Contractor Report 140

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Transport and Road
Research Laboratory

Department of Transport

Urban rail transit - an appraisal

by B J Simpson

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TRANSPORT AND ROAD RESEARCH LABORATORY
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TRRL

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URBAN RAIL TRANSIT - AN APPRAISAL

by B J Simpson

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Preface

The overall aim of this study is to provide a synopsis of the current situation concerning urban rail systems using data and examples of good practice. This is expected to provide a basis on which to develop a research programme which will assist the process of evaluating applications for government funding towards the cost of urban rail developments in the U.K.

All forms of urban rail are considered but the emphasis is on the technology which has customarily been referred to as light rapid transit or light rail transit (LRT). It is on this form of technology where the main interest lies at present. LRT is being considered by the transport authorities of nearly all of Britain's cities of more than half a million population and a few smaller ones. Apart from the Tyne & Wear Metro, opened in 1980, and the London Docklands Light Railway (opened l987), the plans for Manchester, the West Midlands, Bristol, Sheffield and Leeds have probably been taken furthest so far.

Interest in LRT is not confined to Britain. There is a great deal of interest in several European countries, in North and South America and the Far East in particular. In France for example, métros have been opened in Marseille (1977), Lyon (1978) and Lille (1983) and tramways in Nantes (1985) and Grenoble (1987). The two tramways in particular seem to have influenced the proposals in British cities.

This study surveys the field of urban rail systematically by topic in part 1 and then by case study in part 2. These cases have been chosen as examples of good recent practice which replicate some of the facets of the urban environment in Britain today and which affect the development of public transport infrastructure. The study was carried out between mid-August and the end of November 1988. My thanks are due to all those who have helped on the project in particular John Simpson, David Walmsley and Ken Perrett of TRRL for their helpful comments.

Barry J. Simpson MSc PhD,
28th November 1988.

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The author thanks Longman Group UK Limited for kind permission to reproduce figure 11.1 which is taken from his book *Planning and Public Transport in Great Britain, France and West Germany* and Van Nostrand Reinhold (UK) for kind permission to reproduce figure 13.7 from his book *City Centre Planning and Public Transport: case studies from Britain, West Germany and France.*

Contents

PART 1 SYSTEMATIC APPRAISAL

1 Definition of urban rail systems

Many terms are in common use to refer to urban railway networks: tramway, streetcar, Straßenbahn, Stadtbahn, LRT, underground (London), métro, subway, T-bana (Stockholm), U-Bahn, S-Bahn, blue trains (Glasgow), or simply suburban railways. When these terms are used they generally imply reference to some or all or the following characteristics of urban railways:

The weight of construction of the rolling stock
Suburban railways, including S-Bahnen, blue trains and other local and national varieties are more strongly constructed, often to more spacious standards than métros (and undergrounds, subways, U-Bahnen and T-bana) which in turn are 'heavier' than LRT, tramways (streetcars or Straßenbahnen). Sometimes terms such as 'heavy', 'medium' and 'light' rail are used to distinguish between the types of railway.

The right-of-way
Suburban railways and with a few exceptions such as the Midland metro proposals, métros, are entirely segregated from road traffic. LRT is usually mostly segregated, tramways less so, particularly the older networks.

Speed
Suburban railways are generally operated at above 40 km. per hour, whereas for métros the speed would be mostly within the range 30-40 km. per hour. LRT varies in operational speed but is generally slower than métros and tramways operate at speeds comparable to buses in urban traffic conditions (around 16 km. per hour).

Spacing of stops
These follow the same trend as speed. Suburban railway stations are usually more than one kilometre apart, 2-3 kilometres being common, whereas 1 km. is typical for métros, 0.7 km. for LRT and 0.5 km. or less for tramways. Spacing of stops is an important characteristic of an urban railway network as it influences speed (and therefore competitiveness with other forms of transport), length of journey and catchment area.

Signalling
Suburban railways and métros are fully automated whereas tramways and to a less extent LRT are partly visual.

Minimum headways
Headways tend to be lower for tramways at about 1 minute than other forms of urban rail at 1.5 to 2 minutes.

Capacity
Most trams and LRT carriages carry 180-250 passengers when operating in pairs resulting in a maximum capacity of 15,000 to 20,000 passengers per hour in a single direction. Suburban trains often carry 1,000 to 2,000 passengers or about 60,000 per hour. Métros mostly fall in

between at roughly 700-800 passengers per train or 30,000 per hour.

Curvature of the track
The minimum radius for trams and LRT can be as low as 10 metres but 20 metres is more typical. 40-50 metres is typical for métros and 200 metres for suburban railways.

Gradient
Few suburban rail sections are above 3% or for métros 5%. Some LRT trains operate at up to 12% but an upper limit of 8% is achieved on most networks.

It is quite common to refer to urban railways as comprising four groups as indeed, has already been used:

Suburban railways or 'heavy rail' for example, British Rail commuter railways, S-Bahnen (Germany).

'Medium' systems including some métros such as Paris, the Stockholm T-Bana, most West German U-Bahnen.

Light rail or LRT, for example the West German Stadtbahnen, métro léger (France), London Docklands Light Railway.

Tramways for example Gothenburg, Bremen, Blackpool and the Mongy trams in Lille and new systems as in Nantes and Grenoble. In fact there are around 300 urban tramways worldwide, over one-third of them in the USSR.

Such a four-fold classification is more useful as an attempt to clarify what is a very confused situation than it is an unequivocal representation of reality. Many urban rail systems would be difficult to classify. The Tyne and Wear Metro has a mixture of the characteristics of 'medium' and light rail, the London Underground most closely resembles 'medium' rail but in the outer suburbs resembles 'heavy' rail in its speed, spacing of stations and the other characteristics already mentioned. The term métro is used for both 'medium' rail for example in Paris, and for light rail as in Lille and the West Midlands. The term U-Bahn is most commonly used for 'medium' rail such as in Munich and Hamburg, but some U-Bahnen such as those in Frankfurt and Cologne have more in common with light rail. Tramways include those of the pre-motor car age, hardly modernised to those extensively brought up to light rail standards such as in Gothenburg and those newly constructed to light rail standards as in Nantes and Grenoble. Many railways show a mixture of the characteristics of the four classes in terms of their weight of construction, right-of-way, speed, spacing of stops, signalling, headways, capacity, curvature and gradient of track.

To sum up the situation for LRT and the lighter varieties of métro, these can be defined as railways which posess some or all of the following characteristics:

* Rolling stock which is lighter in construction than other suburban railways (commonly less than 1.5 tonnes per metre length) with axle loads of 6-10 tonnes and which can be used on tighter curves (minimum 20 metres radius) and on steeper gradients (up to 8%). Track is usually 1435mm. Standard Gauge.

* Electric traction, most commonly from overhead supply, otherwise from a third rail.

* Due to these characteristics, rolling stock and permanent way are cheaper to construct than

for other suburban railways.

* A maximum capacity of around 20,000 to 35,000 passengers per hour compared with 50,000 or more for suburban railways.

* LRT stops are usually more closely spaced than suburban railway stations, in the majority of European networks, less than 1km apart on average. In North America the spacing is considerably wider:

	Mean spacing of stops (km.)
Frankfurt S-Bahn	3.10
Munich S-Bahn	3.05
San Francisco BART	2.87
Baltimore	2.03
Atlanta	1.87
Washington DC	1.78
Hamburg S-Bahn	1.62
Manchester LRT proposals*	1.54
Edmonton*	1.51
London Underground	1.42
Tyne & Wear Metro*	1.28
Stockholm T-Bana	1.17
Sacramento*	1.13
Portland*	1.04
Hamburg U-Bahn	1.01
Marseille Métro*	0.88
Munich U-Bahn	0.86
Gothenburg tramways*	0.84
Lyon Métro*	0.81
Lille Métro*	0.79
Frankfurt U-Bahn*	0.73
Midland Metro (phase 1)*	0.71
Paris Métro	0.54
Frankfurt Straßenbahn*	0.50
Munich Straßenbahn*	0.50
Nantes tramway*	0.50
Grenoble tramway*	0.44

* Opinion differs on which railways should be classified as light rail but I suggest those marked with as asterisk.

<u>*Mean spacing of stops in selected local railway networks*</u>

* LRT is usually operated at a speed of 22-30 km. per hour, slower than many suburban railways.

* Many LRT networks follow highway alignments. The majority of track is segregated from road

traffic although like the trams of the pre-motor car age, in many cases there is some street running (commonly up to about 20% of the route). Some LRT systems however, are completely separated from the road network. Many have short sections in tunnel, commonly in city centres. Elevated sections are also common. In fact, LRT operates in a variety of urban environments - reserved routes, central reservations of dual carriageway roads, through pedestrian streets or as part of the general traffic circulation.

* The majority of LRT networks use high floor carriages and low platform stations for ease of access by the disabled and others whose mobility is impaired.

When used in relation to LRT, the term tramway implies something more than the trams common in Britain up to about 35 or 40 years ago. It implies greater speed, partly due to greater distance between stops, partly due to greater segregation from road traffic, partly to greater acceleration of rolling stock. Whereas the pre-Second World War trams travelled at about the same speed as buses in urban conditions - about 16km per hour - tramways of the LRT variety are normallty timetabled for at least 22 km per hour, sometimes much faster, depending on the route and in particular the spacing of the stops.

2 Urban rail systems: a survey

Metros and light rail systems in operation

	population of transport authority	*length (km.)*	*stations*	*ridership million journeys 1986*	*staff*	*year opened*
Amsterdam metro	683	24	20	35.0	354	
Atlanta metro	2000	45	25	65.0		1979
Baku	1,500	18.6	12			1967
Baltimore metro	800	22.4	12	13.0		1983
Barcelona metro	2,594	68.5	89	258.3		1924
Beijing (Peking)	9,300	40	29	100.0		1969
Belo Horizonte (Brazil)	3,200	14	7	2.6		
Berlin U-Bahn (East)	1,200	17.6	22	78.0 ('84)		1902
Berlin U-Bahn (West)	1,980	101	119	350.8		1902
Bochum/Gelsenkirchen	969	4.9	6			
Bonn Stadtbahn	373	25.5		20.4	468	1975
Boston LRT	2,600	56		25.9	711	
Boston metro	2,600	69.5	84	93.8	1,431	
Brussels métro	1,085	24.1	38	49.5	1,014	1976
Bucharest	2,198	46.2	31	230.0 ('87)		1979
Budapest metro	2,100	27.1	38	352.0		1896
Budapest LRT	2,100	169		478.0		
Buenos Aires	9,000	39	63	223.7 ('85)		
Calgary LRT	647	27.7		12.0		1981
Calcutta	10,000	10	9	15.0		1984
Caracas metro	3,500	19.9	14	80.0 ('84)		1983
Chicago	7,000	157.5	143	145.3		
Cleveland	1,600	30.6	18	6.1 ('84)		1955
Cologne LRT	1,100	41.6		125.4 ('83)		1968
Dnepropetrovsk	1,100	11.2		39.0 ('85)		1984
Duisburg	592	63	169	25.0 ('83)		
Edmonton	572	10.6	8	7.0		1978
Erevan	1,000	8.4	9	21.0 ('83)		1981
Essen Stadtbahn	663	13.7		6.6		
Frankfurt U-Bahn	2,400	40.3	72	50.2		1968
Fukoka	1,200	14.6	17	71.0		1981
Glasgow Underground	1,643	10.4	15	12.69 ('85)	316	
Gothenburg trams	424	152.7				1902
Gorki	1,400	9.8	8			1985
Grenoble Tramway	373	8.8	21			1987
Hamburg U-Bahn	1,600	92.7	82	182.8		1912
Hannover	1,100	97	160	97.0		1975
Helsinki LRT	485	14.2	10	34.0		1982
Hiroshima LRT	1,140	16.1	18	16.1 ('82)	579	

Hong Kong mass transit	5,500	38.6	37	532.0		
Kiev	2,100	30.6	29	335.0('84)		1960
Kobe metro	1,400	22.6	16	25.0('84)	222	1977
Kyoto	1,500	6.9	8	39.0('85)	536	1981
Lenningrad	3,200	72.7	43	763.0('83)		
Lille Métro	936	13.5	18	27.1	185	1983
Lisbon	2,200	12.5	20	134.0('85)		1959
London Docklands LRT	6,700	12	15	10.5('88)		1987
London Underground	6,700	397	279	563.0		1863
Lyon Métro	1,220	15.4	22	86.0		1978
Madrid metro	4,000	112.6	137	329.0		
Manila	8,000	15	18	90.0		1984
Marseille Métro	1,110	15	19	49.5		1977
Mexico City	18,000	119.4	109	1,324.0('85)		1969
Miami	1,700	34.5	20	6.8		1984
Milan	1,520	56.2	66	250.3		
Minsk	1,300	8.6	9			1984
Montreal	1,900	64	65	207.8		
Moscow	8,000	212	132	475.3		1935
Munich U-Bahn	1,300	42	50	209.7		1972
Nagoya	2,100	60.2	61	338.2		
Nantes tramway	475	10.6	22	11.9		1985
Newark New Jersey	2,000	6.7	11	3.5	54	1935
Newcastle-upon-Tyne	1,140	55.75	43			1980
New Orleans		10.5				1893
New York subway	11,400	388	463	1030.6		1867
Novosibirsk	1,300	8.4	7			1985
Nuremberg-Fürth	759	15		47.0	553	1972
Osaka	2,648	99.1	79	874.7		1933
Oslo	800	48.44	44	36.0		1966
Paris métro	7,161	198	365	1160.0		1900
Paris R.E.R.	7,161	103	62	291.0		
Philadelphia metro	4,000	38.7	62	70.0		
Philadelphia LRT	4,000	54.2		4.5	95	
Pittsburgh	1,400	51		5.3		
Portland LRT	400	24	24	7.23		1986
Prague	1,200	30	33	411.0		1974
Pusan (Korea)	3,200	1.3	20	100.0		1985
Pyongyang	1,800	22.5	17	42.0('83)		1973
Recife	2,500	20.5	17	27.7		1985
Rhine-Ruhr LRT	7,000	80.4				1977
Wuppertal monorail		13.3				1901
Stadtbahngesellscaft		79.1	105			
Rio de Janeiro	10,220	27		496.0('85)		1979
Rome metro	2,185	25.5	33			
Rotterdam Sneltram	783	42	32	63.3	354	1968
Sacramento	929	29.4	27		79	1987
San Diego LRT	2,080	35.4	22	8.0	130	1981
San Francisco BART	2,500	115	34	58.9		
San Jose	1,300	17	15			1987
Santiago de Chile	4,300	28	38	110.6('84)	1489	1975
Sâo Paulo	16,000	40.3	38	410.0('84)		1974

Sapporo	1,590	31.6	33	200.9	1,225	1971
Seattle monorail	1,400			1.5('85)		1962
Sendai (Japan)	730	14.4	16			1987
Seoul	10,200	116.5	102	511.0		1974
Singapore	2,500	25	20	90.9		
Stockholm T-Bana	1,593	116	99	227.0('87)		1957
Stuttgart LRT	2,120	39.5		91.1		1962
Tashkent	1,900	24	19	93.0('84)		1977
Tbilisi	1,100	18.8	16	144.0('85)		1977
Tianjin (china)	7,000	8	8			1980
Tokyo	11,900	61.5	64	456.0	3,615	
Toronto	2,800	56.9	59	161.9('85)		
Tunis	1,390	10	11			1985
Turin	2,400	42.6		207.0('84)		
Utrecht	230	17.7	23	6.0		1983
Vancouver Skytrain	1,200	21.4	15	35.0	251	1986
Vienna U-Bahn	1,500	8.4	10	23.9	302	
Washington D.C.	3,000	112	64	127.0	2,163	1976
Yokohama	3,110	22.1	20	72.0	784	

*Populations in thousands, refer to 1987; ridership in millions of passengers journeys for 1986 except where otherwise stated.

Sources: partly from Jane's Urban Transport Systems (Bushell and Stonham 1988), partly from transport authorities' annual reports.

Medium and light rail systems planned or under construction

	planned or under construction	*length (km.)*	*lines*	*comments*
Abidjan	P	17.3		studies by SOFRETU for a route using existing rail track.
Alexandria	P	14.5		Transsystem SPA (Italy) have studied a track from Bolkli to city centre.
Alma-Ata	C	40.0		construction started in 1984 on an 8.9 km. section of a 40 km. network.
Athens	C		3	construction started in 1987 on an 8 km. section of a three-line network.
Baghdad	P	32.0		design of the first line has started on a 32 km. network
Birmingham (UK)	P	20.0	1	see appendix.

Bordeaux	P	11.0	1	a VAL métro is planned between the main railway station and hospital.
Bratislava	P			a light rail extension is planned on the existing tramway.
Bristol	P	60.0	4	see appendix.
Cairo	C		3	cross-city tunnel linking existing lines is under construction; plans for two more lines.
Damascus	P		4	
Delhi	P	36.0	1	route approved by Ministry of Transport.
Fortaleza				
Guangzhou (China)	P		2	
Havana	P	25.0	1	route planned through the city centre and under the bay.
Honolulu	P	25.0	1	mini metro.
Leeds	P	23.0	2	see appendix.
Liège	P			TAU métro planned to open in early 1990s; see section 3 below.
Lima	P	23.0		
Lód'z	P	21.0	2	to open in mid 1990s.
London Docklands	C			extensions planned and under construction: see appendix.
Los Angeles	C	32.0		
Madras	P	22.0		part of a circular route.
Manchester	P	96.82	3	see appendix.
Medellin (Colombia)	C	27.0	3	construction started on a 27 km. network; two more lines planned.
Naples	C	21.0		construction started on a 21 km. section of a 41 km. network.
Odessa	P	55.0		

Omsk	P	17.0		
Port Elizabeth	P	21.0	1	see Sellin (1988).
Reims				
Riga	C	20.0	1	
Rostov-on-Don	P	17.0	3	
Rouen				
San Juan	P	24.0	1	
Shanghai	P	174.0	7	mostly following streets.
Sheffield	P	22.0	1	see appendix.
Sofia	C	52.0	3	three cross-city routes.
Stockholm	P			
Sverdlovsk	C	12.0	1	
Taipei	C	70.0		
Tehran	C	72.0	2	
Toulouse	P	20.0	2	VAL; proposed to open in 1992.
Tripoli	P	70.0		
Valencia	C	60.0		contractors were appointed in 1981 but little progress made.
Warsaw	C	90.0	4	

Jane's Urban Transport Systems (Bushell and Stonham 1988) lists over 300 tram and light rail systems in operation worldwide:

USSR*	112
West Germany	28
East Germany	27
Japan	19
USA	15
Poland	13
Romania	13
Czechoslovakia	10
Austria	5
Belgium	5
France	5

Canada	4
Egypt	4
Hungary	4
Italy	4
Netherlands	4
Sweden	4
UK	4
Australia	3
China	3
Brazil	2
Norway	2
Portugal	2
Spain	2
Argentina	1
Bulgaria	1
Finland	1
Hong Kong	1
India	1
Mexico	1
Paraguay	1
Philippines	1
Tunisia	1
Vietnam	1
Yugoslavia	1

* A list is contained in *Modern Tramway and Light Rail Transit,* March 1988, pp. 92-3.

Tramways and light rail under construction

Ankara
Baltimore
Chomutor (Czechoslovakia)
Dallas
Genoa
Grenoble (line 2)
Guadalajara (Mexico)
Hong Kong
Istanbul
Konya (Turkey)
Kuala Lumpur
Lausanne
Los Angeles
New Jersey
Paris
Resita (Romania)
St. Louis
Sydney
Tuen Mun (Hong Kong)
Valencia

Trolleybus systems in operation

USSR	184
China	26
Italy	15
Switzerland	15
Czechoslovakia	12
Romania	8
Brazil	6
France	6
Bulgaria	5
Poland	5
USA	5
Canada	4
Korea (North)	4
Austria	3
Hungary	3
East Germany	3
West Germany	3
Argentina	2
Greece	2
Mexico	2
Afghanistan	1
Chile	1
Columbia	1
Mongolian Peoples' Republic	1
Nepal	1
Netherlands	1
New Zealand	1
Norway	1
Portugal	1
Spain	1
Turkey	1
Uruguay	1
Vietnam	1
Yugoslavia	1

Trolleybus systems planned or under construction

USSR	21
Brazil	3
Argentina	1
Austria (Innsbruck)	1
Chile (Santiago)	1
China	1
India	1
UK (Bradford)	1
Yugoslavia (Sarajevo)	1

3 New technology in public transport

Guided bus

Essen
Essener Verkehrs-AG, Zweigertstraße 34, Postfach 10 10 63, 4300 Essen FRG.
Tel: 0201 79971.
Part of the dual-mode technology project (Fabre and Klose 1987; Fabre, Klose and Somer 1987). The Essen system has an electric trolleybar from overhead supply. It is intended to use diesel buses on the existing road system in outer areas and trolleybuses where environmentally desirable. Guideways are shared with rail vehicles. The system began operation in 1980 on a 1.3 km. section of a former tramway. It was extended in 1983 and again in 1985 using the centre of the Autobahn A430. In Essen city centre the buses and trams use the same tunnels.

Adelaide
A 12 km. route, the Northeast Busway is planned, the first 6 km. having been opened in 1986. It was developed by Mercedes-Benz, PO Box 214, Glen Waverley, 3150 Adelaide, Tel: 566 9266. The maximum operating speed is 100 km.p.h. and it carries 4 million passengers per year, 30% more than the buses which it replaced. The 90 Mercedes buses have lateral guide wheels and can be operated on normal roads. Articulated buses may also be used. The concrete dual carriageway track is supported on bored piers. Rear guide wheels have been fitted to some buses to reduce wear of rear tyres but otherwise there have been no substantial technical problems. There are plans for another busway in the southern suburbs.

Rail systems

Advanced light rapid transit system
UTDC Inc. 33 Yonge Street, Toronto, Ontario, M5E 1E7. Tel: (416) 365 7124.
Powered by linear motors with axle bogies which can be steered; expected to reduce noise and maintenance needs; built in Vancouver, Toronto and Detroit.

Aramis (Arrangement en Rames Automatisées de Modules Independents en Stations)
SA Matra Transport, 2 rue Auguste Comte, 92170, Vanves, France. Tel: (1) 45 29 29 29.
Small cars carrying about 10 passengers, can be coupled together in groups of up to 15; speeds up to 54 km.p.h.; has been tested in Paris in the Boulevard Victor and at Orly Airport. At present, development is suspended.

Astroglide
Titan PRT Systems, 118 Mill Road, Park Ridge, New Jersey, 07656, USA.
Tel: (201) 930 0300.
Suspended monorail; linear induction motor maximum speed 120 km.p.h.; cars carry 20-50

passengers; installed in several airports and recreation gardens in the USA including Dallas and Los Angeles.

Bombardier Monorail
A straddle-type monorail running on a single concrete guidebeam, usually elevated; installations in Disneyland and several other recreational areas.

H-Bahn
Siemens AG, Werner von Siemens Straße 50, 8520 Erlangen, Federal Republic of Germany. Tel: 09131 70.
Duewag AG, Duisberger Straße 145, 4150 Krefeld 11, FRG. Tel: 02152 4491.
Elevated guideway with suspended cars of capacity 50 passengers; bogies run within the suspended beam on rubber tyres with eight lateral rollers for guidance; maximum speed 60 km.p.h.; installed on a 1.1 km. track at the University of Dortmund in 1984.

Maglev
People Mover Group, GEC Transportation Projects Ltd., P.O. box 134, Manchester M60 1AH. Tel: 061-872-2431.
A magnetically levitated short distance railway powered by linear induction motor; said to have low maintenance costs as there are no moving parts or wearing surfaces; speed up to 25 km.p.h. Cars carry 6 people seated plus 34 standing. A double track shuttle connecting Birmingham Airport and Birmingham International Railway Station (620 metres) was opened in 1984.

Maglev has a history extending back over more than 50 years. In the 1960s and early 1970s it was seen as a high speed (up to 250 m.p.h.) transport system linking cities in the USA. American interest has declined but there is still development in West Germany and Japan. Money (1984) provides a review of the history, technology and applications of Maglev.

M-Bahn
Magnetbahn GmbH, AEG Aktiengesellschaft, Emslander Straße 3, 8130 Starnberg, FRG. Tel: 08151 7730.
Magnetically powered with linear induction motor; bogie mounted cars with a capacity of 88 passengers and maximum speed of 80 km.p.h. There is a test track at Gleisdreieck U-Bahn Station in West Berlin, extended to a new station at the Philharmonic Concert Hall; also being tested at Brunswick Technical University. A line is under construction in Las Vegas from the city centre to the Cashman Field Sports and Convention Centre.

Mini Metro
Otis Elevator Company, Shuttle Division, 5 Farm Springs, Farmington, Connecticut 06032, USA. Tel: (203) 678 2000.
Linear motor propulsion and air cushion suspension; lateral guidance by rubber tyres on wall-mounted guide rails. Installed at Duke University North Carolina, at Tampa in Florida and at Serfus in Austria.

Newtram
Niigata Engineering Co. Ltd., Ground Transportations Systems Group, 4-1 Kasumigaseki 1-chome, Chiyoda-ku, Tokyo. Tel: 03 504 2111.
Light metro, rubber tyres on concrete guideway; power carried by lateral wheels on guideway; maximum speed 60 km.p.h. Two-axle cars have a capacity of 75 passengers. A 6.6 km. elevated line was opened in Osaka in 1981. It can be unmanned but cars on this line have had an attendant.

Portliner

Kawasaki Heavy Industries Limited, 1-18 Nakamachi-dori, 2-chome, Chuo-ku, Kobe 650-91, Japan. Tel: 078 341 7731.
Automated light metro, rubber tyres on steel or concrete guideway. In 1981 a 6.4 km. line was opened in Kobe. A second line of 4.5 km. is under construction and is due to open in 1989.

TAU (**T**ransport **A**utomatisée **U**rbain)

ACEC SA Transport Department, BP 4, 6000 Charleroi, Belgium. Tel: (3271) 44 21 11.
Automated steel on steel rail; can be used on curves of 10 metres radius. 950V three-phase traction power is collected from enclosed conductor rails. A 16 km. route is planned for Liège.

VAL (**V**éhicule **A**utomatique **L**éger)

SA Matra Transport, 2 rue Auguste Comte, 92170, Vanves, France. Tel: (1) 45 29 29 29.
Lightweight métro with rubber tyres on steel or concrete. Lateral guide wheels pick up the 750V DC current. Two-car sets have a seating capacity of 68. The Lille Métro was opened in 1983 and operates under fully automatic control without driver. A second line in under construction. The Lille métro was, when it was opened, the only one of its kind without driver on board. This has made it possible to adapt very quickly to changes in demand as no extra personnel is needed. Also it operated with only 185 staff, about half those of the Lyon and Marseille métros. Other distinctive design features are that it was the first French métro to be fully adapted to wheelchairs and prams and the separation of platforms and trains by sliding doors, preventing access to the track when there is no train at the platform.
VAL is also being considered in Toulouse, Bordeaux, Strasbourg, Paris (Orly Airport), Chicago (O'Hare Airport) and for Jacksonville Skyway (Florida).
A useful survey of VAL is contained in Felix (1986) and safety measures are explained in Gabillard (1986).

VONA-One

Nippon Sharyo Seizo Kaisha Ltd., 1-1 Sanbonmatsu-cho, Atsuta-ku, Nagoya, Japan.
A 3.6 km. automatic guideway system was opened at Yukarigaoka near Tokyo in 1982.

Westinghouse AGT

Westinghouse Electric Corporation, 2001 Lebanon Road, West Mifflin Road, Pensylvania Road, 15122 USA. Tel: (412) 464 5333.
Automatic guided transit, rubber tyre on concrete; lateral guidance by horizontal wheels running on a steel central guidebeam. Initially developed in 1971 at Tampa Airport (Florida) and since then at about 12 other locations including Orlando International Airport, the Miami Metromover opened in 1985 and Gatwick Airport.

Conclusions

Since the initial development of the railways a hundred and fifty years ago, there has been a steady stream of innovations. Apart from methods of propulsion and in particular the demonstration of electric traction at the turn of the century, the adoption and application of new technology in practice has been roughly inversely proportional to the extent to which it innovates. New technology must overcome both technical and economic hurdles before it can be applied successfully. New technological developments are in many cases expensive to develop, risky in technical terms and also in economic terms if they do not address a clear gap in the market or a substantial technical problem. Usually they involve expensive tooling-up for what is often only a limited production run. This applies even to technically successful developments such as the Grenoble tramway.

Many new technologies are solutions in search of problems. They have failed because they are not a substantial improvement on existing technology in terms of efficiency of operation or other objectives. The problems of the railways are more a product of the development of the motor vehicle and investment in road infrastructure than they are the result of technological limitations of the railways. There are however, some areas where there is scope for technical improvement. One of the clearest is the development of urban rail for physically restricted routes. In several cities there is a dilemma of whether to develop light rail along busy, physically restricted streets where ridership is likely to be high, or physically easier routes with lower ridership potential - disused or lightly used railway track for example. There is scope for improved technology to fit rail into awkward routes and to reduce environmental impacts, particularly vibration to neighbouring properties.

	maximum speed (km. per hour)	*capacity of cars*	*elevated*	*operational*
Adelaide busway	100		no	Adelaide
Aramis	54	10		no
Astroglide	120	20-50		Dallas, Los Angeles
Bombardier Monorail				Disneyland
H-Bahn	60	50		Dortmund
Maglev	25	40	yes	Birmingham Airport
M-Bahn	80	88		Berlin, Brunswick Univ.
Mini Metro				Duke Univ. Tampa, Serfus
Newtram	60	75	yes	Osaka
Portliner				Kobe
VAL		68	yes	Lille
VONA-One				Tokyo

Summary of some new public transport technologies

4 Claims for light rail transit

Some of the claims which have been made for light rail have been fairly international in application. There have, however, been differences in emphasis according to the political system and in particular attitudes towards public/private investment, towards public service provision and density of land uses. In France and several other West European countries the emphasis has been on the improvement of public transport services as an end in itself, seen as facing a crisis in the centres and inner areas of cities of relatively high density (usually more than 7,000 inhabitants per square kilometre) which has aggravated traffic congestion. In North America on the other hand, the development possibilities resulting from light rail have had particular emphasis (Wacher 1970, Potter 1979, Priest 1980, Cervero 1984). In fact, evidence on these effects is often required by central and local government before finance is approved. Except where otherwise stated, the claims outlined below refer to the British proposals as indicated in the appendix.

It has been claimed by transport authorities and other supporters of LRT that it will give greater accessibility to city centres whilst combatting the worst effects of the motor car. As a result, it will help improve the environment and will help economic regeneration. More specifically, the claims, which are very similar from city to city, can be summarised as follows:

* LRT will give access for many more visitors to city centres than would be possible by car and with only a fraction of the environmental damage. There would be distinct advantages over buses in this respect too.

* Like other forms of public transport, light rail gives access for those who do not have a car. It will also provide a better service than buses for the elderly, the disabled, mothers (and fathers) with prams and others for whom getting on a bus is an ordeal.

* LRT will attract motorists away from their cars for some journeys, mainly to city centres and suburban centres. It will help the acceptance of park-and-ride.

* It will increase public transport usage and make it economically stronger. The government has demanded that new urban rail should have no operating subsidy and in response, those proposing it have claimed this to be possible. It has been claimed therefore, that replacement of bus services by rail will reduce operating costs and subsidy.

* As a result of strengthening public transport at the expense of private transport, light rail will enable improvement of the environment: directly by a reduction in the obtrusive and unpleasant effects of motor cars and buses and indirectly by helping other environmental improvements such as pedestrianisation.

* Developing light rail will improve the image of the city in the eyes of industrialists, developers and others in a position to benefit the local economy. Improvement of access and the

environment will provide the conditions for strengthening of the local economy, particularly the shopping, employment and leisure sectors. Investment in transport infrastructure by the municipality or other public bodies will be seen by investors as a gesture of confidence in a city and will stimulate further investment.

Cervero's article (1984) includes the results of a survey on why LRT has been built or planned in twelve North American cities. The reasons most frequently given were as follows:
A) LRT is less costly than other rail;
B) it is more efficient than buses for heavy usage;
C) it gives a higher quality service than buses;
D) LRT can relieve highway congestion;
E) it can focus urban growth and support desired land use patterns;
F) it can be built more quickly and with less disruption than heavy rail.
These amount firstly to a support for urban railways and secondly that light rail is cheaper and easier to build than other forms of railway. In cities where building heavy rail is not an issue, reasons A) and F) would not apply.

Much of the discussion of the benefits of light rail has referred to city centres as it is here that there are the most obvious benefits of substituting public transport for the motor car. Many LRT routes connect suburbs and towns within a conurbation to the main city centre. Improved access to the smaller towns of the conurbation may bring some benefits for them (although improved access *from* them could have the opposite effect).

Less convincingly, it has also been claimed that light rail will result in the creation of office jobs and even less likely, industrial renovation along the route, not necessarily in town centres or suburban centres.

5 Capacity and ridership

Reference was made in section 1 above to the capacities of various forms of urban rail and ridership of those in operation was included in section 2. The relationships between ridership and length of route, number of stations or population of the transport authority are rough and unreliable. No doubt this is due partly to differences in rail technology. There are also fundamental differences between cities in terms of car ownership and policies towards traffic restraint and these have a great effect on public transport usage. Another important question raised by these figures is that of variations in definitions. Some transport authorities define a journey as an occasion when a given means of transport is used. Others define journey as movement from origin to final destination which may involve more than one means of transport. Thus a journey involving bus-metro-bus would be three journeys under the first definition, only one under the second, attributed to the principal mode.

There are also problems in calculating ridership. There are several reasons why in many transport authorities, ridership can only be estimated by ad hoc surveys:

* Through ticketing: it is very common for tickets bought on the first mean of transport in a journey to be usable on subsequent means of transport. Thus it is very common for passengers to buy a ticket on a bus which takes them to a metro station, perhaps with another bus journey subsequently. Often, the ticket must be stamped on the metro and second bus, but this data is not always used to calculate the number of metro passengers or users of the second bus.
* Travelcards usually give unlimited travel with no record or how many times or on what modes of transport they are used.
* In many countries it is possible to buy public transport tickets in shops or travel agents for subsequent use on bus or metro. For these reasons, ticket sales on bus or metro may be only a fraction of those using it.

The great majority of urban rail networks worldwide were started either shortly after the development of electric traction around the year 1900 or since the mid 1960s.

	annual passenger journeys/ km. of route (1986) thousands
Older extensive networks	
Tokyo	7,415
Paris Métro	5,859
Berlin	3,616
Montreal	3,247
Toronto	2,845
New York	2,656
Moscow	2,412
London Underground	1,418
Chicago	923

Recent networks

Lyon métro	5,584
Munich U-Bahn	4,993
Marseille métro	3,300
Lille métro	2,007
Atlanta metro	1,444
Washington DC	1,134
Nantes tramway	1,123
London Docklands LRT	875
Edmonton	660
Baltimore	583
San Francisco BART	512
Calgary	433
Portland (USA)	301
san Diego LRT	232
Miami	197

The new European networks have achieved ridership comparable to the older more extensive networks. The low ridership of the new American networks is very clear. Whilst public transport usage in Canada as a whole is as high as most European countries and several times that of the USA, ridership in Calgary and Edmonton is still relatively low.

The concensus view on the effects of LRT is that there is some increase in ridership where it replaces bus routes although this is not always the case. In Calgary for example, there have been gains for trips to the city centre but compensating losses elsewhere with little net effect on ridership. In Edmonton on the other hand, LRT may have accounted for ridership increases between 9% and 19% depending on assumptions about other factors affecting ridership (Gomez-Ibanez 1985).

Forecasts of ridership

Comparing forecasts with achieved ridership raises some problems of accuracy. Firstly, there are often several substantially different forecasts from different sources. Secondly, the physical development of the network may differ from that anticipated in the forecast. Thirdly, the data for forecasts and achieved ridership are in many cases in units not strictly comparable - differences in definitions of journeys, incomparability of dates and units of measurement (per weekday, per week for example). However, some comparisons are possible. Skinner and Deen (1980) quote forecasts for several recent urban rail networks in the USA: MARTA (Atlanta) phase A, 8,000 riders per day per line mile (1981), Baltimore section A 11,000 (1982), Metro-Dade (Miami) 10,000 (1985). These imply annual riderships of approximately 81.6 million, 55.8 million and 86 million respectively compared with actual riderships of 65 million, 13 million and 6.8 million respectively (section 2 above).

Cervero (1984) reports further ridership forecasts, mostly for years still in the future. There are, however, a few which can be compared with actual ridership. The forecast for Pittsburg was 18,000 journeys per average weekday or perhaps 6.2 million per year for 1985 depending on assumptions about weekend ridership. The actual ridership for 1986 was 5.3 million journeys. Similarly for Calgary, the forcast was 50,000 journeys per weekday or 17 to 17.5 million per year for 1986 compared with actual ridership of 12 million journeys.

The tendency for forecasts to be high in North America has not always been repeated in Europe. The 1988 forecast for the Lyon métro was 252,000 journeys per average winter weekday (Société de Economie Mixte du Métropolitain de l'Agglomération Lyonnaise 1984a). The actual figures are not yet available, but with a 1986 ridership of 86 million journeys, it is quite likely that the forecast figure will be exceeded.

The accuracy of forecasts will depend on several factors:
* public reaction expressed in journeys per person per year, which in turn will be influenced by fares policy, traffic restraint, planning permissions and many other factors within public control;
* the number of people locally, again influenced by publicly controllable factors as well as demographic factors of births, deaths and migration;
* the local economy and its effects on demand for development and degree of segregation of land uses.

Trends in all of these factors are partly a matter of free will, partly a matter of public control. In many cases, control and forecasting are carried out by the same public agencies. This raises the question of whether the forecast is intended to be an estimate of what will happen in the absence of intervention by public authorities or an estimate of what the agency itself will be able to bring about.

Forecasts may vary according to the commitments of those making them and any external pressures which may be present. Many of those working on light rail studies have interests which are not independent of whether or not it is built. If those influencing implementation, perhaps by the granting of subsidies, leave the forecasters with the impression that expected future ridership will influence their decisions, we should not be too surprised if the forecasts are not entirely independent.

Estimation of what will happen in future is not always the sole prpose of forecasting. In pollution control for example, forecasts may have a propaganda value. A high forecast may be used to attract attention to an impending problem so as to cause action to reduce it. The shock effect of the forecast itself may cause the forecast to be too high.

6 Costs and funding

Costs

The construction costs of urban rail vary greatly according to four main groups of factors: the technology being built, secondly the extent of demolition, disturbance and rebuilding, thirdly ground conditions and finally the extent of underground or elevated construction. The following table illustrates the wide variation in costs

	length (km.)		*stations*		*construction costs*	
	total	*underground*	*total*	*underground*	*total*	*per km.*
Caracas line 1 phase 1	12.3	11.0	14	12	1,440	117.1
Nagoya line 6	14.9	14.9	17	17	1,685	113.1
Hong Kong Island Line	12.5	12.5	12	7	1,400	112.0
Sâo Paulo	24.3	17	26	16	2,338	96.2
Osaka	14.1	13.8	13	12	898	63.7
Berlin U-Bahn	4.6	4.6	5	5	275	59.8
Hong Kong Mainland	26.1	20	25	18	1,519	58.2
Baltimore NW line ext.	18.1	6.7	12	6	995	55.0
Santiago	25.6	20.8	35	35	1,015	39.6
Hannover U-Bahn	2.8	2.8			108	38.5
Tunis LRT line 1	8.1	0.2	11	1	233	28.8
Manila LRT	15.0	0.0	18	0	200	13.3
Hannover	69.0	12.0	110	14	750	10.9
San Diego LRT	25.6	0	18	0	127	5.0

Construction costs of some recent local urban railways: million US$ 1983.
Source: World Bank (1983).

Skinner and Deen (1980) quote costs of several recent USA urban rail systems at the time of building, which can be recalculated for comparability with the above data: MARTA (Atlanta) $45.3 m. per kilometre, Baltimore Section A $61.5 m. Miami $26.1 m. Buffalo $44.7 m. The relatively low cost for Miami was possible due to the absence of underground construction.

Other examples are as follows:
Pittsburg $415 m. for 36.22 km. (Taylor 1980);
Edmonton $64 m. for 7.25 km. (1.6 km. underground) 1977 (Sullivan 1980);
Calgary $175 m. for 12.4 km, none underground (Cervero 1985);
Grenoble 1,020 m. francs (1985) for 8.8km., all surface;
Lyon 395 m. francs per kilometre, mostly underground (1983)
Lille 2,600 m. francs for 13.5 km., mostly underground, remainder on viaduct (end 1986);
Marseille 2,700 m. francs for line 2 (9km., mostly underground), 1986.

In several of the proposals in Britain as indicated in the appendix, the costs are very low for the initial phases at least, as they are largely using existing British Rail track or following the alignment of a disused railway.

Operating costs

One of the main justifications put forward for LRT is that operating costs are lower than the buses that it replaces. This is due to it carrying more passengers per driver. Maintenance costs however, may be higher due to the more complex technology of the vehicles and the need to maintain track, power supply and signalling. Thus in San Diego, Gomez-Ibanez (1985) calculates that operating costs on LRT are actually higher at 96 cents to $1.02 per passenger (1982-84) compared with 79 to 82 cents for the buses that were replaced. When allowance for capital costs are made, LRT costs nearly three times as much per passenger compared with buses.

In Calgary, the same author calculates that total costs rose by 3.3% per year for the four years before LRT opened but by 19.1% per year in the four years after. For Edmonton, Bakker (1980) calculated the percentage of operating costs of LRT from fares as 27% in 1978 and 40% in 1979.

Funding

The current schemes in Britain will be considered for central government assistance under section 56 of the Transport Act 1968. Some of the current LRT proposals will be eligible for assistance from the European Regional Development Fund. As a yardstick we may take the sources of finance as being approximately 18-20% section 56 grants, 18-20% locally raised capital, 37.5% ERDF and the remainder from the private sector. This however, will vary from city to city. It seems likely that Bristol for example, will rely to a much greater extent on private capital, not being eligible for ERDF support.

For several cities the most serious obstacle at the moment is achieving demonstrably workable financial arrangements. Apart from London and Bristol, the problem is to arouse sufficient interest from the private sector. As well as the revenue from fares and contracts for development, the prospect of some revenue from increased property values will be a very important factor in attracting private sector interest.

Of the cities with LRT proposals outside London, Bristol has one of the more buoyant property markets. It is no coincidence that the LRT proposals are being promoted by a private sector company, Advanced Transport for Avon Ltd. As well as section 56 finance, ATA expects that private sector developers will recognise that LRT will give them financial benefits sufficient for them to engage in joint venture arrangements with the LRT company. The LRT company would receive a share of the profit in return for a commitment to develop LRT. As elsewhere, there is also the possibility of agreements between planning authority and developers under section 52 of the Town & Country Planning Act 1971. This may bring in some of the betterment where property development is involved. These situations, of course, would only include only some of those where increases in property values have occurred but they may be of some significance.

Where urban rail development results in an increase in land values, one of the obstacles to recouping betterment in Britain is the division of responsibility between the promotion and development of urban rail, which primarily rests with the transport authority, responsibility for land use planning which rests with the local authority, and responsibility for the acquisition and development of land which is partly that of the local authority planning department but is also shared with other local authority departments, public bodies such as British Rail and the private sector. The problems are of fragmentation of powers to implement the land use/transport system and in many cases, unfamiliarity, inadequate expertise and lack of incentive in property development amongst some of the agencies who have the powers. The urban development corporation may have some advantages in implementing urban rail.

In several cities in the USA and Canada, the development of urban rail has been partly financed by deals between public authorities and private sector entreprenneurs. Basically these have depended on the quite simple principle that urban rail has been seen as resulting in increased site values, therefore private sector entreprenneurs have been willing to make contributions towards the cost of construction in order to ensure that urban rail is developed.

Developers of shopping centres such as the Gallery Center in Philadelphia have contributed towards urban rail construction costs (Priest 1980). In this case it was significantly the city agency (the Redevelopment Authority) not the transport authority which pursued the joint public/private development (Orski 1980).

Municipalities have been able to assist urban rail development directly (and indirectly by helping private sector property developers to create betterment) in several ways: land assembly, direction of development by planning powers, financing of related improvements such as footpaths, open space and landscaping, tax reductions and urban aid grants. In Portland (USA) the Transit Investment Corporation was created to foster private investment around stations. Public infrastructure, particularly sewers were improved, land was assembled by public authorities and there were revisions in zoning densities.

It is quite common in the USA and Canada to allow higher density development near to stations as in Portland and Sacramento. In Calgary and Edmonton, up to 80% additional floorspace has been allowed within 400 metres of the stations. In Calgary, parking requirements were reduced and payments allowed in lieu. Stations have been designed as multi-purpose with mixed commercial and residential uses. Around central area stations more floor area has been allowed in buildings which provide pedestrian arcades, public open space and access to the station. If developers provide temperature controlled bridges, even higher density is allowed.

In 1981 the Edmonton line was extended 2.4 km. to Clareview Centre. A special fee was negociated between city authorities and two landowners which raised over half of the cost of $6.2 million (1980 Canadian dollars). Developers paid the city $4,200 per gross developable hectare and donated 4.6 hectares for the right-of-way. The developers were granted the right to the airspace above Clareview station for $1 per year up to the year 2000.

Taxation sources

In most European countries, the construction of local railways is funded from both central and local government. Belgium and the Netherlands are exceptions, where funding for both contruction and operation are exclusively from central government. In all countries, private investment is rare.

Unlike the situation in Britain, in both France and West Germany there are earmarked taxes for public transport subsidy, versement transport and mineral oil tax (Mineralölsteuer). Versement transport was introduced under the Law of 11th July 1973 as a local tax in all towns of more than 100,000 population (extended to communes of 30,000 inhabitants since 1982) and is charged to firms employing ten or more people. The level varies from city to city (2% in

Paris, 1.5% in Lyon for example) and is decided locally. The percentage is charged to the firms on the salaries of employees up to a ceiling (the securité social) determined nationally each year. For example, in a year where the ceiling was 80,000 francs, for an employees earning 50,000 francs the firm would have to pay 1.5% of 50,000 francs (in Lyon for example). For an employee earning 100,000 francs, the firm would be charged 1.5% of 80,000 francs.

The money from versement transport has been used to finance capital works including the new métros in Marseille, Lyon, Lille, Nantes and Grenoble. In Nantes for example, it provided 60% of the capital costs, the remainder coming from central government. For a proposed new rail line in Paris, the proportions will be 39% from central government, 33% from the région, Ile de France, 22% from versement transport and the remainder from the City (Goldsack 1985). It has also been used to repay loans for investments or network extensions or other improvements to services and as compensation to operators for reduced fares for travel to work. In 1980, versement transport provided 3,134 million francs out of a total of 7,710 million francs subsidy in the Paris Region and 1,876 out of a total of 3,638 million francs in other cities (Hanappe 1983). Durand and Pêcheur (1985) point to the differences in services and usage of public transport in towns which have levied versement transport and those which have not. In 1983 levels of both service and usage were about twice as high in those town which levied versement transport.

Articles 7 and 15 of the Loi d'Orientation des Transports Intérieurs 1982 allows for contributions to versement transport by all who gain from public transport services. Fournie and Pêcheur (1985) argue that since 1982, versement transport has not been used for its original purposes but has just been used to fill in deficits in transport authorities. They argue that the principle of employer contribution of versement transport should be extended to shops as they benefit from public transport bringing in their customers as do industrial firms. As the authors point out, there would need to be safeguards such as for small neighbourhood shops whose customers are mostly so local that they walk.

As in France, there is a payroll tax in Vienna, in this case devoted exclusively to the construction of the underground railway. There are no comparable taxes in other Austrian cities.

The mineral oil tax in West Germany is 6 pfennigs per litre. Unlike versement transport, it is used only for capital costs, not operating costs of public transport. In distributing the proceeds of the tax the Federal Government takes into account environmental considerations such as noise and air pollution reduction and effects in reducing accidents as well as economic and operational validity of proposals. If approved, a project can receive up to 60% of construction costs from the Federal Government, 20% from the Land (state) and 20% from the Gemeinde (municipality) (60% from the Federal Government, 40% from the Land for the S-Bahn). Hass-Klau (1987) quotes 50% central government funds, 25% Land and 25% Gemeinde as more usual.

Not all of the proceeds of the mineral oil tax are used for local transport. In 1980, 11% was used for this purpose, 51% went into general tax revenues, 28% for trunk roads and 11% for other transport subsidies. In 1982, Mineralölsteuer raised 2,290 million DM out of a total subsidy of 2,574 million DM (Bundesminister für Verkehr 1984). This was about 20% more than versement transport in France, including inflation between 1980 and 1982. The proceeds of Mineralölsteuer are used equally for both local road construction and local public transport.

Under the Municipal Transport Finance Act (Gemeindeverkehrsfinanzierungsgesetz) 1975 projects can be financed by up to 60% by the Federal Government (75% along the border with

East Germany). In 1982, the Federal Government provided 58%, the Länder (states) 7.5% and the Gemeinden (municipalities) 24% of the money for capital projects. 88.7% of the expenditure was with the catchment areas of the eleven largest cities.

Between 1967 and 1981, 7,600 million DM were spent on S-Bahnen (67% from the Federal Government, 25% from the Länder and 8% from the Gemeinden: Girnau 1983). In recent years, Deutsche Bundesbahn has had over four times the subsidy of British Rail and moreover planning has been allowed on a more secure basis. Five year plans of investment are approved by the Federal Government whereas each project for British Rail has to be approved separately (Abbott 1985).

In the USA there is a range of taxes and user charges earmarked to pay for public transport including payroll taxes, property taxes, vehicle taxes, fuel taxes, sales taxes and mortgage taxes. Tolls for the use of bridges and tunnels and lotteries are also common (Pucher 1980; Erskine 1983). The mechanisms for raising money for transport vary from city to city. In New York bridge and tunnel tolls provide a considerable part of the revenue. In Boston, cigarette tax is important. Petrol and motor vehicle taxes are significant in Chicago, Detroit, Seattle and Miami. Portland and Cincinnati depend on a payroll tax. In those cities which have recently built urban rail networks including Miami, San Diego, Los Angeles and Portland, sales taxes or property taxes are important sources of revenue. A detailed analysis for the period 1973-78 is contained in Pucher (1980).

Pucher (1988) considers that earmarked taxes have reduced the pressure to economise at the local level. In the USA, dedicated taxes have led to inflation of costs and unjustified expansion in services. In France, versement transport has helped to expand public transport services but unit costs have increased at only about the same rate as for other countries.

Recoupment of betterment

For most urban rail proposals it is claimed that there would be a considerable increase in land values and property prices, particularly near to the stations. Some increases in values would precede railway building in anticipation of improved accessibility, some would follow. If some of these increases could be recouped and channelled towards the capital or operating costs of urban rail, this could be a significant contribution, perhaps sufficient to make the difference between viability and non-viability.

Under the Development Land Tax Act 1976 and the Finance Act 1979 there is a levy of 60% on the estimated increase in land values as a result of granting planning permission. Under section 52 of the Town and Country Planning Act 1971 a local planning authority has the power to make agreements with private sector developers. Local planning authorities have had a lot of freedom to determine the scope of these agreements. They have been used to make developers carry out what at the time appeared to offer the prospect of unprofitable development, such as housing in unpopular districts, as a condition of planning permission for a development with better prospects.

Some of the proceeds of increase in land values is recouped by way of the general taxation system on company profits, personal income, death duties on estates, local taxes such as rates (community charge) and in many other diverse ways but this is not earmarked for transport or any other purpose.

In the USA, property taxes may rise with increases in property values resulting from urban rail development. This practice of 'value capture' has been used to finance both capital and operating costs of urban rail. Imitating this in Britain seems to have become even more unlikely since the replacement of the rating system with the community charge.

It is quite possible that some betterment could be diverted towards light rail construction without the need to resort to legislation. Developers, industrialists and others with an interest in the value of land may see the development of an urban railway as beneficial and they may be willing to make contributions to its construction or operation to ensure that it is built. This is one of the main ways that Advanced Transport for Avon Limited expects to finance the proposed Avon LRT network (see appendix below).

In Britain, there are no special powers for recouping betterment in relation to local plans prepared under the Town and Country Planning legislation.

In France there are several types of local plan, each with complementary powers to address the problem of betterment. In a zone d'aménagement concerté, developers may be required to construct public goods such as schools, although this has recouped only a small part of the profits of the private sector (Mény 1982). Also in a ZAC land is exempt from the taxe d'urbanisation, a tax on underdeveloped land. Land owners can insist that the municipality or developer responsible for implementation should purchase the land.

Zones d'aménagement concerté often cover areas which in Britain would probably most usually be declared action areas (Town & Country Planning Act 1971) although they are not necessarily prepared by the communes. They can also be prepared by the département, State, établissement public (public authority) or by a private developer. When undertaken by a developer in the private sector, a formal agreement for the ZAC has to be made with the commune or other public authority. A ZAC is approved by the préfet except for those involving renovation or building of at least 10,000 houses, where a State subsidy is needed to finance infrastructure or where an abnormal subsidy is requested by the commune or by the developer. In those case, ZAC approval must be by the Conseil de Direction du Fonds de Développement Economique et Social advised by the préfet, or in the case of ZACs for industry, commerce or port uses, by the minister responsible for town planning. ZACs have been used to control property speculation and to ensure the planning and implementation of development around several of the Marseille métro stations.

ZACs were instituted under the Loi d'orientation foncière 1967. Zones d'aménagement différé were instituted in 1962 mainly for extensions to urban areas, new towns, tourist areas and prior to urban renewal. When a land owner decides to sell, the public authority or designated private sector developer has the right to purchase land at existing use price one year before declaration of the ZAD. This provision remains for 14 years after declaration.

Whereas ZADs controlled land prices, mainly on the periphery of urban areas, zones d'intervention foncière were introduced in 1975 to extend their powers and to give municipalities the right to be informed of land and property transactions. They could acquire land and property to further planning and social policies including conservation. Like ZACs, ZIFs and ZADs have been used to control speculation in land and property around the new French métro stations.

In West Germany, the Urban Development Act (Städtebauförderungsgesetz) 1971 allows for many powers to secure planning and implementation of renewal programmes. It also includes powers of land acquisition and powers to control land transactions and land values. It is possible to limit profits and municipalities may form valuation panels to control prices. Municipalities may also take powers to freeze land prices.

Formuli for distributing subsidies

In some countries there are defined formuli for the allocation of subsidy from central government. In the USA there are specific percentages to be matched by state and municipal government, the percentages varying from one subsidy programme to another. For public transport, the main determinants of central government subsidy are population, population density, level of service and ridership.

In Sweden, central government subsidy is largely confined to capital investment in rail at a fixed rate of 70%. The limited operating subsidy is calculated according to route length and vehicle kilometres for a pre-determined minimum level of service.

In France there are no distribution formuli. Capital projects attract between 40% and 55% subsidy from central government according to the kind of project.

In Italy the level of central government subsidy to the provinces is mainly determined from past allocations which in turn is determined by past costs. In turn the extent to which these subsidies are distributed to the municipalities is influence by vehicle kilometres with allowance for variations in operating conditions.

	Britain	*France*	*West Germany*	*USA*
from central government	yes	yes	yes	yes
from local government	yes	yes	yes	yes
earmarked taxes	no	versement transport	Mineralölsteuer	various; most cities have such taxes from various sources
recoupment of betterment	s52 agreements (T&CP Act 1971)	ZAC ZIF ZAD	can freeze land values under Städtebauförderungsgeset 1971	property taxes payroll taxes

<u>*Urban rail funding in Britain, France, West Germany and the USA*</u>

7 Responsibilities for operation

Organisation of public transport

France

In France, public transport in most of the large cities is operated either under franchise to the local authority (Nice, Nancy, Strasbourg), under contract to a consortium of local authorities (Bordeaux, Grenoble) or as in Lyon, Toulouse and Nantes for example, a société d'économie mixte, a company in which a municipality has an interest, usually in partnership with other semi-public bodies such as chambers of commerce, banks and statutory undertakers. Marseille has one of the few municipal undertakings. In Paris, Lyon, Marseille, Lille and Nantes there are conurbation-wide transport authorities with clearly defined functions.

West Germany

In the majority of West German cities, public transport is operated by municipally owned companies (e.g. Aachen, Augsberg, Bochum/Gelsenkirchen, Bremen, Cologne, Dortmund, Duisberg, Düsseldorf, Essen, Krefeld, Nuremberg, Stuttgart, Wiesbaden, Wuppertal) or as municipal undertakings (e.g. Bonn, Karlsruhe, Mannheim/Ludwigshafen, Mönchengladbach).

Metropolitan transport authorities or Verkehrsverbünde were created for Hamburg (1965), Hanover (1970), Munich (1972), Frankfurt (1974), Stuttgart (1978) and Rhein-Ruhr (1980) to unify fares between enterprises (over 20 of them in the case of Rhein-Ruhr), to coordinate timetables and eliminate duplicated services. The formation of the Verkehrsverbünde is varied (see entries under Hamburg, Frankfurt and Munich below for example). There are also 45 Tarifgemeinschaften. Transport undertakings are organised into a national association, the Verband Offentliches Verkehrsbetriebe (Association of Public Transport Enterprises) which includes 168 public transport firms, the commuter lines of the Deutsche Bundesbahn, the Federal Post Office bus service and the rail and bus lines of 66 non-Federal public railways.

USA

The USA has only a short history of large scale public ownership of urban transport undertakings. At present, nearly 90% of total passenger miles and nearly 90% of revenues are accounted for by publicly owned enterprises compared with 25% in 1948. Many undertakings came into public ownership in the 1960s and 1970s when ridership, revenue and levels of service were all in sharp decline, but in most cities the change has only slowed down the decline (Dunn 1980).

The fragmentation of jurisdictions in US metropolitan areas has been cited as a significant problem for urban rail (Dunn 1980). By contrast, most west European countries, including West Germany and Britain, have proceeded further with rationalisation of local government areas. Even France, with its 36,363 communes has overcome the problem to some extent with the creation of communautés urbaines to coordinate administratively a large number of communes in a single conurbatiuon and to give cohesion in fanancial, planning and transport services. The problem of fragmentation in public transport in US cities and some approaches to coordination are addressed by Kidder (1980). In some cities there have been taxes applied to the whole transit area, sometimes by the earmarking of state taxes. In other cities, authorities act independently and buy services at a fixed rate.

One of the major points of debate in public transport at present is the extent of private versus public investment and management to be planned for. Pucher (1988) considers that private management and operation increases the efficiency of public transport. He points to several studies of the relationships between levels of subsidy, productivity and cost which come to the conclusion that high subsidies encourage higher costs and low productivity (Bly et al. 1980, Pucher et al. 1983, Anderson 1983 and Pickrell 1985). Almost all the transport systems in France except Paris and Marseille are privately managed which seems to have contributed to cost control.

Below are listed some examples of public transport management, selected to illustrate a range of situations in which light rail and metros are operated:

Atlanta

Bus and metro for Atlanta and neighbouring counties are provided by a transit authority governed by a representative board.

Metropolitan Atlanta Rapid Transit Authority (MARTA), 401 West Peachtree Street NE, Suite 2200, Atlanta, Georgia, 30365, USA.

Calgary

Bus, trolleybus and LRT are operated by a municipal undertaking:
City of Calgary Transportation Department, 928-32, Avenue Connector NE, PO Box 2100, Postal Station M, Calgary, Alberta, T2P 2M5. Tel: (403) 277 9711.

Edmonton

Bus, trolleybus and LRT are operated by a municipal undertaking:
Edmonton Transit, PO Box 2610, Edmonton, Alberta, T5J 3R5. Tel: (403) 428 5648.

Frankfurt

The Frankfurter Verkehrs- und Tarifverbund is a Gesellschaft mit beschränkter Haftung (GmbH: limited liability company) coordinating the operation of public transport by the municipality (Stadtwerke Frankfurt) which operates the U-Bahn, Straßenbahn and about 60% of the buses and Deutsche Bundesbahn which operates the S-Bahn and the remainder of the buses. The FVV has a board and standing committee with equal numbers of representatives of the Stadtwerke Frankfurt and Deutsche Bundesbahn. It also has two managing directors, one nominated by each of Stadtwerke Frankfurt and Deutsche Bundesbahn. There is an advisory body (Rat) consisting of representatives of the City of Frankfurt, the Land Hessen and the Bundesrepublik and an auxiliary advisory body (Beirat) which co-opts other relevant interest.

Frankfurter Verkehrs- und Tarifverbund GmbH, Mannheimer Str. 15-19, 6000 Frankfurt am Main 1. Tel: 06 11/2 69 40.

Gothenburg

Trams, buses and ferries are operated by Göteborgs Spårvägar, Box 424, 401 26 Göteborg. Tel: 031-800 500.

Planning of transport is carried out by the several local authorities that make up the 172 square miles (445 km. sq.) of the transport authority area. Since 1977 fares for regional transport services have been coordinated by the Association of Municipalities for the Gothenburg Region. The Göteborgsregionens Lokaltrafik AB (GLAB) was formed on 1st July 1983 taking over responsibility for coordination of fares for regional public transport covering 13 municipalities. GLAB covers three counties and is a company owned by them. It purchases tram, bus, rail and ferry services. The municipality assumes financial responsibility within the city area and owns Göteborgs Spårvägar. Where Göteborgs Sparvägar routes pass outside the city, GLAB purchases the services outside the boundary. Göteborgs Spårvägar also sells services such as ticket printing and maintenance of ticket validating machines to GLAB for the whole area.

Grenoble

Transport authority:
Syndicat Mixte des Transport en Commun, "Le Forum", 3, rue Malakoff, 38000 Grenoble. Tel: 76.44.46.82

There are two public transport operators:

90% of public transport journeys are accounted for by SEMITAG a société d'économie mixte representing 23 municipalities and responsible to the Syndicat Mixte des Transports en Commun (SMTC).
Société d'Economie Mixte des Transports de l'Agglomération Grenobloise (SEMITAG), 15 avenue Salvador-Allende, 38130 Echirolles, BP 258X, 38044 Grenoble, cedex. Tel:(76)33 04 04

10% of public transport journeys are accounted for by VDF, a company owned by the département.
Régie départementale de voies ferées du Dauphiné (VDF), 20, bd. Agutte-Sembat, 38000 Grenoble. Tel: 76.47.73.08.,

Hamburg

The Hamburger Verkehrsverbund is a Gesellschaft bürgerlichen Rechts, formed from the pre-existing public transport companies operating in the sub-region:
Hamburger Hochbahn Aktiengesellschaft which now operates the U-Bahn and about 70% of the buses;
Deutsche Bundesbahn, Bundesbahndirektion Hamburg which operates the S-Bahn;
Eisenbahn-Aktiengesellschaft Altona-Kaltenkirchen-Neumünster which operates three other Schnellbahn lines;
Verkehrsbetriebe Hamburg-Holstein Aktiengesellschaft which operates about 21% of the buses;
Pinneberger Verkehrsgesellschaft mbH which operates about 7% of the buses;

Kraftverkehr GmbH -KVG which operates about 2% of the buses and
HADAG Seetouristik und Fährdienst Aktiengesellschaft which ferries about 3.3 million passengers per year by sea.

HVV has the duty to secure the provision of publc passenger transport as effectively and efficiently as possible. Relations between HVV and its constituent companies are governed by contracts setting out the rights and duties of each, the distribution of income between them and details of their organisation and working.

Miami

Bus and metro services are provided by a department of the county authority responsible to the board of the County Commissioners.

Dade County Transport Administration (Metro-Dade), 111 MW1 Street, Miami, Florida, 33128, USA. Tel: (305) 375 5765.

Lille

Bus, tram and VAL are operated for the public transport authority by operating undertakings managed under contract. TCC is the operating agency of a syndicat mixte involving the city of Lille and the Département du Nord.

COTRALI was formed in 1981 by the merging of the Lille bus undertaking, Compagnie Générale Industrielle de Transports (CGIT) and the Roubaix-Tourcoing bus and tram undertaking (Société Nouvelle de l'Electrique Lille-Roubaix-Tourcoing (SNERLT). COTRALI works under the overall control of TCC and is managed under contract by the Transexel group. CONTRALI has responsibility for bus and train services and acts as a co-ordinator of these services with the métro.

COMELI is responsible for the operation of VAL. There is a management contract with the Transexel group and MATRA, the manufacturers of VAL. Each of these has a 50% share in COMELI.

Lyon

The Syndicat Mixte des Transports pour le Rhône (SYRTAL) is the owner of the network and is responsible for its operation and development within the Communauté Urbaine. It is the policy making body and has representatives of the Département du Rhône (4) and the Communauté Urbaine (4). It fixes the level of versement transport. It also has two executive companies: the Société d'Economie Mixte du Métropolitain de l'Agglomération Lyonnaise (SEMALY) and the Société Lyonnaise des Transports en Commun (TCL). SEMALY carries out research for construction of the network including the métro, and for equipment. Research includes impact studies and research on transport needs and economics for example. Public transport is operated by the private company TCL.

Société Lyonnaise de Transports en Commun, 50 cours Lafayette, 69423 Lyon cedex 3.
Tel: (7)860.25.53

Marseille

In Marseille, the distinction between policy making and operation is not quite so clear as in Lyon. The Régie des Transports de Marseille (RTM) operates all public transport. At its head, the Council comprises four representatives from the City Council, one conseiller général, two members nominated by the Commissaire de la République, one member of the Chamber of Commerce and two staff representatives. The Société du Métro de Marseille (SMM) is responsible for the construction of the métro. The Office de Coordination des Transports, de la Circulation et du Stationnement de Marseille (OCOTRAM) was formed in 1901 with the aim to promote overall policies for urban journeys. It is presided over by the Mayor and has representatives of the City of Marseille (Agence d'Urbanisme, Direction Générale des Services Techniques), SNCF, SMM, RTM and Société Marseille Parc Auto. It has followed policies based on priority for public transport such as provision of busways, priority at traffic lights and reorganisation of the network.

Régie des Transports de Marseille, 10 Av. Clot-Bey, 13271, Marseille cedex 8 B.P. 334.
Tel: 33.91.95.55.55

Société du Métro de Marseille, 44, Av. Alexandre Dumas, 13008 Marseille.
Tel: 33.91.77.68.82.

OCOTRAM, Parc Valmer, 271 Corniche-Kennedy, 13007 Marseille. Tel: 91 55 31 48.

Montreal

Bus and metro services are operated by an urban transport corporation responsible to Montreal Urban Community.
Société de Transport de la Communauté Urbaine de Montreal, 159 rue Saint-Antoine Ouest, Montreal, Quebec, H2Z 1H3. Tel: (514) 280 5500.

The Commission de Transport de la Communauté Urbaine de Montreal was established in 1970. It has developed the métro network and integrated bus services. It was renamed the Société de Transport de la Communauté Urbaine de Montreal in 1985.

Munich

Bus, Straßenbahn and U-Bahn are provided by a city undertaking which is also responsible for the other public utilities, under the policy of Münchner Verkehrs- und Tarifverbund (MVV). Suburban rail is operated by Deutsche Bundesbahn and suburban buses by 45 operators under MVV policy framework. MVV is responsible for transport planning, definition of services, marketing and tariff structure.

Like the FVV, the Münchner Verkehrs- und Tarifverbund is legally constituted a GmbH, it has two partners, the City of Munich and Deutsche Bundesbahn, each nominating a director. MVV also has a board of directors, administrative board with representatives of the City of Munich, State of Bavaria and the Bundesrepublik and a managerial board responsible for the administration office, press and public relations and research. The City and Deutsche Bundesbahn own the transport infrastructure and bear commercial responsibility. MVV organises transport provision and planning and investment and provides the partners with operating instructions. It also organises ticket sales, pricing, distribution of fare receipts and compensation for services rendered.

Münchner Verkehrs- und Tarifverbund GmbH, Thierschstraße 2, 8000 Munich 22.
Tel: (089) 29 55 52.

Nantes

In Nantes, the Syndicat Intercommunal à vocation Multiple de l'Agglomération Nantaise (SIMAN) was created in 1982 to coordinate conurbation-wide functions of the 19 communes of Greater Nantes. Its main areas of interest are town planning and development, public transport, provision of school transport, provision of the highway network including road safety and facilities for the handicapped. SIMAN has 65 members nominated by the communes and functions rather like a municipal council at the scale of the conurbation (SIMAN 1987). Under the direction of SIMAN, the Société d'Economie Mixte des Transports en commun de l'Agglomération Nantaise (SEMITAN) is responsible for the operation of the public transport network, both buses and the tramway, and the implementation of capital works and investments decided by SIMAN, for example the tramway, busways, bus and tram purchase and maintenance. It is a société d'économie mixte in which SIMAN has 65% interest, the Société Central pour l'Equipement du Territoire has 14.95%, the Chambre de Commerce et d'Industrie de Nantes 10% and the Caisse d'Epargne et de Prévoyance de Nantes 10%. I6 routes are operated under contract by private firms.

Portland

Bus and LRT services are provided by a transport authority Tri-Met responsible to the state and controlled by a representative board. A report is contained in Wilson, Morgan and Clark (1987).

Tri-Met Metropolitan District of Oregon, 4012 Se 17th Avenue, Portland, Oregon, 97202, USA.
Tel: (503) 238 4834.

Toronto

Bus, trolleybus, metro and tramway are provided by a transit commission responsible to the metropolitan council.

Toronto Transit Commission, 1900 Yonge Street, Toronto, Ontario, M4S 1Z2, Canada.
Tel: (416) 393 4000.

Toronto has used transit investment to direct and foster development. In 1985 a 6.5 km. section of advanced LRT from Kennedy metro station to Scarborough in the NE of the city, a developing retail and municipal centre. Also, a new east-west metro line from Scarborough through the developing North York Centre westwards. The Ontario government is expected to contribute 75% of the construction costs, as for previous lines. A report is contained in Thompson (1988).

Vancouver

Bus, trolleybus, ferries and Skytrain are owned and operated by or for the provincial corporation. In 1985 this was merged with the previous government-owned bus operator. The

Vancouver Regional Transit Commission determines policy and funding to guide the provincial corporation.

Skytrain was developed by the provincial government but was contracted out to a private company. the British Columbia Rapid Transit Company (1200 West 73rd Avenue, Vancouver BC, V6P 6MZ Tel: (604) 264 5000).

	France	*West Germany*	*USA*
common modes of organisation	franchise to LA sociéte d'économie mixte	Verkehrsverbünde Tarifgemeinschaften; municipally owned companies	municipal undertakings with representative board from municipalities
public/private operation	largely private	public	90% revenue public

Organisation of public transport in France, West Germany and the USA

8 Technical specifications

A summary of the main characteristics of urban rail was contained in section 1. Other significant characteristics of light rail are as follows:

Height of passenger access

Many transport authorities have felt that high platforms have been an important disadvantage of older urban railcars for access by the elderly, disabled, people with prams or heavy luggage. For most of the new rail systems this problem has received a lot of attention. Many have low floors which with platforms at some of the stops, allow near level boarding. Carriages on several new LRT networks have floors as low as 0.35m. or even less, for example, Würzburg 0.3m., Turin 0.34m., Grenoble 0.345m., Bern 0.35m. This applies to only part of the floor of the car with steps up to a higher floor level over the wheels.

Safety, security and vandalism

These are potentially very serious problems to be overcome if a new rail network is to achieve the public confidence it needs to be successful. Many of the British light rail proposals follow close to existing bus routes. A ride on these routes will often convey vividly the possibilities of mis-treatment that could quickly tarnish the shiny, high-tech image of a new tramway.

Even more serious is the problem of violent crime. The Marseille métro quickly clears of passengers in the evening. Even in Lille, COMELI has gone to great lengths to ensure passenger safety by installing close circuit TV and an intercom systems to patrol guards.

London Docklands light railway has so far fortunately not attracted much crime but has a number of measures to deter it: close circuit TV on every station, brightly lit stations in full public view, a 'panic' button on every platform, 'train captains' with two-way radio and a direct line to Limehouse police station.

	length (m.)	*width (m.)*	*floor ht. (m.)*	*weight (tonnes)*	*axles*	*seats*	*capacity*	*speed (km.p.h.)*
Grenoble	29.41	2.74	0.35	43.90	6	54	254	70
Hannover	28.28	2.40			8	46		
London Docklands	28.00	2.65		36.50		84	224	
Manchester	26.90	2.65	1.00	39.00	6	80	180	80
Nantes	28.37	2.29	0.87		6	60	168	70
Sacramento	25.80	2.65	1.00	35.80		64	175	80
San Jose	26.36	2.67	0.971	39.00	6	76		88
Toronto	23.18	2.59		36.70		61	260	80
Tyne & Wear Metro-Cammel Metrocar	27.80	2.65	0.96	39.00	6	84	209	80
Zurich SWS/BBC tram 2000	20.50	2.20	0.83	26.50	6	50	119	65

Summary specifications of selected light railways

Noise emission

Although LRT has often been presented as an improvement on buses it is certainly not problem-free. The London Docklands Light Railway has caused a considerable amount of vibration and noise to neighbouring properties; see Transnet (1988). Various measures have been tried with some success, including noise reduction mats, noise screens on the bogie sides and skirts on the sides of the cars: see Catling (1987) and Walker (1986).

PART 2 CASE STUDIES

9 The Grenoble Tramway

Grenoble lies near to the junction of the rivers Isère and Drac, 105 kilometres south-east of Lyon. The older part of the town lies on the steep hillside on the right bank of the Isère but today the greater part of the town lies on the left bank. Originally a Gallo-Roman town, Grenoble became the capital of Dauphiné, the domain of the crown princes of France in the twelfth century. During the past hundred years and particularly in the past two decades, Grenoble has expanded rapidly, especially in nuclear technology, associated with the large university. With a population of 156,532 (1988) in the city and 390,656 including the suburbs, Grenoble is amongst the smallest cities with a recently-developed urban railway.

The route

The route comprises 8.8 kilometres, 6 kilometres of which is on reserved track. At present the line continues as far south as Alpexpo. This is an area in the course of development and few trams travel beyond Grand Place, the main commercial centre in southern Grenoble, 300 metres to the north. Grand Place therefore acts as terminus and as the main southern interchange with the buses and trolleybuses. Immediately north of Grand Place, the tramway shares a short section of carriageway with road traffic, and further north, with buses only. In this section it passes between the Olympic Village and Villeneuve, a grand ensemble or high density flat development.

North of avenue Malherbe, the tramway follows one of the main radial roads from the city, avenue Marcellin Berthelot in a separated track on the eastern side of the carriageway. Here the land uses are mostly flats but with some public buildings - the Maison de la Culture, Conservatoire du Music and the Direction Départementale de l'Agriculture.

In the city centre, north and west of Place Pasteur, the tramway runs partly on pedestrian streets, partly sharing with traffic, or where the streets are wide enough, separated from traffic. In the old centre where the tramway follows rue Raoul Blanchard and rue Felix Poulat, the line forms the centre of a network of pedestrian streets to both the north and south with characteristic small shops, restaurants, cafés and other retail premises. Westwards, the tramway follows avenue Alsace Lorraine, one of Grenoble's main shopping streets, now pedestrianised.

At the western end of avenue Alsace Lorraine, the line deviates northwards to serve the main railway station at the western end of the city centre. Westwards of the Place de la Gare, the line follows Cours Berriat, over the Pont du Drac into Fontaine, a separate municipality from Grenoble. Here, the tramway runs through a narrow, typically French high street. Significantly, the tramway has received priority. Although there are frequent crossings by traffic as along the whole route, where the street is wide enough there is one lane of traffic, where not sufficently wide, it is pedestrianised. Beyond the main street in Fontaine, where the road is wide enough there are two carriageways for road traffic in each direction with the tramway separated to the south. The tramway presently ends near the Genty hypermarket in

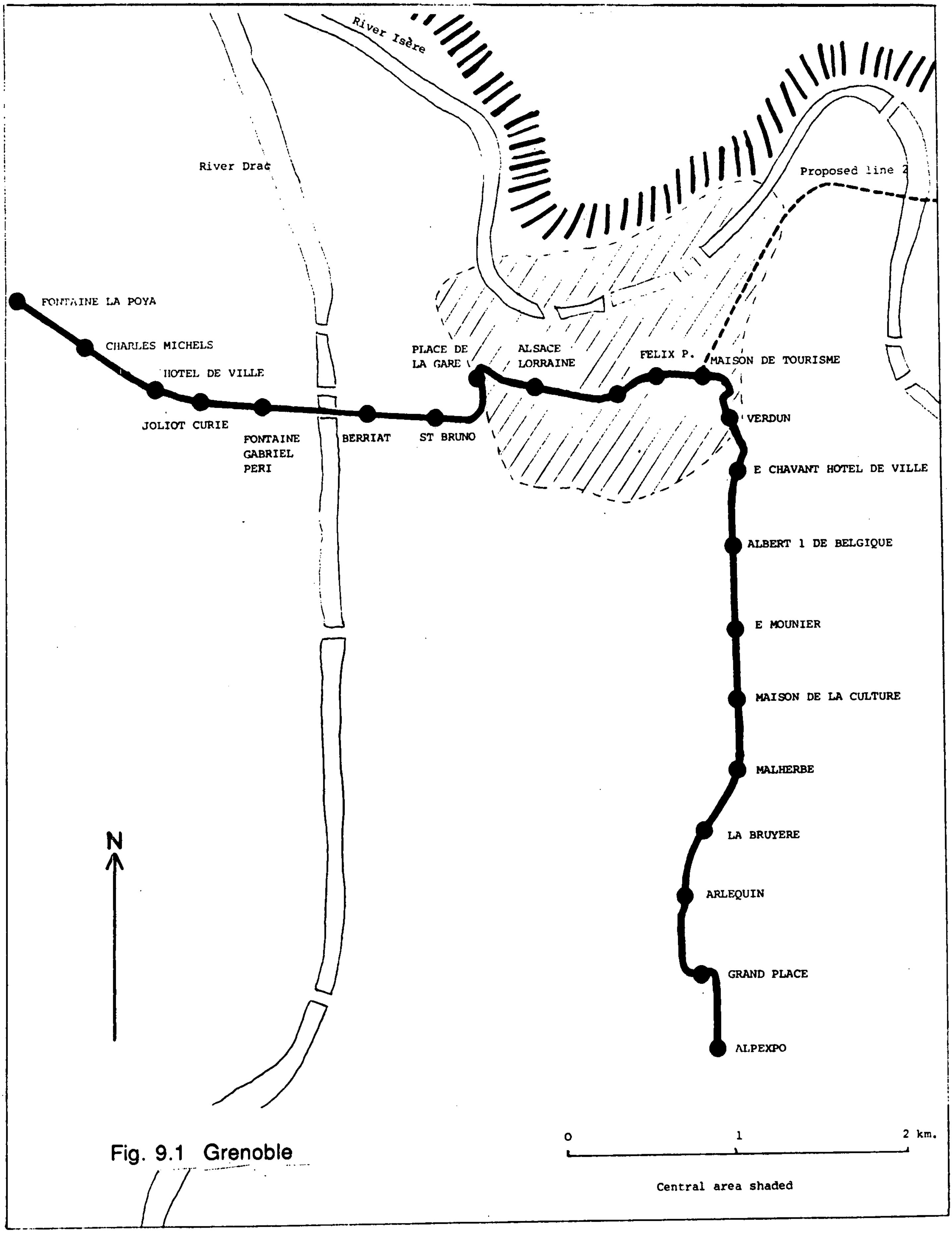

Fig. 9.1 Grenoble

Fontaine, built in the late 1960s.

A second route, presently planned as 6 km. in length is under construction (Syndicat Mixte des Transports en Commun 1988). This connects with route 1 at the Maison du Tourisme in the city centre and extends north-eastwards along avenue Maréchal Randon, past the main hospital, to the university where it ends at the library. It is expected to open in September 1990. It is planned to put this route in a central reservation, with a traffic lane at each side so as to be as far as possible from neighbouring properties.

Justifications for the tramway

Amongst the claims common to LRT outlined in section 4 above, the Grenoble transport authority (Syndicat Mixte des Transports en Commun: SMTC) has put particular emphasis on two reasons for the tramway:

* The improvement of public transport services and in particular the overloading of bus services along some routes into the city centre. As in other cities, the tramway is seen as becoming the backbone of the public transport network which has been restructured around it. The same arguments have been made by transport authorities in Marseille and Lyon. Speed is not seen as being important, probably due to journeys being limited in length by the size of the town. In any case, the speed is hardly higher than the buses. Ease of access for the disabled and others is an important advantage over buses. At the same time as improving public transport services, the tramway is seen as a means of arresting the increasing operating subsidies necessary.

* Improvement of the image of Grenoble. Since the 1960s Grenoble has been transformed from a rather sleepy and isolated medium-sized provincial town to a rapidly growing regional capital with an international reputation for its nuclear and other research establishments and industries. The city authorities are still proud of having been chosen for the Winter Olympic Games of 1968. The tramway is seen as an extension of these image-building activities.

Grenoble has benefitted from being the fifth French town chronologically to have opened LRT recently. The Comité Technique National pour le Développement du Tramway Standard Français has been formed to develop a standard form of rolling stock and this has been much influenced by the Grenoble tramway.

A great deal of attention has been paid to fitting the tramway into the city in urban design terms. Care has been taken with landscaping, paving and other materials and substantial pedestrianisation has accompanied the tramway, in both streets with the tramway and adjoining ones.

Choice of technology

Due to the limited size of the urban area (390,656 population in 1988), SMTC considered that there would not be sufficient demand for a métro. The density (1,880 inhabitants per square kilometre) would also be a limiting factor. The high water table in the urban area would make tunnelling difficult and expensive. Trolleybuses were seen as alleviating only the environmental problems. An elevated railway (POMA 2000) was considered but rejected on grounds of nuisance to occupiers of adjacent properties. A tramway was seen by SMTC as providing higher public transport capacity at street level. Descours (1987) gives an explanation of the criteria for the choice of a tramway.

The design has been influenced particularly by ease of access for the disabled and those with heavy luggage and the desire to provide an image commensurate with Grenoble's aspirations. Syndicat Mixte des Transports en Commun de l'Agglomération Grenobloise (1986b) explains some of the design details:

* windows and doors have been chosen to give a panoramic view whilst using standard industrial products;
* tinted glass has been used to ensure some privacy whilst permitting good visibility from inside;
* panoramic windscreens give a 190° view for the driver;
* cabin design for driving by day or night with non-reflecting materials;
* easy access to equipment in the roof by maintenance staff;
* doors wide enough for easy access by several passengers simultaneously.

Rolling stock

20 Alsthom-Francorail M20

Speed

In the suburbs, up to about 18 km. per hour, in the city centre as low as 5-6 km. per hour, including time at stops and traffic lights. The time taken from the southern terminus to the city centre is 17 minutes and from the western terminus to the city centre, 14 minutes.

Staffing

52 drivers, 4 inspectors, 20 mechanics.

Capacity

254 passengers per double carriage or approximately 3,800 per hour with a four-minute frequency. If needed, this could be increased four-fold.

Ridership

Shortly after opening the tramway was carrying 60,000 passengers per day (*Le Dauphiné Libéré,* 6th October 1987). The forecast by SMTC was that the number of public transport journeys per year would rise from 38 million to 45 million after the opening of the tramway. *Le Dauphiné Libéré* of 10th November 1987 reported a 15% increase in public transport usage since the opening including an increase on the buses and trolleybuses. A report in the same newspaper on 7th November 1987 stated that 15% of the tramways users were new users of public transport.

Markets served

As for other French LRT systems, the market is expected to cover a broader spectrum than do the buses. 80,000 inhabitants (20% of the conurbation) live within 400m. of a stop (which implies a population density of around 7,000 persons per square kilometer in the parts of the city traversed; higher than is possible in most British cities except London). 23% of the total jobs (30% of those in tertiary industries) are also located within 400m. of a tramway stop. A second tramway line is proposed from the city centre eastwards to Gières. The corresponding job percentages after that is opened would be 35% of total jobs and 52% of jobs in tertiary industries.

Costs

land and property acquisition	55
replanning and re-building	130
track and other infrastructure	290
overhead lines and other power installations	55
stations, building works and depôts	155
engineering works, landscape remodelling and surveys	100
rolling stock	235
Total (less tax M.francs (1985)	**1020**

Sources of funding:

State subsidy	390
Loans on financial market	630
Total (less tax, M.francs 1985)	**1,020**

The State subsidy was 50% for the track, stations and buildings plus 16.9 million francs (1984 prices) for noise and vibration reduction measures plus 23.2 million francs for measures for access by the handicapped plus 34.5 million francs for electrification and redevelopment of the Place de la Gare.

The loans will be repaid over 20 years from the proceeds of versement transport which was raised from 1% to 1.5% on 1st April 1986.

Subsidy levels

Capital construction costs of the first line have been subsidised by central government to the extent of 38.24%. It is too early to measure any effects of the tramway on operational subsidy but one of the justifications for the tramway put forward by SMTC was to reduce these. Between 1983 and 1985 managerial measures reduced operating subsidy from 55% to 51%.

Impacts

Descours (1985 and 1987) describes the tramway not as a simple transport project but a large scale town planning project: pedestrianisation in the centre of Grenoble, transport interchange and business centre at the railway station and revitalisation of the centre of Fontaine.

Several bus services have been re-routed to act as feeders to the tramway and to reduce the number of buses in the city centre. 1,000 parking spaces have been provided with the aim of park-and-ride.

The tramway has had no demonstrable effects on land use, density, job creation or property values but these were not amongst the objectives of it. In Fontaine, however, there has been an increase on 2,000 square metres of commercial floorspace at about the same time as the construction of the tramway and pedestrianisation.

A referendum was held on 22nd June 1983 soon after the replacement of Mayor Hubert Dubedout by Mayor Alain Carignon. 37% of the population voted and 53% were in favour of the tramway. Although much lower than comparable questions in the survey of Lyon and Lille (section 13 below) it is usually the case that support for LRT grows rapidly after it has been built.

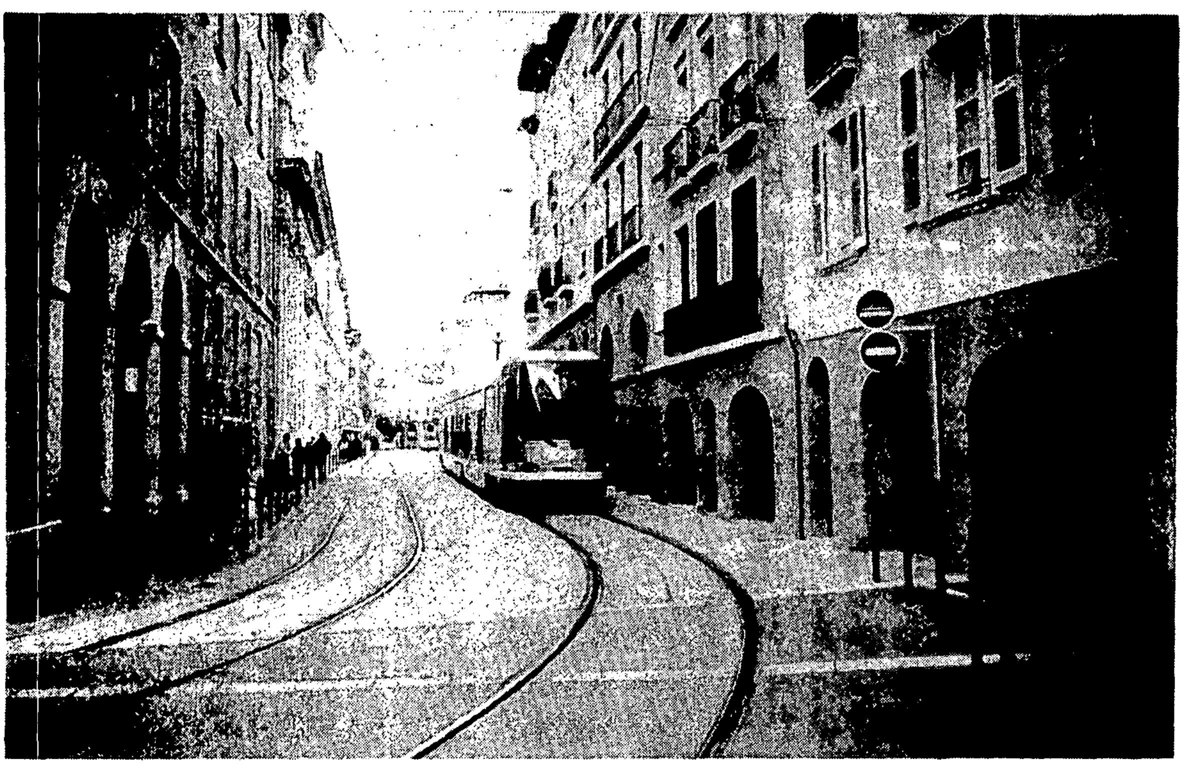

Fig 9.2 Grenoble: rue Raoul Blanchard near to the Maison de Tourisme.

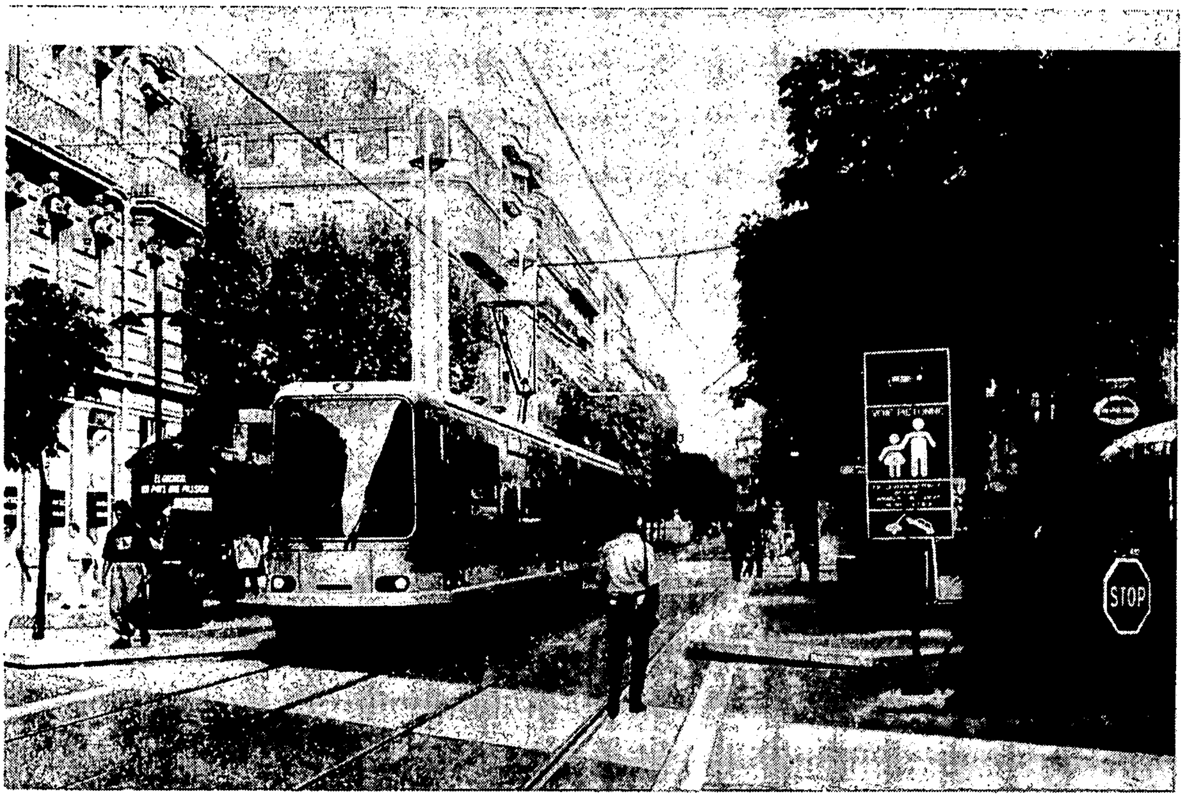

Fig 9.3 Grenoble: avenue Alsace-Lorraine

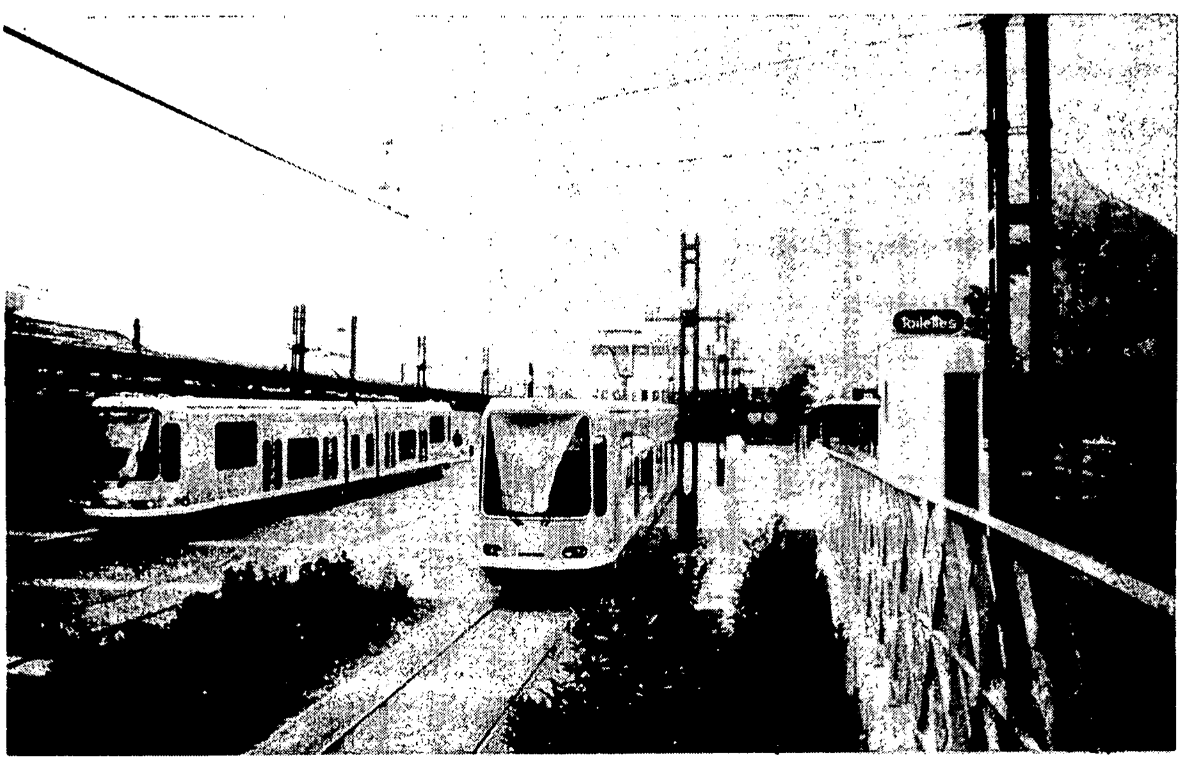

Fig 9.4 Grenoble: Place de la Gare. The main railway station is in the background.

10 The Gothenburg Tramways

The Gothenburg tramways contrast in several ways with that in Grenoble. Whereas the Grenoble tramway was a fresh start after abandoning the old tramways, the extensive Gothenburg network has been a continuous development over several decades. Whilst the Grenoble tramway has been part of a package of traffic and public transport measures, in Gothenburg the interdependence between the tramways, public transport and town planning, particularly in the city centre, are even more direct and clear. In fact, the history of the development of Gothenburg has helped present-day transport and planning.

In the fifteenth and sixteenth centuries, the Göta Peninsula was the site of numerous territorial disputes between Sweden and Denmark. Seeing the need for a fortress to establish his territorial claims, King Gustavus Adolphus II founded Gothenburg in 1619 on the south bank of the river: 'Göteborg' or fortress on the River Göta. Dutch settlers were engaged to plan and build the new city. The remains of the characteristic canals and fortifications are still visible. Some of the canals were later filled in for roads up to about 34 m wide but a canal still surrounds the southern and eastern parts of the CBD on the site of the old ramparts.

The population of the city reached a peak in the early 1970s (1970: 451,800) but has declined to 424,000 in 1984. The Swedish government introduced restrictions on industrial development in the three largest cities to reduced specialisation of the labour market. The population of the region, however, has continued to increase (1970: 677,000; 1984: 699,200). A new town, Angered with a population of 50,000 is being built 10 kilometres to the north-east of the city centre, connected to it by tramway. The city population density of 953 persons per square kilometre is not high. The city area does, however, contain large amounts of open space and is not as difficult to serve economically by public transport as the low density may suggest. The 7 square kilometres of the central urban area (CUA) had a population of 41,000 in 1982, not a particularly high density by continental European standards.

Today Gothenburg is an important industrial city including firms such as Volvo and SKF. It is also the main Swedish port and shipbuilding city. The Göta River has provided a sheltered harbour but also a transport barrier. It separates the industry and harbour to the north-west from the remainder of the city. The Älvsborgsbron to the west of the city centre and the Tingstadstunneln to the north-east were built between 1966 and 1968. Until then the Götaalvbron was the only bridge connecting the two parts of the city.

There are about 65,000 jobs in the central urban area. The other major employment destination is the industrial area of Hisingen in the north-west with 25,000 jobs. The centralised land use pattern causes a need for many cross-city journeys of which the municipality has been aware for some time.

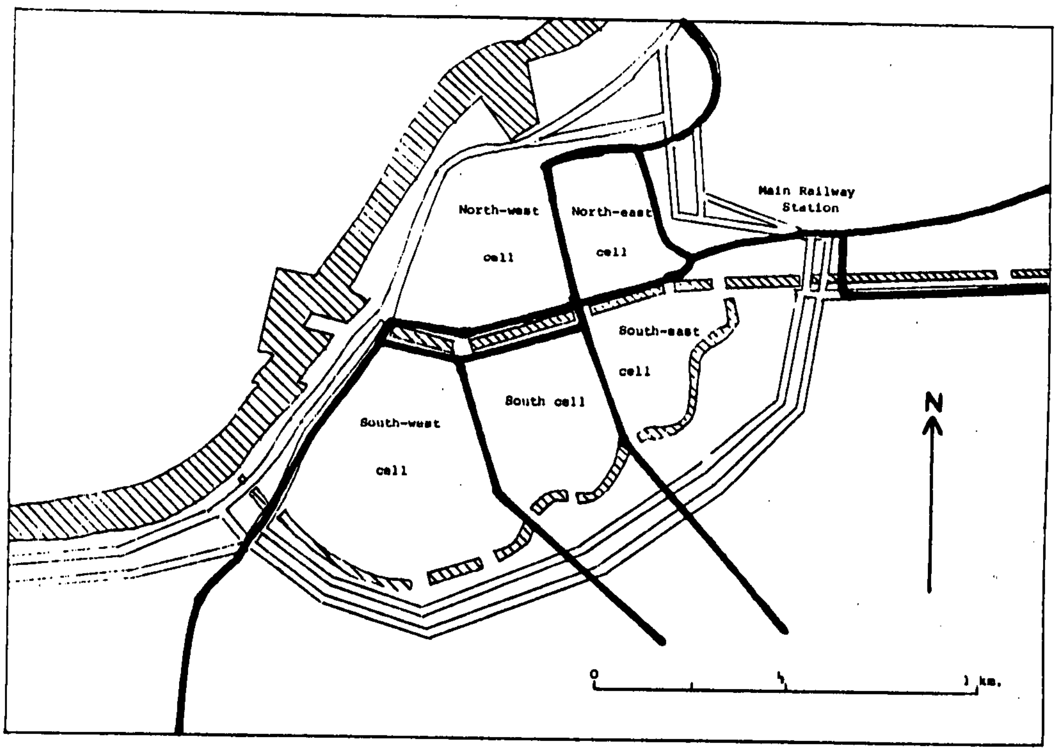

Fig. 10.1 Gothenburg city centre

The routes

An English company began to operate horse trams in 1879. This was purchased by the city council in 1900 and the horses were replaced by electric trams in 1902. Whilst many other European cities replaced their trams by buses, Gothenburg continued to develop them technically, particularly after the Second World War. In Sweden central government provides money for metros and light railways but stations, tracks, signals, vehicles and power are paid for locally.

During the 1970s several important measures were taken to improve public transport. With the introduction of traffic cells, reserved bus and tram lanes, traffic signal priority, introduction of express buses and uniform fares, ridership on public transport increased by around 8% on weekdays between 1970-75 . The sharp increase in the price of petrol also had an effect. In more recent years however, ridership has declined from 97.2 million public transport journeys in 1983 (229 journeys per inhabitant) to 88.2 million or 208 per inhabitant in 1987. Subsidy in 1987 was 56%. Car ownership at 364 per thousand inhabitants in 1987 is even higher than that in Stockholm (339 in 1986).

Trams, buses and ferries are operated by Göteborgs Spårvägar. Public transport in Gothenburg is very much tram-orientated. 281 trams operate on eight routes of total length 152.7 km in 1984 (113.0 km entirely separated from traffic, 21.4 km on separate lanes within streets and 17.9 km on-street). In reserved lanes in the streets, both trams and buses operate using the same stops. All eight routes serve the CBD. All are cross-city except the line from Central Station to Angered new town and it is proposed to continue this line southwards across the city centre. There are only 299 buses (one for every 2,338 inhabitants). 84 of these are articulated. Buses operate on 33 routes of total length 467.7 km. 12 routes enter the CBD or stop on the edge of it and a further 11 enter the central urban area.

Trams get priority at 80 out of 85 junctions in the city centre by activating a switch when approaching traffic lights. Intersecting traffic which has been stopped is compensated in the next phase of the traffic lights unless the system is activated by another tram. The number of consecutive requests for priority which will be granted is determined individually for each junction. Buses also receive priority at about 50 junctions.

It is significant that the tramway network is being extended, even if at a reduced rate compared with the 1970s. As well as the continuation of the line from Angered across the city centre to Tynnered, there are plans to replace the articulated bus service to Backa by light rail and lines 7, 1 and 2 are to be connected et their termini between Slottsskogen and Sahlgrenska. Tramway development was particularly rapid in the early 1970s but has since been reduced due to the growing popularity of terraced houses and detached houses which are much more difficult to serve than flats, perhaps a significant warning for those British cities planning tramways. The transport authority is paying deliberate attention to service and low fares to entice motorists. In 1987 the cost of a monthly season ticket was 160 kroner (about £15).

Justifications

High priority has been given by the public authorities to the preservation and enhancement of the environment. Particularly in the city centre, tramways have been an important part of this policy. It has been recognised that to make the most of the environment there must be clear and decisive policies towards the private car and in order to implement these there must be an attractive public transport system. Rail based transport was chosen as being more effective than buses in this respect and also less damaging to the environment. To appreciate the reasons for the retention of the trams in the city centre, it is necessary to relate them to the whole series of complementary town planning and transport planning measures which have been so effective in improving the environment.

The tramways as part of city centre planning

Today the city centre gives the impression of acceptance of tight traffic control applied to what has always been a planned city since its foundation. Significantly, two-thirds of the journeys to the CBD are by public transport, a high proportion for a city of Gothenburg's size.

Only in a small part of the south-west of the CBD do streets meander around the contours. Elsewhere they are strictly grid-iron, a pattern favourable to tramways. A ring road is formed out of the main road along the bank of the River Göta together with a pair of parallel single-direction roads following the lines of the old fortifications outside the canal. Most streets are one-way and parking is meticulously defined by duration of stay in many small locations. A large multi-storey car park (2,400 places) is located, as may be expected, inside the main ring road junction north of the centre, near to the Central Railway Station and the bus terminal. There are also two smaller multi-storey car parks (200 and 500 places) within the traffic cells. Most long duration parking is near to the ring road whilst short duration is more widely scattered and in smaller units. A fairly extensive network of pedestrian streets connects the large multi-storey car park, Central Station and the bus station with Götagatan, Kungsgatan and most of the central shopping area. In 1982 the 1.2 square kilometres of the CBD, mainly confined to the area within the ring road, had a population of 2,000 but was the location of 25,000 jobs.

Environmental damage caused by the car became an issue and in 1969 a commission of city officials was set up to examine ways of improving the environment and increasing the reliability of public transport. Swedish municipalities have complete control over the whole road network without resort to regional authorities or the state and in 1970 the city centre divided into five cells. Vehicles are not allowed to cross between them except for public transport, including taxis. The grid-iron street pattern, wide streets where there had formerly been canals, the presence of a ring road and retention of the tramways have all helped the planning and implementation of the cells. Significant reductions in traffic, noise, air pollution and accidents and improvements in regularity and speed of public transport were all noticed (Blide and Teasdale 1979). The geographical location and form of the CBD give a very clear boundary and make the definition of cells relatively easy to understand. The cells also gave the CBD a more distinctive image with a clearer path for future development. Older people in particular seem to find the centre more attractive. The tramways have helped acceptance of the cells and other traffic control measures by providing an alternative means of access with minimal damage to the environmental aims of such policies.

An important characteristic of the cells which has no doubt contributed to their acceptance and success is that no group of people can claim to be much worse off as a result. Taxi drivers complained initially. They were not regarded as being public transport and had to make long detours. Subsequently however, the ruling was changed to include them as public transport with a right to cross cell boundaries.

The cells were subsequently widened beyond the CBD. The CBD has only 5% of the whole tram track whilst the central urban area (CUA) has 35%. Thus in the CBD the trams have significantly aided the implementation of the cells. In the CUA, the cells have aided the operation of the tramways. The CUA is defined by the city council as the inner city south-east of the River Göta forming an arc round the CBD. It extends from the E6 road in the east and as far south as the Slottskogsparken in the south-west. It covers 7 square kilometres and in 1982 had a population of 41,000.

Operating costs of the trams have been reduced. The CUA cells were more complicated to implement for several reasons: there was no ring road on which to divert the traffic, the land use is much more mixed with more residential and plans for redevelopment and rehabilitation. A traffic plan was formulated along with a land use plan. The CBD could be considered as a single traffic entity whereas the other cells in the CUA have to be considered as part of a city-wide traffic plan catering for all kinds of traffic. The size of the cells and their design has been affected by re-routing considerations. The area south of the CBD had a poor record of traffic accidents. The cells also gave an opportunity to extend the cycleways. Gothenburg has a comprehensive network of cycleways extending to all parts of the city including the CBD and CUA.

Parking was reduced at the same time as the introduction of the traffic cells. A 10% reduction was aimed for in the late 1970s and it was appreciated that a severe and sudden decrease in parking could have undesirable effects. Also, much parking is in the private sector and would be difficult to reduce under existing legislation. Residential parking is to be given priority but with a standard of 0.6 per dwelling it is lower than the rest of the city except the CBD (0.4). Restrictions on parking for commuters should be harder than those on visitors. As well as a reduction in parking with the implementation of the cells, parking was also relocated to the edges of the cells.

Choice of technology

The trams were originally introduced in 1902 as the most advanced technology of the time. Ever since, there has been a certain presumption to retain and develop them unless alternative technologies are sufficiently attractive to justify replacing them. The two main alternatives have been the buses and more recently, the possibility of a metro. The environmental argument has favoured the trams rather than buses. Supporting this, there has been a willingness to invest and maintain what in financial terms is probably not the cheapest way of providing a public transport service. The city council rejected plans for a metro in the early 1970s on the grounds that the trams were sufficiently advanced to make it unnecessary. However, some rolling stock is quite old and there has been a programme of replacement since 1985. For a city the size of Gothenburg, it is unlikely that public transport demand could justify the higher capacity of a metro.

Rolling stock

In 1987 there were 281 trams and 299 buses. The trams are mostly Hägglunds types M25 and M29, ASJ/ASEA type M28 and the new light rail vehicle ASEA type M21.

Speed

The maximum speeds are 60 km.p.h. for the older vehicles M25, M28 and M29 and 80 km.p.h. for the new light rail vehicle M 21. The operating speed varies from 15 km.p.h. in non-segregated sections in the city centre to approaching 50 km.p.h. on some of the suburban sections segregated from traffic.

Operator

Göteborgs Spårvägar (GS), Box 424, Stampgatan 15, 401 26 Gothenburg; tel: 031 800500.

Staffing

The total staff for buses and trams in 1987 was 2,840, including 288 part-time employees. The transport authority annual report (Göteborgs Spårvägar 1987) draws attention to the difficulty of recruiting drivers for both buses and trams. Another serious problem is the very high rate of sick leave, one day in five for traffic personnel, one day in seven overall.

Capacity

The capacity of the services offered increased by 29% in the 1960s from 1,283 million seat kilometres in 1960 to 1,659 million in 1970. With the introduction of new vehicles in the early 1980s, capacity increased to 1,765 million seat kilometres in 1984. These capacities do not include standing passengers. To include these it would be necessary to multiply by 3 (based on vehicle types M25, M28 and M29). The capacities of the vehicles are 38 seated and 78 standing for types M25, M28 and M29 and 61 seated and 90 standing for M21. The service is 10 minutes on-peak, 10-20 minutes off-peak.

Ridership

The trams account for 58 million passengers per year and the buses 47 million passengers. This represents 379,830 passengers per kilometre of tramway.

Subsidy level and sources of funding

The transport authority annual report 1987 (Göteborgs Spårvägar 1987) indicates total income at 369.4 million kroner and costs at 791.6 million kroner resulting in a subsidy of 53.3% from the city council.

Impacts

As the city has developed with the tramways since 1902 it is difficult to assess what changes in the city are due to the tramways. Also, many of the impacts are likely to be only of historical interest, unlikely to be repeated in future. In particular, the tendency of the trams to lead urban development before the spread of the private car seems far more uncertain in the future. The tramway has no doubt contributed to the development of the new town of Angered but the target population has been successively reduced from 150,000 to 50,000.

The tramways have certainly contributed to the realisation of the city's full environmental potential and may have made some contribution to the overall development of the city. The spread of the settlement since the beginning of the century also indicates the influence of the tramways on the location of urban development, along with land use planning policies.

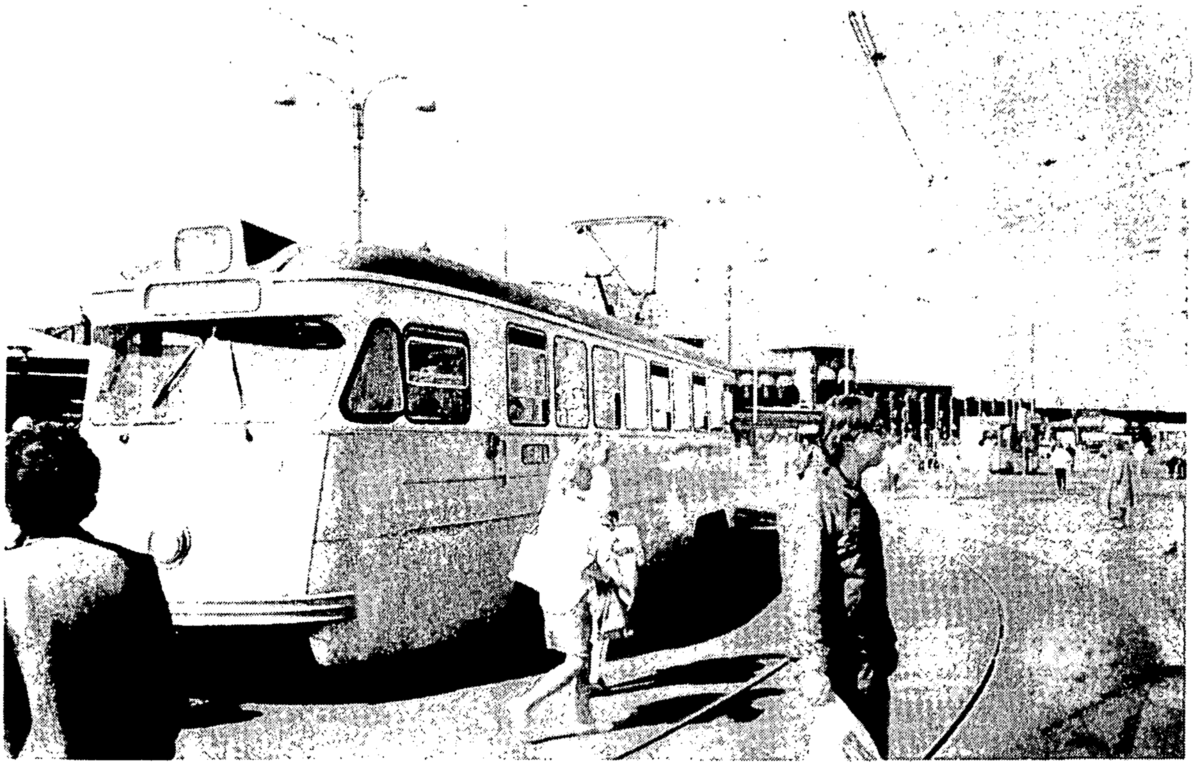

Fig. 10.2 Interchange in front of the main railway station at Gothenburg

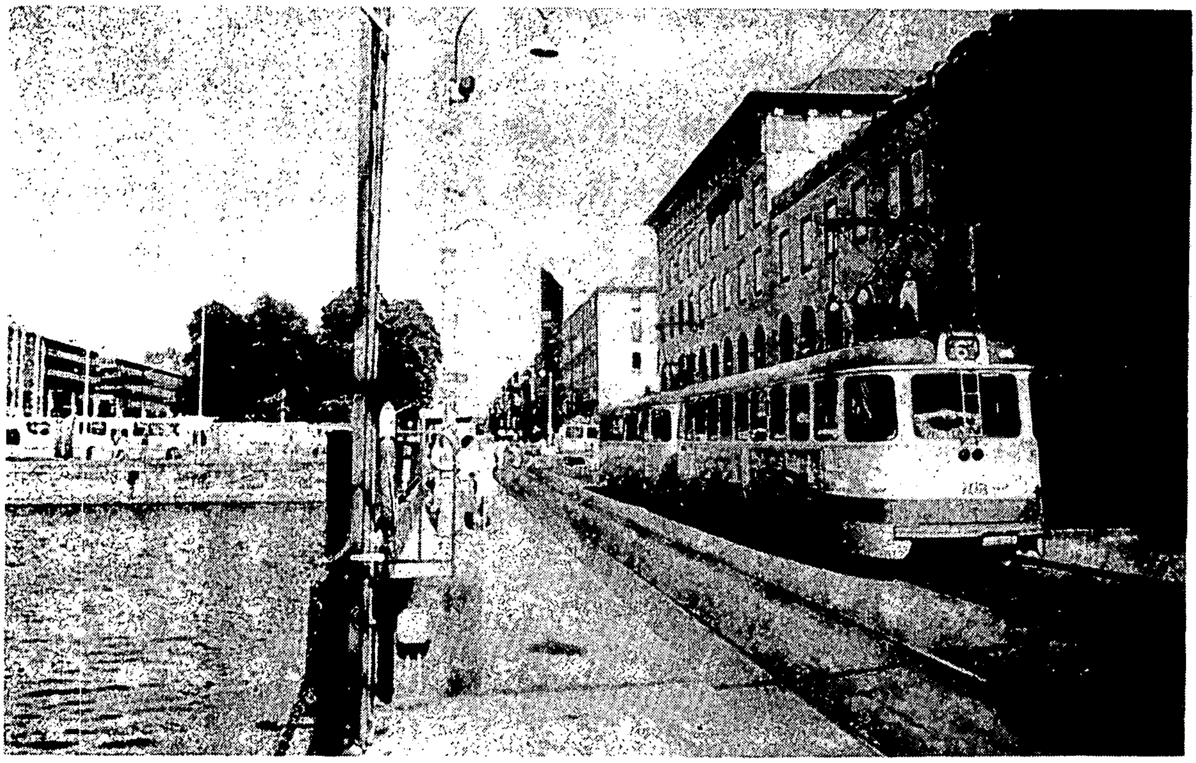

Fig 10.3 Gothenburg: tramways penetrate into the traffic cells

Fig 10.4 Gothenburg's new light rail vehicle M21.

11 The Bremen Straßenbahnen

The city of Bremen in West Germany shares many characteristics in common with Gothenburg in relation to public transport and city planning. The tramways are not so extensive as in Gothenburg (57 kilometres compared with 152.7 kilometres) but Bremen in another good example of how tramways (Straßenbahnen) may be developed to serve the main public transport needs of a city of around half a million population as part of a series of planning measures including traffic restraint in the city centre.

Bremen was founded on a sand dune on the right bank of the River Weser at a river crossing. The city area extends north-west to south-east along the River Weser with a detached area of port uses, also part of the Land (state), in Bremerhaven, 50 km. downstream on the North Sea Coast. It is the smallest of the eleven West German Länder or states both in terms of area (404.23 square kilometres) and population (548,000 in 1982). The population, has, in fact, declined by 60,000 since the peak in 1969. Only 3,600 live in the Innenstadt but 43,000 work there. The population density within one kilometre of the centre is therefore low by German standards, at 5,500 persons per square kilometre (1981) but the inner ring between one and three kilometres is more characteristically German at 11,000 persons per square kilometre, somewhat higher than the comparable part of Gothenburg.

The overall structure of Bremen suburbs and neighbouring towns in Lower Saxony is planned around a series of axes extending north, north-west, south and south-east from the centre, based on rapid transit. For West Germany, car ownership is low (290 cars per 1,000 population compared with 388 per 1,000 in West Germany as a whole and 364 per 1,000 population in Gothenburg). Car parking in the city centre is restricted to 4,100 off-street places, but in addition there are 19,000 on- and off-street car spaces in the CBD.

The routes

The six tram routes, numbered 1,2,3,5,6 and 10 are all cross-city through the centre. The predominantly north-west to south-east orientation of the tramway network matches that of the settlement pattern.

Justifications

In Germany there has been a very strong tradition of investment in tramways and a certain amount of inertia towards their retention. The relatively high residential densities, concern for the environment and the considerable civic heritage and willingness to invest in public goods have all favoured retention of the trams rather than their total replacement by buses.

Like Gothenburg, Bremen city centre is renowned for its traffic restraint and the tramways have been an important part of achieving this. The city centre lies mainly north-east of the streets, Sögestraße (shopping), Obernstraße and Balgebrückstraße, one of the six main access roads to the city centre. The four cells are contained within peripheral main transport routes which give access to parking, mainly inside the inner ring road close to the mostly pedestrian streets right in the very centre. Road traffic can enter or leave each cell from the ring road but can not transfer between cells. This has reduced the need for transit on the same scale as other large West German cities. In fact, Bremen is one of the largest West German cities not to have an S-Bahn or U-Bahn to service the city centre.

For West Germany however, pedestrianisation is not extensive and it is possible that it will be extended in order to stop the present decline in shopping. Public transport penetrates into the pedestrian area. Public transport and particularly the trams are important in supporting central area activities. 48% of those travelling to the city centre do so by public transport (compared with 24.5% of all passenger journeys), 45% by car and 7% by bicycle or motor cycle. Two-thirds of the 34 bus routes are confined to the suburbs and many bring passengers to the tram. A few also act as feeders to the railway. The trams are particularly significant in giving access to the pedestrian areas as they are the only form of passenger transport allowed in several of them.

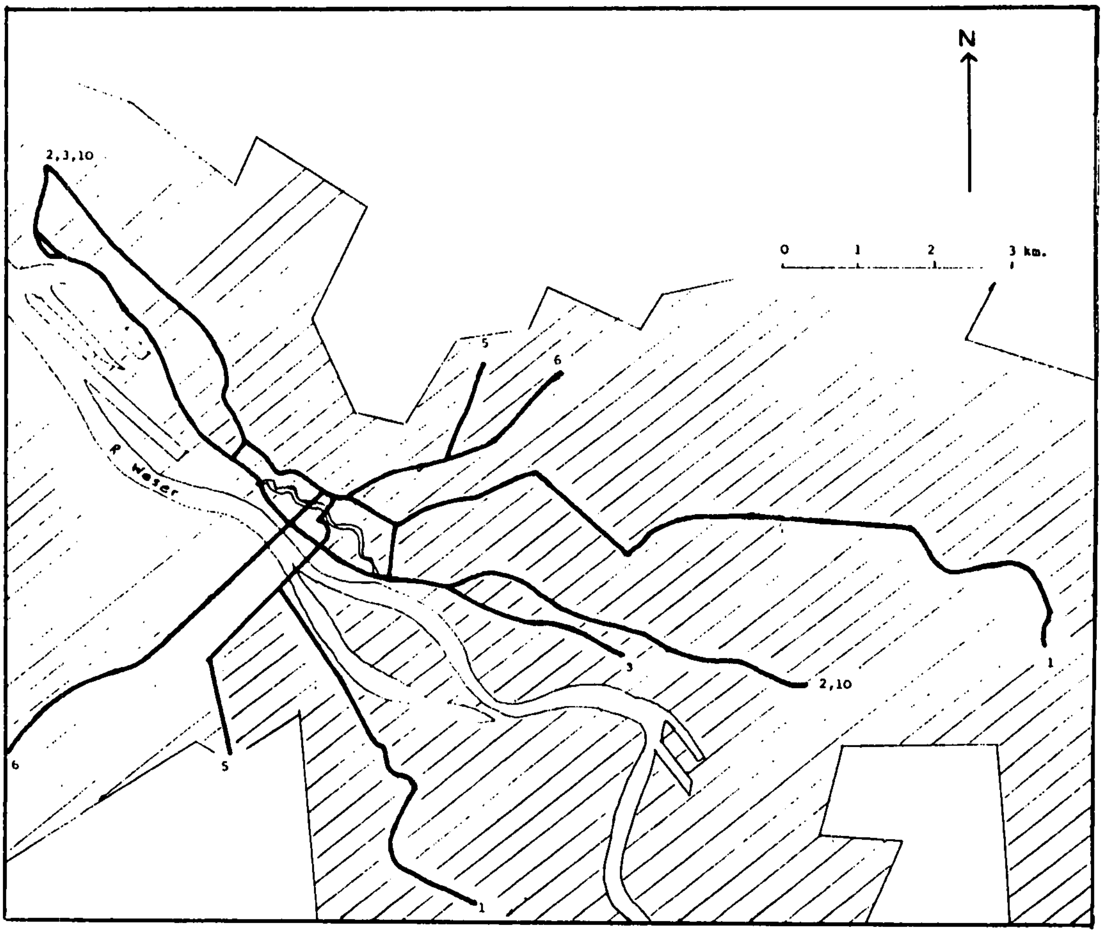

Fig. 11.1 The Bremen Straßenbahnen

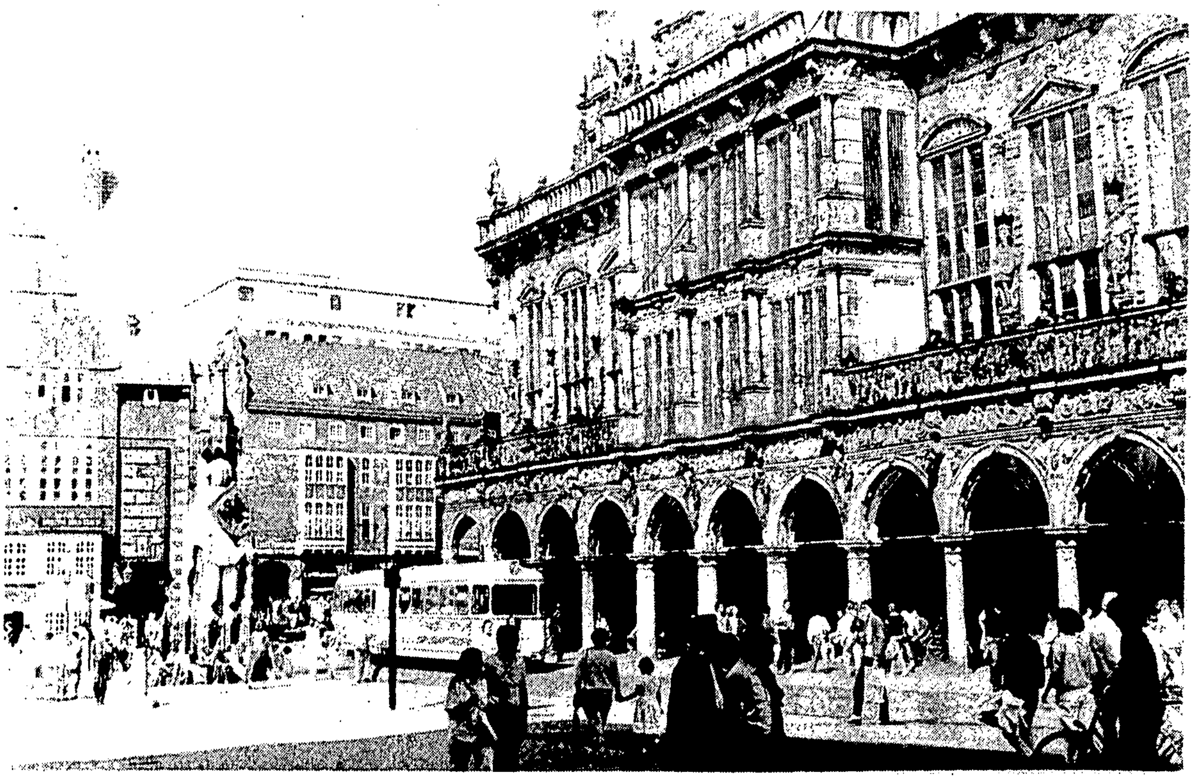

Fig. 11.2 Tramways penetrate into the pedestrian area in the centre of Bremen.

Choice of technology

As in the case of Gothenburg, the limited size of the city has been the principal reason for the decision to develop the trams rather than replace them with a higher capacity and faster urban railway. Journeys in terms of both length and number have not been sufficient to justify a U-Bahn despite relatively low car ownership. There are, however, plans to renovate the whole of the Straßenbahn network to Stadtbahn standards. This would involve measures to increase the speed of operation including more segregation from road traffic, priority at traffic lights where not segregated and some new rolling stock.

Rolling stock

79 Hansa GT4 built 1959-68;
61 Wegman GT4 built 1973-77;
9 Hansa T4b built 1954.

Operator

Bremer Straßenbahn AG, Flughafendamm 12, Postfach 10, 66 27 2800 Bremen 1,
tel: 0421 55961.

Capacity

In 1986, services amounted to 11 million car kilometres or approximately 1,300 million passenger kilometres including standing passengers.

Ridership

Ridership

In 1986 the trams carried 49.2 million passengers compared with 46.9 on the buses (compared with 58 million and 47 million respectively on the more extensive Gothenburg network). In Bremen there were therefore 863,158 passengers per kilometre of tramway and in Gothenburg 379,830 passengers per kilometre.

Sources of funding

For all modes, fares income amounted to 49% of operating costs (1986), other sources 8% and subsidies 43%. Since 1983 subsidies has been made available under legislation which equalises the tax burden fro state to state. There are also contributiuons from neighbouring municipalities.

Competition for the Straßenbahn

Although only 7% of journeys to the city centre are by bicycle or motorcycle, there is some evidence that they substitute and provide competition for public transport. Analysis of the modal split for journeys to the city centre from the whole of Bremen revealed significant correlations between public transport and cycle usage and between public transport and car usage but not between car and cycle. Controlling for car usage, the negative correlation between public transport and cycle was still significant. And so bicycle and public transport are regarded by residents as alternatives and would appear to be competitors for the same market. As well as reducing public transport usage, the possibility of residents taking to their bicycles may pose a safeguard against public transport fare increases. The significant negative correlation between car and public transport is to be expected. It is compatible with the attraction of car users to the tramway but does not prove it.

Conclusions on tramways

Grenoble, Gothenburg and Bremen all illustrate the desirability of viewing public transport in general and tramways in particular as an important part of a series of town planning measures acting simultaneously to achieve the same objectives of improving both access and the environment. In Gothenburg and Bremen there have been tight restrictions on the private car and it would be rash to claim that the improvement of the tramways was more important than these restrictions in achieving the objectives set. Probably in none of the cities would the town planning measures have been possible without an urban railway of some kind. Tramways were chosen as their capacity best fitted requirements for travel and environmental objectives.

In none of these cities have tramways been regarded as a suburban railway with trams as rolling stock. Particularly in Grenoble and Bremen, the market is quite different and more local. Because the Grenoble tramway is new, there has been much discussion of the objectives and purposes of it before and during development. It is very clear that the claims in Grenoble are more limited than those made for the British proposals. Job creation and stimulation of the local economy have hardly been mentioned. Claims for the tramway have been limited to improvement of the public transport services, particularly for the less agile, attraction of new public transport users, to act as a part of urban renewal and improvement and to improve public transport finances, all of which have been justified. The Grenoble route is considerably different from the routes of the British proposals in terms of several important characteristics which can be expected to affect public transport usage. The success of the Grenoble tramway is not evidence to support the prospect of putting similar rolling stock on suburban railway lines.

12 Light rail in Edmonton and Calgary

Calgary is situated 700 km. east of Vancouver in the Canadian province of Alberta. Edmonton is 300 km. to the north of Calgary and is also in Alberta. Light rail transit was opened in 1978 and 1981 respectively and were amongst the first of their kind in North America. Both cities grew quickly during the period 1970-1982 influenced by the prosperity of the Alberta oil industry at the time. With the sharp decline in oil prices in 1983 the population of Calgary declined slightly to 620,700 and that of Edmonton stopped increasing at 560,000.

At the outset, some features of public transport in Canada may be noted. Compared with the USA, public transport usage in Canada is high. At around 100 public transport journeys per inhabitant in Canada as a whole, ridership is as high as in many European countries and more than three times that in the USA. As Pucher (1988) points out, the share of the modal split constituted by public transport is higher in Canada than in most West European countries apart from the UK, although the use of the car is much higher. The explanation lies in the very low proportion of journeys on foot and by bicycle or motorcycle. Canadians seem to combine the car-orientated society of the Americans with public transport usage comparable with most of Europe. Canadian cities have a stronger centre than many USA cities. Also, there are high density residential areas in the suburbs. Most Canadian cities have planned suburban centres to act as focuses for growth and avoid ribbon development along the main roads. All of these characteristics favour public transport. Urban road building has been on a lesser scale in Canadian cities. There are no true expressways with controlled acces in either Edmonton or Calgary.

Both Edmonton and Calgary have a single municipal government which covers the whole of the built-up area and has been extended as the urban area expands. This is an advantage for the development of a form of infrastructure such as urban rail which involves considerable public investment and whose success depends on the need to recoup increases in land values. Both cities have centres which are well-developed by North American standards. Public transport accounts for about 40% of peak hours journeys in each city. Although not as high as in most European cities where the proportion can approach 70% as in Gothenburg, it is much higher than in most cities in the USA.

The routes

Both are suburb to centre routes. The Edmonton line runs 10.6 km. from Clareview north-east of the city centre. The Calgary line originally ran 12.4 km. from Anderson in the south. A second route north-westwards to the university was opened in 1987 making a total length of 27.7 km. l.6 km. of the Edmonton line is underground in the city centre and 2 km. of the second Calgary line is underground but apart from that, both lines are surface with some priority at road junctions. Two further extensions are planned for the Calgary network.

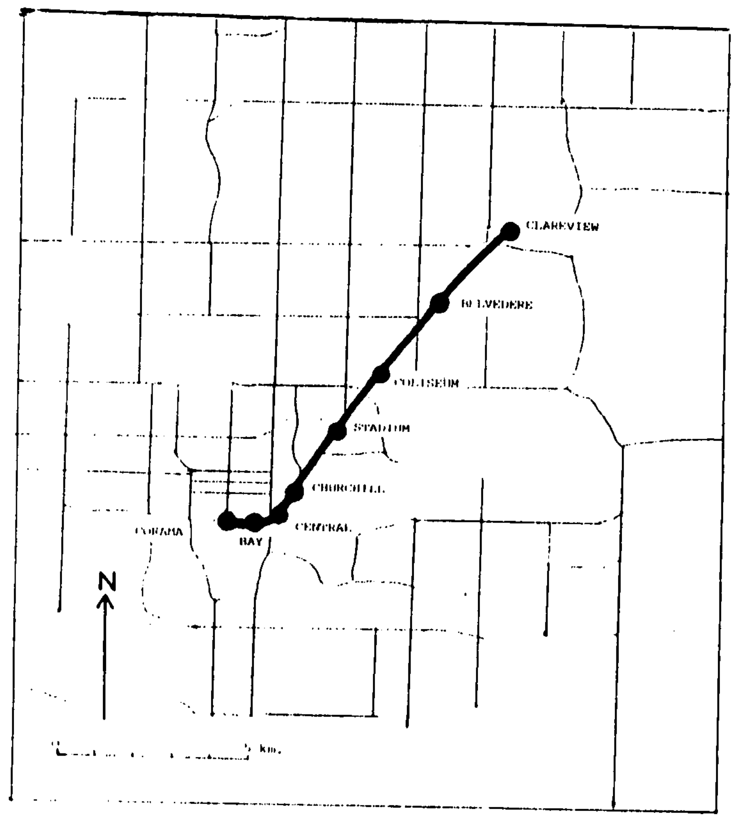

Fig 12.1 Edmonton

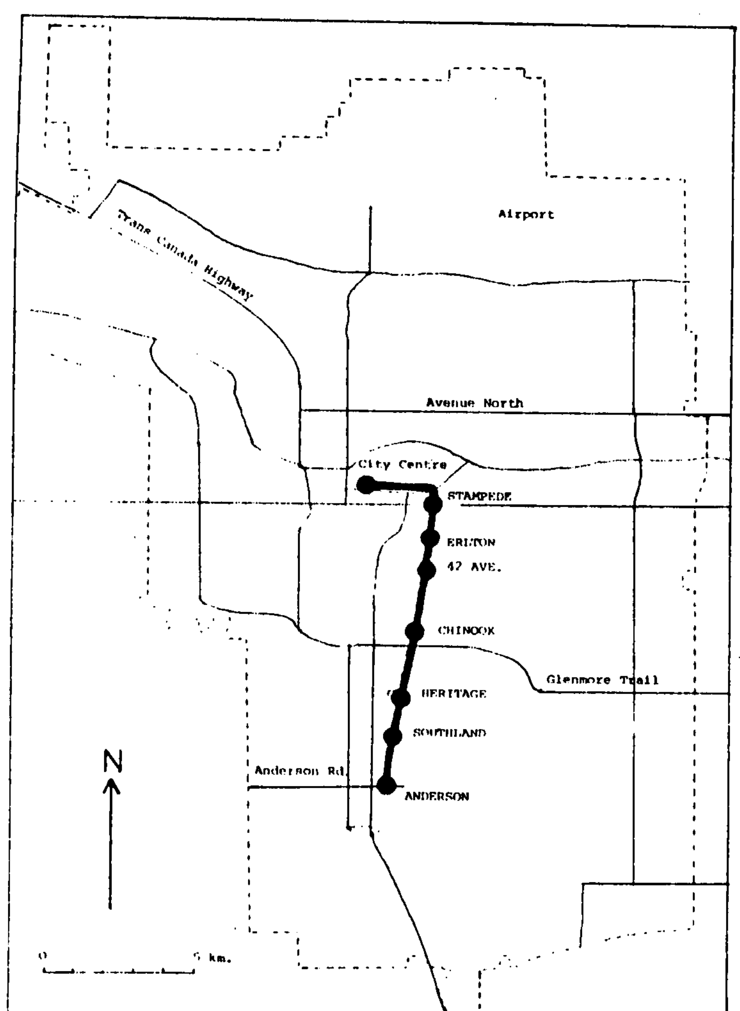

Fig 12.2 Calgary

Both systems connect land uses which generate journeys in significant numbers. Along the Edmonton route is the Commonwealth Stadium, Northlands Coliseum and Clareview Town Centre. The Calgary route passes through mixed comercial and office uses, close to the Calgary Stampede Ground and a regional shopping centre near Anderson. In both cities the bus routes were re-organised to act as feeders to the railway stations. Park-and-ride places were provided with the same purpose but with 2,100 places Calgary is considerably more orientated towards the car than Edmonton (500 places) and correspondingly, the bus services are more extensive in Edmonton.

Justifications for light rail

One of the main aims was to increase public transport usage so as to give access, mainly to the city centres, without the external effects of the private car. This was seen as an essential part of the objective of supporting the continuation of the functions of the city centre and maintaining densities. In fact journeys to the centre by public transport increased from 31% to 52% for the morning peak and from 31% to 42% for the evening peak shortly following the opening of the Calgary line. Off-peak public transport journeys however, have declined to more than compensate for this increase resulting in a net reduction in the proportion of total journeys by public transport.

Authorities in both cities saw light rail as having land use planning objectives. In both cities land use planning incentives such as permission for higher densities around the stations have been a significant way of raising capital costs as was explained in section 6 above.

Energy conservation and improvement of air quality have been influential in shaping governmental opinion on urban rail throughout North America.

Rolling stock

Edmonton: 37 Siemens-Duewag articulated cars M3, M14 and M20
Calgary: 83 cars; Siemens-Duewag U2 M27 and Siemens-Duewag U2 M56

Ridership

Calgary: 12 million passenger journeys (1986), 5 million car-kilometres (1986).
Edmonton: 1.9 million car kilometres (1986).

Service

Both cities 5 minutes, off-peak 10-15 minutes.

Costs and sources of finance

The Edmonton line cost $70 million (1980 Canadian dollars), two-thirds of which came from the province of Alberta. The first Calgary line of 12.4 km. cost $175 million (1980 Canadian dollars).

Edmonton 54.3% from the province
Calgary (all modes) 66.7%, 16.6% from province, 62.6% from the city

Gomez-Ibanez (1985) analyses costs of public transport in both Calgary and Edmonton before and after the opening of light rail. In Calgary operating costs rose by 3.7% per year for the five years prior to LRT and an average of 12.8% for the three years after. In Edmonton the situation is less clear. If the year of opening of LRT (1978) is taken as the dividing line, costs rose less sharply afterwards than before. If we take 1976, the year in which a number of public transport practices were reorganised including the accounting procedure, the pattern is similar to that in Calgary: 1.4% increase per year for the five previous years, 8.1% for the six succeeding years.

Subsidy

In both cities the level of operating subsidy has increased since the opening of LRT. In Calgary it increased from 43% in 1981 to 49% in 1983 and in Edmonton from 52% in 1977 to 70% in 1983. These figures are for all public transport and have possibly been adversely affected by the downturn in the Alberta economy over the period.

Impacts

The land use impacts have been modest despite being supported by land use planning policies and city centre parking restrictions. Additional building permits have been granted around the stations where higher densities and more profitable development has been allowed. There has been a particular interest in flat developments. Housing density in the inner city has continued to decline in both Edmonton and Calgary, particularly in the older established neighbourhoods. there is no evidence of intensification of uses following opening of the railways. Cervero (1985) gives details of the land use changes in Calgary which amount to the relatively low figures of 1,370 residential units, 620,000 square feet of commercial space and 140 hotel rooms for the period 1979-83. In Edmonton, development around the stations following opening of the line was even less with very little activity around the outlying stations. For a four-year period around the time of the opening of the line, severe restrictions were placed on development around the stations in order to secure comprehensive planning. By the time the restrictions had been lifted the local economy had weakened, enthusiasm to develop had melted away and several stations were left amidst open fields. Light rail alone was not sufficient to stimulate development.

13 The Marseille, Lyon and Lille Métros

The cities

Although Marseille, Lyon and Lille are all cities of similar size (populations 1,110,500, 1,220,800 and 936,300 respectively in 1982), all with métros of similar scale built with six years of each other, there are significant differences between the cities which have a bearing on the effects of the métros. Greater Lille, including Roubaix and Tourcoing and several other smaller towns is the only true industrial conurbation in France. No centre is dominant over more than a limited part of the conurbation. Also, the Lille métro is the only one in France which serves a new town, Villeneuve d'Ascq.

Marseille and Lyon are strongly monocentric, particularly Marseille, but the two cities are very different in social and economic terms. Lyon is much more prosperous. At the beginning of the motor car age the physical structure of the city was less inappropriate than that of Marseille. Since then Lyon has been distinctly more effective in keeping traffic moving and setting aside some spaces in the city centre reasonably traffic-free and pleasant for the pedestrian. Public transport usage in Lyon at 168 journeys per inhabitant per year for 1983, is not partcularly high by standards in other west European countries, but is distinctly higher than in Marseille (116 journeys in 1985) or Lille (72 in 1985).

The public transport network in each city has a lot in common. All three cities have conurbation-wide transport authorities with uniform transferable ticketing systems and with separate métro companies. These were explained in section 7 above. Each relies on the métro in the centre and some inner suburbs, and in Lille, extending eastwards to the new town of Villeneuve d'Ascq. The métros are fed by buses from the middle and outer suburbs. Considerable numbers of buses from districts not served still connect to the city centres.

	% public transport journeys		
	Marseille	*Lyon*	*Lille*
Bus	68	68	58.6
métro	28	32	30.6
trams	4		10.8

In Lille, the Mongy tramway connects the three cities of Lille, Roubaix and Tourcoing. In Marseille there is also one remaining tramway extending from the métro station at Noailles three kilometres eastwards to St Pierre with nine stops and accounting for 4% of public transport journeys.

	opened	*Line*	*length (km)*	*stations*		*millions of public transport journeys (1986)*
Marseille métro	1977	1	9	12)		
	1984	2	9	12)	22	49.5
Lyon métro	1978	A	9.4	13)		
		B	3	6)	22	86.0
		C	3	5)		
Lille métro	1983	1	13.5	18		27.1

The routes

Marseille

There are two lines each of 9 kilometres length and 12 stations and as two stations (the main railway station St. Charles and Castellane) are on both lines, there are 22 stations altogether. Line 1 extends from La Rose in the north-eastern suburbs along one of the main roads to the city centre and ends at Castellane in the southern suburbs. Line 2 extends from Ste. Marguerite Dromel south of the city centre north to Bougainville. In the city centre the two routes form a circle serving the greater part of the city most badly affected by severe traffic conditions and poor conditions for the pedestrian. On line 1, the last four stations from St. Just to La Rose are on the surface and on line 2 so are the two termini. Line 2 connects to a short tramway at Noailles station in the western part of the city centre.

The districts through which the Marseille métro passes fall into two categories: the city centre where the métro provides a welcome relief and alternative mode of travel to the badly congested streets and secondly the middle and outer suburbs where it forms a focus for the concentration of commercial and leisure activities and for transport routes. It does not pass through long sections of inner suburban high streets like the Grenoble tramway or the Lille métro, where improved acces may have resulted in increased competition for local shops.

Lyon

Line A extends from Perrache, one of the two main line railway stations, northwards underneath the long pedestrian axis along the central part of the Peninsula to the Hôtel de Ville, where it turns eastwards, underneath the River Rhône and under one of the main east-west routes to Laurent Bonnevay, the terminus on the middle ring road. The south-north section as far as the Hôtel de Ville passes under central area uses whilst the west-east section passes under inner and middle suburbs with many small (and some large) traders. Gratte Ciel station is on the fringe of the centre of Villeurbanne, the second largest commune in Greater Lyon.

Line B extends from the junction with Line A at Charpennes, southwards through Part-Dieu, a large office and commercial centre with the city's second main line railway station, to Jean Macé. Both Jean Macé and Perrache are on the main north-west to south-east route from Paris to Grenoble. Much of line B passes underneath city centre commercial uses. There are plans to extend line B southwards to Gerland, a zone d'aménagement concerté (section 6 above) where substantial commercial, educational and recreational facilities have been developed during the past 5-6 years.

Line C continues the south-north axis of line A from the Hôtel de Ville northwards through the inner suburbs of Croix Paquet and Croix Rousse to Cuire. Although these suburbs are close to the city centre, access by road is difficult. The narrow roads wind up the very steep slopes to Croix Rousse. This section, about 1 kilometre in length is the only substantial part of the whole network where the métro does not follow road lines. The land uses are typical of inner suburbs, the city centre ending as abruptly as the steepness of the land slope behind the Hôtel de Ville.

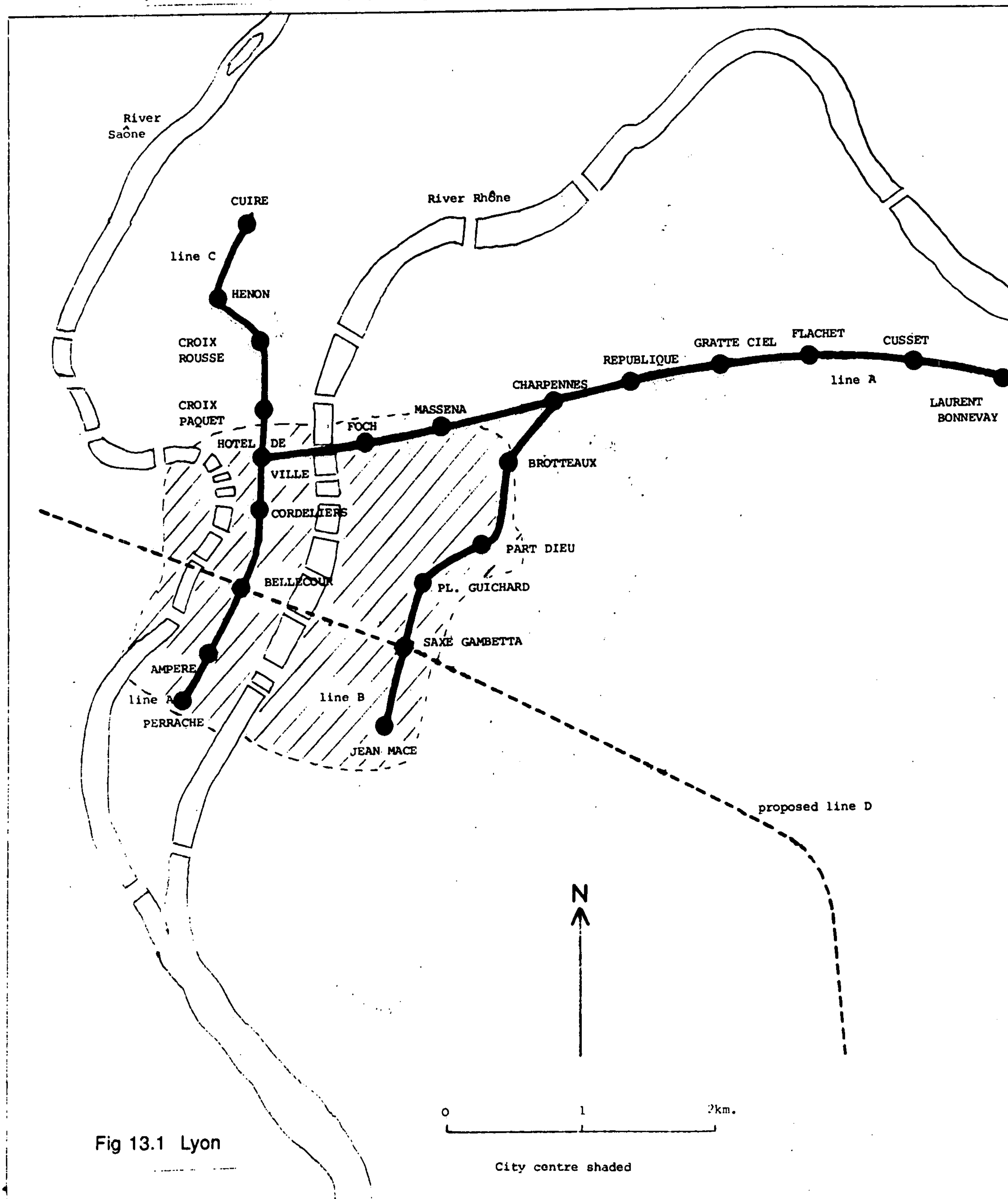

Fig 13.1 Lyon

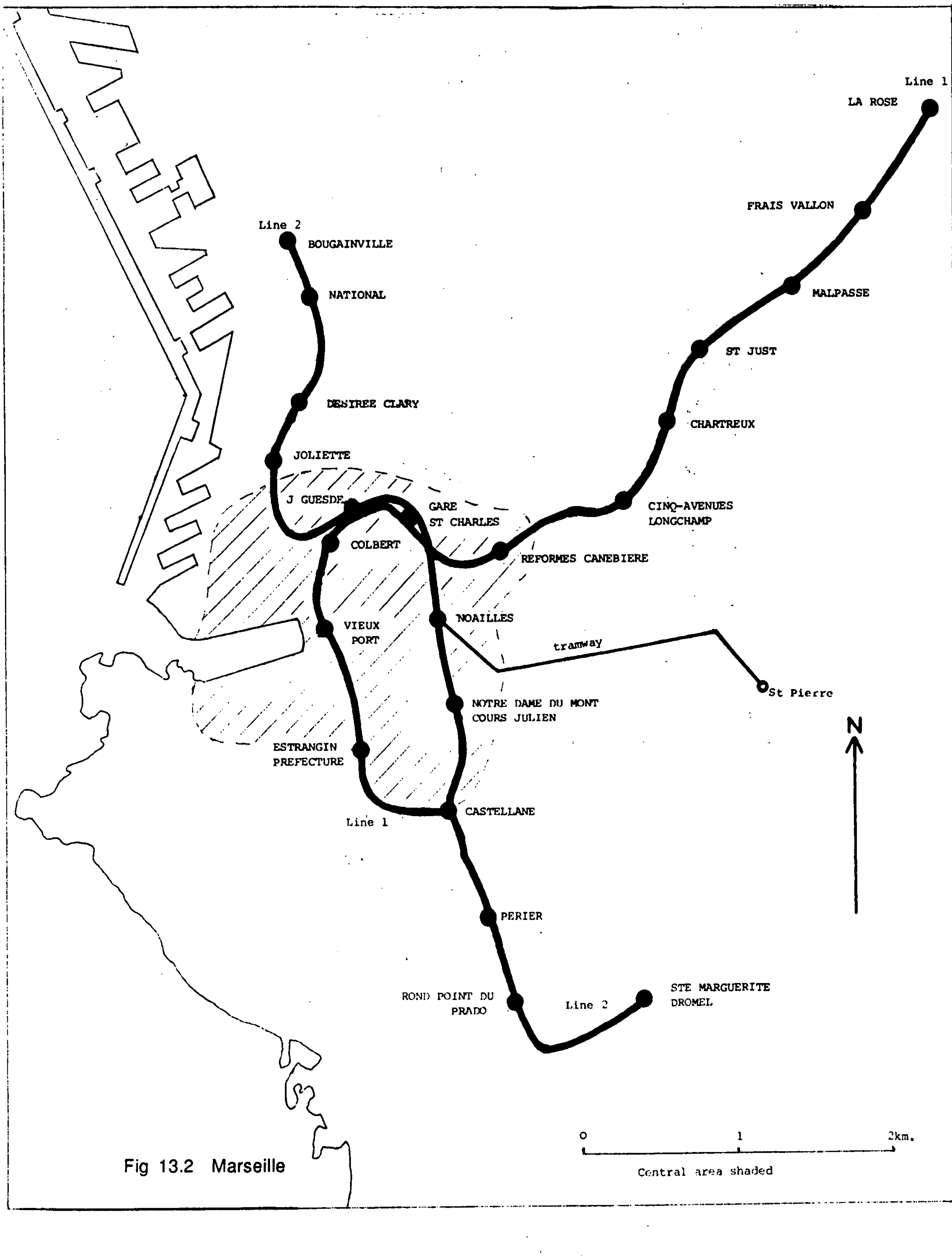

Fig 13.2 Marseille

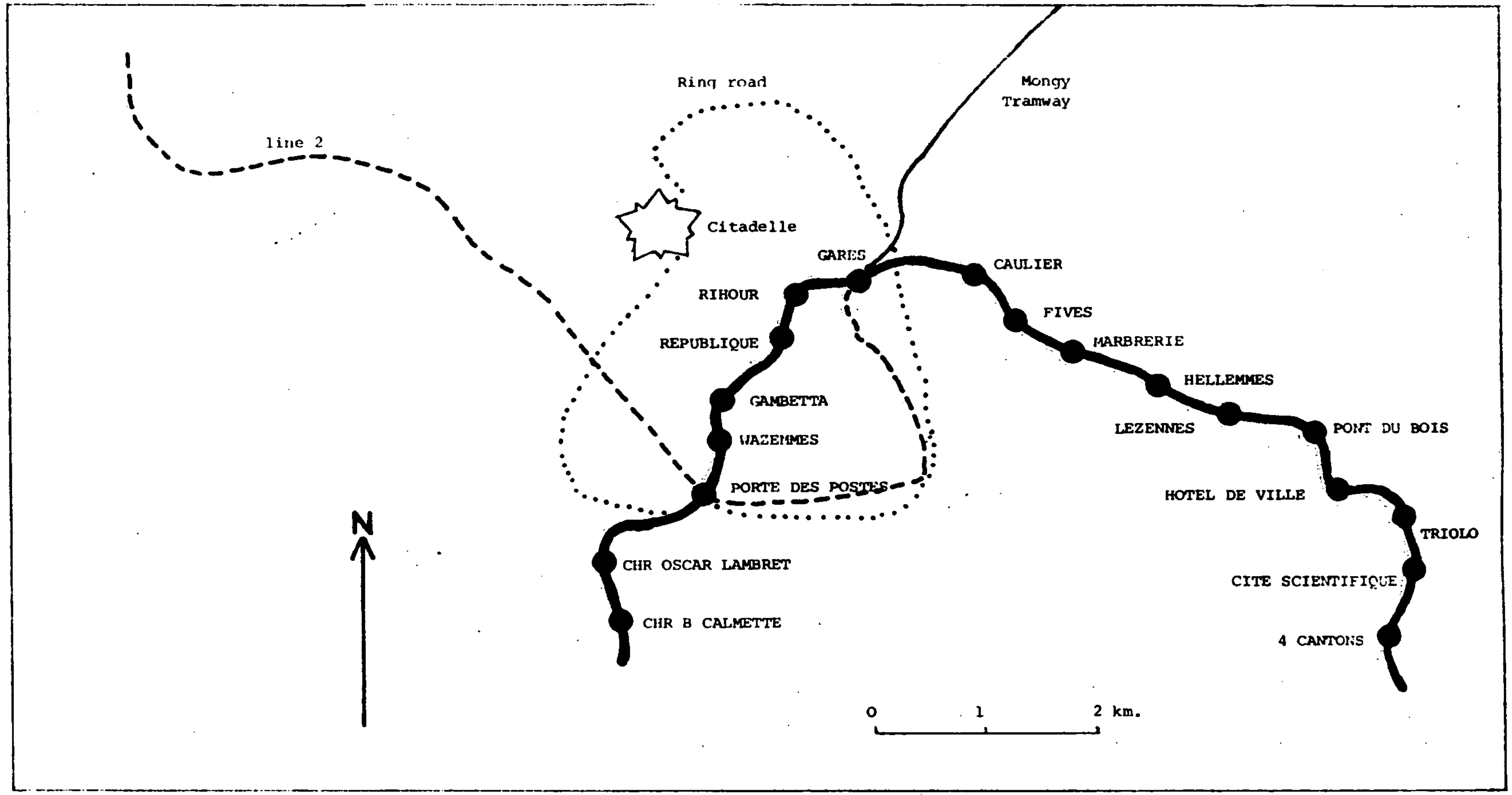

Fig 13.3 Lille

Lille

The métro connects the new town of Villeneuve d'Ascq westwards through the inner suburbs of Hellemmes and Fives where there has been some concern expressed by local shopkeepers of disruption and continuing loss of trade to the city centre and new town. Beyond, the métro enters the city centre at the main railway station in Lille where it connects to the Mongy tramway to Roubaix and Tourcoing. South-westwards, it passes underneath the city centre to Porte des Postes on the ring road and beyond to the main hospital.

A second line is under construction from the main railway station through the southern part of the city centre and north-eastwards to Lomme. It will connect with the first line at the railway station and at Porte des Postes on the ring road.

Justifications for the métros

In developing the new French métros over the past 15 years or so, emphasis has been placed on the improvement of public transport. In comparison with North America and the UK, little has been said about development effects. Even the possibility of recouping betterment has had less attention, although zones d'aménagement concerté and other land use planning procedures have been used to limit speculation in land (section 6 above). Before the métros, the buses were less effective than they are in most large British cities. Ridership on public transport was, and still is less. Amongst the reasons are that streets tend to be narrower and more congested with traffic, development is more dense and land uses more mixed (and therefore journeys tend to be shorter and on foot) and motor cycle usage is high. Restrictions on the use of the private car have not been accepted to an extent comparable with the UK, Sweden or West Germany for example. Some important streets in Lille and Lyon have been pedestrianised but even in these cities, traffic planning and regulation of the motor vehicle is not comparable with Gothenburg, Bremen or Munich for example.

The streets in Marseille tend to be narrow and winding, particularly south of the city centre, in fact, characteristically Mediterranean. On over 80% of the streets, the carriageway width is less than 7 metres and this has resulted in very low traffic speeds. It has also accentuated the need for priority measures for public transport. The average speed of the buses is only 13 kilometres per hour and much less than this in the city centre. Since the 1975 Plan de Transport half of the investment in public transport has been on forms using their own track - métro, tramway, SNCF. The métro is an alternative way of getting about the city which can otherwise be rather difficult and unpleasant. Many streets do not have a pavement more than two feet wide and even this may be blocked every few paces by cars, motor cycles, building works, holes to repair services, in fact every manner of obstruction conceivable. Few streets in central Marseille are pleasant to walk in and the métro provides a means of escape.

The métros have been seen as a way of reversing the declining fortunes of the city centres and inner areas in particular, as a way of connecting the suburbs with the main areas of employment. In these respects there have been some successes. In Lyon the decline in shopping turnover and floorspace was halted following the opening of the métro in 1978 (Watel 1984 and 1985).

Fig 13.4 The Marseille métro at Bougainville, the northern terminus of line 2, opened in 1987.

Fig 13.5 The Lyon métro at Cuire, the northern terminus of line C.

The Lyon métro travels through a more densely built up area than the Marseille métro. There is a population of 123,000 living within 500 metres of Line A (Société Lyonnais des Transports en Commun 1983, p 44) which indicates a population density of 12,870 persons per square kilometre. In Marseille the districts around the Line 1 stations average 8,101 persons per square kilometre and around Line 2 stations, 6,736 persons per square kilometre.

Costs and funding

Central government makes a subsidy of 50% towards the cost of preliminary project design and 40% of related infrastructure costs including engineering studies. The criteria for approval have been primarily connected with improvement in public transport services and achievement of land use planning aims along the lines explained in the previous section. The part of the cost not covered by central government subsidy may be financed by loans at a preferential rate by the state (Fonds de Développement Economique et Social) and repaid from versement transport (section 6 above).

In 1983, versement transport amounted to 88.52 million francs in the Communauté Urbaine de la Région Lyonnaise (COURLY: Lyon Metropolitan Authority) which contained 477,450 employees. In 1981, 43.6% of versement transport was spent on construction of the métro, 13.4% on investment in the surface network, 12.9% on compensation for reduced fares for workers, 4.5% to cover deficits on new routes and 25.6% miscellaneous (Société Lyonnaise des Transports en Commun 1983). The overall split of finance for the métro in Lyon was 72.1% loans funded by versement transport, 25.8% state subsidy, 2% other sources. At 1983 prices the construction of the new métro line was estimated at 395 million francs per kilometre including professional fees and rolling stock (Société Lyonnaise des Transports en Commun 1983).

The 13.5 km. of the Lille métro cost 1,700 million francs at January 1977 prices or 2,600 million francs at 1986 prices (126 million and 193 million francs per kilometre respectively). 20% of construction costs were provided by state subsidy, 60% from loans and 20% was self-financed (Vasseur 1986). Versement transport was raised by stages from 0.75% in 1974 to 1.5% in 1979 to repay loans and to provide funds for the municipal contribution.

The second Marseille métro line from Bougainville to Sainte Marguerite Dromel cost 2,700 million francs at 1986 prices (300 million francs per kilometre). 30% came from the state, 15% from the Département des Bouches-du-Rhone and 55% from the city of Marseille (Société du Métro de Marseille 1986)

Choice of technology

The sizes of the cities was significant in choosing métros. Public transport journeys are long enough for speed to be important and therefore a surface tramway would not be equally attractive. In Marseille there would also be a problem in finding a route for a surface tramway due to the narrowness of so many streets and the unwillingness to effectively regulate motor vehicles. It is possible to envisage that a tramway could have been developed in Lyon or Lille, particularly Lille which already has a tramway connecting the towns of Roubaix and Tourcoing to the métro at Lille central railway station but the slower speed and lower capacity would have made it less attractive than the métro. In both Lyon and Lille there are significant pedestrian streets above the lines of the métros which could have been used for a tramway.

Operational details

Marseille

Operated by Régie Autonome des Transports de la Ville de Marseille, 10-12 avenue Clot-Bey, BP 334, 13008, Marseille, cédex 8, Tel: (91) 95 55 55.

Construction authority: Société du Métro de Marseille, 44 avenue Alexandre Dumas, 13272, Marseille, cédex 8, Tel: (91) 77 68 82.

Rolling stock: 144 cars in 4-car sets; series A (1977) M42 T21; series B (1984) M30 T15; series N (1985/86) M36.

Service: 3 minutes, off-peak 5-10 minutes

Lyon

Operated by Société Lyonnaise des Transports en Commun, 50 cours Lafayette, 69423 Lyon, cédex 3, tel: 7 860 25 53.

Construction authority: Société d'économie Mixte du Métropolitain de l'Agglomération Lyonnaise, 25 cours Emile Zola, 69625, Villeurbanne, cédex, Tel: 7 893 90 09

Rolling stock: 110 cars: Alsthom (métro) M64 T33; Alsthom/SLM (rack line C) M13.

Service: 2-4 minutes, off-peak 5 minutes.

Lille

Operated by COMELI, Cie du Métro de Lille, rue de Cysoing, 59650, Villeneuve d'Ascq, Tel: 20 91 92 01

Rolling stock: 44 2-car sets CMIT M88.

All three authorities operate flat fares from automatic ticket machines. Cut-and-cover construction has been used for the greater part of the routes. The Lille and Marseille métros are partly elevated.

Impacts

In Marseille bus routes especially in the south and north-east of the city converge on the métro and very few buses from these districts go into the city centre. Most buses which do go into the city centre are from the north and east of the city. The Marseille métro serves areas dependent on central area employment instead of the working class districts of the north and east and suburb-suburb journeys. Thus it has helped to maintain activities in the city centre and accentuate the distinction between employment in the centre and residence in the suburbs.

The métro has reduced the need for buses in Marseille city centre, important due to the congested road conditions. The métro does not seem to have had any effect on congestion. It is hard to believe that pre-métro city centre congestion could have been worse than it is now. The métro has attracted some car users but these are only a small proportion of all road users and they have probably been replaced by others. Mazzella (1984) came to the same conclusions for the suburbs of St Antoine and St Loup: public transport has had little effect on the use of private cars for journeys to work. Anyone who has one available will use it.

The métro coincided with a revival in the use of public transport. The annual number of journeys at around 130 million in the mid 1980s is close to what it was in the mid 1950s, having declined to 80-90 million in the decade before the métro was opened. Simultaneously with the métro, tariff reform, a revised marketing strategy and reorganisation of bus routes no doubt contributed to this revival. Despite the revival, subsidies have continued to increase from nothing in 1965 to 15 million francs in 1968 and 170 million francs in 1979.

A study by the Agence d'Urbanisme de l'Agglomération Marseillaise (1979) came to the conclusion that no clear relationship between the métro and house prices could be demonstrated but it may have helped sales in some places. The métro can however, be seen to influence development. Between 1975 and 1978, 25% of new dwellings were built adjacent to Line 1. A science park is being developed adjacent to the north-eastern terminus of Line 1. Also, much housing has been converted to offices along the first métro line. However, the effects of the métro have been rather patchy. The study undertaken by the Agence d'Urbanisme de l'Agglomération Marseillaise shortly after the opening of Line 1 came to the conclusion that it was having little effect on the property market but that in districts in the south of the city, near the planned route of Line 2, prices were already rising in anticipation of the new métro line. Such rises in property values in anticipation of a new railway are fairly common. In Marseille, rises in land and property prices around stations have been controlled by use of the zone d'aménagement concerté and zone d'intervention foncière procedures.

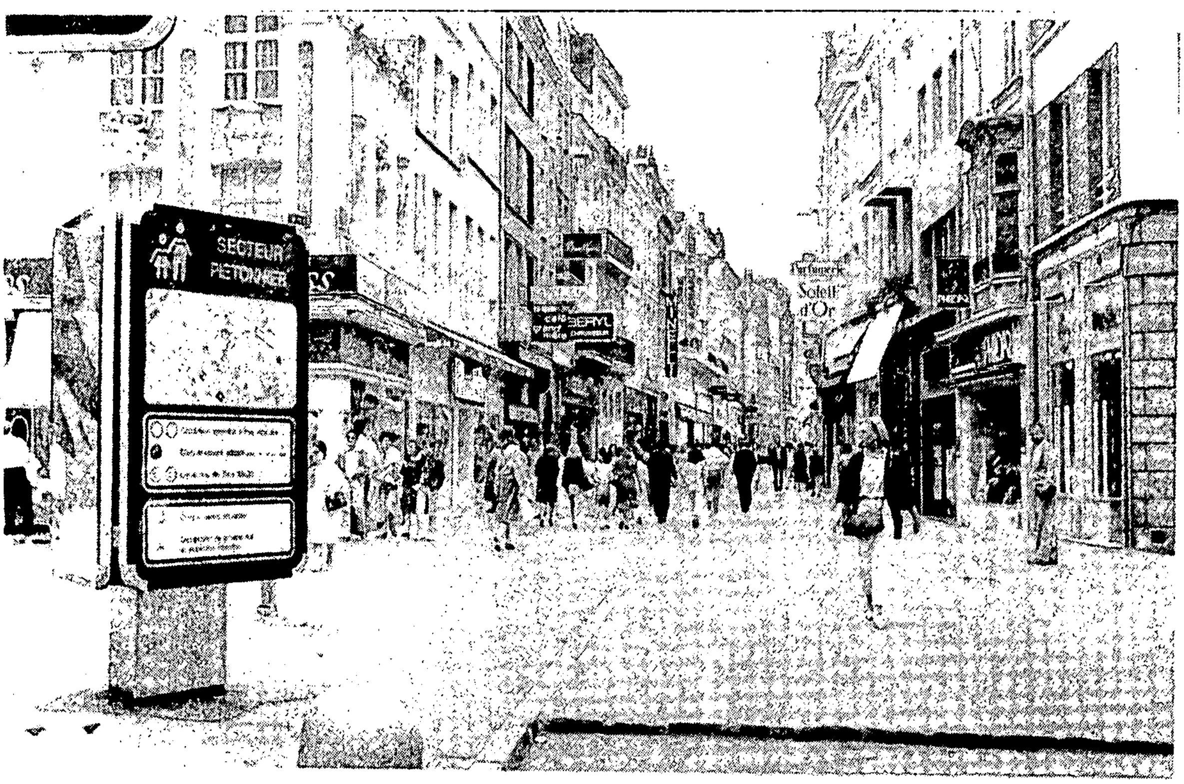

Fig 13.6 Pedestrianisation above the métro in Lille city centre.

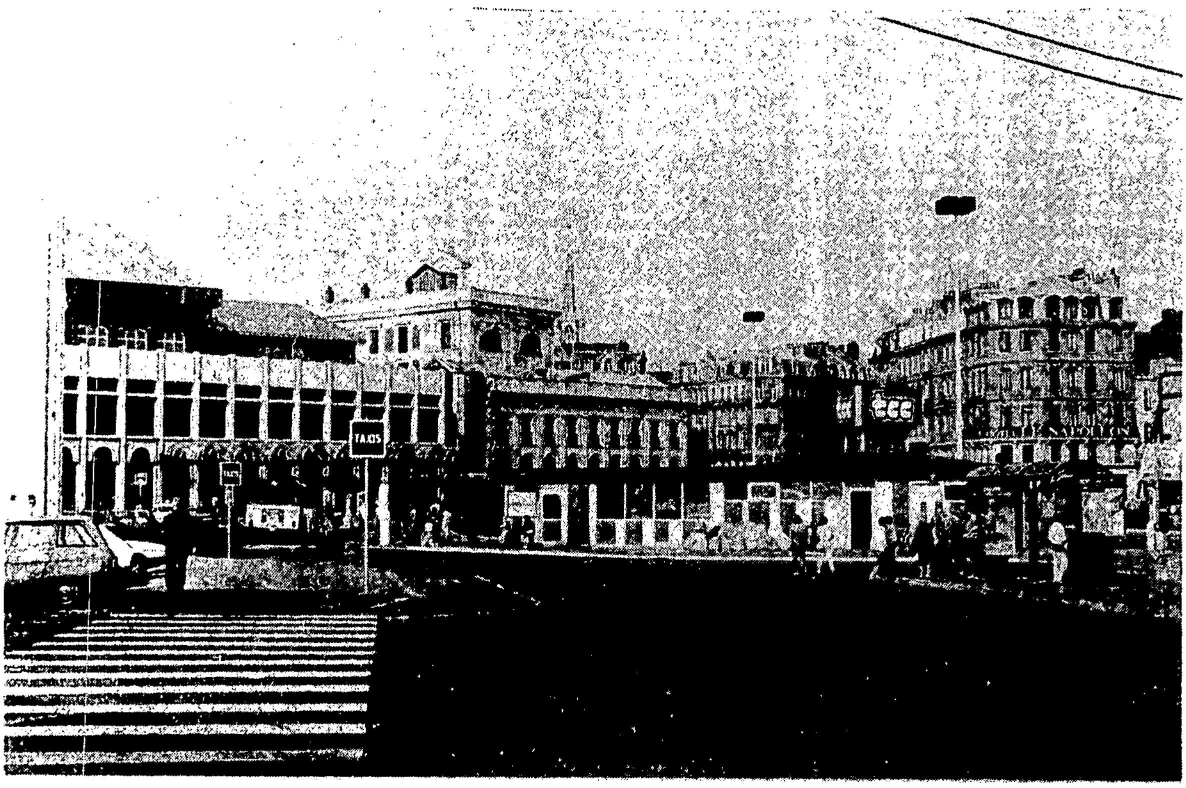

Fig 13.7 Gares, the centre of the Lille public transport network.

The opening of the Lyon métro coincided with a reversal in the fortune of public transport and also a reversal in the downward trend in shopping turnover in the Peninsula (Chambre de Commerce et d'Industrie de Lyon 1983; Watel 1985). It has been observed that the greatest increase in trade in the city centre following the opening of the métro came from the north-west of the city which is not served by it. The métro vacated space for these people to travel in by car (Watel 1985).

The same phenomenon of using the métro to collect some bus routes in the suburbs and some revival of city centre shopping and commerce can be observed in Lille. Although the revitalisation has not been as great as some of the claims made for British and American LRT networks might lead us to expect, the métros in both Lyon and Marseille have been important in improving the images of the two cities and in promoting a closer relationship between city centre and suburbs. It is now not so much a case of directing and planning growth but of 'selling' the town (Dalmais and Mazzella 1985).

As in Marseille, the opening of the Lille métro coincided with a revival in public transport. The number of journeys increased by 47% between 1982 and 1984, mostly by métro. Bus journeys declined by 1.5%, although taking into account the routes replaced by the métro, the remainder increased. Tram journeys increased by 28%. In the period following the opening of the métro, Beaussart (1985) found that 24% of métro journeys were made by those who formerly travelled by car, although these journeys accounted for only 2% of car journeys in Greater Lille.

Malabry (1985) concluded that the métro in Lille had not been a decisive influence on the centre of Villeneuve d'Ascq which has been expanding with the new town but may have been more significant for Lille city centre. It has however, had some detrimental effects on the inner suburbs. It has accelerated the closure of shops run by the elderly and has taken away young people for other activities. Some traders estimated that they lost as much as half of their trade during construction and there was a lot of opposition before, during and after construction from traders and residents in the inner suburbs. Traders around Fives and Hellemmes in particular though that the métro would favour the new town and city centre at their expense (*Voix du Nord* 26 mai 1979, 19 avril 1980, 19 janvier 1983, 13 novembre 1984; *Nord-Matin* 2 février 1985, 1 juin 1985). The survey reported below confirmed that this view of the métro has still not disappeared. Some would regard these effects as a process of accentuating pre-existing trends (Offner 1986).

This fear was also expressed by Dalmais van Straaten (1985) in relation to the Lyon métro. Once shoppers are on the métro they might as well go right through a suburban centre such as Villeurbanne (Gratte-Ciel) to the city centre. The opening of a métro station is unlikely to reverse urban decline but might accentuate urban growth which is already taking place. Where there is a change in mode of transport at a métro station the stimulus to the shopping around the station seems to be greater. Working in Lyon suburbs, Sanson (1984 and 1985) found changes of transport means had a considerable effect on local shopping. Many shoppers called back to the centres at times other than the time of transport exchange. The métro seems to have been more competitive to the private car for shopping than for other journey purposes. In a survey reported by Malabry, 25% of métro users had a private car available at the time of their métro journey. Throughout the Lyon métro network, any changes have been in terms of intensity of activity rather than land use or building development. The only substantial development which has accompanied the métro has been carried out by public authorities.

A questionnaire survey was carried out in all three French cities under the author's supervision during the summer of 1988. Separate questionnaires were used for members of the public and businesses near to the métro stations in the inner suburbns and termini. The main conclusions were as follows:

* A majority of motorists in all three cities travel to the city centre by métro. The métro does appear to release roadspace, but this may be taken up by other motorists.

* The Lyon métro seems to have attracted more non-bus users than the Lille and Marseille métros.

* In all three cities more respondents use the métro for shopping than for any other purpose. This is a journey purpose which is sensitive to price and service since shopping habits can be easily changed, in comparison with work for example.

* In Lille and Marseille there is little difference in journey purpose between car owners and those who do not have a car. In Lyon, car owners are more likely to travel to the city for work and shopping and less likely for education, leisure and to visit friends.

* The métros seem to have had a limited influence on individual decisions about the locations of their activities.

* There is strong support for the extension of the métros by members of the public in both cities.

* More local changes have been for the better in Lyon and Marseille than in Lille. Problems

have been felt particularly in inner Lille. In Fives and Hellemmes, of those who noticed a change in the shopping facilities (28% of the total respondents), 70% said that the change was for the worse. Similar conclusions apply for city-wide changes The changes are attributed more firmly to the métro in Lille than in Lyon or Marseille. Similar conclusions apply to businesses. During the period of métro construction and immediately afterwards, there was a lot of concern about the effects on local shops as reported in the local newspapers (for example, *Voix du Nord* 26th May1979, 19th April 1980, 7th October 1980 and 19th January 1983; *Nord-Matin* 2nd February 1985 and 1st June 1985).

* The métros have influenced locational decisions by business proprietors more than decisions by other members of the public.

* Detrimental effects of the métro have been felt more strongly in Lille than in Lyon or Marseille. In all three cities the great majority of respondents were from inner city areas.

* Not surprisingly in view of the answers to previous questions, there is some opposition from businesses to the extension of the Lille métro.

A full analysis of the questionnaire survey is to be made available as a technical appendix.

Extensions of the métros

All three métros are presently being extended. Line 2 of the Marseille métro was extended by a further two and a half kilometres with three stations in 1987 and further extensions are envisaged beyond the other present day termini. In Lyon, Line C is to be extended northwards and a new line D of eight kilometres and linking Lines A and B is under construction. A second line in Lille from the main railway station, north-westwards to Lomme is under construction. With Line 1, it will form a ring around the city centre, on the same principle as the Marseille métro, although the ring is rather larger. The two connections with Line 1 will be at the main railway station and Porte des Postes (also a junction on the Périphérique).

Conclusions

The three largest cities in France after Paris took the opportunity of the introduction of versement transport in 1973 to improve their public transport services, improve their external image and improve the prospects of planning growth poles, all at no expense to the individual taxpayer. This must have had some attractions in political terms. Whilst the burden of payment for the métros appears to fall on only a small part of th electorate, the benefits are available to all. Métros were the technology of the time, when memories of the old trams may have still been in the minds of many of the electorate. Particularly in Marseille and Lyon, métros did offer advantages of speed and suitability to the physical fabric and demand.

The situation in British cities is rather different. Typical population densities are around half of those of the districts served by the French métros but the British cities with LRT proposals are mostly larger in population and even more so in terms of built-up area. This affects lengths of journey and the attractiveness of speed of public transport. Even without LRT, public transport in most British cities is healthier than in French cities in terms of having lower subsidies and higher usage. This applies even after the building of the métros. Public transport in the large British cities does not have problems equal to those in the French cities before the métros.

Although there is scope for improvement in public transport in British cities, particularly if part of a package of complementary policies towards traffic, transport and the environment, British cities do not face problems of the magnitude experienced in some French cities. Above all, British cities do not have versement transport. They do not have such a politically attractive means of raising finance. Also, Britain has a history of relatively weak local government. Whereas some French senior local politicians simultaneously hold senior national political posts of cabinet rank, in Britain there is the tradition of the amateur local politician.

The proposals for Manchester, the West Midlands and Bristol are not true métros. They would be better described as trams on suburban railway track with some genuine tramway in the city centres. However, the capacity would not be greatly different from those of the new French métros and apart from the on-street sections, the speed too would not be much slower. In these significant respects, the differences are small but the requirements of British cities and the claims made for the LRT proposals are quite different from those in Marseille, Lyon and Lille.

14 Munich

Munich has been selected for study as a city having 'heavy', 'medium' and 'light' urban rail networks - the S-Bahn, U-Bahn and Straßenbahn - acting in a complementary way. It also illustrates well the relationships between public transport planning and land use planning.

Munich is now the largest city and state capital of CSU-voting Bavaria. The centre of the city is still where it has always been - a few hundred metres from the Isar, a fairly fast flowing, non-navigable river, 120 kilometres from its confluence with the Danube. At the end of 1982 the 320 square kilometres of the Landeshauptstadt had a population of 1,287,080 at the high density of 4,022 persons per square kilometre.

During the 1950s and 1960s the Landeshauptstadt gained in population from in-migration to reach 1,338,924 in 1972, also the year of the Olympic Games, opening of the U-Bahn and the S-Bahn and the first main phase of pedestrianisation in the city centre. Since this peak the population has gradually declined although that of the surrounding Kreise has continued to increase. In the 1960s there was a large infux of foreigners. Since then there has been some decline to 212,066 in 1982 or 16.5% of the population.

Growth in car ownership almost stopped in the few year following the opening of the U-Bahn in 1972 and since 1975 it has been below the national average: (in 1980, 360 cars per thousand inhabitants compared with 380 for the Bundesrepublik).

Transport planning

The Generalverkehrsplan (Traffic Master Plan) 1965 proposed the fundamentals of the present public transport system: the U-Bahn and S-Bahn, complementarity of modes of public transport and creation of a city-wide passenger transport authority. Also proposed were the three ring roads and a series of radials.

The main change in the Generalverkehrsplan 1975, was the abandonment of much of the road proposals, partially built. Within the area served by the U-Bahn, the only roads to be constructed would be those to connect existing roads and a few works to increase the capacity of existing roads. Some new roads would be built further out from the city to connect to the S-Bahn, especialy tangential ones. The plan of 1975 also reflected the increasing concern for the environment. Measures were proposed to protect residents from traffic noise - insulation and alteration of internal layout of dwelling. Development of new roads came to depend to the feasibility of protecting residents from their harmful effects.

And so at present, there is near abandonment of new road construction in the centre and inner city. There has even been a reduction in capacity of some completed roads. For example, some

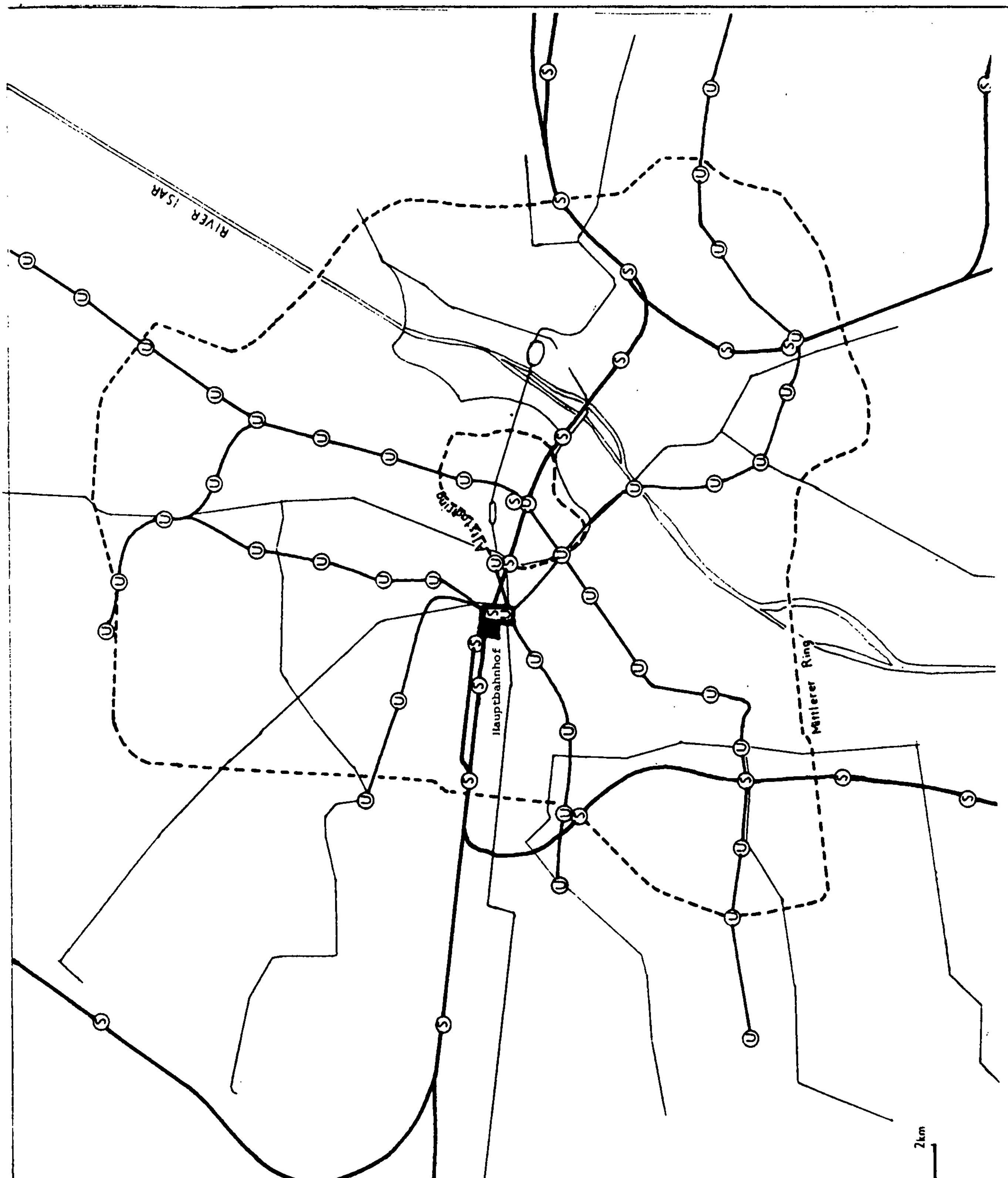

Fig 14.1 Munich

parts of the inner ring were constructed as eight-lane, now reduced to six, the outer lane in each direction being used for parking.

The basic model on which the city centre has been planned has been one of priority for public transport within the area covered by the U-Bahn with access by car limited to well-defined areas. The inner ring is not as well developed as in Birmingham, Coventry or Hamburg for example, but neverthless functions in part as a means of rapid road access. Within there are cells bounded by the two main pedestrian axes of Neuhauser Straße- Kaufingerstraße and Theatinerstraße. Most streets within are one-way and with rather circuitous routing to prevent through traffic even where the way is not blocked by pedestrianisation. Car parking is mostly at the rear and near to the inner ring. The main pedestrian axes are underlain by U-Bahn and S-Bahn to give rapid access from most parts of the Munich region

The first main pedestrianisation was that of Neuhauser Straße-Kaufinger Straße in 1972, incidentally the route of the old road from Augsburg to Salzburg on which the city was founded. It was seen as part of a series of measures - U-Bahn, S-Bahn, ring road and traffic cells - all of which were at least partly dependent on each other for their success. The success was such that in the second phase, Theatinerstraße in 1976, the municipality could collect half of the costs from house and shop owners in the shopping area and still have a viable scheme.

Pedestrianisation and traffic restrictions in the centre have increased through traffic in neighbouring districts of the inner city. One-way systems have been used to discourage through traffic and the U-Bahn has reduced the need for private transport.

The routes

S-Bahn

There are seven lines, five of which are cross-city, the other two (S5 and S7) being from the west and south, terminating at the Ostbahnhof. With a total length of 412 kilometres, they serve and area up to about 45 km. from the city centre. The main east-west axis is between Passing via the Hauptbahnhof and underneath the pedestrian area to the Ostbahnhof, with five underground stations in the city centre. The underground connection between Hauptbahnhof and Ostbahnhof, the city's two main railway stations, was opened in 1972, thus avoiding a great deal of surface traffic through the city centre. The S-Bahn has no lines of its own, all of them being shared with Deutsche Bundesbahn. This creates problems of limiting the capacity at peak times which is receiving priority at present. There is a basic 40-minute service, 20-minute on-peak.

U-Bahn

Four of the five lines are cross-city, predominantly in a north-south direction to complement the main east-west axis of the S-Bahn. With a total length of 42 kilometres, it extends up to about 4-5 kilometres from the city. Services are 5-minute on-peak. Before the opening of the U-Bahn in 1972, 37% of daily journeys in Munich were by public transport, 63% private, whilst by 1974 this had changed to 44% and 56% respectively. The Stadtentwicklungsplan 1983 envisaged investment of DM 1569 million over the coming five years which would enable extensions of about 3 or 4 kilometres per year. In fact the plan proposed to extend the network considerably further in the northern and southern suburbs and the construction of a new line to the east to Arabella Park and Insbrucker Ring, measures which will increase the influence of the city centre. The extensions to Arabella Park and Innsbrucker Ring have been opened recently.

Straßenbahn
The Straßenbahn acts partly as a feeder to the U-Bahn and S-Bahn. All 11 lines connect to them, but most lines also go into the city centre. The south-western section of the inner ring acts as a collecting point for several lines. Some of the lines also fill in gaps not covered by the U-Bahn and are a substitute for it. The Straßenbahn is being gradually reduced as new U-Bahn sections are brought into operation. Between 1974 and 1984 it was reduced from 112 kilometres to 84 kilometres. The minimum viable network is estimated at 55 to 59 kilometres (O.E.C.D. 1984). About half of the Straßenbahn in the central area is on reserved tracks.

Buses
The buses in particular act as feeders to the S-Bahn and U-Bahn. Only 8 of the 75 bus routes enter the inner ring. There are now 10,200 park-and-ride places at S-Bahn stations and 1,500 places at U-Bahn stations and considerably more vehicles are parked than that. In recent years bus services have been particularly developed to bring people into the smaller rural centres to counteract the drawing powers of the S-Bahn and provide connections to it.

Justifications

The city authorities supported by state and federal government have placed a great deal of emphasis on realising the potential of the environment throughout the city and have been willing to back up such policies with heavy investment and continued subsidisy for public transport. State and federal government financial contributions and the availability of finance from the Mineralölsteuer have been essential to the development of the public transport network. Restrictions have been placed on the motor vehicle but heavy investment in public transport infrastructure has been justified partly in order to attract traffic from the private car. By increasing accessibility, the urban railways have also helped to arrest the commercial decline of the city centre and the decentralisation of shopping to the suburbs. There have also been social objectives. An effective public transport system has been regarded as a reasonable expectation of civilised urban life.

As a general rule, incentives rather than compulsion have been used to effect the switch from private to public transport. The Münchner Verkehrs- und Tarifverbund has not attempted to block the use of the private car because it is recognised that it is essential for some journeys such as bulky purchases. However, in 1980, 70% of the 400,000 daily journeys with origin or destination in the Altstadt were by public transport, 30% by private transport (44% and 56% respectively for the 2,500,000 daily journeys in the Landeshauptstadt). Parking has been used as a means of distinguishing the needs for access by car, but not particularly strictly. On-street parking is mostly short term. Long term off-street places in the city centre have been reduced from about 17,000 in the early 1960s to 12,000 at present, still a large number. Workers have been encouraged to park on the outskirts at S-Bahn or U-Bahn stations, whilst the policy has been to provide adequate spaces for shoppers and deliveries in the centre. The maximum permissible parking charges have been increased from 10 Pfennigs to 1DM per half hour. The proceeds go to the Land (state), which has been cited as a reason for the limited desire to apply parking restrictions (O.E.C.D. 1984). In fact, in recent years, parking restrictions have been relaxed slightly, some parking bans having been abandoned. When development takes place in the city centre it is normal to require the provision of parking places. Often, however, space is insufficient and so the requirement is waived. Instead, a fee is charged, in 1984, DM7,500 per place, to allow the city to provide car parking elsewhere, usually nearby in the inner city districts, often underground.

Choice of technology

In the city centre the reasons for the choice of technology have been primarily environmental. The U-Bahn and S-Bahn are particularly efective in giving accessibility with no environmental damage. Elsewhere, speed and the aim of providing an attractive public transport system have been amongst the most important reasons for the replacement of the Straßenbahn with the U-Bahn.

Rolling stock

U-Bahn: 396 cars, MAN/Siemens, MBB, Rathgeber, O&K.
Straßenbahn: 380 cars, Rathgeber M157, T141, M42, T40
S-Bahn: 190 three-car trains.

Ridership

U-Bahn: 209.7 million passenger jhourneys (1986)
Straßenbahn: 89.3 million passenger journeys (1986)
S-Bahn: 191.6 million passenger journeys (1986)
Bus: 32 million passenger journeys (1985)

Sources of funding

The city covers deficits of the U-Bahn, Straßenbahn and buses. Federal government subsidises the S-Bahn.

Subsidy levels

In 1984 operating costs were 825.6 million DM, revenues 487.1 million DM, subsidy 41%. This compares with 493.0 million DM costs, 217.8 million DM revenue and subsidy 55.8% in 1973, the first year of the U-Bahn and S-Bahn.

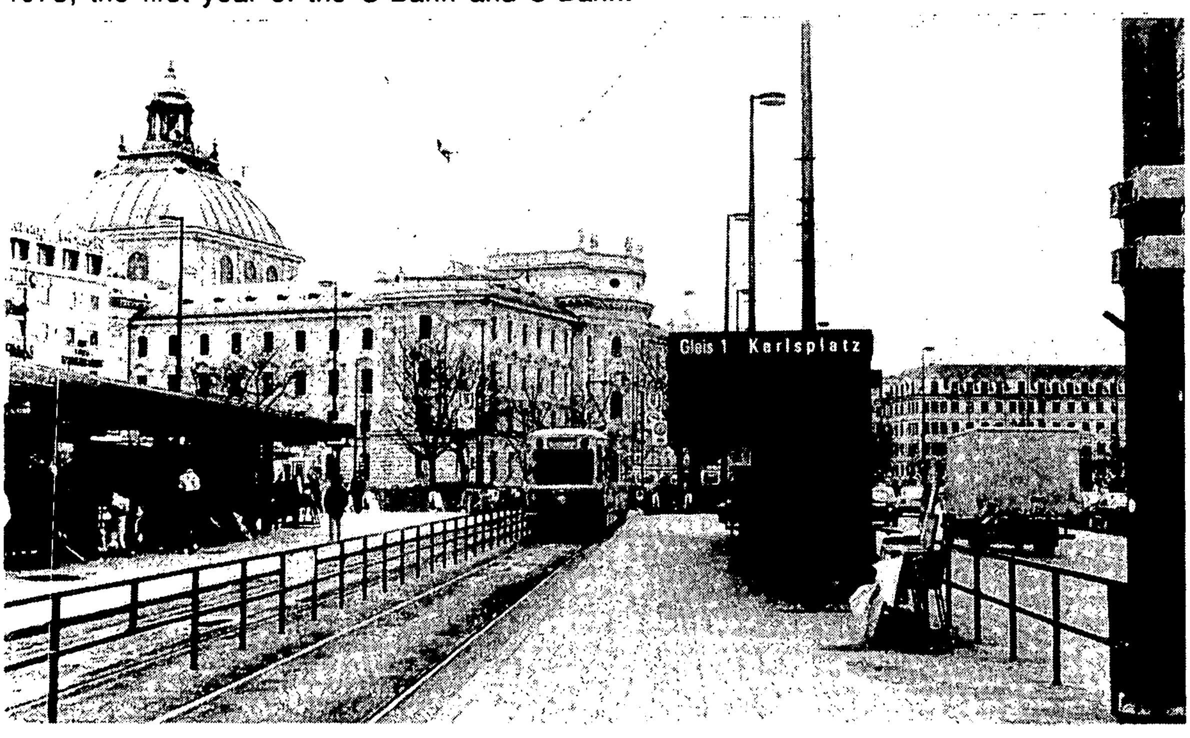

Fig 14.2 The Munich Straßenbahn in the central reservation of the inner ring

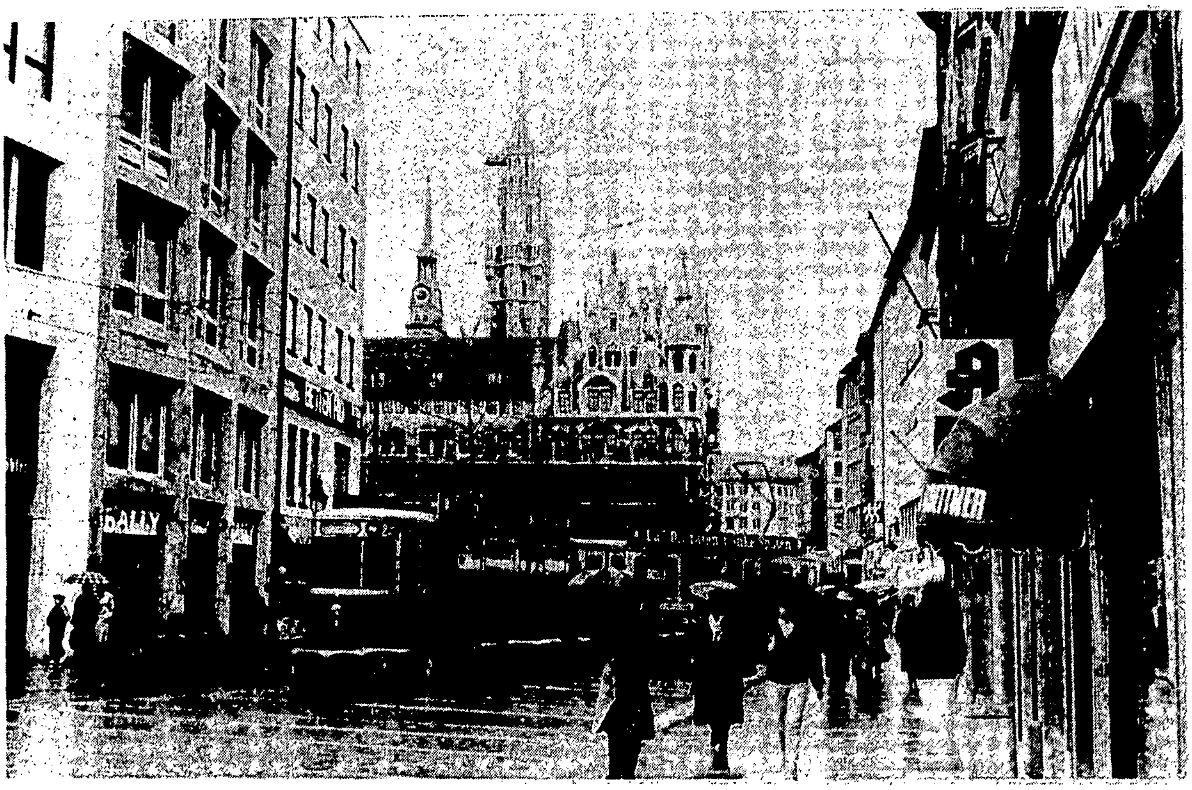

Fig 14.3 The Munich Straßenbahn brings passengers right into the pedestrian area

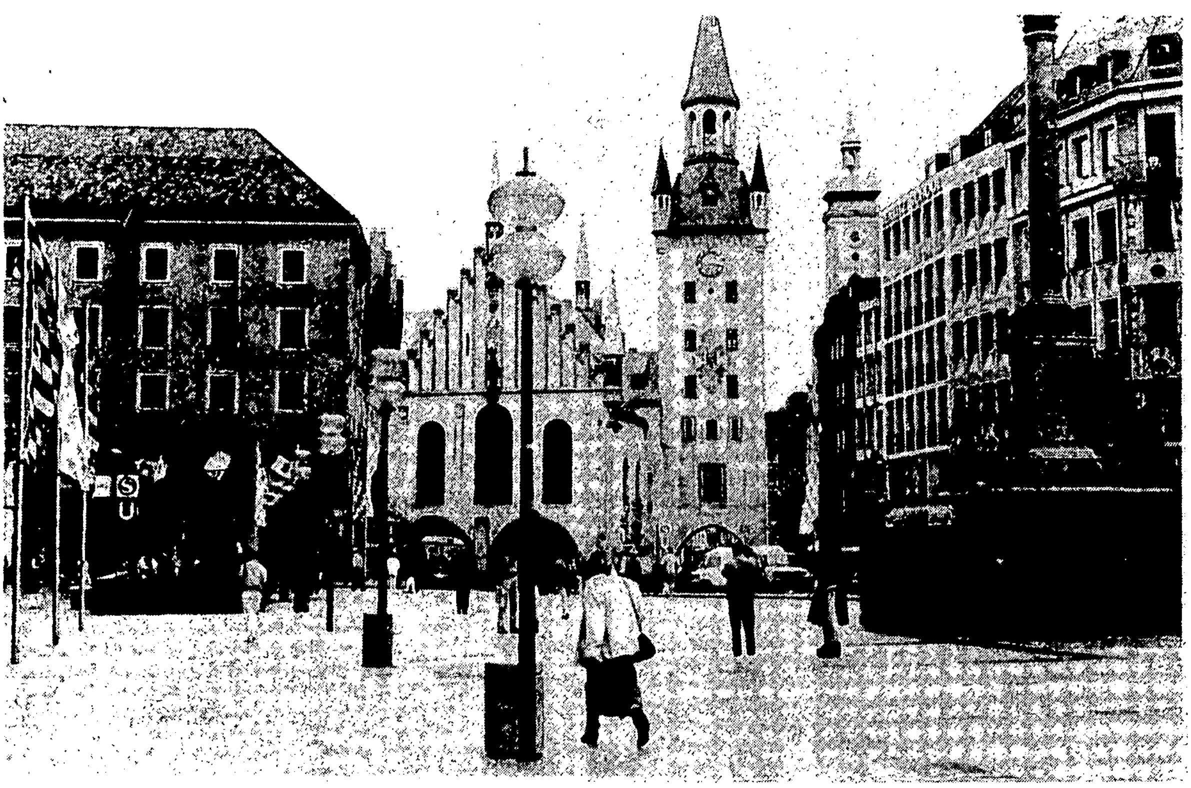

Fig 14.4 Munich Marienplatz: S-Bahn and U-Bahn stations under the pedestrian axis

Conclusions

Munich is typical of many large West German cities in having a hierarchy of public transport modes each with a clearly defined rôle - S-Bahn serving the region, U-Bahn serving the city, Straßenbahn serving the inner city and acting as feeder to the S-Bahn and U-Bahn, buses serving the outlying districts and bringing passengers to the railways. Densities along the rail axes are much higher than in the UK. City centre transport planning is significantly different from policies in most large British cities - more restrictive towards the car, greater emphasis on environmental quality and greater use of the main railway station for local as well as regional and national transport.

Like several other West German cities such as Frankfurt, Munich is replacing the Straßenbahn with U-Bahn sections, perhaps not a supportive sign for the British LRT proposals. The slowness of the Straßenbahn has been one of its main disadvantages. The British proposals which use suburban railway track may avoid this problem.

The land use patterns of a large West German city such as Munich are quite different from typical British cities of similar size. Residential densities are higher and development is more concentrated, with intervening open space: well adapted to rail transport.

Munich is an orderly city - a very good case of integrated planning between buses, Straßenbahn, U-Bahn, S-Bahn, the private car, pedestrianisation and land use planning. The authorities have a clear conception of the rôle of each and the determination to see that these rôles are carried out. 1972 was an important year for Munich. The Olympic Games no doubt acted as the final incentive that was needed to build the U-Bahn, develop the S-Bahn and implement the first stages of what is a very large and attractive city centre pedestrianisation scheme.

15 Conclusions

The case studies show very clearly two requirements in order to achieve the full potential benefits of urban rail:

* The need to adapt the form of urban rail to the characteristics of the city - density of building, particularly home and workplace, degree of centrality of shopping and commerce for example. Thus when we remember the crowded streets of Marseille it is plain to understand why a métro rather than a tramway was chosen. Equally, because of the nature of most of the route of the Grenoble tramway, it has served to unite land uses and act as a focus for renewal possibly more successfully than a métro would have done.

* The desirability of treating urban rail as part of a package of improvements which needs to be backed up by clear, comprehensive and decisive traffic planning and town planning measures. There are some important differences between the French cities on the one hand and the West German and Swedish cities on the other. All four French cities in this study have implemented some land use planning projects to back up LRT and to realise some of the benefits from it. In Marseille, the potential of the termini in particular has been developed and in Lyon, Lille and Grenoble there are significant pedestrian schemes and other environmental improvements in the city centres as well. However, the French cities have not used LRT as part of a comprehensive plan for transport and land use, with powers to control road traffic equal to those of the West German and Swedish cities. French planning is far more effective in implementing projects than it is in comprehensive planning control. The most degraded districts of French cities are worse than their West German and Swedish counterparts.

Borrowing experiences from abroad is always fraught with problems of differences between cities and between countries. Indeed, there is no other country which closely matches British transport and planning legislation and none with cities closely comparable in terms of all of the characteristics likely to affect policies towards urban rail. Continental European cities are mostly more densely built than are British cities, particularly in the inner suburbs. In many districts, 7,000 persons per square kilometre is common in Europe and 15,000 is not unusual. In England, 3,000-4,000 persons per square kilometre is typical and over 9,000 is rare. As the catchment areas of stations seems to be unaffected by density, the potential number of riders is lower in British cities. In some continental countries such as Germany and Sweden (but not France) the pattern of settlement as well as density is better suited to rail than in Britain. In cities such as Frankfurt, Munich, Hamburg and Stockholm for example, settlement tends to be concentrated around high density nodal points, with low density development or open space between, a pattern suited to high capacity urban rail. To some extent, these patterns of land use and density have developed along with urban rail or even because of it. In Stockholm the development of the new towns of Vallingby and Färsta in the 1950s and 1960s has been influenced by the presence of the T-bana. The absence of land use patterns favourable to urban rail does not preclude their development along with rail, if deemed desirable and if supported by land use planning policies.

As there are substantial differences between British cities and continental European cities and even greater differences between North American and European cities, it is relevant to ask how far the experiences are transferable. The evidence in this study supports the view that experiences are indeed transferable. The answers to the main questions raised in these conclusions are remarkably consistent between North American and European cities. The reason is probably that the differences between cities are quantitative rather than qualitative. Numbers of potential riders around stations vary but the technology of both the railways and competitive means of transport are similar. Perhaps we should not be too surprised that public reactions to the introduction of a given technology such as light rail in similar competitive environments with the private car will be similar. The differences are in the numbers of potential riders and the numbers of cars and indeed there are differences in ridership between European and North American cities.

For these reasons, evidence on some of the most significant questions concerning LRT is not as tentative as might be feared.

Will LRT attract motorists away from their cars?

When a new metro is opened it is not usual for it to be accompanied by a decline in the number of cars on city centre roads or elsewhere unless traffic restrictions are made at the same time. In Munich for example, the opening of the U-Bahn, the development of the S-Bahn and substantial pedestrianisation together coincided with a reduction of 70,000 in the number of daily car trips in the city centre (Girnau 1982). Surveys on the new métros in Marseille, Lyon and Lille have come to the conclusion that they do attract some motorists away from their cars but the road space released is taken up by other motorists. Similar conclusions apply in the USA. In San Diego for example, no noticeable reduction in traffic congestion followed the opening of the LRT system (San Diego Association of Governments 1984).

During the 1950s when the private car was increasing in numbers there were many predictions to the effect that traffic in large cities would soon come to a halt. The possibility that a minimum tolerable speed or maximum tolerable congestion would deter futher users was overlooked. In fact in most cities, traffic reached a minimum tolerable speed and stabilised at that level. In the reverse situation, when a new métro offers the potential for less congestion, it is therefore not surprising that more cars come onto the roads and prevent the potential improvement in congestion and speed.

LRT therefore will usually attract some motorists away from their cars but without any noticeable reduction in traffic level. To reduce traffic level, other measures such as pedestrianisation, reduction in parking spaces or increase in charges, are necessary. It is possible that by providing an acceptable alternative means of transport, however, LRT may make these other measures more palatable to motorists and politicians. This may have been the case in Bremen, Munich and Gothenburg where strict control over city centre traffic has been exerted.

Will LRT make public transport as a whole more viable?

Opening of a metro is usually accompanied by an increase in the usage of public transport. In Marseille, soon after the opening of the métro in 1977, ridership levels returned to the levels of the 1950s after a 40% decline to the late 1960s. However, the development of the métro was accompanied by other measures to improve public transport: a revised fares structure including through ticketing, re-organisation of bus services, improved publicity and other measures conscious of the need to present a reasonably efficient, reliable and comfortable public service. Also, with 116 public transport journeys per inhabitant per year (1985), public transport usage is still relatively low in comparison with other west European cities. In North America too there have been public transport ridership increases following the opening of urban rail: Vuchic (1984) quotes several examples such as Toronto where there was a 46% increase in public transport usage between 1961 and 1977.

The evidence that tramways will increase public transport usage is not quite so clear. In Gothenburg, the tramways have been retained since their opening in the year 1900. In the 1970s there was a substantial programme of renovation and extension of lines. Public transport ridership increased from 175 passenger journeys per inhabitant per year in 1970 to 189 in 1975, 199 in 1980 and 229 in 1983. During the 1970s there was also the introduction of traffic cells in the city centre, reserved bus and tram lanes, priority for buses and trams at traffic signals, introduction of express buses and uniforms fares, reduction of city centre car parking and in 1973 the sharp increase in oil prices. Since 1983 there has been some decline to 209 journeys per person for the year 1987.

Several of the large West German cities are replacing Straßenbahn (tram) sections by U-Bahn (metro) and usually this is accompanied by a substantial increase in ridership along the route. In Frankfurt for example, a section of the Straßenbahn from Theatreplatz in the city centre to the Südbahnhof was replaced by an extension of the U-Bahn in 1984. Ridership increased from 31,000 passengers per day to 45,000 shortly afterwards (Frankfurter Verkehrs- und Tarifverbund 1985).

An area of concern is how bus services might react to the opening of LRT, particularly if they remain deregulated. Will bus operators see LRT as a competitor whose options are limited by the inflexibility of fixed track? Or will they see it as a means of improving the attractiveness and commercial potential of public transport as a whole and as a means by which more customers will be attracted to buses as well as to LRT? The first viewpoint may seem more likely. However, there is some evidence that when a metro is opened, buses begin to achieve greater ridership levels. In the study of transport authorities in Britain, France and West Germany (Simpson 1988b), authorities with a métro or tramway had a higher ridership than buses in those authorities without métro or tramway (170,685 and 164,066 passengers per year per bus respectively). Whilst factors other than the presence of a métro or tramway would have influenced ridership, the results certainly do not support the view that urban rail adversely affects bus usage. The data for the study referred to the period when there was public control over bus services in all three countries.

Can LRT operate without subsidy?

The government has made it quite clear that they expect the proposed urban rail networks to be operated by private concession, without subsidy. There are a few examples of small scale light rail systems which operate with little or no subsidy. For example the Lille métro was subsidised less than 5% in 1985. No doubt the very small staff (185) enabled by the trains being without drivers, helped to achieve this low level. Nevertheless these systems are in a very small minority worldwide. In recent years, the Tyne and Wear metro has been subsidised at about the same rate as the buses (30%). In a study of ten recently constructed or planned LRT networks in North America, Cervero (1984) calculated the proportion of passenger revenues/operating expenses at 60.4% with a standard deviation of 16.3%.

Rail-based public transport, especially métros and U-Bahnen, are much more capital intensive than buses. It might be expected that rail networks would incur heavy loan charges but that this would be offset by lower operating costs. Loan charges and wages account for a large part of the costs of public transport.

Reduction in public transport operating costs has been one of the reasons for developing some urban rail networks such as the Grenoble tramway. The reasoning behind this is that there can be one tram or métro driver for perhaps 250 or more passengers whereas there must be one bus driver for 50-120 passengers depending on the kind of bus. Of course this only applies when trams actually are carrying more than the capacity of a bus. Also, it is sometimes overlooked that if extra buses have to be used to cope with heavy demand they can provide a more frequent service than higher capacity vehicles. Indeed, it is hard to reconcile the capacity argument for trams with the trend towards using minibuses, even in some of the cities with LRT proposals. In Manchester central area for example, there has been a very large increase in the use of mini buses during the past 3-4 years. This has been partly due to minibus drivers being paid lower wages than the drivers of standard buses. By the same reasoning, if drivers of small capacity vehicles receive small wages then presumably tram drivers will be able to justify high wages?

Certainly at peak periods however, LRT will offer some saving in operating costs compared with buses. On the other hand, overheads such as maintenance may be higher, as LRT vehicles are more complex than buses and there is also the maintanance of track, power system and signalling. In San Diego for example, 341 buses were operated by 825 employees whereas 14 LRT vehicles required 64 employees in 1982 (Gomez-Ibanez 1985).

In the study of public transport systems in Britain, France and West Germany,the *operating* costs of transport authorities with rail-based networks were found to be significantly higher:

	mean % operating costs from fares	*standard deviation*	*number of TAs providing information*
TAs without rail	63.5	19.3	22
TAs with rail	50.3	13.5	16

The Student's t value is 2.48. The percentage operating costs from fares in public transport networks without rail is higher and this is statistically significant at above the 99% level.

Of the 38 transport authorities for which data on operating costs were available, there was quite an imbalance towards British cities without rail and West German and French cities with rail. Differences in *policies* towards transport subsidy could explain some of the differences in subsidy levels.

Authorities providing information on operating costs

	number of TAs without rail	*with rail*
Britain	14	3
France	5	6
West Germany	3	7

However, data such as this should be a serious concern, given the present government's policy towards subsidy of operating costs. It should be equally of concern to rate (community charge) payers who are being told that LRT will not cost them anything.

Does LRT help to improve the environment?

Obviously LRT offers advantages over the private car in terms of noise, fumes and visual effects. It also avoids the need to use large areas of land for parking and roads which in a car-orientated city will tend to make pedestrian journeys longer.

The advantages over buses are less clear. In terms of land use for roads and stations, the advantages of surface railways are negligible. In fact, as many tramways are on-street, buses may have some advantages over tramways. There seem to be significant variations from city to city in environmental damage caused by buses. It is true that in some cities, passengers waiting at a bus stop may be seen choking in clouds of dirty, unpleasant fumes whilst a driver is revving up. In other cities, it is less common. Perhaps if more transport operators kept their buses in good running order, the case for LRT might not be quite so strong. Also, the claimed noise advantages of LRT are not always justified. The London Docklands light railway has been the cause of many complaints about noise and vibration (Transnet 1988).

In cities relying on buses for public transport, investment in LRT would invariably allow environmental improvements. Rail-based public transport certainly helps the implementation and operation of pedestrianised streets but is not essential for them to be successful. There are examples in Britain such as Coventry where buses operate up to the edges of successful pedestrian zones. Where they are allowed within otherwise pedestrianised areas such as Bull Street or High Street in Birmingham they are more intrusive than where trams only are allowed, as in Bremen. Underground railways offer particular advantages for large scale pedestrianisation as in Munich and Frankfurt. Successful pedestrianisation is therefore possible without urban rail but is likely to be even more successful with it.

Busways are generally a cheaper alternative to the metro and may be just as effective for all but the highest levels of demand. They are also more easily converted back to other road uses if expectations of demand are not fulfilled and are more easily integrated into the suburban bus network (Niblett 1972). Busways could be planned to involve fewer changes of transport than is usual with suburban railways where many passengers have to brought to them by bus.

LRT will therefore have some effect on the environment if it is part of a series of measures including restriction on the private car as in Gothenburg, Bremen or Munich. It is most unlikely that these cities could have achieved such high standards of the city centre environment without urban rail. No doubt rail could be an important part of the improvement of the environment in the large British cities and this is one of the strongest arguments for it. It is however, essential to regard LRT as only one part, albeit an important one, of a series of complementary measures including road traffic restraint. LRT alone will not have a significant effect on the environment.

Will LRT stimulate the local economy?

This would be the consequence of several of the other claimed benefits of LRT. Improved environment and better access might lead to higher demand for commercial and industrial activity reflected in increased property values. Certainly some of the other claimed benefits have some justification but are they sufficiently important to have an effect on economic development?

There are many cases where the development of LRT has been accompanied by commercial development around the stations: Toronto, Washington DC and London Docklands are examples. Where high density development follows railways, there has been interest in developing in the locality irrespective of the railway. Development has been attracted to the railway stations in preference to less accessible sites and it is often directed there by land use planning policies as well. There are also many cases of LRT not being accompanied by commercial or industrial development as in Tyne and Wear. In fact, in none of the case studies in part 2 above, is there any convincing evidence that LRT has attrracted significant development. This is not really unexpected in view of the failure of so many heavy rapid transit networks (alias suburban railways) to stimulate the local economy. Indeed, HRT is more rapid and has higher capacity than LRT and can carry freight as well. If there is interest in developing in the locality, urban railways usually attract development; if there is no interest, urban railways will not create any.

The Tyne and Wear Monitoring and Development Study (Transport and Road Research Laboratory et al. 1986) sums up what is true of many other cities but is rarely stated so unequivocally. The metro had "no discernible effect" on the location of new office development and "no significant impact on locational decisions" for industrial property. Good access to the metro has had "only a very localised effect" on the housing market in the inner city. Prices have risen in some districts and redevelopment has taken place close to the metro at Byker, Howdon and a few other localities. In some places, the arrival of the metro seems to have depressed some property values close to the line. The Metro Monitoring and Development Study concluded that the average rise in property values close to the metro during the period 12 months before its opening was 1.7%. Thus there is some evidence that the metro has caused a slight increase or in some districts, arrested a decline in values, but hardly enough even to detect it.

Although the metro may not have caused much new development in the years immediately following its opening, it has helped to maintain activities experiencing some difficulties. Hotel and guest house proprietors in Whitley Bay and Tynemouth for example certainly regard the metro as an asset for the tourist industry, as expressed in their publicity material. Similarly, many Lyon shops, particularly in the city centre quote the nearest métro station in their advertisement material. The Tyne and Wear metro has also been a part of several environmental improvements including the renovation of Tynemouth Railway Station.

London Docklands Development Corporation carried out a study on the job creation potential of the light railway before it was opened (Docklands Public Transport and Access Steering Group 1982). This came to the conclusion that around 9,300 extra jobs would be expected on nine selected sites as a result of the railway but it is an open question how many would be transferred from elsewhere. It seems likely that by providing good access to the City, the light railway has released the job potential of some parts of Docklands such as West India Docks.

Urban rail often transfers activities, commonly to city centres and large suburban commercial centres at the expense of the inner city and other suburbs. The opening of the Lyon métro reversed the decline in city centre shopping according to the Chamber of Commerce and Industry (Watel 1984 and 1985). A similar opinion was expressed in the survey of Lille explained below.

The results of recent studies on light rapid transit in Canadian cities are not incompatible with those in Europe. The impact of the Edmonton and Calgary light railways on residential and commercial development and densities has so far been modest despite incentives from the city authorities - additional floorspace allowed near stations, relaxation of parking requirements for example (Cervero 1984). Downtown parking has declined slightly to what by European standards would be still a very high level of 33,000 places, despite an increase in office floorspace. Residential density continued to decline in inner city areas and hardly any new construction has occurred at the termini, although there have been more building permits granted around the stations than would otherwise be expected - not surprising in view of the higher densities allowed. Cervero (1985) gives a detailed analysis of the land use impacts.

Railways have been shown to have a greater effect on land uses when the local economy is expanding as was the case in Toronto. Orski (1980) is particularly supportive of the potential of rail transit in directing urban growth. Generally, there would be little disagreement with the conclusion from a range of North American studies that although rapid transit can influence the location of new development, support by other means is necessary to realise the full effects in economic revitalisation.

This leads to the conclusion that LRT is not sufficient in itself to stimulate commercial development in cities where there is otherwise no enthusiasm from developers. Neither is LRT a necessary condition for commercial development. In Birmingham there have been several large-scale commercial developments of the kind which might be claimed to result from LRT at a time when it was far from certain that the metro would ever be built. A new conference centre and concert hall in Broad Street, redevelopment of the canalside area (Gas Street) for expensive housing, the Pavilions Shopping Centre (High Street), the redevelopment of Snow Hill Railway Station, the National Exhibition Centre and the extension to the airport have all gone ahead without the metro. All of them are on frequent bus routes and the NEC and airport are also on the suburban railway and main line to London. Apart from Snow Hill Station none is even close to the proposed first phase metro route: also, the re-opening of the suburban railway services at Snow Hill no doubt contributed to development prospects. As in Birmingham, in Lyon, large scale commercial development in Part-Dieu took place before the métro and in Gerland without it.

The most that can be claimed for LRT is that it is an additional attraction which can be expected to enhance commercial development which would be likely to go ahead irrespective of whether LRT is built. LRT might also influence the precise location of commercial development within an area where developers wish to build.

* *

The case for LRT

It is not the purpose of this study to make a case for LRT but in conclusion it may be worthwhile to sum up what benefits can be realistically claimed in view of the foregoing evidence.

Improvement of access to public transport for disabled, people with prams or heavy luggage.
For a considerable number of public transport users, buses are an ordeal, possibly sufficient to deter some of the most severely encumbered from using them at all. Low level access rail vehicles such as the Grenoble tramway seem to be a significant improvement. However, the benefits of improved access may be quite limited in cities where the rail network is not extensive. Where buses must be used to get to the railway stations, some of the benefits will be lost and some potential public transport users will still be deterred.

Increasing confidence in the city
Public investment in urban rail will be seen by developers, industialists and other investors as a gesture of confidence in a city's future and may have more than a marginal influence on their investment decisions.

A focus for planned development
Whilst it is misleading in the great majority of cities to describe urban rail as a creator of jobs, where there is interest to develop in the locality, urban rail can be used in connection with land use planning policies as a focus for planning development as it has in several West German cities, in Toronto, Washington, Edmonton, Calgary and Marseille for example. Improved access can be considered by a local planning authority as a factor to influence policies towards land uses and density.

Improving the environment of the city
Coupled with other measures, urban rail can aid the implementation of environmental improvement policies. This is very clear from the successes in Munich, Gothenburg and Bremen. The effects of urban rail alone are at best less than they could be, more likely

bordering on insignificance.

Urban rail increases the level of access to some parts of the city
As a result it would allow an increase in density where other factors are favourable and may allow (but not cause) growth of the city as a whole. An increased level of mobility will also allow increased segregation of land uses. Whether any of these potential changes in city form are desirable is a very complicated question heavily dependent on value judgements. It is to be noted however, that the development of an urban rail system could allow quite fundamental and long term changes in the pattern of land uses, density and city size, some of which are likely to be judged beneficial. The presperity and demand for development in a city may fluctuate from decade to decade. A city with a substantial urban rail system may be better placed to realise opportunities in times of prosperity than a city without such a system.

The case against LRT

LRT need public expenditure
Capital subsidies will usually be needed. However, it is sometimes overlooked that the costs of urban rail as indicated in section 6 above include taxes such as income tax, VAT paid by those who receive wages from building LRT and National Insurance contributions. There are also secondary and subsequent effects from spending (or saving) of income by those who receive payment from the building of LRT as any other capital project. In short, resource investments are needed but the costs we usually see can be a considerable overestimate.

Development of urban rail usually results in some people being disadvantaged
Gothenburg has been quoted as a case where this appears not to have happened. More usually however, some people will be disadvantaged by an improvement in mobility and accessibiltiy. Inner suburban shops serving a limited local area have lost custom with the opening of the Lille métro. Activities which serve only a local area (and therefore do not rely on good communications) can be put in jeopardy by an improvement in mobility as occasioned by the development of urban rail. This is particularly so if they are in a weak position at the outset and can not benefit from the improvement in mobility to attract custom from a wider area. Changes in land uses and activities of this kind will also cause customers to have to travel further whether they wish to or not. Improvements in transport facilities not only gives the option of greater mobility, it causes the need for it.

Environmental problems
Vibration to neighbouring properties has been a problem on constricted sites as in London Docklands and a concern with many on-street tramways such as Grenoble line 2. Overhead wires may also be a problem.

Disturbance to adjacent properties during construction
For activities depending on the habits of their clientele such as shops or leisure facilities, this may result in some permanent losses as their costomers acquire the habit of going elsewhere whilst access is restricted during building works. The main reason for the failure of some British LRT proposals in the past has been the disturbance and demolition of neighbouring properties and the fear of compensation being unacceptable.

Urban rail is a long term commitment
Unlike buses, railways are inflexible in route. They can not respond to spatial changes in demand. There are many examples of heavy railways becoming obsolete. Indeed, several LRT proposed routes use the track of obsolete suburban railways. There are fewer cases of light rail

becoming obsolete. This is only partly explained by there being fewer light rail networks. Redundancy is proportionately lower than for heavy rail. There could be several explanations for this:

* Light rail is exclusively in the passenger market which has been less vulnerable to recession than the goods market.
* Light rail provides a more local service than heavy rail. Closer spacing of stops reduces one of the main problems of heavy rail - insuffiient customers within an acceptable distance of the stations.
* Light rail has been built mostly in cities with relatively buoyant economies. Although there are many exceptions for light rail, for heavy rail there are even more.

Urban rail increases the need for changes in mode of transport
Most networks rely substantially on buses to bring travellers to the stations. Some travellers will be inconvenienced by loss of through bus routes when part of a route is replaced by rail.

* *

Finally it is worth remembering that despite not meeting several of the main claims made for them in Britain, it is very conspicuous that métros and tramways, once built, have captured the public imagination to a far greater extent than would probably have been predicted beforehand. They are very popular to an extent which is not always reflected in usage and few cities seem to regret building them. Whilst there is not often much public support for light rail when it is being planned, there is usually a great deal of support when it is operating. Public attitudes do not demand the urban rail should meet all the benefits claimed in the UK. Improvement in public transport services has had a high value according to public opinion. In economic terms it seems that there has been a tendency to underestimate the consumer benefits and probably the consumer surplus to existing users. Bristol, Manchester and Leeds are all cities of considerable character and with a civic presence which has been eroded by heavy traffic. The potential quality of environment of these and other British cities has not been achieved to the same extent as the potential of Munich, Gothenburg or Bremen and achieving this potential is one of the strongest arguments for LRT. In evaluating urban rail proposals we should not look only to the transport authority. Many of the questions raised by LRT fall primarily within the field of the city planning department.

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Appendix: British LRT proposals

London Docklands Light Railway

The two lines opened in July 1987 extend from Tower Gateway and Stratford to Island Gardens on the Isle of Dogs. There are 15 stations on the 12 km. route. Much of the length is elevated, some using former British Rail viaducts and two sections share British Rail alignments. The trains have no driver but there are train captains whose job is to close the doors, initiate the departure from each station, to check tickets and to assist passengers. Three main future developments are under construction or planned:

* An increase in capacity from 2,080 passengers per hour at peak to 7,800 passengers.

* A 1.5 km extension to Bank station, currently under construction and planned to open in 1990.

* A 7.5 km extension from Poplar eastwards to Beckton with 12 stations and interchange with the BR North London Link. This is expected to open in 1991.

A report on the light railway extensions is contained in Wyse (1988a).

Tyne & Wear Metro

Centred on Newcastle, the 55km. of the metro comprises a loop north of the River Tyne extending to North Shields and Whitley Bay, a section from the centre of Newcastle south of the Tyne to Gateshead, Heworth and South Shields and another section from South Gosforth to Bank Foot which stops 3 km. short of the airport. Basically this is the former British Rail suburban railway, modernised to meet the needs of an integrated local public transport system and with some new track, constructed mainly to improve connections across the River Tyne in the centre of Newcastle. 41 km. are converted British Rail line the remainder being new construction. Apart from 6 km. of new tunnel in Newcastle and Gateshead, it is mostly a surface railway. The first section from Haymarket in the city centre to Tynemouth was opened in August 1980 and the present network was completed in March 1984.

It has been conceived as part of an integrated public transport system including co-ordination with buses in terms of planning, route networks, frequencies, timetables, fares and ticketing, promotion, marketing and development. Through tickets were introduced in December 1980 allowing use of buses and metro on a single journey. Travelcards give unlimited travel on almost all local public transport services within a specified area for any combination of the fare zones.

These measures and the opening of the metro have coincided with an increase of about 3% in the number of passenger journeys whilst several factors have worked to the opposite effect: population has declined, unemployment and car ownership have risen. During the same period, public transport usage in most other large cities has declined considerably. The metro has been part of a series of reforms which together have very likely caused a considerable revival of public transport usage. It is impossible to say how much of the revival is attributable to each of the reforms. It is very likely that the effect of the whole has been greater than would have been the effects of each separately.

On weekdays journeys to work form 39% of the total compared with 28% for shopping and personal business, 13% for social purposes and recreation and 12% for education. Apart from at peak times, journeys to work are only a small part of the total. In between and on Saturdays, shopping is the main purpose and it is in this sector that the metro seems to have had its most significant land use effects. As in relation to the new French métros, the main city centre has gained from improved access as it is here that there is the greatest incentive to abandon the private car for shopping, as well as this being the most accessible point on the metro system. It seems that some of the secondary centres have also gained some benefits. Shopping in Gateshead has shifted towards the transport interchange, although this has also been attracted by being off-centre with better parking and from being in an enterprise zone. Even with the metro, difficult-to-let sites in central Gateshead have not been easy to develop (Fullerton, Perrett and Copeland 1985). In fact, there is some evidence of decline in the parts of the shopping centre furthest away from the metro. South Shields seems to be retaining its trade and attracting some shoppers from Jarrow and Hebburn. What is less clear is whether this increased trade has been drawn from other local shopping centres, and if so, which ones. For shopping journeys, the metro seems to have attracted mainly former public transport users.

There has also been some increase in journeys for leisure purposes. This sector, where demand seems likely to be more elastic than for other purposes, could be one of the most significant net benefits of the metro. Whereas increases in some districts for shopping may well be at the expense of losses elsewhere, for leisure purposes it seems more likely that there has been an overall increase in leisure opportunities and enjoyment.

Obviously there have been fewer buses on some city centre streets since the opening of the metro, but these seem to have been replaced by more cars. Peak hour road speeds in Newcastle centre increased by 20% between 1980 and 1984, but as this continued a trend which had been taking place since the mid-1960s, it is not clear whether the metro has caused this improvement.

Unlike the situation in many cities on the continent of Europe, the Tyne and Wear Metro has helped to reduce operating costs of the public transport system overall. The costs of operating the buses has been reduced by about £12.5 million per year and British Rail local services by £9.2 million, whilst the operating costs of the metro amount to £14.9 million (all figures for 1984/5).

There are proposals to extend the metro from Heworth to Washington New Town, from Pelaw to Sunderland, from Bank Foot to the airport, from Benton to Killingworth, from Tyne Dock to Whiteleas, from St. James to Denton Burn and from St. James to Stanfordham Road.

Manchester

A particular problem in Manchester has been the lack of connection between the two main line railway stations, Victoria and Piccadilly. Tramways are seen as a solution to this problem using five existing British Rail lines, one former suburban line closed in 1968 and a few short but important new on-street sections in the city centre.

Three cross-city routes are proposed with a total length of 96.82km:

* *Altrincham - Central Station - Piccadilly Station - Glossop and Hadfield*
* *Bury - Victoria Station - Piccadilly Station - Marple or Rose Hill*
* *Rochdale - Oldham - Victoria Station - Central Station - East Didsbury*

In the city centre the tramways will connect Piccadilly Gardens, St Peter's Square, the Arndale Shopping Centre, Town Hall and other busy destinations. There will be connections to existing bus and rail interchanges at Bury and Altrincham

Parliamentary Bills seeking powers for construction of the city centre sections were deposited in 1984 and 1985 and received Royal Assent in 1988. Tenders were recently invited for the design, construction, operation and maintenance of phase 1.

The first phase, which it is hoped will be complete by 1989 at a cost of £42.5 million, comprises the lines to Bury and Altrincham together with the short city centre on-street connections between Piccadilly Gardens and Piccadilly Station, Victoria Station and Central Station.

A further Parliamentary Bill was deposited in November 1987 for an extension to Salford Quays. Discussions are taking place with the Urban Development Corporation about an extension to Trafford Park. A recent report is contained in Holt (1988).

West Midlands

The route for the first light rail line extends 20 km from Snow Hill Sation in central Birmingham through the centres of West Bromwich, Wednesbury and Bilston to Wolverhampton. It uses the low level line of the former Great Western Railway, now disused with most of the track removed. Much of this passes through old industrial and residential areas, a considerable amount of it derelict or disued. All the first phase line is segregated from the highway except short sections in Wolverhampton town centre.

Eventually it is expected that there will be a network of about 150 to 200 kilometres. The Black Country District Councils (Sandwell, Dudley, Wolverhampton and Walsall) favour a network based on disused or underused BR lines whilst Birmingham City Council favours light rail mostly on track separated from the highway along a central reservation or at one side of the highway.

The carriages will be single-deck electrically-operated trams powered from an overhead catenary system and operating in pairs or singly, very similar to those proposed for Manchester (and already operating in Nantes).

A politically easy route has been chosen for a start. It is likely to attract less traffic than some of the others, but is also less likely to arouse opposition than a route involving a lot of demolition and disturbance.

Anyone who travels along the route can not help but be struck by the economic devastation in the Black Country. Apart from the termini and the stations in the centres of West Bromwich and Bilston, the other 25 stations would have few users if the area remains as it is at present. The majority are amidst underused or unused former industrial land or on the fringe of low density housing, far enough from the main road to Wolverhampton to be inconvenient. If the local economy does improve however, there is a great deal of land for development along this route.

There seems to be little doubt that the proposed first route could not be operated without subsidy for some years at least. The economics of this route depend on how much land values rise in future and how much of this can be channelled to LRT operation.

Bristol

The proposed first phase to be opened in 1992 comprises 60km of track. It uses mainly disued British Rail track connected by on-street sections in Bristol city centre as follows:

* *city centre to Portishead/Portbury using the British Rail line*
* *city centre to Yate via Temple Meads, north-east Bristol, Emerson's Green and the potential M4 interchange*
* *city centre to Filton via Temple Meads, Parkway and Bradley Stoke with a link to British Aerospace, Rolls Royce and Cribbs Causeway*
* *city centre to Bristol south via Bedminster*

A bill is currently before Parliament for the line between Portishead and Wapping (Bristol). A further bill for the remainder of phase 1 is expected in November 1988.

Several issues have affected the need for and design of the tramway: poor location of Temple Meads station for local traffic; growth in Northavon and the east Bristol fringe along the M4 corridor; growth potential of Portishead and Portbury; poor accessibility to south Bristol. A summary of the proposals is contained in Symons and Claydon (1988).

Sheffield

The Sheffield proposals are quite different from those for Manchester, the West Midlands and Bristol in that they are road-orientated rather than re-shaping of BR lines. Politically, this kind of design has been difficult elsewhere. A road-orientated scheme for parts of Birmingham was rejected in 1985 after local protest about demolition and disturbance.

The proposed first line extends 22 kilometres from Hillsborough to the north-west of Sheffield to Mosborough in the south-east linking major retail, commercial and leisure developments existing, planned or under construction. The South Yorkshire PTE Three Year Plan 1988/89 to 1990/91 makes provision for a second line serving the Lower Don Valley which is largely derelict and favoured as a route by the city council. Half the tracks will be non-segregated, in the middle of the road. Elsewhere they will be alongside the road or down the central reservation. A bill for the line is before Parliament.

West Yorkshire

In the late 1970s the West Yorkshire Transportation Study concluded that light rail might be feasible in Leeds but not in Bradford. Possible corridors have been protected from development which might prevent future lines. There are proposals to develop a light rail network from the City Railway Station largely following highway alignments and making much use of former tramway land. The first line appears to follow Park Row northwards then branches eastwards along The Headrow and past Quarry Hill before branching out into the eastern suburbs. The total length would be 23 km., over 20 km. of which would be separate from road traffic. It is expected to deposit a bill before Parliament in November 1988. A second line proceeds northwards from City Railway Station, Woodhouse Lane, past the University to Headingley and terminating at Holt Park.

In Bradford there are proposals for a 10 km. trolleybus route from the city centre to Buttershaw in 1989. By 1993, West Yorkshire Passenger Transport Authority expects to extend this eastwards to Leeds via Thornbury, Stanningley, Pudsey, Farsley and Bramley. The total cost is estimated at £10,177,000 at outturn prices.

A study of dual mode trolleybuses under the EEC Programme of Collaboration in Science and Technology (COST) was concluded in 1986 and supported the introduction of trolleybuses in some situations. This study was a significant part of the PTE's case in applying for a 50% grant from the European Regional Development Fund.

The benefits of trollybuses in West Yorkshire may be summarised as follows:

* environmental: less noise, fumes and vibration than diesel buses;
* less dependent on fluctuations in oil prices than diesel buses;
* better suited to the hilly terrain than light rail;
* fewer buses will be needed. Due to the lesser need for reserves, 29 trolleybuses will be able to replace 34 diesel buses. Trolleybuses are, however, 40% to 100% more expensive.
* Trolleybus maintenance is around 75% of that of diesel buses.

Croydon area light rail study

Following a study of the potential for LRT in several parts of London in 1986, London Regional Transport and British Rail commissioned consultants to investigate the potential of the Croydon area. Several routes were considered including lines from Wimbledon through West Croydon and East Croydon to New Addington and Elmers End. Other extensions to Sutton, Epsom Downs, Caterham and Beckenham Junction have also been considered. Discussions about the next stage are currently being undertaken with local authorities. Reports are contained in Wyse (1987b, 1987c and 1988b).

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In addition, many of the authors cited in the bibliography have carried out research on LRT.