CONVERSION OF CONVENTIONAL RAILWAY TO LIGHT RAIL TRANSIT IN MELBOURNE

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ABSTRACT: *In 1982 a study was instigated by the Victorian Government to examine public transport services in three inner suburbs in Melbourne. This led to an investigation of the possibility of replacing two rail services in the study area by the Light Rail Transit (LRT). This paper summarises the finding of this work which resulted in a recommendation that LRT replace the rail service. The paper addresses the financial, economic, accessibility and patronage implications of the conversion.*

The views expressed in this paper are those of the authors and not necessarily those of the Ministrey of Transport, Victoria or the authors' organisations.

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INTRODUCTION

Light Rail Transit (LRT) is a well established mode in Europe and new systems are being planned, under construction or already in revenue service in a number of countries outside Europe, including the United States (San Diego, Buffalo, Portland), Canada (Edmonton, Calgary), the Philippines (Manila), United Kingdom (Tyne and Wear, London). It was considered for use in Melbourne over 10 years ago (MMTB, 1974) and more recently in Adelaide and Sydney.

While all the systems included here have been categorised as being "Light Rail", they in fact cover a broad spectrum of design standards, performance and cost. In the range of transport modes LRT falls between tram and suburban rail systems. It is not surprising, therefore that it has received some attention in Melbourne where extensive tram and train systems are operated.

This paper describes a study that was undertaken in 1982 which lead to a recommendation that LRT replace trains on two suburban services and the reasons for the recommendation.

LIGHT RAIL TRANSIT

There is no single definition of LRT. Broadly it can be described as being a mode which incorporates features of tram and train operations. It is a railbound, electrified form of transport which is designed to combine the speed and regularity of train services with the frequency, convenience and accessibility of tram services.

LRT Infrastructure

One of the advantages of LRT over conventional rail is that it can operate in a number of environments:

- Shared right-of-way: Sections of track also used by other traffic.

- Separate right-of-way: Track physically separated by curbs, barriers and from other traffic except for at-grade crossings with pedestrians and vehicles.

- Exclusive right-of-way: Fully controlled right-of-way, equivalent to a rail reservation (in some cities, underground sections are also used).

These three categories of right-of-way are currently used on the Melbourne tramway system, although most of the tram network is in streets too narrow to allow for separate or exclusive right-of-way.

Stop spacing on LRT systems is generally in the range 400-700m compared with stop spacings of 150-300m for trams and 1000-2000m for conventional rail.

Stops can be provided with high level platforms like railway stations or can be at street level. Some light rail vehicles (LRVs) are equipped for dual height boarding to allow for a combination of high platform loading in sections with exclusive right-of-way and street level loadings in shared right-of-way environments.

Stops are generally unattended as most LRT systems have "proof-of-payment" fare collection systems which provide for ticket purchase off-vehicle (e.g. from shops, automatic ticket issuing machines) and/or on-vehicle (from machines). Facilities at stops generally include passenger shelters, route maps and timetables.

Vehicles

Light rail vehicles are, in design concept, closer to trams than trains. Some general features of LRV's are:

- generally use 600-750 volt power supply,
- single or double ended operation,
- generally articulated (1 or 2 articulations),
- power collection via pantographs,
- higher acceleration and deceleration rates than trains,
- top speeds in range 70kph-80kph,
- seat 50-80 passengers,
- capacity 130-250 passengers,
- can often be coupled to operate in train sets,
- can have dual height loading platforms.

The electrical components of these vehicles - driver controls, motors, door control, etc. - are similar to those on the new trams operated by the Metropolitan Transit Authority (MTA) in Melbourne.

Operations

Like tram systems, LRT systems generally operate on visual control rather than signal control. Railway type signal control is usually used only in tunnel sections of routes.

This is a critical element of distinction between LRT and conventional rail and is one of the major reasons for differences in operating standards for the two modes and their very different cost structures.

As noted above, LRV's generally operate in a number of environments. As far as possible emphasis is placed on providing maximum protection from operating delays by the extensive use of separation and traffic signal priority. Many LRT systems are also linked to computer operated vehicle control systems which allow operators in central control rooms to monitor services and maintain direct contact with drivers via two way radio. (One of the most sophisticated vehicle control systems of this type is to be introduced on parts of the MTA's tram and bus network in the near future.)

PUBLIC TRANSPORT STUDY - PORT MELBOURNE, SOUTH MELBOURNE. ST. KILDA

In March 1982 a study was instigated by the Victorian Government to examine public transport services and problems in the inner Melbourne suburbs of St. Kilda, Port Melbourne and South Melbourne, and to recommend a course of action for improving services in the area. The study was initiated by the present Government in response to the controversy that surrounded decisions by the previous Government in 1981 to close the Port Melbourne rail line and reduce services on the St. Kilda line, following an inquiry into Melbourne's public transport services (Lonie, 1981).

The study was carried out for the Minister of Transport by a Steering Committee comprising representatives of the local community, transport unions, local Government and transport authorities. The Committee was assisted by a Study Team of officers from the Ministry of Transport and the transport authorities. This paper draws largely on the study team's work which was incorporated into the Steering Committee's report (Steering Committee Report, 1982).

The terms of reference for the study included:

"Based on the analysis of the current situation and predictions of future travel, costs and community needs, options for improving public transport services will be identified and evaluated. A benefit/cost analysis will be required to evaluate options which must pay particular attention to non-quantifiable social benefits and costs as well as quantifiable operating and capital costs."

Features of the Study Area

The first task of the study was an evaluation of existing conditions, analysing available socio-demographic and transport services data. This analysis showed:

- Population in the three municipalities was 78,000 (2.8% of metropolitan Melbourne) in 1981 and had decreased from 100,000 since 1971. This is typical of population trends in inner suburban areas of Melbourne.

- The population is likely to continue to fall, although the reduction may not be as great as in the last decade. At the end of the century population is predicted to be in the range of 50,000-65,000 people.

- The Study Area has a large proportion of elderly citizens.

- Household size in the area is low (2.3 persons/h.h. vs. 3.1 persons/h.h. for Melbourne); residential densities are relatively high. (81 persons/ha. vs. 32 persons/ha. for Melbourne.)

- Home ownership rates are low by metropolitan standards. (35% vs. 70%)

- Income levels are below the metropolitan average.

- The Study area is a very important employment area with approximately 70,000 work spaces (mainly in industrial and commercial activities) which, by the end of the decade, should grow by up to 10,000 work spaces.

- Car ownership rates in the area are well below the metropolitan average, thought to be due mainly to lower income levels, high levels of public transport service and smaller household size, compared with the rest of the metropolitan area.

Public Transport in the Study Area

The area is well serviced by a very comprehensive public transport network of rail, tram and bus services (Figure 1). About 20% of the trips in the area are by public transport, considerably above the metropolitan average of 12%.

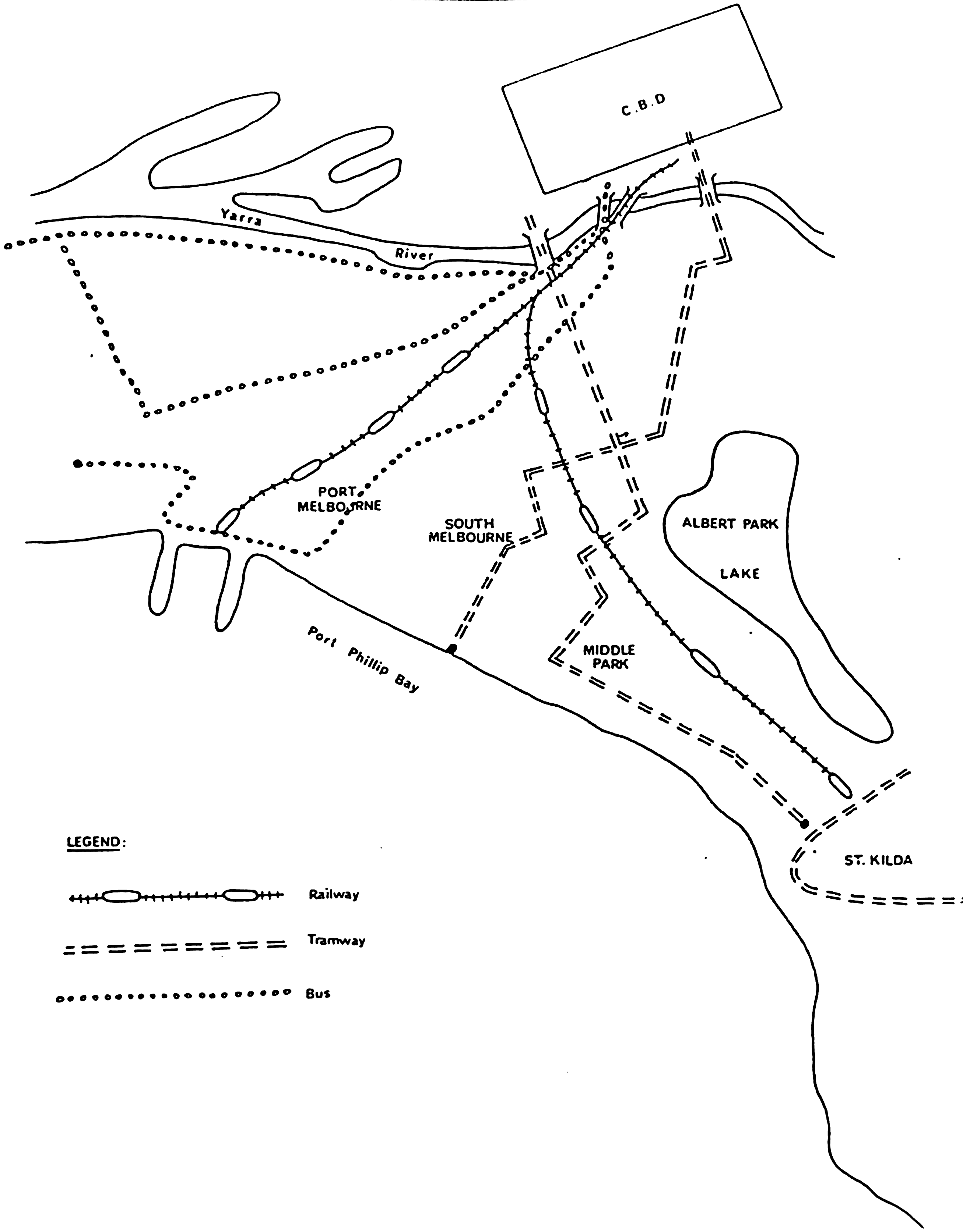

Figure 1 Existing Public Transport Service

Of the 245,000 daily trips in the area, about 38% are within the region, 7% are to and from the Central Business District (CBD) while the remaining 55% involve travel to and from other locations.

An analysis of public transport usage showed that:

- Approximately 28,000 public transport trips are made in the study area on the average weekday.

- 80% of these trips are made to or from regions outside the study area.

- Trams are the main public transport mode used in the area, accounting for 51% of all trips, while train is used for 32% and buses for 17%.

- Patronage on the two train services in the area has decreased by 49% in the last six years, and by 42% on the two main tram routes.

Particular aspects of the two rail lines in the region are:

- loadings on the services in peak periods are bi-directional.

- loadings are, by railway standards, very light. Peak loads rarely rise about 200 on a train and, in the off-peaks, about 30-50.

- almost no rail trips are made within the study area itself.

A rail passenger survey found that unlike other areas served by rail, people in the area were inclined to use the closest public transport service (train, tram and, to a lesser extent, bus) rather than that offering the fastest on-vehicle speeds. This finding was an important factor in developing public transport routing options in the study area which would minimise door-to-door travel time but not necessarily on-vehicle time.

COMPARISON OF CONVENTIONAL RAIL AND LRT

From the outset, the issue of the future of the two rail services in the study area dominated the consideration of the steering committee and, consequently, the work of the Study Team.

It is worth noting that the analysis of alternatives to the existing rail system was limited to some form of electrified transport (rail, LRT, tram). The study group was directed by the steering committee to only consider these modes and not to extend the analysis to include other options such as buses in mixed traffic or bus ways on the rail reserve.

Conventional Rail Option

If heavy rail were to continue to operate in the study area, substantial replacement, maintenance and upgrading of the services would be required, the major elements being:

- the need to replace the Yarra River rail crossing which has reached the end of its design life and would need replacement within the near future. The estimated cost of this bridge replacement was $18 million.

- introduction of new rolling stock.
- refurbishment of stations along the lines.
- extensive maintenance work on track and electrical overhead.

LRT Options

Because of its ability to operate in a range of environments and because of the extensive rail and tram networks in the study area, it was possible to identify a large number of LRT routing options.

The analysis of options was undertaken in two sections, for the corridors and within the CBD itself. Along the St. Kilda corridor three options were identified, two of which (Option I and II) would run for approximately half their lengths along the rail reserve and the other half along (broad) streets with existing tram services. Option III utilised the rail reserve from the Yarra River to the St. Kilda Station. All three options proceeded beyond St. Kilda Station to run via existing tram track to East St. Kilda.

On the Port Melbourne corridor the two options considered would both run via the rail corridor to Port Melbourne, the only difference between the options being that Option I would terminate just off the rail reserve while Option II would be extended a further 800m in a road reservation to Garden City.

For the section north of the Yarra River there were six options identified. One of these would continue along the existing rail reserve and rail bridge to Flinders Street Station, while the other five would access the CBD via an existing road/tram bridge and would operate along existing tram routes within the CBD. All the options in the CBD were designed to provide direct connections with stations on the Underground Loop, to cater for the significant proportion of rail passengers who transfer to/from other rail lines in the CBD.

This paper discusses only the corridor sections of the routes. These are shown in Figure 2.

For LRT to realise its full potential as an effective public transport service that could be considered as an alternative to heavy rail in the St. Kilda and Port Melbourne corridors, it would be necessary to provide a significant level of priority to light rail vehicles in sections not in exclusive right-of-way.

The types of facilities that would be provided include:

Safety Zones
Generally safety zones would be provided at all LRT stops in streets. In wide streets, this would allow two traffic lanes to operate between the zone and the kerb.

Over some street sections the road width would be too narrow to allow for provision of zones.

Separation
In wide roads with safety zones, continuous separation for LRT services would be provided. Legislation was introduced in 1983 providing for the creation of exclusive tram (LRT) lanes in such streets, using painted lines and low profile jiggle bars.

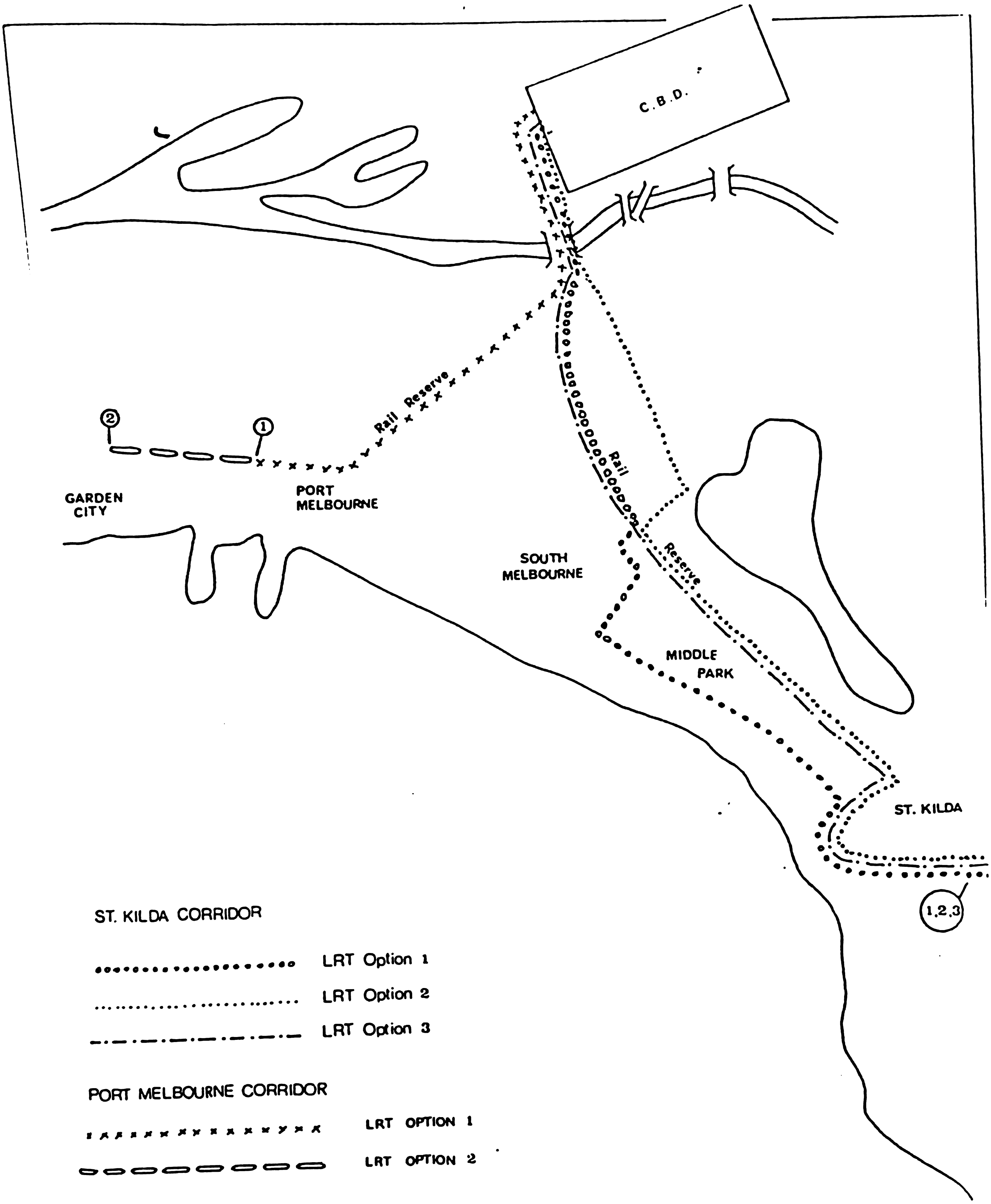

Figure 2 LRT Options

Intersections
At all signalized intersections, traffic signal priority for LRVs would be provided. The separation of LRV's and motor traffic would facilitate the provision of effective traffic signal priority.

Along sections of route in the existing rail reservation, stops would be at 400-500m spacings, which is half the spacing of existing rail stations. In street sections of routes, stops would be placed every 200-400m.

At stops in exclusive right-of-way, high level platforms would be used. In street sections low level or street level loading would be adopted because space limitations would prevent the construction of high level platforms.

The LRT system would be operated by articulated vehicles, based on the prototypes which will enter service in Melbourne's tram network in early 1984. Some design features of the prototype articulated tram are given below:

Vehicle:	Double ended, single articulated LRV
Length:	23530mm
Width:	2670 mm
Seated capacity:	74 passengers
Standing capacity:	106 passengers
Total capacity:	180 passengers
Power collection:	By Pantograph
Doors:	Bi-level loading, minimum of 5 entry/exit points.
Wheel gauge:	1435 mm
Voltage:	600 Volts direct current.

Assessment

The comparison between conventional rail and LRT was undertaken using the following criteria:

. Accessibility
. Travel Times
. Patronage
. Capital Expenditure
. Operating costs
. Financial Evaluation
. Social Benefit - Cost Evaluation

The various assessments are summarised below:

Accessibility
Public submissions to the Committee, and passenger surveys indicated the importance placed on good accessibility to public transport services in the study area. Analysis of ABS Journey to Work data for the area indicated that mode choice and distance to public transport modes are closely linked, as did passenger interviews which showed that 70%-80% of passengers walk to train, tram and bus services.

The number of residents within 400m of a service and service frequency were used as indicators of accessibility. The analysis takes account of stops/station spacing by using a 400m radius from rail and LRT stations. The catchment populations are shown in the table below:

TABLE 1: CATCHMENT POPULATION OF OPTIONS - ST. KILDA CORRIDOR

Population Within 400m of:	Existing Situation	Light Rail		
		Option 1	Option 2	Option 3
- Train	7,620	-	-	-
- L.R.T.	-	22,400	19,470	19,310
- Tram	21,030	6,800	9,760	9,830

Directly comparing rail and LRT services in the St. Kilda corridor, there would be approximately 12,000-15,000 additional residents within 400m of the new LRT service. This substantial increase would obviously be an important factor in maximising potential public transport patronage in the corridor. The increased catchment of LRT, compared with rail is the result of:

(a) the extension of LRT services into the St. Kilda area between Fitzroy Street and Brighton Road.

(b) the closer stop/station spacing with LRT.

The introduction of LRT would result in a significant increase in service frequencies (as is shown in Table 2) and would be similar to those on existing tram routes in the study area. In peak periods more frequent services would be required to accommodate demand while, in the off-peak, improved frequency could be offered at low marginal cost.

TABLE 2: SERVICE FREQUENCIES WITH RAIL & LRT

	Rail	Light Rail (All Options)
St. Kilda Corridor		
Peak	15 mins	5 - 8 mins
Mid-day	15 mins	10 - 12 mins
Evening & Weekend	15 - 20 mins	12 - 20 mins
Port Melbourne Corridor		
Peak	15 mins	10 mins
Mid-day	20 mins	12 mins
Evening & Weekend	20 - 30 mins	12 - 20 mins

Travel Time

Estimates were made of the likely door-to-door travel times for passengers using rail and LRT.

In measuring LRT travel times it was necessary to estimate likely travel times in the various environments in which the vehicles would operate. As far as possible these estimates were based on existing travel times by trams in equivalent parts of the tram network.

Using twenty-one origin-destination pairs, an "average" door-to-door travel time was calculated for each corridor. This average was derived using data from train and tram passenger surveys to weight the door-to-door travel times for each of the origin-destination pairs. The weighted averages are shown in Table 3. In all cases, LRT would provide superior door-to-door travel times.

TABLE 3: WEIGHTED AVERAGE TRAVEL TIMES

Option	Average Travel Time (minutes)
(i) St. Kilda Corridor:	
Heavy Rail	27.9
LRT - Option 1	20.3
LRT - Option 2	23.9
LRT - Option 3	20.3
(ii) Port Melbourne Corridor:	
Heavy Rail	17.7
LRT - Option 1	14.8
LRT - Option 2	13.4

Patronage

Patronage estimates for the LRT services were based largely on existing demand levels on public transport services in the study area. These estimates are considered to be conservative as they only include minimal allowance for additional patronage generated by the superior level of service offered by LRT and the potential to undertake effective marketing of the services in the area. It is considered that the introduction of a new mode into the study area would enhance the potential to undertake such effective marketing. Patronage levels above those shown in Table 4 would not provide any capacity problems for the LRT system.

The patronage estimates are shown in Table 4.

TABLE 4: DAILY PATRONAGE ESTIMATES

A. St. Kilda Corridor:

Mode	Existing Situation	Light Rail Transit		
		Option 1	Option 2	Option 3
Train	6,200	-	-	-
L.R.T.	-	11,350	10,650	10,050
Tram	4,950	1,550	2,050	2,650
Total	11,150	12,900	12,700	12,700

B. Port Melbourne Corridor:

Mode	Existing Situation	Light Rail Transit	
		Option 1	Option 2
Tram	2,950		
L.R.T.	-	3,200	3,800
Bus	1,550	1,450	1,000
Total	4,500	4,650	4,800

The figures indicate that patronage on the LRT services would be 3,850-5,150 per day higher than with the existing St. Kilda train service. The lowest LRT estimate is for the Option 3 where the service would be routed via the rail reserve, and the highest for Option 1 which would be routed via Middle Park.

It is estimated that 16%-17% of the additional patronage on the LRT services would be new passengers, while the remainder would be diverting from existing train, tram and bus services.

Capital Costs
The estimated total capital costs (at December 1982 levels) - construction and vehicles - for each option are summarised below:

TABLE 5: TOTAL CAPITAL REQUIREMENTS FOR HEAVY AND LIGHT RAIL OPTIONS

	Construction Cost ($'000)	Vehicle Cost[b] ($'000)	Total Cost ($'000)
St. Kilda Corridor			
Heavy Rail	9,830[a]	8,000 (2)	17,830
LRT Option 1	4,100	9,000 (12)	13,100
LRT Option 2	5,000	9,750 (13)	14,750
LRT Option 3	5,370	7,500 (10)	12,870
Port Melbourne Corridor			
Heavy Rail	9,200[a]	4,000 (1)	13,200
LRT Option 1	1,830	3,750 (5)	5,580
LRT Option 2	3,740	3,750 (5)	7,490

(a) The Heavy Rail figure includes $18.0 million for replacement of the Yarra River Bridge. This has been equally apportioned between the two lines.

(b) Figures in ( ) are number of train sets or LRV's required for each option

Operating Costs
For the LRT options, crewing costs were assessed on the assumptions that LRV's would be operated with drivers and conductors, even though such vehicles are traditionally operated by drivers only. The more conservative assumption was made because:

- fare systems current at the time of the analysis did not lend themselves easily to a "proof of payment" system that would be necessary with driver only operation,

- uncertainty about which union would operate an LRT service and the award conditions associated with such a service had not been addressed.

Because the introduction of LRT in each corridor would, with some options, result in service adjustments on adjacent tram and bus routes, operating cost estimates were prepared for all modes. The estimates are summarised below:

TABLE 6: ANNUAL OPERATING COST ESTIMATES

Option	Annual Operating Costs			
	Train ($000)	L.R.T. ($000)	Tram/Bus ($000)	Total ($000)
St. Kilda Corridor				
Heavy Rail	4,490		2,180	6,670
LRT Option 1		3,520	870	4,390
LRT Option 2		3,860	540	4,400
LRT Option 3		3,350	2,000	5,350
Port Melbourne Corridor				
Heavy Rail	2,920		350	3,270
LRT Option 1		1,300	270	1,570
LRT Option 2		1,560	190	1,750

Financial and Social Benefit Cost Evaluation
Financial and Social Benefit Cost evaluations were conducted using the LRT options as project cases and heavy rail as the case cases. Each assessment used a 20 year analysis period. The financial assessment used a 6% real discount rate, (representing the approximate real borrowing rate for semi-Government authorities at the time of the assessment) and a 10% social discount rate (the standard rate used for these evaluations in the transport sectors in Victoria). In these evaluations the base case was not a "do nothing" case but rather maintenance and upgrading of the existing heavy rail system.

The Net Present Values (NPV) and benefit cost ratios for the evaluations are summarised below:

TABLE 7: FINANCIAL & SOCIAL BENEFIT COST EVALUATION SUMMARIES

	Financial NPV	Social NPV	Social Benefit-Cost Ratio
A. St. Kilda Corridor			
LRT Option 1	$22.3 mill	$32.8 mill	3.5
- Option 2	$21.3 mill	$26.8 mill	2.8
- Option 3	$11.0 mill	$22.4 mill	2.7
B. Port Melbourne Corridor			
LRT Option 1	$13.7 mill	$11.8 mill	3.1
- Option 2	$11.2 mill	$11.4 mill	2.5

While the assessment assumes that the existing rail bridge would have to be replaced at a cost of $18 million, benefit cost ratios greater than 1.0 would still be obtained even if such replacement was not necessary.

COMMITTEE RECOMMENDATIONS

The findings of the assessment were used as one input by the study committee in making recommendations about public transport services in the study area.

The main committee recommendations were that:

- in the St. Kilda corridor, heavy rail should be replaced by LRT routed via the rail reserve (LRT Option 3)
- in the Port Melbourne corridor, heavy rail should be replaced by a LRT which would terminate short of Option 2 terminus, with the possibility of extension to the terminus following further consultation with the local community
- in the CBD, LRT services be routed via the Collins Street/Bourke Street loop.

The Study Team assessment of the LRT options for the St. Kilda corridor indicated that Option 1 (which was routed through Middle Park on existing tram tracks rather than along the rail reserve) may be a more desirable option than Option 3, which the committee recommended. On all assessment criteria Option 1 was equal to, or better than, Option 3. It would appear that the main factor which caused the committee to opt for Option 3 was that, with this option, the LRT service would be routed for nearly its full length along an existing rail corridor. This route would maximise service reliability. Under Option 1, the service would operate at less than full potential if the required street priority could not be obtained. Option 3 would also result in the continuation of electrified services along all tram routes and the rail corridor, and therefore represented the least change in the area.

CURRENT STATUS

Provision was made in the 1983/84 capital budget for work to commence on the LRT services. However, some delay is likely as prototype LRV's did not enter service until Autumn 1984 and the ordering of LRV's for the St. Kilda and Port Melbourne services cannot be made until these prototypes have entered service.

COMMENTS

Whilst it is difficult to generalise on the basis of one assessment of LRT, in a particular environment, the following comments might still be made:

- there would appear to be some potential to use LRT in Melbourne in medium density corridors, particularly those in which rail loadings have dropped significantly in the past 15-20 years.
- the study indicates that, in Melbourne, LRT can successfully combine the speed and reliability of rail services and the frequency and accessibility of tram services, thereby maximising the likelihood of attracting additional public transport passengers.
- LRT can offer substantial operating economies, compared with tram and rail, if it can be introduced in corridors which allow it to realise its relative operating advantages.
- the introduction of LRT technology could probably be achieved more easily in Melbourne than in other Australian cities as LRT systems can be built on to the existing infrastructure and technical expertise associated with Melbourne's tram system.
- the introduction of LRT could provide a general impetus to the marketing of all public transport services in Melbourne, providing a visible demonstration of the changed approach to the provision of public transport now evident in that city.

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