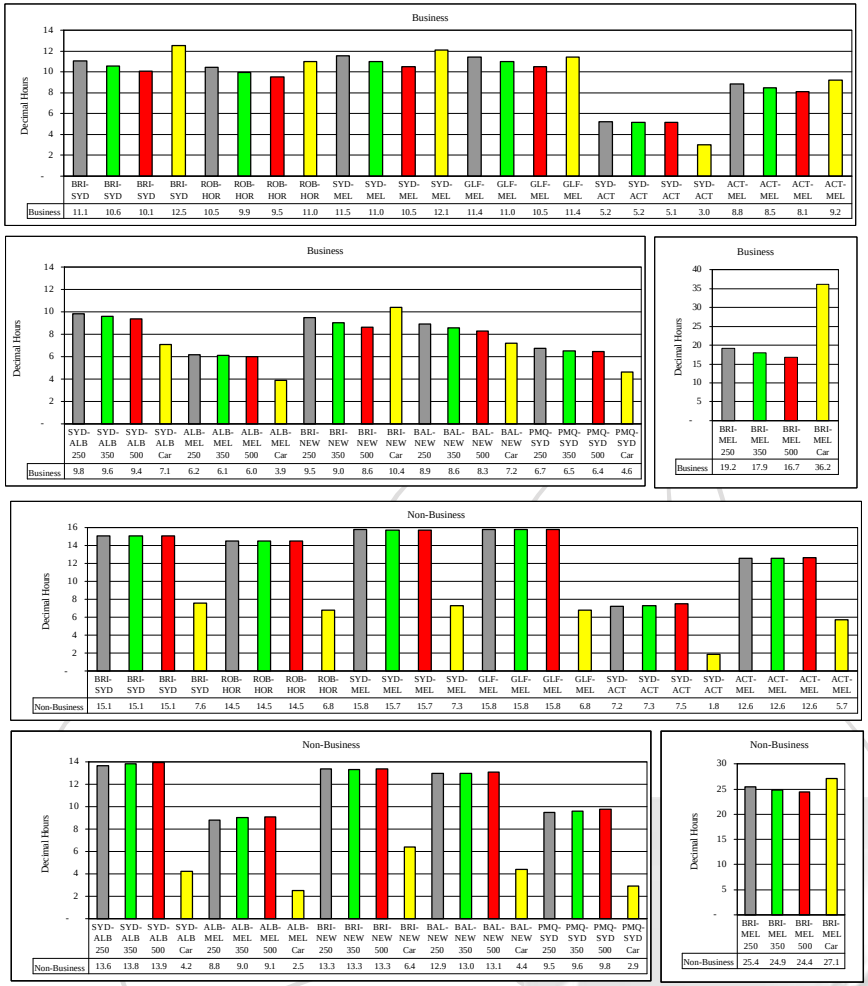
Air retains a marked advantage on Brisbane-Melbourne. Air has a 4½ hour advantage over 500 km/h VHST and nearly seven hours for 250 km/h VHST for non-business travel.

For business travel, VHST has lower generalised time than car for Brisbane-Sydney, Robina-Hornsby, Sydney-Melbourne and Glenfield-Melbourne. For 500 km/h VHST, the advantage is 2.4 hours on Brisbane-Sydney, 1.5hours on Robina-Hornsby, 1.6hours on Sydney-Melbourne and 0.9hours on Glenfield-Melbourne. For the shorter ACT markets, 500 km/h VHST is 2hours longer than car for Sydney-ACT but one hour short for ACT-Melbourne. There is little difference between the three VHST technologies. Car retains a significant advantage on Sydney-Albury and Albury-Melbourne of 3 hours and 2 hours respectively for 500 km/h VHST. Car is forecast to be 1.8 hours less on Port Macquarie-Sydney than 500 km/h VHST and one hour faster on Ballina-Newcastle. On Brisbane-Newcastle, VHST is forecast to have a generalised time two more than 500 km/h VHST. On Brisbane-Melbourne, car is forecast to have a

generalised time of 36 hours which is 17 hours longer, or roughly twice that of 500 km/h VHST.

Inclusion of factors to take account of convenience as well as party size cost advantages held by car for non-business travel produces a marked advantage for car over VHST for all the example markets except Brisbane-Melbourne where the VHST's time advantage becomes more important.

Figure 9.57: VHST and Car Travel Generalised Time

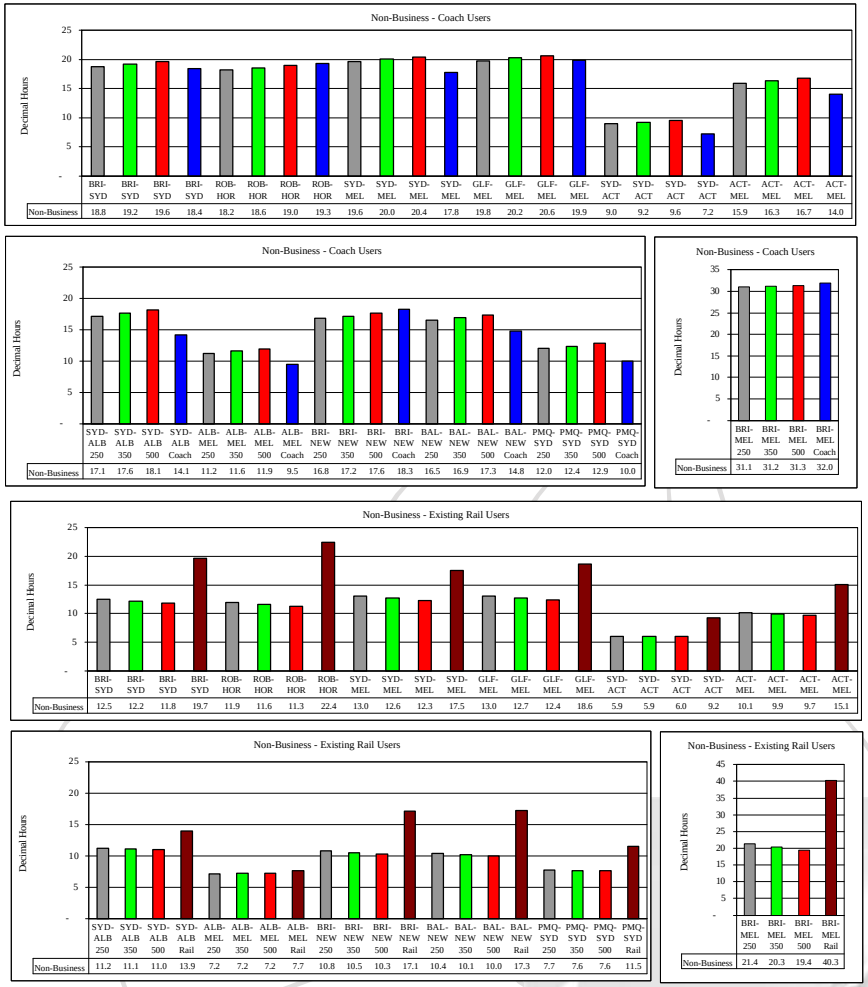


For coach, higher VHST fares offset much of the travel time advantage for non-business travellers. The dilemma is that in seeking to maximising overall revenue, VHST fares have been positioned more in accordance with the larger air market than the relatively smaller coach market. As a result, for coach travellers, much of the speed advantage of VHST is negated by higher fares.

For the key Brisbane-Sydney and Sydney-Melbourne markets VHST and coach are comparable. For Sydney-ACT, ACT-Melbourne and Albury-Melbourne coach retains an advantage of about 2½ hours and about 4 hours on Sydney-Albury. VHST has an advantage of about 40 minutes on Brisbane-Newcastle but is about two hours less on Ballina-Newcastle and Newcastle-Sydney. On Brisbane-Melbourne, coach and the VHST technologies have very similar generalised times.

Compared to rail however, VHST has a marked generalised time advantage. This is largely a result of the increase in VHST frequency to an hourly service compared to the low current rail frequencies of 1-5 per day and the provision of a through Sydney service for Brisbane-Melbourne travellers. For Brisbane-Sydney, the VHST generalised time is 11.8hours compared to 19.7 hours for the existing service. For Sydney-ACT, the VHST generalised time is six hours, three hours less than the existing rail service. For ACT-Melbourne, the difference is just under ten hours compared to 15 hours. For Brisbane-Melbourne, the difference is around 20 hours compared to 40 hours

Figure 9.58: VHST, Coach and Rail Non-Business Generalised Times



9.18 International Benchmarking

9.18.1 Introduction

Actual estimates of VHST demand abstraction and generation for six VHST services from Europe and Japan are compared with corridor forecasts in Section 9.18.2. In Section 9.8.2, diversion and induced demand forecasts reported in 'High-Speed Ground Transportation for America' by the US Department for Transport Federal Railroad Administration in September 1997 and in the Midwest Regional Rail Study 2000 are compared with the corridor forecasts. In Section 9.18.3, data on actual VHST-air shares (VHST/(VHST+air)) was obtained for twenty-three city pairs in Europe (mainly France and Spain) and Japan is compared with the forecasts for EC VHST for the six main city pairs.

9.18.2 Generation and Abstraction Estimates

As part of the study, Dr J Preston, Director of Transport Studies Unit Oxford University provided estimates of VHST demand abstraction and generation for six VHST services. Abstraction refers to VHST trips which would have been made by existing rail services. Generation refers to trips which were not previously made by rail.

The Japanese Shinkansen is estimated to have obtained half its demand from existing rail services with the other half of trips generated mainly from air.

The TGV-SouthEast services are estimated to have increased rail demand by 60% over five years of which 30% was from air, 20% from car with 50% generated. A further growth of 5% was experienced from years 5-8.

The ICE services in Germany have increased rail demand by 40% of which 55% was from car, 40% from air with 5% generated. The higher car share compared to the TGV is attributed to the shorter distance travel market in which the ICE competes.

The X2000 services in Sweden have increased rail demand by 60% of which 60% was from air. However, the situation has been complicated by the introduction of VAT on rail services.

Table 9.21: Generation and Abstraction Estimates

		Service	Abstraction	Generation	Profile of Generated Trips
Country	On existing rail		Air	Road	Induced
Shinkansen Japan	50% abstracted from existing rail	50% generated	Mainly air	Not known	Not known
TGV-SE France	Not known	60% growth years 1-5 further 5% growth years 5-8	30%	20%	50%
ICE Germany	40%	40% growth on existing rail demand	40%	55%	5%
AVE Spain	Not known	150% growth on existing (poor) rail services	33%	33%	33%
X2000 Sweden	Not known	60% growth on existing rail services but complicated by VAT introduced	60%	Not known	Not known
Eurotunnel Dover-Calais and beyond	Not known	Business trip generation estimated at 5%-10% with 10-20% for leisure	Not known	Not known	Not known
VHST 350 km/h	12% of VHST demand	Predicted 60% increase on existing rail corridor demand in 2021	47%	27% Car 22% Coach 5%	23%

By comparison, the forecast for the full EC corridor with 350 km/h VHST (Coastal, Hornsby, Bowral, Inland) is for a 60% increase in rail demand (from 20.2 million trips to 32.4 million trips) in 2021. Of generated trips, 47% are forecast to come from air, 31% from road (25% from car and 6% from coach) with 23% induced. Compared to the overseas examples, the proportion of generated trips sourced from air is forecast to be higher and that from road lower. The proportion induced demand lies midway amongst the overseas examples.

9.18.3 Diversion Forecasts – USA Studies

Forecasts reported in 'High-Speed Ground Transportation for America' by the US Department for Transport Federal Railroad Administration in September 1997 for nine routes suggest low diversion from car and diversion rates relatively insensitive to VHST technology and much higher diversion from air. Diversion from car ranged between 0.5% to 7%.

The highest car diversion forecast is 7% for MagLev technology on the California-North corridor connecting San Diego, Los Angeles and San Francisco/Oakland (a

distance of 600kms). The lowest diversion was 0.5% on the North East corridor connecting Boston, New York, Philadelphia Baltimore and Washington (a shorter corridor of 441kms). The average across all nine routes was 4%. This compares with

Table 9.22: Generation and Abstraction Estimates

				Car		Air
	240 km/hE	VHST	MagLev	240 km/hE	VHST	MagLev
California North -South	*	6%	7%	8%	27%	37%
California South	*	1%	2%	*	22%	25%
Chicago Hub Network	4	4%	4%	17%	27%	35%
Chicago-Detroit	3	3%	3%	17%	33%	42%
Chicago -St Louis	5	5%	5%	24%	30%	35%
Florida	*	4%	4%	*	20%	25%
Northeast Corridor	*	0.5%	0.5%	*	27%	35%
Pacific Northwest	*	3%	3%	*	47%	55%
Texas Triangle	4.7	5%	5%	17%	27%	32%
Average	4	4%	4%	17%	29%	36%
Range	3%-5%	0.5%-5%	0.5%-7%	8%-24%	20%-47%	25%-55%
EC Corridor	250 km/h	350 km/h	500 km/h	250 km/h	350 km/h	500 km/h
Brisbane-Melbourne	3.2%	3.3%	3.3%	28%	34%	41%

'High-Speed Ground Transportation for America' by the US Department fo Transport Federal Railroad Administration in September 1997.
Brisbane-Melbourne 2021 forecasts: Coastal, Hornsby, Bowral, Inland route
E: electrified

Air diversion is forecast to be higher ranging from 8% to 55%. Diversion from air to MagLev is forecast to 25% higher than VHST. VHST is in turn forecast to achieve an air diversion rate divert 70% greater than than 240 km/h electric 'Accelerail'. With MagLev, air diversion is forecast to be the highest on the Pacific Northwest (Vancouver-Seattle-Portland) at 55% and lowest at 25% on the California South (Los Angeles-San Diego) and Florida (Tampa/Orlando -Miami). With VHST, diversion from air ranges from 20% to 47% with diversion again highest on the Pacific Northwest and lowest on the Florida corridor. With 240 km/h Accelerail, diversion ranges from 8% on California North-South to 24% on Chicago St Louis.

The forecasts for the East Coast Corridor are similar. For car, a diversion rate of just over 3% is forecast. This is 1% point lower than the US average. Like the US` study, the car diversion rate is relatively invariant with VHST technology. For air, the 500 km/h and 350 km/h diversion forecasts and 14% and 17% higher than their US counterparts. For 250 km/h, the diversion rate is 28% higher than the 240 km/h Accelerail forecast.

In terms of induced demand, the Midwest Regional Rail Study (op cit) reports estimates from eight studies which range from zero to 48%. The average of the eight US studies is 13%. This compares with 23% estimated for Brisbane-Melbourne with 350 km/h technology.

Table 9.23: Induced Demand - Percent of Diverted Trips

Route	Percent
LA-Las Vegas	48%
Florida	4%
Chicago-Detroit	10%
Pensylvania	Zero
New York-Montreal	17%
Texa Triangle	10%
Ohio	7%
US National MagLev Initiative	10%
Average	13%
Range	0% to 48%
Brisbane-Melbourne 350 km/h	23%

The Midwest Regional Rail Study (op cit)
Brisbane-Melbourne 2021 forecasts: Coastal, Hornsby, Bowral, Inland route. Induced demand as percent of diverted VHST demand (excluding existing rail)

9.18.4 Air-Rail Share Estimates

Data on actual VHST-air shares (VHST/(VHST+air)) was obtained for twenty-three city pairs in Europe (mainly France and Spain) and Japan. The data was compared with the forecasts for EC VHST for the six main city pairs: Brisbane-Sydney; Brisbane-ACT; Brisbane-Melbourne; Sydney-ACT; Sydney-Melbourne and ACT-Melbourne. Forecasts for 250 km/h, 350 km/h and 500 km/h for the Coastal, Hornsby, Bowral and Inland route for 2021 (revenue maximising).

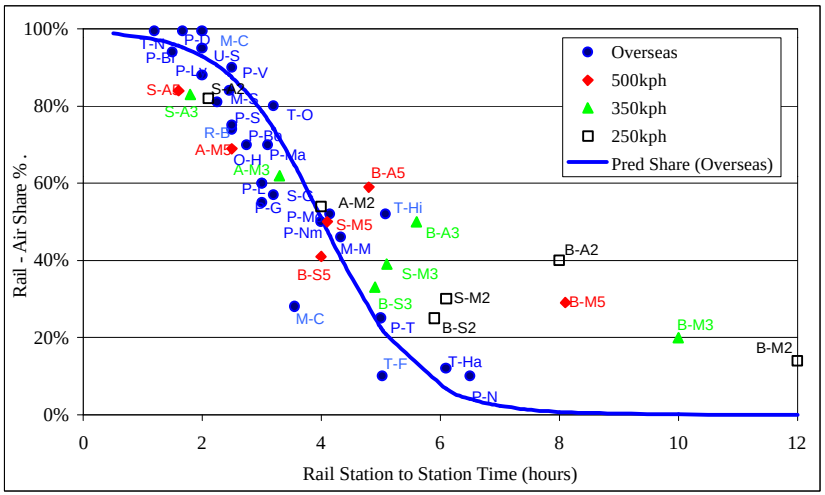
A model was fitted to the overseas points that related VHST share to VHST travel time. A logistic ('S' shaped) curve was fitted (estimated parameters at presented beneath Table 9.21). The model was then used to predict the VHST share for each EC city pair technology market.

The overseas data suggests a strong relationship between VHST journey time (station to station) and VHST-air share[32]. VHST dominates air over rail journeys of under 2½ hours (excluding access and egress). The Madrid-Cordoba air route was withdrawn after the commencement of AVE services in 1992. The Thalys TGV obtains a 95% share on the Paris-Brussels 312km, 1½ hour route. The Tokyo-Nagoya Shinkansen obtains a 100% share of the 312km route. On Madrid-Seville, the AVE 2hr:15 min service has achieved an 80% share on the 470km route.

VHST obtains more than a 50% share of the rail-air market within the 2½hr-3½hr travel band. Examples include the Eurostar Paris-London service that obtains a 70% share with a 2¾ hour service and the Stockholm-Gothenburg X2000 service that obtains a 60% share with a 3hr service.

Figure 9.59: Air – VHST Share with VHST Journey Time

VHST/(VHST + Air)



Based on sources listed in Table 9.21.

VHST share starts falling below 50% when travel times extend over 3½hrs although there are examples of VHST retaining over half the rail-air market. The Sanyo-Shinkansen Tokoyo-Hiroshima service achieves a 56% share with a 4hr travel time. Paris-Nimes obtains half the market with a 4hr service. The dual gauge Talgo Madrid-Cadiz service achieves a 28% share with a 3¾ hour travel time.

Beyond 4 hours, VHST becomes increasingly uncompetitive with air causing market share to drop off rapidly. The AVE Madrid-Malaga service obtains a 46% share with a 4hr 20 min service. The TGV-Atlantique achieves a 25% share for the Paris-Toulouse market with a 5hr service. The Tokyo-Hakata Shinkansen and TGV Sud-Est/Rhone-Alpes services obtain 12%-10% with rail travel times of 6hrs 20 mins and 6½hrs respectively. Unfortunately it was not possible to obtain VHST shares for routes over 1,200kms.

The forecast rail-air 2021 shares for Sydney-Melbourne, the largest EC city pair market is near identical to that predicted on overseas experience for 500 km/h VHST. Based on a 4hr 6 min travel time via the Central Highlands, Inland route a 50% VHST-air share is forecast compared to 49% predicted on the basis overseas experience. By contrast however, the overseas experience predictions are lower than those forecast for 350 km/h and 205 km/h VHST. For 350 km/h VHST, the forecast VHST-air share is 39% compared to 20% based on overseas experience. For 250 km/h VHST, the forecast is 30% compared to 6% based on overseas experience.

[32] It should be noted that VHST share is not the number of trips diverted from air but the total VHST demand from all sources as a percentage of the VHST plus remaining air demand.

Table 9.24: Air – VHST Share with VHST Journey Time

VHST/(VHST + Air)

Route	Code	Time Hrs:mins	Distance Kms	Actual Rail-Air Share %	Predicted Rail-Air Share %
Paris-Dijon (TGV)	P-D	1.15		100%	97%
Paris Brussels (Thalys)	P-Br	1:30	312	94%	96%
Madrid-Cordoba (AVE)	M-C	1:40	343	100%	95%
Tokyo-Nagoya (Shinkansen)	T-N	2:00	342	100%	94%
Ueno-Sendai (Shinkansen)	U-S	2:00		95%	94%
Paris-Lyon (TGV Sud-Est)	P-Ly	2:00	430	88%	93%
Madrid-Seville (AVE)	M-S	2:15	471	81%	91%
Tokyo-Osaka (Shinkansen)	T-O	1:24	515	84%	88%
Paris-Valence (TGV)	P-V	1:30		90%	87%
Paris-St Etienne (TGV)	P-S	2:30		74%	87%
Rome-Bolgna	R-B			75%	87%
Paris-Bordeaux (TGV-Atlantique)	P-B	2:45		84%	84%
Paris-London (Eurostar)	P-Lo	2:45	494	60%	79%
Stockholm-Gothenburg (X2000)	S-G	3:00	455	60%	79%
Paris-Marseilles (TGV)	P-M	3:00		60%	79%
Tokyo-Hakata (Shinkansen)	T-Ha	3.06		70%	76%
Tokyo-Okayama (Shinkansen)	T-Ok	3:12		80%	74%
Paris-Geneva (TGV)	P-G	3.12		57%	74%
Madrid-Cadiz (Talgo)	M-C	3.45	628	28%	65%
Paris-Nimes (TGV)	P-Nm	4:00		50%	51%
Paris-Montpellier	P-Mo	4:15		52%	46%
Madrid-Malaga (AVE)	M-M	4.20		46%	41%
Paris-Toulouse (TGV-Atlantique)	P-T	5:00	827	25%	23%
Tokyo-Fukuoka (Shinkansen)	T-H	5:03		10%	22%
Tokyo-Hiroshima (Sanyo-Shinkansen)	T-H	4:00	821	56%	52%
Tokyo-Hakata (Shinkansen)	T-Ha	6.20	1,069	12%	6%
Paris-Nice (TGV Sud-Est/Rhone-Alpes)	P-N	6.30	1,003	10%	4%
Brisbane-Sydney (500 km/h)	B-S5	4:00	923	41%	52%
Brisbane-ACT (500 km/h)	B-9	5:36	1,203	59%	27%
Brisbane-Melbourne (500 km/h)	B-M5	8:06	1,928	29%	1%
Sydney-ACT (500 km/h)	S-9	1:36	280	84%	96%
Sydney-Melbourne (500 km/h)	S-M5	4:06	1,005	50%	49%
ACT-Melbourne (500 km/h)	A-M5	2:30	725	69%	89%
Brisbane-Sydney (350 km/h)	B-S3	4:54	923	33%	25%
Brisbane-ACT (350 km/h)	B-A3	4:48	1,203	50%	11%
Brisbane-Melbourne (350 km/h)	B-M3	10:00	1,928	20%	0%
Sydney-ACT (350 km/h)	S-A3	1:48	280	83%	95%
Sydney-Melbourne (350 km/h)	S-M3	5:06	1,005	39%	20%
ACT-Melbourne (350 km/h)	A-M3	3:48	725	62%	73%
Brisbane-Sydney (250 km/h)	B-S2	5:54	923	25%	8%
Brisbane-ACT (250 km/h)	B-A2	8:00	1,203	40%	1%
Brisbane-Melbourne (250 km/h)	B-M2	12:00	1,928	14%	0%
Sydney-ACT (250 km/h)	S-A2	2:06	280	82%	93%
Sydney-Melbourne (250 km/h)	S-M2	6:06	1,005	30%	6%
ACT-Melbourne (250 km/h)	A-M2	4:00	725	54%	52%

Model: VHST share = 1- {1/(1+exp(bo + b1.(VHST Time))}

Estimated parameters: bo = 5.36 (t = 8.25); b1 = -1.32 (t=9.57) R square = 0.75 (PCIE/TMG).

Sources:

UIC High Speed Rail Division 'High-Speed Rail Development Madrid-Andalusia' August 2001.

Kasia Y (JR Central) and Rochet (SNCF) in International Rail Journal, March 2001.

PCIE forecasts.

For Sydney-ACT, the forecasts appear conservative. For 500 km/h VHST providing a 1½ hour travel time , an 84% share is forecast compared to 96% based on overseas experience. For 350 km/h offering a 1hr 48 min travel time, the forecasts are 83% and 95% respectively and 82% and 93% for a 250 km/h VHST service providing a 1hr 6 min travel time. A possible explanation for the lower forecasts is the non-consideration of 'second round' reductions in air service levels in response to the high levels of diversion to VHST. Future work could model the impact of such reductions.

The forecasts are also lower than overseas experience might indicate for ACT-Melbourne. For 500 km/h providing a 2½ hour travel time, a rail share of 69% is forecast compared to 89% based on overseas experience. For a 350 km/h 1hr 48 min service, the forecast share is 62% compared 73% predicted The forecasts

are close for 250 km/h VHST. With a four hour travel time, a rail share of 54% is forecast compared to 52% predicted based on overseas experience.

For Brisbane-Sydney, the comparison suggests the 500 km/h forecast to be low, the 350 km/h forecast to be broadly similar to overseas experience and the 250 km/h forecast to be high. With on a 4 hour travel time provided by 500 km/h VHST, a rail-air share of 41% is forecast compared with 52% predicted on overseas experience. A 5hr 350 km/h VHST service is forecast to obtain a 33% share compared to 25% predicted on overseas experience. A 250 km/h VHST six-hour service is forecast to achieve a 25% share compared to 8% based on overseas experience.

For Brisbane-ACT, the forecasts are higher than overseas experience might suggest. With a 5½ hour 500 km/h VHST service, a rail share of 59% is forecast, double that based on overseas experience. For a 350 km/h service offering a travel time slightly under 5 hours, a share of 50% compared to 11% based on overseas experience is forecast. For 250 km/h, the VHST travel time is estimated at 8 hours with a rail share of 40% compared to only 1% based on overseas experience.

For Brisbane-Melbourne, the overseas experience prediction model suggests a zero rail share. At these journey lengths, however, the prediction is an extrapolation since no data was available at these longer journey lengths. Given an estimated current (2001) combined rail and coach versus air share of 3% on the Brisbane-Melbourne market, a share of 10% could be viewed as conservative for the more than halving of travel times forecast with VHST. For a 500 km/h through Sydney service, a rail travel time of just over 8hrs is forecast with a resultant rail-air share of 29%. With a ten hour 350 km/h service, a 20% rail-air share is forecast that then falls to 14% with a 12 hour 250 km/h service.

Overall, the overseas prediction model appears to be more sensitive to VHST travel time than the forecasting model that has been developed in this study. The overseas experience model suggests a higher share at shorter distances and a lower share at longer distances. The model also suggests a higher share for 500 km/h and a lower share for 250 km/h than that forecast.

There is a need for caution in transferring overseas experience to the EC corridor however. Socio-economic, demographic, travel profile and topographic differences all limit the direct transferability of results. The lack of VHST market shares for trips of greater than eight hours also reduces the applicability of the overseas model to the Brisbane-ACT and Brisbane-Melbourne markets. Moreover, the overseas experience model as specified does not take account of the quality of air service. These caveats accepted, the overseas model does provide a benchmark to assess the forecasts and suggests that further work needs to be undertaken to provide support for the forecasts made for the long distance VHST services.



9.19 Further Work

The nature of VHST suggests that perceived demand risk is likely to be high. Even for a hypothetical VHST service operating tomorrow, demand and revenue would be subject to considerable uncertainty, with market size and likely diversion both difficult to estimate. Forecasting ten to fifty years ahead compounds risks greatly, involving alternative socio-economic and demographic scenarios and different transport infrastructure and policy futures. Moreover, the responses of existing transport operators to the introduction of VHST can only be assumed. Although considerable work has been undertaken in this study to identify key drivers and to determine the likely range of demand for a VHST service, the projections are of a preliminary nature, appropriate to the level of a 'scoping' study. The forecasts have been largely based on information gathered by other consultants and organisations. No new market research has been undertaken to assess market size or demand response to a VHST service.

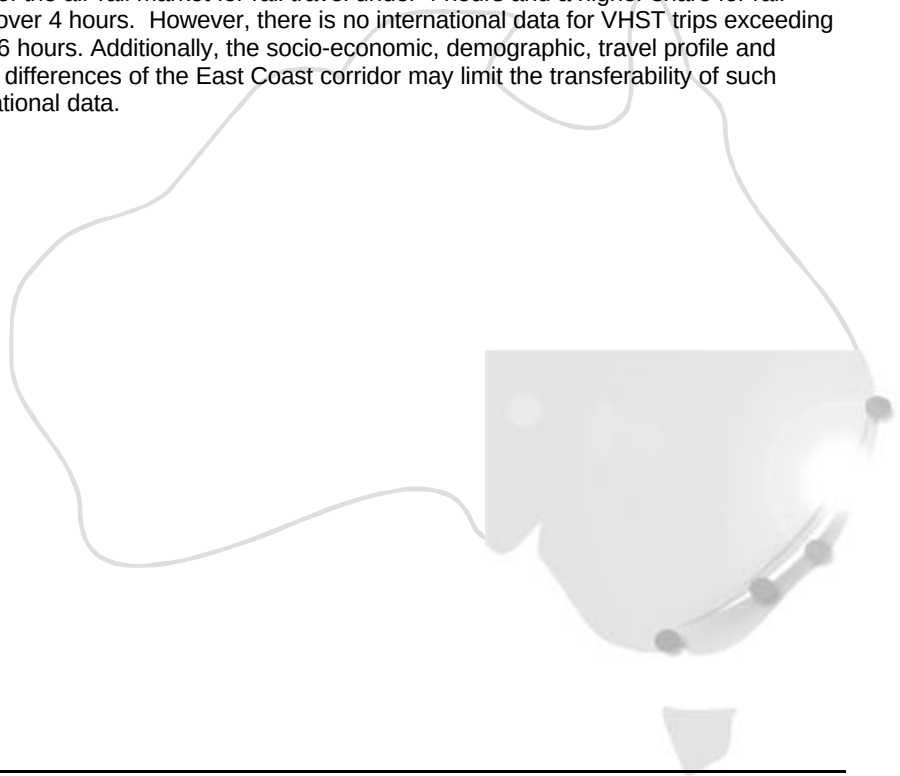
The following components are suggested as areas in which more detailed investigation could improve the confidence in the demand forecasts.

Table 9.25: Areas Suggested as Requiring Further Work

Study Area	Description	Priority
Service Level	Audit the existing service level information included in the model for air, car, coach and rail. Devote special attention to improving the airfare and coach service level specification.	High
Day Trips	The Domestic Tourism Monitor on which the market size estimates rest is based on trips that involve an overnight stay. BTE factors were applied to estimate day trips. On some markets eg Sydney-Canberra this factor is very important. It is recommended that survey work be undertaken to establish day trip factors to apply to trips involving overnight stays.	High
Metro Trips	Verify the preliminary metro trip estimates and establish the level of metro commuting trips on the northern Melbourne corridor. Establish car shares for Brisbane, Sydney and Melbourne.	High
Non East Coast Residents	Fill the gap in base demand of Australian residents who are non-residents of the East Coast corridor but who may use the VHST on holiday or on business.	Medium
Income Growth	The demand forecasts are sensitive to income growth. Income growth was forecast by assumption. These assumptions should be replaced by forecasts from authoritative sources.	High
Income Elasticity	The growth in the total market size resulting from income growth is through an "income demand elasticity" the value of which was assumed. Time series and or cross-sectional analysis should be undertaken to verify or revise the elasticities used in the forecasts.	Medium
Tourism Growth	Authenticate the long-range tourism growth forecasts against industry projections.	Medium
Divertible Car Market	Undertake market research to estimate the likely percentage of car trips that would consider using VHST. The research should be undertaken for business and non-business trips and should cater for different trip distances such as under 500 km, 500-1000 km and over 1000 km.	High
Base Market Behaviour	Use the Domestic Trip Monitor with the service level data to estimate behavioural parameters for travel mode choice that can be used in the base trip projection and VHST diversion models.	High
VHST Market Research	Undertake "Stated Preference" market research particularly on the 500-2000 km markets to estimate values of time and measures of the relative importance of travel components such as service frequency, need to transfer, access and mode comfort relative to main mode time. These parameters can be used in the base market projection model and in the VHST diversion model.	High
Response of Tourists	The model assumes the same behavioural assumptions characterise domestic and overseas trips. Market research should be undertaken of tourists to gauge their likely response to VHST.	Medium
Induced Demand	Undertake research on the Domestic Tourism Monitor to relate total travel to overall service level offered. The relationship could be used with VHST to forecast the induced trips. Market research could also be undertaken to establish induced demand parameters.	Medium
Long Run Commuting	Similar to induced demand. A review of the experience of the TGV and other VHST operations on long distance commuting could also supplement this analysis.	Low
Party Size	Analysis should be undertaken to assess party size and its impact on choice of mode (especially car).	Medium
Second Round Impacts	The likely response of air, coach and rail operators to the introduction of VHST needs to be considered thoroughly. No response was included in these forecasts other than sensitivity tests.	Medium
Long Distance VHST Share	The review was unable to obtain estimates of rail versus air share for markets over 1000 km. There are examples in Japan and Russia that might fill this information gap.	Low
Network Model	Develop a network model to consider the east coast transport system as an integrated system offering complementary rather than competitive links. Multi-modal journeys such as VHST-air could then be modelled explicitly. Alternative routes through Sydney should be explored.	Medium

9.20 Key Points

- A comprehensive patronage forecasting model, based on existing data, has been constructed;
- The East Coast corridor covers an area 2000 kms in length from Melbourne to Brisbane and about 300 kms in width from the coast inland;
- The model is able to forecast VHST patronage for each of the technology choice options and for a number of route options in the East Coast corridor;
- It provides information about the loading on particular sectors of the corridor options and data which may guide priorities for investment under a staged delivery program;
- The model is constructed to forecast the base market for travel for both business and non-business and to determine the share of that market that would be attracted to using a VHST;
- The total base market is forecast to nearly double from 158 million trips p.a. to 291 million trips by 2021 and to be 522 milion trips p.a. in 2051 – a compound growth of 2.4%;
- The amount of the market attracted to a VHST from the alternative mode depends, inter alia, on the calibre of service provided by that mode and the distance/time of VHST travel;
- The VHST's market share also depends more on the quantum of the future population in the corridor rather than its distribution throughout the corridor;
- The model clearly shows that each form of VHST can attract a significant share of the total base market – 10% to 15% for 250 km/h to 500 km/h respectively;
- The model able to predict the patronage by line segment along each of the corridor options and to distinguish between route options in corridors – the heaviest loadings on an EC VHST would occur on the entries and exits to Sydney;
- the Coastal corridor is predicted to have a stronger patronage than the Inland corridor between Brisbane and Sydney;
- patronage between Sydney and Canberra is stronger if the route goes via Wollongong though most of this is Sydney to Wollongong travel;
- between Canberra and Melbourne the coastal route and the inland route are very similar in patronage and that there is insufficient differentiation to make a decision about which route on the basis of the quantum of patronage, passenger-kilometres or revenue alone;
- The 500 km/h VHST generally generates the highest levels of patronage, passenger-kilometres and revenues except in the Newcastle – Sydney, Sydney - Canberra and Canberra - Melbourne sectors when these are considered as stages and all three VHST's perform similarly.
- Sydney has the highest station throughput of over 20,000 passengers per day;
- In 2021 line loading between Gosford and Canberra is predicted to exceed 20,000 passengers per day for the 350 km/h VHST via the coastal, Hornsby, Bowral and Inland corridor;
- The forecast are most sensitive to air fares but is also sensitive to whether a direct service is provided through Sydney; and
- Based on international benchmark data the patronage model is forecasting a lesser share of the air-rail market for rail travel under 4 hours and a higher share for rail travel over 4 hours. However, there is no international data for VHST trips exceeding about 6 hours. Additionally, the socio-economic, demographic, travel profile and terrain differences of the East Coast corridor may limit the transferability of such international data.



Section 10

Financing, Creating and Operating an East Coast VHST



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10 FINANCING, CREATING AND OPERATING AN EC VHST

10.1 VHST Financing Options

Overview

A series of delivery methods are described and broad funding sources identified. Staging is identified as a further consideration. Staging will assist in proving up the patronage risk and thereby reducing the perceived risk and increasing the size and cost efficiency of private sector funding.

Some key funding issues are discussed that effectively provide a capacity limit at any one point in time. The key implication here is that staging will be required if private sector funding limited to patronage-linked revenue streams is to be relied upon.

The review of the development of high speed rail in other countries earlier in this study coupled with the cost of an EC VHST, as indicated in section 8, immediately indicates that the project could not be funded on a private sector basis without some form of major Government financial support. This is because the revenues that could be directly generated by the project (such as fare box revenue and other throughput-related revenue) appear, from the outset, to be insufficient to provide a satisfactory return to the private sector for investment in the project. This conclusion is analyzed in more detail in section 14 of this report.

10.1.1 Alternative Delivery Models

Three main delivery methods have been considered for an EC VHST as outlined below. Each of these methods involves different funding approaches. It is assumed that under each method that an EC VHST business is both in the national interest and is economically justifiable. Clearly, there will be variants around these three.

(i) Governments as Long Term Owners

Under this model, the Governments would intend to be the developer and long-term owner of the business. The Government managing entity would:

- contract with the private sector for the provision of design & construction services, supply of core inputs such as technology provision, track, train sets, operation and maintenance services on a medium term basis and the like;
- provide the funding required for the project, either directly or by way of support to a Government-owned entity undertaking the project; and
- ultimately bear the financial risks associated with the project, including patronage revenues, operating costs and construction and development costs although some of these risks could be out-sourced to the private sector.

Many of the VHST services in existence or currently under consideration have been initially developed or proposed on the basis of such a model. Much of the European VHST network has been developed under such a model either directly by governments or via government-owned entities.

The Japanese VHST services have been developed by Government-owned entities which have more recently progressed towards being independent entities.

A current proposal for a VHST service along an 1,100-km corridor through California has an estimated cost of USD27 billion and a construction period of 16 years. If the project were to proceed, it appears that it would be developed as a public sector project and financing options put forward to date have been various public funding regimes.



(ii) Governments as Developer

Under this model, the Governments would intend to be a developer of the business but not a long-term owner. They would be acting in the ownership role during the construction stage with a desire to exit all or part of their investment post ramp-up period after several years of operation.

The Governments would contract with the private sector for the provision of design & construction services, supply of core inputs such as technology provision, track, train sets. They may also contract operation and maintenance services on a relatively short-term basis. This would involve sale of a concession to a consortium that wished to operate as well as provide or manage other services.

During the construction phase and the early years of operation, funding would be provided by the Governments as proposed above in (i). The terms of any proposed exit by the Governments would see a refinancing of this funding based either on a mixture of private sector provided debt and equity and a retained portion of Government provided debt or equity or purely private sector funding. The mix would depend on the nature and quantum of the asset and/or operation being sold and the project viability at the projected time of exit, as assessed by the market. This is essentially what has occurred with the Commonwealth Government's outsourcing of airport assets.

There are a limited number of examples where Governments have undertaken VHST projects on this basis.

(iii) Governments in Partnership with the Private Sector

Under this model, in response to the Governments' desire to see the project created, the private sector would act as the developer of the business and intend to be a long-term owner of the business. The role of the Governments is to provide implementation assistance and funding by way of contribution to cover the expected gap between the capacity of the private sector to raise capital and the capital needs of the underlying project. The key issue is the means by which a private sector partner is selected.

The private sector concessionaire would contract with the private sector for the provision of design & construction services, supply of core inputs such as technology provision, track, train sets, operation and maintenance services and the like.

Funding could be provided under the following two broad approaches.

(a) Full Private Sector Funding Without Public Sector Financial Support

Funding would be provided by the private sector during the construction phase based on the performance risk of the contractors in the construction phase. There would be an agreed take-out by private sector debt and equity willing to absorb the patronage risk profile. To achieve the take-out, the project would have to be assessed as fully viable on a stand-alone basis.

Full private sector funding would be a possible alternative in the event of one or more of the following scenarios:

- the patronage related revenue considered achievable by the private sector is much greater than currently forecast (through higher patronage expectations, high growth expectations and/or higher fares – it is noted that the overseas experience would indicate that this is unlikely);
- the level of forecast patronage related revenue is increased due to an increase in diversion from the existing transport alternatives (perhaps as a result of the introduction of traffic calming measures on existing routes, constraints on air movements, increasing ground access congestion at airports) or certainty in the forecast revenues is increased (facilitating a higher proportion of debt funding which has a lower cost than equity);
- additional sources of revenue are identified that can be accessed by the private sector to generate a return on the investment (such as the right to control land development around regional stations along the route, air rights in dense urban corridors, placement of utilities in the corridor, advertising and the like); and/or
- significant savings can be achieved in the capital and operating costs of the EC VHST (for example, any ability to stage part or the entire network or develop a single track initially).

A typical structure for patronage risk projects (with or without government financial support) is for a private sector party to be granted a long-term concession to build, own and operate the facility. The asset is transferred to the Governments for little or no consideration at the end of the concession period. The main features of such a structure typically include:

- the project is usually undertaken by a single purpose entity which is contractually supported by appropriate parties in respect of construction, operation, maintenance and finance;
- the project entity will enter into a detailed agreement with the Governments surrounding all aspects of the concession. This would include matters such as the entity's legal right to operate, service obligations of the entity, and fetters on certain government actions that may damage the business of the project (such as the construction of a competing road or new airports);

- detailed agreements will also be required between the Governments and the other various parties involved in the project in order to set out the rights of each party in certain events (such as the application of insurance proceeds where a significant insured event of damage has occurred);
- legislation will be required to facilitate the project (such as the right of the entity to operate); and
- step-in rights are usually provided to allow Governments to be able to act in the event of emergency or major default by the concession holder.

A contemporary example of this form funding is the Sydney Airport Rail Link Project which earlier this year was placed in administration after patronage failed to come up to the forecasts. However, it must be noted that the private sector's financing role was limited to the creation and operation of four key stations. The patronage risk was on the users of those stations not on the through traffic. The railway infrastructure, though constructed by the same private sector entities, was fully financed by the NSW Government.

It has already been noted that full private sector funding is not a realistic possibility.

(b) Combined Private and Public Sector Funding

The most likely solution for funding the project appears to be partial private sector funding combined with funding from the public sector.

The various options that may be used to provide public support to an EC VHST project include the following:

- a common approach to providing financial support to a project is for public funds to be committed to funding part of the construction costs and to then lease the resultant assets to the concessionaire. This approach has been used in Australia as direct government contributions are taxable and are therefore inefficient, particularly in the context of the Australian state and federal government system;
- public funds can be contributed to the project as payments in a variety of forms and over various timeframes. However, as the cost of capital of the private sector entity will usually exceed the cost of funding or discount rate applied by the public sector, significantly deferred payments are generally unattractive. Rather, it is more common for the converse to occur with an upfront contribution of public funds partly or wholly offset by a deferred payment stream (such as deferred lease payments). To some extent this approach is an arbitrage of the difference between the adopted public sector discount rate and the private sector cost of capital. In the context of this project, it may be possible that a party such as the Governments may be willing to provide a long term subordinated loan at a lower cost than private sector equity, thereby increasing the amount of total funding available for the project;
- an alternative to direct subsidisation is shadow tolling, where fares are subsidised by the Governments over and above those paid by users directly. Such a structure may reduce the uncertainty in the forecast traffic diversion levels that arises from the creation of the project in an environment of other competing modes and can allow a greater fare revenue level to be set to enable the private sector to fully fund the road. However, the assessed cost of the forecast shadow payments may exceed the cost of directly funding the construction of the railway as a result of the discount rate and cost of capital differences noted above. There is also a risk for the public sector that patronage is much higher than forecast leading to an excessive windfall for the private sector and disproportionate returns on investment. However, this can be reduced by having a profit share arrangement such as a reduced fare level for patronage above a certain threshold or by a revenue sharing arrangement. A variation on this approach could be for the payment of shadow payments on traffic utilising the existing alternatives. This would be expected to increase the level of private sector funding available as a result of both the increased size of the income stream and the reduction in uncertainty regarding diversion. At the same time the public sector would have some influence over the levels of diversion (and therefore the proportion of, payments borne by the public sector);
- the provision of availability payments is a further mechanism that is aimed to ensure that all operation and maintenance risks are absorbed by the private sector with the Governments making up the difference due to the long term nature of the asset and the national interest issues that are driving its introduction;
- the provision of a patronage guarantee could underwrite the revenue of the project and is effectively the approach that was adopted in the Sydney Harbour Tunnel financing in the 1980s. This approach reflected the limited ability of the private sector to take patronage risk at that time and is not significantly different to providing a financial guarantee. Undertaking such an approach is unlikely to provide any benefit to the public sector.

Examples of financing support provided by Governments for other VHST projects include the following:

- a 345 km high-speed rail link to be completed in 2005 in Taiwan (Taipei-Kaoshiung) has raised approximately USD14 billion to cover the cost of the project. The total amount has been raised from the private sector with approximately USD10 billion in debt and USD4 billion in equity. However, the project is effectively Government guaranteed with the Government obliged to assume the debts of the project if default occurs and is not cured within 6

months. While it is not clear whether the benefit of this guarantee extends to equity or the extent to which Government support for the project could be expected to be called upon, it would appear to be a substantial level of support;

- In 1986 a 55-year concession was granted to the Channel Tunnel Group-FM for the development of the Channel Tunnel. Government support for the project included an underwriting of access charge revenue to 2006 and various changes to the terms of the concession as a result of significant cost over-runs borne by the project;
- Initial work on the Channel Tunnel Rail Link project, intended to link the Channel Tunnel and the City of London, was commenced by the UK Government in 1993 and subsequently 'sold' to the private sector on the basis of a bid of the required Government contribution. The winning bid was £1.8 billion of a total estimated construction cost of £5.2 billion (in addition to £1.0 billion spent by the Government prior to the tender process. Subsequent losses in the existing operations have led to the provision of additional financial support by the Government including debt guarantees and additional Government contributions;
- The Berlin-Hamburg MagLev project was to be the first commercial development of Thyssen Transrapid magnetic levitation technology. The project proposal was developed over almost a decade until early 2000 when the German Government, its rail operator Deutsche Bahn and the private sector partners agreed to abandon the project. The project had been proposed on the basis of Government funding of the "track" to be re-paid by the project during operations by way of access fees. The project appears to have ultimately failed because of changes in economics – construction costs increased by 33% or more from early estimates and patronage halved. In addition, there appeared to be a loss of political will (following a change in Government), environmental concerns were raised and the substantial cost of the project only generated a marginal improvement over ICE VHSTs;
- The German and Shanghai Governments have now committed to the development of the Shanghai MagLev project, which is intended to assist in the commercialisation of the technology. The project comprises a 30-km link between Shanghai and its international airport at a total cost of USD1.2 billion.

10.1.2 Other Delivery Model Issues

Staged Development

The size of any proposed EC VHST will place a very large demand on both physical (ie construction) and financial resources within Australia. For this reason alone, staging the development would be seen as beneficial.

Staging could potentially reduce the private sector's perceived patronage risk by establishing some base experience to better gauge user behaviour. Given recent failures, the private sector may take some considerable time to achieve sufficient comfort with the patronage.

Separation of Infrastructure and Operation

A further approach that could be overlaid on the above delivery models is the separation of the assets into the true long term component comprising the track and related signalling and power supply equipment from the operating assets such as rolling stock, catering and reservations systems and the like.

The Governments are in a better position to finance the track infrastructure assets due to their very long life. The private sector may also be able to absorb the patronage risk given that the rolling stock component is likely to be a relatively lower capital cost component. The private sector may be better able to add value through the provision of superior marketing skills and customer service.

10.1.3 Private Sector Financing Availability

Market Capacity

Of the numerous commercial banks around the globe, only a maximum of about 60 to 70 are active in the global project finance market. For resource projects, the market capacity issue is of less relevance due firstly to the generally shorter financing terms involved and, secondly, to the general availability of US dollar revenue streams due to commodities being sold in US$. This provides funding source diversification given the existence of a natural hedge.

For infrastructure projects, the predominance of revenue streams denominated in domestic currency limits market capacity. Only about half of these project finance banks (30-35) are able to commit to fund in Australian dollars for the long terms necessary for infrastructure projects. The number of banks willing to commit to fund such projects is the first limitation for Australian infrastructure projects.

Finance industry experience with respect to patronage type projects is limited and has been primarily been in the toll road sector. However, the best recent precedence lies with the proposed Speedrail bid for the Sydney-Canberra Very High-Speed Rail project. Here, around $2 billion in bank debt was to be raised against patronage risk with a further $750 million in equity. Institutional debt market was to be tapped to a relatively small extent. On the other hand, the Brisbane Airport Rail Link was funded entirely through institutional debt of the order of $105 million and equity of $89 million.

The AirportLink Company in Sydney raised approximately $275 million from the private sector through predominantly bank debt with the balance of approximately $725 million provided by the Government.

Market capacity for project related institutional debt remains limited unless government revenue streams are evident.

Accordingly, debt and equity markets for project finance are finite, and as more projects get done there may well be an "financial indigestion" problem develop, with too many projects, too few commercial banks with long term appetite and a still relatively undeveloped institutional market.

Risk Profile

A fundamental driver of "funding appetite" in the private sector is an assessment of the relative riskiness of any particular project. Many potential investors have no interest in certain sectors irrespective of price or expected return.

Patronage risk is viewed in the marketplace as relatively risky than risk in other infrastructure asset classes.

The risk profile is very skewed towards obtaining a correct assessment of the likely patronage, as there is very limited remedies in the event of fundamentally flawed assessments. One key issue is the availability of existing competing modes that offer either more convenience, flexibility and/or are subsidised through tax revenues.

Another issue is that, unlike a power station that can contract with a broad market in the event of the loss of a customer, patronage projects require customers to physically come and use the assets provided. This implies a much more concentrated risk profile.

Changing the risk profile of a transaction by simply changing the source of the cash flow stream can have dramatic impacts on the market capacity issue.

Commercial banks appetite for patronage risk needs to be considered. The number of available banks that are willing to accept traffic/patronage risk associated with toll-roads, railways etc is believed to be in the range of 18 to 25 banks. A further issue here is that the desired hold levels (i.e. amount of financing on the banks books) for these projects are less than those for, say, other more stable infrastructure assets such as power stations. This is purely a function of the overall risk profile that the banks seek.

With 9 to12 banks at an average maximum of A$100 million each, this would indicate a commercial bank market capacity of A$900-1200 million for any one project.

The A$1.7 billion Melbourne City Link project expanded these market limits and managed to raise A$800 million in long-term bank debt, A$350 million in institutional debt and A$400 million in institutional equity. It is fair to say that the market does stretch itself to absorb large-scale projects that expand the theoretical capacity of the market at any one point in time.

Maturity Profile versus Asset Life

Private sector funding sources have constraints around available term or maturities. This particular applies to banks that have virtually no appetite to provide funding beyond 20 years. Institutional investors potentially have a longer-term horizon to 30 years but their appetite is even more limited by risk.

These maturity profiles do not sit well with the much longer assets lives that are inherent in VHST type projects.

Determining a Project's Debt Carrying Capacity

The viability of any project will be dependent on the ability of the revenues to generate a positive cash flow after operating costs have been deducted, given expected (and unexpected) fluctuations in operating costs and revenues.

The amount of debt a project is able to service will depend on the cash flow which is available after operating costs have been deducted to service debt.

As the returns to project lenders (after funding costs) are limited to a margin of usually between about 1% and 3%, the level of risk and volatility lenders are willing to accept is commensurately low.

Project lenders require a very high degree of certainty as to capacity for repayment within a particular time frame, irrespective of the security provided. It should be noted that the overriding interest of most project lenders is to seek repayment from

the cash flows rather than by sale of project assets, which is viewed as a last resort action, and may yield as little as 10 cents in the dollar.

The determination of the debt servicing capacity of a project is usually based on an analysis of the expected cash flows, and the associated risks.

Analysing the cash flow involves examining the sensitivity of the project's debt repayment ability to fluctuations in variables such as:

- throughput volume;
- unit price;
- operating costs;
- construction costs;
- construction time;
- ongoing capital expenditure,;
- interest rates;
- exchange rates; and
- taxation.

This process, which is undertaken by constructing a financial model of the project, will allow the lender to determine the key variables effecting the economic viability of the project and the robustness of the project to fluctuations in the key variables. The modelling process is based on forecasts of the expected cash flows and a proposed debt/equity structure.

Any debt structure developed during this analysis is likely to include some form of 'tail' that is the difference between the project life and the proposed debt life. The purpose of the tail is to allow for an extension in the debt term in case of a disruption to the debt repayment schedule. It provides a buffer of cash flow that lenders can access for repayment under adverse circumstances.

Critical in the analysis is the determination of the project's *debt cover ratios* (Debt Cover and Loan Life) - a measure of project cash flow available to meet mandatory interest and principal payments.

The level of the required cover ratios for a particular project will be a function of the industry, the nature of the project, and the sophistication and depth of the capital markets from which funding will be sought. The required ratios are usually determined by a process of intuitive judgement, following a detailed analysis of the project economics and the proposed debt structure. A key aspect of this judgement is precedence in the syndication market. The Loan Life Cover Ratio ("LLCR" = PV of cash flow available for debt service over loan term divided by principal outstanding) is a forward looking ratio and is used extensively in project finance to determine a project's gearing capacity. LLCRs of 1.4 to 1.5 are common for power stations. LLCRs of 1.7 to 2.0 are common for resource projects. LLCRs of 1.5 to 1.8 are common for patronage projects.

The necessary debt cover ratios, and hence the debt carrying capacity of any project, will depend to a large extent on the experience and expertise of the Arranger or lead bank, and its ability to make appropriate judgements about what the market will bear, and then direct and lead all financiers in that direction. Project proponents and governments in Australia are starting to understand, particularly for large projects, that they require an Arranger or lead bank who is intimately familiar with the markets, and who is recognised as a leader amongst its peers.

Determining a Project's Equity Requirement

A requirement of most project loans is that distributions to equity occur only *after* interest and principal obligations have been met. As a result, cash flows to equity are an *output* of the financial modelling process and tend to be more volatile, being subject to fluctuations as a result of changes in costs and revenues.

Equity is therefore more risky than debt, since the timing and magnitude of the cash flows are more subject to change. Consequently, the returns sought by equity investors are usually much greater than those sought by debt investors, in order to compensate for the higher possibility of diminished returns, or even loss.

In the same way that constraints on the debt market determine the structure of lending transactions, limitations in the equity markets have a similar effect. The desired rates of return, which may be derived through, say, the capital assets pricing model, do not usually apply to equity for projects; the risk profile is usually different to listed shares and the investment is usually illiquid. These two factors generally have the effect of increasing the rates of return commanded by equity investors in projects.

On a nominal after-tax basis, the rates of return on equity currently required by investors in "greenfield" infrastructure projects in Australia could be expected to be between 15% and 20% pa. This is consistent with infrastructure projects overseas, including some which have the maximum rates of return to equity capped at around this level (some with an additional incentive for increased efficiency). For resource projects the required returns are usually much higher.

In summary, having previously determined the level of debt that a project can bear, it is therefore possible to determine the size and volatility of the residual cash flows after debt service, which may be available to equity. Based upon current return requirements for participants in the industry, as well as for institutional and public

investors perhaps new to the industry, it is then possible to make a judgement about the level of equity that the project's residual cash flows will support.

As a rule of thumb, lenders require as a minimum an equity contribution of no less than 20% for any project financing. Equity generally ranges between 20-40% for most projects.

Determination of Any Government Contribution

If the sum of the debt and equity available falls short of the optimal capital expenditure required for the project then the gap needs to be filled from a source of funding that does not require the same nature of return. This generally falls to a party such as the Government that can access the broader economic benefits of the project and is not limited to the direct user pay type revenue streams.

10.2 Project Development Timescales

To go forward the Government needs information on a rational time scale for creation of an EC VHST., the following examples providing some reality checks on the rate at which major projects of this kind can be delivered:

- The Sydney Canberra project, over a distance of around 300km, was proposed to be operation in five years after the selection of the preferred proponent in 1998;
- The 412 km Seoul –Pusan TGV line is being delivered in stages over 12 year period. Commencing in 1998, Stage 1 from Seoul to Taegu is due for completion in 2004, while Stage 2 from Taegu to Pusan will be constructed in the period 2004-2010. It is relevant to note that the operation also commences in stages with partial use of completed high-speed sections as well as use of the existing track;
- The 250-km FF25 billion TGV Mediterranee, the latest addition to France's high-speed network took five years to construct. France's next major TGV project, the FF26 billion 300km TGV Est Europeen is planned to have been commenced in the middle of 2001 and be operation by 2006;
- The Spanish AVE VHST project from Madrid to Seville took 3 years from financial close to the first operations. The project involved the construction of 471 km of new double track railway;
- The 9 major German unification VHST projects underway at present have a total length of 1,957 km or an average length of about 220-km each. This is considerably shorter than any Australian intercapital route including Sydney to Canberra. This $32 billion investment is over a 14-year period to 2005;
- The now abandoned 300 km Berlin to Hamburg MagLev VHST, using Transrapid technology, was planned to be constructed in 6 years from 1999 following on from 5 years of planning and Governmental processes;
- In California, the proposed AUD $48 billion, 1125-km high-speed rail system is planned to be delivered over a 16-year program. Of this the first 6 years are dedicated to the further concept planning and EIS processes.

Project creation rates vary significantly as the above shows due to influences such as:

- Planning and approval processes;
- Policy management within Governments;
- Environmental management issues
- The degree of difficulty of the terrain;
- The extent to which existing rail traffic must be accommodated;
- The degree of public & political support; and
- The proportion of the line in tunnel or on viaduct.

While the above projects suggest an overall broad range from 30 km to 140 km of dedicated new VHST alignment creation per annum, a tighter range is from 50 to 70 km per annum of project development life.

This suggests a project delivery time for Sydney to either Melbourne or Brisbane in the range 10 to 20 years. Clearly, these projects could run concurrently if funding was available. On present estimates, the demand on funds would be anywhere between about $1-$2 billion per annum over the planning, design and construction of the project.

Staging

Clearly, an EC VHST could be built in stages, as has the National Highway dual carriageway freeway program between Sydney and Melbourne. However, that project is still uncompleted after over 20 years. Sydney- Newcastle Freeway project took at least 30 years and the Sydney entry is still not complete nor is there a freeway standard alignment into Newcastle itself. The upgrading of the Pacific Highway between Sydney and Brisbane is ongoing, with it expected to take at least another 10-15 years before there is continuous dual carriageway.

Railways are not functionally the same as road systems. Road improvements can be implemented progressively and as such deliver incremental benefits to road users in terms of travel time, operating and fuel saving. While obviously rail alignments can also be progressively improved, without complete city centre to centre stages in place, capturing viable numbers of patrons will likely prove difficult. As a result, the time taken to achieve operating cost recovery, let alone capital investment recovery, could be very extended. Consequently, it seems likely that staging will need to be on longer sectors than has been possible in Europe, if a wholly dedicated VHST system is to be created. For example, possible sector stages for an EC VHST that link major cities in the East Coast corridors, having the potential to generate significant traffic in their own right might be:

- Melbourne – Albury (~300 km);
- Canberra – Sydney (whether or not via Wollongong)(~300 km);
- Sydney – Newcastle(~150 km); and
- Brisbane – Grafton via Coolangatta(~395 km).

While staging is advantageous from a project affordability perspective, it creates some special issues. Unlike France, Australia does not have a single national operator of long distance passenger rail transport that can plan and create new VHST services, as SNCF has done. Furthermore, all the SNCF TGV services radiate from Paris and are therefore centralized. The practicality of these Australian staged sectors being operated by a single entity is questionable given the separation of the sectors. It is conceivable that these sectors could initially be operated as entirely separate business enterprises. Clearly, this would be dependent on the extent to which there is a political and/or service imperative, whether commercial or not, to commence intercapital services from the outset.

To this extent, the geography and disposition of the VHST lines in Japan provides a more comparable model. Japan is a linear country with a continuous VHST system extending over 1700 km from Fukuoka in southwest through Tokyo to Morioka in the northeast. The splitting of JNR in to three separate operating companies - each with its own geographic limits and each of which operates a variety of long distance, regional services and local services - has parallels with the situation on the East Coast of Australia, where presently there are three principal operators:

- The State owned Queensland Rail in the north
- The State owned State Rail of NSW in the centre; and
- National Express - the franchised private sector long-distance passenger operator in Victoria.

It must be noted, however, that all current interstate/inter-capital services are operated by State Rail Authority of NSW (SRA).

These organisations could conceivably become the operators of staged VHST services as noted previously. However, this would be dependent upon the approach to financing these operations if they are not of themselves likely to be commercially viable. As the sponsor and ultimate client for the provision of such services, the Government could call for tenders for an operating franchise. This would follow the model of the United Kingdom where railway operators bid competitively for a government subsidy to operate services on a particular rail corridor. That is, tendered the amount that they would require the government to pay on an annual basis to fund the business above and beyond the farebox revenue.

The above organizations would be possible candidates but it likely that there would be several more from the private sector given the experience of the Sydney – Canberra Project and the outsourcing of a number of other passenger rail services around Australia and internationally.

Clearly, there would be a similar number of potential operators who would be prepared to bid to operate inter-capital services under similar commercial conditions, whether or not a fully complete VHST alignment had been constructed.

A key issue for private operators and their financiers, however, is likely to be the possibility of competitors operating in the same corridor and providing services to the same market. This could arise if initially an operator was awarded a stage such as Sydney-Canberra but as the system was extended other operators were also awarded operating rights. The Governments would need to have a clearly enunciated policy on this issue if private investment is to be attracted.



Photo courtesy of Arup

10.3 Creating an Operating Entity

As noted, internationally, there are virtually no VHST projects that have proven viable to develop without considerable government support. The nature of public – private partnership financing and project delivery arrangements requires careful consideration to ensure that each part bears its appropriate risks and responsibilities. Those projects that have been created and have been proposed provide useful benchmarks, so that the realities of public sector involvement become clear to the Commonwealth.

Determining the answer to the question of who could and should be the entity (ies) which would plan, specify, design, finance, construct and, most importantly operate a VHST system, which covers the 2000km from Melbourne to Brisbane, will become fundamental if the Government moves forward on this project.

The previous competition for the Sydney-Canberra VHST was to a large extent driven by competing rolling stock or technology manufacturers in alliance with civil engineering contractors not by organizations which really wanted to be the long term owner and or operator of the system. Had Government proceeded, it was effectively "buying" a package deal and could not gain the benefit of going to the market for the competitive tendering on some very large components e.g. rolling stock

On the other hand, if the Governments determine to develop the project on an essentially a public sector basis and take the lead in the proving up phase, to define what is basically wanted and what it itself is prepared to invest in, then it can take advantage of the fact that;

- There are several manufacturers who can deliver proven VHST technologies;
- There will then be many organizations which can finance the project;
- There are many contractors who can design and build the required infrastructure. and
- There are fewer but still several organizations that could operate a VHST.

In this case, the Commonwealth in collaboration with the States could create an "East Coast High Speed Rail Corporation" i.e. a public sector business enterprise. In this model, Government could still involve the private sector in large components of delivering the project and operating the system where the risks and rewards are suitably allocated, in one of the delivery forms outlined previously.

An EC VHST project/system should be seen in the context of an operating business enterprise, not as an infrastructure construction or rolling stock delivery project – not withstanding that these are very major investments.

In the long term, assuming that the initial capital investment has created an enduring asset, the financial viability of the system is grounded in the operations and maintenance of the system. Operations and maintenance is the long-term core business of a VHST enterprise and need to be in the hands of a competent corporate entity. This will involve decisions and actions about such matters:

- How the entity is set up in terms of debt and equity;
- Who owns it – government or private interests or some hybrid;
- Its revenue generating capacity;
- its corporate goals;
- Its service providing activities – i.e. the operation of VHST services;
- Its involvement in ancillary activities such as land development ;
- Employment of a workforce to operate maintain and administer the entity;
- Selection of technology;
- Servicing and maintenance strategy and facilities;
- Customer services and Crewing;
- Enterprise management and administration;
- Pricing strategy and ticketing;

- Scheduling;
- Marketing and business development;
- Labour and staff relations; and
- Negotiating access agreements with providers of existing rail assets and with providers of any new assets.

The Commonwealth and the State Governments have progressively been divesting themselves of owning and operating transport enterprises. However, the scale of an EC VHST undertaking, the magnitude of Government funding needed and the risks involved dictate that they must remain involved, if only as lead investors.

If the Commonwealth should determine that it wished to have an EC VHST put in place, it would have the choice as to the extent to which it insourced or outsourced the operation of services. There are now several private passenger rail operators in Australia and for a project of this scale several international operators who would be likely to be interested.

On the basis that the creation of the infrastructure and the operation of the service were to be divorced, a call for bids to operate the service could be made. Such a call would effectively require the private sector to bid against a service performance contract and to offer whether they would require a Government operating subsidy or return a surplus to Government. Such a call could be structured such that the operator and the government share in both the upside and downside of the project.

There is significant precedent for the Governments to create or sustain a business enterprise where it perceived that the national interest is at stake. However, once these are established as viable commercial entities and competent private sector enterprises are available to run them Government can sell them to the private sector. Examples in transport of businesses created by Government and now in private hands are National Rail Corporation; Qantas; ANL; Federal Airports.

By way of example of the scale of this enterprise, a 350 km/h EC VHST system in 2051 would generate the same levels of passenger-km as does JR Central today. Another way to look at it is that an EC VHST in 2051 would have about two/thirds of the income of Qantas in 2001.

Even where Government retains a close "*hands-on role* " in such public enterprises, it always has the power to shape that industry in terms of all the myriad of service providers it requires. The choice always remains open as to what it insources and what it outsources. For example, Government may choose to have the infrastructure delivered by public sector funding and competitive tendering. There are several different ways depending upon the degree to which the design is prescribed and the construction is broken up. Some parts may be suitable for a "finance, design and build" approach. Procurement of the rolling stock would be best done by the entity that is going to operate it. However, selection of the technology will need to be by the organization that plans the system which would appear likely to be the Governments or their agency. For example, as the ultimate owners, the Governments will need to be confident on how easily and reliably high technology equipment needed for an EC VHST can be maintained and replaced.

10.4 Risk Allocation

In developing an EC VHST either in the whole or in parts there will be a need to allocate responsibilities for managing the risks inherent such an undertaking.

Examples of risk categories are, inter alia:

- Inter-governmental relationships
- Project development and strategy;
- System configuration;
- Technology choice;
- System Staging;
- Legislative and Statutory Approvals;
- Land acquisition;
- Design;
- Construction;
- Operations and Maintenance;
- Patronage;
- Access to other public infrastructure;
- Complementary non-VHST system developments;
- Financing – public and private;
- Litigation;
- Public safety;
- Industrial relations;

- Environmental;
- Business climate;
- Technology changes;
- Mode competition; and
- Social and attitudinal changes to VHST as a transport mode.

In structuring an approach to creating an EC VHST or any components of it, the Commonwealth, its State Governments partners and its chosen partners in the private sector will need to have established clear allocation of such matters.

10.5 Business Development Planning

System Plan

A prerequisite would be that an overall system plan be developed at an early stage. Such a plan would establish the standards to which the VHST system would be developed, the sectors in which it would be placed and the rolling stock outline specification and required performance. It is important to understand that rolling stock, power supply and logistical specifications must be an integral part of the overall plan for a VHST system. This is because a railway is a completely contained system whereas development of a highway does not need to incorporate rolling stock specifications and the like.

Staging plan

The staging plan should be developed such that the whole scope of the ultimate project is outlined in order to establish the "big picture" development framework. Once this is established and signed off by the Governments, the sections offering, by way of examples:

- Maximum revenue;
- Best regional development support;
- Maximum integration with and relationship to existing transport systems; or
- Best possibility of private sector involvement.

could be selected and development priorities assigned. From this a staging plan could be established which would direct the way the project is implemented.

Funding Plan

A plan setting out the requirements and mechanisms of funding the project will be required for Government's budgetary purposes and also to determine the availability of private sector funding.

Business and Operating plan

An operating plan defining the service levels in the corridors in which a VHST would operate is needed. This would establish the fleet size, notional timetable and human resources needed to operate services. It would also establish the overall requirement of the business enterprise need to run all or stages of an EC VHST such as the structure of the organization, its leadership and management systems, marketing and business development plan, sources of non-patronage revenue and the like. The business plan would build on the patronage forecasts to develop the financial plan needed to raise debt and equity finance.

10.6 Key Points

- As, prima facie, the project seems non-viable without financial and other support from the Governments, they would need to be the initiators and owners of the project. They will need to create an organization competent to deliver the project however it is structured, staged and operated;
- Project execution is a key risk in any large scale enterprise but given that the Government becomes the financier of last resort any adverse movements in costs or revenues increases the potential direct contribution of Government;
- The sheer size and scale of any proposed EC VHST would require the overall scheme to be broken down with sensible stages to ensure both the financial and physical resources will be available to undertake – this applies regardless of the proportions of private versus public funding;
- The constraints on the private sector mean that they are less likely to efficiently absorb the development risk of such a project;
- It appears more probable that the Governments would have to act as a developer rather than only a facilitator to implement any proposed vision for an EC VSHST;
- There are a variety of mechanisms for public-private sector involvement to directly or indirectly contribute to the funding of the project;
- There is a trade-off between the level of risk borne by the private sector and the level of private sector funding that the project can support;
- Mechanisms that characterise public sector support as a taxable revenue stream may be less desirable as the implicit gross-up required may provide a higher perceived level of contribution than otherwise (notwithstanding the expected recoupment of the gross-up amount in tax receipts);

- Differences between private sector cost-of-capital and discount rates adopted by the public sector may lead to a preference for upfront public sector contributions in exchange for deferred receipts;
- Measures that increase the level of patronage diversion to the project or the certainty of patronage will increase the level of private sector funding that the project could support;
- The minimum realistic time to construct either the Melbourne – Sydney or Sydney – Brisbane sections of an EC VHST, assuming wholly new construction over the majority of the corridor, is ten years with twenty years as an upper limit;
- Funding of at least $1 to $2 billion per annum would be needed to finance this program;
- An EC VHST could be build in stages – the stage lengths would logically correspond to operable sectors e.g. Sydney – Canberra and would be major projects in their own right;
- The project, or any operable subset of it, should be driven from the perspective of the long-term operator. - as a transport business; not from the perspective of the constructor of the infrastructure or the manufacturer of the rolling stock;.
- As the major investors, governments must retain a hands-on role at the top level of decision making in the entity that creates and oversees the operation of an EC VHST in whatever form it takes.



Section 11

Defining the National Interest



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11 DEFINING THE NATIONAL INTEREST

11.1 Introduction

The proposal for an East Coast VHST rail service, which may or may not accommodate freight movements, is being reviewed in a broad context of technological, operational, economic, financial and environmental impacts.

From the outset it has been suggested that such a project would be special because it is, or could be found to be, "in the national interest", the implication being that such projects should be evaluated differently from other or "run-of-the-mill" investment projects.

Politicians, promoters and the public alike speak of the importance of VHSTs to the future of Australia and commonly refer to it as being in the national interest though the metrics by which that criterion can be applied are far from clear.

Two aspects of the concept of national interest need to be considered, being:

- its definition, or the means of determining whether or not a project is in the national interest, this issue being addressed in this Section by discussion of the theoretical issues underlying alternative approaches to the national interest concept, and
- the criteria by which it can be entered into the economic evaluation of projects, the application of this aspect being addressed in Sections 11.10 and 11.14.

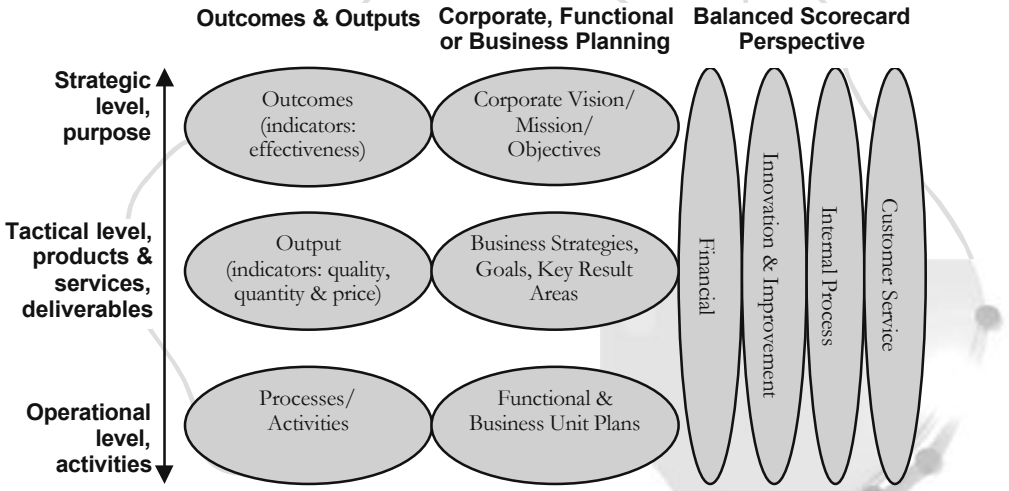
11.2 The National Interest as A Strategic Concern

Unlike a detailed business objective in a corporate planning framework, the national interest must be regarded as a desirable strategic level outcome, or set of outcomes, which could be defined by a mission statement. The Commonwealth Department of Finance and Administration has illustrated the relationship as shown in figure 11.1. Government and the community define the outcomes that are sought; Ministers and Departments attempt to generate the outputs and devise the actions that will achieve those outcomes.

A VHST, however, is not a national goal (or outcome) in itself. It is a means to achieve, or to help to achieve, important national goals. The aim of the analysis in the present report is to establish whether or not an EC VHST could reasonably be put forward as one component of a program of measures designed to achieve broad national interest objectives.

Ideally, the aim must be, to the extent that the information allows, to raise the debate above the level at which the merits of improving long distance passenger rail services in Australia's East Coast region are discussed as a desirable objective in its own right to a level at which it is viewed as a means of helping to create and serve the future that the community and its leaders hope to bring about over the course of the next half century. In a scoping study such as the present one there are limits to the amount of analysis that can be undertaken and hence to the extent to which progress towards this goal can be realised. But the aim of the framework outlined in the following sections is to highlight those aspects of the national interest, or ways of evaluating projects that contribute to national interest goals, which are both most relevant to the role played by a VHST and practicable within the available resources.

Figure 11.1 Department of Finance and Administration Mapping of Outcomes and Outputs to Planning and Balanced Scorecard Systems



Source: Commonwealth Department of Finance and Administration Outcomes and Outputs Framework Guidance Document November 2000.

11.3 Historical Perspective

11.3.1 Case Studies

The notion that some investment projects are different from, and more important than others, is well established in Australia, examination of some cases being illustrative.

Hawkesbury River Rail Bridge

On 1st May 1889 the bridge over the Hawkesbury River was opened, providing for the first time a continuous rail link from west of Adelaide to north of Brisbane, albeit that the journey involved travel over three rail gauges and, as the Sydney Morning Herald observed, the completion of the bridge shortened the journey north of Sydney by only two hours.

Despite those negatives, the practicalities of travel were of great concern to ordinary people and the opening of the bridge was an occasion for national self-congratulation, with a deeply felt confidence that rail links would transform the East Coast of Australia by opening up new areas for development and encouraging migration.

It was opened by Lord Carrington, Governor of NSW, in the presence of representatives from the governments of NSW, Victoria and Queensland and Sir Henry Parkes, premier of NSW, stressed the significance of the event for the unification of Australia and its defining role as a catalyst for political and economic development.

Transcontinental Railways

The construction of the east-west Transcontinental railway, though not completed till 1917, was an absolute condition imposed by the colony of Western Australia for its entry into the federation in 1901. The population of Western Australia at the time was less than 200,000, or 5% of Australia's total, though its mineral wealth was such that it probably could have been viable alone and it is unlikely that anyone would argue that construction of that railway, resulting in Australia's federal structure as it is today, was anything other than a national interest project.

The Northern Territory, by contrast, lacked any political muscle until recent years and the connection of Darwin to the rest of Australia by rail has not been seen as a high priority. Construction of the Alice Springs to Darwin railway is now proceeding and, apart from economic benefits which might result, intangibles such as demonstration of commitment to Asia and development of northern Australia are factors which probably qualify this project as being in the national interest.

Snowy Mountains Scheme

The only peacetime venture in Australia's history with a focus on provision of a single infrastructure project that could be compared to an EC VHST is the Snowy Mountains Scheme. Work started in 1949, during the period of postwar reconstruction and proceeded over a period of 25 years. The Scheme was initiated by the Commonwealth Government, which invoked its defence powers amid debates over the scope and cost of the scheme. The Commonwealth justified its actions on the grounds of nation building, the importance of providing an alternative source of power to the coal-fired powered stations of the coast, and the benefits of irrigating the inland, that being a true Australian vision at the time.

It is unlikely that the Snowy Mountains Scheme, at least in anything like its present form, could be constructed today. It was fully funded by Government and many of its projects would today not be allowed to proceed beyond the EIS stage.

Nevertheless, it could not be argued that the Scheme was anything other than a national interest project. It has provided huge direct economic benefits in the form of hydroelectric power and irrigated agricultural production but, even more significantly, it made a major contribution to the maturing of Australia's national perceptions and aspirations over the period of almost 25 years during which it was implemented.

The Scheme was brilliantly promoted both by governments of the day and by the Authority's founding Chief Commissioner, the engineer Sir William Hudson. Its "can-do" image captured the imagination of the Australian public and the "soft landing" which it provided to the thousands of European migrants who worked on its construction contributed enormously to Australia's later social cohesion.

There are two key differences between the Snowy Scheme and an EC VHST. Firstly, the Snowy Scheme was developed in the isolation of the Australian Alps, whereas an EC VHST would, by necessity, pass through the most densely settled areas of the country. Secondly, in the intervening half-century there have been substantial changes to both Commonwealth and State legislative frameworks affecting all types of development, which would prevent such a unilateral approach.

There are now extensive requirements with regard to planning, environmental, conservation, health & safety, and community consultation, which did not exist in the time of the Snowy Scheme. The impacts of these obligations would be significantly amplified for development of a corridor over a distance of about

1,900 km and the community is increasingly informed of these safeguards and vigilant in ensuring compliance by both government and private agencies.

11.3.2 Conclusion

The conclusions put forward from the above examples are:

- Apart from benefits in conventional economic terms, a national interest project will have some measure of benefit which cannot be readily quantified. Such benefit could be symbolic gestures to international trading partners, defence capability, national unity, social cohesion, or just feelings of convenience and comfort engendered in large numbers of individuals.
- Regardless of the extent of economic and unquantifiable benefits discussed above, a project will not qualify as being in the national interest unless it is widely perceived as such by the public. The citizens, as either customers or taxpayers, are the ones who will eventually pay for the national interest element of a project and the need for them to be informed and supportive is a microcosm of the whole democratic process.



11.4 Contemporary Objectives

11.4.1 Overseas experience

Most of the high-speed rail systems in operation elsewhere in the world have been justified on grounds that go beyond the provision of cost-covering rail services. Almost without exception they have required large subventions from public funds, either to establish the network, as in France, or to cover outstanding debts, as in Japan.

The Japanese Shinkansen network was developed as an alternative to air travel between the main centres of Tokyo and Osaka though with the secondary objective of a growth management strategy designed to encourage the development of other urban centres.

The French TGV system was more focussed on transport needs and less on the spatial reorganisation of activity. The prime consideration was the lowering of transport costs per person/km and increasing the speed of travel for its own sake. A subsidiary aim, quickly recognised, was to encourage the export of French rail equipment with a reputation for technical innovation and proven success.

The German high-speed train project have been directed especially to the improved integration of the German economy, both internally and with neighbouring countries, especially those in Eastern Europe [1]. The emphasis was as much on improved trade links as on the movement of people and, particular attention was paid on many routes to the improvement of the track for high speed freight.

In Italy and Spain the emphasis has been on passenger services and the role of high-speed rail in relation to tourism has been a significant consideration.

At the broader European level, the most important strategic objectives of high speed rail are acknowledged to be twofold:

- European integration, in particular improved links to and the “evening out” of regional disparities with the outlying and less successful regions, such as southern Italy, Portugal, and the countries of Eastern Europe; and

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[1] Najafi, F and Nassar, F. “Comparison of high speed rail and maglev systems” *Jnl of Transportation Engineering*. July 1996, 276-281

- relief to the very over-crowded air services throughout Europe. The aim of relieving air services and airports has been important to many national governments, including France and the United Kingdom, and this trend can be expected to intensify following the terrorist attacks in the USA of September 2001.

Most of the high speed rail projects under consideration in the United States have stressed economic benefits that go beyond simply faster transport links.

The California High Speed Train sponsors noted in particular the relief that a rail service would provide to air services, reducing both direct costs and the costs of air passenger delays. Their conclusion that the project would yield a satisfactory rate of return without the inclusion of more general benefits is noteworthy.

11.4.2 Australian National Interest Objectives

At the broadest level the Commonwealth Department of Transport and Regional Services has indicated that the key objectives of government policy, which are reflected in its approach to the development of rail services, apart from VHST services, include:

- The competitiveness of the Australian economy;
- Industrial and community development;
- Improvements to accessibility for the community at large and individuals;
- Transport safety; and
- Environmental sustainability..[2]

The Hon. Peter Nixon AO, in a Report to the Victorian Government of August 1995 summed up the broad national case for high-speed rail in terms that have been echoed by others, as follows:

"The introduction of a High Speed Train network into Australia must be considered as more than an alternative transport mode to serve existing travel needs. High Speed Train services between Melbourne, Canberra and Sydney would generate significant national, regional and local economic, social and lifestyle benefits. Some of the benefits that could be generated by a High Speed Train service are better utilisation of transport infrastructure; increased international competitiveness of the Melbourne–Sydney region; expansion and better integration of markets for labour, services and products; improved balance of payments; savings in energy, liquid fuels and greenhouse gases and reduction in air pollution and opportunities for regional development, increased employment and improved lifestyles."

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[2] Response of the Federal Government to House of Rep's Standing Committee on Communications, Transport and Microeconomic Reform reports- *Planning not Patching* and *Tracking Australia.* Rail Projects Taskforce report *Revitalizing Rail.* Productivity Commission report *Progress in Rail Reform,* April 2000

11.5 Conventional Economic Evaluation

11.5.1 Introduction

Before the special elements which might define a national interest project can be considered, it is necessary to apply, as far as possible, conventional economic evaluation methodologies as a benchmark.

11.5.2 The scope of conventional economic evaluation

The economic evaluation of major transport investment projects has tended in recent years to include at least the following:

- The benefits to the users of the transport facility;
- The benefits/costs to the users of other transport facilities whose use patterns are changed as a consequence of the new investment;
- The capital, operating and maintenance costs for the facility and any changes in these costs in relation to other transport facilities whose use patterns are changed;
- Other costs and benefits that do not directly affect the users or operators of the facility but impact on other people, such as the costs of accidents, noise and air pollution, greenhouse gas emissions etc; and
- The costs and benefits that are connected with the period of construction, such as disruption to travel or economic activity.

Economic analysis is normally undertaken from a "national" standpoint, counting only increases in economic activity that would not have occurred without the new investment but excluding impacts which involve the transfer of costs and benefits between individuals, groups, or geographical areas.

This principle is fundamental to the economic evaluation of projects and rests on the proposition that equivalent impacts are equal, no matter whom they affect.

The distributional consequences of investment can be described but not evaluated and the weighting of the interests of different people, groups, or areas is a matter of political judgment, albeit with potential controversy, not economic analysis.

Some studies include the benefits of employment creation, both following completion of the project and during its construction. Strictly this should only be admissible if it can be shown that, but for the investment, the level of unused resources would be higher, by way of higher unemployment for instance. In a major metropolitan area this would be implausible, given the diversity of economic activities and investments that are undertaken over time, though the benefit of employment might be real if the construction took place in an area with a history of under-utilised resources or at a time of a macroeconomic downturn.

Others have attempted to capture the macroeconomic "spin-off" benefits from investment in new transport facilities. That there could be such benefits is beyond doubt but the difficulty usually lies with the precision with which such additional economic benefits can be estimated.

What is fundamental to the approach of economic evaluation is that costs and benefits should not be "double-counted". For example, it is wrong to include in any evaluation increases in the value of property arising from investment in transport facilities, where that increase is a consequence of improved accessibility. The improvement to accessibility is evaluated directly through the benefits experienced by transport users. It is a consequence of these benefits that property values change. For example, quicker travel to work may lead to an increase in the value of housing; or more convenient access to a shopping centre may lead to increased custom which in turn is reflected in the value of the land. Most changes in property values are simply the capitalisation of benefits that are separately included within the evaluation framework.

The scope of a conventional economic assessment is therefore "national" in that it:

- Is based on national impacts, ignoring for the most part shifts between areas or groups;
- Incorporates economic effects, such as employment creation or additional development, if and only if there is evidence that, but for the project, the resources would lie idle or the quantum of development would be smaller; and
- Sometimes incorporates estimates of wider macroeconomic impacts based on a macroeconomic assessment of the impact of lower transport costs on the level of output.

11.5.3 Discount Rates[3]

The conventional economic approach to the valuation of future impacts involves the discounting of future costs and benefits relative to those experienced in the present.

Throughout the second half of the last century the real rate of discount (excluding monetary inflation) applied to public investment projects increased steadily in most developed countries..[4]

Two main arguments have been used to explain this rise:

- The need to maintain comparability with investment in the private sector, with the aim of ensuring that capital yields equivalent returns wherever it is invested; and
- The high (and, in the opinion of some, increasing) uncertainty about the "shape" of the future: what the conditions for production and consumption will be like; what new technologies and new tastes or preferences may emerge; unforeseen political and social developments; and so on.

Discount rates primarily embody the following two considerations:

- **The Time preference** of an investor, being the amount of compensation at a future time that the owners of current resources require to renounce the benefit they could derive from their own immediate use of them; and
- **The Risk** C**over** that an investor requires for the uncertainty involved in trading present enjoyment of capital for future gain.

Opportunities for re-investment of returns are a further factor bearing on the evaluation of long-term projects. [5]

In a market economy these influences are reconciled through the capital markets.

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[3] For an extended discussion of the role of discount rates; see Bureau of Transport Economics (BTE) Facts and Furphies in Benefit-Cost Analysis: Transport [Report 100] Canberra 1999.

[4] In the very recent past, there have been some signs of a reconsideration of high real discount rates. Lower discount rates have also been discussed in relation to environmental impacts.

[5] Nijkamp, P and Rouwendal, J "Intergenerational discount rates in long term plan evaluation" Public Finance: Finanaces Publiques 2, 1988, 195-211.

Time preference

It is argued that society's time preference is not limited to the relatively short-term perspectives of those who happen to own and control capital in the private sector. Society is entitled to take a longer term view and indeed needs to do so to ensure its survival and continuing prosperity.

Historical examples highlight the extent to which previous generations accepted the need for "sacrifice" to ensure a better future for succeeding generations.[6]

Some critics go further and point to increasing "greed" as the source of the demand for ever higher real rates of return on investment. In addition to the perception of increasing uncertainty about the future, so it is claimed, the rise in market rates reflects the increasing reluctance of current generations to save. High standards of living have encouraged the view that there is less need to renounce the current enjoyment of resources for the benefit of future generations: future generations will not need a higher standard of living: let them look after their own needs.

According to this line of thinking, the "selfishness" of those who dominate current saving and spending in the private economy of the most developed nations needs to be redressed by a greater altruism in public investment.

Risk

It is argued that risk is a much less significant consideration, and should even be ignored, in relation to "core" public investment projects, including those that are "in the national interest" or intended to be structural in their impact.

The rationale for this view is that such projects are designed to shape the future and indeed to reduce the risk associated with much smaller projects undertaken by other (mainly private sector) players.

The counters to this approach include:

- Systemic, general level risk applies in even the most developed countries;
- Project risk is also real in relation to most public sector projects, even if they are intended to be structural in effect;
- There is even less assurance that long term outcomes will accord with expectations, even if the project is successfully completed; and
- There is very real scope for waste of public resources and the only way to guard against this, where the success of projects are is uncertain, is to require a more rapid rate of return on the investment.

More important perhaps is the difficulty in deciding whether or not a project such as a VHST is truly "structural" in its likely impact on development, in the sense that nation-wide investment in branches of higher education or training could be.

Nonetheless the argument that major public investment can act to reduce risk for other investments is one that does carry some force.

It can further be argued that, to the extent that one objective or outcome of a VHST project would be to reduce emissions of greenhouse gases, there is very little risk involved. It is inevitable that the problems will need to be addressed and, though there may be some uncertainty about the timing of impacts, the anticipation of the problem should greatly outweigh any implied risk.

11.5.4 Moving Beyond Conventional Analysis

It has been argued that the conventional approaches outlined above are inappropriate to the assessment of investment in major public or social capital projects.

Most accounts of major "future-oriented" projects, conceived to be "in the national interest" stress one or other or both of two differences of approach:

- The use of much lower (or even negative) discount rates; and
- The notion that the future is "created" rather than given.

There are four main approaches which go beyond conventional economic evaluation of projects, and by which the benefits of a VHST project to the national interest could be assessed.

These, with the Sections in which they are discussed in detail, are:

- Increasing Real Value over Time; (Section 11.6)
- Alternative Visions of the future; (Section 11.7)
- Extending the scope of the analysis; (Section 11.8)

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[6] The notion of "self-denial" mentioned in the Sydney Morning Herald editorial on the occasion of the opening of the Hawkesbury Rail Bridge exactly captures this approach. Indeed self-denial tends to suggest a negative rate of discount—i.e. the more distant future is more important than the immediate future. See Sydney Morning Herald 2nd May 1889.

- Other social and national considerations. (Section 11.9)

11.6 Increasing Real Value over Time

A different line of thinking about discount rates and their impact on major public investment projects suggests that future benefits tend to be discounted too heavily because insufficient weight is given to the fact that the real value of the assets will increase over time.

The value of "core" projects, those that do in fact have a structural and defining influence on evolving social and economic activity over long periods of time, risk being undervalued if their value in successive years is not reassessed to reflect the increasing productivity of the economy and much higher levels of real wealth.

For example, the loss of community wealth that would be incurred today if Sydney's commuter rail network did not exist is many times larger than the attributable increment of value, even if correctly forecast, assessed as the real value of the component elements in the year of its construction.

More attention, it can be argued therefore, should be paid to assessing the "withdrawal" value of major assets in relation to the likely level of real GDP and real national (or regional) income in future years, lower discount rates being appropriate for projects where the value of benefits can be anticipated to increase to reflect increases in national income and productivity.

11.7 Envisioning and Creating the future

11.7.1 Possible Visions of the Future

Visionary futures differ from standard projections in that they do not presuppose that the investment under investigation will be sufficient to cause the outcome. In this sense they relate to the proposition, which should be taken into account by policymakers, that transport investment alone may be a necessary condition for sub-national economic development but is rarely sufficient.

The vision of the future within which a VHST could play a significant role is the Urban Vision, relating to the spatial organization, distribution of economic activity, and the urban settlement pattern in Australia's East Coast region.

Four population scenarios are explored in this Study under this urban vision, as follows:

- **Scenario A- Base case**:

  This assumes the ABS medium population scenario for 2051; a distribution of population that is proportionately similar to that which currently exists; and a distribution of economic activity that reflects only the changes in the size of the resident population;

- **Scenario B- Urban Future 1**:

  Assumes the same overall population as A but incorporates assumptions about the likely influence of transport investment, in association with other regional development initiatives, on the distribution of population and activity. The changes assumed are those that are likely to result from the EC VHST itself and the continuation of other regional development initiatives;

- **Scenario C- Urban Future 2**:

  Assumes the same overall population but a much more radical spatial redistribution. The key assumptions are:

  a) The proportion of population in the capital cities—especially Sydney and Melbourne—would be restrained;

  b) The population of Canberra would increase substantially;

  c) Population sprawl would be restricted, in areas such as the North Coast and Southern Highlands of NSW and around Canberra particularly; and

  d) Population growth outside the capital cities and Canberra would be concentrated into a discrete set of nodes, where additional economic activity would be encouraged to locate.

- **Scenario D- Urban Future 3**:

  This scenario combines the spatial organization of Urban Future 2 with a substantially increased total population.

The demand projections of section 9 primarily address scenarios A and D.

11.7.2 Evaluating Visions of the Future

(a) Approaches

The evaluation of a specific proposal, such as a VHST, in the context of a broader, visionary future, faces fundamental difficulties.

Inevitably the responses to the issues raised are as varied as the attitudes to this method of formulating plans and policies and questions casting doubts on the value of evaluation include:

- What is involved in getting from now to the future is not clear and cannot therefore be assessed in terms of costs, benefits or implications more generally;
- It is not clear what the visionary future should be compared to;
- What needs to be assessed is the vision as a whole, not simply the component project, and this may involve a very wide range of activities and conditions—for example, the complete reorganisation of the structure of economic activity, patterns of movement, transport utilisation, settlement etc within a region; and
- Assumptions do need to be made about how the outcomes would be achieved.

The uncertainties become less critical if the evaluation of future outcomes is based on low discount rates, allowing the benefits of the "final state" to assume greater significance relative to the costs involved in achieving it.

A more tolerant view would accept as a legitimate evaluation a comparison of "future states" with and without the visionary components. Clearly this is less than a complete evaluation, since it does raise questions about what would be involved in moving to the different futures but it provides a starting point for more detailed investigation of options and approaches.

The simplest approach would admit the legitimacy of a "partial" evaluation of one component of the "future vision" without any attempt to evaluate the vision in toto, in this case the key issue becomes the basis for the comparison.

(b) Base cases

In a conventional economic assessment the future is "given" as a Base Case and the project are fitted into that future, the analysis addressing the difference that the project makes.

Advocates of macro or general equilibrium approaches to economic assessment argue that the future is only partly given and that the project will itself entail significant changes: hence the need for more extensive analysis. But the underlying dynamics of the future are understood.

A thorough evaluation of all that is involved in the future, extending beyond the project under investigation, needs to use a "business-as-usual" projection as the benchmark for comparison though the difficulty of projection of conditions is such that it is likely, or even inevitable, that the demonstrated merits of a visionary future will depend as much on the shortcomings of the projected "business-as-usual" future as on the intrinsic qualities of the alternative.

Where the evaluation is limited to the specific project, rather than the complete future of which it is to be a part, there are two possible bases for comparison:

- The same project set in the context of an alternative future, most likely the "business-as-usual" projection; or
- The visionary future without the projected investment.

The first provides some idea of the extent to which the value of the project is bound up with the realisation of the other (and probably more important) components of the visionary future.

The second would provide an indication of the relevance of the project to the realisation of that future, though this model is the more difficult to achieve.

(c) Non—marginal changes

Economic evaluation is based on the theory that behaviour is a good guide to the relative values that are set on goods and services and changes to their availability.

However, economic theory sets clear limits to the legitimacy of deriving estimates of changes in individual and collective welfare from observations of individual or market responses to changing circumstances.

Where the changes envisaged are not marginal, current behaviour can no longer act as a reliable guide to the changes in welfare, the valuation of benefits in particular.

In the case of a transport project the main measures of achievement (or benefit/disbenefit) are "physical"; consisting of such "things" as time savings or volumes of air pollutants. However, the question of whether or not changes in these quantities will have the same relative valuation at the margin from the perspective of transport users or the population at large or of the impact that such changes might have on the productive economy remains problematical.

Measures transposed from current circumstances and applied to very different futures, whether derived from observed behaviour or from hypothetical inquiries such as choice modelling, may not even provide a sensible ranking of alternatives if the weight attached to different elements of a composite evaluation are different

in the different circumstances of a radically altered future. (To be clear, "sensible" here means sensible from the perspective of those who are going to use the infrastructure in the future and in the very different context that is assumed to be going to apply).

For example, it can speculated that, in the circumstances that applied in 1889 when a trip by rail from Sydney to Brisbane took 35 hours, travellers might have set much greater store by a small improvement in travel time than by a small improvement in comfort. In today's conditions, when the rail trip takes 13 hours but there is a much quicker (albeit very much more expensive) alternative, a small improvement in comfort might be rated more highly, relative to a small improvement in travel time, by those who use the rail services.

It can reasonably be suggested that, as supplies of fossil fuels diminish and awareness of the impact of global climate change becomes more widespread, the weight attached to reductions in morbidity and mortality due to air pollution may increase significantly relative to other components of individual and collective welfare.

11.7.3 Creating the Future

Claims for exceptional treatment for national interest projects are often based on the proposition that it is inconsistent to discount future benefits heavily for public investments whose avowed aim is to create or shape the future.

It is argued that to discount the future is contradictory when the aim of policy is to create a radically different outcome and to do so is to deny the legitimacy of decisions about preferred long term futures. Put the other way round, it is claimed that heavy discounting of the future actually prevents the implementation of any measures that would lead to different outcomes from those currently experienced so that the possibility of a better future is sacrificed to the need to preserve the current patterns of resource use.

The effect of these claims is to justify low, or even negative, rates of discount for designated branches of policy or projects. However, the problems remain that it is not clear how projects should be designed to create new futures or how the value of their outcomes can be determined, whatever approach is adopted to discounting future costs and benefits.

11.8 Extending the Scope of Analysis

11.8.1 Introduction

Significant research has been carried out around the world into the economic development generated by investment in transport infrastructure and the proposition that, If a project cannot be justified solely by conventional economic analysis or on national interest grounds, then it may be possible to point to additional benefits.

This section summarises the findings and positions, as detailed in annexure 1, of the following researchers:

- Bureau of Transport Economics, Australia (BTE);
- Department of Environment Transport and the Regions, UK (UK SACTRA);
- OECD Directorate for Science Technology and Industry (OECD DSTI);
- Quinet, E.- Professeur, École Nationale des Ponts et Chaussées, Paris;
- Aschauer, D;
- Banister, D and Berechman, J;
- Biehl, D;
- Boiteux, M;
- Docwra, G. and West, G;
- Munnell, A.
- Nakamura, H. and Ueda, T;
- Otto, G. and Voss, G;
- Sands, B;
- Scargill, I;
- Vickerman, R;
- Weisbrod, G; and
- Weiss, M.

Quinet has pointed out that the indirect effects of infrastructure is a strongly debated subject which generates divergences of view between public decision-makers, who often foreshadow effects to justify their policy choices, and the scientific analysts, who provide in their turn varied conclusions. The difficulty is understandable because the indirect effects depend on very many specific factors, differ from one case to another, and take a long time to appear.

However, observations have been made from around the world and over a period of many years from which some general conclusions about the economic impacts of high speed rail can be drawn.

In practice, national and regional economic growth are the only significant additional benefits identified by commentators which major transport infrastructure investment projects could generate and which are not identified in conventional economic appraisals.

11.8.2 National economic development

In general, the research suggests that a major transportation project, such as a VHST, could not be justified by the direct benefits, principally reduced transport times and costs alone.

At the micro-economic level, Quinet has referred to the subtle impacts of improved transportation, such as diffusion of innovation and experience, access to a larger variety of services, greater competition between enterprises, and the growth of markets with consequent economies of scale.

However, a micro-economic approach tends to significantly underestimate the total economic value of transportation infrastructure, this being put forward by Aschauer as the reason for the lack of commitment by Unites States federal and state governments to increased funding for transportation services.

From a macro perspective, Aschauer and other researchers have attempted to demonstrate positive links between transport infrastructure on the one hand and private capital investment, productivity of such investment projects, and labour productivity on the other,

The research suggests that macro-economic modeling is most applicable for large-scale projects with significant city/county or larger scale economic impacts and thus may be most appropriate to comparing forms of investment; improved transportation versus education for instance, as suggested by the UK SACTRA.

The most cogent conclusion which can be drawn, particularly from the work of Boitreux and the UK SACTRA,, is that the rate of return of national economic development induced by a major transportaion project cannot be determined in a systematic manner but requires case-by-case analysis of the impacts based on the specific conditions in sectors and areas affected.

11.8.3 Regional impacts

The OECD DSTI has noted that the assessment of the regional impact of transportation developments suffers from the paucity of thorough ex post research. However, most European observers suggest that there is a discernible relationship between investment in transport, VHST in particular, and regional economic development, subject to the following major qualifications:

- The need to distinguish total economic growth from the mere redistribution of activity from one area to another has been noted, by Weisbrod in particular;
- Transport improvements may not benefit the local economy in the area which had been seen as that most in need of support. Transport systems operate in two directions and the ensuing benefits can readily flow to benefit regions already well developed. so that any evaluation needs to take into account the specific activities in each part of a corridor (UK SACTRA, Biehl, Quinet, and Nakamura & Ueda); and
- Quinet, with the general agreement of Vickerman, goes further in noting that:
  - effects are not evenly diffused but are more limited to discrete points of economic activity,
  - effects are, for the most part, limited to a few sectors, notably the “superior tertiary activities” of education, research and business services, as compared to heavy industries, which stand to gain much more from other forms of infrastructure improvement, and
  - Although limited spatially and sectorally, the effects, where they do occur, are typically much larger than those generated by other infrastructure improvements.

The BTE concluded that regional development effects of transport projects are often likely to be small for one or more reasons:

- The project reduces transport costs by only a small proportion;
- Transport costs are not large relative to total production costs or revenues;
- Producers view different modes of transport as poor substitutes;
- Natural constraints limit the development of resource-based industries; and
- Improved transport exposes a region’s industries to greater external competition.

The researchers, the UK SACTRA and the OECD DSTI in particular, most significantly state that regional economic development is seldom achieved through transport investment in isolation. There is a need for a whole range of initiatives covering training, housing, social services etc in order to ensure that spending on regeneration will have the desired effect.

11.8.4 National and Regional Development Policy

The conclusion of the above discussions, as enunciated by Quinet, is that a VHST rail service provides an opportunity for economic development but, for the benefits to be realised, it necessary to know how to seize and utilise the opportunity. Quinet goes on to cite the international experience that, unlike many other types of infrastructure, the indirect effects of a VHST do not appear automatically. The form and significance of its effects on the regions served are closely bound up with the public planning and policy context into which they are inserted.

Governments in many countries are looking to analysts for more inclusive economic and general assessments of transport investments, with an explicit emphasis on economic development impacts.

Such international experience and the realities of Australian conditions lead to the conclusions that government would have to involved in some form in implementation of a VHST.

Quinet also points out that public agencies are increasingly in the process of approximating private business, whether as operators of transport or as the planners and developers of space, and the structures of those public agencies continue to be modified. The European experience is that coordination of the agencies with responsibilities for national and regional development is essential for the economic effectiveness of high-speed rail.

Policymaking is identified by several researchers as the crucial factor in realizing economic growth benefits from a transportation infrastructure investment, Banister and Berechman identifying three sets of necessary conditions:

- the type of investment: mode, scale, location, links to other networks etc;
- the economic conditions that relate to activities in the corridor: the scope for agglomeration economies, labour market externalities, and network economies or the pre-existence of spatially-related inefficiencies; and
- including the organization of agencies and the involvement of government at different levels.

11.9 Other Considerations

Various other considerations have been suggested that might give to a major project a special national interest status.

11.9.1 Defence

The possible use of transport infrastructure in defence of the nation was significant when the first rail link was opened between Adelaide and Brisbane in 1889 and underpinned much of the expenditure on the inter-state highway system an EC VHST would appear to have little significance in Australia's current defense requirements.

11.9.2 Exports

Measures that would specifically assist exports (including import substitution) or that would assist capital inflow might be given additional weight in the planning of public expenditure. [7]

Exports and capital inflow could be assisted by a variety of outcomes, for example:

- Enhanced image of Australia which might help to attract capital and would encourage tourism;
- Specific tourist benefits flowing from the new opportunities for travel and time budgeting opened up by high speed rail travel;
- Opportunities to exploit natural resources more economically; and
- Opportunities to attract and foster new export-oriented industries.

To the extent that a credible link could be established with tourism or other export-generating activities, additional weight might be given to the anticipated benefits of rail investment. However, it would be important to determine that the impacts were additional. The diversion, for example, of tourists from air services

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[7] BTE *op. cit.* 1999 p.182 has pointed out, however, that measures designed to assist exports can also have negative consequences.

to rail would benefit Australia only if a consequence was additional tourist numbers or higher expenditure per head.

11.9.3 Innovation

Innovation, based on research and development, could be stimulated if one effect of the introduction of high speed travel was to open up the possibility of research centres in attractive locations. These centres could be newly-created—for example, on the New South Wales coast—or could be based on the expansion of an existing centre with suitable intellectual infrastructure in place—for example, Canberra.

The failure of the Japanese-inspired concept of the Multi-Function Polis has encouraged skepticism about the viability of such developments. though it can be argued that one reason for the failure of the Multi-Function Polis was the inappropriate choice of location and the poor communications, particularly to other centers of research and knowledge in Australia. There are grounds for believing that research-based enterprises do look for distinct locations with high environmental quality, lower costs than the major cities, and good external communications. Sophia Antipolis in southern France remains a prime example.



11.10 Comparative Experience

There have been very many attempts to evaluate the impact and benefit of high speed train projects world-wide though most have been ex ante evaluations and there is very little authoritative ex post study data available.

One of the most comprehensive ex-ante analysis at a national level has been that undertaken by the US Department of Transportation – Federal Railroad Administration (FRA) titled "High Speed Ground Transportation for America" (September 1997). The aim of this report was to examine "the economics of bringing high speed ground transportation to well-populated groups of cities throughout the United States (refer also to section 2).

This report sets out the basis for pursing very high-speed trains in the United States thus *"HSGT (High Speed Ground Transportation) activity in the United States will only occur because of pressing transportation needs. As travel demand grows, intercity transportation by air and auto increasingly suffers from congestion and delay, particularly within metropolitan areas; at and surrounding airports; and during weekend, holiday and bad weather periods. This declining quality of service adversely affects intercity travellers, other transport system users, carriers and the general public"*.

The approach adopted by the FRA took the perspective that *"intercity transport is a joint product of private and public investments"* and that *"every means of intercity transport in this country represents an implicit or explicit private public partnership that – while incorporating user financing in large measure – also demonstrates governmental support and involvement"*

FRA examined the potential of technologies ranging from 90 mph (160 km/h) non-electric traction to 300 mph (540 km/h) MagLev for 8 major corridors across the USA.

The principal indicator adopted in the report of the aggregate financial and economic impacts of the VHST alternatives in the various corridors was that of "Partnership Potential". The report is careful to note that while partnership potential may act as a broad gauge of the attractiveness of a project it does not address the projects advisability, equity or worth from a public policy perspective nor its practicability from a financing perspective. More particularly, FRA states that such potential does not provide an express or implied criterion for Federal Funding or approval.

The key characteristics of Partnership Potential are:

- Public Investment – the total benefits of a VHST corridor must equal or exceed its total costs;
- Private investment – the VHST system must be a completely self-sustaining (i.e. no operating subsidies) -business enterprise, once the infrastructure is built and paid for. This includes all continuing expense in operating cost, maintenance and replacement of equipment.

In FRA's assessment for the public's investment the following types of costs and benefits were included:

- User Benefits
  - System Revenues; and
  - User Benefits (Consumer Surplus).
- Public Benefits
  - Airport congestion delays;
  - Highway congestion delays; and
  - Emission savings.
- Total costs
  - Initial investment;
  - Operating and Maintenance costs; and
  - Whole of life investments.

These factors were drawn from a wider range of factors and satisfied four criteria relevant to the national level – that they were immediately quantifiable in a study of this scale, moneterizable, not duplicative, and not a transfer cost or benefit.

Factors that did not meet all four criteria included:

- Airport investment deferrals (duplicative);
- Highway investment deferrals (duplicative);
- Commuter rail efficiency benefits (not quantifiable or moneterizable);
- Transport safety improvements(not quantifiable or moneterizable);
- Construction effects (transfer benefit);
- Operations effects (transfer benefit);
- Station development effects (transfer benefit);
- Growth of US VHST industry (not quantifiable or moneterizable);
- Environmental and energy factors including noise, water quality, land consumption, community disruption, endangered species habitat, wetlands. (not quantifiable or moneterizable); and
- Energy Savings (duplicative).

FRA adopted a split approach to discount rates using real rates of 10% for the private sector component i.e. the operation of the system and service and 7% for the publicly funded infrastructure component and all benefit based on the US Office of Management and Budget criteria.

The key findings from the FRA's study were, inter alia:

- The success of VHST "calls for the highest concentration of traffic and revenue over as few route miles as possible, so as to raise the travel volumes and lower unit costs";
- In no corridor was VHST commercially feasible by covering both its capital and operating costs but in most cases it could cover its operating costs without subsidies and some could recover a portion of their capital costs. Of significance was the finding that this coincided with the HST rail upgrade cases rather than the true VHST cases;
- 350 km/h and MagLev were found to have Partnership Potential in several corridors; and
- in most corridors it was demonstrated that total costs would exceed benefits across the spectrum of technologies.

In regard to the latter, the FRA commented that *"transfer effects, mobility concerns and environmental factors may justify further consideration"*, noting that other costs and benefits might be quantifiable in a detailed analysis. Implicit in this statement also seems to be the notion that decisions to consider VHST can be made beyond the indications of conventional cost benefit assessment – i.e. on the basis of some form of the national or state interest.

In an application of the FRA's approach, the California High Speed Rail Commission also included assessments of aircraft operating cost savings and reductions in highway accidents. Their assessment did not include the consumer surplus from express commuter services, high speed freight and benefits to users of the existing system, the data being regarded as not of investment quality. The economics of the project were assessed on a discount rate of 4% but returned an internal rate of return of 8.8%. Factors not included to avoid double counting included redevelopment around stations, construction stage economic effects and freight revenues. They also chose not to quantify other benefits including, inter alia:

- "a major transport capacity improvement that can be tapped by future generations in ways as yet unimagined" pointing to mobility, connectivity, economic vitality and freedom of movement of goods and services;

- stability through diversity of transport systems in case of natural disasters eg earthquakes, floods and climatic problems (fog);
- reduced dependence of liquid fossil fuels;
- strengthening of urban centres and compact development at stations; and
- promoting California's technology leadership image.

Clearly such goals transcend conventional cost benefit analysis and are in the domain of the "national interest", which can ultimately only be determined by the political process.

11.11 Assessment of Projects "in the National Interest"

11.11.1 Strategic goals

The possibility of constructing a VHST to link the capital cities of Australia's East Coast, bringing up to date the vision of the founders of Federation of more than a century ago, has been linked to a number of broader strategic goals.

Such goals exist at both the national and the state level. and cover matters of central concern in the formulation of national, environmental and regional policy, including:

- Reducing Australia's dependence in transport on liquid fuels;
- Relieving pressures on airports;
- Reducing the need for road investment;
- Achieving compliance with international obligations in respect of greenhouse gas emissions;
- Improving equity of access from regional Australia to capital city services;
- Stimulating regional development; and
- Restructuring patterns of settlement in the East Cost corridor.

Goals of this nature are often difficult to quantify and even more difficult to express wholly in economic or money terms. It is also important to separate out those that overlap or that involve transfers of costs and benefits which may not be to the benefit of the national as a whole.

To the extent that the construction of an EC VHST can be linked positively to the achievement of such objectives it will clearly deserve serious consideration, even if on narrow and more conventional economic criteria it rates less highly.

However, before goals such as these can be claimed as significant reasons for developing a high speed rail network, three questions must be addressed:

- Are these objectives themselves clearly articulated and is there evidence of strategic policy formulation independent of the proposal for a rail network? In cases like the control of greenhouse gas emissions and regional development the answer is clearly positive. Other objectives may be less well developed.
- Have these objectives themselves been thoroughly evaluated and has the national interest been clearly defined? Once again regional development, which has been the object of very many studies and initiatives, provides a good example of policy area which is well articulated and into which the proposal for a VHST could be fitted.
- Is the contribution that a VHST could make to the achievement of these objectives the most cost effective and efficient way of addressing the issues? If there are other preferable ways of achieving national goals, then it would be wrong to claim that on these grounds a VHST would make a significant contribution to serving the national interest.

In the last resort, however, it is for the community as a whole and its leaders to decide how much weight should be given to these considerations in supporting a proposal for a High Speed Rail link. The role of analysis is to identify as clearly as possible the impact that a VHST could be expected to achieve.

11.11.2 The approach of the current study and conclusions

The approach adopted in performance of this scoping study has been to:

- identify issues of national concern to which a VHST might contribute;
- explore the possible links between a VHST and these issues, with particular emphasis on the location of population and employment and on regional development impacts; and
- undertake a preliminary assessment of the transport costs and user benefits associated with the project.

At the most straightforward level a VHST is a transport project. It must be assessed as such to determine the extent of the benefits that it could generate for users and the impacts that its operations might have on others, for example through increasing air pollution or transport-generated noise levels.

These issues can be covered by conventional economic cost benefit analysis and the procedures normally applied to the environmental and social assessment of project impacts.

But this is only the beginning and, of the other economic considerations that have been raised in discussion, some appear more worthy of detailed analysis than others.

Most analysis believe, for example, that there are very unlikely to be significant macroeconomic benefits (at the national level) arising from a transport project, however large, that is limited to passenger movements and serves only a small number of discrete localities.

On the other hand, there may be some regional development benefits. Experience elsewhere suggests that these are likely to be limited to the effects of the relocation of certain service activities – particularly those relating to selected business services, research, consultancy and education – and to the economic growth induced by additional tourism, by the extension of commuting areas around the major cities (although ex-urban commuting may also generate problems) and by the greater inducement for the elderly to relocate to non-metropolitan centres.

In the case of regional impacts, however, it is clear that some, if not all, would merely constitute a spatial redistribution of activity that would, in the absence of the VHST, occur in some other location. This would normally be considered a transfer benefit and not included in support of the VHST.

Whether or not such trends would be in the national interest is an issue that will need very careful consideration by policy makers. It goes beyond an economic evaluation.

Some have argued that any redistribution of the future growth of activity away from the capital cities is desirable on social and environmental grounds. It could serve to reduce pollution, reduce the pressure on the housing markets, improve housing affordability, reduce the rate of increase of traffic and road congestion and halt the loss of areas of high environmental value and the pressure on water supplies. On the other hand, others have pointed to the dangers of spreading urban development into areas which have not been heavily urbanised to date and to the potential for the loss of the economic “benefits of agglomeration” which the capital cities currently contribute to the national wealth.

Some of the redistribution moreover may come from other regional and rural areas. There may inevitably be some conflict between the interests of different regions. In these instances the national interest will need very careful consideration.

At the broader strategic level there are indications that an EC VHST might play a positive role in the achievement of other national objectives. It could help to reduce greenhouse gas emissions. It might pay a role as an alternative to air transport. There are other possibilities.

Where there are such links, it will be important to move from the initial scoping of the VHST project to a more detailed analysis of the different ways that these broader national interest policies could be implemented, with and without the VHST, to obtain a clear idea of the role that an EC VHST might play.

The approach adopted in this study is therefore limited to the identification of impacts that would be associated with a VHST. The main impacts that might be regarded as relevant to the national interest, identified in this report, include:

- Shifts in the location of population and employment and stimulus to the process of regional development;’
- Changes in the contribution of the different modes of transport to the long distance travel needs on Australia’s East Coast; and
- Improved scope for reducing greenhouse gas emissions.

Positive impacts in relation to these issues would constitute a major part of the case for an EC VHST over and above the straightforward benefits for transport users that the project may generate. They could help to move the assessment of the VHST from the conventional arena of transport improvement to the broader canvas of the national interest.

11.12 Key Points

- The "national interest", unlike economic value or defence capability, is not something that can be objectively specified, measured or analysed by professional analysts;
- Ultimately, the national interest can only be assessed by the community as a whole, in response to policy frameworks devised by political leaders. The decision as to whether or not an EC VHST would be a worthwhile investment is one for the public, on the basis of terms enunciated by those political leaders. The project will not be successful unless it is “sold” to the public and large numbers of people see it as relevant to them and commit themselves to using it;

- Project justification on national interest grounds has a long and successful history in Australia, though the most significant examples were in times of different forms of economic activity to those applying today and without the alternatives applying at present to a VHST project;
- International VHSTs have been justified on grounds beyond those of a cost covering rail service;
- The fundamental principle in conventional economic assessment is that equivalent impacts are treated equally no matter who they affect. If projects are to be justified on other than conventional principles then they must have other identifiable benefits which are not normally captured in conventional analysis but yet are apparent;
- Projects such as those deemed to be 'national 'interest' whose purpose is to create the future should not have their future benefits heavily discounted;
- While there is a body of evidence that points to a relationship between VHSTs and local/regional economic growth, such transport project investment is a necessary but not sufficient condition for regional development;
- Economic benefits of 'national interest 'projects cannot be realised in a policy vacuum.



Section 12

Regional Development



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12 REGIONAL DEVELOPMENT IMPACTS OF VERY HIGH SPEED TRAIN SYSTEMS

12.1 Context

The aggregate of interests of regions is a major element of the national interest, the possible impacts of development of a VHST system at such a macro-economic being discussed in section 2.

This section 12 investigates possible regional impacts of issues at a more detailed level while possible specific impacts on fifteen East Coast regions through which a VHST could operate are set out in section 13.

12.2 Regional Aspirations

Regional Australia has enthusiastically embraced the concept of VHST projects. With barely an exception, local government areas outside capitals and regional cities along possible corridors have actively promoted themselves to proponents of VHST projects as candidate stopping points. All point to international experience and see their own economic future as being dependent on having better/enhanced transport links to the state capital or major city. All fear the effect of not being effectively linked, particularly where another neighbouring centre might be. These enthusiasms and fears were demonstrated during the Sydney – Canberra VHST competition as a scan of the contemporary regional press reports clearly shows.

Proponents of VHST projects in Australia have drawn on international experience and have attempted to extrapolate it to the Australian context as a rationale for Government to support such projects.

However, enthusiasm must be tempered by the reality that improved transport links will not alone deliver prosperity to a region. That outcome requires, firstly, a base of resources or attractions available for developments and, secondly, policies, clear objectives and skills which can be mobilised to capitalise on the opportunities offered by the improved transport.

The OECD Expert Group on the Effects of Transport Infrastructure on Regional and/or Peripheral Development [1] has highlighted this condition by stating that the

"belief that transport infrastructure projects have significant impacts on the development of regional economies" has often been used to justify projects, however, the clear meaning of these impacts or methods to evaluate impacts "has yet to be established."

The OECD report goes on to conclude that:

"a clear objective for an infrastructure project concerning regional development, including the context and specific strategic needs of the region is necessary. Further, these objectives should also include their relationship to other policies, sectors and tiers of government and the impacts of the project should be evaluated against these broader objectives"

12.3 International Experience

The OECD Study cited in Section 12.2 noted that only a very small number of ex-post evaluation studies with analysis of the broader impacts of investment in transport infrastructure have been completed.

Nevertheless, the available ex-post research on regions serviced by VHST indicates that significant economic changes have taken place, although not all such changes have been beneficial and the causes and effects between introduction of the VHST and the changes are not always established.

Dames and Moore (1989) concluded that regional development does not necessarily follow after the development of a rail system. For example, in the US, over $6 billion was spent on rail reinvestment, but regional development along the corridor was found to be largely as a result of local community efforts. Regional development requires an economic basis, as transport links tend to follow development, not vice versa. Private investment, government and community support are all necessary along with rail investment to promote regional growth.[2]

In France, the TGV stations located in the heart of cities have exercised positive effects on the modernisation of the surroundings. For instance, in the town of Le Mans, a premium office complex has been built with new residential buildings in the city centre. In Lille, where the Eurostar and the TGV arrive at the station in the centre of the city, an international business centre was built at the station. [3]

The Pasteur Station has attracted real estate development and refurbishment of the neighbourhood. Commercially, the value of land in regions of population

[1] OECD- IM2 Working Group. Impact of Transport Infrastructure on Regional Development, Draft Report- 2001

[2] King, Jenny, 1996, Economic Significance of High Speed Rail

[3] Decourriere, Francis, The indirect impact of high-speed rail on regional development

growth on the rail line increased by 67 per cent, while the increase was only 42 per cent in regions not served by the rail line.[4] High-speed trains have been shown to contribute to the growth of the service sector and business-related tourism.[5] The number of transactions relating to services was higher than those relating to products, the purchasing or selling of services rising from 15% to 21%. King (1996) concludes that the TGV did not serve as the central reason for the movement of industries in France though the high-speed rail infrastructure stimulates economic growth near the stations.[6]

Based on the findings and case studies of a number of VHST studies, the indications are the following elements would be required, in addition to the improved transport links, to achieve business growth within a regional centre:

- Regional economic stability;
- Coordinated planning of mixed-use development within or near the station complex;
- Design of aesthetically pleasing rail infrastructure presenting a commercial image;
- Economic strength of community: access to a well-trained and educated workforce, and presence of service firms and industry support[7];
- Links with key towns and airports;
- Proximity to markets; and
- Public-sector 'industry assistance';[8]

High-speed trains in France have had an impact on the tourist industry, with an overall decrease in the number of overnight stays as more day-return journeys were possible. However, there was a development of tourist packages using the TGV and, although there was a decrease of hotel stays in big cities, there was an increase of hotel stays in small cities, such as Abbaye of Fontenay, which is 5 km away from Lyon.

The Shinkansen in Japan also serves as a model for regional development with the introduction of a high-speed rail. The average annual population growth rate in Japan was 1%, while the rate for cities at which the Shinkansen stopped was 1.6%. Increases in population were also noted in municipalities near a city with a station.

There were also substantial increases in the number of employees employed in banking services, real estate agencies and some other service businesses such as research and development, higher education and political institutes, collectively called the "information exchange industries". It was concluded that the impact of the rail line was less significant in regions where commodity industries, such as agriculture or manufacturing, were dominant.[9]

Japanese cities serviced by the Shinkansen experienced 16 to 34% higher growth in retail, industrial and wholesale activities than those cities not served by the train by allowing regional centre based businesses to conduct sales and marketing in the major metropolitan areas. A high-speed rail station in a city attracted business interests and development, including high technology industry and finance and insurance institutions though direct access to information services and educational institutions was also a requirement for such entities. In regional centres with a high-speed rail station, new development was concentrated near the station with vacant former-industrial sites experiencing high rates of development.[10]

Specific examples of the influence on urban development of high-speed rail are cited for the cities of Kakegawa[11] and Anjo, Kariya & Chiryu.[12]

The six prefectures of Tokyo experienced an increase in the number of tourists following opening of the Shinkansen and, specifically, the Jate Prefecture increased tourist numbers from 20 million in 1976 to more than 30 million in 1985.[13]

12.4 Studies of Australian VHST projects

12.4.1. Sydney Canberra VHST

The most recently proposed VHST project in Australia, was that planned to run between Sydney and Canberra. According to reports commissioned in relation to that project [14], the VHST would provide regional centres with readily available

[4] King, Jenny, op. cit.
[5] Decourriere, Francis, op. cit.
[6] King, Jenny, op. cit.
[7] Marvin and Graham, 1996; Hicks and Nivin, 2000; Gillespie, Coombes and Raybould, 1994 and Newlands and Ward (1998).
[8] ibid
[9] King, Jenny, op. cit.
[10] Marvin and Graham et al. op.cit.
[11] King, Jenny, op. cit.
[12] Tanaka, Hiromasa, The socio-economic effects of the Tokaido Shinkansen
[13] King, Jenny, op. cit.
[14] For example see The Allen Consulting Group, Accelerating Regional Renewal: Lessons from Europe About High Speed Rail and Regional Redevelopment, September 1999 and State Chamber of

access to business services, specialised labour skills and gateway facilities in Sydney. Furthermore, these reports also suggested that, due to increased metropolitan access, investment within the regional centres of Canberra and Wollongong would be enhanced and their economies would eventually fuse into that of greater Sydney.

These regions were predicted to have potential for export sales to Sydney and other regions and, in the case of the Illawarra Region, for generation of service employment created by population dispersal from Sydney.

12.4.2 1990 Very Fast Train Report

In 1990, the National Institute of Economic and Industry Research (NIEIR) examined the economic impact of the construction and operational phases of alternative VFT routes on Victoria. The two routes proposed were the inland route via Albury and the coastal route via Gippsland.

That proposal differed fundamentally from the subject of this Study in that it addressed a joint passenger/freight service.

The main findings of the study included:

- the coastal route was predicted to produce a stronger impact on Victorian Gross State Product (GSP) and employment over the construction phase of the project compared to the inland route. On average, NIEIR found that, over the construction phase, Victorian employment would be 5,200 persons higher and total GSP would be $1003 million higher;
- Initially in the operational phase, the inland route was assessed to produce a stronger impact on Victorian GSP and employment over the short term;
- The impact of the VFT on total transport sector activity in the operational phase was not significant;
- The multiplier impact associated with construction expenditure was expected to be stronger for the inland route due to higher concentrations of manufacturing and tertiary activity;
- Post construction, the potential for tourism development in the short term was considered greater in the regions along the inland route. In the long term, the VFT would be likely to stimulate tourism development along both routes;
- In the short-term the impact of the operational stage of the VFT on the decentralisation of manufacturing and tertiary industries would be likely to be more significant along the inland route, given its access to the Hume Highway and its regional private and public infrastructure.[15]

The 1990 *Evaluation of Very High Speed Rail* by the VFT Joint Venture predicted that most of the growth from within regional centres would stem from the expansion and growth of existing industrial and distribution infrastructure. Building and light manufacturing operations along the corridor were predicted to be economically favourable, since they could utilise the VFT as a source of cheap, regular and reliable transport to provide products to Sydney and Melbourne.

Agricultural industry growth was also predicted to occur in the corridor as quality produce could be delivered in prime condition at a premium price. The 1990 report suggested that the VFT had freight opportunities, with a transit time close to airfreight, at an intermediate price level compared to that of airfreight. The VFT Joint Venture suggested that lower costs of transportation would increase the size of the market, therefore creating a more specialised market that is more likely to expand. An increase in specialisation would directly raise the standards of living and create greater incentives for expansion.[16]



Commerce, Getting the Country back on Track: A Study of the impact of Very High Speed Train Systems on regional economies". March 2000.

[15] National Institute of Economic and Industry Research, 1990, *Very Fast Train: Economic Development Effects*.
[16] The VFT Joint Venture, 1989, *VFT: Focus for the Future*.

12.4.3 Victorian HST Proposal

The Victorian Department of Infrastructure (DoI) is currently considering the introduction of four HST (ie 150-200 kph) links in regional Victoria. Nominated benefits of the proposed HSTs would include the widening of employment, investment and educational opportunities in both regional and metropolitan Melbourne areas.

Land development for expansion of satellite and dormitory towns and developments such as retirement villages outside Melbourne were predicted as results of the introduction of HST links

Significantly, the DoI also recognises that the introduction of HST links may produce some negative effects. These negative impacts include:

- Greater retail leakage from regional centres to Melbourne; and
- Stiffer competition for regional business from firms in Melbourne.

It was also noted that, if population were drawn from outlying areas of the State to regional centres served by HST train, the disparity of demand levels and incomes between the "Greater city" and the rest of the state could be exacerbated.[17]

12.5 Regional Development Effects

12.5.1 Population Growth and Migration

A much cited proposition to support the development of a VHST is the effect on population growth in various regional centres in which people may take advantage of a lower cost of living and lifestyle advantages while still commuting to jobs in the city.[18]

This prediction of the future is likely to be oversimplified as it well known that people live in major cities for a broad range of advantages and its realisation is dependent on numerous factors including:

- The availability of social and community infrastructure in the region; and
- Retail and recreational activities.

Such commuter travel is also likely be constrained by its cost, which is likely to be high, in distance terms, relative to suburban rail travel.

On the other hand, any such dispersal of commuters would have multiplier effects, including:

- The increase of population could encourage/generate the construction of more houses in regional areas;
- Population growth in regional centres would facilitate further investment in a wide range of service activities, leading to new businesses and employment; and
- There would be additional household expenditure retailing, wholesaling, construction, leisure and recreation services, cafes and restaurants, health and education services, and a variety of other small scale manufacturing services.[19]

The focal impact of the VHST is that it increases accessibility and mobility. This can potentially generate a range of beneficial population and economic impacts though previous reports have a tendency to overstate these. It can be expected that *'business will migrate to take advantage of lower costs of life and lifestyle opportunities if the conditions in the investment destination are right.'*[20]

It seems that only specific firms, or parts of firms, are likely to relocate to regional centres, particularly production activities and intermediate or back-office tasks such as data, claim processing and call-centres.

This is supported by the finding of numerous authors[21] that structural and technological change is most likely to result in the increasing centralisation of economic power and new industries in a small number of urban centres. This tendency for industry concentration in metropolitan areas also receives additional support from case-studies in France where, for example, a multinational company reportedly decided to locate in Paris, rather than establish a regional office in Nantes –as it was convenient for staff to travel from Nantes to Paris as required.

Case studies from Europe indicate that a VHST may slow or halt a drift of population to major cities though such an effect on population in regional centres appears to be conditional upon the opportunity and quality-of-life factors noted in the Australian studies, with maximum travel times of 1 hour to a major centre.

[17] The Secretary of the Department of Infrastructure and National Express Group (Australia), 2000, *Regional Fast Rail Project.*
[18] The VFT Joint Venture, op. cit.
[19] The Secretary of the Department of Infrastructure and National Express Group (Australia), op. cit.
[20] The Allen Consulting Group, op. cit.
[21] Marvin and Graham et al, op. cit.

A number of studies provide evidence that new investment and higher spending in a region, resulting from the introduction of a VHST, will stimulate job growth. There is evidence from Europe based on econometric studies that the areas serviced by a VHST have higher employment than other areas, varying in proportion to the travel time savings brought by the VHST.

12.5.2 Tourism Development

The literature indicates that a VHST can generate tourism opportunities, subject to the quality of tourism development, connecting travel services and the marketing and promotion of the region. While a number of regions overseas have reported that a VHST can stimulate tourism, the Allen Consulting Group (op cit) notes this increase *'will not happen automatically, even in areas with spectacular tourist attractions'.*

Since Australia's tourist attractions are geographically dispersed, tourists are often limited to the major capital cities and a few selected resort destinations. The tourism industry has expressed the view that, for international tourists in particular, VHST travel from Sydney to Canberra and other Eastern corridor destinations would itself constitute a tourist attraction. The VHST would reportedly directly decrease pressure from Sydney and Melbourne and allow new tourist markets to develop at regional centres along the corridor.[22]

SGS Economics and Planning[23] (1998) concluded that the introduction of a VHST service between Sydney and Melbourne via Canberra and Gippsland would stimulate a significant increase in the number of tourists visiting areas served by the VFT and in visitor nights spent in these areas. It was predicted that by 2007, the VHST would increase the number of visitor nights in Gippsland by about 300,000 p.a. and in the Cooma area by over 200,000 p.a. Over the following three years, it was predicted that the number of visitor nights would increase by 10-12% p.a. until it reached its full potential.

In short, there is both analytical and actual evidence to support the proposition that a VHST can aid tourism.

12.5.3 Summary- Regional Development Effects

Governments in Queensland, Victoria and NSW state that regional development is a priority policy and action area. A number of planning and economic development departments have suggested that increased populations in Melbourne, Brisbane and Sydney is increasing costs of providing public services and that the stimulation of population growth along the VHST corridor is expected to alleviate cost pressures in the cities, easing tax burdens. Any relief of taxes within the business sector would help to improve Australia's international competitiveness.

The introduction of a VHST network can act as a catalyst for regional development, though this is conditional on a number of associated initiatives and also probably on a number of pre-conditions for economic development. Further, it is only able to generate on-going regional development benefits in the regions served by the link, which raises questions for government about the regions that 'miss out'.

The following possible positive effects of the VHST in providing a foundation of strategic regional infrastructure development are:

- An increased demand for goods and services due to population growth;
- Reduction in costs due to faster business travel;
- Business relocation to regional areas as a result of easier access to the metropolitan area; and
- Improved access to the large pool of skilled labour in urban areas, allowing businesses to improve services and expand markets.

On the other hand, negative effects of the VHST on business and regional development could include:

- An increase in escape expenditure; and
- Increased competition from businesses in urban areas to provide services in regional areas.[24]

A VHST with freight capacity, in concert with public sector initiatives aimed at creation of a globally competitive environment, should assist in the expansion of export orientation of regional economies.

12.6 Impacts of VHST on East Coast Metropolitan and Regional Economic Development

It is necessary to progress the above general conclusions to information which might be applied as action plans in the East Coast areas to ensure that opportunities presented by a VHST service could in fact be realised.

[22] The VFT Joint Venture, op. cit.
[23] SGS Economics and Planning, 1998, Regional Impact of a Possible Very High Speed Train Service.
[24] The Secretary of the Department of Infrastructure and National Express Group (Australia), op. cit.

A qualitative review of issues and impacts is set out in section 13. Reference is made in that section to the framework developed by the OECD[25] for evaluation transport infrastructure projects.

Two important insights from that report are:

1. "in developing the case for transport infrastructure proposals, it is essential to specify clearly what it is they are designed to achieve." This is particularly important before the evaluation methodology is selected since different methodologies are available to measure different aspects of economic performance; and
2. Regional development impacts are often broader than conventional economic impacts so that a weighting system or alternate measurement methods may be necessary for a comprehensive evaluation.

Further study objectives which could be appropriate in devising strategies for interfacing to and maximising the benefits of a VHST on particular regions are:

- Identification of specific viable investment sites and development opportunities in the region;
- Identification and support of partnerships to promote opportunities; and
- Creation of supportive policy and actions by government

12.7 Key Points

- VHST projects can act as a catalyst for regional development but not in isolation from appropriate policies and other initiatives;
- VHST projects can assist in increasing population and economic activity in regional centres; and
- Introduction of a VHST service may have negative effects, particularly in areas not in the immediate vicinity of stopping places.



[25] OECD- IM2 Working Group, op. cit.

Section 13

Impacts on EC Development



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13 IMPACTS OF VHST ON EAST COAST METROPOLITAN AND REGIONAL ECONOMIC DEVELOPMENT

13.1 Scope

13.1.1 Overall Impacts of VHST

As derived in section 12, VHST projects can act as a catalyst for local development of the areas served, but not in isolation from other initiatives.

This section sets out the economic development and infrastructure issues, drawn from a range of official sources, confronting fifteen areas of Eastern Australia that could be served by a VHST. The impacts are assessed, in qualitative positive, negative or neutral terms, which a VHST service could have on those issues.

The OECD[1] cites the criteria listed below for assessing the regional development aspects of transport infrastructure projects. "Induced Travel" and "Modal Shift" are specifically addressed in section 9 (Demand) and "Environment" is addressed in preceding sections. The remaining criteria are assessed in this section.

- Direct User Benefits:
  - Travel Time Savings
  - Vehicle Operating Costs
  - Safety
- Wider Effects on the Transport Network:
  - Induced Travel
  - Modal Shift
  - Reliability
  - Quality of Transport Service
- Socio-economic spillovers:
  - Accessibility
  - Employment
  - Efficiency and Output
  - Land-use effect
  - Social inclusion
- Environment:

Caution is required in forecasting the extent to which the effects identified would actually occur as:

- The delineation of many of the areas is somewhat arbitrary,
- The areas are by no means homogeneous,
- The descriptions of the issues and impacts are generally subjective, and
- A VHST service is likely to have, as a maximum, a single stopping place in many of the areas.

The impacts identified therefore cannot be seen as precise or applicable to anywhere other than particular localities served. Nevertheless, they are valuable as a starting point for consideration of regional development initiatives that could be pursued to maximise the development opportunities, which could flow from service of the various areas by a VHST.

13.1.2 Comparative Impacts between VHST Routes

Six areas discussed in this section are "givens" in this Study as being on routes for an East Coast VHST service. They are Brisbane, Hunter, Sydney, Capital Country (Goulburn), Canberra and Melbourne.

The remaining nine areas can be categorised into alternative routes and, in addition to assessing the absolute benefits which a VHST service might generate in all areas, this section addresses the relative merits of those alternatives in terms of prospects for interaction between regional growth and future patronage of a VHST service.

The areas comprising the alternative routes are tabulated below with references to the Clauses in which they are discussed in detail.

[1] OECD – IM2 Working Group, *Impact of Transport Infrastructure on Regional Development*, Paris 2001

Brisbane to Sydney:

INLAND ROUTE	COASTAL ROUTE
New England- North West Region (Cl 13.8)	Moreton Region (Gold Coast) (Cl. 13.9)
	Northern Rivers (Cl. 13.10)
	Mid-North Coast (Cl. 13.11)

Sydney to Canberra:

ILLAWARRA ROUTE	DIRECT ROUTE
Illawarra Region (Cl. 13.12)	-

Canberra to Melbourne

INLAND ROUTE	GIPPSLAND ROUTE
Riverina (Cl. 13.13)	Alpine Region (Cl. 13.15)
North-East Victoria (Strathbogie) (Cl.13.14)	Gippsland (Cl. 13.16)

13.2 Brisbane Metropolitan Area

13.2.1 Area Profile

South East Queensland (SEQ), and Metropolitan Brisbane in particular, are amongst Australia's fastest growing regions and official figures indicate that Brisbane's recent growth is likely to continue. From its current population of about 1.7 million, metropolitan Brisbane is expected to grow to a population of around 2.1 million by 2016, a substantial increase of 25% over 15 years.[2].

In 1996 the key employment sectors by industry in the Brisbane metropolitan area were:

- Wholesale and Retail Trade (52,436 jobs);
- Property and Business Services (44,915 jobs); and
- Community Services (53,293 jobs).

These industry sectors also contained the highest number of business establishments (ABS, 1998).

According to National Economics (1998), key employment growth sectors in metropolitan Brisbane to 2002 are projected to be:

- Transport and Storage;
- Property and Business Services; and
- Utilities (Electricity, Gas and Water).

13.2.2 Key Economic Development and Infrastructure Issues and VHST Impacts – Brisbane

Economic Development and Infrastructure Issues	Impact of VHST
The South-East Queensland (SEQ) region has the largest and most rapidly growing population, labour force and consumer market in Queensland.	A VHST service linking Brisbane has good potential to reinforce this growth.
The Brisbane and SEQ economies are maturing from a traditionally narrow base. There is a receptive new business and investment culture being espoused by governments in the region.	There is moderate potential to create new industry nodes in the precincts and regions around stations. However, this will depend to a degree on the relocation intentions of firms, the business assistance policies of local Councils and State Government as well as local and regional transport and land use planning frameworks. There is good potential to reinforce Brisbane's role as the State's financial and administrative centre. There is moderate potential to attract new industries to the region.
A strength of the area is its Proximity to Asian and Pacific Markets and its potential as an investment location.	The capacity of the VHST to reinforce the region's strategic location is dependent on the focus and outlook adopted by firms and government and the degree to which such a facility would add to the region's 'livability' appeal. Lifestyle and livability are key factors for firms, their managers and staff considering expansion, relocation or start-up. A VHST service, if properly marketed to encourage higher levels of immigration, may help to consolidate Brisbane's status as a capital city strategically located near national and Asia-Pacific markets. Therefore, there is Moderate potential for a VHST to reinforce the region's strategic location.
There are Governance issues – such as the efficient coordination and management of government functions between Brisbane City Council and State Government.	The BCC and State Government are improving and better coordinating their approach to city/region growth and development. A VHST would benefit from a coordinated approach, however, its operation would have Little impact on local governance issues.

[2] Queensland Department of Local Government & Planning; Planning Information and Forecasting Unit (PIFU)

Economic Development and Infrastructure Issues	Impact of VHST
There is a need for additional Employment Land in Brisbane.	The project will have little impact on the provision of additional employment land.
The region has a good Infrastructure Base – including roads, ports, rail and airports.	There is good potential to strengthen the region's infrastructure. It is also Important to create links to other major development nodes such as the Australia Trade Coast area, the Brisbane Airport and the CBD.
The region has a good 'lifestyle image' and high quality of life features.	An area's 'lifestyle' image is dependent on various factors including the availability of essential services and facilities and good access to leisure and employment nodes. There is moderate potential for a VHST to reinforce the region's 'livable' image.
The region has a low risk business environment.	Brisbane has a strong institutional framework and world class infrastructure, which helps to mitigate perceived business risk. A VHST would serve to reinforce this.
There is a lack of technical, professional and knowledge skills in the workforce.	The VHST will have little or no direct impact on skill formation in the region's workforce. However, the project has good potential to facilitate the movement of skilled/knowledge workers from outside the metropolitan area to places of employment in the city. As noted earlier, these workers place a high value an area's quality of life and livability factors. The VHST has moderate potential to improve the area's access to skilled workers.
The region has insufficient business clusters	There is moderate potential to create new industry clusters in the precincts and regions around stations. However, this will also depend on the relocation intentions of firms and other government. support policies such as the implementation of a firm cluster strategy.
There is a weak entrepreneurial culture	The project is likely to have Little direct impact. However, by reinforcing what the region has to offer as an investment (and employment) location (as discussed above), the project may help to attract high quality business owners, managers and staff.

Source for Economic Development and Infrastructure Issues: Strategic Infrastructure for Queensland's Growth, 2000

13.2.3 Conclusion

The indications are that Brisbane is strong on the institutional frameworks which mitigate business risk – an attribute which is shared with most of the rest of Australia, as these frameworks are either national in nature or subject to national 'harmonisation'. Brisbane is also strong on basic infrastructures and livability and a VHST would serve to reinforce these attributes to some degree.

Overall, one might conclude that in the medium term at least the prospects for the Brisbane economy are reasonably good. This assessment is corroborated by a workshop poll undertaken of about 40 property industry leaders by SGS at the Property Council of Australia's "Cities for the New Global Economy" conference held in April 2001.

However, Brisbane's suspected weaknesses on skills and the 'know how' aspects of the competitiveness profile are troubling features that would not be fully addressed by the VHST (though the project may improve the mobility of and access to the 'knowledge workers').

In summary, the positive impacts of the VHST include its potential to facilitate flows of knowledge workers and strengthen economic foundations such as population based growth, good infrastructure and a conducive business culture.

13.3 Hunter Region

13.3.1 Area Profile

In 1996 there were 570,000 people living in the Hunter Region with 83% of the population residing in the Lower Hunter. The fastest growing parts of the region are those areas that offer new economic and lifestyle opportunities such as Lake Macquarie, Port Stephens, Great Lakes and Dungog. Singleton and Maitland are also growing above average, due to economic opportunities in energy, tourism and wine making.

Traditionally, the Hunter is a heavy industrial and resource based region. However, over the past couple of decades the Hunter has undergone a process of transformation. Employment in traditional manufacturing sectors such as Textiles, Clothing and Footwear, Non-metal Mineral Products and Basic Metals has declined.

The region has a strong minerals and energy base, and provides over 80% of NSW's power supplies. The Hunter is one of the world's great coal exporting regions, and sustains world competitive aluminium smelters.

Key employment sectors in the Hunter include:

- Manufacturing;
- Wholesale and Retail Trade; and

- Health and Community Services.

According to National Economics (1998), key employment growth sectors to 2002 are projected to be:

- Transport and Storage;
- Wholesale and Retail Trade;
- Property and Business Services; and
- Arts and Cultural Industries.

13.3.2 Key Economic Development and Infrastructure Issues and VHST Impacts – Hunter

Economic Development and Infrastructure Issues	Impact of VHST
The formation of a new industrial base in the Hunter will mean that transmission lines will need augmentation due to possible additional aluminium smelting capacity at Tomago, development of new industry at Kooragang Island and general load growth in the area.	The VHST will have no impact in this area.
The Newcastle Port Corporation is seeking to diversify into non-bulk general cargo trades, with the development of a multi-purpose terminal. However, efficient container terminals depend on a minimum economic scale, starting at 100,000 container shipments per year. Consequently, the port authority is looking to strengthen its links with regional NSW and to develop an alliance with Melbourne Ports.	A passenger only VHST would have no impact on this situation.
There is inadequate provision of IT&T infrastructure in the region.	The VHST will have no impact in this area.
There is a significant improvement required in rail infrastructure in the Hunter, in particular in terms of improved travel times.	The VHST has a strong potential to improve passenger rail links between the Hunter and other regions.
The Hunter Region is an important transport hub between Sydney, New England North West NSW and northern NSW and Queensland. However, stakeholders in the region have identified a number key road infrastructure projects including: - The Pacific Highway upgrade that will increase opportunities to the north for residential development, tourism and other economic activities. - The New England Highway, which links Newcastle to the Upper Hunter and major regional centres requires significant investment. - The F3 freeway, which links the Hunter to Sydney and which suffers from bottlenecks on the Pacific Highway coming into Sydney.	The VHST has a moderate potential to reduce the number of trips on regional roads by providing an alternative option for commuters.

Source of Economic Development and Infrastructure issues: Regional Activity Profiles (NIEIR, 1996); Economic Development Infrastructure in the Hunter, Illawarra and Western Sydney (National Economics, 2001).

13.3.3 Conclusion

Indications are that the significantly improved commuting times offered by the VHST is likely to attract greater numbers of commuters to the lifestyle benefits of the Hunter region. The VHST also has the capacity to increase visitation and tourism in the region. Additionally, the VHST has the potential to support industry growth and decentralisation through improved links to capital cities and regional centres and access to a larger labour pool.

13.4 Sydney Metropolitan Area

13.4.1 Area Profile

In 1996 there were 3,456,211 people in the Sydney Statistical Division (SSD).

Metropolitan Sydney's key sectors of employment include:

- Wholesale and Retail Trade (303,523 jobs);
- Community Services (262,826 jobs);
- Finance, Property and Business Services (241,166 jobs); and
- Manufacturing (219,133 jobs).

Future growth sectors for Sydney include:

- Finance, Property and Business Services;
- IT&T;
- Health and Community Services; and
- Cultural and Recreation Services.

Sydney is a key driver of the economic performance of the State.

13.4.2 Key Economic Development and Infrastructure Issues and VHST Impacts – Sydney Metropolitan Area

Economic Development and Infrastructure Issues	Impact of VHST
Past reports indicate that Macroeconomic factors are a major force that shape Sydney's competitive environment.	The VHST will have no impact in this area.
Sydney is recognised as Australia's global city. However, Sydney still suffers from low recognition overseas.	By improving the city's strategic infrastructure base, the VHST has good potential to reinforce Sydney's role as global city.
Sydney is the nation's Financial, Property and Business Services Hub.	The VHST has good potential to reinforce this status through the concentration of head offices around station precincts.
Sydney is Australia's recognised IT Hub.	The VHST has moderate potential to reinforce this status. However, this is more dependent on other policies and strategies such as business assistance schemes, taxation policy and government spending on R&D.
There is a lack of a coordinated approach to metropolitan planning. This is evident in the following ways: - There is a job and population growth mismatch. - There are existing policies to encourage urban consolidation. - There has been fragmented development of major centres such as Parramatta and Chatswood.	The VHST presents moderate potential in helping to address some of these issues though it would have no impact on its own.
Sydney is experiencing social polarisation with a mismatch of opportunities and resources between Eastern and Western Sydney.	The VHST presents some potential to address social polarisation if an outer west station was included. However, on its own, the VHST will not address problems of social polarisation in Sydney.
Sydney has a stable economy and has strong government structures.	This feature supports the VHST project.
Sydney is a major domestic and international tourism destination, experiencing strong tourism growth in recent years.	The VHST presents good potential to reinforce this role as a major tourism destination.
There is a significant level of car dependency in the Sydney region.	There is likely to be little impact except for trips to other VHST stations (the fare structure would be important in this regard).
Sydney is a multicultural city.	The VHST is likely to have no impact.
Sydney faces a number of Access and Transport Issues in areas including: - Airport; - Freight; and - Orbital movements.	The VHST is likely to have little or no impact in these areas unless linked to these other development nodes.
Sydney has limited high-tech infrastructure.	The VHST will have no impact.

Economic Development and Infrastructure Issues	Impact of VHST
Sydney has a strong skilled workforce	The VHST has the capacity to reinforce Sydney's role as a centre for knowledge workers through concentration of industry in the station precinct.

Source for Economic Development and Infrastructure Issues – Sydney 2020: The City We Want (PWC, 1998) and Ideas for Sydney's Economy (Spiller Gibbins Swan Pty Ltd and BBC Consulting Planners, 2000)

13.4.3 Conclusion

As discussed in the table above, Sydney is generally a strongly competitive regional economy. Overall, one might conclude that in the medium term at least, the prospects for the Sydney economy are reasonably strong. This assessment is corroborated by a workshop poll of about 40 property industry leaders at the PCA's "Cities for the New Global Economy" conference held in April 2001. The attendees suggested that over the next 10 years Sydney is likely to experience strong GDP growth and increase its proportion of the nation's jobs.

The VHST will provide Sydney with improved links to other capitals and provide further impetus for industry attraction. However, there is likely to be little impact on Sydney's position as a sub-global city unless the VHST is accompanied by other policy and planning changes.

13.5 Capital Country Region

13.5.1 Area Profile

Capital Country is the area of New South Wales surrounding Canberra. Travelling between Sydney to Melbourne via Canberra, drivers on the Hume Highway pass through Capital Country. The region extends from Braidwood to Young and from Marulan to Jugiong. It includes the cities of Queanbeyan and Goulburn and the towns of Crookwell, Yass, Boorowa and Harden.

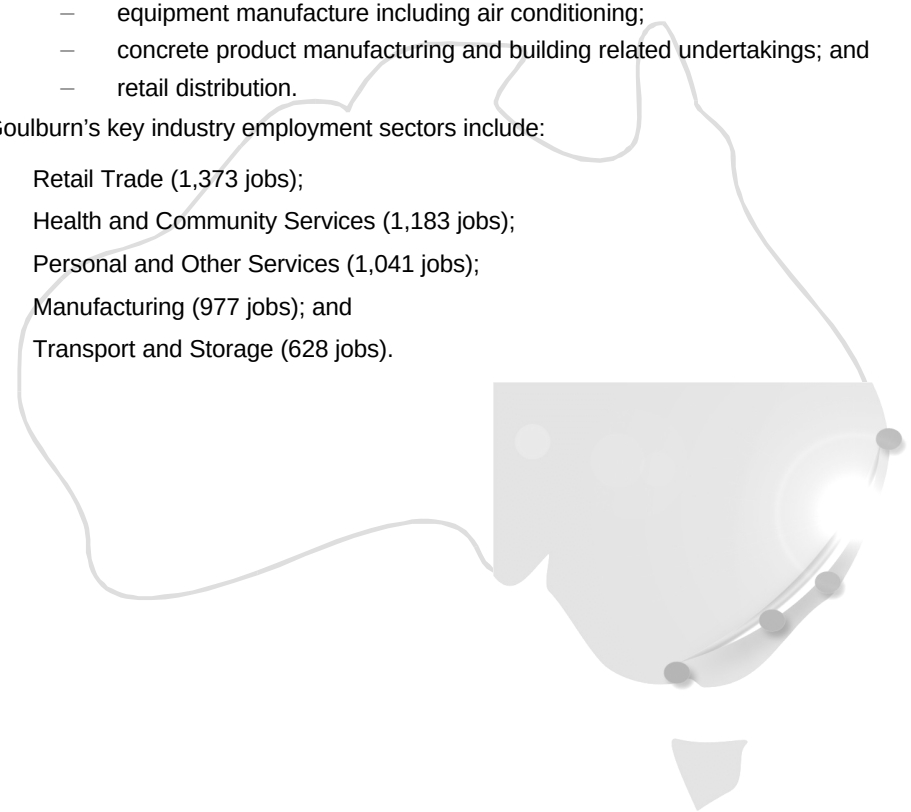
The region contains good farming country. There are orchards, wineries, renowned wool and cattle properties, as well as more unusual (niche) produce such as asparagus, deer, emu and alpacas.

Goulburn is a candidate VHST station location in this region. Key features of Goulburn are as follows:

- The Goulburn LGA covers an area of 43sq kms and is home to 22,500 people. The surrounding districts boost the City's population by a further 15,000 people.
- Goulburn has a well-developed rural industry sector, led by wool.
- Goulburn's secondary industry is based on a mix of private and Government enterprise.
- State and Federal Government workshops exist for Public Works, Roads and Traffic Authority, the Railways, Electricity and Telecommunications.
- In the private sector, firms are engaged in:
  - wool scouring;
  - the manufacture of cotton products and footwear;
  - heavy and light engineering;
  - equipment manufacture including air conditioning;
  - concrete product manufacturing and building related undertakings; and
  - retail distribution.

Goulburn's key industry employment sectors include:

- Retail Trade (1,373 jobs);
- Health and Community Services (1,183 jobs);
- Personal and Other Services (1,041 jobs);
- Manufacturing (977 jobs); and
- Transport and Storage (628 jobs).



13.5.2 Key Economic Development and Infrastructure Issues and VHST Impacts – Goulburn

Economic Development and Infrastructure Issues	Impact of VHST
The area has a strategic location between Sydney and Melbourne.	The VHST has some potential to improve links to capitals and regional centres.
Goulburn has a strong 'heritage identity'.	The VHST would have little or no impact on this feature apart from improving access to the region and awareness of its key attributes.
Goulburn is close to major transport links (now by-passed by the Hume Highway).	The VHST can reinforce transport linkages in the region.
Goulburn has a strong supply of affordable employment land.	There is little potential impact of the VHST on this feature.
There is a need for improved access to major centres.	There is Good potential to improve links to capitals and regional centres though any significant benefit would only be generated with parallel supportive measures.
Goulburn is a key wool region. However, this also makes the region susceptible to fluctuations in commodity prices.	The VHST would have no impact.
There is strong support for major infrastructure projects.	There is good potential to tap local enthusiasm to promote the VHST.
The region is proximate to Canberra.	There is good potential to strengthen links between Goulburn and Canberra. The direct high-speed rail link would support a greater commuter residence role for Goulburn for Canberra based knowledge workers.
The region has a developing education sector (such as the CSU/Police collaboration).	The VHST presents a moderate potential to increase this role, through improved access to larger population centres.
The area is generally experiencing a decline in population.	The VHST has moderate potential to increase the appeal of the region as a place to live and the potential for relocation of population.

Source for Economic Development and Infrastructure Issues: Goulburn City Council Web-site and Southern Tablelands Business Website

13.5.3 Conclusion

The VHST should have a positive impact on the Capital Country region, compounded by the location of one of the stations in Goulburn and the fact that the city is currently by-passed by the Hume Highway.

The greatest benefit will come from the direct high-speed rail link to Canberra, providing increased opportunity for Goulburn to serve as a commuter residence for Canberra's knowledge workers (though it should be noted that Canberra's labour market is still relatively small).

However the potential benefits should not be overstated. Key trends undermining the region's traditional economic base will not be reversed by the introduction of the VHST and the potential for new industry creation is limited.



13.6 The ACT Region (Canberra)

13.6.1 Area Profile

The centre of the ACT region is Canberra. The Canberra economy has proved to be reasonably robust and somewhat immune to the more extreme economic fluctuations characterising the rest of Australia.

The fastest growing sectors in the ACT are:

- Utilities;
- Finance and Insurance; and
- Property and Business Services.

These industries grew by more than 14% in 1994-5. The structure of output by industry in Canberra is markedly different to the rest of Australia. By far the largest sectors in 1994/95 were:

- Government Administration and Defence, accounting for 26% of total output (compared to 4% of output nationally);
- Property and Business Services at 11% of output (9% nationally); and
- Education at 8% (5% nationally).

The growth of the ACT economy has been closely related to decisions of the Federal government on the role of Canberra as the national government centre.

The area has a highly educated workforce, which should be suited to the emerging needs of the international economy. Canberra has a high ratio of employment to resident numbers, with a significantly higher proportion of Canberra residents being tertiary qualified. The 1991 Census revealed that 19.1% of Canberra and Queanbeyan residents had attained a Bachelor's degree or higher, compared to only 8.6% in the rest of Australia. Canberra has a strong education and research base, with numerous educational institutions (for example, 4 tertiary campuses). Population is growing at about 1% per annum.

The Information Technology and Telecommunications (IT&T) sector is a vibrant sector of the ACT economy, with 200-300 firms employing 1,120 people. Average incomes are also higher in Canberra, resulting in a relative wealth of the Canberra market.

13.6.2 Key Economic Development/Infrastructure Issues

Economic Development and Infrastructure Issues	Impact of VHST
Upgrading of Canberra International Airport to increase capacity and capability of hosting international flights.	If the VHST is integrated with the airport, this could have major benefits for other centres along the route in the surrounding region, particularly in terms of access to international visitor markets.
Roll out of broadband cable network to reach all homes and businesses (September 2001), the ACT Government/ACTEW's TransACT project.	The VHST will have no direct impact.
Promotion of smart, clean industries building on a skilled workforce and research/knowledge base with the development of light industrial technology parks adjacent to transport hubs.	The VHST will have a limited impact. However, it may help to facilitate the movement of skilled workers from Sydney to Canberra if the local supply of knowledge workers cannot match demand and vice versa. Further, the wider region will benefit from the greater mobility of skilled labour if it is properly integrated with the local transport network.
High dependence on private car transportation due to an extensive and low congestion road network. (Average commuting times of less than 20 minutes for the journey to work by private car. Travel times by public transport (ACTION buses) are considerably longer).	The VHST will have little impact on local traffic flows.
Modern and sophisticated communications technology infrastructure.	The VHST will have little impact.
Considerable ageing of the population and need to accommodate increased numbers of small households.	The VHST may have a small impact by helping to alleviate demand for housing if it encourages more people to commute from other areas along the VHST route. However, overall, the impact will be very small.

Source of Economic Development and Infrastructure issues: ACT Government Business Gateway website

13.6.3 Conclusion

The VHST would improve links between Canberra and Sydney, particularly in terms of labour flows. The combination of commercial opportunity in Sydney and Canberra's concentration of highly educated personnel and research facilities, could prove a strong stimulus to growth.

The VHST may also encourage Sydney residents to make day trips to Canberra. It could also facilitate greater numbers of international tourists visiting the ACT region out of Sydney.

13.7 Melbourne Metropolitan Area

13.7.1 Area Profile

Metropolitan Melbourne covers a large area, 8,607 square km in total, comprising an estimated resident population of 3,322,401.

At present, residential development remains concentrated in the newly establishing suburbs of metropolitan Melbourne, forcing the decentralisation of various cultural and entertainment facilities, as well as various clustered business activities such as business technology and R&D parks, and key institutions such as Universities and hospitals, away from the CBD.

Key employment industries in Metropolitan Melbourne are:

- Manufacturing, accounting for 17.3% of total employment in 1996;
- Retail Trade, accounting for 13.6% of total employment in Metropolitan Melbourne in 1996;
- Property and Business Services, accounting for 11.3% of total employment in Metropolitan Melbourne in 1996; and
- Health and Community Services, accounting for 9.1% of total employment in Metropolitan Melbourne in 1996.

13.7.2 Key Economic Development and Infrastructure Issues and VHST Impacts – Metropolitan Melbourne

Economic Development and Infrastructure Issues	Impact of VHST
Developing links and synergies with Sydney to enable the South East regions of Australia to better complete in the global market place.	The VHST has good potential to improve passenger service connectivity between Melbourne and Sydney. However, there will be no impact on freight connectivity.
Developing and maintaining a position in the global economy based on strengths in: - Advanced Manufacturing; - Cultural Sports/Tourism; - Clean/Green Technologies; IT&T; and Health Care & Biotechnology.	The VHST will have little impact on inter-regional industry links, but will improve the flow of labour between the two capital cities.
A 'University City'- world class educational facilities.	The VHST will improve access to Melbourne's educational institutions for students living in regional centres and vice-versa.
Fostering R&D, high tech industries.	The VHST will have little or no impact on the capacity to attract these industry sectors.
Attracting and maintaining highly skilled knowledge workers.	The VHST will help to facilitate greater mobility of high skilled workers between capital cities and regional centres.
Strategic investment in freight movement, integration of ports and the airport.	The VHST will have no impact on freight movements as it is a passenger service only.
Redevelopment of Spencer Street Station	Provides an opportunity for VHST services to be integrated in to the redevelopment, enhancing the level of service at Spencer Street.
Key tourism destination.	The VHST has good potential to improve tourist flows between Melbourne and otter capitals and regional centres, further integrating eastern Australia's tourism offer.
Affordable housing	Will have a moderate impact on access to affordable housing and services along the route.

Source of issues: City Plan, Melbourne City Council (1999) and Business Cluster Analysis, SGS Economics & Planning (1999)

13.7.3 Conclusion

The introduction of a VHST station to Metropolitan Melbourne would generate positive economic development outcomes for the City. First, the VHST would improve the strategic connectivity of Metropolitan Melbourne with Sydney and intervening regions and, second, it would facilitate the concentration of skilled workers in key information economy nodes in central Melbourne. These two outcomes would be generated as a result of the connectivity with, and accessibility to Sydney that the VHST would create for Melbourne based industries and workers.

13.8 New England – North West Region

13.8.1 Area Profile

The New England/North West area is dominated by agriculture, up to 12% of the area being used for agricultural purposes. However, the region has a more diversified structure than some other rural areas of Australia. The New England/ North West Region's population was 175,580 in 1996 (ABS, 1998)

Significant areas of employment in 1996 were:

- Agriculture;
- Manufacturing; and
- Business Services.

13.8.2 Key Economic Development and Infrastructure Issues and VHST Impacts – New England/North West Region

Economic Development and Infrastructure Issues	Impact of VHST
The region has a current focus on investment attraction strategies.	The VHST has some potential to help encourage new investment in the region, though this potential is also reliant on a range of other factors such as local governance structures, policy positions including local business facilitation strategies, infrastructure support and land use planning provisions.
The region is experiencing population decline in non-key centres.	The VHST is likely to reinforce this situation with population likely to be concentrated around station precincts.
The region has a strong agricultural industry.	The VHST would have little, if any, impact in this area.
The region wants to promote and encourage opportunities for business reinvestment.	The VHST is likely to encourage business reinvestment in those centres best served by the VHST.
The region is promoting the development of new industries such as: - Aquaculture - Equine - Intensive Agriculture	The VHST is unlikely to directly impact on the development of these industries.
There are difficulties in funding new infrastructure in the region. There are also infrastructure provision issues in areas such as telecommunications.	The VHST is likely to have little impact in this area or may in fact divert resources from other projects.
Enhancing the provision of Education and Training is a priority in the region.	The VHST is likely to have little impact in this area.
The region currently experiences labour shortages.	The VHST would have moderate potential to enhance existing local programs to attract new workers from other areas.

Source: Regional Priorities Framework, New England – North West Region, NSW Premiers Department

13.8.3 Conclusion

Indications are that the New England Region has basic infrastructure and a strong primary industry sector. The largest centres in the region are located on major highways and are serviced by road, rail and air. The links to major ports and capital centres can be improved, and proposals to develop an inland port at Gunnedah reflect these access problems.

The agricultural industry still remains a strong basis for the regional economy. The potential impacts of the VHST on the region appear to primarily relate to tourism, population and workforce flows. The project has little impact on other infrastructure issues, though it may reinforce the decline of the region's non-key centres. Nevertheless, the VHST provides a major transit link into the major centres.

13.9 Moreton Region (Gold Coast)

13.9.1 Area Profile

The Moreton Statistical Division comprises both the Sunshine Coast and the Gold Coast and, while only the Gold Coast is relevant to this Study, the two areas exhibit similar prospects for high growth. Between 1991 and 1996 Albert Shire (now merged with Gold Coast City) was the fastest growing local government area (LGA) in Australia, while Maroochy Shire was ranked 5th.

Population projections (ABS, 2001) indicate that the Moreton region is expected to record one of the highest population growth rates in Queensland, population being projected to increase from 618,230 in 1996 to 1,002,160 in 2016. This represents an increase of 62%. A survey by Price Waterhouse Coopers (1996) ranked Maroochy Shire as the second most active business region in Australia. This ranking was based on an economic activity index using indicators including housing commencements, labour force numbers, retail sales, shopping floorspace, commercial development approvals and an ABS affluence index for each area. However, the report also showed that population growth in the Gold Coast had not translated to increased economic prosperity. Both the Gold Coast and Sunshine Coast recorded a high proportion of visitors (around 15%), on Census night in 1996, as part of their population base.

Key employment sectors in the Moreton Region are:

- Tourism;
- Property and Business Services; and
- Retail Trade.

According to National Economics (1998), the Moreton region's key employment growth sectors to 2002 are projected to be:

- Transport and Storage;
- Community Services;
- Public Administration;
- Tourism and Recreation; and
- Mining.

13.9.2 Key Economic Development and Infrastructure Issues and VHST Impacts – Moreton Region (Gold Coast)

Economic Development and Infrastructure Issues	Impact of VHST
The South-East Queensland region has the largest and most rapidly growing population, labour force and consumer market in Queensland.	A VHST service linking the Moreton Region has good potential to reinforce this growth.
In parts of the region, increased economic prosperity has not accompanied population growth.	The development of a VHST has moderate potential to entice population with a higher socio-economic status to the area. However, this is also strongly linked to developing employment in the region.
The SEQ economies are maturing from a traditionally narrow base. There is a receptive new business formation culture	There is moderate potential to create new industry nodes in the precincts and regions around stations. However, this will also depend on the relocation intentions of firms and other Government. support policies.
A strength of the area is its proximity to Asian and Pacific Markets.	The capacity of the VHST to reinforce the region's strategic location is dependent on the focus and outlook adopted by firms and government and the degree to which such a facility would add to the region's 'livability' appeal. If a VHST encouraged higher levels of in-migration (and hence, population growth), this may help to enhance the region's strategic location. Therefore, there is moderate potential for a VHST to reinforce the region's strategic location.
The region has a strong tourism industry.	There is good potential for the project to facilitate increased tourism.
The area has a good infrastructure base – including roads, ports, rail and an airport.	There is good potential to reinforce the region's infrastructure base. However, it is also important to create links to development nodes such as the Coolangatta Airport and primary activity centres such as Beenleigh.

Economic Development and Infrastructure Issues	Impact of VHST
The region has a good 'lifestyle image' and high quality of life features.	An area's 'lifestyle' image is dependent on various factors including the availability of essential services and facilities and good access to leisure and employment nodes. There is moderate potential for a VHST to reinforce the Moreton region's 'livable' image.
The region has a low risk business environment.	SEQ has a strong institutional framework and world class infrastructure, which helps to mitigate perceived business risk. A VHST would serve to reinforce this.
There is a lack of technical, professional and knowledge skills in workforce.	Little impact on direct skill formation in the workforce. However, the VHST has a good potential to facilitate movement of skilled/ knowledge workers who value an area's quality of life and livability factors.
The region has insufficient business clusters.	There is moderate potential to create new industry clusters in the precincts and regions around stations. However, this will also depend on the relocation intentions of firms, governments' business assistance and related policies (such as a firm cluster strategy) and local and regional planning provisions.
There is a weak entrepreneurial culture.	The project is likely to have little direct impact. However, by reinforcing what the region has to offer as an investment (and employment) location (as discussed above), the project may help to attract high quality business owners, managers and staff.

Source for Economic Development and Infrastructure Issues: Strategic Infrastructure for Queensland's Growth, 2000

13.9.3 Conclusion

Indications are that the Moreton Region has strong institutional frameworks, which mitigate business risk. The Moreton Region is also strong on basic infrastructures and livability. Further, there have been recent advances in knowledge infrastructure such as the establishment of an IT&T industry network at the Gold Coast, and continued expansion of Griffith University. Nevertheless, the low number of 'knowledge workers' is a constraint on the region's economic development.

The positive impacts of the VHST for the region revolve around reinforcement of the area's capacity to serve residential development and greater visitor numbers (tourism).

The recent opening by Queensland Railways of a rail link between Brisbane and Robina may represent a negative impact on potential patronage of a VHST from the northern part of the Gold Coast.

13.10 Northern Rivers

13.10.1 Area Profile

The Northern Rivers Region stretches from the Clarence Valley to the Queensland border. Northern Rivers is the fastest growing region in NSW. The population of the region is currently 250,000 and is growing rapidly at 2.6% per annum. The labour force is growing more rapidly at around 3.1% per annum. However, the region has a high level of unemployment, estimated at 14.5% in 1999 (NIEIR).

Key features of the regional economy include:

- a large and diverse agricultural, forestry and fishing sector;
- a small manufacturing sector focussed on processed foods and wood products; and
- a large number of family and 'micro' businesses, and only a handful of larger firms in timber, dairying and sugar cane. Large public sector employers include Southern Cross University, North Coast Institute of TAFE and local councils.

The key employment sectors in the region are those supporting population growth. These are:

- Wholesale and Retail Trade;
- Community Services; and
- Construction.

The key employment growth sectors are expected to be:

- the rapidly growing Tourism and Hospitality sector;
- emerging opportunities in Niche Rural Products; and
- Multimedia, Design and Entertainment.

Northern Rivers has sustained the highest rate of regional economic growth in NSW since the early 1990s (along with the Central Coast). Gross regional product averages 5.5% per annum. Main drivers of economic growth are the population-based sectors of activity, the maintenance of competitive industries and the attractiveness of the region to visitors and tourists.

Over the past 15 years, environmental and lifestyle attributes have driven employment growth in the region. Between 1981 and 1999, the number of employed residents has grown by 50 percent, from 60,000 to 90,000. More jobs have been created for women, and 60 percent of all new jobs have been part-time.

13.10.2 Key Economic Development and Infrastructure Issues and VHST Impacts – Northern Rivers

Economic Development and Infrastructure Issues	Impact of VHST
The region is constrained by poor information technology and computing skills.	The VHST will have no direct impact on this situation. However, it may assist in encouraging high skilled workers to relocate to the area.
Improved freight access is a requirement in the region.	A passenger only VHST would have no impact on this situation.
Long distances and poor intra-regional transport networks constrain employment opportunities.	The VHST has limited potential to address shortages with intra-regional transport links.
At present, job growth in the region is concentrated in the emerging coastal centres of Ballina, Byron Bay and, to a lesser extent, Tweed Heads.	The location of VHST stations will encourage a concentration of population and employment around station precincts (though there may be only one station in the region). However, this is largely dependent on local planning provisions.
Currently, there is a mismatch between the skills of the regional workforce and some of the fastest growing occupations including multimedia, information technology, business and technical services and some high skilled jobs in tourism and hospitality.	The VHST has little impact on skills formation in the labour force. However, the project has good potential to facilitate the flow of knowledge workers who are attracted to the area's lifestyle and livability factors.
The local and regional public transport network is under-developed and the rail network needs considerable improvement.	The VHST has the potential to have a moderate impact on improving transport networks, on regional transportation in particular.
Local stakeholders believe that improved rail links to Coolangatta International Airport are needed.	The proposed route and station placement outlined for the VHST indicate there is strong potential to achieve a better link to Coolangatta Airport.

Source of Economic Development and Infrastructure issues: Labour Market Information and Analysis for the Northern Rivers Region– Employment growth and skills formation: trends, patterns and changes (National Economics, 1999); Regional Activity Profiles (NIEIR, 1996); Economic Development Infrastructure in the Hunter, Illawarra and Western Sydney (National Economics, 2001).

13.10.3 Conclusion

This assessment of the impact of the VHST on the Northern Rivers Region indicates that the project would facilitate a better integration of the region with the fast growing regions of global Sydney and Brisbane-Gold Coast. This may be sufficient to induce additional population and economic growth in a region already on the cusp of higher order development.

The VHST also appears to be able to provide much needed improvements in the regional rail network, but may also cause a reallocation of resources away from other transport infrastructure such as ports. The VHST has strong potential to result in increased tourism and visitation to the area.

13.11 Mid North Coast

13.11.1 Area Profile

The Mid-North Coast includes the local government areas of Bellingen, Coffs Harbour, Gloucester, Hastings, Great Lakes, Nambucca, Kempsey and the City of Greater Taree.

The Mid North Coast of NSW is a population growth area. Between 1986 and 1996 the population increased at an average annual rate of 2.7% which was almost double the State average. Rapid growth has led to satellite areas that were once rural now being rezoned as residential.

As a direct result of retirement-generated migration and reduced mortality rates, the region has a high percentage of aged persons in its population.

The Mid-North Coast's key employment sectors are:

- Retail Trade (17% of employment);
- Community Services (11% of employment);
- Manufacturing (10% of employment); and
- Tourism and Recreation (13% of employment).

Agriculture, Forestry and Fishing are traditionally an important sector for the Mid-North Coast region, though the contribution of this sector to regional economic activity has diminished over time.

According to National Economics (1998) the key future employment growth areas include:

- Community Services;
- Construction;
- Retail Trade; and
- Hospitality/Recreation/Tourism.

The Mid-North Coast has traditionally experienced high levels of unemployment. The region's unemployment rate in 1999 was 16.4% compared with 8.8% for NSW. Unemployment is also very high for the region's youth and its large indigenous population.

13.11.2 Key Economic Development and Infrastructure Issues and VHST Impacts – Mid North Coast

Economic Development and Infrastructure Issues	Impact of VHST
The region has excellent quality of life features.	The VHST is likely to have little direct impact on the region's quality of life attributes. However, by improving access to the region, the VHST has good potential to increase the appeal of the Mid-North Coast as a place to work and live in to professionals or knowledge workers who maintain regular contact with Sydney or Brisbane.
The region has strong population growth.	The VHST offers good potential to enhance existing flows of new residents to the region (as explained above).
The region has a narrow economic base.	The VHST provides moderate potential for the attraction of new industry and a greater concentration of activity around station precincts. However, this is dependent on factors such as firm relocations, government policies on business assistance and local and local land use planning provisions.
The region is currently not winning knowledge based jobs.	Overall, the VHST has good potential to facilitate flows of knowledge workers. However, the impact of the VHST is more likely to reinforce the status of 'global' cities such as Sydney.
The region is facing a situation where jobs are not keeping pace with population growth.	The impact of the VHST is dependent on the concentration of jobs and population growth in the future. As a 'lifestyle region' the VHST may reinforce the current scenario – with the population growing faster than employment. However the VHST also offers the opportunity to diversify the industry base by attracting limited skilled workers, commuting to clients in Sydney or Brisbane, who would seek lifestyle options and would otherwise invest in the region.
The region has good rail freight access.	A passenger only VHST would have no impact on this situation.
A substantial upgrade of skills is required in the region	The VHST would have no impact on direct skills formation in the workforce. However, by improving transport links along the eastern seaboard, the VHST may help to attract skilled workers from outside the region who are looking for an alternative lifestyle. As mentioned above, professionals with part time commitments in Sydney or Brisbane may be prepared to commute (say 3 days per week) on a VHST (though this depends on the fare and competition with air services).
The region currently has a limited number of major economic nodes (centres).	The VHST is most likely to have a negative impact. The VHST is more likely to strengthen the role of station precincts to become the primary centres in the region.

Economic Development and Infrastructure Issues	Impact of VHST
The region has high unemployment for youth and indigenous people.	The VHST would have limited direct impact. This issue requires specific employment strategies to target the youth and indigenous populations.
There is a need for more medium and large employers, that is, employers with 25+ staff.	The VHST would have a moderate potential impact on attracting larger firms. The overall impact would also depend on approach of firms and government to relocation as described earlier.
The region is home to a range of emerging niche industries.	The VHST would have moderate potential to strengthen emerging industries by providing improved access to markets and workers.

Source: for Economic Development and Infrastructure Issues Australia Holiday Coast ACC – Strategic Regional Plan 2001 to 2004 and Mid-North Coast Employment and Labour Market Study (National Economics, 2000)

13.11.3 Conclusion

Indications are that the Mid-North Coast Region has good basic infrastructure and strong 'livability' features. The region is situated mid-way between Sydney and Brisbane and rail carries inter-capital freight and CountryLink services. The Pacific Highway also serves as one of Australia's most significant freight routes. Farmers and businesses are being encouraged to use rail freight from inter-modal terminals at Grafton, Casino and Coffs Harbour.

The Mid-North Coast also has one of Australia's fastest growing populations and population growth and economic opportunities are concentrating around the coastal centres, in particular Port Macquarie and Coffs Harbour. The traditional centres such as Kempsey and Taree, as well as the Nambucca and Gloucester Shires, are not sharing in the benefits of growth to the same degree. Nevertheless, these areas are developing new approaches to encourage economic growth (eg supporting niche industries, tourism, community services and building on the area's lifestyle appeal).

As discussed in the table above, the VHST appears more likely to serve to reinforce the roles of the major centres and enhance the lifestyle appeal of the region – though this depends on station location. A VHST effectively serving the 'coastal' centres (Port Macquarie, Coffs Harbour) would accelerate their already significant growth, as lifestyle and professional opportunities are able to be combined. This would be at the continued expense of the traditional 'inland' centres on the Pacific Highway.

13.12 Illawarra Region

13.12.1 Area Profile

The Illawarra region is a diverse region, in terms of both its economic and geographic structure. The Illawarra includes the local government areas of Wollongong, Shellharbour, Kiama, Shoalhaven and Wingecaribee. The region is often broken into three sub-regions. These are:

- Greater Wollongong, which covers the industrial city of Wollongong and the localities of Shellharbour and Kiama;
- The rapidly growing Shoalhaven region to the south, based largely on lifestyle and environmental attributes; and
- The Highlands areas around Wingecaribee, which is separated from the rest of the region by the Illawarra escarpment and has closer links to Sydney.

Wollongong City has developed over the past 50 years as an important industrial city based around heavy industry associated with coal, steel, clothing and engineering industries. Traditionally, demand for lower skilled industrial workers and specialised tradespeople was the major driver of population growth in the region. With labour shortages nationally, migration provided a major source of labour, resulting in the creation of a diverse multicultural community.

The northern part of the region is becoming more integrated with metropolitan Sydney, as Wollongong is around 80km from Sydney. Livability attributes in many parts of the region are high. People are moving to Wollongong because of affordable housing, the attractiveness of its beaches and natural environment and its accessibility to Sydney. The NSW Department of Urban Affairs and Planning (DUAP) forecast a population increase of 36,900 in Greater Wollongong from 255,700 in 1996 to 292,600 in 2021. National Economics has argued that a higher population than this may be desirable, mainly to take pressure off Sydney, but can only be realised if the region strengthens its high value industry base and strategic infrastructure, notably more efficient rail access to Sydney.

The key employment sectors in the region include:

- Manufacturing;
- Wholesale and Retail Trade;
- Health and Community Services; and
- Education.

Emerging industries include:

- Higher value added manufacturing;
- IT&T, in particular, telecommunications; and
- Health and Community Services.

13.12.2 Key Economic Development and Infrastructure Issues and VHST Impacts – Illawarra

Economic Development and Infrastructure Issues	Impact of VHST
Major new residential developments in the region are located at Shellcove in Shellharbour and are planned for West Dapto, but public transport links to major employment centres are poor.	The VHST is likely to have little impact on intra-regional travel.
The Illawarra region has a relatively weak labour market, which has encouraged the growth of commuting, with around 15% of the labour force working in Sydney.	The VHST has a strong potential to assist commuting between Illawarra and Sydney – but also enhance access to Sydney's skills base.
New industries, particularly high value added manufacturing and service based industries are expected to drive employment growth in future.	The VHST is likely to have moderate impact on the development of new industries.
As an important manufacturing centre for the foreseeable future, the transformation of engineering and other supplier firms to the local steel industry remains a challenge. Stakeholders believe that more needs to be done to strengthen industry networks, links to education and training institutions and to attract investment in advanced manufacturing.	The VHST has moderate potential to facilitate the attraction of new manufacturing industry. Improved strategic infrastructure will enhance the appeal of the region as a place to live. However, the attraction of new manufacturing enterprises is dependent on such things as market conditions, government policy on business assistance, the ability of new businesses to tap in to existing networks, other infrastructure support including (freight) transport links and land use planning frameworks.
The availability of suitable and adequate employment land may constrain future development opportunities, but BHP may offload land as it restructures its steel operations.	The VHST is likely to have no impact in this area.
Completion of the Eastern Gas Pipeline, linking Longford in Victoria to Horsely Park in Western Sydney via Wollongong is forecast to generate substantial economic and employment benefits. The aim is to attract new energy-intensive industries to the Illawarra, based on competitive electricity and gas prices. Suitable land and transport infrastructure will also be a factor in the success of the strategy.	The VHST has a moderate potential to help reinforce the maximisation of benefits from the Gas Pipeline.
A long-term vision is to build a cluster of industries around the technology-oriented educational institutions of the University of Wollongong, the Illawarra Institute of TAFE and Wollongong Technology High School.	The VHST has the potential to facilitate the flow of knowledge workers and support new industry creation in precincts around stations. However, this relies on firm relocation and government policy.

Source of Economic Development and Infrastructure issues: Regional Activity Profiles (NIEIR, 1996); Economic Development Infrastructure in the Hunter, Illawarra and Western Sydney (National Economics, 2001).

13.12.3 Conclusion

The VHST is likely to encourage an increase in the number of commuters to Sydney that reside in the northern part of Wollongong. The project would also significantly improve travel times and could reduce overcrowding on trains during peak travel periods (provided 'short haul' services are also expanded on the VHST route).

The VHST is also likely to improve transport infrastructure links to other regions. This will be especially beneficial for Shoalhaven, an area with poorly developed transport links. (For example, the Princes Highway, which runs from north to south of the region, is in poor condition and a major upgrading is long overdue. Further, much of the Shoalhaven is without rail links. The rail line is single track and not electrified.)

Lack of broadband capacity and higher relative costs also constrain development in the region, particularly the success of the South Coast Educational Network.

13.13 Riverina

13.13.1 Area Profile

Using the classification of the Riverina Area Consultative Committee (Riverina ACC, 2001) the region includes the following LGAs: Carrathool, Hay, Griffith, Leeton, Murrumbidgee, Narrandera, and Gundagai. The major towns in this region include Albury/Wodonga, Wagga Wagga and Griffith.

Between 1986 and 1996 the region experienced modest population growth. However this was heavily concentrated in Albury/Wodonga and Wagga. Most other centres experienced negative or at best static growth. Existing jobs are also heavily concentrated in Wagga and Albury/Wodonga.

Key employment sectors in the region include:

- Agriculture and Horticultural;
- Textiles;
- Wine;
- Forestry;
- Government and Defence;
- Tourism;
- Wholesale and Retail Trade; and
- Community Services.

The Riverina produces one seventh of NSW's total agriculture and over 25% of total fruit and vegetables (NSW Agriculture, 1999).

According to National Economics (1998) projected future growth industries are:

- Construction;
- Community Services; and
- Education.

The Riverina region is also susceptible to salinity, areas of major concern existing in a north-south belt to the north of Canberra (Yass River Valley), in the south-western part of the Lachlan, and east of Wagga Wagga in the Murrumbidgee catchment. (Bradd and Gates, 1995).

13.13.2 Key Economic Development and Infrastructure Issues and VHST Impacts – Riverina

Economic Development and Infrastructure Issues	Impact of VHST
The region has good rail infrastructure, particularly for freight transport.	The VHST, which is a passenger service, would have no impact on the region's rail freight capacity.
The region is experiencing population decline in non-key centres.	The VHST would not be expected to reverse this trend on its own. Some minor 'above trend' growth in cities with stations could be expected.
The region has a strong agricultural Industry.	The VHST would have little impact in this area.
The region is experiencing slow tourism growth.	The VHST has the potential to marginally increase tourist flows to the region by improving links to capital cities and other regions.
There is high use of irrigation for crop production. This has impacts on water charges and levels of salinity.	The VHST would have no impact.
The region has a low value-adding tourism sector. In particular, tourists visiting the region are currently self-drive tourists; and people visiting friends and relatives.	The VHST provides some potential to increase interstate visitation through improved transport links along the eastern seaboard.
The region has significantly lower average household incomes than the State Average.	The VHST would have little direct impact in this area. However, there may be some impact if the VHST assists in attracting skilled, knowledge workers to the region.
There is a good education presence in the region.	The VHST would have little impact.
The region currently experiences labour shortages.	The VHST would have modest potential to enhance existing local programs to attract new workers.

Source for Economic Development and Infrastructure Issues: Riverina ACC and Riverina Regional Business Survey and Skills Audit, 1999.

13.13.3 Conclusion

The Riverina region has basic infrastructure and a strong primary industry sector with direct rail links to Sydney and Melbourne.

The agricultural industry still remains a strong basis for the regional economy. The VHST may have a marginal positive impact on tourism, population and workforce flows in the region. However, the project has little impact on other economic development issues such as the decline of non-key centres and agricultural and salinity issues.

13.14 North-East Victoria (Strathbogie)

13.14.1 Area Profile

The Strathbogie Shire is a rural municipality located 150km north of Melbourne, serving townships such as Euroa, Nagambie, Violet Town, Avenal and Strathbogie. Strathbogie Shire boasts a population of 9,500 people, and covers an area of 3,285.9 square km. This area is well accessed by the Hume Freeway and the Goulburn Valley Highway, which traverse the Shire, rail to Melbourne and also via an airport at Magalore.

Historically, the economic base of the Shire has been through the production of wool, cattle and grain. However, today these traditional industries are being supplemented by strong growth in viticulture and thoroughbred horse breeding and training, as well as the subsequent tourist market that this creates.

13.14.2 Key Economic Development and Infrastructure Issues and VHST Impacts – Strathbogie Shire

Economic Development and Infrastructure Issues	Impact of VHST
The area's traditional economic mainstay is agriculture.	As the local economic base diversifies, the VHST will help to enhance the mobility of skilled workers between the region and the capital cities.
The area is faced with a 'brain drain' and youth drain to larger cities, which is a threat to the region's ability to retain skilled workers and business leaders.	The VHST will support the retention and attraction of skilled workers by improving links to the major metropolitan centres.
The region has strong tourism potential.	The VHST will help to improve visitor access to the area and will help to integrate the tourism offer along the eastern seaboard.
The area has a strong viticulture industry.	The VHST will have little impact on industry links or access to markets. However, the tourism component of this sector could benefit from the VHST.
Access to education.	The VHST will improve access to Melbourne's educational institutions for students living in regional centres and vice-versa.
Strathbogie is a site for the film making industry (Film Victoria).	The VHST will help to improve access to the Strathbogie region and increase people's general awareness of the area.
Strathbogie has good rail/ bus access to major centres.	The VHST could provide the impetus for an integrated transport hub, with established feeder services.
A feature of the Strathbogie economy is its industry in back office functions.	The VHST has moderate potential to support the further development of this sector by providing improved commuter links for office staff.

Source of issues: Strathbogie Shire Council

13.14.3 Conclusion

Overall, the VHST would have a marginal though positive effect on the Strathbogie Shire. First, it could act to boost tourism to the region, which is currently limited to 'day visits', and could support further population growth and help to retain/attract young and skilled workers. It may also support the further development of 'back office' functions close to the railway.

13.15 Alpine Region

13.15.1 Area Profile

The Alpine Region includes the Local Government Areas (LGAs) of Bombala, Cooma-Monaro, Snowy River, Tumut and Tumbarumba as well as the Kosciuszko National Park.

The Alpine Region is significant because:

- it has been internationally recognised for its biological diversity;
- it has natural and scenic qualities which make the Region distinctive and therefore, attractive as a major tourist destination;
- it has important agricultural and forestry industries; and
- it is the headwater for the Murray, Murrumbidgee and Snowy Rivers.

Key industry sectors in the Alpine Region include:

- Sheep and Cattle Agriculture;
- Horticultural Industry;
- Wholesale/Retail Trade;
- Tourism; and
- Forestry.

In 1995/96 the Snowy Mountains region attracted 3.4% of NSW's domestic visitor nights (Tourism NSW, 1996). An earlier study (ASAA, 1994) estimated that the economic impact of the NSW Alpine industry was $547.5 million. However, only a small proportion of overseas visitors pass through the region.

The Alpine Region Planning Strategy (1998) states that future opportunities for employment and economic activity in the region are in adding value to existing industries and responding appropriately to structural change. In particular, economic change has resulted in an increase in employment within service industries and a significant increase in their overall economic contribution.

13.15.2 Key Economic Development and Infrastructure Issues and VHST Impacts – Alpine Region

Economic Development and Infrastructure Issues	Impact of VHST
There is a Need to diversify the region's tourism base, in particular by encouraging overseas visitors, rural tourism, ecotourism and summer tourism.	There is good potential to assist the region in diversifying its tourism base and increasing tourist numbers, by providing improved links to capital cities and other regional centres. However, VHST travel would need to be supported by feeder and other services to induce significant percentage increases.
There is a need to establish an Alpine Regional Identity.	The VHST would have Little direct impact apart from improving domestic awareness of the area through improved transport links.
There is a need to promote networks between local businesses.	The VHST would have little direct impact.
There is a need to develop farming adjustment packages.	The VHST would have little direct impact.
There is a need to maintain a strong environment protection policy.	The construction of the VHST would most likely have a negative impact on the region's natural environment. However, comparatively, it may prove to be the better option (compared to new highway infrastructure for example).
There is a lack of tertiary education and research facilities in the region.	The VHST provides good potential for better commuter links to Canberra. The VHST provides moderate potential to support the relocation of R&D facilities to the area. However, this would also be dependent on decentralisation commitments of governments and firms.
There is a high dependence on road transport in the region.	There is good potential for reduced dependence on road travel for trips made to other VHST stations. However, there is likely to be little impact on other inter-regional travel or intra-regional travel.
There is currently poor access to work opportunities and difficulty attracting skilled workers and seasonal employees.	The VHST provides good potential for improved access to new work opportunities and provides the opportunity to access the workforce in other areas.
Currently there is poor access to international markets.	The VHST provides little potential to improve the region's access to international markets. There may be some potential for improving access to international tourism markets if the region's improved links to capital cities and other regional centres was properly marketed.
Currently the region has poor air facilities.	The VHST may put further pressure on air services, if it is considered a direct competitor in a 'marginal' market. The impact on access to a local airport is dependent on the upgrade of Cooma Airport.

Source of Economic Development and Infrastructure Issues: Alpine Region Planning Strategy, 1998.

13.15.3 Conclusion

Relatively speaking, the Alpine Region has basic infrastructure and strong environmental features, potential impacts of the VHST on the environment of the area being a major issue.

The region is served by the Monaro and Hume Highways and the upgrade of Alpine Way was designed to encourage travellers to travel through the region. At present, there are limited transport options for travel to other regions or within the region itself (which will not necessarily be alleviated by the VHST).

Employment opportunities for the Alpine Region depend on the potential for economic diversification and value adding within existing industries. As shown in the table, the VHST has some potential to at best, support efforts and activities in these areas.

13.16 Gippsland

13.16.1 Area Profile

The region of Gippsland is broken into two local government areas, East Gippsland Shire and South Gippsland Shire. Key industry sectors in Gippsland are related to the region's rich natural resource base. Energy production in the LaTrobe Valley based on brown coal, hydro, oil and gas, is a key sector of Gippsland's economy and a major employer in the region. Forestry and siviculture are also key industries with Gippsland boasting extensive plantation (hardwood and softwood) and natural forests (hardwood) resources. Tourism is a key feature of the East Gippsland economy, particularly for the domestic market.

Water is also a key industry for Gippsland based on the abundant raw surface and ground water resources. Gippsland is a large exporter of water to Melbourne (potentially up to 60% of Melbourne's requirements).

13.16.2 Key Economic Development and Infrastructure Issues and VHST Impacts – Gippsland

Economic Development and Infrastructure Issues	Impact of VHST
High unemployment due to structural economic change from downsizing of energy sector.	The VHST will have a minor impact by improving inter-regional transport links for potential commuters to Melbourne, particularly from South Gippsland. This may create flow-ons for other local sectors such as retailing and construction, going some way to alleviating unemployment in the region's traditional sectors.
Important industries: - Dairying - Energy & Energy Education - Engineering - Fishing and Aquaculture - Horticulture - Timber - Tourism	The VHST will have a minor impact on industrial development in the region (as described above). The greatest impact will be in tourism, which may benefit from improved access to the region.
Poor transport infrastructure: - distance to Melbourne Airport - high cost to transport goods to major centres - not located on any direct routes to major centres.	A passenger only VHST would have no impact on freight transport capacity but would improve inter-regional passenger services.
Social problems: - youth alienation. - family dysfunction. - insufficient aged and disabled services.	The VHST will have no direct impact on the region's social problems.
High cost of telecommunications	The VHST will have no direct impact on telecommunications costs in the region.
Limited access to education services	The VHST will improve access to Melbourne's educational institutions for students living in regional centres and vice-versa.

Source of issues: Gippsland Region Economic Development Strategy, Spiller Gibbins Swan Pty Ltd et. al (1996)

13.16.3 Conclusion

Overall, the VHST would have a marginal, though positive impact on the Gippsland Region. In terms of industry, tourism would have the most to gain from the project.

The VHST also has the potential to improve Gippsland's role as a commuter base for workers in the city. It would better integrate the Gippsland Region with metropolitan Melbourne as well as Sydney by providing much improved inter-regional commuter transport links, which at present are quite poor. This might assist to stem population decline in areas around centres with stations.

The value of a VHST service through Gippsland may be diminished if the Victorian Government proceeds with the HST service currently being considered.

13.17 Input to Route Selection

Australia's regions have been subject to profound economic changes, from which, in summary, four classes of regions have emerged.

- metropolitan regions prospering from population growth and links to global economic opportunities (Sydney, Melbourne, and SEQ);
- regions dependent on rural industries suffering from economic and population decline (many parts of inland Australia including parts of the Hume Corridor and New England region;
- regions with an 'old economy' production focus but rapidly changing fortunes (the Hunter, Illawarra, and West Gippsland have these traits); and
- lifestyle regions often on the cusp of higher order development (the mid-north coast and northern rivers regions of NSW are in this category).

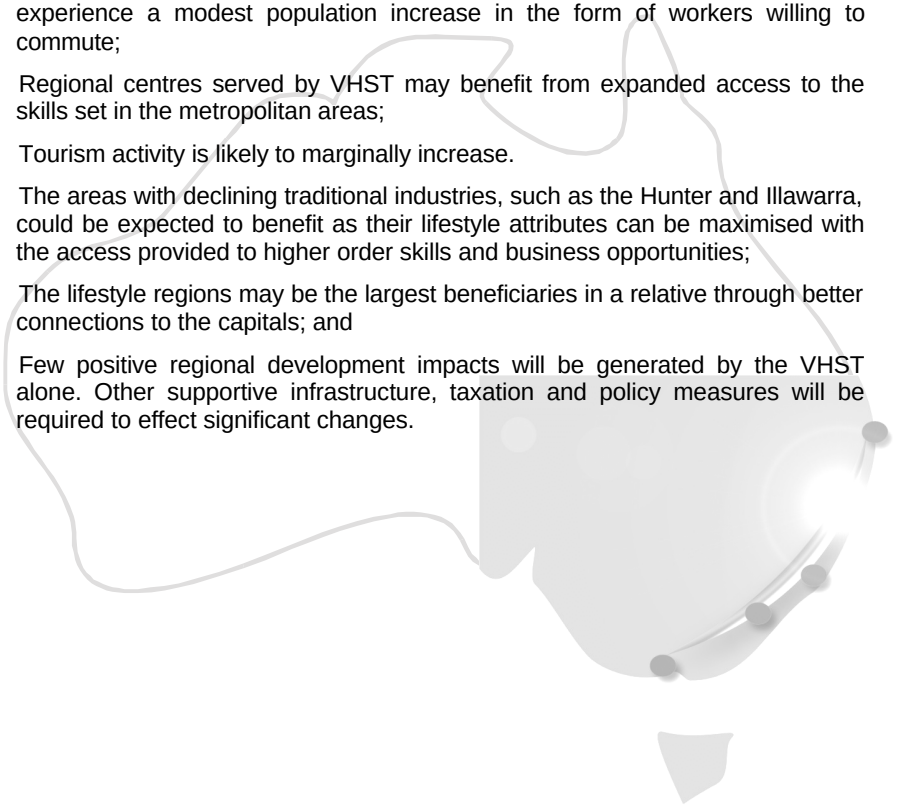
This discussion of route selection is relevant to Regions Classes 2, 3, and 4 and qualitative assessment of the "Impacts of VHST" tabulated in section 13.8 to 13.16 leads to the conclusion that its effects are likely to be most beneficial in supporting growth which is already occurring in Regions Classes 3 and 4. The VHST could do little to generate growth in areas which are already in decline or small centres, no matter how socially desirable support for such regions may appear to be.

Route selection will be affected by a number of factors but, in terms of beneficial interaction between regional growth and future patronage of a VHST service, it can be stated that the following routes are the preferred options:

- **Brisbane to Sydney - Coastal Route** (via the Gold Coast, Northern Rivers, and Mid-North Coast Regions).
- **Sydney to Canberra - Illawarra Route** (though it is recognised that the regional development benefits of that route may be strongly outweighed by other considerations.)
- **Canberra to Melbourne - Inland Route** (via Wagga Wagga, Albury/Wodonga and North Eastern Victoria)

13.18 Key Points

- The dominance of metropolitan areas is likely to be reinforced by high speed rail connections;
- Centres with VHST stations at not too greater distance from major centres may experience a modest population increase in the form of workers willing to commute;
- Regional centres served by VHST may benefit from expanded access to the skills set in the metropolitan areas;
- Tourism activity is likely to marginally increase.
- The areas with declining traditional industries, such as the Hunter and Illawarra, could be expected to benefit as their lifestyle attributes can be maximised with the access provided to higher order skills and business opportunities;
- The lifestyle regions may be the largest beneficiaries in a relative through better connections to the capitals; and
- Few positive regional development impacts will be generated by the VHST alone. Other supportive infrastructure, taxation and policy measures will be required to effect significant changes.



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Section 14

Evaluation of East Coast High Speed Rail



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14 EVALUATION OF EAST COAST HIGH SPEED RAIL

14.1 Overview of Evaluation Approach

As shown in section 8, the construction and operation of a VHST would require substantial capital investment. The financial, economic and environmental effects of such a project need to be balanced against the contribution to the transport task and urban settlement patterns made by a VHST. Furthermore, and as noted in section 11, there is likely to be a set of strategic or national interest objectives sought by the community and brought forward through the political process to which the VHST may be an appropriate response or means of achieving them.

In this evaluation six key criteria for examination of the merits of a VHST are considered:

- functional capacity;
- financial feasibility;
- economic feasibility;
- distributional impacts;
- macro economic and strategic impacts; and
- environmental impacts.

As noted in section 10, to the practical extent possible, the cost and benefit inputs (whether direct or indirect, primary or secondary) to these assessments should be complete while avoiding double counting of such items. The assessment is also rendered more effective if inputs to quantitative assessment are not also used to assess the worth of the project in parallel qualitative assessments. Conventional cost-benefit analysis can be used to many significant effects in monetarised terms. However, monetarising all impacts is rarely possible or indeed meaningful. While environmental effects on flora and fauna and cultural heritage can be identified, quantifying this impact in dollar terms is a highly subjective process. Distributional impacts are hampered by difficulties in making inter-regional, inter-temporal and interpersonal comparisons. For those impacts that defy sensible quantification or monetarisation, standalone independent assessments are required. By considering the outcomes of all such evaluations, decision-makers can make better-informed judgements based on the broadest of considerations.

To be of value, a VHST must play a desired role in the future urban structure and transport task facing South Eastern Australia. A VHST has to be competitive with the existing modes and attract significant and sustained demand in the future transport market place. In section 14.2 the functionality of a VHST in terms of its role in the future East Coast transport task is assessed.

Section 14.3 describes the model used to undertake the financial and economic evaluation of VHST in the East Coast Corridor.

At the most basic level of consideration and over the long term, projected benefits must exceed expected project disbenefits. No project is likely to sustain an argument in its favour even if it is said to be in the national interest unless it can satisfy this simple criterion. As shown in section 11.10, there are two ways to consider this issue:

- in terms of cash transactions only – the financial or business enterprise perspective; or
- in terms of benefits to the public which include both cash and other transactions which can be represented in monetary terms – the economic or public good perspective.

Section 14.4 presents a preliminary financial assessment from both public and private sector perspectives. Projected revenues and costs are compared at appropriate discount rates, reflecting their likely level of risk. Even for a hypothetical VHST service operating tomorrow, costs and revenue would be subject to uncertainty. Market size, likely diversion, operating and capital costs are all difficult to estimate. Forecasting ten to thirty years ahead compounds risks greatly by added socio-economic and demographic uncertainties.

Section 14.5 presents a preliminary economic evaluation which widens the assessment perspective from that of a financial or business enterprise evaluation to one of the worth of a public investment as made by Governments. This evaluation widens the scope of analysis to include user benefits, indirect benefits to users of existing transport modes, and benefits to the community from reductions in externality costs. It also introduces the notion, as outlined in section 11, that Governments can take a view on the rate at which future costs and benefits should be discounted. This can range from approximating the private sector required rate of return to levels of return similar to its own most basic financial instruments e.g. Commonwealth Bonds.

The economic evaluation was unable to quantify some potentially important indirect benefits for other rail freight and passenger services of corridor enhancement for a VHST. A brief qualitative assessment is provided in section 14.6.

Section 14.7 looks at the incidence of VHST benefit and disbenefit in terms of inland versus coastal, capital versus region, and city versus country relativities. An economic appraisal aggregates benefits and costs to whomsoever they accrue. No weighting is applied. Consideration of whether there are different weights to be ascribed to disbenefits and benefits according to their distribution in the corridor clearly goes beyond conventional cost-benefit analysis and into the realm of satisfying national interest considerations as reflected through policy and the political process.

Section 14.8 presents forecasts of additional population and employment that regional centres may attract with a VHST.

Section 14.9 presents an assessment in which levels of forecast demand are divided by gross capital cost to estimate a set of benefit-cost ratio indicators. This analysis is helpful in assessing the relative performance of the alternative routes in the EC corridor.

Section 14.10 briefly discusses some of the downstream impacts, industry interactions and economic linkages that may be affected by a VHST.

In Section 14.11, an introductory assessment is provided of four issues of national or strategic benefit that the VHST may provide:

- safe long distance travel;
- reduced fossil fuel dependency;
- international obligations regarding greenhouse gas-producing emissions; and
- a greater choice and balance in regional transport provision.

Section 14.12 summarizes the results of the environmental appraisal of the VHST routes drawing out the main adverse impacts that the construction of a VHST might have and how these potential adverse impacts could be appropriately mitigated.

Section 14.13 provides an summary assessment across all of the above dimensions of evaluation.

Except as noted, many of the evaluations in this section have been made for the 350 km/h VHST technology on the basis that this is reasonably representative of the 250 km/h to 500 km/h range at this level of assessment. To the extent practical, any particular differentiating characteristics of the faster and slower technologies are commented upon.

14.2 VHST's Role in the Future East Coast Transport Task

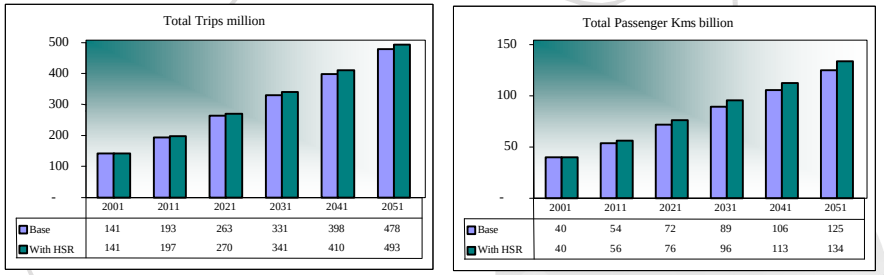
14.2.1. The Future EC Transport Market

As noted in section 10, an EC VHST is not a strategic goal or in the national interest in itself. The issue is whether it can perform a task, which leads to the achievement of strategic goals which themselves are in the national interest. Before looking at the effect of a VHST on such matters, an appreciation is needed of what role it would play in the overall EC transport task. 2021 is taken as an indicator year being ten years after the assumed date of service startup.

The EC VHST travel market is forecast to increase by 3.4 times between 2001 and 2051. Trips are forecast to increase from 141 million to 478 million, an average annual increase of 2.5%. A VHST is forecast to increase the total inscope market by inducing additional travel. In 2021, total trips are forecast to increase by 7 million, an increase of 3.7% with passenger kilometres increasing by 4 billion, 5.6% as a result of the introduction of VHST.

.

Figure 14.1: Total Travel Market with and without VHST



14.2.2. Relative Size of EC Market

The estimates compare with a total non-urban passenger task of 109 billion passenger kilometres estimated for Australia for 2000-01 as a whole by Apelbaum[1]. There are definitional problems that limit the comparability of the two

[1] Apelbaum Consulting Group 1997. "The Australian Transport Task; Energy Consumed and Greenhouse Gas Emissions, September". The Apelbaum figures were updated to 2000 by ACIL Consulting and reported in "Rail in Sustainable Transport" A Report to the Rail Group of the Standing Committee on Transport". October 2000.

estimates, the key one being the definition of non-urban passenger transport adopted by Apelbaum and the inscope VHST potential market adopted in this study. However in broad terms, the inscope market as estimated represents 37% of the non-urban passenger task for the whole of Australia.

Table 14.1: Assessment of Relative Size of Inscope Market

Mode	Australia Non-urban Passenger Task Pax km (b)	EC VHST Inscope Market Size Pax km (b)	EC Share Non-urban %
Air	27	12.6	47%
Car	69	24	35%
Coach	11.1	1.6	14%
Rail	1.9	1.7	90%
Total	109	39.9	37%

Source: Apelbaum 1997 /ACIL 2000, PCIE

14.2.3. Air Travel Market

Air travel is forecast to experience the strongest growth of any mode over the next fifty years. VHST is forecast to reduce EC air travel significantly. Without VHST, the inscope air market (excluding air transfer trips) is forecast to increase 5.5 times from 11 million trips in 2001 to 61.3 million trips in 2051, a percentage increase of 3.5% per annum. Air passenger kilometres are forecast to increase from 10 billion to 56 billion. These forecasts assume that the air service level remains at 2001 levels but that air fares increase at 0.75% pa in real terms.

The introduction of VHST reduces the air travel market to 17.9 million trips in 2021 from 30.8 million, a decrease of 12.9 million trips or 42%. With VHST in place, air travel is still forecast to increase but only to just over half the forecast market size in 2051. The forecast is for 33.5 million trips in 2051, a threefold increase on 2001 levels or 2.2% a year. Passenger kilometres are forecast to be slightly less affected by VHST. In 2021, VHST reduces air passenger kilometres from 37 billion to 23 billion, a reduction of 14 billion or 38%. With VHST, air passenger kilometres increase to 32 billion in 2051 an annual increase of 2.4% compared to 3.5% without VHST.

The size of the reduction is such that air infrastructure will almost certainly be different in the two situations. Moreover, the relationship between air demand and air service supply will be different with associated impacts for airport congestion.

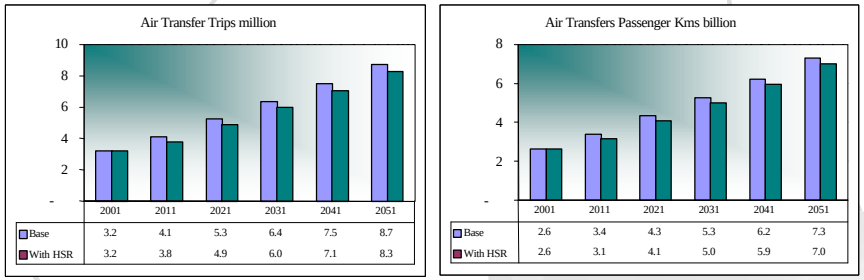
Figure 14.2: Air Market with and without VHST



14.2.4. Air Transfer Market

Air transfer trips represent one fifth of the total air market in terms of trips. The air transfer market is forecast to grow from 3.2 million trips to 8.7 million trips in 2051. Although VHST is forecast to divert some trips, the impact is forecast to be much less than for the origin-destination air market. In 2021, VHST is forecast to reduce the number of air transfer trips by 0.4 million or 7.5%.

Figure 14.3: Air Transfer Market with and without VHST



14.2.5. Car Travel

Car travel is by far the largest market with 112 million trips in 2001 although the average distance travelled is less than for air (214 km compared to 284 km). The car travel market is forecast to grow to 368 million trips by 2051, a percentage increase of 2.4% p.a. The growth in passenger kilometres is forecast to increase from 24 billion to 56 billion (1.7% p.a.).

The effect of VHST on car travel is forecast to be less significant than on the air travel market. VHST reduces car travel by 8 million trips (8.3% decrease) and passenger kilometres by 3 billion (4% decrease) in 2021

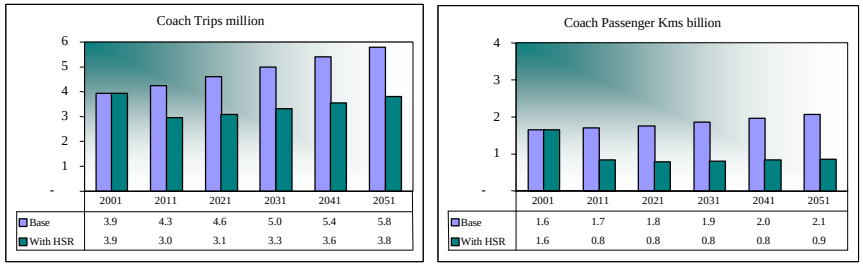
Figure 14.4: Car Market with and without VHST



14.2.6. Coach Travel

The growth in coach travel is forecast to be lower than for air, car or rail travel. In terms of trips, the coach travel market is forecast to increase from 3.9 million trips in 2001 to 5.2 million in 2051, an annual average increase of 0.8%. Passenger kilometres are forecast to grow at a slower rate, averaging 0.5% p.a. Increasing real income is forecast to lead to a switch to air travel at longer distances. VHST has a marked impact because of the faster travel times than coach and lower fares than air. In 2021, coach travel falls by 1.5 million trips (-32%) and by 1 billion passenger kilometres (-56%). The demand reductions strongly suggest that coach service levels would be reduced with VHST. The VHST demand forecasts may therefore be conservative. The second-round impacts on remaining coach users should be assessed in future work.

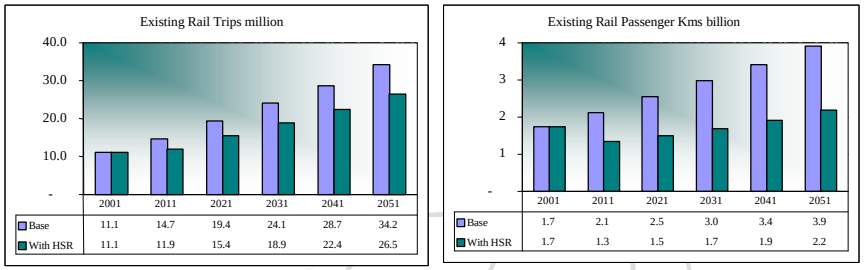
Figure 14.5: Coach Market with and without VHST



14.2.7. Existing Rail Travel

Trips are forecast to increase from 11.1 million trips in 2001 to 34.2 million in 2051, an annual increase of 2.2%. Passenger kilometres are forecast to grow less rapidly from 1.7 billion to 3.9 billion, an increase of 1.6% p.a. implying a slower growth in longer distance rail travel than shorter distance metro rail travel. The demand forecast assumes that existing rail services will continue running to their current service level with the VHST. VHST is forecast to reduce trips by 4 million in 2021, a percentage reduction of 21%. The impact on passenger kilometres is nearly twice as great in percentage terms. Distance travelled falls by 1 billion passenger kilometres, a percentage reduction of 40%. Shorter metro trips, served by frequent conventional rail services, are forecast to be less affected than longer distance trips serviced by interurban services that generally are at lower service levels.

Figure 14.6: Existing Rail Market with and without VHST



14.2.8. VHST Market

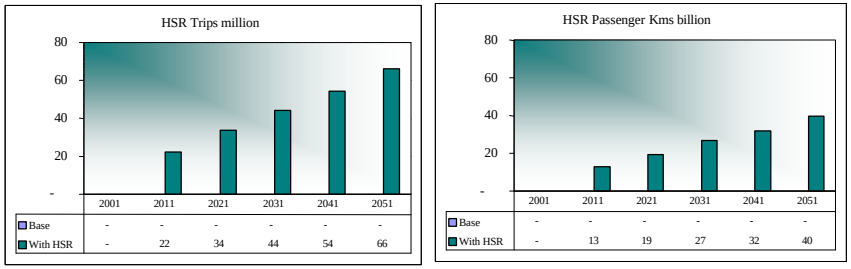
VHST demand is forecast to increase from 22 million trips in 2011 to 66 million trips in 2051 - a threefold increase and an average annual increase of 2.8%. Passenger kilometres, measured in terms of road distance, are forecast to increase from 13 billion to 40 billion.

VHST is forecast to carry 34 million trips and 19 billion passenger kilometres in 2021. These figures compare with a total air market (including air transfers) of 22.8 million trips and 21.1 billion passenger kilometres with VHST. VHST is therefore forecast to achieve a 60% trip share and a 47% passenger kilometre share with respect to air travel.

In terms of the overall market, VHST is forecast to achieve a 12.5% trip share and 25% passenger kilometre share.

If the non-urban passenger market size for Australia as whole increases at the same rate as that projected for the base EC market, the VHST would obtain in 2021 a 9.25% share of the overall non-urban EC passenger transport market.

Figure 14.7: VHST Market



14.2.9. Summary

The future growth in the base travel market is summarised in figure 14.8. The demand for air travel is shown to exhibit the strongest growth over the next fifty years. Significant growth in car travel is also forecast but the future growth in demand for regional ground public transport is shown to be weaker. These projections point to an increasing strain on existing air and road infrastructure and potentially higher externality costs borne by the community at large from increased regional travel. Additional capacity in airports, air control systems and roads is likely to be required to accommodate this travel market growth.

From 2001 to 2051, the total number of trips in the East Coast corridor is forecast to rise from 141 million to 478 million. The air share of this total is forecast to rise from 7.8% to 12.8%. As would be expected, car remains the mode of the majority of trips.

Figure 14.9 summarises the distribution of trips by mode after the introduction of VHST in to the corridor. It shows that air travel would be only 54% of what is predicted in 2051 with no VHST but that the VHST is predicted to have twice the number of air trips.

Figure 14.10 summarises the sources of VHST trips. While VHST captures its market from all modes, it captures most from air followed by car and existing rail. It is also forecast to expand the travel market by inducing travel in the corridor.

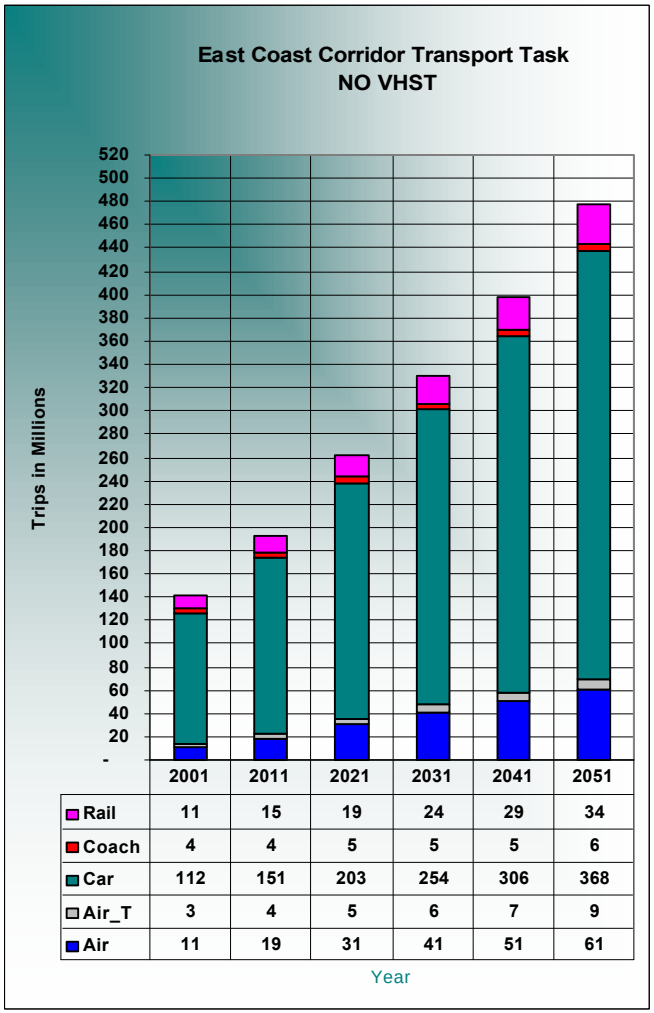
The VHST demand forecasts assume that existing air and road service levels are maintained. To accommodate growth in the travel market, while maintaining existing service levels, will more than likely require additional infrastructure. Under this scenario, VHST is shown to capture significant market share and induce some additional trips. Moreover, VHST is also shown to attract significant demand from air. VHST may therefore be considered as a functional alternative to the investment in additional air infrastructure, which is needed to satisfy the forecast growth in air travel such as a second Sydney Airport. Moreover, if VHST was instead evaluated as an alternative to additional airport infrastructure, VHST demand would tend to increase on the levels presented, other things being equal.

As noted in section 7, VHST will not deliver travel times competitive with air for the Brisbane to Sydney and Melbourne to Sydney sectors. However, it clearly captures a significant market in its own right.

While VHST captures twice the number of trips that air does in 2051, it does not generate twice the number of passenger kilometres, suggesting that air remains the mode for long haul travel in the East Coast corridor and that VHST is providing a more regionally based service.

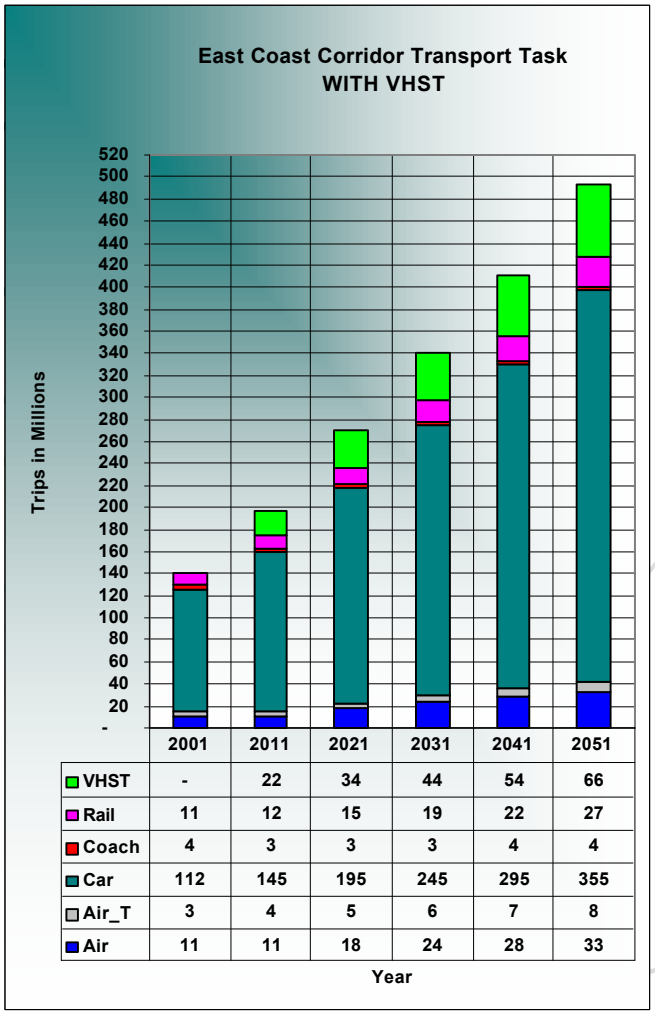
On these forecasts then an EC VHST would play a very significant role in the global East Coast transport task. It would provide a faster service than the existing rail and coach, lessen dependence on car and reduce amount of air traffic in the corridor. Later in this section the manner in which VHST substitutes for air is explored in greater detail to look at which trips and from where a VHST captures its market.





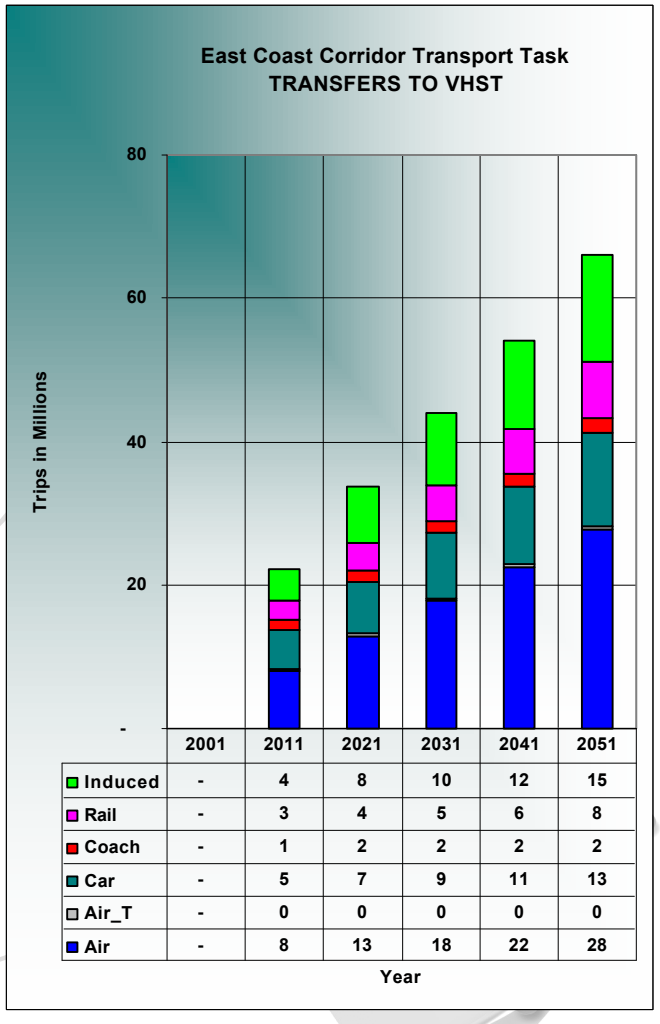
	2001	2011	2021	2031	2041	2051
Rail	11	15	19	24	29	34
Coach	4	4	5	5	5	6
Car	112	151	203	254	306	368
Air_T	3	4	5	6	7	9
Air	11	19	31	41	51	61

Figure 14.8: Base Travel Market



	2001	2011	2021	2031	2041	2051
VHST	-	22	34	44	54	66
Rail	11	12	15	19	22	27
Coach	4	3	3	3	4	4
Car	112	145	195	245	295	355
Air_T	3	4	5	6	7	8
Air	11	11	18	24	28	33

Figure 14.9: Base Market with VHST



	2001	2011	2021	2031	2041	2051
Induced	-	4	8	10	12	15
Rail	-	3	4	5	6	8
Coach	-	1	2	2	2	2
Car	-	5	7	9	11	13
Air_T	-	0	0	0	0	0
Air	-	8	13	18	22	28

Figure 14.10: VHST Market

14.3 Description of Options in Functional Financial and Economic Evaluation

The evaluation model constructed for this study attempts to identify and quantify, where possible, the tangible and intangible costs and benefits associated with an EC VHST. The model adopts a standard discounted cash flow approach and incorporates both financial and economic assessment components. The model is based upon an evaluation period up to 2061. As indicated in section 9, there are a large number of possible permutations available for technology and alignments. Therefore, at this stage, one case considered to be most representative of the possibilities in the context of an EC VHST in Australia was adopted. Other cases are capable of being similarly assessed in the future.

14.3.1. Route and VHST Technology Options Evaluated

The evaluation uses 350 km/h VHST technology as an example. Three corridor sectors were evaluated:

- Brisbane-Sydney;
- Sydney-Melbourne; and
- Brisbane-Melbourne.

Based upon the preliminary corridor analysis presented in section 6, the VHST route adopted as an example was:

- Brisbane-Newcastle coastal;
- Newcastle-Sydney via Hornsby and the Main North line;
- Sydney-Canberra via the Southern Highlands; and
- Canberra-Melbourne via the Inland route.

The three sectors were evaluated separately with no explicit phasing for the complete corridor option[2].

14.3.2. Demand Scenarios

Central, high and low demand projections were developed and used in the financial and economic evaluations. The scenarios were presented in Table 9.16.1.

14.3.3. Cost Scenarios

Central, high and low unit costs ranges were applied to capital and recurrent unit costs.

14.3.4. Evaluation Cases

The combination of the demand scenarios and the unit cost scenarios produced nine overall evaluation cases as shown in Table 3.5.

Table 3.5: Nine Scenarios Evaluated

	Low Demand	Central Demand	High Demand
High Unit Costs	Low Case		
Central Unit Costs		Central Case	
Low Unit Costs			High Case

As indicated, the Low, Central and High cases were evaluated.

14.3.5. Revenue

The VHST fare structure was set to maximise ticket related revenue. Revenue attributable to CityRail, SRA, QR, National Express and bus operators was removed from the gross VHST revenue forecast. GST was subtracted from the net VHST revenue figure. Additional onboard revenue from food and drink and other sales was included net of materials cost. An estimate of station concession net rental was also included based on the number of large and small VHST stations. Net onboard and concession revenue was about 2% of net ticket revenue. Revenue was reduced by 0.5% to take account of service unreliability or cancellation. This is equivalent to VHST services being closed for two days a year[3]. In the evaluation of the likely private sector funding contribution, revenues were increased with expected inflation at 2.5% p.a.[4].

[2] Partial operation before completion is factored into the financial analysis.

[3] For comparative purposes, JNR Railways estimates a reliability figure of 0.6 minutes late per train. If the average train journey is 2½ hours, this is equivalent to 0.4% a year.

[4] In contrast to the economic evaluation that was undertaken in real or constant 2001 dollars.

Table 3.6: Accuracy of Revenue Forecast

	2011	2021	2031	2051
± CV %				
BRI-SYD	22%	26%	42%	57%
SYD-MEL	22%	25%	30%	50%
BRI-MEL	20%	25%	37%	50%
± CV $b				
BRI-SYD	0.09	0.24	0.36	1.19
SYD-MEL	0.10	0.22	0.33	0.54
BRI-MEL	0.26	0.66	1.34	2.73
Central Forecast $b				
BRI-SYD	0.45	0.95	1.33	2.09
SYD-MEL	0.45	0.85	1.11	1.56
BRI-MEL	1.29	2.66	3.58	5.41

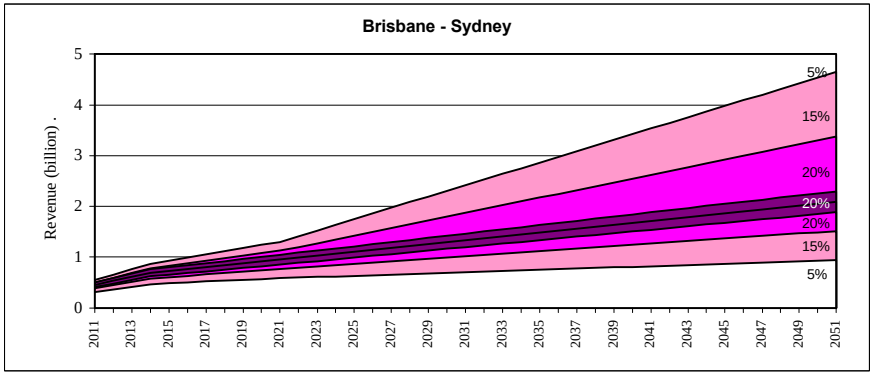
1. CV = Square error expressed as a ratio of the mean forecast.
2. Revenue reduced by 0.5% to take account of service unavailability
3. Note the CV unlikely to be symmetrical – the forecasts suggest more upside than downside.
4. PCIE Indicative forecasts.

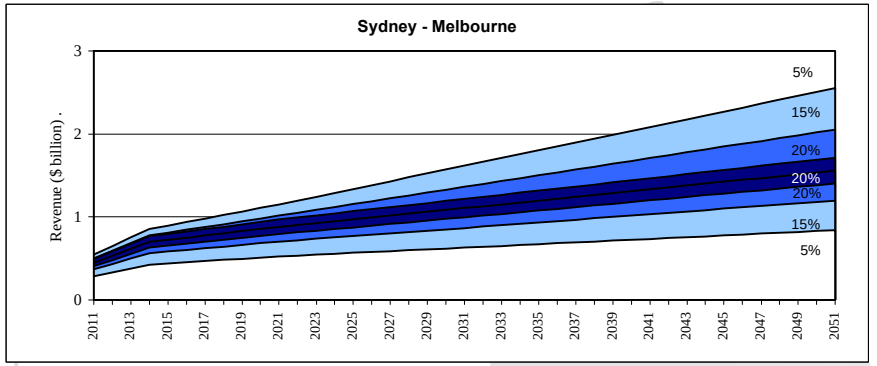
Uncertainty increases the further out the forecast year. The Sydney-Melbourne corridor has a narrower range than Brisbane-Sydney after 2031 reflecting a greater uncertainty in demographics north of Sydney in later forecast years. For 2011 for the full corridor, the central forecast is $1.29 billion with a range of ±$0.26 billion (±20%). There is a 90% chance that the forecast will be within $1.03 billion and $1.55 billion.

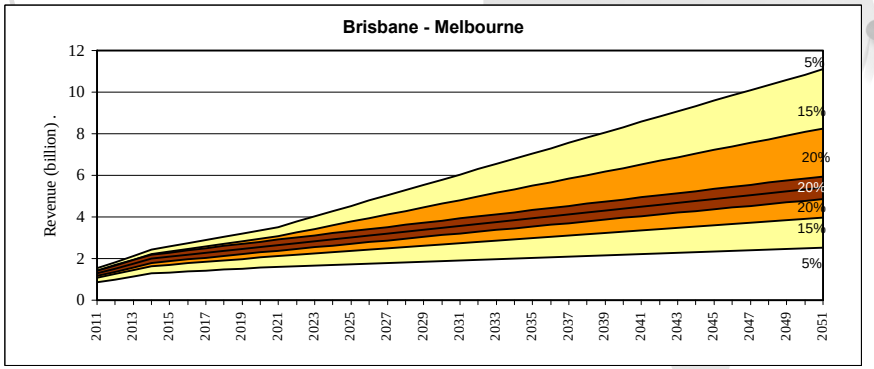
For Brisbane Sydney, the forecast range is $360-540 million in 2011, an accuracy of ±22%. For Sydney-Melbourne, the forecast range is very similar $350-550 million. The forecast range widens to $710-1,190 million for Brisbane-Sydney, to $630-107 million for Sydney-Melbourne and to $2-3.32 billion for the full corridor in 2021.

By 2051, uncertainties in population, employment, real average incomes and tourism growth widen the forecast range for Brisbane-Sydney to ±57%. Tighter population and employment projections narrow the range to ±50% for Sydney-Melbourne. For the full corridor, the forecast range is also estimated at ±50%. It should be noted however that forecast error in non-symmetrical. More upside opportunity is suggested than downside risk especially for Brisbane-Sydney.

Figure 14.11: VHST Revenue Range







14.3.6. Construction Costs

Construction costs were based on estimates contained in section 8. The analysis was based primarily on the central cost estimate. High and low estimates were also tested to allow for cost variance. It should be stressed, however, that while costs were derived from authoritative sources, greater definition would be beneficial.

Table 14.2: Construction Costs
2001 Billion Dollars

VHST Corridor	Low	Central	High
BRI – SYD	18.4	20.5	26.7
SYD – MEL	15.3	17.0	22.1
BRI – MEL	33.7	38.5	48.8

For the private sector financial evaluation, capital costs were escalated for inflation (2.5% p.a.) with allowance for development costs (5%). Construction was assumed to occur over a ten year period following an 'S' shaped profile. The evaluation assumes a 2011 start date for full VHST operations [5].

14.3.7. Rolling Stock Costs

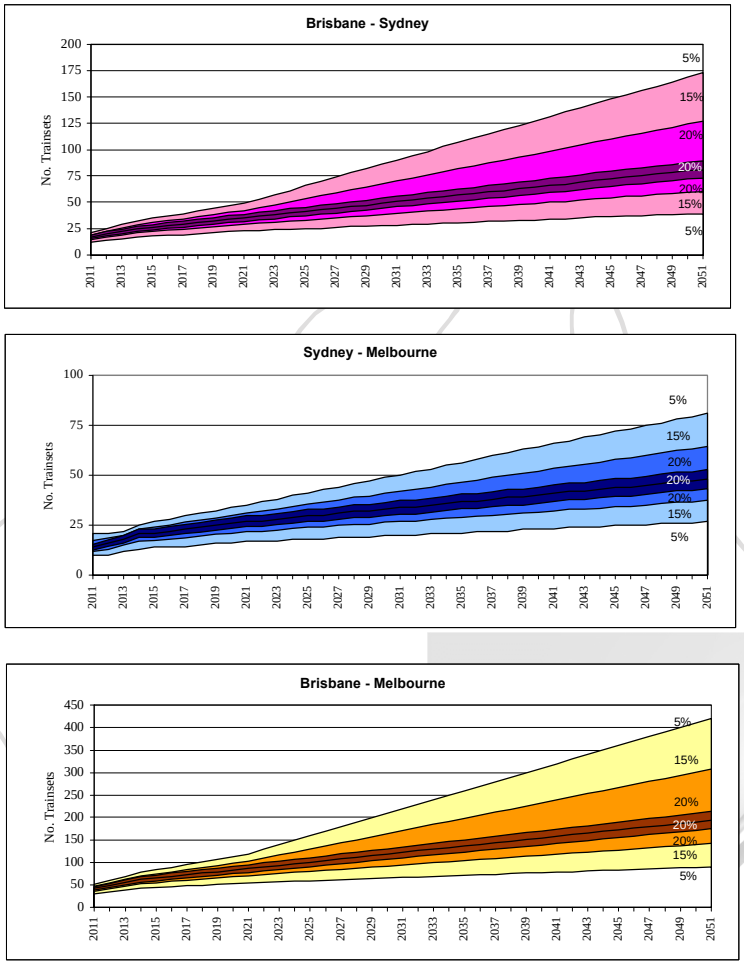
Rolling stock costs were based on scheduled train frequency, forecast demand, train seat capacities, round trip train times, spare requirement, unit rolling stock prices and expected asset life.

The central forecast assumes 16 southbound trains per day (i.e. hourly service), the high forecast 24 trains per day and the low forecast 12 trains per day.

For each year, the maximum passenger load at any point on the route was determined and compared with the number of seats provided. The evaluation assumed 8 car trains of 52 seats each. To take account of demand peaking, the effective number of seats was reduced by 10% (i.e. 47 seats per train). The number of additional trains needed to cater for excess demand was then determined. The required train fleet assumed travel times of 5 hours for Brisbane-Sydney and Sydney-Melbourne and 10 hours for Brisbane-Melbourne. A turn-around time of 1 hour was included and an operating day of 16 hours was assumed to determine fleet requirement. Trains were stabled overnight at appropriate route locations to increase utilisation. Rolling stock was initially purchased in 2011 with subsequent purchases to accommodate demand growth.

VHST train sets were assumed to have a life of 20 years with repeat purchases made when life expired. A cost of each 400-seat trainset of $47 million was adopted. Low and high estimates were also evaluated. Costs were increased for inflation.

Figure 14.12: VHST Rolling Stock Requirements



[5] This implies a notional start in 2001 for initial planning and construction costs and a ten year design and construction period.

14.3.8. Operation Costs of VHST

Operation costs were based on forecast train requirements, route distances, and average cost parameters. Costs were compiled for the following operating components: train operations, train maintenance, station operations and maintenance, track maintenance, passenger volume related and general management overheads.

Train operations and maintenance included train energy, crew and rolling stock cleaning and maintenance. Energy costs were based on an average train weight of 420t, energy consumption of 75 Wh/tkm and a unit cost of $0.0725/KWhr. Track distances of 923 kilometres for Brisbane-Sydney and 1005 kilometres for Sydney-Melbourne were used. Crew costs were based on $242/hr for six crew.

Train cleaning and maintenance was based on train kilometres and the number of trains in the fleet. An annual cleaning cost of $170,000 per train set and a maintenance cost of $1.80 per train kilometre (with a train set multiplier of 1.4) was used in the central forecast.

Track, overhead wiring (OHW) maintenance, signals and communication costs were estimated using average track-kilometre figures. Double track was considered necessary so the costs were doubled.

Table 14.3: Track Maintenance Costs
2001 Thousand Dollars per Track Kilometre

Cost Item	Low	Central	High
Track	39	55	77
OHW	12	17	24
Signals & Communications	11	15	21
Total	62	87	122

Source; Indicative, TMG International 2001

Station operating and maintenance costs were based on $5 million for Brisbane, Newcastle, Sydney, Canberra and Melbourne and $1 million for other stations.

Table 14.4: Number of Stations

Station Size	BRI-SYD	SYD-MEL	BRI-MEL
Large	3	3	5
Medium	12	11	23

Source: Indicative, TMG International 2001

14.3.9. Management and System Overhead Costs

A per passenger cost of $2/trip was included to take account of ticketing and some marketing elements. A management charge of 50% of train operating costs was also included.

14.3.10. Operational Phasing

The revenue forecasts allow for demand ramp up. For analysis purposes a notional operational phasing was included that allowed for some operations to commence before full project completion. With 40% of construction costs incurred, the VHST was assumed to be 25% operational achieving 25% of first year revenue and incurring 25% of first year operational costs. With 80% completed, 50% of revenue and operating costs are assumed.

These are notional estimates that could be replaced in a more detailed study[6].

Table 14.5: Operational Phasing

Completion %	Operational %
0%	0%
40%	25%
80%	50%
100%	100%

14.3.11. Measures of Project Worth

Four measures of the economic worth of VHST were calculated: Net Present Value (NPV); Benefit Cost Ratio (BCR); Net Present Value of Capital Infrastructure (NPVI) and the Internal Rate of Return (IRR).

NPV is the difference between the Present Value (PV) of project benefits (PV (B)) discounted at the chosen discount rate (r) minus the PV of discounted costs (PV (C)):

$$NPV = PV(B) - PV(C) = \sum_{t=0}^{T} \frac{B_t}{(1+r)^t} - \sum_{t=0}^{T} \frac{C_t}{(1+r)^t}$$

VHST may be considered worthwhile if NPV is greater than zero. The Benefit Cost Ratio (BCR) is the ratio of the present value of benefits to the present value of costs:

[6] Operational phasing was only applied in the financial appraisal.

$$BCR = \frac{PV(B)}{PV(C)}$$

VHST is potentially worthwhile if the BCR is greater than 1. In the presence of funding constraints, the BCR provides a way of ranking VHST against other projects. The BCR enables projects to be ranked in terms of the benefit per dollar of cost. The BCR uses all the cost items to determine the benefit ratio. If the constraint is limited to be the infrastructure capital funds (CC) needed to construct the VHST, the Net Present Value of Investment provides a better index:

$$NPVI = \frac{NPV}{PV(CC)}$$

The VHST would be worthwhile if NPVI is positive and should be undertaken if project NPVI exceeds that for other projects competing for capital funding. The economic internal rate of return is the discount rate at which economic NPV is equal to zero. VHST is potentially worthwhile if the IRR is greater than the test discount rate.

14.4 Financial Evaluation

14.4.1. Overview

A preliminary analysis of the indicative level of private sector funding that an EC VHST could support has been undertaken. The key assumptions made in the analysis undertaken are:

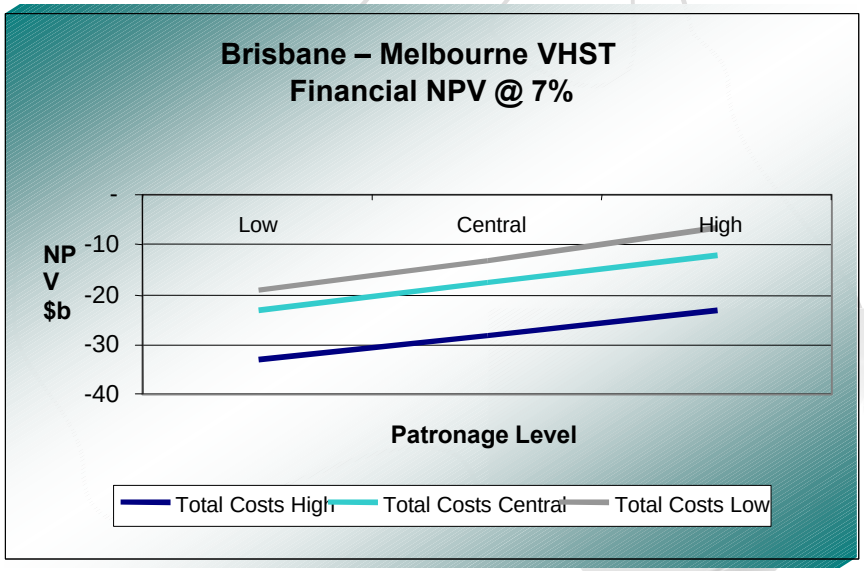
- Construction costs were based on estimates presented in section 8. All costs were escalated for inflation and an allowance was made for associated development costs. Project planning design and construction was assumed to occur over a 10 year period 2001;
- Revenues were based on estimates presented in section 9. Given the long construction timeframe, some revenue was assumed to be derived before completion due to some level of staging; and
- Funding from Governments was also assumed at various levels and for the purposes of analysis this funding was assumed to contribute toward construction costs on a pro-rata basis. Financing costs for the portion assumed to be funded by the private sector were also included.

14.4.2. The Government as Sole Financier

The main question to be addressed here is how well the VHST performs purely in financial terms as a wholly Government funded project. That is to say, what net present value (NPV) does the project have considering only the cash flows from the costs to create and operate it and the revenues, from all sources but principally from fare revenue? Assuming a 350 km/h technology, the evaluation was carried out for a range of demand and cost levels to explore the NPVs which might be achieved and is shown in figure 14.13. The discount rate of 7% was adopted as being representative of the rate Government might impose from its own commercial perspective having regard to its cost of capital and risk in the project.

The result is that, for the full Brisbane to Melbourne VHST project the NPV under any combination does not exceed zero. This is saying that the project would not recover its costs in a purely financial sense over its lifetime.

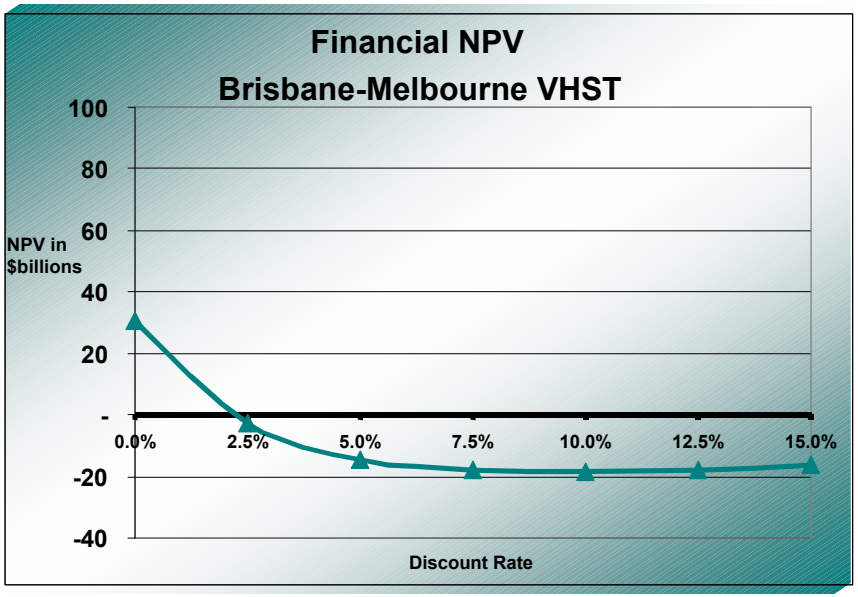
Figure 14.13: Financial NPV at 7% discount rate for Low, Central and High Evaluation Cases



An alternative analysis was undertaken to determine the internal financial rate of return of the project - the discount rate at which financial NPV is zero. Unlike the private sector funding analysis, this preliminary analysis was undertaken without any increase in revenues and costs for inflation. The analysis was undertaken in real terms.

The analysis suggests the financial rate of return to be around 2% for the full EC corridor under the central forecast scenarios. Clearly, if the hurdle rate is higher than 2%, additional benefits wider than purely the financial need to be included.

Figure 14.14: Financial NPV
Central Evaluation Case 350 km/h VHST



Under the low demand scenario, the internal rate of return was not positive for the full EC corridor indicating forecast operating costs exceed forecast revenue. Only for the high demand scenario and the medium demand scenario with low costs is the financial rate of return estimated to be positive.

Table 14.6: Public Sector Financial Internal Rate of Return

Financial IRR (%) at which Financial NPV is zero									
Unit Costs	High Unit Costs			Central Unit Costs			Low Unit Costs		
Pax Scenario	L	C	H	L	C	H	L	C	H
BRI-SYD	-	-	2.8	-	-	3.0	-	1.1	4.1
SYD-MEL	-	-	0.5	-	-	2.2	-	1.2	3.3
BRI-MEL	-	0.3	3.4	-	2.1	4.6	-	3.3	5.6

At these levels of financial return, the Governments would need to be prepared to adopt the arguments put forward in section 11.5.4 in respect of very low discount rates when contemplating a project which in the view of decision makers "creates the future". Powerful arguments would be needed to sustain such a decision in the face of competing investments with more conventional financial returns.

A less severe test is that adopted by the FRA as described in section 10. This tests whether the project is self financing in the operating phase and therefore would not require any ongoing public subsidies once the infrastructure had been created.

The preliminary analysis suggests that the Brisbane-Melbourne corridor could meet the FRA test. At a discount rate of 7% the project has an NPV of $10 billion for the central case scenario. This suggests that once created the VHST could be financially self-sufficient. This is a preliminary finding, however, and would required additional work regarding the capital costs, revenues, rolling stock and operating costs for it to be confirmed with confidence. The scenarios tested highlight a wide range in result. For the full EC corridor, financial NPV ranges from $2 billion in with low demand and high costs to $19 billion with high demand and low costs. Financial performance is suggested to be far more sensitivity to demand than the unit cost assumptions.

Table 14.7: VHST Financial Operating Performance

Operating NPV (Revenue – (Operating Costs + Rolling Stock Capital Costs)) Discounted at 7%									
Unit Costs	High Unit Costs			Central Unit Costs			Low Unit Costs		
Pax Scenario	L	C	H	L	C	H	L	C	H
BRI-SYD	-0.2	2	4	1	3	6	1.5	4	7
SYD-MEL	-0.3	2	3	1	3	4	1.5	3	5
BRI-MEL	2	7.5	13.5	4	10	17	5.5	12	19

Operating BCR (Revenue/(Operating Costs + Rolling Stock Capital Costs)) Discounted at 7%									
Unit Costs	High Unit Costs			Central Unit Costs			Low Unit Costs		
Pax Scenario	L	C	H	L	C	H	L	C	H
BRI-SYD	1.0	1.3	1.5	1.2	1.6	1.8	1.5	1.9	2.2
SYD-MEL	0.9	1.3	1.5	1.2	1.6	1.8	1.5	2.0	2.2
BRI-MEL	1.2	1.5	1.7	1.5	1.9	2.0	1.8	2.2	2.4

Brisbane-Sydney performs slight better than Sydney-Melbourne. The financial NPV range for the central cost scenario is $1 billion-$6 billion for Brisbane-Sydney compared to $1 billion-$4 billion for Sydney-Melbourne.

There is suggested to be considerable financial advantage from combining the two corridors. For the Central Evaluation Case, financial NPV is forecast at $10 billion for the full corridor. This compares with $6 billion for the sum of the northern and southern corridors. Revenue increases far more with both corridors linked than do costs[7].

If this project delivery system is adopted, Governments would still need to contribute 75% or more of the total discounted lifetime cost of the VHST project with the private sector contributing the remainder.

At a rate of return of 15%, the private sector might contribute 11% of Brisbane-Sydney total project costs, 14% for Sydney-Melbourne and 22% for Brisbane-Melbourne. The private sector contribution is forecast to be higher for the full corridor than for the two individual sectors because of the "package" effect.

14.4.3. Private Sector Financing Capacity

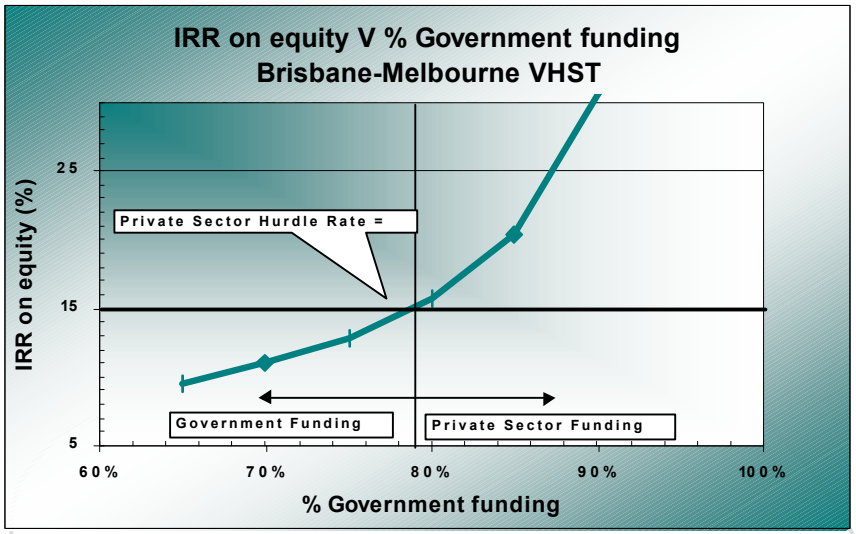
The aim in this regard was to determine what level of private sector debt and equity the project could support based on the costs and revenues assumed. To this end it was assumed that the debt coverage ratios and equity returns required were in line with those stated in section 10. For the purposes of this exercise debt and equity market limitations, as were described in section 10, were ignored.

The main points to come out of this analysis were:

- The estimated gross margin of the project, being the difference between revenues and costs, is relatively small in relation to the capital cost. Consequently, the estimated proportion of the initial construction cost that could be covered by private sector debt and equity would be in the order of 20% as indicated in figure 14.15. This indicates a required contribution from Governments of approximately 80% of the project cost (say $31 billion out of $38.5 billion in 2001$).
- An analysis of the extremes – high costs with low revenues and low costs with high revenues – yields a wider range for this estimate from 60% to almost 95% of the project cost for the full corridor.
- For financial assumptions, the total term debt period is forecast at 20 years (ranging from 18 to 22 years for the full EC VHST).

The degree to which the private sector could contribute to financing stages of the project is shown in figure 14.16. It is relevant to note that the private sector is able to contribute a higher percentage of the costs for the full project, as the gross margin is relatively higher. This results from the network effect described in section 9. Implicit in this assessment is that all of the operating revenues would accrue to the private sector to service operating expense, debt, and equity

Figure 14.15: % Government Funding
Central Evaluation Case 350 km/h VHST



[7] See section 11.XXX. Some costs such as rolling stock requirement, train operating and ticketing costs were related to volume.

Figure 14.16: Funding Levels at notional Private Sector hurdle rate
Central Evaluation Case (Central demand, revenues and costs)

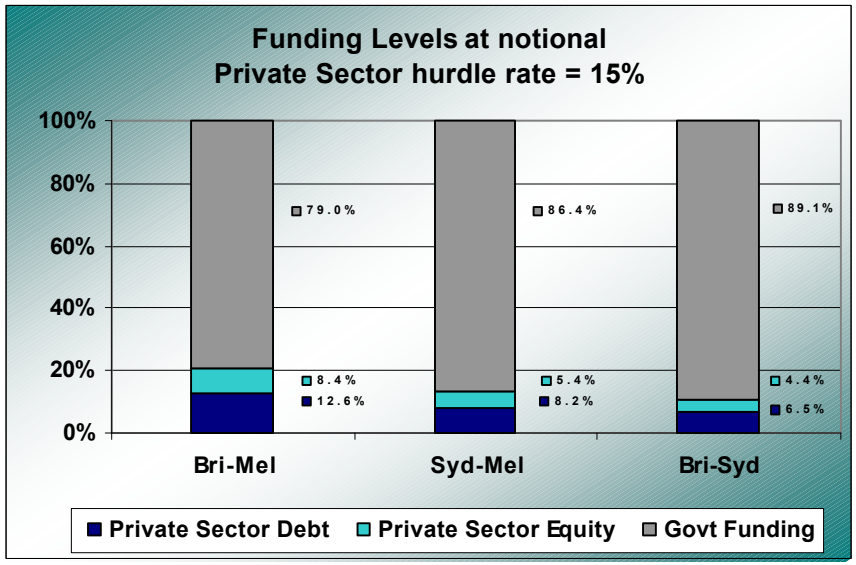


Table 14.8 shows the sensitivity of the private sector % funding and debt payback period across a range of costs and rate scenarios.

Table 14.8 Private Sector Financial Results

Private Sector Funding % with IRR on Private Sector Equity set at 15%									
Unit Costs	High Unit Costs			Central Unit Costs			Low Unit Costs		
Pax Scenario	L	C	H	L	C	H	L	C	H
BRI-SYD	-	5	10	3	11	18	8	16	16
SYD-MEL	-	6	12	5	14	21	8	19	28
BRI-MEL	4	12	18	10	21	31	14	28	40

Debt Pay Back Period (Years) with IRR on Private Sector Equity set at 15%									
Unit Costs	High Unit Costs			Central Unit Costs			Low Unit Costs		
Pax Scenario	L	C	H	L	C	H	L	C	H
BRI-SYD	-	20	23	18	21	23	20	21	23
SYD-MEL	-	19	21	18	20	21	19	20	21
BRI-MEL	18	20	22	19	21	22	20	21	22

The range on the private sector's capacity to share in the financing of the project is from nil under the evaluation case where cost are high and demand is low for the two main sectors to 40% where costs are low and demand is high for the full EC VHST project.

As shown in figure 14.16 and table 14.8, under the central cost and central demand scenarios, the private sector may be able to contribute 11% to the Brisbane-Sydney sector, 14% to the Sydney-Melbourne sector and 21% to the full project.



14.5 Economic Evaluation

14.5.1. Introduction

The financial analysis suggests that it is unlikely that any financial mechanism within the existing taxation and benefit-capture regime will meet the required return of private investors for 100% private sector funding. More than three-quarters of capital finance is likely to be required from governments. To justify taxpayer contributions, benefits in addition to demand revenue need to be demonstrated. This widens the perspective to that of an economic evaluation undertaken from the community perspective.

A Cost Benefit Appraisal has been undertaken to a preliminary level. The 350 km/h technology scenario was selected as a mid-range VHST example. Three key corridor sections: Brisbane-Sydney, Sydney-Melbourne and Brisbane-Melbourne have been evaluated.

The Cost Benefit Appraisal extends the financial appraisal to include user benefits, indirect benefits to users of air and road from reduced congestion and to the community from reductions in road accidents, pollution and greenhouse gas emissions. On the disbenefit side, disruption costs during construction and environment externality costs during operation were added to the capital and recurrent costs included in the financial evaluation.

14.5.2. Evaluation Assumptions

A key difference compared to the financial evaluation is that the economic evaluation is undertaken in constant prices. The economic evaluation is "inflation neutral" with all prices expressed in 2001 constant dollars. All costs and revenues excluded GST. The assumption is that all revenues, costs and benefits will increase at the same rate.

A test discount rate of 7% real was adopted based on the arguments briefly outlined in section 3.11. The economic internal rate of return (EIRR) of VHST was also estimated.

The evaluation was undertaken over a sixty-year period from 2001 to 2061. A 100-year life was attributed to physical infrastructure costs. Rolling stock was assumed to have a twenty- year life. Any capital cost and rolling stock residual value was included 2061[8].

As in the financial evaluation, central, high and low demand projections were used. Forecasts were developed for 2011 (with ramp up), 2014 (ramp up impact ended), 2021 and 2051. Demand was assumed to remain constant at 2051 levels thereafter. A range in capital and operating unit costs was also incorporated to provide a range in economic outcome.

Table 14.9: Benefits and Disbenefits Evaluated

Benefit/Cost	Description
1. Revenue Benefits	- Ticket revenue net of GST and service unavailability. - On-board food and beverage sales net of materials cost. - Station concession-trading net of costs.
2. User Net Benefits	- Time savings to VHST passengers. - Improved convenience and comfort. - Allowance for changes in fare.
3. Decongestion Benefits to Air Users	- Time and operating cost savings to remaining air users and operators from reduced air movement delays from diversion of demand to VHST.
4. Decongestion Benefits to Road Users	- Time and operating cost savings to remaining road and air users (passenger and freight) from reduced road congestion from diversion of traffic from road to rail.
5. Reduced Accident Costs	- Reduced road accidents and associated public costs from diversion of passengers from road to rail.
6. Environmental Benefits	- Benefits to society in general from reduced air and noise pollution and in green house gas emissions time as a result of the diversion of traffic from road and air to rail.
7. Capital Costs	- Physical infrastructure works. - Tunnel, track and signalling costs. - Land acquisition costs. - Rolling stock costs to carry project generated passenger demand.
8. Recurrent Costs	- Train operating costs. - Train maintenance costs. - Track maintenance costs. - Passenger related Costs - marketing and ticketing. - Management and overheads
9. Environmental Costs of VHST operation	- Environmental cost of VHST train operation.
10. Disruption Costs of VHST construction	- Disruption costs during construction.

Note: Items 1, 7 and 8 were included in the financial evaluation

[8] A more detailed evaluation may consider using Terminal Value instead of residual value. Terminal value is the value of future net benefits expresses as Net Present Value accruing in 2061. Terminal value will usually exceed residual value for projects of positive worth and be less than residual value for projects of negative net worth.

14.5.3. Revenue

VHST revenue includes VHST net ticket revenue, on sales and net station concession rentals (all net of GST), as described in the financial evaluation.

With the full VHST corridor, the present value (PV) of future revenue discounted at 7% to 2001 and expressed in 2001 constant prices ranges from $12 billion to $33 billion. With the Brisbane-Sydney VHST corridor, the revenue benefit ranges from $4.4 billion to $12.9 billion. Benefits for the northern corridor are forecast to be 15% more than for the Sydney-Melbourne corridor which ranges from $4 billion to $9.5 billion. The full corridor produces 37% more benefit than the sum of the northern and southern corridors.

Table 14.10: VHST Revenue Benefit

PV 2001 $billion at 7% in 2001 Dollars by VHST Sector

VHST	Low	Central	High
BRI-SYD	4.4	7.8	12.9
SYD-MEL	3.9	6.8	9.4
BRI-MEL	12.0	21.2	33.0

350 km/h VHST
Revenue adjusted for service unavailability
Indicative forecasts, PCIE November 2001

14.5.4. User Benefit

User benefit may be thought of as the difference between the fare the user is willing to pay and the fare actually paid. Generally, the higher the service level, the greater the willingness to pay. To maximise revenue, the VHST operator should set fares to extract as much benefit as possible from the user. The likelihood is however, that fares will not be set to internalise all benefit. Users will retain some residual benefit over and above the fare they pay.

The preliminary analysis estimates that, with the preliminary fare structure, surcharge and discount policies, user benefit in fact exceeds revenue to be the largest component of overall benefit. By comparison, the US Department of Transport assessment of VHST rail in California and the Midwest forecast user benefits and revenue benefits to be roughly equal at US$6.4 and US$6.8 billion respectively[9].

Users of VHST may benefit from travel time reductions, more frequent services, more accessible services, greater comfort, reduced transfer connections (especially through Sydney) and fare reductions. In the demand forecast, these benefits were fully internalised by the fare structure set by the VHST operator.

User benefit was calculated for business and non-business trips separately for each geographic market for each donor mode. A total of 9,872 user benefit estimates were produced for each forecast year[10].

Although the VHST can be considered as "a new mode" it can also be as considered as an improvement on existing rail services. By referencing the existing rail service level, the maximum user benefit was constrained. The overall service level offered by VHST was then compared with the existing rail service level to estimate net VHST user benefit.

For an average passenger diverting to VHST, the benefit can be considered as half the total benefit. A user may be just unwilling to divert to rail at the existing (non-VHST) service level. The benefit obtained is the full benefit of VHST compared to existing rail (100%). Another user may be indifferent to diverting to VHST at the VHST service level. User benefit for this passenger (over and above the fare paid) is zero. The average benefit is therefore half the change in benefit[11].

With the full VHST corridor, the PV of future user benefits discounted at 7% to 2001 and expressed in 2001 constant prices ranges from $17 billion to $74 billion. The wide range is attributable in part to the variation in real average income that affects the value of travel time savings as well as base market demand and diversion levels. For the Brisbane-Sydney VHST corridor, user benefit ranges from $6 billion to $28.5 billion. Benefits for the northern corridor are forecast to be 43% more than for the Sydney-Melbourne corridor for which user benefit is forecast to range from $4.5 billion to $15.9 billion. The full corridor produces 66% more benefit than the sum of the northern and southern corridors.

[9] " Midwest Regional Rail System: A Transportation Network for the 21st Century" Executive Report Prepared for Illinois Department of Transport (DoT), Indiana DoT, Iowa DoT ,Michigan DoT ,Minnesota DoT ,Missouri DoT, Nebraska Department of Roads, Ohio Rail Development Commission, Wisconsin DoT, Amtrak. Report by Transportation Economics & Management Systems, Inc in association with Paine Webber Incorporated and Quandel & Associates, February 2000.

[10] 1,230 flows for 4 modes (air, car, coach and existing rail) times 2 journey purposes (business and non-business) plus 16 flows for air transfers times 2 journey purposes.

[11] Commonly referred to as the "rule of a half". The use of a half assumes a straight-line demand curve. If the demand curve is curved, average user benefit will differ from 50%.

Table 14.11: VHST User Benefits

PV 2001 $ billion at 7% in 2001 Dollars by VHST Sector

VHST	Low	Central	High
BRI-SYD	6.0	14.2	28.5
SYD-MEL	4.5	9.9	15.9
BRI-MEL	16.9	40.1	73.9

Indicative forecasts, PCIE November 2001

User benefit is forecast to be twice the revenue benefit for the full corridor (Central Evaluation Case). This suggests some scope for increasing revenue through greater price discrimination or an increase in VHST real fares over time.

14.5.5. Airport Decongestion Benefits

By diverting patronage from air, decongestion benefits may be conferred to remaining users of air services. Alternatively public costs may be saved if additional airport capacity can be avoided or deferred.

Decongestion benefits were included in comparable US Department of Transport assessments of VHST rail in California and the Midwest. For the Midwest Regional Rail System, airport congestion relief and air carrier operating cost reductions were estimated at US$1.1 billion out of a total benefit of US$15.9 billion in 1998 dollars. Air congestion savings represented 7% of total project benefits.

For East Coast Australia, benefit will depend on air congestion, which in turn will depend on whether additional air capacity such as a second Sydney airport is constructed. Defining the "Base Case" is therefore important. In the demand study, the Base Case assumes air service levels remain at 2001 levels.

Sydney Airport has an aircraft handling limit set by legislation at 80 movements per hour. The Airport is forecast to reach capacity between 2006 and 2011 depending on the use of larger aircraft[12]. The Second Sydney Airport (SSA) EIS expects total aircraft movements to/from Sydney will increase from 291,000 in 1999-2000 to 381,000 in 2009-2010 and 480,000 in 2021-2022. If current trends in aircraft size and loading continue, Sydney Airport is forecast to reach capacity in 2006-2007. Alternatively, if regional passengers are carried in larger aircraft, the number of regional aircraft movements could be reduced to allow slots for domestic and international services. Under this scenario, capacity would be reached in 2010-2011.

If capacity is not increased, the quality of air service provision will deteriorate and/or demand may be constrained.

The SSA EIS identified the following consequences of an increase in passengers at Sydney Airport within given maximum traffic levels:

- need for additional terminal space eventually in new precincts on the current site;
- significant upgrading of road access to the airport;
- as only limited developments can occur on and around the current airport site, the cost of such development would be expected to grow significantly over time;
- ground congestion would also feature more highly with consequent costs to passengers and airlines;
- noise impacts of larger aircraft and air quality and noise impacts of an increase in road traffic to Sydney Airport.

The implication for VHST, is that demand, revenue and user benefit may be underestimated by assuming future air demand is unconstrained.

On the other hand, if a Second Sydney airport is provided and/or additional terminal, runway and air carrier capacity provided elsewhere there will be less scope for congestion savings. Indeed, if service levels are improved on current levels, the VHST demand forecasts could be overestimated.

The 1999 SSA EIS Supplement, assessed VHST as an alternative to additional airport and road infrastructure. VHST was considered alongside five strategic alternatives to a second Sydney Airport at Badgery's Creek:

- do nothing option.
- expanded use of Bankstown airport for regional traffic.
- major expansion of Sydney airport.
- use of other capital city airport.
- very high speed rail linking capital cities.
- second Sydney airport at Badgery's Creek.

The assessment of VHST considered links between Sydney and Brisbane, Canberra and Melbourne. Based on assumed diversions[13] to VHST for main capital city air pairs, an estimate of the aircraft movement capacity of Sydney Airport was

[12] " Second Sydney Airport Proposal - Environmental Impact Statement Supplement Report" Report prepared by PPK Environment and Infrastructure Pty Ltd for Department of Transport and Regional Services, 1999

[13] SYD-CAN 90% to VHST; SYD-MEL 40%; SYD-BRI 40%; CAN-BRI 20%; MEL-BRI 10% Table 4.3 "Second Sydney Airport Proposal Environmental Impact Statement Supplement". A footnote to these estimates was included "The percentage estimates quoted in this table are for illustration only and do not represent estimates by the Department of Transport and Regional Services of the likely market impact of very high-speed train services".

made. The analysis suggested that Sydney airport could be extended by four years from 2010-11 to around 2015-16. The assessment argued that:

> *"…A very high speed train service is unlikely to be a substitute for a Second Sydney Airport. The very large scale of investment requirement to establish very high speed train services would only displace a relatively small number of aircraft movements at Sydney Airport".*

The assessment did not consider diversion of regional services and the impact of significant reductions in regional aircraft movements. For 1997-1998, regional flights accounted for one third of total movements, the same as scheduled domestic flights. International flights accounted for 12% with non-scheduled services accounting for the remaining 22%[14]. If some of the regional services were reduced as a result of passenger diversion to VHST, there would be greater capacity for jet services.

The VHST demand model was used to provide an indicative estimate of the reduction in aircraft movements for Sydney and other airports within the EC corridor for each of the VHST options. A jet size of 175 passengers and turbo-prop plane size of 25 was assumed with allowance for growth in passengers per movement of 0.8% p.a.[15] the reduction in aircraft movements was estimated for each airport within the EC corridor.

Table 14.12: Forecast Reduction in Aircraft Movements with VHST

Number of takeoffs and landings at East Coast Airports (thousands per year)

	2011			2021			2051		
VHST Sector	Jet	Prop	Total	Jet	Prop	Total	Jet	Prop	Total
Sydney									
BRIS-SYD	6	53	59	9	78	87	9	78	87
SYD-MEL	14	16	30	18	22	40	25	38	63
BRIS-MEL	25	100	125	35	159	194	54	284	338
Total									
BRIS-SYD	18	133	151	28	214	242	52	389	441
SYD-MEL	14	33	47	19	46	65	26	73	99
BRIS-MEL	46	250	296	67	406	473	113	738	851

Indicative forecasts, PCIE November 2001

This admittedly indicative analysis suggests that the reduction in regional turbo-prop movements could be far larger than the reduction in jet movements. For 2021, 35,000 fewer jet movements at Sydney Airport and 159,000 fewer turbo-prop movements are forecast with a full VHST Brisbane-Melbourne VHST. The reduction in total movements is suggested to be 4.5 times the reduction in jet movements. The analysis also shows that four airport movements are removed from Sydney Airport (2021 full corridor) for every ten airport movements in the whole corridor. The reduction in air movements is therefore forecast to be greatest where airport congestion is currently at its worst.

The analysis suggests that by including regional air movements, the reduction in movements at Sydney Airport could be significantly more than that estimated in the SSA EIS. It should be stressed again that the forecasts presented here are indicative, providing only an order of magnitude assessment. The future pattern of regional movements could be rationalised reducing the number of airport movements per passenger trip. Hub flights based on Sydney could be decreased in future years.

Nevertheless the important corollary is that VHST could delay the need for a second Sydney Airport beyond the four years reported in the SSA EIS. The number of years deferred will depend on the VHST corridor constructed. With the continuation of the existing pattern of air services, a Brisbane-Sydney VHST corridor is forecast to reduce air movements by 75% more than a Sydney-Melbourne VHST corridor. This result stems from the greater number of smaller regional services from northern NSW that use Sydney as a hub. A complete Brisbane-Melbourne VHST corridor also produces a greater reduction in aircraft movements than the sum of the northern and southern sections (96,000 more in 2011 or around one third more).

Any deferral of a SSA could represent a significant saving in public costs to offset against VHST capital requirements. Based on the SSA EIS, the cost of a SSA (essentially construction of the airport and associated infrastructure) is estimated at $4.1 billion in 2001 dollars. The SSA economic evaluation estimated that a subsidy of $1.4 billion (2001 dollars) would be required at a discount rate of 7%. Alternatively an additional user charge of $20 (2001 dollars) per ticket would need to be levied (6% of a typical airfare) on passengers to make a SSA viable.

For the purposes of the VHST economic evaluation, the subsidy per passenger was converted into a cost of $1,600 per aircraft movement assuming an average load of 80 passengers per flight[16]. Congestion characterises Sydney airport far

14 Estimated from figure 4.2 SSA EIS 1999.

15 Assumption made in SSA by DoTRS.

16 Based on 1997-98 passenger numbers of 21.3 million and 276,300 aircraft movements into Sydney SSA EIS section 4.3.2.

more than other EC airports however. The $1,600 congestion charge was applied to the reduction in Sydney aircraft movements only. A notional figure of $160 per movement (10% that of Sydney) was applied to Brisbane and Melbourne with a zero charge applied to all other EC airport movements.

With the full VHST corridor, the PV of airport decongestion benefits ranges from $1 billion to $3.8 billion. With the Brisbane-Sydney VHST corridor, the PV of airport decongestion benefits ranges from $0.5 billion to $1.7 billion. Benefits for Brisbane-Sydney are 2.3 times greater than Sydney-Melbourne. The full corridor produces 60% more benefit than the sum of the northern and southern corridors.

Table 14.13: Airport Decongestion Benefit

PV 2001 $ million at 7% in 2001 Dollars by VHST Sector

VHST Sector	Low	Central	High
BRI-SYD	530	1,109	1,714
SYD-MEL	202	480	692
BRI-MEL	1,076	2,401	3,840

Indicative forecasts, PCIE November 2001

14.5.6. Road Decongestion Benefit

By diverting traffic from road, the VHST may confer a net benefit to remaining road users through reducing road congestion. Clearly, savings will depend on future congestion levels without VHST.

In metropolitan areas, decongestion savings of around 28c per car kilometre are possible, based on estimates reported in the Parramatta Rail Link EIS. Masson, Wilson and Twiney used an all-day Sydney wide road traffic model to assess the effect of road traffic diversion to the new rail link. Based on their estimates, a road decongestion benefit of 28c per diverted car kilometre was used in the economic evaluation. A similar decongestion benefit per car kilometre has also been estimated for Melbourne.

The likelihood is that savings per diverted car kilometre will be much greater in metropolitan areas than in regional areas. A UK study by Peirson[17] provided an estimate of the relative cost of road congestion in inter-urban areas compared to urban peak road travel (non London). Congestion costs per passenger kilometre in inter-urban areas were estimated at 0.3% of urban peak travel. This percentage was applied to the Sydney estimate of 28c to give a notional inter-urban congestion benefit of 0.084c per diverted car kilometre. The urban and inter-urban rates were then applied to the estimate of diverted car kilometres forecast by the demand model.

For 2021 for the full VHST corridor, the reduction in car kilometres is forecast at 1.5 billion of which 140 million (9%), is forecast to be in metropolitan areas. The associated annual road decongestion benefit is forecast at $40 million. At $24 million, 60% of decongestion benefits are forecast to be between the Central Coast and Sydney. A benefit of $5.8 million (14%) is forecast between Sydney and ACT, $4.1 million between Brisbane and the Gold Coast (10%) and $3.9 million (10%) on the northern route into Melbourne. Of the total benefit of $40m, $39 million (97.5%) is estimated to be in metropolitan areas and $1 million (2.5%) on inter-urban roads. It should be stressed that these forecasts are indicative. No decongestion benefit from the reduction in coach kilometres has been included.



[17] Estimating the External Costs of UK Passenger Transport: The First Step Towards an Efficient Transport Market" Discussion Paper 94/2 June 1994, Peirson J., Skinner I ., and Vickerman R ., Centre for European, Regional and Transport Economics.

Table 14.14: Diverted Car Kilometres and Decongestion Benefit
Forecast Year 2021 350 km/h VHST Central Evaluation Case

Road section	Metropolitan Diverted Car km (million)	Total Diverted Car km (million)	Decongestion Benefit $million
Brisbane - Gold Coast	14	54	4.1
Gold Coast - N.NSW	-	179	0.2
N.NSW-Newcastle	-	337	0.3
Brisbane-Toowoomba	-	1	0.1
Toowoomba-N.NSW	-	5	-
N.NSW-Newcastle	-	9	-
Newcastle-Central Coast	-	80	0.1
Central Coast-Sydney	87	116	24.3
Sydney-Wollongong	1	2	0.2
Wollongong-ACT	-	-	-
Sydney-ACT	20	207	5.8
ACT-Albury	2	52	0.7
Albury-Shepparton	-	180	0.2
Shepparton - Melbourne	14	96	3.9
ACT - Cooma	1	27	0.4
Cooma - Gippsland	-	122	0.1
Gippsland - Melbourne	-	-	-
Total	**140**	**1,469**	**40.3**

VHST Route: BRI-NEW (Coastal); NEW-SYD via Hornsby; SYD-CAN via Central Highlands; CAN-MEL (Inland)
Note: numbers may not sum due to rounding
Indicative forecasts, PCIE.

With the full VHST corridor, the PV of road decongestion benefits ranges from $296 million to $426 million. With the Brisbane-Sydney VHST corridor, the PV of benefits ranges from $160 million to $244 million. Benefits for the northern corridor are nearly double those of the Sydney-Melbourne corridor. The full corridor produces 15% more benefit than the sum of the northern and southern corridors.

Table 14.15: Road Decongestion Benefit
PV 2001 $ million at 7% in 2001 Dollars by VHST Sector

VHST Sector	Low	Central	High
BRI-SYD	160	179	244
SYD-MEL	81	96	138
BRI-MEL	296	316	426

Indicative forecasts only, PCIE November 2001

Road decongestion benefits are forecast to be considerably less than airport benefits. For the Central Evaluation Case road decongestion benefits are 13% that of airport decongestion benefits. This is attributed to the much lower diversion rate from car than for air, the relative high cost of airport congestion in Sydney and the benefits of reductions in regional air traffic and the long inter-urban road distances where congestion costs are low.

14.5.7. Impact on Accident Costs

A significant shift in usage from air and road to VHST may also be beneficial if accident costs are reduced. Air, rail and coach are comparatively safe modes of transport and a redistribution of demand to VHST is unlikely to affect accident costs significantly. Section 10.1 provides an estimate of the relative accident rate for road and rail. The BTE estimates the cost of a road crash involving a road fatality at $1.7 million and the cost of a crash not involving a fatality at $19,500[18]. Based on the forecast reduction in road accidents resulting from traffic diversion to VHST, the PV of accident savings is estimated at $146-201 million for the full EC project. The PV benefit for Brisbane-Sydney ranges from $128 million to $153 million, compared to $125-138 million for Sydney-Melbourne.

Table 14.16: Reduced Fatalities
Total Number Fatalities Avoided over Fifty Years (2011 - 2061)

VHST Sector	Low	Central	High
BRI-SYD	128	138	153
SYD-MEL	125	131	138

[18] It should be noted that there is an argument that only a portion of accident savings should be included since those switching from road and air to VHST would implicitly make a relative risk assessment when deciding to pay the VHST fare. Hence accident benefits are already included in user benefit + revenue. Including accident savings again is therefore double counting. For example, the UK Department of Transport Section 56 Public Transport Grant Scheme allows only 7.5% of costs relating to fatalities, 6.6% to serious injury and 7% to slight injuries as cost elements that accrue to society as a whole rather than reflecting users' willingness to pay. However 100% of accident savings to pedestrians and cyclists are allowed.

BRI-MEL	146	172	201

Indicative only, PCIE November 2001

The monetised value of accident savings is forecast to be 2.6 times that of road decongestion. With the full VHST corridor, the PV of accident savings ranges from $785 million to $1,056 million. With the Brisbane-Sydney VHST corridor, the PV of benefits ranges from $372 million to $542 million. Benefits for the Brisbane-Sydney corridor are 54% greater than Sydney-Melbourne. The full corridor produces 22% more savings than the sum of the northern and southern corridors. The estimates are only intended to be indicative.

Table 14.17: Accident Cost Savings

PV 2001 $ million at 7% in 2001 Dollars by VHST Sector

VHST Sector	Low	Central	High
BRI-SYD	372	401	542
SYD-MEL	228	260	354
BRI-MEL	785	808	1,056

Indicative forecasts only, PCIE November 2001

14.5.8. Noise and Local Air Pollution

The diversion of traffic to VHST will also be beneficial to the community if local air and noise pollution is reduced. These benefits need to be offset against increased power station emissions resulting from VHST power generation and any significant noise impacts where mitigation measures fail to keep VHST noise below acceptable levels.

Air transport is associated with significant noise externalities for communities living close to airports. The SSA EIS stated that "major environmental considerations (particularly for Sydney Airport Capacity Scenario 2) are likely to include the noise impacts of larger aircraft and air quality and noise impacts of an increase in road traffic to Sydney Airport". The SSA mentions the possibility of a scenario in which "the capacity of Sydney Airport is further constrained by more stringent noise management practices, or by a failure to obtain necessary environmental approvals to expand ground infrastructure to cope with an increase in passengers beyond its current level of development".

At Sydney Airport when a B747-200 (the loudest aircraft type to commonly use KSA) takes off to the south from the main north-south runway about 4,000 persons are exposed to a noise event louder than 70 dBA[19]. Currently 840,000 people live within 10 kilometres of Sydney Airport. With the current 300,000 aircraft movements per year, the SSA EIS estimates that there are 11 million individual instances of exposure to a noise event louder than 70 dBA. This would rise to 13.3 million if the number of aircraft movements increases to 353,000[20].

It is important to note however that VHST will also have a noise impact[21]. Indeed, for Europe, Mauch and Rothengatter estimate air and rail to have similar noise pollution costs.

Mauch and Rothengatter estimate air transport produces 2.5 times the local air pollution per passenger kilometre of rail and is 1.45 times worse than rail in terms of noise pollution[22]. By comparison, Peirson estimates car to be four times worse than rail in terms of noise pollution. For local air pollution, Mauch and Rothengatter estimate car to produce an emission cost 3.3 times that of rail. This compares with a ratio of 1.54 estimated by Peirson.

The PRL EIS update[23] included a benefit of 0.16c for noise and 0.82c for local air pollution per car kilometre saved.

Table 14.18: Relative External Costs of Transport

	Mauch & Rothergatter ERU 17 ECU per 1,000 pkm				Peirson UK Inter-Urban (Ukp/pkm)			PCIE C/carkm Car
Effect	Car	Bus	Air	Rail	Car	Bus	Rail	Car
Noise	4.5	4.2	3.0	3.1	0.08	0.02	0.02	0.16
Air Pollution	6.6	4.1	5.0	2.0	0.17	0.18	0.11	0.82

Within the EC corridor, Noise and local air pollution outside the populated areas should have relatively little impact compared to pollution within metropolitan areas. A noise externality cost per passenger kilometre of 0.02c for car, 0.005c for coach and 0.04c for air was considered reasonable based on the evidence reviewed. Local air pollution costs of 0.2c, 0.2c and 0.15c respectively were also assumed.

19 If the aircraft had taken off to the north and flown towards the northwest more than 250,000 persons are exposed to a noise event louder than 70dBA.

20 A Second Sydney airport at Badgery's Creek is estimated to reduce the number of instances. If operating to 130,000 movements a year, the number of individual instances of exposure to a noise event louder than 70dBA is estimated at between 0.18 and 0.35.

21 Refer to Section 6 which discusses the Environmental Impacts of the proposed VHST corridors.

22 Section 14.10.4 compares the emissions of air, car, coach, VHST and existing rail.

23 " Parramatta Rail Link Economic Evaluation", PCIE August 2001, Report to Parramatta Rail Link Company.

Table 14.19: Externality Benefit per Car Kilometre
Cents per Passenger Kilometre

Externality Benefit	Car	Coach	Air
Noise Pollution	0.02	0.005	0.04
Local Air Pollution	0.2	0.2	0.15

PCIE based on various sources (refer to text).

With the full VHST corridor, the PV of local air pollution savings is forecast to range from $105 million to $266 million for the full EC VHST. Noise savings are smaller, ranging from $18 million to $59 million. Local air and noise pollution savings are 40% and 45% higher for the northern corridor. A full EC corridor is forecast to produce 46% the benefit of the sum of the northern and southern sections.

Table 14.20: Noise and Local Air Pollution Savings
PV 2001 $ million at 7% in 2001 Dollars by VHST Sector

	Noise			Local Air Pollution		
VHST Sector	Low	Central	High	Low	Central	High
BRI-SYD	7	14	25	42	71	117
SYD-MEL	5	10	14	31	49	68
BRI-MEL	18	37	59	105	174	266

Indicative forecasts, PCIE November 2001

14.5.9. Reduction in the Cost of Greenhouse Gas Emissions

The reduction in the cost of greenhouse gas emissions was based on CO_2 and other GHG emissions rates for air, car and coach[24] and a cost of $60/t of CO_2[25].

With the full VHST corridor, the PV of GHG savings ranges from $577 million to $2 billion. The PV of GHG savings for the Brisbane-Sydney VHST range from $263 million to $883 million and are 45% more than for the Sydney-Melbourne VHST. A full EC corridor is forecast to produce 50% the benefit of the sum of the northern and southern sections.

[24] GHG emissions were expressed in terms of their Global Warming Potential (GWP) which expresses the relative effect of a tonne of methane relative to a tonne of CO2. This is discussed in more detail in section 10.3.

25 ABARE, Outlook 1999 "The Kyoto Protocol, Economic Impacts on Annex B Economies" presented a cost range of $37 to $82 per tonne of GHG emissions. Commonwealth of Australia, "The Australian Transport Task, Energy Consumed and Greenhouse Gas Emissions", Sept 1997

Table 14.22: GHG Emission Savings
PV 2001 $ million at 7% in 2001 Dollars by VHST Sector

VHST Sector	Low	Central	High
BRI-SYD	383	657	1,103
SYD-MEL	268	449	626
BRI-MEL	937	1,609	2,499

Indicative forecasts, PCIE November 2001

14.5.10. Discounted Construction Costs

The capital cost for the full EC corridor is estimated to range from $23.7 billion to $34.3 billion, discounted at 7%, expressed in 2001 dollars and including residual life[26]. The central discounted cost of $34.4 billion is 70% of the undiscounted construction cost of $37.5 billion. The discounted capital cost of Brisbane-Sydney ranges from $13 billion to $18.8 billion and is about 25% higher than Sydney-Melbourne, which ranges from $10.8 billion to $15.6 billion.

Table 14.23: Discounted Construction Costs
PV 2001 $ million at 7% in 2001 Dollars by VHST Sector (includes residual value)

VHST Sector	Low	Central	High
BRI-SYD	13.0	14.4	18.8
SYD-MEL	10.8	12.0	15.6
BRI-MEL	23.7	26.4	34.3

350 km/h VHST
TMG/Arup estimates

14.5.11. Discounted Rolling Stock Costs

Rolling stock costs are a function of the scheduled frequency, maximum passenger load (which determines the need for any additional trains) and the cost parameters. A range in cost estimate dependent on demand and unit costs was estimated. For the full corridor, the PV of rolling stock costs discounted at 7% and expressed in 2001 constant dollars ranged from $1.3 billion with low demand and low unit costs to $5.8 billion with high demand and high unit costs. With central unit costs, the range narrows to between $1.7 billion and $4.9 billion. For the Brisbane-Sydney

[26] Residual values have been calculated according to straight line depreciation (i.e. the proportion of remaining economic life) and accrue in 2041. Construction phasing has been taken into account in determining remaining life.

corridor, the PV cost ranges between $0.6 billion and $2.4 billion compared to a range of $0.4 billion and $1.4 billion for Sydney-Melbourne. For the central estimate, rolling stock costs are 42% higher than Sydney-Melbourne.

Table 14.24: Discounted Rolling Stock Costs

PV 2001 $ million at 7% in 2001 Dollars by VHST Sector (includes residual value)

	Low Unit Costs			Central Unit Costs			High Unit Costs		
	Demand Scenario			Demand Scenario			Demand Scenario		
VHST Sector	Low	Central	High	Low	Central	High	Low	Central	High
BRI-SYD	0.6	1.0	1.6	0.7	1.24	2.0	0.8	1.4	2.4
SYD-MEL	0.4	0.7	1.0	0.5	0.8	1.2	0.6	1.0	1.4
BRI-MEL	1.3	2.3	3.9	1.7	2.9	4.9	2.0	3.5	5.8

350 km/h VHST

14.5.12. Operation Costs of VHST

VHST operating costs depend on the scheduled frequency, maximum passenger load (which determines the need for any additional trains), track distance and turn-round times and unit cost parameters. For the full corridor, the PV of operating costs ranges from $5.9 billion with low demand and low unit costs to $16.1 billion with high demand and high unit costs and narrows to between $7.2 billion and $13.7 billion with central unit costs. For Brisbane-Sydney, the cost range is from $2.6 billion to $6.8 billion and from $2.3 billion to $5.3b for Sydney-Melbourne. For the central estimate, operating costs are 14% higher than Sydney-Melbourne.

Table 14.25: Discounted Costs of VHST Operation

PV 2001 $ billion at 7% in 2001 Dollars by VHST Sector

	Low Unit Costs			Central Unit Costs			High Unit Costs		
	Demand Scenario			Demand Scenario			Demand Scenario		
VHST Sector	Low	Central	High	Low	Central	High	Low	Central	High
BRI-SYD	2.6	3.4	4.9	3.2	4.1	5.7	4.0	5.0	6.8
SYD-MEL	2.3	2.9	3.6	3.0	3.6	4.3	3.8	4.5	5.3
BRI-MEL	5.9	8.2	12.0	7.2	9.7	13.7	8.9	11.7	16.1

350 km/h VHST

14.5.13. Externality Disbenefits of VHST Operation

Externality costs for VHST operation include accidents, noise and local air pollution and GHG emissions. Accident costs were based on a cost of $1.7m per fatal accident factored by 1.28 to allow for non-fatal accident costs. The accident rate is discussed in section 14.11.2. An externality cost of cost per train kilometre of 1.6 cent and 0.4 cents for local air pollution was based on estimates used in the Parramatta-Chatswood EIS. The estimate of VHST greenhouse gas emissions is presented in section 10.3.

Table 14.26: Rail Externality Cost Parameters

Externality Benefit	Estimate	Units
Fatal accident	$1.7 million	Cost per fatality
Non-fatal accident factor	1.28 times	Applied to fatal accident cost to allow for non-fatalities
Air pollution	40 cents	Cents per train kilometre
Noise pollution	$1.60	Cents per train kilometre

PCIE estimates

The cost of GHG emissions is forecast to be the largest externality cost. The cost of GHG emissions ranges from $269 million to $760 million for the full project, from $87 million to $250 million for Brisbane-Sydney and from $69 million to $163 million for Sydney-Melbourne. The cost of VHST accidents is forecast to be the second largest externality cost. For the full EC corridor, accident costs range from $59 million to $162 million. Rail accident costs for the Brisbane-Sydney range from $22-62 million compared to $18-42 million for the Sydney-Melbourne corridor. By comparison local air pollution costs are relatively small ranging from $6.7 million to $19.5 million with noise pollution costs ranging from $1.7 million to $4.9 million.

Table 14.27: VHST Externality Costs

PV 2001 $ million at 7% in 2001 Dollars by VHST Sector

	Greenhouse Gas Emissions		
VHST Sector	Low	Central	High
BRI-SYD	87	148	250
SYD-MEL	69	113	163
BRI-MEL	269	451	760
	Accident Cost		
BRI-SYD	22	37	62
SYD-MEL	18	30	42

BRI-MEL	59	103	162
	Noise Pollution		
BRI-SYD	0.6	1.0	1.6
SYD-MEL	0.4	0.7	1.0
BRI-MEL	1.7	2.9	4.9
	Local Air Pollution		
BRI-SYD	2.2	3.8	6.4
SYD-MEL	1.8	2.9	4.2
BRI-MEL	6.7	11.6	19.5

VHST is forecast to produce a net externality benefit. For the full EC corridor under the Central Evaluation Case, accident costs reduce by $69 million, greenhouse gas emission costs by $1.2 billion, local air pollution costs by $162 million and noise pollution costs by $34 million.

14.5.14. Disruption Costs During Construction

Externality costs associated with construction include disbenefits to rail passengers from the temporary closure of rail stations and track; disbenefits to road users from road closure or construction traffic resulting from rail construction; road damage from construction traffic; and, construction noise on residents, businesses and rail travellers.

Disruption costs are often omitted from economic appraisals. No studies could be obtained that document actual disruption costs during construction of VHST corridors. The economic evaluation of the Parramatta-Chatswood Rail Link, a project costing around $2.3 billion and involving earthworks and underground tunnelling, included an externality construction cost of 2% of gross capital costs with disruption costs spread over the construction period according to the construction cost profile[27]. This figure, admittedly for a project undertaken in a metropolitan area, was applied to the gross infrastructure costs of the VHST options to provide a preliminary estimate of disruption costs.

The disruption costs for the full EC corridor is estimated to range from $0.5 billion to $0.7 billion discounted at 7% and expressed in 2001 dollars. For Brisbane-Sydney disruption costs range from $0.3 billion to $0.4 billion compared to a range of $0.2 billion to $0.3 billion for Sydney-Melbourne.

Table 14.29 Discounted Disruption Costs
PV 2001 $billion at 7% in 2001 Dollars by VHST Sector
(includes residual value)

VHST Sector	Low	Central	High
BRI-SYD	0.3	0.3	0.4
SYD-MEL	0.2	0.2	0.3
BRI-MEL	0.5	0.5	0.7

Indicative forecasts only, PCIE November 2001

14.5.15. Economic Results

At a 7% discount rate, 350 km/h VHST has economic merit. For the central demand and operating cost scenarios, economic benefits are forecast at $66 billion against an economic cost of $40 billion. NPV is estimated at $24 billion with a benefit cost ratio of 1.7. Each dollar of infrastructure capital is estimated to return $1 in economic NPV. The EIRR is estimated at 10.4%, which is above the "test" 7% discount rate.

There is a wide range in results, however. Under the low demand and high unit cost scenario, the VHST produces a negative NPV of -$15 billion. With high demand and low unit costs, NPV is $73 billion.

Table 14.30: Economic Results

PV Economic Benefits 2001 $billion at 7% in 2001 dollars									
Unit Costs	Low Unit Costs			Central Unit Costs			High Unit Costs		
Sector	Low	Central	High	Low	Central	High	Low	Central	High
BRI-SYD	12	24	45	12	24	45	12	24	45
SYD-MEL	9	18	27	9	18	27	9	19	27
BRI-MEL	32	66	114	32	66	114	32	66	114

[27] " Parramatta Rail Link Economic Evaluation" for Parramatta Rail Link Company by PCIE August 2001.

PV Economic Costs 2001 $billion at 7% in 2001 dollars									
Unit Costs	Low Unit Costs			Central Unit Costs			High Unit Costs		
Sector	Low	Central	High	Low	Central	High	Low	Central	High
BRI-SYD	24	26	29	19	20	23	17	18	20
SYD-MEL	20	22	23	16	17	18	14	15	16
BRI-MEL	46	51	58	36	40	46	32	35	41

Economic NPV 2001 $billion in at 7% 2001 dollars									
Unit Costs	Low Unit Costs			Central Unit Costs			High Unit Costs		
Sector	Low	Central	High	Low	Central	High	Low	Central	High
BRI-SYD	-13	-2	16	-7	4	22	-5	6	25
SYD-MEL	-11	-4	4	-7	1	9	-5	3	11
BRI-MEL	-15	15	56	-5	26	68	0	31	73

BCR									
Unit Costs	Low Unit Costs			Central Unit Costs			High Unit Costs		
Sector	Low	Central	High	Low	Central	High	Low	Central	High
BRI-SYD	0.5	0.9	1.6	0.6	1.2	2	0.7	1.4	2.2
SYD-MEL	0.5	0.8	1.2	0.6	1.1	1.5	0.7	1.2	1.7
BRI-MEL	0.7	1.3	2	0.9	1.7	2.5	1	1.9	2.8

NPVI									
Unit Costs	Low Unit Costs			Central Unit Costs			High Unit Costs		
Sector	Low	Central	High	Low	Central	High	Low	Central	High
BRI-SYD	-0.7	-0.1	0.9	-0.5	0.3	1.5	-0.4	0.5	1.9
SYD-MEL	-0.7	-0.2	0.3	-0.6	0.1	0.8	0.4	0.3	1.0
BRI-MEL	-0.4	.5	1.6	-0.2	1.0	2.6	0	1.3	3.1

Economic IRR %									
Unit Costs	Low Unit Costs			Central Unit Costs			High Unit Costs		
Sector	Low	Central	High	Low	Central	High	Low	Central	High
BRI-SYD	2%	7%	10%	4%	8%	11%	5%	9%	12%
SYD-MEL	1%	6%	8%	3%	7%	10%	4%	8%	11%
BRI-MEL	4%	9%	11%	6%	10%	13%	7%	11%	14%

Numbers may not sum due to rounding.
Indicative forecasts, PCIE November 2001

Economic NPV is more sensitive to demand range than to the range in unit costs. With central unit costs, NPV ranges from -$4.5 billion to $68 billion for the full EC VHST. The BCR ranges from 0.9 to 2.5 with the EIRR ranging from 6% to 13%.

With central demand and variations in unit costs, NPV ranges from $35 billion to $51 billion. The EIRR ranges from 6% to 13% with NPVI ranging from 0.6 to 1.1.

A Brisbane-Sydney VHST produces greater economic benefit than Sydney-Melbourne. For the central demand and unit cost scenario, Brisbane-Sydney produces an NPV of $4 billion, compared to $1 billion for Sydney-Melbourne. The BCR for Brisbane-Sydney is estimated at 1.7 compared to 1.1 for Sydney-Melbourne. EIRR is estimated at 8% for Brisbane-Sydney and 7% for Sydney-Melbourne.

For Brisbane-Sydney, NPV ranged from -$13 billion to $25 billion with EIRR ranging from 2% to 12%. VHST is not economic under either the low demand scenario or the central demand scenario with high unit costs. For Sydney-Melbourne, NPV ranged from -$11 billion to $11 billion with EIRR ranging from 1% to 11%. VHST is not economic under the low demand scenario or the central demand scenario with high unit costs.

Significant incremental economic benefit is forecast for constructing the complete Brisbane-Melbourne corridor. For the full corridor, NPV is estimated at $26 billion under the central demand and cost scenarios. This compares with a combined NPV of $5 billion from adding the Brisbane-Sydney and Sydney-Melbourne sections together. The complete corridor raises economic benefits from $42 billion to $66 billion, an increase of $24 billion whilst forecast costs increase by $3 billion (from $37 billion to $40 billion). The BCR for the full project is estimated at 1.7 compared to 1.2 for Brisbane-Sydney and 1.1 for Melbourne-Sydney. EIRR is estimated at 10% for the full corridor compared to 8% for Brisbane-Sydney and 7% for Sydney-Melbourne. Incremental NPV of the full project compared to the sum of the two corridors is $21 billion with incremental BCR equal to 8.

Evaluated as individual corridors, Brisbane-Sydney and Sydney-Melbourne meet the 7% discount rate. By contrast, for the full corridor the discount rate can be increased to 10% before NPV is reduced to zero.

It should be stressed however that the results are indicative. The analysis suggests that demand is the greatest source of uncertainty. Future work should attempt to reduce this uncertainty. Further sensitivity tests could be undertaken on the parameters underlying the benefit estimates especially user benefit and revenue that are the most pivotal components.

14.5.16. Analysis of Present Value (PV) Benefits and Costs

An analysis of benefits and costs was undertaken for the central evaluation case. User benefit and revenue dominate benefits. Infrastructure capital costs dominate total costs. **The degree of dominance indicates the priority of these areas for future analysis**.

For the complete corridor, user benefit is forecast at $40 billion, roughly twice the revenue benefit of $21 billion. Air decongestion benefits are estimated at $2.4 billion, one-eleventh the revenue benefit. The reduction in the cost of GHG emissions is estimated at $1.6 billion with accident savings totalling $200 million. Other externality benefits are forecast to be relatively small. In total, user benefits are estimated at 61%, revenue benefits 32% and externality benefits 7%.

Physical infrastructure costs dominate total costs accounting for $26 billion out of $40 billion or 65%. Rolling stock capital costs are estimated at $3 billion, 6% of infrastructure costs. Total capital costs account for 73% of costs. Total VHST operating and maintenance costs are estimated at $10 billion representing 24% of total costs. Train operating costs account for $3 billion, track maintenance $2.3 billion, station operations and maintenance $0.4 billion, ticketing and marketing $0.5 billion and management and general overheads $3 billion. Externality costs are forecast to be relatively small. Disruption costs during construction are forecast to be the largest externality cost at $0.5 billion. GHG emissions are forecast at $0.5 billion. VHST accident costs are forecast at $0.1 billion. Noise and air pollution costs are forecast to be relatively small.

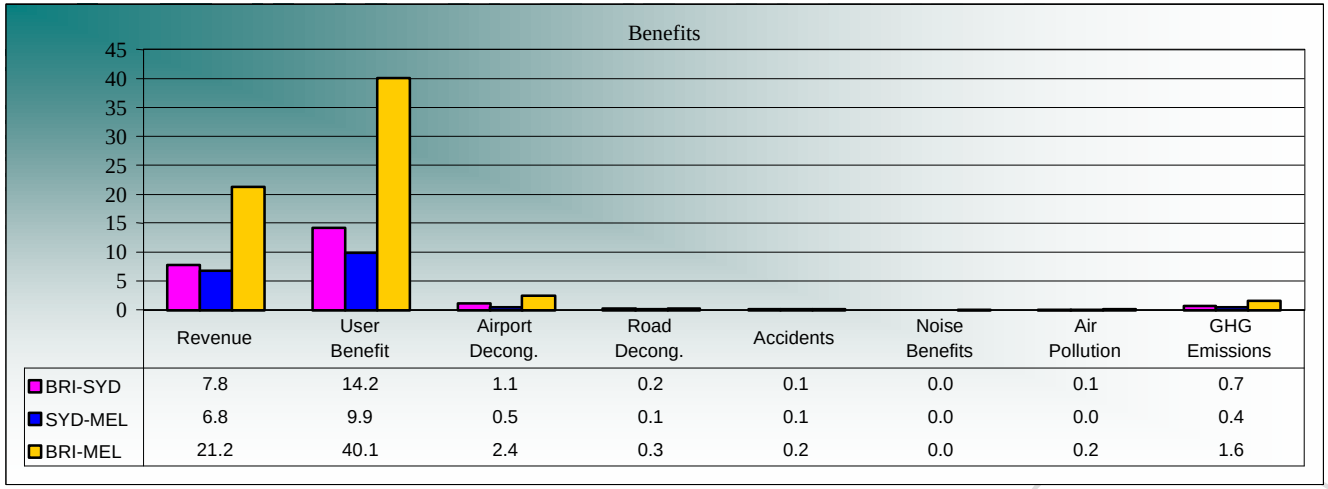
A slightly higher percentage of benefit is received by users and the public at large on the Brisbane-Sydney corridor compared to Sydney-Melbourne. User benefit is forecast at $14 billion on Brisbane-Sydney, 59% of total benefit. By comparison, user benefit is forecast at $10 billion on Sydney-Melbourne, 55% of total benefit. At $2 billion, externality benefit is forecast to be twice that of Sydney-Melbourne. Revenue is forecast to be closer at $8 billion on Brisbane-Sydney compared to $7 billion on Sydney-Melbourne.

Capital costs (infrastructure + rolling stock) on Brisbane-Sydney are estimated at $16 billion compared to $13 billion on Sydney-Melbourne. Total VHST operating and maintenance costs are estimated at $4 billion each with externality costs estimated at $0.5 billion.

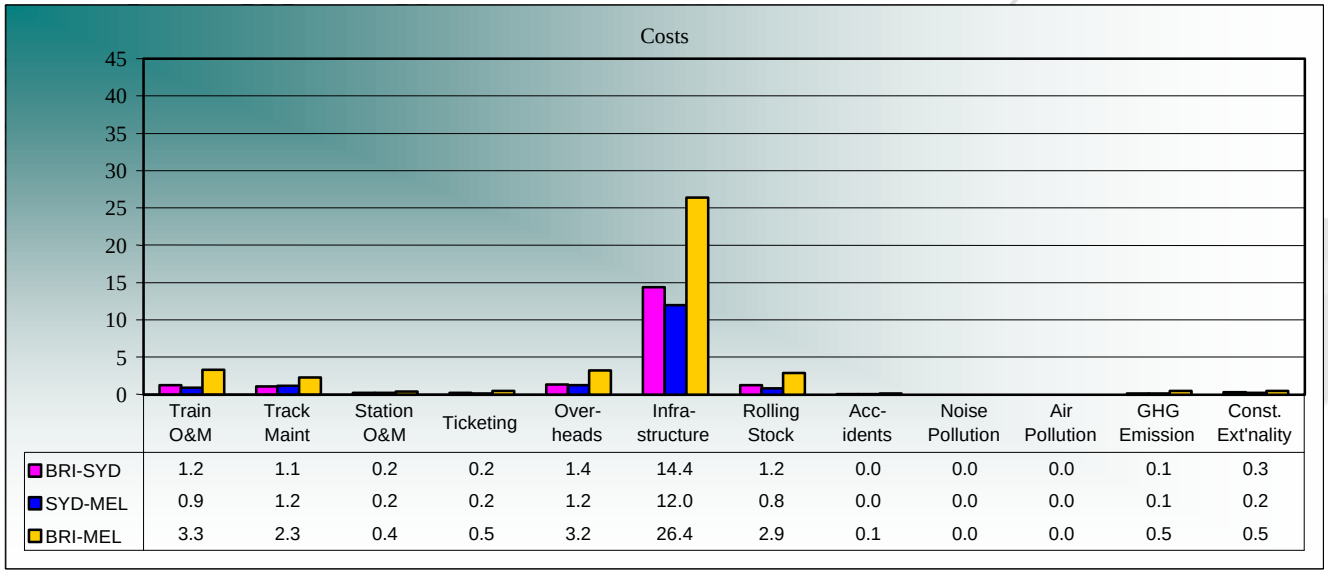


Figure 14.17: Benefits and Costs $billion

PV 2001 $ billion at 7% in 2001 Dollars by VHST Sector (includes residual value)

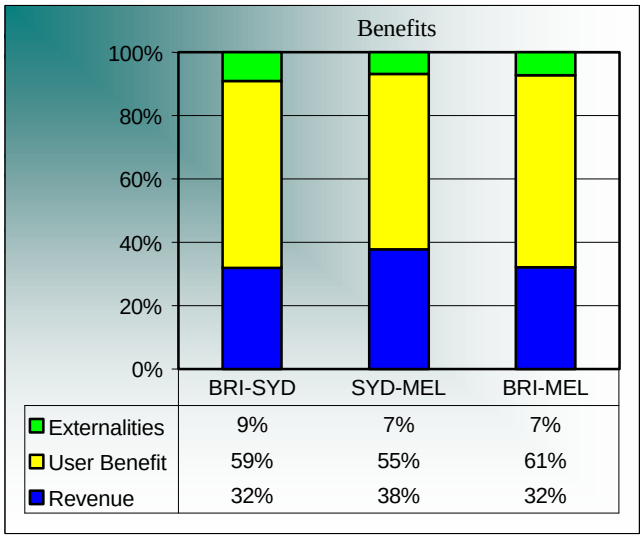


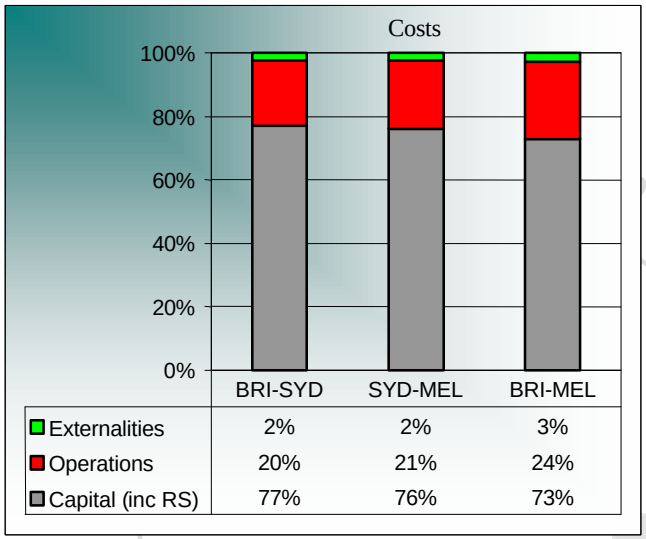
	Revenue	User Benefit	Airport Decong.	Road Decong.	Accidents	Noise Benefits	Air Pollution	GHG Emissions
BRI-SYD	7.8	14.2	1.1	0.2	0.1	0.0	0.1	0.7
SYD-MEL	6.8	9.9	0.5	0.1	0.1	0.0	0.0	0.4
BRI-MEL	21.2	40.1	2.4	0.3	0.2	0.0	0.2	1.6



	Train O&M	Track Maint	Station O&M	Ticketing	Over-heads	Infra-structure	Rolling Stock	Acc-idents	Noise Pollution	Air Pollution	GHG Emission	Const. Ext'nality
BRI-SYD	1.2	1.1	0.2	0.2	1.4	14.4	1.2	0.0	0.0	0.0	0.1	0.3
SYD-MEL	0.9	1.2	0.2	0.2	1.2	12.0	0.8	0.0	0.0	0.0	0.1	0.2
BRI-MEL	3.3	2.3	0.4	0.5	3.2	26.4	2.9	0.1	0.0	0.0	0.5	0.5

Figure 14.18: Benefits and Costs Profile %
PV Percent at 7% in 2001 Dollars by VHST Sector (includes residual values)





14.5.17. Measures of Benefits and Cost Incidence

Benefits to VHST users comprise:

- System revenues the benefit of user benefit that VHST users actually pay
- User benefit which is the residual benefit over an above the fare paid

In addition there are benefits to the "public at large" which accrue to the general public and users of travel modes other than VHST as a result of traffic diversion.

Total costs may be considered to fall into two categories:

- costs borne by users which equates to VHST revenue; and
- publicly-borne costs - the total costs of the system including any environmental costs minus the revenues.

At the 7% test discount rate, total benefits exceed total costs. The incidence of benefits and costs indicate users derive most benefit. For the full EC 350 km/h VHST, users derive a PV total benefit of $61.4 billion comprising $21 billion that is paid for through fares and $40 billion that is unpaid through fares (consumer surplus user benefit). For each dollar of fare paid by VHST users, a total benefit of $2.82 is received. On this measure, VHST users derive the greatest benefit per dollar of cost.

Assuming, for ease of exposition, that the VHST is a "state owned enterprise" operating to a 7% return on capital, the PV of future revenue would fall $18 billion short of future costs (excluding externality costs). The financial BCR is forecast at 0.5. For every dollar of cost borne by the operator 54c in revenue is obtained.

The "public at large" does least well. Benefits from decongestion, accident savings, reductions in local air and noise pollution and reductions in GHG emissions are forecast at $5 billion for the full EC VHST. In total these “non-user” externality benefits relatively small relative compared to publicly borne costs - the financial subsidy (plus construction disruption costs and externality costs during VHST operation) that are forecast at $19 billion. The PV difference between public benefits and public costs is forecast at -$14 billion with the ratio of public at large benefits to publicly borne costs estimated at 0.3. For every dollar of publicly borne costs, the public receives 30c in externality benefits.

The conclusion that may drawn from this preliminary analysis is that VHST users benefit exceed the fares they pay but that the public at large bears costs well in excess of the externality benefit conferred by VHST. The distributional impacts are therefore forecast to be quite significant. Future work could examine ways in which VHST fares could be revised to internalise a greater share of user benefit thereby reducing the publicly borne cost of VHST. Future work could also seek to integrate the assessment of private sector contribution into the analysis of benefit and cost distribution. There may also be some merit in attempting to trace the flow of benefit from VHST users - the initial recipients - to final beneficiaries. The use of standard macro economic type modelling (or general equilibrium) may be useful in determining how regional economic activity is affected by improved connectivity and general transport efficiency afforded by the VHST. A significant portion of user benefit may trickle down to service industries such as tourist operators, housing and office developments. These benefits need to be compared against activity losses resulting from the contraction of the air, coach and ancillary car industries.

Table 14.31: Measures of Benefits and Cost Incidence

Measure	BRI-SYD	SYD-MEL	BRI-MEL
Benefits to VHST Users $billion	22	17	61
Revenue Benefits $billion	8	7	21
Public Benefits $billion	2	1	5
Total Benefits $billion	24	18	66
Costs Borne by Users $billion	8	7	21
Costs Borne by VHST Operator	20	16	39
Publicly Borne Costs $billion	13	10	19
Total Costs $billion	20	17	40
Benefits to VHST Users - Costs Borne by Users $billion	16	10	40
Benefits to VHST Operator - Costs Borne by VHST Operator $billion	-12	-10	-18
Public Benefits - Publicly Borne Costs $billion	-10	-9	-14
NPV (Total Benefits - Total Costs) $billion	4	1	26
Ratio of Total Benefits over Total Costs (BCR)	1.2	1.1	1.7
Ratio of Revenue over Costs borne by VHST Operator Financial BCR	0.4	0.4	0.5
Ratio of Total Benefits to VHST Users over Costs Borne by VHST Users	2.8	2.5	2.9
Ratio of Benefits to Public at Large over Publicly-Borne Costs	0.2	0.1	0.3

14.5.18. Benefits and Costs Omitted

Cost Benefit Analysis has been used to monetise many of the significant impacts attributable to VHST using 350 km/h for an example corridor route. However, not all impacts were able to be included. Potentially important spin-off benefits on users and operators of other rail services were not included. Some environmental disbenefit such as the impact of VHST construction on flora and fauna; archaeological and cultural heritage were omitted. The omission was deliberate. It is not sensible to monetise environmental impacts other than include necessary mitigation measures in the capital cost estimate. Some strategic effects that are inherently difficult to monetise were also omitted. Some distributional impacts were assessed (temporal through the application of discount rates and the incidence of initial benefits and costs) but inter-regional and interpersonal weightings were not assessed. Benefits and costs went no further than an assignment to "initial" recipients.

For those impacts that defy sensible quantification or valuation, standalone independent assessments are required. As part of the scoping study a preliminary environmental impact assessment has been prepared - a summary is presented in section 9. Some potentially important strategic benefits are also discussed in section 8. Some comment on the spatial distribution of benefits is provided in section 6. Finally, some potentially important spin-off impacts on travellers and operators of other rail services that might be valued in further work are outlined in the section 5.

By collating all the assessments both quantitative and qualitative, decision-makers will be able to attach their own weighting to each impact. This will then enable an informed judgement to be made regarding the net merit of VHST.

14.6 Transport Impacts not included in the Economic Evaluation

14.6.1. Introduction

The economic evaluation does not address some potentially important spin-off benefits for other rail services of corridor enhancement. In the metropolitan areas surrounding Brisbane, Sydney and Melbourne, additional suburban commuter services could be introduced. It may also be possible to operate some freight services on VHST track sections. Alternatively, if some existing passenger services are transferred to VHST track, capacity on existing lines will be freed up enabling service improvements to existing passenger and freight service. Outside metropolitan areas, VHST track may warrant the abandonment of existing track sections saving track maintenance.

14.6.2. Metro Services

One of the challenges for an EC VHST service is exiting the various conurbations along the corridor. By their nature, the Melbourne, Sydney and Brisbane metropolitan areas stretch significant distances from their respective Central Business Districts (CBD). For example, Broadmeadows in Melbourne is at least 17 kilometres north from central Melbourne, Campbelltown is at least 45 kilometres southwest from central Sydney and Beenleigh is 40 kilometres south from central Brisbane. Interurban corridors extend much further, for example, Bowral is roughly 120 kilometres southwest of Sydney, Wyong is roughly 100 kilometres north of Sydney and Robina is roughly 85 kilometres south of Brisbane. Much of this territory is settled, albeit at densities considerably lower than in European or Japanese cities, and thus limit the development of new transport corridors through them. For example, the proposed Parramatta - Chatswood Rail Link in Sydney will have to be constructed underground between Chatswood, Epping and Carlingford because there is no pre-existing rail corridor. This is because parallel highway corridors do not traverse territory suitable for stations nor are they wide enough to accommodate a railway alignment with its more stringent horizontal and vertical geometric requirements.

EC VHST corridors exiting these conurbations and the outer suburban commuter belts beyond, for example the South Coast, Southern Highlands and Central Coast surrounding Sydney and the Gold Coast south of Brisbane, must either cohabit with existing commuter rail corridors or demand completely new underground corridors. These existing corridors would probably have to be augmented to handle the increase in rail traffic presaged by the introduction of VHST services. However, suitably configured quadruple track (i.e. fast and slow tracks paired by direction of travel) would allow trains of different speed bands to be separated from each other thereby offering more overall line capacity than if these corridors were augmented for independent traffics. Joint use corridors would offer benefits to both existing commuter services, i.e. by accommodating additional growth and by allowing the separation of fast and slow commuter services, and prospective VHST services, i.e. by providing economical exit corridors to the metropolitan boundaries. Nevertheless, VHST services would not be able to travel at their full potential because of alignment constraints and overall traffic density. However this appears to be the case in most urba VHST corridors in Europe.

These circumstances are no different, in principle, than the Channel Tunnel Rail Link (CTRL) on which Eurostar, long distance commuter and intermodal freight trains are expected to cohabit on only a double - track railway. Under these circumstances the total train flows are only the same order as existing suburban and interurban commuter services, e.g. 12-14 trains per hour, on, say the East Hills

Line in Sydney. Therefore it is assumed that a four-track railway would be more appropriate in Australian conurbation exits.

14.6.3. Freight Services

Australian rail corridors rapidly reduce in infrastructure as they exit the Melbourne, Sydney and Brisbane conurbations. There may still be significant levels of traffic, particularly south and north of Sydney, e.g. 40-80 trains per day in each direction within a 150-200 kilometre radius of Sydney. However, this level of traffic is much less than might be encountered within urban areas, e.g. 120-150 trains per day within 50-60 kilometres radius of Sydney. Therefore, one rail corridor must currently serve all non-urban uses however well or otherwise this is achieved. In contrast, much of the former Paris-Lyon-Mediterannee (PLM) corridor to Marseilles was already four tracks prior to the planning of the Paris-Sud-East Ligne a Grande Vitesse (LGV-PSE). The French railway planners realised that a six-track rail corridor would permit the efficient separation of different rail traffics, including the TGV-PSE, residual passenger and freight, from each other and better use of total line capacity.

There are currently only modest levels of long distance passenger rail traffic on Australian inter-capital mainlines. The predominant traffic is interstate freight and passenger traffic overlaid with significant, but localised, intrastate freight traffic. If the urban example of a multi-track corridor is extended to the middle distances between conurbations the multiplication of rail corridors can be avoided thereby, limiting severance and alienation of productive rural land. Intermodal freight trains would gain significant travel time and energy savings through being able to use the spare capacity available from a suitably configured joint-use high speed railway corridor after VHST trains use their train path entitlements. Such freight train benefits would accrue from straighter and shorter alignments on which intermodal freight trains would be able to run faster than at present. Consequently, there would be more opportunities for competitive arrival and departure times for scheduled freight trains without their having to sacrifice payload for speed.

The transit performance and economics of the Melbourne to Brisbane corridor was recently the subject of a major investigation by Australian Rail Track Corporation (ARTC) Australian Rail Track Corporation in 2001 (www.artc.com.au). ARTC stated that:

"In the Melbourne-Sydney-Brisbane freight corridor the optimal investment is $398 million.

- *This would boost market share over the whole corridor by 59% (Sydney-Melbourne by 77%).*
- *This is the highest priority investment on the national rail network. It would remove 111,000 long distance truck movements from the overstretched highway system (the Hume, Pacific and Newell Highways)*
- *This rail corridor has seen very little investment for several decades, so additional investment produces very high benefits (more than $1 billion).*

The majority of the investment in the north-south corridor will be on the Sydney Freight Priority Project ($146 million), to reduce the time taken to move freight in and out of Sydney, and improve service reliability. Sydney's rail system is the major bottleneck in the national transport network. Eliminating this bottleneck, to control future growth in truck traffic on Sydney arterial roads, should be a very high priority goal for Australia's transport system.

Such investment would also create a reservoir of additional capacity within which significant traffic could be accommodated. However the scale of investment is modest when compared to the cost of highway upgrades."

Clearly, if the investment needs of Australia's major freight corridor can be incorporated into any investment for VHST, economies and benefits would accrue.

Irrespective of whether freight would be diesel or electric hauled there would be energy savings through much more rapid transits than are presently achievable.

14.6.4. Track Maintenance Savings and Countrylink CSOs

VHST corridors would not necessarily be built and maintained to higher standards than existing interstate mainlines in East Coast Australia. Based on the Channel Tunnel Rail Link Project, the basic track plant would not be substantially different from current new mainline construction, i.e. 60 kg/m rail on substantial concrete sleepers and a good depth of ballast. However, line and top would have to be maintained to much finer tolerances than are currently accepted in Australian general traffic conditions. There are benefits to all rail users by running on high quality alignments. Trains damage the track much less because the track is smoother. Higher levels of superelevation allow freight trains to run with little or no cant excess or deficiency, thereby reducing lateral forces and corresponding rail wear.

In societal terms, a VHST corridor between Melbourne and Brisbane would also facilitate the operations of residual long distance passenger rail services. VHST services necessarily must be sparing in their stops in order to deliver their travel time savings. The lower speeds of long distance V/Line Passenger and Countrylink services allows them to effectively serve the intermediate communities between VHST stops. A suitably configured multi-use high speed rail corridor could permit existing high speed, i.e. 150-200 km/h passenger services, to perform competently in the middle distances between conurbations and to connect with VHST services.

14.6.5. Second Round Effects on Air, Coach and Rail Services

Counteracting the decongestion benefits for remaining air users could be reduced service convenience. For some air routes, particularly turbo-prop regional services and medium distance jet services (e.g. Canberra - Sydney), the level of diversion to

VHST is forecast at over 60%. On these routes, service frequency could be cut back significantly on introduction of a VHST to maintain profitability. Any reduction will reduce user benefit and may cause more passengers to divert to VHST. On some routes, demand loss may be such that routes are withdrawn. The demand study has not modelled these second rounds effects. The likelihood is that VHST demand, revenue and associated externally benefits will be underestimated with disbenefits to remaining air passengers underestimated. These complex second round effects would need assessment if the VHST proposal is taken further. Similar effects may also characterise the coach market.

In the central demand scenarios, SRA's Countrylink and other interurban rail services are assumed to continue. With this assumption, the only disbenefit is some revenue abstraction from existing rail services (which was taken into account in the financial and economic evaluations). If interurban services were to be reduced, there will be some reductions in user benefit offset by reductions in subsidy.

14.7 Distributional Impacts

14.7.1. Introduction

Conventional economic analysis rarely applies weights to costs and benefits affecting individuals or groups in different geographical areas. Indeed, often equity values of travel time and costs are deliberately applied. In the demand model, business travellers had a higher value of time than non-business travellers with air passengers having a higher value than car and rail passengers. These weights influence the level of benefit.

The presentation of aggregate measures is important. However, also important is the distribution of benefit amongst society. This section presents an analysis of the impact of the VHST by locality along the corridor. The number of additional trips induced by the VHST, the level of expenditure spent on the VHST and the amount of benefit received by users is assessed by aggregated travel zone within the VHST corridor. Total benefit is shown to accrue to the capital cities. On a per capita basis, however, the ACT and non-metropolitan areas derive markedly better benefits. The choice of inland or coastal route is critical however. The impact of the future population and employment scenarios is also important in the incidence of total benefit.

The analysis has been structured according to trip origin with trips made by international visitors excluded. The analysis has been undertaken using 350 km/h VHST technology as an example. The analysis has been undertaken for 2021 using population forecasts produced by ABS and also as constructed under the scenarios described in section 11.

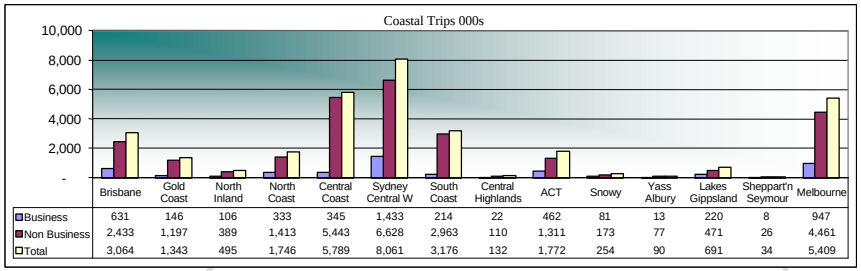
14.7.2. Impact on Trip Making

The analysis has been structured according to trip origin with trips made by international visitors excluded to focus on the effect on resident trips. Most VHST trips are made by residents of Sydney region, with the coastal throughout corridor, Sydney (including NSW Central West) and the NSW Central Coast are the two largest VHST trip generators. Melbourne is third with Brisbane roughly equal to the NSW South Coast, which is forecast to be a well-patronised area for commuting. ACT, Gold Coast and North NSW Coast are roughly equal.

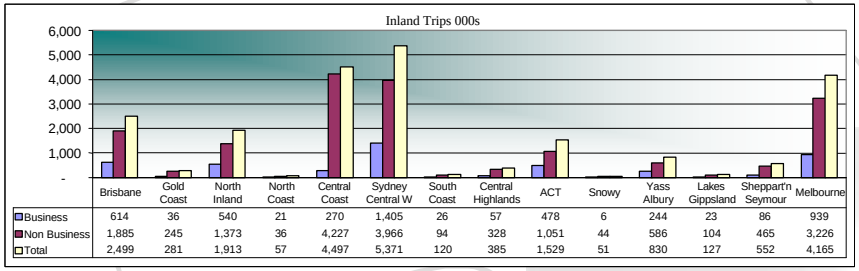
With the inland route, North inland, Yass/Albury and Shepparton/Seymour increase although Sydney and the Central Coast remain dominant.

Figure 14.22: Domestic Trips by VHST Corridor

2021 Coastal Throughout and Inland throughout VHST Corridor



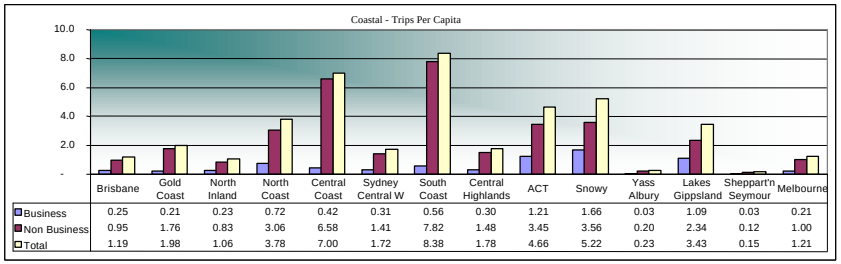
	Brisbane	Gold Coast	North Inland	North Coast	Central Coast	Sydney Central W	South Coast	Central Highlands	ACT	Snowy	Yass Albury	Lakes Gippsland	Sheppart'n Seymour	Melbourne
Business	631	146	106	333	345	1,433	214	22	462	81	13	220	8	947
Non Business	2,433	1,197	389	1,413	5,443	6,628	2,963	110	1,311	173	77	471	26	4,461
Total	3,064	1,343	495	1,746	5,789	8,061	3,176	132	1,772	254	90	691	34	5,409



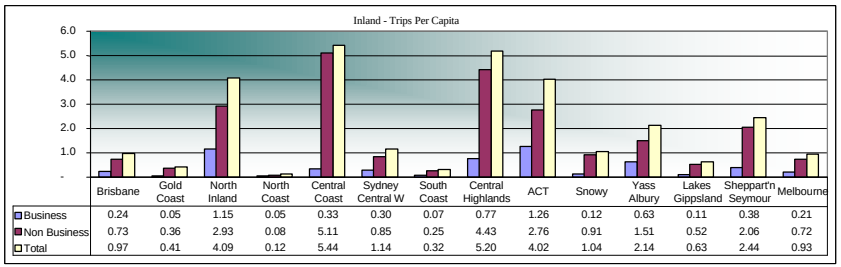
	Brisbane	Gold Coast	North Inland	North Coast	Central Coast	Sydney Central W	South Coast	Central Highlands	ACT	Snowy	Yass Albury	Lakes Gippsland	Sheppart'n Seymour	Melbourne
Business	614	36	540	21	270	1,405	26	57	478	6	244	23	86	939
Non Business	1,885	245	1,373	36	4,227	3,966	94	328	1,051	44	586	104	465	3,226
Total	2,499	281	1,913	57	4,497	5,371	120	385	1,529	51	830	127	552	4,165

The picture is noticeably different in terms of trips per head of population. The NSW South Coast, NSW Central Coast, areas forecast to be relatively large VHST commuter generators, with VHST trip rates of 8 and 7 single trips per year (2021) respectively. These rates are far greater than any of the capital cities which generate between 1.5-2 VHST trips a year per capita. The ACT, Snowy, North Coast and Lakes/Gippsland areas are also forecast to generate relatively higher trips per head of population. For the ACT, each resident is forecast to make 4-5 single trips a year (2-2.5 return trips).

Figure 14.23: Domestic Trips per Capita by VHST Corridor
2021 Coastal Throughout and Inland throughout VHST Corridor



	Brisbane	Gold Coast	North Inland	North Coast	Central Coast	Sydney Central W	South Coast	Central Highlands	ACT	Snowy	Yass Albury	Lakes Gippsland	Sheppart'n Seymour	Melbourne
Business	0.25	0.21	0.23	0.72	0.42	0.31	0.56	0.30	1.21	1.66	0.03	1.09	0.03	0.21
Non Business	0.95	1.76	0.83	3.06	6.58	1.41	7.82	1.48	3.45	3.56	0.20	2.34	0.12	1.00
Total	1.19	1.98	1.06	3.78	7.00	1.72	8.38	1.78	4.66	5.22	0.23	3.43	0.15	1.21



	Brisbane	Gold Coast	North Inland	North Coast	Central Coast	Sydney Central W	South Coast	Central Highlands	ACT	Snowy	Yass Albury	Lakes Gippsland	Sheppart'n Seymour	Melbourne
Business	0.24	0.05	1.15	0.05	0.33	0.30	0.07	0.77	1.26	0.12	0.63	0.11	0.38	0.21
Non Business	0.73	0.36	2.93	0.08	5.11	0.85	0.25	4.43	2.76	0.91	1.51	0.52	2.06	0.72
Total	0.97	0.41	4.09	0.12	5.44	1.14	0.32	5.20	4.02	1.04	2.14	0.63	2.44	0.93

14.7.3. Fare Expenditure of VHST Services

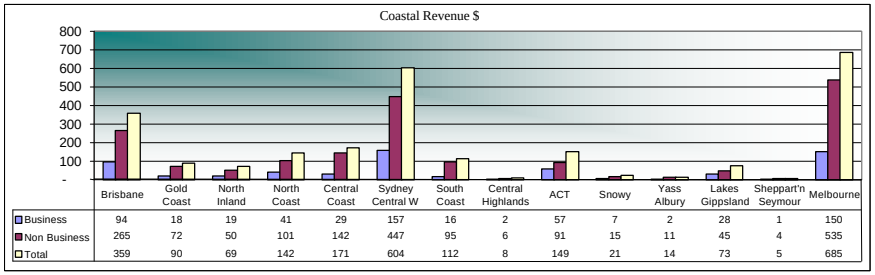
The revenue spend indicates the level of costs borne by users of the VHST system. The three capitals dominate with Melbourne the highest at $700m, Sydney second at $600m and Brisbane third with $350 million at 2021. The NSW Central Coast and NSW South Coast, both high in terms of trips by VHST, spend less per trip reducing the total spend on VHST travel.

A fully Inland VHST results in a lower spend by the capital cities. Melbourne drops to $500 million, Sydney to $450 million and Brisbane $350 million.

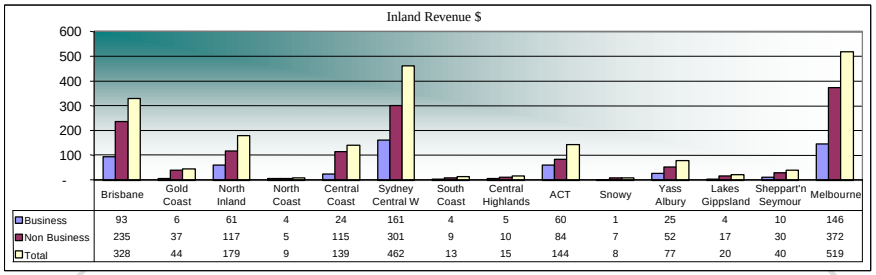
Excluding areas not directly served, the spend on a coastal VHST ranges from $140 Brisbane for Brisbane residents to $440 per year for Snowy region[28] residents. ACT residents are forecast to spend $400 each, the highest of the large cities. State capital residents are forecast to spend roughly the same ($130-$155 each).

With the Inland route, the highest spend per capita is by ACT and NSW North Inland residents at $380 per year. State capital residents spend less, Brisbane down $12, Sydney down $70 and Melbourne down $40.

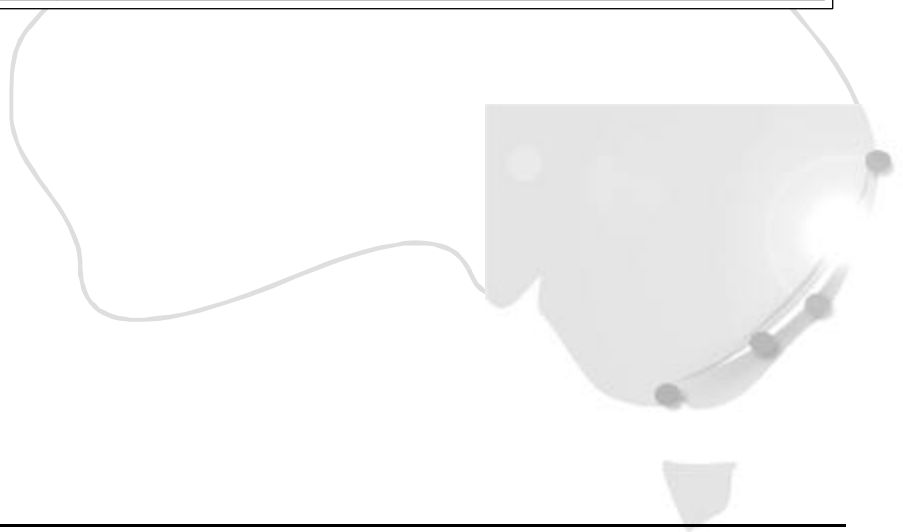
Figure 14.24: Domestic Revenue $ million by VHST Corridor
2021 Coastal throughout and Inland throughout VHST Corridor



	Brisbane	Gold Coast	North Inland	North Coast	Central Coast	Sydney Central W	South Coast	Central Highlands	ACT	Snowy	Yass Albury	Lakes Gippsland	Sheppart'n Seymour	Melbourne
Business	94	18	19	41	29	157	16	2	57	7	2	28	1	150
Non Business	265	72	50	101	142	447	95	6	91	15	11	45	4	535
Total	359	90	69	142	171	604	112	8	149	21	14	73	5	685

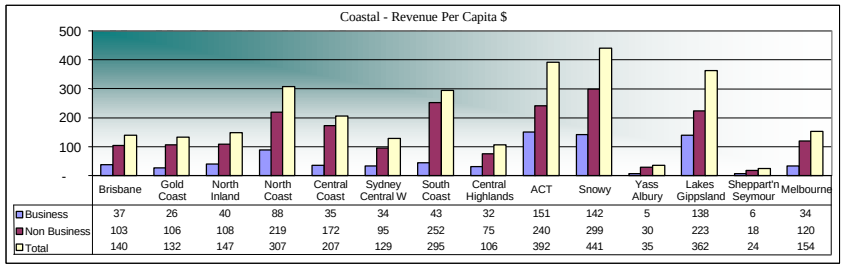


	Brisbane	Gold Coast	North Inland	North Coast	Central Coast	Sydney Central W	South Coast	Central Highlands	ACT	Snowy	Yass Albury	Lakes Gippsland	Sheppart'n Seymour	Melbourne
Business	93	6	61	4	24	161	4	5	60	1	25	4	10	146
Non Business	235	37	117	5	115	301	9	10	84	7	52	17	30	372
Total	328	44	179	9	139	462	13	15	144	8	77	20	40	519

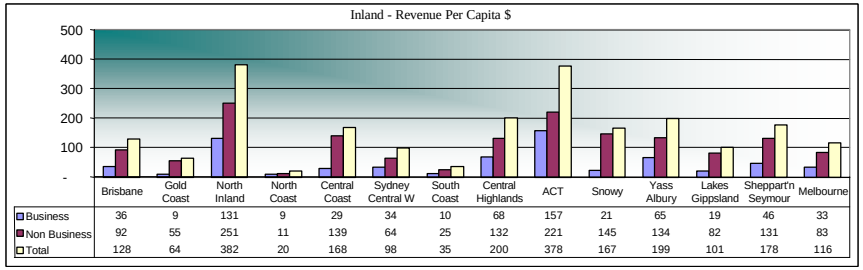


[28] In the demand model this area covers a large area, including down to the coastal towns of Bega, Merimbula and Eden whose alternative transport modes and /or connections, particularly to Melbourne are not strong.

Figure 14.25: Domestic Revenue per Capita $ by VHST Corridor
2021 Coastal Throughout and Inland throughout VHST Corridor

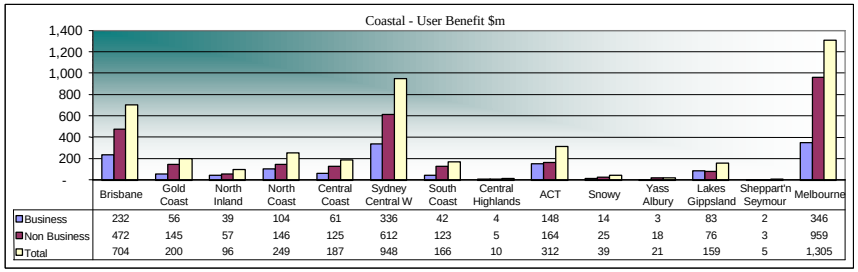


	Brisbane	Gold Coast	North Inland	North Coast	Central Coast	Sydney Central W	South Coast	Central Highlands	ACT	Snowy	Yass Albury	Lakes Gippsland	Sheppart'n Seymour	Melbourne
Business	37	26	40	88	35	34	43	32	151	142	5	138	6	34
Non Business	103	106	108	219	172	95	252	75	240	299	30	223	18	120
Total	140	132	147	307	207	129	295	106	392	441	35	362	24	154

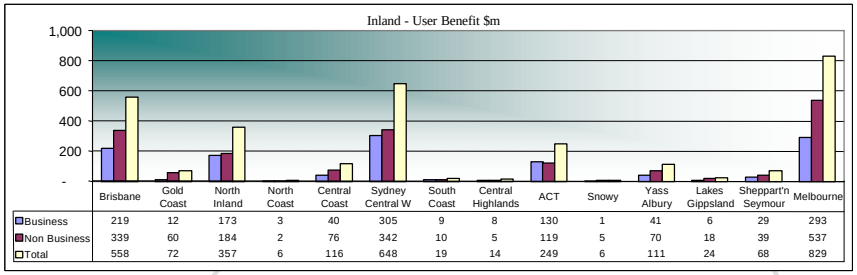


	Brisbane	Gold Coast	North Inland	North Coast	Central Coast	Sydney Central W	South Coast	Central Highlands	ACT	Snowy	Yass Albury	Lakes Gippsland	Sheppart'n Seymour	Melbourne
Business	36	9	131	9	29	34	10	68	157	21	65	19	46	33
Non Business	92	55	251	11	139	64	25	132	221	145	134	82	131	83
Total	128	64	382	20	168	98	35	200	378	167	199	101	178	116

Figure 14.26: Domestic User Benefit $ million by Corridor
2021 Coastal Throughout and Inland throughout VHST Corridor



	Brisbane	Gold Coast	North Inland	North Coast	Central Coast	Sydney Central W	South Coast	Central Highlands	ACT	Snowy	Yass Albury	Lakes Gippsland	Sheppart'n Seymour	Melbourne
Business	232	56	39	104	61	336	42	4	148	14	3	83	2	346
Non Business	472	145	57	146	125	612	123	5	164	25	18	76	3	959
Total	704	200	96	249	187	948	166	10	312	39	21	159	5	1,305



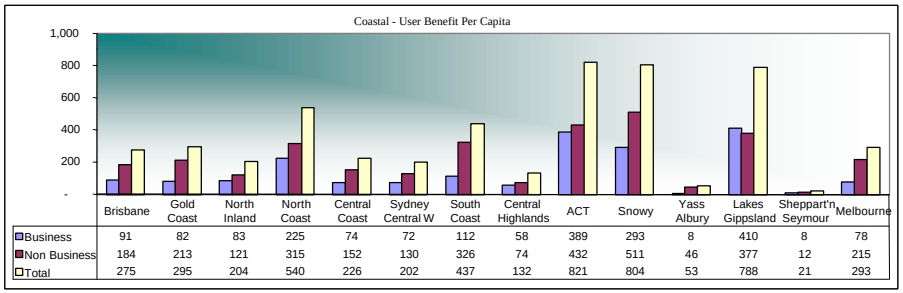
	Brisbane	Gold Coast	North Inland	North Coast	Central Coast	Sydney Central W	South Coast	Central Highlands	ACT	Snowy	Yass Albury	Lakes Gippsland	Sheppart'n Seymour	Melbourne
Business	219	12	173	3	40	305	9	8	130	1	41	6	29	293
Non Business	339	60	184	2	76	342	10	5	119	5	70	18	39	537
Total	558	72	357	6	116	648	19	14	249	6	111	24	68	829

14.7.4. User Benefit

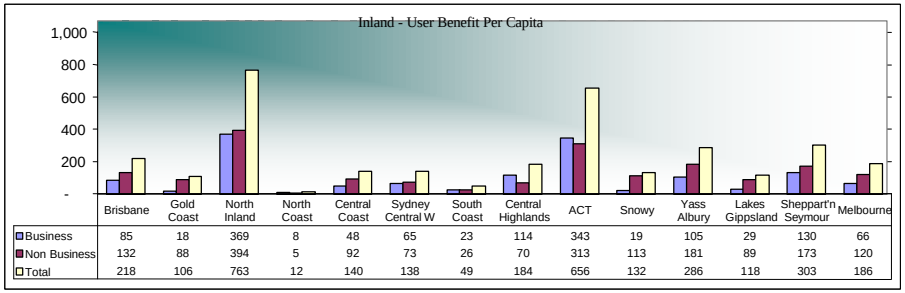
User benefit (excluding that included in the fare) is similar in profile to revenue. With the coastal route, Melbourne residents derive the greatest annual (2021) total benefit at $1.3 billion with Sydney second at $950 million and Brisbane third $704 million. However per capita, ACT, Snowy and Lakes/Gippsland benefit the most at $800 each in 2021. State capital residents benefit less per person - Sydney $200, Brisbane $275 and Melbourne $300.

With the inland throughout VHST, North Inland residents benefit by $760 per head and ACT residents by $660. User Benefit to state capital residents falls to $140 per Sydney resident, $190 per Melbourne resident and $220 per Brisbane resident.

Figure 14.27: Domestic User Benefit per Capita $ by Corridor
2021 Coastal Throughout and Inland throughout VHST Corridor

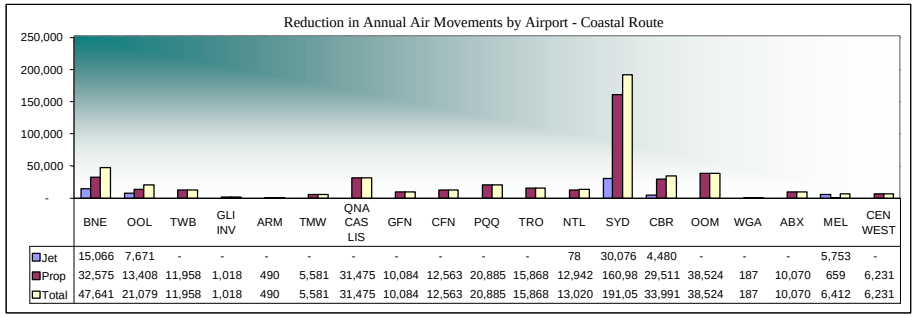


	Brisbane	Gold Coast	North Inland	North Coast	Central Coast	Sydney Central W	South Coast	Central Highlands	ACT	Snowy	Yass Albury	Lakes Gippsland	Sheppart'n Seymour	Melbourne
Business	91	82	83	225	74	72	112	58	389	293	8	410	8	78
Non Business	184	213	121	315	152	130	326	74	432	511	46	377	12	215
Total	275	295	204	540	226	202	437	132	821	804	53	788	21	293

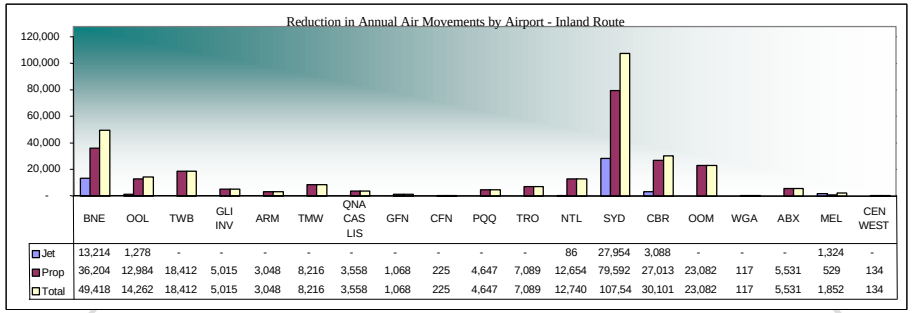


	Brisbane	Gold Coast	North Inland	North Coast	Central Coast	Sydney Central W	South Coast	Central Highlands	ACT	Snowy	Yass Albury	Lakes Gippsland	Sheppart'n Seymour	Melbourne
Business	85	18	369	8	48	65	23	114	343	19	105	29	130	66
Non Business	132	88	394	5	92	73	26	70	313	113	181	89	173	120
Total	218	106	763	12	140	138	49	184	656	132	286	118	303	186

Figure 14.28: Reduction in Air Movements by VHST Corridor
2021 Coastal Throughout and Inland throughout VHST Corridor



	BNE	OOL	TWB	GLI INV	ARM	TMW	QNA CAS LIS	GFN	CFN	PQQ	TRO	NTL	SYD	CBR	OOM	WGA	ABX	MEL	CEN WEST
Jet	15,066	7,671	-	-	-	-	-	-	-	-	-	78	30,076	4,480	-	-	-	5,753	-
Prop	32,575	13,408	11,958	1,018	490	5,581	31,475	10,084	12,563	20,885	15,868	12,942	160,98	29,511	38,524	187	10,070	659	6,231
Total	47,641	21,079	11,958	1,018	490	5,581	31,475	10,084	12,563	20,885	15,868	13,020	191,05	33,991	38,524	187	10,070	6,412	6,231



	BNE	OOL	TWB	GLI INV	ARM	TMW	QNA CAS LIS	GFN	CFN	PQQ	TRO	NTL	SYD	CBR	OOM	WGA	ABX	MEL	CEN WEST
Jet	13,214	1,278	-	-	-	-	-	-	-	-	-	86	27,954	3,088	-	-	-	1,324	-
Prop	36,204	12,984	18,412	5,015	3,048	8,216	3,558	1,068	225	4,647	7,089	12,654	79,592	27,013	23,082	117	5,531	529	134
Total	49,418	14,262	18,412	5,015	3,048	8,216	3,558	1,068	225	4,647	7,089	12,740	107,54	30,101	23,082	117	5,531	1,852	134

14.7.5. Other Benefits by Area

The economic evaluation included an assessment of the benefits that could be achieved from a reduction in aircraft movements. A further analysis is presented here that compares the coastal and inland routes for 350 km/h VHST. All diverted air demand is included (i.e. including international visitors).

Both VHST corridor alternatives show a significant reduction in aircraft movements with reductions concentrated on Sydney Airport. Most of reductions are to and from Sydney. However, the reduction is forecast to be twice as large for the coastal route as for the inland route, largely due to the diversion of air demand to and from the North NSW Coast that currently use turbo-propeller aircraft.

The economic evaluation also included an assessment of the benefits that could be achieved from a reduction in car traffic. These benefits are proportional to car kilometres saved although for decongestion benefits, the location of kilometre savings is important.

In total, the coastal route reduces car kilometres by 1.6 billion, 0.3 billion more than an inland throughout route. The greatest reduction in road kilometres is forecast to occur in NSW with 68% of savings for the coastal throughout route and 58% for the inland throughout route. Victoria obtains 22% of coastal reductions and 32% of inland reductions. Of the road links, the greatest savings are between North NSW coast with a fully coastal route and between Albury and Shepparton for a fully inland route.

Figure 14.29: Reduction in Car Kilometres by Link by VHST Corridor
Fully Coastal Route throughout Corridor

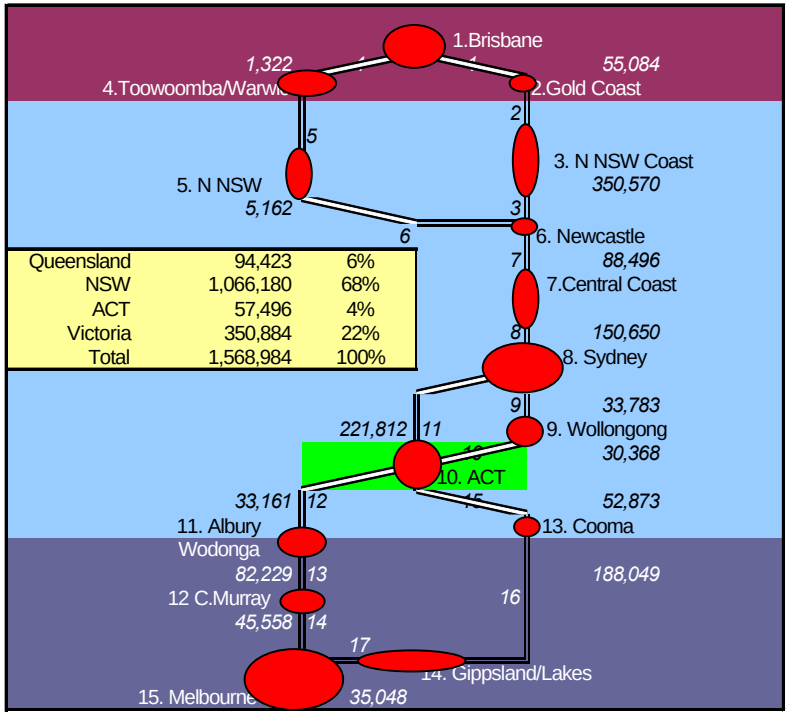
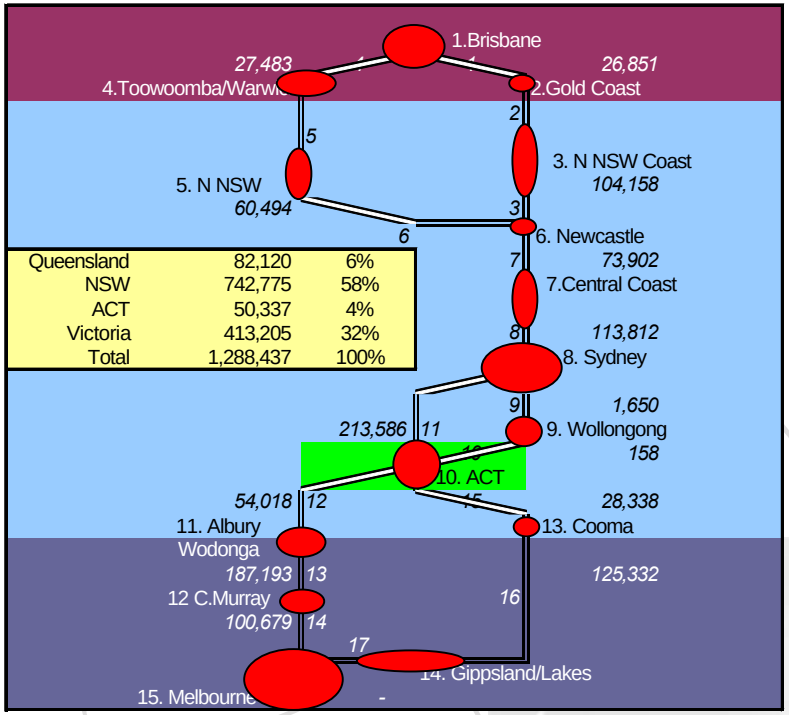


Figure 14.30: Reduction in Road Kilometres - Inland Corridor
Fully Inland Route throughout Corridor



14.8 Impact of VHST on Regional Population and Employment

14.8.1. Introduction

VHST may have a significant impact on the spatial allocation of population and employment. A preliminary assessment of the possible distributional impacts was made. It was not possible to undertake a rigorous and detailed study of the impact for each small area of VHST along the alternative corridors. Instead, a broad pattern of related regional growth in population and employment was assumed that provided a basis for a general assessment of the possible related impacts of the VHST. It should be noted however that the assumed pattern of growth and change would not necessarily come about solely as a consequence of the introduction of the VHST. It would be essential for there to be other supportive measures to achieve the implied changes in regional development.

14.8.2. Population and Employment Scenarios

The central demand forecasts were based on a trend or central population scenario. An alternative high growth scenario was also tested as part of a high demand scenario.

Three other population and employment scenarios were developed to assess regional development policies with and without the VHST. In this way the feedback" effect of VHST on population and employment was assessed.

Under Scenario A (Trend Population and Employment Growth) the absolute growth of population in the relevant parts of Victoria, New South Wales and Queensland is as forecast by the ABS (under its median assumptions) with the employment implications as forecast in this study. Scenario A assumes that there is no impact of VHST on population or employment. Scenario A was adopted in the central evaluation scenario in the economic and financial assessments.

Scenarios BI and BC (Trend Growth with impact of VHST and related regional support policies - Inland and Coastal respectively) were based on an assessment of the likely growth of population throughout the East Coast region if the VHST was constructed. The forecasts also took account of the impact of associated regional development policies similar in kind to those currently employed by the Commonwealth and State governments but tailored to provide support for the VHST. The forecasts model was developed to enable the four combinations of inland and coastal VHST routes north and south of Sydney.

Table 14.32: Population and Employment Scenarios

Scenario	Description
A: Trend Population and Employment Growth	Absolute growth of population in the relevant parts of Victoria, New South Wales and Queensland are as forecast by the ABS (under its median assumptions) with employment forecasts made in this study.
BI: Trend Growth with Impact of Inland VHST and Related Regional Support Policies.	The likely growth of population throughout the East Coast region if the VHST was constructed and followed the inland route. The projections took account the impact of associated regional development policies similar in kind to those currently employed by the Commonwealth and State governments but tailored to provide support for the VHST.
BC: Trend Growth with Impact of Coastal VHST and Related Regional Support Policies.	As BI but assuming the VHST followed the Coastal route
C: Trend Growth with Restricted Metropolitan Growth and Concentrated Urban Settlement Pattern.	Stronger policy action would be taken in future to limit the growth of population in the capital cities and at the same time to concentrate population (and employment) growth into a discrete number of major regional centres, mainly along the proposed VHST route(s).
D: Higher Population Growth with Restricted Metropolitan Growth and Concentrated Urban Settlement Pattern.	The effects of a similar settlement policy as C combined with a much higher overall population growth (for Australia as a whole and the East Coast region in particular).

A broad pattern of related growth in population and employment throughout the region was assumed that provided a basis for a general assessment of the possible related impact of the VHST. A rigorous and detailed study of the impact for each small area of VHST along the alternative corridors was beyond the scope of this study. It should be noted however that the assumed pattern of growth and change would not necessarily come about solely as a consequence of the introduction of the VHST. It would be essential for there to be other supportive measures to achieve the implied changes in regional development, as noted in section 12.

The spatial reallocation of population and employment was done in an impressionistic way. The analysis suggests a possible spatial population and employment response to the provision of an inland or coastal VHST service. It should be noted that any response would be governed by the improvement in service level afforded by the VHST in relation to that of existing ground and air public transport (and the service response of existing modes to that level). Clearly

there will be differences in response between the 250 km/h, 350 km/h and 500 km/h VHST options. Intuitively, 500 km/h VHST should, other things being equal, produce a greater reallocation of population and employment than 250 km/h VHST. However, higher fares to maximise 500 km/h revenue may dampen response. Moreover, station locations and stopping patterns will also influence the outcome. Reduced stopping services and/or VHST stations located further apart will probably reduce the reallocation of population to regional centres.

As a guide, assuming the forecasts accord with the mid range 350 km/h VHST technology with the routes, stations and frequencies broadly as described in section 9, it is suggested that the response to 500 km/h is likely to be higher and the response to 250 km/h lower than that presented, other things being equal. A more detailed analysis of the scope for each of these types of development in relation to the introduction of a VHST by local area will be needed if the project is to be developed further.

In producing the forecasts, cognizance of the impact of VHST (with at best only limited scope for the improvement of rail freight services) on regional (non-metropolitan) development was considered on three main activity fields based on the findings of international studies:

- A growth in ex-urban residential development based on a mix of commuting and tele-working, together with the associated residential services.
- An expansion of certain types of higher level business and educational services: for example, tertiary education and research facilities, consulting and business-related services and professional activities.
- An increase in tourism from improved connectivity of regional centres and the VHST itself.

It is likely that any resulting patterns of development would almost certainly display significant variations between local areas, dependent on the scope of each of the above types of impact.

Scenario C (Trend Growth with Restricted Metropolitan Growth and Concentrated Urban Settlement Pattern) assumes that a stronger policy action would be taken in future to limit the growth of population in the capital cities and at the same time to concentrate population (and employment) growth into a discrete number of major regional centres, mainly along the proposed VHST route(s). A corollary would be much more limited growth in smaller regional centres or those not served by the VHST.

The justification for the type of development pattern under scenario C would probably rest with some or all of the following objectives:

- Benefits of restricting the growth of Sydney and Melbourne, to be measured mainly in terms of reductions in pollution, after use, the need for wastewater treatment and waste disposal, traffic congestion and in more affordable housing etc.
- Economies of scale in development and the provision of infrastructure and social facilities within new concentrated regional centres.
- The prevention of inter-urban sprawl, such as is occurring on the NSW coast between Newcastle and the Queensland border.
- The generation of economies of agglomeration in the new designated centres of concentrated activity which could increase the rate of employment creation and income generation.

Set against these positive physical, social and transport infrastructure savings might be following issues that would need to be resolved:

- Would the loss of agglomeration economies (or potential economies) in the capital cities “cost” Australia more than the gains from additional regional growth?
- What would be the balance of environmental cost and benefit between restricting the size of the existing major urban settlements and increasing the size of major urban agglomerations in selected locations?
- Would the cost of infrastructure for new settlements be supportable and how would it compare with incremental expansion and refurbishment of the infrastructure of existing major urban areas?

The answers to questions such as these are not obvious, requiring careful analysis, specific to concrete proposals for action. Moreover, considerable political will or administrative capacity would be required to bring about such a significant restructuring of the settlement pattern throughout Australia’s East Coast. The adoption of this scenario in the study does not presume an answer to any of these questions. The scenario has been put forward purely for illustrative purposes. It is designed to illustrate a set of circumstances that would not themselves be generated by the construction and opening of a VHST linking the East Coast capital cities but in which a VHST might play a useful role and, in return, might be more easily justified (through earning a high rate of return or generating a higher ratio of benefits to costs).

Scenario D (Higher Population Growth with Restricted Metropolitan Growth and Concentrated Urban Settlement Pattern) illustrates the effects of a similar settlement policy to the scenario C combined with much higher overall population growth (for Australia as a whole and the East Coast region in particular). The aim of this scenario was to explore the extent to which the justification for investment in VHST is itself linked to the scale and distribution of population and economic

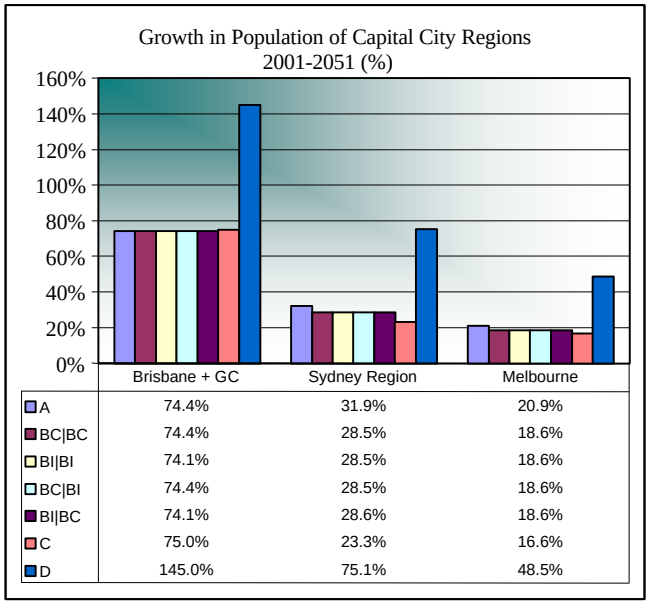
activity. Scenario D was used in the high demand scenario evaluated in the financial and economic evaluation. It was shown that under these high growth conditions, the performance of VHST improved significantly. For the full corridor with 350 km/h VHST economic NPV nearly tripled from $23.9 billion to $66.3 billion with the ratio of benefits to economic costs increasing from 1.56 to 2.37,

It is important to emphasise that this is not an outcome that the VHST would itself produce. The scenario is intended to represent a "possible future" – the merits and demerits of which would need to be discussed, assessed separately and in their own right. The way in which VHST could facilitate or benefit from such a scenario would need to be further assessed in greater detail.

14.8.3. Regional Population and Employment Forecasts

Analysis in this study suggests that a VHST will only have a small effect on population growth for the EC capital city regions between 2001 to 2051. Brisbane is forecast to decline very slightly, Melbourne to increase slightly and Sydney to increase modestly. The most marked effect is the high population growth scenario (D) that pushes up the populations of all three capitals, Brisbane especially experiencing significant growth.

Figure 14.31: Growth in Capital Region Population



	Brisbane + GC	Sydney Region	Melbourne
A	74.4%	31.9%	20.9%
BC|BC	74.4%	28.5%	18.6%
BI|BI	74.1%	28.5%	18.6%
BC|BI	74.4%	28.5%	18.6%
BI|BC	74.1%	28.6%	18.6%
C	75.0%	23.3%	16.6%
D	145.0%	75.1%	48.5%

Brisbane, including the Gold Coast, is forecast to have the largest growth rate, increasing by 74-75% in population over the fifty-year horizon. The VHST is forecast to have little effect on population with a reduction of 0.9% (Inland) compared to scenario C (the closest comparison). With scenario D, the population of Brisbane and the Gold Coast is forecast to increase by 145%.

Sydney, including the Central Coast, South Coast and Blue Mountains is forecast to grow by 31.9% in scenario A VHST. Scenario's B are forecast to increase the Sydney region population by around 5% more than compared to scenario C. With the high growth scenario (D), population is forecast to increase by 75%, half the increase forecast for Brisbane.

Melbourne region (including Great Ocean Road, Goldfields and Mornington) is forecast to grow the least increasing by 21% in scenario A VHST. Scenario's B are forecast to increase population by 2% over scenario C. With the high growth scenario, the population of Melbourne region is forecast to increase by 48.5%.

The impact of VHST is forecast to be more marked at the regional level. For the purposes of analysis the population forecasts have been aggregated by DTM Travel Zone[29].

All the aggregated zones in the northern VHST corridor (Brisbane-Sydney) are forecast to experience population growth except the Hunter region where population is forecast to decline by 3% in scenario A. The most rapid population growth is forecast to be on the southeast Queensland coast with growth ranging from 76% to 87% for scenario A. Inland growth is forecast to be less rapid. For Darling Downs, growth is forecast at 41%, roughly half that on the coast. In northern NSW, modest growth is forecast under scenario A of around 4% to 7%. Again the rate for New England (inland) is much less than on the coast. Higher growths are forecast in the Central Coast and in Sydney Region.

South of the Sydney, under the Central Evaluation Case, growth is forecast to be generally lower with some declines south of Canberra.

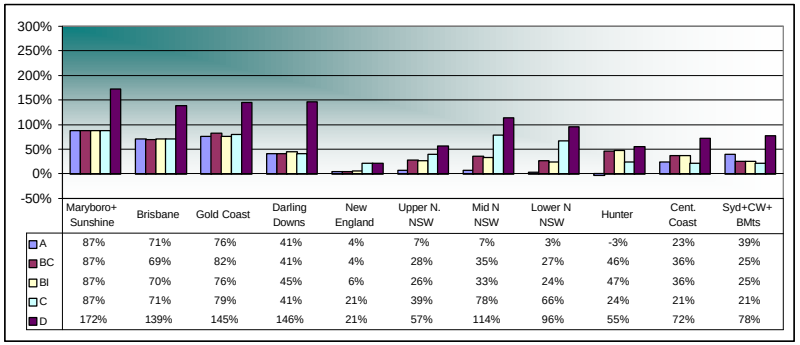
The impact of Scenario C (Trend Growth with Restricted Metropolitan Growth and Concentrated Urban Settlement Pattern) is most marked on the Southern Tablelands raising population growth to 173%. Elsewhere the impact is less marked. Increases on scenario A are forecast in Mid North NSW (Grafton and Coffs Harbour) and Lower North NSW (Port Macquarie and Taree) of 20%-25% points. South of Canberra, the growth rate for the Murray region (Cootamundra Albury / Wodonga) is forecast to increase to 60% instead of a 1% declines with scenario A.

VHST adds 6% points to the growth of the Gold Coast compared to scenario A Further south, the coastal VHST route increases population growth of the inland route to 28% and 35% for the Mid North NSW coast and Lower North NSW coast

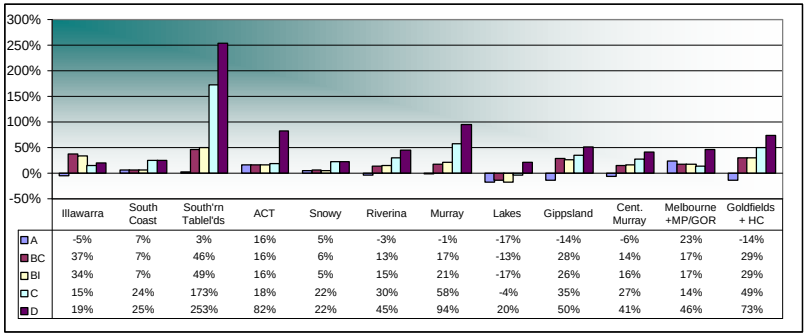
[29] As described in the Demand Model

(from 7% under scenario A) respectively. For the Hunter, Central Coast and Illawarra regions, significant additional population growth is forecast with VHST. The population of ACT is forecast to be largely unaffected by VHST. Population growth in southern NSW is forecast to be greater with the VHST For Victoria, the impact of the coastal and inland VHST is picked up in higher growth rates in Lakes and Gippsland with the coastal route and higher growth in Central Murray with an inland route.

Figure 14.32: Growth in Population by Region – Brisbane to Sydney 2011-2051



	Maryboro+ Sunshine	Brisbane	Gold Coast	Darling Downs	New England	Upper N. NSW	Mid N NSW	Lower N NSW	Hunter	Cent. Coast	Syd+CW+ BMts
A	87%	71%	76%	41%	4%	7%	7%	3%	-3%	23%	39%
BC	87%	69%	82%	41%	4%	28%	35%	27%	46%	36%	25%
BI	87%	70%	76%	45%	6%	26%	33%	24%	47%	36%	25%
C	87%	71%	79%	41%	21%	39%	78%	66%	24%	21%	21%
D	172%	139%	145%	146%	21%	57%	114%	96%	55%	72%	78%



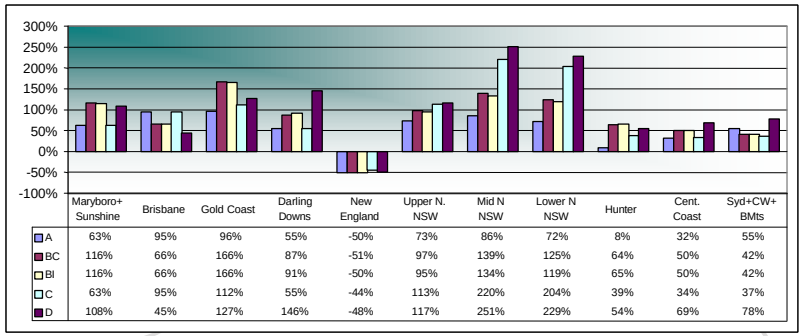
	Illawarra	South Coast	South'rn Tablel'ds	ACT	Snowy	Riverina	Murray	Lakes	Gippsland	Cent. Murray	Melbourne +MP/GOR	Goldfields + HC
A	-5%	7%	3%	16%	5%	-3%	-1%	-17%	-14%	-6%	23%	-14%
BC	37%	7%	46%	16%	6%	13%	17%	-13%	28%	14%	17%	29%
BI	34%	7%	49%	16%	5%	15%	21%	-17%	26%	16%	17%	29%
C	15%	24%	173%	18%	22%	30%	58%	-4%	35%	27%	14%	49%
D	19%	25%	253%	82%	22%	45%	94%	20%	50%	41%	46%	73%

At the aggregate corridor level, the alternative scenarios BI, BC and C were found not to have a major impact on VHST demand. Increases in demand from (and to) regional centres that attract more population and employment as a result of the VHST were offset by demand reductions in the trips from the capitals that lose population and employment. Therefore, the impact may be considered as limited to the impact of VHST on the distribution of population.

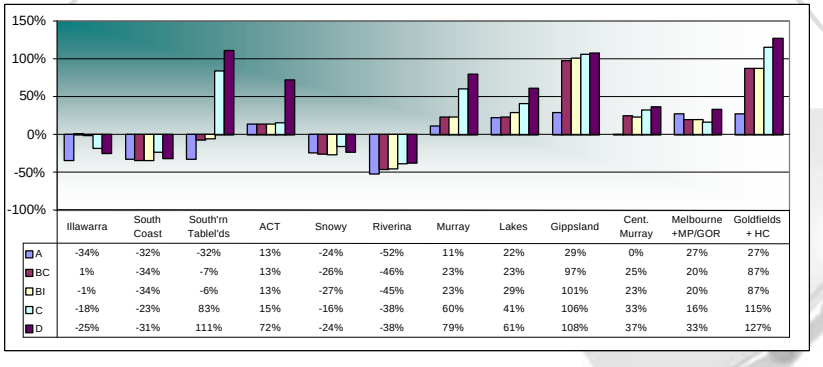
The impact of VHST on employment growth was assessed by this study team. As with population, it is not assumed that the employment effects would be generated by the rail investment in isolation. This would need to be accompanied by other regional support policies that would have to include support for regional economic development and further investment in roads.

Employment is expected to grow more rapidly in regional parts of Victoria and Queensland with VHST and other regional measures put in place. The pattern of employment growth for parts of NSW shows that some areas may lose employment while others gain.

Figure 14.33: Growth in Population by Region – Sydney to Melbourne 2011-2051



	Maryboro+ Sunshine	Brisbane	Gold Coast	Darling Downs	New England	Upper N. NSW	Mid N NSW	Lower N NSW	Hunter	Cent. Coast	Syd+CW+ BMts
A	63%	95%	96%	55%	-50%	73%	86%	72%	8%	32%	55%
BC	116%	66%	166%	87%	-51%	97%	139%	125%	64%	50%	42%
BI	116%	66%	166%	91%	-50%	95%	134%	119%	65%	50%	42%
C	63%	95%	112%	55%	-44%	113%	220%	204%	39%	34%	37%
D	108%	45%	127%	146%	-48%	117%	251%	229%	54%	69%	78%



	Illawarra	South Coast	South'rn Tablel'ds	ACT	Snowy	Riverina	Murray	Lakes	Gippsland	Cent. Murray	Melbourne +MP/GOR	Goldfields + HC
A	-34%	-32%	-32%	13%	-24%	-52%	11%	22%	29%	0%	27%	27%
BC	1%	-34%	-7%	13%	-26%	-46%	23%	23%	97%	25%	20%	87%
BI	-1%	-34%	-6%	13%	-27%	-45%	23%	29%	101%	23%	20%	87%
C	-18%	-23%	83%	15%	-16%	-38%	60%	41%	106%	33%	16%	115%
D	-25%	-31%	111%	72%	-24%	-38%	79%	61%	108%	37%	33%	127%

14.9 Cross Sectional Analysis of Technology and Route Options

14.9.1. Introduction

Detailed financial and economic analysis has only been undertaken for one technology and for one route option. This section presents a cross-sectional for 2021 in which a set of demand indicators are divided by gross capital cost to estimate benefit-cost ratios. This analysis provides an indication of the relative effectiveness of the different VHST technologies considered in this study as well as the relative attractiveness from an economic and financial perspective of the corridors and the sectors

The ratios considered are:

- VHST Trips to Capital Cost;
- VHST Revenue – Operating Costs to Capital Cost; and
- VHST Revenue + User Benefit – Operating Costs to Capital Cost;

These ratios are shown in figure 14.34, figure 14.35 and figure 14.36. The codes in the tables should be interpreted thus:

- Top line – this identifies the major city pairs by their initials e.g. **B**risbane, **N**ewcastle, **S**ydney, **W**ollongong, **C**anberra, **M**elbourne;
- Bottom line – this identifies the waypoints which define the corridor sectors i.e. from the north to south - **I**nland, **C**oastal, **H**ornsby, **F**renchs Forest, **B**owral, **W**ollongong, **I**nland, **C**oastal.

14.9.2. VHST Trips - Capital Cost Ratio (trips/$)

On the basis of this ratio (refer figure 14.34) the most attractive sector in the entire East Coast Corridor is Sydney- Canberra via Wollongong. As noted in section 9, this sector is strongly driven by Sydney- Wollongong commuting demand. Moreover, for this section, 250 km/h produces higher returns than faster but more expensive 350 km/h and 500 km/h technology. This shows that it is the initial improvements in infrastructure and hence travel time reduction that are the most significant in regional sectors of the corridor. However, the next best sector, again using 250 km/h technology is the Newcastle –Canberra sector again via Wollongong.

Of significance is that for most sections of route, the trips/$ return of 250 km/h is above or equal to the 350 km/h operation. In almost all cases they both are above the 500 km/h technology operation.

North of Newcastle, the coastal route produces higher demand returns than the inland route. Between Gosford and Sydney, a postulated route via Frenchs Forest[30] produces similar returns as improvements to the existing route via Hornsby and the existing Main North. Taken separately, a Sydney-Melbourne sector outperforms a Sydney-Brisbane sector on this indicator and both outperform a Canberra- Melbourne link which is the poorest performer of all.

The value of the whole corridor being in operation can be seen from the Brisbane to Melbourne set of indices. Here all technologies are closely equivalent and in all cases the coastal corridor combinations are strongest. The full corridor ranks just ahead of a Brisbane to Canberra staged sector.

14.9.3. VHST Revenue Capital Cost Ratio (Revenue/$)

This ratio (refer figure 14.35) shows up differences in the performance of the 250 km/h to 500 km/h technology range as well as in the performance of the corridor sectors. For revenue/$ the 350 km/h and 500 km/h were strongest except in the Sydney- Canberra sector. On this index the alignment via Wollongong and the alignment via Bowral were essentiality the same.

The highest revenue/$ index in the East Coast corridor was for the Newcastle to Canberra sector on alignments via Hornsby and Bowral and again for the 250 km/h to 350 km /h range. This reinforces the argument for an EC VHST being started in the shortest and most densely populated sector in the corridor and also for connectivity of several major regional cities to enhance travel opportunities.

The faster technologies perform best over the longer sectors with 500 km/h MagLev technology slightly outperforming both SWSR technologies in the Brisbane-Sydney sector and the overall Brisbane to Melbourne sector.

This analysis further confirms the best performing sector to be that of Newcastle to Canberra regardless of which alignment option is selected – though that via Hornsby and Bowral remains the strongest.

Again, the next strongest is the full Brisbane to Melbourne corridor.

[30] This route was postulated to achieve route length reduction between Sydney and the Central Coast. It would need to be in continuous tunnel at least 44 kilometres long and would have to pass deep beneath Ku-ring-gai National Park and the Hawkesbury River near its mouth. It would be the most significant engineering work of any required on an EC VHST and would generate an intense environmental issue. It has no known status as a real option for any railway.

14.9.4. VHST (Revenue + User Benefit) to Capital Cost Ratio (Benefits/$)

The conclusions that can be drawn from this index (refer figure 14.36) are identical to those for revenue/$.

As has been shown previously the project feasibility rests on its economic or public benefit performance. Revenue and user benefits are by far the major components of the public benefits.

Again the best performing sector is Newcastle to Canberra and again the whole performs better than the sum of its parts. The index continues to suggest that, in this sector, the more effective technology would be SWSR 250 km/h to 350 km/h.

However, as noted previously, 350 km/h to 500 km/h technologies perform best in the longer corridor sectors with 500 km/h being the most effective in the full length corridor.

14.9.5. Influence on Corridor Selection and Staging

The inferences that can be drawn from this analysis, as shown in Figures 14.34 to 36, are:

- The choice of a preferred alignment between inland and coastal is not as clear cut as might be expected. North of Sydney, a coastal route generates more revenue but on a benefits/$ basis is about the same as inland. The reason for this is that a VHST would deliver a greater increment in service to the inland population than it does to the coastal population. South of Canberra the opposite is the case but for the same reasons – here coastal is only very slightly ahead on these indicators.
- On its own the Sydney – Newcastle corridor does not perform well – probable due to its high capital cost and low revenue generation – however, if combined into a Newcastle to Canberra sector becomes a part of the top performing sector in the entire corridor. This emphasizes the significant of achieving service connectivity in the corridor having the greatest concentration of population.
- Brisbane to Sydney slightly out performs Melbourne to Sydney on all indices but Brisbane to Canberra and Newcastle to Melbourne are basically the same;
- A Canberra to Melbourne link is outperformed by a Brisbane to Newcastle link.
- However, after the Newcastle to Canberra stage of an EC VHST the next best performing sector on these indices is the whole corridor from Melbourne to Brisbane.
- For the full corridor the optimal alignment is via the coast north of Sydney while south of Canberra a coastal alignment is only very marginally ahead.



Figure 14.34

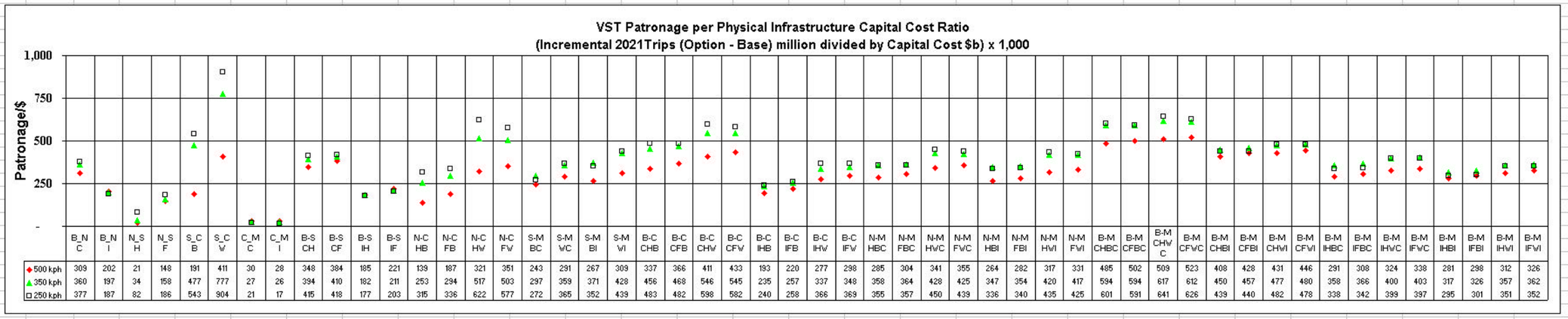


Figure 14.35

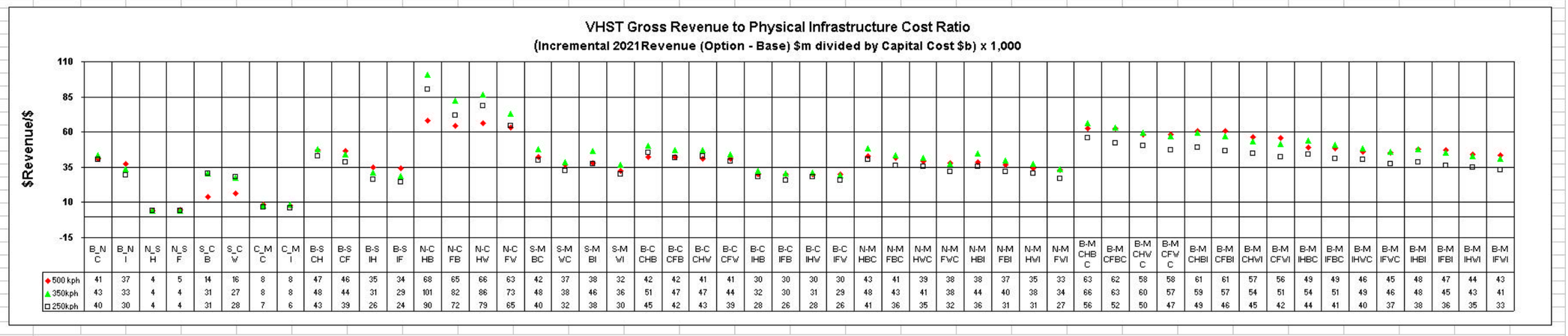
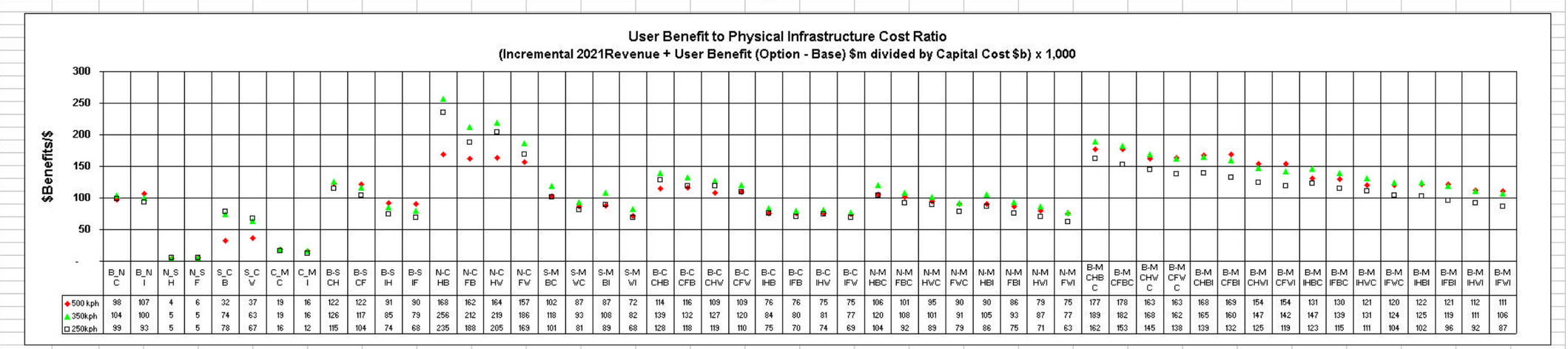


Figure 14.36



14.10 Inter-Industry and Strategic Issues

A complete 2,000 km East Coast VHST linking the three largest cities in Australia requires a wide ranging evaluation framework. Although less than national in scope, the EC corridor accounts for 75% of the population of Australia. Economic and social impacts significant within the EC corridor will remain significant at the national level. Moreover, at $3 billion a year - a complete VHST corridor could account for 4% of national annual capital expenditure for at least ten years. The size and incidence of project funding - private versus public - domestic versus international will have significant impacts on the pattern of financial flows. Moreover the possibility that there might be ongoing subsidies of the VHST will almost certainly result in some deferral of other investments and/or consumption activity. This "shadow price" of private and public funds needs to be recognised. Other transport projects that produce some or all the capacity and efficiency gains attributable to VHST, such as Pacific Highway improvements or additional airport capacity, need to be compared. Furthermore, other non-transport investments may become subject to tighter funding constraints. Therefore, for the VHST to be in the national interest, not only should benefits exceed costs but also a VHST project should outperform other investments both in the transport and non-transport sectors, while also delivering a set of other strategic or national goals.

The cost benefit appraisal focussed on initial effects. It will also be important to look at downstream impacts, industry interactions and economic linkages that may be affected by the introduction of VHST. In the absence of the VHST, funds may become available for other projects that may or may not lead to a different level of national income. Income and employment levels for the national economy with the VHST may differ from those without the VHST.

An expansion in the rail industry is likely to promote growth in support industries. Counterbalancing this may be contractions in the aviation industry and ancillary sectors. At the national level, inflation or exchange rates movements may affect net benefits. Fuel imports and aircraft purchases may reduced. The exchange rate may rise slightly. Depending on the flexibility of resources, some economic gains may be offset by increases in wages or factor prices leading to some economic activities becoming less competitive. At the corridor level, some industries may become more efficient within the EC but at the expense of similar industries elsewhere.

Some studies have shown that ignoring inter-industry effects may understate both gross benefits and costs. The Centre for Regional Economic Analysis, University of Tasmania adopted a general equilibrium type of approach to forecast the effects of the Sydney Olympics[31]. They identified considerable net benefits above those included in a conventional Cost Benefit Analysis. However it is difficult to presuppose the direction of General Equilibrium impacts for VHST. Moreover in terms of ranking schemes such as improved road or air infrastructure with VHST infrastructure it is important that comparable methods are used. There are currently few examples of the application of General Equilibrium analysis to transport improvements of a similar nature to VHST to aid assessment of the forecast levels of project return.

14.11 National and Strategic Benefits

14.11.1. Introduction

The VHST may provide four key benefits of national or strategic importance:

- reduced accidents associated with regional travel
- reduced dependency on imported oil
- assistance in achieving international obligations regarding greenhouse gas emissions
- provision of a greater balance in regional transport.

Sections 14.11.2 to 14.11.4 discuss each benefit.

14.11.2. Safer Long Distance Travel

Accidents have a high social and economic cost. For 1996, the BTE estimates the total cost of road crashed in Australia at $15 billion[32]. Costs include human costs estimated at $8.4b (56% of total costs), vehicle related costs $4.1b (27%) and general costs estimated at $2.5b (17%). Human costs include medical costs; ambulance and rehabilitation costs; long term care; reduced labour in the workplace and in the household; reduced quality of life; legal costs and correctional services; workplace disruption; funeral and coroner expenses. Vehicle related costs included repairs, vehicle unavailability and towing. General costs include travel delays, insurance administration, police costs, property damage and fire costs.

[31] NSW Treasury, "The Economic Impact of the Sydney Olypic Games", TRP 97-10, Sydney, November 1997.

[32] BTE “Road Crash Costs in Australia” Report 102 May 2000.

A significant demand shift from road to VHST will be beneficial if accidents reduce. Air, rail and coach are comparatively safe modes of transport and a redistribution of demand to VHST is unlikely to affect accidents significantly. Long distance car travel however is significantly less safe. By diverting trips from road therefore, the VHST will help promote safer inter-regional travel in South-East Australia.

For Australia, ACIL Consulting[33] reports a non-urban rate of 16 fatalities per billion car passenger kilometres. This compares with 7.7 fatalities per billion private vehicle (car and motorcycle) passenger kilometres reported by the BTE (op cit) for Australia as a whole. These rates imply non-urban private vehicle travel to have a fatality rate nearly four times that of urban private vehicle travel. Applied to the East Coast inscope travel market, 175 private vehicle road fatalities are estimated to have occurred in 1996[34], 9% of the national total representing an cost to the Australian economy in the order of $1.35 billion.

Table 114.33 Estimated Private Vehicle Road Fatalities 1996

	National 1996	Non-Urban (est)	Urban (est)	East Coast Corridor (est)
Fatalities	1,880	1,104	776	175
Billion Passenger Km	244	69	175	11.8
Fatalities per passenger km (b)	7.7	16.0	4.4	14.8

Sources: ACIL (op cit).
BTE "Road Crash Costs in Australia" Report 102 May 2000
est: PCIE estimates based on national (BTE) and non-urban (ACIL)
estimates and PCIE estimate of East Coast corridor car passenger kilometres for 2001

The BTE estimates there were 616 thousand crashes involving private vehicles in 1996, 230 times the number of crashes involving fatalities. Over time, BTE figures show a declining accident rate over time. Expressed in relation to the number of vehicle registrations, the crash rate per thousand vehicles registered involving fatalities fell from 0.93 in 1978 to 0.3 in 1996 whilst the non-fatal crash rate fell from 102 to 70. Between 1978 to 1996, the fatal crash rate reduced by 6.1% a year with the non-fatal crash rate reducing by 2.1% a year.

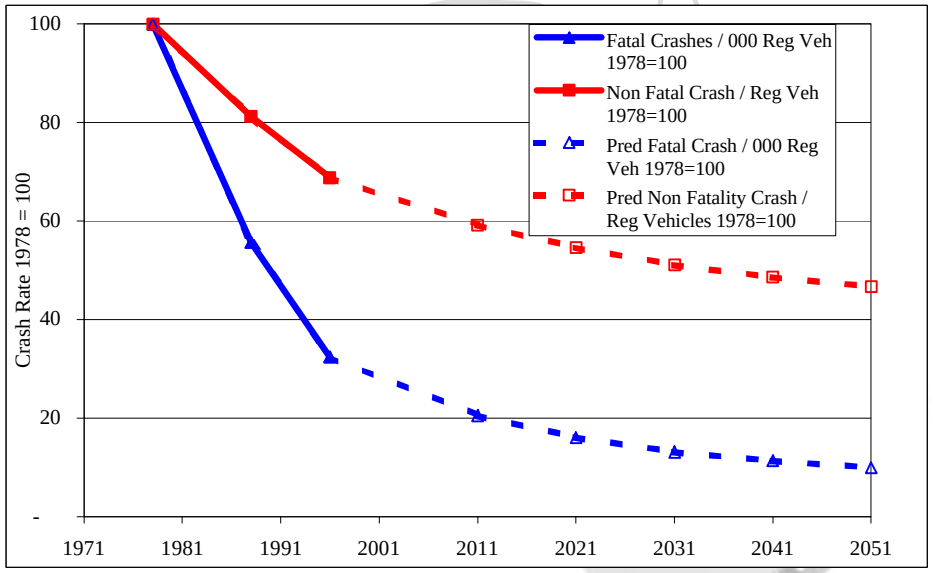
Table 14.34 Trend in Private Vehicle Crash Rate

	Private Vehicle Crashes			Private Vehicle Crash Rate Per thousand vehicle registrations			Vehicle Registrations
Year	Fatal	Non Fatal	Total	Fatal	Non Fatal	Total	000s
1978	5,098	551,725	556,823	0.93	102	101	5,462
1988	3,718	587,134	590,852	0.52	83	82	7,158
1996	2,681	615,919	618,600	0.30	70	70	8,862

BTE "Road Crash Costs in Australia" Report 102 May 2000

The downward trend experienced over the last eighteen years was extrapolated to 2051. For 2011 the fatality rate is forecast to be 63% that of 1996 with the non-fatal accident rate 86% that of 1996.

Figure 14.37 Projected Trend in Road Accident Crash Rate



BTE trends 1978-1996
Indicative Forecasts 1996 to 2051 (PCIE)

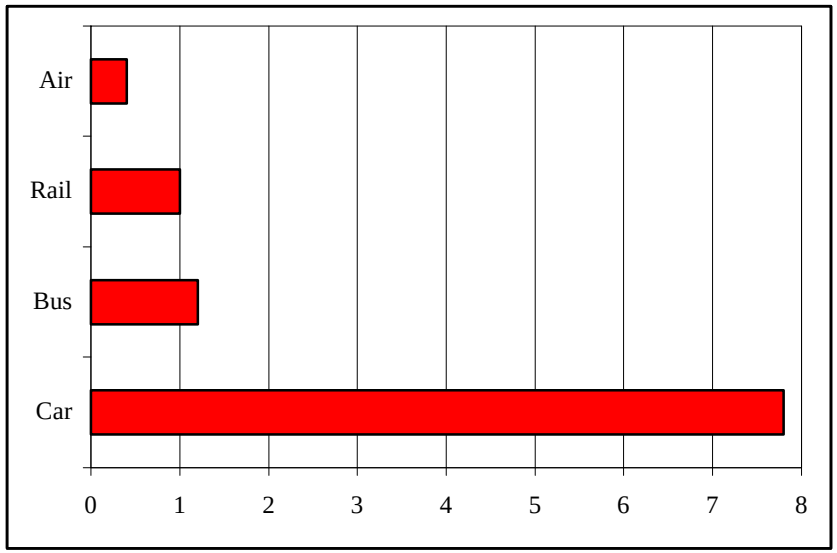
The reported accident rate for coach travel is much lower than that for private vehicle use. The BTE reports a fatality rate of 0.26 per billion occupant kilometres,

[33] "Rail in Sustainable Transport" Report by ACIL Consulting to the Rail Group of the Standing Committee on Transport 6th Oct 2000.

[34] Based on 11.8 billion car passenger kilometres estimated for the East Coast corridor in 2001.

5% that of private vehicle travel. In the UK, Department of Transport figures show car travel to have an accident rate 7.8 times that of rail transport and 1.2 times that of bus transport. Compared to air travel however, rail is 2.5 times less safe. In terms of externality cost, Mauch and Rothengatter estimate the external accident cost of car travel in Europe to be 15 times higher than rail[35] and 3.4 times higher than bus (no estimate was made for air).

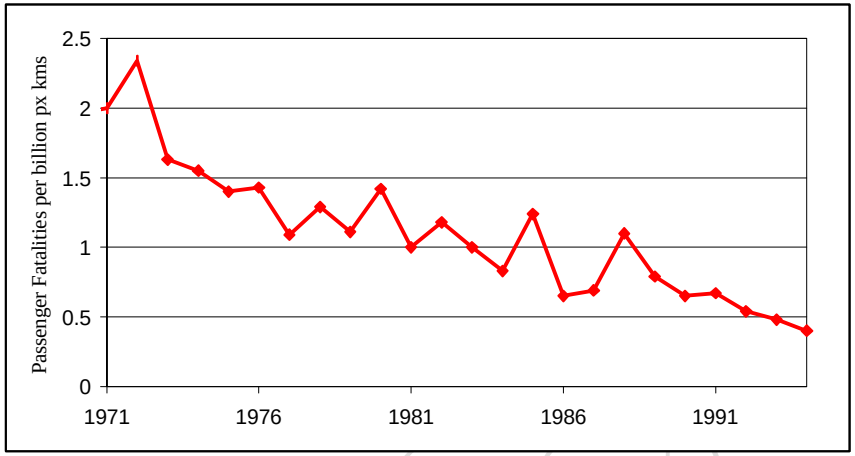
Figure 14.38 Comparison of Relative Accident Rates in the UK



Source: UK Department of Transport reported in "The Economist" Feb 21 1998

Data compiled for European railways by the UIC estimates an accident rate of 0.4 fatalities per billion rail passenger kilometres for 1994. The fatality rate has declined by an average rate of -6.4% a year between 1971 and 1994. The European rail fatality rate is estimated to be 3% of the estimated rate of 14.8 fatalities per billion private vehicle passenger kilometres estimated for East Coast Australia.

Figure 14.39: Trend in European Rail Safety



"The Trans-European High Speed Rail Network – The Field of Railway Excellence" UIC 1997

However, compared to bus, the european rail fatality rate is 50% higher than that estimated for Australia by the BTE. The higher rail fatality rate however conflicts with the UK Department of Transport and Maunch and Rothengatter comparisons that suggest a higher fatality rate for bus. For the purposes of this preliminary evaluation, the same fatality rate has been assumed for VHST, coach, existing rail services and air.

Table 14.35 Projected Fatality Rate

Fatalities per billion passenger kilometre

	2011	2021	2031	2041	2051
Car	12.70	11.70	11.00	10.40	10.00
VHST	0.24	0.18	0.13	0.11	0.10

PCIE indicative projection
Note air, coach and existing rail is assumed to have the same fatality rate as VHST

[35] "External Effects of Transport", IWW and INFRAS AG Consultants Final Report for UIC Paris.

Based on the relative accident rates and the forecast of VHST passenger kilometres and passenger kilometre diversion from car, coach, air and existing rail, fatalities are forecast to reduced by 690-883 over fifty-years of operation.[36]. This represents an annual reduction of 14 to 18 fatalities, or –0.8% on the 1996 national road fatality estimate. The reduction is forecast to be higher on the Brisbane-Sydney corridor at 404 to 549 fewer fatalities than on the Sydney-Melbourne corridor with 229 to 344 fewer fatalities. Non fatal road crashes are forecast to reduce by 25-35 thousand over the fifty-year period, an average of 500 to 700 per year.

Table 10.1.4: Net Reduction in Fatalities with Introduction of VHST

Total Number Fatalities Avoided over Fifty Years of Operation

VHST Corridor	Low	Central	High
		Fatalities	
BRI-SYD	419	404	549
SYD-MEL	229	232	344
BRI-MEL	821	690	883
		Non Fatal Road Crashes 000s	
BRI-SYD	13	13	20
SYD-MEL	8	8	12
BRI-MEL	27	25	35

350 km/h VHST
Indicative forecasts, PCIE November 2001

14.11.3. Reduced Dependency on Imported Oil

Liquid fossil fuels are finite. Satisfying the ethical problem of the right of future generations to a share in fossil resources has become a key theme for those promoting sustainable development[37].

Liquid fossil fuels are the dominant source of energy for transport. Most energy currently used is from non-renewable sources - but used today precludes its use tomorrow. Current oil reserves stand at 60-70 years. In the OECD, demand is increasing at 1%-2% a year. Long term, fuel prices are forecast to rise. Even if new reserves are found, supplies may run out in an economic sense. Alternatives will need to be found. If the preservation argument is accepted, then it may be justified to raise the fuel price today. Limited response suggests that the increase would need to be significant. Such increases would be politically unpopular.

Energy security is also an issue in national energy policies. The Middle East is a dominant supplier of world oil. OECD dependence on fuel imports is around 60%-70% with the share of imports from the Middle East around 35%.

Attempting to reduce fuel usage must be set against a background of increasing travel demand. The demand study forecasts that the total EC inscope market will grow from 40 billion passenger kilometres a year in 2001 to 72 billion passenger kilometres in 2021 an increase of 3% a year.

By providing a fast - high volume transport mode, VHST provides a viable alternative to energy intensive air transport for longer distance trips and car and coach for shorter distance trips. VHST would use electricity from largely coal-fired power stations. In this light, VHST may also be considered as an insurance policy against future oil price shortages and fuel price hikes and a shift away from oil dependency.

Roos[38], Apelbaum[39] and ARRB[40] provide estimates of the relative energy efficiency of air, car, coach and conventional rail for non-urban operations. The estimates are in petajoules per billion passenger kilometres (PJ/bpk). As a very rough guide, one petajoule is the approximate electricity used by a town of 50,000 people per year[41].

The reported figures suggest air to be the least energy efficient travel mode, using between 1.4 and 3.1 PJ/bpkm depending on aircraft type and study. Car is estimated to use 1.5-2.5 PJ/bpk. Non urban, conventional diesel rail is estimated to use 0.8-1.8 PJ/bpk.

36 The reduction in fatalities in the low VHST demand scenario is forecast to be higher than in the central scenario due to a higher demand diversion from car.

37 "Energy Use Sustainability and Transport" by Douglas, N., Nuttall H., and Lewthwaite N., Published by SDG NZ LTD, 1992, ISBN 0-473-01655-9.

38 Roos, Bleijenberg, Dijkstra, "Energy Use and Emissions from Aviation and Other Modes for long distance Travel in Europe (September 1997), cited in ECTM 1998.

39 Apelbaum Consulting Group, 1997 "The Australian Transport Task: Energy Consumed and Greenhouse Gas Emissions", Sept 1997

40 ARRB Transport Research "Toward a Methodology for Comparative Resource Consumption: Modal Implications for the Freight Task, Research Report ARR 318 April 1998.

41 A joule is the energy required to heat 1cc of water by about a quarter (0.239) of a degree Celsius or the energy needed to lift a kilogram by 10 (10.2) centimetres. Powers of Ten conversions are: M mega 6, G giga 9, T tera 12 and P peta 15. A metric tonne is 1000 kilograms, 41.86m PJs is equivalent to 1 million tonnes of oil. There are about 8 barrels of oil per tonne (depending on the density of the oil reserve). In November 2001, the spot price for Brent crude was $US 18 per barrel. Median prices have been around during 2001 US$25. The Aus$ is currently trading at 50 US cents. The estimate of electricity consumption was reported for Napier NZ a town of 50,000 people.

A comparable energy efficiency for VHST was calculated for the full Brisbane-Melbourne 350 kph VHST (coastal, Hornsby, Bowral, Inland route) for 2021 based on the energy consumption and passenger loading. With the central demand forecasts, VHST is forecast to be comparable with coach - the most efficient existing travel mode. Compared to air, VHST is forecast to be four times as efficient and 5 times as efficient as car.

Table 14.37: GHG Energy Consumption

Energy Consumption	PJ per billion passenger kilometres			
	Roos[1]	ARRB[9]	Apelbaum[10]	Values Adopted[11]
Air - 500 km	2.22[2]	-	-	-
Air - 1,500 km	1.6[3]	-	-	-
Air - Average	1.4[4]	-	3.1	2.0
Car	1.5[5]	2.5	2.35	2.4
Bus/Coach	0.3[6]	0.5	0.46	0.48
Conv. Rail	0.87	1.8	1.77	1.8
VHST	0.78	-	-	0.5

1. Roos, Bleijenberg, Dijkstra, "Energy Use and Emissions from Aviation and Other Modes for long distance Travel in Europe (September 1997), cited in ECTM 1998.
2. Average of F50 and B737-400 load factor of 65% with detour factor of 1.2
3. Average of B737-400, B757-200, B767-300ER, B747-400 - load factor 65% & detour factor 1.15
4. Simple average
5. Modern medium sized petrol car (2l) with detour factor of 1.3
6. Load factor of 65% and detour factor of 1.3
7. Conventional international train with load factor of 40% and detour factor of 1.3
8. Load factor of 65% and detour factor of 1.3
9. ARRB Transport Research "Toward a Methodology for Comparative Resource Consumption: Modal Implications for the Freight Task, Research Report ARR 318 April 1998.
10. Apelbaum Consulting Group, 1997 "The Australian Transport Task: Energy Consumed and Greenhouse Gas Emissions", Sept 1997
11. Values used in this study for assessment of energy efficiency. "Detour factors" have been removed since "actual" passenger kilometres are estimated by the demand model.

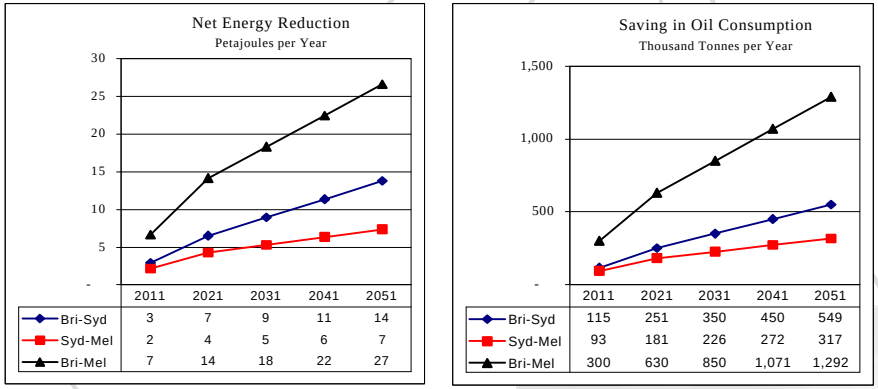
The evaluation has assumed that conventional rail services will continue to operate to the same service level as now with VHST. There will therefore be no savings in convention rail energy. The evaluation has also made the assumption that energy efficiency will remain at current levels.

The reductions in air, car and coach passenger kilometres are forecast to generate a net saving after deduction of VHST energy. The annual net energy saving is estimated at 14 PJs, the equivalent of electricity consumption of seven towns of 50,000 people.

In terms of oil, the reduction in air, car and coach travel is forecast to reduce oil use by 630,000 tonnes in 2021, the equivalent of three 200,000t supertankers. On a daily basis the reduction in oil consumption is 216 barrels per day. At a price of Aus$50 per barrel of Brent crude, this equates to a saving of $3.9 million in 2021. The PV of oil savings is estimated at $32 million over the fifty-year operating life of the project discounted at 7%[42].

The total reduction for the sum of the two corridors is less than for the whole corridor. For Brisbane-Sydney, the reduction in energy consumption is forecast at 7 PJ for 2021 compared to 4 PJ for Sydney-Melbourne. The whole corridor achieves a saving of 14 PJ, 3 PJ more than the sum of the two corridors. The whole corridor provides 27% more efficiency savings than the sum of the two corridors.

Figure 14.40: Reduction in Energy Consumption



14.11.4. Impact on Greenhouse Gas and Other Emissions

A second strategic reason for assessing energy separately is the detrimental impact that energy emissions from burning fossil fuels has on the environment.

42 It should be noted that energy savings are included in the VHST revenue and user benefit (i.e. energy costs are implicitly included alongside all other costs and benefits in the decision to divert to VHST). If however individuals value energy less than is desired socially, an additional benefit social benefit could warrant inclusion.

The Cost Benefit Appraisal incorporated a benefit of reduced local air pollution and green house gas emission from the diversion of road and air trips to VHST. The benefits were relatively small however. Air pollution savings were estimated at $174 million with the reduction in GHG emissions estimated at $1.3 billion compared with a total benefit of $66.4 billion for a full 350 km/h Brisbane-Melbourne VHST. Emission benefits therefore represent 2.2% of total benefits. The implied weight attached to emissions may be considered too low by some decision-makers. An indicative assessment has been undertaken for the 350 km/h VHST of the net change in emissions.

The following emissions have been assessed:

- carbon dioxide (CO_2) emitted by the burning of fossil fuel.
- carbon monoxide (CO), hydrocarbons (HC) and volatile organic compounds (VOCs) resulting from incomplete combustion.
- oxides of nitrogen (NOx) generated at high combustion temperatures.
- nitrogen oxide (N_20)
- non-methane volatile organic compounds (NMVOC).

Not quantified but important are:

- fine particulates present in diesel.
- formaldehyde and other aldehydes.
- sulphur dioxide (SO_2) from the high sulphur content of diesel.

The contribution of CO_2 and other emissions to an accelerated greenhouse effect is undoubtedly the most debated issue. CO_2 in the atmosphere acts to trap some of the sun's heat when radiated back from the earth's surface. Oxides of nitrogen (NOx), nitrogen oxide (N_20), non methane volatile organic compounds (NMVOC), carbon monoxide (CO), methane also contribute to the trapping process.

There is pressure at the political level to act now (or at least to be seen to be taking action) to reduce greenhouse gas emissions rather than wait for absolute scientific confirmation. This is reflected in the Kyoto Protocol that Australia has signed, which if ratified, will require signatories to reduce their greenhouse emissions. The Kyoto limitations on greenhouse gas emissions, combined with the development of international trading in greenhouse gas credits will establish a value on greenhouse gas emissions and therefore an implied cost from emitting them. Much will depend on the nature of the market for greenhouse gas emissions. In the economic evaluation a value of $60 per tonne of CO_2 was included - a value at the top end of the scale.

The transport sector will be important in achieving any emission reduction target. Amongst International Energy Agency member countries, transport accounts for 30% of total carbon emissions and about 15% of all anthropogenic greenhouse gas emission including a large proportion of total carbon monoxide (CO) and nitrogen oxides (NOx) that prolong the lifetime of atmospheric greenhouse gases.

CO_2 contributes 82% of total Global Warming Potential (GWP) emissions. Oxides of nitrogen and nitrogen oxide are the second largest contributors: 8.5% and 6.7% respectively for air, car, coach and conventional rail. CO_2 contributes 99% of GWP emissions from thermal power stations (weighted average of black and brown coal fired) which would be used to generate the electricity to power VHST.

ACIL (op cit) reports emission rates in grams per passenger km for air, car, bus/coach and conventional rail. As part of this study, a comparable emission rate was calculated for VHST based on forecast passenger kilometres, VHST energy usage and emission rates for brown and black coal fired power stations[43]. The estimate is reported for 2021 for the Brisbane-Melbourne 350 km/h VHST (coastal, Hornsby, Central Highlands, Inland route).

VHST is forecast to produce significantly less GWP emissions per passenger kilometre than all the donor modes: 38 grams per passenger kilometre compared to 245 for air (VHST emits 16% of the emissions produced by air), 339 for car (11%), 76 for coach (55%), 140 for conventional diesel-rail (27%).

Table 14.38 Global Warming Potential and Emission Share

GWP Over 100 year time horizon

Emission	GWP[1]	Share of GWP %	
		Donor Modes	VHST
CO_2	1	82.2%	99.2%
CH_4	24.5	0.4%	0.0%
N_20	300	6.7%	0.4%
CO	1	0.6%	0.3%
NOx	8	8.5%	0.1%
NMVOC	8	1.7%	0.0%

[1]ACIL 2000
PCIE/TMG International indicative Forecasts

[43] Source: http://www.greenhouse.gov.au "National Greenhouse Inventory" 1999

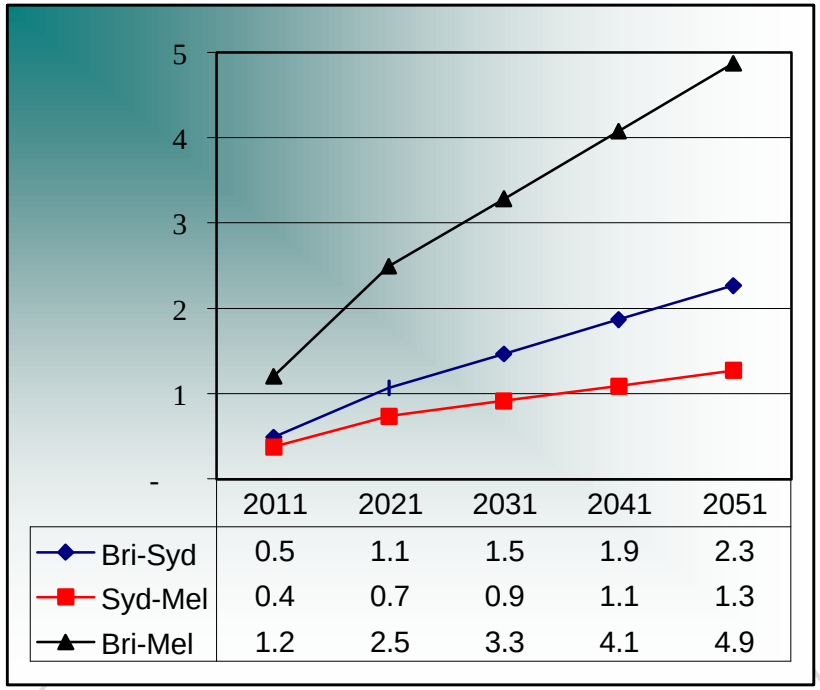
Table 14.39: Greenhouse Gas Emissions by Mode
Grams per passenger km in GWP

Emission	Air	Car	Coach	Conv. Rail	VHST
CO_2	220	162	68	135	38
CH_4	0.7	2.9	0.1	0.2	-
N_2O	19.2	6.1	0.6	1.0	-
NOx	1.7	1.3	0.4	1.8	0.1
CO	2.8	141	5.3	1.8	0.005
NMVOC	0.9	26	1.5	0.6	0.001
Total GWP	245	339	76	140	38

[1]ACIL 2000
PCIE/TMG International indicative Forecasts

The forecast impact of trip diversion to VHST (350 km/h, central demand scenario) is forecast to reduced greenhouse gas emissions by 2.5 million tonnes (mt) of greenhouse gas for the full Brisbane-Sydney corridor in 2021, 1.1 mt for Brisbane-Sydney and 0.7 mt for Sydney-Melbourne.

Figure 14.41: Reduction in Greenhouse Gas Emissions from VHST
GHG GWP million tonnes, 350km/h VHST, Central evaluation case



Put in context, the total greenhouse gas emission for the total non-urban passenger task in Australia for 2000-01 is estimated at 32 mt[44]. Assuming 3% p.a. growth in the transport task to 2021 increases greenhouse gas emissions to 48 mt. On these assumptions, the reduction of 2.5 mt for VHST (full corridor) represents a reduction of 5% in national non-urban passenger greenhouse gas emissions.

The impact of emissions will also have regional and local impacts. Sulphur dioxide and nitrogen oxides contribute to "acid rain", VOCs and nitrogen oxides contribute to a build-up of ozone concentrations in the troposphere. Local impacts vary by emission: hydrocarbons, VOCs, aldehydes, ethylene dibromide and dichloride

[44] Apelbaum Consulting Group "The Australian Transport Task: Energy Consumed and Greenhouse Gas Emissions", Sep 1997 estimated the non urban transport task at 69.6bpkm for car, 11.5bpkm for air, 30bpkm for bus and 1.9bkm for rail. These figures were updated to 2000-01 by ACIL (op cit). The GHG GPW emission rates were then applied to these totals.

have localised and direct impacts. Carbon monoxide can disrupt oxygen uptake and lead to respiratory problems particularly in the elderly, young and unborn babies. Air toxins emitted in relatively small quantities have been linked with cancer. Aldehydes and some other emissions also have potential carcinogenic effects. Nitrogen oxides can lower lung function particularly amongst asthmatics. Ozone is irritating to the respiratory system. Respirable particles are associated with a wide range of respiratory symptoms.

The SSA economic evaluation included an effect of the degradation of air quality from air movements at Badgery's Creek on the local population. The effect of increased ozone levels, air toxins and particulates was assessed on cancer rates. The assessment was that "up to 5 additional deaths might be expected each 100 years as a consequence of the regional population being exposed to the operation of SSA"[45]. These benefits relate to a SSA handling 130,000 movements a year and for a population of 18,000 people living within 10 km of the proposed airport. For Sydney Airport, air movements are 300,000 and 840,000 live within 10 km of the airport. If applying these rates to Sydney Airport, the result is an estimate of 538 cancer-related deaths over 100 years or 5.38 per year. If the VHST reduces Sydney air movements by one-third, the number of cancer-related deaths may decline by 1.61 per year.

14.11.5. Option Value for Regional Communities

By introducing a technology comparable with air, VHST provides an additional choice for fast regional public transport. Regional communities currently reliant on air transport may derive an additional benefit equal to the "option value" that is additional to the sum of individual user benefits.

The argument is that non-users of VHST obtain a "standby" benefit from the existence of VHST even though they do not use it. Advocacy for option value in public transport has a long history[46]. However, although conceded in theory it has been viewed illusory in practice[47]. Some attempts have been made to elicit option value through direct questioning. For VHST, total option value might be considered as the benefit of knowing VHST is available should air services be withdrawn for all residents of communities served by VHST. The benefit could be measured by comparing VHST with the next best method of transport in the event of air being unavailable (from their normal airport). Travel alternatives might be conventional rail, coach and car and air via a different airport. This value would then be multiplied by the perceived probability of air being unavailable to provide an "expected" option value. The value may be inflated to take account of risk aversion. Given the number of alternatives available including alternative airports and activity rescheduling, option value is likely to be fairly small[48] perhaps no more than ten percent of estimated user benefit for regional flows.

14.12 Environmental Evaluation

14.12.1. Introduction

This section summarizes the results of the environmental assessment, elsewhere in this report, drawing out the main impacts that the construction and operation of a VHST might have and how the potential adverse could be avoided or reduced and mitigated. The effects described here are additional to those described in the economic evaluation in which a monetarized assessment was made. The assessment here is qualitative and made on different aspects of environmental effects of VHST.

The adverse environmental impacts of VHST construction can be considered against the alternatives of:

- additional airport, terminal, runway and ancillary services; and
- road upgrading or construction

that would be avoided or deferred as a result of construction of a VHST The adverse environmental impacts of VHST construction and operation should also be considered against the potential environmental benefits of VHST operation from the diversion of air and road traffic and the potential for a reduction

14.12.2. Net environmental impacts of an EC VHST

- Construction – land 'footprint' required

In terms of a land 'footprint', a VHST system requires about half the land required for a new freeway. In the Australian context, the average width for a VHST alignment would be approximately 40 metres compared with an average minimum reservation width for a 4-lane freeway of 75 metres. Thus, for a route length of say 1,000 kilometres, the overall comparative land take for a freeway would be a minimum of 7,500 hectares compared with approximately 4,000 hectares for a VHST system. By comparison, Melbourne Airport currently has an area of 2,367 hectares and land acquisition to accommodate the two future additional runways

[45] Appendix J1 Section 5.6. "Benefit Cost Study of a Second Sydney Airport at Badgery's Creek" PPK Environment & Infrastructure.

[46] For example: Beesley, M.E. "Economic criteria for the maintenance, modification or creation of public transport services which may not be profitable", Forth International Symposium on Theory and Practice in Transport Economics, The Hague, 1971.

[47] " Market Failures, Subsidy and Welfare Maximisation" Gwilliam K. in "Transport Subsidy" Edited by Glaister S. Policy Journal 1987.

[48] A conclusion reached by Savage in an assessment of the option value of rural bus services in the UK. Reported in "The Deregulation of Bus Services" Savage I.P. Gower Press, 1987.

would increase the Airport's size to approximately, 2,667 hectares (Australia Pacific Airports [Melbourne] Pty Ltd 1998, 13). The area of Sydney Airport is currently approximately 810 hectares and the proposed (and now deferred) Second Sydney Airport at Badgerys Creek had a site area of approximately 2,900 hectares to accommodate development of two 4,000m parallel runways (PPK, 1997, 9-6 and 9-11).

Implementation of an EC VHST in the short to medium term is not likely to significantly reduce (that is to say, help to avoid) the environmental impact of upgrading of major interstate road links for reasons including:

- upgrading of the Melbourne to Sydney road link (and connecting road links to Canberra) to continuous 4 lane dual carriageway freeway standard provided by the Hume Freeway, Federal Highway and Barton Highway is largely complete or committed. No major (i.e. beyond the local level) environmental impacts are expected for those sections yet to be completed, such as the Albury bypass.
- the existing commitment to the ten year $2.2 billion upgrading of the Pacific Highway between Newcastle and the NSW border funded by the NSW ($1.6 billion) and Commonwealth ($600 million) Governments. This program is halfway through its ten-year implementation and, when this commitment is completed, there will still be substantial sections of the Pacific Highway remaining as single carriageway roadway. Community pressure and increased road traffic growth along the Pacific Highway corridor is likely to result in further upgrading works on this Highway for many years into the future until a complete 4 lane dual carriageway freeway standard coastal road connection is provided between Sydney and Brisbane.
- with the exception of metropolitan and near metropolitan sections of these major road links, four lane dual carriageway roads are likely to meet traffic growth requirements for the foreseeable future.
- there will also continue to be investment in the inland Melbourne to Brisbane road corridor (based on the Goulburn Valley, Newell and Cunningham Highways) to achieve standards consistent with a high proportion of long distance, heavy vehicle traffic that will assist in providing improved land transport capacity along the East Coast.

As a result, the principal environmental impact that the EC VHST could notionally save is the net difference between the environment impact of the construction of the EC VHST and the staged construction of a second Sydney Airport at Badgerys Creek. As indicated above, the footprint of a new 1,000 km VHST corridor would require up to 4,000 ha while the land required to accommodate development of a high capacity airport at Badgerys Creek with two 4,000m parallel runways would be approximately 2,900 hectares. So unless a VHST is located largely within existing rail corridors – a proposition that is inconsistent with the alignments that are needed to achieve optimum performance - there is unlikely to be a net saving in terms of the footprint required (and related environmental impacts) of an EC VHST.

This is evidently a very global and qualitative assessment of effect. Obviously, it does not account for the relative effects of a very long thin corridor passing through many different environments against a very large but geographically localized development site. The cumulative and strategic environmental impacts of an EC VHST are thus likely to be greater and would affect a wider range of biodiversity resources then would those associated with a second Sydney Airport.

14.12.3. Environmental savings deriving from the operation of an EC VHST

This effect derives from the likely diverted demand from other less energy efficient modes of transport (per passenger/km) and the efficiency (load factors) that could be achieved on the EC VHST and associated energy use. This was taken into account in the economic assessment. (see section 14.5)

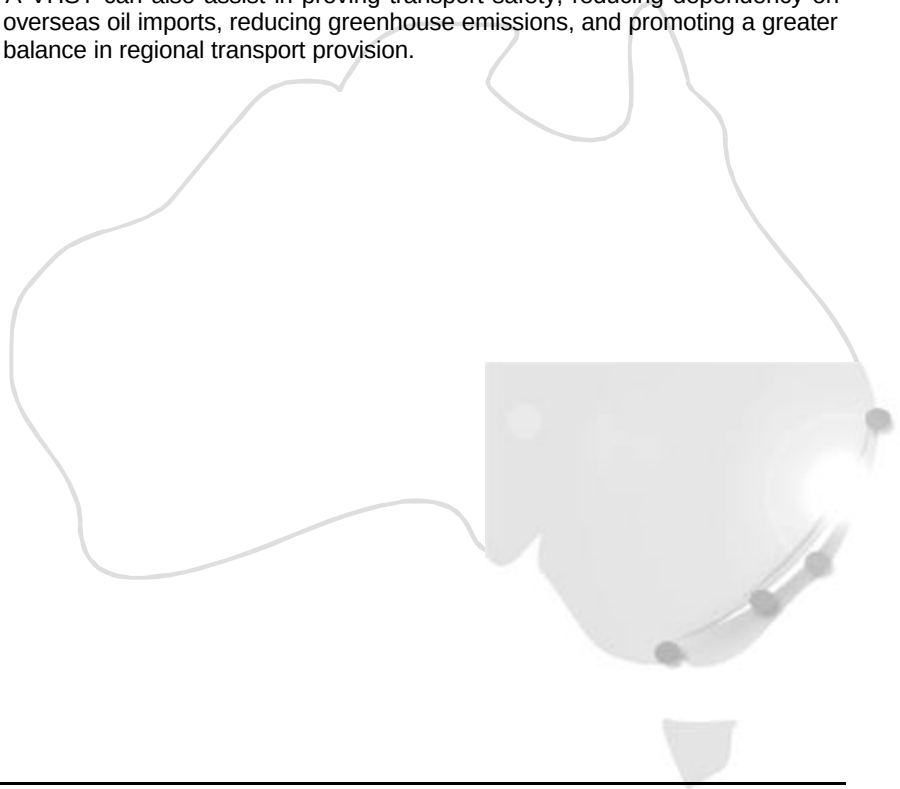
14.12.4. Environmental Preferences for Corridor Selection

As was outlined in Sections 5 and 6:

- The inland corridor via Albury-Wodonga between Melbourne and Canberra is preferable in overall environmental terms to the coastal corridor via Gippsland.
- Between Canberra and Sydney, routes via Bowral/Campbelltown and via Bowral/Wollongong were reviewed. A preference was determined on environmental grounds for a route via Campbelltown/Bowral.
- No feasible inland alternative exists to a coastal corridor between Sydney and Newcastle – it would bypass centres of population, pass through very rugged terrain and be longer. However, two routes were tested – one essentially in the existing corridor and a new shortened route, all in tunnel, under urban Sydney, National Parks and the Hawkesbury River to Gosford. The latter route must be regarded as futuristic and involving policy decisions on environmental effects beyond this study to contemplate.
- demand potential and engineering costs indicate a preference for a coastal route between Newcastle and Brisbane despite the likely greater environmental effects. However, as has been demonstrated by the progressive upgrading of the Pacific Highway, with careful planning and detailed community involvement, a route that meets environmental planning policy and goals to acceptable standards can be expected be found in this section of the corridor.

14.13 Key Points

- A VHST clearly captures a significant part of the future transport task in the East Coast corridor – its share comes principally at the expense of air.
- At a discount rate of 7%, no combination of costs and revenue delivers a positive NPV on a purely financial assessment.
- The full Melbourne-Brisbane VHST project, implemented as a 350 km/h technology, has a financial internal rate of return (IRR) of 2% for the central case scenario.
- For the private sector to achieve a 15% hurdle discount rate would require the Government to fund around 80% of the full project. This assumes all revenue going to service private sector debt and equity.
- A VHST would generate a range of economic benefits such as passenger timesaving, air and road decongestion, reduced road accidents, and reduced greenhouse emissions.
- However, revenue and user benefits are an order of magnitude greater than the benefits to the public at large; Costs are dominated by infrastructure costs.
- At a 7% discount rate, 350 km/h, VHST produces an economic NPV of $26 billion for the central case scenario. The range in NPV is wide, however, reflecting uncertainty in demand and cost. With the range in benefits and costs, NPV ranges from -$15 billion to $68 billion.
- The NPV at 7% for the Sydney-Brisbane corridor ranges from -$13 billion to $25 billion whereas that for the Melbourne-Sydney ranges from -$11 billion to $11 billion.
- At the macro level, the economics of the Sydney-Brisbane corridor appears the economically stronger case, driven by the demand in the Sydney-Newcastle sector.
- The full project has a significantly greater NPV than either of the parts indicating that the more extensive travel possibilities and greater connectivity, due especially to the Newcastle-Canberra corridor increases in revenue.
- Users enjoy a significant multiple of benefits 2.5 times their costs, whereas the ratio of public benefits to publicly borne costs is in the range 0.1 to 0.3.
- The distribution of changes in population is estimated to have less impact than the change in the absolute level of corridor population.
- 250 km/h technology is more cost effective in generating demand in the short to medium range corridors (Newcastle to Canberra).
- 350 km/h and 500 km/h are equally cost effective in the longer range corridors in generating demand per dollar of capital invested.
- VHST would have a significant impact on regional air services and would reduce the number of aircraft movements at Sydney Airport.
- VHST could assist in avoiding the adverse environmental effects of airport expansion but would generated a set of different effects spread over a very long corridor – some may be regarded as adverse by the specific communities affected as are airport effects.
- VHST would reduce road vehicle-kilometres travelled in the corridor with the greatest effect being on the NSW North Coast and south of Canberra.
- VHST could assist in the economic development of regional communities.
- Corridors can be selected to avoid, at the national state and regional level, major environmental effects.
- A VHST can also assist in proving transport safety, reducing dependency on overseas oil imports, reducing greenhouse emissions, and promoting a greater balance in regional transport provision.



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Section 15

Is there a Place for An East Coast VHST in Australia's Transport Future?



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15 IS THERE A PLACE FOR AN EC VHST IN AUSTRALIA'S TRANSPORT FUTURE?



15.1 The East Coast Transport Context for VHST

The East Coast corridor, which includes Melbourne, Canberra, Wollongong, Sydney, Newcastle, the Gold Coast and Brisbane and many regional towns, accommodates about 14 m people, or 75% of Australia's total population.

The inscope East Coast market from which an EC VHST might draw its market is about 40 % of the total Australian non-urban passenger task.

As the major location of Australia's economic activity, the corridor requires excellent transportation links, both passenger and freight, to facilitate the continued growth and development of the urban centres and the regions lying between them.

The total transport task on the East Coast of Australia between Melbourne and Brisbane is forecast to increase by 3.4 times between 2001 and 2051.

However, existing transport systems are focussed on very specific transport tasks or are of limited utility to cope with this future task, examples being:

- the alignment and condition of the mainline railway network, despite various upgrades over the years, is such that even the current 160 km/h passenger train technology cannot perform to its potential. In its current state, rail is totally un-competitive with air travel and barely competitive with road travel between the major regional and capital cities in the corridor;

- due to upgrading of the alignment and capacity improvements, travel on the highway linking Sydney and Melbourne is approaching the point of minimum legal road travel times and the Sydney - Brisbane Pacific Highway route is also already being improved;

- regional aviation routes are primarily oriented toward one of Melbourne, Sydney or Brisbane with relatively poor connections inter-regionally along the corridor.

15.2 What transport task could an EC VHST perform?

The demand analysis indicates that a VHST could capture very significant patronage in the East Coast Corridor.

As an example, and depending on the corridor selected, introduction of a 350 km/h VHST is forecast to attract, by 2021:

- about 13 % of the total number of trips in the corridor and to expand the overall market by 3%. More specifically, it is forecast to capture 13 million trips from air. If achieved, this would limit growth in air trips to 54 % of the forecast for the air mode without an EC VHST.

- Up to 5.4 million Melbourne –Sydney trips;

- Up to 3.2 million Sydney to ACT trips and up to 1 million ACT to Melbourne trips;
- Up to 2 million Brisbane to Sydney trips.

However, the Sydney-Brisbane and Sydney Melbourne sectors are similar in terms of total trips, revenues, passenger kilometres travelled and user benefits generated. On these measures, Brisbane to Canberra averages about 6% higher than does Newcastle to Melbourne.

All measures are maximized for the full corridor, clearly showing that a network effect increases overall corridor patronage to up to nearly 40 million trips p.a.

In terms of corridor options over the long-distance sectors, the demand projections indicate that:

- between Newcastle and Brisbane, the coastal corridor would be 30 % stronger in patronage than the inland, New England, route;
- between Canberra and Melbourne, the Gippsland corridor is indicated to be only slightly stronger than the inland corridor via Albury-Wodonga.

Although travel times by VHST over the Sydney- Brisbane and Sydney – Melbourne routes could not equal those offered by air, an EC VHST could progressively capture a large share of the projected total market for air travel. Analysis indicates that, by 2021 with even a 250 km/h service, 31% of the VHST's patronage could be that diverted from air while, at 500 km/h, this proportion could rise to 47%.

Assuming a 350 km/h VHST, for Sydney to Canberra and Canberra to Melbourne, 72% and 59% respectively of the air market in 2021 could be captured with the possibility that, as air services reduce, yet more patronage could accrue to VHST

For regions within 2 hours by VHST of a capital city (e.g. NSW North Coast to Sydney) now served by smaller propjet aircraft, the VHST could capture up to 84% of the air market, depending on the competitive response of the airlines. An EC VHST would have a major impact on the number of smaller propjet aircraft travelling to and from regional centres in the corridor and Sydney. An EC VHST would also reduce car travel in the corridor.

15.3 Corridors and Regional Development

Corridor options for VHST development were assessed in terms of their broad environmental, urban and regional development potential and engineering alignment issues. Put simply, a good VHST corridor is one that passes through as many population centres as possible while maintaining as straight an alignment as possible. In the East Coast corridor, these objectives are constrained by the terrain and environmental assets of the corridor. Within each major sector there are basically two optional alignments. On the basis of these broad criteria:

- Melbourne to Canberra

  The Inland route via NE Victoria and Riverina region of NSW is preferred to the alternate Coastal route via the Gippsland region of Victoria, principally on environmental grounds;

- Canberra to Sydney

  The Inland route via Southern Highlands and Campbelltown preferred to the alternate Coastal route via Wollongong and Sutherland, on both environmental and engineering grounds;

- Sydney to Newcastle

  The existing corridor is generally preferred on engineering and environmental grounds over shorter faster but very long (> 40 km) tunnel alignments;

- Newcastle to Brisbane

  The Coastal route via the Northern Rivers and Gold Coast is preferred to the inland route via Tamworth and Toowoomba, on engineering and on urban and regional development grounds.

VHST access to the large metropolitan areas of Melbourne, Sydney and the Gold Coast/Brisbane presents major challenges including:

- Creating fast alignments deep into the centre of the East Coast cities due to the great difficulty in developing new surface corridors;
- Limited capacity and relatively slow journeys on existing corridors; and
- Major costs associated with overcoming either of the above, principally because of tunnelling costs.

The preferred corridors all contain significant centres of economic activity which an EC VHST is considered likely to support and enhance, provided there are supportive action plans and policies in place.

15.4 Environmental and ESD Issues

VHST routes could be located within all corridors which are compatible with the major environmental assets of the East Coast region of Australia, though routes would need to be investigated in detail and appropriate environmental protection provisions made in the alignment design.

Electric traction VHSTs could assist in the reduction of greenhouse gas emissions by reducing travel in cars and by air. However, VHSTs are energy intensive, particularly at higher speeds, and the extent to which an EC VHST could comply with the principles of ecologically sustainable development would require further investigation in relation to electricity supply arrangements.

Planning, creation, and delivery of an EC VHST would be subject to environmental controls applying in the States and Territories through which it would to pass. A coordinated approach across all Governments to project assessment and approval under environmental legislation would be essential.

15.5 VHST Technology

There are two fundamental forms of VHST which could be considered for an EC VHST – 250 km/h to 350 km/h Steel Wheel on Steel Rail (SWSR) rolling stock – and MagLev for speeds up to approximately 500 km/h. No other technology is currently or in the foreseeable future a serious contender for an EC VHST.

There are several different suppliers of operationally proven 250-350 km/h SWSR technologies but only one for 500 km/h technology.

The selection of technology and staging of implementation of a VHST system are related and major issues, as follows:

- SWSR VHSTs are compatible with joint user routes so can operate at full speed where permitted by traffic density and track standard or can travel, albeit at lower speeds, with other traffic and on lower standard tracks, while
- MagLev trains are suitable for longer corridor sectors but require fully dedicated infrastructure so that construction of any stage would commit the whole corridor to being in that technology.

Continued development of SWSR VHST systems can be expected, given the huge sunk commitment to this technology by the nations of Europe and North America and also by Japan. With one commercial project under construction and the potential for others in the near term in the USA and Germany, interest in and development of revenue service MagLev appears set to continue.

The availability of VHST technology suppliers is not currently an issue. However, the choice of a technology is critical because of the degree to which the system owners and operator(s) of the VHST system could become locked into the one technology source. A choice of SWSR technology would mean that rolling stock could be supplied on a competitive basis and that according to the sector being operated, rolling stock could be chosen from a range of 250 km/h to 350 km/h technologies. For 500 km/h technology system owners and the service operator would need to prepared to negotiate with only one technology provider both for the supply and maintenance of the system.

15.6 Capital costs, construction, and financing

Assuming that the full project were to be constructed as a double track system from Melbourne to Brisbane, the total cost (A$ 2001) of the railway infrastructure, according to the standards of construction needed, is estimated (–10%/+30%) to be:

- For 250 km/h SWSR VHST **$33 - $41 billion;**
- For 350 km/h SWSR VHST **$38 - $47 billion;**
- For a MagLev VHST similar to Transrapid: **$56 - $59 billion.**

To this would need to be added the cost of setting up the operating company and the acquisition of rolling stock.

Construction of the whole EC VHST would take between 10 and 20 years, depending on the rate of funding and the strength of the Australian contracting industry over the period. The majority of the cost of an EC VHST would be in civil and infrastructure engineering. There exists a strong and capable infrastructure industry in Australia and worldwide to deliver this project. All the civil infrastructure capability exists in Australia but some aspects of the power systems, signalling, control and communications may need to be derived from international expertise.

Planning of the stages of construction would be dependent upon the selection of technology and prioritisation of regional centres to be served. Each stage should potentially be a self-contained operation and it is probable that the early stages would need to address the difficult issues of entry into the centres of capital cities.

Almost without exception, VHST systems around the world have been developed on the basis of majority government financing. Public/ private partnerships would be feasible for financing defined portions of an EC VHST, depending upon the manner in which risks were shared. The private sector would need to be involved in the operation of the service in order to gain access to the revenue streams.

Private sector investment would depend upon the availability of cashflows to service debt funding. On the basis of the median revenue to operating cost differential identified in this study, the private sector could carry up to about 20% of the capital funding required for the whole project. The range on private sector funding under the range of revenues and costs evaluated was from 0% to 40%.

15.7 Stageability of an EC VHST

Given the lengthy construction time, it obviously would be financially, economically and politically unsatisfactory to await the full alignment to be complete before any revenue service was operated. Therefore, an EC VHST would need to be constructed such that it could be opened to revenue service, preferably in commercially viable stages.

This study has identified that a promising initial stage, based on:

- fulfilling a solid transport task
- generating substantial user benefits in relation to its capital cost;
- attracting patronage,

would be from Newcastle to Canberra, probably delivered in two sub stages - Sydney to Canberra and Sydney to Newcastle. The estimated cost range for this full stage would be from $8.8 billion to $20.8 billion depending upon the technology chosen and the route options selected.

One of the key findings of the patronage analysis in this study has been the network effect – the patronage of a sector of the corridor being forecast to be higher than the sum of the patronage of its subsections operating alone. In the case of the suggested first stage, this effect relies on the VHST service not being purely Sydney centric but providing fast efficient transit through Sydney, thereby affording new alternative travel patterns between such regional centres as Newcastle and Canberra or Gosford and Campbelltown.

The cross sectional analysis indicated that, beyond this stage, either of the Newcastle to Brisbane or Canberra to Melbourne sectors would be a candidate for the second major stage. The Melbourne- Sydney route

generates the highest intercapital flows – i.e. patronage strictly between the capital cities. However, the Brisbane to Sydney corridor generates the highest number of trips on the VHST system demonstrating its effect on interregional travel.

A key issue then would be whether to invest in extending:

- south from Canberra and north from Newcastle –i.e. extending the existing VHST operation; or
- build sections extending out of Melbourne and out of Brisbane – i.e. create isolated sections of VHST alignment for which different operators might be required.

Two possible stages that would support this latter approach would be:

- Melbourne to Albury-Wodonga – assuming that an inland route was selected this would be complementary to the Victorian Fast Trains project currently underway and with VHST technology of 250 km/h or greater would bring these cities well within a 2 hour or less travel time.
- If a coastal route south of Brisbane were to be selected, upgrading to standard gauge and extension of the Gold Coast Railway in to Northern NSW could be a possible stage. The extent of this stage would require more detailed consideration of a Brisbane terminus and the market available in Northern NSW. This stage has significant implications for the existing QR Gold Coast services.

In both cases the issue of whether these would be separate operations from that for the suggested initial stage requires consideration.

15.8 Operations

Efficient operation and maintenance is the key to a successful VHST service and the EC VHST would need to be set up as a business enterprise, whether in the hands of the public or the private sectors, acting jointly or severally.

The key player in any private sector consortium bidding to build, own, and operate any part of an EC VHST is the system owner/operator. This is the party taking the long-term risk on the commercial viability of the system, not the infrastructure contractor or rolling stock supplier. This party will need to be involved in the system design, the selection of the technology and the design of the business enterprise.

There are relatively few experienced private sector operators of VHST services though the number is expanding. Some operators with such experience are already operating passenger rail franchises in Australia.

There is a mature and competitive industry capable of maintaining SWSR railways including rolling stock and control systems in Australia. There is no experience in operating and maintaining MagLev systems in Australia However, several global electrical engineering companies, including one of the owners of the Transrapid MagLev technology, have established capability in Australia and could be partners in a technology transfer process.

On the basis of both the findings of this study and international experience, it is anticipated that an EC VHST, once its infrastructure is in place, could to cover the cost of its rolling stock acquisitions and its operating and maintenance costs.

15.9 Benefits from an EC VHST

This study confirms that an EC VHST would need to be, at its core, a public sector work although there would be many opportunities for the private sector to be involved. As a public work an EC VHST needs to deliver public benefits that exceed to a satisfactory degree its costs. Conventional cost benefit assessment undertaken in this study indicates that for at least one technology and corridor assumption total benefits would exceed total borne costs. However, it should be noted that externality benefits of an EC VHST are 10% or less of the total benefits.

Significantly, while the users of a VHST derive a positive return on their costs, non-users in fact incur a surplus of costs over benefits. This latter finding for the 350 km/h technology is consistent with that of the Federal Railroad Administration in its 1997 study of a large number of VHST corridors in the USA.

Beyond cost-benefit analysis is consideration of whether a VHST performs a task that supports or contributes to the attainment of other public goals. While in a monetarized assessment the contribution of externality benefits may be small, there may be no other way to achieve them. An EC VHST is forecast to bring about a major reduction in regional airline services operating smaller aircraft to and from Sydney. It is also forecast to reduce car travel in some key road corridors. Both shifts in mode aid reduction of exhaust pollutants, greenhouse gas emissions and dependence on liquid fossil fuels.

A further, possibly highly desirable outcome not identified in the global indices of conventional cost benefit analysis, is the way the benefits are distributed to the communities throughout the corridor. While the populations of the capital cities contribute the highest quantum of revenue and enjoy the highest quantum of user benefits, it is some of the regions in the corridor that enjoy the highest per capita benefits of a VHST.

15.10 Policy and the national interest

Commonwealth and State Governments have invested in a number of major pieces of infrastructure, at least partially on the basis of their perceived contribution to what at the time was considered to be in the national Interest.

For the EC VHST to contribute to the national interest in a similar manner there would need to be clarity of vision on:

- how future development should occur in East Coast region and an appreciation that the benefits conferred by a VHST investment could be distributed in what would be a relatively narrow band in comparison to the scale of Australia and
- how this development can positively contribute to "Nation Building" more effectively than alternative measures.

Such a project could only be implemented if a significant degree of inter-governmental goodwill, agreement, and commitment to the concept were achieved across the five jurisdictions affected and if the constitutional issues associated with the interfaces between the Commonwealth and the States/ACT were resolved. Private sector confidence would flow from a strong and visible commitment by the governments.

A joint State/Commonwealth entity would need to be established to oversee and facilitate the delivery of the project. Significant financial and other resources would need to be committed by all involved governments.

International experience indicates realization of regional development benefits is typically dependent on a much wider and more complex set of parameters than simply a new transport system. As indicated in this study, an EC VHST could act as a catalyst for urban and regional growth in the corridor if accompanied by a range of complementary policy measures and initiatives.

Without such active and effective policy measures, a VHST may only serve to reinforce the dominance of the major metropolitan areas at the expense of regional development.

The policy imperative in regard to high-speed rail is well summarized by the following words of Etienne Schouppe, President of the International Railway congress and president of the Board of Management of Belgian National railways

"It is not possible to take decisions about investment in the rail network when they are based merely on classical cost benefit analysis. The cost profile and long life of railway infrastructure are inextricably linked to large-scale socio economic consequences and the development of additional rail capacity affects many aspects of the country as a whole. It is clear that the onus in making investment choices lies with the authorities who define transport policy and who act as the main shareholders for most of Europe's railways. They must also accept that they should provide substantial help in financing expansion of railway infrastructure" (Railway Gazette – Rail Investment – V157 2001)

15.11 Arguments for an East Coast VHST

The following arguments for an EC VHST are drawn from this study and from other commentary on the subject:

- A VHST is a way in which reliable high speed alternative transport capacity can be injected into the longer-distance travel market in the East Coast corridor;

- An EC VHST can be complementary to air in the development of a fast transport network;

- Insufficient passenger transportation diversity in such a vital corridor places the economic well being of the Nation at risk. Air travel is routinely reported as being subject to increasing limitations imposed by factors including:

  - Airport capacity and the need for capacity augmentation by way of extensions to runways and terminals, or even whole new airports,

  - Peak-time pressure for landing slots at major airports being such as to discriminate against flights serving regional centres relative to those serving the major centres;

  - Aviation energy costs;

  - Environmental degradation, by aircraft noise and greenhouse gas emissions in particular; and

  - Operational, security or industrial threats.

- Equally, cars do not offer the travel time advantages that VHST's do and in and around the State capitals road corridors are becoming saturated.

- For some outer suburban commuters able to afford the service, a VHST would provide relief from overcrowding on normal suburban services.

- The patronage study has shown that any VHST from 250 km/h to 500 km/h could capture a significant market share – the faster the more so but at exponentially increasing cost.

- Eastern Australia could benefit from a new vision of urban and regional structure transcending State boundaries and a VHST system could provide a defining spine for the regions lying between the major conurbations. There is sufficient evidence from international experience to show that, provided other forms of regional development investment accompany it, VHST transport will be a change agent in those regions.

- A VHST system would bring equity of high-speed travel opportunity and mode choice to more people along the corridor. Similar VHST trains would operate over the whole of the corridor in contrast to air where some communities are served by commuter standard aircraft while others are served by larger, faster and more comfortable aircraft.

- As an example, at the level of investigation made in this study and under the assumptions made, a 350 km/h EC VHST satisfies two important criteria:

  - commerciality criterion - In its operating phase its revenues are assessed to exceed its costs and, if so, an operating subsidy would not be needed; and

  - public benefit criterion –in its economic assessment, total benefits exceed total costs.

- If created as an SWSR double track railway, capacity on an EC VHST is likely to exceed requirements for many years. This additional capacity could be used to alleviate congestion on existing lines and also to provide for superior transit times for interstate freight. Investment in an appropriately designed constructed and operated EC VHST alignment could be beneficial to a wide range of rail operators.

- The major concerns of both the public and private sector are development and operating risk and consequent financial exposure – staging provides a means to limit such exposure.

- An EC VHST could be developed in discrete stages in a way that would allow operations to commence in sections of the corridor

where they would have the best possible chance of being commercially successful.

15.12 Arguments against an East Coast VHST

The following arguments against an EC VHST are drawn from this study and from other commentary on the subject:

- The most basic argument against an EC VHST is that at a construction cost of around $40 billion of which some 80% would have to be directly funded by Governments, it is simply unaffordable. However, that is a matter for Governments to decide for themselves;

- Even though an EC VHST does appear capture a market, ongoing patronage risks are substantial, and a VHST's patronage gain is largely at the expense of the air market. Loss of market share to a public enterprise on the major trunk routes could impact on the viability of Australia's private sector airlines;

- In any event, a strong passenger aviation industry is important to Australia because only air transport can link bind the whole of the Australia with fast intercapital travel- a EC VHST or any VHST system could never replace air travel on a fully national scale in that function;

- An EC VHST would confer disproportionate benefits to the major regional urban centres on its route and benefits to certain regional areas along the route;

- Although an EC VHST at this level of analysis passes the basic tests of commerciality and public benefit, its financial and economic indices are not strong enough for it to attract funding away from other competing governmental investments in Australia's future wellbeing. Neither are there sufficiently compelling reasons in terms of the externality and distributional benefits or the potential for reshaping the distribution of population in the East Coast corridor;

- Governments are less and less in the business of running transport enterprises and certainly not in supporting marginally economic and possibly unfinancial transport enterprises, even in partnership with the private sector. Governments are generally unwillingly become the financier and/or operator of last resort of business enterprises and it must be assumed that this would apply should an EC VHST prove to be non-viable;

- more cost-effective ways to achieve incremental improvements to the existing rail network, such as selective route realignments and addition of crossing loops could be adopted instead of an EC VHST. These could permit the running of passenger trains at speeds of up to 250 km/h, provided the corridor was electrified, and substantially improve rail freight performance without capital expenditure and risk of the scale involved in implementation of a full VHST. There was evidence in the Sydney-Canberra VHST bid process to indicate that this approach was of interest as an investment to the private sector;

- There is as yet no overarching vision at a national level of the future urban and industrial structure of the whole of the East Coast corridor and its importance to Australia as a whole. An EC VHST is only justified as a part of such a vision not as the vision itself; and

- Until such time as the Governments reach a common vision and agree on the systems including transportation needs to support that vision, consideration of a VHST is premature.

15.13 Next Actions

This study is the first that has been commissioned by the Commonwealth to examine, from the perspective of Government, the issues inherent in an East Coast High Speed Train. Though a preliminary study, it has provided a broad range of insights into those issues. It necessarily brings together large amounts of data and makes many assumptions. The next actions in consideration of an EC VHST should include:

- ongoing engagement of key government players to find a common purpose and vision which is national in nature and transcends the particular interests of the Commonwealth, the States and the major cities in the corridor;
- analysis of the future economic function of the East Coast corridor, the total transport task in that corridor and the role of very high speed rail transportation in achieving that function;
- further work to prove up the assumptions and data upon which this study derives its estimates of patronage, revenues, capital and operating costs;
- more detailed patronage studies, with, for example market research;
- more detailed corridor analyses to confirm or change preferences;
- further detailed financial and economic analyses; and
- refinement of the processes by which an EC VHST could be created.

There is no need at present to commit to a particular VHST technology though the choice between SWSR and MagLev cannot be delayed indefinitely. Nor is there a need to entertain any private sector offer in respect to any part of the system until Governments have formed their own view of what an EC VHST should do and where it should do it.



15.14 Is there a place for an EC VHST in Australia's transport future?

Very High Speed Trains for intercapital travel have been under consideration for over 15 years in Australia. Such is the level of interest that the private sector has been prepared to invest heavily and to compete vigorously for the right to build, own, and operate such a massive project.

Business interests, regional government and communities continue to lobby Governments in support of the concept. Its image as a means to bring about renewed growth in regional southeast Australia is untarnished.

The scale of an EC VHST must be not underestimated. An EC VHST linking Melbourne, Sydney, and Brisbane is on the same scale as all of the Japanese Shinkansen constructed to date or the whole of the German High Speed Rail program and greater in length than the proposed California High Speed Rail project.

It would be, on any set of measures, a project of national interest and impact on national and regional economies. Its cost and risks would be of such magnitude and its construction and operation of such scale that it could only be achieved through the leadership of Australia's Commonwealth and State Governments working in concert to the common purpose. Under such leadership, there would be many opportunities for private-public cooperation and partnerships to deliver and possibly operate elements of the project.

It has been shown that an EC VHST could capture a significant part of the future East Coast travel market and provide relief to the other modes. International experience indicates that economic growth in a VHST corridor can occur but requires more than just construction of the VHST to be realized. The project appears to have economic merit, if it can be funded. Nevertheless, there may be alternatives which are more affordable and which deliver greater public benefits.

For these reasons, an EC VHST could have a place in Australia's transport future. The securing of that place, however, would be dependent on whether it can become an integral part of a vision and action plan for a new paradigm of development, mobility and transportation connectivity in the East Coast corridor.

If it does have a place, an EC VHST will not achieve it in the absence of political vision and leadership, long-term bipartisan political commitment, the full participation of all Governments and the collective will and skills of Australians.



ARUP-TMG

Annexure 1

National Interest



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A1. National Interest - Extending the Scope of Analysis

This Annexure should be read in conjunction with Section 11.8, which summarises the material contained herein.

A1.1 Introduction

If a project that does not otherwise meet the tests of conventional economic analysis is to be justified on "national interest" grounds, then it should be possible to point to additional benefits.

In practice, the only significant additional benefits identified by commentators which major transport infrastructure investment projects are believed to generate, that are not obviously identified in conventional economic appraisals, are national and regional economic growth, or at least employment growth.

The benefits represented by alternative "visions" of the future are reviewed in the following sections of this Report.

A1.2 Types of Economic Impact

The issues involved in the identification of economic impacts have been the object of intense debate and investigation.[1] Quinet, for example, has noted:

"The indirect effects of infrastructure is a strongly debated subject which seems to generate divergences of view between public decision-makers, who often put forward before the event these effects to justify their policy choices, and the scientific analysts, who provide in their turn very varied conclusions. The difficulty of the subject is understandable because the indirect effects depend on very many specific factors, that differ from one case to another, and their impact, which takes a long time to appear, is difficult to isolate.[2]"

Where many analysts have argued that the impacts are not sufficiently clear to be admissible, at least in the present state of knowledge, Quinet adds:

"However, in relation to High Speed Rail, there exist now, from all around the world, enough observations, and observations covering a sufficiently long period of time, so that it does not appear too ambitious to draw from them some general conclusions [about the economic impacts of High Speed Rail].[3]

A1.3 National economic development

Many commentators have suggested that conventional economic cost benefit analysis does not adequately capture the economic development benefits that investment in transport infrastructure generates.

The strongest statement was made by Aschauer:

"The conventional method of measuring the economic feasibility of a transportation facility involves a narrow structured, partial equilibrium calculation of travel time savings, travel generated revenue and job creation from a facility and comparing those benefits to the construction cost of the facility. These traditional methods, which tend to significantly underestimate the total economic value of transportation infrastructure, can also be identified as a reason for the lack of commitment by [United States] federal and State governments to increased funding for transportation services.[4]"

Supportive evidence came from Munnell but others found fault with Aschauer's approach.[5]

A similar view has been expressed in the Australian context by Otto and Voss, among others:

"cost-benefit studies are generally considered unable to measure all the indirect benefits….primarily because of the benefit externalities….which are difficult to identify and measure.[6]"

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1 See, e.g., Bureau of Transport Economics (BTE) *Facts And Furphies In Benefit-Cost Analysis: Transport* [Report 100] Canberra, 1999; [UK] Department of the Environment, Transport and the Regions (UK SACTRA) *Transport and the Economy* [Report of the Standing Advisory Committee on Trunk Road Assessment] London, 1999; OECD Directorate for Science Technology and Industry (OECD DSTI) *Impact of Transport Infrastructure on Regional Development* [IM2 (2001) 1], Paris, 2001.

2 Quinet, E (Professeur, École Nationale des Ponts et Chaussées, Paris) "La grande vitesse, une choix pour le développement économique" in *Proceedings of the 3rd World Congress on High Speed Rail* Berlin, 1998, vol 2, 64-70. [Author's translation from original French.]

3 Quinet, E *op. cit.* 1998, p.64. [Author's translation from original French.]

4 Aschauer, D "Is public expenditure productive?" *Journal of Monetary Economics* 24, 1989; Aschauer, D *Public Investment and Private Sector Growth* Washington DC, Economic Policy Institute, 1990.

5 See Munnell, A "Infrastructure investment and economic growth" *Jnl of Economic Perspectives* 6, 1992, 189-198.

6 Otto, G and Voss, G "Roads in the national economy" in Kneebone, D (ed) *Roads in the Community Part II* Sydney, Austroads, 1997.

Aschauer approached the issue from a completely "macro" perspective. He claimed to demonstrate:

- a positive relationship between transport infrastructure spending, private capital investment and labour productivity; and
- a positive link between transport infrastructure and returns on private investment and hence productivity.

Quinet provides a more "micro" perspective on the possible impacts of High Speed Rail on national output. Apart from the direct effects due to the lowering of transport costs, he points out, there are "more subtle" impacts; improved communications may lead to an increase in the overall productivity of businesses, through the diffusion of innovation and experience, access to a larger variety of services, the growth of markets (permitting economies of scale) and greater competition between enterprises.[7]

In the course of the 1990s many analysts attempted to demonstrate a relationship between public expenditure on infrastructure—or transport infrastructure specifically—and economic development, either through macro level analysis of national economic expenditure and output (often based on input-output analysis) or through general equilibrium analysis of micro-level projects (such as major road and rail investment projects).

Both lines of approach have generated considerable debate.[8]

In relation to the macro approach, UK SACTRA (1999) concurs with others in concluding that, while transport investment may have a small positive impact on productivity and output better returns may be derived from other forms of public or private investment—e.g. education.

BTE (1999) quotes with approval the conclusions of an earlier study by the Bureau of Transport and Communication Economics (BTCE) *that "such research has serious limitations".*[9]

In relation to the use of a "general equilibrium" approach to the likely impact of transport projects, BTE (1999) is unconvinced that of the reliability of the findings in most cases. It concludes:

"An estimate [of net benefit] derived from a national economic model may incorporate a broader range of effects [than conventional Cost Benefit analysis]. But some of these effects do not matter much and many, such as the impact on aggregate employment, are anyone's guess.[10]"

UK SACTRA (1999) concluded that, if the conditions for "perfect competition" were satisfied the conventional economic assessment would adequately cover all the economic development impacts of transport projects. However,

"[to the extent that there are significant imperfections] even the most complete conventional appraisal method that could, theoretically, be devised….would still leave out some wider economic impacts. These are the circumstances where claims for additional economic impacts, with a value which is not captured in the calculation of direct transport benefits and costs, may be valid.[11]"

However, it goes on to note that these impacts could be either positive or negative. It concludes therefore:

"For this reason, assessment of the economic impacts would have to be calculated for each case, based on the specific conditions in sectors (or economic activities) in areas affected.[12]"

Much earlier, a review of transport project evaluation methods for the French government had reached a similar conclusion:

"The effect on the rate of return of economic development induced by the project cannot in general be calculated in a systematic manner but relies rather on a case-by-case analysis.[13]"

Some United States analysts have suggested that:

"Macro-economic modelling is most applicable for large-scale projects with significant city/county or larger scale economic impacts.[14]"

The more limited aim of evaluating simply the employment impacts of major transport projects—beyond those that arise from the construction and

[7] Quniet, E *op. cit.* 1998, p.65.
[8] For a review of two Australian models, see, e.g. Docwra, G and West, G "Predicting the impact of road investment on Gross State Product and employment" in *Papers of the Australian Transport Research Forum* 23, 1999, 931-945.
[9] Bureau of Transport and Communication Economics *Econometric evidence on the benefits of infrastructure investment* Working Paper 25, Canberra 1996.
[10] BTE *op.cit.* 1999 p141.
[11] UK SACTRA *op.cit.*[Summary: para 33], 1999.
[12] UK SACTRA *op.cit.*[Summary: para 38], 1999.
[13] Boiteux, M Transports: Pour Un Meilleur Choix des Investissements La Documentation Francaise, 1994 [author's translation from original French].
[14] Weisbrod, G and Weiss, M *Alternative Methods for Valuing Benefits of Transportation Projects* Transportation Association of Canada Benefit Cost Analysis Symposium, February 2001.

operation of the infrastructure in question—have also been criticised. BTE (1999) concludes:

"Reliable estimates of the aggregate employment effects of transport investments are unavailable. Transport [assessments] should exclude such effects from their estimates of net benefit; the working assumption should be that such effects are absent.

Assessments of transport projects can usefully discuss aggregate employment effects without actually estimating them….transport investments can either increase or decrease aggregate employment, depending on the investment ad circumstances.[15]*"*

A1.4 Regional impacts

Regional impacts require careful analysis because they may involve the redistribution of activity from one area to another. From the perspective of the region the effects may be positive. But the "national interest" would certainly require that losses in other areas are offset against any local gains.

As UK SACTRA points out,

"Studies….confirm that there is no guarantee that transport improvements will benefit the local or regional economy at only one end of the route – [transport systems] operate in two directions, and in some circumstances the benefits will accrue to other, competing, regions.[16]*"*

Biehl and Quinet, basing their analysis on European experience, go further.[17] Quinet, for example, states clearly that:

"Theoretical analyses, like the empirical studies, make it possible….to show that the improvement of accessibility leads to the polarisation of [geographical] space and has a tendency to benefit rich regions more than poor regions.[18]*"*

The OECD DSTI report notes the paucity of *ex post* studies compared to the number of *ex ante* assessments that incorporate assumptions about regional development and employment impacts.

The OECD DSTI report concludes that it is not possible to provide a:

"firm quantitative basis to the claims about the impact of infrastructure investment on regional economies and regeneration. Thus its ability to provide guidance on how project appraisal methodology could be improved is limited.[19]*"*

BTE (1999) similarly concluded:

"Regional development effects of transport projects are often likely to be small for one or more reasons:

- The project reduces transport costs by only a small proportion.
- Transport costs are not large relative to total production costs or revenues.
- Producers view different modes of transport as poor substitutes.
- Natural constraints limit the development of resource-based industries.
- Improved transport exposes a region's industries to greater external competition.[20]"

Various studies of the impact of the Shinkansen on regional development in Japan, of which Nakamura and Ueda's work is typical, have pointed to somewhat faster rates of growth of population in areas served by Shinkansen lines.[21] The direction of causation remains a matter of debate. Sands, while accepting the influence of the Shinkansen, noted as other critical conditions, the presence of information exchange services (business services) and higher education.[22]

Most European observers also believe that, with some important qualifications, there is a discernible relationship between investment in transport—and in high speed rail in particular—and regional or local economic growth and development.

Quinet, writing from a French perspective, stresses the "specificity" of the impacts of high speed rail. He notes in particular that:

[15] BTE *op. cit.* 1999, p.55.
[16] UK SACTRA *op.cit.*[Summary: para 40], 1999.
[17] Biehl, D "The role of infrastructure in regional development" in Vickerman, R *Infrastructure and Regional Development* London, Pion, 1991; Quinet, E *op.cit.* 1998.
[18] Quinet, E *op.cit.* 1998, p.65. [Author's translation from original French.]
[19] OECD DSTI *op. cit.* [Executive Summary], 2001.
[20] BTE *op.cit.* 1999, p.160.
[21] Nakamura, H and Ueda, T "The impact of the Shinkansen on regional development" in *Proceedings of the 5th World Congress on Transport Research, Yokohama* 1989.
[22] Sands, B "The development effect of high-speed rail stations and implications for California" *Built Environment* 19 (3/4), 1993, 257-284.

- The effects are limited to discrete points, or concentrations, of economic activity, often far from one another, and are not evenly diffused;
- The effects are for the most part limited to a few sectors, notably the "superior tertiary activities", that is education, research and business services: by contrast "heavy" industries stand to gain much more from other forms of infrastructure improvement; and
- Although limited spatially and sectorally, the effects, where they do occur, are typically much larger than those generated by other infrastructure improvements.[23]

Vickerman offers a similar perspective.[24] He notes that:

- Corridors which stand to benefit from transport improvements start with very different levels of accessibility in different locations;
- Planned improvements to accessibility tend to favour those areas that already have relatively good accessibility;
- New transport infrastructure has differential effects on different sectors; and
- Any evaluation needs to take into account the specific activities in each part of a corridor.

In relation to the French TGV, observers have noted how the first (and still the most heavily used service) between Paris and Lyon stimulated significant development around the station in Lyon (where space was available) but had almost no impact at stations such as Le Creusot and Maçon where the economic conditions for development did not exist. The extent to which the development in Lyon constituted *additional*, as opposed to relocated growth, is less clear. But the general view that the TGV has played a role in the growth of areas outside Paris is supported by the evidence from the most recent French census that population in areas and regions away from Paris is now growing more rapidly than in the Isle de France.[25]

Both UK SACTRA and OECD DSTI, although somewhat more hesitant about the scale of the impacts, recognise that the outcomes to which policymakers are directing the attention of analysts—specifically regional and local economic development—are very rarely achieved through transport investment in isolation. As the OECD DSTI report points out:

Employment impacts and contributions to improved accessibility and social inclusion are unlikely to be created by transport investment alone. There is a need for a whole range of initiatives covering training, housing, social services etc in order to ensure spending on regeneration will have the desired effect.[26]

Quinet also emphasises this point:

"The indirect effects of a high speed line do not appear automatically, unlike other types of infrastructure. The form and significance of these effects are closely bound up with the public planning and policy context into which they are inserted: choice of route, choice of stops, accompanying public planning decisions.[27]*"*

Despite these concerns, however, governments in many countries are looking to analysts for "more inclusive" economic and general assessments of transport investments, with an explicit emphasis on economic development impacts.[28]

Weisbrod has summed up the situation as follows:

"There should be no question that indirect and induced impacts do occur. The real question is whether they provide a net increase in economic growth or merely displace other uses of the same workers and resources. For a very large area in which there is already near-full employment and relatively limited ability to attract additional labor or capital…, the additional "multiplier" effects on total growth can be negligible. For a smaller area, the use of previously under-utilized resources and/or the attraction of additional workers and investment from outside can lead to significant multiplier effects on total growth.[29]*"*

In Quinet's words:

"The result of the specificity [of impacts] is that a high speed rail service provides an opportunity for economic development but this opportunity—it is necessary to know how to seize it and how to make it bear fruit.[30]*"*

He concludes therefore:

[23] Quinet, E *op. cit.* 1998.
[24] Vickerman, R "Transport provision and regional development in Europe" Chapter 7 of Banister, D (ed) *Transport Policy and the Environment* London, E&FN Spon, 1998. See also Vickerman, R "High speed rail in Europe: experience and issues for future development" *Annals of Regional Science* 31, 1997, 21-38.
[25] Scargill, I "The French Census of 1999; challenges for planners at the intra-regional scale" *Town and Country Planning* 68 (12), 1999.
[26] OECD DSTI *op. cit.* [Executive Summary], 2001.
[27] Quinet, E *op. cit.* 1998, p.65. [Author's translation from original French.]
[28] For example, US "Transportation Equity Act for the 21st Century" (TEA-21) explicitly incorporates assessments of "economic vitality", defined as covering the global competitiveness, productivity and efficiency of areas or regions.
[29] Weisbrod, G *Evaluation of Public Infrastructure Effects on Macro-Level Public Welfare* Workshop on Economic Impacts of Infrastructure Investments, Den Haag, Nederlands, 1997.
[30] Quinet, E *op. cit.* 1998, p.65. [Author's translation from original French.]

"At the [national] level, as at the regional and urban level, the consequences of high speed rail present specific characteristics in common: selective effects on the precise sectors of activity (essentially the "superior" branches of the tertiary sector), a spatial concentration of the impacts on economic activity, polarisation which is the [practical] translation of the economic development [process] and a dependence on the impacts on the "macro-decisions" of several economic agents".

He goes on to note:

"Coordination between these agents is thus essential and the natural workings of the market are not sufficient to ensure it."

He therefore sums up his analysis of experience in Europe and elsewhere as follows:

"Moreover in all countries public power is implicated in one form or another. The point is that the stakeholders, in previous times essentially public bodies, are increasingly in the process of approximating private business, whether as operators of transport or as the planners and developers of space. Besides, the public authorities themselves see their structures being modified. The coordination of all these agents, so important to the economic effectiveness of high speed rail, is going to need to become the object of growing attention and perhaps to implant new ways of putting to work [the relevant] institutions and procedures [if the economic development potential of high speed rail is to be realised].[31]"

The same point is also stressed by Banister and Berechman.[32]

They observe:

"If there is one lesson to be learnt…it is that of the crucial role that policy design can play in influencing and strengthening the potential impact of transportation infrastructure investment on local economic development…It is essential that three sets of necessary conditions be met.[33]"

They identify the three necessary conditions that relate to the successful generation of economic development by new rail investments as follows:

- the type of investment: mode, scale, location, links to other networks etc;
- the economic conditions that relate to activities in the corridor: the scope for agglomeration economies, labour market externalities and network economies or the pre-existence of spatially-related "inefficiencies"; and
- policymaking, including the organization of agencies and the involvement of government at different levels.

They conclude:

"Policymaking, which affects both the economic conditions and, more importantly, the investment type, is the crucial factor in realizing economic growth benefits from a transportation infrastructure investment.[34]"



[31] Quinet, E *op. cit.* 1998, p.69-70. [Author's translation from original French.]
[32] Banister, D and Berechman, J *Transport Investment and Economic Development* London, UCL Press, 2000, especially Chapter 10 "The economic impacts of rail".
[33] Banister, D and Berechman, J *op. cit.* 2000, p.332-333.
[34] Banister, D and Berechman, J *op. cit.* 2000, p.334.

Annexure 2

Environmental



Annexure 2 – Environmental Analysis

1. Melbourne to Sydney – inland corridor

Segment	From	To	Approx Length (km)
1.1	Melbourne	Seymour*	117
1.2	Seymour	Albury*	186
1.3	Albury	Wagga*	120
1.4	Wagga	Yass	150
1.5	Yass	Canberra	55
1.6	Canberra	Goulburn	80
1.7	Goulburn	Bowral	75
1.8	Bowral	Campbeltown	65
1.9	Campbeltown	Sydney	50

2. Melbourne to Sydney – coastal corridor

Segment	From	To	Approx Length (km)
2.1	Melbourne	Morwell	135
2.2	Morwell	Bairnsdale	120
2.3	Bairnsdale	Bombala	195
2.4	Bombala	Cooma	180
2.5	Cooma	Canberra	110
2.6	Canberra	Goulburn ***	80
2.7	Goulburn	Bowral ***	75
2.8	Bowral	Wollongong	120
2.9	Wollongong	Sydney	75

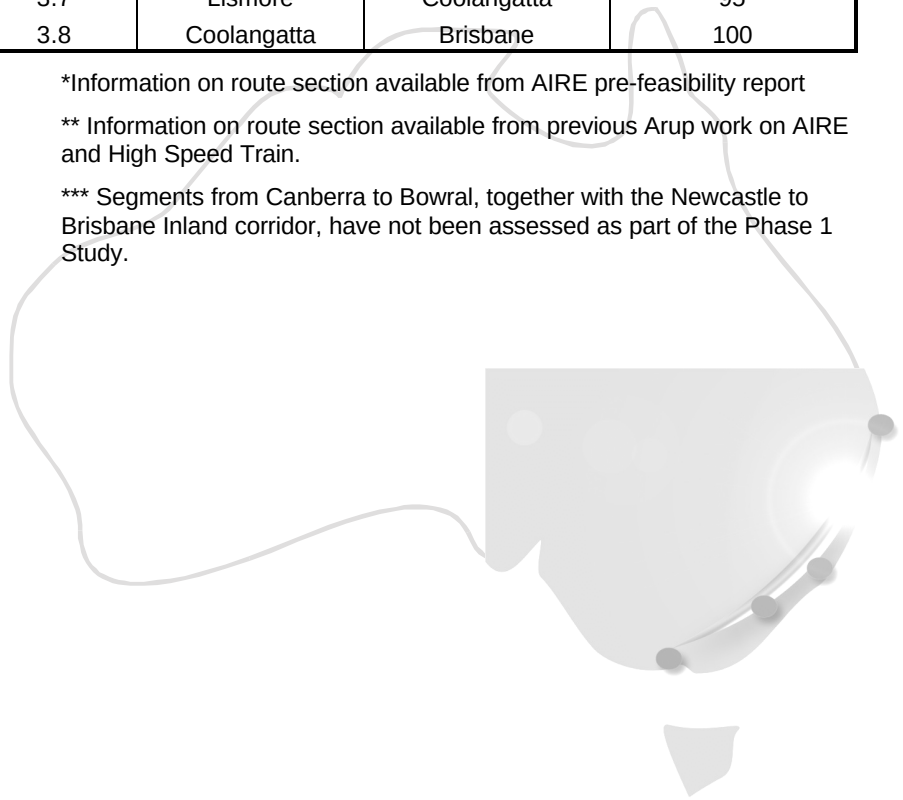
3. Sydney to Brisbane – coastal corridor

Segment	From	To	Approx Length (km)
3.1	Sydney	Newcastle**	130
3.2	Newcastle	Taree**	140
3.3	Taree	Kempsey**	100
3.4	Kempsey	Coffs Harbour**	90
3.5	Coffs Harbour	Grafton**	75
3.6	Grafton	Lismore	115
3.7	Lismore	Coolangatta	95
3.8	Coolangatta	Brisbane	100

*Information on route section available from AIRE pre-feasibility report

** Information on route section available from previous Arup work on AIRE and High Speed Train.

*** Segments from Canberra to Bowral, together with the Newcastle to Brisbane Inland corridor, have not been assessed as part of the Phase 1 Study.



Segment 1.1	Melbourne to Seymour
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Organ Pipes National Park, Dandenong Ranges National Park, Kinglake National Park, Mount Disappointment State Forest (14km south-east of Broadford), Tallarook State Forest, Toorourrong Park, Yan Yean Park, Warrandyte State Park, unnamed nature conservation reserves.
Flora & Fauna	EPBC database indicates the possible presence of 33 threatened species, 11 migratory species and 9 marine protected species within a 50km wide corridor between Melbourne and Seymour. One of the largest remaining old growth stands of grey box south of the Divide (Radar Hill Grey Box Forest) is situated on the north-west corner of Melbourne airport. This forest supports a suite of native fauna. Mount Piper, 3km west of Broadford, is a significant habitat to over 35 species of butterflies – the highest known butterfly diversity in Victoria. Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Ramsar sites within a 50km corridor are the catchment areas of Port Phillip Bay, Barmah Forest and Western Port. The major river is the Goulburn River. Important reservoirs are the Toorourrong Reservoir and Yan Yean Reservoir near Whittlesea.
Topography	
PLANNING	
Local Government	Melbourne City, Hume City, Whittlesea City and Mitchell Shire.
Land Use	Outside the Greater Melbourne urban area consists of mixed commercial (including woollen mills, confectionary, paper and porcelain manufacturing), general industry and agricultural (mixed farming, dairying, lambs and wool, and timber from State Forests) activities. Also rural residential.
Infrastructure	Melbourne urban area, existing rail tracks within urban area and between Melbourne and Seymour,
SOCIAL	
Communities & Population density	Population Melbourne approx 2 865 000. Communities other than Melbourne with a population in excess of 10 000 includes Craigieburn. Communities with a population of between 2000 and 10000 includes Kilmore East and Bradford.
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/Victorian Heritage Register) are concentrated in the urban, town and residential centres within and between Melbourne and Seymour. Areas of natural significance listed on the National Estate database include the Radar Hill Grey Box Forest within Hume City Shire and Mt Piper butterfly habitat within Mitchell Shire.
Indigenous	No searches or field surveys have been conducted at this stage.

Segment 1.2	Seymour to Albury
CONSERVATION	
Protected Areas: National Parks, State Forests &	Alpine National Park, Mount Buffalo National Park, Chiltern-Ironbark State Park, Mount Samaria State Park, Warby Range State Park,

Segment 1.2 Seymour to Albury	
Nature Reserves	Seven Creeks Nature Conservation Reserve, Benalla State Forest, Magenta Park, McDonald Hill, Mount Wombat – Garden flora and fauna reserve (10km SE of Euroa), Beechworth historic park.
Flora & Fauna	EPBC database indicates the possible presence of 39 threatened species, 7 migratory species and 7 marine protected species within a 100km wide corridor between Seymour and Albury. Warby Range Eucalyptus Cadens Sites: Two sites, 6.5km north of Glenrowan and at the eastern foot of the Warby Range contain over half the known population of the nationally endangered tree species *Eucalyptus Cadens*. Sites are Registered on the National Estate database. Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Ramsar sites within the 100km corridor are the catchment areas of Ginini Flats Subalpine Bog Complex, Gunbower Forest and Barmah Forest. Murray River, Lake Mokoan, Lake Hume.

Segment 1.2 Seymour to Albury	
PLANNING	
Local Government	Hume Shire, Whittlesea City, Mitchell Shire, Strathbogie Shire, Delatite Shire, Indigo Shire, Wangaratta Rural City Council and Wodonga Rural City Council.
Land Use	A wide range of commercial (dairy produce, boat manufacturing, newsprint, knitting and timber mills, building industry manufacturing at Seymour, sawmills at Euroa, wineries at Glenrowan, woollen mills at Wangaratta), and agricultural (market gardens, pastures and vineyards in the Goulburn River alluvial plain, beef cattle, dairying, wool, wheat, fruit and honey) activities. Also urban and rural residential areas.
SOCIAL	
Communities & Population density	The communities of Albury, Wodonga and Wangaratta each have a population in excess of 10 000.
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/Victorian Heritage register) are concentrated in the town and residential centres within and between Albury/Wodonga and Wangaratta. • Sites listed on the Register of the National Estate include: Beechworth Central Conservation Area; • Yackandandah Conservation Area; • Nine Mile Creek Historic Area - east of Beechworth;

Segment 1.2 Seymour to Albury

	• Mt Pilot Range Landscape Area near Beechworth (Indicative Place); • Reedy Creek Landscape Area near Eldorado; and • Warby Range Eucalyptus Cadens Sites.
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 1.3 Albury to Wagga

CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Burrowa-Pine Mountain National Park, Wiesners Swamp Nature Reserve, Tabletop Nature Reserve, Mount Granya State Park, Mount Lawson State Park, The Rock Nature Reserve.
Flora & Fauna	EPBC database indicates the possible presence of 26 threatened species, 8 migratory species and 7 marine protected species within the 100km wide corridor between Albury and Wagga. Tarcutta Hills Woodland Remnant (10km south west of Tarcutta), listed on the Register of the National Estate, is one of the best of the known remnants of grassy white box woodland with less than 0.01% of the original grassy white box woodland remaining in NSW. Significant flora and fauna are expected to be found in and around National Parks and other

Segment 1.3 Albury to Wagga

	onservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Murray River, Murray Valley Floodplain, Lake Hume. The corridor is within the catchment area of the following Ramsar sites: Ginini Flats Subalpine Bog Complex, Gunbower Forest Barmah Forest.
PLANNING	
Local Government	Albury City, Hume Shire, Culcairn Shire, Lockhart Shire, City of Wagga Wagga,
Land Use	Albury-Wodonga and Wagga are the commercial and industrial centres of this region. Major activities include manufacturing industries in the urban centres, dairy produce, and a newsprint mill at Albury-Wodonga. Agricultural activities in the region comprise wheat, sheep, cattle, wool and wine grapes.
SOCIAL	
Communities & Population density	The communities of Wagga, Albury and Wodonga each have a population in excess of 10 000.

Segment 1.3 Albury to Wagga

CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the town and residential centres within and between Albury and Wagga.
	Tarcutta Hills Woodland Remnant, listed on the Register of the National Estate, is one of the best of the known remnants of grassy white box woodland with less than 0.01% of the original grassy white box woodland remaining in NSW. 325ha, located 10km south west of Tarcutta, on the lower western slopes of the Dividing Range in the Central West of NSW.
	Sites listed on the Register of the National Estate in Hume Shire includes the Gerogery Railway Station Group on the Main Southern Railway.
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 1.4 Wagga to Yass

CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Ulandra Nature Reserve (listed on the Register of the National Estate), Burrinjuck Nature Reserve, Wee Jasper Nature Reserve.
Flora & Fauna	EPBC database indicates the possible presence of 2 threatened ecological communities, 24 threatened species, 8 migratory species and 7 marine protected species within a 100km wide corridor between Wagga and Yass.
	A remnant of Grassy White Box Woodland, a threatened ecological community, is located within the corridor (1km south of Muttama). This is an Indicative Place on the Register of the National Estate (see below).
	The largest known population of the nationally endangered species *Grevillia laspicula* is located near Burrinjuck town and is listed on the Register of the National Estate (see below).
	Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Ramsar sites within the 100km corridor is the catchment area of Ginini Flats Subalpine Bog Complex.
	Murrumbidgee River, Lake Burrinjuck, Jugiong Creek.

Segment 1.4 Wagga to Yass

PLANNING	
Local Government	Wagga Wagga City, Gundagai Shire, Harden Shire, Yass Shire.
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the town and residential centres within and between Albury and Yass. Sites listed on the Register of the National Estate include: • Murrumbidgee River Rail Bridge, spans Murrumbidgee River at Wagga Wagga, on the Main South Line (also listed on the NSW Heritage Register). • Wagga Wagga Railway Station, situated at Station Place, at the southern end of Baylis Street (also listed on the NSW Heritage Register). • Gundagai Rail Bridge Approaches, timber approaches to the north and south ends of the rail bridge carrying the Cootamundra to Tumut railway across the Murrumbidgee River at Gundagai. • Yass Junction Railway Station, Fauldner Road, 3km north of Yass on the Main Southern Line railway (also listed on the NSW Heritage Register). • Old Gundagai Town Site at Gundagai. • Yabtree Homestead Landscape and Homestead, 12ha, 13km west-south-west of Nangus, is important as an example of a pastoral homestead landscape. • Yass Urban Conservation Area, 45ha in central Yass including the railway reserve. • Coolac Geological Site, 130ha, 4km north-east of Coolac, is the best known example in Australia of a substantial ophiolite assemblage - a distinctive rock assemblage that uniquely defines events in the continental evolution of eastern Australia. • Muttama Cemetery Grassy Box Woodland (Indicative Place, 1km south of Muttama, on the eastern side of the road to Coolac). • Burrinjuck Dam (Indicative Place, Burrinjuck Dam Access Road on the Murrumbidgee River, 35km south west of Yass). • Derringullen Creek Area (about 72ha, located 6km north-west of Yass along Derringullen Creek) is one of the State's classic fossiliferous sites. • Lake Burrinjuck Grevillea Iaspicula Sites 1 and 2 (0.5km east-south-east and 2.5km east-north-east of Burrinjuck town) suuport the largest known population of the nationally endangered species *Grevillia Iaspicula.* Sites listed on the NSW Heritage Register and not on the Register of the National Estate include the following: • Bowning Railway Station Group, Main Southern railway, Bowning and • Yass Town rail bridge over Yass River.
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 1.5 Yass to Canberra

CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Namadgi National Park, Brindabella National Park, Mundoonen Nature Reserve, Hattons Corner Nature Reserve, Canberra Nature Park Nature Reserve, Woodstock Nature Reserve, Goorooyarro Nature Reserve, Stony Creek Nature Reserve, Bullen Nature Reserve.
Flora & Fauna	EPBC database indicates the possible presence of 2 threatened ecological communities, 19 threatened species, 7 migratory species and 7 marine protected species within a 60km wide corridor between Yass and Canberra. Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Lake Burrinjuck, Molonglo River, Yass River. The corridor is within the catchment area of the Ramsar site Ginini Flats Subalpine Bog Complex..
PLANNING	
Local Government	Yass Shire, Yarrowlumla Shire, ACT.

Segment 1.5 Yass to Canberra

SOCIAL	
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the town and residential centres within and between Yass and Canberra. In excess of 300 sites are listed in the ACT. Sites listed on the Register of the National Estate include: • Yass Junction Railway Station, Fauldner Road, 3km north of Yass on the Main Southern Line railway. • Yass Urban Conservation Area, 45ha in central Yass including the railway reserve. • Upper Lake Burrinjuck Area (about 9,000ha, Wee Jasper Yass Road, surrounding the south-eastern arm of Lake Burrinjuck) is nationally famous for the extraordinarily well displayed large scale folding of the fossiliferous Devonian limestones, and has international scientific significance as type locality for many Devonian fossils. • Upper Murrumbidgee River (about 400km of the river extending from Tantangara Dam to the mouth of Oaky Creek, 300m south-west of Yeumburra Homestead and about 20km north of the northern border of the ACT). Site listed on the NSW Heritage Register include: • Burrinjuck Dam and Greater Dam site; • Burrinjuck Dam Site - Barren Jack Creek Water Supply Dam; and • Yass Junction Railway Station Group;

Segment 1.5 Yass to Canberra

Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 1.6 Canberra to Goulburn

CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Morton National Park, Mundoonen Nature Reserve (12km E of Yass), Canberra Nature Park Nature Reserve, Woodstock Nature Reserve, Goorooyarroo Nature Reserve, Molonglo Gorge Nature Reserve, Queanbeyan Nature Reserve.
Flora & Fauna	EPBC database indicates the possible presence of 2 threatened ecological communities, 26 threatened species, 9 migratory species and 9 marine protected species within the 70km wide corridor between Canberra and Goulburn. Minda Eucalyptus Site (Register of the National Estate, Indicative Place), 25km south of Bungonia, is one of only two known sites of the very rare, endangered *Eucalyptus recurva* plant. Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.

Segment 1.6 Canberra to Goulburn

ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Molonglo River, Murrumbidgee River, Yass River, Lake George, Lake Bathurst, Wollondilly River. The corridor is within the catchment area of the Ramsar site Ginini Flats Subalpine Bog Complex.
Topography	
PLANNING	
Local Government	ACT, Yarrowlumla Shire, City of Goulburn, Mulwaree Shire.
Land Use	Yass Shire – Predominantly agricultural and retail industries with the major industries being superfine wool production, fat lambs, vineyards and wine production.
SOCIAL	
Communities & Population density	Goulburn has a population of approx 21 500, Canberra population approx 300 000.
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the town and residential centres within and between Canberra and Goulburn.

Segment 1.6	Canberra to Goulburn
	Areas of natural heritage significance listed on the Register of the National Estate include • Wombeyan Caves Area (14km north-east of Taralga); and • Minda Eucalyptus Site (25km south of Bungonia, 'Indicative'). The Goulburn Railway station, yard and workshop on the Main Southern Railway is listed on the NSW Heritage Register.
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 1.7	Goulburn to Bowral
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Nattai National Park, Tarlo River National Park, Macquarie Pass National Park, Morton National Park, Budderoo National Park, Cecil Hoskins Nature Reserve (3km north-east of Moss Vale), Robertson Nature Reserve, Red Rocks Nature Reserve
Flora & Fauna	EPBC database indicates the possible presence of 1 threatened ecological communities, 47 threatened species, 8 migratory species and 8 marine protected species within the 60km wide corridor between Goulburn and Bowral.
	Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Shoalhaven River, Wollondilly River, Wingecarribee Swamp.
PLANNING	
Local Government	City of Goulburn, Mulwaree Shire, Wingecarribee Shire
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the town and residential centres within and between Goulburn and Bowral. Natural areas registered on the National Estate database (excluding those listed in the first section) within the corridor includes Wingecarribee Swamp. Sites listed on the NSW Heritage Register include: • Moss Vale rail underbridge over Argyle Street (Main southern railway); • Moss Vale Railway Station and yard group (Main

Segment 1.7	Goulburn to Bowral
	southern railway); • Wingello Railway Station Group (Main southern railway); • Marulan Railway Station and Yard Group (Main southern railway); • Tallong Railway Station yard and water supply (Main southern railway); • Goulburn Railway Station, yard and workshop (Main southern railway); • Goulburn Viaduct (Main southern railway).
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 1.8	Bowral to Campbelltown
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Blue Mountains National Park, Royal National Park, Heathcote National Park, Thirlmere Lakes National Park, Gulguer Nature Reserve, Dharawal Nature Reserve, Macquaries Pass National Park, Budderoo National Park, Robertson Nature Reserve.
Flora & Fauna	EPBC database indicates the possible presence of 2 threatened ecological communities, 52 threatened species, 8 migratory species and 8 marine protected species within a 50km wide corridor between Bowral and Campbelltown. Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Nepean River, Lake Nepean and Nepean Dam, Avon River and Dam, Nattai River, Bargo River, Georges River, Cataract River.
PLANNING	
Local Government	Wingecarribee Shire, Wollondilly Shire, Campbelltown City.
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the town and residential centres within and between Bowral and Campbelltown. Items listed on the Register of the National Estate include: • Bargo River Gorge and Mermaids Pool, 200ha, 1.5km south-east of Tahmoor (Indicative Place); • O'Hares Creek Catchment, 7,500ha, 3km east of Appin; • Picton Railway Station Group (Indicative Place and also listed on the NSW Register); • Wirrimbirra Sanctuary, about 88ha, Remembrance Drive, 2.5km north of Bargo; Items listed on the State Heritage Register include:

Segment 1.8	Bowral to Campbelltown
	• Cataract Dam; • Cordeaux Dam; • Menangle Rail bridge over Nepean River and the Menangle Railway Station Group (on Main Southern Railway); • Tahmoor Railway Station Group; • Bowral Railway Station Group (Main Southern Railway); • Mittagong Railway Station and yard Group (Main southern railway); • Bargo Railway viaduct; • Couridjah Railway Station; • Picton Railway Station Group and Picton railway viaduct over Stonequarry Creek (Main southern Railay); and • Tahmoor Railway Station Group (Main southern Railway).
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 1.9	Campbelltown to Sydney
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Blue Mountains National Park, Georges River National Park, Royal National Park, Heathcote National Park, Agnes Banks Nature Reserve, Castlereagh Nature Reserve, Mulgoa Nature Reserve, Gulguer Nature Reserve.
Flora & Fauna	EPBC database indicates the possible presence of 2 threatened ecological communities, 52 threatened species, 17 migratory species and 35 marine protected species within a 70km wide corridor between Campbelltown and Sydney. Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Georges River, Harris Creek, Cabramatta Ck, Port Jackson.

Segment 1.9	Campbelltown to Sydney
PLANNING	
Local Government	Campbelltown City, Liverpool City, Fairfield City, Sydney City and surrounds.
Land Use	Suburban
Infrastructure	Intensive
SOCIAL	
Communities & Population density	Suburban

Segment 1.9	Campbelltown to Sydney
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the town and residential centres within and between Campbelltown and Sydney. There are over 900 sites in the Sydney City region listed on the Register of the National Estate. Items listed on the Register of the National Estate include: • Prospect Reservoir Area; and • Cubbitch Barta National Estate Area, about 18,000ha, at Holsworthy Items listed on the State Heritage Register include: • Liverpool Railway Station Group (Main southern railway); and • Fairfield Railway Station Group (Main southern railway)
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 2.1	Melbourne to Morwell
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Yarra Ranges National Park, Kinglake National Park, Baw Baw National Park, Morwell National Park, Warrandyte State Park, Dandenong Ranges National Park, Churchill National Park, Bunyip State Park, Moondarra State Park, Bull Beef Creek Nature Conservation Reserve, Mount Worth State Park.
Flora & Fauna	EPBC database indicates the possible presence of 39 threatened species, 21 migratory species and 19 marine protected species within the 100km wide corridor between Melbourne and Morwell. Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Latrobe and Thomson River Catchment Areas,
Topography	Flat to Low Hills
PLANNING	
Local Government	La Trobe Shire, Baw Baw Shire, Melbourne City.
SOCIAL	
Communities & Population density	Population of Warragul approx 9000, population of Drouin approx 5000.

Segment 2.1	Melbourne to Morwell
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/Victorian Heritage register) are concentrated in the town and residential centres within and between Melbourne and Morwell. There are over 600 sites listed on the Register of the National Estate within the city of Melbourne. The Warragul to Noojee Railway, located within the corridor, is listed on the Register of the National Estate.
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 2.2	Morwell to Bairnsdale
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Alpine National Park, Morwell National Park, Mitchell River National Park, Baw Baw National Park, Tarra-Bulga National Park, The Lakes National Park, Avon Wilderness Park, Stringybark Creek Reference Area, Moondarra State Park, Holey Plains State Park, Macks Creek Reference Area, Mullungdung Reference Area
Flora & Fauna	EPBC database indicates the possible presence of 34 threatened species, 9 migratory species and 9 marine protected species within the 100km wide corridor between Morwell and Bairnsdale.

Segment 2.2	Morwell to Bairnsdale
	The Munro Remnant Grassland (Register of the National Estate Interim list, located near Munro and occupying part of the Melbourne-Bairnsdale Railway reserve) supports several rare and threatened floral species, including the nationally endangered gaping leek-orchid *Prasophyllum Correctum*. This species is close to extinction. Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Gippsland Lakes Area, Gippsland Lakes Coastal Park, Lake Wellington, Lake Victoria, Aberfeldy River and catchment, Lake Glenmaggie, Blue Rock Lakes, Lake Thomson, Tyers River, La Trobe River, Mitchell River.
PLANNING	
Local Government	La Trobe Shire, Wellington Shire, East Gippsland Shire.
Land Use	The major industries of the La Trobe Valley include power generation, dairying and dairy products, and forest products. Major industries in the Wellington Shire include aviation, oil and gas, plastics, footwear, printing, clothing and leather production.

Segment 2.2	Morwell to Bairnsdale
SOCIAL	
Communities & Population density	Morwell, Traralgon and Sale each have populations in excess of 10 000, with populations of 13 800, 19 000, and 13 400 respectively.
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/Victorian Heritage register) are concentrated in the town and residential centres within and between Morwell and Bairnsdale. Natural areas registered on the National Estate database include: • Morwell National Park (Original); • Rintoul Creek site (3km north of Tyers, fossil flora site); • Aberfeldy Upper River Catchment; • Briagolong Forest Reserve (Indicative Place); • Dowd Morass State Game Reserve; • Gippsland Lakes Area and Coastal Park; • Mullungdung Forest Area; and • Munro Remnant Grassland.
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 2.3	Bairnsdale to Bombala
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	**National Parks**: Kosciuszko National Park (Biosphere Reserve), Nungatta National Park, Nalbaugh NP, South East Forest NP, Alpine NP, Snowy River NP, Mount Imlay NP, Errinundra NP, Coopracambra NP, Alfred NP, Lind NP, Croajingolong NP, Coolungubra NP. **Nature Reserves and other Conservation Areas**: Coolumbooka NR, Tingaringy Wilderness Zone, Bondi Gulf Nature Reserve, Mount Delegate Natural Features reserve, Bowen Wilderness Zone, Mount Bendock Natural Features Reserve, Little Bog Creek Nature Conservation Reserve, The Gap Natural Features Reserve, Genoa Wilderness Zone, Kanuk Creek Natural Features Reserve, Martins Creek Natural Features Reserve, Nunnet Plain Natural Features Reserve, Cann River NFR, Arte River Nature Conservation Reserve, Bemm River NFR, Brodribb Nature Conservation Reserve, Mottle Range nature Conservation Reserve, William Hunter Nature Conservation Reserve, Wood Point NCR, Cabbage Tree Creek NCR, Cabbage Tree Palms NCR, Lake Curlip NFR, Ewing Marsh NFR, Lake Corringle – Lake Wat Wat Natural Features Reserve, Colquhoun Regional Park. Many of these areas are on, or proposed for inclusion on, the Register of the National Estate.
Flora & Fauna	EPBC database indicates the possible presence of 2 threatened ecological communities, 41 threatened species, 11 migratory species and 11 marine protected species within the 100km wide corridor between Bairnsdale and Bombala. Significant rare, endemic flora and old growth forest is found in the Bendoc Road -

Segment 2.3	Bairnsdale to Bombala
	Hutchinson Creek Area (6km SW of Bendoc). This area is on the Interim list of the National Estate.
	Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	The corridor is within the catchment area of the Ramsar sites of Blue Lake and Gippsland Lakes.
	Mitchell River, Nicholson River, Tambo River, Snowy River, Brodribb River, Cann River, Bemm River area, Genoa River, Bombala River, Betka River, Bucchan River.
	Lake Tyers, Lake King.
Topography	
PLANNING	
Local Government	East Gippsland Shire, Bombala Shire
SOCIAL	
Communities & Population density	Communities with a population in excess of 10 000 include Bairnsdale. Communities with a population between 2000 and 10 000 include Lakes Entrance and Orbost.

Segment 2.3	Bairnsdale to Bombala
CULTURAL HERITAGE	
European	The corridor between Bairnsdale and Bombala, located within the East Gippsland Shire, is a patchwork of over 300 sites listed on the Register of the National Estate, with numerous geological, reserve and river catchment areas that contain significant flora and fauna. Registered sites include: • Bairnsdale-Orbost Railway Line; • Bemm River area; • Bucchan River geological area; and • Coolangubra Forest Area (14km SE of Bombala)
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 2.4	Bombala to Cooma
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Kosciuszko National Park, Wadbilliga National Park, Biamanga National Park, Bemboka National Park, South East Forest National Park, Dangelong Reserve, Dangelong Nature Reserve, Coolumbooka Nature Reserve, Tantawangalo National Park, Bournda Nature Reserve.
Flora & Fauna	EPBC database indicates the possible presence of 1 threatened ecological communities, 29 threatened species, 8 migratory species and 8 marine protected

Segment 2.4	Bombala to Cooma
	species within the 100km wide corridor between Bombala and Cooma. The nationally endangered species *Eucalyptus Pulverulenta* is predominant in this region, with a notable habitat area registered on the National Estate database (see below). Nunnock Swamp Flora Reserve, 14km south-west of Bemboka, contains some of the most significant stands of the rare eucalypt, *Eucalyptus Parvifolia*. Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Lake Jindabyne, Snowy River, Bombala River, Numeralla River. The corridor is within the catchment area of the Ramsar sites of Blue Lake and Ginini Flats Subalpine Bog Complex.
PLANNING	
Local Government	Bombala Shire, Cooma-Monaro Shire
SOCIAL	
Communities & Population density	Cooma has a population of approx 7000.

Segment 2.4	Bombala to Cooma
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the town and residential centres between Bombala and Cooma. Areas of natural significance, registered on the National Estate database, include: • Mount Fraser Eucalyptus Pulverulenta Site (12km south of Numeralla); and • Nunnock Swamp Flora Reserve (14km south-west of Bemboka). The NSW Heritage Register includes the Cooma Railway Station and Yard Group on the Goulburn-Bombala Railway.
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 2.5	Cooma to Canberra
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Namadgi National Park, Kosciuszko National Park, Deua National Park, Wadbilliga National Park, Canberra Nature Park Nature Reserve, Bullen Nature Reserve, Tidbinbilla Nature Reserve, Gigerline Nature Reserve, Tinderry Nature Reserve. Scabby Range Nature Reserve, Badja Swamps Nature Reserve.

Segment 2.5	Cooma to Canberra
Flora & Fauna	EPBC database indicates the possible presence of 2 threatened ecological communities, 37 threatened species, 8 migratory species and 8 marine protected species within the 100km wide corridor between Cooma and Canberra. The nationally endangered species Eucalyptus Pulverulenta is predominant in this region, with several notable areas listed on the Register of the National Estate (see below). The nationally endangered plant species *Rutidosis Leptorhynchoides* is found in 2 areas of the ACT (Red Hill Rutidosis Site and Stirling Ridge). These areas are registered on the National Estate database. The saddle near the summit of Gibraltar Rocks, approx 13km NW of Tharwa is an important habitat of the endangered wingless grasshopper, *Keyacris Scurra*. The area, *Keyacris Scurra* Grasshopper Habitat, is registered on the National Estate database. Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Murrumbidgee River, Lake Eucumbene, Tantangara Reservoir, Numeralla River, Queanbeyan River, Googong Dam, Molonglo River, Cotter River, Corrin Dam, Bendora Dam, Lake Burley Griffin, Jerrabomberra Wetlands (eastern end of Lake Burley Griffin) The corridor is within the catchment area of the Ramsar sites of Blue Lake and Ginini Flats Subalpine Bog Complex.
PLANNING	
Local Government	Cooma - Monaro Shire, City of Queanbeyan, ACT, Yarrowlumla Shire.
SOCIAL	
Communities & Population density	Population of Canberra approx 300 000, population of Queanbeyan approx 29 000, population of Cooma approx 7000.
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the town and residential centres within and between Cooma and Canberra (>300). This includes the following areas: **Natural areas of national heritage significance** (other than National Parks and Nature Reserves): Cappawidgee Eucalyptus Pulverulenta Site, Dowling Fire Trail Sites, Numeralla Zieria Sp Site, Waanyarra Eucalyptus Pulverulenta Site, Gibraltar Falls/Woods Reserve Area, Gudgenby Nature Reserve (former), Jerrabomberra Wetlands, Madjura Valley Native Grassland Site. **Built areas of national heritage significance**: Acton Conservation Area, Braddon Conservation Area, Corroboree Park

Segment 2.5	Cooma to Canberra
	Ainslie Urban Conservation Area, Forrest Conservation Area, Griffith Conservation Area, Reid Conservation Area, Red Hill Conservation Area, RMC Duntroon Conservation Area. The Bredbo River Rail Bridge and the Ingelara Creek Rail Bridge on the Goulburn Bombala Railway are also registered on the National Estate database. The NSW Heritage Register includes the following sites: Cooma Railway Station and Yard Group and the Michelago Railway Station Group on the Goulburn-Bombala Railway.
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 2.8	Bowral to Wollongong
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Macquarie Pass National Park, Morton National Park, Budderoo National Park, Berkeley Nature Reserve, Cecil Hoskins Nature Reserve, Robertson Nature Reserve, Barren Grounds Nature Reserve, Five Islands Nature Reserve
Flora & Fauna	EPBC database indicates the possible presence of 46 threatened species, 16 migratory species and 34 marine protected species within a 40km wide corridor between Bowral and Wollongong.
	Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Wingecarribee Reservoir, Avon Dam, Cordeaux Dam, Lake Illawarra.
PLANNING	
Local Government	Wingecarribee Shire, Wollongong City.
SOCIAL	
Communities & Population density	
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage Register) are concentrated in the town and residential centres within and between Bowral and Wollongong. Sites listed on the Register of the National Estate include: • Dapto Railway Station Group, Illawarra Railway (also on the NSW Heritage Register);

Segment 2.8	Bowral to Wollongong
	• Fitzroy Falls Geological Area, About 2000ha, at Fitzroy Falls within Morton National Park; • Wingecarribee Swamp. Sites listed on the NSW Heritage Register include: • Bowral Railway Station Group; • Wollongong Railway Station Group
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 2.9	Wollongong to Sydney
CONSERVATION	
National Parks, State Forests & Nature Reserves	Sydney Harbour National Park, Georges River National Park, Botany Bay National Park, Heathcote National Park, Towra Point Nature Reserve, Dharawal Nature Reserve.
Flora & Fauna	EPBC database indicates the possible presence of 3 threatened ecological communities, 62 threatened species, 32 migratory species and 51 marine protected species within a 40km corridor between Wollongong and Sydney. Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.

Segment 2.9	Wollongong to Sydney
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Georges River wetlands, Lake Cordeaux, Lake Cataract, Woronora River, Hacking River,
PLANNING	
Local Government	Wollongong City, Sutherland Shire, Sydney City and surrounding Shires.
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the city and residential centres within and between Wollongong and Sydney. There are over 900 sites listed on the Register of the National Estate occur within the city of Sydney, and a thorough investigation is required within the urban region. Sites listed on the Register of the National Estate include: • Austinmer Beach Geological Site, 1.5ha, at Bells Point, Austinmer, displays a natural outcrop of the Tongarra coal seam; • Austinmer Railway Station Group, (Indicative Place); • Helensburgh Railway Station Group (Indicative Place, listed on the NSW Heritage Register); • Stanwell Park Coastal Conservation Area (Indicative Place), about 950ha, comprising the catchment of Stanwell and Hargraves Creeks;

Segment 2.9	Wollongong to Sydney
	• Stanwell Park Rail Bridge, on the Illawarra railway over Stanwell Creek (Indicative Place and listed on the NSW Heritage Register); • Bundeena Headland (Indicative Place); • Cubbitch Barta National Estate Area (or Holsworthy Military Training Area); • Woronora Dam (Indicative Place), Waterfall; • Waterfall Railway Station Group (Indicative Place); • Pyrmont Point Railway Cutting & Tunnel, Pyrmont. Site listed on the NSW Heritage Register include: • Scarborough Railway Station Group (Illawarra Railway); • Thirroul Railway Station Group; and • Wollongong Railway Station Group.
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 3.1	Sydney to Newcastle
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Brisbane Water National Park, Ku-Ring-Gai Chase NP, Wyrrabalong NP, Bouddi NP, Garrigal NP, Lane Cove NP, Sydney Harbour NP, Dharug NP, Popran NP, Yengo NP, Watagans NP, Marramarra NP, Scheyville NP. Awabakal Nature Reserve, Muogamarra NR, Lion Island NR (2km south-east of Pearl Beach), Pelican Island and Rileys Island Nature Reserves (located in Brisbane Water

Segment 3.1	Sydney to Newcastle
	near Woy Woy), Spectacle Island Nature Reserve (1km south-east of Mooney Mooney, in the Hawkesbury River, comprising the whole Island), Wamberal Lagoon NR, Awabakal NR, Dalrymple-Hay NR.
	State forests (indicated in mapping)
Flora & Fauna	EPBC database indicates the possible presence of 3 threatened ecological communities, 68 threatened species, 32 migratory species and 52 marine protected species within a 50km corridor between Sydney and Newcastle.
	Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Hunter River Estuary (Interim List of Register of the National Estate, comprising Hexham Swamp; the north-eastern section of Kooragang Island, north of railway line; and area surrounding and including Fullerton Cove and extended west along River to Tomago)
	Port Jackson, Broken Bay, Tuggerah Lake, Munmorah Lake, Lake Macquarie, Hunter River, MacDonald River.
PLANNING	
Local Government	City of Sydney and surrounds, Ku-ring-gai

Segment 3.1	Sydney to Newcastle
	Shire, Warringah Shire, Pittwater Shire, Hornsby Shire, Gosford City, Wyong Shire, Lake Macquarie City, Newcastle City.
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the city and residential centres within and between Sydney and Newcaste. There are over 900 sites listed on the Register of the National Estate within the city of Sydney. Items listed on Register of the National Estate include: • Civic Railway Station (Indicative Place, Hunter St Newcastle); • Newcastle Conservation Area, • Fennell Bay Reserve (Public Reserve R 38237), located at Blackalls Park, Newcastle City; • Long Reef Barrenjoey Coastal Rocks, Mona Vale (Approx 100ha, comprising all exposed rocks, cliff faces and rock shelves on the coastal headlands from the northern end of Long Reach Beach to and including, the Barrenjoey Headland). • Angophora Reserve / Hudson Park, located in Avalon on the Palm Beach peninsular, is an important refuge and protected movement corridor for fauna. • Big Bay Marramarra Creek Area, about 100ha of mangrove swamp and water on the middle reaches of Marramarra Creek. • Hawkesbury River Rail Bridge, on the Sydney-Newcastle line between Long Island and Mullet Head, 1km north of Brooklyn (also on the State Register). • Mooney Mooney Creek Site, located 2km east-south-east of Calga along a semipermanent creek , contains an unusally diverse and rich fly fauna and is particularly important as a habitat for two winged flies; • Wahroonga Railway Station (also listed on the State Register). Items listed on the State Heritage Register includes • Hawkesbury River Railway Station Group, on the Main Northern Railway near Brooklyn; • Glenrock early coalmining sites, located in the Glenrock State Recreation Area • Hamilton Railway Station Group, Great Northern Railway, Hamilton; • Newcastle Railway Station and Group • Manly Dam, located at King Street, Manly Vale; • Gordon Railway Station Group, North Shore railway, Gordon;
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 3.2	Newcastle to Taree
CONSERVATION	
Protected Areas: National Parks, State Forests &	The 70km width coastal corridor passes through the World Heritage Area of the Central Eastern Rainforest Reserves.

Segment 3.2	Newcastle to Taree
Nature Reserves	Tapin Tops National Park, Barakee NP, Woko NP, Barrington Tops NP, Ghin-Doo-Ee NP, Wallingat NP, Booti Booti NP, Myall Lakes NP, Tomaree NP, Bugan Nature Reserve, Bretti Nature Reserve, Khatambuhl NR, Camels Hump NR, Brimbin NR, Khappinghat NR, Talawahl NR, Darawank NR, Wallamba NR, Running Creek NR, The Glen NR, Coolongolook NR, Killarney NR, Monkerai NR, Karuah NR, Wallaroo NR, Seaham Swamp NR, Worimi NR, Moffats Swamp NR, Kooragang NR, Hexham Swamp NR. State forests (indicated in mapping)
Flora & Fauna	EPBC database indicates the possible presence of 54 threatened species, 41 migratory species and 63 marine protected species within a 70km corridor between Newcastle and Taree. There are extensive regions of Littoral Rainforest within this corridor. Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Port Stephens Estuary, Wallis Lake (7000ha, 0.5km west of Forster), Myall Lake, Hunter River, Williams River, Myall River, Harrington Inlet.

Segment 3.2	Newcastle to Taree
	The corridor passes through the catchment area of the following Ramsar sites: • Kooragang Nature Reserve; and • Myall Lakes.
PLANNING	
Local Government	Newcastle City, Port Stephens Shire, Great Lakes Shire, Greater Taree City.
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the town and residential centres within and between Newcastle and Taree. National Parks and Nature reserves (listed in section one above) are listed on the Register of the National Estate. Other sites listed on the Register of the National Estate include: • Civic Railway Station (Indicative Place); • Hunter River Estuary (Interim List); • Alum Mountain Geological Site 1, about 50ha, 1km east of Bulahdelah; • Cape Hawke Coastal Area, 4.5km south-east of Forster at Cape Hawke, littoral rainforest region; • Seal Rocks Littoral Rainforest; • Harrington inlet including Manning Point; and • North Harrington Littoral Rainforest. The following items, not listed on the Register of the National Estate, are listed on the State Heritage Register: • Taree Rail Bridge over Manning River;

Segment 3.2	Newcastle to Taree
	• Taree Railway Station group; • Seaham Quarry; • Glenrock Early Coalmining sites; and • Newcastle Railway Station additional group on the Great Northern Railway.
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 3.3	Taree to Kempsey
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	The 60km wide corridor passes through the World Heritage Central Eastern Rainforest Reserves. Oxley Wild Rivers National Park, Willi Willi NP, Crowdy Bay NP, Kumbatine NP, Werrikimbe NP, Maria NP, Biriwal Bulga NP, Bago Bluff NP, Tapin Tops NP, Dooragan NP, Yoorigan NP, Coorabakh NP, Boonanghi Nature Reserve, Yarravel NR, Yessabah NR, Limeburners Ck NR, Cooperabung Ck NR, Koorebang NR, Rawdon Ck NR, Jasper NR, Macquarie NR, Lake Innes NR, Sea Acres NR, Weelah NR, Queens Lake NR, Boorganna NR, Killabakh NR, Kattang NR, Coxcomb NR, Goonook NR, Brimbin NR, Towibakh NR. State forests (indicated in mapping) North Harrington Littoral Rainforest
Flora & Fauna	EPBC database indicates the possible presence of 48 threatened species, 31 migratory species and 50 marine protected species within a 60km wide coastal corridor between Taree and Kempsey. The Lorne Flora Reserve, about 54ha, 10km north-west of Kendall, is a virgin forest region containing moist and dry blackbutt, brush box, turpentine, flooded gum and coachwood rainforest. Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Harrington Inlet (425ha, 0.5km south of Harrington), Macleay River, Wilson River, Watson Taylors Lake.
PLANNING	
Local Government	Greater Taree City, Hastings Shire, Kempsey Shire.
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the town and residential centres within and between Taree and Kempsey.

Segment 3.3	Taree to Kempsey
	Natural items listed on the Register of the National Estate include: • North Harrington Littoral Rainforest; • Banda Banda Flora Reserve (1,400ha, 40km west-south-west of Kempsey within the World Heritage listed rainforest region); • Lorne Flora Reserve, virgin forest area, about 54ha, 10km north-west of Kendall (Indicative Place); • Wilson River Primitive Preserve (Indicative Place, Old growth forest 150ha, 18km north-west of Bellangry); • Yessabah Caves Area, 4ha, located 13km west of Kempsey. Items listed on NSW Heritage Register include: • Taree rail bridge over Manning river; North Coast railway; • Taree railway station group, North Coast railway; • Wauchope Railway Station Group, North Coast railway; • Kempsey Railway Station Group; and • Kempsey rail bridge over Macleay River.
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 3.4	Kempsey to Coffs Harbour
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	The 50km wide corridor passes through the World Heritage Central Eastern Rainforest Reserves area. Hat Head National Park, Nymboi-Binderay NP, Cascade NP, Bindarri NP, Junuy Juluum NP, Dorrigo NP, New England NP, Bongil Bongil NP, Bellinger River NP, Dunggir NP, Willi Willi NP, Muldiva Nature Reserve, Deer Vale Nature Reserve, Baalijin NR, Ganay NR, Juugawaarri NR, Jagun NR, Bowraville NR, Bollonolla NR, Valla NR, Ngambaa NR, Fishermans Bend NR, Gads Sugarloaf NR, Skillion NR, Boonanghi NR, Yarravel NR, Mutton Bird NR. State forests (indicated in mapping) Bielsdown State Forest
Flora & Fauna	EPBC database indicates the possible presence of 60 threatened species, 31 migratory species and 65 marine protected species within a 50km wide coastal corridor between Kempsey and Coffs Harbour. The Lorne Flora Reserve, about 54ha, 10km north-west of Kendall, is a virgin forest region containing moist and dry blackbutt, brush box, turpentine, flooded gum and coachwood rainforest. Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and

Segment 3.4	Kempsey to Coffs Harbour
	mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Nymboida River, Bellinger River, Macleay River
PLANNING	
Local Government	Kempsey Shire, Nambucca Shire, Bellingen Shire, Coffs Harbour City.
SOCIAL	
Communities & Population density	
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the town and residential centres within and between Kempsey and Coffs Harbour. Items listed on the Register of the National Estate include: • Yessabah Caves Area, 4ha, located 13km west of Kempsey; • Warrell Creek Coastal Forest, Interim List, about 925 ha, 500 metres north of Scotts Head; • Bobo River Area, along the Bobo River near Cascade (Indicative Place);
	Items listed on the NSW Heritage Register include: • Kempsey Railway Station Group; and • Kempsey rail bridge over Macleay River; and • Macksville Railway Station Group.
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 3.5	Coffs Harbour to Grafton
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Yuraygir National Park, Nymboi-Binderay National Park, Cascade NP, Bindarri NP, Ulidarra NP, Chambigne Nature Reserve, Yuraygir Reserve, Koukandowie Nature Reserve, North Rock NR, Sherwood NR, Hortons Creek NR, Byrnes Scrub NR, Moonee Beach NR, Coramba NR, Kororo NR, Muttonbird Island NR, Solitary Islands Marine Park. State forests (indicated in mapping)
Flora & Fauna	EPBC database indicates the possible presence of 66 threatened species, 31 migratory species and 62 marine protected species within a 60km wide coastal corridor between Coffs Harbour and Grafton.

Segment 3.5	Coffs Harbour to Grafton
	Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Oraro River, Clarence River. SEPP14 Wetlands (indicated in mapping)
PLANNING	
Local Government	Coffs Harbour City, [former] Ulmarra Shire, Grafton City.
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the town and residential centres within and between Coffs Harbour and Grafton. Items listed on the Register of the National Estate include: • Susan Island Nature Reserve, 23ha, in the Clarence River, 2km west of Grafton; Items listed on the NSW Heritage Register include: • Grafton City Railway Station Group; • Grafton Rail and road bridge over Clarence River

Segment 3.5	Coffs Harbour to Grafton
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 3.6	Grafton to Lismore
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Nightcap National Park, Goonengerry NP, Broadwater NP, Bungawalbin NP, Bundjalung NP, Fortis Creek NP, Yuraygir NP, Ramornie NP. Snows Gully Nature Reserve, Andrew Johnstone Big Scrub Bature Reserve, Bungabbee Nature Reserve, Mucklewee Mountain Nature Reserve, Boatharbour Nature Reserve, Iluka Nature Reserve, Wilson NR, Davis Scrub NR, Uralba NR, Victoria Park NR, Tuckean NR, Tucki Tucki NR, Bungawalbin Reserve and NR, Mount Neville NR, Tabbimoble Swamp NR, Bundjalung Reserve, Banyabba Reserve and NR, Mororo Creek NR, Chapmans Peak NR, Laurence Road Reserve, Wombat Creek Reserve, Gurranang Reserve, Waragai Creek NR, Corymbia Reserve, Chamigne NR, Yuraygir Reserve, Koukandowie NR. State forests (indicated in mapping)
Flora & Fauna	EPBC database indicates the possible presence of 92 threatened species, 20 migratory species and 47 marine protected species within a 60km wide coastal corridor between Grafton and Lismore.

Segment 3.6	Grafton to Lismore
	Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	Clarence River, Bungawalgin Creek, Richmond River. SEPP14 Wetlands (indicated in mapping)
PLANNING	
Local Government	Grafton City, Copmanhurst Shire, Maclean Shire, [former] Richmond River Shire, [former] Casino Shire, Lismore City.
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the town and residential centres within and between Grafton and Lismore. Items listed on the Register of the National Estate include: • Susan Island Nature Reserve, 23ha, in the Clarence River, 2km west of Grafton; • Jerusalem Creek Area, 20,000 ha, between Evans Head and Illuka, surrounding the Esk River; • Lismore Railway Station; and

Segment 3.6	Grafton to Lismore
	• Rotary Park Rainforest reserve; Items listed on the NSW Heritage Register include: • Grafton City Railway Station Group; • Grafton Rail and road bridge over Clarence River; • High Conservation Value Old Growth Forest; • Lismore Railway Station Group (North Coast Railway); and • Lismore railway underbridges (North Coast Railway)
Indigenous	No database searches or field surveys have been conducted at this stage.

Segment 3.7	Lismore to Coolangatta
CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Mount Warning National Park, Nigthcap NP, Border Ranges NP. Limpinwood Nature Reserve, Numinbah Nature Reserve, Springbrook NR, Stotts Island NR, Ukerebagh NR, Broken Head NR, Brunswick Heads NR.
Flora & Fauna	
ENGINEERING	
Hydrology: Wetlands,	Wilsons and Coopers Creek.

Segment 3.7 Lismore to Coolangatta

significant rivers & floodplains	
PLANNING	
Local Government	Lismore City, Byron Shire, Tweed Shire, Gold Coast City.
CULTURAL HERITAGE	
European	Many sites and buildings of heritage significance (National Estate/NSW Heritage register) are concentrated in the town and residential centres within and between Grafton and Lismore. Items listed on the Register of the National Estate include: • Boomerang Falls Flora Reserve, 42 ha, 4.5 km north-west of Rosebank; • The following areas of the 'Big Scrub' rainforest remnants of Mt Warning Volcano lowland rainforests: Boomerang Falls Scrub (Interim List), Brockley Scrub No 1,2,3 (Interim List), Dawes Bush Scrub (Interim List), Currie Park Scrub (Interim List), Elliot Road Scrub, Glendower Scrub, Mortons Scrub, Minyon Falls Scrub (Interim List), Mollys Grass Scrub (Interim List), Rotary Park Rainforest reserve, Andrew Johnston Memorial Scrub and Adjacent Areas (Interim List), Bennys Creek Scrub, Booyong Scrub (Interim List), Emerys Scrub, Hayters Hill Scrub, Midgen Flat Scrub (Interim List), Wilsons River Scrub; • Lismore Railway Station; • Blackbutt Plateau, 320 ha, located 12 km west of Mullumbimby;

Segment 3.7 Lismore to Coolangatta

	• Border Ranges Region; Items listed on the NSW Heritage Register include: • Byron Bay Railway Station and yard group; • Murwillumbah Railway Station and yard group.

Segment 3.8 Coolangatta to Brisbane

CONSERVATION	
Protected Areas: National Parks, State Forests & Nature Reserves	Nicoll Scrub NP, Springbrook NP (including Gwongorella NP, Wunburra NP, Mount Cougal NP), Lamington NP, Natural Bridge NP, Burleigh Head NP, Tamborine NP (including Palm Grove NP, Cedar Creek NP), Venman Bushland NP, Southern Moreton Bay Islands NP. Ukerebagh Nature Reserve, Tallebudgera Creek CP, Plunkett CP, Corbould Land Trust (Wolffdene) Nature Refuge, Currumbin Hill CP, Coombabah Lake Nature Reserve, Ivan Gibbs Wetlands Reserve, Coombabah Lake CP, Karawatha Forest, Pine Ridge CP, Burleigh Knoll CP, Corbould Land Trust (Jacobs Well) Nature Refuge, Buccan CP, Serpentine Creek CP, Carbrook Wetlands CP, Boronia Bushland CP, Egret Colony Wetlands, Eprapah Conservation Reserve, Whites Hill Reserve, Boondall Wetlands Park, Rosins Lookout CP, Turtle Rock EP, Toowong Ridge Conservation Area, Toohey Forest CP, Sandy Creek Cons Area, Springwood CP, Mount Gravatt Outlook Reserve

Segment 3.8	Coolangatta to Brisbane
	Numinbah State Forest, Austinville SF, Nerang SF, Daisy Hill State Forest, Bunyaville SF.
Flora & Fauna	EPBC database indicates the possible presence of 72 Threatened species, 28 Migratory species, and 58 Marine protected species within a 30km wide corridor between the NSW/Qld border and Brisbane.
	There is a known koala habitat area in the Daisy Hill – Springwood region (registered on the National Estate database).
	Significant flora and fauna are expected to be found in and around National Parks and other conservation areas and waterways. An ecological survey is required to identify the species present and any potential impacts and mitigation measures.
ENGINEERING	
Hydrology: Wetlands, significant rivers & floodplains	The entire coastal strip is comprised of a chain of waterways (lakes, estuaries, wetlands and rivers). **Significant waterways include**: Tweed River, Terranora Broadwater, Cobaki Broadwater, Currumbin Creek, Tallebudgera Ck, Swan Lake to Burleigh Waters coastal strip, Advancetown Lake, Nerang River, Mermaid Waters region to Broadbeach Waters region, Nerang River, Coomera River, Logan River, Albert River, Coombabah Lake, Tingalpa Reservoir, Moreton Bay, Brisbane River.
PLANNING	
Local Government	Brisbane City, Logan City, Redland Shire and Gold Coast.

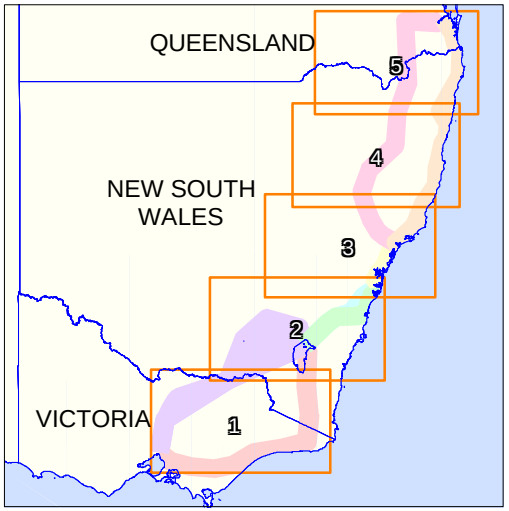
Segment 3.8	Coolangatta to Brisbane
Land Use	A mix of urban residential, commercial, industrial, rural residential and agricultural (tropical fruits, sugar cane, pine plantations) activities. A large area used as a Land Warfare Centre is located in the Gold Coast hinterland.
SOCIAL	
Communities & Population density	Brisbane and surrounds, and the coastal region of the Gold Coast is heavily populated. Approximate populations as follows: Brisbane City 863 769, Logan City 170 000, Redland 112 000 and Gold Coast 400 000.
CULTURAL HERITAGE	
European	Many sites are listed on the Register of the National Estate and the Qld Heritage Register throughout this corridor. 400 sites within Brisbane City, 26 sites within Redland Shire, 7 sites within Logan City and 46 sites within Gold Coast City (15 of which are conservation areas) are listed on the Register of the National Estate. A similar number of sites are listed on the Qld Heritage Register.
Indigenous	No database searches or field surveys have been conducted at this stage.

Annexure 3

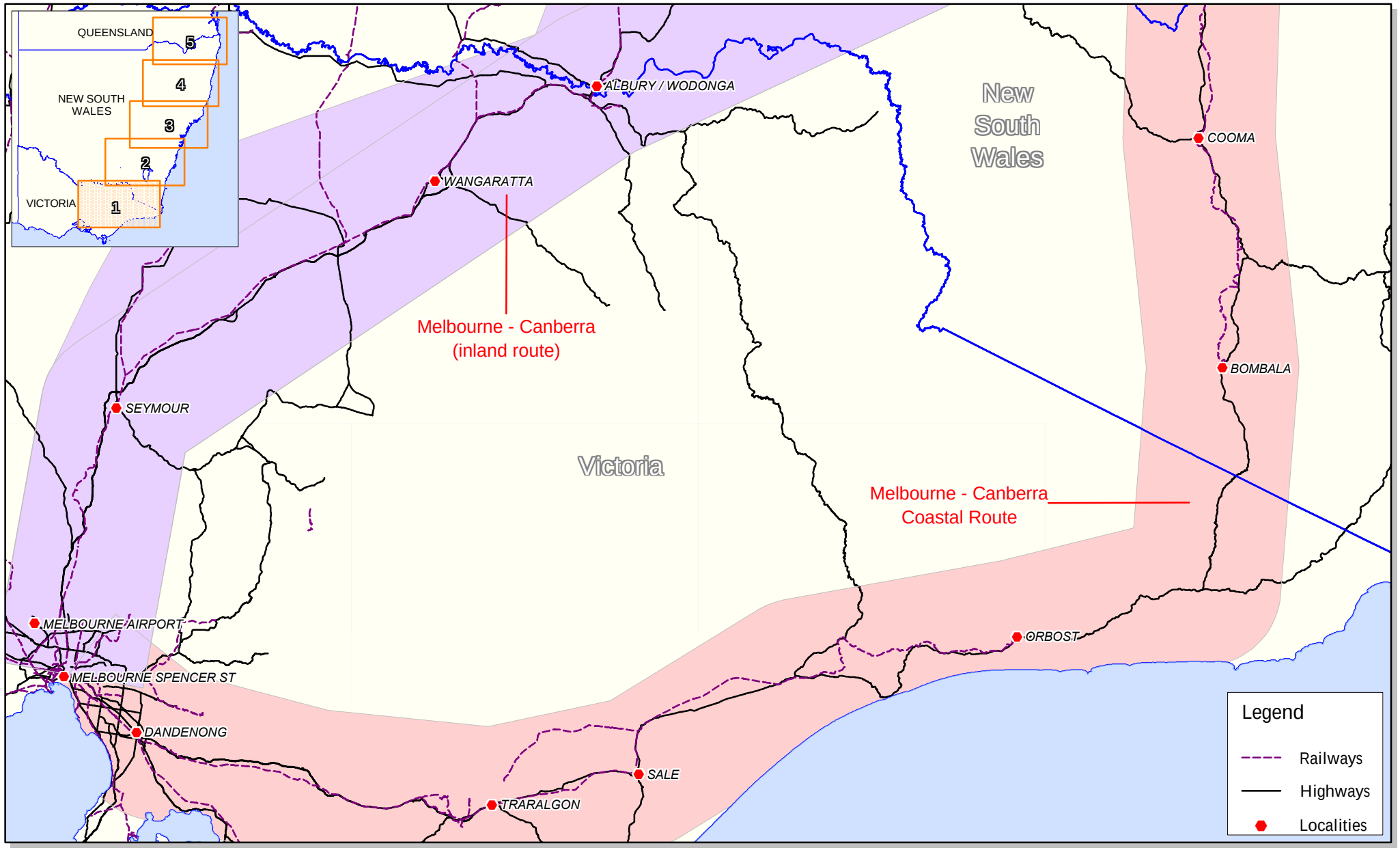
Australian Maps



EAST COAST VERY HIGH SPEED TRAIN SCOPING STUDY

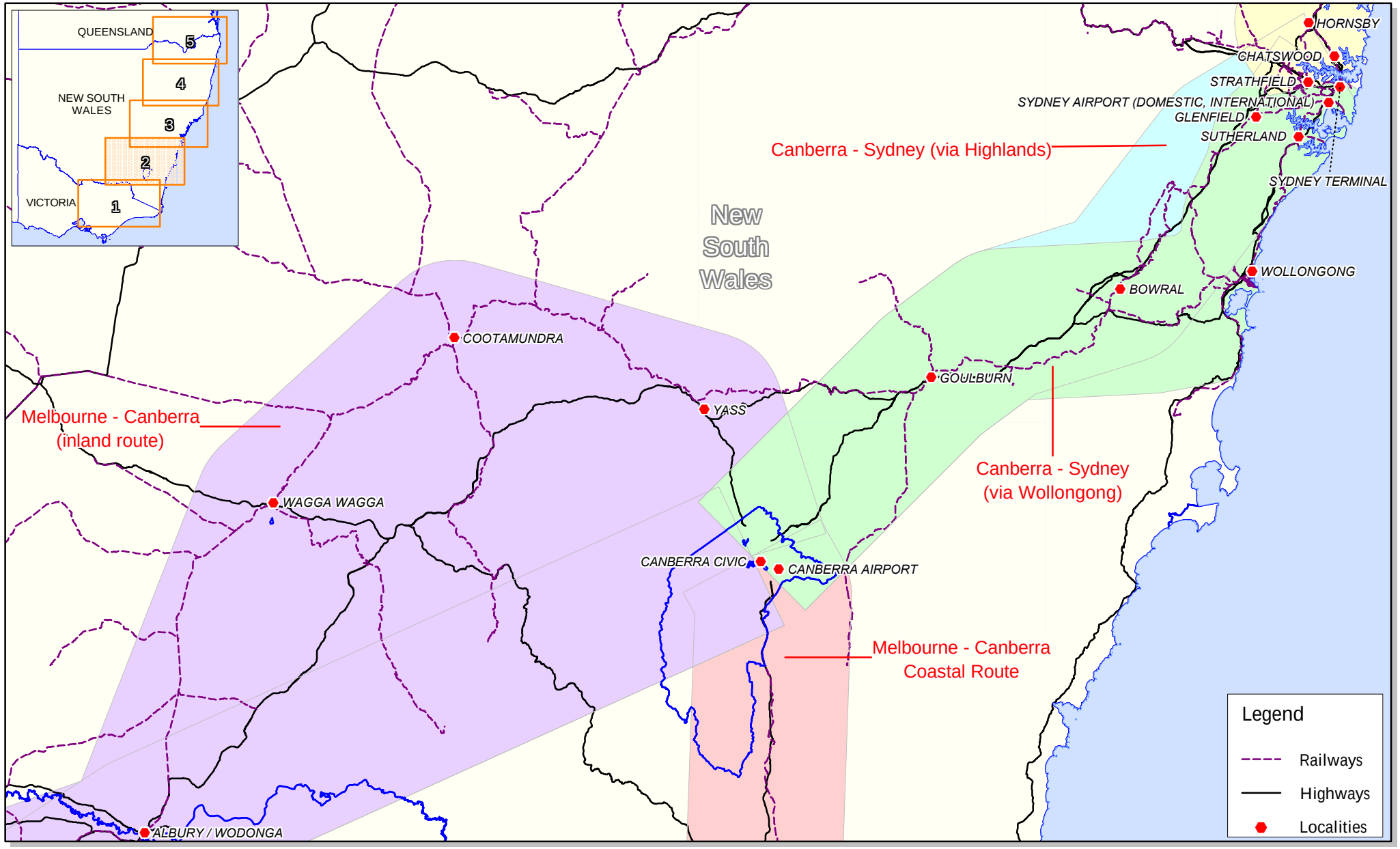


Indicative Corridors
Detailed Corridor Maps



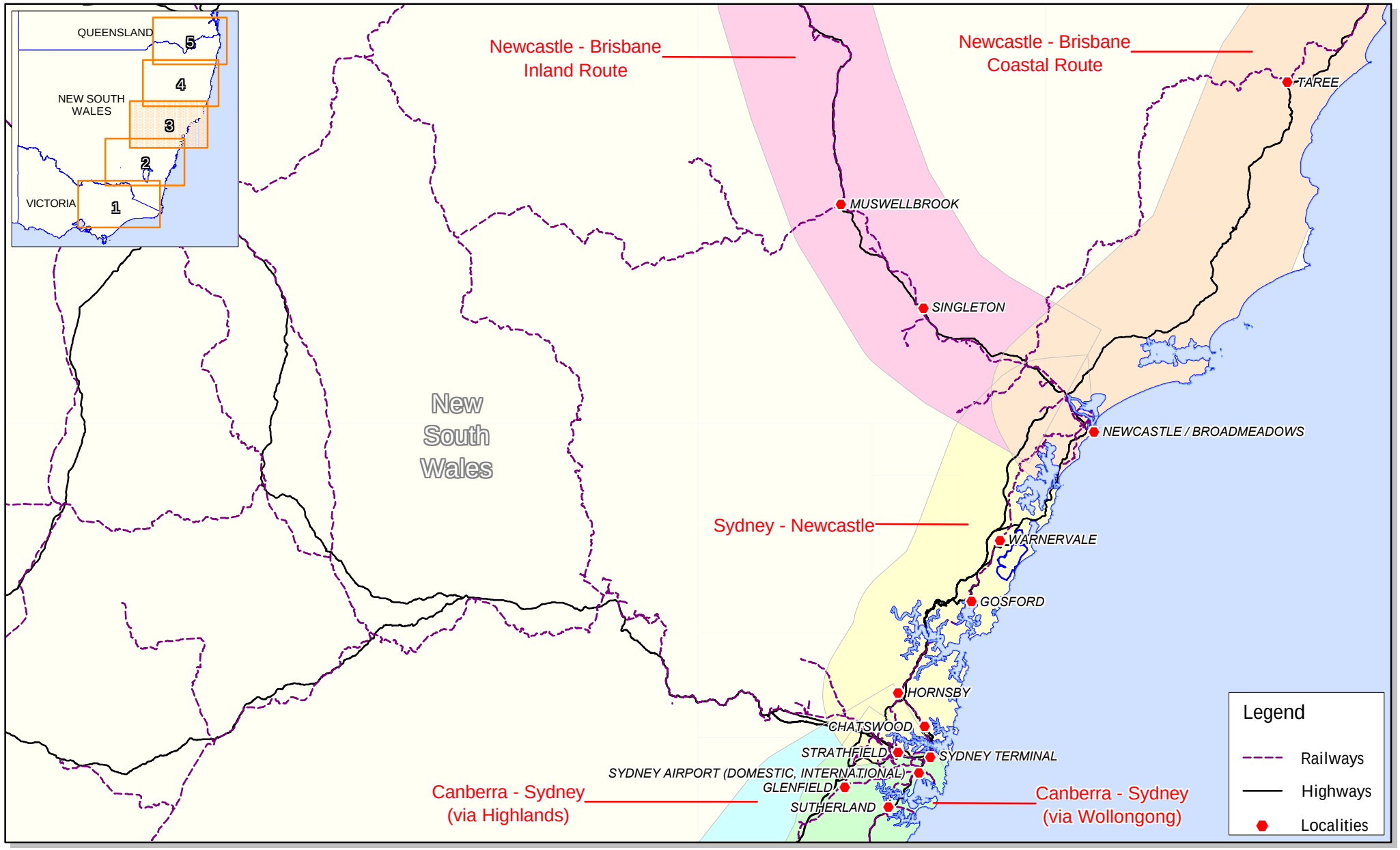
Candidate VHST Corridors Map Sheet 1

Figure A3.1.1



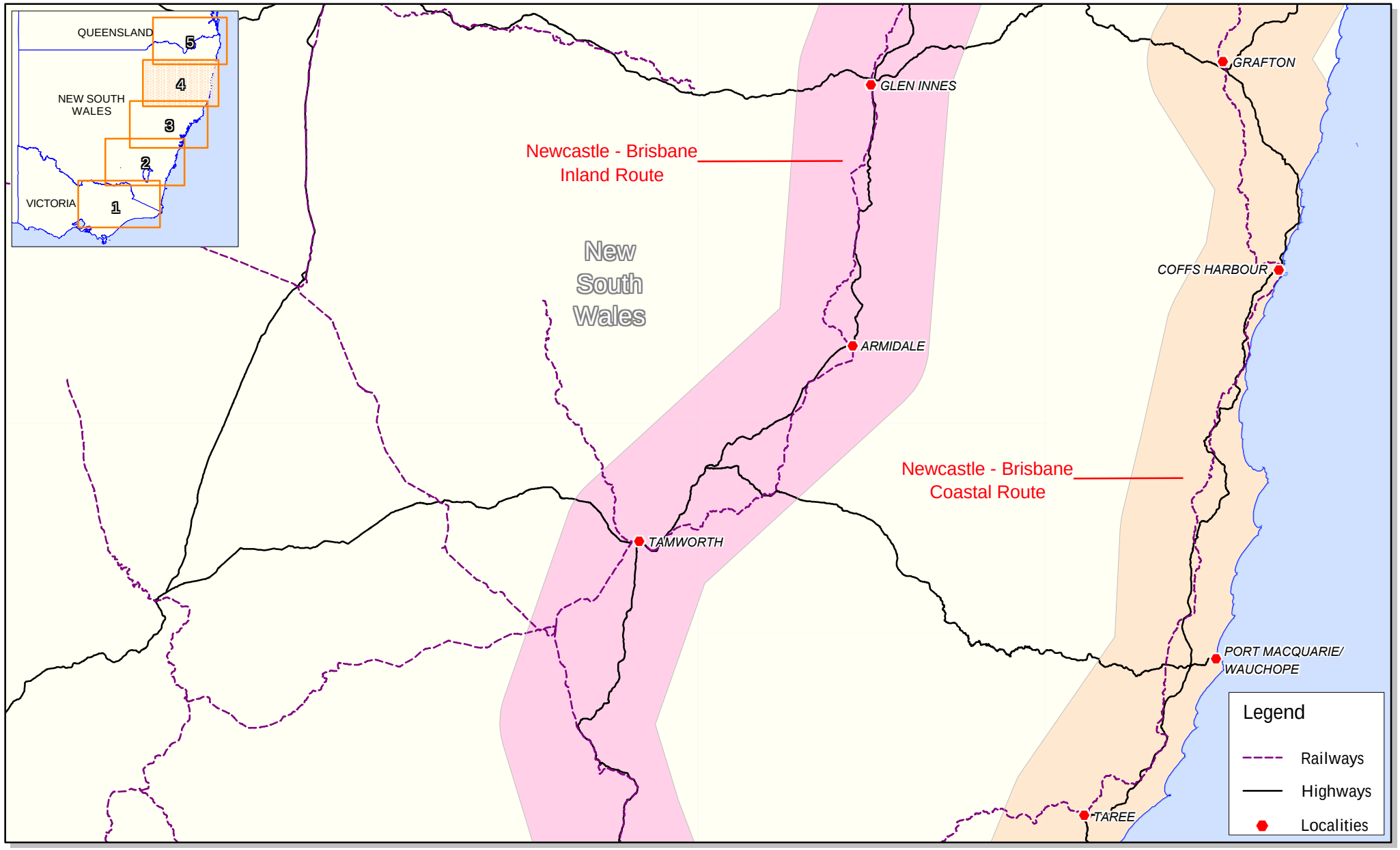
Candidate VHST Corridors Map Sheet 2

Figure A3.1.2



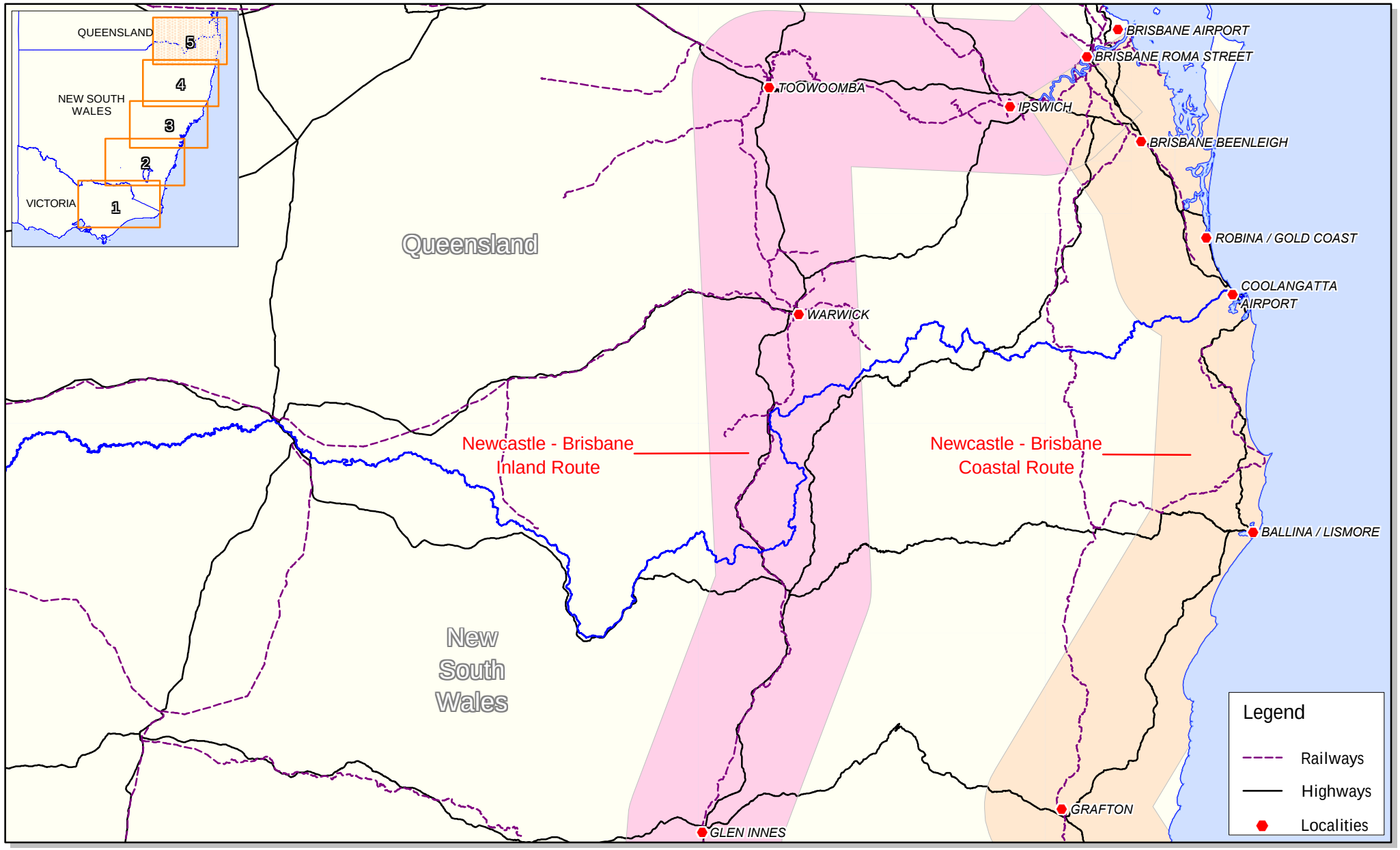
Candidate VHST Corridors Map Sheet 3

Figure A3.1.3



Candidate VHST Corridors Map Sheet 4

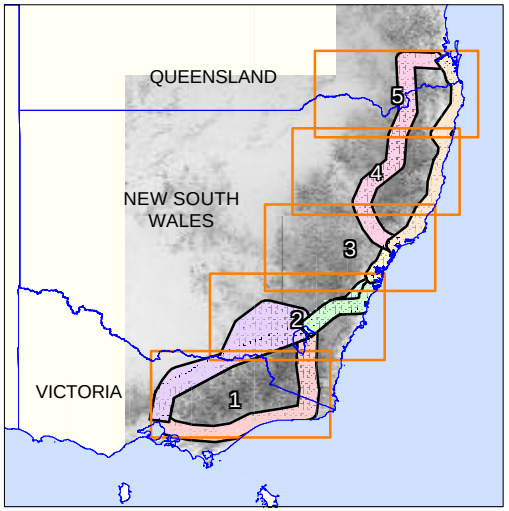
Figure A3.1.4



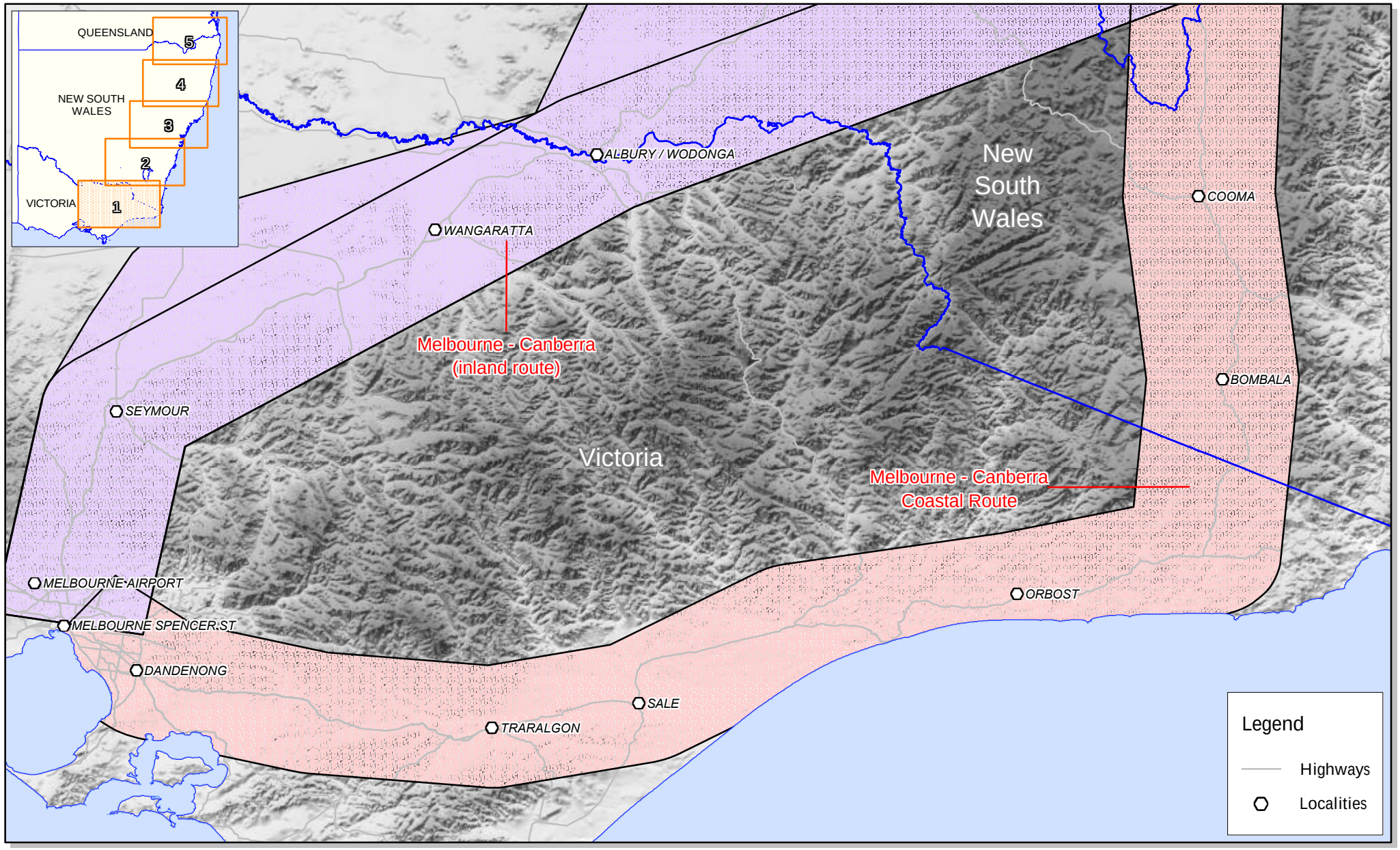
Candidate VHST Corridors Map Sheet 5

Figure A3.1.5

EAST COAST VERY HIGH SPEED TRAIN SCOPING STUDY

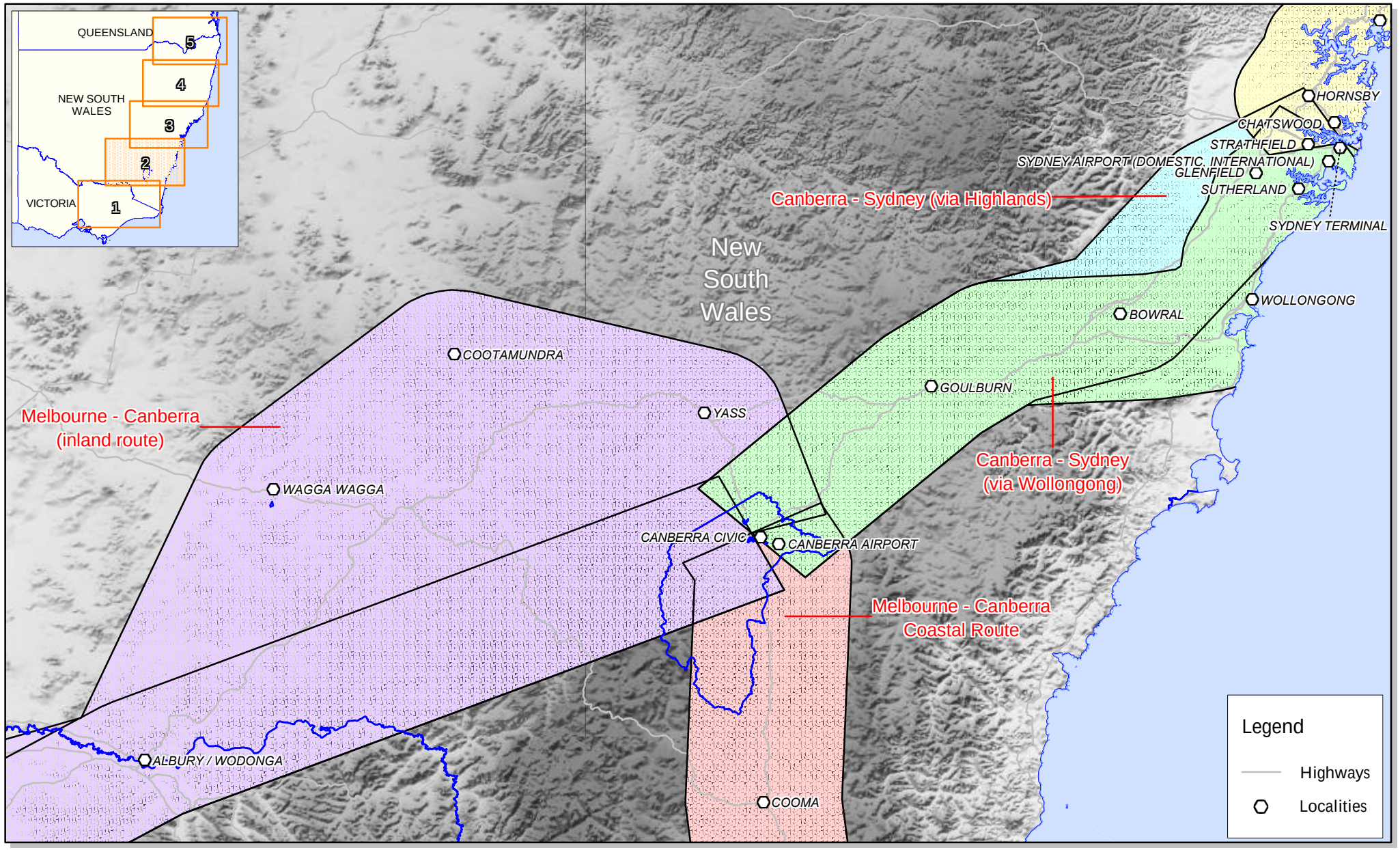


Candidate VHST Corridors with Terrain Features



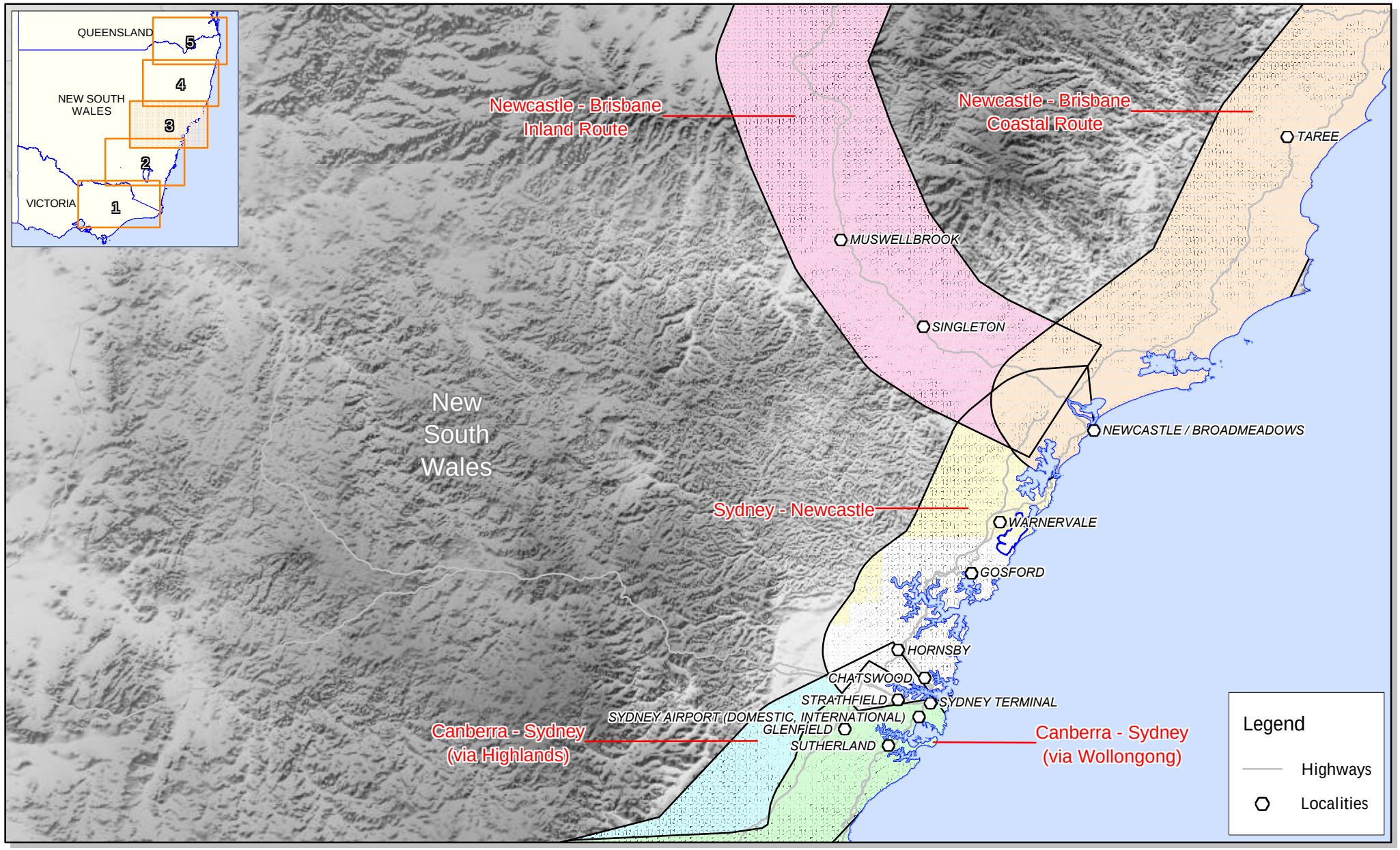
Candidate VHST Corridors with Terrain Features Map Sheet 1

Figure A3.2.1



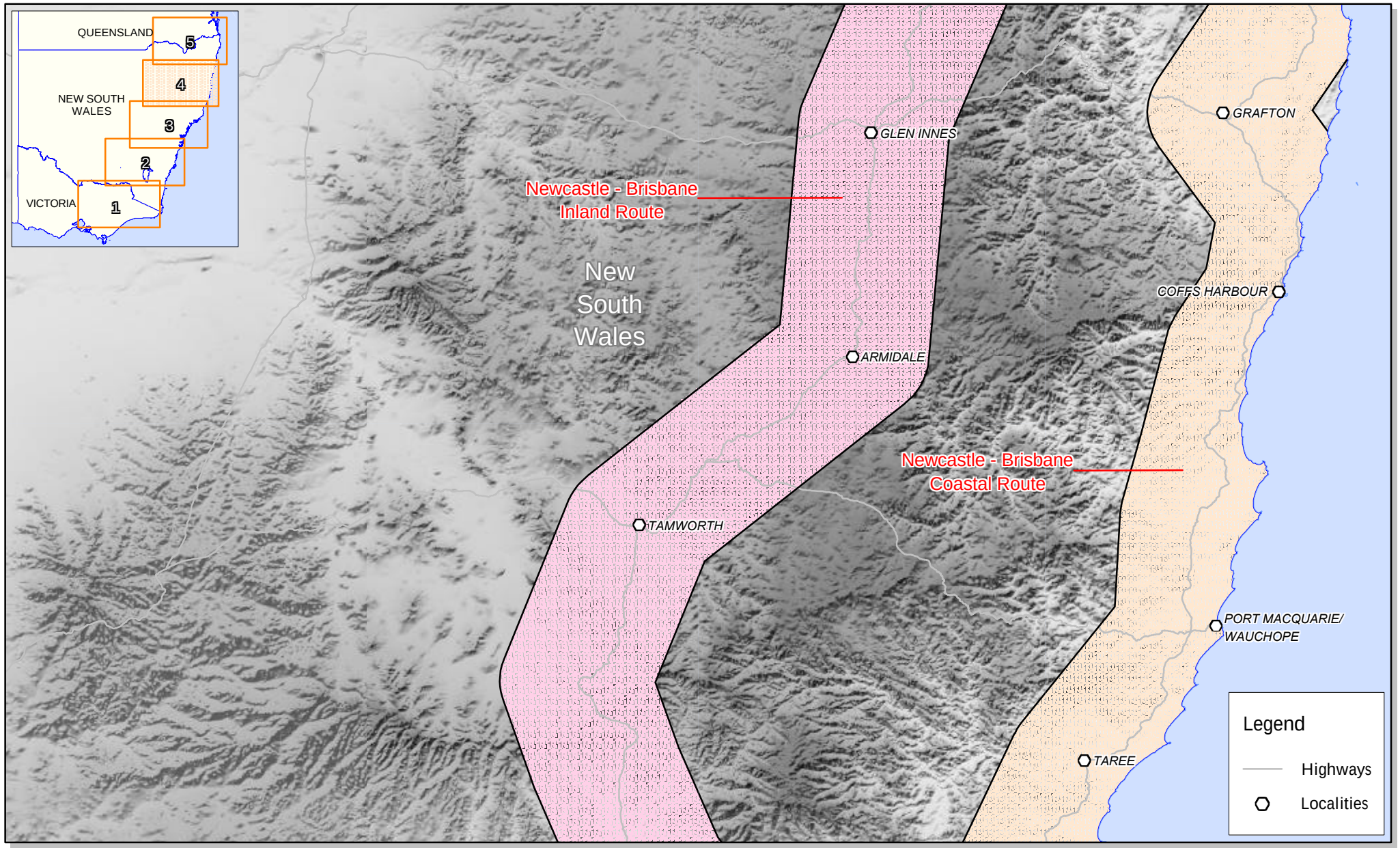
Candidate VHST Corridors with Terrain Features Map Sheet 2

Figure A3.2.2



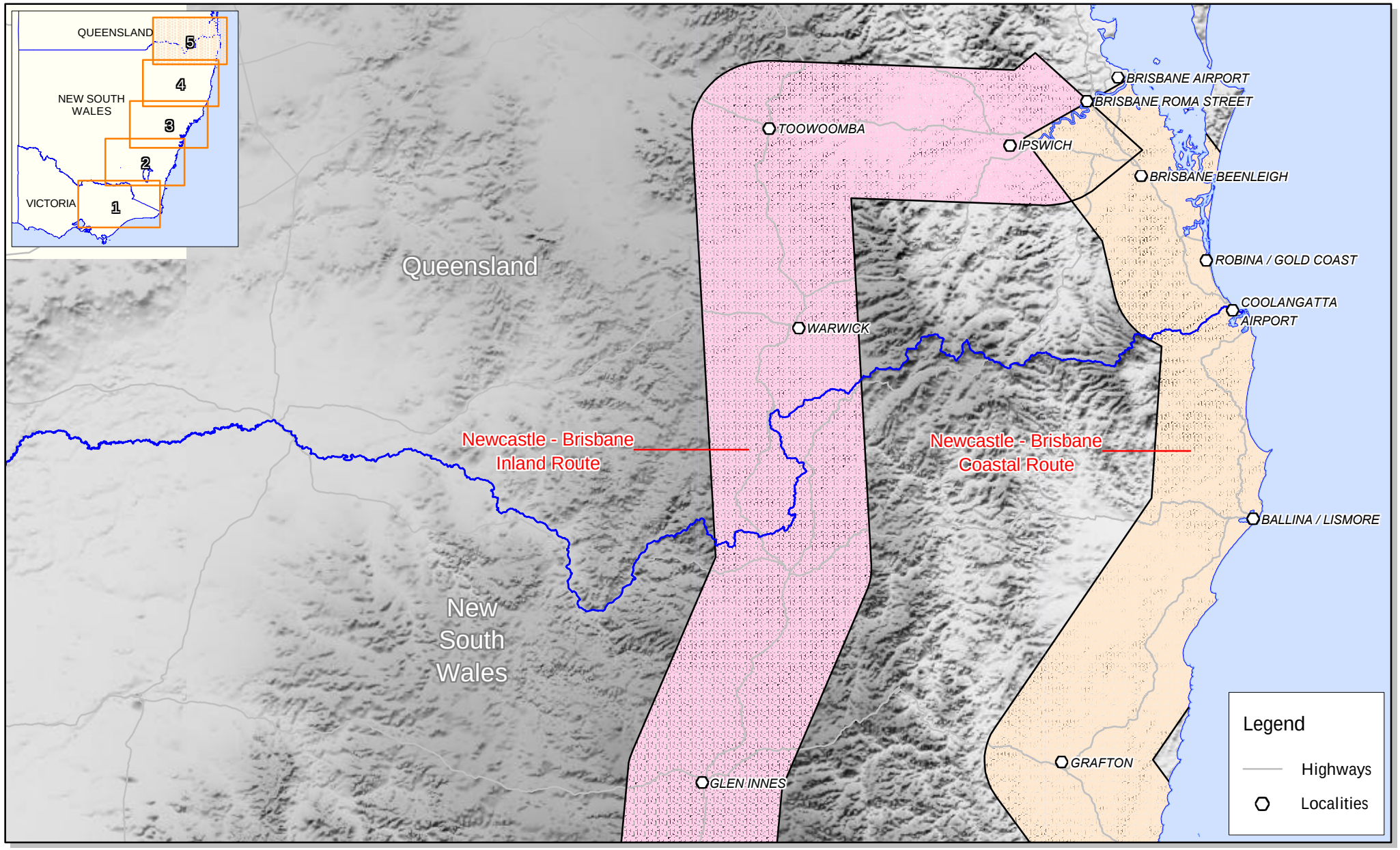
Candidate VHST Corridors with Terrain Features Map Sheet 3

Figure A3.2.3



Candidate VHST Corridors with Terrain Features Map Sheet 4

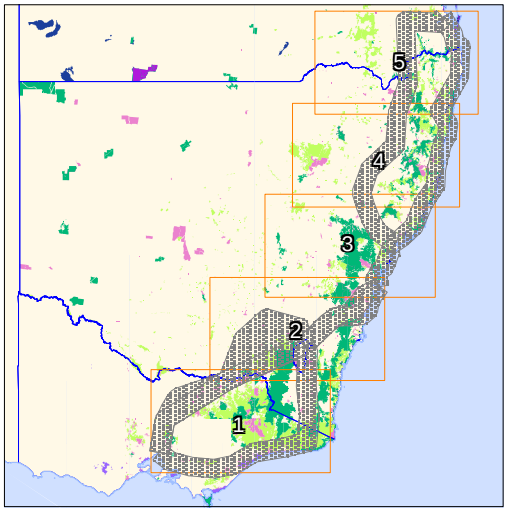
Figure A3.2.4



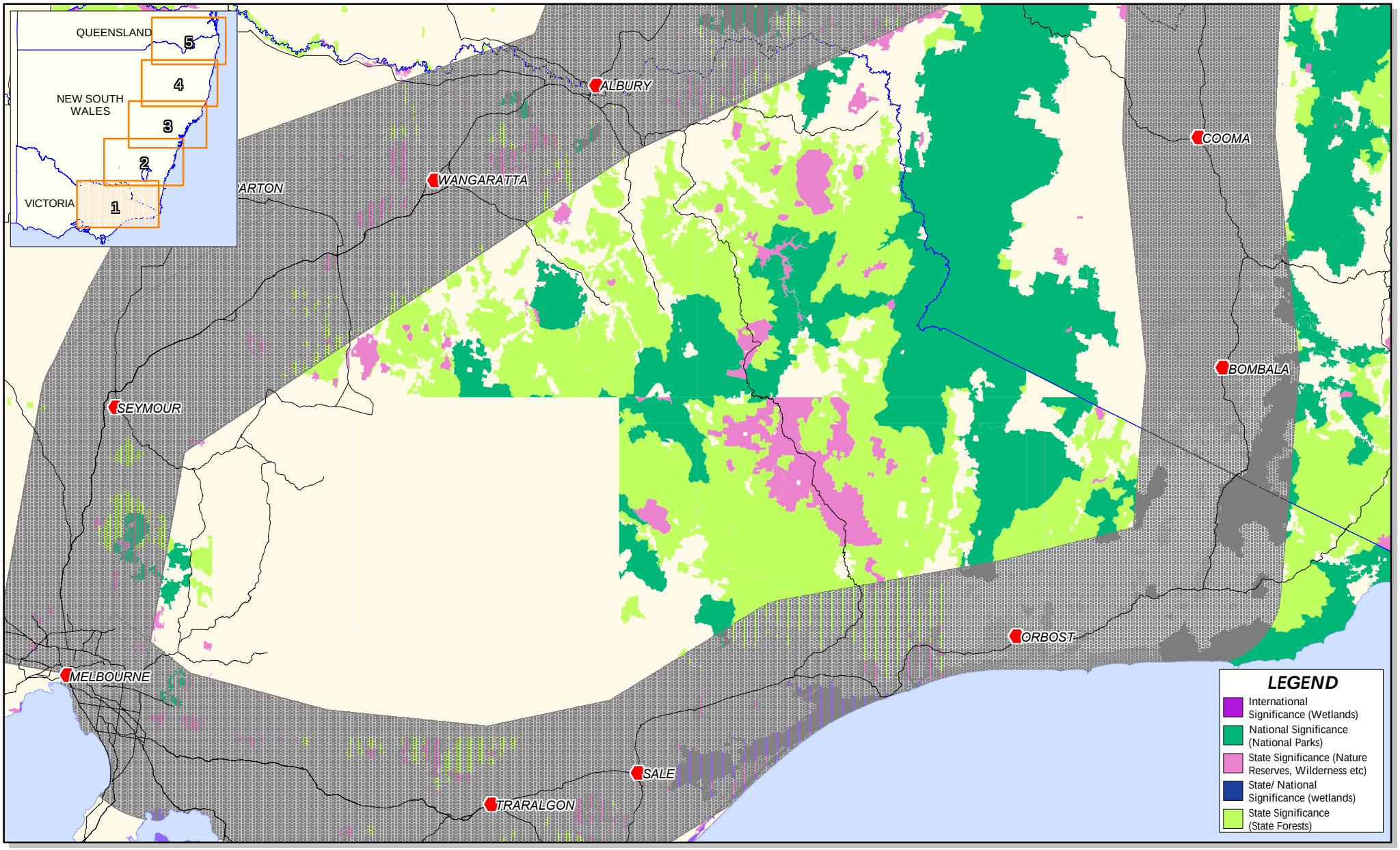
Candidate VHST Corridors with Terrain Features Map Sheet 5

Figure A3.2.5

EAST COAST VERY HIGH SPEED TRAIN SCOPING STUDY

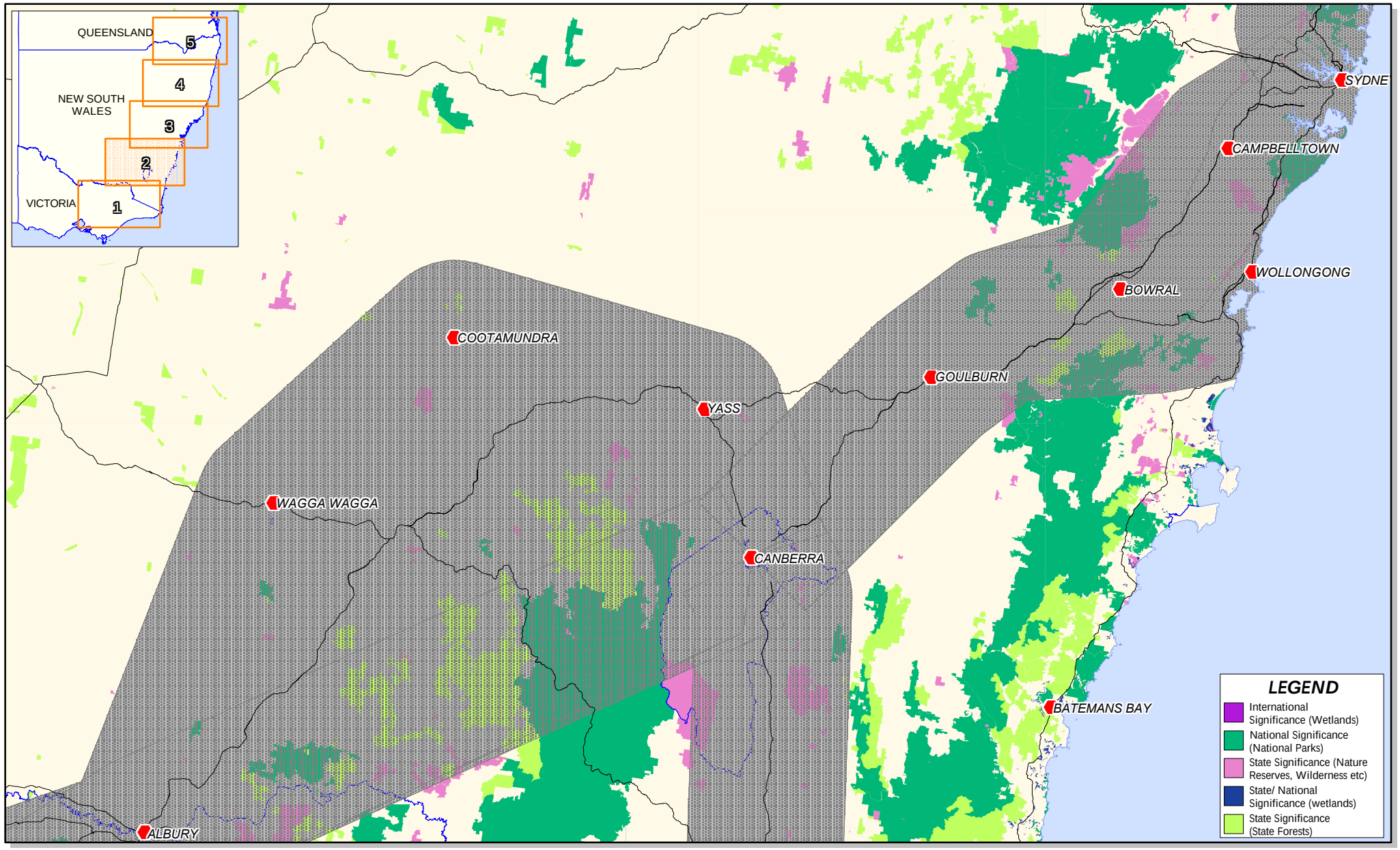


Candidate VHST Corridors with Areas of Environmental Significance



Candidate VHST Corridors with Areas of Environmental Significance

Figure A3.3.1

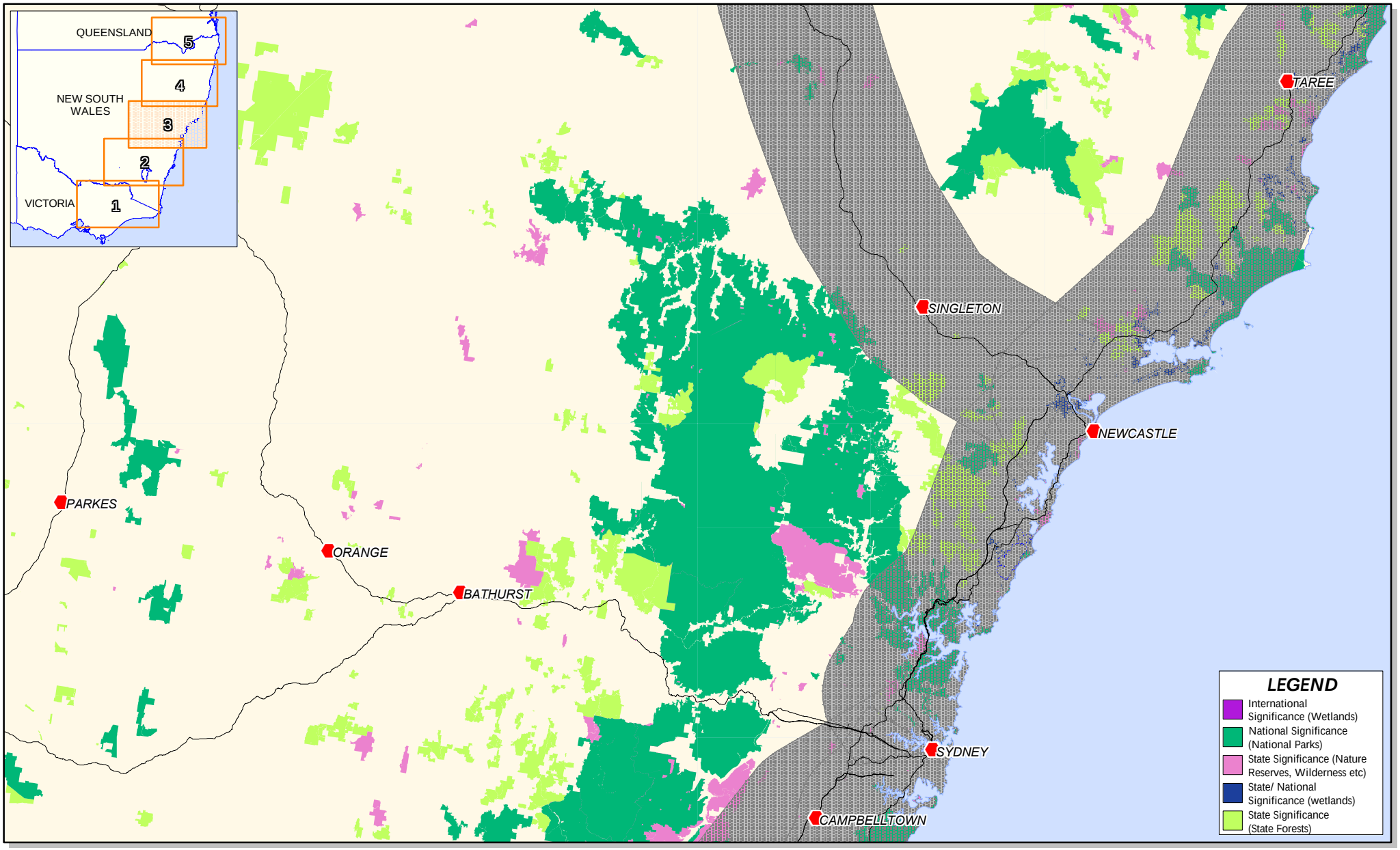


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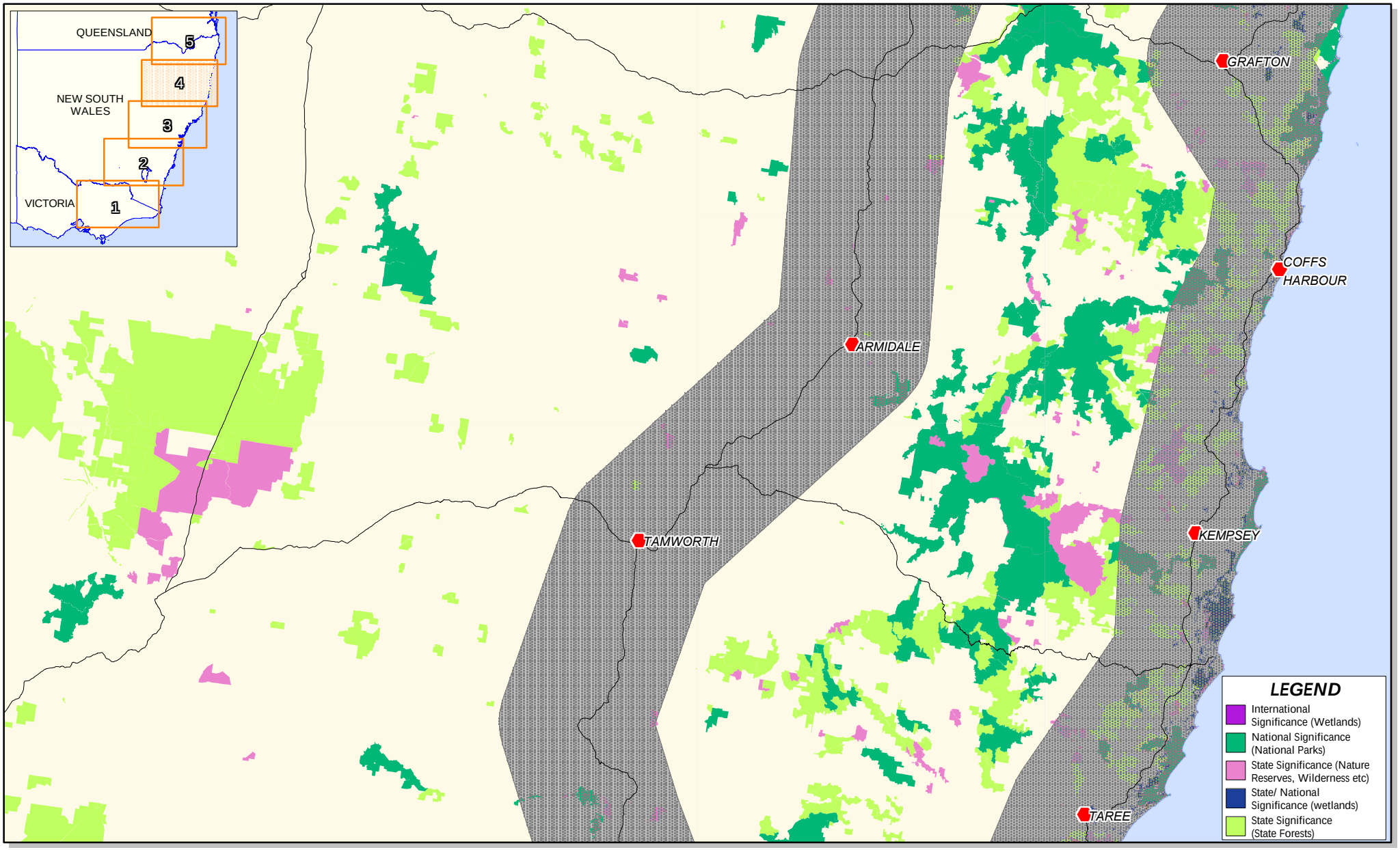
Candidate VHST Corridors with Areas of Environmental Significance

Figure A3.3.2



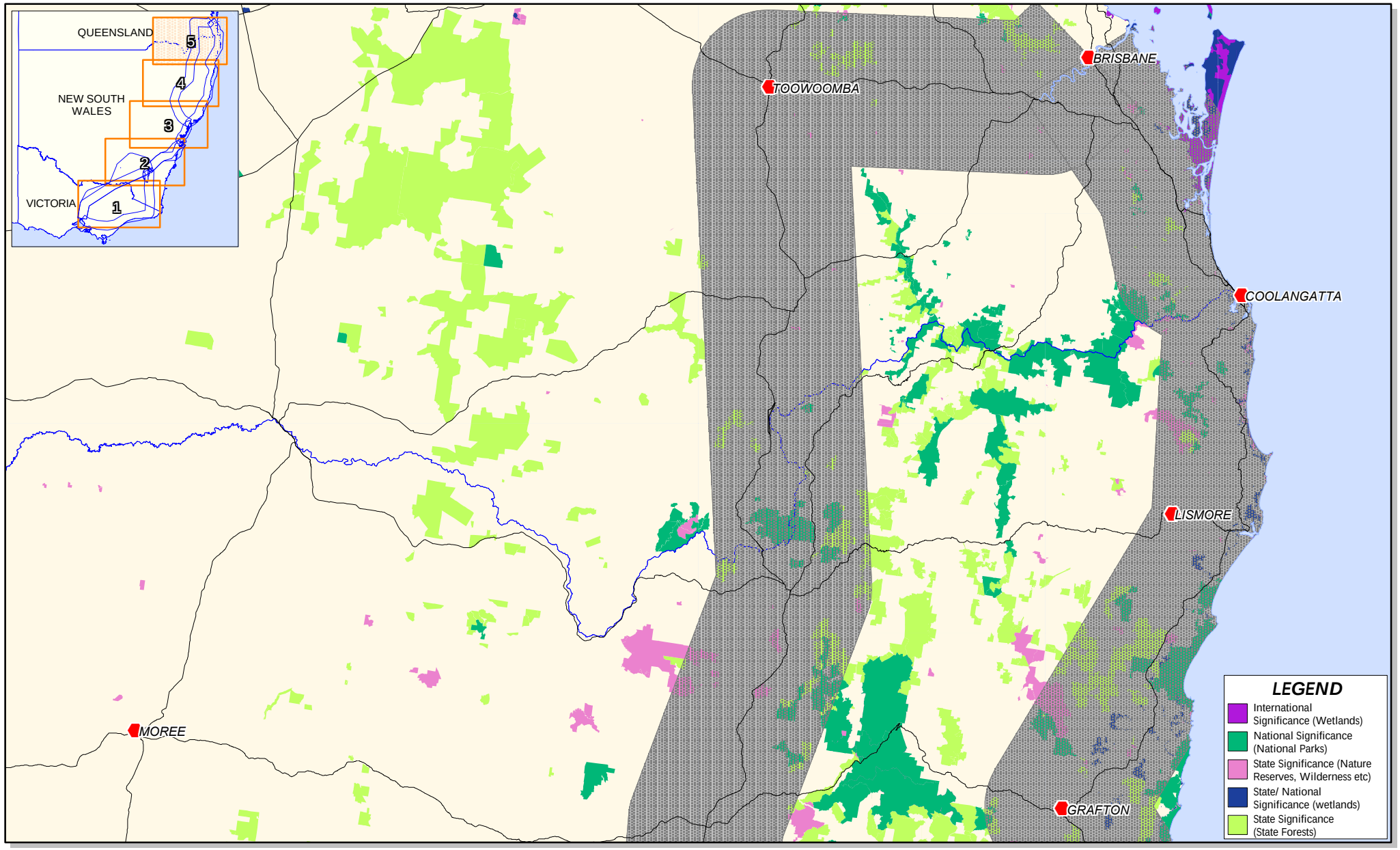
Candidate VHST Corridors with Areas of Environmental Significance

Figure A3.3.3



Candidate VHST Corridors with Areas of Environmental Significance

Figure A3.3.4



Candidate VHST Corridors with Areas of Environmental Significance

Figure A3.3.5