

**LIGHT RAIL**

**FOR**

**CANBERRA**



***Comeng***

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## 1. Introduction

A fixed guideway public transport link has been part of Canberra's long term strategic planning since the 1960s.

Rapid development of the CBD and increased demand for the intertown express bus service has resulted in new pressures on the ACTION bus system.

Additionally, the trends in development that are now becoming apparent suggest that the possibility of installing a fixed guideway public transport service should be re-examined.

This report proposes a light rail system to serve the nation's capital. Light rail is a system that combines the advantages of a suburban rail system with those of a modern tram system. It has greater capacity and reliability than a traditional bus system, and greater flexibility than a full suburban train system.



## 2. The Choice of Mode

The trunk express route from Woden to Belconnen is operating at high frequencies. Already, there is a bus every 2.5 minutes between Woden and Civic during the peak hour. Buses operating at such high frequencies on streets shared with other traffic will invariably bunch, and it is unlikely that the user will perceive the 2.5 minute frequency.

Also, the inconvenience caused to the public if such frequencies are reduced is minimal, and there are potential savings from using larger vehicles operating every, say, 5 minutes.

As articulated buses already make up the bulk of the intertown express fleet and as the service is so frequent, further increases in capacity using buses would require more operators and more terminal facilities.

A well constructed light rail system would provide a better service with a more comfortable ride and more passenger appeal. It would allow the use of larger vehicles, with potential for further capacity increases. It would also use electricity, which is generated from readily available energy sources, compared with diesel fuel, which very soon will be largely imported.

Studies conducted on cities in Europe and the USA indicate that rail modes are more able to attract patrons than buses. This matter is dealt with in detail in Appendix A. For example, Fig. 1 shows the patronage of the light rail lines of the USA, over the period 1953 to 1973. It shows a continuing decline in bus usage, compared to an almost static light rail patronage, until parts of the San Francisco system were closed for refurbishing. Since then, the San Francisco system has had a 50% increase in patrons.

Fig. 2 compares patronage of public transport systems in European cities. It is clear that those cities with a rail-based component to their public transport systems attracted more passengers than those with only buses.

Further examples in Appendix A show the ability of a good fixed-rail public transport system to attract passengers from private car usage, and thus reduce the need for roads and parking facilities.



### 3. The Current Situation

The approach taken up to the present has been to maintain the long-term concept of having an off-street public transport link, and to periodically review technology developments as well as changes in the structure of and plans for Canberra.

Many planners have believed that Canberra would eventually need some form of off-street public transport facility, but that the time for its implementation had not yet arrived.

Until recently, NCDC has correctly concluded that buses can cost-effectively maintain an acceptable level of service. The previous studies on this topic are summarised in Appendix B.

Several factors are now coming into play that may modify the previous conclusions. They will be discussed in the next section.

The bus service in Canberra is organised around a trunk express service linking the town centres and the CBD. Local services are based on one or more of the town centres, and passengers interchange there to and from the line haul service.

The trunk service uses articulated buses and now operates on a 5 minute headway most of the day. At the height of peak hour, the service operates at a 2.5 minute average frequency. It is a very efficient service, using a small number of buses which stop at a very limited number of places and which, until recently, have suffered little congestion.

Despite the car-oriented nature of Canberra, ACTION has achieved a remarkable increase in patronage, from 57 trips per head in 1976, to 95 per head in 1987. 15% of the trips were on the intertown express.



#### 4. Changes That Make a Fixed Guideway System More Attractive

##### 4.1. Development of the CBD

The planning of Canberra since very early in its history has been based on a low density, dispersed, structure, with development of satellite town centres rather than that of the CBD.

Recently, the policy has changed, and a considerable number of relatively high rise buildings have been approved and/or built in Civic. Areas that were previously available for parking for a relatively small workforce have been built on, and at the same time, the number of people employed in the CBD has increased to 23,000 in 1985. It is expected to reach 35,000 by 1995.

This change has dictated a change in the modal split for travel to the CBD. Loder and Bayly's 1986 study and the Metropolitan Canberra Plan suggest that 30% of the workforce will need to use public transport, compared with 18% in 1987.

##### 4.2. Traffic Management in the CBD

In parallel with the developments in the CBD, there has been extensive signalisation of London Circuit. Because of the multiple phases used on most of the intersections, and the normal priorities used in traffic management, the buses have a very slow trip around London Circuit. Travel times of up to six minutes have been quoted for that segment.

##### 4.3. Congestion at Interchanges

The intertown express service is currently run with articulated buses. Despite this, there are problems developing with the interchanges. At Civic, the interchange uses city streets, and provides relatively little protection against the elements. The available space is limited, and when the Gungahlin area is developed, there will be problems accommodating all the buses unless a higher capacity mode is implemented.

At Woden, there are also problems accommodating passengers and buses at the interchange.

##### 4.4. Changes in the Development Pattern

Until recently, NCDC has exercised very strong control over the development of Canberra as a whole. It has therefore been possible to implement the dispersed planning model.

Current policies give more emphasis to market forces, and the decisions of property development companies.

Such companies generally have a different perception of value from that of organisations like NCDC. The 1982 Civic Centre plan found a strong private sector interest in development in Civic and a reluctance to invest in other centres.

In general, commercial developers prefer to be "where the action is", or to be visibly connected to such places.

Thus the trend towards a more densely developed centre will probably continue, and intensify as the market forces play a greater role in planning.

Developers who consider investing in a centre other than the CBD will almost certainly find the presence of a fixed guideway, off-street public transport system a positive factor in evaluating the site. The Tuggeranong and Gungahlin sites, particularly, will benefit from a strong link to the rest of Canberra.

#### 4.5. Increases in Tourist Activity

The presence of a fixed guideway spine in a public transport system makes it more comprehensible to visitors. Experience in European and US cities shows that tourists are far more likely to use a fixed guideway system, and closely coordinated feeder buses, than a pure bus system.

#### 4.6. The VFT Line

The VFT will link the centres of Sydney and Melbourne. The Canberra station will be some distance from the city. One of the major attractions of the VFT, compared with air travel, is its ability to serve the city centres. In Canberra, this is impossible, and a strong, visible, effective link to the major business areas will greatly enhance the appeal of the system.

As the VFT will put Canberra within day-trip reach of tourists who currently find the air-fares too expensive, it is highly likely that there will be a considerable increase in the number of visitors using the public transport system in Canberra.

The VFT will itself be a tourist attraction, and a well-constructed and operated off-street public transport system in Canberra could complement it.

#### 4.7. Foreclosure of options

As the city develops, particularly with the higher density projects that have appeared in recent years, route options for a new, off-street public transport system are being reduced.

While it is still possible today, in mid-1988, to find a route for the system at relatively low cost, some parts are already sub-optimal, and it is clear that developments, particularly in the CBD and around Belconnen could unintentionally make it far more expensive to implement a fixed-guideway system in the future than is currently the case.

In particular, the number of options for getting through the CBD area without tunnelling is rapidly diminishing. If the carpark area on the east side of the area bounded by London Circuit (section 19) is developed without public transport provision, there will be no opportunity left to find a fast, traffic free route that passes near the centres of employment and retailing for a public transport service.

On the other hand, if a suitable interchange were incorporated into the lower floors of a development of a site like the one mentioned, the value of that site and adjacent ones could be enhanced. Additionally, the



attractiveness of the public transport service would be enhanced, because of the protection provided against extremes of climate, the proximity of facilities provided in the building, and the increase in operating speed of the public transport system that would result from a dedicated route through the CBD.

Already, cheap options for providing a stop with direct access to Parliament House have been foreclosed. There are still ways of providing a service to it (important for tourists and business), but the quality of the access and the directness of the line as a whole will not be as good as if the planning of the building had included provision for a public transport link.

#### 4.8. Development of Tuggeranong and Gungahlin

The location of the Tuggeranong Town Centre and adjacent suburbs will make it difficult to extend the trunk express service into that area.

Gungahlin will require a separate trunk express route, if the pattern is to be maintained.

The capacities of existing interchanges will be strained if buses from Tuggeranong and Gungahlin have to be accommodated.

#### 4.9. Efficiency of the Present Public Transport Network

The system of trunk express services with feeder buses has been very successful in Canberra. The success can be measured in terms of the efficiency of the trunk service and the growth of patronage in such a car-oriented city.

As the trunk service and interchanges reach capacity, there are pressures for direct express services, which by-pass the interchanges. Such services are superficially attractive, but have many drawbacks, which, in the long term, could undermine the cost-effectiveness of the network.

There is usually insufficient demand for direct services to allow for a frequent service, and the city is sufficiently spread out to ensure that there will be pressure for a large number of direct expresses. These will have to be provided in addition to existing local services.

The net result could be a much larger number of bus routes, all operating at very low and/or irregular frequencies. Such a network is only useful to people whose travel times can be tied to particular journeys, and who always travel the same route. The networks are usually sufficiently complicated that most travellers do not know about services other than the one they regularly use.

## 5. Type of Service to be Provided

The nature of the existing public transport service, the layout of the city, the potential competition of the private car, and the size of the potential demand all constrain the type of service to an extent. The ways in which they do will be discussed below.

### 5.1. Frequency and Capacity

The frequency provided by the current trunk expresses has set standards and created expectations among the users.

A light rail system is best able to provide greater transport capacity and growth potential without an appreciable fall in service frequency.

If the buses operating every 5 minutes were replaced by an off-street system operating, say, every 15 minutes, most patrons would perceive a decline in the service standards, and rightly so. While some decrease in frequency could be tolerated without degrading the service, the 5 minute pattern of service is particularly easy for users to understand, and should not be abandoned lightly.

A 10 minute frequency is noticeably sparser than a 5 minute one, and would undoubtedly bring some complaints. Depending on other factors in play at the time of implementation, it may be possible to operate the new system with a 10 minute frequency, but any further reduction would most likely be completely unacceptable. A 6-minute or 7-minute frequency could be viable, particularly the former, as it can still be easily implemented as a memory timetable.

During peak hours, it should be possible to replace the 2.5 minute service with a 5 minute service using more capacious vehicles, because the more frequent service cannot be operated perfectly on schedule, the buses tend to bunch and the difference between the two frequencies will not be perceived as being as great as it is on paper.

As a result of the above, it can be seen that the extent to which the trunk route can justify larger vehicles is limited. The capacity of the existing buses is approximately 110. A large light rail vehicle has a capacity of 180, and a coupled set of these, 360.

If an off-street system were to be introduced in the near future, it would be highly unlikely that unit capacities larger than 180 would be needed, and 360 (two light rail vehicles coupled together) would serve adequately for the foreseeable future.

It can be seen that there is little to be gained from very high capacity systems, such as the Sydney suburban rail system. Cost-effective use of such facilities would dictate a very low frequency service.

If a light rail system were installed, one would therefore expect base intertown services to operate at frequencies between 5 and 10 minutes.

### 5.2. Speed and Stops

The buses operate at relatively high speeds because of the few stops and the lack of significant traffic congestion.



Any fixed guideway system would need to at least match the speed of the bus service at the time the new system was implemented.

Given the need to limit acceleration and deceleration rates for the comfort and safety of standing passengers and the distances involved, it is improbable that any form of fixed guideway system could have very many more stops than the existing bus service, without suffering a travel time penalty.

The implications for a light rail system are important. In order to provide an improvement over the existing service, the quality of the right of way would need to be relatively high. In particular:

at-grade crossings of roads would need to be kept at a minimum, and/or provided with a high priority for rail vehicles.

sections of shared operation on busy streets or in pedestrian malls would need to be minimised.

### 5.3. Locations to be served

The general level of population density and commercial activity density in Canberra is low by most standards. There are a number of established nodes of activity, in particular:

#### a. Current transport interchanges

Civic  
Belconnen  
Woden

#### b. Other present nodes

Parliamentary triangle (including Barton and Parkes)  
Russell offices area  
Erindale Centre  
Tuggeranong Town Centre  
Kippax Centre (Holt)  
Fyshwick

Other shopping centres also act as minor nodes.

#### c. Future nodes

Gungahlin  
VFT Station/Airport

The Northbourne Ave corridor is also the site of linear development from Civic to Dickson, and it was the route of early plans for a fixed guideway service. There is also linear development along Canberra Ave.

It is appealing to try serving all these nodes. Such a service would require many lines, and it is clear that some of them will have to remain as bus destinations for a long time.

In the light of the above, whatever other facilities the fixed guideway system provides it will have to provide a base express service connecting Belconnen, Civic and Woden:

1. with a frequency between 5 and 10 minutes
2. with a speed at least the speed of the present buses
3. with vehicles of capacity somewhat greater than the capacity of an articulated bus, but not too much greater

The provision for coupling units to provide more capacity in the future is also an important attribute of the system.

On each segment of the route, it may be possible to have a small number of additional stops, say no more than 3, for the express service, if the guideway is of high standard. If average speeds are constrained by the need to share lanes with other vehicles, then the potential for additional stops is reduced.

With good design of the system, it may be possible to operate both express and non-express services on the one line. This may involve having passing bays at selected stops.



## 6. Proposed Route

The base route has always been envisaged as replacing the intertown express buses, and, since this is the most heavily trafficked route in Canberra, there is every reason to retain the concept.

The development of Tuggeranong has created commercial centres and residential areas a long way south of Woden interchange, and the amenity of these new areas would be considerably enhanced by a high quality public transport connection to Woden and the CBD.

West Belconnen is a long way from the town centre, and an opportunity exists to extend the new link west. This would allow the rationalisation of the bus services, and reduce operating costs, as well as making the area more accessible.

It is proposed that the first line could be implemented in three stages:

1. Woden-City-Belconnen (about 18 km)
2. Woden-Tuggeranong (about 11.5 km)
3. Belconnen-Kippax Centre (about 5.8 km)

The first stage would replace only the intertown express buses, 333 and 999, although if stations were provided along the route, it is envisaged that some minor rationalisation of the local buses could be achieved as a result of people's perception of a fixed guideway system as being more attractive than a street bus service. People tend to be more willing to walk to a railway station than to a bus stop.

The second stage would involve a major re-organisation of the bus network in Woden. The route proposed, from Woden via Athllon Drive, Sulwood Drive and the Erindale Centre to Tuggeranong Centre, would allow simplification of the bus network, and it is believed that the peak bus demand in this area would drop by about 10 buses. As the Tuggeranong area develops, it is envisaged that the benefits of a high quality, high capacity link would be greater.

The third stage, from Belconnen to Kippax, is a relatively low cost extension, and would probably save about 5 buses in peak hours. An alternative is to locate the route further north, centred on Ginninderra Drive to Charnwood Centre.

Later stages of the proposed system include:

4. City-VFT Station (about 6.2 km)
5. City-Gungahlin (6.5 to 9 km)
6. VFT Station-Fyshwick (2.6 km)
7. Fishwick-Symonston (about 3.3 km) (or Queanbeyan)

The route from the CBD to the VFT station/airport would pass the Russell offices. Beyond Russell, the alignment could be of very high quality, since there is as yet little development there. Eventually, if the Symonston area were developed, a link could be built between it and Fyshwick.

There are two options for the Gungahlin service - a direct link via Northbourne Ave, or a spur from the Belconnen line. In terms of track to be laid, the former is only about 3 km longer than the latter, and would provide service to the offices and other commercial developments along Northbourne Ave. The Northbourne Avenue route between Civic and Gungahlin would be shorter than the alternative. However, in order to achieve high service speeds, it would require extensive signal coordination, and redesign of many intersections.

Only stages 1 to 3 are considered here, although all the above options are indicated in Fig. 3.



## 7. Significant Obstacles to Construction

As mentioned earlier, as Canberra has developed, some options for construction of an off-street public transport link have been preempted by other construction.

Most of the basic corridor still remains, but there are places in which construction will be expensive, or difficult. Elsewhere a corridor still exists but is in danger of encroachment. Some of these places will be discussed below:

### 7.1. Crossing Lake Burley Griffin

Space exists between the existing bridges for an additional deck, to hold rail tracks. The construction of the deck will be relatively expensive, but there are no significant engineering problems expected. Approaches to the bridge on the Civic side could pose problems, since the track must get into the median between the two carriageways.

### 7.2. The CBD

The new system must be capable of serving the CBD, and also of passing through it without excessive delay. It must be integrated with the bus services currently using the Civic interchange.

In order to achieve this, a reasonable amount of space is needed. There are currently 12 bus bays in the interchange, and it is probable that about two more will be required when Gungahlin is developed.

The current arrangement does not provide effective protection from rain and cold. The interchange would be far more appealing to passengers if the entire facility were under cover.

As a result of the building boom in the CBD, there is not much suitable, well-located space available. Also, there are few options available for getting a new link through the CBD.

One option is to use a tunnel. This would be the most elegant solution, and, subject to the locations of foundations and services, it could be routed optimally to serve the CBD and bus interchange. However, it is likely to be very expensive. Our estimate is that approximately 1 km of tunnel is needed. It is most likely that this would need to be constructed by cut and cover techniques under streets and open spaces. The cost will depend mainly on the services that need moving and the amount of underpinning needed for buildings.

A number of surface routes are possible. It is desirable to have a reasonably direct route, with gentle curves and as few conflicts with traffic as possible. The route shown in Fig. 4 is a viable possibility, but the bus interchange would need to move. It could be relocated on the Canberra Theatre site, along with a station, on the lower floors of a new development. The combined development would enhance the value of the new building as well as providing a fully under-cover interchange.

It is also possible to use a tunnel to access an interchange in a building such as the Theatre site.

### 7.3. Parliament House

While the long-term plans have always allowed for a public transport route along the median of Commonwealth Avenue, no allowance was made in the design of the ramps to Parliament House for the ultimate construction of any off-street transport link.

Similarly, there is no provision for a station at Parliament House, or a route past it. As the building is a major tourist attraction, and a major employment node, it seems appropriate to have any mass transit service stop there.

The most appropriate way to install a transit route past Parliament house appears to be on the western side of the building, on Capital Circle. The roadway would be moved west by 7 m, and the tracks installed adjacent to the Parliament House site.

A station could be provided, with an escalator to the forecourt, or a tunnel to the public carpark, whence access to the building is available.

### 7.4. Woden Centre

In order to obtain a right-of-way south from Woden interchange, it will be necessary to rearrange the roads. Callam St would need to be connected across to Easty St, which would be connected directly to Athllon Drive. The right-of-way would also be connected directly to Athllon Drive.

### 7.5. Belconnen East

The construction of the Australian Institute of Sport, plus the new clean industrial area has constrained the route options considerably, and some property acquisition may be necessary to provide a high speed alignment.

### 7.6. Belconnen West.

If an extension via Southern Cross Drive is built, then access from the present bus roadway to it will be needed. At present, it may still be possible to use Luxton St and an alignment near or on Ranken Place and Totterdell St. The options to do this are being reduced by housing construction, and, unless a route is defined soon, there may be difficulties getting a surface route in this area.



## 9. Vehicles

Most cities tend to have vehicles specially designed for their purposes. However, there are some designs in use that would be well suited to Canberra's needs. These include the Stadtbahn B vehicles in use in northern Germany and the Utrecht light rail vehicles from Holland. Comeng is supplying a high capacity light rail vehicle for the new Hong Kong light rail line.

Generally, these vehicles have crush loads of 180 or more, with seating for at least 80. One such vehicle can effectively replace one articulated plus one rigid bus.

Some new European designs feature a low floor near the doors. This enables passengers to board and alight rapidly, even if raised platforms are not available. An example of such a design is the one produced by Comeng for intended use in Sydney. The applicability of low floor vehicles could be decided at the conceptual design stage.

The top speed of the vehicles can be chosen at will. Typical top speeds are 80 to 100 km/hr. For the Canberra system, the express services will benefit significantly from the higher top speeds. Good acceleration and braking is necessary, and average acceleration and braking rates of 1.0 and 1.3 m<sup>2</sup>/s respectively were assumed. The maximum acceleration can be up to 1.6 m<sup>2</sup>/s.

A design detail that would need to be finalised is whether the vehicles should be single-ended or double-ended. If adequate space is available for turning loops wherever necessary, the vehicles could be single-ended.

### 10. Stops, Service Speed and Vehicle Numbers

The number of vehicles required for any particular segment depends on the service frequency, vehicle performance and the standard of the track provided.

The current express bus service has eight stops between Belconnen and Woden. It is envisaged that a light rail service on the same route could have, say, 10 scheduled stops, plus another 8 stops at traffic signals and other intersections, if a partially segregated right of way were used. Wherever possible, the stops would be located on the approach side of intersections, in order to minimise delays caused by them.

On the assumption that stops were located, on average, 1 km apart, and that the average dwell time was 20 sec, average service speed would be 45 kph, giving a one-way trip time of about 24 minutes.

In that case, the base service between Belconnen and Woden could be provided with 13 to 14 vehicles, including one spare. (The actual number will depend on industrial agreements.) If a high standard alignment is used, the number of vehicles could be cut to about 10.

The extension from Woden to Tuggeranong would operate at slightly lower speed. The route passes through residential areas and can serve them. Thus stops will need to be somewhat closer together than on the stage 1 route. It is envisaged that the stops will be about 900 m apart, and the speed will be about 42 kph. For the foreseeable future, a 10 minute frequency will probably be adequate on this sector. The one-way trip would take about 16 minutes, and it would require about 6 vehicles.

It would also be possible to operate a slower service with more stops on the same route. It could operate in parallel with the faster service. An additional 7 vehicles would be needed for this purpose if a 10 minute service is desired. Some passing loops may be needed.

The Kippax extension could have about 7 stops, at an average stop spacing of about 800 m. The average speed would be about 39 km/hr, and a one-way trip would take about 9 minutes.

A 10 minute frequency would require about 3 vehicles. A slower service with more stops could also be provided on a 10 minute frequency with 4 vehicles.

TABLE 1 - APPROXIMATE VEHICLE REQUIREMENTS

| Segment                       | Vehicles | Service Frequency |
|-------------------------------|----------|-------------------|
| Woden - Belconnen             | 13       | 5                 |
| Woden - Tuggeranong (express) | 6        | 10                |
| Woden - Tuggeranong (slow)    | 7        | 10                |
| Belconnen - Kippax (express)  | 3        | 10                |
| Belconnen - Kippax (slow)     | 4        | 10                |
| Spares                        | 3        |                   |



# 11. Capital Costs

At this stage, it is not possible to give detailed costings, since that would require lengthy studies of the route. Approximate figures are given below:

TABLE 2 - CAPITAL COSTS

|                                                     | Cost<br>\$ millions |
|-----------------------------------------------------|---------------------|
| Stage 1.                                            |                     |
| Track and overhead (18 km)                          | 36                  |
| Civic interchange                                   | 5                   |
| Commonwealth Ave Bridge                             | 10                  |
| Capital Circle rearrangement                        | 2                   |
| Overpasses etc                                      | 2                   |
| Traffic signal alterations                          | 1                   |
| Stops and ticket machines                           | 1                   |
| Rolling stock                                       | 20                  |
| Service relocations                                 | 5                   |
| Substations                                         | 3                   |
| Depot (modify part of Woden or Belconnen bus depot) | 4                   |
| TOTAL                                               | 89                  |
| Stage 2. Woden-Tuggeranong                          |                     |
| Track and overhead (11.5 km)                        | 23                  |
| Traffic signal alterations                          | 1                   |
| Stops                                               | 1                   |
| Rolling stock                                       | 9                   |
| Service relocations                                 | 1                   |
| Substations                                         | 2                   |
| Depot augmentation                                  | 1                   |
| Property acquisition                                | 1                   |
| TOTAL                                               | 39                  |

TABLE 2 - ctd

## Stage 3. Belconnen - Kippax

|                              |    |
|------------------------------|----|
| Track and overhead (5.75 km) | 12 |
| Traffic signal alterations   | 1  |
| Stops                        | 1  |
| Rolling stock                | 5  |
| Service relocations          | 1  |
| TOTAL                        | 20 |



## 12. Financing

Of the listed capital costs, it is envisaged that the cost of the Civic interchange will be completely met by a developer who would build a commercial facility on the site. Indeed, it is likely that the value of the site would be enhanced further by the presence of the rail connection.

Other, smaller, capital cost contributions are likely to come from the private sector for other interchange sites. In particular, the value of all sites in the Tuggeranong centre will be enhanced by the system. At Woden and Belconnen, it is possible to sell air rights above the interchange as a result of the enhanced importance of the location.

These arrangements are likely to raise over \$10 million towards the system. Other benefits are likely to accrue to the Government through increased land values.

The ACTION bus system will require a smaller bus fleet than it otherwise would, and the level of staffing will not need to grow so rapidly. We estimate that the first stage would result in a reduction of about 12 in the operating staff, and a reduction of 24 in the number of buses required.

The second and third stages will each save about 8 buses. If the stations are sufficiently attractive, and the rail service good enough, further savings in buses may be possible.

The operating cost saving per bus is currently over \$ 120,000.

### 13. Public Benefits

Apart from the more comfortable interchange conditions to be provided, the new system will provide a faster journey for all passengers using the system. It appears that the average peak hour time saving on the trunk route will be of the order of 5 minutes per passenger - over 300,000 person hours per year. If travelling time is notionally valued at \$5 per hour (in keeping with several recent studies), the annual time saving to the community will be worth about \$1.6 million, based on today's patronage.

If CBD development and transport mode split move as predicted, the time saving to the community in future years can be expected to be about double the above figure, in 1988 dollars.

The increase in property values near stations and interchanges is not easily tapped by the operator of the system, but is generally reflected in higher property taxes. In some cities, betterment taxes have been imposed to try to make the funding of such facilities more equitable.

The appreciation in total property values can, under some circumstances, be very significant, because of the high value of land in intensely developed areas. For example, in Sydney, large city sites are already fetching hundreds of millions of dollars. A small increase in the value of a few such sites could fund a large proportion of the capital cost of a transport system.

It appears that provided action is taken now to preserve potential rights of way, Canberra could have a trunk rail service for less than \$90 million, and a fuller system for about \$150 million. Further extensions, to Gungahlin and towards Fyshwick could be implemented relatively cheaply provided development did not encroach on the proposed routes.



APPENDIX AEXPERIENCE IN OTHER CITIES

Major public transport improvements have recently been undertaken in big cities throughout the developed world. In this section, a few of these improvements will be examined, in an attempt to draw lessons for Canberra.

The following cities will be discussed:

1. Hannover, West Germany
2. Cologne and Bonn, West Germany
3. Newcastle on Tyne, UK
4. San Diego, USA
5. Selected Sydney suburbs

1. Hannover

Hannover is a German city with a population in the older central area of about 550,000. The population of the city and suburbs is about 1,100,000.

The CBD area of the city was declining in the 1960s, because of traffic congestion and inaccessability. German policy is to revitalise old city centres. The 1960s and 1970s were a period of strong growth in the German economy, and cities were vying with one another for new industries and developments. It was found that the regeneration of the city centre improved the climate for new industries, through the cultural and environmental benefits that accrued. People were prepared to accept lower wages in order to work in pleasant cities.

Hannover had a traditional tram system and a bus network, as well as a suburban rail service. In 1967, it was decided to upgrade the tram system to a modern light rail network. This was integrated with an extensive bus network.

Public transport patronage had reached a peak in 1960, and declined steadily between then and 1969, when the first results of the improvements were measurable. From 1969 to 1981, there was a steady growth in patronage, from 98 million in 1969 to 139 million in 1981. At the same time, the number of private cars in the greater Hannover area increased by approximately 60%. After 1981, the patronage began to fall, largely because of the economic difficulties that set in in Germany. These trends are shown in Fig. 4.

The basic concept of the system is :

1. radial travel needs are served by the light rail system and the suburban rail system.

2. most buses do not enter the city centre, but rather provide circumferential and infill services, which connect with the light rail system.
3. wherever possible, transfer stations are provided between bus and light rail that provide rapid, cross platform interchange with co-ordinated services.
4. within and near the CBD, the light rail service is underground, while further out it uses median and roadside reservations, and is in some parts, mixed with other traffic.
5. the high quality of service provided to and from the CBD has allowed the pedestrianisation of most of it.

The development of the light rail system out of the tram system is illustrated in Fig. 5. Not only have the improvements resulted in a change in the total modal split towards public transport, but also they have drastically uplifted the atmosphere in central Hannover and encouraged people to shop and spend time there.

On the first line to be converted to light rail, route A, daily patronage is approximately 115,000, about 50% higher than it was before conversion. Of the total ridership, over 30% on this line are either converts from cars or making "new" trips. On route B (north), the patronage increase was about 30%, of which two thirds were converts from cars.

The change in modal split is illustrated in Fig 6. The shift away from private cars is remarkable, and illustrates the potential of an integrated, city-wide public transport improvement policy.

In a survey of households covered by route A, the following conclusions were drawn:

1. 78% of all CBD trips are made by light rail
2. 50% of all those people who have a private car at their disposal nevertheless use light rail for their CBD trips
3. Over 90% of people interviewed were satisfied with the light rail service's punctuality, service frequency, comfort and speed.

Over 90% of people interviewed considered the money spent on the system to be a good investment.

The Hannover example illustrates three things:

1. that a high quality, city-wide public transport system can win people back to public transport, even in societies with high per-capita car ownership and high per-capita income



2. that central commercial areas can be made vastly more attractive to people by eliminating motor traffic as far as possible, and providing attractive pedestrian zones.
3. that modal interchange can be made attractive by properly designed facilities, integrated ticketing and frequent services.

Most medium sized and large cities in Europe have, like Hannover, established extensive pedestrian zones, both in their CBDs and in sub-regional centres.

Principal Sources: ÜSTRA Hannoverische Verkehrsbetriebe AG

Enersol Files

## 2. Cologne-Bonn

The public transport systems of both these cities are based on light rail/tram services on the busier routes, and buses on the other routes. They are both part of the same Verkehrsverein, an association of public transport operators who recognise each others' tickets and co-ordinate their services.

The centres of the two cities are about 45 km apart and are linked by the German Railways mainline, and also by two lighter railway lines, owned and operated by the KBE, an organisation which is now part owned by the public transport undertakings of Cologne and Bonn. These lines are the Rheinuferbahn and the Vorgebirgsbahn and they are shown in Fig. 7 where the Rheinuferbahn is the upper of the two heavy lines and the Vorgebirgsbahn is the lower.

The Rheinuferbahn was a conventional railway. In 1978, it was converted to light rail. At the Cologne end, the terminus was on the bank of the Rhein, on the outskirts of the CBD. It ran south along the river bank for a few kilometres, sharing tracks with Cologne's tram route 16, then veered inland to the outer suburb of Rodenkirchen. Tram route 16 followed the Rhein a little further than the Rheinuferbahn, and then ran on the streets to Rodenkirchen.

The railway then passed through a few villages, and then through a port area to the industrial town of Wesseling, almost 20 km from the centre of Cologne. The section between Wesseling and Hersel (to the south) is used jointly by goods and passenger services. In this area, the line traverses some farming country and villages as it approaches the outskirts of Bonn.

Previously, the line then ran in the main rail reservation to a terminal station some 500 m north of the main German Railways station.

The upgrading and conversion of this line to light rail involved route alterations at both ends. At the Cologne end, it was diverted inland along existing tramlines, about 2 km south of its old terminus, and taken through the city centre in light rail tunnels shared by all tram and light rail services, to the north of the CBD, and then further north along the

Rhein and across it to a terminus at Weiner Platz, Mulheim (a suburb of Cologne). The Rodenkirchen tramline was abandoned and replaced by faster services along the rail track, and a feeder bus.

In Bonn, the line now dips underground just north of the old terminal and runs into the light rail station under the main railway station. From here it continues south and emerges onto a street centre alignment which it follows through Bonn's suburbs to the terminus in Bad Godesberg.

The line uses the Stadtbahn B light rail vehicles, standard throughout northern Germany, and they operate through platforms of three different heights - 350 mm in Cologne, which is compatible with the older trams, 200 mm high in the section shared with freight vehicles, and at car floor level in the Bonn area.

Although the cars operate a through service, the ownership of the track is still in the hands of three separate organisations - the KBE, and the Cologne and Bonn public transport authorities. Local services are maintained over parts of the line by the local authorities at both ends. Vehicles for the through service are provided by both the Cologne and Bonn undertakings.

Patronage on the route has shown a significant rise following conversion, as a result of three factors:

1. The new service provides a direct connection to the centres of both cities, and beyond, and reduces the need for changing vehicles.
2. The new service with modern vehicles is faster.
3. The new vehicles and stations are more attractive and more comfortable.

Patronage figures, section by section, are shown in Fig. 8, for the period 1965 to 1982. Conversion took place in 1979. Over the whole route, excluding those part formerly served by local tram services, patronage more than doubled between 1977 and 1982. It is also interesting to note the decline in patronage between 1965 and 1977 (reminiscent of public transport patronage in Sydney) and the growth that has taken place since.

The conversion has been so successful that the other line, the Vorgebirgsbahn, will also be changed over to light rail in the near future.

The overall population density around both these lines, when they are outside the cities, is low, even by comparison with Canberra. The major difference is that the population is concentrated around the railway stations, and typically the housing in the villages is duplex style. The parts of the lines near the cities pass through growing commuter areas, and that is reflected in the patronage figures, which show that most of the growth in usage has taken place around the ends of the Rheinuferbahn, rather than in the middle.



Principal Sources: Kölner Verkehrsbetrieb AG

Enersol files

### 3. Newcastle on Tyne

Tyne and Wear County is the major industrial and commercial conurbation in north-east England, with a population of 1.2 million. The topography includes the River Tyne and many steep valleys. Newcastle is the main city.

In the 1950s and 1960s, there was a policy of re-housing people away from the congested inner areas, and this resulted in low density infill housing, and similar developments on the periphery of the cities.

Between 1969 and 1973, the bus services in the region were integrated under the control of one authority - Tyne and Wear PTE. In 1973, the buses carried about 850,000 passengers a day, while the local rail services carried only about 42,000.

The Tyne and Wear transport plan, a study commenced in 1969, recognised that the railway lines along both banks of the Tyne were not meeting their full potential, largely because they did not penetrate the central area nor other important local centres like Gateshead and South Shields.

Their conversion to a high frequency rapid transit operation with additional stations and new alignments to serve key areas enabled the rail network to provide the backbone of a fully integrated transport system.

The system comprises 55 km of route, made up of 42 km of former British Rail track and 13 km of newly constructed tunnels and surface railway. The tunnels took the route under the centres of Newcastle and Gateshead. A new bridge was built across the River Tyne. The complete network is shown in Fig. 9.

Although the system is fully off-street, the vehicles used have many of the characteristics of light rail cars.

The system is fully integrated with the bus network (Fig. 10), and extensive carparking has been provided at outer metro stations.

Before the metro was opened, there was a steady decline in public transport patronage. Extrapolation of these trends suggests that by 1982, in the absence of the metro, the patronage would have fallen to 251 million; in fact the system carried 310.5 million, of which approximately 50 million used the metro - over three times the patronage of the former rail services. By 1984, public transport patronage had risen to 312 million, of which 55 million were metro passengers.

There has been a pronounced effect on the total modal split. Road traffic in Newcastle has dropped by 3%. Air rights above stations are now beginning to be taken up, and developments are occurring near them.

Principal Sources: Howard, D. F., "Tyne and Wear Metro - A Light Rapid Transit System", Tyne and Wear PTE, 1984.

Modern Tramway, September, 1985

The Metro Report, Tyne and Wear PTE, 1985

#### 4. San Diego

San Diego County contains over 1600 square km in the extreme Pacific south-west corner of the USA. The urbanised area lies within the western third of the region, along the coastal plain and foothills. The southern boundary is the Mexican border.

The total population of the San Diego County region is about 2.0 million people, with over 1.5 million living in the southern part of the urbanised area that includes central San Diego. Population density in this region is less than 600 per square km.

In 1980, there were 840,000 jobs in the region, and employment grew by 4.6% between 1980 and 1983. Between 1970 and 1980, San Diego County was the fifth fastest growing metropolitan area in the USA, with an average annual population growth of 3.7%. Between 1980 and 1984, population grew by an average of 2.5% per year.

The Metropolitan Transit Development Board (MTDB) was created in 1975, with responsibility for short range planning and coordination of the whole public transport network, and also for the planning and implementation of a fixed guideway system in the southern part of the urbanised area.

Light rail was selected as the appropriate mode after extensive economic and technical studies. The system was approved for construction in 1978, and was opened for operation two and a half years later, in 1981.

The route is 26 km long, operating between the centre of San Diego City and the international border at San Ysidro. The route is shown in Fig 11. It operates on existing streets for a distance of 2.7 km in the city, then for 22 km shares tracks with a goods railway. Near the southern terminus, the route re-enters the streets to reach the border crossing point.

Six of the 11 suburban stations have a total of 2000 free car parking spaces, and all suburban stations have pedestrian access, bus access and bicycle storage facilities. Local bus routes have been modified to feed the light rail line.

The light rail line's corridor is defined as shown in Fig. 11. Within this area, the population density is 2100 persons per square kilometre. There are 1.2 million trips in the corridor, of which 3.6% were by public transport in 1980. This was twice the modal split in the whole region.

Of the 435 km of freeway in the region, 42 km are in the corridor. There is no severe congestion on the freeways, and only one area of moderate congestion (less than 30% over capacity).



The corridor area land use includes residential (31.2%), agriculture (13.3%) and manufacturing (12.7%). A significant amount of the agricultural land is in close proximity to the line. The residential areas are mainly to the east of the line, and most residents live beyond walking distance from the stations.

Between 1980 and 1983, employment in the corridor grew at twice the rate of the region as a whole.

The population of the corridor area in 1984 was 204,900, and they occupied 69,700 dwellings. More than 50% of these are detached houses. The population increase in the corridor area over the period 1980 to 1984 was about 8%.

The corridor has in it a very large military establishment, and the service provided to the Mexican border gives the line a tourist market which makes weekend ridership nearly equal to weekday ridership. Fig. 12 shows the average ridership in the period 1982 to 1984, while Fig. 13 shows the patronage hour by hour, compared with the bus service that preceded the inauguration of the light rail service.

Overall public transport ridership in the corridor area increased by more than 20% in the first three years of light rail operation. This is in marked contrast with patronage decreases experienced in the remaining portions of the MTDB region, where ridership dropped by about 18% in the same period.

The decrease in bus patronage experienced in San Diego, outside the light rail service area was part of a national trend. Between 1981 and 1982, the total number of urban public transport trips in the USA dropped by 9%. Generally, the fixed rail services held their patronage, while the bus services lost.

A survey conducted in 1981 indicated the following previous travel modes among light rail passengers:

|                   |     |
|-------------------|-----|
| Bus               | 56% |
| Car Driver        | 24% |
| Car Passenger     | 6%  |
| Other             | 4%  |
| Did not make trip | 10% |

Thus 30% of riders are converts from cars, despite the relatively high quality of service available from the freeways and road network. 10% of riders would not have made the trip. The opening of the line did not coincide with an increase in the number of transit-dependent riders, so the new trips could have been made by private car.

The income of light rail patrons was significantly higher than that of users of the bus services in the same area. Over 25% of light rail patrons had incomes greater than \$US 25,000, and this percentage more than doubled between 1980 and 1983.

Although the light rail service has attracted riders who are not transit dependent, the number of passengers who did not have a driver's licence or had no access to a car has not changed, despite the service changes and the higher fares that were charged.

Principal Source: "San Diego Trolley - The First Three Years", San Diego Association of Governments, 1984.

##### 5. Sydney - Woollahra and Waverley compared with Warringah

While Sydney is a larger city than Canberra, the effect on patronage of the different types of public transport offered in different parts of Sydney is of interest. Warringah Shire is a low density part of Sydney, with a population of about 180,000.

Woollahra and Waverley are the two Local Government Areas that are served by the Eastern Suburbs Railway, opened in 1979. Demographically, there are differences between them and Warringah, which has extensive bus services but no railway, in that the age structure of Warringah has approximately equal numbers of people aged between 10 and 40, while Waverley and Woollahra both had peaks in the 20 to 30 years age range.

Income distribution in Woollahra showed significantly more people earning more than \$24,000 pa than in Warringah, while in Waverley, there were more people earning between \$10,000 and \$15,000, with correspondingly fewer earning over \$16,000.

If Waverley and Woollahra together are compared with Manly and Warringah together, the income distributions are very similar.

Waverley has a higher population density than most of Warringah.

Waverley is remarkable by comparison with most other LGAs in that the modal split in work journeys actually shifted significantly towards public transport between 1976 and 1979. According to the ABS Journey to Work statistics, overall, 38% of Waverley residents used public transport to get to work in 1981, compared with 34% in 1976. Of those going to the City of Sydney, 62% used public transport in 1981, compared with 58% in 1976.

Woollahra had a slight increase in public transport use, of about 1.6%. 31% of Woollahra residents used public transport to get to work, and 48% of those going to the City of Sydney did so. In Manly-Warringah, public transport only caters for 18% of the journeys to work, and 49% of work journeys to the City of Sydney. Manly has the benefit of ferry services. If Warringah is considered alone, then only 33% of journeys to work in the City of Sydney were made by public transport.

On journeys for shopping, personal business, social welfare and medical purposes, the public transport share in Woollahra was 14% and in Waverley 18%. In Warringah it was 9%.



A relatively small increase in public transport usage in Woollahra occurred with the opening of the Eastern Suburbs Railway. This can be interpreted as an indication that the ESR does not offer sufficient benefits to Woollahra residents, because it only affects a very short part of the journey of the vast majority of residents. The time savings gained in the train can be almost completely negated by the time lost in changing vehicles and walking at the city end. The poor design of interchanges results in long walks for changing passengers.

The situation in Waverley is different. Public transport's market share increased as a result of the opening of the ESR. The longer journey from Bondi Junction makes changing vehicles more worthwhile.

#### 6. Effect of Mode

World-wide experience has shown that people prefer rail-based systems. Vukan Vuchic, in his text *Urban Public Transportation - Systems and Technology*, shows that public transport usage in cities with a rail system is much higher than in those without. All cities surveyed have extensive bus services. The results are reproduced in Fig. 2.

In the United States, most of the extensive tram and interurban (early light rail) networks were closed between 1940 and 1965. Only seven operators persisted with parts of their former systems. The portions retained invariably involved a high percentage of off-street running. However, until the oil crisis of the 1970's, these systems received no capital funds and all were using vehicles at least 25 years old. Since then, most of these operations have received new vehicles and had their tracks upgraded.

Tennyson surveyed the performance of three of the remaining light rail systems, and compared them with the general patronage of public transport in the USA. The survey was conducted up to 1977, before any of the light rail systems was refurbished. The results, shown in Fig. 1, show that the light rail lines were able to retain their patronage while the public transport system as a whole was losing patrons at a rate of about 2.5% per year.

Since the study was done, subway construction for the BART system in San Francisco has been completed, and the light rail system has been upgraded, resulting in a patronage increase on the light rail lines of about 50%.

It seems highly probable that public preference for fixed guideway systems will be based largely on the level of service and the physical permanence of the system. However, the information available suggests that light rail is a successful and popular mode for achieving patronage increases.

#### 7. Effect of Rising Car Ownership

Experience in Australia correlates declining public transport usage with increasing private car ownership. The relationship between the two is not necessarily causal. Figures 14 and 15 show this relationship as it exists in a number of countries. It can be seen that in certain countries, rising car ownership does not affect per capita public transport patronage. Indeed, in Hong Kong, per capita patronage and car ownership rose together. Germany, from which two examples have been given above, has not suffered a decline in public transport usage even though car ownership rates are very similar to Australia's.



In Australia, there have been, until recently, taxation incentives encouraging companies to give their employees cars, and to pay for their upkeep. This, together with an attitude that driving has higher status than using public transport, has until now worked against the latter.

#### 7. Summary of Experience from Other Systems

The Hannover example illustrates three things:

1. that a high quality, city-wide public transport system can win people back to public transport, even in societies with high per-capita car ownership and high per-capita income
2. that central commercial areas can be made vastly more attractive to people by eliminating motor traffic as far as possible, and providing attractive pedestrian zones
3. that modal interchange can be made attractive by properly designed facilities, integrated ticketing and frequent services.

The Cologne-Bonn light rail line shows that through routing to major activity centres, plus an increase in service speed and use of modern facilities greatly increases patronage.

The Tyne and Wear Metro in Newcastle, UK, illustrates the positive effect of an integrated public transport system. It shows that even if direct bus services are replaced with a bus-train journey, total patronage can increase, provided there is some time benefit in using the new system.

San Diego shows that even in a very affluent society very with high car ownership, low population density and relatively low traffic congestion, riders can be attracted to a well-designed public transport facility.

In Europe, cities with a fixed rail network tend to have higher per-capita public transport use than those which do not, and in the USA, ageing light rail lines have held their patronage while bus networks have not. A high level of car ownership does not necessarily mean low per-capita public transport use.

Travel patterns in Waverley and Woollahra, suburbs of Sydney, indicate that the introduction of a fixed guideway system does attract passengers to public transport. The Bondi Junction interchange has won public acceptance, but Edgecliff has not - suggesting that changing vehicles there offers little in time savings compared with the inconvenience of the interchange. It suggests that interchanges need to be built for minimum walking and waiting, and that users need to be rewarded with a time saving if they are to use them.



APPENDIX BSUMMARY OF CANBERRA'S PUBLIC TRANSPORT-RELATED STUDIES

Transport studies of the 1960s and early 1970s have been summarised in the National Capital Development Commission's 1976 publication Intertown Public Transport - Alternatives for Canberra. The GENERAL PLAN CONCEPT REPORT, 1967 supported the use of buses for a population of 500 000. The CANBERRA PUBLIC TRANSPORT STUDY, 1970, concluded that both duo-rail and urban busway could provide for transport needs of the 1980s, the deciding factor being the extent of subway required. It appeared clear that Canberra would want an express, private right-of-way service, and the importance of reserving such a right-of-way was emphasised. It was also clear that an urban busway would meet the requirements. The CANBERRA MODAL SPLIT STUDY in 1974 concluded that whilst transfers to public transport could be influenced by parking restrictions, rapid transport would not result in significant increase in usage. There was no widespread commitment to increasing public transport usage, and rather than displace car users on to public transport, it is better to increase the efficiency of use of private cars. Other studies concentrated on movement within the new towns (Pak Poy and Associates, 1967), and in assessing needs of bus travellers, particularly those captive to public transport (Casey, 1976).

Alan Voorhees and Associates' CANBERRA PUBLIC TRANSPORT STUDY, (1970) compared a number of alternatives, discarding monorail, fixed guideway systems and pneumatic tyred systems. This left duo-rail and busway. In favour of rail they found the potentially higher capacity, and electric motors which allow long tunnel sections and enclosed stations. Busways allow more flexible operation, with little or no exhaust problems. It is necessary, however, to dilute emissions in tunnels, and ventilation becomes extremely difficult in tunnels of 2 miles. Further problems with busway are increased difficulty of operation in bad weather, and the lack of collision avoidance controls. Operational cost of busway and rail without tunnelling are comparable for an hourly capacity up to 12 000. Increasing wage rates will tend to increase bus operation costs more than rail, but this is unlikely to be significant.

An assessment of route alternatives between Woden and Tuggeranong was undertaken. The chosen route would occupy the Adelaide Avenue median, cross the lake along the route of Kings Avenue, then run in open cut alongside Constitution Avenue to Civic, where some subway could be expected. Passing the Australian National University and Canberra CAE, topography would dictate the remainder of the route. Stations were proposed to be close in Civic and the town centres - widely spaced between centres. There would be no parking in the city, limited parking at town centres and liberal amounts at other stations. It is possible that the city stations may be a block or 2 from the centre to reduce ventilation needs.

The National Capital Development Commission's INTERTOWN PUBLIC TRANSPORT ALTERNATIVES FOR CANBERRA followed in 1976. This study concluded that conventional bus system would handle Canberra's public transport needs for the next 5-10 years, and that any transport improvements for the next 15 years are most likely to be associated with conventional bus and taxi.



However, steps should be taken to ensure a reservation wide enough for possible long term (1990) conversion from bus to rail should public transport patronage increase sufficiently to warrant grade separation. The major determinant of public transport usage will be Central Area employment, which had not been resolved in either the medium or long term.

A number of conventional and non-conventional (automated) systems were considered also in this study, and the non-conventional systems discarded. Bus priority arrangements were preferred to rail although further consideration should be given to alternative systems in case of high public transport useage. Unfavourable operating costs in the source data resulted in the relative disadvantage of light rail being exaggerated. The major constaint on continued use of buses is the capacity of stations, which may create some congestion. Grade separated systems, particularly commuter rail, have advantages in ease of scheduling, reliability and safety, and it was felt that users woud also be attracted to greater reliability, shorter travel times and lower fares.

Appendices to the Draft Report of Intertown Public Transport - Alternatives for Canberra showed journey to work trips on public transport, which earlier had been declining, were on the increase. Sixty to 80% of employees in central locations drive to work, and off-peak daily transport use approximately equals peak use. Low off-peak use was confirmed by a Department of the Capital Territory survey in 1975. Congestion was evident, with local sections of low speed and delays each day in the peak period.

The National Capital Development Commission appeared to be primarily concerned with residential density and environmental concerns from this time until the mid 1980s, when increasing urbanization, increasing centralisation and increasing congestion brought public transport to the forefront.

In 1984 the METROPOLITAN CANBERRA POLICY PLAN DEVELOPMENT PLAN (NCDC) assessed population growth and transport prospects in relation to desirable directions for Canberra's future expansion. Population projection figures were revised from previous estimates of 747 000 by 2000 t 378 000, and 292 000 by 1991. Employment growth is estimated at 2.1% in the government sector - 33 000 jobs over the next 20 years plus a similar number in the private sector.

Private car dominates travel with the exeption of school trips - 75% of all trips are made by car. Primary access and internal distribution roads in Civic are congested for 1-2 hours per day, but there is little congestion in centres other than Civic. Economic pressure is forcing some current changes to existing policy of meeting unrestrained demand for car parking.

Bus accounts for 8-10% of average daily travel demand - 7.5% of work trips and 15-18% of work trips to town centres are made by bus. Seventy percent of bus trips relate to school and work, 35% of daily bus use is in the 2 hour morning peak, and 20% in one hour morning peak. Eighty eight percent of public transport trips are made by travellers with no alternate means of travel.

Parking controls in both Woden and Civic will lead to increased use of public transport - the maximum practical modal split is estimated at 30%.



Loder and Bayly - PUBLIC TRANSPORT ALTERNATIVES IN CANBERRA, March 1986 - feel that a future modal split of 30% is unlikely to be achieved. A line-haul and feeder system is appropriate for the future, but the existing line-haul system is likely to decay as the city and congestion grow, exacerbating the problem of buses sharing the road.

A number of line-haul alternatives were assessed - articulated bus, articulated bus priority, busway, trams, automated grade separated light rail and heavy rail. It was assessed that priority bus will accommodate 38 000 jobs in Civic, and 30% modal split. Light rail has a greater capacity - 115 per vehicle compared with 65 per bus - articulated vehicles 180 compared with 105 per articulated bus. There is less pollution and light rail offers a smoother ride. Against this vehicles cost 4.5-5 times as much, annual operating costs are estimated at \$1m more and overall costs \$7m more - an overall result of doubling the operating costs for 70% more people. In addition, a broken down tram delays all following vehicles.

The 1986 METROPOLITAN CANBERRA POLICY PLAN AND DEVELOPMENT PLAN comprised 3 volumes - Implementation, Transport and Land Use. Factors that will effect the transport system include:

Population is expected to grow to 292 000 by 1991 and 378 000 by 2003.

Employment will increase from 115 700 in 1983 to 186 000 by 2003.

Eighty percent of employment growth between 1976 and 1981 was part time. There is a high local employment retention rate - Tuggeranong, Belconnen and Queanbeyan residents took over 65% of local jobs, 35% in Woden and Civic - and a high labour force participation rate - 70% compared with 60.6% for rest of Australia. Increased female participation rate (45% in 1966 to 59.6% in 1985) demonstrates increasing need for after hours shopping. Women have a greater tendency to work close to home - in 1981 70% of jobs in Belconnen held by women were held by Belconnen residents.

More than 80% of current office construction is in Civic. Office development is to be encouraged at Belconnen, Civic will become the most specialised retail centre

Of students at ANU and Canberra CAE, more than 38% and 17% respectively come from more than 40km away.

In general the population is well educated with a higher than average income, but there is an increasing gap between the income of the bottom 10% and the median family income. Low income is associated with low mobility and a reliance on public transport, and government housing tends to be concentrated on the urban fringe. This suggests that those on low incomes are especially disadvantaged within the generally affluent community.

Travel demand is expected to be similar to today, with a possible reduction in discretionary travel. There is unlikely to be a significant change in peak travel. Currently 90% of the total number of daily trips are by bus. Eighty eight percent of bus trips are made by people with no alternative means. Forty percent of the population does not have a driving licence, 8.4% of households do not have a car.



Loder and Bayly are quoted as having concluded that light rail is inappropriate. It travels no faster, has higher operating costs, is inflexible, and, given Canberra's good roads and buses, would not provide a better ride. They recommend bus priority plus taxi share-riding - fixed track cannot be supported at present population levels.

The aims of the CIVIC CENTRE CANBERRA POLICY PLAN IMPLEMENTATION PLAN (NCDC, 1987), are to increase retailing, tourist and leisure facilities, residential population density and expand commercial and government offices. The previous Civic Plan in 1982 found strong private sector interest in development in Civic, and a reluctance to invest in centres other than Civic. Employment in Civic is expected to increase from 23 000 to 35 000 by early - mid 1990s. The expected employment growth will increase travel demand by 70%. Some roads are congested in peak hours, with capacity limits having been reached at some points. There are currently higher than desirable lead levels on major roads, and there is a noise problem from traffic in Civic in peak hours.

Proposed developments that will affect transport demand are the development of Gungahlin in the early 1990s, the relocation of CSIRO and the Defence receiving station at Belconnen, development of Symonston and south east Fishwyck after relocation of the Bonshaw transmitting station, and a higher level of residential redevelopment. At the intended population level of 500 000 employment will increase from the present 140 000 to 250 000, of which 90% will be within 15km of Civic. There is a possibility of a major mixed employment corridor from the parliamentary zone to Queanbeyan. The Plan states that it is clear that the longer term development of Civic is dependant on a highly efficient and attractive public transport system'.

Three scenarios for Civic's future development have been presented, the favoured option being to consolidate development and redevelopment within Civic. This option will allow for greater efficiency in the transport system, with greater emphasis on modal split. The employment aim of 35 000 needs a modal split of 25%. Existing access to Civic is 76% by car, 18% public transport and 6% foot and bicycle.

Also in 1987 the NCDC and the Department of Territories prepared a transport strategy for the next 10 years: SERVING THE COMMUNITY - THE FUTURE DIRECTION FOR PUBLIC TRANSPORT IN CANBERRA, together with a Summary Report. The principal finding is that the bus-based system will cater for at least the next 10 years providing Action is reorganized and funded. In this period Action will grow by 65% and handle double the number of passengers. A 40% subsidy is predicted. Failure to increase the present modal split from 17% to 25% over the next 3 years will result in high levels of private transport expenditure, more traffic congestion and more intrusion into residential streets.



Alternative modes, including light rail and guided bus, were investigated in this document. It was concluded that estimated future travel demands will not warrant a higher capacity system in the next 10 years (from 1987). The existing bus capacity can meet employment increases in centres other than Civic. A higher capacity system would require most passengers to change vehicles, which they do not like, and the extra cost - between \$100m and \$1000m - cannot be economically justified at this time. However, in view of the required lead times light rail or guided bus should be reviewed again in 5 years.

The public consultation programme identified some reasons for non-use of public transport. These included: too many changes on home/work trip, time delays, driver attitudes both to driving and passengers, lack of comfort, lack of available information and lack of service at needed times to Fyshwick. Amongst measures that would increase the appeal of public transport were more direct services into work locations, park and ride facilities and seriously consideration of a light rail system in the context of increased patronage and a faster and more reliable service.

The Operating Strategy in this report recommended against light rail in the next 10 years for the following reasons: bus has ample capacity, light rail capital and operating costs are disproportionately high in relation to express bus services, travel times do not decrease but interchanging increases, and the same bus infrastructure would be required. However, by 1991 it is anticipated that all major roads will be operating at full capacity with extensive periods of delay, and light rail should be considered again.

The option of privatisation was mentioned, but whilst this should not be ruled out indefinitely, currently both Action and the community have registered strong objections. It is felt that the economic benefits are questionable in a period when complex growth factors will effect both revenue and costs, and profitable operation will be at the expense of new area residents and off-peak services.

The final documents are the GUNGAHLIN ENVIRONMENTAL IMPACT STATEMENT and the DRAFT GUNGAHLIN POLICY PLAN IMPLEMENTATION PLAN published in April 1988.

The Gungahlin new town is planned to accommodate 30-32 000 dwellings at existing densities, an ultimate population of 84 000 by 2008. Gungahlin is likely to have a disproportionate number of young families, and a high level of labourforce participation is expected in comparison with the national average. Of a planned resident workforce of 40 000, 8-12 000 could be employed in Gungahlin town centre - 30,000 will travel elsewhere..

Transport policy places major emphasis on the journey to work, with some consideration of educational, shopping and recreational travel. Car is likely to be the preferred mode of work trips, although it is estimated that 1/3 of the population will not have a car available during the working day. Further, Canberra is moving away from the trend towards greater car ownership evident in other capital cities. The use of public transport for the journey to work is to be encouraged, and provision should be made for an intertown public transport reservation capable of accommodating busway or light rail.

BIBLIOGRAPHY:

Pak Poy and Associates, NCDC and Department of the Interior. 1967. Some principles for planning public transport routes in Canberra's new towns.

Allan M. Voorhees and Associates. 1970. Canberra Public Transport Study.

Casey, C. 1976. Some issues regarding transport in Canberra - a working paper. Council of Social Service of the ACT.

National Capital Development Commission and Department of the Capital Territory, June 1976. Intertown Public Transport Alternatives for Canberra (plus draft report appendices)

NCDC, July 1984, Metropolitan Canberra Policy Plan Development Plan.

NCDC, 1986. Canberra's population forecasts 1986-96

Loder and Bayly, March 1986. Public Transport Alternatives for Canberra. A Report to the National Capital Development Commission

NCDC, August 1986. Metropolitan Canberra Policy Plan and Development Plan:  
Implementation - Technical Paper 47  
Urban Consolidation - Technical Paper 50  
Transportation - Technical Paper 53

NCDC, July 1987. Serving the Community. The future direction for public transport in Canberra (plus summary report)

NCDC, November 1987. Civic Centre Canberra Policy Plan Implementation Plan

NCDC, April 1988, Gungahlin Policy Plan Implementation Plan.

NCDC, April 1988, Gungahlin Environmental Impact Statement



FIGURES

1. Trends in patronage for US light rail lines compared with other surface transit modes (from Tennyson, E. in LRT: System Design for Cost-Effectiveness).
2. Per capita public transport usage as a function of mode and city size - Europe (from Vuchic, V. - Urban Public Transportation).
3. Canberra light rail system.
4. Annual Patronage of the public transport network in Hannover.
5. Conversion of the Hannover tram system into a light rail network.
6. Changes in modal split - Hannover, 1976-1980.
7. Public transport between Cologne and Bonn.
8. Patronage of the Rheinuferbahn before and after conversion to light rail in 1978.
9. Tyne and Wear Metro map.
10. Principal bus connections with the Tyne and Wear Metro.
11. San Diego light rail service area and route map.
12. Average daily ridership - San Diego Trolley.
13. Patronage by hour - before and after trolley opening.
14. Trends in transit ridership and car ownership, USA and W. Germany (from Vuchic, V. Urban Public Transportation).
15. Relationship between public transport patronage and level of car ownership (from UK Transport and Road Research Laboratory).

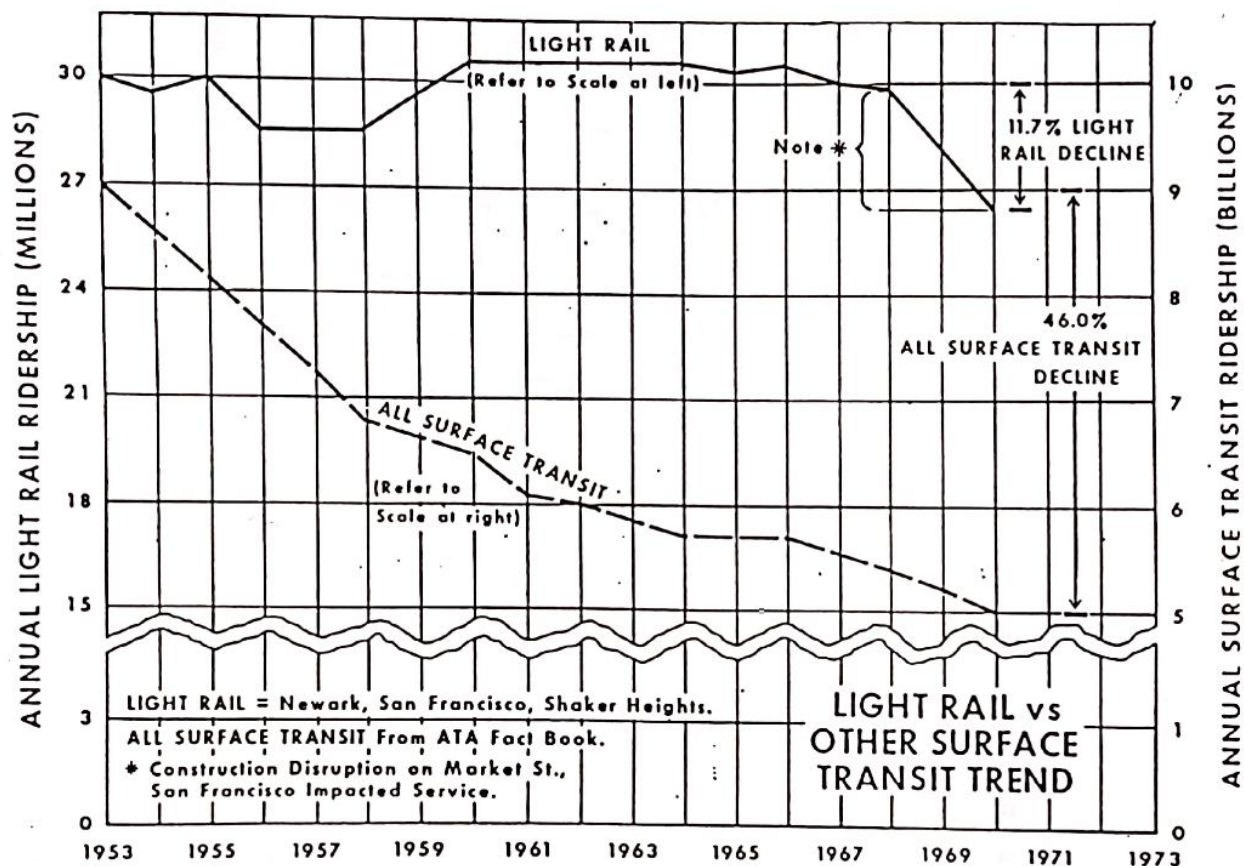
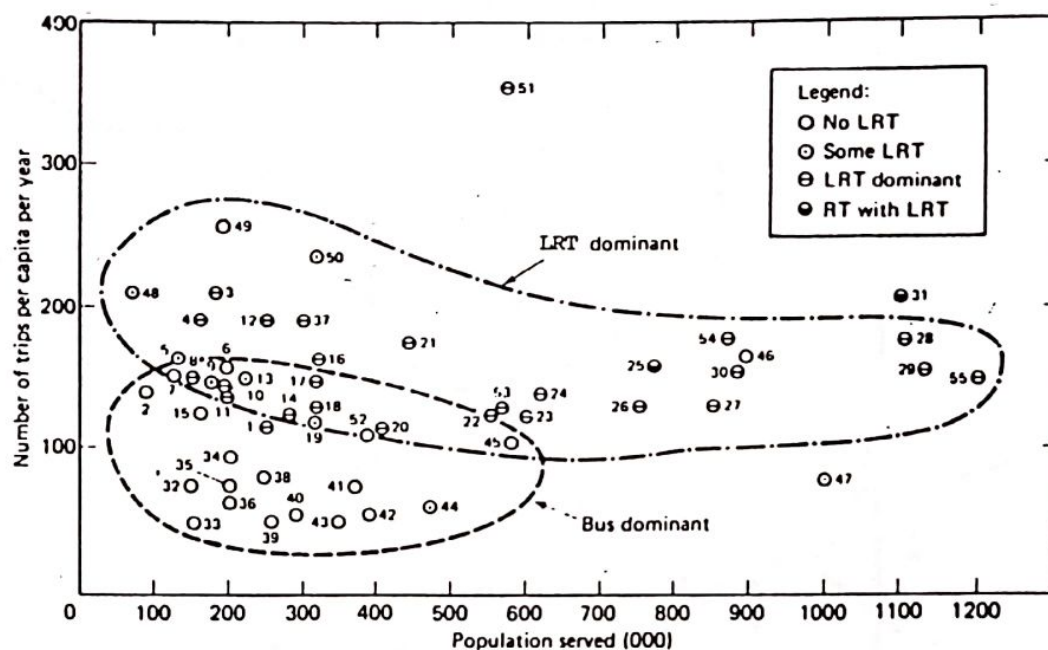


FIG.1. Trends in patronage for US light rail lines compared with other surface transit services.





City/country classification

|                         |                   |                |                |
|-------------------------|-------------------|----------------|----------------|
| West Germany            | 1. Heidelberg     | 12. Kassel     | 22. Wuppertal  |
|                         | 2. Trier          | 13. Mainz      | 23. Duisburg   |
|                         | 3. Ludwigshafen   | 14. Bielefeld  | 24. Bremen     |
|                         | 4. Freiburg       | 15. Osnabrück  | 25. Nürnberg   |
|                         | 5. Ulm            | 16. Karlsruhe  | 26. Essen      |
|                         | 6. Offenbach      | 17. Augsburg   | 27. Hannover   |
|                         | 7. Pforzheim      | 18. Hagen      | 28. Düsseldorf |
|                         | 8. Würzburg       | 19. Kiel       | 29. Cologne    |
|                         | 9. Bremerhaven    | 20. Bonn       | 30. Stuttgart  |
|                         | 10. Darmstadt     | 21. Mannheim   | 31. Munich     |
|                         | 11. Mülheim       |                |                |
| France                  | 32. Metz          | 38. Nancy      | 43. Rouen      |
|                         | 33. Le Mans       | 39. Le Havre   | 44. Lille      |
|                         | 34. Tours         | 40. Grenoble   | 45. Bordeaux   |
|                         | 35. Mulhouse      | 41. Strasbourg | 46. Lyon       |
|                         | 36. Toulon        | 42. Nantes     | 47. Marseille  |
|                         | 37. Saint-Etienne |                |                |
|                         |                   |                |                |
| Switzerland             | 48. Neuchâtel     |                |                |
|                         | 49. Lausanne      |                |                |
|                         | 50. Geneva        |                |                |
|                         | 51. Zurich        |                |                |
| Belgium and Netherlands | 52. Utrecht       |                |                |
|                         | 53. The Hague     |                |                |
|                         | 54. Rotterdam     |                |                |
|                         | 55. Brussels      |                |                |

FIG.2. Per capita public transport usage as a function of mode and city size - Europe.

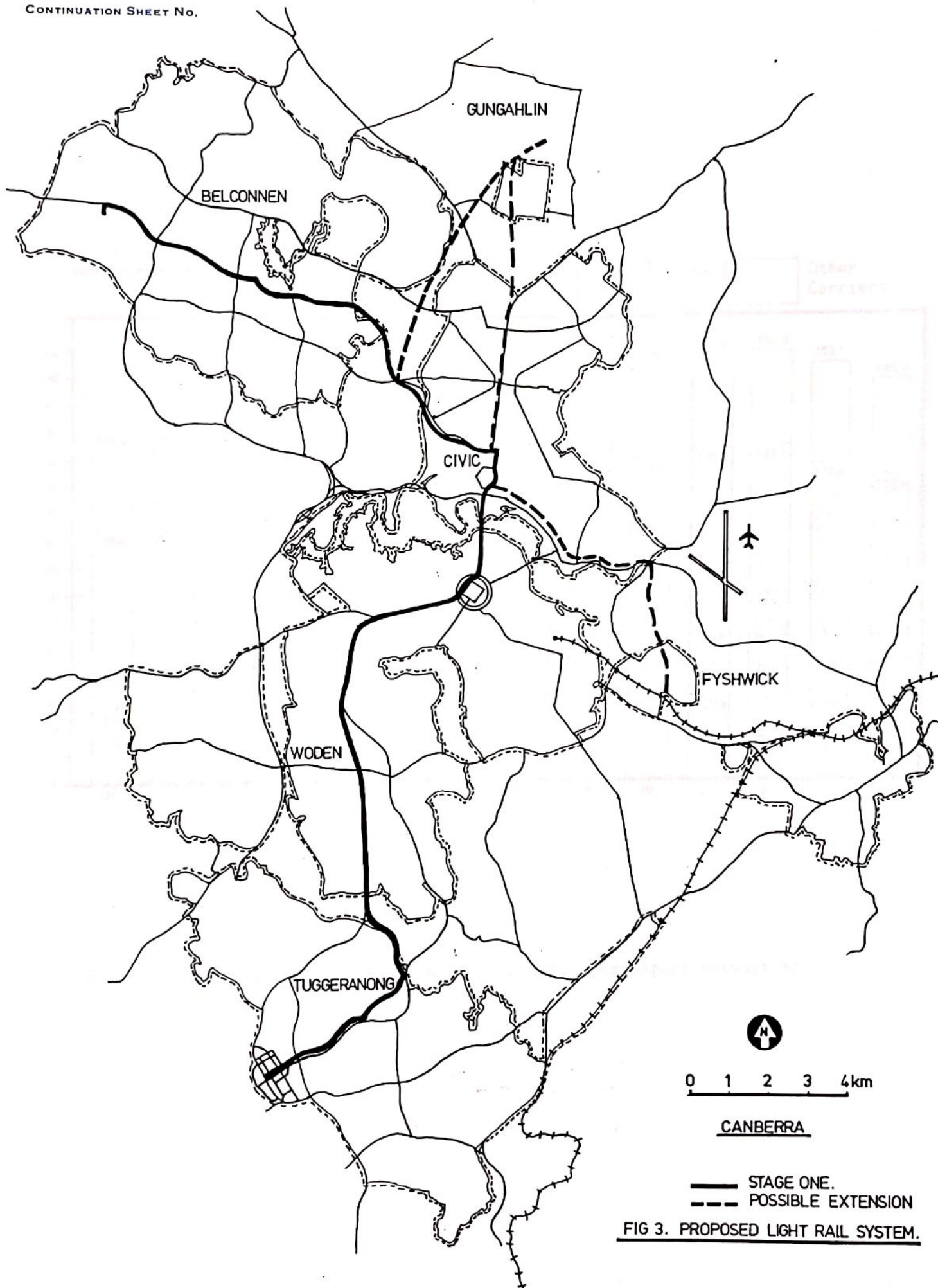


FIG 3. PROPOSED LIGHT RAIL SYSTEM.



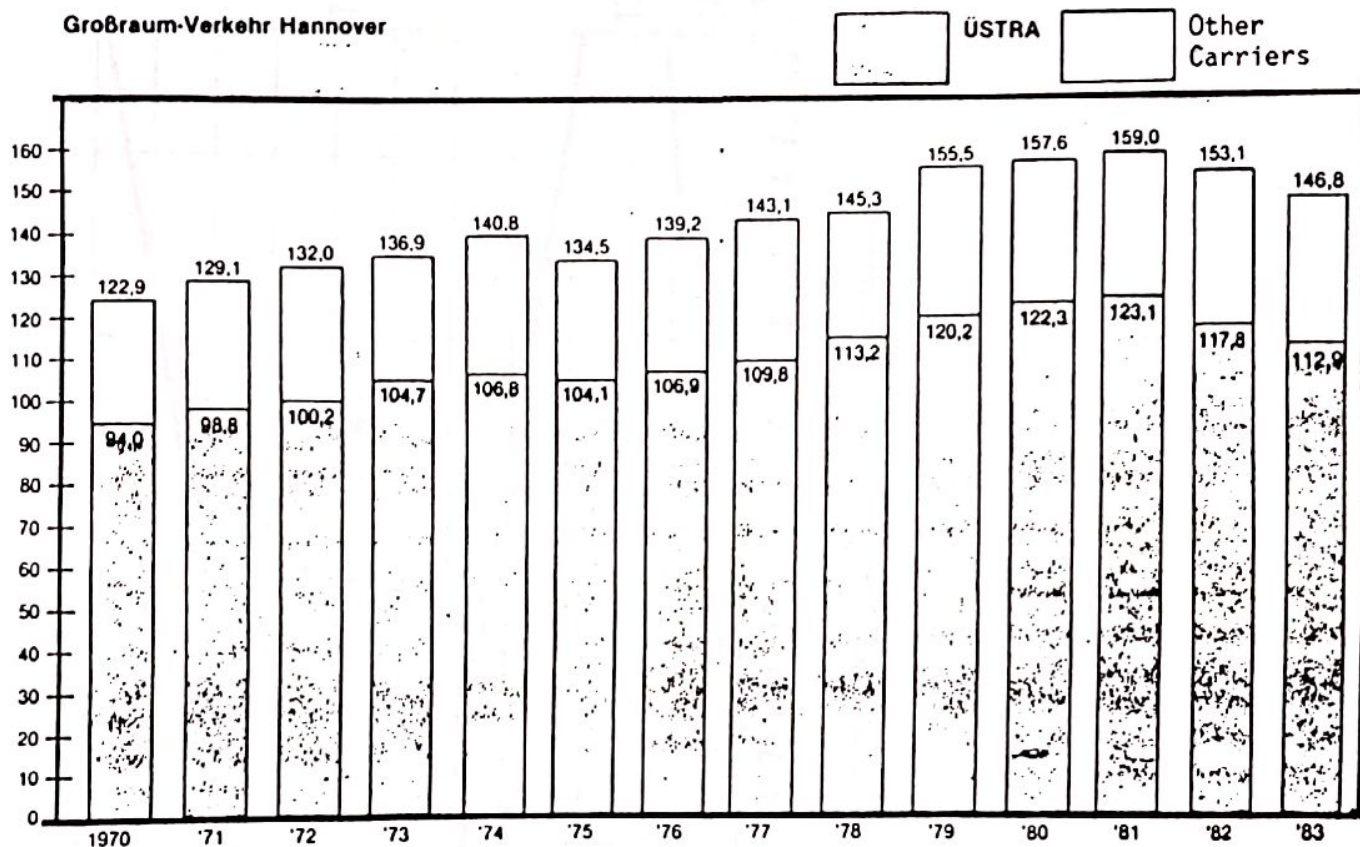


FIG. 4. Annual patronage (millions) of the public transport network in Hannover, W. Germany.

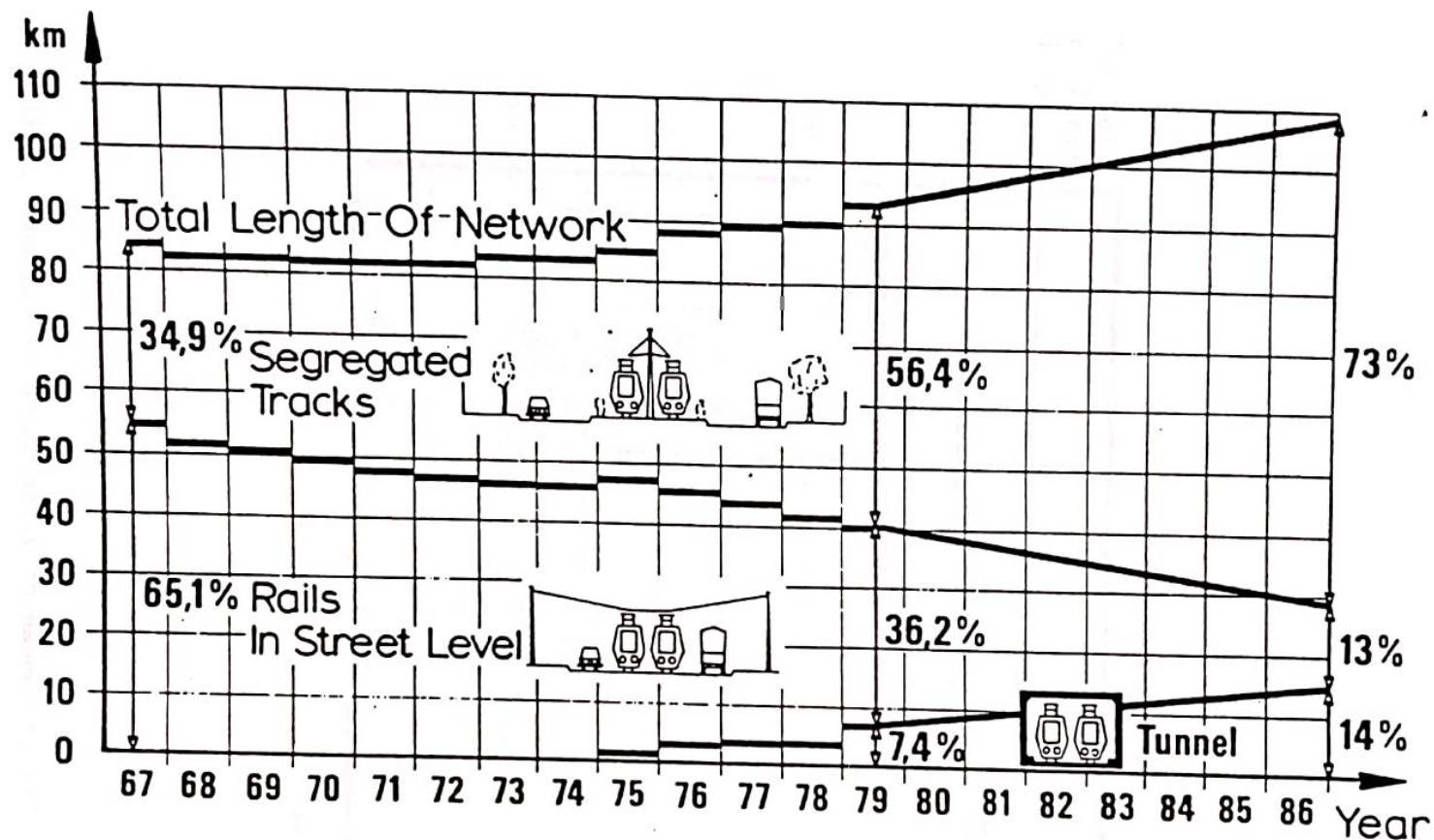


FIG.5. Conversion of the Hannover tram system into a light rail network.



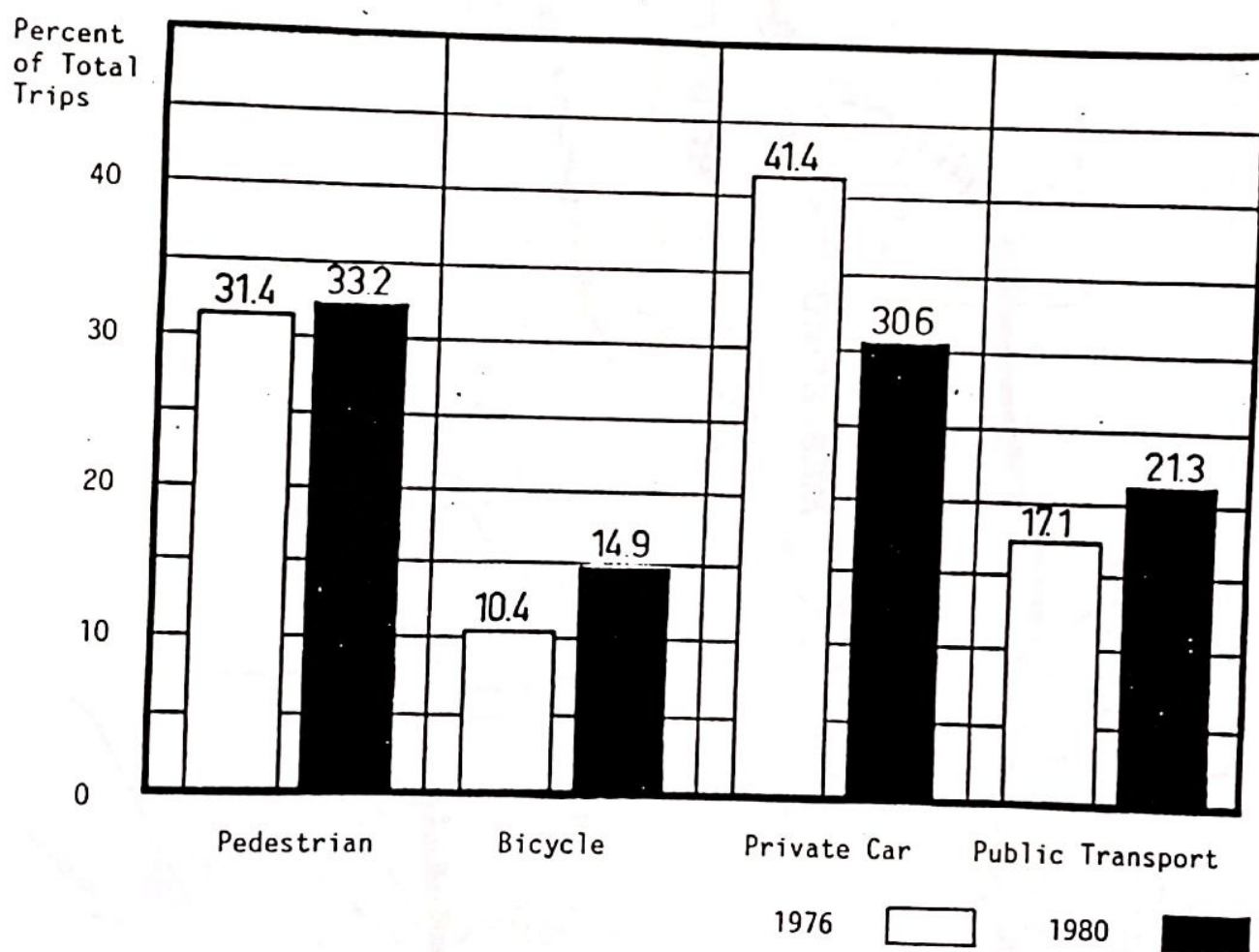


FIG.6. Changes in modal split in Hannover, 1976 - 1980.

FIG. 7.



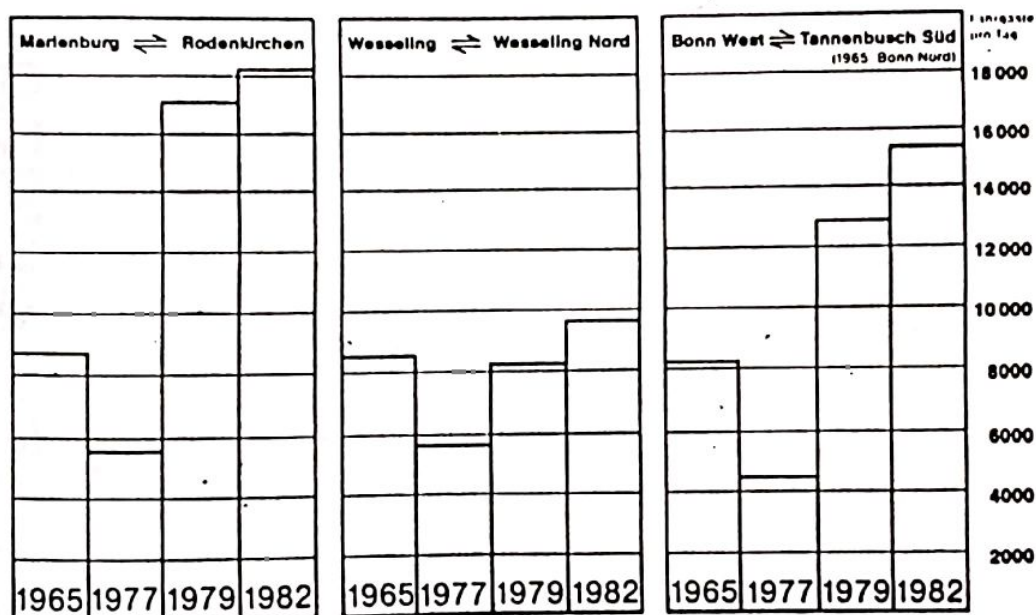


FIG. 8. Patronage of the Rheinuferbahn before and after conversion to light rail in 1978. (Vertical axis - daily boardings.)

# Tyne and Wear Metro

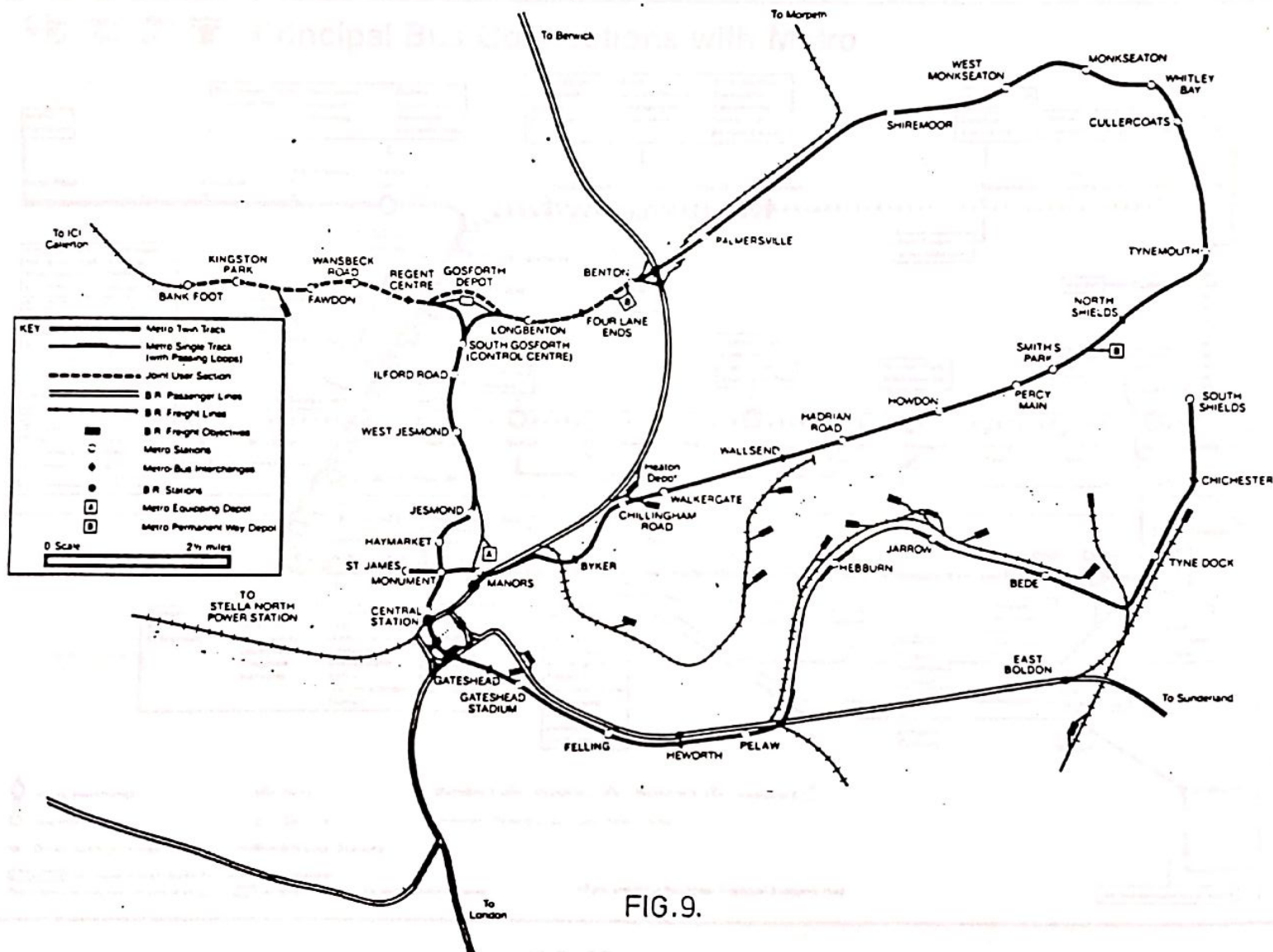


FIG.9.







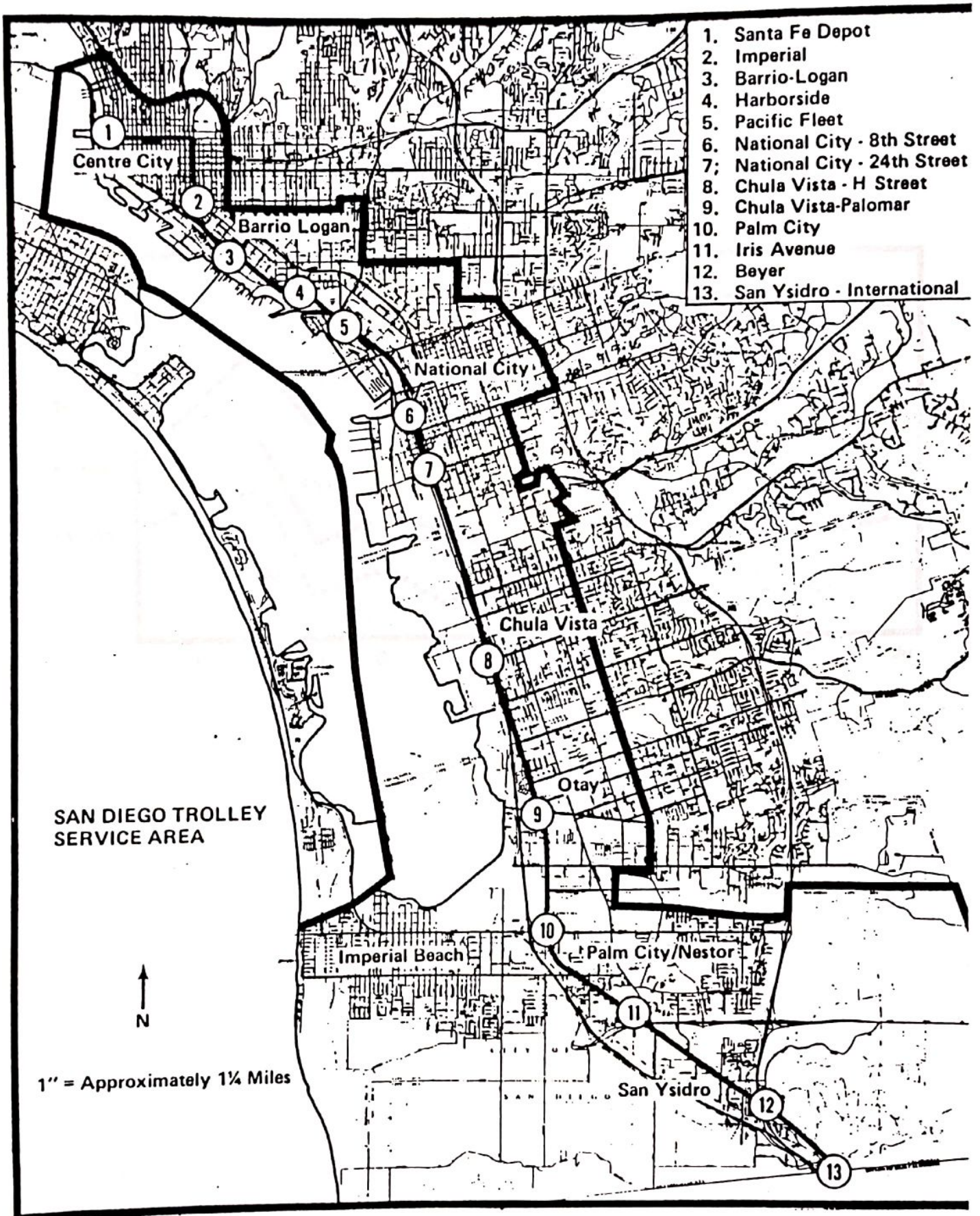


FIG.11.



# AVERAGE DAILY RIDERSHIP San Diego Trolley July 1981-May 1984

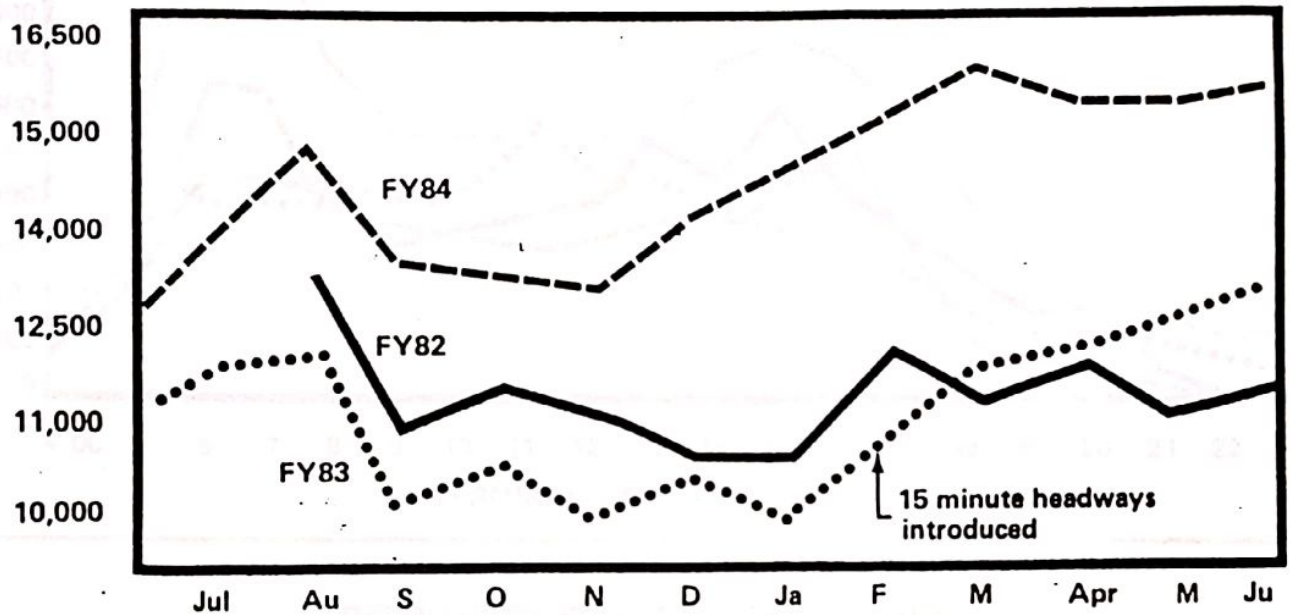
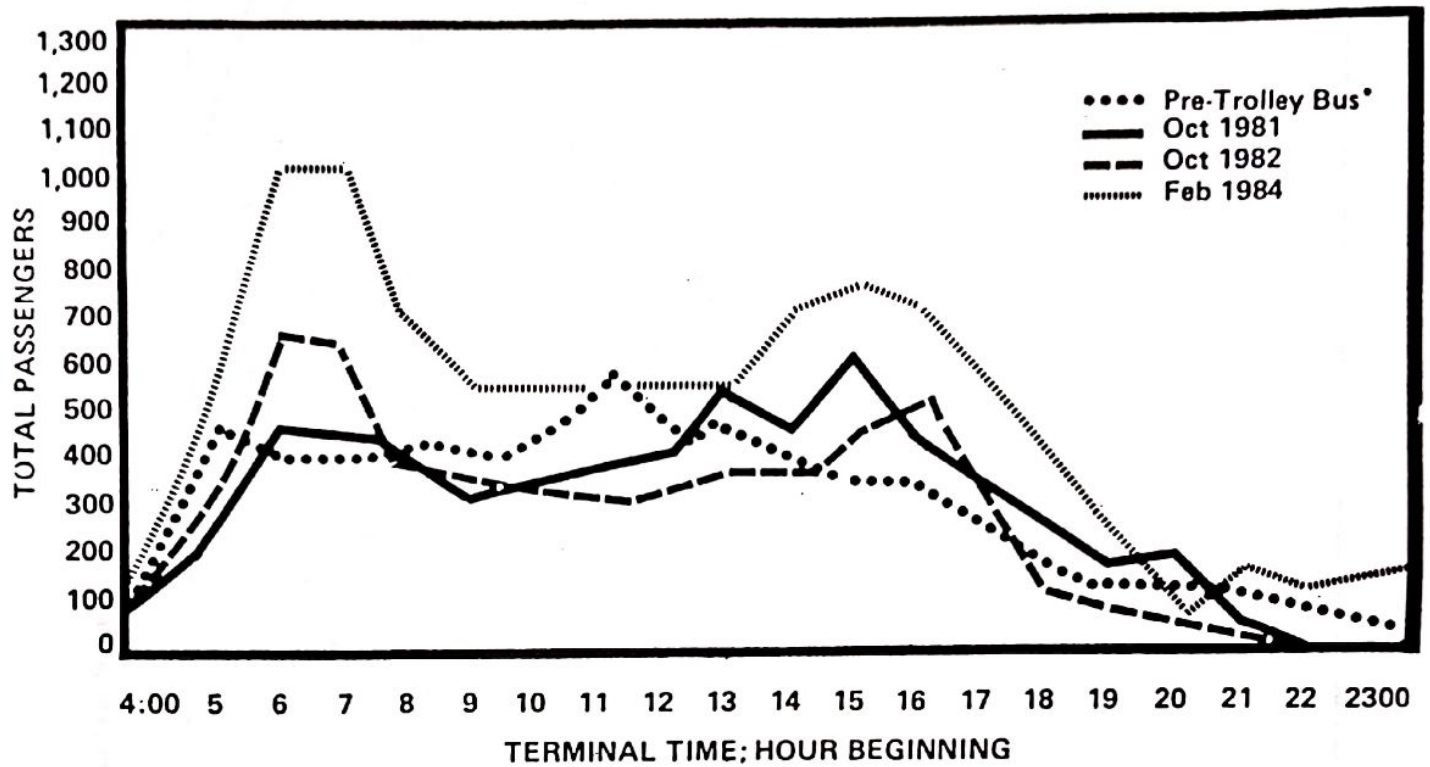


FIG.12.

### PATRONAGE BY HOUR: INBOUND San Diego Trolley/Pre-Trolley Bus



### PATRONAGE BY HOUR: OUTBOUND San Diego Trolley/Pre-Trolley Bus

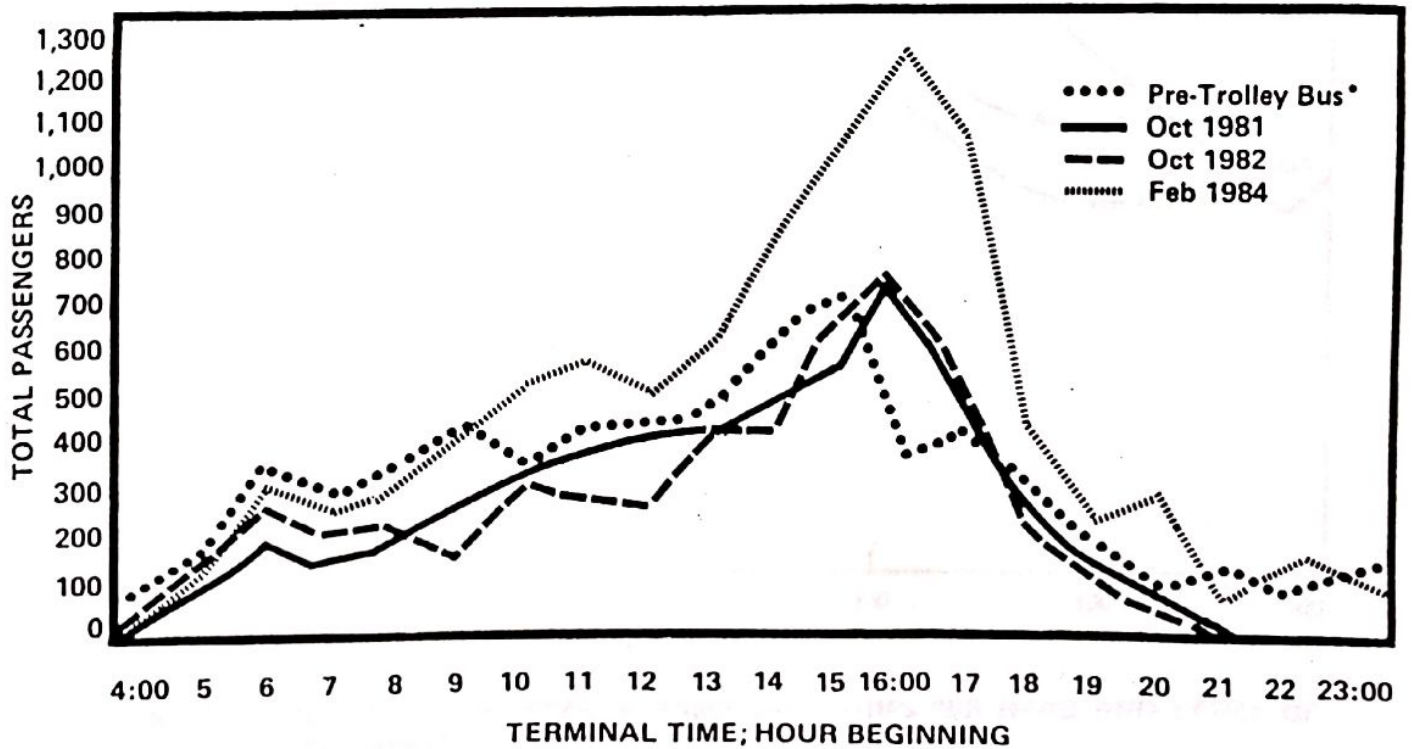


FIG. 13.



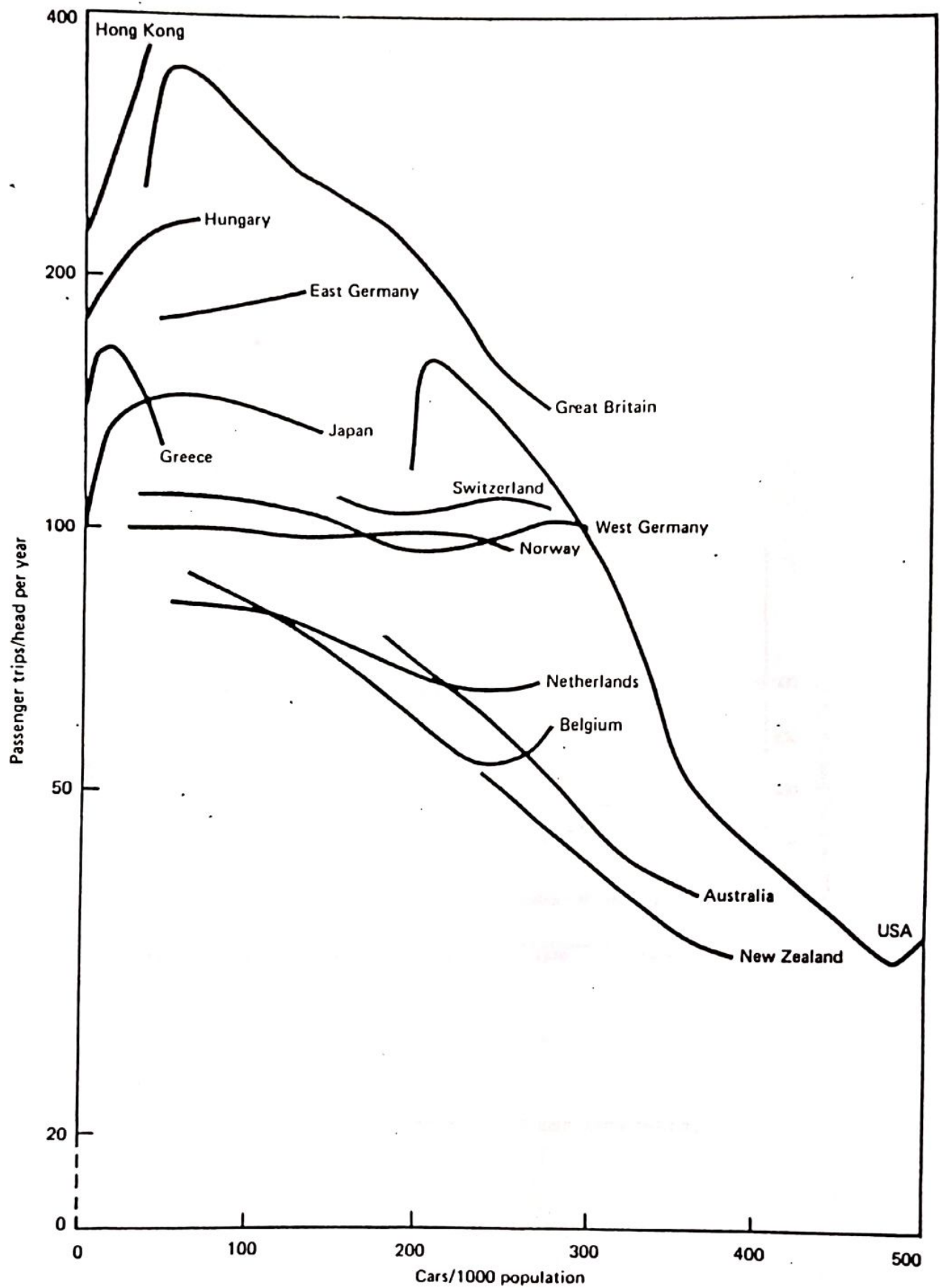


FIG.15. RELATIONSHIP BETWEEN PASSENGER TRIPS PER HEAD AND LEVEL OF CAR OWNERSHIP

Source: The Demand for Public Transport, UK Transport and Road Research Laboratory, 1980.

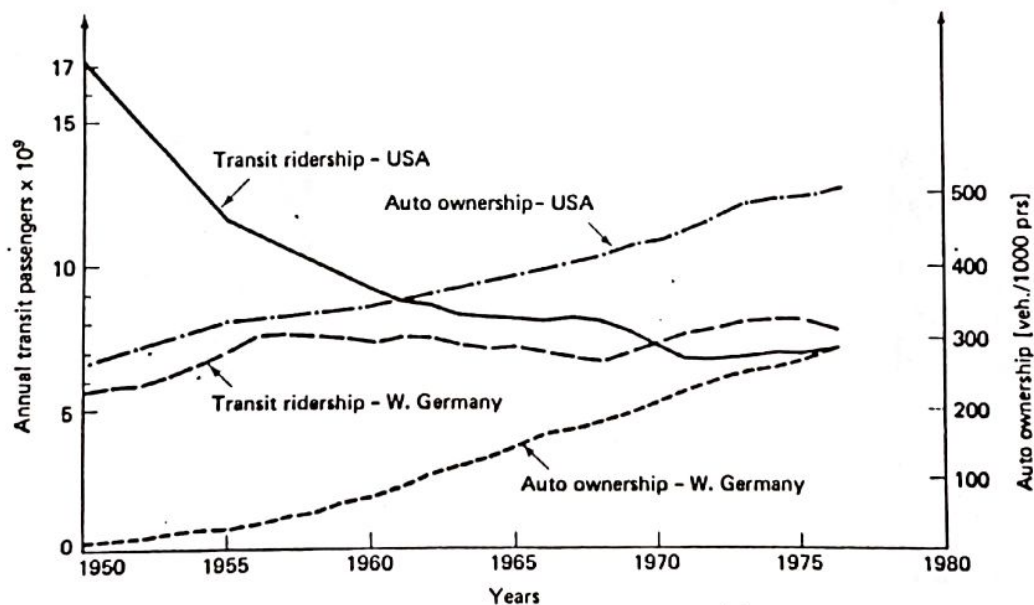


FIG. 14. Trends in transit ridership and car ownership, USA and W. Germany.



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# LIGHT RAIL

## ECONOMICAL, MODERN, ATTRACTIVE TRANSPORT



*A modern light rail vehicle in Stuttgart, West Germany.*

Light rail is the fastest-growing public transport mode in the world. There are today some 100 cities in more than 25 countries engaged in extending existing systems or in the construction of totally new networks. In North America alone, there are now 15 cities operating or building light rail systems, and another 14 planned. Worldwide, more than 300 networks are in operation.

Light rail technology has evolved from the tramcar. Traditional street tram systems still exist in many cities (Melbourne has the largest in the western world) but the shift is away from street operation to the use of separate right-of-way. Most modern cities are becoming increasingly congested with road traffic and efficient public transport access is more and more difficult to sustain.

Heavy rail (such as the suburban railways of Sydney and Melbourne) remains the only mode capable of moving very large numbers of people

in and out of cities and to and from suburbs. However, the cost of new heavy rail networks is becoming prohibitive. In capacity, light rail falls half-way between buses and trains, so that where buses or trolley buses may be inadequate on the one hand, and heavy rail too expensive on the other, light rail is proving to be a viable alternative.

Light rail has the advantage of providing a public transport mode of fairly high capacity, but at relatively low cost. The exceptional flexibility of the technology permits the use of vehicles which can operate in a number of different environments. For example, although dedicated, separate right-of-way is desirable, it is not essential for successful operation. The vehicles may operate at ground level, on elevated structures, on existing railway tracks, in existing streets or underground. Segregated sections can be fully automated if necessary.

The vehicles are exceptionally quiet in operation, are non-polluting and energy efficient. Their spacious interiors and superior riding qualities ensure a very high passenger appeal. Compared to heavy rail, LRV's can negotiate grades at least twice as steep, and curves six times as sharp.

Light rail systems do not require signals, stations, platforms or heavy overhead catenary. They do not require grade separation at road crossings, and where appropriate the tracks can be laid in road surfaces. It is from these cost savings that light rail derives its economic advantage over heavy rail.

Because of a unique combination of capacity, flexibility and comparatively low cost, light rail is increasingly the choice of transport operators around the world.

**Comeng**





## CASE STUDY NUMBER 1: LONDON

Construction work has begun on a 12 km light rail line to link London's financial centres with a former dockland area to the east of the city on the north bank of the Thames. Following the transfer away of cargo shipping services, this area is being redeveloped for residential and commercial use.

The decision to adopt light rail came some 35 years after London closed down the last of its street tramsways. Since then the city has relied on the Underground, British Rail commuter services and on coach buses, but has now recognised the value of light rail in filling the gap between existing transport modes.

The Docklands Light Railway will serve communities on the Isle of Dogs, a peninsula jutting into the Thames, with a northern fork serving the industrial East London suburb of Stratford. Part of the line will be built along the route of a long defunct railway which once served the area. The terminus of the line is opposite Royal Greenwich, former royal palace and present naval college. Accordingly, the light rail line is expected to be a popular tourist route.

2

## RESERVED RIGHT-OF-WAY

A key characteristic of light rail is its flexibility of location. Light rail can operate underground, on elevated structures, or along existing streets. In most cases however light rail operates on a reserved right of way, so that vehicles are not slowed by road traffic congestion. Where light rail lines cross roads at intersections, they may be given priority at traffic lights or may be provided with level crossing protection similar to heavy rail lines.

The nominal width required for a double track light rail line, capable of carrying around 18,000 passengers per hour in each direction is less than 7.0 metres. By comparison, the same number moved in private cars would require a roadway of at least seven lanes per direction, each of 3.5 metres width.

Light rail lines can blend harmoniously with the environment. The tracks may be grassed, and/or bordered by low hedges. The illustrations show light rail operating on reserved rights of way in Zürich (3 and 7), Neuchâtel (4), Basle (5 and 8) and Hannover (6), the latter showing the use of offset stopping places to maximise use of space. These examples indicate the way in which light rail lines can operate in suburban areas with minimal impact on the environment.



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## ACCESS FLEXIBILITY AND UNDERGROUND OPERATION

Operation on reserved right-of-way provides only partial separation from road traffic because the lines must cross roads at intersections. Where total separation from road traffic is desirable, such as in central city areas, light rail can operate underground. The smaller profile of light rail vehicles means that tunnelling costs are reduced compared with heavy rail.

It is common for underground stations to be equipped with high-level platforms. Light rail vehicles which operate underground for part of their routes are frequently fitted with adjustable-height steps.

When operating on the surface, light rail vehicles may be boarded from street level or from low platforms. If platforms are not provided, cars with lower floor heights are operated, so that passenger access is facilitated. The illustration shows a car in Geneva (9) whose floor is only 0.48 metres above street level. Other photos show light rail cars in Essen (10), Calgary (11) and Frankfurt (12).



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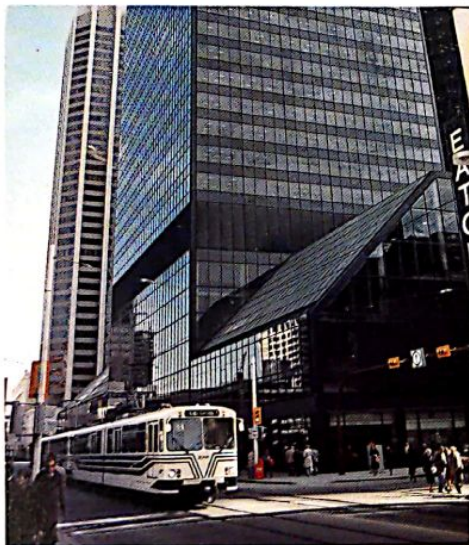


12

## PEDESTRIAN AND TRANSIT MALLS

Light rail can operate through pedestrian malls with minimal detrimental impact. The quietness and freedom from pollution of light rail vehicles, together with their confinement to a fixed and relatively narrow operating alignment, means that their operation

through pedestrian malls is acceptable and can indeed enhance access to these areas. Such operations have given rise to the term "transit mall". The illustrations show such operations in Calgary (13), Zürich (14) and Bern (15).



13



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## CASE STUDY NUMBER 2: PARIS

The city of Paris once had an extensive tramway system, which was progressively converted to bus operation in the 1930s. Although the city is well served by the underground Metro, by heavy rail and diesel bus services, some 50 years after the abolition of trams the decision has been taken that light rail has a place in the transport of Parisians. A light rail line is now under construction between St Denis and Bobigny in the north-west suburban area. The 9.1 km light rail line will operate at a scheduled speed 40% faster than the present bus route. 22 stations along the route will provide interchange with three metro lines, two heavy rail lines and 28 bus routes. The rolling stock will be the low-floor version of the French standard light rail vehicle, pictured in service on the new light rail network in Nantes.

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# STREET OPERATION

Where traffic densities are low, typically at the outer ends of suburban routes, light rail vehicles can operate along existing streets. In some cases traffic separation measures are adopted to discourage motorists from obstructing light rail vehicles. Additionally, light rail vehicles are usually afforded priority at traffic lights so that schedule speeds are enhanced. The ability to operate along street alignments provides improved access to the transport facility while lowering costs, since expensive property resumptions are not required. The illustrations show street operation of light rail vehicles in Mülheim (17), Hannover (19), and on the Forchbahn in Zürich (18).



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## CAPACITY MATCHED TO DEMAND

Light rail vehicles may be of different sizes depending on the requirements of a particular city or route. The most common light rail cars are two-unit articulated vehicles, which are carried on three two-axle bogies, the central bogie being placed under an articulated joint. Such vehicles have seating capacities ranging up to 84, with maximum loads of around 240. The example shown operates in Utrecht (21).

Where traffic demands are lower, smaller vehicles, carried on two bogies and without articulation, are used. Seating capacities for such cars range up to 50, with total capacities

reaching 150. An example is shown in Toronto (20).

For heavier loads, three-unit articulated designs are used, in which the vehicle has four bogies and two articulated joints. An example is shown in Brussels (22).

A characteristic of all these vehicle types is that they can be coupled together to provide increased capacity at peak periods. Such operation is extremely economical as all vehicles are controlled by a single driver. A combination of three-unit articulated vehicles has a potential total capacity of some 600 people.



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## CASE STUDY NUMBER 3: SAN FRANCISCO



Well known to Australians as an arrival point on the west coast of the U.S.A., San Francisco is renowned for its historic cable cars. Less well known is the fact that the city also operates a light rail network which has been developed from an older tramway system.

In the 1950s San Francisco converted many tram routes to trolley bus or diesel bus operation, but tramway operation was retained on five lines. In 1970, a Transit Improvement Program was approved which included the purchase of 100 new light rail vehicles together with route extensions. Associated with this program was a decision to put the light rail route underground in the city area. Modernisation of the network was completed in 1982, but further route extensions are planned. Upgrading to modern light rail standards resulted in a marked increase in patronage, from about 85,000 passengers per day to some 145,000 per day on the new system.

San Francisco is unique in the variety of modes of public transport which serve the city. They include light and heavy rail (the BART system and double-deck commuter trains), trolley buses, diesel buses, cable cars and ferries.

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## INTEGRATION WITH OTHER MODES

Light rail typically complements other modes of public transport: buses, trolley buses and heavy rail. Typically, modes with lower capacities, such as buses and trolley buses, feed light rail routes which may in turn feed heavy rail lines. Where passengers must travel on more than one mode of transport to complete their journeys, it is important that interchange between the vehicles is as simple and convenient as possible. The ideal form of interchange occurs when vehicles operate on either side of a platform, involving passengers in a level walk of only a few metres. Where single level interchange is not possible, escalators are usually adopted to maximise convenience.

Light rail often provides an important facility for tourists as well as for commuters and other users of public transport. In some cases tourist services may involve integration with older forms of public transport such as horse drawn cabs, antique buses, historic trams or, in the unique case of San Francisco, cable cars.

The illustrations show the easy transfer between light rail and buses in Nantes (24), and a park-and-ride facility in Hannover providing interchange between private cars and light rail (25).



24



25

## THE NORTH AMERICAN LIGHT RAIL REVIVAL

North America has an image for many of being the home of expressways, and a continent in which public transport plays a minor role. This is certainly true of many cities, which dispensed with tramways or even heavy rail services in bygone years in favour of reliance on the automobile as the primary form of transport.

Yet some of North America's largest cities, including New York and Chicago, have continued to rely on public transport. New York's subway system, despite its problems, is vital to the life of the city. Some other cities, including Boston, Cleveland, Philadelphia, Pittsburgh, San Francisco and Toronto never dispensed with their tramway systems. Now these cities are upgrading to light rail, and are being joined by numerous other cities which are developing completely new light rail systems.

Already San Diego, Edmonton, Calgary and Buffalo have commissioned new light rail systems. Other cities with light rail lines being constructed include Vancouver, Portland, San Jose, Detroit, Sacramento and Los Angeles, while some further 14 cities are actively planning light rail services. In some cases these cities are adding light rail to existing public transport modes. In others, the introduction of light rail effectively represents a re-introduction of public transport. A notable example of the latter is the San Diego system, which was built for a relatively low cost and was paid for by the city without federal funding. It was completed on time and within budget and now attracts 17,000 passengers per day, a figure which is still rising.

The illustrations show planned and current light rail operations in Los Angeles (26) and Cleveland (27).



26



27



# COMFORT AND CONVENIENCE FOR PASSENGERS

Light rail vehicles provide outstanding levels of passenger comfort. They are quiet, and smooth in acceleration and braking. A predictable path around curves minimizes jerks and jolts which are particularly disturbing to standing passengers. They operate at speeds approaching those of heavy rail services, yet provide easier access through the more frequent location of stopping places.

Multiple doors provide quick loading and unloading. Air conditioning may be provided where climatic conditions warrant it; in other cases heating or forced ventilation are provided. High crush loading capacities mean that in peak periods few passengers are left to wait for a following service.

The illustrations show the easy access of the low floor vehicles in Geneva (28); ticket machines in San Diego (29); and modern interior design in Utrecht (30).



28



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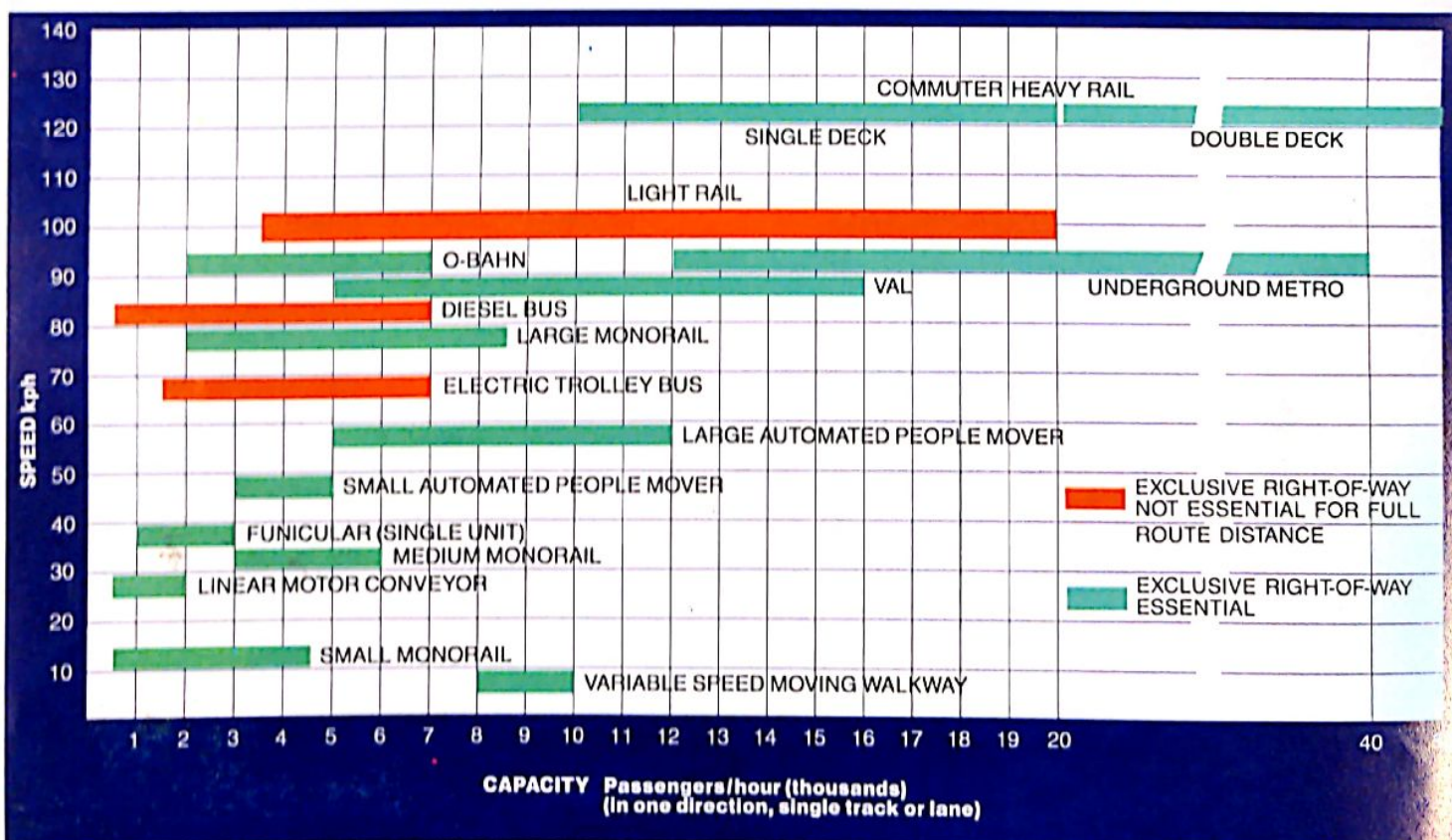
## CAPACITY – COMPARISON WITH OTHER MODES

Each mode of public transport has a place in the spectrum of requirements. The choice of mode for a public transport service depends

primarily on the anticipated demand, and on the speed required. The accompanying diagram shows potential carrying capacities

and speeds for a range of public transport modes. (The speeds shown are representative and vary from country to country.)

### MAXIMUM POTENTIAL SPEEDS VS. CARRYING CAPACITY





# ENERGY CONSUMPTION

Comparison of the energy consumption of different types of transport vehicles is complicated by a number of factors. The energy consumed by a public transport operation depends on the nature of the service (average loadings, frequency of stops etc.) and externally-imposed characteristics such as gradients. Given that these factors will themselves play a role in determining the choice of a vehicle type, useful and accurate comparisons are difficult to make. Typically, electric vehicles derive their energy from coal, while buses use energy from oil.

Comparisons of consumption on a vehicle/km basis are insufficient because of the differing passenger carrying capacities of the vehicles. To ensure that comparisons are made as far as possible on a like-for-like basis, it is desirable to make those comparisons in terms of primary energy consumption, and to extend them to energy consumed per seat kilometre and per capacity kilometre, given that for many public transport vehicles, crush loading capacity is significantly higher than seated capacity. Subject to these qualifications, the

accompanying table indicates primary energy consumption figures for light rail vehicles, diesel buses and electric trains such as those operating in Australia. It should be noted that the high energy efficiency of suburban trains is due mainly to their relatively widely spaced stops and lack of cross traffic.

## PRIMARY ENERGY CONSUMPTION

|                | LRV  | Bus  | Train |
|----------------|------|------|-------|
| Total (MJ/km)  | 30   | 19   | 152   |
| MJ/seat km     | 0.40 | 0.58 | 0.3   |
| MJ/capacity km | 0.16 | 0.31 | 0.13  |

# OPERATING COSTS

As with energy consumption, operating costs for light rail depend heavily on the nature of the service being operated. Such factors as operating frequency, stopping frequency, gradients and average loadings all have a significant bearing on operating costs. It is therefore possible only to present indicative figures based on typical light rail systems now being built in a variety of cities. These figures are shown in the accompanying table.

## ESTIMATED LRV OPERATING COSTS PER VEHICLE KM (1985)

|                                                 |        |
|-------------------------------------------------|--------|
| Traffic operation and associated costs          | \$1.10 |
| Traction energy*                                | .21    |
| Electrical maintenance                          | .11    |
| Track maintenance                               | .11    |
| Vehicle maintenance                             | .34    |
| Miscellaneous                                   | .38    |
| TOTAL                                           | \$2.25 |
| * Electrical energy priced at about \$0.08/kWh. |        |

# LIGHT RAIL — MODERN CHOICE AROUND THE WORLD

Light rail is increasingly the choice of urban transport operators around the world. For example, in 1984-85 the following cities announced significant developments in the planning or commissioning of new light rail routes or systems:

Amsterdam  
Beograd  
Birmingham  
Bologna  
Buffalo  
Bursa, Turkey  
Calgary  
Changchun, China  
Charleroi  
Constantza, Roumania

Dallas  
Grenoble  
Guadaloupe  
Hong Kong  
Houston  
Istanbul  
Kuala Lumpur  
Lausanne  
London  
Los Angeles  
Manchester  
Melbourne  
Nantes  
Newcastle U.K.  
Norfolk USA  
Oklahoma

Paris  
Pittsburg  
Portland  
Prague  
Rochester, New York  
Sacramento, California  
San Diego  
Santa Clara County, California  
Seattle  
Sheffield U.K.  
St. Louis  
Strasbourg  
Toronto  
Toulouse  
Volograd



31 Coupled double-articulated cars in Düsseldorf, West Germany.

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Comeng gratefully acknowledges the following sources of photographs for this publication:

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Comeng Vic 33,34  
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28,29,31,32

GEC Traction 2  
Hall, K. 19  
Hazemeyer-Holec (Aust) Pty Ltd 21,30  
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Bruxelles 22  
Stadtbahn-Gesellschaft Rhein-Ruhr mbH 10  
USTRA, Hannover 6,25



# COMENG AND LIGHT RAIL

Unlike other Australian cities, Melbourne never took a decision to replace trams with buses. Since 1975 it has been undertaking the progressive replacement of its older trams by new vehicles which are similar to the light rail vehicles operated in other countries. Existing routes are being extended using reserved rights-of-way: these route extensions are comparable in every way with the latest in light rail practice. Along some older sections of route where street running predominates, traffic management measures have been introduced to separate trams from motor traffic.

Comeng has supplied to Melbourne 230 single-unit vehicles of the Z series (32), and is currently supplying 52 cars of the later A series. After the introduction of two prototypes in 1984, an order for 130 two-unit articulated vehicles was placed (33). These cars will operate on existing lines, and may also be used on sections of suburban railway which are proposed for conversion to light rail. On completion of these orders, Comeng will have supplied more than 400 modern light rail vehicles to Melbourne, all designed and built in Australia.

The expertise of Comeng in the design and manufacture of light rail vehicles, and the growing world-wide market for light rail, has led the company to seek export orders. In mid 1985 Comeng won an order for 70 single-unit vehicles, with a further 40 options, for the new light rail network in Hong Kong (34). Melbourne's Metropolitan Transit Authority and civil contractor Leighton formed an all-Australian consortium which successfully bid for the design and construction of the Hong Kong light rail system, in the face of world-wide competition.



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Design and construction of the light rail vehicles for Hong Kong is being carried out at Comeng's plant in Dandenong, Victoria.

Photo 35 shows a modern vehicle concept developed recently by Comeng for future markets. This car has a low floor, plug doors, and is air-conditioned.

Comeng is playing a leading role in further efforts to win orders for light rail vehicles built in Australia for both local use and export.



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