Railway Freight Operations: Survey of Wagon Utilisation

Occasional Paper

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BUREAU OF TRANSPORT ECONOMICS

RAILWAY FREIGHT OPERATIONS: SURVEY OF WAGON UTILISATION

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FOREWORD

The Bureau of Transport Economics has been conducting a series of studies on railway freight operations. These studies were initiated by the Australian Transport Advisory Council in July 1973. A number of reports have already been published by the Bureau concerning options for upgrading main railway lines and work is continuing on the subject of regional freight centres. This report describes the results of a study of the utilisation of the railway freight wagon fleet.

The study was based on analysis of all wagon movements in NSW, Victoria, South Australia and on the ComRail system (as it was then) for the month of May 1974. Data editing and analysis proved difficult and time consuming, but it has resulted in a detail assessment of wagon utilisation dissected by wagon type and commodity or traffic carried.

The results indicate that 80 per cent of the task involved reasonably efficient use of rolling stock. The remaining 20 per cent of the task, especially the provision of general freight services to a large number of small stations, involved very poor utilisation of railway resources. The results suggest that potential cost reductions of the order of $40 million per annum exist.

The study was begun by the former Operations Research Branch of the Bureau under the direction of J.C.M. Jones and completed within the Planning and Technology Branch under R.W.L. Wyers. The project team was led by L.S. Watson. His principal assistants during the data collection, editing and preliminary analysis stages were S. Paice and B.B. Stokes. Assistance during the final analysis phase was provided by L. Riggs, J. Flood and K. Porra.

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Director

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Canberra
September 1979

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SUMMARY

The survey of rail wagon usage in NSW, Victoria and South Australia is one of a number of sub-studies forming the major study of railway freight operations requested by the Australian Transport Advisory Committee (ATAC) in July 1973. The survey used existing documents of the NSW, Victorian, South Australian and ComRail systems which gave details of rail wagon movements between 28 April and 25 May 1974.

Data editing and compilation of the movement history of each wagon from information contained in Guard's Journals was undertaken using computer processing techniques. These data were further analysed using a combination of computer and manual procedures to provide information on terminal dwell times, empty wagon movement and capacity utilisation. High cost or high volume operations were isolated and the potential for cost reduction examined.

It should be noted that simple measurement of utilisation in the sense of proportion of time spent by a wagon in loaded transit is only one indicator of overall efficiency. Other factors including demand characteristics, wagon size limitations and special purpose vehicles need to be included in the analysis of overall efficiency.

It appears that approximately 80 per cent of the tonne-km of work done by the rail system during the survey period was being undertaken with a reasonable degree of efficiency, given the constraints of variability of demand, availability of backloading and current standards of service. However, for the other 20 per cent of traffic there was potential for cost reductions of the order of $14 million per annum in NSW (at June 1977 prices), $20 million per annum in Victoria and $7 million per annum in South Australia.

Approximately $8 million of these potential savings were associated with the movement of wheat, fertiliser and briquettes in

Victoria. Since the survey period, Victoria has been progressively scrapping the oldest of its 4 wheel wagon fleet. However, the full potential for cost reduction in these bulk traffics will not be realised until major improvements have been made to grain handling facilities at Geelong.

The remaining $32 million per annum was associated with potential savings in the general freight traffics. The analysis showed that the provision of general freight services to a large number of small stations was the main cause of under utilisation. This led to small route traffic volumes and low loading efficiencies. The problem was exacerbated by extended cycle times caused principally by unavailability of back loading and by wagon allocation delays.

The process of analysing the wagon usage data has shown that accurate estimation of the cost of rail freight movements is very complex. Research is still some way from being able to determine an optimum configuration of rolling stock and terminals. However, the wagon survey has provided important costing information which has assisted those who are attempting to develop more effective ways of costing and pricing freight operations in order to control railway deficits.

CHAPTER 1 - INTRODUCTION

At its forty-first meeting in July 1973 the Australian Transport Advisory Council (ATAC) recommended that the Bureau of Transport Economics (BTE) undertake a study which was to include:

'(a) An examination of efficient utilisation of existing resources in railway freight operations.

(b) A survey of investment needs for railway freight operations, including track, signalling, rolling stock and terminals.'

The survey of railway wagon usage was undertaken as part of this ATAC study. Its purpose was to provide some general understanding of the nature of railway freight wagon utilisation on the NSW, Victorian, South Australian and ComRail[(1)] systems. It was to determine areas of the wagon movement operation where there appeared to be potential for improved usage and reduction of costs.

In the past it had been difficult for these systems to undertake analyses of their own wagon fleets since large numbers of wagons were able to move freely into the other systems. The ATAC recommendation made it possible for the BTE to overcome this problem by gathering the necessary data simultaneously from the four systems.

The BTE was also able to use high capacity computing resources which had become available at the CSIRO in 1973 to edit and sort the large volume of data generated by the 36 900 rail wagons owned by the four systems.

The survey used existing wagon movement data that were recorded by train guards when trains were marshalled. The data allowed the movement of a wagon through the rail system to be traced and gave

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(1) Throughout this report the term ComRail is used to refer to what was the Commonwealth Railways standard gauge system from Port Pirie to Parkston and Marree. These lines are now operated by Australian National Railways.

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details of the type and weight of commodity carried. Inconsistencies in wagon identification and commodity classification made the analysis task complex, however, satisfactory statistical procedures were finally developed to overcome most of the data deficiencies.

Chapter 2 provides general information on the survey procedure and the reliability of the results. In Chapter 3 the analysis terminology is defined and an overview of wagon usage is presented. Chapter 4 examines the determinants of the large terminal dwell times for wagons which were common in the freight system. In Chapter 5 the high cost freight operations are isolated and the potential for cost reduction is discussed.

CHAPTER 2 - THE SURVEY PROCEDURE

THE APPROACH

The approach followed in this survey was determined by the following constraints and requirements:

- An overview of the entire system was required.

- It was essential that sufficient data be collected to allow the BTE to make an independent assessment of the potential areas for improvement, without being influenced by the preconceived notions of the various freight transport interest groups. However, as the survey was for comparative purposes only and covered the entire wagon fleet, it was not essential for results to be highly precise.

- The railway authorities could not allocate significant manpower to the study. Cooperation depended on reducing the workload carried by the rail systems to a minimum.

Fortunately, existing train running and loading information recorded by the guards on trains provided a source of wagon movement data that were able to satisfy most of the needs and constraints of this study. Although these data contained some wagon identification errors, there were sufficient good data to be able to establish useful histories of individual wagon movements.

Detailed analysis of survey data of this type is expensive in terms of both computing and staff resources and a survey of four weeks of operations was chosen as being the smallest sample adequate for the study, based on existing knowledge of wagon cycle times.

The 28 April 1974 to 25 May 1974 was nominated as the sample period. March 1974 would have been a more desirable month, since the wheat movements in Victoria would have been imposing a significant load on the system at that time. However, May 1974 was the earliest that a full set of data was available from all systems. Later periods were associated with high levels of industrial unrest and a reduction in rail traffic as economic recession set in.

THE DOCUMENTS

The data for the survey were drawn from the following documents:

- NSW Guard's Journals;
- Victorian Goods Train Load Sheets and Guard's Statement of Running;
- South Australian Enginemen's Pay Sheets and Truck Sheets;
- ComRail Train Running Statements and Guard's Train Waybills.

All contained similar data and formed part of the normal documentation prepared by enginemen and train guards each time a train was marshalled.

The following information was selected from the documents:

- train identification number and district;
- date of commencement of journey;
- stations at which wagons were attached and detached;
- times of arrival and departure from these stations;
- for each wagon attached,
  - station of attachment,
  - wagon type and serial number,
  - type of commodity carried (except in South Australia where commodity information was not available),
  - gross tonnes of wagon,
  - station of detachment,
  - final destination or unload indicator.

DATA PROCESSING

The transcription and editing required the following tasks to be completed:

- transcription of data from forms to magnetic tape;
- tabulation of all data in unedited form;
- manual check of all tabulations by railway operations staff;
- transcription of amendments to magnetic tape;
- computer transformation of transcribed terms to standard terms.

More details of this process are provided in Annex A but the following statistics indicate the size of the task:

- initial transcription (13.9m keystrokes), 16 man months;
- transcription of amendments (4.8m keystrokes), 10 man months;
- manual checking by railways, 22 man months;
- manual checking by BTE staff, 10 man months.

An iterative process of computer editing was used, which allowed recovery of 98.5 per cent of data(1). A computer system then created records corresponding to each wagon entry on each journal, giving the details of time and place of attachment and detachment to and from the train. This generated 616 147 records which were sorted by wagon identification and time of attachment. The sorting operation brought all observations related to each wagon together, giving a history or chronology of its movements during the sample period.

These wagon histories provided a basis for further detection of data errors. For example, wrong identification of a wagon would cause that particular record to be misplaced and create a detectable gap in the wagon's movement chronology. Random samples of approximately 1000 wagon chronologies from each system were

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(1) Any further recovery would have involved expensive manual examination of rejected records.

extracted and subject to manual scrutiny to determine the quality of the data and to derive correction factors which were used in the detailed analysis (see Annex A).

DATA RELIABILITY

Manual scrutiny of samples and computer analysis of wagon movement histories revealed the following principle discrepancies in the data:

- 15 per cent of wagon movements were not documented, of these 71 per cent were local metropolitan movements;
- 6 per cent of wagon 'type/serial number' identifiers were transcribed incorrectly;
- there was inconsistency in commodity codes and insertion of unload indicators.

These errors created the following situations:

- It was not always possible to reliably determine the unloading events by using computer programs. Estimates of total number of unloads for classes of wagons were obtained by using correction factors derived from manual analysis of small samples.
- Although 53 per cent of wagon terminal dwell events could be isolated by computer systems, the distribution of wagon terminal time between city and country terminals had to be determined by manual analysis of small samples.

Although the data were sufficiently reliable to allow identification of inefficient operations, more comprehensive data on specific facilities would have to be collected before it would be possible to determine actual procedures for improving these inefficient operations.

CHAPTER 3 - AN OVERVIEW OF FREIGHT WAGON OPERATIONS

In this chapter the variables which were used in the analysis of operations are defined and some general results of the analysis are presented to give an overview of freight operations.

THE VARIABLES MEASURED

The survey of wagon usage provided data on the following characteristics of each type of wagon:

- tonne capacity;
- tare weight;
- average load of different commodities;
- wagon cycle time (the average time between successive loadings of a wagon);[1]
- average loaded transit time during each wagon cycle[2]; and
- average empty transit time during each wagon cycle.

This chapter and Chapter 5 analyse the performance of 36 856 wagons, which were responsible for 90 per cent of total wagon transit time. The weighted average capacity of all the wagons in the fleet was 28.8 tonnes[3]. The average tare weight of wagons in transit was 15.4 tonnes and the average load of wagons in loaded transit was 20.6 tonnes. The average wagon cycle time was 8.34 days or 200.2 hours. The average loaded transit time was 13.3 hours per wagon cycle and the empty transit time was 6.0 hours

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(1) Estimates of cycle time were obtained by counting the number of unload events in the 28 day sample period for each group of wagons then calculating:

$$\text{wagon cycle time} = \frac{\text{28 days x number of wagons in group}}{\text{number of unload events.}}$$

(2) In this survey transit time is the time that a wagon spends connected to trains, this may include the time waiting in sidings for signals to clear or for shunting to be completed.

(3) This capacity is an average of all wagon type capacities weighted by the fleet size of each type of wagon. A full explanation is given in Annex C.

per cycle. The remaining 7.54 (180.9 hours) days per cycle was spent in terminals waiting for further connections, being unloaded or waiting for allocation to the next task and being loaded. In other words 6.6 per cent of wagon time was spent in loaded transit with a load that used 71.4 per cent of capacity. Empty transit accounted for another 3.0 per cent of wagon time, and the other 90.4 per cent was spent in terminals.(1)

A FINANCIAL MEASURE OF EFFICIENCY

In a survey such as this where there is a need to scan all operations and isolate problem areas, it was necessary to bring the six independent wagon utilisation variables together into one measure of performance. A unit cost which was a function of the six variables was developed in order to study the effect of these variables on the cost per net tonne-km for each type of freight operation. There are many other determinants of cost but in this analysis these were held constant at system wide average values.

Four important components of cost which are affected by the six variables are listed below:

- the cost of providing motive effort to move the net freight load (that is, the cost of doing revenue earning work);
- the cost of providing motive effort to move the tare weight of loaded wagons;
- the cost of providing motive effort to move empty wagons; and
- the long-term opportunity cost of providing capital for wagon renewal.

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(1) It should be noted that there are many factors affecting efficiency of railway operations (traffic demand patterns, wagon size, special purpose wagons, etc). "Idletime" is not regarded as a complete measure of utilisation, but as one indicator.

These four components of cost include the following items:

- long-term opportunity cost of locomotive renewal capital,
- train crew costs,
- locomotive maintenance costs,
- track maintenance cost attributable to gross tonne-km of work done,
- wagon maintenance costs,
- long-term opportunity cost of wagon renewal capital.

The following significant costs could not be included:

- signalling,
- traffic control,
- terminal shunting,
- terminal load handling,
- track construction capital opportunity costs, and
- central management overheads.

The following system wide performance characteristics were estimated from data provided by the railways and were held constant for the analysis:

- Locomotive down time plus light running was assumed to be 20 per cent.

- Average train speed was assumed to be 25 km/h when averaged over an entire trip. This was a typical system wide average, but branch line averages can be 17 km/h and mainline averages can be 30 km/h, or as high as 50 km/h for some special traffic.

- Average trailing load per locomotive was assumed to be 430 tonnes.

- Average trailing load per train crew was assumed to be 645 tonnes.

- An average speed on duty of 32.4 km/h was assumed for purposes of calculating crew costs. This was based on the NSW award covering train crew pay, and is not directly related to actual train speeds.

These assumptions provide reasonable comparisons between wagons that typically move on all sections of the systems. However, they lead to underestimation of costs for wagons that are used principally on branch lines and overestimation of costs for wagons which only travel on mainlines. More information on costing is contained in Annex B.

Table 3.1 shows the component costs for the survey period in both unit and total cost terms. All costs in this report are based on June 1977 prices.

TABLE 3.1 - COMPONENTS OF COST FOR 36 856 WAGONS OBSERVED ON THE RAIL SYSTEMS OF NSW, VICTORIA, SOUTH AUSTRALIA AND COMRAIL DURING 28 DAYS FROM 28 APRIL TO 25 MAY 1974

Cost component	Unit cost (c/t.km)	Total attributable costs for 28 days ($m)
Movement of net tonnes	0.84	7.10
Movement of loaded tare	0.50	4.25
Movement of empty tare	0.30	2.54
Wagon renewal capital opportunity cost	1.06	8.93
Total costs	2.70	22.82

PHYSICAL MEASURES OF EFFICIENCY

Three physical measures of efficiency were used in the analysis. Firstly a primary determinant of the locomotive and track maintenance component of cost per net tonne-km is the ratio of gross tonne-kms of work done to net tonne-kms of revenue earning work achieved. For example, the average gross to net tonne-km ratio for the 36 856 wagons was 2.09, which means for 1.00 tonne of freight hauled a kilometre there was an additional 1.09 tonnes of tare weight[(1)].

Again in calculating the wagon maintenance component of cost per net tonne-km it is necessary to know what proportion of the tonne-days of capacity provided by wagons in transit was used. This can be expressed as:

$$\frac{\text{capacity used}}{\text{capacity in transit}} = \frac{\text{tonnes of freight in transit}}{\text{tonnes of capacity in transit}}$$

$$= \frac{\text{load x loaded transit time}}{\text{capacity x (loaded + empty transit time)}}$$

In the survey 42.6 per cent of tonne-days of capacity provided by wagons in transit was used.

A similar proportion is required to calculate the wagon capital cost component per tonne-km. In this case it is necessary to determine the ratio of tonnes of freight in transit to the total tonnes of capacity, both in transit and in terminals. This can be expressed as:

$$\frac{\text{capacity used}}{\text{capacity available}} = \frac{\text{tonnes of freight in transit}}{\text{tonnes of capacity in the fleet}}$$

$$= \frac{\text{load x loaded transit time}}{\text{capacity x wagon cycle time}}$$

In the survey 4.7 per cent of the total tonne-days of fleet capacity was used.[(2)]

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(1) This is inclusive of empty wagon movement.

(2) This is a very low rate of wagon utilisation. As an illustration, assume an ideal unit train operation is providing a continuous general freight service between Sydney and Melbourne with wagons loaded to 80 per cent of capacity in both directions. The survey showed that the average transit time for the trip in one direction was 17 hours. The train could be unloaded and reloaded within 7 hours giving a wagon cycle time of 24 hours. Under these conditions 57 per cent of the tonne-days of capacity of the unit train wagon fleet would be used.

The loading efficiency of a wagon is another physical measure of efficiency referred to in this report. The loading efficiency is the ratio of the average tonnes of load carried to the tonne capacity of the wagon (usually expressed as a percentage).

All the physical efficiency measures(1) are, when applied to a group of wagons, calculated using appropriate weighted averages. The weighting procedures are discussed in Annex C.

GENERAL CHARACTERISTICS OF THE OPERATIONS OF EACH RAIL SYSTEM

In this section the concepts defined in the last two sections are used to discuss the overall characteristics of operations on each rail system. Figures 3.1 and 3.2 give a comparison of the use of wagon capacity. The first diagram in Figure 3.1 refers to wagons which were used for inter-system freight movements. The areas of segments are proportional to tonnes-days of wagon capacity and show that empty wagon capacity in transit was 3.7 per cent of total fleet capacity. The capacity of wagons which were loaded and in transit was 12.7 per cent of fleet capacity but the freight carried utilised only 53.3 per cent of this tonne-day capacity. The other 83.6 per cent of fleet capacity sat in terminals detached from trains. Overall, 6.7 per cent of the tonne-days of fleet capacity available were used for the movement of freight. The other diagrams in Figures 3.1 and 3.2 show that the performance of most other groups of wagons was worse than this, South Australian 4 wheel wagons used only 1.9 per cent of the tonne-days of fleet capacity for the movement of freight.

Figures 3.3 and 3.4 show the distribution of the gross tonne-km task between the non-reducible activity of moving the net freight and the reducible activities of moving the tare weight of loaded and empty wagons. For inter-system bogie wagons the net freight

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(1) In addition to these "physical efficiency" measures it must be remembered that demand characteristics (peaks, one way loading, etc) have an impact on overall efficiency of the system utilisation.

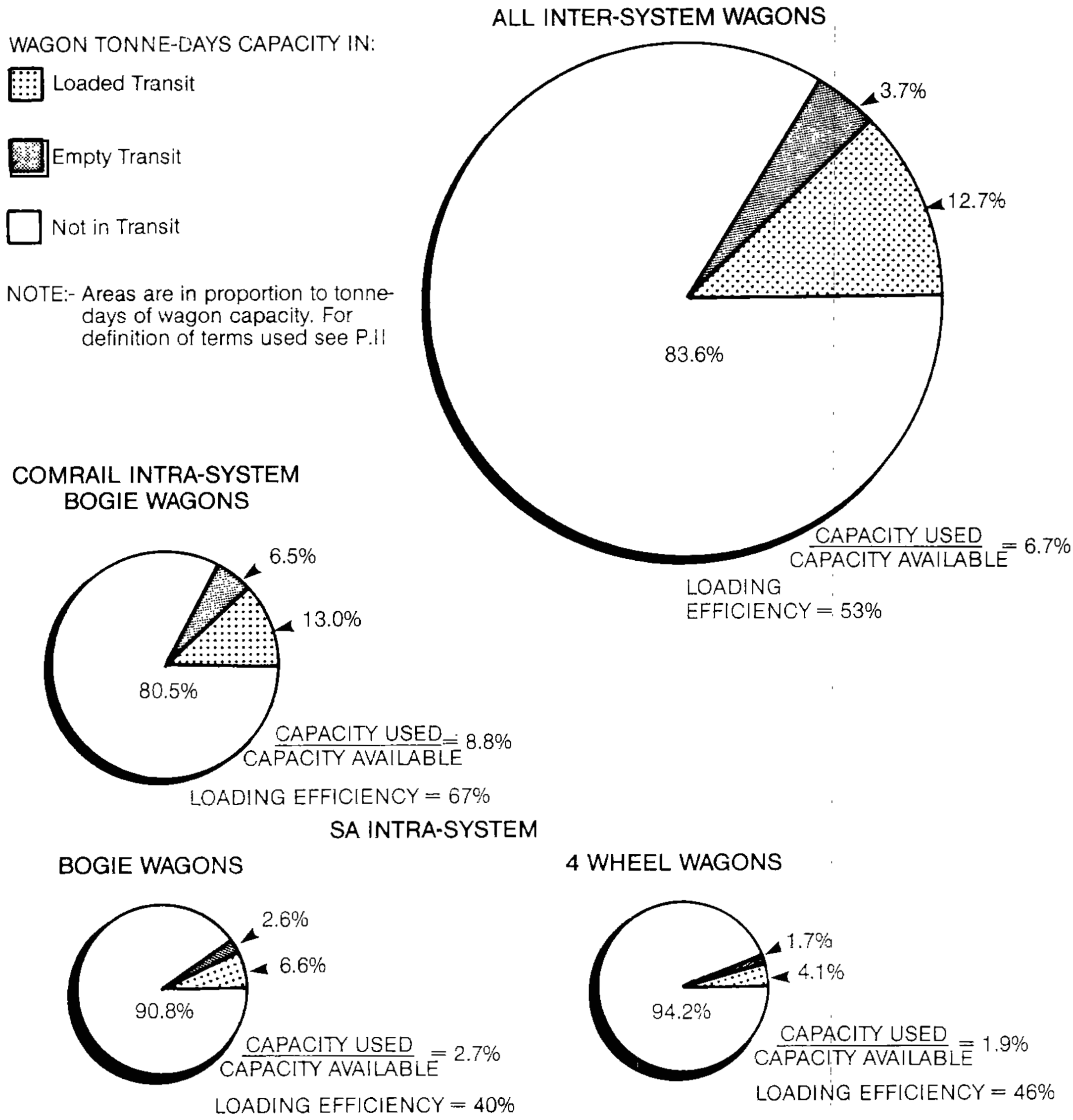


FIGURE 3.1
UTILISATION OF WAGON CAPACITY FOR ALL INTER-SYSTEM WAGONS, COMRAIL INTRA-SYSTEM AND SA INTRA-SYSTEM WAGONS

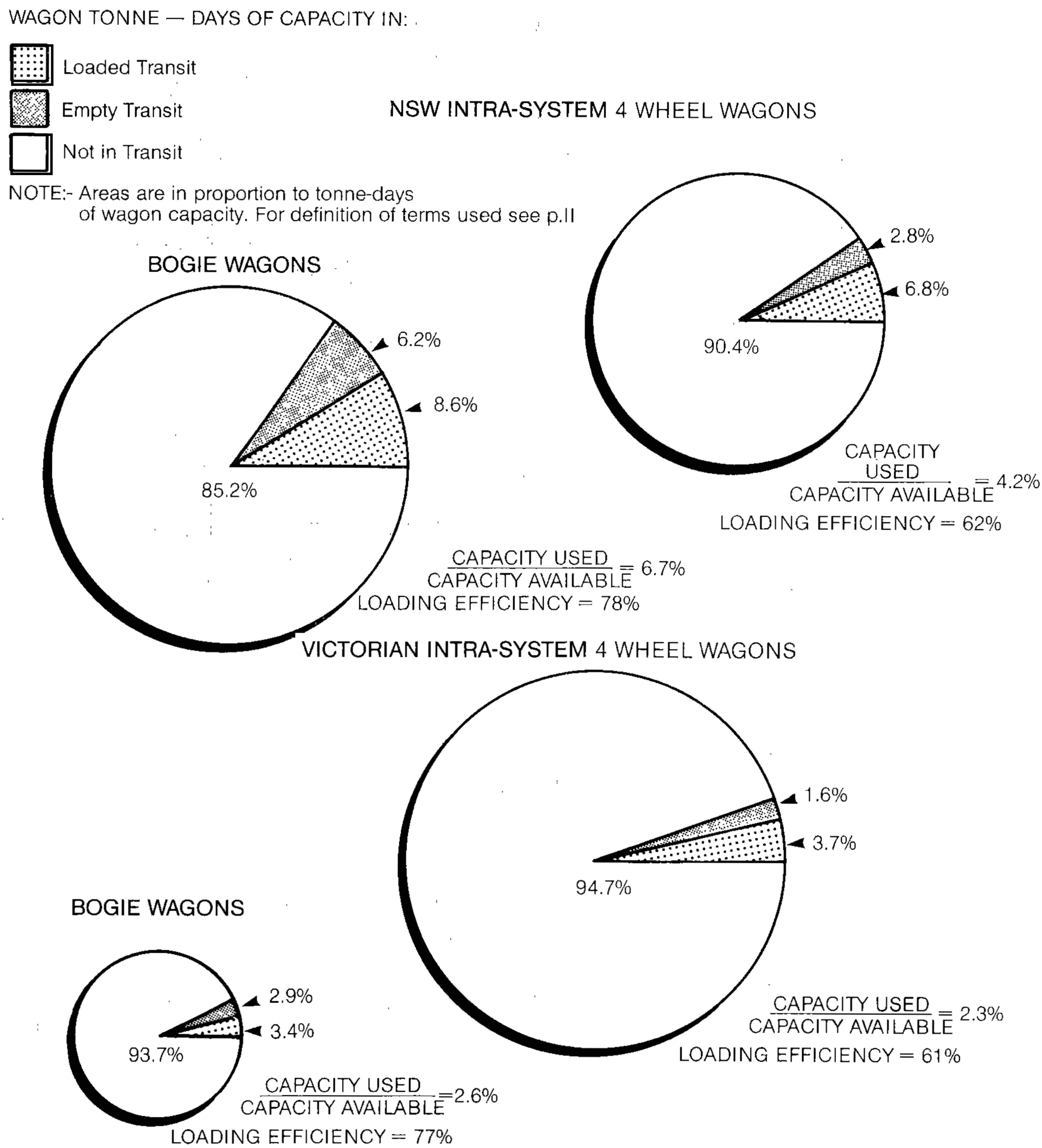


FIGURE 3·2
UTILISATION OF WAGON CAPACITY FOR NSW AND VICTORIA

Net Load t.km

Loaded Tare t.km

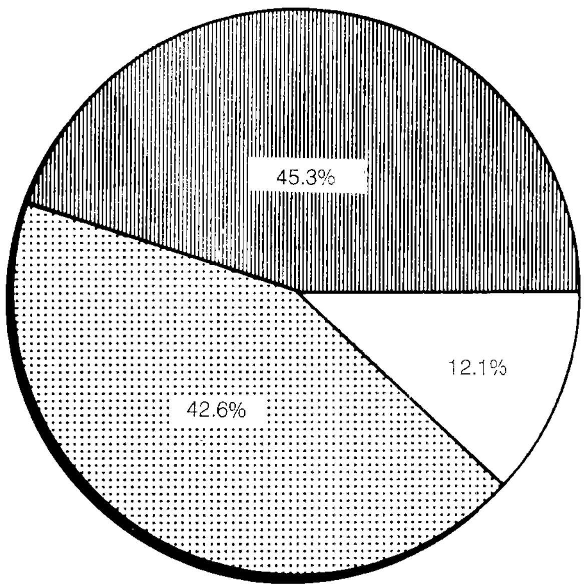
Empty Tare t.km

NOTE:- Areas are proportional to gross tonne-km performed

GNR is the ratio of gross tonne-km to net tonne-km

ALL INTER-SYSTEM BOGIE WAGONS

GNR = 2.21



COMRAIL INTRA-SYSTEM BOGIE WAGONS

GNR = 1.91

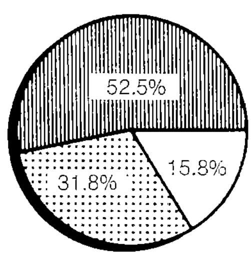


FIGURE 3·3
DISTRIBUTION OF TOTAL MOVEMENT TASK, ALL INTER-SYSTEM AND COMRAIL INTRA-SYSTEM WAGONS

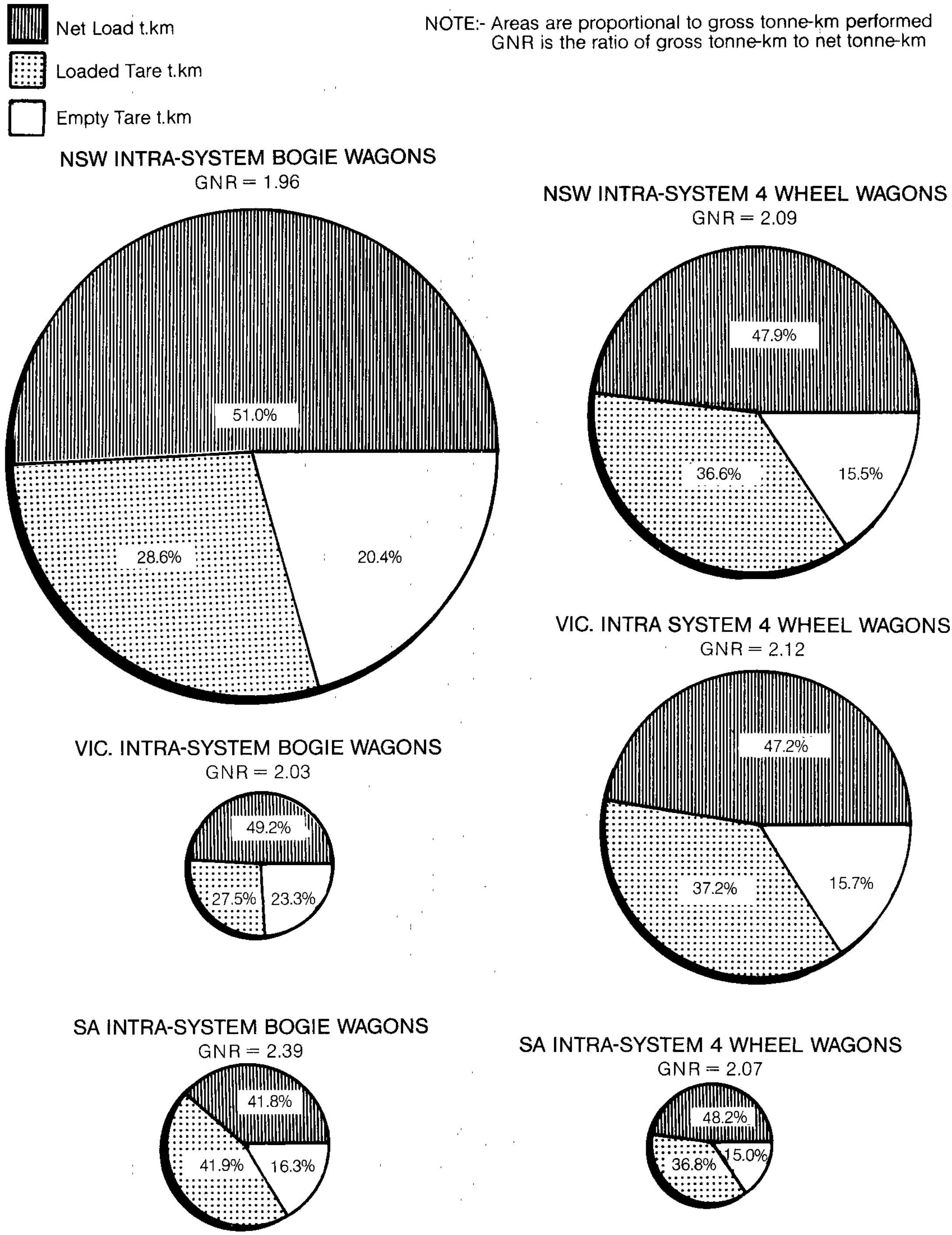


FIGURE 3·4
DISTRIBUTION OF TOTAL MOVEMENT TASK, NSW, VICTORIA AND SA WAGONS

movement made up 45.3 per cent of the gross tonne-kms of work done. The movement of tare weight of the loaded wagons contributed another 42.6 per cent to the gross tonne-kms and empty wagon movement made up the remaining 12.1 per cent. This gave an overall gross tonne-km to net tonne-km ratio of 2.21.

At this system wide level of aggregation there is little difference in the gross to net ratios. The large coal movements on the NSW and ComRail systems are mainly responsible for the slightly lower gross to net ratios of 1.96 and 1.91 respectively for intra-system bogie wagons. This compares with the largest ratio 2.39 for South Australian intra-system bogie wagons.

Figures 3.5 and 3.6 are the most important of the six figures, since they show estimates of freight movement costs which can be attributed to net load movement, wagon tare weight movement and opportunity cost of capital tied up in the wagon fleets. In contrast to Figures 3.1 to 3.4 there are significant differences between the systems. All intra-system operations in Victoria and South Australia and 4 wheel wagon operations in NSW show a high proportion of cost attributable to wagon capital opportunity costs. These capital costs represent 55 per cent of the total costs attributable to these wagon classes. This contrasts with inter-system wagons and intra-state bogie wagon operations on NSW and ComRail systems where only 27 per cent of the attributable costs are associated with wagon capital. These high cost intra-system operations in Victoria, South Australia and NSW used a fleet of 2466 bogie wagons and 23 369 four wheel wagons (that is, 70 per cent of wagons in this analysis). They did 32 per cent of total net tonne-kms for the period and were responsible for 44 per cent of attributable costs. Although the book value of most of these wagons is zero, if the long-term policy was to continue this form of operation with continuous renewal of 4 wheel wagons, the long-term opportunity cost of the capital involved would be $71 million per annum (assuming a wagon life of 25 years and a capital opportunity cost of 10 per cent per annum).

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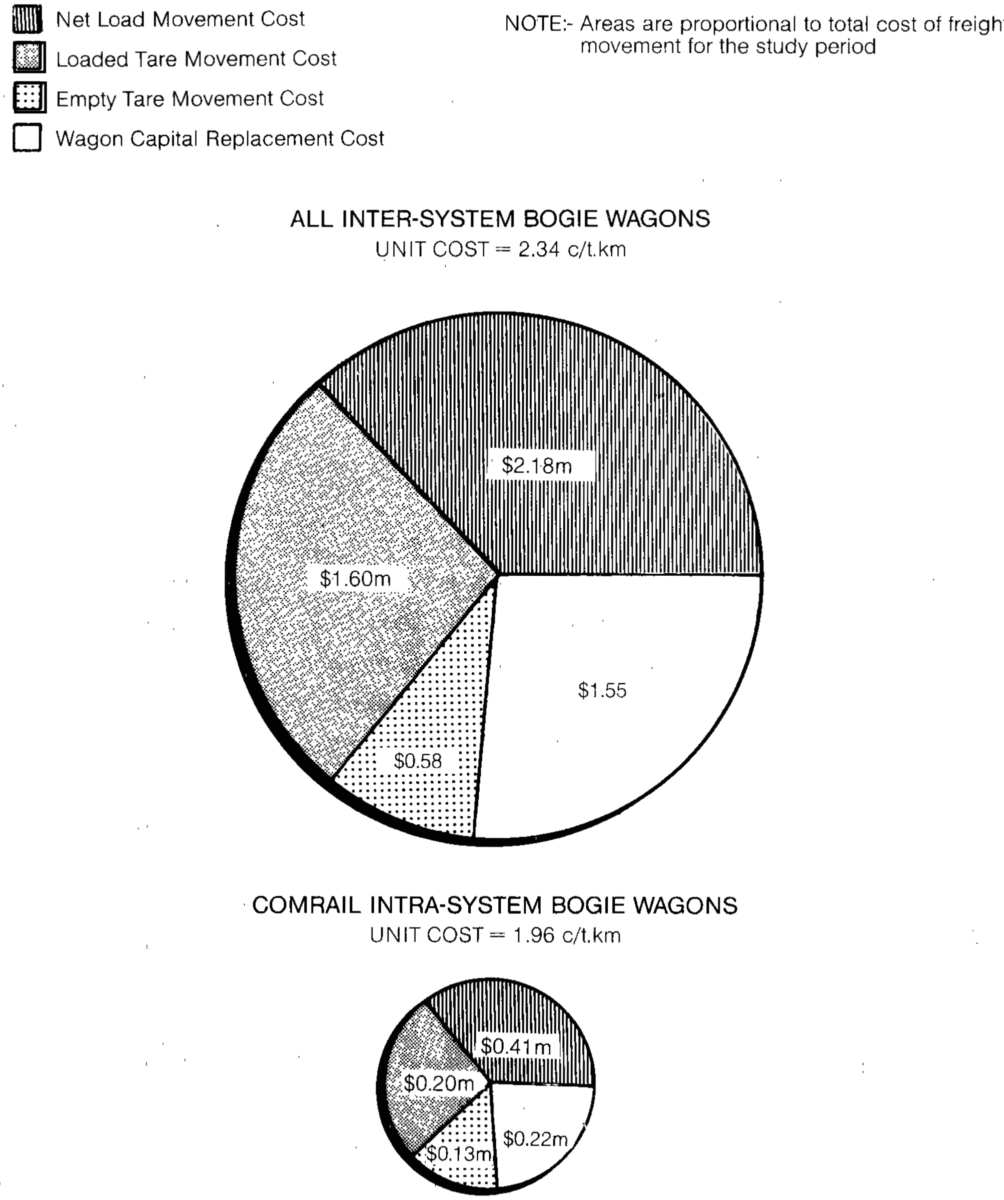

FIGURE 3·5
DISTRIBUTION OF FREIGHT MOVEMENT COSTS, ALL INTER-SYSTEM AND COMRAIL INTRA-SYSTEM WAGONS

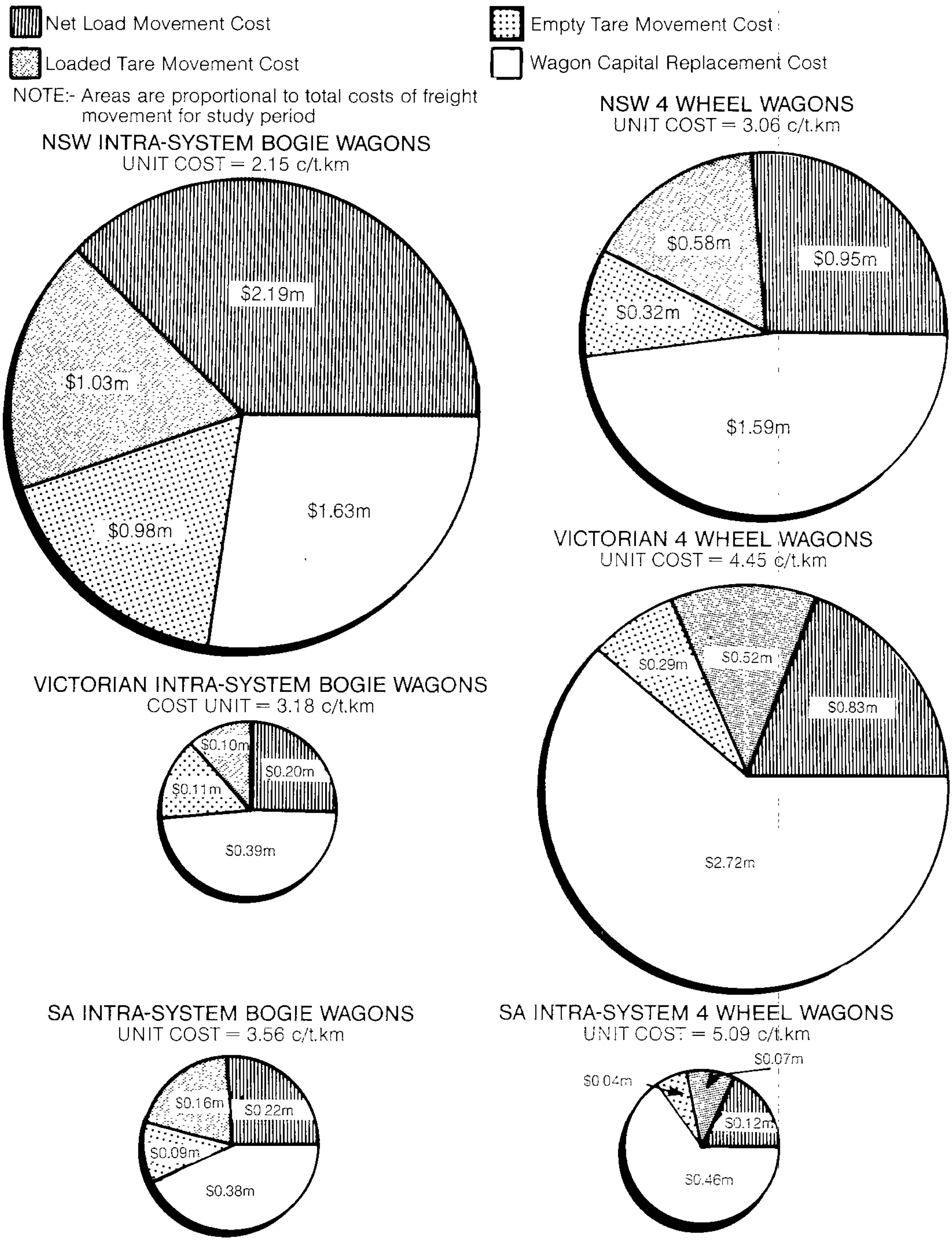

FIGURE 3·6
DISTRIBUTION OF FREIGHT MOVEMENT COSTS, NSW, VICTORIA AND SA

The railway authorities are aware of this situation and there are no plans to continue to replace 4 wheel wagons. If the capital costs of 4 wheel wagons are written off, the average unit costs for this group of wagons falls from 3.8 cents per net tonne-km to 1.7 cents per net tonne-km.

In financial terms the movement of loaded and empty tare weight around the system is nearly as significant. If this level of activity were maintained throughout the year the total tare weight movement cost would be $88 million per annum. This cost component varies from being 45 per cent of movement costs for ComRail intra-system bogie wagons to 53 per cent of movement costs for South Australian intra-system bogie wagons.

The introduction of sophisticated wagon tracing and allocation systems to reduce empty wagon movement has been proposed on several occasions. Consequently it is of interest to note that empty wagon movement at this level of activity has an attributable cost of $33 million per annum and varies from being 13 per cent of movement costs in the case of inter-system wagons, to 27 per cent from Victorian intra-system bogie wagons.

All the costs and figures quoted have been taken from Annex C which gives detailed tables of performance and cost for each major group of wagon types. Annex D gives a more detailed breakdown than Annex C, with information provided by principle wagon type and commodity carried. The detailed results in Annex D have been accumulated to give the histograms in Figures 3.7 and 3.8. These show total attributable costs and net tonne-km of work done at different levels of unit cost. Accumulative distributions show that the 28 per cent of tonne-km undertaken at the high cost end of the distribution generated 46 per cent of costs.

Examples of high and low unit cost traffics from the tables in Annex D are shown in Table 3.2. This table shows the range in values of the wagon performance characteristics and some indication of the compensating effect of the different parameters can be

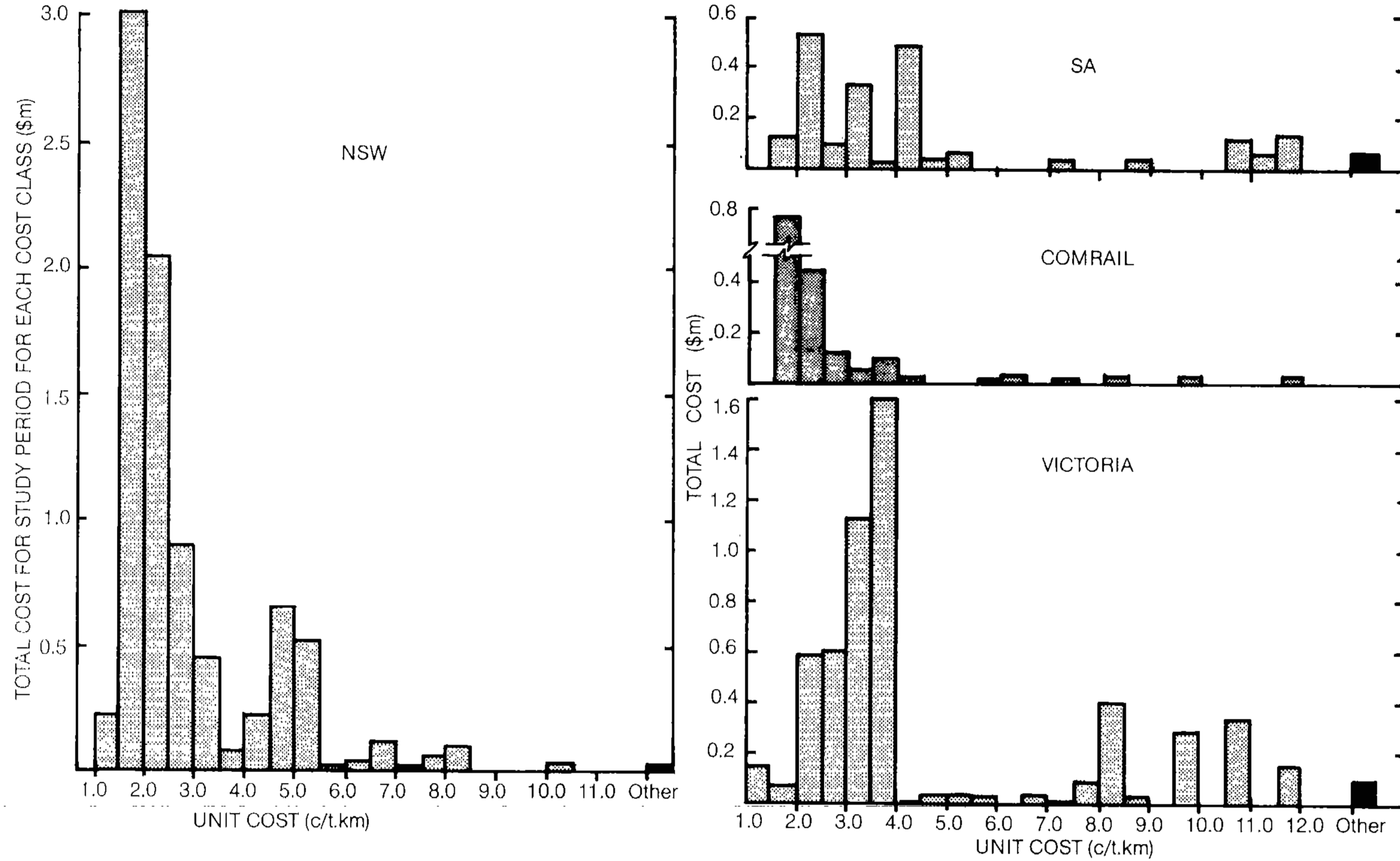

FIGURE 3·7
TOTAL COSTS FOR FREIGHT TASK BY UNIT COST CLASS, FOR STUDY PERIOD
28 APRIL TO 25 MAY 1974

These results have been accumulated from Annex D and only account for 72 per cent of total movement in the study period

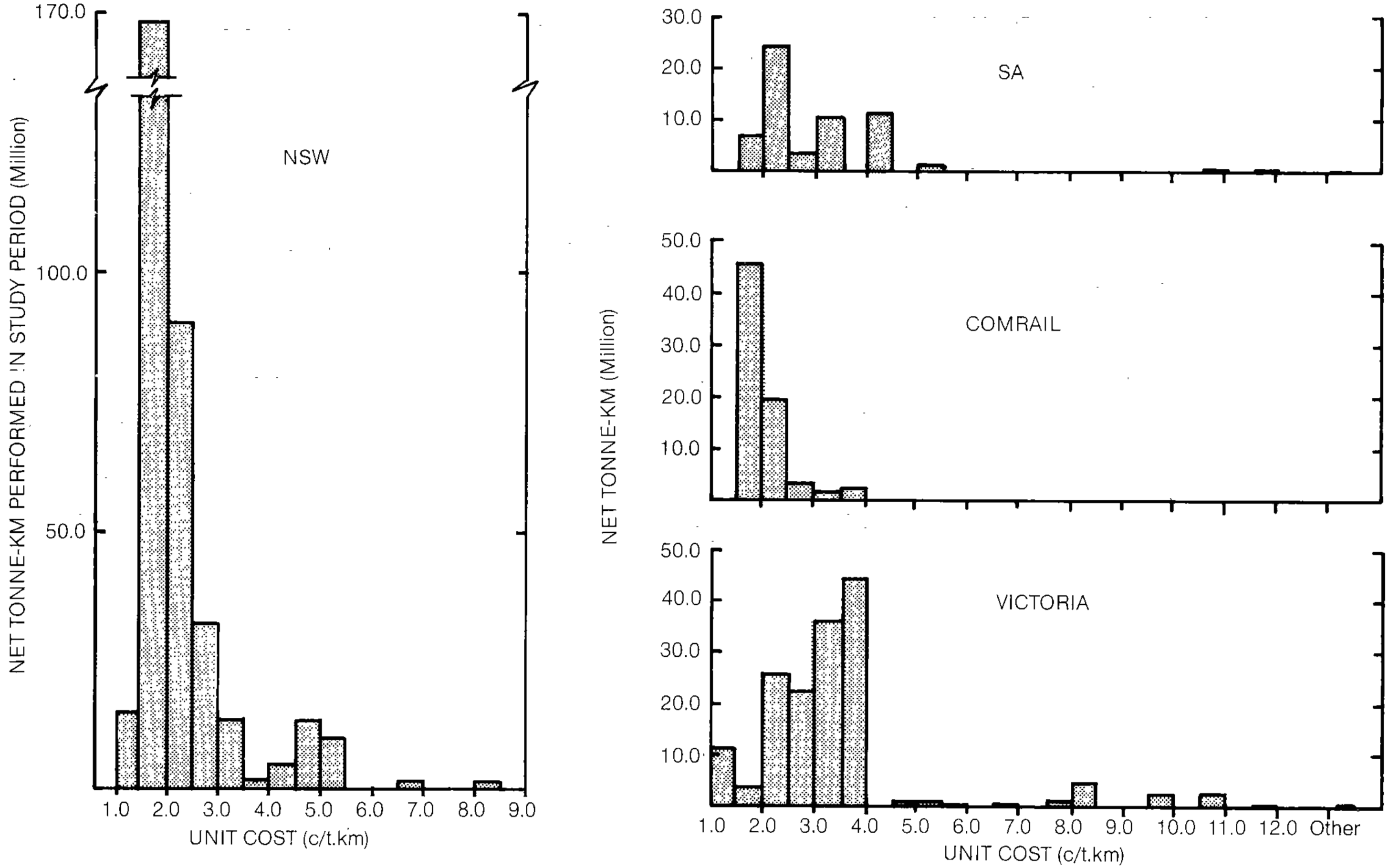

FIGURE 3·8
TONNE-KM PERFORMED IN EACH UNIT COST CLASS FOR STUDY PERIOD 28 APRIL TO 25 MAY 1974

These results have been accumulated from Annex D and only account for 72 per cent of total wagon movements, in addition cost classes of less than 1.0m tonne-km have not been shown

TABLE 3.2 - EXAMPLES OF HIGH AND LOW UNIT COST TRAFFICS

Owner	Wagon class	Area of operation	Wagon type	Average cycle time (days)	Average transit time (days)		Commodity carried	Ratio of load to capacity	Estimated net tonne-km (million)	Unit cost (c/t.km)
					Loaded	Empty				
NSW	Bogie flat	All [a]	BCX	3.1	0.81	0.09	Forwarder [c]	0.81	11.80	1.46
	Bogie hopper	NSW	WH	6.0	0.84	0.81	Wheat	0.97	18.63	1.57
	4 wheel hopper	NSW	CCH	15.1 [b]	0.20	0.23	Coal	0.77	0.76	7.76
	4 wheel flat	NSW	KF	17.1	0.92	0.72	Machinery	0.10	0.08	14.24
VIC	Bogie flat	All	SKX	2.4	0.74	0.02	Forwarder	0.80	7.59	1.35
	Bogie open	All	ELX	12.2	0.88	0.23	Steel	0.89	3.62	1.85
	4 wheel stock	Vic	L	33.7	0.55	0.55	Sheep	0.42	0.18	15.66
	4 wheel open	Vic	RY	10.0	0.35	0.16	Machinery	0.12	0.15	18.01
SA	Bogie flat	All	FQX	7.1	1.01	0.17	Semi-trailer	0.84	0.32	1.39
	Bogie open	All	OX	10.5	1.29	0.13	Steel	0.81	1.06	1.60
	Bogie van	SA	DS	6.1	0.42	0.09	General	0.11	0.29	12.89
	4 wheel stock	SA	SF	17.4	0.34	0.32	Sheep	0.26	0.17	18.73
ComRail	Bogie open	All	GD	12.5	2.06	0.58	Lead	1.00	0.11	1.45
	Bogie open	All	GOX	12.3	1.69	0.28	Forwarder	0.77	2.46	1.82
	Bogie van	ComRail	LDX	16.0	0.96	0.66	General	0.19	0.06	9.51
	Bogie flat	All	RMX	6.1	1.24	0.09	Cars	0.05	0.10	11.32

(a) All systems operation.
(b) Long delays in unloading due to breakdown of Port Kembla coal unloading facility.
(c) "Forwarder" indicates traffic subject to consolidation by freight forwarders.

Source: Tables in Annex D.

seen. For example NSW 4 wheel coal hopper wagons had a cycle time of 15.1 days and were loaded to 77 per cent of capacity. ComRail inter-system bogie open wagons had a similar cycle time (12.3 days) and the same loading efficiency[(1)], however, the unit cost attributed to the NSW wagons was 7.76 cents per tonne-km in contrast to 1.82 cents per tonne-km in the case of ComRail. The difference was almost entirely due to the difference in loaded transit time per wagon cycle, being 0.20 days for the NSW wagons and 1.69 days for the ComRail wagons. The sensitivity of the unit cost to changes in operating characteristics is discussed in more detail in Chapter 5.

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(1) The loading efficiency of a wagon is defined as the ratio of tonnes of load to tonnes of capacity expressed as a percentage.

CHAPTER 4 - A MACRO VIEW OF TERMINAL OPERATIONS

It has been observed in Chapter 3, that 90.4 per cent of wagon days were spent in terminals detached from trains. This chapter examines some of the general characteristics of wagon movement through terminals and discusses the factors producing low utilisation of wagon capacity.

GENERAL CHARACTERISTICS

Table 4.1 gives a summary of average terminal dwell times associated with the loading, unloading and through connection of wagons on the four rail systems surveyed.(1) It also shows the proportion of wagon terminal time taken up by each type of event.(2)

With the exception of ComRail terminals, the type of event occurring had little impact on average terminal dwell times. For example, in NSW the average terminal dwell times for wagons which were subjected to the single operations of loading or unloading were 1.1 days and 1.6 days respectively. The double operation of unloading and reloading required an average wagon terminal dwell time of 1.4 days.

Examination of the terminal dwell events associated with wagons which were unloaded and reloaded in the same terminal shows that there was more back loading of wagons on the Victorian system than on the other systems. In Victoria 38 per cent of tonnes loaded was available as back loading. This compares with 25 per cent, 18 per cent and 15 per cent on the NSW, SA and ComRail systems respectively.

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(1) A terminal dwell event commenced when a wagon which was to be detached from a train arrived at the terminal. It finished when the wagon departed from the terminal on a different train.
(2) These proportions were based on analysis of manually corrected samples of data.

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TABLE 4.1 - TERMINAL EVENTS AND ASSOCIATED DWELL TIMES: BY SYSTEM

System	Event[a]	Proportion of system total[b]				Average dwell time (days)
		Terminal events	Tonnes loaded	Tonnes unloaded	Terminal wagon days	
NSW	Loading of Empty wagon	19	75	-	23	1.1
	Unloading only	18	-	66	30	1.6
	Unloading and reloading	11	25	34	17	1.4
	Thru connection of loaded wagon	23	-	-	13	0.5
	Thru connection of empty wagon	29	-	-	17	0.6
Vic	Loading of empty wagon	16	62	-	23	2.5
	Unloading only	16	-	51	26	3.1
	Unloading and reloading	16	38	49	23	2.6
	Thru connection of loaded wagon	34	-	-	17	0.8
	Thru connection of empty wagon	19	-	-	11	1.0
SA	Loading of empty wagon	17	82	-	26	2.1
	Unloading only	16	-	62	31	2.5
	Unloading and reloading	7	18	38	16	2.9
	Thru connection of loaded wagon	29	-	-	9	0.4
	Thru connection of empty wagon	31	-	-	18	0.8
ComRail	Loading of empty wagon	31	85	-	19	0.8
	Unloading only	29	-	90	34	1.4
	Unloading and reloading	8	15	10	14	2.4
	Thru connection of loaded wagon	15	-	-	6	0.5
	Thru connection of empty wagon	17	-	-	27	2.0

(a) An event is here defined as the passage of a wagon through the terminal, where:
- loading is receiving an empty wagon, loading and despatching;
- unloading is receiving a loaded wagon, unloading and despatching empty;
- unloading and reloading is receiving a loaded wagon, unloading, loading with another load and despatching;
- thru connection, the wagon is neither loaded or unloaded.

(b) Totals may not add due to rounding.

Table 4.2 gives a more detailed analysis of terminal events and shows the distribution of wagon terminal time across various classes of terminals. The importance of the city terminals is shown by the large proportion of wagon days spent in these terminals; in NSW 49 per cent of wagon terminal time was spent in Sydney, Newcastle and Port Kembla; in Victoria 45 per cent was spent in Melbourne and Geelong; and in SA 46 per cent was spent in Adelaide.

Tables in Annex E give details of terminal operation characteristics classified by type of event, class of terminal and bulk and non-bulk traffic. These tables have been aggregated to form Table 4.3. This table shows that for loading or unloading wagons in NSW, bulk traffic[(1)] has shorter dwell times (1.1 days) than non-bulk traffic (1.7 days). In Victoria the situation is reversed with 3.2 days for bulk handling compared with 2.5 days for non-bulk. However, better loading efficiency and larger capacity per wagon allowed the bulk traffic to be moved with a smaller loss of terminal wagon days (25 per cent for 50 per cent of total tonnes loaded) than non-bulk traffic (47 per cent for 50 per cent of total tonnes loaded).

The tables in Annex E also show that loading of bulk freight at major rural terminals in NSW provided 50 per cent of the tonneage loaded in the State but only generated 9 per cent of total terminal wagon days (average dwell time of 0.7 days). Unloading showed a similar pattern, bulk freight at major city terminals was 48 per cent of total tonnes unloaded and generated 14 per cent of terminal wagon days (average dwell time of 1.5 days).

In South Australia 44 per cent of tonneage was loaded at country sidings and generated 10 per cent of terminal wagon days (average dwell time of 1.9 days); 38 per cent of tonneage was unloaded at

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(1) Bulk includes wheat, grain, coal, coke, fertiliser, cattle, stock, sheep, cement, limestone, ore and metal. Non-bulk encompasses all other commodities including wool, steel, oil and other liquids.

TABLE 4.2 - TERMINAL EVENTS AND ASSOCIATED DWELL TIMES BY CLASS OF TERMINAL AND SYSTEM

System	Terminal class	Event[a]	Proportion of system total[b]			Average dwell time (days)
			Terminal events	Tonnes loaded	Terminal wagon days	
NSW	Major city terminal	Loading, unloading or reloading	16	19	26	1.5
		Thru connection	21	-	16	0.7
	City siding	Loading, unloading or reloading	5	5	7	1.4
	Major rural terminal	Loading, unloading or reloading	19	58	23	1.1
		Thru connection	31	-	14	0.4
	Rural siding	Loading, unloading or reloading	8	18	15	1.6
Vic	Major city terminal	Loading, unloading or reloading	17	50	23	2.4
		Thru connection	18	-	13	1.2
	City siding	Loading, unloading or reloading	7	11	9	2.5
	Major rural terminal	Loading, unloading or reloading	14	18	21	2.7
		Thru connection	28	-	10	0.6
	Rural siding	Loading, unloading or reloading	10	22	20	3.6
		Thru connection	6	-	4	1.2
SA	Major city terminal	Loading, unloading or reloading	13	28	26	2.7
		Thru connection	31	-	13	0.6
	City siding	Loading, unloading or reloading	6	4	7	1.6
	Major rural terminal	Loading, unloading or reloading	11	23	22	2.7
		Thru connection	26	-	12	0.6
	Rural siding	Loading, unloading or reloading	10	44	17	2.1
		Thru connection	3	-	2	0.8
ComRail	Major terminal[c]	Loading, unloading or reloading	60	83	47	1.0
		Thru connection	29	-	28	1.3
	Other terminals	Loading, unloading or reloading	8	17	20	3.4
		Thru connection	3	-	5	2.0

(a) See footnote to Table 4.1 for definition of terms.
(b) Totals may not add due to rounding.
(c) Maree, Telford, Stirling North and Port Augusta.

TABLE 4.3 - TERMINAL OPERATION CHARACTERISTICS FOR BULK AND NON-BULK FREIGHT

System	Type of traffic	Proportion of system total[a] (per cent) Terminal events	Tonnes loaded	Terminal wagon days	Average dwell time (days)
NSW	Bulk only, loading, unloading & reloading	28	75	35	1.1
	Bulk through connections	14	-	7	0.4
	Non-bulk only, loading, unloading & reloading	17	25	31	1.7
	Non-bulk through connections	9	-	5	0.6
	Combined bulk and non-bulk loading, unloading & reloading	3	Included above	5	1.3
	Empty through connections	29	-	17	0.6
Vic	Bulk only, loading, unloading & reloading	14	50	25	3.2
	Bulk through connections	17	-	9	0.9
	Non-bulk only, loading, unloading & reloading	32	50	47	2.5
	Non-bulk through connections	18	-	7	0.7
	Combined bulk and non-bulk loading, unloading & reloading	1	Included above	2	3.8
	Empty through connections	18	-	10	1.0
SA	Not empty, loading & unloading	40	100	72	2.4
	Not empty through connections	29	-	10	0.4
	Empty through connections	31	-	18	0.8
ComRail	Bulk only, loading, unloading & reloading	51	76	24	0.6
	Bulk through connections	4	-	0	0.1
	Non-bulk only, loading, unloading & reloading	17	24	43	3.1
	Non-bulk through connections	11	-	5	0.6
	Combined bulk and non-bulk loading, unloading & reloading	-	Included above	-	-
	Empty through connections	17	-	28	2.0

(a) Totals may not add due to rounding.

major city terminals and generated 16 per cent of terminal wagon days (average dwell of 2.7 days).

A further analysis of the impact of commodity type on terminal dwell times in NSW and Victoria was carried out by examining those terminal dwell events which were associated with a single operation of loading or unloading and eliminating all the reloading operations from the analysis (the proportions of reload operations for different States and terminal classes are shown in Table 4.4). The results of the analysis are shown in Tables 4.5 and 4.6. The commodities have been ranked in order of average dwell times for through connections. The results show that commodity type had a very significant impact on the through connection dwell times in NSW with perishables and other high priority freight exhibiting short through connection dwell times. In Victoria the effect was not so marked.

A separate analysis of terminal dwell times at system border stations was carried out. The results of this are shown in Table 4.7. Dwell times for through traffic at Serviceton, Broken Hill and Albury were approximately 0.3 days. This contrasts with the other major system border station Port Pirie, where the average dwell time for through traffic was 1.2 to 1.3 days. This extra time was due to the delay associated with bogie exchange of traffic moving between the broad gauge and standard gauge systems.

VARIABILITY OF DWELL TIMES

Detailed analysis revealed that there was a very wide variation in the terminal dwell times associated with the averages quoted in the last section. For most types of terminal dwell time the ratio of standard deviation to mean was greater than 1.0. This means that a small number of wagons contributed a large proportion of the wagon days spent in terminals. For example, in an analysis of NSW good train traffic it was found that the average dwell time of wagons in terminals was 1.8 days. Only 16 per cent of these

TABLE 4.4 - RELOADS AS A PROPORTION OF TOTAL TERMINAL EVENTS: BY CLASS OF TERMINAL AND SYSTEM[a] [b]

Terminal class	Reloads as a proportion of total number of terminal events in each system (per cent)			
	NSW	Vic	SA	ComRail
Major city terminal	3	8	4	-
City siding	1	1	0[c]	-
Major rural terminal	5	4	2	6
Rural siding	3	3	0[c]	1
TOTAL	12	16	7	8

(a) A reload operation is defined as the unloading and reloading of a wagon at the one terminal.
(b) Totals may not add due to rounding.
(c) Figure greater than 0.0 but not significant.

TABLE 4.5 - AVERAGE TERMINAL DWELL TIME OF WAGON IN NSW: BY EVENT TYPE AND COMMODITY CARRIED

Commodity Carried	Average terminal dwell time[a] (days)		
	Thru connection	Load	Unload
Livestock	0.1	1.5	0.9
Fruit, vegetables	0.1	1.7	1.0
Perishables	0.2	1.6	1.1
Wheat	0.3	0.9	1.0
Other grain	0.3	1.1	1.2
Motor vehicles	0.3	1.5	0.8
Petroleum	0.4	1.1	1.4
Bulk general	0.4	1.8	1.7
Coal, coke	0.5	0.5	1.7
Minerals	0.5	0.9	0.9
General goods	0.5	1.4	1.9
Iron & steel	0.5	2.7	2.6
Cement	0.5	1.1	2.0
Fertiliser	0.6	2.5	3.3
Other primary	0.6	2.7	2.1
Manufacturers	0.7	2.3	2.0
Departmental	0.9	2.4	1.5

(a) Reloads excluded from the analysis.

TABLE 4.6 - AVERAGE TERMINAL DWELL TIME OF WAGONS IN VICTORIA: BY EVENT TYPE AND COMMODITY CARRIED

Commodity Carried	Average terminal dwell time[(a)] (days)		
	Thru connection	Load	Unload
Livestock	0.3	2.2	2.0
Petroleum	0.4	1.4	3.7
Other primary	0.5	2.8	3.2
General goods	0.6	2.3	2.8
Minerals	0.7	2.9	3.2
Perishables	0.7	2.0	3.0
Manufacturers	0.7	3.0	3.0
Cement	0.8	1.2	1.9
Bulk general	0.8	2.6	3.5
Other grains	0.8	3.6	3.2
Coal, coke	0.9	2.1	3.3
Wheat	1.0	4.3	3.5
Fertilisers	1.0	2.8	4.8
Motor vehicles	1.1	1.1	2.6
Iron & steel	2.0	4.0	3.4

(a) Reloads excluded from analysis.

TABLE 4.7 - TERMINAL DWELL TIMES AT SYSTEM BORDER STATIONS

Station	Type of train service	Mean dwell time (days)	
		Through traffic	All traffic
Albury	Goods	0.3	0.6
	Express Freight	0.3	0.4
Broken Hill	Goods	0.3	1.4
	Express Freight	0.3	0.6
Mt Gambier	Goods	1.0	1.8
	Express Freight	0.1	1.7
Pinaroo	Goods	1.2	2.3
Pt Pirie	Express Goods	1.3	1.4
	Goods	1.2	1.7
Serviceton	Fast Goods	0.3	0.3
	Goods	0.4	0.6
	Express Freight	0.2	0.4

dwell events were more than 2 days in duration; however, these contributed 45 per cent of the terminal wagon days. Figures 4.1 and 4.2 show distributions of terminal dwell time which were determined during detailed analysis of wagons associated with general goods train operations in NSW and Victoria.

It is apparent that the following factors have a significant impact on variability of terminal dwell times:

- Given the nature of track layout in many terminals the last empty wagons to be shunted into a holding area are often the first wagons to be removed from it. This results in a group of highly utilised wagons with short terminal dwell times and another group of under-utilised wagons with very long terminal dwell times.

- There are very large fluctuations in demand for wagons. For example in a large rural centre of NSW, fluctuations in general freight loading from 100 tonnes to 500 tonnes per week were observed. There are overall fluctuations of 20 per cent from week to week even at the system level and larger seasonal and general economic cycles on top of these variations.

Given the above it would be rash to assume that it is possible to reduce the long dwell times and wagon fleet size without affecting quality of service. Obviously a large fleet guarantees quality of service by reducing the probability of having an inadequate supply of wagons for peak periods. However, there is potential to achieve large reductions in fleet size through marketing schemes and changes in operations policy directed toward the achievement of more uniform demand for wagons.

DETERMINANTS OF TERMINAL DWELL TIME

There has been much discussion in overseas countries of wagon delays caused by missed connections at marshalling yards. This does not appear to be a significant problem on the systems surveyed.

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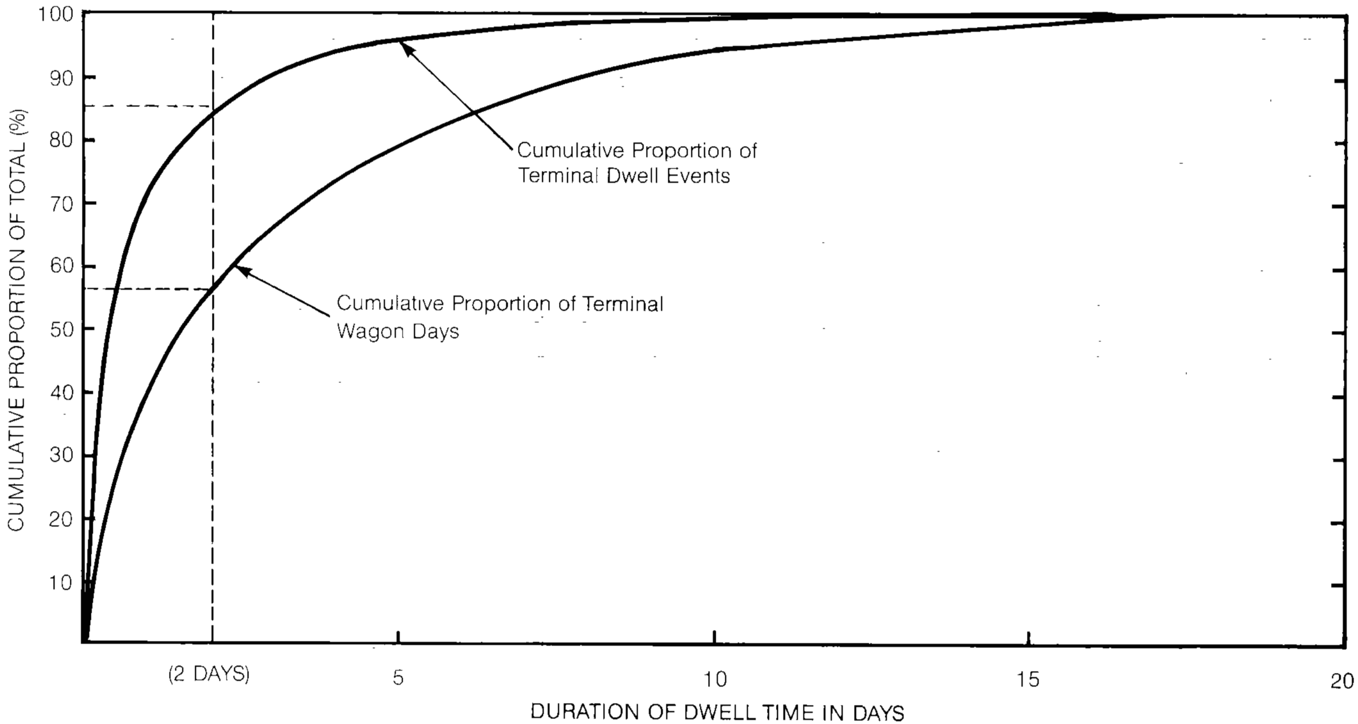

FIGURE 4·1
NSW: VARIABILITY OF TERMINAL DWELL TIMES FOR WAGONS ATTACHED TO GENERAL GOODS TRAINS

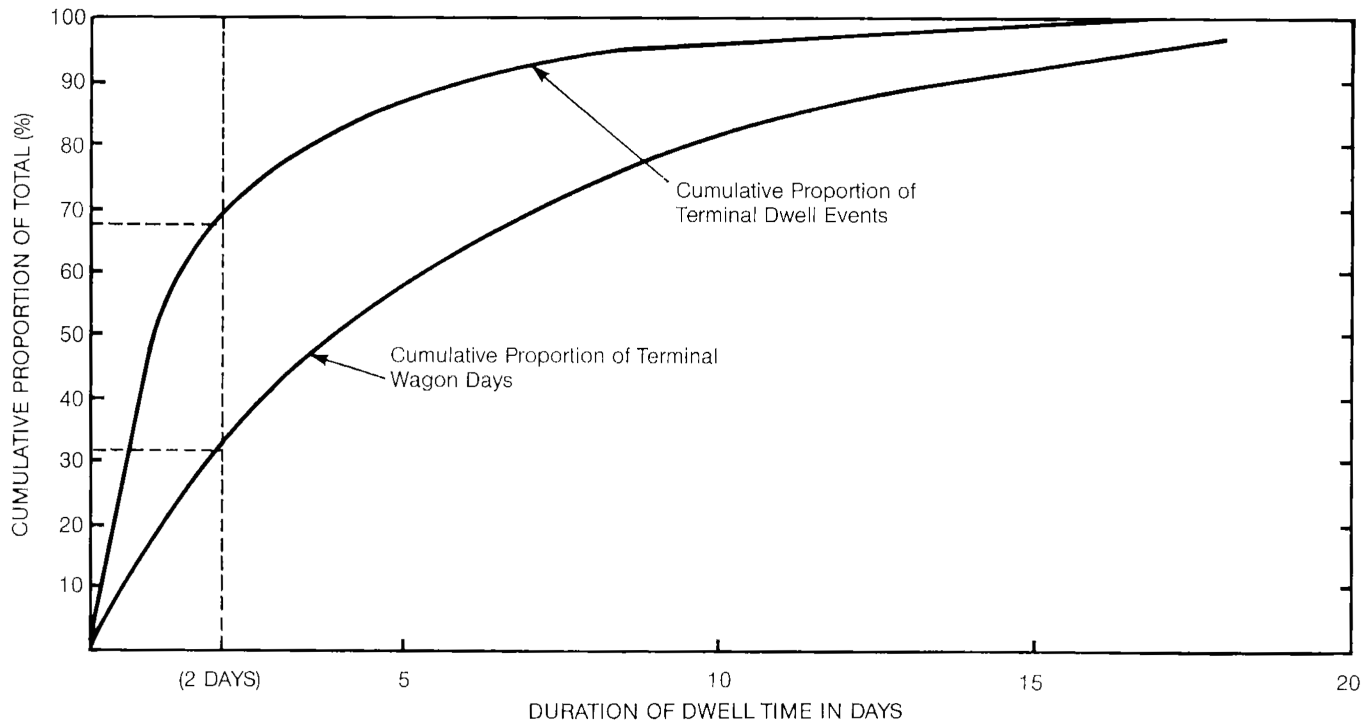

FIGURE 4·2
VICTORIA: VARIABILITY OF TERMINAL DWELL TIMES FOR WAGONS ATTACHED TO GENERAL GOODS TRAINS

Remarshalling dwell times of loaded wagons varied from a minimum of 6 per cent of terminal wagon days on the ComRail system, up to a maximum of 17 per cent in Victoria (Table 4.1). Although resources were not available to do a complete study of missed connections, the samples which were extracted showed that 72 per cent of wagons making through connections left terminals on the first available train.

For other types of terminal transit involving loading or unloading operations, only 19 per cent of wagons left on the first available train. For the other 81 per cent of wagons the further terminal dwell time would have been due to:

- unavailability of loading;
- restriction of loading and unloading operations to one shift of the day;
- delays in the wagon allocation process;
- lack of capacity on the train services operated; or
- maintenance of the wagon.

There are few parts of the system where frequency of train service and restricted operation of loading and unloading facilities would produce terminal dwell times greater than 2 days. Figure 4.1 shows that for non-bulk traffic on goods trains in NSW, approximately 45 per cent of wagon days lost in terminals were associated with dwell times greater than 2 days(1), therefore unavailability of loading and wagon allocation delays must account for a large proportion of the time spent in terminals.

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(1) In Victoria, the figure was 69 per cent of wagon days.

CHAPTER 5 - TRAFFIC ANALYSIS

HIGH COST WAGON OPERATIONS

This chapter examines the potential for cost reduction associated with high volume and high unit cost wagon movements.

Figures 5.1 to 5.4 plot movement costs against tonne-km performed for various classes of wagon and commodity type. The global average unit cost was 2.7 c/t.km. A sensitivity analysis of the unit cost function showed that it was theoretically possible to reduce the cost of most operations to 2.0 c/t.km or less. The shaded sections on the right hand bars of Figures 5.1 to 5.4 show the savings that would be achieved if all operations were performed at this unit cost. Though in practice there may be many constraints that prevent achievement of this 2.0 c/t.km, the procedure helps to isolate wagon operations worthy of closer study.

Figure 5.1 shows the most aggregated form of this analysis, with operations accumulated by wagon class over all commodity types and systems.(1) The figure indicates potential for significant improvement for three main classes:

- 4 wheel open wagons
- bogie vans
- 4 wheel vans.

There are minor operations with higher unit costs, but the level of resources used is too small to warrant major analytical effort.

Four Wheel Open Wagon Operations

Figure 5.2 provides a breakdown of the cost of 4 wheel open wagon operations, by State and commodity, using information from

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(1) This diagram is based on data from Annex C and represents 90 per cent of total wagon movement.

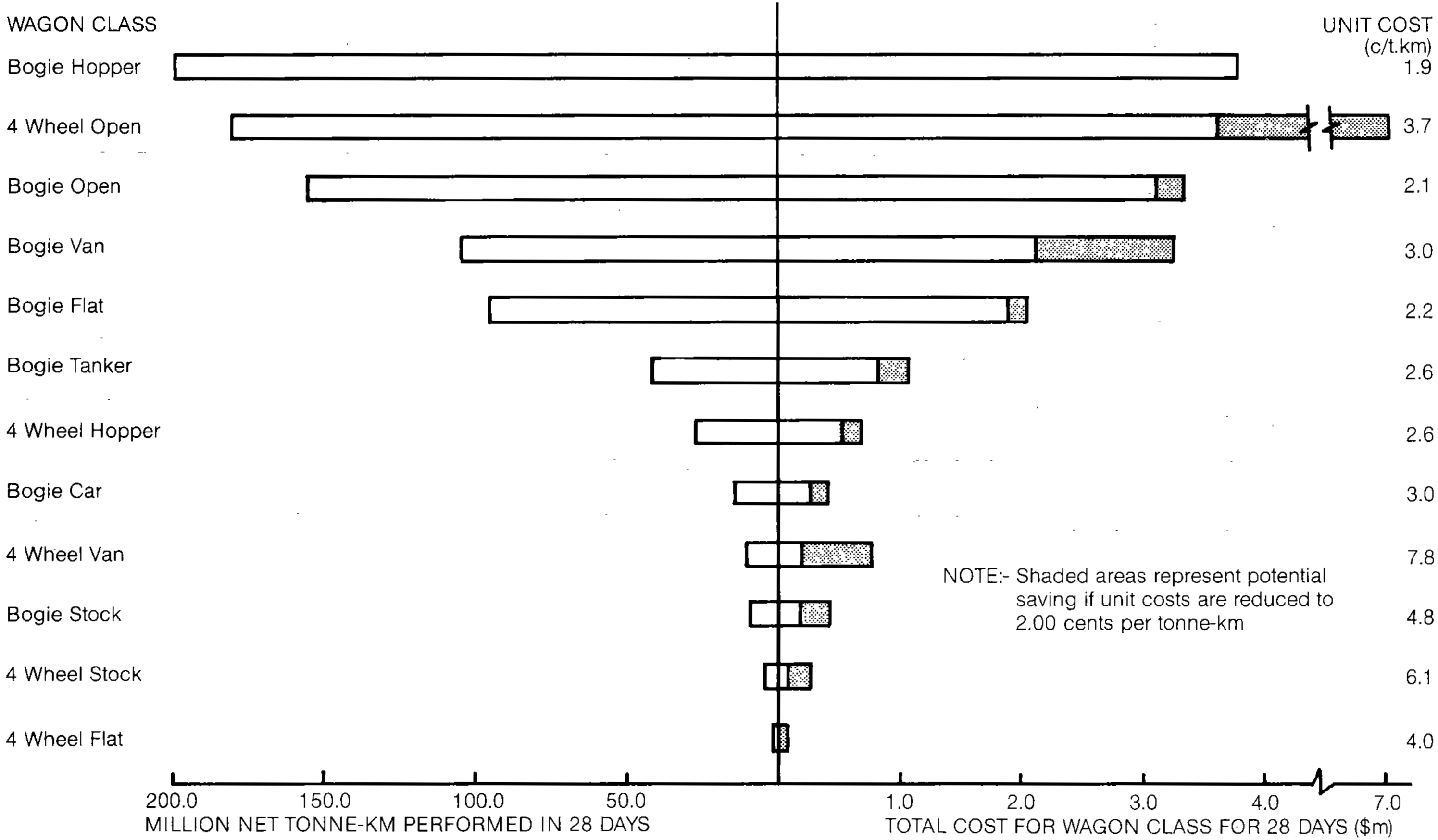

FIGURE 5·1
COMPARISON OF NET TONNE-KM PERFORMED AND TOTAL AND UNIT COSTS DURING STUDY PERIOD FOR WAGON CLASSES AGGREGATED OVER NSW, VIC, SA AND COMRAIL SYSTEMS

(SOURCE: ANNEX C)

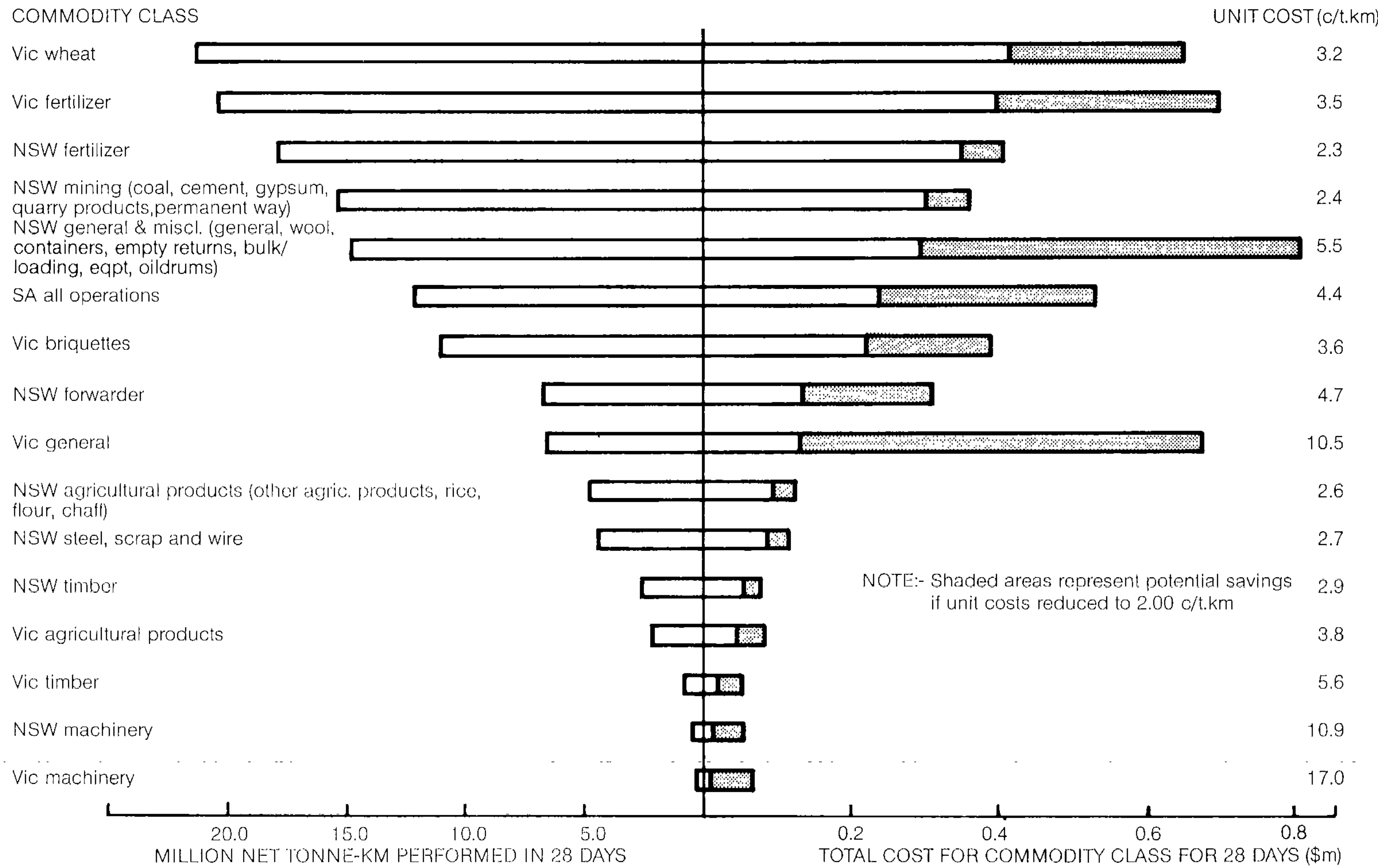

FIGURE 5·2
COMPARISON OF NET TONNE-KM PERFORMED AND TOTAL AND UNIT COSTS FOR 4 WHEEL OPEN WAGONS, BY SYSTEM AND COMMODITY CLASS

SOURCE: Annex D

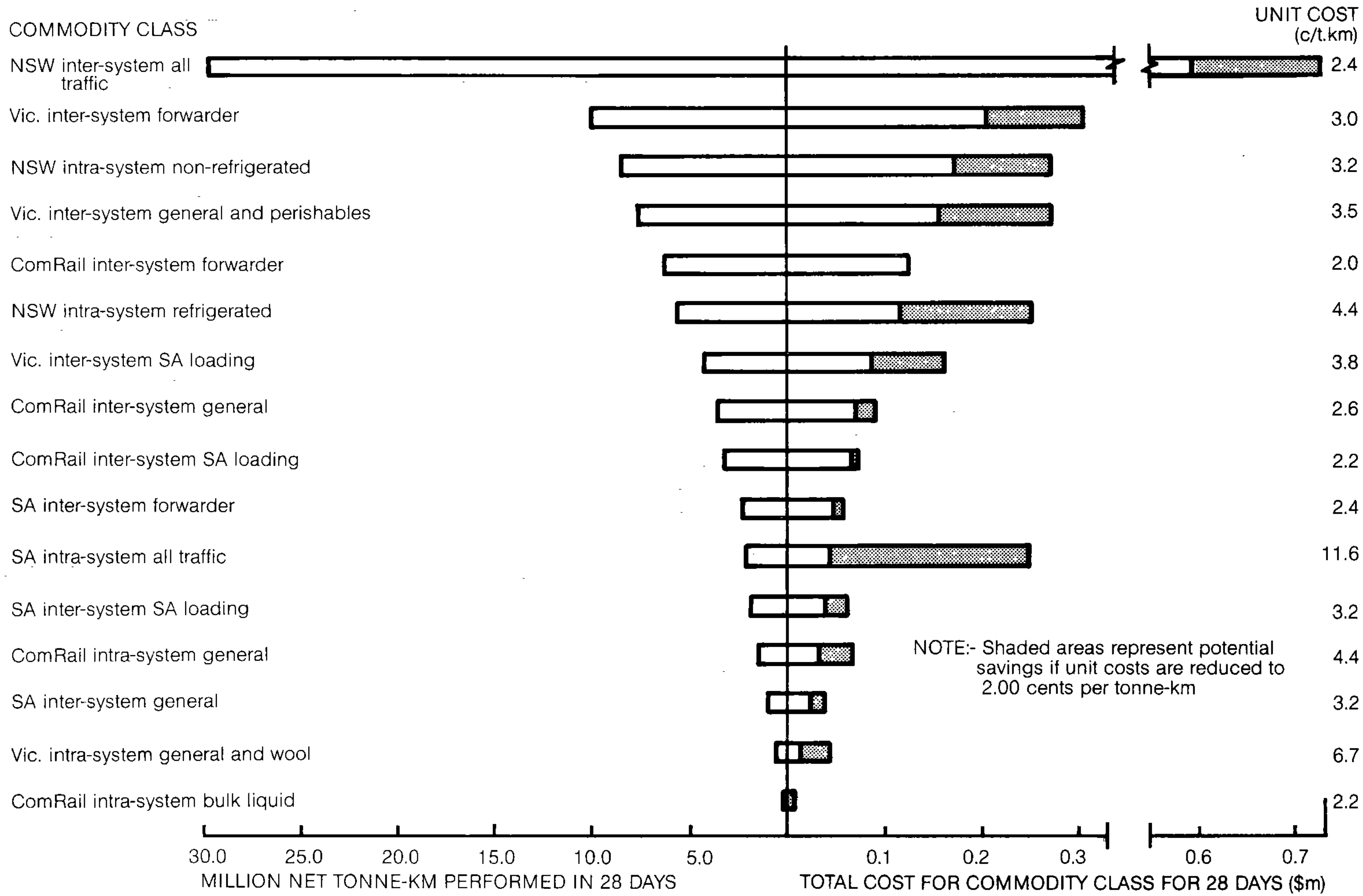

FIGURE 5·3

COMPARISON OF NET TONNE-KM PERFORMED AND TOTAL AND UNIT COSTS FOR BOGIE VANS; BY SYSTEM AND COMMODITY CLASS

SOURCE: Annex D, except for NSW and SA intra-system from Annex C, and NSW inter-system from Annex F.

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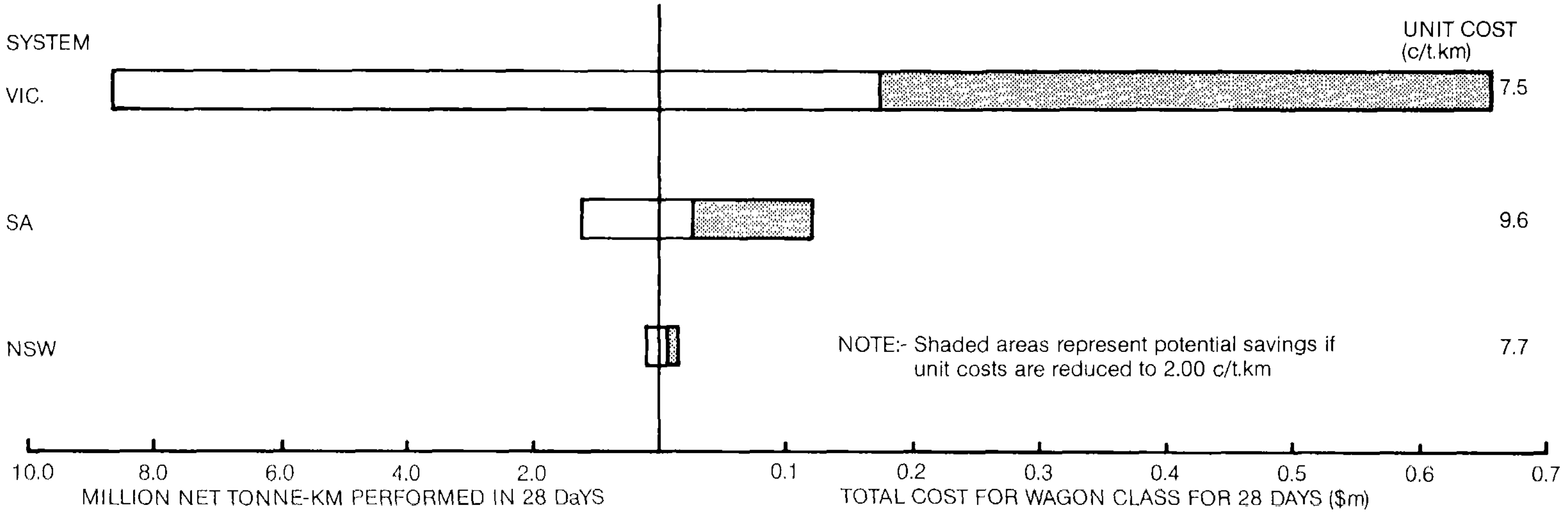

FIGURE 5·4
COMPARISON OF NET TONNE-KM PERFORMED AND TOTAL AND UNIT COSTS FOR 4 WHEEL VANS BY SYSTEM

SOURCE: Annex C

Annex D.[1] The major high cost traffics are:

- Victorian wheat
- Victorian fertiliser
- Victorian briquettes
- Victorian general
- Victorian machinery
- NSW general and miscellaneous
- NSW forwarder
- NSW machinery
- SA loading.

Annex F gives more detailed information on all the major high cost traffics. Table F.1 compares the high cost 4 wheel traffics with NSW fertiliser movement, which has the lowest cost of the major 4 wheel open wagon operations.

The "problem" traffics can be grouped into three categories: all Victorian traffic (particularly bulk commodities), machinery in NSW and Victoria and general traffic in all States. These three categories are discussed in turn.

It can be seen from Figure 5.2 that all Victorian commodities have a higher unit cost than their NSW counterparts. Examination of Table F.1 reveals that the major cause of the difference between Victoria and NSW costs is the high wagon capital opportunity cost in Victoria. This in turn is mainly due to the longer cycle times for Victorian wagons (10.8 to 13.8 days as opposed to 8.0 to 8.3 days in NSW).

This long wagon cycle time in Victoria is mainly due to the maintenance of a fleet of wagons large enough to cope with the peak of the wheat harvest from December through to February. This problem does not arise in NSW where the rural storage is large

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(1) Annex D provides information on major commodity classifications, but includes only 72 per cent of total wagon movements.

enough to absorb most of the harvest peak. The problem in Victoria is further excerbated by grain unloading facilities at Geelong which do not allow continuous movement of wagons through the terminal. The level of congestion is such that there is little incentive to undertake a large wagon replacement programme to introduce modern hopper wagons.

Since the survey, a large number of 4 wheel wagons have been scrapped in Victoria but this will only compensate for the reduced need for 4 wheel wagons as regional freight centres are introduced.

The high unit cost of machinery movement in both Victoria and NSW is due to the low density of machinery and the resultant low use of tonneage capacity (2.6 tonnes load in a wagon with 18.5 tonne capacity) which in turn leads to high capital costs and high costs for movement of tare weight. The solution to this problem is not obvious, specially designed wagons may allow a reduction in tare weight to be achieved but there may not be any significant reduction in construction and replacement cost which is still the dominant cost. Use of special wagons may lead to more empty running due to restricted opportunity for back loading. Despite this, the total cost of these machinery movements is small in comparison to the bulk freight and general freight operations and may not warrant urgent attention provided charges can be based on volume-kms as is the normal practice in the road freight industry.

The problems with general freight will be discussed in more detail later; however, at this point it is sufficient to note that the freight forwarder general traffic was being carried in NSW at a unit cost of 4.7 cents per tonne-km compared with 5.5 cents per tonne-km for other 4 wheel general freight. In Victoria 4 wheel general freight was being carried at a cost of 10.3 cents per tonne-km. The difference in cost between forwarders' general traffic and other general traffic within NSW was mainly due to the better use of load capacity by the forwarders. They used 36 per cent of wagon capacity as compared to 30 per cent for other general freight in NSW and 24 per cent in Victoria.

Bogie Van Operations

The results of a similar analysis of bogie van operations is shown in Figure 5.3.

High cost traffics selected for closer examination are listed below:

- SA intra-system operations,
- NSW inter-system operations for ordinary bogie vans,
- NSW intra-system operations for ordinary bogie vans,
- NSW intra-system operations for perishables in refrigerated vans,
- Victoria inter-system forwarders freight,
- Victoria inter-system general freight,
- Victoria inter-system SA loading.

Annex Table F.2 gives the operating characteristics of these wagons. The high cost was due to a combination of poor loading efficiencies and a small proportion of time spent loaded and in transit.(1)

The most outstanding problem was the South Australian intra-system bogie van operation with a unit cost of 11.6 cents per tonne-km. Examination of the results in Annex D show that this was due to the very low use of capacity when loading intra-system general goods. The best average was 15 per cent use of load capacity (for SCL wagons) and the worst was 11 per cent (for DS wagons).

Four Wheel Van Operations

Figure 5.4 presents an analysis of 4 wheel van operations. The critical traffics were Victorian intra-system general goods and all SA operations. Annex Table F.3 provides details of these operations. The two problems were the poor loading efficiency and

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(1) Loading efficiency is defined as the ratio of wagon load to wagon capacity.

the high tare weight of the wagons. For every tonne of load moved, 2.81 tonnes to 3.80 tonnes of wagon were moved. This compared with the global average of approximately one for one.

THE GENERAL FREIGHT PROBLEM

In all of these analyses it was the general freight operations which were responsible for the most significant under-utilisation of wagon resources.(1) A more detailed analysis of the data available on these operations is now presented.

General freight operations in the study period were characterised by poor loading efficiencies resulting in high capital opportunity costs per tonne-km and high proportions of motive effort being devoted to tare weight movement. Consequently it is useful to examine the determinants of loading efficiency.

The most significant determinants of loading efficiency for general freight are:

- the volume of traffic available on the route;
- the frequency of train services.

Figures 5.5 to 5.7 show observations(2) of average load of general freight per wagon as a function of the general freight available per train for all major origin destination pairs in Victoria and NSW. Forwarder traffic is also shown for comparison in NSW.

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(1) It should be noted that the analysis above tends to under-estimate costs of 4 wheel wagon operations. The assumptions of 25 km/h for average speed and 430 tonnes average trailing load per locomotive are not achieved on branch line operations where much of the 4 wheel general freight traffic is generated.

(2) There was insufficient data to produce meaningful results for the SA and ComRail systems, and intra-system bogie wagons in Victoria showed no discernable pattern.

The figures also include a curve produced from a simulation which modelled loading of general freight wagons for varying traffic flows.(1)

The simulation shows that high loading efficiencies cannot be obtained with freight flows of less than 30 to 50 tonnes per day (approximately 10 000 tonnes per annum). The heavy concentration of observations at the lower end of the tonnes per day scale in Figures 5.5 to 5.7 show how few routes provide sufficient tonneage to enable efficient loading of wagons. A further indication of the difficulty of achieving high loading rates on intra-system general freight routes is indicated by Tables 5.1 and 5.2, which show that even with the grouping of stations into 27 regions in NSW or 11 regions in Victoria there were very few origin destination pairs which average more than 25 tonnes of non-bulk traffic(2) per weekday. Apart from movements focussed on the major urban centres there were only 4 intra-system routes in Victoria and 11 intra-system routes in NSW which averaged more than 25 tonnes of non-bulk freight per day in 1975-76.(3)

The effect of the low utilisation of tonne capacity on cost is shown in Figures 5.8 to 5.13. For example, if loading of 4 wheel wagons was brought to 50 per cent of capacity (as achieved on heavily trafficked routes) there would be a possible annual saving of approximately $3.7 million per annum in NSW and $7.1 million per annum in Victoria in the long term.(4)

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(1) The simulation model assumptions were as follows:
- the size of load waiting for clearance by a train can be represented by a random variate uniformly distributed from zero to twice the average load;
- loads less than one tonne were allocated to brakevans;
- each train service cleared all available loading on its route;
- the average full load used 50 per cent of wagon tonne capacity.

(2) See definition of non-bulk on Table 5.1.
(3) Equivalent to 6500 tonnes per annum.
(4) As stated previously the costing assumptions lead to underestimation of costs of branch line operations, consequently these estimates of savings are conservative.

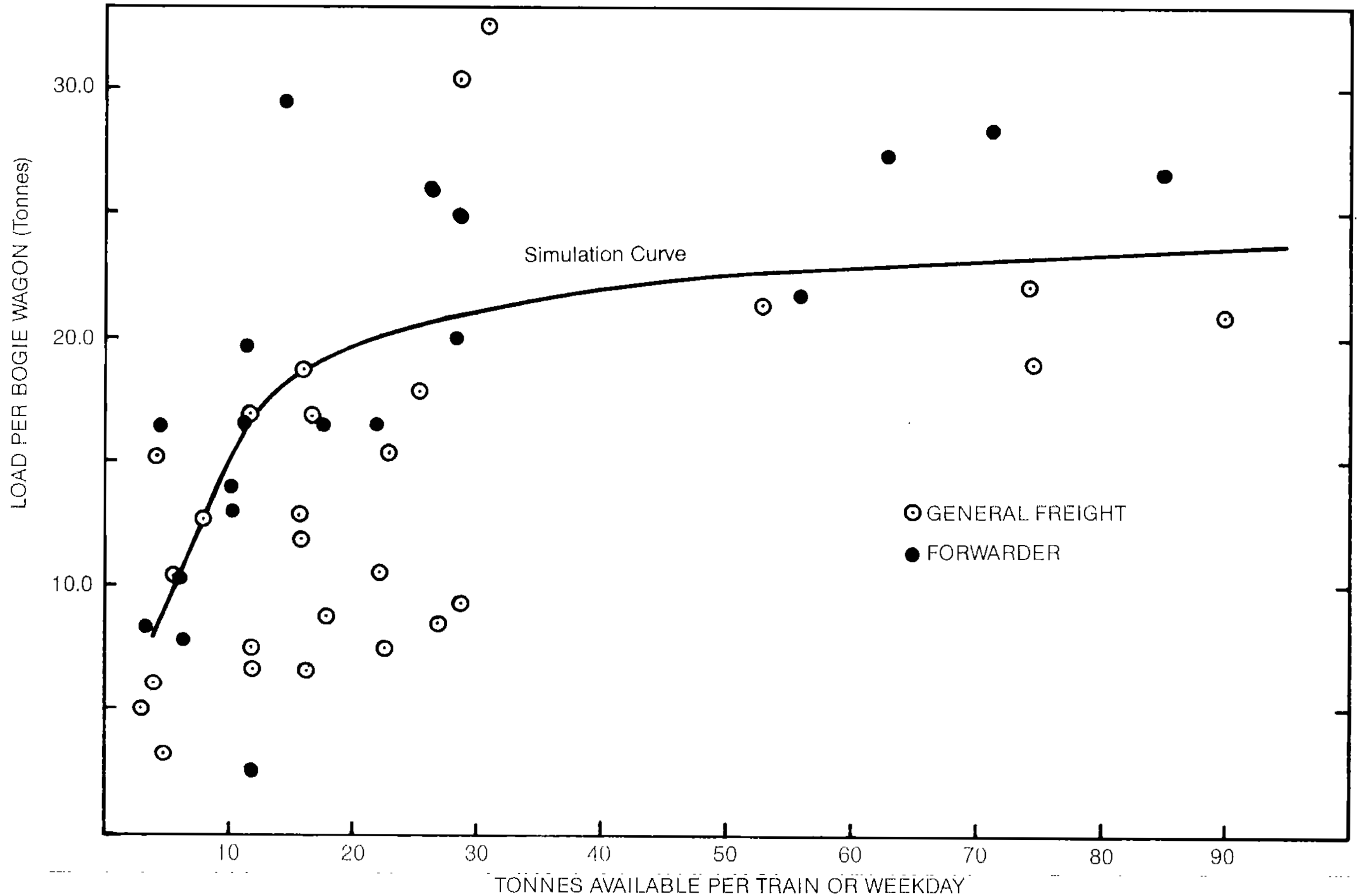

FIGURE 5·5

NSW BOGIE WAGON LOADS AS A FUNCTION OF GENERAL OR FORWARDER TRAFFIC AVAILABLE PER TRAIN OR WEEKDAY FOR INDIVIDUAL ORIGIN DESTINATION PAIRS

NOTE:- Traffic flows are for one direction only.
If number of trains per week is greater than 5, then tonnes available is taken to be tonnes available per weekday.
Simulation parameters, minimum load 8 tonnes, average full load 25 tonnes

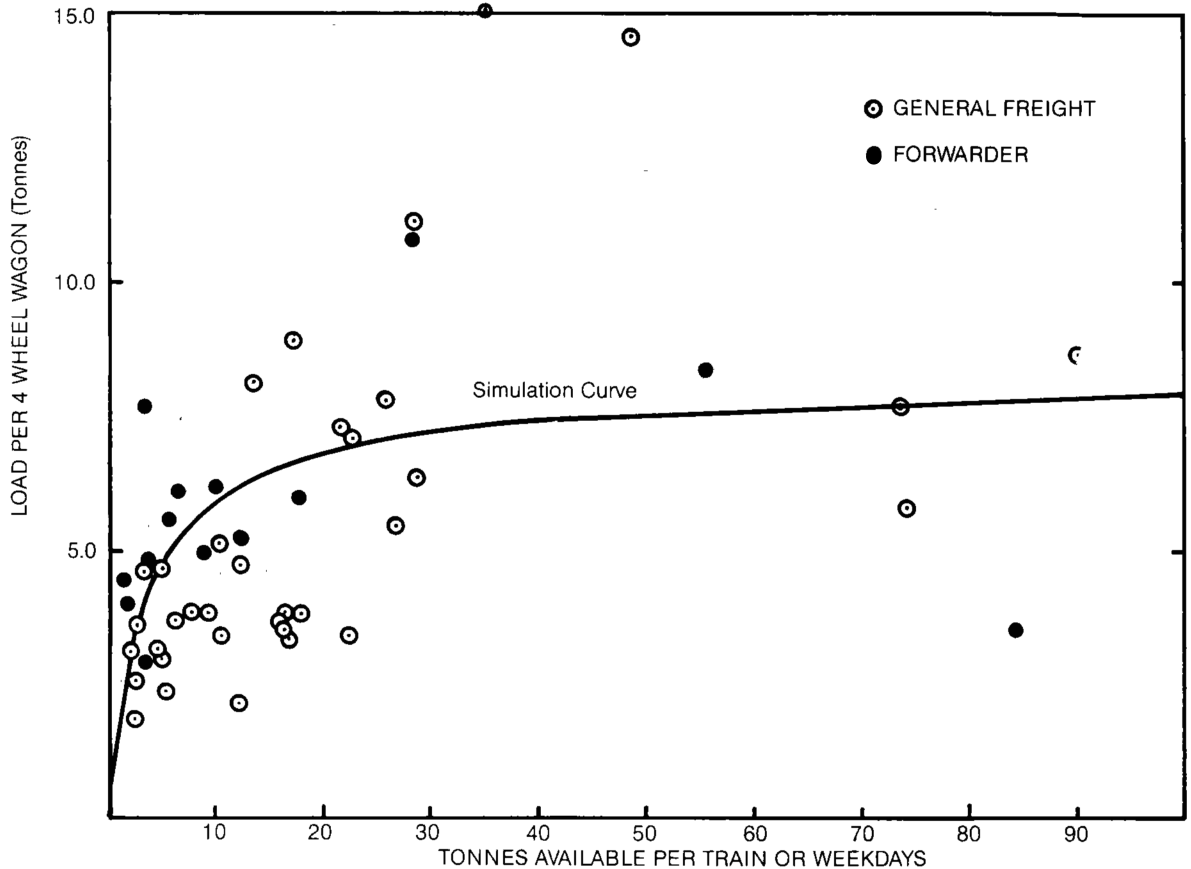

FIGURE 5·6
NSW 4 WHEEL WAGON LOADS AS A FUNCTION OF GENERAL OR FORWARDER TRAFFIC AVAILABLE PER TRAIN OR WEEKDAY FOR INDIVIDUAL ORIGIN DESTINATION PAIRS

NOTE:- Traffic flows are for one direction only.
If the number of trains per week is greater than 5, then tonnes available is taken to be tonnes available per weekday.
Simulation parameters, minimum load 1 tonne, average full load 8 tonnes.

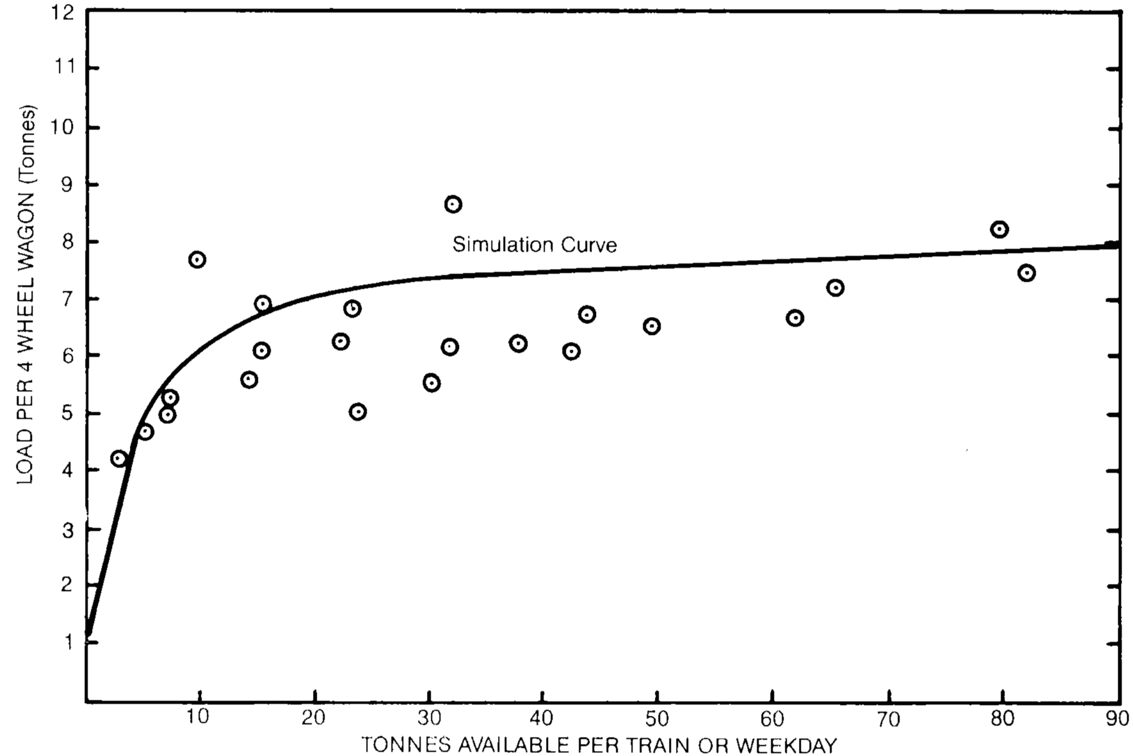

FIGURE 5·7
VIC. 4 WHEEL WAGON LOADS AS A FUNCTION OF GENERAL FREIGHT TRAFFIC AVAILABLE PER TRAIN OR WEEKDAY FOR INDIVIDUAL ORIGIN DESTINATION PAIRS

NOTE:- Traffic flows are for one direction only.

If the number of trains per week is greater than 5, then tonnes available is to be taken tonnes available per weekday.

Simulator parameters, minimum load 1 tonne, average full load 8 tonnes.

TABLE 5.1 - NON-BULK RAIL FREIGHT FLOWS GREATER THAN 25 TONNES PER DAY BETWEEN RURAL REGIONS IN NSW, 1975-76[a][b]

Origin	Destination	Average daily flow (tonnes)[c]
Hunter	Hunter	27
Hunter	Lower Murrumbidgee	77
Illawarra	Canberra-Queanbeyan	35
Clarence	Richmond-Tweed	38
Clarence	Hastings	54
Hastings	Far West	73
Northern Tablelands	Northern Tablelands	35
Northern Tablelands	Lower Murrumbidgee	27
Northern Tablelands	Upper Murray	58
Macquarie-Barwon	Southern Tablelands	38
Southern Tablelands	Outer Sydney	27

(a) Excluding all flows centred on Sydney, Newcastle and Wollongong.
(b) This definition of non-bulk includes livestock and is not therefore compatible with the definition used elsewhere in this report.
(c) Annual figure divided by the number of weekdays in a year (260). Little freight moves on weekends.

Source: Australian Rail Freight Movements, 1975-76, BTE.

TABLE 5.2 - NON-BULK RAIL FREIGHT FLOWS GREATER THAN 25 TONNES PER DAY BETWEEN RURAL REGIONS IN VICTORIA, 1975-76[a][b]

Origin	Destination	Average daily flow (tonnes)[c]
Western	Western	38
Western	Wimmera	27
Northern	Western	46
Gippsland	Gippsland	31

(a) Excluding all flows centred on Melbourne and Geelong.
(b) This definition of non-bulk includes livestock and is not therefore compatible with the definition used elsewhere in this report.
(c) Annual figure divided by the number of weekdays in a year (260). Little freight moves on weekends.

Source: Australian Rail Freight Movements, 1975-76, BTE.

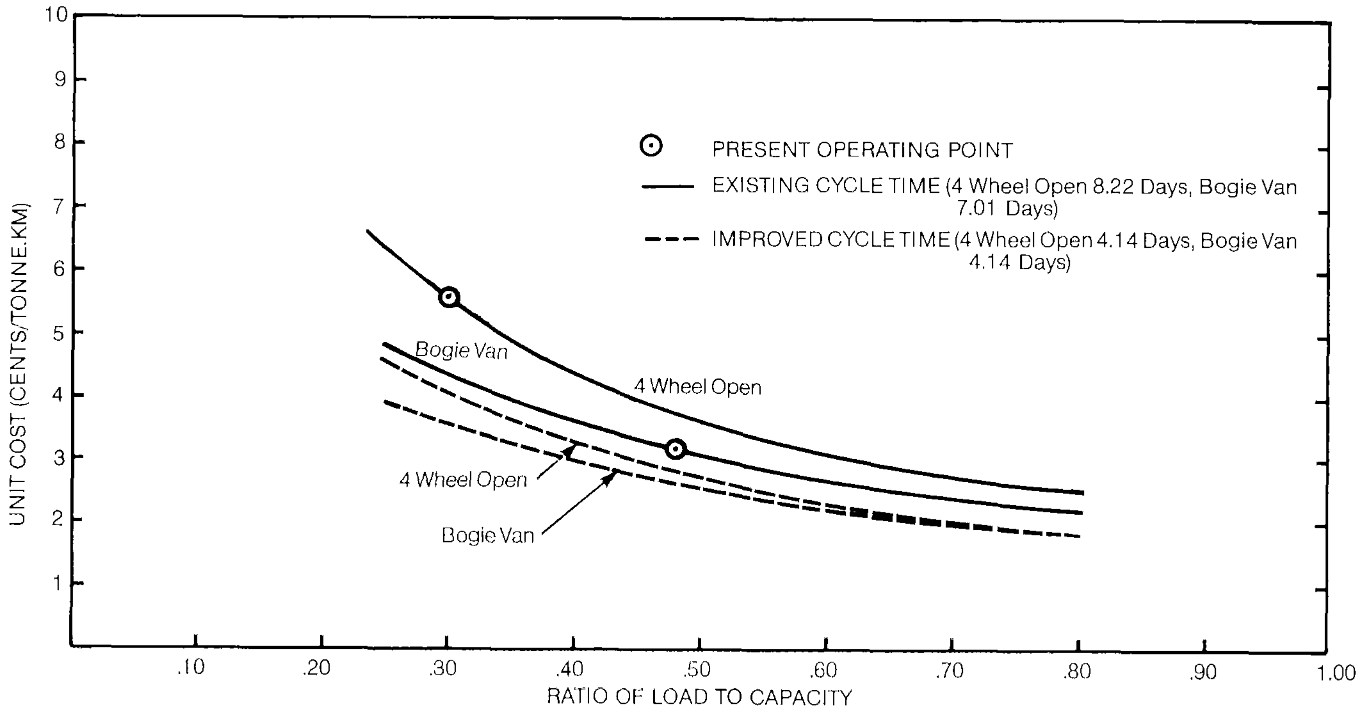

FIGURE 5·8
NSW UNIT COST AS A FUNCTION OF LOADING EFFICIENCY AND CYCLE TIME FOR 4 WHEEL OPEN WAGONS CARRYING GENERAL AND MISCELLANEOUS FREIGHT AND NON-REFRIGERATED BOGIE VANS CARRYING INTRA-SYSTEM FREIGHT

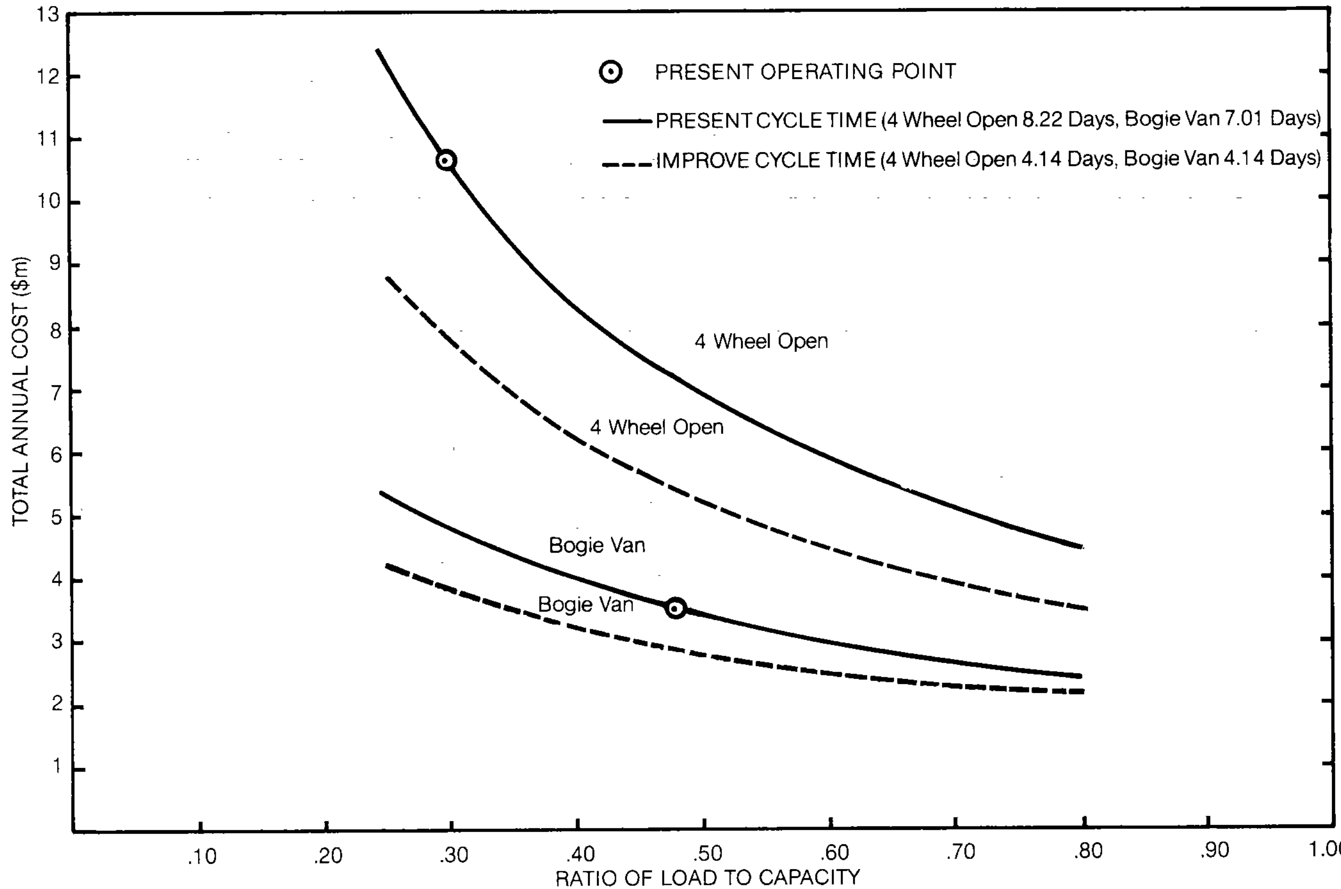

FIGURE 5·9
NSW — TOTAL ANNUAL COST AS A FUNCTION OF LOADING EFFICIENCY AND CYCLE TIME FOR 4 WHEEL OPEN WAGONS CARRYING GENERAL AND MISCELLANEOUS FREIGHT AND NON-REFRIGERATED BOGIE WAGONS CARRYING INTRA-SYSTEM FREIGHT

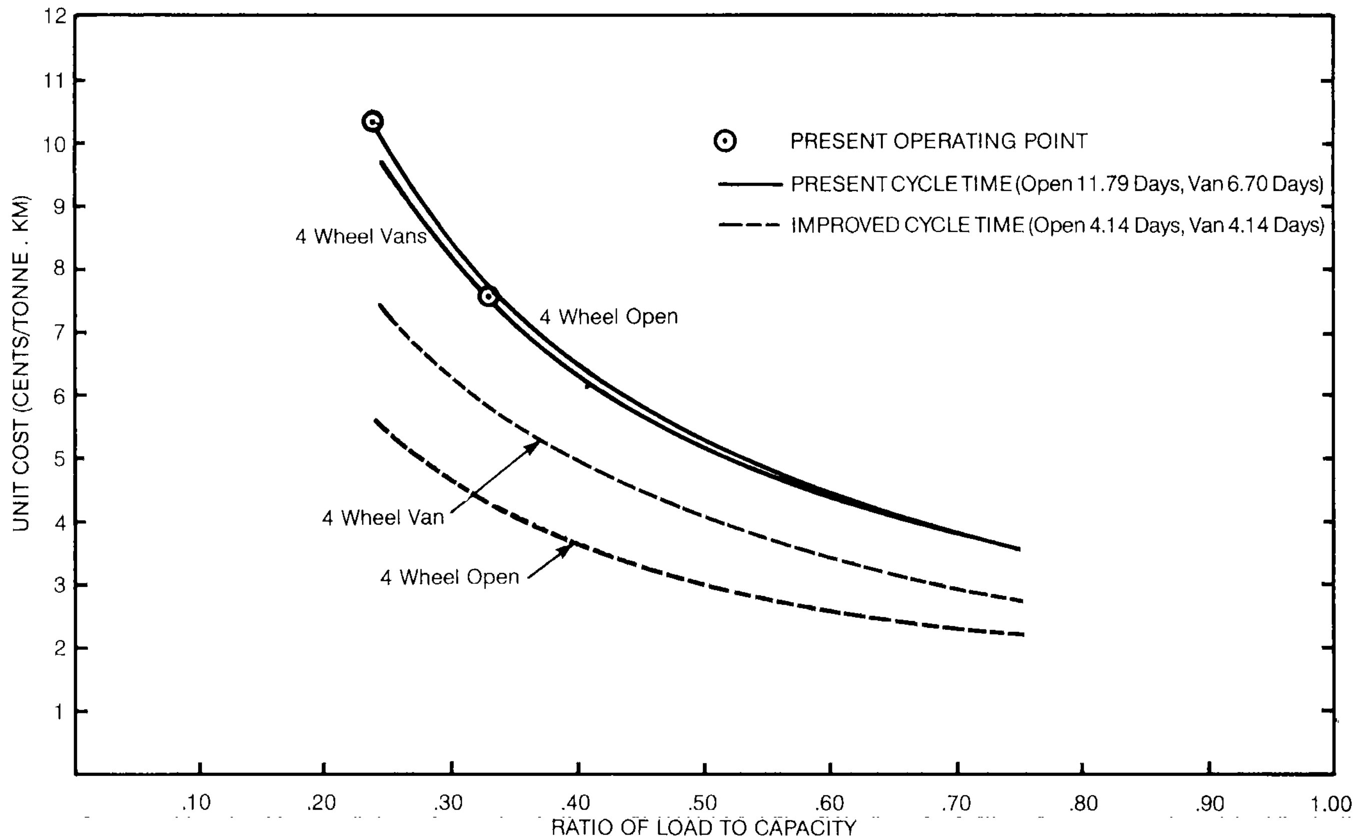

FIGURE 5·10
VIC UNIT COST AS A FUNCTION OF LOADING EFFICIENCY AND CYCLE TIME FOR 4 WHEEL OPEN WAGONS CARRYING GENERAL FREIGHT AND ALL 4 WHEEL VAN OPERATIONS

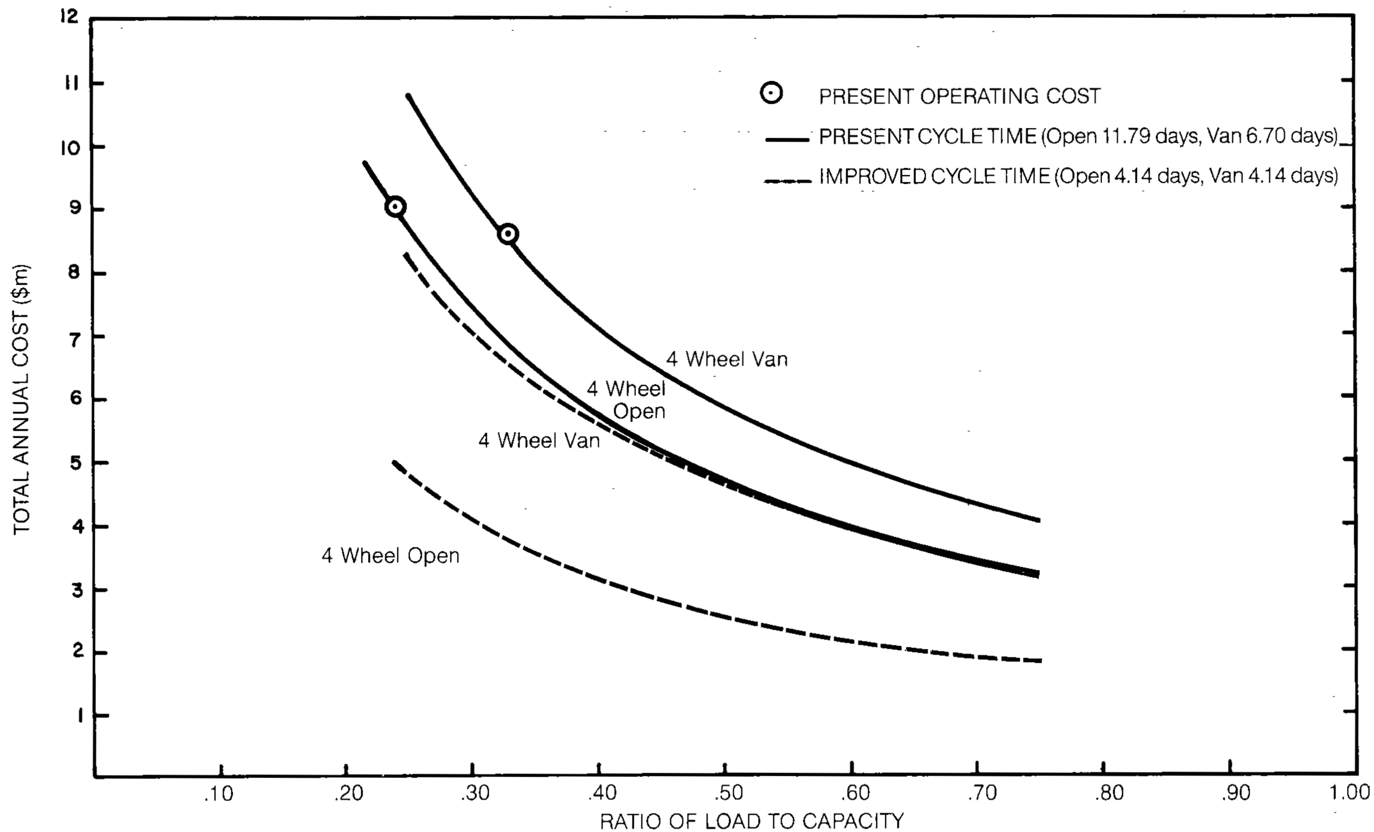

FIGURE 5·11
VIC TOTAL ANNUAL COST AS A FUNCTION OF LOADING EFFICIENCY AND CYCLE TIME FOR 4 WHEEL OPEN WAGONS CARRYING GENERAL FREIGHT AND ALL 4 WHEEL VAN OPERATIONS

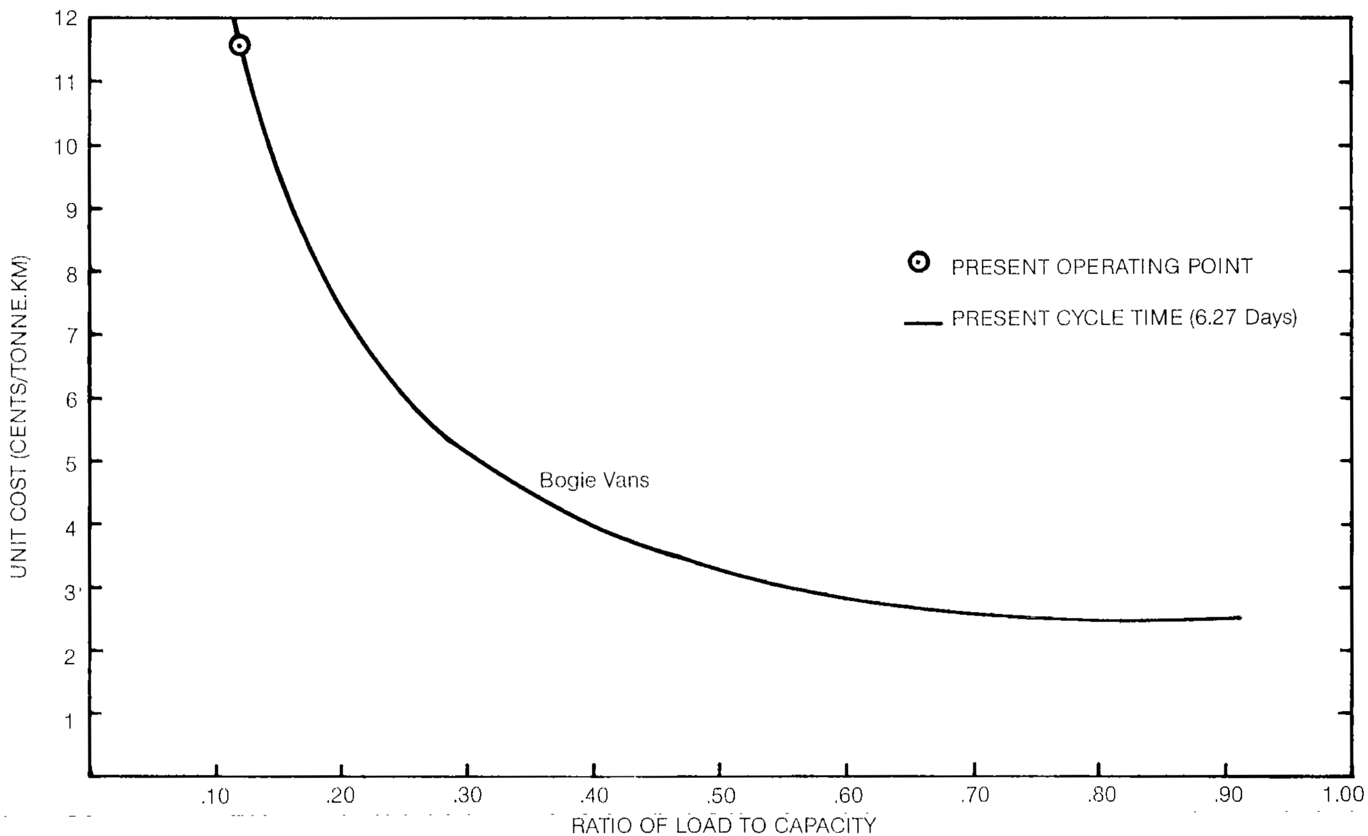

FIGURE 5·12
SA UNIT COST AS A FUNCTION OF LOADING EFFICIENCY FOR INTRA-SYSTEM BOGIE VAN OPERATIONS

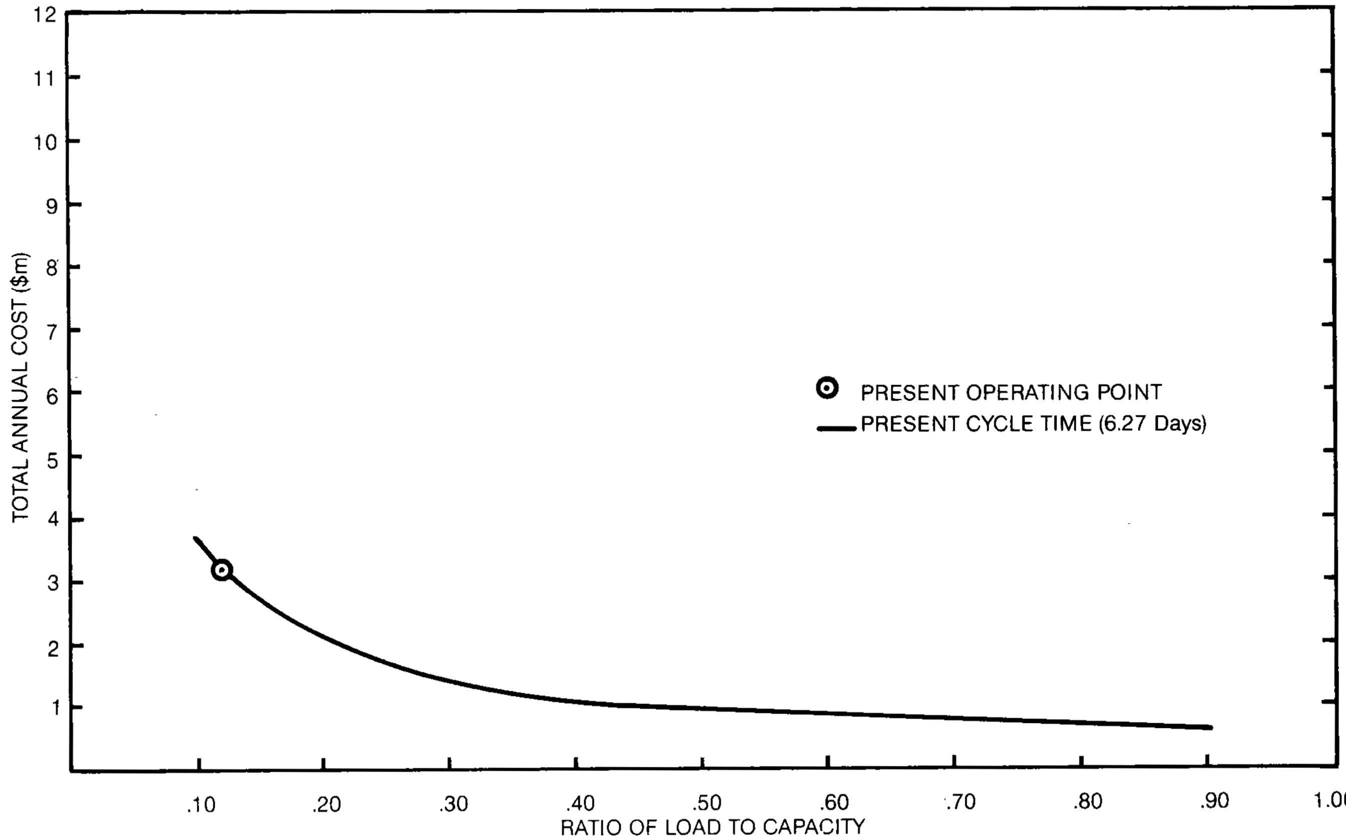

FIGURE 5·13
SA TOTAL ANNUAL COST AS A FUNCTION OF LOADING EFFICIENCY FOR INTRA-SYSTEM BOGIE VAN OPERATIONS

Introduction of regional freight centres will allow simplification of the rail network and reduction in wagon allocation delays. It may then be possible to reduce the average cycle time to a little over 4 days.(1) Total cost curves for these improved conditions are shown for 4 wheel open wagons for NSW and Victoria in Figures 5.9 and 5.11 respectively.

Further reductions in cost could be brought about by using bogie wagons, which have a lower replacement cost per tonne of capacity, provided the efficiency of space usage could be maintained.

The effect of various combinations of changes in loading efficiencies, cycle times and wagon types are shown in Tables 5.3 to 5.7. There are many possible ways to reduce the cost of railway general freight operations. These are examined in more detail by the current BTE study of railway regional freight centres (which was initiated when the first preliminary results of the wagon utilisation study became known).

POTENTIAL SAVINGS FOR ALL HIGH COST OPERATIONS

In Table 5.8 we show estimates of potential reductions in costs of all traffics isolated as high cost operations by this analysis. The general order of cost reduction amounts to $14 million per annum in NSW, $20 million in Victoria and $6.5 million in South Australia. This would be a reduction of approximately 14 per cent in the total cost of wagon usage.

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(1) An estimate based on BTE analysis of changes in traffic patterns made possible by the introduction of regional freight centres.

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TABLE 5.3 - POTENTIAL SAVINGS FROM OPERATIONAL IMPROVEMENTS FOR NSW 4 WHEEL OPEN WAGONS CARRYING INTRA-SYSTEM GENERAL AND MISCELLANEOUS FREIGHT[a]

(at June 1977 prices)

Possible improvement[b]												
Ratio of load/capacity (0.30 to 0.50)	Existing Load/Capacity						Improved Load/Capacity					
Wagon cycle time (8.22 to 4.14 days)	Existing cycle time			Improved cycle time			Existing cycle time			Improved cycle time		
Change of wagon type (4 wheel open to bogie open or van)	4 Wheel open(c)	Bogie open(d)	Bogie van(e)	4 Wheel open	Bogie open	Bogie van	4 Wheel open	Bogie open	Bogie van	4 Wheel open	Bogie open	Bogie van
Costs												
Unit cost (cents/net tonne-km)	5.5	4.4	5.3	4.0	3.4	4.0	3.6	2.9	3.5	2.7	2.3	2.7
Annual cost[f] ($m)	10.6	8.4	10.3	7.7	6.5	7.7	6.9	5.6	6.8	5.2	4.4	5.2
Potential annual saving ($m)	0.0	2.2	0.3	2.9	4.1	2.9	3.7	5.0	3.8	5.4	6.2	5.4

(a) Miscellaneous comprises, wool, containers, empty returns, bulk loading, equipment and oil drums.
(b) Parameters held constant; loaded run time 13.0 hours, empty run time 3.9 hours.
(c) 4 Wheel open; capacity 18.3 tonnes, tare 8.5 tonnes, value $1080 per tonne of capacity.
(d) Bogie open; capacity 44.9 tonnes, tare 18.7 tonnes, value $720 per tonne of capacity.
(e) Bogie van; capacity 44.4 tonnes, tare 23.9 tonnes, value $939 per tonne of capacity.
(f) Assumes rate of effort for study period continued throughout the year. Annual task 193.7 million tonne-km.

Source: Annex D and Table F.1.

TABLE 5.4 - POTENTIAL SAVINGS FROM OPERATIONAL IMPROVEMENTS FOR VICTORIAN 4 WHEEL OPEN WAGONS CARRYING INTRA-SYSTEM GENERAL FREIGHT

(at June 1977 prices)

Possible improvement[a]												
Ratio of load/capacity (0.24 to 0.50)	Existing Load/Capacity						Improved Load/Capacity					
Wagon cycle time (11.79 to 4.14 days)	Existing cycle time			Improved cycle time			Existing cycle time			Improved cycle time		
Change of wagon type (4 wheel open to bogie open or van)	4 Wheel open(b)	Bogie open(c)	Bogie van(c)	4 Wheel open	Bogie open	Bogie van	4 Wheel open	Bogie open	Bogie van	4 Wheel open	Bogie open	Bogie van
Costs												
Unit cost (cents/net tonne-km)	10.3	7.9	9.8	5.6	4.8	5.7	5.3	4.1	5.0	3.0	2.6	3.1
Annual cost[d] ($m)	9.0	6.9	8.6	4.9	4.2	5.0	4.6	3.6	4.4	2.6	2.3	2.7
Potential annual saving[e] ($m)	0.0	2.1	0.4	4.1	4.9	4.0	4.4	5.4	4.6	6.4	6.7	6.3

(a) Parameters held constant; loaded run time 9.9 hours, empty run time 4.3 hours.
(b) 4 Wheel open; capacity 19.9 tonnes, tare 8.6 tonnes, value $1080 per tonne of capacity.
(c) Wagon characteristics as in Table 5.3.
(d) Assumes rate of effort for study period continued throughout the year. Annual task 87.5 million tonne-km.
(e) Figures may not add due to rounding.

Source: Annex D and Table F.1.

TABLE 5.5 - POTENTIAL SAVINGS FROM OPERATIONAL IMPROVEMENTS FOR VICTORIAN 4 WHEEL VANS CARRYING INTRA-SYSTEM FREIGHT

(at June 1977 prices)

Possible improvement[a]								
Ratio of load/capacity (0.33 to 0.50)	Existing Load/Capacity				Improved Load/Capacity			
Wagon cycle time (6.70 to 4.14 days)	Existing cycle time		Improved cycle time		Existing cycle time		Improved cycle time	
Change of wagon type (4 wheel van to bogie)	4 Wheel van(b)	Bogie van(c)	4 Wheel van	Bogie van	4 Wheel van	Bogie van	4 Wheel van	Bogie van
Costs								
Unit cost (cents/net tonne-km)	7.5	7.1	5.8	5.4	5.2	4.9	4.0	3.8
Annual cost[d] ($m)	8.5	8.0	6.5	6.0	5.8	5.5	4.6	4.2
Potential annual saving[e] ($m)	0.0	0.5	2.0	2.5	2.7	3.0	3.9	4.2

(a) Parameters held constant; loaded run time 8.3 hours, empty run time 2.8 hours.
(b) 4 Wheel van; capacity 17.6 tonnes, tare 12.2 tonnes, value $1380 per tonne of capacity.
(c) Wagon characteristics as in Table 5.3.
(d) Assumes rate of effort for study period continued throughout the year. Annual task 112.5 million tonne-km.
(e) Figures may not add due to rounding.

Source: Annex C and Table F.3.

TABLE 5.6 - POTENTIAL SAVINGS FROM OPERATIONAL IMPROVEMENTS FOR NSW NON-REFRIGERATED BOGIE VANS CARRYING INTRA-SYSTEM FREIGHT[a]

(at June 1977 prices)

Possible improvement[b]				
Ratio of load/capacity (0.48 to 0.75)	Existing Load/Capacity		Improved Load/Capacity	
Wagon cycle time (7.01 to 4.14 days)	Existing cycle time	Improved cycle time	Existing cycle time	Improved cycle time
Costs				
Unit cost (cents/net tonne-km)	3.2	2.6	2.3	1.9
Annual cost[c] ($m)	3.5	2.9	2.5	2.1
Potential annual saving ($m)	0.0	0.6	1.0	1.4

(a) Bogie van; capacity 44.4 tonnes, tare 23.9 tonnes, value $939 per tonne.
(b) Parameters held constant; loaded run time 14.3 hours, empty run time 3.5 hours.
(c) Assumes rate of effort for study period continued throughout the year. Annual task 110.1 million tonne-km.

Source: Annex C and Table F.2.

TABLE 5.7 - POTENTIAL SAVINGS FROM OPERATIONAL IMPROVEMENTS FOR SA BOGIE VANS CARRYING INTRA-SYSTEM FREIGHT[a]

(at June 1977 prices)

Possible improvement[b]				
Ratio of load/capacity (0.12 to 0.50)	Existing Load/Capacity		Improved Load/Capacity	
Wagon cycle time (6.27 to 4.14 days)	Existing cycle time	Improved cycle time	Existing cycle time	Improved cycle time
Costs				
Unit cost (cents/net tonne-km)	11.6	9.5	3.4	2.9
Annual cost[c] ($m)	3.2	2.7	0.9	0.8
Potential annual saving[d] ($m)	0.0	0.6	2.3	2.4

(a) Bogie Van; capacity 33.7 tonnes, tare 18.1 tonnes.
(b) Parameters held constant; loaded run time 10.4 hours, empty run time 2.7 hours.
(c) Assumes rate of effort for study period continued throughout the year. Annual task 27.9 million tonne-km.
(d) Figures may not add due to rounding.

Source: Annex C and Table F.2.

TABLE 5.8 - POTENTIAL FOR REDUCTIONS IN WAGON MOVEMENTS COSTS

(at June 1977 prices)

System	Wagon class	Traffic type	Estimated net tonne-km performed in study period (million) (a)	Unit cost (cents/tonne-km)(b) Under existing conditions	Unit cost (cents/tonne-km)(b) Under best conditions (c)	Potential annual savings(d) ($m)
NSW	4 Wheel open	General and miscellaneous	14.9	5.5	2.3	6.2
		Forwarder	6.7	4.7	2.3	2.1
		Machinery	0.5	11.0	4.0	0.4
	Bogie van	Inter-system operations	30.0	2.4	1.9	2.0
		Intra-system operations	8.5	3.2	1.9	1.4
	Bogie refrigerated van	Intra-system operations	5.6	4.4	2.7	1.3
	4 Wheel vans	All operations	0.2	7.7	3.2	0.1
NSW SUBTOTAL			66.4			13.6
Vic	4 Wheel open	Wheat	21.0	3.2	2.3	2.4
		Fertiliser	20.2	3.5	2.3	3.2
		Briquettes	11.2	3.6	2.3	1.9
		General	6.7	10.3	2.6	6.7
		Machinery	0.4	17.4	4.0	0.7
	Bogie vans	Inter-system forwarders	10.0	3.0	2.9	0.2
		Inter-system general	7.5	3.5	2.9	0.6
		SA loading	4.2	3.5	2.9	0.3
	4 Wheel vans	All operations	8.7	7.5	3.8	4.2
Vic SUBTOTAL			89.9			20.3
SA	4 Wheel open	All operations	12.0	4.5	2.5	3.0
	Bogie vans	Intra-system	2.2	11.6	2.9	2.4
	4 Wheel van	All operations	1.3	9.6	3.2	1.0
SA SUBTOTAL			15.4			6.5
TOTAL(f)			171.4			40.4

(a) Survey period 28 days in May 1974.
(b) Costs include wagon and locomotive capital opportunity costs, train running cost and maintenance costs for locomotives wagons and track (see Annex B).
(c) Best conditions assume bogie wagons 4 day cycle time and loading rates currently achieved on high volume routes.
(d) Potential savings are calculated by inflating survey period costs by 13, that is traffic levels of survey period assumed for entire year.
(e) Miscellaneous for NSW includes wool, containers, empty returns, bulk loading, equipment and oil drums.
(f) Total and Subtotals may not add due to rounding.

Source: Annex C, except for NSW and Vic 4 wheel open wagons and Vic bogie vans which are taken from Annex D to enable commodity information to be provided, and NSW bogie van inter-system operations which are taken from Annex F.

CHAPTER 6 - CONCLUSION

The most important achievement of this study of wagon utilisation was the establishment of a data base that made it possible for the BTE to undertake independent analysis of railway operations in NSW, Victoria and South Australia. As a result many conflicting opinions on the efficiency of these rail operations have been resolved.

The analysis revealed that comparison of wagon performance based on single characteristics of performance, such as wagon cycle time or loading efficiency would be of little use to executive level management. There were many situations where poor performance as measured by one attribute was offset by good performance in some other. The final approach was to bring together six characteristics of performance in a cost function[(1)], it was then possible to isolate the high cost traffics.

The following traffics showed potential for major cost reduction:

. NSW 4 wheel open wagons carrying general freight and machinery;

. NSW bogie vans both intra and inter-system and intra-system refrigerated bogie vans;

. Victorian 4 wheel open wagons carrying general freight, wheat, fertiliser, briquettes and machinery;

. Victorian bogie vans both intra and inter-system operation;

. Victorian 4 wheel vans;

. South Australian 4 wheel open wagons;

(1) The six wagon characteristics were tonne capacity, tare weight, average load, wagon cycle time, loaded transit time and empty transit time. Costs do not include terminal shunting or load handling or track construction capital opportunity costs.

- South Australian intra-system bogie vans;

- South Australian 4 wheel vans.

There were many instances of under-utilisation of wagons. The best performance for non-bulk freight was achieved by the Victorian SKX bogie flat wagons with a unit cost of 1.35 cents per tonne-km and using 24.7 per cent of tonne-day capacity[1]. The worst non-bulk case was the South Australian fleet of DS bogie vans with a unit cost of 12.89 cents per tonne-km and 0.8 per cent use of tonne-day capacity. In the bulk freight area the best performance was the ComRail GD open wagons carrying lead. These achieved a unit cost of 1.45 cents per tonne-km and 16.5 per cent use of tonne-day capacity; the worst case was the South Australian fleet of SF stock wagons with a unit cost of 18.73 cents per tonne-km and 0.5 per cent use of tonne-day capacity. The global averages for all traffic were 2.70 cents per tonne-km and 4.7 per cent use of tonne-day capacity.

It is emphasised again that simple utilisation measurements are only one indicator of overall efficiency, and in calculating potential cost savings it is necessary to take account of other factors (demand pattern, etc.).

It appears that approximately 80 per cent of the tonne-km of work done by the rail system was being undertaken with a reasonable degree of efficiency, given the constraints of variability of demand, availability of backloading and current standards of service. However, for the other 20 per cent of traffic there was potential for cost reductions of the order of $14 million per annum in NSW (at June 1977 prices) $20 million per annum in Victoria and $7m per annum in South Australia.

Approximately $8 million of these potential savings were associated with the movement of wheat, fertiliser and briquettes in

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(1) Proportion of tonne day capacity used

$$= \frac{\text{average load transit time x average load tonnes}}{\text{cycle time x capacity tonnes}}$$

Victoria. Since the survey period, Victoria has been progressively scrapping the oldest of its 4 wheel wagon fleet; however, the full potential for cost reduction in these bulk traffics will not be realised until major improvements have been made to grain handling facilities at Geelong.

The remaining $32 million per annum is associated with potential savings in the general freight traffics. The analysis showed that the provision of general freight services to a large number of small stations was the main cause of under-utilisation. This lead to small route traffic volumes and low loading efficiencies. The problem was exacerbated by extended cycle times caused principally by unavailability of loading and wagon allocation delays.

All systems are attempting to introduce regional freight centres, which will allow all the branch line type traffic to be consolidated and distributed locally using road vehicles. Dramatic changes in rail operations and major reductions in cost could result. The cost reductions referred to here are only those associated with wagon usage, and even greater savings could be effected in terminal labour costs. However, political and institutional constraints are hindering reform and it will be many years before the benefits of these changes are evident. This problem is being explored more fully in a current BTE study of railway regional freight centres.

Wagon surveys of the type described in this report provide a useful means of reviewing the operation of the total rail freight movement system. They provide insights into the effectiveness of present and proposed policies, bring attention to special problem areas and provide important costing parameters. Consequently, it will be useful to repeat this type of survey after major changes in operating policy. However, before repeating a survey of this type, consideration should be given to the generation of wagon fleet usage information from the daily reporting systems that are used by the centralised wagon and locomotive allocation groups in each State. These systems have potential for providing the information required to determine fleet size requirements and monitor the efficiency of wagon usage on a continuous basis. The development costs would be small in comparison to the cost of a wagon survey of the type reported here.

The process of analysing the wagon usage data has shown that accurate estimation of the cost of rail freight movements is very complex. Research is still some way from being able to indicate an optimum configuration of rolling stock and terminals. However, the wagon survey has provided important costing information which has assisted those who are attempting to develop more effective ways of costing and pricing freight operations in order to control railway deficits.

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ANNEX A

DATA PROCESSING PROCEDURES

This annex describes the basic data files and computer programs which were used to produce the information presented in this report. Many other programs and files were produced during the study in attempts to improve the quality of the data and define activities associated with long terminal delays. However, simple computer processing and manual scanning of the outputs were found to produce the best results. This was the method finally adopted and the inputs and programs concerned are described below.

GUARD'S JOURNAL MASTER FILE

The guard's journal master file contained abstracts from the guard's journal documents. Each journal was described by two sets of records. The first provided train running information associated with shunting operations; one record for each station at which the train stopped for shunting.

The record fields were as follows:

- train system code;
- record amendment date;
- data batch number;
- record number;
- record type (set to 1);
- train type;
- train system and district code;
- train number;
- date train journey commenced;
- train direction (up or down);
- station code, an identifier which includes the system code, the first eight characters of full station name, and a station affix (N for north, Y for yard etc.);
- train arrival time at station;
- train departure time from station;

The second set of records described the train load. Each of these records contained the following information for a wagon:

- system code;
- record amendment date;
- data batch number;
- record number;
- record type (set to 2);
- train type;
- train system and district code;
- train number;
- date train journey commenced;
- train direction (up or down);
- station code of station where wagon was attached;
- wagon type;
- wagon serial number;
- commodity as written by the guard;
- cross tonnes in wagon;
- station code of station where wagon was detached;
- S-flag set to S if the detach station was also the unload station.

Separate files were created for data from each rail system. The records were held in order of batch number and record number (within the batch).

WAGON CHRONOLOGY MASTER FILES

The wagon chronology files were the starting point for most of the analyses of wagon usage. They were derived from the guard's journal master files. The process is outlined in Figure A.1.

A program collected all the station commodity and train type codes found in the guard's journal data. The commodity code list was the largest list with 2046 codes. A series of translation tables was set up to convert all synonyms to common unique codes. Every

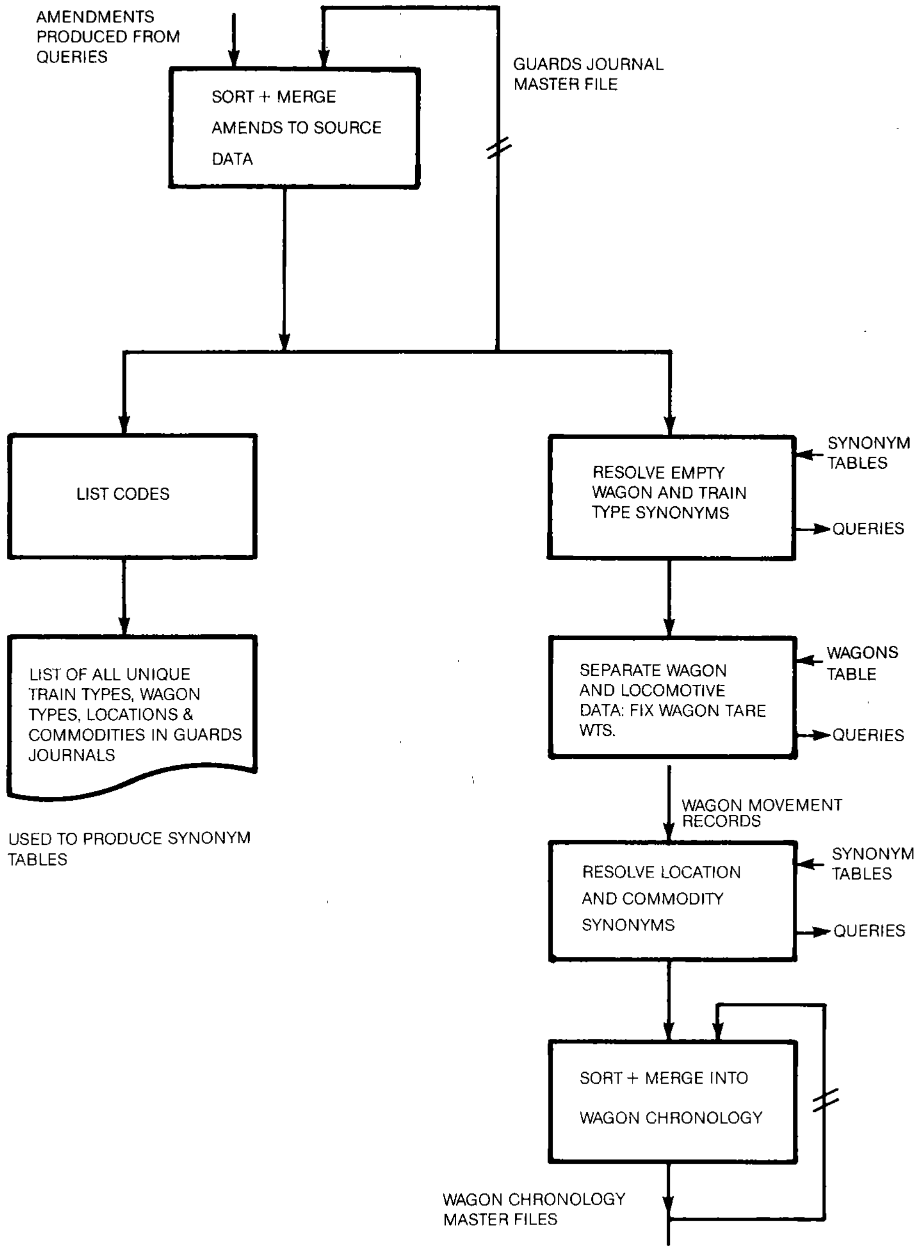

FIGURE A·1
GUARD'S JOURNAL TO WAGON CHRONOLOGY SYSTEMS CHART

attempt was made to retain the detail as recorded by guards on the original journals. The commodity table was reduced to 193 unique codes.

Wagon chronology records contained the following data:

- translated wagon attach station code;
- wagon type;
- wagon serial number;
- translated commodity code;
- commodity weight;
- translated wagon detach station code;
- time attached (in minutes from beginning of survey period);
- time detached from train (in minutes from beginning of survey period);
- unload indicator (or S-flag);
- train identification;
- data batch number.

The records were sorted by wagon type, wagon serial number and time attached. This brought together all records which referred to a wagon and provided a history of its movements during the sample period. This sequence of records will be referred to as the wagon's chronology.

DATA RELIABILITY

In the process of generating the wagon chronology files, 1.5 per cent of data were finally discarded due to inability to match wagon attach and detach station codes with the codes associated with train running information. The extent of other errors was determined by extracting random samples of approximately 1000 wagon chronologies from each of the wagon chronology files.

Analysis of these samples revealed the following discrepancies:

Unrecorded movements. In the samples, 15 per cent of wagon transits were not documented; of these unrecorded movements, 71 per cent were local metropolitan movements, mainly of empty wagons. In the wagon cycle time analysis the metropolitan movements were treated as additional terminal delays.

Incorrect wagon identification. In the samples, 6 per cent of wagon 'type/serial' number identifiers were transcribed incorrectly.

Commodity class inconsistencies. There were many instances of change in commodity classification during the movement of a wagon from point of consignment to point of unload. For example, a wagon load may have been described as 'machinery' when it left a terminal then described as 'general' at the next marshalling point and perhaps 'forwarder' at the next.

Omission of unload indicator. In the samples, 15 per cent of unload indicators were omitted and of the remaining some were inserted in the wrong place.

Duplicate wagon identifiers. In NSW most oil wagons are given the common wagon type of 'BOT', regardless of ownership. Apparently no attempt had been made to ensure that serial numbers on privately owned wagons do not coincide with publicly owned wagons. As a result 'BOT' wagon chronologies became superimposed on each other making it impossible to produce reliable cycle time statistics for oil wagons.

There was some overlap in wagon serial numbers for other types of wagons, which made it difficult to determine the owner and type of the wagons concerned (see Table A.1). In these situations it was assumed that wagons belonged to the system on which they were travelling and were allocated to the appropriate wagon type.

TABLE A.1 - WAGONS WITHOUT UNIQUE IDENTIFICATION

Wagon type	System	Wagon description	Fleet size	Number of wagons not uniquely identified
R	ComRail	Bogie flat	2	4
	SA	4 Wheel refrigerator van	13	
S	NSW	4 Wheel open	5457	8
	ComRail	Bogie sheep van	27	
SO	NSW	4 Wheel open	12	12
	SA	Bogie open ore wagon	159	
T	ComRail	Bogie tank wagon	6	4
	Vic	Refrigerator van	421	
TW	NSW	Special purpose 16 wheeled or 24 wheeled wagon	3	
	Vic	Bogie oil tank	174	8
	SA	Bogie water tank	4	
W	ComRail	Bogie miscellaneous	1	2
	SA	Bogie open	167	
L	ComRail	Bogie louvre van	2	4
	Vic	4 Wheel sheep van	712	

TERMINAL DELAY REPORTS

The terminal delay reports provide mean terminal dwell times for each terminal, broken down by class of train on which the wagon departed, class of wagon, commodity and tonnes in the wagon when it arrived and departed, and activity in which the wagon was engaged.

Figure A.2 describes the processing system for the generation of these reports. The first step was to examine pairs of chronology records and create a single terminal delay record giving wagon arrival and departure data. These records could only be generated where there were correctly matched chronology records. Gaps in wagon chronologies caused by unrecorded movements and incorrect wagon identification prevented 47 per cent of terminal delay records from being generated.

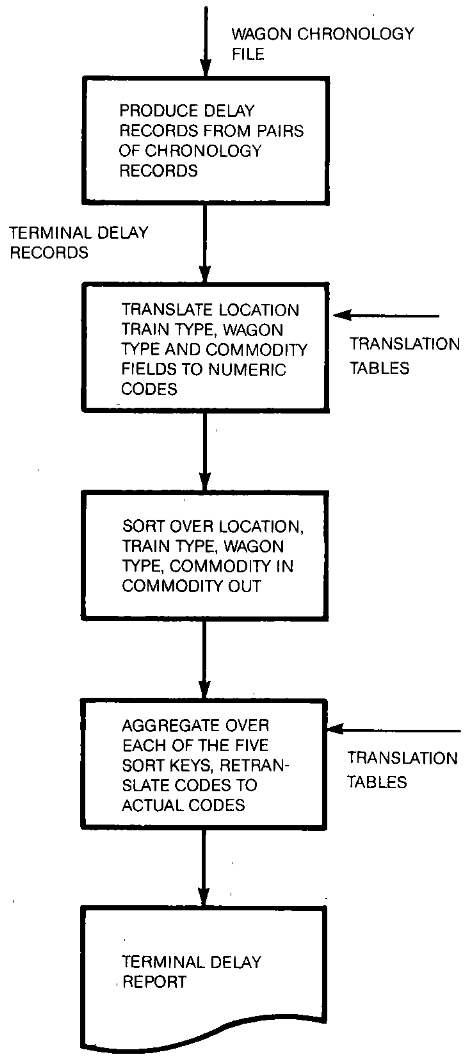

FIGURE A·2
WAGON CHRONOLOGY TO TERMINAL DELAY REPORT
SYSTEMS CHART

There was some bias in the loss of data and the computor analysis of the distribution of terminal delays between city terminals, city sidings, country main stations and sidings had to be adjusted using correction factors derived from manual analysis of small samples.

Translation tables were used to aggregate commodity and wagon codes as recorded on the chronology master files.

INTER-SYSTEM WAGON MOVEMENTS

It was not possible to produce a master chronology file that contained all data for all systems. Initially data for each system were held on a separate file. A second series of files was then produced by putting all chronologies that contained a reference to a border station into one file and leaving the remainder in their separate rail system files. This inter-system file was used to create terminal delay information for border stations and wagon cycle time data for wagons involved in inter-system operations.

It should be noted that although it was possible to isolate wagons that only engaged in intra-system operations, the wagons engaged in inter-system operations were nearly always involved in some intra-systems operations as well. It was not possible to produce results for purely inter-system operations.

WAGON CYCLE TIME ANALYSIS

Figure A.3 shows the process of creating the inter-system wagon chronology file as the first stage of the cycle time analysis system. Cycle time is the average time between successive unloadings of a wagon.

As discussed above the unload indicator (S-flag) was not always marked correctly, but statistical analysis of samples showed that by using a correction factor, reasonable estimates of cycle time

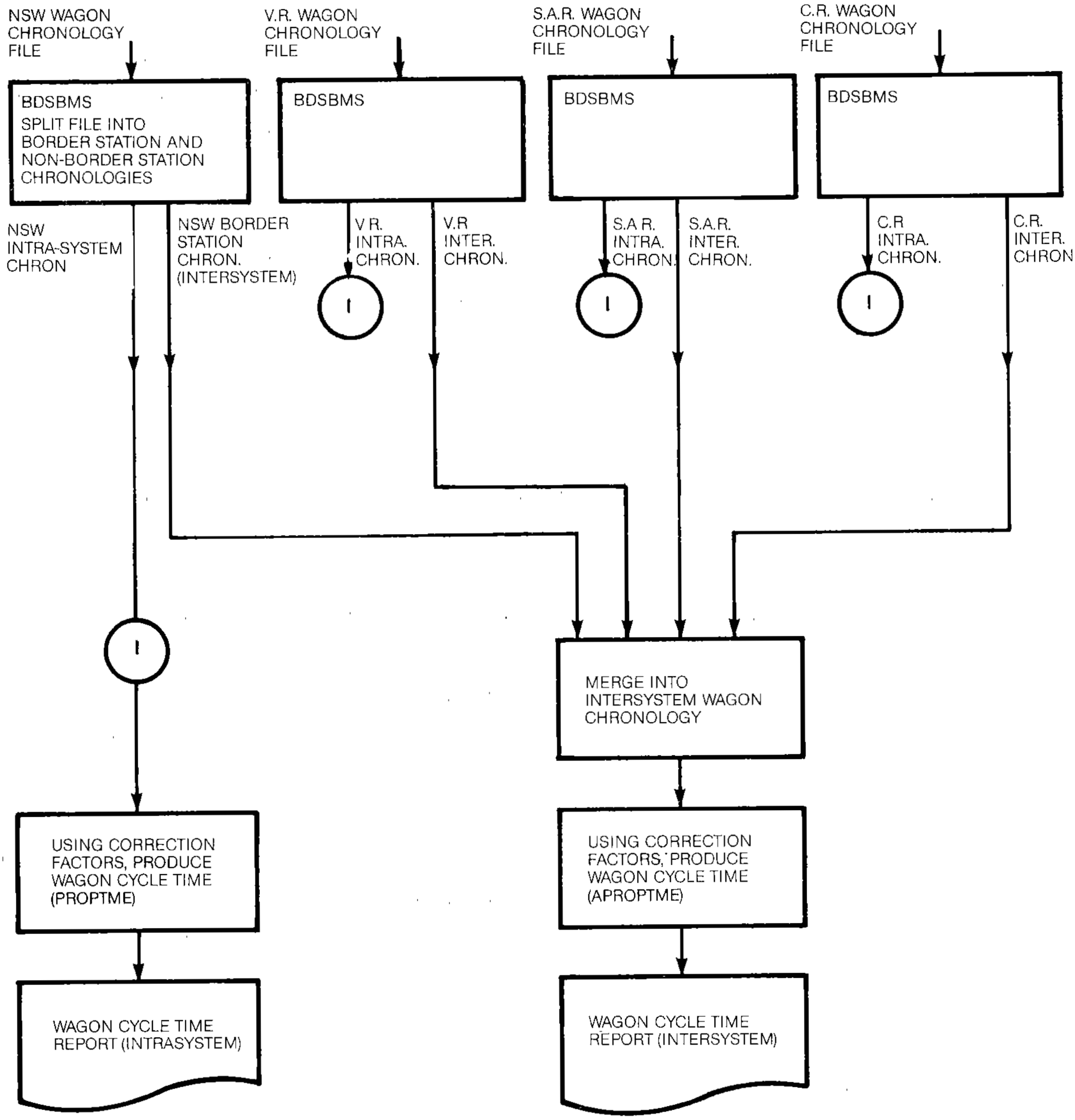

FIGURE A·3
WAGON CHRONOLOGY TO CYCLE TIME REPORT INTRA-AND INTER-SYSTEM SYSTEMS CHART

could be produced for the larger groups of wagons using the relationship:

CT = (ND.NW)/(NS.CF),

where CT is the average cycle time for wagons in the fleet,
ND is the number of days in the study period,
NW is the number of wagons in the fleet,
NS is the number of unload indicators for that fleet,
CF is the correction factor for the system concerned.

As quality of the data from the systems varied, separate correction factors were derived for each.

The factors used are shown in Table A.2.

TABLE A.2 - UNLOAD INDICATOR CORRECTION FACTORS

Rail system	Unload indicator correction factor
NSW	1.26
Victoria	1.00
South Australia	1.08
ComRail	1.00
Inter-system wagons	1.17

An essential task in wagon cycle time analysis was to determine the amount of time spent by wagons running in transit either loaded or unloaded. To do this it was necessary to compensate for errors in wagon identification which caused records to be lost or superimposed. In many cases an error in wagon identification created a single record chronology. Both single and two record chronologies were eliminated from the analysis. Analysis of samples was used to derive correction factors to compensate for the gaps in the chronologies. Statistical analysis showed that these correction factors varied significantly from system to system but did not vary significantly between different types of wagons within an individual system (see Table A.3).

TABLE A.3 - TRANSIT TIME CORRECTION FACTORS

Rail system	Transit time correction factor
NSW	1.09
Victoria	1.15
South Australia	1.08
ComRail	1.05
Inter-system wagons	1.08

The ComRail guard's journals did not cover the Parkston to Perth movements, so a fixed transit time was assumed and added into transit time accumulations each time an event of this type was detected. A similar process was used for gaps in the chronology associated with movement between capital cities and border stations.

Having made these adjustments it was possible to produce a report which gave the following information for each type of wagon:

- wagon type;
- proportion of time spent loaded and in transit;
- proportion of time spent empty and in transit;
- proportion of time in terminals;
- mean cycle time;
- mean weight of load in transit;
- number of wagons of type;
- number of movement records;
- number of unload flags;
- transit time to be added in for Perth-Parkston runs and the border station to capital city linkup where applicable.

The results for wagon types containing less than 10 wagons were considered unreliable and the analysis for this report was restricted to the major wagon types, which performed 90 per cent of loaded wagon transit days. The wagon types selected are listed in Annex D.

WAGON AND COMMODITY TRANSIT INFORMATION

Figure A.4 shows the processing sequence used to produce the detailed analysis of commodity loading for each type of wagon. The commodity codes were carried through from the chronology files to the report files without modification. The data for each wagon type was then ranked by total tonne-days performed for each commodity to allow easy identification of the principle commodities carried by each type of wagon. This process also separated most of the spurious code data from the genuine data. These reports provide the following information for each wagon-commodity pair:

- number of transits;
- maximum, minimum and mean weight of load;
- total transit time;
- total tonne-days of effort.

This data was used together with the wagon cycle time analysis to produce the analysis of wagon performance by wagon class, operation and commodity in Annex D.

ORIGIN-DESTINATION TRANSIT ACTIVITY REPORTS

Figure A.5 gives an outline of the procedures used to produce reports on flows between origins and destinations. In this series of reports the wagons were aggregated into four classes:

- bogie wagons;
- 4 wheel wagons;
- brakevans; and
- wagon type unknown.

Full commodity information was retained in the initial phase which produced a micro-fiche record of movements between origins and destinations during different shifts of the week and commodity loading and transit time information aggregated over the 28 day sample period.

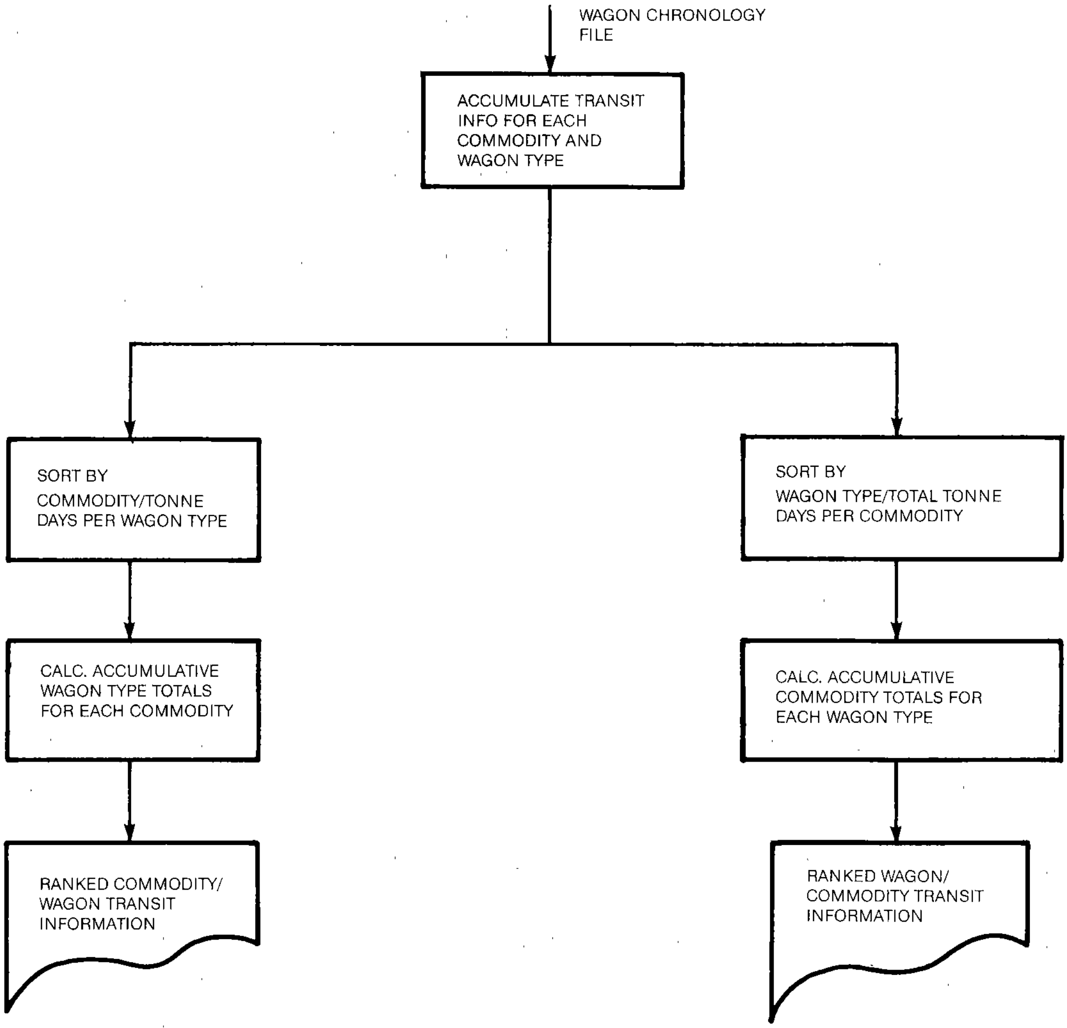

FIGURE A·4
GENERATION OF COMMODITY/WAGON AND WAGON/COMMODITY LOADING AND TRANSIT INFORMATION REPORTS:COMMODITY SUMMATION AND WAGON SUMMATION

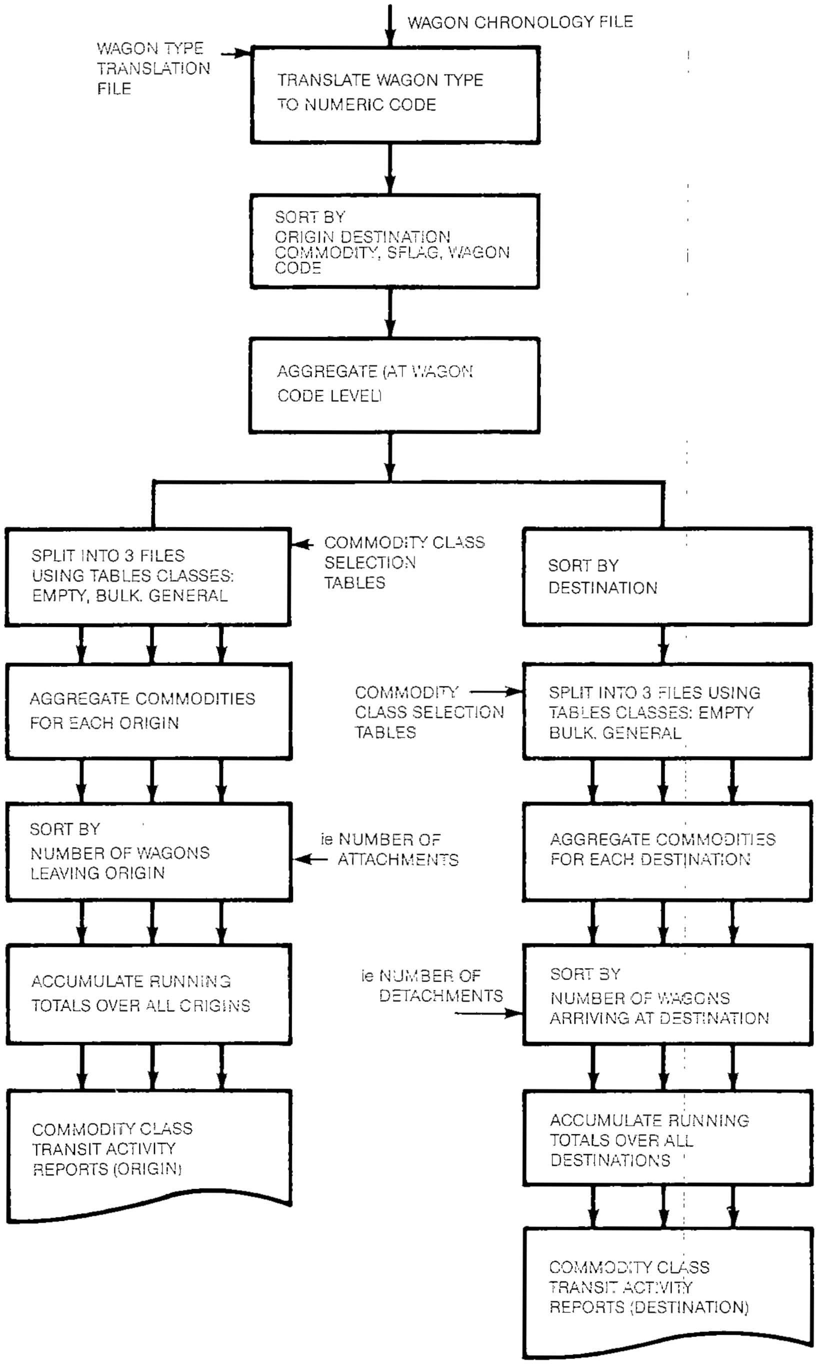

FIGURE A·5
WAGON CHRONOLOGY TO COMMODITY CLASS ORIGIN AND DESTINATION TRANSIT ACTIVITY REPORTS SYSTEMS CHART

In the second phase the commodity codes were grouped into the following three classes:

- empty;
- bulk freight, being wheat, grain, cattle sheep, stock, fertiliser coal, coke, limestone, ore, cement, metal;
- general freight.

The encoded data was sorted and accumulated to provide six reports showing;

- tonnes and number of wagons departing from stations
  - empty
  - with bulk freight
  - with general freight

- tonnes and number of wagons arriving at stations
  - empty
  - with bulk freight
  - with general freight.

DATA PROCESSING RESOURCES USED

The conditions under which the data were collected were by no means ideal;

- the existing guard's journal forms had to be used but were not designed for EDP data collection purposes; and

- there were no built-in methods for ensuring correct wagon identification or consistant commodity coding.

In fact given the condition of the data all credit for the reasonable quality of the transcribed data must be given to the data preparation team. Anybody anticipating repetition of this exercise using a similar data source will require very conscientious data preparation staff. A small number of railway staff were used to correct the data as transcribed by key punch operators. A better result could have been achieved by using experienced railway staff to transcribe the raw data to proper forms but suitable staff could not be released from operational duties at the time. However, no matter what system was used little improvement in wagon identification or commodity identification would have been achieved.

The initial system of computer analysis depended on identification of wagon cycles that were free of error, but commodity identification inconsistencies made this approach unreliable. The final approach used statistical procedures and correction factors based on extensive manual analysis of randomly selected wagon movement histories. Some manual editing of computer analyses was required in the production of all the results in this report. The reliability of the result depended to a great extent on the effort that was put into these manual editing processes.

To repeat the survey it would be virtually essential to have all the rail systems use a more appropriate form of guard's journal (such as the West Rail journal) and take special precautions to eliminate duplicate journals before the data preparation phase. If this was done, given the experience we have had so far, we would expect the following resources to be required to produce data of similar quality to that used in this report:

Data assembly	5 man months
Data transcription	20 million keystrokes
Manual checking	24 man months
Generation of translation tables	2 man months
Determination of correction factors	2 man months
Manual extraction of analysis data	1 man month
Compilation of tables	2 man months
Computer programming	12 man months
Computer processing	$30 000 (CSIRO 1977 prices on CYBER 76) (or $150 000 at a commercial EDP service bureau)
Planning and co-ordination	9 man months.

Computer processing of the data required a number of large sorting operations and time consuming table look-up procedures. The costing of these operations in any similar survey should be examined very carefully.

If a further survey was to be attempted some effort should be made to incorporate distance travelled (through a table look-up system). It would also be valuable to develop sub-systems for the analysis of locomotive trailing loads and determination of the amount of terminal wagon dwell time that was directly attributable to train scheduling constraints.

ANNEX B

COSTING PROCEDURES

There has been no attempt in this report to develop a high precision cost estimating procedure. It would have been possible to develop sophisticated formulae but the data required for evaluation of such formulae were not available.

Since the purpose of this study was to scan the total operation of the rail systems and isolate problematic operations, it was not necessary to achieve high levels of precision. A cost per tonne-km provided a convenient means of bringing together the six wagon characteristics listed at the start of Chapter 3 into one measure. This allowed cost comparisons to be made between diverse wagon activities.

The cost used here is the long-term cost of owning wagons and moving them around the system. It includes the following components:

- opportunity cost of locomotive capital;
- train crew;
- locomotive maintenance;
- track maintenance;
- wagon maintenance;
- opportunity cost of wagon capital.

It does not include track inspection, signalling, marshalling or terminal handling costs. It assumes continuous replacement of wagons (including 4 wheelers).

The cost equation was:

$$\text{Unit wagon usage cost at June 1977 prices (c/t.km)} = 0.6755 \frac{\text{Gross tonne-km}}{\text{Net tonne-km}} + 0.1040 \frac{\text{Tonne-days of wagon capacity moved}}{\text{Tonne-days of wagon capacity used}}$$

$$+ \quad 5.583 \times 10^{-5} \text{ Value of wagon capacity per tonne}$$

$$\times \quad \frac{\text{Tonne-days of wagon capacity available}}{\text{Tonne-days of wagon capacity used}}$$

$$= \quad 0.6755 \left(1 + \frac{T}{L} \, \frac{(R_L + R_E)}{R_L}\right)$$

$$+ \quad 0.1040 \, \frac{C}{L} \, \frac{(R_L + R_E)}{R_L}$$

$$+ \, 5.583 \times 10^{-5} \left(V.\frac{C}{L}.\frac{W}{R_L}\right),$$

where C = capacity of the wagon (tonnes)

T = tare weight of the wagon (tonnes)

L = average load (tonnes) in the wagon (during loaded transit time)

W = wagon cycle time (that is the average number of days between one loading of a wagon and the next)

R_L = average loaded transit time during a wagon cycle

R_E = average empty running time during a wagon cycle

V = replacement value of the wagon in dollars per tonne of capacity.

This equation can be rearranged to give the following component costs per net tonne-km.

Cost of moving the net load $= 0.6755 + 0.1040 \, \frac{C}{L}$.

Cost of moving tare weight of loaded wagons $= 0.6755 \left(\frac{T}{L}\right)$.

Cost of empty wagon movement $= 0.6755 \left(\frac{T}{L}.\frac{R_E}{R_L}\right) + 0.1040 \, \frac{C}{L}.\frac{R_E}{R_L}$.

Long term opportunity cost of wagon renewal capital $= 5.583 \times 10^{-5} \left(V.\frac{C}{L}.\frac{W}{R_L}\right)$.

The derivation of the constants required the following assumptions:

- system wide average for trailing load of a locomotive was 430 tonnes;
- locomotive capital cost was $750 000;
- life of locomotive was 20 years;
- long-term opportunity cost of capital was 10 per cent per annum;
- locomotive down time for maintenance and inspection was 10 per cent of time(1);
- locomotive maintenance cost was 83 cents per locomotive-km;
- fuel cost was 0.060 cents per gross tonne-km;
- average train speed from origin to destination was 25 km/h;
- crew and crew management cost was 73.23 cents per train-km;
- system wide average for trailing load of a train was 645 tonnes;
- track maintenance cost was 0.173 cents per gross tonne-km;
- wagon maintenance cost was 5.2 cents per wagon-km;
- wagon life was 25 years;
- long-term opportunity cost of wagon capital was 10 per cent per annum;
- wagon downtime for maintenance inspection was 10 per cent of total time.

The wagon and locomotive maintenance costs were derived from 1973 data supplied by Victorian Railways for BTE mainline upgrading studies. They were inflated to June 1977 values by using an index based on average weekly earnings.

The track maintenance costs were derived from ten years of statistics on net tonne-km of work done and expenditure on track repair and maintenance on the four systems. System wide gross to net tonne ratios from this May 1974 wagon survey were used to convert net tonne-km data to gross tonne-km. This approach was appropriate for a study such as this which examines broad system

(1) Ten per cent down time is achieved by most classes of locomotive, but the system average in NSW is often brought to 20 per cent by failure of a small group of old locomotives.

characteristics. However, maintenance costs for different sections of track vary considerably, consequently this figure should not be used in studies of routes or corridors. It should also be noted that it is a marginal cost and only a small part of the total expenditure on track maintenance. The larger part of this total cost is explained by length of track rather than traffic carried.

Average train speed of 25 km/h was a typical system wide average for NSW and Victoria at the time of the survey but again average speed on individual routes can range from 17 km/h to 50 km/h.

Wagon down time of 10 per cent was again typical for NSW and Victoria at the time of the survey but can vary from 8 per cent to 15 per cent for the major wagon types.

Wagon replacement costs were provided by Victorian Railways for June 1977. They are expressed in dollars per tonne of wagon capacity (see Table B.1).

TABLE B.1 - WAGON REPLACEMENT COSTS

(Dollars per tonne of wagon capacity, June 1977)

Class of wagon	Bogies	4 wheel
Vans	939	1380
Open	720	1080
Hopper	720	1080
Flat	519	810
Car carriers	720	-

ANNEX C

AGGREGATE OPERATING CHARACTERISTICS FOR CLASSES OF WAGONS

The terms in this table are defined in Chapter 4 of this report. This note is included to explain the process which was used to aggregate the performance characteristics of wagon types.

The tables in Annex C present the performance characteristics of the major wagon types. The data were taken from the wagon cycle time analysis report described in Annex A. The wagon types were ranked in descending order of total fleet running time, and wagon types accounting for 90 per cent of the global total were analysed. There were too few observations available to allow calculation of reliable averages for the remaining wagon types.

The classification into inter-system and intra-system wagon types used in Annex D was retained with one exception. NSW bogie louvres are classified as A (inter-system) in Annex D; however these wagons (with the exception of the HLX type) had a substantial number of wagons which remained in NSW. It was therefore possible to split these wagon types into two fleets, intra-system and inter-system for the purposes of this Annex.

Some care was required when aggregating characteristics across a number of wagon types. The aggregated usage ratios and costs were calculated using four capacity and tare parameters for each group of wagon types. These were as follows:

- Mean capacity of the group wagon fleet

$$= \frac{\Sigma(\text{wagon type fleet size x capacity of wagon type})}{\Sigma\text{wagon type fleet size}} .$$

- Mean capacity of the group wagon fleet which was loaded and in transit

$$= \frac{\Sigma(\text{wagon type loaded transit time x capacity of wagon type})}{\Sigma\text{wagon type loaded transit time}} .$$

- Mean capacity of the group wagon fleet which was empty and in transit was calculated in a similar manner using empty transit time.

- Similarly mean capacity of wagons in transit was weighted by loaded transit time plus empty transit time.

The four group tare weights were calculated in the same manner.

The wagon capacity shown in the tables is weighted by fleet size. The average load is weighted by loaded transit time. The tare weight shown in the tables has been weighted by total transit time.

In most cases the other mean capacities and mean tare weights differed by only a small amount from the figures shown in the tables.

It should be noted that totals may not add due to rounding.

TABLE C.1 - GLOBAL PERFORMANCE CHARACTERISTICS FOR ALL WAGONS ON NSW, VICTORIAN, SA AND COMRAIL SYSTEMS DURING STUDY PERIOD (28 APRIL TO 25 MAY 1974)

Number of trips	123711
Number of wagons identified	36856
Average wagon capacity (tonnes)	28.84
Average load (tonnes)	20.58
Average wagon tare (tonnes)	15.40
Net tonne-km (million)	844.89
Average cycle time (days)	8.34
Average loaded transit time (hours)	13.3
Average empty transit time (hours)	6.0
Distribution of wagon days (%)	
Loaded in transit	6.6
Empty in transit	3.0
In terminals	90.4
Distribution of gross tonne-km (%)	
Net tonne-km	47.9
Loaded tare tonne-km	35.8
Empty tare tonne-km	16.3
Performance measures	
Gross to net ratio	2.09
Capacity used/Capacity moved (%)	42.6
Capacity used/Capacity available (%)	4.7
Breakdown of unit cost (c/tonne-km)	
Net movement	0.84
Loaded tare movement	0.50
Empty tare movement	0.30
Wagon capital opportunity cost	1.05
TOTAL UNIT COST	2.70
Breakdown of total cost ($'000)	
Net movement	7095
Loaded tare movement	4255
Empty tare movement	2542
Wagon capital opportunity cost	8930
TOTAL COST	22822

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TABLE C.2 - CHARACTERISTICS OF INTER-SYSTEM BOGIE WAGON OPERATIONS

	Open	Vans	Flats	Car Carriers	Totals
Number of trips	3556	5236	5711	1157	15660
Number of wagons identified	1746	1748	1090	319	4903
Average wagon capacity (tonnes)	50.00	42.07	51.60	16.29	45.34
Average load (tonnes)	29.06	22.21	26.88	12.34	24.16
Average wagon tare (tonnes)	22.06	23.13	22.74	20.04	22.62
Net tonne-km (million)	83.42	86.95	67.55	13.95	251.87
Average cycle time (days)	13.75	9.35	5.34	7.72	8.77
Average loaded transit time (hours)	32.3	29.9	17.6	39.1	26.63
Average empty transit time (hours)	7.6	10.9	2.1	21.2	7.70
Distribution of wagon days (%)					
Loaded in transit	9.8	13.3	13.7	21.1	12.7
Empty in transit	2.3	4.9	1.7	11.4	3.7
In terminals	87.9	81.8	84.6	67.5	83.6
Distribution of gross tonne-km (%)					
Net tonne-km	51.6	41.3	51.3	26.6	45.3
Loaded tare tonne-km	39.4	43.3	43.5	47.5	42.6
Empty tare tonne-km	9.0	15.3	5.1	25.8	12.1
Performance measures					
Gross to net ratio	1.94	2.42	1.95	3.75	2.21
Capacity used/Capacity moved (%)	47.2	38.3	46.9	49.5	43.7
Capacity used/Capacity available (%)	5.7	7.0	7.1	16.0	6.7
Breakdown of unit cost (c/tonne-km)					
Net movement	0.85	0.88	0.87	0.81	0.86
Loaded tare movement	0.52	0.71	0.57	1.21	0.64
Empty tare movement	0.16	0.32	0.09	0.73	0.23
Wagon capital opportunity cost	0.71	0.75	0.41	0.25	0.61
TOTAL UNIT COST	2.24	2.66	1.94	3.00	2.34
Breakdown of total cost ($'000)					
Net movement	712	761	590	113	2176
Loaded tare movement	430	616	387	168	1601
Empty tare movement	133	280	62	102	577
Wagon capital opportunity cost	590	649	274	35	1548
TOTAL COST	1865	2306	1313	418	5902

TABLE C.3 - CHARACTERISTICS OF NSW INTRA-SYSTEM BOGIE WAGON OPERATIONS

	Open	Vans	Refrig. Vans	Flat	Coal & Limestone	Wheat	Stock	Tankers	Totals
Number of trips	1209	1110	914	1321	14746	4779	1580	2055	27714
Number of wagons identified	570	278	259	604	1394	976	607	758	5446
Average wagon capacity (tonnes)	44.94	44.44	29.96	48.09	49.18	46.56	13.26	58.00	44.21
Average load (tonnes)	31.67	21.33	14.18	24.27	48.77	46.80	8.77	34.31	34.47
Average wagon tare (tonnes)	18.68	23.91	27.63	18.45	18.76	19.16	20.00	16.00	19.31
Net tonne-km (million)	23.89	8.47	5.64	21.97	84.57	89.11	7.98	30.03	271.67
Average cycle time (days)	13.20	7.01	7.93	12.80	2.65	5.72	10.76	10.33	5.50
Average loaded transit time (hours)	25.0	14.3	17.4	27.4	4.7	15.9	23.0	17.0	11.4
Average empty transit time (hours)	11.9	3.5	11.2	14.0	3.6	14.7	20.2	11.5	8.2
Distribution of wagon days (%)									
Loaded in transit	7.9	8.5	9.1	8.9	7.4	11.6	8.9	6.9	8.6
Empty in transit	3.8	2.1	5.9	4.6	5.6	10.7	7.8	4.6	6.2
In terminals	88.3	89.4	85.0	86.5	87.0	77.7	83.3	88.5	85.2
Distribution of gross tonne-km (%)									
Net tonne-km	53.4	41.7	23.8	46.5	59.6	56.0	19.0	56.1	51.0
Loaded tare tonne-km	31.5	46.8	46.2	35.4	22.9	22.9	43.2	26.2	28.6
Empty tare tonne-km	15.1	11.5	30.0	18.1	17.4	21.1	37.8	17.7	20.4
Performance measures									
Gross to net ratio	1.87	2.40	4.20	2.15	1.68	1.79	5.28	1.78	1.96
Capacity used/Capacity moved (%)	47.6	38.5	28.7	33.3	56.2	52.4	35.2	35.3	46.3
Capacity used/Capacity available (%)	5.6	4.1	4.3	4.5	7.3	11.7	5.9	4.1	6.7
Breakdown of unit cost (c/tonne-km)									
Net movement	0.82	0.89	0.90	0.88	0.78	0.78	0.83	0.85	0.81
Loaded tare movement	0.40	0.76	1.31	0.51	0.26	0.28	1.54	0.32	0.38
Empty tare movement	0.26	0.24	0.99	0.37	0.28	0.35	1.49	0.33	0.36
Wagon capital opportunity cost	0.73	1.29	1.21	0.64	0.55	0.35	0.89	0.99	0.60
TOTAL UNIT COST	2.21	3.18	4.41	2.40	1.87	1.75	4.75	2.49	2.15
Breakdown of total cost ($'000)									
Net movement	197	76	51	194	660	694	66	256	2193
Loaded tare movement	95	64	74	113	220	246	123	95	1030
Empty tare movement	62	20	56	81	234	312	119	100	984
Wagon capital opportunity cost	173	109	68	142	464	307	71	297	1631
TOTAL COST	527	269	249	530	1578	1559	379	747	5838

TABLE C.4 - CHARACTERISTICS OF NSW INTRA-SYSTEM 4 WHEEL WAGON OPERATIONS

	Open	Vans	Flats	Coal	Wheat	Stock	Totals
Number of trips	24071	336	639	1366	3171	969	30552
Number of wagons identified	7058	54	174	436	521	263	8506
Average wagon capacity (tonnes)	18.26	12.00	26.00	21.38	24.00	6.00	18.51
Average load (tonnes)	10.73	2.88	8.40	19.91	20.60	4.76	11.48
Average wagon tare (tonnes)	8.44	9.00	8.64	9.79	11.00	9.00	8.88
Net tonne-km (million)	83.68	0.22	1.77	3.26	20.78	2.46	112.17
Average cycle time (days)	8.21	4.50	7.62	8.94	4.60	7.60	7.80
Average loaded transit time (hours)	13.0	8.9	13.2	4.8	12.7	21.4	12.8
Average empty transit time (hours)	3.8	1.9	5.3	5.2	11.3	19.9	5.2
Distribution of wagon days (%)							
Loaded in transit	6.6	8.2	7.2	2.2	11.5	11.7	6.8
Empty in transit	1.9	1.8	2.9	2.4	10.2	10.9	2.8
In terminals	91.5	90.0	89.9	95.4	78.3	77.4	90.4
Distribution of gross tonne-km (%)							
Net tonne-km	49.6	20.8	41.0	49.3	49.8	21.5	47.9
Loaded tare tonne-km	38.9	65.1	42.2	24.3	26.6	40.6	36.6
Empty tare tonne-km	11.5	14.1	16.9	26.4	23.6	37.9	15.5
Performance measures							
Gross to net ratio	2.02	4.80	2.44	2.03	2.01	4.65	2.09
Capacity used/Capacity moved (%)	45.2	19.7	23.1	44.6	45.5	41.0	44.4
Capacity used/Capacity available (%)	3.9	2.0	2.3	2.1	9.9	9.3	4.2
Breakdown of unit cost (c/tonne-km)							
Net movement	0.85	1.11	1.00	0.79	0.80	0.81	0.84
Loaded tare movement	0.53	2.11	0.70	0.33	0.36	1.28	0.52
Empty tare movement	0.21	0.55	0.41	0.48	0.43	1.31	0.29
Wagon capital opportunity cost	1.56	3.91	1.94	2.90	0.61	0.83	1.41
TOTAL UNIT COST	3.15	7.68	4.05	4.50	2.20	4.23	3.06
Breakdown of total cost ($'000)							
Net movement	713	2	18	26	166	20	945
Loaded tare movement	445	5	12	11	75	31	579
Empty tare movement	176	1	7	16	89	32	321
Wagon capital opportunity cost	1307	8	34	95	127	20	1591
TOTAL COST	2641	16	71	148	457	103	3436

TABLE C.5 - CHARACTERISTICS OF VICTORIAN INTRA-SYSTEM BOGIE WAGON OPERATIONS

	Open	Vans	Hoppers	Tankers	Totals
Number of trips	669	572	1687	665	3593
Number of wagons identified	334	110	502	337	1283
Average wagon capacity (tonnes)	33.60	28.90	55.87	42.00	44.12
Average load (tonnes)	14.82	8.04	51.20	34.44	33.96
Average wagon tare (tonnes)	16.82	18.59	20.81	18.00	19.00
Net tonne-km (million)	2.07	0.82	15.55	6.59	25.03
Average cycle time (days)	13.98	5.38	8.33	14.20	10.00
Average loaded transit time (hours)	8.3	7.2	7.2	11.5	8.2
Average empty transit time (hours)	6.2	3.6	6.0	13.0	6.9
Distribution of wagon days (%)					
Loaded in transit	2.5	5.5	3.6	3.4	3.4
Empty in transit	1.9	2.8	3.0	3.8	2.9
In terminals	95.6	91.7	93.4	92.8	93.7
Distribution of gross tonne-km (%)					
Net tonne-km	33.5	22.4	57.3	47.4	49.2
Loaded tare tonne-km	38.0	50.8	23.3	24.8	27.5
Empty tare tonne-km	28.5	26.8	19.4	27.9	23.3
Performance measures					
Gross to net ratio	2.98	4.47	1.75	2.11	2.03
Capacity used/Capacity moved (%)	24.6	18.1	50.0	38.6	41.2
Capacity used/Capacity available (%)	1.1	1.6	3.3	2.8	2.6
Breakdown of unit cost (c/tonne-km)					
Net movement	0.92	1.04	0.79	0.80	0.81
Loaded tare movement	0.77	1.54	0.28	0.35	0.38
Empty tare movement	0.75	1.02	0.32	0.54	0.44
Wagon capital opportunity cost	3.67	3.31	1.22	1.45	1.55
TOTAL UNIT COST	6.11	6.91	2.61	3.14	3.18
Breakdown of total cost ($'000)					
Net movement	19	9	123	53	204
Loaded tare movement	16	13	43	23	95
Empty tare movement	16	8	50	36	110
Wagon capital opportunity cost	75	27	190	96	388
TOTAL COST	126	57	406	208	797

TABLE C.6 - CHARACTERISTICS OF VICTORIAN INTRA-SYSTEM 4 WHEEL WAGON OPERATIONS

	Open	Box Vans	Louvre Vans	Hoppers	Stock	Totals
Number of trips	24188	2558	4701	866	909	33223
Number of wagons identified	10634	613	1125	242	608	13222
Average wagon capacity (tonnes)	20.44	14.89	19.00	16.54	10.00	19.51
Average load (tonnes)	13.61	5.33	6.04	15.90	5.22	11.90
Average wagon tare (tonnes)	8.72	12.46	12.00	9.53	9.17	9.35
Net tonne-km (million)	84.93	2.86	5.79	2.56	1.71	97.86
Average cycle time (days)	12.31	6.71	6.70	7.82	18.72	11.14
Average loaded transit time (hours)	10.3	8.4	8.2	7.4	14.4	9.9
Average empty transit time (hours)	4.3	3.4	2.4	6.5	11.0	4.2
Distribution of wagon days (%)						
Loaded in transit	3.5	5.2	5.1	4.0	3.2	3.7
Empty in transit	1.5	2.1	1.5	3.5	2.5	1.6
In terminals	95.0	92.7	93.4	92.5	94.3	94.7
Distribution of gross tonne-km (%)						
Net tonne-km	52.4	23.4	28.0	47.1	24.4	47.2
Loaded tare tonne-km	33.6	54.7	55.6	28.3	42.8	37.2
Empty tare tonne-km	14.0	21.9	16.4	24.6	32.8	15.7
Performance measures						
Gross to net ratio	1.91	4.27	3.57	2.12	4.10	2.12
Capacity used/Capacity moved (%)	46.9	25.6	24.6	51.3	29.6	43.1
Capacity used/Capacity available (%)	2.3	1.9	1.6	3.8	1.7	2.3
Breakdown of unit cost (c/tonne-km)						
Net movement	0.83	0.97	1.00	0.78	0.88	0.85
Loaded tare movement	0.43	1.58	1.34	0.39	1.19	0.53
Empty tare movement	0.25	0.75	0.49	0.43	1.06	0.30
Wagon capital opportunity cost	2.60	4.13	4.78	1.60	4.61	2.77
TOTAL UNIT COST	4.11	7.43	7.61	3.20	7.74	4.45
Breakdown of total cost ($'000)						
Net movement	706	28	58	20	15	827
Loaded tare movement	368	45	78	10	20	521
Empty tare movement	209	21	28	11	18	287
Wagon capital opportunity cost	2205	118	277	41	79	2720
TOTAL COST	3488	212	441	82	132	4355

TABLE C.7 - CHARACTERISTICS OF SOUTH AUSTRALIAN INTRA-SYSTEM BOGIE WAGON OPERATIONS

	Ore	Vans	Flats	Hoppers	Tankers	Open	Totals
Number of trips	186	1997	442	1083	272	799	4777
Number of wagons identified	159	447	118	147	84	228	1183
Average wagon capacity (tonnes)	59.00	33.72	49.56	56.84	40.86	47.75	44.78
Average load (tonnes)	58.10	4.13	10.85	50.25	24.94	20.78	18.11
Average wagon tare (tonnes)	17.00	18.11	17.81	17.58	18.00	18.67	18.07
Net tonne-km (million)	3.30	2.15	1.32	6.86	1.59	8.52	23.73
Average cycle time (days)	24.00	6.27	7.47	3.80	8.65	8.00	6.93
Average loaded transit time (hours)	12.2	10.4	11.0	5.0	9.4	20.5	10.9
Average empty transit time (hours)	18.2	2.7	1.9	4.3	10.1	4.6	4.3
Distribution of wagon days (%)							
Loaded in transit	2.1	6.9	6.1	5.5	4.5	10.7	6.6
Empty in transit	3.2	1.8	1.0	4.7	4.9	2.4	2.6
In terminals	94.7	91.3	92.9	89.8	90.6	86.9	90.8
Distribution of gross tonne-km (%)							
Net tonne-km	57.8	15.4	34.2	60.6	40.0	47.7	41.8
Loaded tare tonne-km	16.9	67.4	56.2	21.2	28.9	42.9	41.9
Empty tare tonne-km	25.2	17.3	9.6	18.2	31.1	9.4	16.3
Performance measures							
Gross to net ratio	1.73	6.50	2.92	1.65	2.50	2.10	2.39
Capacity used/Capacity moved (%)	39.5	9.8	18.7	47.6	29.4	35.2	29.2
Capacity used/Capacity available (%)	2.1	0.8	1.3	4.9	2.8	4.7	2.7
Breakdown of unit cost (c/tonne-km)							
Net movement	0.78	1.52	1.15	0.79	0.85	0.92	0.92
Loaded tare movement	0.20	2.96	1.11	0.24	0.49	0.61	0.68
Empty tare movement	0.45	0.98	0.27	0.30	0.71	0.19	0.37
Wagon capital opportunity cost	1.92	6.13	2.17	0.82	1.46	0.86	1.58
TOTAL UNIT COST	3.35	11.59	4.70	2.15	3.51	2.58	3.56
Breakdown of total cost ($'000)							
Net movement	26	33	15	54	13	78	219
Loaded tare movement	7	64	15	16	8	52	162
Empty tare movement	15	21	4	21	11	16	88
Wagon capital opportunity cost	63	131	28	57	23	74	376
TOTAL COST	111	249	62	148	55	220	845

TABLE C.8 - CHARACTERISTICS OF SOUTH AUSTRALIAN INTRA-SYSTEM 4 WHEEL WAGON OPERATIONS

(Excludes narrow gauge operations)

	Open	Vans	Stock	Totals
Number of trips	2655	1249	260	4164
Number of wagons identified	1060	406	175	1641
Average wagon capacity (tonnes)	32.84	15.00	10.79	26.07
Average load (tonnes)	15.92	4.17	3.96	11.98
Average wagon tare (tonnes)	8.88	10.00	8.40	9.11
Net tonne-km (million)	11.97	1.25	0.30	13.53
Average cycle time (days)	11.17	9.10	18.82	11.03
Average loaded transit time (hours)	11.3	9.6	11.0	10.8
Average empty transit time (hours)	4.3	3.1	12.5	4.5
Distribution of wagon days (%)				
Loaded in transit	4.2	4.4	2.6	4.1
Empty in transit	1.6	1.4	2.8	1.7
In terminals	94.2	94.2	94.6	94.2
Distribution of gross tonne-km (%)				
Net tonne-km	56.6	23.9	18.6	48.2
Loaded tare tonne-km	31.6	57.4	39.5	36.8
Empty tare tonne-km	11.9	18.7	41.9	15.0
Performance measures				
Gross to net ratio	1.77	4.18	5.37	2.07
Capacity used/Capacity moved (%)	34.4	21.0	17.8	32.4
Capacity used/Capacity available (%)	2.0	1.2	1.0	1.9
Breakdown of unit cost (c/tonne-km)				
Net movement	0.90	1.05	0.96	0.91
Loaded tare movement	0.38	1.62	1.43	0.51
Empty tare movement	0.22	0.65	1.82	0.30
Wagon capital opportunity cost	2.95	6.31	8.08	3.37
TOTAL UNIT COST	4.45	9.63	12.29	5.09
Breakdown of total cost ($'000)				
Net movement	107	13	3	123
Loaded tare movement	45	20	4	69
Empty tare movement	27	8	6	41
Wagon capital opportunity cost	353	79	24	456
TOTAL COST	532	120	37	689

TABLE C.9 - CHARACTERISTICS OF COMRAIL INTRA-SYSTEM BOGIE WAGON OPERATIONS

(Excludes narrow gauge operations)

	Open (coal)	Vans	Flats	Stock	Tankers	Totals
Number of trips	2959	334	475	139	121	4028
Number of wagons identified	279	123	145	81	44	672
Average wagon capacity (tonnes)	52.35	41.01	50.22	37.54	49.27	47.83
Average load (tonnes)	52.23	10.11	11.64	15.08	38.50	32.26
Average wagon tare (tonnes)	19.88	19.67	19.23	16.11	20.00	19.52
Net tonne-km (million)	38.02	2.37	4.63	0.87	3.14	49.04
Average cycle time (days)	2.64	10.30	8.53	16.28	10.22	4.67
Average loaded transit time (hours)	9.4	28.1	33.4	16.6	27.1	14.6
Average empty transit time (hours)	6.2	8.2	5.2	17.2	27.1	7.3
Distribution of wagon days (%)						
Loaded in transit	15.5	11.4	16.3	4.3	11.0	13.0
Empty in transit	9.8	3.3	2.6	4.4	11.0	6.5
In terminals	74.6	85.3	81.1	91.4	78.0	80.5
Distribution of gross tonne-km (%)						
Net tonne-km	61.7	28.5	34.4	31.5	49.1	52.5
Loaded tare tonne-km	23.5	55.4	56.9	33.7	25.5	31.8
Empty tare tonne-km	14.9	16.1	8.7	34.8	25.5	15.8
Performance measures						
Gross to net ratio	1.62	3.51	2.91	3.17	2.04	1.91
Capacity used/Capacity moved (%)	61.0	19.1	19.4	19.7	39.1	43.7
Capacity used/Capacity available (%)	15.5	2.8	3.8	1.7	8.6	8.8
Breakdown of unit cost (c/tonne-km)						
Net movement	0.78	1.10	1.14	0.93	0.81	0.83
Loaded tare movement	0.26	1.31	1.12	0.72	0.35	0.40
Empty tare movement	0.23	0.51	0.24	1.02	0.48	0.27
Wagon capital opportunity cost	0.26	1.88	0.77	3.08	0.47	0.45
TOTAL UNIT COST	1.53	4.79	3.27	5.75	2.11	1.96
Breakdown of total cost ($'000)						
Net movement	296	26	53	8	25	408
Loaded tare movement	98	31	52	6	11	198
Empty tare movement	87	12	11	9	15	134
Wagon capital opportunity cost	99	44	35	27	15	220
TOTAL COST	580	113	151	50	66	960

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ANNEX D

ANALYSIS OF WAGON PERFORMANCE BY WAGON CLASS, OPERATION AND COMMODITY

The tables that follow were derived from the computer wagon cycle time analysis and the wagon-commodity reports described in Annex A.

The principal concern of this Annex is to analyse the characteristics of performance of the major wagon types with respect to the major commodities carried. This was achieved by ranking wagon types in descending order of total fleet running time and selecting all the wagons up to a cut-off point representing 90 per cent of the global total.[1]

Similarly, for each wagon type the major commodities selected were those responsible for at least 80 per cent of wagon days performed by that wagon type (including empty running).

The tables presented in Annex D are therefore not a complete analysis and are not comparable with the totals presented in Annex C which accumulate all data available for the given wagon type.

TERMINOLOGY

The report headings are defined as follows:

Area of Operations

'A': (all systems operation) - the majority of wagons of this type operated in more than one rail system during the 28 day sample period.

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(1) NSW bogie tankers, though coming within the 90 per cent cut-off, had to be excluded from the final analysis in Annex D, due to wagon identification problems discussed in Annex A.

'C,N,S and V': the majority of these wagons remained captive to, respectively, the ComRail NSW, South Australian or Victorian rail system during the 28 day sample period. It should be noted that most of these fleets were completely captive due to bogie exchange restrictions.

Wagon capacity (t): specifies the maximum load in tonnes that could be carried by the type of wagon.

Number of wagons identified: wagons were identified by wagon type and serial number. Approximately 6 per cent of these identifiers were recorded incorrectly. The existence of a particular wagon was assumed to have been established where at least three guard's journal entries were found containing identical wagon type and serial number. Obviously some genuine wagons may have been rejected by this process, but comparisons with railway fleet size statistics for each wagon type showed that the number identified was within 1 per cent of the actual fleet size, with the exception of the 4 wheel coal wagon fleet in NSW which was poorly utilised during the study period due to failure of a tippler at Port Kembla.

Mean cycle time: Average time between successive loadings of a wagon averaged over all traffics carried. The cycle time is split into three components defined below.

Terminal time: The average days that a wagon spends detached from a train during a wagon cycle, averaged over all traffics carried.

Loaded and empty transit times: Transit time is the average number of days that a wagon spends attached to a train between each loading operation also averaged over all traffics carried. Separate figures are given for time spent attached to a train while loaded and time attached but empty. Terminal time plus these two transit times gives the average wagon cycle time.

Commodity carried: As far as possible the commodity coding as recorded on the guard's journals has been retained. Translation processes were used to reduce obvious synonyms to common codes.

The South Australian truck sheets only indicated whether the wagon was loaded or empty. The code 'SA loading' or 'SALD' was used for all wagon loads observed in South Australia. There were some exceptions with express traffic coming into South Australia from Victoria where copies of the Victorian Goods Train Loading sheets, with full commodity coding, were used.

Proportion of total TT (%): This column shows the percentage of wagon transit time spent carrying each commodity. The totals for each wagon type may not add to 100 due to rounding.

Ratio of load to capacity (%): This is a measure of the efficiency of capacity usage. It is the average net tonnes of load in the wagon expressed as a percentage of tonne capacity of the wagon.

Estimated work done: The estimated net work done (expressed in millions of tonne-km) is a measure of the contribution of each type of wagon to the total railway freight transport effort for that particular commodity. It was not possible to incorporate distance data in the survey analysis systems. Consequently these tonne-km figures have been calculated by using the system wide average train speed for NSW and Victoria, which was approximately 25 km/h, to convert transit time to distance.

$$\text{Estimated work done (t.km)} = \text{Total transit time for wagon type} \times \text{Proportion of transit time for commodity} \times \text{System average speed} \times \text{Average wagon load for commodity}$$

Unit cost: This is the unit cost referred to in the main report. It is an estimate of the cost of owning and using each type of wagon (expressed in cents per tonne-km). It includes locomotive and wagon capital opportunity costs; locomotive and wagon maintenance costs; marginal track maintenance costs; and train crew costs. It is assumed that the average transit and terminal times for all commodities are the same. A fuller explanation is given in Annex B.

D.1-NSW: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
Open Bogie	A	BDX	50	512	11.59	1.48	0.33	Steel	18	77	7.95	1.74
								Frt Forward	15	40	3.44	2.74
								General	13	45	3.36	2.49
								SA Loading	8	44	2.02	2.53
								Other	28			
								Empty	18			
	A	CCX	49	40	7.58	0.98	0.84	Steel	36	97	2.19	1.89
								SA Loading	2	69	0.09	2.35
								Other	16			
								Empty	46			
	A	HGM	50	236	12.10	1.19	0.51	Steel	23	83	4.66	1.89
								Frt Forward	14	39	1.33	3.24
								General	11	44	1.18	2.95
								SA Loading	5	45	0.55	2.88
								Other	17			
								Empty	30			
	N	BD	34	211	9.74	0.91	0.45	Steel	30	91	4.04	1.92
								Frt Forward	14	46	0.95	3.17
								General	10	42	0.62	3.42
								Other	13			
								Empty	33			
	N	BDL	50	111	13.15	1.15	0.40	Steel	22	75	1.63	2.03
								Frt Forward	21	40	0.83	3.24
								General	12	38	0.45	3.35
								Other	19			
								Empty	26			
	N	CG	55	68	13.92	1.06	0.62	Ore	31	97	2.04	1.82
								Copper	5	99	0.34	1.78
								Steel	7	71	0.34	2.24
								Other	20			
								Empty	37			

D.1-NSW: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION							COMMODITY ANALYSIS				
Wagon Class & Area of Operation	Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
N	GP	50	140	13.47	1.16	0.57	Ore	30	96	3.86	1.82
							Steel	11	75	1.11	2.14
							Fertiliser	5	97	0.65	1.78
							Timber	5	67	0.45	2.28
							Other	16			
							Empty	33			
Open 4 Wheel N	K	25	1780	9.43	0.59	0.18	Fertiliser	6	97	3.26	2.24
							Frt Forward	12	42	2.82	4.31
							General	14	35	2.75	5.06
							Timber	7	68	2.67	2.92
							Scrap	4	65	1.38	3.03
							Coal	2	95	1.08	2.43
							Wool	5	33	0.84	5.31
							Container	5	27	0.78	6.34
							Empty Rtns	3	23	0.37	7.33
							Machinery	2	13	0.13	12.45
							Other	17			
							Empty	23			
N	S	16	5278	7.01	0.53	0.16	Fertiliser	13	87	14.38	2.34
							General	15	31	5.91	5.36
							Cement	5	85	5.40	2.38
							Frt Forward	9	34	3.89	4.94
							Coal	3	83	2.85	2.42
							Quarry Prds	2	87	2.76	2.36
							Rice	2	94	1.91	2.22
							Gypsum	2	94	1.79	2.22
							Wool	4	36	1.60	4.71
							Wire	1	88	1.57	2.32
							Perm Way	1	74	1.32	2.64
							Agri Prds	1	66	1.26	2.88
							Flour	1	73	1.11	2.66
							Empty Rtns	4	19	1.06	8.31

D.1-NSW: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
								Scrap	1	63	0.86	2.98
								Bulk Load	2	29	0.60	5.68
								Steel	1	80	0.56	2.49
								Equipment	1	34	0.51	4.94
								Chaff	1	50	0.45	3.58
								Oil Drums	1	43	0.40	4.05
								Machinery	2	15	0.36	10.35
								Other	6			
								Empty	23			
Flat Bogie	A	BCX	49	99	2.20	0.81	0.09	Frt Forward	62	81	11.80	1.46
								Container	8	77	1.45	1.50
								Other	20			
								Empty	10			
	A	TVX	46	33	1.75	0.80	0.05	Flexivan	48	84	3.22	1.46
								Frt Forward	34	79	2.14	1.50
								Other	12			
								Empty	6			
	N	ICX	51	41	8.27	1.23	0.50	Container	41	38	0.95	2.78
								Frt Forward	25	46	0.70	2.39
								Other	5			
								Empty	29			
	N	JME	41	91	14.71	0.85	0.64	Steel	45	91	2.38	2.10
								Other	12			
								Empty	43			
	N	MLE	41	123	12.60	0.76	0.64	Steel	37	91	2.85	2.14
								Other	17			
								Empty	46			
	N	OCX	54	113	9.11	1.84	0.65	Container	45	50	4.96	2.03

D.1-NSW: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class &	Area of Operation	Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
								Frt Forward	21	45	2.09	2.17
								Other	8			
								Empty	26			
	N	OCY	52	67	8.12	1.30	0.48	Container	46	45	2.17	2.42
								Frt Forward	21	35	0.77	2.92
								Other	6			
								Empty	27			
	N	UME	41	169	12.48	0.85	0.57	Steel	32	92	3.50	1.96
								Pipes	7	45	0.37	3.28
								Other	21			
								Empty	40			
Flat 4 Wheel	N	CKF	26	108	5.10	0.48	0.12	Container	53	36	0.95	3.35
								Frt Forward	19	41	0.39	3.03
								Other	8			
								Empty	20			
	N	KF	26	66	15.46	0.92	0.72	Machinery	28	10	0.08	14.24
								Cars	13	7	0.03	20.52
								Other	15			
								Empty	44			
Van Bogie	A	GLV	47	90	5.14	0.94	0.22	Frt Forward	29	53	2.02	2.42
								Perishable	22	38	1.10	3.10
								General	12	38	0.60	3.10
								Other	18			
								Empty	19			
	A	GLX	47	130	6.41	1.16	0.33	Frt Forward	17	45	1.48	2.78
								General	15	37	1.07	3.24

D.1-NSW: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

Wagon Class & Area of Operation	Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
WAGON INFORMATION							COMMODITY ANALYSIS				
							Perishables	13	41	1.03	2.99
							SA Loading	14	27	0.73	4.20
							Other	19			
							Empty	22			
A	HLX	47	66	6.60	1.17	0.33	Frt Forward	28	56	1.50	2.35
							General	15	45	0.65	2.78
							Perishable	13	51	0.63	2.53
							SA Loading	9	33	0.28	3.52
							Other	13			
							Empty	22			
A	JLX	47	129	6.88	1.04	0.18	Frt Forward	31	70	3.30	2.06
							Perishable	14	59	1.26	2.31
							General	13	53	1.05	2.49
							SA Loading	6	35	0.32	3.45
							Other	21			
							Empty	15			
A	KLV	47	56	6.50	1.23	0.37	Frt Forward	32	67	1.86	2.14
							Perishable	15	52	0.68	2.56
							General	8	49	0.34	2.67
							SA Loading	5	70	0.30	2.10
							Other	17			
							Empty	23			
A	LLV	41	268	5.67	0.93	0.20	Frt Forward	30	55	5.09	2.42
							Perishable	21	44	2.85	2.85
							General	15	34	1.57	3.49
							Other	16			
							Empty	18			
Refrig Bogie N	MRC	20	44	8.69	0.76	0.65	Meat Peris	35	61	0.44	5.34
							Other	19			

D.1-NSW: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
								Empty	46			
	N	TRC	32	215	6.44	0.72	0.44	Meat Peris	35	41	2.57	4.66
								Frt Forward	8	50	0.72	3.95
								Other	19			
								Empty	38			
Louvre 4 Wheel	N	LV	12	54	4.05	0.37	0.08	General	57	22	0.14	8.29
								Frt Forward	8	31	0.03	6.09
								Other	17			
								Empty	18			
Car Bogie	A	BKX	15	61	5.26	1.65	0.89	Cars	46	74	1.76	3.03
								SA Loading	10	68	0.35	3.24
								Other	9			
								Empty	35			
Hopper Bogie	N	BCH	48	1002	2.37	0.19	0.14	Coal	32	100	30.34	1.89
								Limestone	16	100	15.05	1.89
								Other	10			
								Empty	42			
	N	BLH	43	65	1.91	0.17	0.12	Limestone	56	95	3.31	1.96
								Other	2			
								Empty	42			
	N	CH	54	327	2.20	0.22	0.18	Coal	49	95	21.27	1.82
								Other	6			
								Empty	45			

D.1-NSW: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
	N	BRH	41	216	5.59	0.33	0.38	Cement	43	87	6.29	2.60
								Other	4			
								Empty	53			
	N	BWH	41	380	3.94	0.68	0.58	Wheat	37	94	22.19	1.89
								Other	17			
								Empty	46			
	N	WH	56	156	4.35	0.84	0.81	Wheat	48	97	18.63	1.57
								Other	3			
								Empty	49			
	N	WHX	56	224	5.93	0.82	0.75	Wheat	47	95	24.83	1.60
								Other	5			
								Empty	48			
Hopper 4 Wheel	N	CCH	16	298	14.67	0.20	0.23	Coal	43	77	0.76	7.76
								Other	4			
								Empty	53			
	N	RV	24	521	3.60	0.53	0.47	Wheat	30	82	11.25	2.28
								Sorghum	11	97	4.88	2.03
								Other	12			
								Empty	47			
	N	UT	25	138	4.39	0.20	0.21	Coal	47	99	2.32	2.99
								Other	1			
								Empty	52			
Tanker	N	BMF	24	41	2.75	0.34	0.31	Milk	41	48	0.62	3.74
								Other	11			
								Empty	48			

D.1-NSW: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
Stock Bogie	N	BCW	14	196	3.91	1.00	0.89	Cattle	39	59	3.47	4.59
								Stock	12	63	1.14	4.34
								Other	2			
								Empty	47			
	N	BSV	12	411	16.55	0.89	0.76	Sheep	23	57	0.99	6.55
								Stock	20	54	0.81	6.87
								Other	11			
								Empty	46			
Stock 4 Wheel	N	CW	6	263	5.88	0.89	0.83	Cattle	46	69	1.91	4.73
								Other	6			
								Empty	48			

D.2-VIC: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
Open Bogie	A	ELX	51	448	11.09	0.88	0.23	Steel	11	89	3.62	1.85
								Frt Forward	14	47	2.43	2.92
								SA Loading	12	53	2.35	2.67
								General	14	41	2.12	3.24
								Other	28			
								Empty	21			
	V	E	44	67	10.54	0.37	0.29	Paper	20	57	0.33	4.06
								General	20	30	0.17	7.08
								Other	16			
								Empty	44			
	V	QR	31	267	14.31	0.34	0.25	General	21	25	0.29	10.79
								Stone	6	89	0.29	3.52
								Department	8	56	0.25	5.20
								Machinery	5	14	0.04	18.87
								Other	18			
								Empty	42			
Open 4 Wheel	V	GY	22	6072	13.12	0.48	0.20	Wheat	21	91	20.86	3.17
								Fertiliser	23	80	20.08	3.52
								General	11	25	3.00	9.79
								Other	16			
								Empty	29			
	V	I	16	1613	10.74	0.39	0.17	Briquettes	23	82	4.12	3.56
								General	23	24	1.20	10.57
								Machinery	4	16	0.14	15.56
								Other	20			
								Empty	30			
	V	IA	16	1394	10.54	0.39	0.17	Briquettes	19	80	2.91	3.63
								General	24	23	1.06	10.89
								Timber	4	50	0.38	5.38

D.2-VIC: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
								Machinery	4	14	0.11	17.48
								Other	19			
								Empty	30			
	V	RY	22	1555	9.49	0.35	0.16	Briquettes	17	78	3.91	3.56
								Agri Prds	10	73	2.22	3.82
								General	21	22	1.24	11.93
								Timber	4	41	0.53	5.70
								Machinery	4	12	0.15	18.01
								Other	13			
								Empty	31			
Flat Bogie	A	CSX	53	89	8.97	0.46	0.27	Steel	39	87	2.13	2.06
								SA Loading	21	75	0.99	2.31
								Other	3			
								Empty	37			
	A	FQX	56	360	5.40	0.55	0.05	Containers	56	44	8.71	2.24
								SA Loading	20	47	3.32	2.14
								Other	15			
								Empty	9			
	A	SFX	50	120	6.11	0.50	0.19	Containers	25	45	1.22	2.95
								Pipes	17	63	1.16	2.31
								SA Loading	14	43	0.65	3.06
								Other	16			
								Empty	28			
	A	SKX	50	66	1.64	0.74	0.02	Frt Forward	55	80	7.59	1.35
								SA Loading	12	74	1.53	1.42
								Containers	10	77	1.33	1.39
								General	6	79	0.82	1.39
								Other	14			
								Empty	3			

D.2-VIC: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
Van Bogie	A	BLX	40	110	9.14	1.16	0.60	Frt Forward	16	63	1.23	2.56
								General	18	48	1.06	3.13
								SA Loading	13	41	0.65	3.56
								Other	19			
								Empty	34			
	A	BMX	35	85	8.00	0.65	0.35	General	27	35	0.57	4.86
								Frt Forward	11	55	0.34	3.39
								SA Loading	10	34	0.20	5.05
								Perishable	5	37	0.10	4.69
								Other	12			
								Empty	35			
Louvre Bogie	A	VLX	40	667	7.75	0.97	0.48	Frt Forward	21	48	7.19	3.13
								General	17	41	4.97	3.56
								SA Loading	11	36	2.82	3.95
								Other	18			
								Empty	33			
	A	VSX	50	68	10.67	1.53	0.60	Frt Forward	24	60	1.38	2.46
								General	20	53	1.01	2.71
								SA Loading	12	53	0.61	2.71
								Other	16			
								Empty	28			
	V	UB	16	40	6.08	0.34	0.08	General	56	32	0.13	6.62
								Wool	5	49	0.02	4.56
								Other	20			
								Empty	19			
	V	VF	35	70	4.44	0.28	0.18	General	44	28	0.47	6.80
								Other	17			
								Empty	39			

D.2-VIC: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
Box Van 4 Wheel	V	B	14	339	6.35	0.35	0.10	General	57	23	0.70	10.79
								Other	20			
								Empty	23			
	V	T	16	274	6.08	0.34	0.18	General	53	34	1.05	8.22
								Other	12			
								Empty	35			
Louvre 4 Wheel	V	U	16	1125	6.26	0.34	0.10	General	58	29	3.91	8.26
								Wool	5	27	0.31	8.83
								Other	15			
								Empty	22			
Car Bogie	A	ALX	15	57	4.89	1.68	1.03	Cars	44	68	1.53	3.63
								SA Loading	10	62	0.32	3.92
								Other	8			
								Empty	38			
Hopper Bogie	V	CJ	51	96	3.77	0.13	0.10	Cement	55	93	2.46	2.74
								Other	1			
								Empty	44			
	V	JX	51	76	11.98	0.41	0.31	Cement	55	91	1.84	2.88
								Other	2			
								Empty	43			
	V	GJF	56	330	10.13	0.42	0.35	Wheat	38	91	7.89	2.49
								Barley	14	81	2.59	2.71
								Other	3			
								Empty	45			

D.2-VIC: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
Hopper 4 Wheel	V	J	20	74	7.02	0.24	0.24	Cement	48	91	0.70	3.81
								Other	2			
								Empty	50			
	V	O	17	65	26.50	0.56	0.54	Briquettes	30	95	0.19	4.84
								Limestone	4	100	0.03	4.63
								Other	17			
								Empty	49			
	V	OC	15	103	4.93	0.32	0.25	Sand	45	100	1.25	2.60
								Other	11			
								Empty	44			
Stock 4 Wheel	V	L	10	183	32.60	0.55	0.55	Sheep	42	42	0.18	15.66
								Other	8			
								Empty	50			
	V	M	10	425	14.65	0.61	0.44	Cattle	55	45	1.18	7.83
								Other	3			
								Empty	42			
Tanker Bogie	V	TW	42	176	13.89	0.57	0.64	Bulk Liquid	47	81	3.80	3.02
								Empty	53			
	V	TWF	42	161	11.78	0.58	0.44	Bulk Liquid	57	83	5.18	2.58
								Empty	43			

D.3-S.A.: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
Open Bogie	A	OX	45	98	9.08	1.29	0.13	SA Loading	26	45	1.18	2.31
								Steel	13	81	1.06	1.60
								Frt Forward	13	38	0.50	2.63
								General	11	41	0.46	2.49
								Other	28			
								Empty	9			
	A	SGMX	51	79	9.54	1.62	0.24	SA Loading	21	51	1.19	2.21
								Frt Forward	16	63	1.12	1.92
								Steel	12	84	1.12	1.60
								General	8	52	0.46	2.17
								Other	30			
								Empty	13			
	A	SGX	55	96	9.06	1.43	0.21	SA Loading	22	47	1.42	2.21
								Steel	12	81	1.33	1.57
								Frt Forward	17	53	1.23	2.03
								General	10	45	0.62	2.28
								Other	26			
								Empty	13			
	S	ELX	51	72	8.36	1.58	0.26	SA Loading	86	45	4.30	2.24
								Empty	14			
	S	OS	45	50	6.44	0.71	0.25	SA Loading	74	48	1.74	2.60
								Empty	26			
	S	OWS	45	67	6.37	0.47	0.16	SA Loading	75	27	0.92	4.68
								Empty	25			
	S	SGC	50	39	6.76	0.77	0.07	SA Loading	92	47	1.56	2.23
								Empty	8			

D.3-S.A.: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
Open 4 Wheel	S	OBF	36	865	10.23	0.49	0.18	SA Loading	73	48	11.29	4.25
								Empty	30			
	S	SGBZ	22	39	10.57	0.21	0.12	SA Loading	64	46	0.13	8.76
								Empty	36			
	S	Y	18	156	12.49	0.43	0.18	SA Loading	70	36	0.56	7.44
								Empty	30			
Flat Bogie	A	FCS	36	82	6.98	0.56	0.06	Containers	36	37	0.55	2.85
								SA Loading	35	38	0.55	2.78
								Other	19			
								Empty	10			
	A	FQX	57	79	5.92	1.01	0.17	Containers	39	43	2.13	2.03
								SA Loading	16	40	0.81	2.14
								Cars	7	41	0.36	2.10
								Semitrailer	3	84	0.32	1.39
								Other	21			
								Empty	14			
	S	FB	56	44	5.60	0.52	0.08	SA Loading	87	15	0.51	5.38
								Empty	13			
	S	PFB	30	74	8.02	0.39	0.09	SA Loading	82	26	0.45	5.30
								Empty	18			
Van Bogie	A	LX	41	158	8.55	1.28	0.57	Frt Forward	16	59	1.85	2.46
								SA Loading	20	40	1.57	3.31
								General	12	37	0.87	3.52
								Other	21			
								Empty	31			

D.3-S.A.: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class &	Area of Operation	Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
	A	SLX	41	22	8.11	1.79	0.63	Frt Forward	25	68	0.54	2.12
								SA Loading	20	47	0.30	2.77
								General	12	66	0.25	2.17
								Other	17			
								Empty	26			
	S	DS	34	68	5.59	0.42	0.09	SA Loading	83	11	0.29	12.89
								Empty	17			
	S	DW	30	18	5.49	0.49	0.12	SA Loading	80	13	0.09	11.04
								Empty	20			
	S	SLC	32	26	5.45	0.47	0.08	SA Loading	85	15	0.16	8.62
								Empty	15			
	S	M	34	241	5.65	0.43	0.12	SA Loading	78	12	1.13	11.96
								Empty	22			
	S	MG	34	94	6.16	0.43	0.11	SA Loading	79	13	0.45	11.43
								Empty	21			
Van 4 Wheel	S	DWF	15	406	8.57	0.40	0.13	SA Loading	75	28	1.25	9.63
								Empty	25			
Car Bogie	A	ALX	15	76	4.21	1.42	0.87	Cars	62	75	3.14	3.10
								Empty	38			
	A	OAX	41	34	9.94	1.81	0.25	Frt Forward	30	55	0.67	2.06
								SA Loading	23	52	0.49	2.14
								Containers	6	93	0.23	1.50
								General	6	72	0.18	1.74
								Other	23			

D.3-S.A.: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
								Empty	12			
	A	SAX	15	20	4.00	1.7	0.8	Cars Empty	68 32	80	1.08	3.28
Hopper Bogie	S	SH	55	41	3.42	0.26	0.12	SA Loading Other Empty	59 10 31	82	1.84	1.92
	S	SHBX	60	52	4.30	0.22	0.18	SA Loading Empty	55 45	87	2.14	2.24
	S	HS	56	54	2.80	0.18	0.22	SA Loading Empty	44 56	99	2.72	2.17
Ore Bogie	S	SO	59	159	22.73	0.51	0.76	SA Loading Empty	40 60	99	3.29	3.35
Tanker	S	TA	50	40	6.28	0.36	0.46	SA Loading Empty	44 56	66	1.14	3.06
	S	TV	30	44	10.02	0.42	0.36	SA Loading Empty	54 46	41	0.36	5.48

D.3-S.A.: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION									COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty		Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
Stock 4 Wheel	S	CF	4	74	19.52	0.74	0.84		SA Loading Empty	47 53	66	0.12	8.69
	S	SF	20	98	16.74	0.34	0.32		SA Loading Empty	52 48	26	0.17	18.73

D.4-COMRAIL: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
Open Bogie	A	GBX	51	18	8.39	1.68	0.23	Steel	24	82	0.57	1.50
								SA Loading	20	56	0.32	1.85
								General	10	18	0.05	4.38
								Other	34			
								Empty	12			
	A	GD	46	23	9.87	2.06	0.58	Steel	11	84	0.35	1.60
								SA Loading	10	55	0.21	2.09
								Timber	11	35	0.15	2.89
								Frt Forward	6	50	0.12	2.23
								Lead	3	100	0.11	1.45
								Other	37			
								Empty	22			
	A	GMX	46	36	9.40	1.67	0.23	Steel	18	90	0.76	1.67
								SA Loading	20	74	0.69	1.89
								Containers	9	53	0.22	2.39
								General	5	31	0.07	3.60
								Other	36			
								Empty	12			
	A	GOX	48	190	10.33	1.69	0.28	Steel	21	94	4.86	1.60
								SA Loading	19	72	3.36	1.89
								Containers	20	57	2.80	2.21
								Frt Forward	13	77	2.46	1.82
								Other	13			
								Empty	14			
	C	GB	52	259	1.91	0.42	0.27	Coal	37	100	22.15	1.52
		GF						Steel	3	83	2.52	1.70
		GP						Frt Forward	6	61	2.28	2.07
								Other	15			
								Empty	39			
	C	GH	51	25	16.05	0.75	0.70	Coal	45	100	0.80	2.28
								Other	7			

D.4-COMRAIL: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION									COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
								Empty	48			
	C	GQ	58	20	1.90	0.61	0.79	Zinc	61	77	1.24	1.96
								Other	1			
								Empty	38			
Flat Bogie	A	RMX	55	75	4.77	1.24	0.09	Containers	28	28	1.21	2.56
								Semitrailer	16	32	0.79	2.35
								SA Loading	11	34	0.58	2.24
								Cars	13	5	0.10	11.32
								Other	25			
								Empty	7			
	A	ROX	51	87	5.94	1.31	0.15	Containers	29	36	1.53	2.46
								Semitrailer	9	28	0.37	2.99
								SA Loading	4	40	0.24	2.28
								Cars	13	10	0.19	7.16
								Other	35			
								Empty	10			
	C	RG	56	71	5.96	1.44	0.20	Semitrailer	19	33	0.90	2.31
								Containers	19	22	0.60	3.17
								Cars	22	6	0.19	9.75
								Frt Forward	4	29	0.17	2.56
								Other	24			
								Empty	12			
	C	RGB	20	10	11.68	1.05	0.57	Frt Forward	41	100	0.17	2.24
								Furniture	21	75	0.06	2.78
								Other	3			
								Empty	35			
	C	RH	41	22	5.99	0.70	0.11	Containers	60	24	0.26	4.13
								Cars	8	9	0.01	9.47

D.4-COMRAIL: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
								Other	18			
								Empty	14			
	C	RLX	54	26	9.74	1.80	0.16	Semitrailer	29	30	0.34	2.67
								Containers	21	22	0.18	3.42
								Cars	17	9	0.06	7.37
								Other	25			
								Empty	8			
	C	RM	50	16	8.50	2.21	0.49	Containers	48	35	0.54	2.17
								Cars	17	19	0.10	3.42
								Other	17			
								Empty	18			
Van Bogie	A	LCX	46	27	11.91	1.76	1.03	Frt Forward	11	51	0.22	2.85
								General	20	20	0.17	6.13
								SA Loading	11	36	0.16	3.77
								Other	21			
								Empty	37			
	A	LEX	45	38	11.92	3.01	1.17	Frt Forward	28	81	1.56	2.03
								SA Loading	12	64	0.53	2.39
								General	17	39	0.45	3.49
								Other	15			
								Empty	28			
	A	VFX	46	112	11.10	3.07	0.63	Frt Forward	28	76	4.63	1.89
								General	23	58	2.90	2.24
								SA Loading	18	65	2.54	2.06
								Other	14			
								Empty	17			
	C	LC	26	15	10.58	1.51	0.31	General	53	31	0.15	4.45
								Other	30			

D.4-COMRAIL: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION									COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capacity (t)	No. of Wagons Identified	Components of Mean Cycle Time in Days: Terminal Time	Transit Time (TT): Load	Transit Time (TT): Empty		Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capacity (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
									Empty	17			
	C	LD	21	10	6.77	1.03	0.20		General	56	44	0.15	3.10
									Other	28			
									Empty	16			
	C	LDX	45	12	14.38	0.96	0.66		General	38	19	0.06	9.51
									Other	21			
									Empty	41			
	C	VC	46	53	8.54	1.15	0.31		General	47	12	0.35	8.44
									Other	32			
									Empty	21			
	C	VD	46	33	8.06	1.17	0.37		General	40	51	0.83	2.49
									Bulk Liquid	7	62	0.18	2.17
									Other	29			
									Empty	24			
Car Bogie	A	GCX	15	24	5.52	1.82	1.16		Cars	54	63	0.73	3.95
									Other	7			
									Empty	39			
	A	GNX	12	47	5.74	1.73	0.93		Cars	55	88	1.46	3.52
									Other	10			
									Empty	35			
Tanker Bogie	C	TF TK TL	52	24	10.30	1.50	1.50		Water	50	90	2.11	1.89
									Empty	50			
	C	TOC	46	20	6.28	0.86	0.86		Oil Tanker	50	61	1.06	2.60

D.4-COMRAIL: ANALYSIS OF WAGON PERFORMANCE BY CLASS, OPERATION AND COMMODITY

WAGON INFORMATION								COMMODITY ANALYSIS				
Wagon Class & Area of Operation		Wagon Type	Wagon Capa-city (t)	No. of Wagons Ident-ified	Components of Mean Cycle Time in Days: Term-inal Time	Transit Time (TT): Load	Transit Time (TT): Empty	Commodity Carried	Prop of Totl TT (%)	Ratio Load to Capa-city (%)	Est. Work Done t.km (m)	Unit Cost c/t.km
		TOG TOH						Empty	50			
Stock Bogie	C	CB	45	33	13.29	0.72	0.59	Cattle	33	33	0.24	5.96
								Horse	7	78	0.12	2.91
								Other	15			
								Empty	45			
	C	CD	17	17	11.50	0.69	0.61	Cattle	38	79	0.15	3.39
								Other	15			
								Empty	47			
	C	SC	45	31	20.63	0.65	1.02	Sheep	31	50	0.27	6.05
								Other	8			
								Empty	61			

ANNEX E
ANALYSIS OF TERMINAL DWELL TIME

The tables that follow summarise the very large wagon terminal dwell time reports produced by the computer analysis described in Annex A. Analysis of manually corrected samples of wagon chronologies showed that the distribution of errors in the data was not entirely random. For example, there were a larger proportion of missing empty wagon movements within major city terminals than within major rural sidings. Correction factors for various classes of movement were applied to produce Tables E.1, E.6, E.11 and E.16.

Mean dwell times and mean loads were calculated from the 53 per cent of wagon terminal dwell events which were identifiable by computer analysis. Wagon days and total tonneages handled were calculated by multiplying the corrected number of terminal dwell events by mean terminal dwell time and mean tonneage handled.

The dwell events were grouped according to:

- class of terminal;
- commodity carried by the wagon when it arrived at the terminal;
- commodity carried by the wagon when it departed from the terminal; and
- type of event.

Terminals were classified as follows:

- 'Major city terminal' a city terminal which receives whole train loads of wagons daily.

- 'City siding' a city terminal which is normally only serviced by 'metropolitan trip trains'. Usually these terminals only have pick-up and drop services with no remarshalling of through traffic.

- Major rural terminals' a rural terminal which provides train marshalling facilities and is served directly by daily mainline trains.

- 'Rural siding' a rural terminal which is normally served by a 'pick-up' train operating from a major rural terminal.

Commodity was coded as either:

- empty;
- non-bulk;
- not empty (SA only).

Bulk included commodities shown on the guard's journal as wheat, grain, coal, coke, fertiliser, cattle, stock, sheep, cement, limestone, ore and metal. All other commodities were coded as non-bulk freight.

The type of event at the terminal was classified as:

- through connections;
- others.

If a loaded wagon was not unloaded and reloaded but merely marshalled it was classified as 'through connection', as was a remarshalled empty wagon.

There are five tables for each rail system:

- The first shows how terminal dwell events are distributed through the system. For example, in the top left hand corner of Table E.1 for NSW it can be seen that 0.5 per cent of all wagon dwells are events where the wagon brings a bulk commodity into a major city terminal and carries a different bulk load out of the same terminal.

- The second table give a similar breakdown for the mean dwell time.

- The third table distributes wagon terminal time in the same way. Table E.3 for NSW shows that the largest percentage of terminal wagon days (12.5 per cent) is associated with wagons that arrive at major city terminals loaded with bulk commodities and depart empty.

- The fourth table shows distribution of tonneages loaded, by terminal type and commodity handled. For example in the first column of Table E.4 it can be seen that 7.1 per cent of all tonnes loaded in the State was bulk traffic loaded at major city terminals into wagons which had arrived at the terminal empty. For comparison through connection tonneages are also shown on this table, arbitarily expressed as a proportion of the total tonnes loaded in the State.

- The fifth table gives a similar distribution for tonneages unloaded.

Given that the probability density functions of many of these classes of terminal dwell times are approximately exponential, the truncation of terminal dwell events at the beginning and end of the survey period will cause more observations of long dwell times to be truncated than short dwell times. This causes the sample mean to be smaller than the population mean. The effect becomes noticeable for some of the larger mean dwell times. For example wagons carrying bulk commodities into Victorian rural sidings and leaving empty have a sample mean dwell time of 4.6 days. If the probability density function of the individual events is exponential the population mean would be 6.3 days. For a sample mean of 1.00 day the population mean would be 1.04 days. The results shown have not been corrected for this bias since there was insufficient data to establish estimates of the population probability density functions for all classes of dwell event.

It should be noted that totals may not add due to rounding.

TABLE E.1 - DISTRIBUTION OF TERMINAL DWELLS IN NSW, GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING FOR STUDY PERIOD 28 APRIL TO 25 MAY 1974

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded with Bulk	Non-bulk	Empty	Through connection
Major city terminal	Carrying bulk	0.5	0.9	7.6	5.7
	Carrying non-bulk	0.3	1.4	1.7	3.5
	Empty	1.4	2.2	-	11.9
City siding	Carrying bulk	-	-	2.0	-
	Carrying non-bulk	-	0.4	0.9	-
	Empty	0.5	0.7	-	-
Major rural terminal	Carrying bulk	1.3	0.7	1.5	8.4
	Carrying non-bulk	1.3	2.2	1.7	5.7
	Empty	8.7	1.4	-	17.0
Rural siding	Carrying bulk	0.8	-	0.9	-
	Carrying non-bulk	0.2	1.4	1.1	-
	Empty	2.6	1.3	-	-

TABLE E.2 - MEAN DWELLS IN NSW, GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(days)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded with Bulk	Non-bulk	Empty	Through connection
Major city terminal	Carrying bulk	0.9	1.4	1.5	0.5
	Carrying non-bulk	1.0	1.3	1.6	0.7
	Empty	1.3	1.7	-	0.8
City siding	Carrying bulk	0.8	-	1.5	-
	Carrying non-bulk	-	1.2	1.2	-
	Empty	1.4	1.6	-	-
Major rural terminal	Carrying bulk	0.6	1.5	1.3	0.4
	Carrying non-bulk	1.1	1.6	1.9	0.4
	Empty	0.7	1.8	-	0.4
Rural siding	Carrying bulk	1.7	-	1.7	-
	Carrying non-bulk	1.9	1.9	1.9	-
	Empty	0.9	2.4	-	-

TABLE E.3 - DISTRIBUTION OF TOTAL TERMINAL WAGON DAYS IN NSW, GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded with Bulk	Newly loaded with Non-bulk	Empty	Through connection
Major city terminal	Carrying bulk	0.4	1.5	12.5	3.0
	Carrying non-bulk	0.3	2.0	3.0	3.0
	Empty	2.0	4.0	-	10.0
City siding	Carrying bulk	-	-	3.5	-
	Carrying non-bulk	-	0.5	1.0	-
	Empty	0.8	1.0	-	-
Major rural terminal	Carrying bulk	1.0	1.0	2.0	4.0
	Carrying non-bulk	1.5	4.0	4.0	3.0
	Empty	6.5	3.0	-	7.0
Rural siding	Carrying bulk	1.5	-	2.0	-
	Carrying non-bulk	0.5	3.0	2.0	-
	Empty	2.5	3.0	-	-

TABLE E.4 - DISTRIBUTION OF TONNEAGE LOADED IN NSW TERMINALS GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded with Bulk	Newly loaded with Non-bulk	Through connection
Major city terminal	Carrying bulk	1.5	2.1	22.7
	Carrying non-bulk	0.8	2.9	8.2
	Empty	7.1	5.0	-
City siding	Carrying bulk	-	-	-
	Carrying non-bulk	-	0.7	-
	Empty	2.3	2.1	-
Major rural terminal	Carrying bulk	4.2	1.5	25.9
	Carrying non-bulk	3.4	3.5	10.7
	Empty	42.8	2.5	-
Rural siding	Carrying bulk	2.1	0.5	-
	Carrying non-bulk	0.6	1.6	-
	Empty	10.7	2.3	-

TABLE E.5 - DISTRIBUTION OF TONNEAGE UNLOADED IN NSW TERMINALS GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure		
		Newly loaded with		
		Bulk	Non-bulk	Empty
Major city terminal	Carrying bulk	1.7	2.6	44.0
	Carrying non-bulk	0.8	3.1	4.0
City siding	Carrying bulk	-	-	8.3
	Carrying non-bulk	-	0.9	2.1
Major rural terminal	Carrying bulk	4.6	1.9	6.6
	Carrying non-bulk	3.1	4.0	3.6
Rural siding	Carrying bulk	2.2	0.8	2.3
	Carrying non-bulk	0.3	1.7	1.4

TABLE E.6 - DISTRIBUTION OF TERMINAL DWELLS IN VICTORIA, GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure			Through connection
		Newly loaded with			
		Bulk	Non-bulk	Empty	
Major city terminal	Carrying bulk	1.5	0.3	1.1	5.4
	Carrying non-bulk	-	6.2	0.7	6.1
	Empty	2.3	4.4	-	6.7
City siding	Carrying bulk	0.2	-	1.0	-
	Carrying non-bulk	-	0.7	2.9	-
	Empty	1.0	1.3	-	-
Major rural terminal	Carrying bulk	0.5	0.2	1.0	9.0
	Carrying non-bulk	0.2	2.9	5.6	9.5
	Empty	0.7	3.1	-	9.7
Rural siding	Carrying bulk	1.0	-	1.8	2.3
	Carrying non-bulk	0.3	1.8	1.6	2.0
	Empty	2.1	1.0	-	2.1

TABLE E.7 - MEAN DWELL TIMES IN VICTORIA, GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(days)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded with Bulk	Newly loaded with Non-bulk	Empty	Through connection
Major city terminal	Carrying bulk	2.6	3.8	2.6	1.3
	Carrying non-bulk	-	2.4	3.4	1.1
	Empty	1.5	2.3	-	1.2
City siding	Carrying bulk	3.1	-	2.6	-
	Carrying non-bulk	-	2.2	2.9	-
	Empty	1.9	2.0	-	-
Major rural terminal	Carrying bulk	3.3	3.6	4.2	0.7
	Carrying non-bulk	3.1	1.9	2.9	0.4
	Empty	2.5	2.7	-	0.7
Rural siding	Carrying bulk	5.0	-	4.6	1.0
	Carrying non-bulk	4.3	2.1	2.7	1.2
	Empty	4.1	3.0	-	1.4

TABLE E.8 - DISTRIBUTION OF TOTAL TERMINAL WAGON DAYS IN VICTORIA, GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded with Bulk	Newly loaded with Non-bulk	Empty	Through connection
Major city terminal	Carrying bulk	2.0	0.7	2.0	4.0
	Carrying non-bulk	-	9.0	1.0	4.0
	Empty	2.0	6.0	-	5.0
City siding	Carrying bulk	0.3	-	1.0	-
	Carrying non-bulk	-	0.8	5.0	-
	Empty	1.0	1.0	-	-
Major rural terminal	Carrying bulk	0.9	0.3	2.0	4.0
	Carrying non-bulk	0.3	3.0	9.0	2.0
	Empty	0.9	5.0	-	4.0
Rural siding	Carrying bulk	3.0	-	5.0	1.0
	Carrying non-bulk	0.8	2.0	2.0	1.0
	Empty	5.0	2.0	-	2.0

TABLE E.9 - DISTRIBUTION OF TONNEAGE LOADED IN VICTORIAN TERMINALS GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded with Bulk	Wagon status on departure: Newly loaded with Non-bulk	Through connection
Major city terminal	Carrying bulk	6.1	1.1	22.1
	Carrying non-bulk	-	15.2	18.1
	Empty	17.2	10.3	-
City siding	Carrying bulk	0.4	-	-
	Carrying non-bulk	-	0.9	-
	Empty	3.6	5.9	-
Major rural terminal	Carrying bulk	1.8	0.5	41.7
	Carrying non-bulk	0.6	3.8	17.5
	Empty	2.5	8.3	-
Rural siding	Carrying bulk	3.9	-	10.9
	Carrying non-bulk	1.4	2.1	3.5
	Empty	12.3	2.4	-

TABLE E.10 - DISTRIBUTION OF TONNEAGE UNLOADED IN VICTORIAN TERMINALS GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded with Bulk	Wagon status on departure: Newly loaded with Non-bulk	Empty
Major city terminal	Carrying bulk	7.0	1.7	9.3
	Carrying non-bulk	-	17.8	2.4
City siding	Carrying bulk	0.7	-	4.2
	Carrying non-bulk	-	1.3	11.4
Major rural terminal	Carrying bulk	2.0	0.8	4.8
	Carrying non-bulk	0.4	4.6	14.3
Rural siding	Carring bulk	4.6	-	7.6
	Carrying non-bulk	0.5	1.9	2.8

TABLE E.11 - DISTRIBUTION OF TERMINAL DWELLS IN SA, GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure Newly loaded	Empty	Through connection
Major city terminal	Not empty	4.3	3.5	13.3
	Empty	5.0	-	17.7
City siding	Not empty	-	4.5	-
	Empty	1.5	-	-
Major rural terminal	Not empty	2.4	5.0	13.9
	Empty	3.5	-	12.0
Rural siding	Not empty	0.3	3.3	1.7
	Empty	6.5	-	1.7

TABLE E.12 - MEAN DWELL TIMES IN SA, GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(days)

Terminal class	Wagon status on arrival	Wagon status on departure Newly loaded	Empty	Through connection
Major city terminal	Not empty	3.1	2.3	0.4
	Empty	2.6	-	0.7
City siding	Not empty	-	1.7	-
	Empty	1.3	-	-
Major rural terminal	Not empty	2.6	3.1	0.4
	Empty	2.1	-	0.9
Rural siding	Not empty	3.0	2.7	0.9
	Empty	1.8	-	0.7

TABLE E.13 - DISTRIBUTION OF TOTAL TERMINAL WAGON DAYS IN SA, GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded	Wagon status on departure: Empty	Through connection
Major city terminal	Not empty	10.0	6.0	4.1
	Empty	10.0	-	9.3
City siding	Not empty	-	6.0	-
	Empty	1.0	-	-
Major rural terminal	Not empty	5.0	12.0	4.0
	Empty	6.0	-	8.0
Rural siding	Not empty	0.6	7.0	1.0
	Empty	9.0	-	1.0

TABLE E.14 - DISTRIBUTION OF TONNEAGE LOADED IN SA, GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded	Through connection
Major city terminal	Not empty	12.3	57.9
	Empty	16.1	-
City siding	Not empty	-	-
	Empty	4.3	-
Major rural terminal	Not empty	5.7	52.0
	Empty	17.7	-
Rural siding	Not empty	0.5	9.5
	Empty	43.5	-

TABLE E.15 - DISTRIBUTION OF TONNEAGE UNLOADED IN SA, TERMINALS GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded	Wagon status on departure: Empty
Major city terminal	Not empty	16.6	21.8
City siding	Not empty	-	15.1
Major rural terminal	Not empty	7.3	22.1
Rural siding	Not empty	0.3	16.9

TABLE E.16 - DISTRIBUTION OF TERMINAL DWELLS ON THE COMRAIL SYSTEM GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded with Bulk	Wagon status on departure: Newly loaded with Non-bulk	Wagon status on departure: Empty	Through connection
Major terminals (1)	Carrying bulk	-	-	23.4	3.6
	Carrying non-bulk	-	6.1	3.2	10.8
	Empty	24.8	2.9	-	14.7
Other terminals	Carrying bulk	-	-	0.4	-
	Carrying non-bulk	-	1.4	2.2	0.4
	Empty	2.2	1.4	-	2.5

(1) Maree, Telford, Port Augusta and Stirling North.

TABLE E.17 - MEAN DWELL TIMES ON THE COMRAIL SYSTEM; GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(days)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded with Bulk	Wagon status on departure: Newly loaded with Non-bulk	Wagon status on departure: Empty	Through connection
Major terminals(1)	Carrying bulk	-	-	0.8	0.1
	Carrying non-bulk	-	2.0	3.9	0.6
	Empty	0.3	2.7	-	2.0
Other terminals	Carrying bulk	-	-	2.6	-
	Carrying non-bulk	-	3.9	4.5	1.1
	Empty	1.4	4.3	-	2.1

(1) Maree, Telford, Port Augusta and Stirling North.

TABLE E.18 - DISTRIBUTION OF TOTAL TERMINAL WAGON DAYS ON THE COMRAIL SYSTEM GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded with Bulk	Wagon status on departure: Newly loaded with Non-bulk	Wagon status on departure: Empty	Through connection
Major terminals(1)	Carrying bulk	-	-	15.0	0.3
	Carrying non-bulk	-	10.0	10.0	5.0
	Empty	6.0	6.0	-	23.0
Other terminals	Carrying bulk	-	-	0.7	-
	Carrying non-bulk	-	4.0	8.0	1.0
	Empty	2.0	5.0	-	4.0

(1) Maree, Telford, Port Augusta and Stirling North.

TABLE E.19 - DISTRIBUTION OF TONNEAGE LOADED IN COMRAIL TERMINALS GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded with Bulk	Wagon status on departure: Newly loaded with Non-bulk	Through connection
Major terminals (1)	Carrying bulk	-	-	-
	Carrying non-bulk	-	12.5	-
	Empty	64.1	6.0	-
Other terminals	Carrying bulk	-	-	-
	Carrying non-bulk	-	2.2	1.1
	Empty	11.4	3.8	-

(1) Maree, Telford, Port Augusta and Stirling North.

TABLE E.20 - DISTRIBUTION OF TONNEAGE UNLOADED IN COMRAIL TERMINALS GROUPED BY TYPE OF TERMINAL AND COMMODITY ARRIVING AND DEPARTING

(per cent)

Terminal class	Wagon status on arrival	Wagon status on departure: Newly loaded with Bulk	Wagon status on departure: Newly loaded with Non-bulk	Wagon status on departure: Empty
Major terminals (1)	Carrying bulk	-	-	72.0
	Carrying non-bulk	-	12.4	6.7
Other terminals	Carrying bulk	-	-	2.1
	Carrying non-bulk	-	2.1	4.7

(1) Maree, Telford, Port Augusta and Stirling North.

ANNEX F

DETAILS OF HIGH COST TRAFFICS

This annex gives further details of the high cost traffics discussed in Chapter 5 of the report. The results in these tables have been calculated to a higher degree of accuracy than the results in Annex D and are therefore not completely consistant with them though in most cases differences are insignificant.

Table F.1 provides a comparison of high cost 4 wheel traffics with the low cost NSW fertiliser traffic.

Table F.2 has amalgamated all NSW traffics and SA traffics into the general headings of inter-system, intra-system and refrigerated and non-refrigerated. This allowed the use of better quality data and was permissible as bogie vans carry little but general and forwarder traffic. Table F.3 has amalgamated all traffics under intra-system 4 wheel van traffic for the same reasons.

It should be noted that totals may not add due to rounding.

TABLE F.1 - COMPARISON OF CHARACTERISTICS OF THE MAJOR HIGH COST 4-WHEEL OPEN WAGON TRAFFICS WITH THE LOW COST NSW FERTILISER TRAFFIC[(a)]

	NSW Fertiliser (Low cost)	Vic Wheat	Vic Fertiliser	Vic Briquettes	SA All operations	Vic Machines	NSW Machines	Vic General	NSW General and miscellaneous[(b)]	NSW Forwarder
Number of trips	3621	3644	3991	3340	2655	682	576	5753	8269	3004
Number of wagons identified	1030	1796	1967	1291	1060	261	170	2422	2627	894
Average wagon capacity (tonnes)	17.21	22.00	22.00	18.48	32.84	18.72	18.45	19.92	18.31	18.79
Average load (tonnes)	15.11	20.02	17.60	14.80	15.92	2.59	2.60	4.75	5.54	6.82
Average wagon tare (tonnes)	8.23	9.00	9.00	8.30	8.88	8.35	8.48	8.58	8.45	8.55
Net tonne-km (million)	17.61	21.01	20.23	11.19	11.97	0.40	0.49	6.73	14.90	6.71
Average cycle time (days)	7.96	13.90	13.80	10.82	11.17	10.76	8.25	11.79	8.22	8.33
Average loaded transit time (hours)	12.9	11.5	11.5	9.1	11.3	9.0	13.0	9.9	13.0	13.1
Average empty transit time (hours)	3.9	4.8	6.8	4.0	4.3	4.0	3.9	4.3	3.9	4.0
Distribution of wagon days (%)										
Loaded in transit	6.7	3.5	3.5	3.5	4.2	3.5	6.6	3.5	6.6	6.5
Empty in transit	2.0	1.4	1.4	1.5	1.6	1.5	2.0	1.5	2.0	2.0
In terminals	91.2	95.1	95.1	95.0	94.2	95.0	91.4	95.0	91.4	91.5
Distribution of gross tonne-km (%)										
Net tonne-km	58.5	61.1	58.0	55.3	56.6	17.7	19.1	27.8	33.5	38.0
Loaded tare tonne-km	31.9	27.5	29.7	31.0	31.6	57.0	62.1	50.4	51.1	47.6
Empty tare tonne-km	9.6	11.4	12.4	13.7	11.9	25.3	18.8	21.8	15.5	14.4
Performance measures										
Gross to net ratio	1.71	1.64	1.72	1.81	1.77	5.66	5.24	3.59	2.99	2.63
Capacity used/Capacity moved (%)	68.0	64.1	56.5	55.6	34.4	9.6	11.0	16.6	23.6	27.4
Capacity used/Capacity available (%)	5.9	3.2	2.8	2.8	2.0	0.5	0.9	0.8	2.0	2.4
Breakdown of unit cost (c/tonne-km)										
Net movement	0.79	0.79	0.81	0.81	0.90	1.43	1.40	1.11	1.01	0.96
Loaded tare movement	0.37	0.30	0.35	0.38	0.38	2.18	2.20	1.22	1.03	0.85
Empty tare movement	0.15	0.17	0.20	0.23	0.22	1.30	0.89	0.71	0.41	0.34
Wagon capital opportunity cost	1.02	1.91	2.17	2.17	2.95	12.53	6.50	7.28	3.02	2.54
TOTAL UNIT COST	2.33	3.19	3.52	3.59	4.45	17.44	10.99	10.32	5.48	4.69
Breakdown of total cost ($'000)										
Net movement	140	166	163	90	107	6	7	75	151	64
Loaded tare movement	65	64	70	42	45	9	11	82	154	57
Empty tare movement	26	37	40	25	27	5	4	48	62	23
Wagon capital opportunity cost	180	401	439	242	353	50	32	489	451	171
TOTAL COST	410	667	712	400	532	69	54	695	817	314

(a) The results in this table will have minor differences to the results presented in Annex D and Figure 5.2, for reasons discussed in the introduction to Annex F.
(b) Miscellaneous includes wool, containers empty returns, bulk loading equipment and oil drums.

TABLE F.2 - COMPARISON OF CHARACTERISTICS OF MAJOR HIGH COST BOGIE VAN OPERATIONS

	NSW inter-system vans(a)	NSW intra-system vans	NSW intra-system refrigerated	Vic inter-system forwarder	Vic inter-system general only(b)	Vic inter-system SA loading	SA intra-system
Number of trips	1642	1110	914	799	743	454	1997
Number of wagons identified	449	278	259	273	253	156	447
Average wagon capacity (tonnes)	45.26	44.44	29.96	40.57	40.05	40.3	33.72
Average load (tonnes)	22.30	21.33	14.18	20.82	17.22	15.55	4.13
Average wagon tare (tonnes)	24.38	23.91	27.63	21.41	21.31	21.33	18.11
Net tonne-km (million)	30.03	8.47	5.64	10.01	7.48	4.22	2.15
Average cycle time (days)	7.66	7.01	7.93	9.56	9.55	9.59	6.27
Average loaded transit time (hours)	32.8	14.3	17.4	24.0	23.4	23.9	10.4
Average empty transit time (hours)	7.1	3.5	11.2	11.8	11.5	11.8	2.7
Distribution of wagon days (%)							
Loaded in transit	17.9	8.5	9.1	10.5	10.2	10.4	6.9
Empty in transit	3.9	2.1	5.9	5.1	5.0	5.1	1.8
In terminals	78.2	89.4	85.0	84.4	84.8	84.5	91.3
Distribution of gross tonne-km (%)							
Net tonne-km	42.9	41.7	23.8	39.5	35.1	32.8	15.4
Loaded tare tonne-km	46.8	46.8	46.2	40.7	43.5	45.1	67.4
Empty tare tonne-km	10.3	11.5	30.0	19.8	21.4	22.1	17.3
Performance measures							
Gross to net ratio	2.33	2.40	4.20	2.53	2.85	3.05	6.50
Capacity used/Capacity moved (%)	40.5	38.5	28.7	34.4	28.6	25.8	9.8
Capacity used/Capacity available (%)	8.8	4.1	4.3	5.4	4.4	4.0	0.8
Breakdown of unit cost (c/tonne-km)							
Net movement	0.88	0.89	0.90	0.88	0.92	0.95	1.52
Loaded tare movement	0.74	0.76	1.31	0.70	0.84	0.93	2.96
Empty tare movement	0.21	0.24	0.99	0.44	0.53	0.59	0.98
Wagon capital opportunity cost	0.60	1.29	1.21	0.98	1.20	1.00	6.13
TOTAL UNIT COST	2.43	3.18	4.41	3.00	3.49	3.47	11.59
Breakdown of total cost ($'000)							
Net movement	267	76	51	88	69	40	33
Loaded tare movement	221	64	74	70	63	39	64
Empty tare movement	62	20	56	44	40	25	21
Wagon capital opportunity cost	179	109	68	98	89	42	131
TOTAL COST	729	269	249	299	260	146	249

(a) Does not include NSW wagons captive to other systems during the study period.
(b) No perishables included.

TABLE F.3 - COMPARISON OF CHARACTERISTICS OF HIGH COST 4-WHEEL VAN OPERATIONS

	NSW all operations (intra-system)	Vic all operations (intra-system)	SA all operations (intra-system)
Number of trips	336	7259	1249
Number of wagons identified	54	1738	406
Average wagon capacity (tonnes)	12.00	17.55	15.0
Average load (tonnes)	2.88	5.79	4.17
Average wagon tare (tonnes)	9.00	12.16	10.00
Net tonne-km (million)	0.22	8.66	1.25
Average cycle time (days)	4.50	6.70	9.10
Average loaded transit time (hours)	8.9	8.3	9.6
Average empty transit time (hours)	1.9	2.8	3.1
Distribution of wagon days (%)			
Loaded in transit	8.2	5.1	4.4
Empty in transit	1.8	1.8	1.4
In terminals	90.0	93.1	94.2
Distribution of gross tonne-km (%)			
Net tonne-km	20.8	26.2	23.9
Loaded tare tonne-km	65.1	55.3	57.4
Empty tare tonne-km	14.1	18.5	18.7
Performance measures			
Gross to net ratio	4.80	3.81	4.18
Capacity used/Capacity moved (%)	19.7	24.9	21.0
Capacity used/Capacity available (%)	2.0	1.7	1.2
Breakdown of unit cost (c/tonne-km)			
Net movement	1.11	0.99	1.05
Loaded tare movement	2.11	1.42	1.62
Empty tare movement	0.55	0.57	0.65
Wagon capital opportunity cost	3.91	4.56	6.31
TOTAL UNIT COST	7.68	7.54	9.63
Breakdown of total cost ($'000)			
Net movement	2	86	13
Loaded tare movement	5	123	20
Empty tare movement	1	49	8
Wagon capital opportunity cost	8	395	79
TOTAL COST	16	653	120

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