BTE Publication Summary

Adequacy of Transport Infrastructure: Multimodal

Working Paper

This Working Paper is the sixth in a series of Working Papers which disseminates the results of a large research project into the adequacy of Australia's transport infrastructure over the next 20 years. The assessment covers all four modes of transport - road, rail, air and sea - with the primary focus on freight.

Bureau of Transport and Communications Economics

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Adequacy of transport infrastructure
Multimodal

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FOREWORD

The National Transport Planning Taskforce (NTPT) was established in October 1993 by the former Minister for Transport and Communications to report on national infrastructure needs and operational improvements required to meet future demands for freight transport.

The Bureau of Transport and Communications Economics was commissioned by the NTPT to carry out assessments of the adequacy of road, rail, seaport and airport infrastructure. In doing this it has attempted to adopt a strategic multimodal orientation. A summary of the Bureau's work is given in *Building for the Job: A Strategy for Australia's Transport Network, Commissioned Work vol. 1* produced by the NTPT.

The project was undertaken under the leadership of Mark Harvey and John Miller. Officers who contributed specific components included Johnson Amoako, Jane Brockington, Peter Collins, Glen D'Este, Bozena Dziatkowiec, Edwina Heyhoe and Chikkegowda Puttaswamy. Other officers of the BTCE, particularly Maurice Haddad, also made valuable contributions.

Details of the research undertaken for each component of the study are provided in a series of six working papers. The papers dealing with individual modes of transport describe the methodology used, future demand, and results of the adequacy analysis, and give options for future research. This paper on multimodal issues draws on the work set out in the other papers in the series and considers the possible effects of inter-relationships between the modes on the findings of the study.

The examination of multimodal issues was undertaken by Dr Glen D'Este who was seconded to the Bureau for part of the duration of study from the Transport Systems Centre at the University of South Australia. Dr Bob Batterham of the University of Sydney was engaged to undertake some modelling work the results of which are summarised in this paper. The dedication of Dr D'Este and all the Bureau staff involved and the consultants has been appreciated.

Russ Reynolds
Research Manager

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Canberra

January 1995

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ABSTRACT

The Bureau of Transport and Communications Economics has undertaken a series of studies that examines the adequacy of road, rail, seaport and airport infrastructure to meet Australia's future transport needs. Each of these modes has a specific role in the overall transport system but they also compete with and complement each other. The present study extends the analysis by examining the multimodal issues associated with adequacy, infrastructure investment, transport externalities and allied modal interactions.

The overall conclusion is that modal interactions and associated modal shifts are unlikely to have a major impact on the need for or timing of infrastructure investment; or on the externalities associated with interstate freight transport. The impacts are likely to be small or swamped by other factors, such as the dominance of local and regional traffic on interstate highways, the existence of considerable spare capacity in railways and seaports and the dominance of passenger services in shaping airport infrastructure development.

The process of investigating interactions between the modes has revealed areas in which current information and understanding is deficient, and aspects of the overall study of modal and multimodal issues that could be improved if it were repeated. The primary lesson is to adopt a network and multimodal approach from the outset. There are many subtle interactions between the modes both on an operational level and in terms of the market's response to the available transport options. Any follow-up studies should adopt an improved understanding of these modal interactions as a starting point and engender a holistic approach that flows from the identification and forecasting of demand through the complete chain of analysis.

KEY FINDINGS

Assuming current levels of service are maintained over the next 20 years, rail is expected to lose market share to road in all corridors where they compete.

The technical assessments found that for both road and rail, the coastal corridors from Adelaide around to Cairns are the most inadequate.

The economic assessments of corridor infrastructure found that:

- road makes much heavier demands for investment expenditure than rail and generally has higher benefit-cost ratios;
- for both modes, the forecast future investment needs are highest on Sydney–Brisbane, Brisbane–Cairns and Sydney–Melbourne corridors;
- Melbourne–Adelaide has modest investment requirements for road but more substantial investment needs for rail; and
- Adelaide–Perth has relatively small needs for both modes with the needs for rail being greater. This could be seen as appropriate since rail is more competitive over longer distances.

Investment needs for seaports, airports and urban roads are concentrated in growth areas, particularly in Sydney, Melbourne and Brisbane.

Investment in rail will have little affect on investment needs for road because road traffic on the major interstate corridors is dominated by local and regional traffic (that is, it enters and/or leaves the corridor at intermediate points) as well as passenger vehicles. If rail captured the entire growth in the freight task beyond 1995, the result would be to delay timing of economically justifiable road projects by less than five years in the Sydney–Melbourne corridor and by less than three years in other corridors.

If, after 1995, all the forecast growth in corridor road freight went to rail, there would be an estimated fall in total CO_2 emissions for Australia of less than 0.2 per cent. Similarly, the same modal shift from road to rail would only reduce total road accident costs for Australia by an estimated 0.3 per cent.

CHAPTER 1 INTRODUCTION

The adequacy of transport infrastructure for a given mode and corridor is largely determined by the balance of supply of infrastructure capacity and the demand for transport services. In turn, the level of demand for a particular mode depends on the total volume of freight and passengers in the market and the market share held by that mode. The various transport modes are competing for shares of the same aggregate transport market. As a result, changes in the pattern of modal market shares will alter the balance between supply and demand. Hence there is potential for interactions between the modes which will have a bearing on market shares and ultimately, on the adequacy of the transport infrastructure.

Changes in modal shares can arise from many different sources, one of which is differential investments in infrastructure for the competing modes. It is conceivable that investment in one mode will produce improved performance by that mode, leading to increased market share and a reduction in demand for its competitors. As a result, the need for investment in infrastructure in the competing modes may be diminished. Instances in which one project reduces the need for another could be called substitutable investments. In addition to potential impacts on investment strategies, differences between the operational characteristics of the various modes may result in modal shifts producing impacts in terms of transport externalities such as congestion, emissions and accidents.

The present paper examines the significance of interactions between the modes in terms of implications for infrastructure investment and transport externalities. It is part of a series of working papers (BTCE 1994b-f) which examines the adequacy of Australian transport infrastructure for each of the modes and for urban transport. Whereas the other papers in the series consider individual modes or sectors, this study focuses on the likely consequences of multimodal interactions for nonbulk goods. Most bulk commodities are essentially captive to a particular mode as a result of their physical characteristics, location, need for specialised handling technologies and other factors. Consequently the scope for multimodal interactions for bulk commodities is limited, except in the very long term.

The analysis of modal interactions is based on comparison of a number of demand and modal split scenarios, rather than a detailed model of the operation of the freight market and infrastructure network. Detailed analysis of related investments in a transport network requires the use of complex mathematical programming techniques once the number of interrelated investments rises above a small number. It also requires extensive data on demand relationships and traffic flows by origins and destinations. It was therefore not possible to fully analyse potential multimodal network effects in the course of the present strategic study. However, it is argued that this does not compromise the results. A model of the Melbourne–Adelaide corridor was developed as a case study in the application of mathematical programming techniques to corridor adequacy assessment. Results of the case study are described in this report.

As argued above, the discussion of modal interaction, infrastructure, investment and externalities, is inseparable from a consideration of modal competition and modal shifts. It is traditional to discuss modal competition in terms of market shares, however proposed changes in railway routing patterns will blur the relationship between corridors and markets. National Rail Corporation (NRC) has indicated an intention to significantly reduce its use of the Sydney–Adelaide line for general cargo rail traffic and divert goods travelling by rail from Sydney to Adelaide and Perth via Melbourne. As a result, rail freight tonnages on the Sydney–Melbourne link will include Sydney–Melbourne, Sydney–Adelaide, Sydney–Perth and Melbourne–Brisbane consignments. Likewise, rail tonnage on the Melbourne–Adelaide rail link will include Sydney–Adelaide, Sydney–Perth and Melbourne–Adelaide rail traffic. The corresponding road tonnage is spread across several corridors and is also interacting with freight on other corridors.

As a result, the interpretation of road/rail modal shares on particular inter-capital corridors becomes problematic. A simple comparison of tonnages on parallel road and rail links will not reflect the state of competition between the modes. It follows that modal shares on individual corridors will no longer be valid indicators of the relative attractiveness and efficiency of the competing modes. This is typical of situations in which freight carriers are adopting a network strategy to improve the overall efficiency of their operations. Accordingly, the practice of stating corridor modal shares in percentage terms has been avoided in this report.

Despite modal shares becoming blurred by network effects, the fundamental process at work in the freight transport market is competition between the modes. Significant modal interactions will only take place in circumstances where there are opportunities for modal shifts. Since observed freight flows are the aggregate of a large number of modal and carrier choice decisions made by many individual decision makers, the logical starting point for a discussion of interactions between the modes is an understanding of the structure of the freight market and the shipper decision making process.

The key process involved in selecting a transport mode (and carrier) for movement of freight is matching the attributes of the mode with the requirements of the consignment. Each mode offers a package of service attributes, including cost, transit time, frequency, reliability, and responsiveness. The relative importance of the attributes depends on the characteristics of the consignment and the expectations of the market into which it is being sold.

At the most basic level, freight can be categorised as cost sensitive or time sensitive, depending on the relative importance of freight rate versus service quality. For cost sensitive freight, minimising the cost of transport has a higher priority than transit time and other factors. Conversely, for time sensitive consignments, the decision maker will aim to minimise transit time even at the expense of a higher freight rate. Time sensitive goods are typically high value and/or highly perishable cargos. For these cargos, the cost of delays outweigh a freight rate premium typically associated with exceptional speed of delivery. Between these two extremes, there is a spectrum of commodities for which shippers trade-off the relative importance of the modal service attributes.

Figure 1.1 provides a conceptual framework for discussing the respective market segments occupied by road, rail, sea and air freight and the likely interactions for a typical 'mainland' corridor.

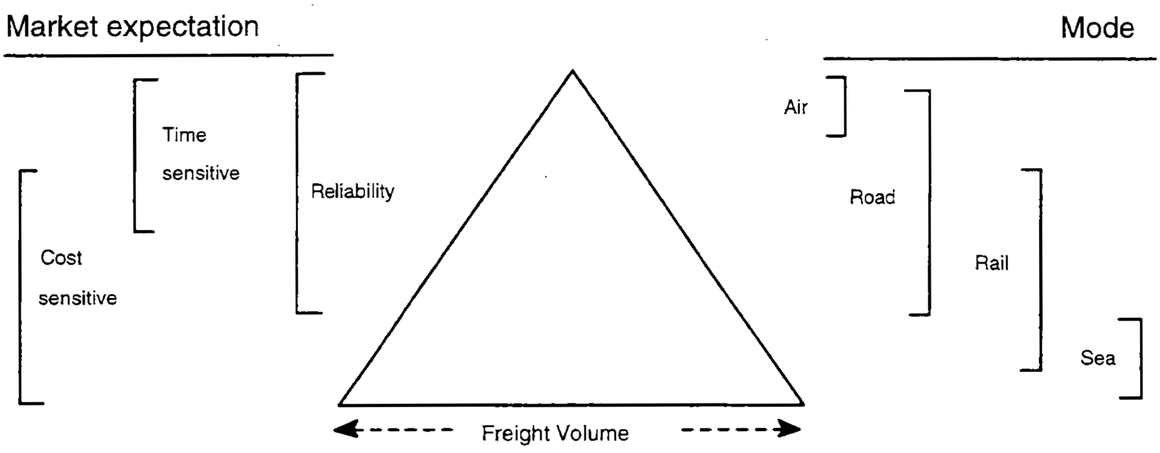

Figure 1.1 Structure of the freight market

As indicated in figure 1.1, air is the preferred mode for transport of cargo that is extremely time-sensitive. Typically this is cargo that must be transported on the same day or overnight. The only competition for air freight in these markets comes from overnight express road freight services. This is a small market in tonnage terms, but a large market in terms of value and potential profitability for transport operators.

The segment of the overall freight market for which road and rail compete is much larger. Road and rail are in direct competition for cargo with a balance of time and cost sensitivity. This represents the largest component of the nonbulk freight market and is dominated by intercapital movements with a guarantee of delivery on the next day between adjacent states (or a prescribed day for longer distances).

Rail and coastal shipping compete for consignments for which cost is a higher priority than transit time. Another characteristic of this market segment is that single consignments tend to be larger than typical road freight consignments. As a result the freight is moved in large blocks, taking advantage of economies of scale.

There is no significant overlap between the service characteristics and hence market segments of air and rail, air and sea, and road and sea. Competition between these modal combinations will be insignificant in terms of the overall freight market and the adequacy of transport infrastructure. Consequently the following discussion focuses on the more significant interactions between air and road transport, road and rail transport, and rail and sea transport.

The discussion of multimodal interactions would not be complete without some mention of transport terminals. Terminals are the principal modal interfaces and as such, are pivotal points in the freight transport system. The terminal can involve transfers between modes (road and rail, road and sea, road and air, rail and sea) or between links for the same mode, especially rail-rail. Terminals are also the shopfront for freight transport services and a significant factor in customer perception of the mode. An important characteristic of modal interfaces is that the performance of the terminal impacts on both modes, thereby compounding inefficiencies or benefits. Terminals have the potential to be serious bottlenecks and cost impediments to the efficient flow of cargo. On the other hand, investment in modal interfaces can simultaneously benefit both, and significantly improve the door-to-door performance of the transport chain. For example, reductions in truck delays are estimated to be some 25–50 per cent of total benefits accruing from investment in rail terminals (BTCE 1994c). Terminals have been discussed for each of the modes in other volumes of this series of Working Papers and will not be discussed at length in this report. However, it is important to note their importance in the context of modal interactions.

Investment in infrastructure which is part of an interrelated transport network can increase the need for investments in related transport infrastructure. In contrast to substitutable investments discussed above, instances in which one project *increases* the need for another could be called complementary investments. An example of a complementary investment considered in this paper is investment in rail leading to increased landbridging of international shipping containers and hence port investment needs. Complementarity can also occur within the same mode. Investment along one segment of a highway could generate traffic which will travel over other sections of the same highway thereby increasing investment needs along these other sections. Improvements in eastern state rail corridors could lead to more freight travelling by rail from the east to Perth, improving the viability of investments in the Adelaide–Perth rail corridor. Issues of complementarity within the same mode are considered in the mode specific working papers.

CHAPTER 2 INFRASTRUCTURE INVESTMENT NEEDS BY CORRIDOR

Table 2.1 places some of the principle findings for road and rail in each corridor side by side so they can be compared. The demand growth rates shown in table 2.1 are for distance weighted averages for road, and for end-to-end corridor traffic for rail. With road freight forecast to grow at 3 per cent per annum, rail is expected to lose market share to road on the assumptions that service levels provided by the infrastructure remain unchanged for road after 1995–95 and for rail after 1996–97. Little correlation is evident between the two sets of growth rates shown in the table. This is not surprising since the variations in forecast demand growth rates across the corridors for the two modes arise from very different causes. For road infrastructure, the variations between corridors arise from differences in population forecasts. For rail, competitiveness with road appears to explain the variations. Rail's prospects are strongest on high volume Sydney–Melbourne, and long distance Adelaide–Perth routes where rail's competitive advantages relative to road are greatest.

Some correlation is visible in the level of service columns. The coastal corridors from Adelaide to Cairns are relatively poor performers for both modes. Looking at the most deficient links, Brisbane–Gympie is the only point of coincidence. Large anticipated growth in commuter traffic north of Brisbane is expected to cause congestion on both road and rail modes unless investments are undertaken to expand capacity. There are also tight curves restricting rail speeds.

Some correlation is evident between corridors for forecast future expenditures although road makes much heavier demands than rail. Sydney–Brisbane, Brisbane–Cairns, Sydney–Melbourne have relatively high investment needs for both modes. Melbourne–Adelaide has modest investment requirements for road but more substantial investment needs for rail. Adelaide–Perth has relatively small needs for both modes with the needs for rail being greater. This could be seen as appropriate since rail is more competitive over longer distances.

The greatest demands for future infrastructure spending will be along the Sydney–Brisbane, Brisbane–Cairns and Sydney–Melbourne corridors for both road and rail. Investing significant amounts in both modes in the same

TABLE 2.1 ROAD AND RAIL CORRIDOR COMPARISONS

	Expected annual % growth rate		Technical assessment: Level of service: 2014-15		Technical assessment: Most deficient link: 2014-15		Indicative costs ($ millions)	
	Road traffic	Rail traffic	Road corridors A is highest	Rail corridors 1.0 is highest[1]	Road	Rail[1]	Road	Rail
Sydney-Brisbane:								
Pacific Highway	2.4	0.4	F	0.6	Port Macquarie-Brisbane F and Hornsby-Minmi E	Maitland-Kempsey 0.5	4 254	970
New England Hwy	1.4		E				2 114	
Brisbane-Cairns	2.5	0.9	D	0.6	Brisbane-Gympie F	Brisbane-Gympie 0.5 and Townsville-Cairns 0.5	1 372	445
Sydney-Melbourne	2.0	1.2	D	0.7	Melbourne-Seymour E	Chullora-Goulburn 0.6	1 346	980
Melbourne-Brisbane	2.0	-	D	-	Narrabri-Qld border D	-	621	-
Melbourne-Adelaide	2.3	0.9	C	0.6	Ballarat-SA border C	Tailem Bend-Adelaide 0.5	340	540
Brisbane-Darwin	2.1	-	A	-	Ipswich-Toowoomba D	-	344	-
Sydney-Adelaide	1.8	0.2	B	0.7	Vic border-Adelaide C	Chullora-Parkes 0.5	260	-
Canberra connections	2.0	0.5	D	0.9	Barton Highway F	Canberra-Goulburn 0.9	256	-
Hobart-Burnie	1.4	0.5	D	na	Devonport-Burnie D	na	153	-
Adelaide-Perth	1.3	1.1	B	0.8	Adelaide-Port Augusta C	Kalgoorlie-Perth 0.6 and Crystal Brook-Port Augusta 0.6	99	288
Perth-Darwin	2.4	-	A	-	Perth-Meekatharra B	-	74	-
Adelaide-Darwin	2.3	0.5[2]	A	0.8[2]	Katherine-Darwin A	-	40	-

Note 1 The technical assessments for rail shown here are based on performance standards, not physical standards.

2 Adelaide to Alice Springs

Source BTCE (1994b) and (1994c)

corridors should reduce the tendency for one mode to gain at the other's expense as infrastructure improves. The conclusion that the greatest needs for spending on transport infrastructure over the next 20 years will be along the eastern corridors, extends to airports, seaports and urban roads as well. Of the $638M of known projects with costs available for seaports, 87 per cent occur at east coast ports from Cairns to Melbourne. No seaport projects were identified for Fremantle and Adelaide. East coast airports (Cairns, Brisbane, Coolangatta, KSA, SWA and Melbourne) account for 89 per cent for forecast airport expenditure needs. Although it was not possible to arrive at investment forecasts for urban roads, it is clear that the bulk of the needs will be in Sydney, Melbourne and Brisbane. The greater infrastructure spending needs of the above corridors arise from the facts that the greater part of the present population and economic activity is in the east and high population growth rates are expected along the coast between Sydney and Cairns. In addition, allocations of funding for infrastructure spending in the past may have been influenced by attempts to achieve regional balance.

Benefit-cost ratios (BCRs) for projects tend to be considerably higher for road than rail indicating that road investments should receive higher priority if the aim is to achieve greater economic efficiency. BCRs for intercity road projects were not estimated explicitly; but the technique employed to estimate future expenditure needs, based on optimal timing of investments, ensures that potential investments having traffic levels that just pass the hurdles have BCRs of about 2 to 2.5. A large proportion of the investments involve traffic levels well above the hurdle levels and would have BCRs in excess of 2.5. For urban roads, the Allen Consulting Group (1993) referred to a project with a BCR of 20. Average BCRs for groups of urban projects were reported as ranging between 5 and 7 by the Allen Group and between 3 and 8 by the Bureau. For rail, the highest BCR found in the present study was 14 and the average for the warranted projects was estimated at 1.6. The rail evaluations did not allow for benefits in the form of improved levels of service to customers. However, it is considered that these, if valued, would be unlikely to be sufficient to raise average rail BCRs to levels comparable with road.

CHAPTER 3 INTERACTION BETWEEN ROAD AND RAIL TRANSPORT

There is considerable overlap between the markets for road and rail transport, particularly for cargo with a balance of time and cost sensitivity. Therefore there is potential for transfers of significant volumes of cargo from one mode to the other, with resultant impacts on infrastructure adequacy, patterns of investment and transport externalities. This chapter explores the impact on the need for and timing of infrastructure investments of significant changes in the balance of road and rail traffic resulting from modal shifts or other potential sources. Other factors, including the impact of changes in road vehicle technology, and external effects, such as emissions, accidents and congestion, are also considered.

THE SIGNIFICANCE OF INTERSTATE ROAD TRAFFIC

The degree to which modal shifts can influence the timing of road investment and the external impacts of road traffic, is largely determined by the significance of interstate traffic as a component of total traffic on road corridors. Road traffic on major interstate corridors is currently dominated by local and regional travel, and demand projections (BTCE 1994b) suggest that this will continue to be the case. Table 3.1 shows estimated light and heavy vehicle traffic on major intercapital corridors for 1995–96.

It is clear that intercapital light and heavy vehicle movements are a minor component of traffic, even on the most lightly trafficked links of each corridor. Adelaide–Perth is the only corridor with a significant percentage of intercapital traffic over a significant proportion of its length. On most National Highway links, intercapital traffic is less than 20 per cent of total AADTs, and on the heaviest trafficked links it is typically well under 10 per cent. End-to-end traffic (both light and heavy vehicles) represents a small proportion of total traffic on most interstate road corridors.

In most cases, traffic on National Highways is dominated by traffic that only uses part of the corridor. This includes local traffic, regional traffic moving between intermediate destinations in the corridor and regional traffic with one or both endpoints outside the corridor. With intercapital traffic as a minor component of total traffic, this immediately constrains the potential magnitude of the impact of modal shifts since road and rail are competing for the end-to-end freight traffic in the corridor. The market for rail transport of nonbulk goods between intermediate points in the corridor is too small to have a significant impact on investment or adequacy. This is especially true since the emergence of NRC which aims to offer reliable and timely intercapital rail freight services with a minimum of stops. In effect, the insignificance of intercapital road movements as a component of total traffic means that changes in modal share between road and rail are likely to have a small impact on road adequacy and investment.

TABLE 3.1 INTERCAPITAL ROAD TRIPS PER DAY 1995–96

Corridor	*Light Vehicles*	*Heavy Vehicles*	*Total*	*Percentage of traffic on lightest trafficked link*	*Percentage of traffic on heaviest trafficked link*
Sydney-Brisbane[1]	100	250	350	9%	1%
Sydney-Melbourne	500	930	1 430	30%	6%
Sydney-Adelaide	70	180	250	25%	6%
Melbourne-Brisbane	50	270	320	31%	3%
Melbourne-Adelaide	380	500	880	39%	3%
Adelaide-Perth	25	110	135	52%	3%

Note 1. Figures refer to the New England Highway; traffic volumes and percentages for the Pacific Highway are similar.

Source BTCE estimates.

IMPACT OF MODAL SHIFTS ON INFRASTRUCTURE INVESTMENTS

Since road and rail are competing for the same freight market there may be an opportunity for substitutable investments in major Australian interstate corridors. At the very least, modal shifts have the potential to effect the timing of investments in infrastructure for a particular by changing the volume of traffic on the corridor for that mode. To gauge the impact of modal shifts on timing of investment, three scenarios have been examined. The scenarios represent extremes of conceivable modal shifts plus a Base Case that corresponds to the BTCE demand forecasts. The scenarios are explained in table 3.2. It is unlikely that foreseeable developments in the modes will produce results that lie outside these bounds so the scenarios can be used to test the extreme cross-modal impacts of modal shifts.

Note that the analysis is limited to the Brisbane–Sydney–Melbourne–Adelaide–Perth corridor. On this corridor there will be significant competition between road transport operators and nonbulk rail freight services operated by NRC. Tonnages on the Adelaide–Alice Springs corridor are small and little investment in rail projects is anticipated, so this corridor has been omitted from the analysis on the basis that there are no significant road-rail issues. The only other major rail freight corridor is Brisbane–Cairns which is a long corridor with many major towns and very small volumes of end-to-end freight. The corridor is dominated by bulk freight movements (especially coal) and road-rail competition for movement of nonbulk goods will not have a significant impact on overall infrastructure development for either mode. It should also be noted that the Sydney–Adelaide rail link is not included in the analysis, in line with NRC plans. NRC has indicated an intention to significantly reduce its use of the Sydney–Adelaide line for general cargo rail traffic and divert goods travelling by rail from Sydney to Adelaide and Perth to the route via Melbourne.

TABLE 3.2 ROAD/RAIL MODAL SPLIT SCENARIOS

Scenario	*Description*
1. Base Case	This scenario corresponds to the demand forecasts used for the road and rail adequacy and investment analysis in BTCE (1994b,c). The implication for modal shares is that rail increases its overall modal share on all corridors up to 1998 and then slowly loses modal share so that by 2014-15, modal shares are similar to the present.
2. All growth to road	This is a pessimistic scenario for rail. Rail tonnages remain constant at 1995-96 levels and all growth in the period 1995-96 to 2014-15 is captured by road freight resulting in a declining overall market share for rail.
3. All growth to rail	This is an optimistic scenario for rail. As a result of investment, operating efficiencies, better rolling stock, and other factors, it is assumed that all growth is captured by rail while road tonnages remain constant. As a result, rail's overall market share increases significantly under this scenario.

The implications of the scenarios in terms of the tonnages and tonne-kilometres of intercapital road and rail freight on major corridors in 2014–15 are shown in table 3.3. The table also shows the maximum rail tonnage capacities for each of the corridors after the completion of *One Nation* projects. The base case (scenario 1) tonnages shown in table 3.3, were calculated directly from the road and rail demand forecasts for each link, as described in BTCE (1994b and 1994c). This provides a basis for creating the other two scenarios, and also establishes a pattern of road and rail freight assignments to links of the transport network. Scenarios 2 and 3 are variants of the base case. Either the rail tonnage (scenario 2) or road tonnage (scenario 3) is fixed at the 1995–96 base case level for each link because all growth in the freight task has been captured by the other mode. The tonnage that has shifted mode is the difference between the 1994–95 base case figure and the corresponding 2014–15 base case forecast for rail (scenario 2) or road (scenario 3). The modal shift tonnage for each link is then assigned to the appropriate road links (scenario 2) or rail links (scenario 3) according to the pattern of freight flows established in the base case and added to the 2014–15 base case forecast for the link.

Since the road and rail networks have different configurations, there is not a direct correspondence between road and rail corridors. Hence, the network effects mean that particular corridors cannot be considered in isolation from the network and that the figures in table 3.3 should be interpreted carefully. As explained above, rail consignments may travel over more than one corridor, so that rail tonnages in the table cannot be added and the total tonnages of freight will vary from scenario to scenario. For example, consignments travelling from Sydney to Adelaide by rail will be counted in both the Sydney–Melbourne and Melbourne–Adelaide rail corridors.

However if there is a modal shift to road, the consignments would only be counted in the Sydney–Adelaide road corridor. In addition, when freight is transferred from rail to road, the resulting road traffic may be spread across several different corridors because some rail links serve several intercapital corridors. For example, if freight shifts from rail to road in the Sydney–Melbourne corridor, the additional road traffic will be spread between the Sydney–Melbourne, Sydney–Adelaide and Melbourne–Brisbane road links. The aggregate impact of these network effects is a complex interaction between the corridors. In terms of rail infrastructure, it follows directly from the table, that with the exception of the Sydney–Melbourne corridor, there is sufficient rail corridor capacity after completion of *One Nation* projects to cater for rail tonnages under all scenarios on all corridors. On the Sydney–Melbourne corridor a significant capacity shortfall would exist if all growth after 1995 is captured by rail (scenario 3). If this scenario eventuates, there will be a requirement for considerable investment in projects aimed at increasing capacity on the Sydney–Melbourne corridor. Sydney–Melbourne is the exceptional case because of the relatively small amount of initial spare capacity, the large tonnage and small initial market share held by rail. In summary, the only capacity driven rail investments that would be initiated by modal interactions would occur on the Sydney–Melbourne rail link. If all growth in freight task was captured by rail in the Sydney–Melbourne corridor, then significant investments would be required in the period 2000–2010 to increase rail link capacity.

TABLE 3.3 INTERCAPITAL FREIGHT VOLUMES 2014-15

		Sydney-Brisbane	*Sydney-Melbourne*	*Melbourne-Adelaide*	*Adelaide-Perth*
RAIL (Million Tonnes)					
Scenario	1	5.5	8.5	7.2	3.3
	2	3.7	4.8	4.8	2.5
	3	8.8	15.9	11.2	3.8
Maximum Capacity [1]		11.4	10.6	16.4	6.5
RAIL (Billion Tonne-Kms)					
Scenario	1	5.3	8.2	5.8	8.6
	2	3.6	4.6	3.8	6.5
	3	8.5	15.3	9.0	9.9
ROAD (Million Tonnes)					
Scenario	1	5.6	11.9	6.0	1.2
	2	7.2	14.5	7.5	2.0
	3	3.2	6.8	3.4	0.7
ROAD (Billion Tonne-Kms)					
Scenario	1	5.0	10.7	4.8	3.2
	2	6.5	13.1	6.0	5.4
	3	2.9	6.1	2.7	1.9

Note 1. Theoretical maximum capacities from Maunsell consultants (1994)

Source BTCE (1994b) and (1994c)

Using an average (truck) load of 19.3 tonnes on eastern corridors (BTCE 1993) and 16 tonnes on the Adelaide–Perth corridor, the road tonnages shown in table 3.3 can be converted to equivalent numbers of road vehicles. Table 3.4 shows the 2014–15 outcomes of the modal scenarios in terms of the estimated difference in road traffic volumes between the base case (scenario 1) and the two alternative scenarios.

In absolute terms, the effect of the growth in freight task being captured by road or rail is to produce small changes in AADTs. A significant increase in modal share held by road freight (scenario 2) leads to increases in traffic by up to 400 vehicles per day in 2014–15. Consider the case of a road link that has a rate of growth of traffic of 2 per cent per annum (typical on most major corridors) and is approaching the need for duplication at a threshold traffic level of 7 000 AADT, see BTCE (1994b) for a detailed explanation of the use of AADT thresholds as a trigger for road upgrading. If there is an exceptional increase in the number of heavy vehicles, then the threshold will be reached sooner. The effect of all growth going to road, as compared to maintaining current market shares, is to accelerate the need for duplication by less than 3 years on the Sydney–Melbourne corridor and by less than 2 years on other corridors. These figures are equivalent to the time taken for the underlying 2 per cent growth to produce the same increase in AADT as the modal shifts under scenario 2.

TABLE 3.4 ADDITIONAL INTERCAPITAL HEAVY VEHICLE TRAFFIC 2014-15 RELATIVE TO BASE CASE (SCENARIO 1)

	Scenario 2 *Additional heavy vehicles per day*	*Scenario 3* *Additional heavy vehicles per day*
Sydney-Brisbane	230	-720
Sydney-Melbourne	370	-340
Melbourne-Adelaide	220	-370
Adelaide-Perth	140	-90

A significant increase in rail's overall modal share (scenario 3) leads to a reduction in traffic by up to 720 vehicles per day on the Sydney–Melbourne corridor in 2014–15 and by under 400 vehicles per day on other corridors. Considering the same case as above, the effect of all growth going to rail as compared to maintaining current market shares, is to delay the need for duplication by around 5 years on the Sydney–Melbourne corridor and by less than 3 years on other corridors. The longer delay on the Sydney–Melbourne corridor is a consequence of the large freight tonnage in the corridor and the low initial market share held by rail.

It follows that changes in the road/rail modal shares on major intercapital corridors will have little impact on the need for road investment. If rail captured all growth in the freight task beyond 1995, the result would be to delay the timing of economically justifiable road projects by 4 to 5 years in the Sydney–Melbourne corridor and by less than 3 years in other corridors. On the other hand, a significant modal shift to road will bring forward the timing of economically justifiable road projects by less than 3 years on all corridors.

The conclusion that modal shifts for freight will have a small (even insignificant) impact on road infrastructure investment was anticipated in the preceding discussion of the significance of interstate road traffic. The bulk of traffic on interstate highways is light passenger vehicles and local/regional freight movements. The cumulative growth in these categories of road users will more quickly swamp the effects of modal shifts in interstate freight. Despite the fact that interstate highways are constructed to a standard appropriate for high speed travel by heavy vehicles, it appears that the need for upgrading is largely driven by other road users.

IMPACT OF CHANGES IN ROAD VEHICLE TECHNOLOGY

Road vehicle technology can have a significant impact on modal competition and the significance of road freight on the traffic stream. For intercapital road freight, growth in the use of B-doubles is the most important foreseeable technological change. The average payload of typical B-double is some 50 per cent higher than a typical six-axle articulated truck. As a result, the number of vehicle movements required for a given freight task is significantly smaller. At the same time, operating costs are lower for B-doubles, with typical unit costs for a six-axle articulated truck at 7 c/NTK and 6 c/NTK for a B-double. (Hall, N. *et al* 1994). This will tend to increase the competitiveness of road freight with respect to rail, stimulate a modal shift to road and counteract the reduction in vehicle numbers produced by higher payloads. Therefore, the impact on road freight activity will be mixed as a result of countervailing efficiencies in cost and payload.

In calculating the imputed heavy vehicle AADTs in table 3.4, it has been assumed that average vehicle payload will be fixed at current levels throughout the timeframe. However, changes in vehicle technology may increase average payloads and hence reduce the number of vehicles required for a given freight task. If the entire intercapital six-axle articulated fleet was replaced by B-doubles, the number of vehicles trips would reduce by up to one third. Clearly this can have an impact on the timing of investments.

Consider the four major intercapital road corridors and a road link on each that has a rate of growth of traffic of 2 per cent per annum (the typical growth rate on most links) and will approach the need for duplication at a traffic level of 7 000 AADT by 2014–15. If all six-axle articulated trucks on major intercapital corridors were replaced by B-doubles, then the impact would be to delay the need for road infrastructure upgrading by up to 4 years on the Hume Highway and less than 2 years on other corridors. However, the superior cost efficiency of a B-doubles will increase the relative competitiveness of road freight and cause a modal shift to road. Allowing for this generated traffic, the overall impact of large-scale introduction of B-doubles is likely to be to delay the need for road infrastructure investment by only a few years. However, this represents an extreme scenario since there is likely to be only a partial replacement of the heavy fleet within the 20 year study timeframe. The high capital cost of B-doubles has been a significant factor in slowing the uptake of this technology.

In summary, it appears that foreseeable changes in modal split, road vehicle technology or a combination will have little impact on the timing of or need for infrastructure investment. There is sufficient capacity to soak up probable growth on all rail corridors except Sydney–Melbourne and under all likely scenarios, the timing of road upgrading is accelerated or delayed by only a few years at most.

IMPACT OF MODAL SHIFTS ON TRANSPORT EXTERNALITIES

The impact of changes in the freight transport market extends beyond its implications for investment in transport infrastructure because transport produces a range of side effects. These side effects are known collectively as externalities and include congestion, emissions and accidents. This section of the report evaluates the external impact of the modal scenarios described in table 3.2.

When assessing of the impact of modal shifts on investment, it was sufficient to consider the nonurban component of freight movements. For externalities, there are significant impacts experienced at the urban endpoints of the trip. These impacts are a result of the structure of the freight movement and must be included in an overall assessment of externalities.

In most cases involving nonbulk freight delivery, rail does not provide a door-to-door service so most rail movements will be accompanied by a road trip at one or both ends of the journey. The need for distribution by road will be most prevalent in the general freight market and this constitutes the market niche with greatest scope for road and rail competition and modal shift. On the other hand, for road freight, the trip will typically be from door-to-door. Therefore, a modal shift from road to rail involves replacing one long road trip with a long rail trip plus one or two short urban road trips. This has important implications for the impact of modal shifts on urban areas.

There are important differences between the distribution of road and rail terminals that will have an influence on the relative impacts of different modal shares. The current NRC strategy is to consolidate rail terminal operations at a single site (or small number of sites) in each State capital. This has obvious operational advantages in terms of economies of scale and potential for cost and operating efficiencies. However these terminals tend to be located at a central location in the city. The South Dynon terminal is located adjacent to the Melbourne CBD and terminals in most other cities are centrally located. This means that the pickup and delivery road trips associated with interstate rail freight are focused on a single location, typically in an area of the city in which the effects of congestion and emissions are already severe. Conversely, intercapital road freight is not centred on a single (or small number) of terminals in each city. Interstate road freight can directly service origins and destinations that are dispersed throughout the urban region. Recent trends in industrial location and urban form (Industry Commission 1994) have involved a decentralisation of employment and freight generating enterprises away from the inner city areas. In addition, road terminals for freight forwarders are being increasingly located on the urban fringes where major highways meet the city (Ogden 1992). Distribution to final destinations is then made using smaller vehicles.

In summary, urban pickup and delivery are an integral part of the overall general freight task and an overall assessment of the externality implications of modal shifts needs to include a consideration of urban impacts. Since the urban road vehicle trips generated by interstate freight are centralised if rail is the linehaul mode and dispersed if road is the linehaul mode, modal shifts can be expected to have significant implications for urban externalities.

Congestion and emissions

It is sometimes claimed that rail consumes less fuel per tonne of freight than road, so intuitively it may be expected that a modal shift from road to rail for interstate freight will have benefits in terms of reduced greenhouse emissions. Similarly, a modal shift from road to rail should reduce congestion on major road corridors. The magnitude of these potential benefits can be placed in perspective by considering the contribution of interstate road freight towards total congestion and emissions, and by examining the implications of the three scenarios introduced above.

According to DASETT (1991), trucks and buses contribute some 19 per cent of CO_2 emissions from the transport sector. The comparable figure for rail is some 5 per cent, so it is clear that heavy road vehicles contribute a significantly greater share of CO_2 emissions. However, movements of interstate articulated trucks constitute only some 20 per cent of total truck tonne-kms (ABS 1991). It follows that intercapital road transport contributes less than 4 per cent of transport sector CO_2 emissions. The true figure is probably significantly less than 4 per cent because the stop-start nature of urban traffic and use of smaller trucks will produce higher rates of CO_2 emissions per tonne-kilometre of freight task than will the comparatively free flow traffic conditions in large trucks on intercapital links. Further, the transport sector contributes some 25–30 per cent of Australian CO_2 emissions (DASETT 1991) so intercapital road freight produces only around 1 per cent of total CO_2 emissions. The calculation is summarised in table 3.5.

It follows that the impact of changes in the road/rail modal split will be small in the context of overall transport contribution, and very small in terms of total

CO_2 emissions. The situation for other greenhouse gases and emissions in general will be similar.

TABLE 3.5 INTERSTATE ROAD FREIGHT CONTRIBUTION TO GREENHOUSE EMISSIONS

(per cent)

	Transport sector shares	*Total economy shares*
Total economy		100
Transport sector	100	25-30
Trucks and buses	19	5
Interstate articulated trucks	4	1

The conclusion that interstate road freight only contributes about 1 per cent of greenhouse gas emissions in Australia places bounds on the potential impact of modal shifts between road and rail. The outcome of all growth in intercapital freight being captured by road or rail, or of modal shares being maintained, can be evaluated by estimating total CO_2 emissions for each scenario. According to BTCE (1991), the rate of CO_2 emissions for nonurban freight transport is 104 grams per tonne-km for road and 60 grams per tonne-km for rail. Table 3.6 shows projected CO_2 emissions for 2014–15 for the three road/rail scenarios described in table 3.2. Total emissions are shown for two greenhouse scenarios; the first assumes that the target of 'no growth' in total emissions has been achieved, and the second is a 'low growth' scenario that assumes a 2.5 per cent annual growth in emissions mitigated by a 20 per cent discount for technological change. The table also shows the relative CO_2 emissions of scenarios 2 and 3 versus the base case scenario.

If there is some growth in emissions, then clearly the magnitude of the impact of modal shifts is greater in tonnage terms. However in percentage terms, the changes are similar since all contributions grow in approximate proportion. If there is no growth in total CO_2 emissions (the National Greenhouse Target), then the outcome of a modal shift to road (scenario 2) will be an increase in CO_2 emissions of around 2 per cent in the nonurban freight sector and around 0.3 per cent increase in overall emissions from the transport sector. A modal shift to rail (scenario 3) will have a larger impact in the opposite direction. Nonurban freight emissions are reduced by some 3 per cent and total transport related emissions by some 0.5 per cent. When road transport at the ends of the rail journey are taken into account, the overall reductions become even smaller. Since transport contributes approximately one quarter of total greenhouse emissions, it follows that the impact of a major modal shift in intercapital freight will be a change in total Australian CO_2 emissions from all sources by less than 0.15 per cent.

TABLE 3.6 EMISSIONS SCENARIOS 2014-15

CO_2 emissions (kilotonnes)	*Totals*	*Differences*
NO GROWTH IN CO_2		
Major Corridors - Scenario		
1. Constant market shares	3 100	-
2. Growth to road	3 300	200
3. Growth to rail	2 700	-400
All Non-urban Freight	13 000[a]	
Total Transport Sector	71 000[a]	
LOW GROWTH IN CO_2		
Major Corridors - Scenario		
1. Constant market shares	5 000	-
2. Growth to road	5 400	400
3. Growth to rail	4 500	-500
All Non-urban Freight	20 000[a]	
Total Transport Sector	110 000[a]	

a. Figures for Constant market shares scenario.

It is important to note that the emissions reduction resulting from any future modal shift to rail will produce a benefit in rural areas but not necessarily in urban areas. Likewise, a modal shift to rail may have a negative impact on urban road congestion. This conclusion, as explained below, arises from several factors including the requirement for pickup and delivery by road for intercapital rail freight, the pattern of freight destinations and facilities in the urban area, and the overall composition of urban road traffic.

As noted above, interstate heavy vehicle traffic is a minor percentage of traffic even on the most lightly trafficked rural links of the major corridors. On National Highways links on the urban fringes, the percentage of interstate heavy vehicles is typically less than 5 per cent, so in terms of the entire urban road system the contribution to total traffic is negligible. Further, the final destinations of intercapital road freight traffic will tend to be dispersed throughout the urban area. As a result, the contribution to the urban traffic stream and congestion will likewise be widely and thinly dispersed. Recent trends by major road freight operators to build freight distribution centres on the urban fringes and/or close to National Highway links have further reduced the impact on urban areas. In particular, the proportion of interstate heavy road vehicles that travel to the inner city is small.

The majority of rail consignments will require distribution by road from the rail terminal to the final destination. This requirement will be increasingly evident as NRC concentrates its activities at a single intermodal terminal in each capital city. Therefore, modal shifts from road to rail for interstate freight do not eliminate the urban road segment of the door-to-door trip. On the contrary, the urban road trip is reorientated in a way that may have a negative impact on urban congestion and emissions. Rail terminals are often in the inner city. South Dynon is a prime example. Consequently, a modal shift from road to rail will replace distribution by road from the urban fringe (where the National Highway meets the urban area) with distribution by road from the inner city where congestion and emission problems are most acute. As a result, the outcome of a modal shift from road to rail can be counterproductive in terms of reducing congestion and emissions in urban areas.

Accident costs

A modal shift from road to rail for interstate freight might also be expected to generate benefits in terms of reduced road accidents and accident costs to the community. BTCE (1988) explored the cost to the community of various road accident types and the total cost of all road accidents. It was concluded that the total cost to the community was some $5B in 1985. In BTCE (1993), these figures were used to derive a rate of 0.2¢/NTK in 1990 prices for the cost of accidents involving articulated vehicles. Using figures for the current freight task, it follows that articulated vehicles on intercapital routes contribute less 1 per cent of the cost of road accidents.

Using the projected magnitude of the freight task in 2014–15, the figure of 0.2¢/NTK can be used to estimate the relative accident costs of the three modal split scenarios described in table 3.2. If constant market shares (scenario 1) is taken as the base case, then a significant modal shift to rail (scenario 3) will reduce the cost to the community of motor vehicle accidents by an estimated 0.3 per cent. On the other hand, if the growth is captured by road (scenario 2), then accident costs rise by 0.2 per cent. These figures assume that recent trends will continue to the extent that improvements in roads, vehicles, technology and other factors will counteract growth in the road transport task and stabilise the total cost of accidents in constant prices.

It is clear that the reduction in intercapital road freight traffic that would result from a growth in rail's modal share is likely to be very small compared to total road accident cost. Any benefits are swamped by accident costs arising from other road traffic activity.

CASE STUDY : MELBOURNE–ADELAIDE CORRIDOR

As noted in chapter 1, detailed analysis of related investments in a transport network requires the use of complex mathematical programming techniques once the number of interrelated investments rises above a small number. It also requires extensive data on demand relationships and traffic flows by origins and destinations. Although it was not possible to use this approach in the present strategic study due to constraints of time and resources, a case study of road and rail investment in the Melbourne–Adelaide corridor was undertaken using mathematical programming techniques. The aim was to assess the feasibility of using the approach for future investment analyses on corridor and network scales.

The Melbourne–Adelaide corridor model was constructed as a multiperiod nonlinear mathematical programming model. The corridor was divided into a series of road and rail links, and the 20 year analysis timeframe, into a sequence of two year time periods. Investments, and the impacts of the investments in terms of operating cost savings, were then defined for particular road and rail links. The timing of the investments is an output from the model and is determined in such a way as to minimise the net present value of the sum of investment in transport infrastructure and transport operating and congestion costs. Further technical details of the model are available in BTCE (1993) and Batterham and Ockwell (1991).

The Melbourne–Adelaide rail corridor was modelled as a single link with a staged program of investments that sequentially upgrade the track to initially allow double stacking of containers, then follows twenty five tonne axle loads and finally 'best practice' operating standards. These three investment projects cost a total of $595M. The road corridor was broken into 8 separate links and a series of investments projects were defined that upgrade 2 lane links to 4 lanes, and 4 lane links to 6 lanes. There were five potential road investments costing a total of $475M. The programming model calculates the combination and timing of investment projects that minimise the discounted present value of the sum of project investment capital costs and the social cost of operating the corridor over the timeframe. Note that the optimal timing of some investment projects may be beyond the timeframe which means that they are not justifiable in the period covered by the model.

Ideally demand functions would be specified for road and rail whereby the quantities carried by the two modes would depend on the prices charged. In the absence of sufficient data on demand, the model was set up assuming that freight travels by the cheapest mode. Despite the limitations of the model due to its preliminary and aggregate nature, the modelling process provided some valuable insights into the interaction between road and rail investments and into the efficacy of the modelling framework.

When no account is taken of the preferences of consignors who are prepared to use a more expensive mode in exchange for a real or perceived higher service quality, the cost minimising solution is to send as much freight as physically possible by the cheapest mode. In the present case, the model indicates that all freight should be transported by rail and that the rail line should be upgraded to double stacking as soon as possible. The model also indicates that towards the end of the 20 year planning horizon, the rail system should be upgraded to 25-tonne axle loads and 'best practice'.

This type of mathematical programming model can make a valuable contribution to the analysis of multimodal interactions and the evaluation of alternative infrastructure investment programs in a transport corridor. However its usefulness for strategic analysis of an extended program of investments over a transport system is constrained by the intensity of its data and computational requirements. The creation of a detailed model of this type requires a substantial amount of information about operational and behavioural aspects of the transport system. Key inputs are accurate values for the cross elasticities of demand and a set of demand functions that faithfully reproduce the behaviour of purchasers of transport services. This information can be difficult to assemble even for a limited study of a single corridor. This does not preclude the use of a mathematical programming approach but reinforces that it is a sophisticated technique that demands painstaking research along with considerable technical expertise and resources, if it is to be successfully implemented in a transport investment framework.

CHAPTER 4 INTERACTION BETWEEN SEA AND RAIL TRANSPORT

The relationship between rail and sea modes can be either competitive or complementary depending on the characteristics of the freight market. For domestic transport over long distances, coastal shipping is slower than rail but, under certain circumstances, can offer lower unit costs and hence a package of price and service attributes that is competitive with rail transport. For Australian international trade, rail and sea modes do not compete, but rail can provide the vital land link and complement the service provided by international shipping. The first and second order effects of both types of modal interaction will be considered in this section of the report.

The interaction between sea and rail modes is somewhat different than that between road and rail because there is no fixed linehaul infrastructure for sea transport. As a result, interactions between rail and shipping services will be expressed at the sea ports in terms of implications for port development and investment.

COMPETITION : COASTAL SHIPPING

Reforms in shipping and on the waterfront have produced significant gains in efficiency (BIE 1993, BTCE 1994a). In addition, shipping has been promoted as offering advantages in terms of energy efficiency, lower generation of greenhouse and other emissions, and reductions in road congestion. This has prompted a reappraisal of the role of coastal shipping as a possible alternative to landbased modes.

The NTPT commissioned a study of the potential feasibility of coastal shipping for nonbulk cargos (Thompson-Clarke 1994). The study investigated several coastal shipping scenarios and found that the only routes on which coastal shipping can be competitive are Melbourne–Adelaide–Perth, Melbourne–Brisbane and Brisbane–Darwin. In general, it was found that financial viability for a coastal shipping service is reliant on very long distance haulage to offset the fixed port and waterfront costs, on achieving very high load factors and on stable rail freight rates. This suggests that the future viability of coastal shipping for nonbulk cargo depends in part on rail maintaining its current price/service package. Significant reductions in rail freight rates and transit times could seriously undermine the potential viability of competing coastal shipping services.

If substantial investment in rail infrastructure is undertaken, the principal outcome will be to reduce costs and transit times and to improve reliability. For example, investment in the rail system to allow double-stacking on the Melbourne–Adelaide corridor has the potential to reduce operating costs by some 25 per cent. This order of magnitude of cost reduction could have significant impacts on the ability of coastal shipping to compete with rail for nonbulk freight.

It follows that investment in rail infrastructure has the potential to increase rail's competitiveness and substantially retard opportunities for a resurgence in coastal shipping. This does not diminish the potential for coastal shipping to provide viable services in specialised niche markets but does suggest that coastal shipping is unlikely to capture a significant share of the general cargo market.

Whether or not coastal shipping expands will have little impact on the need for port investment. Most Australian sea ports currently have sufficient capacity to cater for likely demand increases flowing from expected changes in the pattern of shipping services (BTCE 1994d). In particular, there is considerable under-utilised port facilities suitable for coastal shipping operations. Equally, further investment in port infrastructure is unlikely to produce modal shifts that impact on rail freight since sea port infrastructure capacity is not an impediment to coastal sea freight operations.

COMPLEMENTARITY : LANDBRIDGING

Sea and rail modes compete for certain types of domestic cargo but can be complementary for international cargo, particularly for landbridging operations. Landbridging refers to the intermodal movement of large numbers of international shipping containers in such a way that the consignment is transported significant distances by both sea and land modes. Typically, containers are loaded (unloaded) at a port which is not the closest port to the origin (destination) and the transport movement is completed by rail. Transport modes other than rail are not considered to be viable alternatives for transporting landbridged cargo. Road transport is a comparatively inefficient and expensive way of transporting 'blocks' of several hundred containers and coastal shipping is uncompetitive due to slower transit times (thereby negating the landbridge advantage) and the high stevedoring cost associated with multiple handling.

Several recent studies (ANL 1994, Gentle and Carlson 1992) have concluded that landbridging of substantial volumes of international shipping containers in Australia is unlikely in the foreseeable future. Unlike USA, Australia is not inherently suited to the development of landbridging. In the USA there were several conditions that were favourable to the growth of landbridging through west coast ports to mid-west and east coast markets. The conditions included substantially reduced transit times over an all-sea route (up to 12 days), large inland sources and destinations of cargo, highly efficient rail services, strong local markets at gateway ports and an imbalanced east-west trade flow leading to attractive backloading rates.

These conditions are not mirrored in Australia. Under current Australian conditions, the transit time advantage is much smaller (maximum 7 days but may be as low as one day); there are no major inland cities; the major markets of Sydney and Melbourne are not well positioned as gateway ports; rail freight rates are currently too high; and current rail volumes are small enough so that a significant volume of landbridged cargo would quickly remove any attractive backloading rates. As a result, it is likely that the majority of Australian international sea freight will continue to be loaded and unloaded at the port nearest the origin or destination.

A significant growth in landbridging in Australia will require a quantum improvement in rail performance corresponding to world's best practice operations. Double-stacking of containers on rail services is likely to be a prerequisite for obtaining the necessary rail efficiencies. It follows that investment in rail infrastructure that produces lower costs and transit times is complementary to the requirements of viable landbridging. Investment in rail, particularly investments that enable double-stacking of containers, will facilitate the development of landbridging. The benefit will then flow back to rail, since increased landbridging will in turn lead to increased rail freight volumes.

The impact on ports of investment in rail infrastructure and increased landbridging activity is likely to be mixed. The outcome of a growth in landbridging activity would be to redistribute port activity from one port to another, with improved rail efficiency enhancing the prospects of ports (notably Brisbane and Fremantle) competing to become gateway ports for landbridging services. According to BTCE (1994d) most ports have sufficient capacity to cater for likely demand increases flowing from a change in the pattern of shipping services. Therefore, the net result is likely to be better utilisation at the gateway ports, but equally, reduced utilisation at ports to which landbridging develops. Whatever eventuates, it is unlikely that increased landbridging will necessitate capacity driven investment in port infrastructure within the study timeframe.

CHAPTER 5 INTERACTION BETWEEN AIR AND ROAD/RAIL TRANSPORT

Air is the preferred mode for transport of high value, time sensitive cargo that must be transported on the same day or overnight. The high cost of air freight relative to other modes means that air will cater for small tonnages of freight in specialised niche markets. As shown in figure 1.1, the only significant competition to air freight in these markets comes from road freight in general, and particularly from overnight express road freight services. There are no significant overlaps between the markets served by air freight and those of rail and sea transport. Accordingly, this section of the report concentrates on interactions between air and road transport. Air transport shares the property of 'free' access to linehaul infrastructure with sea transport so, like the sea mode, the effects of modal interactions on infrastructure will be expressed at its ports.

THE SIGNIFICANCE OF AIR FREIGHT VOLUMES

The significance of potential interactions between air and road modes can be gauged by considering the magnitude of the current air freight market. In terms of modal share, air freight caters for less than 1 per cent of tonnages on major corridors (BTCE 1990). It follows that the volume of domestic air freight is very small compared to road freight, and is negligible if expressed in terms of equivalent road traffic volume.

The total volume of air freight on major corridors of the Australian domestic network is estimated to be only some 240 000 tonnes in 1995–96 (BTCE 1994e). This corresponds to approximately 13 000 articulated truck movements per annum or an average of some 35 truck movements per day across the entire national road network. By 2014–15, the annual volume of air freight is forecast to rise to only 390 000 tonnes (BTCE 1994e) but this is equivalent to less than 60 truck trips per day across the road network. These figures are considerably smaller than current interstate road freight traffic volumes as shown in table 3.1.

In addition, there are limited opportunities to significantly increase the modal share of the interstate freight market held by air transport. The volume of cargo that requires air transport and that can support the high cost of air freight is small in tonnage terms. Other factors that will limit the opportunity to increase the air freight modal share include the intensity of competition with road transport for express freight, and limits on the supply of air freight capacity. The majority of air freight is carried on passenger services of which the supply and pattern of activity is largely dictated by the passenger market. In effect, domestic air freight capacity is largely a subsidiary product of passenger services. It follows that there are opportunities for modal shifts from road to air freight but the tonnages are likely to be small.

Although the focus of this study is on freight movements, in the case of air transport, it is also worthwhile considering the potential for modal shifts in the passenger transport market. The air passenger market on the major interstate corridors is dominated by business travel (over 75 per cent on the Sydney–Melbourne corridor, see BTCE 1991). This market segment places a high value on transit time and convenience, and a relatively low emphasis on price, so there is little likelihood of substantial modal shift to road or a conventional rail service. Modal shifts are more likely for nonbusiness travel that is less time sensitive. On the Sydney–Melbourne corridor, the number of nonbusiness air travellers is approximately half the number of intercapital passengers travelling by road (BTCE 1991). A similar situation is duplicated on other corridors so the potential volumes of modal shifts are of the order of several hundred vehicles per day on the busiest corridors (Sydney–Melbourne, Sydney–Brisbane, Melbourne–Adelaide) and less than one hundred vehicles per day on other corridors. As shown in table 3.1, the volume of the interstate passenger transport market is smaller than the volume of intercapital freight traffic, and this constitutes a very small component of total traffic on interstate road corridors.

IMPLICATIONS FOR INFRASTRUCTURE INVESTMENT

Air transport caters for specific and specialised freight and passenger markets. There is little prospect for modal shifts of sufficient volume to have a significant impact on the need for infrastructure investment. As noted above, interstate freight tonnages and passenger numbers are very small compared to total road traffic volumes. Indeed, a doubling of air freight market share would only reduce nationwide traffic volumes by an estimated 60 truck movements per day in total. The potential impacts are much smaller than would result from road–rail modal shifts and it has already been shown that substantial modal shifts to and from rail will have a minor impact on the timing of road investments. It follows that the impact on the need for road investment of road–air freight modal shifts will be negligible.

Whereas modal shifts will have little impact on intercapital road corridors, the need for distribution of air freight by road places significant demands on the urban and regional road networks. The air freight market is very time sensitive and is largely composed of movements of high value perishable goods (fruit, flowers, fish etc) plus express delivery of non perishables. Consequently, efficient road links to the urban area and hinterland are vital for air freight operations. It follows that the most significant impact of air freight on road infrastructure investment arises from the need for efficient road linkages between the airport and the surrounding urban and regional road network.

Investment in major airport infrastructure (runways, aprons, passenger terminals, control systems) will result from high growth rates in passenger travel and is not postulated on growth in freight volumes or significant modal shifts from road transport (see BTCE 1994e). As noted above, the potential for significant modal shifts to air freight is limited and is unlikely to have a significant impact on investment in major items of airport infrastructure. Any impacts are more likely to be expressed in terms of demand for air freight terminals and associated facilities. These are typically small scale facilities that can be developed quickly on airport peripheries by private operators in response to market opportunities.

COMPLEMENTARY INVESTMENT EXAMPLES

Surface access can be a problem at major Australian airports. Experience with the development of Kingsford Smith, Melbourne and Brisbane airports indicate that the problem emerges when traffic volumes approach seven to eight million passengers per year. Each of these airports now suffers road congestion because their peak hour operations coincide with the morning and evening peak periods for urban commuter traffic.

In Sydney, airport related traffic shares the northern perimeter road (constructed for international/domestic transfer of passengers) with local traffic using the link as a short cut between the suburbs of Arncliffe and Mascot. Traffic using this short cut causes congestion at the junction of O'Riordan Street and the General Holmes Drive roundabout.

Congestion around Sydney airport will increase, with passengers processed forecast to more than double over the next twenty years.

On completion of the extension of the M5 east, M5 traffic will be injected into the Sydney Airport environs. Currently, there are restrictions on dangerous goods being carried through the General Holmes Drive tunnel which passes underneath the north–south runway. If these restrictions still apply this will force some M5 traffic to go around the airport using airport roads, thereby adding to congestion on the airport road system.

The NSW Government recently announced the go ahead for an underground rail link between Kingsford Smith Airport and the central business district. The link will be predominantly publicly funded, with the private sector undertaking the construction of the link and funding the four new stations along the link. The project is forecast to cost approximately $600M and is due to commence in early 1995 for completion in mid–1999. The link is expected to relieve road congestion to and from Kingsford Smith Airport by attracting 20 per cent of all airport generated trips.

The Federal Government is currently funding an engineering study to examine a rail corridor to link the new Sydney West Airport with the Main Southern Line, north of Campbelltown. With the development of the KSA–CBD rail link, this would provide a direct rail link between the airports. Development of the Sydney Orbital Road will join the M5 and Elizabeth Drive, providing road access to Sydney West Airport. The extension of the M5 will provide a direct road link between the airports.

Melbourne Airport suffers generally similar problems via the Tullamarine freeway. Since the airport was first opened in 1970 with a new high speed expressway between the CBD and the then remote Tullamarine airport, residential and other development has occurred adjacent to that transport corridor. The road traffic in the morning and evening peak hours now severely inconveniences air travellers connecting with their flights. Plans outlined by the Federal Airports Corporation to develop Melbourne Airport into a major freight hub, known as 'Freight City', will require major road development, with a dedicated freight road identified as a possibility. Rail links to Tullamarine are also under investigation.

Brisbane Airport currently processes 7.9M passengers, increasing to a forecast 19.2M in a twenty year period. It suffers traffic congestion around Kingsford Smith Drive and Newstead Road. Currently, congestion is marginal, but with the forecast growth in airport passengers, it should not be ignored. However, the issue has not been addressed in this report.

Although total passenger throughput at Adelaide airport will not reach the volumes currently experienced at Sydney, Melbourne or Brisbane by the end of the study period, already there are indications that the road feeder system is approaching capacity during peak hour. Further, any extension of the main runway will require either the realignment of Tapleys Hill Road or a tunnel to be built under the runway for the road.

CHAPTER 6 CONCLUDING COMMENTS

The overall conclusion is that modal interactions and associated modal shifts are unlikely to have a major impact on the need for or timing of infrastructure investment, or on externalities associated with interstate freight transport.

Road traffic on major interstate corridors is dominated by local and regional vehicle movements. Intercapital light and heavy vehicle movements are minor components of traffic, even on the most lightly trafficked links of each corridor. As a result, capacity driven investment will be largely stimulated by growth in local and regional road traffic and will not be greatly influenced by modal shifts from rail or air, or by changes in heavy vehicle technology. If the AADT thresholds for investment are higher, then modal shifts will have an even smaller impact on the timing of road projects. For the same reasons, modal shifts will have a small effect on externalities such as emissions, congestion, and accidents.

Investment in rail infrastructure that leads to significant operating efficiencies has the potential to substantially retard opportunities for a resurgence in coastal shipping. Conversely, the same investments can create a rail transport system that is conducive to the development of landbridging of international sea freight and hubbing of sea freight services on gateway ports. This has benefits for both rail and sea ports but is unlikely to necessitate capacity driven investment in sea ports.

Investment in airport infrastructure (runways, aprons, terminals, control systems) will result from high growth rates in passenger travel and is not postulated on significant modal shifts from road transport. Modal shifts between air and road will have negligible impact on the need for investment in road infrastructure.

Finally, the process of investigating interactions between the modes has highlighted areas in which current information and understanding is deficient, and aspects of the study that could be improved if it was repeated. The primary lesson that has been learnt from the study is to adopt a network and multimodal approach from the outset. A significant component of the freight market is not captive to any particular mode or route. This means that the various modes and routes/corridors cannot be considered in isolation from each other. This holistic approach should flow from the identification and forecasting of demand through the complete chain of analysis. Particular areas which warrant further research include:

- the fundamental processes underlying the mode and carrier choice process in Australian freight transport. There is an established body of research in this area, including studies relating to Australia conditions (Gilmour 1976, Ogden and Rattray 1982, D'Este and Meyrick 1989, D'Este 1992), but there is scope for the development of a comprehensive theory that can be applied to practical problems in an Australian context;
- the structure of the Australian freight transport market and its disaggregation into contestable *(in the sense of open to competition rather than the strict economic sense)* and captive sub-markets;
- the significance of service quality factors (reliability, ease of use, etc) and information factors (EDI, consignment tracking etc) in shipper decision making, and techniques for incorporating these factors into a choice model; and
- complementarity between the modes. Traditionally the modes have been viewed as alternatives in competition with each other. The growth of intermodal transport services and the use of feeder modes opens opportunities for investigation of the impact of modal integration on infrastructure and regulatory frameworks.

The lessons and areas for further research can be synthesised into a recommendation for the development of an integrated and modular network-based model of the core freight transport network on a national basis. The model should be integrated at several levels. It should include all relevant modes, and integrate freight flow database functions, demand forecasting, mode/route assignment, and impact and adequacy analysis in a single framework. Further, a modular approach would allow each of the components to be developed, refined and upgraded independently and the various modules to be at different stages of refinement, while still providing a fully functional research environment.

REFERENCES

ABBREVIATIONS

ABARE	Australian Bureau of Agriculture Economics
ABS	Australian Bureau of Statistics
ANL	Australian National Line
BIE	Bureau of Industry Economics
BTCE	Bureau of Transport and Communications Economics
DASETT	Department of the Arts, Sport, the Environment, Tourism and Territories
NRC	National Rail Corporation
NTPT	National Transport Planning Taskforce

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ABBREVIATIONS

AADT	Annual Average Daily Traffic
ABARE	Australian Bureau of Agriculture Economics
ABS	Australian Bureau of Statistics
ANL	Australian National Line
BIE	Bureau of Industry Economics
BTCE	Bureau of Transport and Communications Economics
CO_2	Carbon di-oxide
DASETT	Department of the Arts, Sport, the Environment, Tourism and Territories
NRC	National Rail Corporation
NTK	Net Tonne-Kilometre
NTPT	National Transport Planning Taskforce