Mainline Upgrading - Evaluation of a Range of Options for the Trans Australia Link

Report

For the purposes of this study the east-west rail link across Australia was considered in sections: Sydney to Broken Hill, Broken Hill to Port Pirie (including Adelaide to Peterborough and Adelaide to Port Pirie), The Port Pirie Bogie Exchange and Port Pirie to Kalgoorlie. For each section the study procedure adopted was similar to that used in previous BTE studies with possible upgrading options evaluated in light of the forecast growth in traffic. Upgradings were evaluated from both a commercial and a resource cost point of view.

BUREAU OF TRANSPORT ECONOMICS

MAINLINE UPGRADING - EVALUATION OF A RANGE OF OPTIONS FOR THE TRANS AUSTRALIA LINK

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FOREWORD

This report is part of a series produced by the Bureau of Transport Economics as part of a general assessment of railway freight operations. It covers the evaluation of a number of options to upgrade the east-west link between Sydney, Adelaide, Port Pirie and Kalgoorlie.

Apart from the problem of the Bogie Exchange at Port Pirie there appears to be no significant capacity constraint likely to occur in the foreseeable future. Some extension of the system of Centralised Train Control can be justified, as can some investment in extension and addition of crossing loops, but the only major investment which would appear to be justified is the automation and possible relocation of the bogie exchange.

The study was primarily the work of L. Krbavac of the Operations Research Branch under the general direction of R.W.L. Wyers.

I would like to acknowledge the cooperation and assistance provided by the management and staffs of NSW Public Transport Commission, Australian National Railways Commission, South Australian Railways and Westrail in the conduct of the study.

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Acting Director

Bureau of Transport Economics
Canberra
March 1978

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SUMMARY

This report is one of a series by the Bureau on mainline upgrading which forms part of a general assessment of railways freight operations which is being undertaken at the request of the Australian Transport Advisory Council (ATAC).

For the purposes of this study the east-west rail link across Australia was considered in five sections:

- Sydney to Broken Hill
- Broken Hill to Port Pirie (including Adelaide to Peterborough and Adelaide to Port Pirie)
- The Port Pirie Bogie Exchange
- Port Pirie to Kalgoorlie
- Kalgoorlie to Perth

Evaluation of possible upgradings to the Kalgoorlie-Perth link are presented in a separate report. This report covers the first four sections.

For each section the study procedure adopted was similar to that used in previous BTE studies with possible upgrading options evaluated in light of the forecast growth in traffic. Upgradings were evaluated from both a commercial and a resource cost point of view.

For the Sydney-Broken Hill link no consideration was given to upgrading the Sydney to Lithgow section. Requirement for additional capacity there is dependent upon the growth of coal traffic and this cannot be predicted at this time. A full study will be required once the coal export position has been clarified.

No upgrading of the Lithgow to Broken Hill section is necessary on capacity grounds, but the introduction of Centralised Traffic Control (CTC) between Orange and Molong can be justified immediately on grounds of reduced operating costs. Introduction of

CTC between Molong and Parkes is marginal on direct cost savings grounds, but, on balance, it would seem sensible to instal the system through to Parkes.

Extension of crossing loops between Orange and Parkes is considered to be a marginal proposition at present and should be delayed for two or three years to assess actual traffic growth.

Indications are that there will be no significant congestion on the main links in South Australia over the next 20 years. On cost savings grounds installation of CTC can be justified on the Adelaide-Port Pirie link, but not on the Adelaide-Peterborough link. Possible extension of crossing loops on the Adelaide-Port Pirie line should be considered by the railways as a possible cost saving measure.

Immediate upgrading of the bogie exchange facility at Port Pirie is justified and relocation to a new site should be undertaken in three to five years' time, if standardisation of the Adelaide-Port Pirie link is not completed within 10 years. If it is anticipated that standardisation will be complete inside 10 years, then the bogie exchange should be upgraded immediately and then transferred to Adelaide following standardisation.

The greater question of whether or not standardisation is justified is beyond the scope of this particular study. However, limited analysis has indicated that standardisation of the Adelaide-Port Pirie link would not be warranted before 1985-86. The position should be re-examined at that time in light of actual growth patterns for traffic.

No upgrading of the Port Pirie-Kalgoorlie link is justified in the immediate future. The possibility of additional crossing loops should be reexamined in about five years time in light of actual traffic growth patterns.

CHAPTER 1 - INTRODUCTION

This report forms part of a general assessment of rail freight operations conducted by the Bureau of Transport Economics (BTE) which was initiated by a request from the Australian Transport Advisory Council (ATAC) in July 1973. It presents an evaluation of possible upgrading options for the east-west rail link between Sydney and Kalgoorlie. Studies have now been completed for upgrading of all the intercapital rail links on the Australian mainland.

Because of the fact that three separate railway systems are involved in the operation of the Sydney-Kalgoorlie link, and because the bogie exchange operation at Port Pirie is a major factor in the system operation, the main body of this report is divided into four stand-alone parts. The intention has been to make each part present a complete evaluation for a particular part of the east-west link which may be read and acted upon by the individual authority concerned. The breakdown is as follows:

Part 1: The Sydney-Broken Hill Line
Part 2: The South Australian Section
Part 3: The Port Pirie Bogie Exchange
Part 4: The Port Pirie-Kalgoorlie Line.

A separate report has been prepared on the Kalgoorlie to Perth link because the basic reasons for upgrading on that section are different from those applying on the remainder of the link, and, indeed for the remainder of the lines evaluated by the BTE in the present series of studies.

The evaluation procedures adopted in this study have been the same as those in similar studies of this type. Traffic forecasts were made for a twenty year study period and train movements were simulated to ascertain when and where congestion was likely to occur. A range of possible upgrading options was then examined and those judged most effective in reducing congestion were further analysed to determine the optimal time for implementation.

Two bases were used for evaluation. The options were first evaluated on the basis of their impact on the financial viability of the railway operation, i.e. from a commercial standpoint. Secondly the upgrading options were judged on the basis of their economic impact on the community as a whole. That is, the resource costs to the community were used as a basis for evaluation, including the costs associated with diverting traffic from rail to road when rail capacity was reached.

PART 1

THE SYDNEY TO BROKEN HILL LINE

CHAPTER 2 - DESCRIPTION OF EXISTING FACILITIES

PHYSICAL LAYOUT

The Western Line from Sydney to Broken Hill is 1125 km long; it is double track from Sydney to Bathurst and mainly single track from Bathurst to Broken Hill.

The line is electrified from Sydney to Lithgow. Both crews and locomotives are changed at Lithgow for the haul to Broken Hill. For the purposes of the study the two parts of the line have been treated separately. Main emphasis has been placed on the sections between Lithgow and Broken Hill since the section between Lithgow and Sydney is not expected to become congested during the twenty year study period. Upgrading the Sydney-Lithgow link may need to be reconsidered if there is rapid growth in the export coal traffic.

Figures 2.1, 2.2 and 2.3 present a schematic diagram of the line from Lithgow to Broken Hill showing the position and length of crossing loops.

The section from Lithgow to Bathurst operates under normal double line working while the section from Bathurst to Molong operates under the Electric Train Staff system. All stations or intervening crossing loops are manned by signalmen at most times of day.

The Molong to Broken Hill section operates under the ordinary Train Staff system; no station on this section is attended by signalmen. At unmanned stations, crossing trains incur a delay of at least 8-10 minutes.

Distance from Sydney (km)		Loop Length (m)
0	SYDNEY	
156	LITHGOW	
240	BATHURST	1500(4)
252	GEORGE'S PLAINS	457
256	TUMULLA	387
263	WIMBLEDON	399
273	NEWBRIDGE	-
287	MURROBO	-
290	BLAYNEY	609
297	POLONA	386
303	MILLTHORPE	574
309	SPRING HILL	-
323	ORANGE	-
332	NASHDALE	395
338	BORENORE	698
350	GAMBOOLA	405
360	MOLONG	403

FIGURE 2.1

POSITION AND LENGTH OF LOOPS

SYDNEY-MOLONG

Distance from Sydney (km)		Loop Length (m)
360	MOLONG	403
385	MANILDRA	641
407	BUMBERRY	401
430	COOKAMIDGERA	648
446	PARKES	1500(4)
448	GOOBANG JUNCTION	500
483	BOGAN GATE	561
505	YARRABANDAI	914
546	CONDOBLIN	858
592	GUNEBANG	521
619	EUABALONG WEST	519
633	MELLELEA	396
666	MATAKANA	914
707	ROTO	519
750	TRIDA	916
770	CONOBLE	523
816	IVANHOE	680

FIGURE 2.2

POSITION AND LENGTH OF LOOPS

MOLONG-IVANHOE

Distance from Sydney (km)		Loop Length (m)
816	IVANHOE	680
848	ORICAR	579
881	DARNICK	914
900	MANARA	533
944	KALEENTHA	914
1007	MENINDEE	512
1035	BOX-TANK	512
1066	KINALUNG	914
1096	THE GORGE	488
1125	BROKEN HILL	1500(4)

FIGURE 2.3

POSITION AND LENGTH OF LOOPS

IVANHOE-BROKEN HILL

TERMINALS

The effect of traffic growth on the operation of terminals was not considered in this study. Clearly the capacity of terminals to handle increased traffic must be considered in parallel with upgrading of lines if total system capacity is to be increased. However, one element of terminal operations was considered implicitly in the study. This arises from the fact that benefits of longer loops depend on use of longer trains and this implicitly demands an improvement in the facilities for train marshalling at Parkes. The study took account of the development necessary at Goobang Junction to allow use of longer trains.

CURRENT TRAFFIC

The gross tonneage along the line decreases with distance from Sydney. In 1975-76, total of UP and DOWN traffic between Sydney and Lithgow was over 8 million gross tonnes and between Parkes and Broken Hill it was just under 2 million.

In this study, the trains on the line were divided into five different classes, depending on the relative importance of the traffic they carry. The priority allocated to each class for the purpose of computer simulation is shown below. These priorities coincide approximately with those used when the timetables are prepared. The priority given to any train on any particular day by a train controller does, of course, take account of many additional factors.

Priority	Train Type
1	Indian Pacific
2	Passenger Motors
3	Fast Goods
4	Goods
5	Wheat
6	Ore

The distribution of traffic within these train classes for a typical busy day in 1976 is given in Table 2.1.

TABLE 2.1 - NUMBER OF TRAINS IN EACH PRIORITY CLASS

Section	Priority Class						
	1	2	3	4	5	6	Total
Lithgow-Orange	2	12	6	12	4	1	37
Orange-Molong	2	4	6	8	4	1	25
Molong-Parkes	2	4	6	6	2	1	21
Parkes-Broken Hill	2	1	6	6	0	1	16

In addition there are a number of low priority trains which are run on an as required basis and are scheduled so as not to interfere with operations of the trains indicated in the table. For the purposes of calculating capacity and for simulating train movements these trains have been ignored.

Freight trains on this line average about 1000 gross tonnes each, while, under existing conditions, the present maximum trailing load is 1230 gross tonnes.

CHAPTER 3 - RAIL TRAFFIC PROJECTIONS

The preparation of traffic forecasts for use in this study was undertaken in two steps. Firstly the expected growth in total traffic between centres was estimated and, secondly, factors affecting the proportion carried by rail were assessed. The study is primarily concerned with freight traffic, but passenger traffic must be included in the assessment since passenger trains are important in determination of the degree of congestion on a line.

For the purposes of analysis three forecasts have been produced. They are:

(a) the expected traffic on the railwav;

(b) an optimistic forecast of the traffic on the railway (i.e. the maximum traffic likely to eventuate); and

(c) a pessimistic forecast of the traffic on the railway (i.e. the minimum traffic likely to eventuate).

The optimistic and pessimistic forecasts were prepared primarily as a basis for investigating the sensitivity of the evaluation results to changes in traffic. In practice the optimal timing of upgrading depends heavily on the traffic patterns and sensitivity analysis makes it possible to adjust the year of implementation to match the pattern of traffic growth which actually occurs.

For the purposes of forecasting the freight traffic has been divided into general goods and various special commodities (wheat, ores, coal, etc.) which are of major importance and which exhibit growth patterns different from qeneral goods. In the case of general goods, interstate and intrastate traffics have been treated separately.

In formulating projections account was taken of the demise of the ASP shipping service between the east coast and Perth, and of port development at Botany Bay which has an important bearing on projected coal traffic on the east-west line.

FREIGHT TRAFFIC

General goods traffic on the line may be forecast in two separate components:

(a) interstate movements; and
(b) intrastate movements.

General goods movement interstate is generally between capital cities and growth is expected to parallel the general economic growth of the country as a whole. It is anticipated that overall growth in this traffic will be at a rate of 4 per cent per annum compounding over the next ten years and falling off slightly after that in line with expected fall in the rate of population growth. The growth in intrastate general goods traffic is heavily dependent on development of the Bathurst-Orange growth centre. Based upon planned development it is estimated that general goods traffic from Sydney to Orange will increase at a rate of 5 per cent per annum compounding for the first ten years and at a rate of 7 per cent per annum after that. Traffic to other areas, e.g. Parkes and Broken Hill, is expected to grow at about 2.5 per cent per annum throughout the study period. There is expected to be no growth in east bound intrastate general goods traffic.

There are no known factors likely to cause a change in the modal split for general goods in the corridor concerned and so projections are made from a base of a notional 1974-75 rail traffic level. This notional base level was obtained by removing short term trends from the actual rail traffic figures for the period 1969-70 to 1974-75.

The general freight projections used in the evaluation are summarised in Table 3.1.

There are three major commodities which move on the western line in N.S.W. and which need separate assessment with respect to their likely growth; these are wheat, ores and coal.

Wheat from the centre and west of the state flows to the Sydney area for export. The actual tonneage carried varies from year to year, depending upon seasonal factors and the state of the world wheat market. However the Bureau of Agricultural Economics has indicated that wheat production in N.S.W. is unlikely to show any general increase over the next ten to twenty years either as a result of increased productivity or of expanded plantings. Thus, for the purposes of this study total wheat movements were assumed to be static over the study period. There appears to be no reason why any change of mode should occur in the foreseeable future and so wheat traffic by rail has been assumed to be constant at the median level for the last six years. For the purpose of modelling traffic flows the origins of the wheat traffic have been assumed to be 490,000 net tonnes per year from Molong and 274,000 net tonnes per year from Parkes.

Mineral ore traffic moves from Broken Hill to the Metropolitan region and is not expected to change significantly in the study period. Thus the median tonneage for the last six years (200,000 tonnes per year) was assumed for analysis.

The third major commodity flow on the NSW sections of the east-wes link is coal from the Lithgow area to Sydney. The problem of forecasting the growth in this traffic is made particularly difficult by the uncertainty surrounding the development of new port facilities in the Sydney area. At this stage it is not possible to predict whether a major upsurge in coal exports througl Sydney will occur or whether the expected export orders will be met from other sources. In the former case it is likely that there

TABLE 3.1 - FORECAST GENERAL GOODS TRAFFIC GROWTH

Origin/ Destination	Westbound Traffic				Eastbound Traffic			
	1974-75 Volume ('000 net tonnes)	Growth Rate (% per year)			1974-75 Volume ('000 net tonnes)	Growth Rate (% per year)		
		Pessimistic	Expected	Optimistic		Pessimistic	Expected	Optimistic
Orange	463	2.5	5.0 to 1985-86 then 7.0	7.0	240	0.0	0.0	2.5
Parkes	125	0.0	2.5	3.5	100	0.0	0.0	2.5
Broken Hill	12	0.0	2.5	3.5	86	0.0	0.0	2.5
Interstate	325 (a)	2.0 (b)	4.0 to 1985-86 then 2.5	5.0	264 (a)	2.0 (b)	4.0 to 1985-86 then 2.5	5.0

(a) An addition is made to the base in 1975-76 representing the component from demise of the ASP shipping service.

(b) Assumes also that coastal shipping resumes in 1981-82 and ASP component falls to zero from then on.

would be a rapid growth in coal traffic on the western line while in the latter case the coal traffic between Lithgow and Sydney is likely to remain static over the study period.

PASSENGER TRAFFIC

Historically, passenger traffic by rail has been in a state of stagnation or decline with only a few exceptions, and this condition has been assumed to continue. The Indian Pacific, operatin a service four times a week in 1975-76, has been assumed to increase to a daily service by 1985 and then to remain at that level. Presently operating diesel and rail motor services are expected to continue for the period of the study.

CHAPTER 4 - UPGRADING ALTERNATIVES

Preliminary analysis has indicated that there is unlikely to be major congestion on the Sydney to Broken Hill link within the time horizon of the study. This would be the case even if the present practice of running 1230 gross tonne general goods trains between Lithgow and Broken Hill is continued. However, the NSWPTC has been considering the use of longer trains, and the introduction of CTC between Orange and Molong as measures for cost saving. Both these proposals would also reduce the likelihood of congestion.

The main proposal is to introduce trains up to 2500 gross tonnes in the UP direction between Broken Hill and Sydney and combine 1230 gross tonne DOWN trains at Parkes to form 2500 gross tonne units for the run to Broken Hill. This would involve the extension of eleven passing loops and upgrading of the yard at Goobang Junction to permit the handling of long trains.

CENTRALISED TRAFFIC CONTROL

The introduction of CTC on densely trafficked lines has two major benefits. Firstly, it reduces the delays experienced at unmanned crossing loops from about 8 to 10 minutes, required for manual setting of switches and points, to about 1 minute. This leads to both an increase in line capacity and more effective utilisation of crews and rolling stock. The second major benefit from CTC is that it allows considerable manpower savings in reduced manning of stations. In addition, centralised control may lead to more effective scheduling by facilitating the train controller's task and thus may increase line capacity indirectly. This latter benefit has not been quantified in this study.

NSWPTC has plans to instal CTC equipment on all crossing loops between Orange and Parkes, but for the purposes of this study an additional alternative case has been considered involving the installation of CTC from Orange to Molong only. The capital costs and manpower savings for these two schemes are given below.

(i) <u>CTC Scheme 1 - Orange to Molong</u>

There is a need to signal 5 loops on this line. The capital cost of this scheme is estimated to be:

	$(1976)
- Signal 5 loops @ $160,000 each	800,000
- CTC equipment @ $25,000/loop	125,000
- Linewires (37km) to carry CTC supervisory circuits and signalling interlocking circuits @ $2,800 per km	103,600
	1,028,600

Savings accrue from the introduction of CTC because all stations may then operate without signalling staff. The saving in manpower is estimated at $140,000 per annum, which includes the base salary and allowances for 20% overtime and 25% railway standard on-costs for the 14 staff saved.

(ii) <u>CTC Scheme 2 - Orange to Parkes</u>

In addition to the 5 loops of the CTC Scheme 1, there is need to signal 4 additional loops.

The capital cost of this scheme is estimated to be:

	$(1976)
- Signal 9 loops @ $160,000 each	1,440,000
- CTC equipment @ $25,000 per loop	225,000
- Linewires (123km) @ $28,000 per km	344,400
	2,009,400

The definite benefits of this scheme are the savings on wages of the 14 staff on the Orange to Molong line and the possible avoidance of having to employ up to 10 staff on the Molong to Parkes section. The total possible savings are $240,000 per year.

LOOP EXTENSIONS

The number of trains to perform a given task may be reduced by running longer trains. There are obvious advantages in doing this: firstly, there are savings in crew wages (which account for 10% to 15% of line haul costs); secondly, there may be savings in locomotive capital costs, for locomotive prices are less than proportional to their engine power; thirdly, it is quite possible that by having fewer trains on the line, the total delays to all trains may be lower, even though the average delay per train may have increased (due to the longer trains not being able to effect a crossing at some of the shorter crossing loops); and finally, capacity may be increased.

In order to be able to run longer trains, some passing loops must be extended and marshalling yards must be enlarged to accommodate the longer wagon consists.

As mentioned previously NSWPTC is considering the option of introducing longer trains, particularly on the 685 km line haul between Parkes and Broken Hill (this section is 61% of the total Sydney to Broken Hill run). The proposal is for 2500 gross tonne trains (about double the present size), pulled by the equivalent of 2 mainline locos (No. 44). The train consist would be the equivalent of 66 bogie wagons or about 880 metres long. Of the major crossing loops between Broken Hill and Parkes only six are 914 m long.

This proposal has now been extended, so that in the UP direction only, the longer trains from Broken Hill would continue as long trains past Parkes and into Sydney. In the DOWN direction, the shorter (1230 gt) trains would run from Sydney to Parkes and then they would be amalgamated into 2500 gross tonne trains to continue the journey to Broken Hill.

In order to be able to do this, at least 7 loops, and possibly 11 loops, between Broken Hill and Bathurst need to be extended to at least 900 metres. In addition to this, the Goobang Junction yard must be expanded to permit the marshalling and amalgamation of shorter DOWN trains into longer trains.

Three loop extension schemes have been assessed in this study. The first involves the extension of loops at Menindee, Ivanhoe, Euabalong, Bumberry, Molong, Borenore and Tumulla plus the improvements needed at Goobang Junction. The second scheme involves additional loop extensions at Cookamidgera and Gamboola. The third scheme requires extensions also at Manildra and Nashdale. The capital costs for the three options are given below.

		$(1976)
(i)	Scheme 1	
	Improve Goobang Junction	1,000,000
	Extend 7 loops to 900m @ $90,000 each	630,000
	Total	1,630,000

		$(1976)
(ii)	Scheme 2	
	Improve Goobang Junction	1,000,000
	Extend 9 loops to 900m @ $90,000 each	810,000
	Total	1,810,000

		$(1976)
(iii)	Scheme 3	
	Improve Goobang Junction	1,000,000
	Extend 11 loops to 900m @ $90,000 each	990,000
	Total	1,990,000

OPTIONS EXAMINED

Combining the two CTC alternatives with the three loop extension options gives six alternative upgrading schemes which were assessed during the study. For the purposes of this report the options are referred to as Scheme 1A, 1B, 2A, 2B, 3A and 3B where the number refers to the loop extension scheme in the order listed above and the letter A refers to the option of full implementation of CTC from Orange to Parkes while the letter B refers to implementation of CTC only between Orange and Molong.

CHAPTER 5 - METHOD AND ASSUMPTIONS

The question of how and when to upgrade a railway line is not a simple one. Given a traffic forecast, the problem is essentially one of trading off the reductions in transport costs resulting from the upgrading against the cost of introducing the upgrading. Like any other production facility, railway lines exhibit an increasing average cost characteristic as output is increased beyond a certain point. The main source of additional cost is congestion, reflected as increased train crew costs and motive power investment. The ultimate point is reached beyond which the railway can no longer carry any further increase in traffic and further growth in freight movements is diverted to alternative transport modes which generally incur higher costs. This suggests two points of view for economic evaluation of railway line upgrading; firstly, the commercial viewpoint which, in essence, is a profit maximising exercise, and secondly, the resource viewpoint which takes into account the additional cost of having to divert traffic to another mode.

In this particular case, however, the problem was simplified by the fact that projected traffic during the study period was not high enough to cause diversion to another mode. That is the railway is not expected to encounter capacity limitations within the study time horizon. Thus the assessment was undertaken from the commercial viewpoint.

The analysis of the upgrading from the commercial viewpoint, being a profit maximisation, requires not only an estimate of the direct and indirect costs of carrying the growth in traffic, but also an estimate of the revenue generated by that traffic. There are several reasons why the revenue rate should be dependent on the demand and supply characteristics of the system, but experience suggests that it is valid to regard revenue rate as a constant over the study period. The average revenue rate for traffic on the Sydney to Broken Hill link has been taken as 1.42 cents/tonne km.

The alternative upgrading options were assessed using the following broad approach. Firstly freight demand was estimated for each year of the study period and this was used to calculate the number of trains in each direction for an average busy day. Movement of the resulting traffic was then simulated to ascertain the level of delays for both the existing and upgraded line configurations. The estimated delay characteristics were then translated into delay costs which were used to calculate annual net revenues. Finally the optimum timing of introducing an upgrading was determined based on maximising the present value of the net revenue.

TRAIN MOVEMENTS TO MEET EXPECTED DEMAND

Since interstate freight is the only growth area in rail traffic, all other traffics were assumed to operate indefinitely on the present timetable. In practice, the timetable would be adjusted periodically to take account of operational and demand changes, but it is assumed that in terms of the trend of growing congestion delays, the effect of these adjustments may be ignored.

In the particular case of Sydney-Broken Hill, heavier trains would not be practical until the introduction of an upgrading measure which involves crossing loop extensions.

In fact, the scheduling of new interstate trains is complex because such trains, in the course of their journey, travel on several railway systems which have distinctly different operating practices. Because the consists of trains remain constant at most within one railway system, it is not even possible to speak of an interstate train as an entity for the whole trip between the origin and the destination. For example, a wagon leaving Sydney on its way to Perth will be reassembled into different consists at Broken Hill, Peterborough, Port Pirie and Kalgoorlie.

As an example of the considerations involved in the scheduling of trains which carry interstate goods, consider the introduction of new train out of Sydney; its scheduling will depend on at least three factors:

- its ability to connect with a west bound train out of Broken Hill,
- constraints on its departure time out of Sydney marshalling yards,
- The requirement that the total door-to-door time be about 2 days for freight-forwarder's consignments from Sydney to Adelaide and about 4 days between Sydney and Perth.

With respect to the first of these points, westbound trains out of Broken Hill are longer than trains arriving from Sydney, so that it is generally necessary for two trains to arrive from Sydney before one westbound train may be assembled. Trains out of Sydney would then be expected to arrive pairwise into Broken Hill. If, in order to meet increased traffic out of Sydney, it is necessary to schedule new westbound trains out of Broken Hill, then the whole chain of train connections must be examined in the light of the three factors outlined above.

With regard to the departure time of trains, it is generally preferred by freight forwarders that the trains out of Sydney should leave as late as possible in the afternoon, to allow them the daylight working day for the loading of wagons. For similar reasons, the preferred time of arrival into Sydney is the early morning.

Similar types of constraints apply in scheduling eastbound trains from Broken Hill.

The following broad assumptions were made in developing notional timetables to cope with the expected traffic over the study period:

(a) In calculating the number of trains/day, given a freight forecast and train weight, it is unrealistic to assume that the traffic would be uniformly distributed across 365 days/year. From an examination of the timetable it has been estimated that the 'average busy day' traffic may be calculated on the basis of 312 days/year.

(b) Existing intrastate freight trains were assumed to be sufficient to carry future intrastate traffic with present 'conditional' trains made regular.

(c) The arrival and departure of intrastate traffic is less critically constrained than that of interstate traffic although a limited number of intrastate trains should leave Sydney in late afternoon and arrive at their destinations as early as possible the following day.

(d) During the early part of the study period, interstate freight trains are timetabled to depart during normal working hours in order to defer the introduction of multiple shifts for as long as possible. However, more overtime may be worked. Because of delays imposed by existing goods yards (especially Sydney), a minimum of 90 minutes is generally required between the departure of consecutive trains. Thus, at the beginning, the working day is filled in at 1.5 to 2.0 hour intervals.

(e) By about 1980, it is likely - according to some freight forwarders - that city congestion or legislation will force most freight to be delivered at night. It is therefore likely that train departure times between 10 pm and 6 am would be introduced. Thus, existing loading and unloading facilities would be more fully utilised and the traffic on the line would become more evenly spread by making use of what now amounts to an 'off-peak' period.

CHAPTER 6 - EVALUATION OF OPTIONS

Table 6.1 shows the number of inter and intra state trains needed to carry the traffic forecast for the study period. Year 1 corresponds to 1975-76.

It should be noted that the interstate general goods train requirement for 1975-76 is less than the number of trains actually run at that time. The reason for this is that it is NSWPTC policy to run three trains per day between Sydney and Broken Hill, with a possible fourth if needed. In general, however, the three trains are not loaded to full capacity and the goods could be carried by fewer trains. This approach has no significant effect on the assessment of options since it is reasonable to assume that these trains would be loaded to full capacity before any additional trains were scheduled to carry the increased freight available during the study period.

Figure 6.1 shows the delay curves for the existing and upgraded line configurations when the general freight traffic grows at the 'expected' forecast rate. The delays are plotted in the form of a congestion factor which is defined as the average delay/train divided by the base average transit time/train. The graph presented in Figure 6.1 is the delay function for the line when all trains (passenger, general freight and other) are included.

It may be observed that the upgrading proposals appear to increase delay in some cases. This is because the upgrading allows an increase in the size of trains from some 1230 to 2500 gross tonnes. These longer trains suffer greater individual delay, but the overall total delay is reduced because fewer trains are operating.

Three points should be noted about these graphs

(i) Normalising delay patterns along all mainlines in Australia in this way permits comparisons to be made between lines on a common basis.

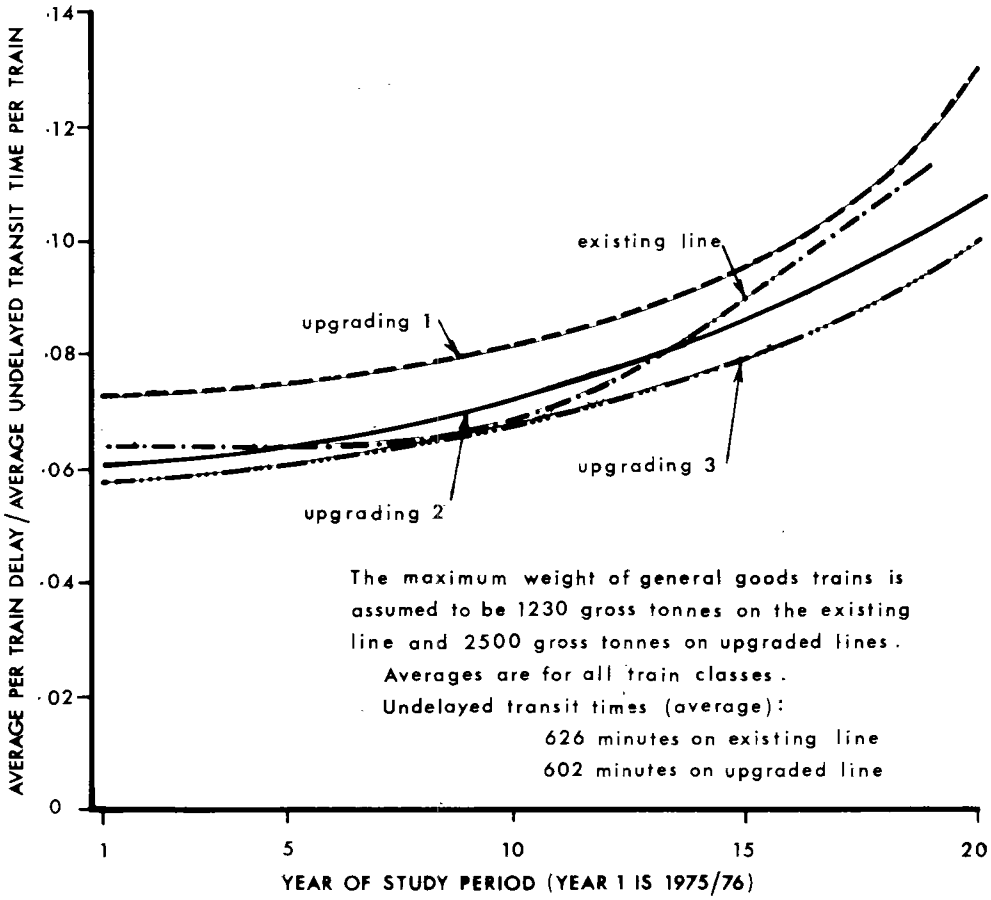

FIGURE 6·1

DELAY CHARACTERISTICS ON THE BROKEN HILL–LITHGOW LINE FOR FORECAST TRAFFIC

(ii) Experience gained in previous studies and working with the present one has shown that unless the congestion factor for a particular line configuration exceeds about 0.20 to 0.25 during the 20 year study period, it is unlikely that any upgradings can be economically justified on the sole grounds of increasing capacity.

(iii) Congestion graphs for each line give an indication of the order in which the lines are likely to become bottlenecks and thus they provide a basis for establishing a priority order in which the lines are to be upgraded.

(iv) The graphs do not, however, give any definite guide to the <u>optimal timing</u> of these upgradings.

SYDNEY TO LITHGOW SECTION

No major upgrading options for this section have been assessed since it is clear from a preliminary examination that no congestion problems are likely to occur within the study period. Any requirement for additional capacity is likely to be generated by the possible shipment of coal through Botany Bay and the associated railway costs and revenue together with alternative methods of financing upgradings would need to be examined in detail once decisions for development had been made in principle. Such matters are clearly outside the scope of the present study.

LITHGOW TO BROKEN HILL - CTC OPTIONS

As indicated previously, the two options examined are for introduction of CTC between Orange and Molong, and the introduction of CTC over the whole section from Orange to Broken Hill.

The introduction of CTC between Orange and Molong can be justified simply on the grounds of savings in signalling manpower costs. As previously indicated NSWPTC estimate a saving of $140,000 per year in wages cost and this would justify the capital expenditure of

TABLE 6.1(A) - NUMBER OF INTERSTATE FREIGHT TRAINS/BUSY DAY

EXPECTED FORECAST

Year	Sydney-Broken Hill		Broken Hill-Sydney	
	Short Trains [a]	Long Trains [b]	Short Trains	Long Trains
1	2.1	1.1	2.1	1.1
2	2.2	1.1	2.2	1.1
3	2.3	1.1	2.3	1.1
4	2.4	1.2	2.4	1.2
5	2.5	1.2	2.5	1.2
6	2.6	1.3	2.6	1.3
7	2.7	1.3	2.7	1.3
8	2.8	1.4	2.8	1.4
9	2.9	1.4	2.9	1.4
10	3.0	1.5	3.0	1.5
11	3.1	1.5	3.1	1.5
12	3.2	1.6	3.2	1.6
13	3.3	1.6	3.3	1.6
14	3.4	1.7	3.4	1.7
15	3.5	1.7	3.5	1.7
16	3.6	1.8	3.6	1.8
17	3.7	1.8	3.7	1.8
18	3.9	1.9	3.9	1.9
19	4.0	2.0	4.0	2.0
20	4.1	2.0	4.1	2.0

(a) Short Trains means 1230 gt weight.
(b) Long Trains means 2500 gt weight.

TABLE 6.1(B) - NUMBER OF 1230gt INTRASTATE FREIGHT TRAINS/BUSY DAY

EXPECTED FORECAST

Year	Between Sydney and Orange			Between Orange and Parkes		Between Parkes and Broken Hill	
	DOWN	UP	(a)	DOWN	UP	DOWN	UP
1	4.0	2.6	1.4	1.2	1.2	0.5	0.5
2	4.1	2.6	1.6	1.2	1.2	0.5	0.5
3	4.4	2.7	1.7	1.3	1.3	0.5	0.5
4	4.5	2.7	1.8	1.3	1.3	0.5	0.5
5	4.7	2.7	2.0	1.3	1.3	0.5	0.5
6	4.9	2.7	2.2	1.3	1.3	0.5	0.5
7	5.1	2.7	2.4	1.3	1.3	0.5	0.5
8	5.3	2.8	2.5	1.4	1.4	0.5	0.5
9	5.5	2.8	2.7	1.4	1.4	0.5	0.5
10	5.7	2.8	2.9	1.4	1.4	0.5	0.5
11	6.0	2.8	3.2	1.4	1.4	0.5	0.5
12	6.4	2.9	3.5	1.5	1.5	0.5	0.5
13	6.7	2.9	3.8	1.5	1.5	0.5	0.5
14	7.1	2.9	4.2	1.5	1.5	0.5	0.5
15	7.5	2.9	4.6	1.5	1.5	0.5	0.5
16	8.0	3.0	5.0	1.5	1.5	0.5	0.5
17	8.6	3.1	5.5	1.6	1.6	0.5	0.5
18	8.9	3.0	5.9	1.6	1.6	0.5	0.5
19	9.4	3.0	6.4	1.6	1.6	0.5	0.5
20	10.0	3.1	6.9	1.6	1.6	0.5	0.5

(a) These are trains taking back only empty wagons. This arises from the great expected imbalance between tonneages flow out of Sydney (into Orange-Bathurst) and the reverse flow.

TABLE 6.1(C) - NUMBER OF 2500gt INTRASTATE FREIGHT TRAINS/BUSY DAY

EXPECTED FORECAST

Year	Between Sydney and Orange (a)		Between Orange and Parkes (a)	Between Parkes and Broken Hill	
	UP	(b)	UP	DOWN	UP
1	1.3	0.7	0.6	0.2	0.2
2	1.3	0.8	0.6	0.2	0.2
3	1.4	0.8	0.6	0.2	0.2
4	1.4	0.9	0.6	0.2	0.2
5	1.4	1.0	0.6	0.2	0.2
6	1.4	1.1	0.6	0.2	0.2
7	1.4	1.2	0.6	0.2	0.2
8	1.4	1.3	0.6	0.2	0.2
9	1.4	1.4	0.6	0.2	0.2
10	1.4	1.4	0.6	0.2	0.2
11	1.4	1.6	0.7	0.2	0.2
12	1.5	1.7	0.7	0.2	0.2
13	1.5	1.9	0.7	0.2	0.2
14	1.5	2.1	0.7	0.2	0.2
15	1.5	2.2	0.7	0.2	0.2
16	1.5	2.5	0.7	0.2	0.2
17	1.6	2.7	0.7	0.2	0.2
18	1.6	2.9	0.7	0.2	0.2
19	1.6	3.2	0.7	0.2	0.2
20	1.6	3.4	0.8	0.2	0.2

(a) It is not possible to operate 2500 gross tonne trains in the DOWN direction between Sydney and Parkes. The traffic would be in 1230 gross tonne trains as in Table 6.1(B).

(b) These are trains taking back only empty wagons. This arises from the great expected imbalance between tonneages flow out of Sydney (into Orange-Bathurst) and the reverse flow.

$1.03 million for discount rates as high as 13 per cent. This takes no account of additional benefits arising from better utilisation of train crews and rolling stock which are not likely to be significant immediately, but which may well become significant towards the end of the evaluation period.

The case for installation of CTC over the whole Orange to Parkes section is less clear cut. It revolves around the NSWPTC estimate that additional signalling staff will have to be employed on the Molong to Parkes section if CTC is not installed. If this additional staff is necessary then the annual wages cost saving arising from introduction of CTC would amount to an estimated $240,000, which would be sufficient to cover the capital cost of $2.0 million without consideration of any additional benefits arising. If the line can continue to operate effectively without additional staff, however, then the cost savings would amount to only $140,000 per annum and this would not provide a return adequate to cover the investment at a discount rate of higher than 7 per cent.

LITHGOW TO BROKEN HILL - CTC PLUS LOOP EXTENSIONS

These options are those identified as Schemes 1A to 3B in Chapter 4 of this report.

Consider first the introduction of CTC over the whole section from Orange to Parkes, i.e. Schemes 1A, 2A and 3A involving extensions to seven, nine and eleven loops respectively. The capital costs of the schemes would be $3.63 million, $3.81 million and $3.99 million respectively.

The results of evaluation of these schemes are summarised in Tables 6.2, 6.3 and 6.4. As well as showing the results for each scheme individually, the tables show the effects of undertaking loop extensions sequentially, for example the extension of seven loops, followed by two more at a later date and the remaining two at a later date still.

As may be seen from the tables, full CTC between Orange and Parkes plus loop extensions does produce an increased net present value of revenue over costs except in the case of a pessimistic traffic growth estimate combined with a high discount rate. In fact, however, the actual increase in net present value is small and the optimal year for introduction is sensitive both to the interest rate used for discounting cash flows and the estimated traffic growth.

Although the actual results presented could be used as justification to extend nine loops immediately and the remaining two in some years' time, it would be more prudent to simply install CTC and leave loop extensions to the future. The benefits from CTC are more certain and more precisely known than for loop extensions and a few years' delay in implementing the latter will not lead to any significant loss, even if traffic growth parallels the 'optimistic' forecast. On the other hand, if traffic growth corresponds to the 'pessimistic' forecast then delay of loop extensions for a few years would give the optimal commercial results.

The results of the evaluations of Schemes 1B, 2B and 3B, i.e. introduction of CTC from Orange to Molong and extension of seven, nine and eleven loops, are summarised in Tables 6.5, 6.6 and 6.7. The capital costs of the three schemes are $2.60 million, $2.78 million and $2.96 million respectively.

In many respects the results parallel those for the cases where CTC is installed over the whole section from Orange to Parkes with the net present value and the optimal timing being dependent on the discount rate and the quality of the traffic forecast. Once again the benefits from loop extensions are less certain than from CTC and it would be wise to delay implementation of loop extensions for a year or two, which would not involve any significant loss of benefit even if traffic growth proved to be higher than expected.

TABLE 6.2 - LOOP EXTENSION EVALUATION RESULTS - FULL CTC
OPTIMISTIC FORECAST

Interest Rate	7%		10%		12%	
Upgrading Scheme	Best year of Introduction	NPV ($m)	Best year of Introduction	NPV ($m)	Best year of Introduction	NPV ($m)
Existing	-	99.63	-	72.40	-	59.19
Scheme 1A	1	101.7	4	73.24	6	59.63
Scheme 2A	1	102.7	2	74.05	2	60.16
Scheme 3A	1	103.0	2	74.23	2	60.30
1A, 2A	1,2	102.7	2	73.97	2,3	60.09
1A, 3A	1,2	102.9	2,3	74.17	2,3	60.24
2A, 3A	1,4	103.0	2,5	74.25	2,5	60.33
1A, 2A, 3A	1,2,4	102.9	2,3,5	74.18	2,3,5	60.25

TABLE 6.3 - LOOP EXTENSION EVALUATION RESULTS - FULL CTC
EXPECTED FORECAST

Interest Rate	7%		10%		12%	
Upgrading Scheme	Best year of Introduction	NPV ($m)	Best year of Introduction	NPV ($m)	Best year of Introduction	NPV ($m)
Existing	-	87.48	-	64.42	-	53.10
Scheme 1A	1	88.32	13	64.64	15	53.19
Scheme 2A	1	89.11	1	64.92	11	53.30
Scheme 3A	1	89.17	7	64.96	11	53.35
1A, 2A	1,2	89.04	1,2	64.85	11,12	53.27
1A, 3A	1,2	89.12	7,8	64.91	11,12	53.32
2A, 3A	1,7	89.23	1,7	65.00	11,12	53.34
1A, 2A, 3A	1,2,7	89.16	1,2,7	64.93	11,12,13	53.31

TABLE 6.4 - LOOP EXTENSION EVALUATION RESULTS - FULL CTC
PESSIMISTIC FORECAST

Interest Rate	7%		10%		12%	
Upgrading Scheme	Best year of Introduction	NPV ($m)	Best year of Introduction	NPV ($m)	Best year of Introduction	NPV ($m)
Existing	-	73.39	-	55.01	-	45.84
Scheme 1A	6	73.61	15	55.02	17	45.81
Scheme 2A	1	74.22	11	55.11	15	45.86
Scheme 3A	1	74.48	3	55.19	15	45.87
1A, 2A	1,2	74.17	15,16	55.09	15,16	45.84
1A, 3A	1,2	74.41	6,7	55.13	15,16	45.85
2A, 3A	1,2	74.46	3,4	55.17	15,16	45.87
1A, 2A, 3A	1,2,3	74.38	11,12,13	55.12	15,16,17	45.85

TABLE 6.5 - LOOP EXTENSION EVALUATION RESULTS - CTC ORANGE TO MOLONG
OPTIMISTIC FORECAST

Interest Rate	7%		10%		12%	
Upgrading Scheme	Best year of Introduction	NPV ($m)	Best year of Introduction	NPV ($m)	Best year of Introduction	NPV ($m)
Existing	-	99.63	-	72.40	-	59.19
Scheme 1B	1	102.7	2	74.12	2	60.30
Scheme 2B	1	103.8	1	75.04	1	61.10
Scheme 3B	1	104.0	1	75.21	1	61.22
1B,2B	1,2	103.7	1,2	74.95	1,2	61.02
1B,3B	1,2	104.0	1,2	75.14	1,2	61.15
2B,3B	1,4	104.1	1,5	75.24	1,5	61.26
1B,2B,3B	1,2,4	104.0	1,2,5	75.16	1,2,5	61.18

TABLE 6.6 - LOOP EXTENSION EVALUATION RESULTS - CTC ORANGE TO MOLON
EXPECTED FORECAST

Interest Rate	7%		10%		12%	
Upgrading Scheme	Best year of Introduction	NPV ($m)	Best year of Introduction	NPV ($m)	Best year of Introduction	NPV ($m)
Existing	-	87.48	-	64.42	-	53.10
Scheme 1B	1	89.35	1	65.26	1	53.46
Scheme 2B	1	90.14	1	65.95	1	54.09
Scheme 3B	1	90.20	1	65.95	1	54.06
1B,2B	1,2	90.07	1,2	65.88	1,2	54.02
1B,3B	1,2	90.15	1,2	65.91	1,2	54.02
2B,3B	1,7	90.26	1,7	66.03	1,8	54.15
1B,2B,3B	1,2,7	90.19	1,2,7	65.96	1,2,8	54.08

TABLE 6.7 - LOOP EXTENSION EVALUATION RESULTS - CTC ORANGE TO MOLONG
PESSIMISTIC FORECAST

Interest Rate	7%		10%		12%	
Upgrading Scheme	Best year of Introduction	NPV ($m)	Best year of Introduction	NPV ($m)	Best year of Introduction	NPV ($m)
Existing	-	73.39	-	55.01	-	45.84
Scheme 1B	1	74.59	2	55.41	1	45.92
Scheme 2B	1	75.25	1	55.97	1	46.35
Scheme 3B	1	75.51	1	56.18	1	46.54
1B,2B	1,2	75.20	1,2	55.92	1,2	46.30
1B,3B	1,2	75.44	1,2	56.10	1,2	46.46
2B,3B	1,2	75.49	1,2	56.16	1,2	46.52
1B,2B,3B	1,2,3	75.41	1,2,3	56.08	1,2,3	46.44

CHAPTER 7 - CONCLUSIONS FOR SYDNEY-BROKEN HILL LINE

The following conclusions have been drawn from the analysis of traffic growth on the Sydney to Broken Hill line.

(a) No upgrading of the Sydney-Lithgow section was considered in this study. Any requirement for additional capacity is likely to be generated by export coal trade. Decisions on any upgrading and the method of financing should be considered in detail once the pattern of generated traffic can be established.

(b) No upgrading of the Lithgow to Broken Hill section is necessary on grounds of capacity limitations, but some upgrading can be justified in terms of reducing railway operating costs.

(c) The introduction of CTC between Orange and Molong is justified immediately on grounds of reduced operating costs.

(d) Introduction of CTC between Molong and Parkes may be justified depending upon just how many additional signalling staff will be needed if it is not introduced. On balance it would seem sensible to extend CTC over the whole of this section.

(e) The extension of crossing loops between Orange and Parkes is considered to be marginally justified at this time. It would seem to be prudent to delay this upgrading for two or three years and to monitor traffic growth to determine when the extensions should be undertaken.

PART 2

THE SOUTH AUSTRALIAN SECTION

CHAPTER 8 - DESCRIPTION OF EXISTING FACILITIES

The South Australian portion of the East-West rail link comprises, in addition to the Adelaide-Serviceton link, which is discussed in a separate report(1), four other sections:

(i) Adelaide-Port Pirie (218km)
(ii) Adelaide-Peterborough (248km)
(iii) Port Pirie-Peterborough (114km)
(iv) Peterborough-Broken Hill (283km)

The first two of these are broad gauge sections and the last two are standard gauge sections. Goods wagons travelling between Adelaide and Sydney change gauge at Peterborough while goods wagons travelling between Western Australia and Adelaide or Melbourne normally change gauge at Port Pirie.

The Adelaide to Port Pirie line is entirely broad gauge and single track from Virginia to Port Pirie. Figure 8.1 presents a schematic diagram showing the position and length of loops along the line. The shortest loop, at Bumbunga is 436 metres long, allowing trains up to 62 four-wheel vehicles long (including engine) to cross there.

The Adelaide to Peterborough line is also completely broad gauge and single track from Roseworthy to Peterborough. The shortest crossing loop is situated at Gumbowie, where only 58 four-wheel vehicles including engine, can be parked in the loop. Figure 8.2 shows the main features of the line.

The Port Pirie-Peterborough and Peterborough-Broken Hill sections are both standard gauge, forming part of a completely standard gauge link between Sydney and Perth. Both sections are characterised by the relatively long distances (an average of 28.3km)

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(1) Bureau of Transport Economics, "Mainline Upgrading - Evaluation of a Range of Options for the Adelaide-Serviceton Link", Canberra, 1977.

Distance from Adelaide (km)		Loop Length (m)
217	PORT PIRIE	
198	NUROM	550
187	MERRITON	549
171	RED HILL	543
161	LAKEVIEW	762
145	SNOWTOWN	767
129	BUMBUNGA	436
119	NANTAWARRA	456
101	BOWMANS	466
92	KALLORA	544
85	AVON	
76	LONG PLAINS	551
70	CALOMBA	
60	MALLALA	563
43	TWO WELLS	591
33	VIRGINIA	547
20	SALISBURY	
	MILE END (Adelaide)	

FIGURE 8.1

POSITION AND LENGTH OF EXISTING LOOPS

ADELAIDE-PORT PIRIE

Distance from Adelaide (km)		Loop Length (m)
248	PETERBOROUGH	
237	GUMBOWIE	408 (approx)
225	TEROWIE	999 (approx)
215	WHYTE-YARCOWIE	429
193	HALLETT	431
178	MT BRYAN	459
163	BURRA	455
142	FARRELL FLAT	445
133	MERILDIN	
122	MANOORA	518
110	SADDLEWORTH	450
101	RIVERTON	549
87	TARLEE	437
79	STOCKPORT	
72	HAMLEY BRIDGE	471
59	WASLEYS	642
49	ROSEWORTHY	539
40	GAWLER	
30	SMITHFIELD	
20	SALISBURY	
	MILE END (Adelaide)	

FIGURE 8.2

POSITION AND LENGTH OF EXISTING LOOPS

ADELAIDE-PETERBOROUGH

Distance from Adelaide (km)		Loop Length (m)
531	BROKEN HILL	
500	THACKARINGA	1000
483	COCKBURN	1000
458	MINGARY	1000
443	CUTANA	1000
414	OLARY	1000
377	MANNAHILL	1000
334	YUNTA	1000
307	PARATOO	1000
285	HILLGRANGE	1000
261	UCOLTA	1000
248	PETERBOROUGH	-
258	YONGALA	1000
268	MANNANARIE	1000
283	JAMESTOWN	1000
298	CALTOWIE	1000
313	GLADSTONE	1000
334	CRYSTAL BROOK	1000
347	WARNERTOWN	
362	PORT PIRIE	

FIGURE 8.3

POSITION AND LENGTH OF EXISTING LOOPS

PORT PIRIE-BROKEN HILL

between crossing loops; the longest, stretch being between Yacka and Mannahill (43.6 km). These sections are shown diagramatically in Figure 8.3.

SIGNALLING

The Adelaide-Port Pirie and Adelaide-Peterborough lines rely on a token system of safeworking (Train Staff). All locations at which safeworking is performed are manned by a signalman for at least 8 hours every day. This means that a train proceeding straight through can exchange staffs automatically without slowing down, but a train being passed has to wait an additional time (called "safeworking delay") after the through train has passed to allow the signalman to walk to the driver and hand over a staff. It has been estimated by railway authorities that the safeworking delay is of the order of 3 to 3.5 minutes, not including the acceleration and retardation times, but it may be higher for longer trains.

The safeworking system on the Port Pirie-Peterborough and Peterborough-Broken Hill sections is automatic signalling under train control, while between Olary and Mannahill, a distance of 37 km, there is a block signal system enabling two trains travelling in the same direction to occupy this section at the same time.

TERMINALS

The analysis presented in this report does not consider the implications of traffic growth on the capacity of terminals. This means that the terminal at Adelaide will not be given any further consideration. It is obvious, however, that the upgrading of terminals and main lines must be co-ordinated and balanced if the full benefits of upgrading are to be realised.

PRESENT TRAFFIC

In this study, the trains on all the lines were divided into five different classes, depending on the relative importance of the traffic they carry. The priority allocated to each class is shown below. These priorities coincide approximately with those used when the timetables are prepared, though the priority given to any train on any particular day by a train controller is, of course, subject to many additional factors.

Priority	Train Type
1	Express Passenger
2	Passenger, Passenger Motor
3	Fast Goods, Express Goods
4	Goods
5	Ore, Wayside goods, Livestock

The distribution of traffic within these train classes on a typica busy day in 1976 is given in Table 8.1.

TABLE 8.1 - NUMBER OF TRAINS IN EACH PRIORITY CLASS

Section	1	2	3	4	5
Adelaide-Port Pirie	2	4	5	3	-
Adelaide-Peterborough	-	4	4	3	-
Port Pirie-Peterborough	2	-	1	4	1
Peterborough-Broken Hill	1	-	4	3	1

Other trains not included in the above listing run only occasionally as the need for extra capacity arises and are assumed to run at times which cause no delay to the more important trains in the above table.

CHAPTER 9 - RAIL TRAFFIC PROJECTIONS

As for the other parts of this study, the forecasting of future rail traffic was undertaken in two steps. Firstly the expected growth in total traffic was estimated and, secondly, the proportion expected to be carried by rail was assessed in light of factors affecting modal split. Primary emphasis was placed on projection of freight traffic, but some consideration had to be given to passenger traffic since the presence of passenger trains affects the congestion on a line and, hence, the operation of freight services.

Three forecasts were prepared (expected, optimistic and pessimistic) as a basis for studying the sensitivity of study results to changes in traffic forecasts. The optimal timing of upgrading investment depends heavily upon the actual traffic pattern occuring in practice and any decisions on investment should be regarded as a function of the traffic pattern and not tied to a particular year in the future.

For the purposes of forecasting traffic was divided into general goods and special commodities. The latter include items such as mineral ores, livestock, wheat, etc. which do not necessarily follow the same growth patterns as general goods. In addition, general goods has been divided into intrastate and interstate for the purposes of analysis.

FREIGHT TRAFFIC

As stated previously, the interstate general goods traffic consists primarily of items moving between capital cities and the growth in this traffic is expected to reflect the general growth in the economy as a whole. In this instance the major traffics are Melbourne and Adelaide to and from Perth, and Perth and Adelaide to and from Sydney. It is anticipated that this traffic will increase at a rate of 4 percent per year compounding, over the next ten years and then increase at a slightly lower rate in line with the expected fall in population growth rate.

The growth in intrastate goods depends heavily upon the development of centres such as Port Pirie and Port Augusta. Population growth in Port Pirie has been substantially zero in recent years while in Port Augusta it has been slightly above the national average, at about 2.5 percent per annum. It has been assumed tha growth in intrastate traffic will be slightly less than that for interstate traffic.

Two factors have been identified which could have a significant impact on the amount of the total traffic being carried by rail on the lines under consideration in this part of the study. They are, firstly, the demise of the ASP shipping service between Perth and the east coast in 1975 and the possibility of re-establishment of such a service, and, secondly, the completion of sealing of the Eyre Highway in 1976.

At this stage it appears unlikely that a coastal service on the scale of the ASP operation will be established in the foreseeable future. Thus, for the expected traffic growth case, the gain in 1975/76 traffic by rail from the ASP coastal shipping service is assumed to remain on rail. In the pessimistic case it has been assumed that a coastal shipping service is introduced in 1981 so that the contribution of that traffic to rail is zero from then on.

It is difficult to estimate what will be the impact of sealing of the Eyre Highway. It seems likely that some traffic between Adelaide and Perth may be lost by the railways, but unlikely that there will be any significant change in traffic on the Sydney to Perth link. For the purposes of the study no special allowance has been made for this effect, but developments should be continuously monitored over the next year or two to identify any change in traffic patterns. The results of the study could then be reviewed in light of any changes.

The base values for the general freight projections used in the study are summarised in Table 9.1.

TABLE 9.1 - BASE VOLUMES FOR GENERAL FREIGHT

Link	Base Volume	ASP Injection ('000 net tonnes)
Adelaide-Port Pirie	600	25
Port Pirie-Adelaide	425	9
Adelaide-Peterborough	210	-
Peterborough-Adelaide	220	-
Port Pirie-Peterborough	300	12
Peterborough-Port Pirie	330	40
Peterborough-Broken Hill	400	12
Broken Hill-Peterborough	443	40

For interstate traffic, the growth rate has been taken as 4 percent per annum up to 1985 and 3.5 percent per annum beyond that. For the optimistic case, i.e. that providing the maximum traffic likely to eventuate, a constant growth rate of 5 percent per annum has been assumed. For the pessimistic case a growth rate of 2 percent per annum has been assumed for the whole study period and, in addition, the ASP component has been assumed to fall to zero from 1981 onwards.

For intrastate freight the expected growth rate has been taken as 2.5 percent per annum with optimistic and pessimistic rates of 3.5 and zero respectively.

The only special freight requiring separate analysis in this region is the ore traffic from Broken Hill to Port Pirie. Indications are that there is unlikely to be any significant overall change in the volume of this traffic over the study period and so it was assumed to remain constant at 794 000 tonnes per annum.

PASSENGER TRAFFIC

For the purposes of this study it has been assumed that the four times per week Indian Pacific service will be increased to a daily service by 1985 and then remain constant. Other passenger service have been assumed to remain at their present frequencies.

CHAPTER 10 - UPGRADING ALTERNATIVES

The degree to which upgrading of the Adelaide-Port Pirie and Adelaide-Peterborough links is justified depends heavily on the possible standardisation of the line from Adelaide to Crystal Brook. Once standardised, this line would be expected to carry most of the interstate traffic currently carried by the two broad gauge lines. The standardisation project itself was not evaluated in this study, but its possible year of completion was used as a constraint in identifying the benefits of possible upgrading schemes on the two broad gauge lines. Four possible introduction periods have been considered for the standardisation project:

- within the next 6 years
- within the next 10 years
- within the next 20 years (the study period)
- not within the next 20 years.

There is some doubt as to whether the standardisation will be completed within six years, but informed opinion is that there is a very high probability that it will be completed in less than ten years.

At present there are five express goods and three ordinary goods trains operating each day on the Adelaide-Port Pirie link. Assuming that trains are increased to maximum length and/or weight before additional trains are scheduled, the traffic would increase only to eight trains per day plus one every second day by 1984/85 even under the optimistic traffic forecast. Such an increase would not lead to any significant degree of congestion and so no upgrading options need be examined in detail if the assumption is made that the line will be standardised within ten years.

It has been assumed also that standardisation would include provision of centralised traffic control (CTC) and the extension of loops to the order of 1000 metres. If this is done the capacity of the line would be adequate for all projected traffic within the study period, i.e. to 1994-95.

The question of upgrading options for the Adelaide-Port Pirie broad gauge link becomes much more complex if standardisation is assumed to occur between the tenth (1984-85) and twentieth (1994-95) years. However, based on the traffic forecasts used in this study, the total number of trains per day would be expected to rise from the present fourteen to about twenty by 1995. Such a rise could be handled on a temporary basis by changed operational practices to cover the period between congestion becoming significant and the standard gauge line coming into operation.

If, however, standardisation is delayed beyond twenty years then it is necessary to evaluate possible interim upgradings of the broad gauge line. The two options considered for upgrading this line were introduction of CTC and the extension of some or all of the seventeen passing loops.

The standardisation of the Adelaide-Crystal Brook line has implications for the Adelaide-Peterborough line similar to those for the Adelaide-Port Pirie line. The degree of congestion on the line is heavily dependent on the timing of standardisation. An additional factor in this case concerns the possible rerouting of Adelaide-Perth traffic via Peterborough if no improvement is made to the Port Pirie bogie exchange. However, upgrading of the exchange can be shown to be justified (see Part 3 of this report) and so it is likely that no significant diversion of traffic will occur. In that case, even if the assumption is made that the Adelaide-Crystal Brook standardisation project is delayed beyond the present study period, i.e. beyond 1994/95, forecast traffic growth will not be sufficient to require any additional trains on the Adelaide-Peterborough link. Thus no capacity upgrading need be considered for this link within the study period. Introduction of CTC has been evaluated, however, in terms of its effect on operating costs.

The Port Pirie to Peterborough and Peterborough to Broken Hill links are not affected by the standardisation of the Adelaide to Crystal Brook link. The number of freight trains on the Port Pirie to Peterborough link is 6 per day which is expected to increase only by an additional 4 trains per week over the next 20 years if the existing trains are brought up to current maximum weights before additional trains are added. Thus no capacity problems are foreseen for this link within the study period. On the Peterborough to Broken Hill link the existing 7 trains per day should be adequate to handle the forecast traffic until 1991-92 after which one additional train would be needed. The only section of the line likely to suffer congestion problems is that between Yunta and Mannahill. At present the section takes 59 minutes to traverse and trains are often subject to delay. Construction of an additional loop on this section would cost about $140 000. This option was not evaluated in detail, but would appear to be justified by the time an additional train is scheduled for this link.

CHAPTER 11 - EVALUATION OF OPTIONS

Because of the low probability of congestion in this part of the railway system no simulation work was undertaken, but a limited analysis of three upgrading options was made. The three options were:

- extension of crossing loops between Adelaide and Port Pirie
- installation of CTC on the Adelaide to Port Pirie link
- installation of CTC on the Adelaide to Peterborough link

EXTENSION OF LOOPS (ADELAIDE TO PORT PIRIE)

As previously indicated growth of goods traffic on this line is not sufficient to produce any significant degree of congestion in the next twenty years. Thus any benefits from loop extension would be in terms of reduced operating costs for the railway.

Extension of loops by 500 metres would permit the running of 2100 gross tonne trains which would allow a significant reduction in train crew costs. There would be potential for savings in capital and running costs of locomotives also, since larger locomotives would be used which are cheaper per kilowatt than smaller locomotives, but these savings would not be great. The extension of loops by 500 metres is estimated to cost about $90,000 each or a total of some $1.53 million for all 17 loops. A 50 per cent increase in train size gives a potential saving of about one third of total crew costs which, over a 20 year period, are estimated to have a present value of $1.35 million. Thus a loss of some $0.18 million could be expected.

Clearly the crew savings alone would not be sufficient to justify extension of all loops on the Adelaide to Port Pirie link, but it does indicate that development of a loop extension programme aimed at running heavier trains is worth further investigation by the railway itself.

CTC INSTALLATION (ADELAIDE TO PORT PIRIE)

The cost of installation of CTC for the Adelaide to Port Pirie link has been estimated at $4.5 million. The benefits to the railway would be in the form of reduced numbers of signalling staff and a reduction of crew costs through the faster movement through sections. South Australian Railways estimated the potential savings at $391 000 per year. Thus at a 7 percent discount rate the installation of CTC would be justified on staff savings alone, while at a 10 percent discount rate the project would not be justified.

However, the general operational improvements brought about by use of CTC are such that, on balance, installation on this link could be justified.

CTC INSTALLATION (ADELAIDE TO PETERBOROUGH)

The estimated cost of installation of CTC on the Adelaide to Peterborough link would be about $4.5 million. In this case, savings in crews and signalling staff would amount to only about $236 000 per year, and so the installation would not be justified, even taking into account the additional unquantified benefits of CTC.

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CHAPTER 12 - CONCLUSIONS FOR SOUTH AUSTRALIAN SECTION

Indications are that there will be no significant congestion on the Adelaide-Peterborough, Adelaide-Port Pirie, and Port Pirie-Peterborough-Broken Hill lines within the next 20 years.

Installation of CTC appears to be justified on the Adelaide-Port Pirie link, on the basis of reduced operating costs, but not on the Adelaide-Peterborough link.

Possible extension of crossing loops on the Adelaide-Port Pirie line to make possible the use of 2100 gross tonne trains should be considered by the railways as a means of reducing train operating costs.

PART 3

THE PORT PIRIE BOGIE EXCHANGE

CHAPTER 13 - INTRODUCTION

As a result of the historical development of the Australian railway network, the lines joining Sydney to Brisbane and Melbourne are standard gauge, as is the direct link from Sydney (through Broken Hill, Peterborough, Port Pirie and Kalgoorlie) to Perth, while the lines from Melbourne to Adelaide and from Adelaide to Port Pirie and Peterborough are broad gauge. Thus rail traffic from Melbourne and Adelaide to Perth and to the Northern Territory must undergo a gauge change at Port Pirie. Similarly traffic from Adelaide to Sydney must undergo a gauge change at Peterborough.

Change of gauge is achieved via the medium of bogie exchange facilities and the operation of these facilities has an important impact on the capacity of the east-west link. Evidence of congestion at Port Pirie has been noted for some time, but became much more visible following the increase in traffic resulting from the demise of the ASP shipping service between Perth and the Eastern States. The Bureau of Transport Economics undertook a study of the operations of the Port Pirie bogie exchange aimed at identifying the causes of the problem and evaluating possible options for remedial action. That study has been reported in detail elsewhere(1), and this report simply discusses those aspects relevant to the question of the capacity of the east-west link.

The upgrading options considered for the Port Pirie bogie exchange, and the timing of their implementation, are sensitive to the possible conversion to standard gauge of the Adelaide to Crystal Brook link. Standardisation of this line within the next 6 years would negate the need for a heavy capital commitment in the upgrading of the Port Pirie bogie exchange. However, a short term solution, which may involve limited capital expenditure,

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(1) Bureau of Transport Economics, 'A Study of the Port Pirie Bogie Exchange', Canberra 1977.

could still be economically viable, particularly if the equipment could then be employed in a new bogie exchange near Adelaide. These possibilities were taken into account in the study.

CHAPTER 14 - RAIL FREIGHT PROJECTIONS

The bogie exchange at Port Pirie is situated in the Port Pirie yard and the operations of bogie exchange and general train marshalling interact with each other. The throughput of the bogie exchange depends upon a steady supply of vehicles for exchange and this supply is affected by the general level of activity in the yard. Thus in forecasting the future performance of the exchange and in evaluating alternative upgrading proposals it is necessary to consider the total flow through the Port Pirie yard not just the flow through the bogie exchange facility itself.

The traffic affecting the bogie exchange operation is that which may be loosely termed "general freight". This includes all the freight carried on general traffic vehicles (but including motor cars) and excludes special traffic such as iron ore, coal and wheat. For the purposes of analysis, traffic has been broken into seven origin-destination pairs. Base year (1974-75) values for origin-destination pairs are presented in Table 14.1 together with the injection of traffic in year 1975-76 brought about by the cessation of the ASP shipping service. In each case the base year values were obtained by examination of traffic over the last four to six years to eliminate short term fluctuations. The pattern of movements through the Port Pirie and Peterborough bogie exchanges is indicated in Figure 14.1 and 14.2.

The traffic is expected to grow at the rates specified in Table 14.2. The growth rates predicted are based on past trends modified in light of anticipated changes in population and economic performance in the regions concerned. The effect of possible competition from other modes has also been taken into account.

The projected traffic was converted to wagon loads and Table 14.3 gives the projected number of wagons passing through Port Pirie and Peterborough bogie exchanges (in both directions) for the expected rate of traffic growth. The number of additional wagons

TABLE 14.1 - RAIL FREIGHT TRAFFIC IN THE ADELAIDE/PORT PIRIE/ PETERBOROUGH TRIANGLE - BASE YEAR VALUES

Item	Origin/Destination Pair	Traffic ('000 net tonnes)			
		Westbound		Eastbound	
		1974-75 (1)	ASP1975-76 (2)	1974-75 (1)	ASP1975-76 (2)
1	Perth-Adelaide	100	-	127	-
2	Perth-Melbourne	51	9	225	25
3	Perth-Broken Hill	136	12	191	40
4	Adelaide-Broken Hill	185	-	185	-
5	Port Pirie-Broken Hill	72	-	-	-
6	Alice Springs-Adelaide	13	-	108 (3)	-
7	Trans Line-Adelaide	75	-	45	-

(1) Derived from trends over previous several years.
(2) Former ASP traffic diverted to rail in 1975/76.
(3) Only 54% of this traffic actually originates south of Port Pirie, remainder may be regarded as originating in Port Augusta.

TABLE 14.2 - TRAFFIC GROWTH FACTORS FOR PERIOD 1975-1995

Traffic Item	Growth Rate (% per annum compounding)		
	Pessimistic	Expected	Optimistic
1, 2, 3, 4	2 with ASP component falling to zero after 1981-82(1)	4 to 1985-86 3½ 1986-87 onwards(2)	5
5	0	2½	3½
6 (4)	5 (3)	9 to 1985-86 5 1986-87 onwards (2)	9
7	0	0	0

(1) Assumes that a shipping service is re-established in 1981-82.
(2) Reflects expected fall in general population growth rate.
(3) Total rail traffic to be reduced by 20% for years following 1985 when it is assumed that the Stuart Highway will be sealed.
(4) In calculating traffic for each year an additional 38 000 tonnes northbound and 5 000 tonnes southbound must be added to reflect presence of non-growth general goods traffic.

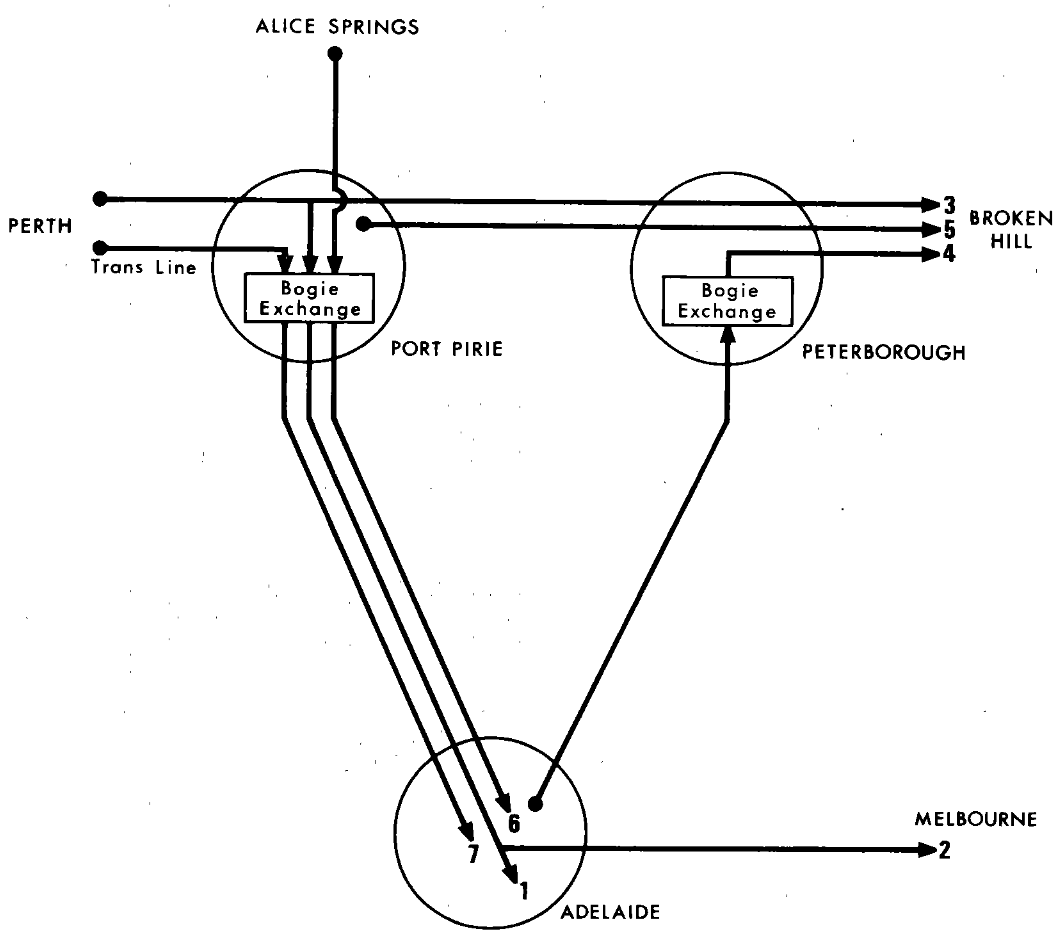

FIGURE 14.1

EASTBOUND TRAFFIC THROUGH BOGIE EXCHANGES

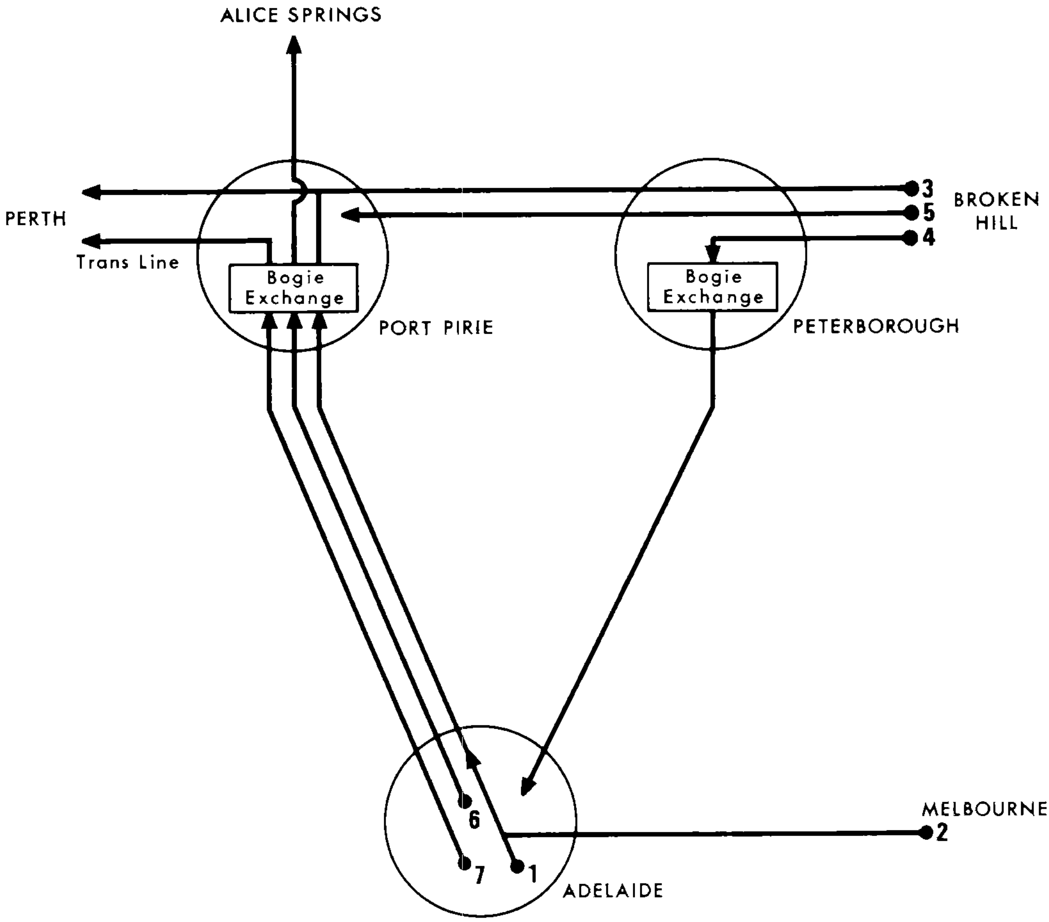

FIGURE 14.2

WESTBOUND TRAFFIC THROUGH BOGIE EXCHANGES

passing through the Port Pirie yard, but not subject to bogie exchange, it also included in Table 14.3.

In obtaining Table 14.3, it was assumed that average net tonnes per wagon exchanged will remain at the present value of 17.0 for the whole of the study period. This conversion factor was used to calculate, from the net tonnage, the number of wagons that will be passing through Port Pirie and Peterborough, including the exchanges.

In all upgrading options, other than the standardisation of the Adelaide-Crystal Brook rail link, the Adelaide and Melbourne traffic will both continue to be bogie exchanged.

Under standardisation, all of the Melbourne traffic will have to be exchanged in Adelaide. Two possible scenarios for the Adelaide traffic were then considered: one, where it is thought that, rather optimistically, no Adelaide traffic will have to be exchanged, and another, thought more probable, where 50% of the Adelaide traffic needs exchanging because it is generated at other points on the existing broad gauge system. That is, Adelaide is only the nominal origin of this traffic.

TABLE 14.3 - PROJECTED NUMBER OF WAGONS PASSING THROUGH PORT PIRIE AND PETERBOROUGH BOGIE EXCHANGES (EXPECTED GROWTH RATE)

Year	Potential Load for Port Pirie Bogie Exchange		Wagons passing through at Port Pirie (2)	Wagons offered at Peterborough Bogie Exchange (3)
	Adelaide traffic	Melbourne traffic		
1975-76	27000	18882	27412	22647
1976-77	27942	19647	28741	23529
1977-78	29000	20412	29529	24471
1978-79	30118	21235	30588	25471
1979-80	31353	22118	31765	26471
1980-81	32529	22941	32941	27529
1981-82	33824	23941	34235	28647
1982-83	35235	24882	35529	29765
1983-84	36647	25882	26824	31000
1984-85	38647	26882	38235	32235
1985-86	39412	27824	39529	33353
1986-87	40706	28824	41000	34529
1987-88	41941	29824	42235	35706
1988-89	43294	30824	43647	36941
1989-90	44706	31941	45118	38235
1990-91	46176	33118	46647	39588
1991-92	47647	34176	48235	41000
1992-93	49294	35412	49824	42412
1993-94	50941	36647	51471	43882
1994-95	52588	38412	53235	45471

(1) Adelaide traffic consists of traffic 1, 6, 7 summed over east and west directions
Melbourne traffic consists of traffic 2.

(2) Traffic 3, 5.

(3) Traffic 4.

CHAPTER 15 - UPGRADING OPTIONS

Figure 15.1 shows that the delay per wagon passing through the Port Pirie yard and requiring an exchange of bogies is of the order of 27 hours. If the expected rate of growth of traffic eventuates, then the facility will reach its absolute maximum capacity in 4 to 6 years[1], although before this point is reached delays would have increased to a level which would most likely be unacceptable to customers.

The bogie exchange facility itself seems to be the limiting factor at present, as the yard could feed the exchange at a greater rate than the exchange can process the wagon. The capacity of the bogie exchange could be increased by automating the present facility, but this could only increase the system capacity by at most 30%, because congestion in the Port Pirie yard would then be the limiting factor. It is estimated that the absolute capacity of the existing yard and the automated bogie exchange would be reached by about 1986, but once again the delays would be extensive before that date.

It is quite possible that, in the short term, these congestion levels could be reduced by improved operating practices. As an example, if the trains from WA were marshalled in sections according to an Adelaide or Sydney destination, there would be no need for this selection to be made in the Port Pirie yard. This has the effect of slowing down the rate of feeding of the bogie exchange, partly because the wagons for the exchange have to be selected and partly because the process of marshalling blocks the feeding tracks to the bogie exchange.

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(1) It is thought that the maximum practical number of wagons that the Port Pirie exchange could handle is 55000 per year. This assumes that out of a possible 42 shifts per week, 38 are being worked and only 4 (on Thursday and Wednesday) are not.

Not all of the delay to wagons should be attributed to the process of bogie exchanging. For example, wagons on the two evening trains from Adelaide may be exchanged in the evening shift, but as the morning train out of Port Pirie is at present limited in size, some of the wagons from these trains are left over for the evening train. This extra 12 hour delay is often attributed to the exchange, yet it could be avoided if a long train out of Port Pirie were run in the morning.

However, these observations do not alter the fact that in the long run, the construction of a new yard and associated bogie exchange facility will be required.

Standardisation of the line from Adelaide to Crystal Brook would eliminate the need to bogie exchange some or all of the traffic originating in, or destined for, Adelaide (but indications are that if the present standard rail plan were implemented, then about 50% of this traffic would still need to be exchanged). The Melbourne traffic would still need to be exchanged. The bogie exchanging facilities would be shifted to Dry Creek (a few kilometres outside Adelaide).

In relation to the standard gauge project (at least as recommended in the Maunsell[1] report), it has been claimed that it would do more than just remove the need to bogie exchange some of the East-West traffic; for example, the terminal facilities in Adelaide would be extended and made more accessible. While this may be so, and hence a proper examination of the <u>standardisation project</u> (which is not the objective of this study) should take all these factors into account this particular analysis considers standardisation only as one of the options to improve transit times along the East-West rail link and so the analysis is

(1) Maunsell & Partners, <u>South Australian Railways Gauge Standardisation Adelaide to Crystal Brook</u>, Jan 1974. Prepared for the Government of South Australia, Department of Transport and for the Australian Government, Department of Transport.

restricted to an evaluation of the capital expenditure that would be justified in view of the benefits to be obtained from not having to exchange bogies at Port Pirie.

In the base case, it is assumed that the railways will have to perform their task without any expenditure on capital upgradings of facilities. Furthermore, it is assumed that the task is performed at total minimum cost to the railways, so that a certain amount of wagon rerouting to achieve this objective is allowed. It is thought that this would be the likely response of the railways to the prevailing situation.

There are two possible re-routing options. Firstly, when the Port Pirie bogie exchange becomes more congested, a certain number of wagons may be rerouted via Peterborough into Adelaide, and secondly, as Peterborough itself becomes more congested, then some of the Adelaide to Sydney traffic is rerouted via Dynon(1).

In the base case, the absolute maximum number of wagons that the exchange can handle in Port Pirie is assumed to be 55000 per year (after reaching this level, all other traffic is rerouted), and for Peterborough the number is taken as 60,000 wagons per year. However, rerouting would take place well before these limits are reached, as indicated in Figure 15.2.

All upgrading options considered alter the physical configuration of the Port Pirie-Peterborough-Adelaide triangle only, and, apart from the standardisation of the line from Adelaide to Crystal Brook which alters the system fundamentally, the other options have the effect of decreasing in one way or another the waiting time of wagons in the Port Pirie yard or in the Port Pirie bogie exchange.

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(1) Consideration was given to the possibility of rerouting some of the Melbourne-Perth traffic via NSW, so that its journey would be completely standard gauge. However, this trip is some 600 km longer than the journey via Adelaide, and our preliminary analysis indicated that the least cost option was to allow all Melbourne traffic to go via Adelaide and reroute, instead, some of the Sydney-Peterborough-Adelaide traffic through Melbourne.

In setting up the base case, it has been assumed that Port Pirie traffic which is rerouted via Peterborough has to undergo a two-hour marshalling operation[(1)] in the Port Pirie yard before the train is allowed to proceed to Peterborough. A bypass loop would allow trains to avoid this two-hour delay.

Furthermore such a bypass loop constructed just outside Port Pirie would allow Sydney to Perth traffic to bypass the Port Pirie yard, thus easing the congestion in the yard and indirectly aiding the work of the bogie exchange facility. However, the transit time for these wagons would not be decreased, as they would still have to wait for a timetabled connection either in Peterborough or just outside Port Pirie (or possibly Port Augusta). The cost of the loop is estimated at about $200 000.

If the present bogie exchange were automated, the delays to wagons would be less, partly because of faster exchange of bogies and partly because the Port Pirie yard, being less congested with waiting wagons, would be able to feed the exchange more efficiently. In addition, the number of wagons that the new exchange could handle would be about 71,000 wagons/year (in contrast to the 55,000/year possible with the existing facilities). The manpower requirements per shift would also fall from 7 to 4.

The capital cost of automating the present bogie exchange is estimated to be about $500,000.

(The delay curve for wagons passing through an envisaged automated bogie exchange in the present yard is shown in Figure 15.3).

It has been suggested that a new bogie exchange away from the presently constricted Port Pirie yard would solve many of the current problems. The location suggested is Warnertown, some

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(1) This is the average present time taken, according to Peterborough Australian National Railways officials.

6 km out of Port Pirie. Another advantage of such a siting would be the possibility for future expansion by the addition of a second bogie exchange alongside the first.

Compared to simply automating the present exchange, relocation would provide increased storage and marshalling facilities and so improve the feeding of wagons into the bogie exchange, thus decreasing the delays to wagons dramatically, see Figure 15.4. In addition, the number of wagons that could be processed by such a bogie exchange would rise to some 110,000 per year.

The capital cost of relocation and automation is estimated at between $5 million and $10 million, but would probably be about $7.5 million.

If the line is standardised the bogie exchange facilities are assumed to be shifted to Dry Creek and their performance is assumed to be as good as the proposed relocated and automated bogie exchange near Port Pirie.

The Melbourne to Perth traffic will continue to be bogie exchanged.

The Adelaide to Sydney, Adelaide to Perth and Adelaide to Alice Springs traffic has been assumed, in the first instance, not to need any exchange of bogies, but the evaluation has also been done for the more probable situation where 50% of this traffic continues to be bogie exchanged.

The capital cost of the Maunsell report[(1)] recommendations for the standard gauge project is estimated at about $120 million in 1976 dollars.

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(1) Op. cit.

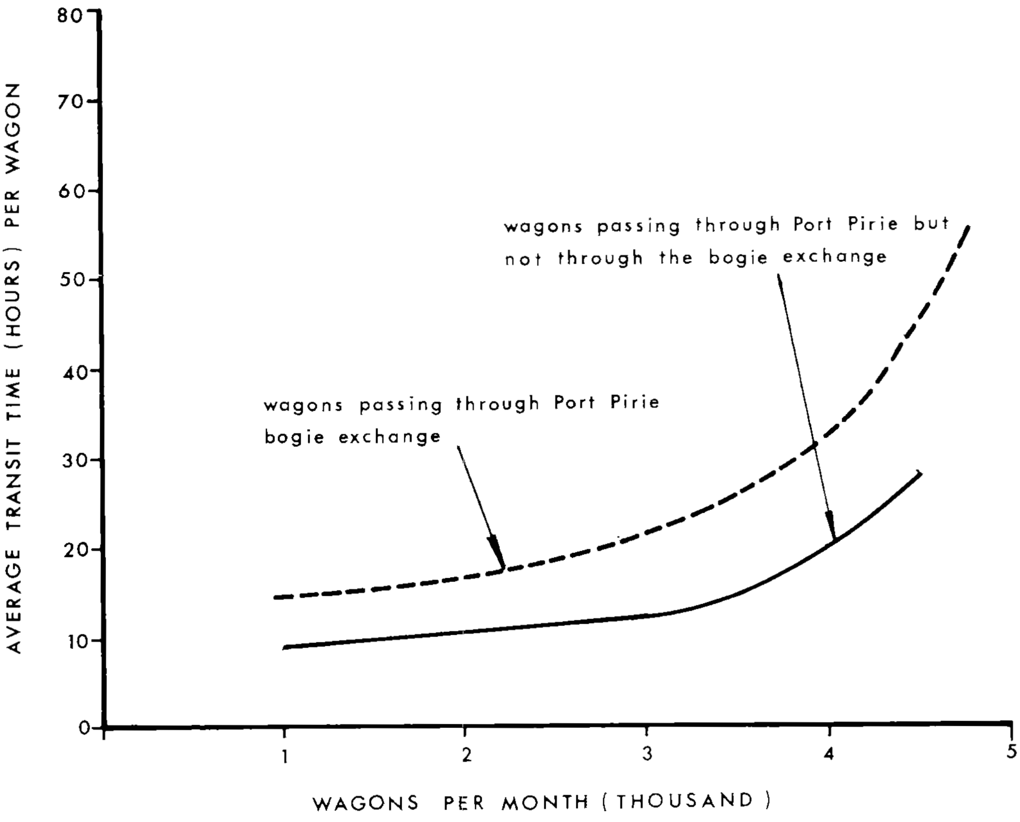

FIGURE 15·1
AVERAGE TRANSIT TIME OF WAGONS PASSING THROUGH EXISTING FACILITIES AT PORT PIRIE

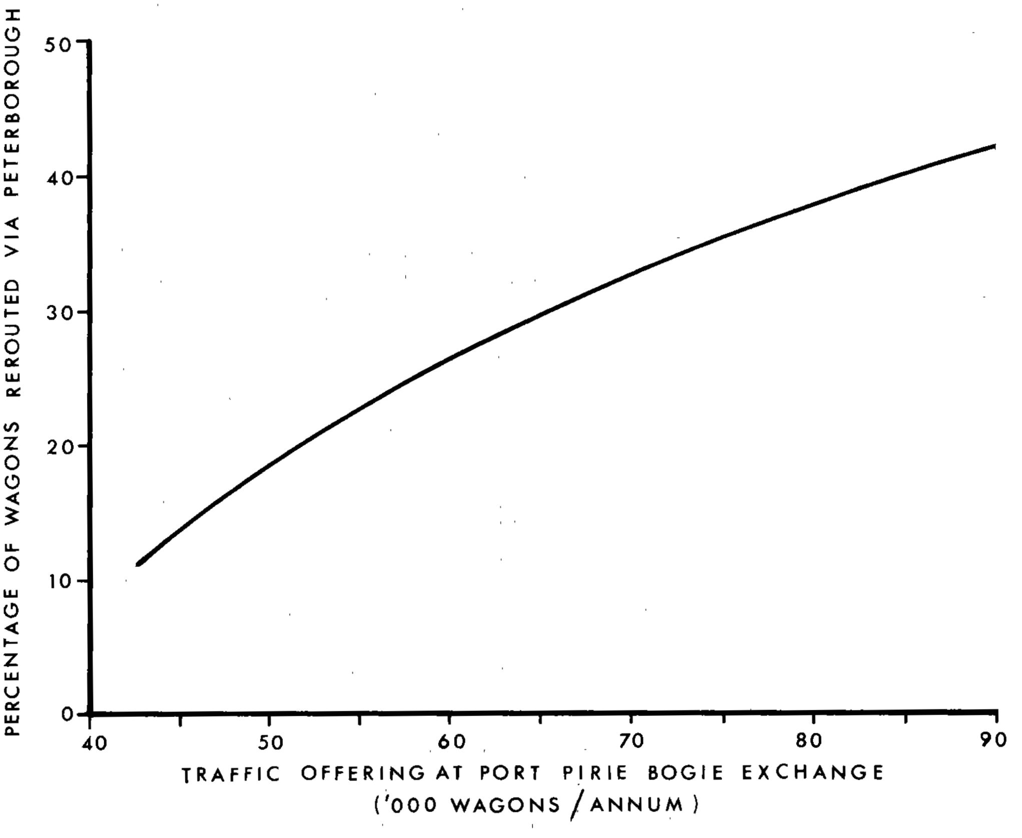

FIGURE 15·2

PROJECTED REROUTING OF TRAFFIC OFFERING IN PORT PIRIE BOGIE EXCHANGE IF EXISTING FACILITIES ARE NOT UPGRADED

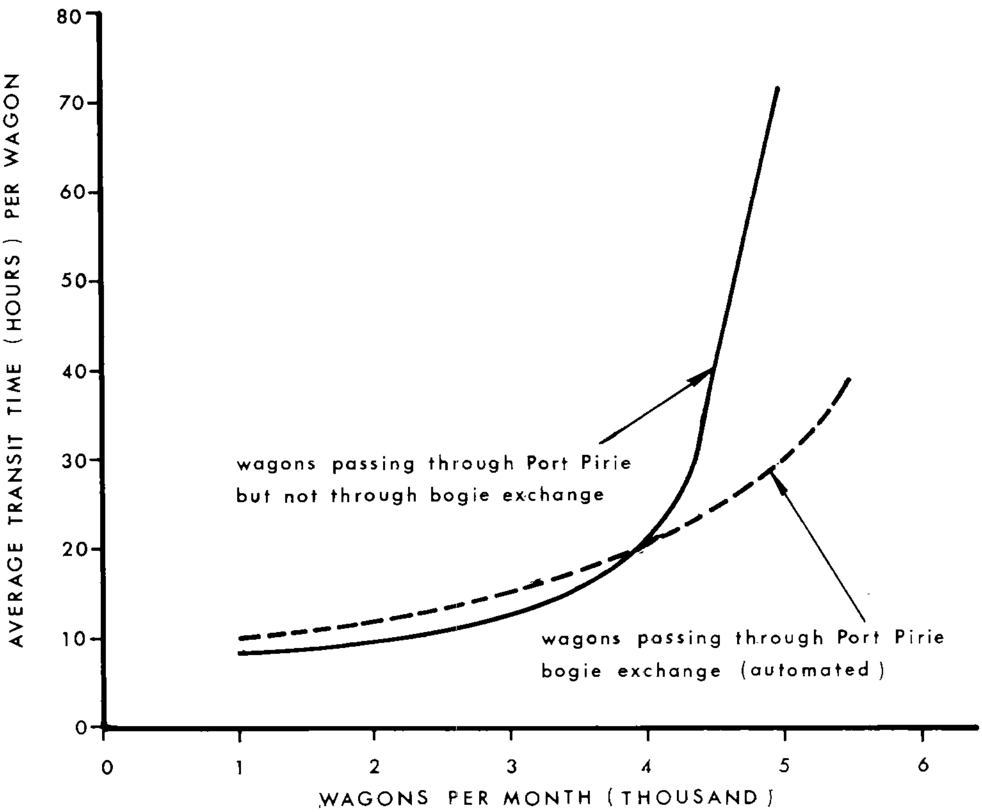

FIGURE 15·3

AVERAGE TRANSIT TIME OF WAGONS PASSING THROUGH THE FACILITIES AT PORT PIRIE UPGRADED WITH AN AUTOMATED BOGIE EXCHANGE

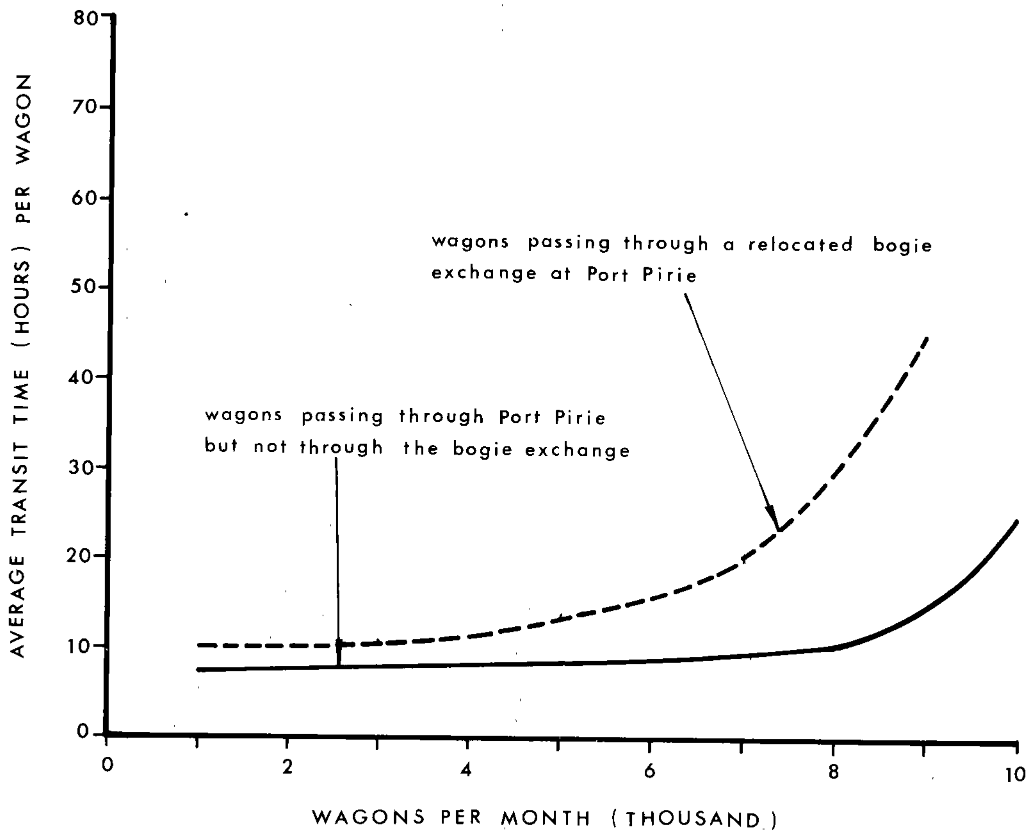

FIGURE 15·4

AVERAGE TRANSIT TIME OF WAGONS PASSING THROUGH THE FACILITIES AT PORT PIRIE WITH A RELOCATED AND UPGRADED BOGIE EXCHANGE

CHAPTER 16 - METHOD AND ASSUMPTIONS

The aim of the evaluation was to determine which, if any, of the identified possible upgradings was economically justified and when would be the best time to implement such an upgrading. The evaluation took into account the fact that Port Pirie is simply a node in a total railway system and that costs of congestion at Port Pirie percolate through the whole system, as do any benefits obtained from upgrading.

The evaluation was undertaken in two parts, the first based on the effect of upgrading options in reducing total resource costs of the bogie exchange process. This included assessment of the costs incurred by customers in having freight delayed by the bogie exchange operation. The second part of the evaluation was based on the commercial interests of the railways and considered the financial effects of the upgrading proposals.

The evaluation procedure began with the forecasting of traffic affecting the bogie exchange over the next 20 years. This included traffic actually subject to bogie exchange and also the additional traffic passing through the Port Pirie yard which has some effect on the bogie exchange operations. The operational features of the existing bogie exchange system were examined and a model of the system was developed. Similarly, the operational features of the upgraded system were examined and a model of its operation developed. Line haul and bogie exchange costs were calculated and converted to a per unit basis, as were the expected returns in the form of revenue. Benefit-cost and financial analysis were then undertaken.

For the benefit-cost analysis the benefit was taken to be the reduction in resource cost of operations over the period of evaluation for the upgraded exchange compared to that which would have been incurred if no upgrading took place. The procedure used was to calculate the cost stream for the complete network for each year of the study period for both the base case, i.e. continuing with the existing facility, and for the various upgrading options. The costs for the upgraded options[1] were then subtracted from those for the base case and the difference discounted to present values. The results for each year of the evaluation period were then summed. This sum was divided by the capital cost of the upgrading option (discounted from the year of implementation to present value) to determine the benefit-cost ratio.

In the cost analysis line haul costs were separated from bogie exchange delay costs. No account was taken of delays on the main lines feeding the Port Pirie exchange; average transit times for timetabled schedules were used throughout. This approach was adopted because mainline delays outside the Port Pirie-Peterborough Adelaide triangle have equivalent effects on the existing and upgraded facility. The delay costs were obtained by development of delay curves for wagons passing through the exchange and calculation of the value of time for a wagon, including the value of the load. A brief description of the delay curves and the method used to obtain them is given in Annex B. The value of time to be used in calculating delay costs is discussed in Annex C.

For the financial analysis, i.e. the effect on the commercial results of the railway, a slightly different approach was used. The mainline and delay costs were calculated as before, but in this case only the delay costs relevant to railway commercial interests were included, i.e. the costs associated with delays to goods were excluded. In addition, the capital cost for each upgrading was annualised and included in the cost stream. For each year, the value of revenue earned was then calculated and the cost was subtracted from the revenue to give the net revenue. These net revenues were discounted and summed to give the net present value for each option considered. This parameter was

(1) Note that the cost stream for the upgraded option is the same as for the base case up to the year of implementation of the upgrading.

used as choice criterion between options. The revenues and costs calculated apply to the whole east-west network and not just the Port Pirie-Peterborough-Adelaide triangle. This is necessary because consideration of the triangle alone underestimates the losses incurred by the railway once physical capacity is reached since the whole network is affected by the congestion.

Several factors were identified which have a significant effect on the outcome of the evaluation and so were subject to special study. These factors were:

(i) the traffic forecast;
(ii) interest rate on capital;
(iii) capital cost of upgrading;
(iv) identification of full benefits arising from upgradings;
(v) visible costs and revenue i.e. bogie exchange costs, line haul costs, terminal costs; and
(vi) invisible costs i.e. rolling stock investment needs due to wagons being delayed in bogie exchanges and marshalling yards.

The forecast traffic growth is the most important factor in the timing of an upgrading option, i.e. the best year for upgrading. Thus the outcome of the evaluation process is not, in fact, an optimum year of upgrading, but an optimum point on the traffic growth curve for upgrading. It is important that the study results should be interpreted in this manner.

A change in forecast growth rate can, however, change the order of various alternative upgrading projects and so it is important to test the sensitivity of the result to changes in forecast traffic levels. Thus the present evaluation was conducted using pessimistic and optimistic growth rates as well as the expected values.

The discount rate used in calculating the present value of future cost and benefit streams can have an important bearing on the evaluation of a series of alternative projects. In this study a single value of discount rate (10%) was used.

The capital costs of moving the bogie exchange or of standardising the Adelaide to Crystal Brook link are high and subject to a considerable degree of uncertainty. Thus it was appropriate to test the sensitivity of the evaluation to capital cost changes. The effect of three different costs for relocation and five different costs for standardisation have been used in the evaluation.

Identifying the full benefits of upgrading is dependent on how well the operations of the existing and the upgraded system are known and are capable of being modelled. On the modelling side, the most significant aspect of the system which needed to be determined was the average transit delay/wagon for vehicles passing through the Port Pirie, Peterborough and Dynon exchanges. A queueing model was used to devise a formula relating average delay to the total number of wagons passing through the station, and a short validation of this expression against computed values of delay for the month of May 1976, confirmed that the formula was correct to about 10%. It could be argued that while this result allows us to use the formulae with some degree of confidence, nevertheless the best option would have been to produce a set of high and low estimates for the delay curve, and then evaluate the upgradings against them. Since it would have been difficult to generate such curves, and the important issue is to cost the value of such transit delays, then the objective of providing a high and low limit was achieved by using an upper and a lower limit for the cost of one hour's delay to a wagon.

Other operational aspects of the existing system and of the upgraded system (except when the upgrading is the standardisation) were known reasonably accurately so that due allowance was made for them in the model. Much less detailed information was known about the likely operations of the standardised line so that wherever a doubt existed the assumption made was always such that it would never lead to an underestimation of the benefits that would accrue.

Line haul costs and terminal costs were calculated from data supplied by the railway authorities, so that they must be considered a good reflection of 1975/76 average marginal costs.

Revenue was a calculated weighted average of actual revenues received by NSWPTC for interstate goods.

The costing of a one hour delay to a loaded wagon in transit is derived in Annex C. For sensitivity testing, an upper limit of $1.00 and a lower limit of $0.75 were used for resource cost calculations with limits of $0.60 and $0.40 for commercial evaluation.

CHAPTER 17 - EVALUATION OF OPTIONS

The evaluations were carried out under two bases: the resource cost criteria and the commercial or financial gains to the railways criteria. The results of these analyses are presented as separate sections. The essential difference between these two cases is the value of the delay cost/wagon hour that was used in the evaluation; for resource cost criteria, $1.00 and $0.75 were adopted, and for commercial criteria, $0.60 and $0.40.

All identified practically feasible upgrading sequences, including not only single options but also combinations of options have been evaluated. The basic upgrading proposals are listed in Table 17.1. After assessing the results, it was noted that the option of introducing a bypass loop outside Port Pirie did not improve operations as significantly as the other options considered, so that the presentation of most results obtained for upgrading schemes which include the bypass loop have been omitted.

TABLE 17.1 - DESCRIPTION OF UPGRADING PROPOSALS

Abbreviation	Description
Existing	Existing line and bogie exchange facilities
A	Automation of present bogie exchange
R	Relocation of bogie exchange to new site (automated facilities included)
L	Bypass loop outside Port Pirie
S	Standardisation of Adelaide-Crystal Brook line

A sequence such as ARS implies the introduction of upgrading A followed by R and then S.

RESOURCE COST CRITERIA EVALUATION RESULTS

In this evaluation phase, upgradings are considered from the point of view of the social or resource cost to carry out the task. Revenue factors have been excluded from the evaluation.

In this respect, it is assumed that total traffic travels on the rail mode up to the physical capacity of the system after which the excess traffic switches to the road mode. This switching arises within the study period only for the optimistic forecast and for the existing (i.e. not upgraded) system. Under these conditions the year of spill over onto road is year 14.

Evaluation results are discussed under three headings: firstly, the evaluation results achieved by using expected capital costs for the upgrading options are presented; then the effect on the evaluation results of varying some of these capital costs are analysed; and finally the cost savings brought about by upgrading are broken down by categories.

In general, the evaluation results for any particular upgrading are presented as an optimum year of introduction and the present value of resource cost. The evaluation process was such that the latest that an upgrading could be introduced was year 19, whether this was optimal or not, and this is the way some results should be interpreted.

General Evaluation of Upgrading Options

The capital costs used for the evaluation of the upgradings were the expected values, apart from that for the standardisation project for which $30 million was used. This is believed to be the absolute minimum possible cost for a standardisation of the line and the reason for using this value is that if the results reflect poorly on the standardisation option at a capital cost of $30 million, then they would be no better at higher capital costs.

The results are presented in Table 17.2 (Optimistic Forecast), Table 17.3 (Expected Forecast) and Table 17.4 (Pessimistic Forecast).

TABLE 17.2 - RESOURCE COST CRITERIA: OPTIMISTIC FORECAST

Upgrading Scheme	Delay Cost/Wagon hour			
	$0.75		$1.00	
	Best year of introduction	Present value of resource cost ($ million)	Best year of introduction	Present value of resource cost ($ million)
Existing Configuration	-	262.3	-	269.1
A	1	256.3	1	262.1
L	14	262.2	7	269.0
R	2	251.7	1	255.1
AR	1,7	250.4	1,5	254.3
AS	1,12	253.7	1,10	258.2
RS	2,19	252.4	1,19	255.8
ARS	1,7,19	251.1	1,5,19	255.0
S	10	257.3	8	261.7
AS*	1,9	249.5	1,8	252.7
RS*	2,12	250.4	1,10	253.1
ARS*	1,7,12	249.1	1,5,10	252.3
S*	7	252.1	5	255.1

NOTE: (1) S and S* refer to different extreme practices that may arise after standardisation is completed. Under S, it is expected that 50% of Adelaide traffic will need to be bogie exchanged in Adelaide, while under S* this percentage is 0.

(2) Capital Costs

A = $.5 million, L = $.2 million, R = $7.5 million, S = $30 million

TABLE 17.3 - RESOURCE COST CRITERIA - EXPECTED FORECAST

Upgrading Scheme	Delay Cost/Wagon hour			
	$0.75		$1.00	
	Best year of introduction	Present value of resource cost ($ million)	Best year of introduction	Present value of resource cost ($ million)
Existing Configuration	-	253.9	-	259.1
A	1	247.9	1	252.6
L	11	253.9	6	259.0
R	2	246.8	1	249.7
AR	1,8	245.2	1,7	248.7
AS	1,14	247.4	1,13	251.2
RS	2,19	247.3	1,19	250.2
ARS	1,8,19	245.7	1,7,19	249.2
S	11	251.3	9	255.0
AS*	1,11	245.8	1,9	249.1
RS*	2,15	246.9	1,13	249.6
ARS*	1,8,15	245.3	1,7,13	248.6
S*	8	248.8	7	251.9

NOTE: (1) S and S* refer to different extreme practices that may arise after standardisation is completed. Under S, it is expected that 50% of Adelaide traffic will need to be bogie exchanged in Adelaide, while under S* this percentage is 0.

(2) Capital Costs

A = $.5 million, L = $.2 million, R = $7.5 million, S = $30 million

TABLE 17.4 - RESOURCE COST CRITERIA: PESSIMISTIC FORECAST

Upgrading Scheme	Delay Cost/Wagon hour			
	$0.75		$1.00	
	Best year of introduction	Present value of resource cost ($ million)	Best year of introduction	Present value of resource cost ($ million)
Existing Configuration	-	207.4	-	211.1
A	1	203.3	1	206.8
L	19	207.4	18	211.1
R	4	206.6	1	209.1
AR	1,19	203.5	1,17	206.7
AS	1,19	204.1	1,19	207.5
RS	4,19	207.2	1,19	209.7
ARS	1,18,19	204.1	1,17,19	207.3
S	19	208.0	19	211.6
AS*	1,19	204.0	1,18	207.3
RS*	4,19	207.0	1,19	209.5
ARS*	1,18,19	204.8	1,17,19	207.2
S*	19	207.9	16	211.6

NOTE: (1) S and S* refer to different extreme practices that may arise after standardisation is completed. Under S, it is expected that 50% of Adelaide traffic will need to be bogie exchanged in Adelaide, while under S* this percentage is 0.

(2) Capital Costs

A = $.5 million, L = $.2 million, R = $7.5 million, S = $30 million

The results in Tables 17.2, 17.3 and 17.4 suggest the following comments:

(i) The effect of traffic forecast, all other things being equal, is to change the best year of introduction of an upgrading, by bringing it forward for higher volumes of traffic, but the B/C ratio is not significantly affected;

(ii) Similarly, higher delay costs/wagon hour will bring forward the best year of introduction of an upgrading, and will also increase the B/C ratio of an upgrading;

(iii) If the upgrading schemes are ranked in terms of the lowest resource cost, then in general the best option is to introduce automation in the present bogie exchange and, after a few years, to relocate the bogie exchange at a new site. The standardisation scheme is better, i.e. it has a lower resource cost, only under the most favourable conditions for its implementation (high delay costs, high traffic volumes and if is assumed that its implementation would remove the need for any Adelaide traffic to be bogie exchanged).

(iv) If, for any reason, relocation cannot follow automation at the present site, then the best option is to relocate immediately;

(v) Under all conditions of traffic volume and delay costs, the automation of the present bogie exchange is justified in year 1 of the study period;

(vi) The introduction of automation before standardisation delays the optimum year for standardisation by some 2 to 4 years, but the relocation of the bogie exchange, except under the most favourable conditions for the introduction of the standard gauge line, obviates the need to introduce standardisation within the study period;

(vii) If it is decided to standardise by year 10, the automation of the present bogie exchange would still be a cost-saving upgrading which would easily pay for itself in less than 5 years. The relocation upgrading would take more than 8 years to repay its cost, depending on traffic volumes, interest rates and delay costs. Hence if the standardisation project is budgeted before year 10, automation of the present exchange would be all that could definitely be justified.

<u>Sensitivity of evaluation results to the capital costs of the standard gauge project</u>

The standardisation project is unlikely to be as inexpensive as $30 million, although its cost at this stage is not accurately known. For this reason a sensitivity analysis was carried out on this parameter. This analysis serves another purpose also in that it provides an upper limit on the capital costs which will result in the best year of introduction of the project to fall within the study period.

The results presented in Table 17.5 are for the expected traffic forecast. A delay cost per wagon hour of $1.00 is used, i.e. we are considering the most favourable conditions for the introduction of standardisation.

The table may be used to determine the optimal timing of the upgrading once the capital costs are known.

The following conclusions may be drawn from the table:

(i) Standardisation should not be considered within the study period if the cost is expected to exceed $60 million.

(ii) If the project is completed in or around year 10, then this would be optimal only if the cost was between $30 million and $40 million. If the cost is higher than this it should not be implemented until later in the study period.

(iii) In all cases, the phased introduction of automation and relocation before standardisation provides the best investment.

Sensitivity of the evaluation results to the capital cost of the relocation project

Three values of capital cost for the relocation project are used in a sensitivity study of this parameter. The results are presented in Table 17.6; other parameters were set at their expected values.

The main points arising out of the table are:

(i) Higher capital costs retard the optimum year of introduction of the project and reduce the B/C ratio.

(ii) The optimal introduction of the relocation project, if not preceded by the automation of the present exchange, should be before year 5.

(iii) The B/C ratio of the relocation project is between 1.8 and 3.4, but if it is preceded by automation, the incremental B/C ratio is between 1.6 and 2.3.

It should be noted that the timing of the relocation project has negligible effect on the timing of standardisation provided that there is a 10 year gap, at least, between the two.

Break-down of Costs

It is instructive to consider the break-down of the actual costs[1] in the movement of goods traffic[2] to identify where savings

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(1) Marginal costs only are included, with loading and unloading neglected.
(2) This is the traffic that is affected by the operations of the bogie exchange at Port Pirie, and so includes traffic re-routed via Dynon due to congestion developed at Port Pirie and Peterborough.

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TABLE 17.5 - RESOURCE COST CRITERIA: DEPENDENCE OF RESULTS ON COST OF STANDARD GAUGE PROJECT

Expected Traffic Delay Cost/Wagon hour = $1.00

Upgrading Scheme	Capital Cost of Standard Gauge Project ($m)							
	120		50		40		30	
	Best year of intro-duction	Present value of resource costs ($m)	Best year of intro-duction	Present value of resource costs ($m)	Best year of intro-duction	Present value of resource costs ($m)	Best year of intro-duction	Present value of resource costs ($m)
Existing	-	259.1	-	259.1	-	259.1	-	259.1
AS	1,19	254.1	1,19	253.4	1,16	253.4	1,13	251.2
RS	1,19	251.7	1,19	250.9	1,19	250.4	1,19	250.2
ARS	1,7,19	250.9	1,7,19	250.1	1,7,19	249.6	1,7,19	249.4
S	19	260.5	16	258.6	13	257.9	9	255.0
AS*	1,19	253.9	1,16	253.0	1,14	252.6	1,13	249.1
RS*	1,19	253.1	1,19	250.7	1,19	250.3	1,13	249.6
ARS*	1,7,19	252.1	1,7,19	249.9	1,7,19	249.5	1,7,13	249.8
S*	19	260.3	14	258.2	10	255.9	7	251.9

NOTE: S and S* refer to different extreme practices that may arise after standardisation is completed. Under S, it is expected that 50% of Adelaide traffic will need to be bogie exchanged in Adelaide, while under S*this percentage is taken as zero.

TABLE 17.6 - RESOURCE COST CRITERIA: DEPENDENCE OF RESULTS ON COST OF RELOCATION PROJECT

Expected traffic

Delay cost per wagon ($/hour)	Upgrading Scheme	Capital Cost of Relocation project ($m)								
		5			7.5			10		
		Best year of intro-duction	Present value of resource cost ($m)	B/C	Best year of intro-duction	Present value of resource cost ($m)	B/C	Best year of intro-duction	Present value of resource cost ($m)	B/C
	Existing	-	253.9	-	-	253.9	-	-	253.9	-
0.75	A	1	247.9	13.0	1	247.9	13.0	1	247.9	13.0
0.75	R	1	244.3	2.9	2	246.8	2.0	5	248.6	1.8
0.75	AR	1,5	244.0	3.6[1]	1,8	245.2	3.2[2]	1,11	246.1	3.2[3]
	Existing	-	259.1	-	-	259.1	-	-	259.1	-
1.00	A	1	252.6	14.0	1	252.6	14.0	1	252.6	14.0
1.00	R	1	247.2	3.4	1	249.7	2.3	4	251.9	2.0
1.00	AR	1,3	247.1	3.6[4]	1,7	248.7	3.4[5]	1,9	249.8	3.1[6]

NOTE: Capital Cost of A = $2.5 million

(1) Incremental B/C = 2.2
(2) Incremental B/C = 1.8
(3) Incremental B/C = 1.6
(4) Incremental B/C = 2.3
(5) Incremental B/C = 2.0
(6) Incremental B/C = 1.7

accrue. The break-up is presented in Table 17.7 which presents costs within the Port Pirie-Peterborough-Adelaide triangle and the cost of some rerouted traffic via Dynon. It is important to note that it is the differences in the total origin-destination costs between the upgraded system and the existing system which are accurately reflected in the differences between values in Table 17.7.

For the purposes of this analysis, the years of introduction of the upgradings have been fixed either to their optimal year or, with regard to the standardisation, to the most likely year of introduction. The expected traffic forecast has been used and the delay cost/wagon hour was taken as $1.00.

The following points arise from the table:

(i) Automation of the present bogie exchange would, over the study period, bring cost savings (discounted to year 1) of $7m, made up of $2m savings in delay costs, $2.4m in actual bogie exchange costs (due to a more efficient operation of the bogie exchange facilities) and $2.6m in running costs (due to less rerouting being needed) (1).

(ii) If the bogie exchange is relocated, then the cost savings amount to $17.0, of which 54% (or $9.2m) is savings in delay cost and only 20% (or $3.4m) are savings in bogie exchange costs. Relocation thus considerably decreases delay costs even with respect to automation of the present bogie exchange. Note that just under 50% of the delay cost savings accrue to the railways (in terms of higher rolling stock utilisation) and the rest accrues to the customers.

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(1) The B/C ratio may easily be obtained as the ratio of the cost savings and the capital cost of the upgrading (discounted to year 1). The capital cost is the capital expenditure to bring the upgrading performance up to that required to cause the specified cost savings.

(iii) The cost savings accruing for the scheme involving automation and relocation amount to $14.87m, less than the $17m for relocation alone, because of the higher delay costs incurred in the first six years before the operation of the relocated bogie exchange. Where this scheme gains on the relocation alone is in not having to invest in the relocated exchange until year 6.

(iv) The introduction of standard gauge in year 1 may bring a cost saving of $30m or $38.6m, depending on whether or not 50% of the Adelaide traffic will still need to be bogie exchanged. This suggests that one would be justified to spend at the most $30m on a standardisation project which would do away with the need to bogie exchange 50% of the Adelaide traffic and a further $8.6m to remove the need to exchange the remaining 50% of the traffic.

(v) The introduction of the standard gauge in year 6 brings about savings of between $19.41m and $24.68m i.e. the capital expenditure justified in year 6 would be between $34.4m and $43.7m, with the same provisos as above.

(vi) The cost savings from standardisation are equally distributed between savings in delay costs, savings in cost of bogie exchanging and savings in running costs. Thus, attempting to justify the project on savings from bogie exchange costs (which at most are $8.1m) would grossly underestimate the benefits arising from the standardisation.

COMMERCIAL CRITERIA EVALUATION RESULTS

In this evaluation phase, upgradings are considered from point of view of the financial or commercial interests of the railways. For this reason, inventory costs due to delays to wagons are omitted and the upper and lower limits on the delay cost/wagon

TABLE 17.7 - RESOURCE CRITERIA: BREAKDOWN OF COSTS ON THE PORT PIRIE-PETERBOROUGH-ADELAIDE TRIANGLE

Expected Forecast   Delay Cost/Wagon hour = $1.00

Upgrading Project	Year of introduction	Present value of delay cost (1)	Present value of bogie exchange cost (2)	Present value of running costs (3)	Present value of manual exchange cost (4)	Present value of total cost	Net (5) present value
Existing	-	20.67	17.54	28.23	1.31	67.75	0
A	1	18.62	15.13	25.68	1.31	60.69	7.06
R	1	11.57	14.11	23.80	1.31	50.79	16.96
AR	1,6	13.37	14.40	23.80	1.31	52.88	14.87
S (6)	1	8.58	7.63	21.52	0	37.73	30.02
S	6	12.74	11.85	23.17	.58	48.34	19.41
S*	1	4.23	3.40	21.52	0	29.15	38.60
S*	6	9.90	9.42	23.17	.58	43.07	24.68

(1) Cost of wagon waiting time in the 3 bogie exchanges, and times in goods yards awaiting connection.

(2) Costs imputed directly to the operation of the bogie exchanges.

(3) Train running costs for trips within the Port Pirie-Peterborough-Adelaide triangle. For Sydney to Adelaide traffic which is rerouted via Melbourne, the difference in running costs between the actual route taken and the normal route via Peterborough is included. Running costs comprise crew wages, fuel, track and train maintenance and the train capital (this amounts to about 40% of the total running costs).

(4) Presently some goods are manually transhipped in Port Pirie, but would be bogie exchanged if the standard line Adelaide to Crystal Brook were constructed. The standardisation would allow a transfer saving of about $50,000 per year.

(5) Net Present Value is taken to be the difference between the present values of the upgraded and existing facilities.

(6) Under S, it is expected that 50% of Adelaide traffic will need to be bogie exchanged in Adelaide, while under S* this percentage would be 0.

hour were set at $0.60 and $0.40. Revenue has been included in the analysis, as the evaluation is essentially a profit maximisation one. In this respect, it must be noted that under optimistic forecasts, the existing system is unable to accept all traffic offering after year 14, so that after that year the net revenue to the railways remain constant at the year 14 level.

The net revenue over the whole network makes up the figures shown in the tables.

As before, this discussion of evaluation results is separated into three segments. Firstly, the evaluation results achieved by using expected capital costs for the upgrading options are presented; then the effect on the evaluation results of varying some of these capital costs are analysed; and finally the cost savings brought about by upgrading are broken down into some generally useful categories.

In general, the evaluation results for any particular upgrading are presented as an optimum year of introduction and the net present value.

<u>General Evaluation of Upgrading Options</u>

The capital costs used in the evaluation were the expected values, apart from that for the standardisation project for which a capital value of $30 million was used. This is believed to be an absolute minimum possible for standardisation. The reason for using this value is that if our results reflect poorly on the standardisation upgrading at a capital cost of $30 million, then they would be worse at higher capital costs.

The results are presented in Table 17.8 (Optimistic forecast), Table 17.9 (Expected forecast) and Table 17.10 (Pessimistic forecast).

The following points arise out of these tables:

(i) In general, the same comments and the same main conclusions are reached under these criteria as under the resource cost criteria

(ii) The best years of introduction of most upgradings are later than for resource cost criteria. For the automation project the best year is still year 1, but for the relocation project, its introduction has been pushed back by 5 to 10 years. The standardisation project, by itself, would now be introduced some 2 to 3 years later, i.e. around year 9.

(iii) As under the previous criteria, if the upgrading schemes are ranked by the higher Net Present Value (NPV) then, in general, the best option is to introduce automation in the present bogie exchange and, after at least 8 years, to relocate the bogie exchange in a new site. Under no conditions, even at the low capital cost of $30 million, does the standardisation project have a higher NPV than the above option. This confirms the findings based on resource criteria, in which the standardisation project could be judged a better option only under extreme conditions (ie high valuation of delay costs, high traffic volumes and the most favourable assumption about the operation of the system after standardisation).

(iv) Although under all parametric conditions the automation of the present bogie exchange is justified in year 1, if, because of engineering or other operational difficulties, this option cannot be followed by relocation, then the better option is relocation. Under these circumstances relocation should take place sometime between year 3 and year 15, depending on the traffic volumes and the valuation of delay costs.

(v) If standardisation is to be introduced at all, then the best option to take up in the intervening period is to automate the present bogie exchange. This combined upgrading has a consistently higher NPV than either standardisation alone or relocation followed by standardisation[1]. Furthermore the automation will pay for itself within 5 years of its implementation.

Sensitivity of results to the capital costs of the standard gauge project

The standardisation project is likely to cost more than $30 million, although its cost at this stage is not accurately known. For this reason a sensitivity analysis was carried out on this parameter. This analysis serves another purpose as well, for it provides lower and upper limits on the capital costs that will allow the best year of introduction to fall within the study period.

The results presented in Table 17.11 are for the expected traffic forecast. A delay cost per wagon hour of $0.60 is used, i.e. the conditions most favourable to the introduction of standardisation.

This table may be used to identify the optimal timing of the upgrading given that the capital costs are known. Upgrading at a time different from the optimal is economically inefficient.

The following conclusions may be drawn from this table:

(i) As for resource criteria, the project should not be considered for introduction within the study period if its cost exceeds $60 million.

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(1) This was true also for most, but not all, of the parametric analyses under resource criteria.

TABLE 17.8 - COMMERCIAL CRITERIA: OPTIMISTIC FORECAST*

Upgrading Scheme	Delay cost/wagon hour			
	$0.40		$0.60	
	Best year of introduction	NPV ($million)	Best year of introduction	NPV ($million)
Existing Configuration	-	384.7	-	378.6
A	1	391.0	1	386.4
L	15	384.7	10	378.8
R	5	393.5	3	390.4
AR	1,10	394.5	1,8	392.0
AS	1,14	393.2	1,12	389.8
RS	5,19	392.7	3,19	389.8
ARS	1,10,19	394.7	1,8,19	391.4
S	11	389.5	9	386.2
AS*	1,12	394.4	1,11	391.4
RS*	5,19	392.9	3,19	389.9
ARS*	1,10,19	394.9	1,8,19	391.5
S*	9	391.2	8	388.5

NOTE: (i) S and S* refer to different extreme practices that may arise after standardisation is completed. Under S, it is expected that 50% of Adelaide traffic will need to be bogie exchanged in adelaide, while under S* this percentage is 0.

(ii) Capital Costs

A = $0.5 million, L = $0.2 million, R = $7.5 million, S = $30 million.

TABLE 17.9 - COMMERCIAL CRITERIA: EXPECTED FORECAST

Upgrading Scheme	Delay Cost/Wagon hour			
	$0.40		$0.60	
	Best year of introduction	NPV ($million)	Best year of introduction	NPV ($million)
Existing Configuration	-	389.4	-	384.9
A	1	394.6	1	390.6
L	12	389.4	14	384.9
R	6	393.4	3	390.7
AR	1,12	395.7	1,9	392.6
AS	1,16	394.5	1,14	391.0
RS	6,19	392.6	3,19	389.8
ARS	1,12,19	394.9	1,9,19	391.7
S	12	390.8	11	387.3
AS*	1,13	396.0	1,11	393.2
RS*	6,18	392.9	3,17	390.3
ARS*	1,12,18	395.2	1,9,17	392.2
S*	10	393.0	8	390.4

NOTE: (i) S and S* refer to different extreme practices that may arise after standardisation is completed. Under S, it is expected that 50% of Adelaide traffic will need to be bogie exchanged in Adelaide, while under S* this percentage is 0.

(ii) Capital Costs

A = $0.5 million, L = $0.2 million, R = $7.5 million, S = $30 million

TABLE 17.10 - COMMERCIAL CRITERIA: PESSIMISTIC FORECAST

Upgrading Scheme	Delay Cost/Wagon hour			
	$0.40		$0.60	
	Best year of introduction	NPV ($million)	Best year of introduction	NPV ($million)
Existing Configuration	-	322.8	-	319.7
A	1	326.1	1	323.5
L	19	322.8	19	319.7
R	15	322.8	9	320.0
AR	1,19	325.9	1,19	323.3
AS	1,19	325.3	1,19	322.7
RS	15,19	322.0	9,19	319.2
ARS	1,18,19	325.0	1,18,19	322.4
S	19	322.1	19	319.1
AS*	1,19	325.4	1,19	322.8
RS*	15,19	322.0	9,19	319.2
ARS*	1,18,19	325.1	1,18,19	322.5
S*	19	322.2	19	319.2

NOTE: (i) S and S* refer to different extreme practices that may arise after standardisation is completed. Under S it is expected that 50% of Adelaide traffic will need to be bogie exchanged in Adelaide, while under S* this percentage is 0.

(ii) Capital Costs

A = $0.5 million, L = $0.2 million, R = $7.5 million
S = $30 million

(ii) If the project is completed in about year 10, then the investment will have been optimally timed only if it costs at most $30 million, and it will have been introduced too early if it costs more.

(iii) In all cases, irrespective of the capital costs (within the range $120 million to $30 million), the phased introduction of automation and relocation before standardisation provides the best investment, and obviates the need to standardise within the study period.

Sensitivity of the results to the capital costs of the relocation project

The results obtained from an analysis in which three different values of the capital cost of the relocation project were used is presented in Table 17.12. The other parameters were the delay cost per wagon hour ($0.40 and $0.60) and the expected traffic forecast.

Note that the optimal timing of the relocation project will be retarded by the higher capital costs, but, provided that there is at least a 10 year gap between this and the timing of the standardisation project, then the timing of the latter is not affected by a later introduction of the relocation project.

Other points arising out of the analysis are:

(i) Higher capital costs reduce the B/C ratio of the project.

(ii) The optimal introduction of the relocation project, if not preceded by the automation of the present bogie exchange, should be before year 9.

(iii) The B/C ratios are slightly less than in the case of the resource cost analysis, but not sufficiently lower to change either the ranking of the upgradings or the relative magnitudes of the B/C ratios.

Break-down of Costs

The break-down of the actual costs in the movement of goods traffic has been examined so that the savings from upgradings can be traced to particular operational improvements. Similarly, by including revenues in Table 17.12, we are able to deduce if part of the gain in net revenue after upgrading has come about from actual increases in traffic flows. For the expected traffic forecasts, all the traffic could be carried by the railway system under the existing system and under any of the upgraded systems, so that there was no gain in revenue from upgrading.

As in the case of resource costs, it is important to note that the difference in the total origin-destination costs between the upgraded system and the existing system are reflected in the differences between the respective values in Table 17.12.

For this analysis, the expected traffic forecast has been used and the delay cost/wagon hour has been set at $0.60. The years of introduction are set to their optimal values as determined earlier on, in the case of the standardisation project, to the most likely year of introduction.

Essentially the same conclusions are drawn as in the case of resource cost criteria and may be summarised as follows:

(i) The automation option would allow savings of $6.2 m and the relocation option would save $13.2 m in costs. If the relocation is introduced in year 6, then, at 10% discount, one would be justified in spending about $18 million on its implementation.

(ii) Introducing standard gauge in year 1 justifies at most an expenditure of $29.84 m and if introduced in year 6, at most $33.7 m.

TABLE 17.11 - COMMERCIAL CRITERIA: DEPENDENCE OF RESULTS ON COST OF STANDARD GAUGE PROJECT

Expected Traffic   Delay Cost/Wagon hour = $0.60

Upgrading Scheme	Capital Cost of Standard Gauge Project ($m)							
	120		50		40		30	
	Best year of introduction	NPV ($m)	Best year of introduction	NPV ($m)	Best year of introduction	NPV ($m)	Best year of introduction	NPV ($m)
Existing	-	384.9	-	384.9	-	384.9	-	384.9
AS	1,19	388.8	1,19	389.5	1,18	389.9	1,14	391.0
RS	1,19	390.8	3,19	389.1	3,19	389.5	3,19	389.8
ARS	1,6,19	391.4	1,9,19	391.0	1,9,19	391.3	1,9,19	391.7
S	19	383.3	18	384.1	14	385.1	11	387.3
AS*	1,19	389.2	1,17	390.1	1,15	391.1	1,11	393.2
RS*	1,19	391.2	3,19	389.5	3,19	389.9	3,17	390.3
ARS*	1,6,19	391.8	1,9,19	391.4	1,9,19	391.7	1,9,17	392.2
S*	19	383.8	15	385.3	12	387.2	8	390.4

NOTE: S and S* refer to different extreme practices that may arise after standardisation is completed. Under S, it is expected that 50% of Adelaide traffic will need to be bogie exchanged in Adelaide, while under S* this percentage is 0.

TABLE 17.12 - COMMERCIAL CRITERIA: DEPENDENCE OF RESULTS ON COST OF RELOCATION PROJECT

Expected Traffic

Delay Cost per Wagon hour ($)	Upgrading Scheme	Capital Cost of Relocation Project ($m)								
		5			7.5			10		
		Best year of introduction	NPV ($m)	B/C	Best year of introduction	NPV ($m)	B/C	Beat year of introduction	NPV ($m)	B/C
	Existing	-	389.4	-	-	389.4	-	-	389.4	-
	A	1	394.6	10.4	1	394.6	10.4	1	394.6	10.4
0.40	R	1	395.4	2.2	6	393.4	1.9	9	392.2	1.6
	AR	1,9	396.5	3.5 (1)	1,12	395.7	3.0 (2)	1,14	395.2	2.7 (3)
	Existing	-	394.9	-	-	384.9	-	-	384.9	-
	A	1	390.6	11.4	1	390.6	11.4	1	390.6	11.4
0.60	R	1	393.0	2.6	3	390.7	1.9	7	389.1	1.7
	AR	1,6	393.6	3.4 (4)	1,9	392.6	2.9 (5)	1,12	391.8	2.7 (6)

NOTE: Capital Cost of A = $0.5 million

(1) Incremental B/C = 1.8 (2) Incremental B/C = 1.4 (3) Incremental B/C = 1.2

(4) Incremental B/C = 2.0 (5) Incremental B/C = 1.6 (6) Incremental B/C = 1.3

TABLE 17.13 - COMMERCIAL CRITERIA: BREAKDOWN OF COSTS AND REVENUE ON THE PORT PIRIE-PETERBOROUGH-ADELAIDE TRIANGLE

Expected Forecast

Delay Cost/Wagon hour = $0.60

Upgrading Scheme	Year of Introduction	Present Value of Delay Cost (1)	Present Value of Bogie Exchange Cost (2)	Present Value of Running Costs (3)	Present Value of Manual Exchange Cost (4)	Present Value of Total Cost	Present Value of Revenue	Net (5) Present Value
Existing	-	13.30	17.55	27.15	1.31	59.31	48.86	0
A	1	11.79	15.08	24.92	1.31	53.10	48.86	6.21
R	1	6.99	14.11	23.74	1.31	46.15	48.86	13.16
AR	1,6	7.89	14.37	23.75	1.31	47.32	48.86	11.99
S (6)	1	3.69	8.79	21.73	0	34.21	48.86	25.10
S	6	6.63	12.25	22.90	.58	42.36	48.86	16.95
S*	1	3.19	4.55	21.73	0	29.47	48.86	29.84
S*	6	6.22	8.70	22.90	.58	38.40	48.86	20.91

(1) Cost of wagon waiting time in the 3 bogie exchanges, and times in goods yards awaiting connecting trains.

(2) Costs imputed directly to the operation of the bogie exchanges.

(3) Train running costs for trips within the Port Pirie-Peterborough-Adelaide triangle. For Sydney to Adelaide traffic which is rerouted via Melbourne, the difference in running costs between the actual route taken and the normal route via Peterborigh is included. Running costs comprise crew wages, fuel, track and train maintenance and the train capital (this amounts to about 40% of the total running costs).

(4) Presently some goods are manually transhipped in Port Pirie, but would be bogie exchanged if the standard line Adelaide to Crystal Brook were constructed. The standardisation would allow a transfer saving of about $50,000 per year.

(5) Net Present Value is the difference between the present value for the upgraded system and that for the existing system.

(6) Under S, it is assumed that 50% of the Adelaide traffic will need to be bogie exchanged, while under S* this percentage is 0.

CHAPTER 18 - CONCLUSIONS FOR PORT PIRIE BOGIE EXCHANGE

On the basis of both resource and commercial criteria the automation of the bogie exchange and its present site is justified.

If the standardisation of the Adelaide to Crystal Brook line is not undertaken within 10 years, then the optimal procedure is to automate the bogie exchange at its present site and then relocate it at a new site in three to five years' time.

If the Adelaide to Crystal Brook line is standardised inside ten years then the automated bogie exchange should be relocated in Adelaide following standardisation.

PART 4

THE PORT PIRIE TO KALGOORLIE LINE

CHAPTER 19 - DESCRIPTION OF EXISTING FACILITIES

Traffic between the Eastern States and Western Australia travels along the whole stretch of the Trans Australia line between Pt Pirie and Parkeston (6km east of Kalgoorlie), a total distance of 1782 km. The operations centre for this line is at Pt Augusta, situated 92 km north of Port Pirie and 1690 km east of Parkeston. The line is entirely single track, crossing mainly open flat country, with easy grades. Speed restrictions due to possible track faults because of the heat may be imposed during summer on sections where concrete sleepers have not yet been placed.

Figures 19.1 to 19.4 show a schematic diagram of the sections of line between Pt Pirie and Kalgoorlie, giving the position and length of crossing loops. All but nine crossing loops are 1500 metres long (adequate to allow 3500 gross tonne trains to cross); of the nine, three are about 1000 metres, while the other six are essentially sidings and are never used to cross trains. The policy of the Australian National Railways is to construct all new loops 1750 metres in length.

East-West traffic joins the line at Pt Pirie and at Parkeston, where trains are formed and they then run essentially unaltered between these two stations except for a few wagons which may leave or join the consist at Pt Augusta. Locomotives normally run right through from Pt Pirie to Parkeston and sometimes the same locomotives pull the trains on the Westrail line from Kalgoorlie to Perth, but with Westrail crews. Five different crews operate a train between Pt Pirie and Parkeston. For a westbound train crew changes take place at Pt Augusta (92 km and 1hr 48 min out of the last crew changing station i.e. Pt Pirie), Tarcoola[(1)] (413 km;

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(1) The longest shift for a train crew is 9hrs, including 30 minutes for signing on and 15 minutes for signing off. Sometimes, a train out of Pt Pirie leaves with two crews on board, so that a crew change can take place en route between Pt Pirie and Tarcoola, without any change being necessary at Pt Augusta.

7hr 35 mins), Cook (505 km; 7hr 20 mins), Rawlinna (489 km; 7hr 25 mins), and Parkeston (373 km; 6hr 35 mins).

SIGNALLING

All stations on the route, apart from the crew-changing stations, are unattended and the entire line is worked on the train order system of safeworking. The operation of this system is as follows. Telephones are placed at both ends of a crossing loop (and sometimes at the middle as well) at most stations on the line. When a train stops at a crossing loop, the train controller at Pt Augusta issues the same set of instructions to the engine driver and to the guard, who then both repeat them to the controller, to double-check for errors. Additional safety is provided by recording the conversation on magnetic tape. The controller's instructions state the next station at which a new set of instructions will be relayed and also formulate the actions to be taken by the train crew at each intervening station.

TERMINALS

The analysis in this section does not consider the implications of traffic growth on the capacity of terminals as the whole question of terminal performance and freight wagon utilisation is under separate study. However, the Port Pirie bogie exchange bottleneck is analysed in considerable detail in Part 3. It is obvious, however, that the upgrading of terminals and mainlines must be co-ordinated and balanced if the full benefits of upgrading are to be realised. At this stage, however, apart from Port Pirie, there is no suggestion of any other terminal on this line needing significant improvements.

PRESENT TRAFFIC

In this study, the trains on the line were divided into five different classes depending on the relative importance of the traffic they carry. The priority allocated to each class for the

DISTANCE FROM PORT PIRIE (KM)		LOOP LENGTH (M)
	PORT PIRIE	
25.5	PORT GERMEIN	1577
45	MAMBRAY CREEK	1536
60.5	NECTAR BROOK	1563
71.5	WINNINOWIE	1667
85	STIRLING NORTH	
92	PORT AUGUSTA	366
95	SPENCER JUNCTION	
119.5	TENT HILL	1737
146.5	HESSO	1609
177	BOOKALOO	1530
210	McLEAY	1850
220	BIRTHDAY	323
242	WIRRAPPA	1555
273.5	PIMBA	1571
311	BURRANDO	1082
342	WIRRAMINNA	1527
375.5	COONDAMBO SIDING	401
394	KULTANABY	1840
426.5	KINGOONYA	1761
469	FERGUSON	1829

FIGURE 19.1

POSITION AND LENGTH OF LOOPS

PORT PIRIE - FERGUSON

DISTANCE FROM PORT PIRIE (KM)		LOOP LENGTH (M)
469	FERGUSON	1829
485	WILGENA	362
504.5	TARCOOLA	1564
541.5	MALBOOMA	1610
565	LYONS	1629
606.5	WYNBRING	1633
638	MT CRISTIE	1565
667	MUNGALA	1533
693.5	BARTON	1871
725.4	BATES	1043
744.5	IMMARNA	298
776	OOLDEN	1549
809	WATSON	1547
839	O'MALLEY	1572
861.5	FISHER	953
914	COOK	1557

FIGURE 19.2

POSITION AND LENGTH OF LOOPS

FERGUSON - COOK

DISTANCE FROM PORT PIRIE (KM)		LOOP LENGTH (M)
914	COOK	1577
956.5	DENMAN	1620
1001.5	HUGHES	1515
1054	DEAKIN	1566
1106.5	REID	1582
1137.5	FORREST	1609
1192	MUNDRABILLA	1583
1239.5	LOONGANA	1628
1287	NURINA	1524
1330.5	HAIG	952
1369.5	WILBAN	1524

FIGURE 19.3

POSITION AND LENGTH OF LOOPS

COOK - WILBAN

DISTANCE FROM PORT PIRIE (KM)		LOOP LENGTH (M)
1369.5	WILBAN	1524
1403	RAWLINNA	1547
1450.5	NARETHA	1626
1512.5	KITCHENER	1885
1572	ZANTHUS	1830
1611	COONANA	1868
1642	CHIFLEY	1532
1670.5	KARONIE	1683
1699.5	RANDELLS	198
1722.5	CURTIN	1830
1758	GOLDEN RIDGE	1679
1776	PARKESTON	1682
1781.5	KALGOORLIE	

FIGURE 19.4

POSITION AND LENGTH OF LOOPS

WILBAN - KALGOORLIE

purposes of either manual or computer simulation is shown below. These priorities coincide approximately with those used when the timetables are prepared. The actual priority given to any train on any particular day by a train controller does, of course, take into account many additional factors.

Priority	Train Type
1	"Trans Australian" Passenger Express
2	Passenger Motors and Rail Budd Cars
3	Express Goods
4	Goods
5	Wayside goods, Livestock.

The distribution of traffic within these train classes for a typical busy day (e.g. a Thursday) in 1976 is given in Table 19.1.

TABLE 19.1 - NUMBER OF TRAINS IN EACH PRIORITY CLASS

Section	Priority Class				
	1	2	3	4	5
Port Pirie-Kalgoorlie	2	2	4	1	1
Port Pirie to Central Australian Railway (C.A.R.)	1	-	-	1	1

The priority 2, 4 and 5 trains do not travel along the whole length of the line.

The C.A.R. trains are included because at present they congest the Port Pirie to Port Augusta line and, after the completion of the Tarcoola to Alice Springs standard gauge line, they will travel along the Trans-Australian link to Tarcoola.

Any trains not included in the table above are assumed to run at times which cause no delay to the more important trains in the table.

CHAPTER 20 - UPGRADING ALTERNATIVES

A preliminary analysis of the capacity of the line revealed that under optimistic forecasts, the daily traffic by the end of the study period (1994-95), in a particular "busy" day, would increase over the present traffic by 4 interstate passenger trains (of the Trans Australian and Ghan type) and 4 express freight trains between Port Pirie and Tarcoola and only 2 passenger trains and 2 freight trains from Tarcoola to Kalgoorlie.

This traffic could be handled by the existing line with only small increases in transit time per train due to the waiting in crossing loops.

Although there would not appear to be any need for the introduction of capacity-increasing measures, such as new loops, nonetheless adding new loops at appropriate points along the line has the effect of decreasing the transit time per train and this brings about savings in crew wages, it reduces locomotive and rolling stock fleet sizes, and decreases in-transit inventory capital. It is for this reason that the possibility of introducing some new loops was considered.

The line between Port Pirie and Port Augusta, apart from being used by the East-West traffic is also used by the Alice Springs and the Whyalla rail goods and passenger movements. It has been suggested by officials at Port Augusta that a case exists for introducing CTC on this line, and this option was also evaluated.

NEW LOOPS

New loops along the line will allow a train to cross where otherwise it may have had to wait for a long period for other trains to pass it. Thus, capacity of the line (i.e. the number of trains per day that can travel along the line without blocking it) will be increased. The theoretical line capacity is determined by the running time along the longest section. As a general rule, when new loops are being programmed, it is reasonable to place the first new loop somewhere in the section with the longest running time and then progress to the section with the next longest running time and so on, until the number of loops is deemed sufficient. This is a particularly useful method on such lines as the Trans Australia, which is not highly trafficked and has sections with long running times. Adopting this technique, it was decided to consider two new loops between Tarcoola and Kalgoorlie and one between Port Pirie and Tarcoola; no further loops were considered necessary. This proposal was in agreement with the ANR perception of what the future capacity-increasing measures should be.

The proposal is for new loops to be established:

(i) between Pimba (274 km from Port Pirie) and Burando (311 km),

(ii) between Naretha (1451 km) and Kitchener (1513 km), and

(iii) between Kitchener (1513 km) and Zanthus (1572 km).

These loops would be 1750 metres long and would be provided with telephone installations to enable the train order system to operate.

ANR has estimated that the cost of each new loop would be somewhere between $125,000 and $150,000. The low cost, in comparison to most other lines in Australia, is partly due to the easier terrain on the Trans Australia line and partly to the ANR policy of using second-hand 80lb rail and reflection point indicators.

CENTRALISED TRAFFIC CONTROL (CTC)

In addition to remote control of the power signals from a central point, CTC schemes may also incorporate the construction of new crossing loops or extension and rationalisation of existing crossing loops. Even if nothing is done about the crossing loops, delay reductions are expected from the introduction of CTC, especially on densely trafficked lines, because CTC reduces each crossing delay at unmanned crossing loops from 8-10 minutes for the manual setting of switches and points, to about 1 minute. Under a train order system, there may be further delays at some crossing loops due to the telephone exchange of instructions between the controller and the train crew. ANR suggest that the crossing delay for long freight trains may be as high as 25 minutes at some loops. The reduction in crossing delays effected by the introduction of CTC may then bring significant increases in line capacity.

The replacement of the train order system by a centralised control brings no savings in manpower as the stations are not manned by signalling staff, but CTC may lead to more effective scheduling by considerably facilitating the train controller's task, and thus it may increase line capacity indirectly. This possible resulting improvement is not quantified in this study.

ANR Scheme for CTC between Port Pirie and Port Augusta

The authorities in Port Augusta have designed a CTC system for the Port Pirie to Port Augusta section. The estimated cost of the project is $1.45 million (in 1975-76).

It has been estimated that the system would allow trains to cross with a total saving in crossing delays of 6 to 12 minutes per train over the train order system.

ANR Scheme for CTC Between Port Augusta and Tarcoola

This scheme would form a second phase of the scheme to introduce CTC on the Port Pirie to Port Augusta line. Its cost is estimated at $1.7 million (1975-76).

This option was considered to be feasible by ANR only if the coal finds at Lake Philipson were to be mined in large quantities, thus leading to increased traffic. The Bureau of Mineral Resources consider that this is an unlikely development in the next 20 years. In view of this fact, the traffic on the line would not, within the study period, justify the introduction of CTC and so this option was not investigated further.

CHAPTER 21 - METHOD AND ASSUMPTIONS

In this study of the Port Pirie to Kalgoorlie link, the expected congestion on the line within the study period is not sufficiently high to warrant expensive upgradings. Furthermore even in the do-nothing case, the railways would be in a position to accept all the forecast increases in traffic. This means that the higher cost road mode will not be required to take up any growth traffic which would normally travel by rail. Thus the study results will be the same under the commercial and the resource cost viewpoint. Hence as the railway will be able to handle all its forecast traffic, even without upgrading, then the upgrading proposals are, in themselves, merely cost-saving devices.

The analysis of the upgrading from the commercial viewpoint, being a profit maximisation, requires not only an estimate of the direct and indirect costs of carrying the growth in interstate freight traffic, but also an estimate of the revenue generated by that traffic. There are several reasons why the revenue should be dependent on the demand and supply characteristics of the system, but experience suggests that in fact it is valid to regard revenue rate as a constant over the study period. The average revenue rate for traffic on the Port Pirie to Kalgoorlie link is of the order of 1.50 cents/tonne km.

The step by step evaluation procedure used in this study is as follows. Starting from the freight forecast for each year, the average number of trains in each direction is calculated for an "average busy day"; new trains are timetabled and the delays for both the existing line and the proposed upgraded configurations are calculated. The estimated delay characteristics are then translated into delay costs and incorporated into an annual net revenue variation as traffic grows. The optimal timing of each upgrading and the net present value (NPV) of each upgrading scheme are then calculated.

TRAINS REQUIRED TO MEET PROJECTED DEMAND AND THEIR TIMETABLING

Since interstate freight is the only growth area in rail traffic on this line all other traffics are assumed to operate indefinitely on the present timetable. In practice, the timetable would be adjusted periodically to take account of operational and demand changes, but it is assumed that in terms of the trend of growing congestion delays, the effect of these adjustments may be ignored.

It is assumed that new freight trains will be 3500 gross tonnes and that no new trains will be introduced until the capacity on presently scheduled trains is exhausted. The growth in traffic is spread uniformly over the year.

The ANR timetable valid in late 1976 contained schedules for trains that run only infrequently and were classified as either "conditional trains" or "shunt goods". By converting 4 of these trains into daily express trains the forecast train demand for the study could be met.

Table 21.1 summarises the freight train timetable and the order of introduction of new trains.

TABLE 21.1 - INTERSTATE EXPRESS FREIGHT TRAINS

Departure Time	Train Number	Order of Introduction
From Port Pirie		
6 a.m.	23	Existing
11 a.m. - 12 p.m.	43	3
6.15 p.m.	73	Existing
12.00 p.m. - 1 a.m.	05	4
From Kalgoorlie		
8.45 a.m.	34	Existing
10 a.m. - 11.a.m.	36	4
12.30 p.m. - 1.30 p.m.	46	3
7.30 p.m.	72	Existing

CONGESTION DELAYS AND CAPACITY

The congestion delays were obtained by timetabling the various trains for a complete journey. The train is said to be delayed if it suffers waiting time at crossing loops or stations due to other trains being on the line.

SELECTION AND TIMING OF UPGRADING

The upgradings were compared on the basis of net present value of net revenue over a range of discount rates, 7%, 10% and 12%, and over a band of traffic forecasts.

A specially developed computer program was used to select the optimal year (or years) in the study period in which to introduce an upgrading (or sequence of upgradings) in such a way as to maximise the net present value of net revenue (NPV) of the project over the study period.

In this study, the upgradings are either economically justified before commercial capacity is reached or they are not justified at all. In this case, it can be shown[(1)] that the optimal timing is independent of the selection criterion (commercial or resource) and the revenue rate.

The total resource cost of transporting the rail's share of the interstate freight can be calculated as the sum of the following:

(a) total rail line haul cost, and rail/road transfer at the railheads;

(b) cost of rail upgrading expressed as an annuity during the appropriate part of the study period; less savings directly attributable to upgradings;

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(1) Bureau of Transport Economics, "Mainline Upgrading - Evaluation of a Range of Options for the Melbourne-Serviceton Rail Link", Canberra, 1975, p. 53 et seq.

(c) average truck operating cost for diverted traffic, when applicable; and

(d) additional cost to diverted traffic and other road users, when applicable.

The year by year total resource cost may then be discounted to a single present value at specified discount rate. The difference between the present values for the situations with and without rail upgradings is the gain of net present value attributable to the upgradings.

If the alternative road mode is not called upon to accept diverted traffic, then the resource cost is simply the sum of (a) and (b), which is exactly the cost used in the commercial analysis. In that case, maximising net revenue (the commercial viewpoint) is equivalent to minimising resource cost (the resource cost viewpoint).

CHAPTER 22 - EVALUATION OF OPTIONS

The freight projections used in this study were calculated from the base year of 1975-76. Table 22.1 sets out the interstate freight train projections. The study period is 1975-76 to 1994-95 with all costs expressed in 1976 Australian dollars and all discounted present values are based on 1975-76. For convenience, the years of the study period are designated 1 to 20.

EVALUATION OF UPGRADINGS

In this study, because of the relatively low traffic levels, neither the commercial nor the physical capacities are reached. This means that whatever conclusions are reached on the basis of commercial considerations to the railways are also valid on the basis of resource considerations for the whole transport task.

Following an initial screening process, only two upgrading schemes were studied in detail - the addition of new loops and the introduction of CTC.

Introduction of New Loops

Five basic upgrading options were evaluated in detail. These were:

Option 1 - The addition of two new loops between Port Pirie and Kalgoorlie.
Option 2 - The addition of one new loop between Tarcoola and Kalgoorlie.
Option 3 - Option 1 followed by Option 2.
Option 4 - Option 2 followed by Option 1.
Option 5 - Simultaneous implementation of Options 1 and 2.

The results of the evaluation of those options are summarised in tables 22.3 to 22.5. The evaluations cover optimistic, pessimistic and expected freight projections and are based on a revenue

TABLE 22.1 - NUMBER OF INTERSTATE FREIGHT TRAINS/BUSY DAY FOR AN OPTIMISTIC FORECAST

Year	Between Port Augusta and Tarcoola(1)	Between Tarcoola and Kalgoorlie
1	2.4	2.4
2	2.8	2.8
3	3.0	3.0
4	3.0	3.0
5	3.2	3.2
6	3.4	3.4
7	3.6	3.6
8	4.6	3.6
9	4.8	3.8
10	5.0	4.0
11	5.4	4.2
12	5.6	4.4
13	6.0	4.6
14	6.2	5.0
15	6.6	5.2
16	7.0	5.4
17	7.4	5.6
18	7.8	6.0
19	8.2	6.2
20	8.8	6.6

(1) The Port Pirie to Port Augusta section would also carry the CAR traffic; this amounts to less than 1 train/day for the first 7 years. The CAR traffic joins the Port Augusta-Tarcoola line in year 8.

rate of 1.5 cents per net tonne kilometre and a capital cost of $150,000 per loop.

The results indicate that sequential addition of new loops is likely to be justified on commercial grounds beginning in year 6, i.e. in 1980-81, if the traffic growth is as high as the optimistic forecast. If growth is as expected or lower then the building of new loops should be delayed until late in the study period or beyond, depending upon the actual traffic growth pattern.

Introduction of CTC between Port Pirie and Port Augusta

The installation of CTC is normally justified mainly from savings in wages of station staff in attendance at crossing loops. As there are no signalling staff on the Port Pirie to Port Augusta line, the CTC program can only be justified by the value of train time savings, and savings in equipment maintenance that sometimes accompany a change in safeworking methods. In the present case there would be no savings expected from the latter.

It has been estimated that the introduction of CTC would save a train about 8 minutes at each crossing loop stop. Thus total transit time savings of the order of 20 minutes per train could be expected. On a typical busy day in October 1976 there were 12 trains using this link, a figure expected to grow to 18 by the end of the study period. Given these figures there is no prospect of savings from crew wages and vehicle capital being anywhere near sufficient to offset the capital costs of installing CTC on this link, estimated at $1.45 million.

TABLE 22.2 - COMMERCIAL EVALUATION - OPTIMISTIC FORECAST

Upgrading Option	Evaluation Results for Discount Rate of:					
	7%		10%		12%	
	Best year of introduction	NPV	Best year of introduction	NPV	Best year of introduction	NPV
Existing	-	261.3	-	190.8	-	156.8
1	10	261.4	10	190.9	11	156.9
3	7,8	261.8	7,8	191.1	7,8	157.1
2	6	261.7	6	191.1	6	157.0
4	6,10	261.8	6,10	191.2	6,11	157.1
5	7	261.8	8	191.1	8	157.1

TABLE 22.3 - COMMERCIAL EVALUATION - PESSIMISTIC FORECAST

Upgrading Option	Evaluation Results for Discount Rate of:					
	7%		10%		12%	
	Best year of introduction	NPV	Best year of introduction	NPV	Best year of introduction	NPV
Existing	-	238.1	-	175.7	-	145.4
1	11	238.1	12	175.7	13	145.4
3	8,9	238.3	9,10	175.8	9,10	145.5
2	7	238.3	8	175.8	8	145.5
4	7,11	238.3	8,12	175.9	8,13	145.5
5	9	238.3	9	175.9	9	145.5

TABLE 22.4 - COMMERCIAL EVALUATION - EXPECTED FORECAST

Upgrading Option	Evaluation Results for Discount Rate of:					
	7%		10%		12%	
	Best year of introduction	NPV	Best year of introduction	NPV	Best year of introduction	NPV
Existing	-	192.9	-	145.4	-	122.0
1	19	192.9	19	145.4	19	121.9
3	18,19	192.9	18,19	145.4	18,19	121.9
2	18	192.9	19	145.4	19	122.0
4	18,19	192.9	18,19	145.4	18,19	121.9
5	19	192.9	19	145.4	19	121.9

CHAPTER 23 - CONCLUSIONS FOR PORT PIRIE-KALGOORLIE LINE

Analysis has indicated that no significant degree of congestion is likely to occur on this line over the next 20 years.

Additional passing loops could not be justified at present, but the situation should be reviewed in about 5 years' time in light of actual traffic growth.

Cost savings would not be sufficient to introduce CTC between Port Pirie and Port Augusta in the foreseeable future.

ANNEX A

COST DATA

INTRODUCTION

In the evaluations presented in this report, the following five cost items are included in the analysis of railway costs:

(a) Fuel and crew

(b) Motive power and rolling stock maintenance

(c) Track maintenance

(d) Motive power and rolling stock capital

(e) Traffic congestion delays

Following research at the BTE into track maintenance costs, it appears that these costs are essentially usage dependent, expressed say, in dollars per gross tonne kilometre. By including all components of track in the maintenance function, and treating existing earthworks, bridges, tunnels and drainage as having an infinite life, the imputed cost is, in fact, the long term cost of maintaining the track indefinitely, treating the original investment in earthworks etc. as sunk.

It is assumed that, under steady traffic conditions over the long term, average annual distances travelled can be imputed to locomotive and wagons engaged in a given traffic. Expressing their capital cost as an annuity, at a given discount rate, a motive power and rolling stock capital cost component can be assigned to a traffic, train by train, given the train weight and the number of journeys per year. The implicit assumption is that each increment in traffic is continuously absorbed by a continuously replenished and expanded stock of locomotives and wagons.

In fact, this increased demand for wagons arising from increased traffic need not result in expanded rolling stock if the present wagons are being underutilised. This certainly seems to be the case with four-wheel wagons, which are mainly used to carry intrastate traffic, and consequently it has been assumed that all increments in intrastate traffic will be able to use presently underemployed wagons. On the other hand, wagons carrying interstate traffic seem to be utilised more efficiently and it has been assumed that the fleet will have to expand with increasing traffic.

Traffic congestion delay costs can be conveniently divided into two parts - direct delay costs, e.g. crew, and indirect delay costs resulting from degraded utilisation of equipment. Passenger time costs are considered negligible since the transit time of high priority trains would only suffer a slight increase with traffic growth. This increase in delay is expected to be offset by the decrease in the number of passengers. Indirect delay costs have been simplified by aggregating equipment costs.

There are two bounds to the effect of traffic delays. At one extreme there is the situation in which small delays do not lead to loss of motive power and rolling stock utilisation, as occurs, for example, to intrastate services, which are not as frequent as interstate. Other than additional crew cost, the only cost to the railway may be idle manpower cost at the terminal. At the other extreme there are delayed arrivals at a busy terminal, turning trains around almost continuously over the 24 hour period. In this situation, transit delays would be predominantly reflected as reduced utilisation of wagons and locomotives, which in turn, leads to a requirement for a larger vehicle fleet to meet a given task. This may be expressed simply as an inflation of the motive power and rolling stock capital, in direct proportion to the fractional increase of transit time caused by delay. It has been assumed that interstate rail freight operations tend to the latter extreme.

The growing traffic also causes congestion delays to other traffic and this increased congestion delay must be quantified, for all traffic. Delays to locomotives are computed as mentioned earlier, but delays to wagons are treated with greater caution.

Some allowance is also made for delays to long distance passenger trains, although country and suburban services are ignored. Long distance passenger trains are generally typified by low frequency and rolling stock that can be treated as unique to the service. Passenger coaches tend to operate in sets, travelling in each direction on alternate days; for a typical transit time between Sydney and Broken Hill of over 20 hours, a delay of one or two hours would not directly affect utilisation of rolling stock. Some time on the journey is taken up by cleaning etc., but it has been assumed that adequate tolerance is available to absorb delays. Delay costs for train crews are treated in the same way as for freight trains, noting that passenger trains carry conductors and catering staff.

In relation to terminal loading/unloading costs, it has been assumed in this study that all increases in interstate traffic will come about from freight forwarding traffic, and that the loading/unloading of wagons will be carried out by the freight forwarders themselves. The function of the railways is then merely that of a line-haulier, which includes the marshalling of trains. A different assumption has been made about intrastate traffic, which is received by the railways at the terminals and is loaded/unloaded by railways staff. This extra operation is reflected in the higher revenues per tonne kilometre that intrastate traffic returns.

THE BROKEN HILL - LITHGOW-SYDNEY RAIL LINK

The Lithgow to Sydney section was not fully costed since the evaluation results did not depend on more detailed knowledge of this link.

Distances

Broken Hill	-	Parkes	679 km
Parkes	-	Molong	86 km
Molong	-	Lithgow	204 km
Lithgow	-	Sydney	156 km

Transit Times

General goods train take 26.05 hours (averaged over UP and DOWN transit times) for the journey between Broken Hill and Sydney.

Locomotive and Wagon Requirements

Passenger Trains

Interstate

Indian Pacific (645 tonnes)
Loco requirement: between Lithgow and Parkes, 2 x 44 Class Loco, and between Parkes and Broken Hill, 1 x 44 Class Loco.

Intrastate

All intrastate passenger trains require at most 1 x 44 Class Loco.

Wheat Trains

Weight of an UP train (loaded wagons)	1840 gross tonees
G/N ratio	1.30
Wagons per train	25.7 (average)
Weight of a DOWN train (empty wagons)	425 gross tonnes

Locomotive Requirements:

UP trains (between Parkes and Lithgow)	3 x 44 Class Locos
DOWN trains (between Lithgow and Parkes)	1 x 44 Class Locos

Ore Trains

Weight of an UP train (loaded wagons)	1800 Gross Tonnes
G/N ratio	1.44
Wagons per train	27.5 (average)
Weight of a DOWN train (20 empty wagons)	400 gross tonnes

Locomotive Requirements:

UP train	Broken Hill	- Parkes	2 x 44 Class Locos
	Parkes	- Lithgow	3 x 44 Class Locos
DOWN train	Lithgow	- Broken Hill	1 x 44 Class Locos

General Goods Trains

Bogie wagons per 1230 gross tonne train	33
Bogie wagons per 2500 gross tonne train	67
G/N ratio	2.0

Locomotive Requirement for a 1230 gross tonne train:

UP train	Broken Hill	- Molong	1 x 44 Class Locos
	Molong	- Lithgow	2 x 44 Class Locos
DOWN train	Lithgow	- Parkes	2 x 44 Class Locos
	Parkes	- Broken Hill	1 x 44 Class Locos

Locomotive requirements for a 2500 gross tonne train are double the above requirement.

Trains are limited to 33 wagons under the present loop configuration, but this maximum would increase to 67 if the loop extensions were carried out.

Trains carrying only empty wagons (e.g. in the UP direction between Orange and Sydney) would have the following locomotive requirements

33 wagon train	1 x 44 Class Loco
67 wagon train	2 x 44 Class Locos

Locomotive and Wagon Capital Costs and Performance Characteristics

Locomotive capital cost (44 class Loco)	$640 000
Annual distance (km)	144 000
Lifetime (years)	20
Bogie wagon capital cost (average)	$35 000
Annual distance (km)	144 000
Lifetime (years)	20

Maintenance Costs

Locomotive

NSW PTC Data indicates an average of 74.5 cents/km for each mainline locmotive.

Wagon

The 1975-76 average figure taken over the total NSW PTC general goods wagon fleet is 3.76 cents/wagon km (NSW PTC estimate).

Track

The BTE calculated that the marginal cost of maintenance on sections of single track was of the order of 0.06 cents/gross tonne km for the overall NSW PTC network.

Fuel Costs

NSW PTC estimates (based on 1975-76 fuel consumption costs) that the average fuel consumption was 0.021 cents/gross tonne km.

Train Crew Cost

	$
Freight Train	26
Intrastate Passenger	34
Interstate Pacific	117

The above figures are BTE estimates from data provided by NSW PTC on the operation of trains on the North Coast.

Terminal Handling of Freight

Growth of interstate traffic is assumed to be loaded and unloaded by freight forwarders at the origin and destination terminals. The railways task is to collect and deliver wagons to the forwarders' sidings and make up and marshal trains.

Intrastate traffic is assumed to be loaded and unloaded by the railways and the NSW PTC estimate the costs of this task as $5/tonne (in 1975-76). As these costs include some elements of fixed costs, the BTE estimate the variable component at 75% of the quoted figure.

Marshalling of trains

NSW PTC indicate the following costs per train:

		$
At Parkes	DOWN train	40
	UP train	95
At Broken Hill	DOWN train	107
	UP train	111
In Sydney	DOWN train	138
	UP train	138

Revenue

NSW PTC provided data from which the following 1975-76 estimates were deduced:

Interstate General Goods	1.42 cents/tonne km
Intrastate General Goods	2.96 cents/tonne km

THE ADELAIDE - PORT PIRIE - PETERBOROUGH - BROKEN HILL RAIL LINK

Distances

Adelaide	-	Port Pirie	218 km
Adelaide	-	Peterborough	248 km
Port Pirie	-	Peterborough	115 km
Peterborough	-	Broken Hill	283 km

Transit times

These refer to general goods trains only.

Adelaide	-	Port Pirie	6.0 hours
Adelaide	-	Peterborough	5.0 hours
Port Pirie	-	Peterborough	4.25 hours
Peterborough	-	Broken Hill	5.5 hours

General Goods Train

Adelaide-Port Pirie

Maximum feasible train weight	1453 gross tonnes
G/N ratio	2.0 (comparable with ANR)
Wagons per train	33 bogie wagons
Locomotives per train	1.0 (average) (930 Class)

Adelaide-Peterborough

Maximum feasible train weight	800 gross tonnes
G/N ratio	2.5 (comparable with NSW PTC)
Wagons per train	22.5 bogie wagons
Locomotives per train	1.0 (average) (730 Class)

Port Pirie-Peterborough-Broken Hill

Maximum feasible train weight	1700 gross tonnes
G/N ratio	2.0 (comparable with ANR)
Wagons per train	38.6 bogie wagons
Locomotives per train	2.0 (average) (1 x 830 class + 1 x730 class)

<u>Note</u>: Due to current loop lengths, the maximum train lengths which still enable crossings to be effected, are

Adelaide -	Port Pirie	66 four wheel wagons
Adelaide -	Peterborough	50 four wheel wagons
Port Pirie -	Broken Hill	77 four wheel wagons

(1 bogie wagon = 2 four wheel wagons assumed)

Ore Train

Weight of a loaded train	3123 gross tonnes (average potential load)
G/N	1.36
Wagons for loaded train	65 four-wheel wagons or 42 bogie wagons
Locomotives per train	2 x 700 Class

Locomotive and Wagon Capital Costs and Performance Characteristics

Locomotive capital cost ($)	640 000
Annual distance (km)	101 700
Lifetime (years)	20
Bogie wagon capital cost (average) ($)	35 000
Annual distance (km)	144 000
Lifetime (years)	20

Maintenance Costs

Locomotive (source: SAR maintenance records for selected locomotive classes)

Adelaide	-	Port Pirie	16.9 cents/km
Adelaide	-	Peterborough	16.9 cents/km
Port Pirie	-	Broken Hill	20.4 cents/km

Wagon

The SAR state-wide average cost of wagon maintenance was 3.8 cents/km. SAR had no specific information on intersystem wagons, and so the ANR/WAGR average of 1.6 cents/km has been used. Intersystem wagons are newer and in better condition than the majority of intrastate wagons; furthermore, they tend to require less maintenance as they are of the open or flat variety.

Track

The BTE estimate that the marginal cost of maintenance on the South Australian sections of track is of the order of 0.05 cents/gross tonne km. It was not possible to separate the costs further into the separate links.

Fuel Costs (source: 1975-76 SAR data on locomotive consumption)

Adelaide	-	Port Pirie	33.7 cents/km
Adelaide	-	Peterborough	17.2 cents/km
Port Pirie	-	Broken Hill	36.6 cents/km

Train Crew Cost

The average cost of manning a general goods or ore train in 1975-76 was of the order of $21.62 per train hour.

Revenue

Sources from the various railway networks indicate that the revenue received during the 1975-76 financial year was of the order of 1.42 cents/net tonne km for intersystem traffic.

ADELAIDE - PORT PIRIE - PETERBOROUGH TRIANGLE UNDER PROPOSED STANDARDISATION SCHEME

Distances

Port Pirie	-	Peterborough	115 km
Adelaide	-	Port Pirie	226 km
Adelaide	-	Peterborough	285 km
Adelaide	-	Crystal Brook	198 km

Transit Times

Assuming that general goods trains achieve the same average speed (46.3 kph) as on the Trans Australian link, then the following transit times are applicable:

Adelaide	-	Port Pirie	6.22 hours
Adelaide	-	Peterborough	6.14 hours
Port Pirie	-	Peterborough	4.25 hours

Locomotive and wagon requirements

It has been proposed that general goods trains should be of the order of 2000 gross tonnes. Then, at a G/N ratio of 2.0, the required number of wagons would be 45.4 (using the tare weight of currently utilised bogie wagons). On average, 2 locomotives would be required for loaded trains.

Fuel Costs

The same fuel consumption per GTK as currently applies for these links is assumed. Thus for a 2000 gross tonne train the figure is 43.0 cents/km.

All other data is same as already tabulated for the Adelaide-Port Pirie-Peterborough triangle.

THE TRANS AUSTRALIA RAIL LINK (PORT PIRIE - PARKESTON)

<u>Distance</u>

Port Pirie - Parkeston	1776 km

<u>Transit Time</u>

The intersystem general goods train takes about 26.65 hour for the journey.

<u>Locomotive and Wagon requirements</u>

Intersystem general goods

Weight of a fully loaded train	3500 gross tonnes
G/N	2.0 (applies currently for westbound trains e.g. No. 73 Type)
Wagons/train	70 bogie wagons
Locomotives per train	2 x CL type locos.

<u>Locomotive and Wagon costs and performance characteristics</u>

CL Type Loco capital cost ($)	750 000
Annual distance (km)	180 000
Lifetime (years)	25
Bogie wagon cost (average) ($)	35 000
Annual distance (km)	144 000
Lifetime (years)	20

<u>Maintenance Costs</u>

Locomotive	21.9 cents/km
Wagon	1.27 cents/km

Track

The BTE estimate that the marginal cost of track maintenance on the Trans Australia link is of the order of 0.04 cents/GTK.

Fuel Costs

For the CL locomotives, the average consumption is 16.8 cents/1000 GTK.

Train Crew Costs

The average cost of wages per train hour on the Trans Australia railway was $39.17 in 1975-76.

Revenue

Sources from various railway authorities indicate that the revenue received during the 1975-76 financial year was of the order of 1.42 cents/net tonne km for intersystem traffic.

PORT PIRIE TO ALICE SPRINGS

At present, traffic between Port Pirie and Alice Springs travels on the standard gauge line from Port Pirie to Maree, where loads are transhipped into narrow gauge wagons for the journey to Alice Springs. After 1981, the same traffic would reach Alice Springs after an all-standard-gauge journey via the new Tarcoola-Alice Springs railway.

(i) Before 1981 - Journey via Port Pirie-Maree-Alice Springs

Distance

Port Pirie - Spencer Junction - Maree	435 km
Maree - Alice Springs	869 km

Transit Time

For general goods trains,

Port Pirie - Spencer Junction - Maree	10.08 hours
Maree - Alice Springs	29.25 hours

Locomotive and Wagon Requirement

General goods trains

	Standard Gauge	Narrow Gauge
Weight of loaded train	1000 gross tonnes	800 gross tonnes
G/N ratio	2.0	2.0
Wagons per train	20	20
Locomotives per train	1 x GM Class Loco (average)	1 x Narrow Gauge Loco

Locomotive and Wagon Capital Costs and Performance Characteristics

	Standard Gauge	Narrow Gauge
Locomotive capital cost ($)	640 000	445 000
Annual Distance (km)	180 000	55 340
Lifetime (years)	20	20
Wagon capital cost ($)	28 000	24 000
Annual distance (km)	144 000	55 000
Lifetime (years)	20	20

Maintenance Costs

	Standard Gauge	Narrow Gauge
Locomotive (cents/km)	22	44
Wagon (cents/km)	1.27	2.2
Track (cents/GTK)	.05	.05

The track maintenance cost has been estimated by the BTE from data on aggregate maintenance expenditure.

Fuel Costs

	Standard Gauge	Narrow Gauge
Locomotive fuel consumption (cents/km)	11.4	27.5

Train Crew Cost

On standard gauge section on Port Pirie - Spencer Junction - Maree, the average train crew costs are $21.00 per train hour; on the narrow gauge section, between Maree and Alice Springs, the costs are $43.00 per train hour.

Revenue

Sources from various railway authorities indicate that the average revenue received during 1975-76 was of the order of 1.42 cents/ net tonne km.

(ii) After 1981 - Journey via Port Pirie - Port Augusta - Tarcoola - Alice Springs

Distance

Port Pirie - Tarcoola - Alice Springs	1336 km

Transit Time

For general goods trains	30.0 hours

Locomotive and wagon requirements

General goods trains

Weight of loaded train	3500 gross tonnes (maximum)
G/N ratio	2.0
Wagons per loaded train	69
Locomotive per train	2.0 x CL Class Loco

Locomotive and wagon capital costs and performance characteristics

Locomotive capital cost ($)	640 000
Annual distance (km)	180 000
Lifetime (years)	20
Bogie wagon capital cost ($)	35 000
Annual distance (km)	144 000
Lifetime (years)	20

Maintenance Costs

Locomotive (cents/km)	21.9
Wagon (cents/km)	1.27
Track (cents/GTK)	.04

Fuel Costs

Locomotive fuel comsumption 16.8 cents/1000 GTK

Train Crew Cost

Based on current experience of the Australian National Railways on the Trans Australian link and on projected operations of the trains to Alice Springs, the crew costs are expected to be of the order of $34.90 per train hour.

Revenue

Sources from various railway authorities indicate that the average revenue received during 1975-76 was of the order of 1.42 cents/ net tonne km.

ANNEX B

SOME NOTES ON THE BOGIE EXCHANGE DELAY FORMULAE

For a full explanation of the derivation of these curves and formulae, reference should be made to the BTE report on the Port Pirie bogie exchange[(1)].

Wagons arriving into a station and waiting either to pass through or to be bogie exchanged create a queueing situation. The "service rate"[(2)] for a wagon is dependent on the performance of the yard and/or the exchange facility and the arrival and departure times of the train to which the wagon is attached. Essentially, then, a queueing theory approach can be used to derive the transit time for wagons through the station.

In deriving the formulae for the transit time through the existing yard and through the existing bogie exhange, the current operating procedures and the current timetabling of trains was used. In deducing the results for the automated exchange in the existing yard and the automated exchange in a yard in a new location, wagon throughput was changed according to predicted exchange and/or yard operational performance, but the present timetable for arriving and departing trains was retained. These guidelines were used both for the Port Pirie station and for the Peterborough station.

As there was so little information available on the Dynon bogie exchange, it was assumed that the Dynon bogie exchange and yard had the same performance characteristics as their Peterborough

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(1) Bureau of Transport Economics, " A study of the Port Pirie Bogie Exchange", Canberra, 1977.

(2) The "service rate", as understood in queueing theory terms, is an indication of the throughput, in wagons/hour, possible under no congestion conditions. The service rate, u, is used in conjunction with λ, the arrival rate (in wagons/hour) to obtain $\rho = \lambda / u$, the traffic intensity.

counterparts, and so the same delay formula was used. The number of wagons that need to be rerouted via Dynon is not great, and, in addition, re-routing via Dynon would occur late in the study period so that the effect of re-routing via Dynon on the study results is minimal. In relation to Dynon, the "natural" load of the exchange which consists of traffic from and to the broad gauge spur lines in country Victoria, was assumed constant at 22641[1] wagons per year over the study period, and any re-routed traffic was added to this load.

The delay experienced by traffic passing through the Port Pirie yard, but not being bogie exchanged,is due to time-tabling constraints so that for example, east bound wagons on standard gauge bypassing Port Pirie[2] would have to wait the same number of hours for a connecting train in Peterborough as they would have had to do if they had entered the existing yard in Port Pirie. For wagons passing through the congestion levels in the yard do not contribute very significantly to the wagon transit time during the study period, so that it is valid to assume the same delay patterns for wagons passing through both the Port Pirie yard and the Peterborough yard.

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(1) The 1975-76 load for the Dynon exchange. The assumption is in line with our forecasts for traffic in rural areas outside the regional growth centres.

(2) This would happen if a bypass loop were constructed just outside Port Pirie.

ANNEX C

COSTS OF WAGON DELAYS

If the transit time of wagons and the quantity of goods to be freighted between an origin and a destination for a transport corridor are known, then this determines

(i) the railway's rolling stock requirements, and

(ii) the inventory and the warehouse requirement of the freight forwarder.

If the transit time increases (due to more time being spent at terminals) then both the railway rolling stock pool and the inventory and warehouse needs of the freight forwarder must be enlarged; the costs of these extra acquisitions are the penalties to be paid because of the increased transit times(1).

This annex discusses the assessment of the value of one hour's increase (or decrease) in transit time of a wagon. Three contributions are noted:

(i) the capital costs (due to changed rolling stock needs)

(ii) inventory costs (due to in-transit goods); and

(iii) warehouse costs.

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(1) If the increase in transit time is sufficiently large, then this may cause a diversion of some traffic to another mode. This would, from the railways' point of view, obviate the need to increase considerably the rolling stock and, from the shippers' point of view, it would mean decreased inventory and warehousing costs. However, for the traffic that remains on rail, the increased transit time imposes penalties both on the railways and on the shipper as outlined.

THE CAPITAL COSTS

The total available annual wagon time (8760 hours) is made up of running time, terminal time (loading and unloading) and repair and maintenance time. There is some indication that repair and maintenance takes place on a regular basis, irrespective of wagon utilisation, so that the repair and maintenance time would be an annual constant; then, the running time plus terminal time (referred here as utilisation time) would also be a fixed value.

In order to determine how delays affect the cost of the rolling stock pool needed to accomplish the railway task, the value of one hour of utilisation time is needed (this is then equal to the capital value of one hour's delay).

The data from ANR suggest that locomotives travel a distance of something like 180 000 kilometres per year. Assuming that they are captive to the Adelaide to Perth run (2657 km), then this gives 67.75 trips/year. The transit time is 68 hours and an allowance of 12 hours is made at each end for the locomotives to pick up another train. This means that the total in-service time of the locomotives is 67.75 x (68 + 12) = 5420 hours. The rest of the time (8760 - 5420 = 3340 hours) would be spent by the locomotives in maintenance and repair workshops. It would be expected that wagons would spend a lesser proportion of the time being serviced. In fact, the above figure is probably a lower limit for the wagon utilisation time. An upper limit would be obtained by assuming that wagons spend only about 5% to 10% of the total available annual time being serviced. This would give a utilisation of about 8000 hours.

So, for a wagon lifetime of 25 years at 10% discount, the annuity factor is 11.02%; the cost of a wagon in 1975-76, on average, is $28 000; thus, the value of one hour of utilisation time is somewhere between 38.6 cents and 56.9 cents.

INVENTORY COSTS

Consider firstly the in-transit goods.

In this respect, the function of the railway is that of a pipeline which transmits goods from sender to receiver.

If the total annual tonnage from sender to receiver is T, and the trip time is t hours, then we may assume that the quantity of goods in the pipeline (and hence the in-transit goods) is $\frac{T}{8760} \times t$. If the value per tonne of goods is p, the value of in-transit goods is $\frac{pTt}{8760}$.

If the journey time is decreased from t_o to t_1, the savings to in-transit value of goods is $\frac{pT}{8760}(t_o - t_1)$. This is a once-and-for-all saving, which eventuates at the time of the introduction of the upgrading. It may however, be converted into a perpetuity which then spreads the savings over the whole future.

Furthermore, the in-transit goods suffer depreciation, so that the total annual inventory cost may be put as $\frac{pT}{8760}(t_o - t_1)(r + d)$

where r = interest rate on capital
d = depreciation rate

This reduces to $\frac{p}{8760}(r + d)$ for the cost per tonne hour.

A wagon on average carries 17 tonnes (averaged over loaded and empty wagons) on the East-West rail link; the interest rate is 10%; the depreciation rate is 5%.

The value of goods depends on the commodity carried, being about \$900 per tonne for foodstuffs, about \$4200[1] per tonne for

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(1) Data supplied by Woolworths Ltd in October 1976.

variety goods and about $4 000 per tonne for motor vehicles. An average value of between $1 500 and $2 000 per tonne was assumed[(1)]. Under these conditions, the inventory costs are between 43.7 cents and 58.2 cents per wagon hour.

WAREHOUSING COSTS

Not much is known about how receivers determine their stock size, but it seems that the main concern is reliability of on-time arrival of consignments, in which case the stocks would not alter much if transit times were improved.

Indications are that these costs are negligible compared to inventory costs.

THE COST OF ONE HOUR DELAY TO A WAGON

It would then seem that the cost of an hour's delay to a wagon is somewhere between 82 cents and 115 cents.

Study evaluations were based on a value of 75 cents as a lower limit and 100 cents as an upper limit. These values correspond closely to present demurrage charges.

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(1) A commodity breakdown of goods on the East-West rail link is not available, so that the Woolworths proportions were used.