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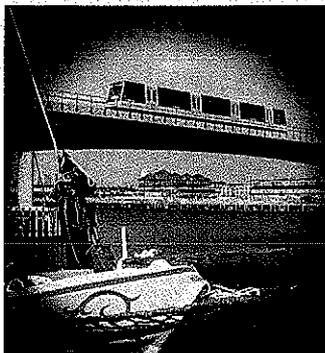
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**Front cover:**  
 London's automated Docklands Light Railway was built by Mowlem and equipped by GEC Transportation under a turnkey contract in just three years

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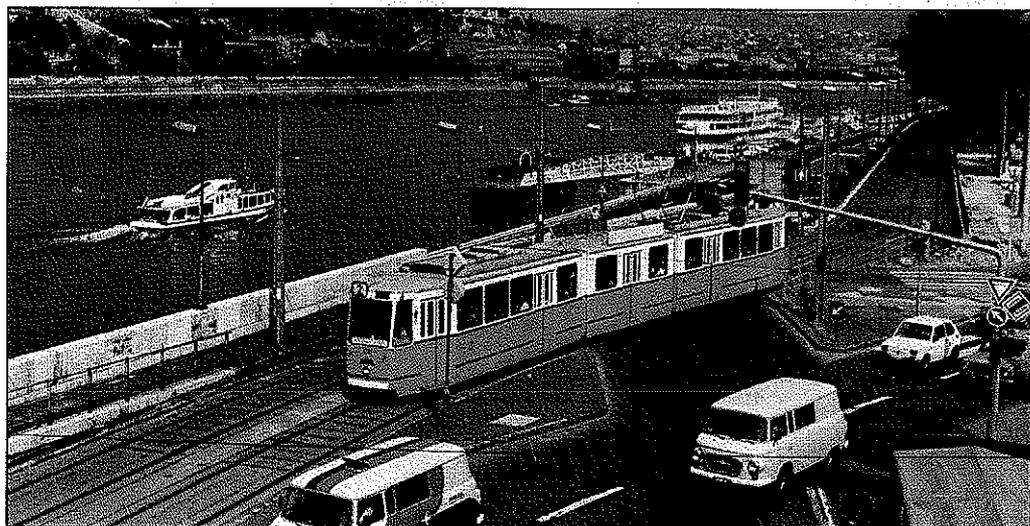
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# DEVELOPING METROS 89

METROS  
 TRAMS  
 LIGHT RAIL  
 COMMUTER RAIL

REVIVAL of the moribund metro in Tehran and a serious start on construction in Shanghai are just two pointers to renewed urban rail activity in the world's great metropolises. Further evidence comes in our survey of metro projects on p23. New starts are expected in cities ranging from Lima to Manchester, where progress with a design, build, operate and maintain contract for the first part of a light rail network will be closely watched by the urban rail industry. Similar proposals mooted in Ankara, Bangkok and elsewhere have yet to bear fruit as the contractors struggle to secure funds. If Manchester proves to be a successful formula for embracing the private sector in urban rail transport, it will help to win renewed acceptability for public transport in the eyes of governments wedded to privatisation. As the International Union of Public Transport gathers for its 48th Congress in Budapest, delegates might well reflect how best to demonstrate in financial terms the social benefits of urban rail.



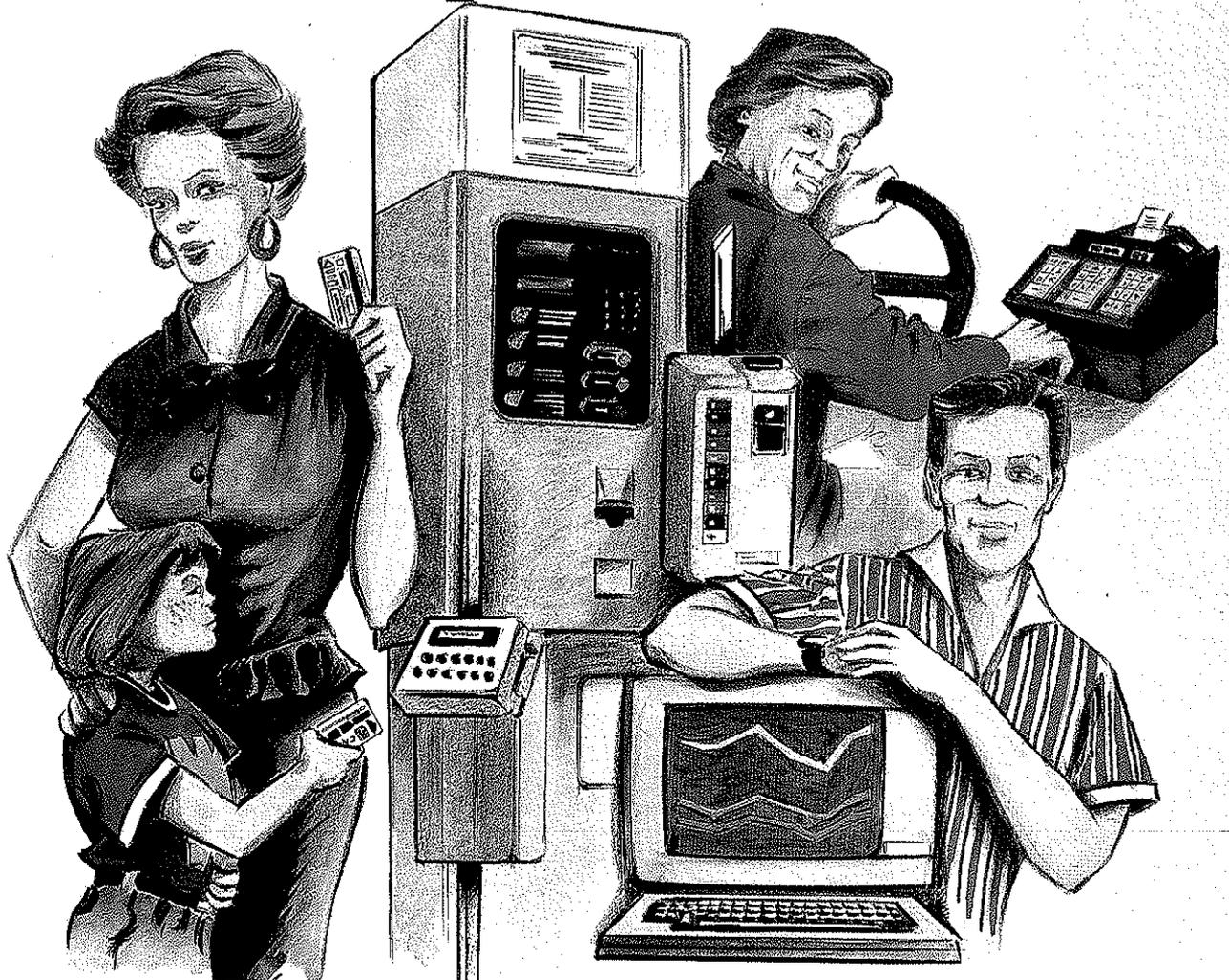
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# Easy transportation!



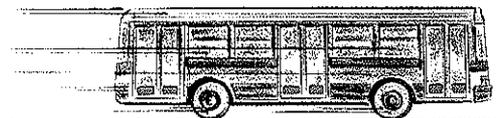
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# TRANSPORT HARMONY IN UITP HOST CITY

*Dr József Zahumenszky, Director General of Budapest Transport Company, outlines the development of the metro in the Hungarian capital and welcomes delegates to the 48th UITP Congress*



of metro, tram, trolleybus and bus routes. The metro and suburban railways form the backbone of the network, with the trams and buses acting as feeders. City dwellers share their public transport network with commuters from 43 towns in the surrounding area — 22 per cent of Hungary's jobs are in the capital, as are 80 per cent of universities and other higher education institutes.

### Millenium line renewal

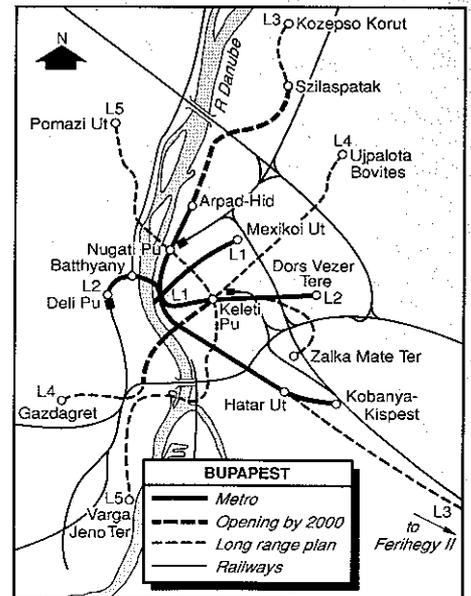
The metro in Budapest reflects both the city's industrial past and its present role. We are particularly proud of the Millenium route, whose first 3.2 km section was inaugurated by the Emperor and King of Hungary, Franz-Joseph I, on May 8 1896.

Its original fleet of 20 wooden bodied cars ran singly until 1960, when they were reformed into two-car sets with trailers. By then it was becoming increasingly evident that renewal of rolling stock and tunnel

BUDAPEST, chosen by the International Union of Public Transport as the venue for its 48th Congress on June 12-16, has 2.1 million inhabitants. Many of them live in the compact and densely built-up city centre which covers 27 km<sup>2</sup>, although the city spreads out to cover a total area of 525 km<sup>2</sup>.

The Budapest Public Transport Co (BKV) was formed in 1968, integrating the tramways and suburban railways, both of which were then 100 years old. BKV also embraced the Millenium line, built in 1896 as the first underground railway on the European continent. This pointed the way for construction of the city's modern metro (below), whose first line opened in 1970.

Every working day BKV handles 4.5 million journeys on its 1 221 km network



**BKV will start construction of Line 4 when the extension of Line 3 to Szilaspatok is completed**

equipment was necessary, and a major programme of refurbishment work was launched. This was completed in December 1973. It embraced renewal of the permanent way, which had originally been laid with 24 kg/m Vignole rails, modernisation of the stations, reconstruction of the terminus at Vörösmarty Square, replacement of the power supply, catenary, signalling and telecommunications equipment, changes to allow right-hand running, and purchase of a new fleet of rolling stock.

The 21 three-section articulated cars were built by Ganz Mavag and Ganz Electric. With special 600 V DC overhead current collection gear for the reduced clearances, the cars also featured Alex Friedmann automatic wheel flange lubricators and Storno train radio.

Since the 1970s wear and tear on the old infrastructure has taken its toll. The tunnel structure, now nearly 100 years old, is suffering the effects of heavy traffic on the Népkötársaság avenue above it, which it had originally been conceived as a pleasure drive from the inner city to the park. It is now constantly pounded by cars, buses, and heavy goods vehicles, and major investment



## SPECIAL FEATURE

will be needed to rebuild it. This will inevitably lead to serious disruption of road traffic.

BKV engineers are already working on the design of replacement structures, and a timetable is being drawn up for the work to be carried out. BKV's aim is to retain the original beauty of the Millennium line, but at the same time it is essential that passengers benefit from the most up-to-date operating and safety equipment.

### Expansion plans

The stages of opening of the metro reflected the inexorable build-up of road traffic to saturation levels. It is interesting to note, however, that tram services have been widely retained, as with their frequent stops they provide a vital role in distributing and collecting passengers in the busiest and most densely built up parts of the city.

Line 2, which runs on an east-west alignment from Deli Pu to Őrs Vezér Tere, was opened in two stages in 1970 and 1972. Sections of Line 3, which runs north-south, opened in 1976, 1980, 1981 and 1984, and the current network length totals 26.7 km.

*Now under evaluation is a prototype six-car trainset developed in 1987 by Ganz Loco Works*

For economic reasons the rate of expansion slowed down in the second half of the 1980s. Construction is at present under way on Line 3 between Árpád-Híd and Újpest Bajcsy-Zsilinszky Street, and this is due to be finished at the end of 1990. Next stage would take the line to Szilaspaták by 1995.

During the 1990s work will start on construction of the section between Bocskai Street and Baross Square of the line from South Buda to Rákospalota. Later, the north-south line will be extended through the new residential area of Káposztásmegyér in the northwest. In the south the metro will eventually be extended to serve other dormitory areas at Kelenföld, Őrmező, Gazdagrét, and in the north to Bosnyák Square. No schedule has yet been drawn up for other extensions, for example from Hatar Ut on Line 3 to Ferihegy in the southeast.

As the organiser of the 48th UITP Congress and Exhibition, I should like to



take this opportunity of welcoming delegates to Budapest and inviting them as public transport experts or industry representatives to our hospitable capital. I am sure that the programme drawn up for the Congress will be a success, benefiting not only professional and human interests but also revealing the importance of the city's 150 year old public transport history. □

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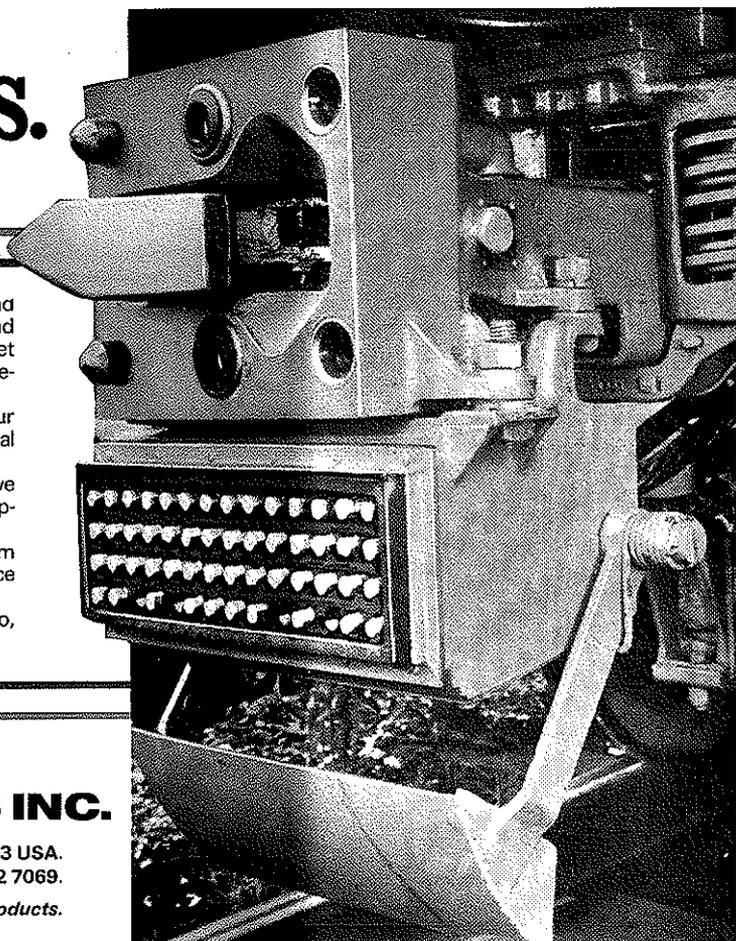
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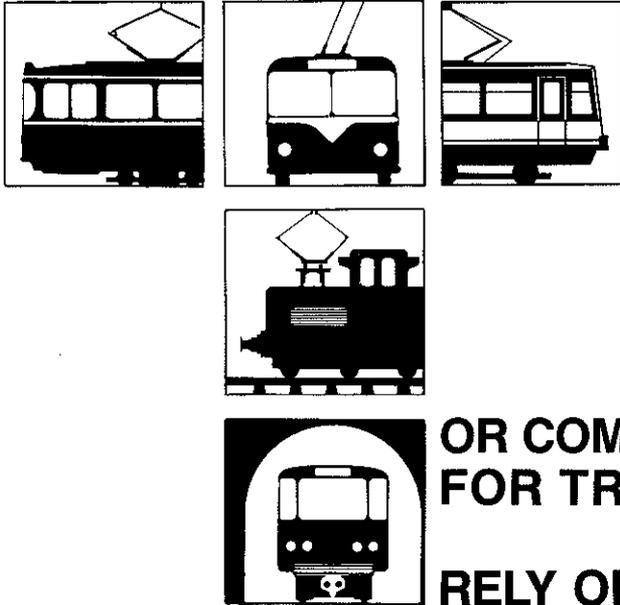
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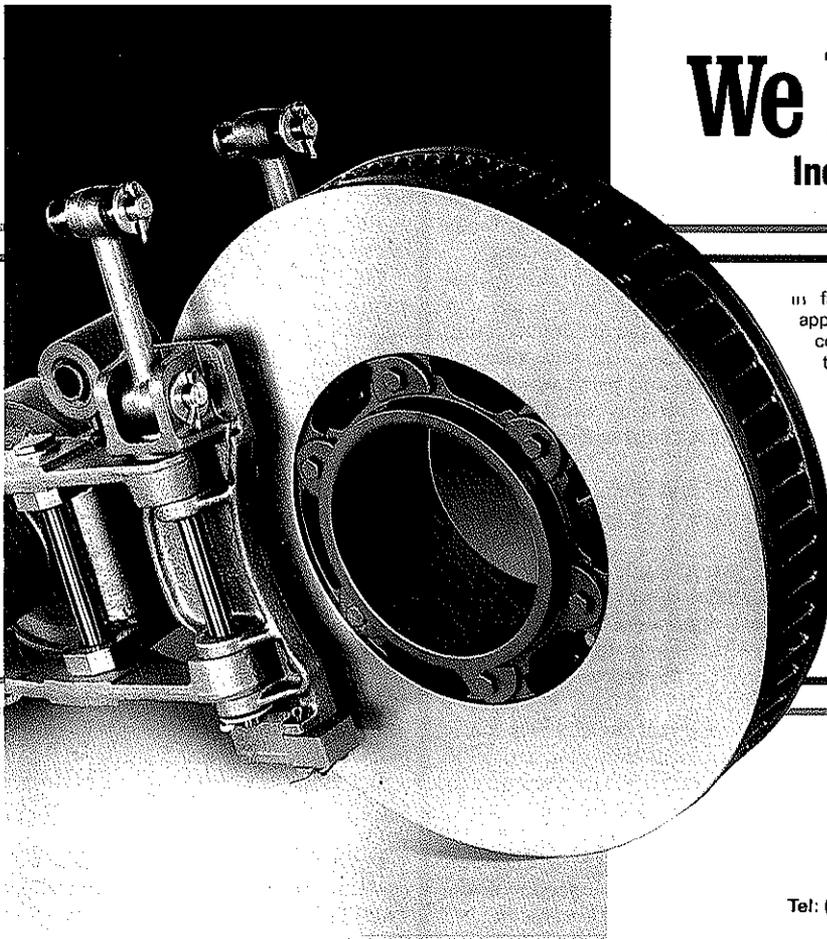
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# PUBLIC TRANSPORT IS

*Ingemar Bäckström, President of the International Union of Public Transport, explains that although the 48th Congress in Budapest will focus on urban public transport, it will be rooted in the general need for mobility in today's society. Delegates from around the world will debate subjects like deregulation, marketing, human resources and transport modes, exchanging views about the best way to plan for the future*

CERTAIN TRENDS in the field of transport can be identified today. One of them is deregulation, sometimes combined with privatisation. We find this keyword to success or failure in the market — deregulation — used in different contexts. In air transport, deregulation in the USA has changed the traffic pattern and created a new market situation. Other countries are to follow, among them Sweden. Deregulation is also the keyword behind the revolutionary market regulations being introduced by the European Community.

Britain has taken the lead when it comes to full scale deregulation of public transport combined with privatisation of publicly-owned undertakings. This has not only resulted in profound changes in the British transport market; it has also acted as an alarm bell, triggering new policy debates in many other countries. No wonder that one of the workshops of the UITP Congress in Budapest will deal with 'Deregulation and Liberalisation'.

Among other trends to be found when we study different countries is a powerful need for better mobility. This is interesting, if we recall that researchers predicted years ago that the need for personal travel would decrease as a consequence of rapid development in electronic communications.

It has not happened. On the contrary, travel has increased for reasons which are

so complex and interesting that an article could be written on this subject alone.

The fact is that the need for individual mobility continues to increase, a trend that is common to industrialised and developing countries alike. Total traffic volume increases, and will continue to do so, as is evident from Fig 1, taken from a CEMT report.

Yet the immense traffic volume concentrated in urban areas causes problems which are so serious that we can today identify them as additional trends. Here is the negative side of the mobility created by the motor car: urban congestion, environmental problems, and increasing energy consumption.

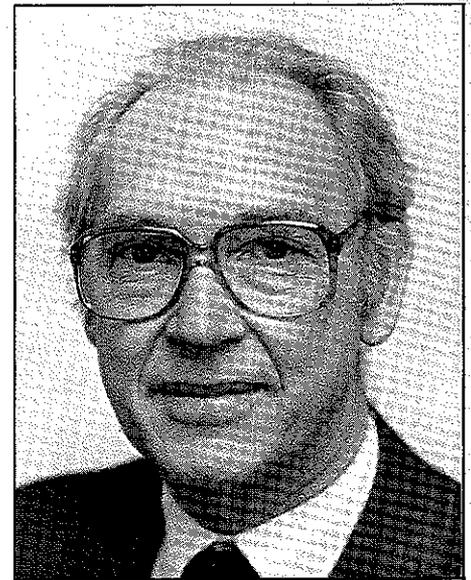
Urban congestion and environmental deterioration have reached alarming proportions, and not just in big cities; problems exist in conurbations of almost any size. The ever-increasing use of cars which has brought wealth and mobility to modern society tends to destroy nature and immobilise cities.

This is easy to demonstrate. Buildings and statues which for centuries have been kept in good shape suddenly started deteriorating during recent decades, as the pictures opposite show. Trees and parks which used to be green oases offering relief to overstressed people were transformed into brown mysteries:

A self-evident reflection: if all this can happen to plant life, what is the effect upon human beings?

Cars and buses, built for high-speed performance, crawl through city centres at a speed almost equivalent to horse-drawn cabs. If this situation is to continue, the mobility created by the motor car will itself create immobility.

This is the reality that the city and traffic planners have to face as they plan and build future conurbations. They can foresee easily



enough a need for still greater mobility, while at the same time today's traffic already creates enormous difficulties, producing unacceptable changes in city life.

If traffic jams are not to kill the conurbations, the planners must find solutions in renewed and extended public transport. But public transport must be competitive with the private car in dense traffic corridors, as well as offering an acceptable standard on other routes. The main objective must be to find an optimal balance between public transport and the private car.

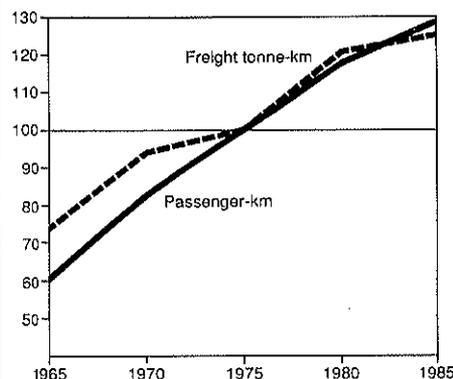
The positive value of efficient, energy saving and environmentally friendly public transport must be measured and evaluated carefully by the planners. This is hardly the case today — at least, not every time in every city. All too often, the business economy and not the social economy is the deciding factor when passenger transport systems are the subject of debate. This is truly amazing in a field which has such a major influence upon the development of the urban society.

## Social efficiency

By underlining the need to measure the value of public transport in socio-economic terms, I am not necessarily arguing in favour of subsidies to public transport operators in general. Like any business, public transport must be competitive and efficient.

But efficient to whom — its customers or society as a whole? The simple answer is both.

Public transport must be efficient to the customer who has the right to demand good value for the money he is willing to spend on his daily or occasional trips by rail or



**Fig 1. Growth of total passenger-km and freight tonne-km in 15 west European countries (1975 = 100)**

# A SOCIAL RESOURCE

bus. Otherwise, public transport will lose customers — in the long run, even so-called 'captive' riders.

But public transport must also perform efficiently for society. The measurement and evaluation of the social efficiency is far more complicated than customer evaluation. We have to evaluate the positive or negative effect on passengers' time, on road congestion, on the environment and on energy.

Economic research during recent years has provided decision makers with better methods for such evaluation. These methods must be used to help policy makers choose the right mix of transport modes, and to determine standards in all respects.

All of us have now and then heard the slipshod statement that public transport can never compete with the car. Of course it can. It depends where and when. Urban railways and buses aided by traffic priorities can obviously be faster in congested areas than cars, and thus more efficient.

But does this mean that society can afford to invest in commuter rail, metro, light rail, or bus priority schemes? How much are the gains and losses in passengers' time actually worth? How much is less congestion, a better environment and lower energy consumption worth to society? It seems to me inevitable that a monetary value must be placed on the following parameters before we can arrive at useful decisions on regional and urban land-use related to the choice of transport modes:

- passengers' gains or losses in travelling



time; their preferences must be noted, and their evaluation of travelling (seated or standing), of walking distances to and from stops, of waiting time, of frequency of delays and so on taken into account;

- the relative comfort of transport modes, both vehicles and stations/stops;
- safety and security, not only comparing public transport with cars but also different public transport modes;
- environmental effects of noise and exhaust pollution of different transport modes;
- energy consumption of different modal alternatives;
- any increase in land values, which cannot always be 'captured' by the community or public transport undertaking in the form of a contribution towards investments.

Armed with these systems of evaluation, the positive and negative effects of different transport modes can be properly weighed by the decision maker who faces pressure

for heavy investment in transport systems necessary to keep conurbations alive in the future.

## Conclusion

Such cost/benefit analysis will provide national, regional and local authorities with an essential tool for planning, while ongoing deregulation and privatisation will contribute to higher productivity in public transport.

But there is a built-in risk in privatisation. If the scope of regional and local transport is restricted to a level which is justified solely in business terms, this can conflict with the objectives of society. In such circumstances, the prosperity and development of the community may be put at risk by lack of transport facilities.

Every investment in passenger transport, and roads, must therefore be evaluated to ensure that the choice of transport modes and the level of planned operation coincides with the interest of the communities and their inhabitants. This is only possible if the choice is based upon cost/benefit analyses that include not only business economy but also socio-economic factors. □

*A graphic indication of the effects of traffic pollution is given by this stone figure on a house in Stockholm. Carved in 1650, it was still in pristine condition in 1907. After another 80 years, atmospheric pollution has corroded it beyond repair*

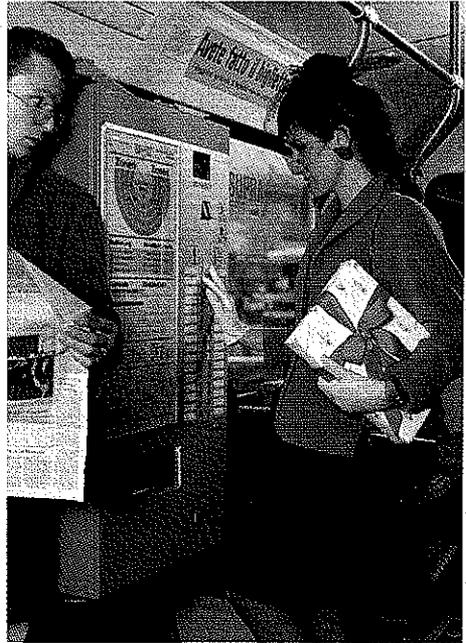


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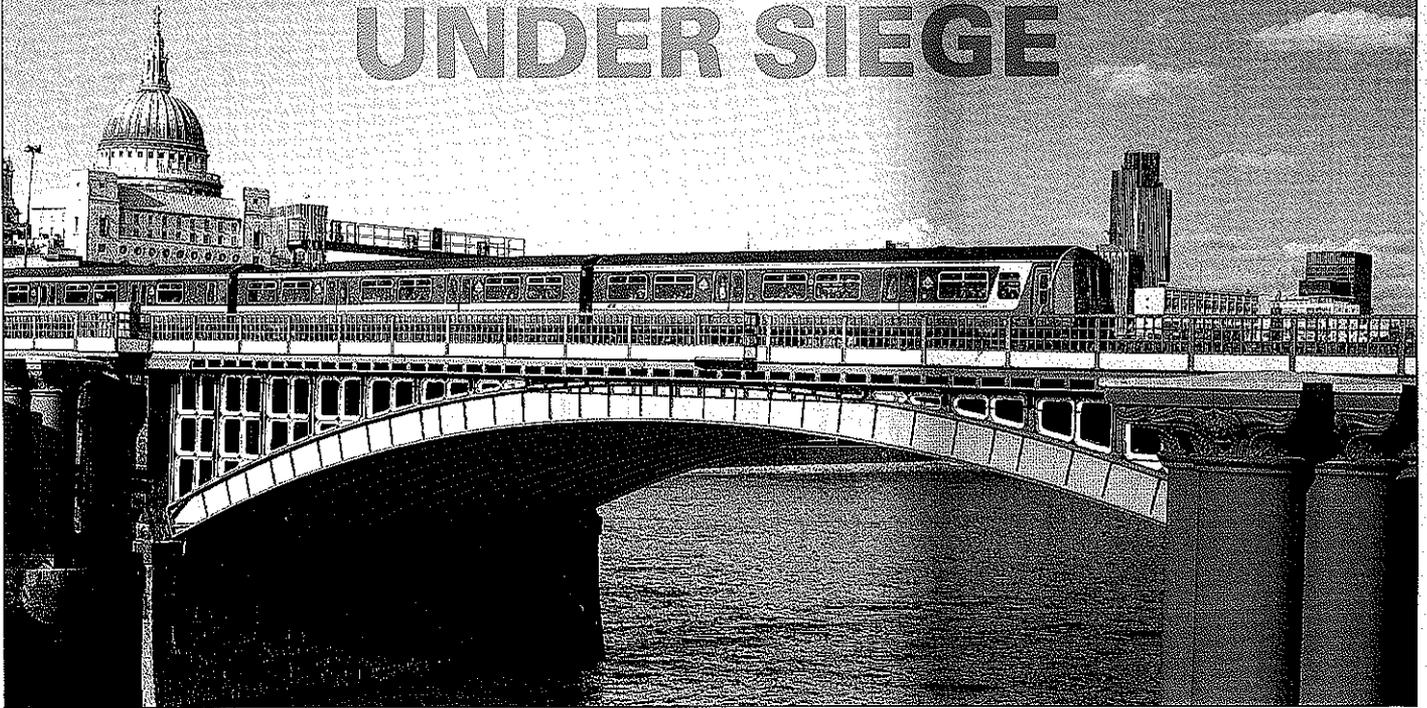


foreign coins? With value cards, credit cards and CP8 smart cards? And what about change? Are you satisfied with a self-replenishing change system with four coin storage units? Or would you prefer six? And how many large-size auxiliary coin storage units do you need: one or two? How many ticket sizes do you require? Maybe you have some questions to ask us. At any rate, there are a lot of interesting questions that we should sit down together to analyse. We want you to have a good ticket vending machine, but above all the right one.

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# NETWORK SOUTHEAST UNDER SIEGE



*Just three years have elapsed since Chris Green launched the red, white and blue image which London commuters rightly associate with a better service. Now the challenge is overcrowding, despite a real increase in fares which means NSE's revenue now covers 85 per cent of fully-allocated costs*



**Chris Green** (45) was appointed Director of BR's then London & South East business sector in January 1986. A career railwayman, he joined British Rail in 1965, and came to prominence as Chief Operating Manager of Scottish Region (ScotRail) in 1980, rising to become General Manager by 1984. It was here that the policy of bright colours and cheerful stations designed to lift the spirits of staff and passengers alike became his personal trademark. Three years ago, few would have believed that the huge London commuter network could respond so quickly to similar treatment. There is still a long way to go, as Green freely admits, but the fact that off-peak patronage is rising even faster than commuting is proof that the improvement is more than cosmetic

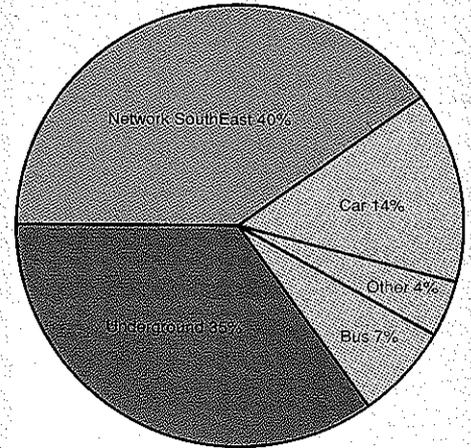
IT WAS JUST a year ago that the *Evening Standard* — the London commuters' paper — invited me to use its columns to talk to our customers. I wrote then: 'running Network SouthEast feels more like riding a tiger than a train at the moment.'

Twelve months on, nothing has changed. If anything, the tiger is wilder. Customer demand has gone through the roof. Extra trains are being rushed into traffic, and investment schemes are reaching record levels. The creation of Network SouthEast, just three years old on June 10, has brought London's surface rail system into a single focus at a most opportune time.

Network SouthEast could be described as the world's largest urban rail network. Although our trains range far into the countryside over some 4 000 route-km, NSE exists first and foremost to carry 40 per cent of more than a million commuters who work in central London.

It is a task that stretches our resources to the limit. The historic record for working day peak arrivals (07.00 to 09.59) at London's 15 termini was 465 000 in 1970. By 1983-84, that figure had dropped to 386 000, but in the year ended March 31 1989 a new record of 468 000 peak arrivals was set — up by 26 per cent in five years.

With London Underground, we now carry



Above: Fig 1. Modal split by primary mode of commuters into central London during 1987

Left: After Liverpool Street, Waterloo is the busiest of NSE's 15 London termini

75 per cent of commuters into central London (Fig 1), up from 69 per cent three years ago, which proves conclusively (if there were ever a doubt) that London's recent growth in jobs has only been possible because of its railways. For those of us professionally involved, this renaissance is exciting and stimulating. It is a real tonic for NSE's 40 000 hard-pressed staff who keep the trains moving day by day.

### The vision

The official launch of Network SouthEast just three years ago in June 1986 was based on a clear vision for the future. The central philosophy was positive thinking — changing the past emphasis from cost escapement to income maximisation. We sought a virtuous circle where major increases in

income would fund both investment in higher quality and reduced subsidy from the taxpayer, a clear target set by government. At that stage, the true extent of underlying growth in commuting was not fully appreciated. There had been a 9 per cent rise in the previous two years (Fig 2), but this could have been a blip on the graph like 1979.

Our objective was not so much to increase commuting, which poses problems familiar to every urban railway, as to generate additional leisure travel and fill empty seats off-peak and justify further investment.

The keystone supporting this vision was that quality standards should and would be raised, and become synonymous with NSE. On June 10 1986 every customer and member of staff was given a manifesto setting out our commitment to quality. We publicly

committed ourselves to the hard slog that would be needed to meet the customers' prime requirements — improvements in reliability, punctuality and overcrowding.

### Concrete results

The vision of three years ago has been turned into concrete results.

Comparing 1988-89 with 1985-86, the year before the NSE launch, two key indicators of reliability have both improved. NSE trains reaching their destination within 5 min of right time are up from 91.0 to 92.0 per cent, while the number cancelled has dropped from 1.6 to 1.5 per cent.

The timekeeping target agreed with government is 90 per cent and this has been bettered. The cancellation target is 1 per cent, and we have some way to go here, hampered particularly by train crew shortages aggravated by high employment and house prices around London. The introduction this year of driver-only operation (DOO) on suburban services out of Victoria and London Bridge — one of the worst affected areas — should ease this problem.

Our market research tells us that customers have noticed and appreciated our cleaner trains and brighter, improved stations. Here is where the biggest change has come, with every one of NSE's 942 stations repainted since 1986 and 40 per cent modernised.

Off-peak growth — where our customers have a choice that is not always available to the commuter — has been enormous and is

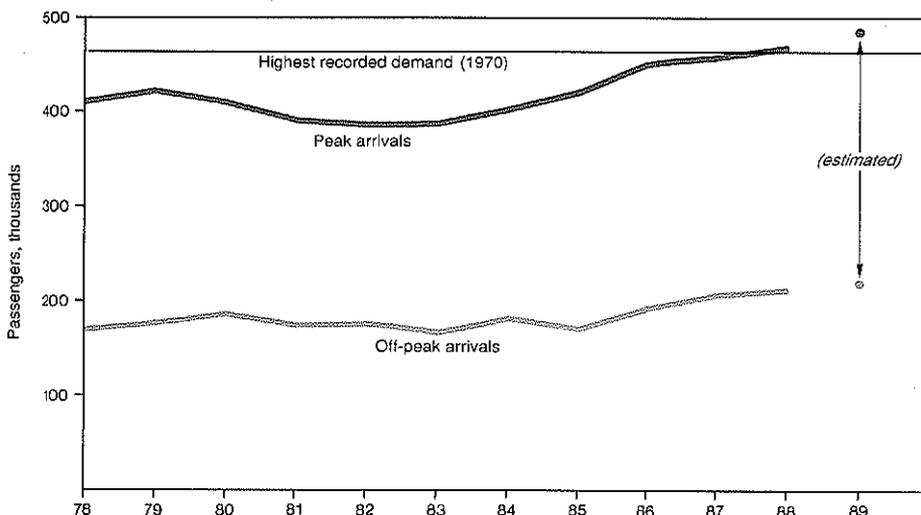


Fig 2. Peak (07.00 to 09.59) and off-peak (all other times) arrivals at London termini on a typical working day

still going up; the last two years have seen a 23 per cent increase. Sales of One Day Travelcards, giving the freedom of NSE, Underground and buses within roughly a 25 km radius of London, are now running at about 1.5 million a month.

### Surge in investment

There is one index of quality where we cannot report progress towards the government's targets. While reliability has improved despite the extra load we are carrying, it has obviously not been possible to reduce overcrowding. Once the available track capacity and rolling stock has been squeezed to the limit, only more coaches and, ultimately, major investment in extra tracks can bring down levels of overcrowding on trains, and this has become our top priority.

The increase in NSE commuting over the last three years equals the entire rail commuting flows in Manchester, Liverpool and Glasgow. Congestion is the area where our customers needs are least satisfied; research confirms that it heads the list of concerns, even taking precedence over punctuality.

Our colleagues at London Underground live with the same problem every day, and the average speed of road traffic in central London is 18 km/h — no higher than when horse drawn vehicles were the rule. A survey published last March by the Confederation of British Industry put the total cost of transport congestion in London and the surrounding area at a staggering £15bn a year, five times the previous estimate.

Our projections are that NSE traffic growth will continue at 2 per cent every year to the end of the century. The key to solving the congestion problem is major investment and our plans are well laid.

During the five years to March 1993 £1.4bn will be devoted to medium-term measures. Half will go on 2 000 new coaches (Table I), although hardly a month goes by without us having to write up the projections. The rest will be spent on resignalling for shorter headways, lengthening platforms, strengthening power supplies, new depots, and so on.

By 1985, the average age of NSE's fleet of 6 998 coaches had been allowed to build up to 24 years. It is now down to 21 years, and still falling despite the fact that we are delaying scrapping to ease congestion and now have 7 160 coaches in service.

Central to our plans for new trains will be the Networker family bringing significant benefits never seen before in commuter trains. Externally styled to improve performance, the interior will be designed with the customers' needs as the prime objective.

Using the same basic body design, the first member of the family will be a diesel version



— the Network Turbo — for the Chiltern lines out of Marylebone from late 1990.

The first 750V DC third-rail version, now in design, will serve south-east London from Charing Cross and Cannon Street. Longer distance models for both Kent (DC) and Essex (25 kV AC) will follow. Better comfort and access, and on-board passenger information systems will be standard.

This train represents a radical breakthrough in design. For the first time in Britain, three-phase AC traction motors will be used. Operating costs should fall by 25 per cent, maintenance will be lower, and better acceleration will cut journey times.

The ultimate version of this family will be a fleet of luxury trains for domestic services running on the new high speed line from London to the Channel Tunnel, reducing journey times by up to 50 per cent.

### Total route modernisation

Backed by a recommendation in the 1987 report on NSE by the Monopolies & Mergers Commission, we now focus our investment by route and so spread the butter more

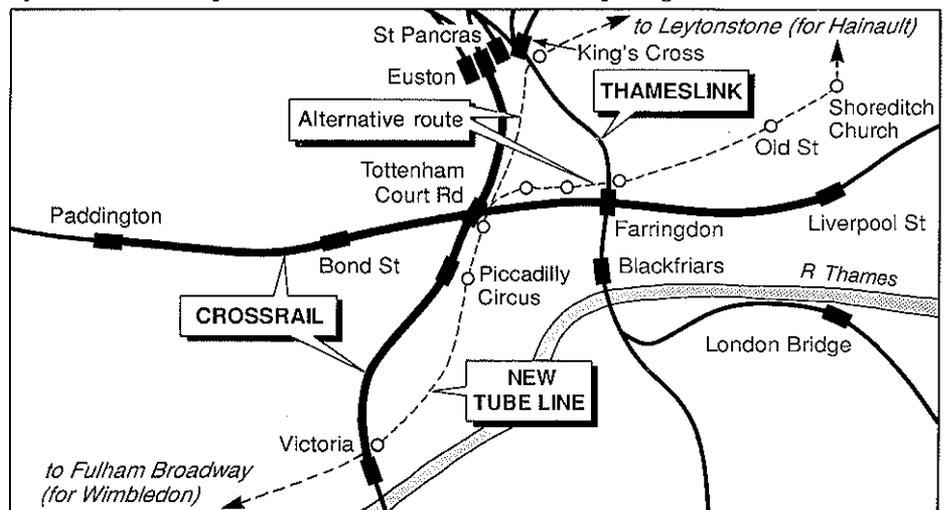
*Latest generation of EMU for NSE's 25 kV 50 Hz lines is the Class 321, of which 114 four-car units are being delivered from Brel's York works during 1988-91*

thickly. In fact, total route modernisation really started with the Bedford — Moorgate line in the early 1980s, followed by the Great Northern routes out of King's Cross.

Investing by route produces enormous synergy. The GN boasts new trains, signalling and track, DDO and a robust timetable. There is less to go wrong, and a motivated staff to keep it running. No wonder it out-performs most European railways. Punctuality and reliability have both risen, demonstrating the effects of this concerted approach. In January 1989, punctuality was 96 per cent and cancellations only 0.3 per cent, much better than the NSE average.

Three more routes (out of the 27 which

*Now being planned is the £1.7bn Crossrail scheme for cross-London links which, with Thameslink, would transform NSE into an RER-style regional metro network*



NSE operates) are scheduled for modernisation in this way:

- **Chiltern lines 1989-90:** £60m replacement of DMUs by 77 Network Turbo cars together with complete resignalling, modern track and better passenger information systems;
- **Great Eastern 1988-92:** £68m replacement of track and signalling between Liverpool Street and Colchester plus up to 400 new EMU cars;
- **London Tilbury & Southend 1991-93:** £200m total replacement of all trains and signalling together with higher train speeds and passenger information systems.

### Crossrail

All this investment will go a long way to meet the projected demand for travel into London, notably in the south-east segment where platforms are being lengthened from 10 to 12 cars as Networkers are introduced. By 1995, we shall have increased our capacity to carry commuters into London by 30 per cent through medium-term measures.

However, on past experience, the higher quality will also attract new business. What this investment cannot do is relieve present and future congestion on both the roads and the Underground. This was the purpose of the Central London Rail Study. The conclusions, published by Transport Secretary Paul Channon on January 26, point to the need for new tunnels under London.

Top priority is an £870m east - west Crossrail connecting NSE services into Liverpool Street with those into Paddington, and perhaps also Chiltern line and LUL Amersham services via a Neasden - Old Oak Common link. This would relieve LUL's Central line which is the most congested.

A second possible Crossrail, costed at £840m, would run north - south, again connecting NSE's routes and relieving the pressure on LUL's Victoria line. This option is being evaluated alongside the alternative of a £1bn Chelsea - Hackney tube. All three figures exclude the cost of rolling stock.

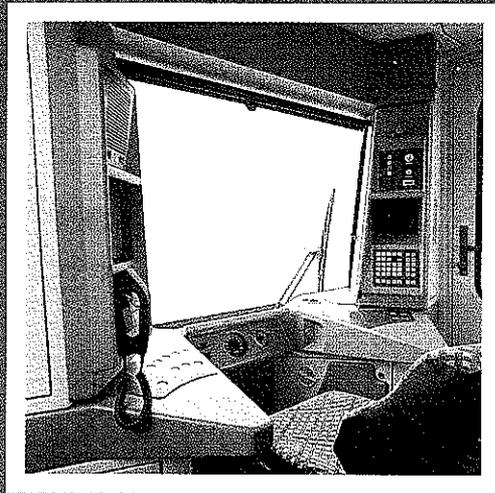
At present the three basic funding options are being examined: fares, private capital or government grants. However the money is raised, such a radical solution must come if London is to match the attraction to employers of Paris, Frankfurt and other major European cities, many of which already enjoy the benefits of modern, flexible and adequate public transport. □

*Considerable emphasis has gone into station design to promote a standard NSE image suitable for such differing examples as London Bridge (centre) and the new station opened at Arlesey on the Great Northern line in 1988 (right)*

Table 1: Five-year rolling stock procurement plan for 1988-89 to 1992-93

Class	Route(s)	88-89	89-90	90-91	91-92	92-93
EMU DMU						
Authorised						
442	Wessex Electrics	70				
319	Thameslink	104		112		
321	Anglia and North	136	296	24		
456	Southwest			48		
322	Stansted Airport			20		
	165 Chiltern			77		
Planned						
482	Waterloo & City					20
165	Thames (inner)				111	
465	Southeast			52	348	200
471	Southeast (outer)					200
	165 Various				18	
	166 Thames (outer)				20	60
	171 Waterloo-Exeter					78
TOTAL		310	296	333	497	558





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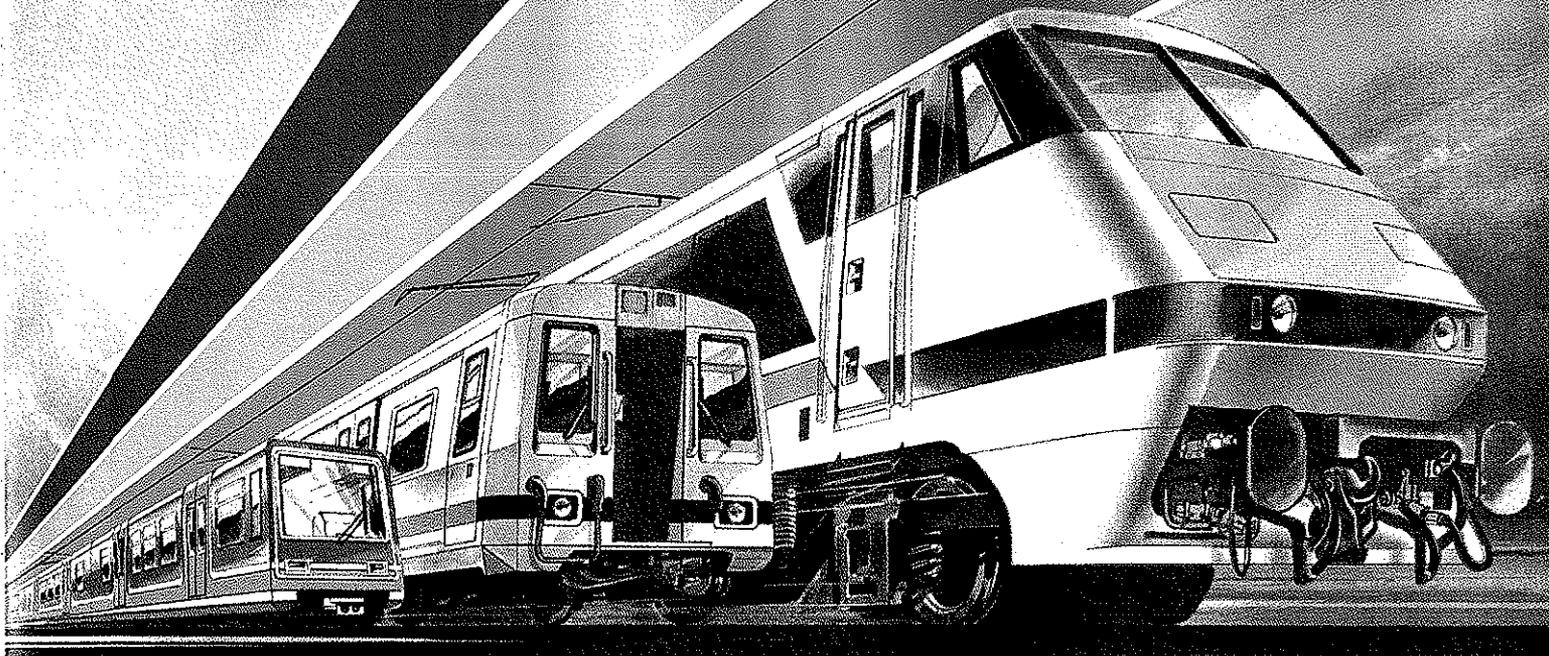
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# LIGHT RAIL ON THE STREET

*As Tuen Mun has shown, street running of light rail cars requires careful planning to ensure that the pitfalls of mixed operation with road traffic are avoided*

**A A Thompson**

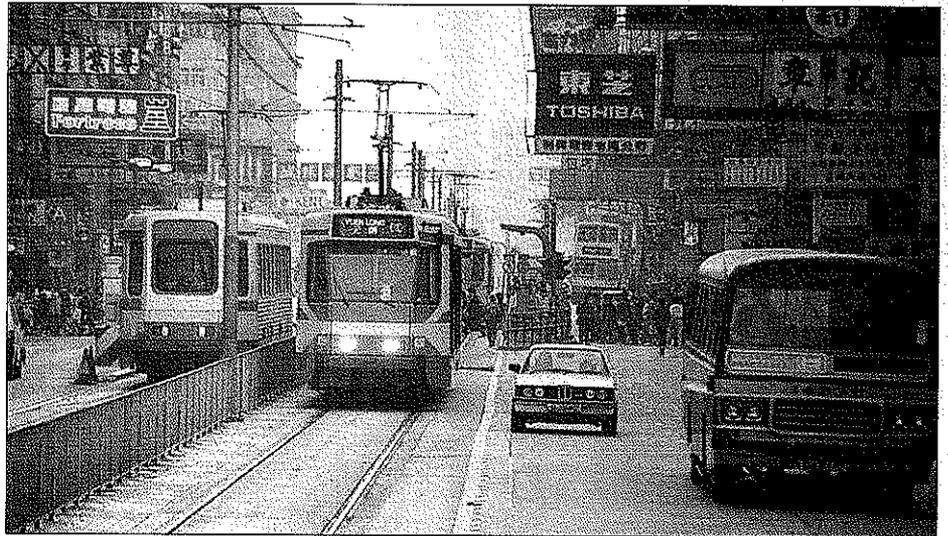
The MVA Consultancy

THE UPSURGE of interest in light rail technology reflects a desire to reap the benefits of urban rail transit without paying the high cost of a full metro. It also leads many cities to consider on-street running. Among the planning and design problems that this engenders is the need for railway and highway traffic engineers to broaden their perspectives and work closely together.

Traditionally, to a railway engineer, road traffic and pedestrians are to be avoided at all costs. Pedestrians are only encountered as passengers, and road traffic is only experienced at the few level crossings which everyone would much prefer to be without. Railway planning, design and operation has grown up in this isolated environment, and signalling and control are based upon individual, relatively infrequent trains.

Highway traffic engineers are similarly unused to railways, and base their designs upon traffic lanes with vehicles able to move freely between them. Bus lanes are the closest that they have come to an exclusive public transport facility, but buses can move out of the lane if it is obstructed. Other vehicles can legally use the lane in certain circumstances, and frequently do so illegally in others. Signalling and control is based upon vehicles moving in groups along the road.

This article highlights the problems of LRT on-street running and offers an approach to solving them. It is based upon experience gained during design and early



*Yuen Long town centre is thronged with pedestrians crossing the tracks on this Sunday afternoon*

operation of one of the world's most recent LRT networks. Serving Tuen Mun and Yuen Long in Hong Kong, it first carried fare paying passengers last September.

In many respects Tuen Mun represented a tougher challenge than most, with some junctions handling 100 LRVs each hour; dense road traffic flows and intense pedestrian activity compounded the problems.

General observance of signals and road regulations is not of the highest order, and even the slow moving trams on Hong Kong Island suffer an average of two injury accidents a week. Despite this, and a degree of undeserved adverse publicity, the Tuen Mun network and its integration with road traffic and pedestrians is very successful.

As with any new network, it is not without faults, but these are of a minor nature and are being overcome.

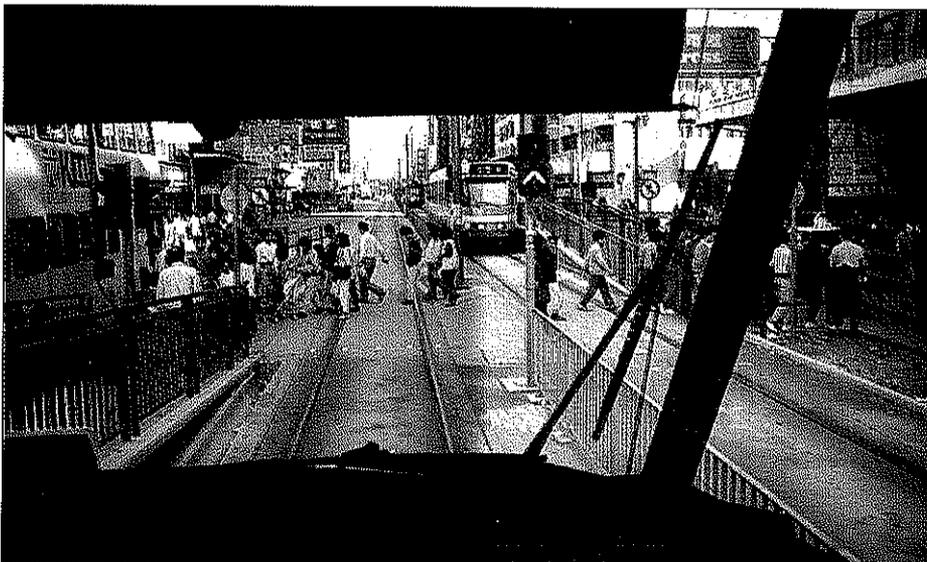
## Planning issues

It cannot be overemphasised that planning and implementing an LRT system is a co-operative venture, with the public transport authority and their consultants and contractors working closely with the highway authority and their respective consultants and contractors. Any body with an approval role must also be closely involved; in Britain and Hong Kong this is the Department of Transport's Railway Inspectorate. To establish the necessary level of interworking and co-operation is not easy, but it is essential for successful implementation.

It is almost equally important to ensure that no LRT alignments or reservations are finalised until road traffic matters have been properly investigated. If they are, there is a great danger that unworkable situations will be created.

## Calculating journey times

During the planning stage the main issues are the effects of road traffic on light rail journey times, the effects of light rail on



*An LRT driver's view of pedestrians ignoring 'red man' traffic signals telling them not to cross*

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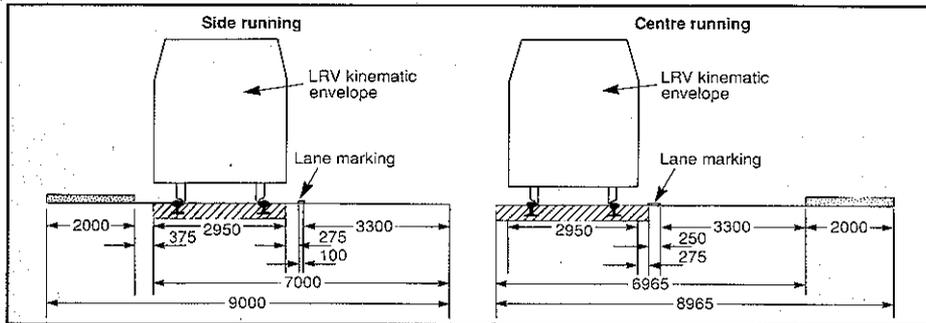


Fig 1. Tracks can be located either to one side or in the centre of a street

highway capacity, and safety implications.

LRT viability depends upon patronage which in turn depends on journey time. At the planning stage several alternative alignments may be considered, each with different catchment areas and different on-street problems. Journey times will have to be calculated for each of them.

A theoretical 'maximum performance model' can be produced by analysing the

route without taking into account road traffic effects. Maximum line speed can be based on road speed limits, except where complete segregation permits a higher speed. It may be possible to evaluate the effects of superelevation to allow higher speeds in curves, but initially it is probably advisable to assume no superelevation.

Location of stops and associated deceleration, dwell time and acceleration can then be calculated. Typical maximum figures for acceleration and deceleration are  $1.3 \text{ m/s}^2$ , but slightly lower figures may be used to allow for variation in driver performance.

Dwell times of 15 s were used initially in Tuen Mun, but in practice they vary from 12 to 60 s or more at the busier stops; it may be more realistic to use different values at minor and major stops.

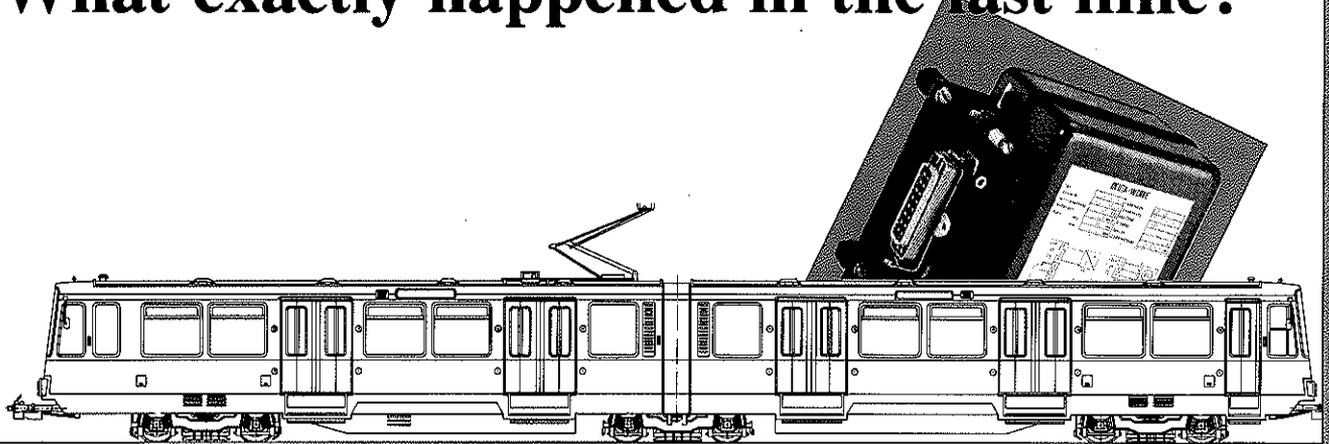
Points control arrangements can significantly affect speed, and this becomes especially important where LRVs bound for different destinations may have to queue at a junction. In Tuen Mun the equipment which detects the required LRV direction and initiates setting is within one vehicle length of the point blades. To allow time for setting and checking, LRVs are restricted to 15 km/h across points, and this has a noticeable effect upon journey time.

Initial estimates along the main end to end route gave a 30 min journey time, but this proved to be 20 per cent too low. Signalling delays at road junctions are approximately as predicted and dwell times are higher, but the main factor seems to be the cautious approach of many drivers, as the LRVs are driven on sight. This may change in time, but a 10 per cent allowance seems necessary.

One way of tackling interaction with road traffic is to examine each route in turn to see

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what measures are required to keep the LRVs moving freely. This will provide a list of desirable traffic management changes which can then be judged for acceptability. To aid this judgement, particularly where traffic capacity is low, a computer based traffic assignment model should be used. It is necessary to take into account traffic and pedestrian forecasts for the planned opening year and, say, five years after.

Where a traffic management change is judged unacceptable, an estimate of the consequent LRT delay must be made and input into the LRT model. Measures needed to maintain LRV speed are likely to be the most significant factors influencing road traffic. LRVs will probably be fairly infrequent, so the presence of one is unlikely to cause long delays to other road users.

To study a route, it is best to consider separately the junctions and the sections between them. Stops will also have an effect. Sections can be classified according to the available road width. For roads with a wide central reserve, or space to make one, the LRT tracks can be separated from the traffic lanes. A central reservation allows both tracks to run together where they are removed from kerbside activity.

### Pedestrian problems

Passengers and pedestrians must be able to cross safely both road and tracks, and they must also have easy access to stops in the centre of the road. Platform width will probably be restricted, so it is necessary to assess carefully pedestrian movement and space available, taking into account the disabled, prams and shopping trolleys.

One early problem in Tuen Mun was inadequate pedestrian crossing space and platform width in the central part of Yuen Long. A barrier between the tracks has the desired effect of keeping pedestrian movement to designated crossings, but as these also feed large numbers of passengers to and from the platforms, considerable pedestrian congestion is caused. Changes have been made, but it is important to remember that a central alignment limits improvements that can be made without adding delay to road traffic.

For narrower roads, mixed running must be adopted. Where the road is four or more lanes wide, the choice is between running down the centre, or next to the pavement. Typical dimensions are shown in Fig 1. From the passengers' point of view, an alignment next to the pavement provides easier access if sufficient width is available to allow for platform areas. It does mean, however, that traffic has no access to the kerb. Some service or delivery access is normally needed for property alongside the kerb, and alternative



*Construction of double track within a central reservation through Yuen Long*

arrangements may have to be made.

Kerbside parking must also be banned, a measure which significantly increases road capacity and reduces the effect of the LRT, although it may be locally unacceptable.

Central running allows kerbside activity to continue as traffic can run over the tracks, but it may lead to delayed running of LRVs when road vehicles waiting to turn have to stop on the tracks for a gap in the opposing traffic. Passenger access to stops must also be considered. Very narrow roads pose yet more problems, and it is worth considering one-way traffic or removing it altogether to try and raise LRV speed.

### Junction control

A reasonable objective in designing junctions is to provide maximum priority for LRVs with an acceptable level of delay to other traffic. Unfortunately, road traffic control systems are designed to handle large numbers of vehicles with minimum overall delay. To adapt them to give priority to relatively infrequent LRVs is not easy.

Another factor is that service braking performance of LRVs is lower than road traffic, requiring longer safety clearance times. To ensure efficient control, this extra time should only be provided when required by an LRV. Together with the need to detect LRVs in order to provide priority, this

requires relatively sophisticated LRV detection, such as a transponder-based system. The detection package will be part of the LRT control system, but will also need to interface with the traffic controls.

Various control methods are possible, and can be complex if maximum traffic efficiency is to be combined with minimum LRV delay. At the planning stage, the details are not important, but the interaction of LRVs and road traffic must be analysed so that LRV delays and reductions in traffic capacity for different strategies can be examined.

In Hong Kong, a computer program called FLEXYT, developed by the Dutch Ministry of Transport, proved very helpful. It was used mainly at complex junctions with little spare capacity, but it also helped at simple junctions where several potential control problems that would otherwise have been overlooked were identified.

Detailed analysis of all junctions is not necessary, so classification into junctions with full LRT priority, junctions with some problems and critical junctions may suffice.

FLEXYT can analyse critical junctions and help to determine modifications. The traffic assignment model combined with FLEXYT simulation can assist in determining the effects of traffic management measures and whether a solution may be possible without building an expensive LRT flyover or underpass.

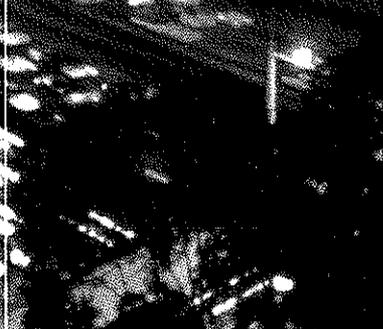
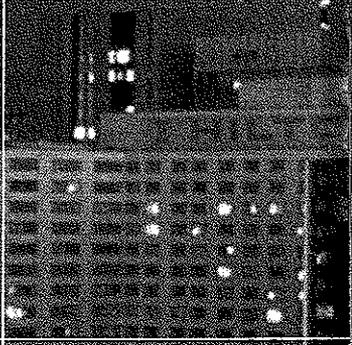
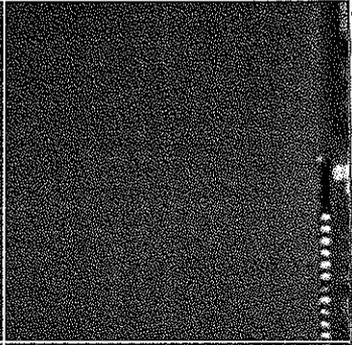
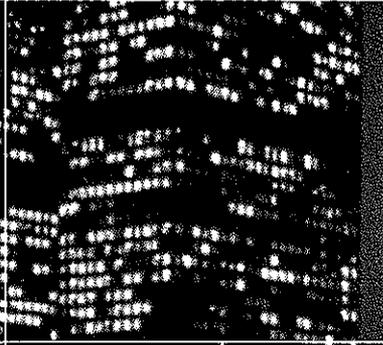
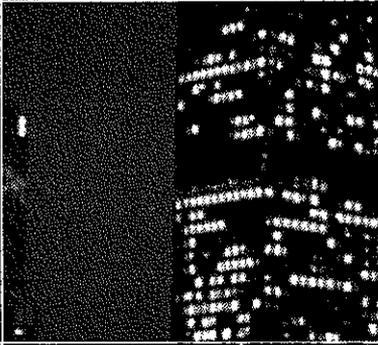
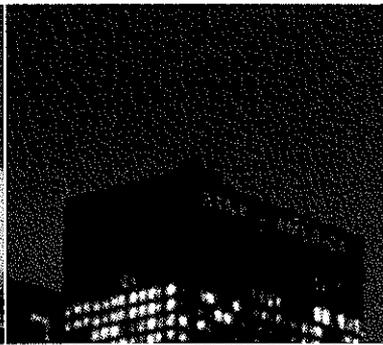
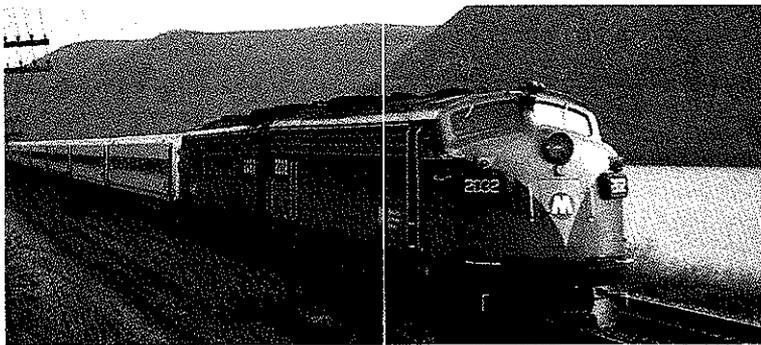
### Safety

While safety of an on-street LRT network is of prime importance, it must be accepted that accidents will happen, so the aim must be to achieve a design that is as safe as possible consistent with reasonable economic constraints. Basic design standards for on-street running give the necessary clearances between the LRV kinematic envelope and traffic.

Particular attention must be given to the swept path on bends, and high pedestrian activity needs to be safely catered for at stops, especially where they are in the centre of the road. Traffic lights must be designed to take into account LRV acceleration and deceleration performance.

Several recently completed LRT systems including Tuen Mun have recorded fairly high initial accident rates, but these drop as the public grows accustomed to the newcomers in the street. To reduce the initial accident rate, a major education programme must be undertaken to alert the public to the dangers as well as the benefits of LRT.

Proper planning and design at the outset will ensure that the system is not only safe, but provides all the required benefits with minimum traffic impact, and is thus appreciated by all. □





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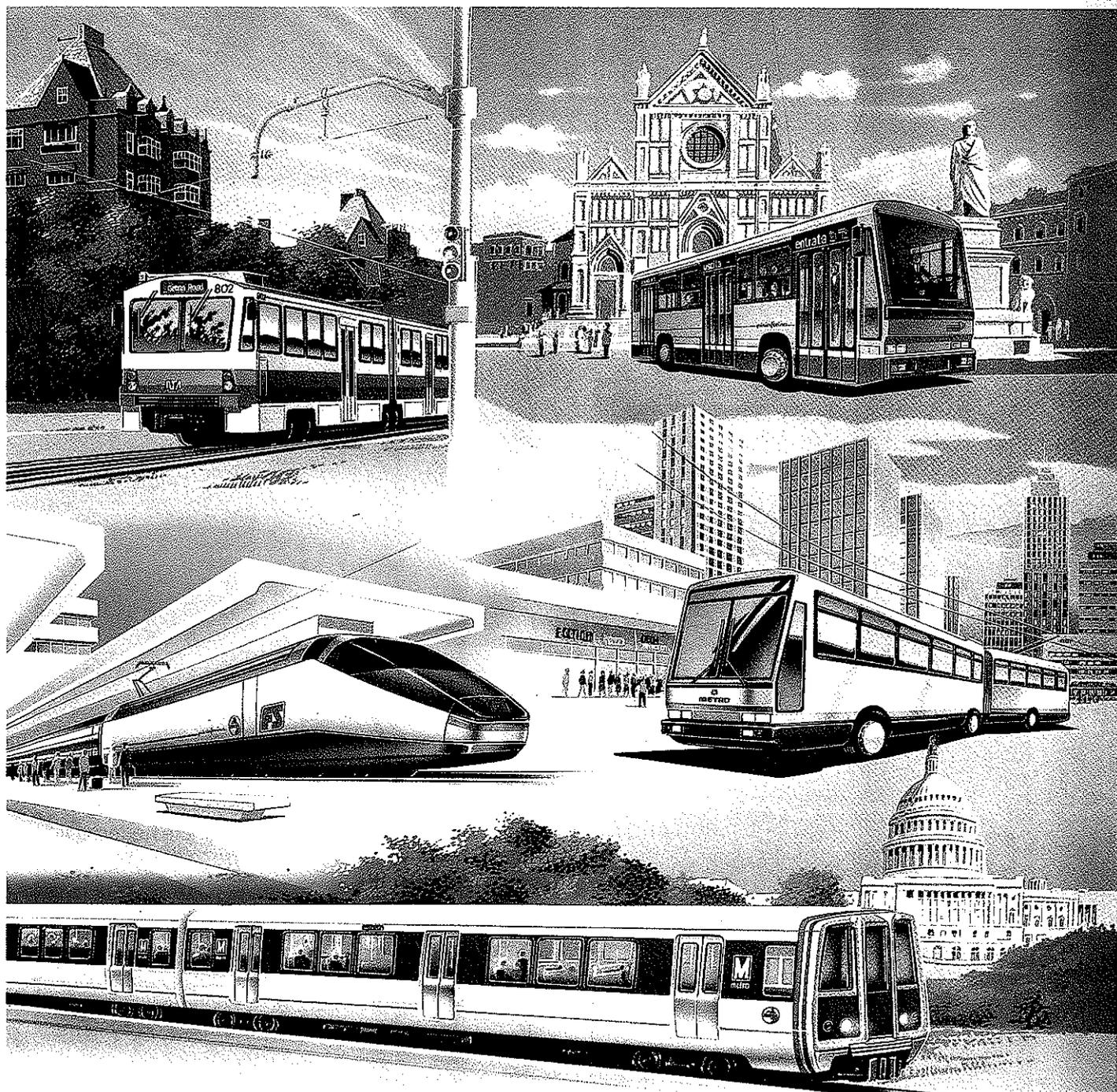
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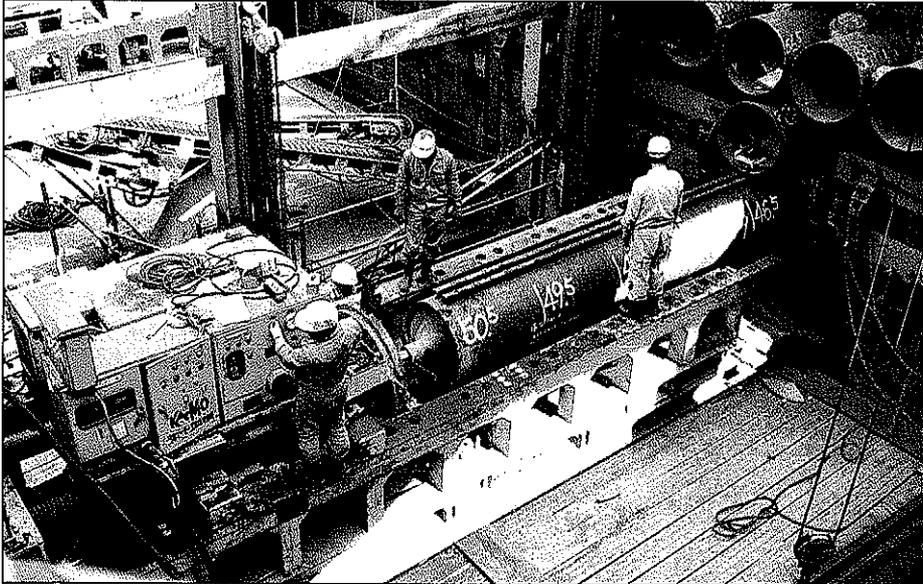
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# METRO PLANS SPAN THE WORLD

*In his latest survey of world metro construction, Chris Jackson finds that the USA has overtaken the USSR as leading promoter of urban railways*



URBAN RAILWAY construction has increased dramatically in the last decade, as more and more countries have recognised that the private car cannot provide the required level of urban mobility. In third-world cities, where new stops may be added daily to suburban bus routes, planning authorities have started looking to rail for economical and environmentally-friendly mass transport.

Opening of new metros continues apace, with 23 urban rail networks inaugurated in the last four years. Quite apart from these new networks, an indication of rapid development comes from the 200 extensions to existing undertakings which have been completed. Since January 1 1985, over 1 120 km of urban railway has been opened for traffic in 101 cities.

At the same time, the amount of line under construction has continued to rise. Urban railways are mainly being promoted by:

- beleaguered municipalities seeking to reduce urban congestion;
- growing cities looking to join the metro club before congestion develops.
- private developers keen to increase property values;

The resulting level of metro activity can be seen in Table I. For this survey, I have grouped the various types of urban rail projects into five categories:

**Regional:** urban or suburban railways dedi-

cated to local passenger traffic on segregated tracks. Suburban services on main lines are normally excluded, but urban lines such as Japan's private railways are included;

**Metro:** conventional heavy metro, high capacity, fully segregated, frequent services;

**Minimetro:** automated lines of small profile, frequent services, also known as Intermediate Capacity Transit Systems;

**Light Metro:** light-rail derived lines with mostly segregated alignments, high-platforms, intensive operations, manually-driven LRV-derived cars;

**Light Rail (LRT):** upgraded tramways, mostly on horizontally segregated alignments but with grade crossings, low-platform boarding, traditional light rail vehicles or modern trams.

Within and between these general categories are inevitable variations; Japan's monorails, for example, are classified separately. Conversion of disused or freight lines to carry urban passenger services presents another problem; these are normally included where any new construction is involved. Although this may result in some inconsistencies, the overall pattern should be clear.

For the first time since these surveys began, the USA has overtaken the USSR in terms of the length of urban railway under construction. Close behind comes Japan, where private regional railways and municipal metros are expanding to serve the dense

Table I: Metro projects in hand (km)

Country	Building	Design	Project
Algeria	34.5	4.0	50.0
Argentina	3.7	13.5	
Australia		25.0	30.0
Austria	14.2	15.1	22.0
Belgium	23.1	47.9	22.0
Bolivia			19.6
Brazil	92.4	69.6	9.0
Bulgaria	18.3	33.7	60.0
Canada	15.1	42.9	59.4
Chile		16.0	22.0
China	18.1	46.2	378.6
Colombia	29.0	44.8	
Cuba			25.0
Czechoslovakia	13.6	16.5	
Denmark			12.5
Ecuador			15.0
Egypt		40.1	67.0
Finland	1.6	1.8	20.0
France	62.8	83.9	147.3
German Dem R	6.1		
German Fed R	116.4	98.9	92.7
Great Britain	1.5	122.8	752.1
Greece	0.9	25.4	5.2
Guatemala			28.0
Guyana			28.0
Hong Kong	4.5	9.1	22.7
Hungary	3.5	4.8	41.2
India	32.9	57.3	346.0
Indonesia	2.5		
Iran	48.0	45.0	25.0
Iraq		11.0	32.0
Israel			32.0
Italy	79.7	74.1	264.7
Ivory Coast			17.3
Jamaica			19.0
Japan	234.8	120.1	193.8
Kenya			20.0
North Korea			10.0
South Korea	27.0	36.7	183.7
Libya			70.0
Malaysia		14.5	153.0
Mexico	39.1	25.8	227.6
Morocco			10.0
Netherlands	19.0	2.0	
New Zealand			10.0
Nigeria			28.5
Norway	2.4		37.0
Pakistan			19.0
Peru		23.0	
Philippines		11.0	124.0
Poland	31.7	32.5	162.5
Portugal	9.4	5.0	
Puerto Rico			24.0
Romania	28.0		
Singapore	27.0	15.0	17.7
South Africa			70.0
Spain	23.0	28.1	10.0
Sweden		5.0	98.0
Switzerland	20.7	1.5	77.8
Syria			118.0
Taiwan	38.9		50.0
Thailand		36.2	
Tunisia	19.1		
Turkey	40.0	7.6	171.0
USA	254.5	443.7	1359.0
USSR	199.3	330.5	885.5
Venezuela	26.6	35.2	287.5
Yugoslavia	13.0		24.0
Zimbabwe			25.0
<b>TOTAL</b>	<b>1676</b>	<b>2201</b>	<b>7063</b>

# SPECIAL FEATURE

**Table II: Urban rail lines under construction**

City	Type	km	Details
Algiers	Metro	22.5	Tafourah - Dar el Beida
	Regional	12.0	Tafourah - Bab el Oued
Alma Ata	Metro	8.9	Line 1 Oktyabrskaya - Auesova
Amsterdam	Met/LRT	16.0	Amstelveen line opens 10.1990
Ankara	Lt Met	14.6	Line 1 Kislilay - Batikent
Antwerpen	LRT	12.6	Premetro tunnels open 1992
Athens	Metro	0.9	Line 2 Attiki - Sepolia
Atlanta	Metro	3.0	Chamblee - Doraville
Baku	Metro	6.7	L1 Neftshilar - Aslani Aslanov
		11.8	L2 Mikrorayon - Gynli
Baltimore	LRT	44.2	Hunt Valley - Glenburnie
Barcelona	Metro	2.1	L1 Av Carrilet - Ciudad Sanitaria
		0.9	L1 C Sanitaria - Cami del Fons
	Regional	4.0	Pl.Espana - Cornella tunnel
Belo Horiz	Regional	4.2	Central - São Paulo opens 1989
		18.8	Calafate - Barreiros opens 1991
Beograd	Regional	13.0	Cross-city tunnel
Berlin (E)	Metro	3.0	Line E Wuhletal - Honow
Berlin (W)	Metro	4.0	U8 Paracelsus Bad - Wittenau
	Mini	1.6	M-Bahn demonstration line
Bilbao	Metro	11.0	Line 1 San Ignacio - Etxebarri
Bochum	LRT	13.7	Bochum - Herne / Witten
Bombay	Regional	18.0	Mankhurd - Belapur started 1985
Boston	Metro	1.0	Blue L, Bowdoin - Charles Center
Bronx	LRT	2.5	Extension opens 1989
Brussels	Metro	4.0	Line 2, Place Louise - Albert
		1.5	Line 1, Heysel - Amandiers
		3.0	Line 1, Alma - Stokkel
	LRT	2.0	Line 3, Midi - Albert
Bucharesti	Metro	23.0	Line 3 southern ring
Budapest	Metro	3.5	Line 3 Arpad Hid - Ujpest
B. Aires	Metro	3.7	Ministro Carranza - Monroe
Calcutta	Metro	6.5	Central part of Line 1 opens 1991
Calgary	LRT	7.0	NW Line, University - Crowchild
Caracas	Metro	4.4	Line 1 Dos Caminos - Palo Verde
		9.5	Las Adjuntas - Los Teques
		12.7	Palo Verde - La Rinconada
Chiba	Mono	3.0	JR station - Government Offices
		7.4	Sports Centre - Chiba Harbour
	Regional	5.0	Chiharadai - Ama Arika
Chicago	Metro	1.2	Downtown link (RG1.88 p47)
		15.0	Southwest line to Midway Airport
	Mini	7.0	O'Hare airport peplemover
Constanza	LRT	5.0	Line 3 started 1987
Dniepr't'sk	Metro	5.6	Line 1 extension opens 1990
Dortmund	LRT	10.3	Line 2 North
Edmonton	LRT	2.1	S line to University opens 1990
Essen	LRT	4.3	Westendstraße - Altenessen
Fortaleza	Regional	22.7	Fortaleza - Maracanao
Frankfurt	Lt Metro	2.1	U6/7 Zoo - Eissporthalle
	Regional	3.5	Konstablerwache - Offenbach
Fukuoka	Metro	4.0	Hakata - Fukuoka-Kuko Airport
Genova	LRT	7.9	Rivarolo - Brignole
Gorky	Metro	2.6	Line 1 Komsomolsk - Zahidan
		3.0	L1 Moskovsk. - Mestersheskaya
Grenoble	LRT	4.7	Line 2 to University opens 1990
Guadalajara	LRT	4.0	Second phase of N-S project
Hamburg	Metro	2.9	U3 to Mümmelnsberg, 1990
		2.4	U2 to Niendorf Nord opens 1990
Hannover	LRT	7.0	Line C East and Line B North
Helsinki	Metro	1.6	Kontula - Mellunmäki opens 1989
Hong Kong	Metro	4.5	Kwun Tong - Quarry Bay
Istanbul	Lt Met	15.0	Otogar - Ataköy to open 1991
Jacksonville	Mini	1.0	VAL test section ready for trials
Jakarta	Mini	2.5	Aeromovel demonstration line
Karlsruhe	LRT	3.6	Hammacker - Forchheim
		6.4	Rheinstellen - Rastatt
		3.6	Rheinstrandsiedlung - Mörsch
Kharkov	Metro	6.2	Line 3 Sportivnaya - Lenin Square
		2.6	L3 Lenin Square - Vict. Prospect
Kiev	Metro	16.9	Line 2 south, Line 3, Ley - Oski
Kobe	Metro	7.5	Hohushin line
	Mini	4.5	Rokko Liner opens 6/89
Konya	LRT	10.4	Alaaddin - Cumhuriyet open 1990
Krakov	LRT	1.5	Extn to Oseidla Azory
Krivoy Rog	LRT	4.0	Phase 1A extension
Kuybyshev	Metro	10.3	Line 1 Gagarin Pros. - Kirovsky
Kyoto	Metro	1.5	Kitaoji - Kitayama
		13.0	Line 2, Nijo - Daigo opens 1995
	Regional	2.3	Sanjo - Demachi
Las Vegas	Mini	2.0	M-Bahn maglev peplemover
Lausanne	LRT	8.5	TSOL, Flon - Renens, opens 1991
Leningrad	Metro	12.0	L4 Ploschad Mira - Pr. Bolshevik
Lisboa	Metro	1.6	L3, Alvalade - Campo Grande
		2.5	L1, Sete Rios - Colleege Militaires
		2.3	L2, Entre Campos - C Grande
		3.0	L2, Campo Grande - Lumiar
London	Mini	1.5	DLR Bank extension opens 1990
Los Angeles	LRT	35.3	LA - Long Beach opens 1990
	Mini	34.0	Norwalk - El Segundo
	Metro	7.1	Union Station - Wilshire Blvd
Lyon	Metro	11.2	Line D to open 1990
Madras	Regional	8.4	Madras Beach - Luz core line
Marseille	Metro	1.2	Line 1 Castellane - La Timone
Medellin	Metro	29.0	N-S and E-W lines open 1990-91
Mexico City	Metro	4.2	Line 9 Centro Medico - Tacubaya
	LRT	13.4	Line A Pantitlan - Santa Marta
Milano	Metro	11.1	Yellow Line opens 1990
		0.9	Red Line Inganni - Bisceglie
	Regional	9.0	Cross-city link near completion
Minneapolis	LRT	22.6	Minneapolis - Minnetonka
Minsk	Metro	7.2	Frunzenskaya - Tractorny Zavod
Monterrey	Lt Met	17.5	Elevated line
Moscow	Metro	6.7	Belayavo - Bitseski Park

conurbations of Tokyo, Osaka and Kobe. Much of the US development comes in light rail or light metro, following the success of the west coast lines in San Diego and Portland. Apart from Baltimore's north-south light rail line, heavy metros continue to dominate thinking in the eastern USA, although only Washington still has substantial amounts under construction.

A similar change of policy is evident in Europe, where Great Britain and France have both seen a dramatic leap in light rail proposals. Several French cities are opting

for VAL-derived automated minimetros, but in West Germany the split between light metro (Stadtbahn), metro (U-Bahn) and regional (S-Bahn) remains similar to previous years. Elsewhere in Europe, Italy, and Sweden are rediscovering light rail, whilst Belgium continues to upgrade tramways to premetro and then to metro in a phased, if slow, progression.

The Soviet Union's policy of building metros whenever a city grows to over 1 million residents has brought several new schemes into the detailed planning stage,

although the rate of construction has slowed following opening of initial routes in several cities since 1985. Light rail lines have been pioneered in Krivoy Rog and Volgograd, whilst Moscow is slowly developing its project for high speed regional lines to overlay the expanding metro network.

Eastern European countries continue to build Soviet-style metros in their principal cities, although both Poland and Yugoslavia are planning regional networks based on existing main line railways.

Chinese cities have long harboured plans

Moscow	Metro	3.9	Preobrazenskaya – Podbelskovo	Sevilla	Metro	5.0	Project to use unfinished tunnel
		2.4	Molodyezhenaya – Krylarskoye	Shanghai	Metro	14.6	Line 1 Bei – Xin Long Hua
		14.6	Line 9 Otradnoye – Borovitskaya	Singapore	Metro	1.6	Lakeside – Boon Lay
		7.0	Lyublinski line			5.0	Jurong – Choa Chu Kang
München	Metro	6.5	U2 Scheidplatz – Feldmoching			1.2	Raffles Place – Marina Bay
		7.8	U3 Implerstraße – Furstenried W			19.2	City Hall – Pasir Ris
		2.9	U6 Holzapfkr. – Klin. Großhadern	Sofia	Metro	7.7	Line 1W, City centre – Lyulin
	Regional	6.0	Maisach – Nannhofen			10.6	Line 1E, City centre – Iskr
		19.0	S3 Ismaning – Erdinger Moos Apt	Stuttgart	Regional	7.5	Rohr – Echterdingen Airport
Nagoya	Metro	2.4	L3 Joshin – Shonairyokuchikoen	Sverdlovsk	Metro	11.7	L1 Cosmonautov Pros. – 1905 Sq
		14.9	Ninami – Nakamurakuyakusho	Taipei	Metro	22.9	Red line, Taipei Main – Peitou
Nantes	LRT	6.1	Line 2 south section to open 1991			2.0	Green line started 1988
Napoli	Metro	9.8	Rest of Line 1			14.0	Brown VAL line to Mucha Airport
		20.8	L2 contract to Ansaldo 1986	Tashkent	Metro	15.0	Three extensions under way
New York	Metro	4.0	57 St – 21 St Queens opens 12.89	Tbilisi	Metro	2.0	Line 1 extension, TEVZ – Gldani
Novosibirsk	Metro	4.0	L1 Krasnyy Pros. – Pl Kalinina			1.2	Line 1 extension from Varketli
		2.0	L1 Studentchesk. – Pl Marksa			8.1	Line 3 Rustaveli – Vasisubani
Nürnberg	Metro	1.3	U2 Hbf – Rathenauplatz	Tehran	Metro	48.0	Work resumed 1989 (p64)
Osaka	Metro	1.5	Dobutsuenmae – Tengachaya	Tianjin	Metro	3.5	Line 1, Xi Zhen – Liutan
	Mini	5.6	L7 Kyobashi – Tsurumi-Ryokuchi	Tokadai	Mini	7.4	Vona, Tokadai-higashi – Komaki
	Mono	13.7	Airport – Minami-Ibaraki	Tokyo	Mini	4.8	Line 12, Nerima – Hikarigaoka
Oslo	Metro	2.4	Bergkrystallen – Klemetstud	" (Toei)	Metro	2.8	Shinozai – Motoyawata
Paris	Metro	2.4	Line 1 Neuilly – La Défense			1.6	Mita – Tokyu
	LRT	9.1	St Denis – Bobigny started 1988	" (Eidan)	Metro	6.4	Shintomicho – Wangan
	Regional	11.2	RER A Torcy – Eurodisneyland			0.9	Mitsukoshimae – Kakigaracho
	Mini	7.2	OrlyVAL Airport peoplemover			6.8	L7, Iwabuchi-cho – Komagome
Porto Alegre	Regional	15.0	Sapucaia – Novo Hamburgo	" (Haneda)	Mono	6.1	Haneda Seibijo – Higashi-Kuko
Poznan	LRT	7.1		" (Tama)	Mono	6.0	Tachikawa – Shin Omekaido
Praha	Metro	1.5	Line A Strasnice – Skalka	" (Keio)	Regional	8.8	Tama Centre – Hashimoto
		5.1	Line B Dukelská – Zlicin	" (Keisei)	Regional	12.2	Takasago – Hohuso
		4.5	Line B Sokolovska – Zápotockého	" (Odakyu)	Regional	2.6	Tama Centre – Karakida
Pusan	Metro	4.0	Line 1 City Hall – Gudok	" (Seibu)	Regional	2.3	Nerima – Shinsakuradai
Recife	Regional	4.5	Rodoviária – Timbi	" (Toyo)	Regional	16.2	Nishi Funabashi – Katsudata
Riga	Metro	8.9	Line 1 Lenin Square – Imanteu	Torino	Regional	6.0	Lingotto – Porta Susa tunnel
Rio de Jan.	Metro	4.0	Botafogo – General Osório		LRT	2.0	R Rivadella – R della Forza
	Lt Met	2.8	Estácio – Barcas			0.5	L3 to Continassa
	LRT	6.5	Iraja – Pavuna	Toronto	LRT	2.0	Harbourfront line opens 1990
Roma	Metro	8.0	Line B Termini – Rebibbia	Toulouse	Mini	9.7	VAL Line A Jolietmont – Mireil
		3.7	Line A Ottaviano – Cornellia	Tunis	Lt Met	19.1	Northern lines to open in 1989
Rotterdam	Metro	3.0	L2 Capelsbrug – Capelle a/d IJssel	Ufa	Metro	8.3	Line 1, Promzona – Oktober Pros
San Diego	LRT	17.7	Euclid Ave – El Cajon opens 1989	Vancouver	Mini	4.0	New Westminster – Scott Rd
		3.2	Bayside line opens 1990	Warsaw	Metro	23.1	Line A to open in 1991-96
San Francisco	Metro	2.4	Daly City – Colma	Washington	Metro	31.4	See p 72
	LRT	1.0	Embarcadero turnback	Wien	Metro	4.9	U3 Erdberg – Volkstheater
		3.7	30th St – Balboa Pk opens 1990			9.3	U6 extn to Philadelphiabrucke
San José	LRT	17.7	Southern section to open by 1991	Yerevan	Metro	3.9	Line 1 Zhinvarneri – Achapniak
São Paulo	Metro	3.4	Line A Santana – Turcuruvi	Yokohama	Metro	10.8	Shin Yokohama – Azamino
		6.0	Line B Itaquera – Guarapuava		Mini	12.0	Kanazawa Seaside peoplemover
		4.5	Line C, Paraiso – Clinicas	" (Sogami)	Regional	19.0	Futamatagawa – Kawasaki
Sapporo	Metro	5.6	L2 Higashi-Sushino – Fukuzumi	" (JR-East)	Regional	12.1	Higashi-kanagawa – Neigishi
Sendai	Metro	1.2	Yautome – Izumi	Zürich	Regional	2.0	Hbf – Stadelhofen opens 1989
		2.9	Line 2, Sendai – Hisodei			8.6	Stadelhofen – Dietlikon (p79)
Seoul	Metro	15.4	Line 3, Yangjae – Kodokdong			1.6	SZU Selnau – Hbf opens 1990
		7.6	Line 4, Sandang-dong – Kwachon	Zwickau	LRT	3.1	L1 Leipzigerstrasse – Eckersbach

for metro networks, and following the examples of Beijing and Tianjin the first are now starting to take shape. Construction is under way in Shanghai and Guangzhou, with several more schemes on the drawing board. The latest plans for Beijing envisage six more lines totalling 163 km.

Another city with a massive master plan is Seoul, where a further 13 lines are on the drawing board. The first of four extensions to existing lines are getting under way, with the new routes now expected to open in 1995-96. Both lines of Pyongyang's metro

have been extended in recent years, and a third is on the drawing board. Taipei has finally started its Red and Brown lines after years of planning, although Bangkok continues negotiations over its two-line minimetro project.

Latin American countries have tended to ignore their existing railways in favour of new networks which are perceived as the only answer to urban congestion. The expanding Caracas metro has proved very successful, but the prospects for a metro in Bogota and regional lines in Venezuela are

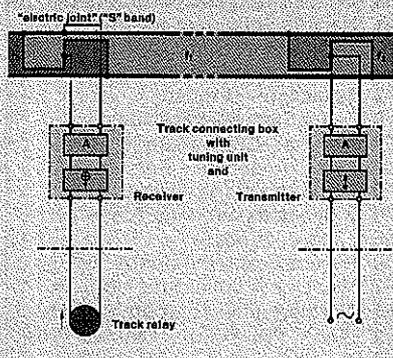
less certain. Established metros in São Paulo and Buenos Aires continue to grow steadily, whilst the troubled Rio de Janeiro metro is at last making progress again.

Metro development in Africa remains limited to the north and south. Port Elizabeth and Casablanca are looking to follow Tunis into light rail or light metro, while Cairo and Johannesburg are planning heavy metro networks. Consultants have recommended regional electric services in Harare and light rail in Nairobi, but no decisions have been taken. □

## An Economic Alternative - FTG S from Siemens

Higher economic efficiency and safety - on balance, these are the decisive advantages of the new Siemens FTG S, remote-fed audio frequency (AF) track circuits with "electric joints". There is no trackside electronic equipment. With the FTG S, insulated block joints are no longer used. The advantages for the railway are: reduced wear and tear on track, less track maintenance, a smoother ride and better track current return.

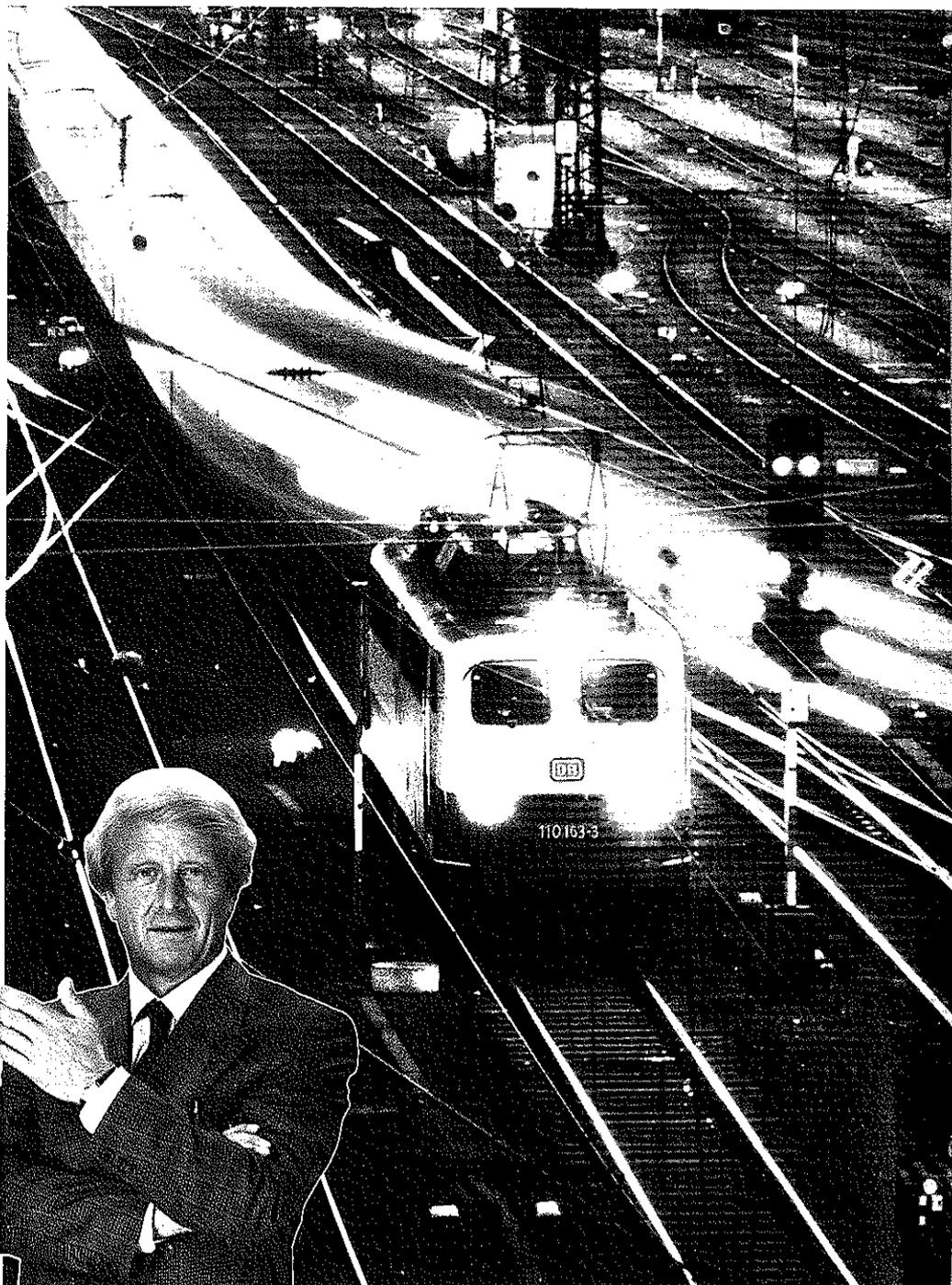
Schematic diagram of an AF track circuit



Track circuits are remotely fed - from an interlocking. By employing frequency shift keying and a safety code, the FTG S is immune against interference. As an optional feature, it is also capable of conveying track-to-train information, e.g. for ATC.

Adaptability poses no problem for the FTG S; it can be fully integrated into any interlocking.

Take advantage of Siemens high tech - it exemplifies economic efficiency. The FTG S, a vacancy indication system based on experience gained from 13,000 AF track circuits.

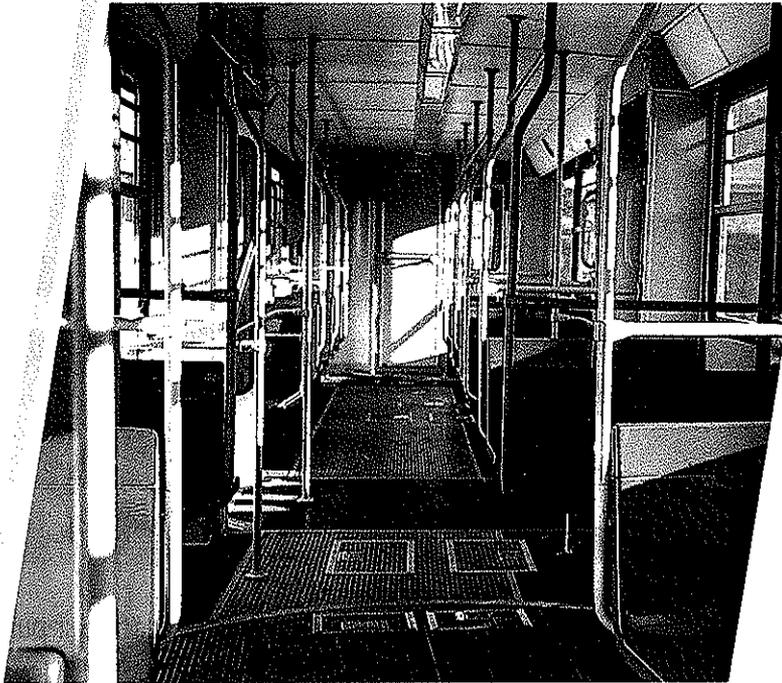


With high tech  
into the future.

Electronic signalling  
from Siemens.

Circle 12 on express enquiry card

# LRVs for Rome metro line G



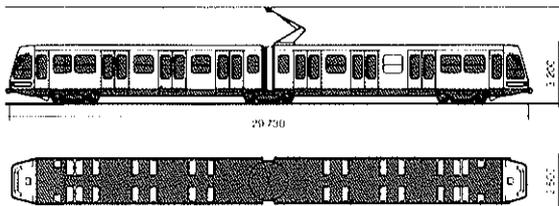
*FIREMA delivered six three car articulated trainsets, type T 81, to A.CO.TRA.L. (Rome Transport Authority) for service on future metro line G. Each trainset has a top speed of 80 km/h and a capacity of 286 passengers (66 seated).*

**FIREMA Consortium**  
Corso di Porta Romana, 63  
20122 Milano - Italy  
Tel. (02) 5465708 - Fax (02) 5460133  
Telex 322255 FIREMA I

**FIREMA** Consortium  
Engineering

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# THE INVERTER TRAMCAR: THE DESTINATION OF URBAN TRANSPORT.



Total accommodation: 290. Boarding capacity: 140 passengers/10". Top speed: 75 kph. Starting acceleration:  $1 \text{ m/sec}^2$ . Bidirectional, articulated, three-bogie electric tramcar (2 motor bogies). Pneumatic suspensions. Inverter type traction system with asynchronous motor and on-line regenerative braking. One traction unit for each half of the vehicle. Up to three cars can be coupled for multiple operation.

Circle 14 on express enquiry card

City-dwellers are constantly on the move. They expect their public services to be efficient, economical and kind to the environment. A town management policy designed to speed up the flow of vehicles and cut down the distance times between one district and another. Fiat Ferroviaria is active in this scenario, faithful to its long tradition of commitment to the development of new pacesetting solutions for urban public transport systems. Solutions aimed at the constant improvement of safety, comfort, swiftness and roominess.

**FiatFerroviaria**

# MARTA TO THE AIRPORT

EVEN WHEN there is little traffic on the highway, it takes more than 30 min to drive from downtown to Atlanta's international airport — if you are lucky enough to park in less than 5 min. Since June 18 1988, when Marta extended its North – South line from East Point, the airport has been only 15 min away.

The shell of the airport station was completed in 1980, concurrently with the mid-field terminal, although fitting out to make it ready for trains did not begin until January 1986. Located inside the west end of the central passenger terminal building, our airport station has an island platform. Below are the concourse areas, conveniently located on the same level as the airline ticket counters and baggage claim. Escalators and a luggage slide make transfer between plane and train as convenient as possible.

The Airport station is designed for trains to run through the terminal building and over the parking area to a yard at the end of the line where 95 cars can be stored. This arrangement provides for future extension of the line further south, if required.

Mondays to Fridays, trains run through to the airport every 12 min while a 6 min interval is maintained on the mid-section of the North – South line between Lakewood

**K M Gregor**

**General Manager, Metropolitan Atlanta Rapid Transit Authority**

and Lennox. Frequency throughout the East – West line from Avondale to Hightower is 6 min. Minimum frequency at quiet times is 15 min.

On the same day as the Airport extension opened, service began to nearby College Park station just outside the airport perimeter. This station, 13 km from downtown Atlanta, has parking space for 2 000 cars, and acts as a railhead for park-and-ride commuters coming into the city from the south. It is also well placed to serve the city of College Park, with an attractive residential neighbourhood close by.

Marta's metro, first opened in 1979, now consists of two lines totalling 52 km serving 29 stations. The network is by no means complete, and work continues on the planning of extensions and branches off the two basic lines.

Recently, Marta broke ground in conjunction with the Northwest Perry – Bankhead Oversight Committee for the Bankhead station on the Proctor Creek branch, which will leave the East – West line just to the

west of Ashby. Scheduled to open with the rest of the line in 1992, Bankhead is being constructed early to tie in with a major office and retail development. In addition to parking, there are to be three bays for buses, and full access for handicapped passengers. The area is industrial to the north and residential to the south, with a commercial strip running east – west along the Bankhead Highway.

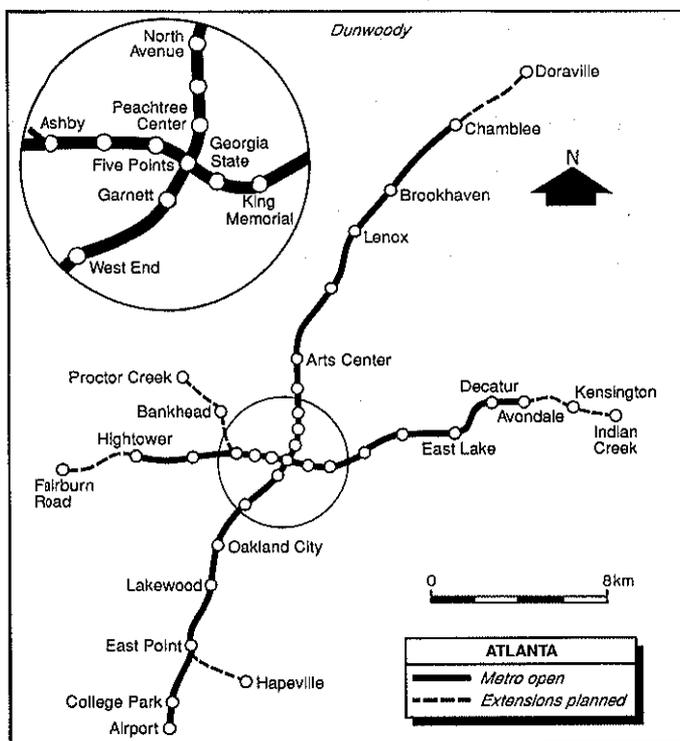
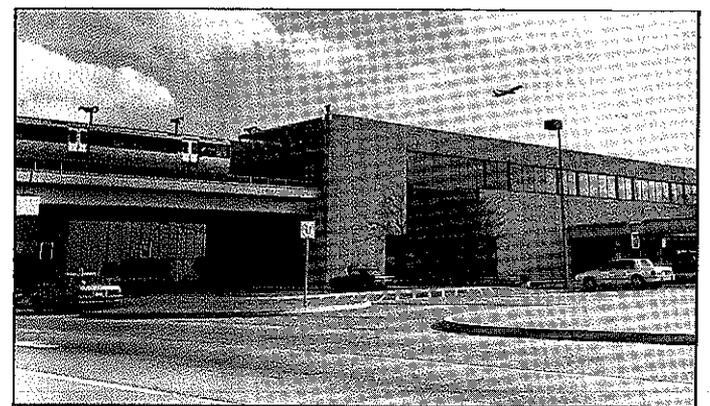
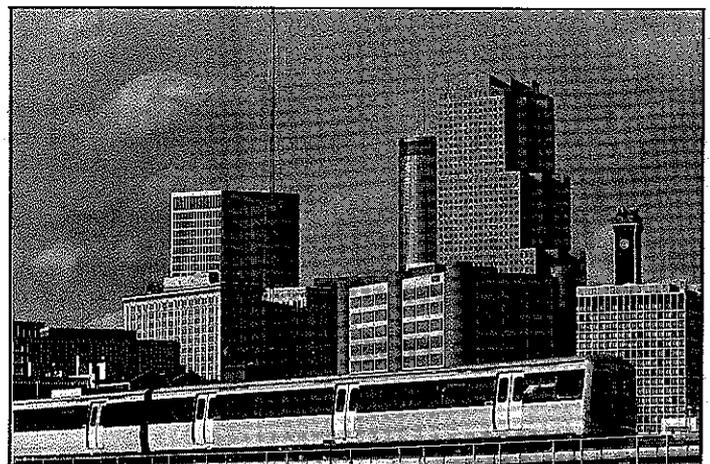
Marta planners expect 9 600 passengers a day to use Bankhead station in 2000, with 78 per cent interchanging from buses, 15 per cent walking to the station, and the rest arriving by car.

Last November, a community meeting was held to discuss six possible alternatives for transit service in the Dunwoody area to the north of Atlanta. These range from enhancing existing bus services through to a rail line. One of the rail options calls for three stations at Dunwoody (Perimeter Mall), Sandy Springs and North Springs. In June 1989, public hearing will begin with a view to starting construction in the mid-1990s.

Beyond Avondale, conceptual design of an extension to Indian Creek has been completed. Final design of the first section to Kensington is under way. □

*Downtown Atlanta is well served by the east-west line on the surface (right upper) and the north-south line bored in deep tunnels*

*Right lower: Marta's airport station is conveniently sited in the upper floor of the terminal building*



# BARCELONA STARTS TO

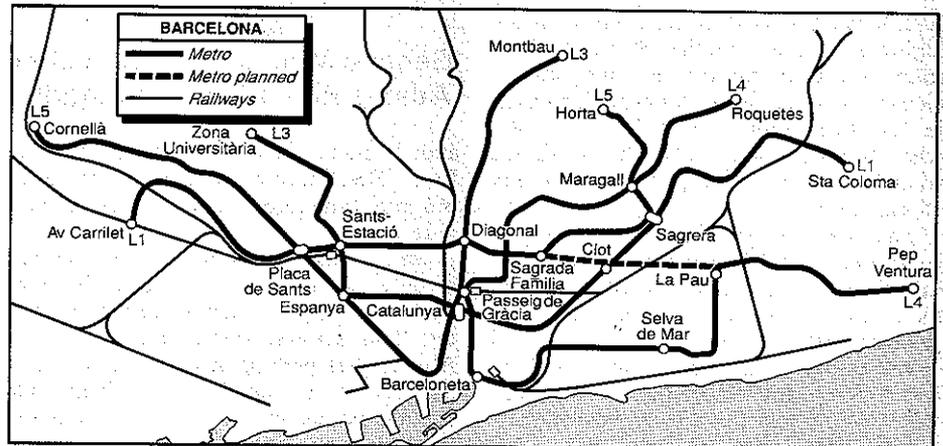
**Jesús Zanduetta Vera**  
 General Manager  
 Barcelona Metro

THE PRESENT metro network in Barcelona consists of four lines with a total length of 68.5 km. Of the 96 stations, 10 are interchanges between metro lines, while others offer connections to main line services, local railways and funiculars.

A number of extensions are planned for the next few years; 1989 will see completion of a 2.1 km section of Line 1 with two stations, and a further 0.9 km will be added in 1991. A year later the 7.1 km Line 2 with 10 stations between Sagrada Família and Pep Ventura is to be inaugurated, taking over Line 4 beyond La Pau.

A major programme of rolling stock renewal has been under way for some time. The trains working the 1 674 mm gauge Line 1, electrified at 1.5 kV DC with third rail current collection, are being replaced by 24 five-car sets of Series 4000. A fleet of 18 similar trains designated Series 3000 has already replaced the 1 435 mm gauge sets for 1.2 kV DC operation on Line 3. The first of these entered service in September 1986, and the last began to earn its keep during 1988. This allowed withdrawal of the ageing Series 300 cars, and a special train ran on March 12 1988 from Plaça de Catalunya to Lesseps to mark the retirement of the last set.

Although the 24 broad gauge sets for Line 1 have wider bodies giving room for 30 extra standees in a power car and 34 more in a trailer, they have identical electrical equipment including GTO thyristors in the control circuits and a fault monitoring and diagnosis system. Manufacture is shared between five companies: CAF, Cenemesa, Maquinista y



Terrestre, (now part of Mediterránea de Construcciones Ferroviarias) Macosa and Mitsubishi Electric of Japan. The first train of Series 4000 stock ran on March 11 1987.

The present fleet totals 400 motored and 87 trailer cars. For peak hour operation 82 sets have to be available. By the end of this year the whole fleet will consist of modern stock, the Series 1000 trains used on Lines 4 and 5 dating only from the 1970s. Completion of this replacement programme will greatly facilitate maintenance work and allow the number of spares held to be cut.

The renewal programme is being accompanied by refurbishing of the 52 Series 1000 trains to bring them up to similar standards. They are being fitted with air-conditioning and better sound insulation. About 30 sets had been modified by the start of this year.

### ATO planned

Barcelona's modernisation programme also embraces signalling, maintenance of track and trains, depots and workshops, and train cleaning equipment. A new stabling depot for 12 five-car trains been built at Sant Genís, and a maintenance workshop is planned at Onze de Setembre.

It is important to bear in mind that introduction of sophisticated technology requires staff to be qualified to handle it. Job functions are changing rapidly, and station-masters, for example, have been relieved of their traditional function of controlling trains thanks to installation of a CTC system. Staff are in radio contact with drivers, who are now in sole command of trains thanks to introduction of automatic train protection.

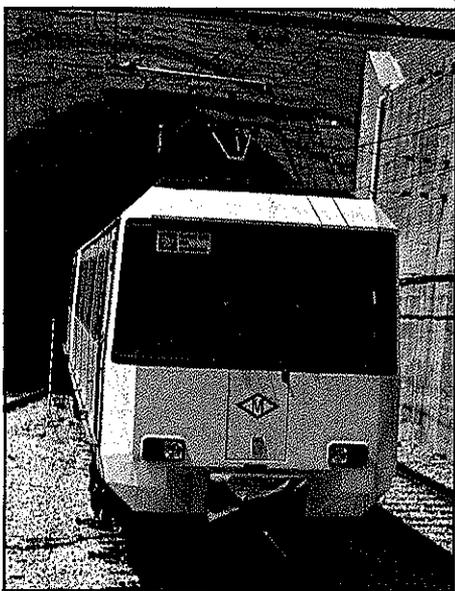
The latest ATP equipment has been designed for use with jointless track circuits. It is a step on the way to full automatic train operation, which will in due course give smoother acceleration and deceleration and contribute to reduced maintenance costs. ATO will also bring energy savings and better reliability.

The latest type of ATP is due to be commissioned on Line 5 next year and on Lines 1 and 3 by 1991. Equipment now being installed is designed to allow the status of safety-related plant throughout the network to be remotely monitored.

In the meantime we are carrying out trials this year for an automatic traffic regulation system. This is due to be fully commissioned in January 1990.

### Ticket sales and stations

Next step is to update the revenue collection system. We are planning to install automatic ticket vendors for all types of



*Barcelona is introducing new CAF-built cars to replace older vehicles. The Series 3000 cars (left) on Line 3 and Series 4000 (right) on Line 1 show how different gauges, profiles, and power supplies preclude full standardisation*



# RAISE ITS STANDARDS

ticket; these will provide data for our management and accounts systems. The traditional ticket validation machines will disappear, and ticket sales will no longer depend on the availability of station staff, who will be able to give more attention to providing passengers with information and maintaining the station and its equipment in good order.

Station modernisation is an important facet in our programme. Due to be completed by 1992, this work is more fundamental than mere facelifting, as it is aimed at improving the metro's image, easing traffic flows, enhancing safety, simplifying maintenance and raising comfort standards for our passengers.

Our customers will soon have the benefit of videotext information that we are planning to provide, and they will appreciate installation of station air-conditioning plant to ensure the atmosphere is maintained at acceptable temperatures. Where air-conditioning is already installed, it will be renewed with modern equipment. Lifts and escalators will also be replaced, and station cleaning methods will be improved.

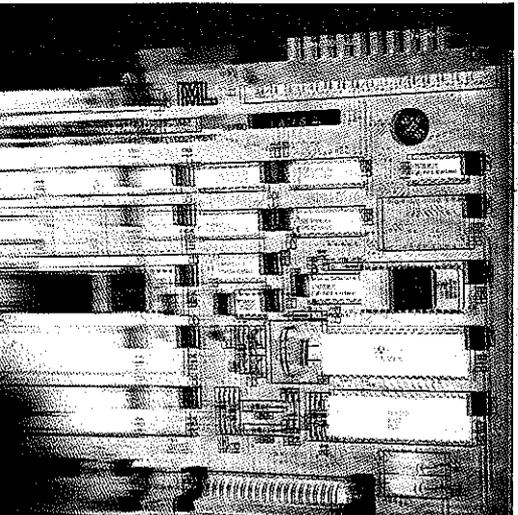


The first fruits of the modernisation programme are already evident, in that the number of fare-paying passengers using the metro has been rising steadily. Traffic rose from 214 million passenger-journeys in 1982 to nearly 246 million in 1986. □

*Older Series 400 trainsets remain in service on the broad-gauge Line 1, but 24 five-car trains of air-conditioned Series 4000 air-conditioned stock are being delivered by CAF and Macosa to replace them*

*Photos: Barry Cross*

# ML



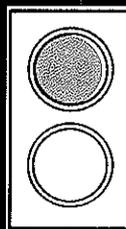
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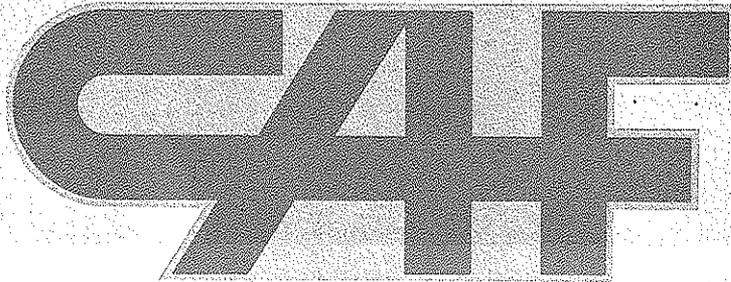


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# CAIRO CARRIES CROWDS

ON APRIL 12th, Egyptian President Hosni Mubarak officiated at ceremonies marking the completion of Cairo's regional metro line, and trains began running through from Helwan in the south to El Marg in the north. Since the 4.7 km cross-city tunnel was opened by the president on September 27 1987, trains from Helwan used a temporary terminus at Mubarak outside Egyptian Railways' main station in Ramses Square.

Upgrading and modernisation of the 15 km from Mubarak to El Marg formed the second phase of the project. Work entailed electrification at 1.5 kV DC, installation of a new power supply network, resignalling, track renewals with 54 kg/m rail and concrete monobloc sleepers, rebuilding of stations, lengthening of platforms to allow for future operation of nine-car trains, and replacement of level crossings by underpasses or overbridges. Also included in Phase 2 was construction of a rolling stock maintenance depot at Tura el Balad south of El Maadi on the Helwan line.

Trains run at frequent intervals throughout the day from 05.00 to 23.30, and the timetable had 298 booked workings before

## Eng Mohamed Mabrouk General Manager, Cairo Metro

the through services to El Marg were introduced. The trains are drawn from a fleet of 52 French-built three-car EMUs augmented by a further 48 sets whose centre cars were built locally by Semaf of Helwan.

Special attention is paid to keeping the Cairo metro clean. Around 600 policemen ensure that hefty fines are paid for dropping litter, and smoking is also banned.

Around 300 000 trips are made on a typical weekday, and in the first year of operation the metro carried 98 million people, bringing in revenue of E£17.5m.

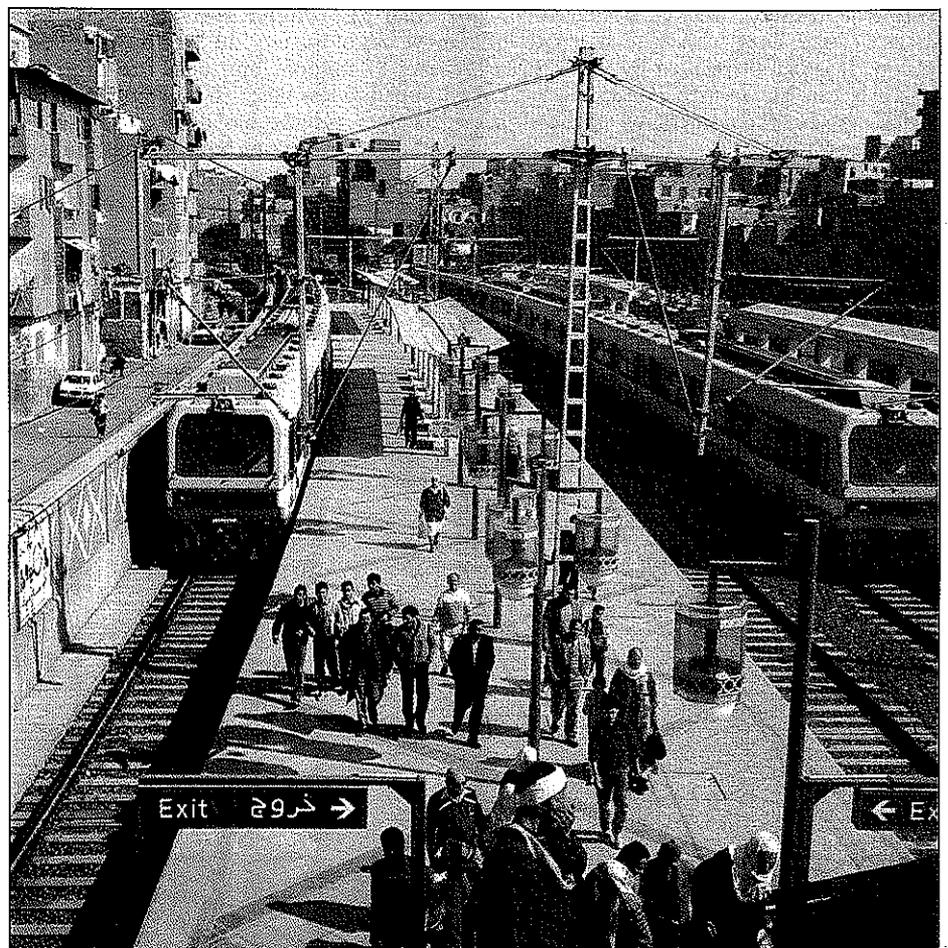
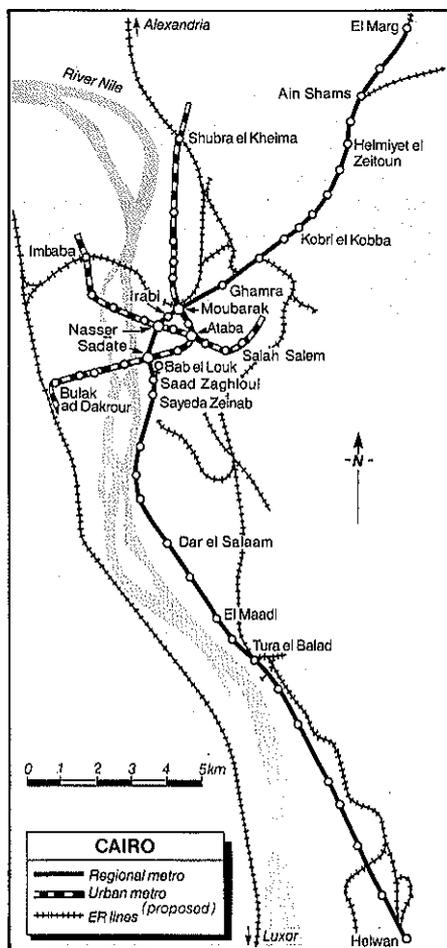
Apart from Mubarak, the busy central section has stations at Irabi, Nasser, Sadate and Saad Zaghoul, where the old route to the former terminus at Bab el Louk is joined. Mubarak, Nasser and Sadat stations are designed to cater for passenger flows of up to 85 000 an hour. On a typical day 17 000 tickets would be sold at Mubarak, another 16 000 at Sadate under Tahrir Square, and 12 000 at Helwan.

In the central section the tracks run in tunnels built 7 or 8 m below the surface by the cut-and-cover method. The need to keep the line close to the surface was dictated by the ground water conditions and the need to minimise the distance passengers had to transfer between the streets and the metro below. To avoid an unpleasant build up of heat in the stations and tunnels, the former are air-conditioned.

The Phase 1 work was carried out by Interinfra-Arabco under the supervision of Arab Consulting Engineers of Cairo and Sofretu of Paris. Trackwork for Phase 2 has been the responsibility of a consortium known as TSO-Egyfrail, while civil engineering work has been shared between Cameco, the Nile Co and Green Valley. Electrification and signalling was provided by Interinfra.

We have not yet decided when a third phase of work will begin. This would raise capacity of the regional metro by allowing trains to run at 2½ min intervals.

In the meantime we are examining bids for construction of the first urban metro line which is to run from Shubra el Kheima to Boulak ad Dakroul. □



# HAMBURG ACTS TO STEM

WITH THE EXCEPTION of Berlin, Hamburger Hochbahn Aktiengesellschaft (HHA) is the largest public transport operator in the Federal Republic of Germany. About 390 million passengers travel on HHA trains and buses every year.

Today's volume of traffic is being handled on infrastructure dating back to the early years of this century when the city parliament decided to build a metropolitan railway on elevated and underground alignments. When Hamburg's Ring line opened in 1912, it was an example of the latest technology, but nowadays the ageing buildings and track greatly inhibit the use of modern operating methods on this line.

For instance, some platforms only accommodate trains with six cars instead of eight, the minimum curve radius is less than 100 m, and some stations have curved rather than straight platforms. These features are not perpetuated on new lines, but HHA's most modern DT4 trains must still be able to cope with them.

Hamburg's metropolitan rail network grew after the second world war to meet the needs of an expanding population, but at the same time the city's extensive tram services were wound down. Today, the metro consists of three lines with a total length of 93 km. It is complemented by the S-Bahn, which is run by German Federal Railway. It too has been considerably extended in recent years.

*HHA is taking delivery of 30 DT-4 four-car trainsets from Linke-Hofmann-Busch (below) to augment its fleet of DT-3 sets (below right) ready for several line extensions opening in 1990*



**Prof Dipl.-Ing Hans H Meyer**  
Hamburger Hochbahn

City planners expected Hamburg's population to rise to 2.1 million, but events proved them wrong as increased ownership of private cars caused many Hamburgers to move out of the city. In 1962 the population was 1.87 million, but today the figure has dropped to less than 1.6 million. Since 1980 passenger volume has decreased by 1 per cent per year, making it increasingly difficult to cover operating costs.

### Planning for the future

HHA and the responsible politicians in the city's parliament are now faced with the task of operating the metro as economically as possible while taking into account reduc-

ing demand and the need for low fares. At the same time passengers' higher expectations of comfort and safety have to be met. On an established network that has grown over a period of more than 75 years the improvement, maintenance and modernisation of facilities and installations is a continuous process going on at the same time as construction of new sections of line. Because of HHA's very limited budget we have used cost-benefit analyses and economic studies to determine what measures are most urgent.

Five priorities have emerged for the years up to 2000:

- extension of lines;
- modernisation of old sections to permit higher speeds and shorter journey times;
- station modernisation and installation of lifts;
- purchase of new rolling stock;
- introduction of computer-assisted operations to help reduce personnel.

### Network extensions

In 1990 regular services will begin on new sections of Line U2 to Niendorf Nord (2.4 km, 3 stations) and on Line U3 to Mümmelmannsberg (2.9 km, 2 stations). Later we plan to extend Line U1 from Garstedt to Norderstedt Centre, although this 2.7 km section lies outside the city boundary in the neighbouring Land of Schleswig-Holstein. This will bring the total length of the metro to 101 km.

Studies are also in progress to examine the possibility of connecting Hamburg's airport, which is not far from the city centre, to the public transport network, either by metro, S-Bahn or peoplomover.

HHA plans to continue modernising the



# A DECLINE IN TRAFFIC

older parts of its network to bring them up to current technical standards. This means that many steel and masonry viaducts and bridges will be repaired or rebuilt to permit trains to run over them at higher speeds. On Lines U2 and U3 we have already raised the speed from 50 to 60 km/h on some sections, and this has resulted in a substantial improvement in punctuality, especially at the interchanges of Barmbek, Kellinghusenstraße, and Berliner Tor where cross-platform connections are provided.

Speed on Line U1 is to be increased from 70 to 80 km/h as soon as permanent way work is completed and train protection equipment has been adjusted. A round trip will take 10 min less than at present.

## Station modernisation

In the 1960s and 1970s stations were always built with a large number of escalators. These are mostly 'up' escalators to help passengers overcome the sometimes quite considerable differences in level. In recent years, because of the high cost of electricity, maintenance and repairs, down-escalators for small differences in level have not been renewed but have been replaced by flights of stairs. In future, HHA intends to install lifts wherever there is a difference in level of 7 m or more between street and platform. Only lifts can offer reliable assistance to the handicapped and to passengers with prams.

So in the next 10 years there will be only about 100 escalators on the network instead of the 200 we have today. Installation of lifts means 40 per cent of stations will offer easy access to platforms for handicapped people. Operating costs will be reduced to 60 per cent of current expenditure, the cost of a lift being three-fifths that of an escalator.

## Rolling stock

The extensions to Niendorf Nord, Mümmelmannsberg and Norderstedt Centre and the need to replace obsolete units have required purchase of 30 Type DT4 four-car trainsets. The first of these was delivered last year from Linke-Hofmann-Busch and ABB, and the rest of the fleet should be in service by 1991.

HHA has spent many years researching the latest railway technology so that passengers enjoy the highest possible degree of comfort and safety. In spite of narrow tunnel dimensions on older parts of the network it has proved possible to increase the width of the new cars by 100 mm compared with existing vehicles, allowing use of wider seats. Large windows at each end of the cars permit passengers to watch the driver and see the interior of other cars, while intercom in each car enables passengers to talk with the driver or the control centre.



Highly fire-resistant materials have been used for interior decor, and the DT4 is the first metro car with automatic water sprinklers. If a passenger activates the emergency brake in a tunnel it can be cancelled by the driver, so the train can proceed to the next station where rescue and emergency services have faster and easier access.

The DT4s have water-cooled three-phase asynchronous traction motors, and micro-processors control almost all operating functions. Sealed motors, low-noise gearing, noise-absorbing wheels, silent static converters and newly developed compressors reduce sound emission to a minimum. The traction package also saves energy by up to 30 per cent thanks to regenerative braking.

## Help from computers

A programme to centralise signalling and train protection functions was started 10 years ago. In the meantime routes, points and signals are monitored and controlled from signalling centres in eight of the 11 network sectors. Until now interlockings equipped with traditional technology have been used, but future installations will include solid-state interlockings. A pilot SSI is currently being installed in Wartenau by Standard Elektrik Lorenz of Stuttgart.

HHA is in the process of transferring the routine task of dispatching from station staff to train drivers. All cabs are being fitted with a TV monitor which will receive two pictures simultaneously transmitted by cameras installed at the platform edge to permit drivers to observe passengers on the platform. When all passengers are aboard and the departure time has been reached — it is displayed on the cab monitor — the driver closes the doors and drives off.

Platforms, stairs and ticket offices will in future be monitored by CCTV from the

*The control centre at Hagenbecks Tierpark includes the signalling panel for Line U2 and closed-circuit television monitors for dispatching and station security*

control centres. This will enhance security and reduce vandalism. The control centres will also monitor and control station equipment such as lighting, ticket vending machines, escalators, lifts, emergency communication and information terminals and train information displays. Should a fault occur, the appropriate department will be informed immediately. Furthermore, stations will be checked by roving staff several times a day.

Train dispatching by drivers and centralised monitoring of station equipment and activities mean that station staff will no longer be required. Some employees will be transferred to the control centres while others will join the service personnel whose job it will be to give assistance and information to passengers.

The new operating methods will be flexible enough to allow them to be introduced on older sections, but because of the considerable technical investments required some years will elapse before they are standard throughout the network. The changes will permit continuous reductions in staff, and before the turn of the century the entire network will have been brought up to the latest standards. So Hamburg's metro will once again be an example of the newest technology.

Trials carried out in 1982-85 on a 10 km section of the existing network showed that one day fully automated trains will be in operation in Hamburg, but preparations for the introduction of driverless trains have been postponed until 2000. □



Grenoble tramway

Lyon pneumatic metro

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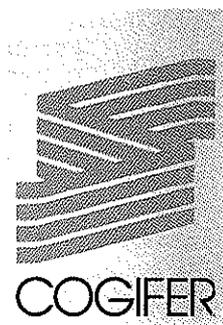
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*Just because cities keep moving →*

# MARSEILLE MOVES AHEAD

STEADY IMPROVEMENTS are being made to the rubber-tyred metro in Marseille. The network is developing harmoniously with the city's main line railways and tramway, and work has started on the first metro extension beyond the core network. This 1.5 km section at the southern end of Line 1 from Castellane to Timone is due to open in September 1992. It will have two new stations serving a densely populated area and the main city hospitals, as well as the medical university. Extensions of Line 2 north to Madrague Ville and south to Saint Loup are also planned.

The age of the city and its tightly-knit urban structure mean that there is very little space available to develop surface transport. Renovation of the city centre and construction of new commercial and housing zones in the suburbs has only aggravated the situation, forcing people to travel longer distances to and from work. Travel conditions began to deteriorate seriously during the mid-1960s, when the city council decided that a mass transit network was needed. Approval for the project was granted in 1969. Three main objectives were set:

- to provide links from the largest suburbs and industrial zones to the city centre;
- to ensure the best possible connections with main line railway stations and to provide easy access from principal car parks;
- to preserve the possibility of extending the network to meet future demand.

The now-completed core network comprises two lines which enclose the city centre at the inner end between St Charles main



**Jean Clavier**  
General Manager  
Marseille Metro

line station and Castellane. It is agreed policy to extend these lines to development areas as demand requires.

Stations are typically 750 m apart; in the city centre this is reduced to 600 m and in the suburbs spacing is around 1 100 m. Each station has been carefully sited to give good connections with other public transport and to try and encourage motorists to leave their cars outside the city centre.

Line 1 with 12 stations runs for 9 km between La Rose and Castellane, 3 km of which is on elevated structures. Line 2 is also 9 km long and has 12 stations between Bougainville and Sainte Marguerite.

A fleet of 36 four-car trainsets works both lines. Each set seats 136 passengers, with room for 336 standing at a density of 4/m<sup>2</sup>.

Since the first line opened in 1976 public transport use has grown; in the first three years traffic rose from 78.9 million passenger trips to 97.5 million. It remained stable until

1983 when the second line opened, climbing again to pass the 100 million mark in 1986. In the following year traffic reached 103.6 million and last year it was 104.7 million.

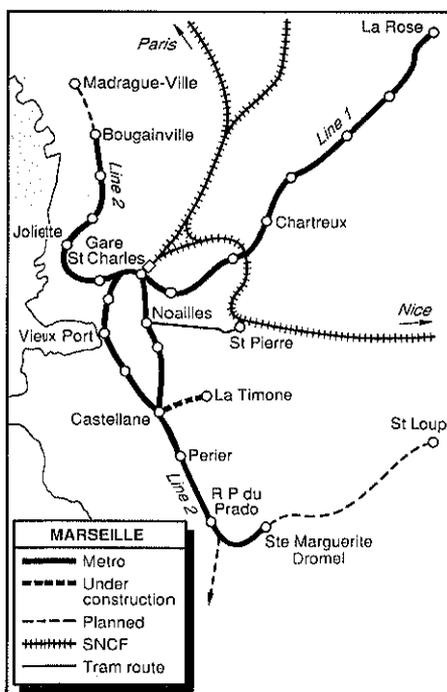
Studies investigating better mobility in the whole Marseille urban area led to a decision to remodel the bus network to coincide with opening of metro Line 2. Our policy is for buses to act as feeders to the metro and the tram line from St Pierre to Noailles. Resources released by this process can then be used to build up services in corridors not served by rail.

Reorganisation of the bus network was completed in 1987 when the last section of Line 2 was opened; 17 bus services were rerouted to feed it at Bougainville, Rond Point du Prado and Sainte Marguerite.

Early in 1987 we commissioned a solid state interlocking installation controlling the depot and workshop area at Zoccola on Line 2. Using a modular hierarchy of micro-processors, the equipment has 550 inputs and 500 outputs. Able to set up 64 different routes, it dispatches trains and monitors movements throughout the area. Screens in the control centre display the track layout, status of signals and points, and the location of trains, identified by reporting numbers.

The computers also perform a number of other status monitoring and control functions designed to facilitate maintenance of the equipment. Alarms are automatically logged, and staff are able to interrogate remote equipment by sending test messages from their keyboards. The 750 V DC power supply and distribution is also monitored and controlled by the same equipment.

We envisage that these computers will take over many routine functions, and in the long term they can be married to automatic train control, information systems and traction equipment to pave the way to fully integrated computerised operations. □



# MÜNCHEN ADDS MORE

ON OCTOBER 27 last year two important sections of line were added to the München U-Bahn network. Totalling 7.7 km, they took the network length to 56.5 km.

The 4.1 km section from Odeonsplatz to Innsbrucker Ring is used by Line 4 and 5 trains from Laimer Platz; Line 4 services now run over the new 3.6 km branch from Max Weber Platz, where a new signalling control centre is located, to Arabellapark.

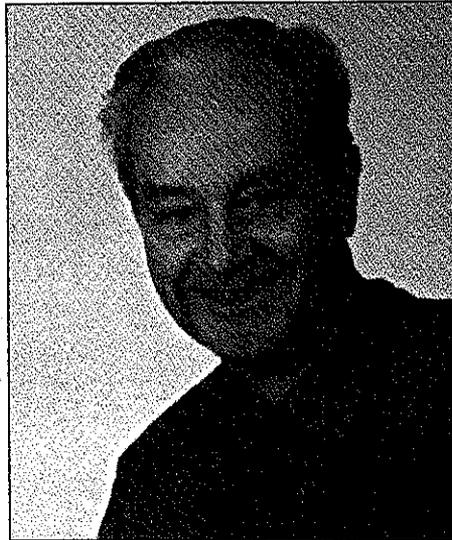
Known as U5/9 during the construction phase, which began in 1982, this project presented the civil engineers with a considerable challenge. Only 25 per cent of the line could be built by cut-and-cover methods, and the rest had to be bored through ground with difficult hydrological and geological conditions.

Each of the seven new stations was specially designed to provide a smart attractive environment, with substantial use made of natural stone. To ensure speedy access from the surface to platform level, 73 escalators and 14 lifts for use by disabled passengers were installed. Closed circuit television cameras monitor passenger flows in ticket halls and on platforms. Sensitive smoke detectors are installed to guard against the risks of fire, while a sophisticated communications system ensures that passengers can be contacted at any time in stations, tunnels or trains. The passenger information system includes station clocks that are synchronised by radio.

Completion of this DM730m project

*Below left: München U-Bahn has taken delivery of 35 two-car Type B sets from MAN and MBB based on six prototype sets built in 1981*

*Below right: Another 17.1 km of new lines is under construction following opening of the link from Odeonsplatz to Arabellapark*



**Dipl.-Ing Werner Beier**  
Director  
München U-Bahn

marks the end of construction of the core network in the city centre as agreed by München's city council in 1970. At that time it was decided that three rather than four cross-city lines would suffice to serve all important central areas. Since then the U-Bahn network plan has been considerably refined, and much work remains to be completed in the inner suburbs in years to come.

## Extensions

Another 17.8 km are under construction, and this year should see the first 6.1 km of the southern extension of Line 3 from Implerstraße to Forstenrieder Allee completed; work on this section began in February 1983, and the final section to Fürstenried West will be finished in 1991-92.

Work began on a 2.9 km extension of Line 6 from Holzapfelkreuth to Klinikum Großhadern in August 1987, and this should be commissioned in 1993. It will be followed by the important 6.9 km northern extension of Line 2 from Scheidplatz to Feldmoching, where interchange will be made to the S-Bahn. Work commenced on this project in March 1987, and the first stage as far as Dülferstraße (5 km) will open in 1994. Feldmoching will be reached in 1997.

Plans are already well advanced for a 3.6 km extension at the southern end of Line 1 from Kolombusplatz to Mangfallplatz. When Federal Transport Minister Dr Jürgen Warnke took part in the opening ceremony for the lines to Arabellapark and Innsbrucker Ring last October, he announced that funds were available for the Mangfallplatz extension to start.

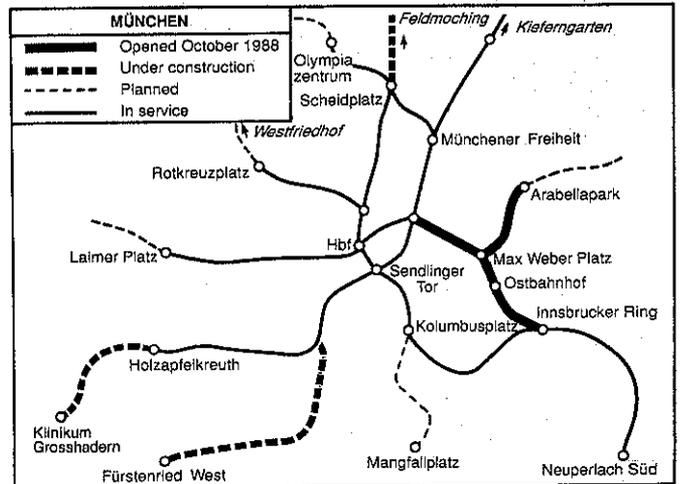
Plans for Line 1 to be lengthened by 2.1 km from Rotkreuzplatz to Gern and Westfriedhof at its northern end are also well advanced.

A number of long-term U-Bahn extension projects are being examined. These include:

- Westfriedhof to Olympia-Einkaufszentrum (U1, 3.4 km);
- Innsbrucker ring to Riem-Ost (U2, 7.4 km);
- Olympiazentrum to Moosach (U3, 4.1 km);
- Laimer Platz to Pasing (U5, 3.5 km);
- Mangfallplatz to Krankenhaus Harlaching (U1, 1.7 km);
- Arabellapark to Engschalking (U4, 2.0 km).

If all these projects go ahead, Münchners will enjoy a U-Bahn network of over 100 km.

Since the city's first 12 km line opened between Freimann and Goetheplatz in 1971, traffic has risen steadily. In that year 6.7 million people used the U-Bahn. With 35 km in service 10 years later, the figure had risen to 155 million. The 200 million mark was



# STRINGS TO ITS BOW

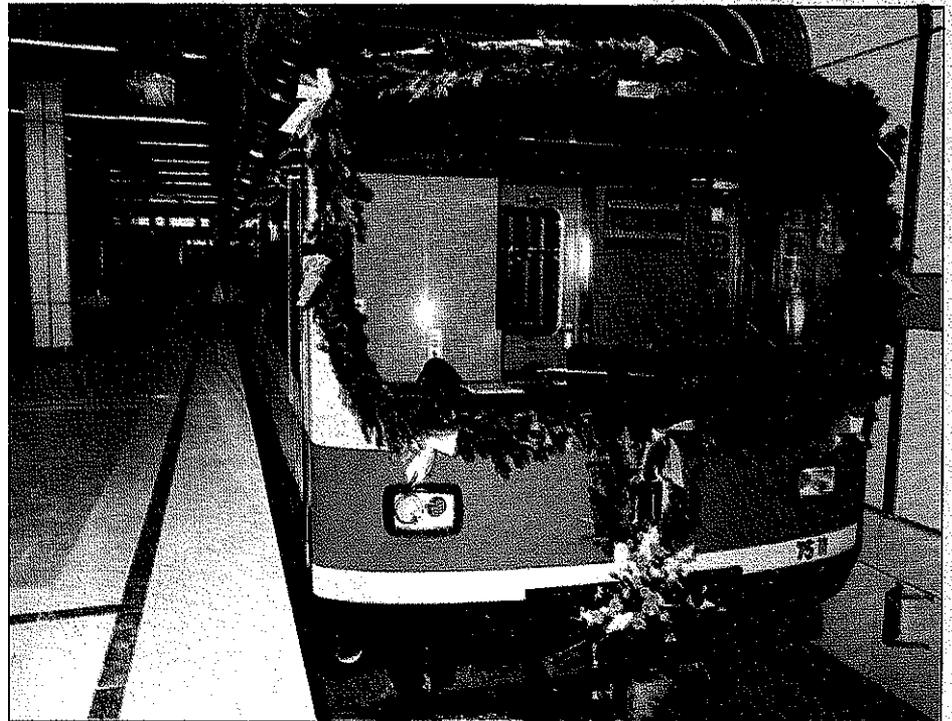
passed in 1984, and 215 million trips were made in 1987.

## Fleet expanded

To handle the extra traffic on the sections of line opened last year the U-Bahn took delivery of 35 more two-car trainsets from MAN of Nürnberg and Messerschmitt-Bölkow-Blohm of Donauwörth. Easily recognised by their large windscreens, these sets each have 98 seats and space for a further 192 standing passengers at a density of 4/m<sup>2</sup>. Up to three sets can run in multiple.

The cars are of an advanced aluminium bodied design with individual three-phase 92.5 kW traction motors on each axle. Blended rheostatic and regenerative braking is able to bring the train to a standstill without use of friction brakes. The design is based on six prototype sets delivered in 1981 which were evaluated in service for four years. Substantial changes were made from the prototypes to reduce the weight of a two-car set from 59.2 to 57.1 tonnes. □

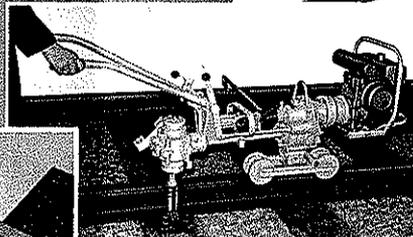
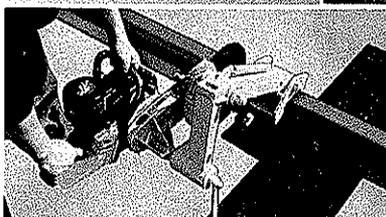
*One of the latest Type B sets was used for the inaugural special to Arabellapark*



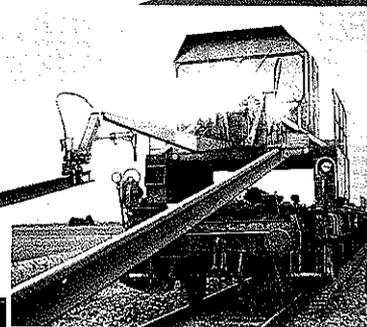
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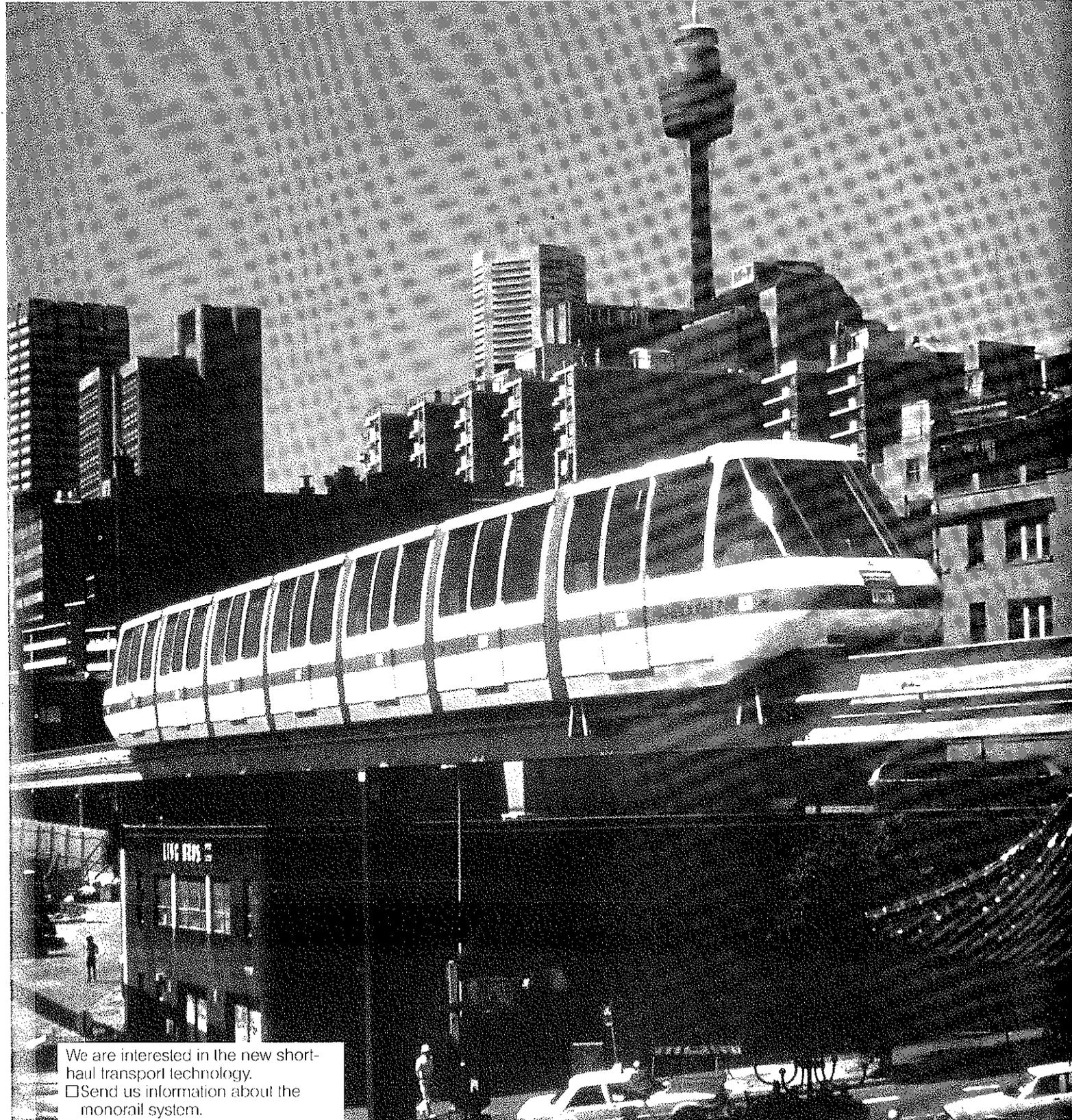


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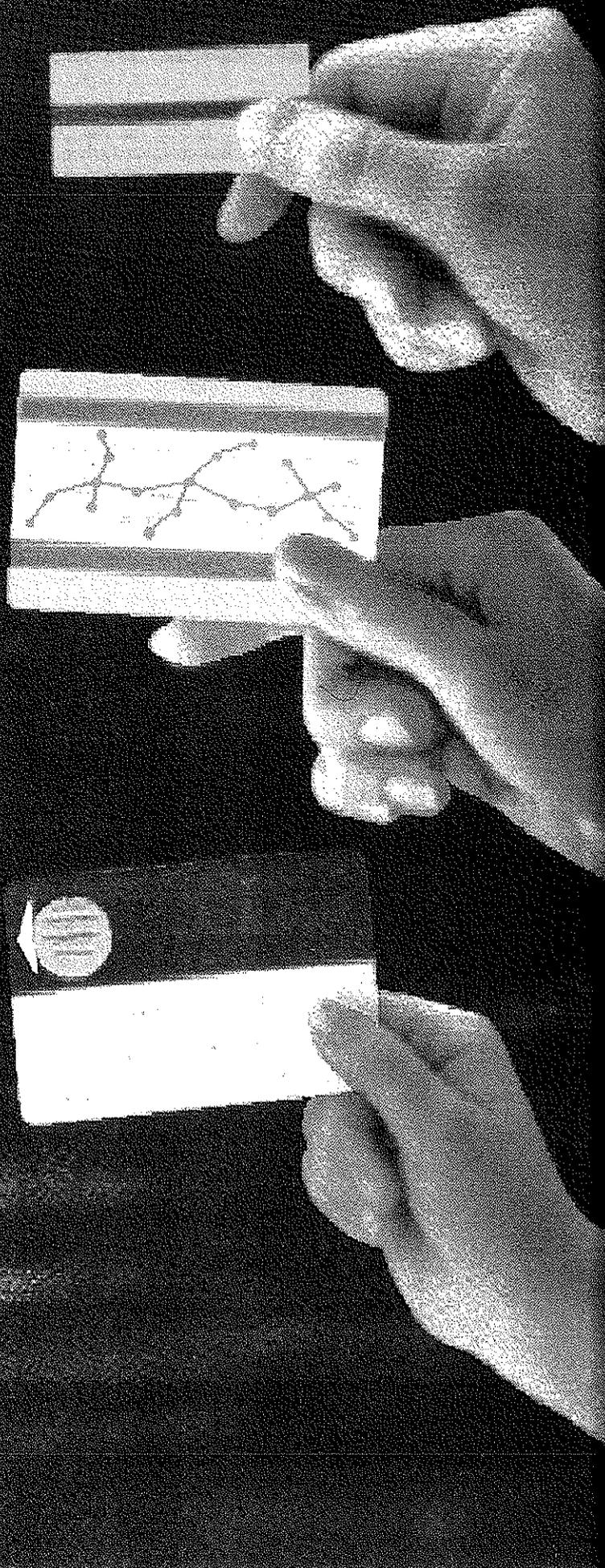
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# PARIS PLANS SUPPORT

EVERY DAY six million journeys are made on the urban metro and Regional Express Metro (RER) in Paris. The metro is operated exclusively by Paris Transport Authority (RATP), but operation of the RER is shared with French National Railways (SNCF).

In 1988 the urban metro carried 1 193 million passengers, while 292 million used the sections of RER operated by RATP. Traffic on all RATP's services rose by 1.6 per cent compared with 1987, despite a series of strikes at the end of the year. The result was well above RATP's internal target of an annual increase in traffic of 1 per cent, and a 5 per cent rise in revenue.

In the long term RATP expects its staff at all levels to play their part in meeting the twin challenges of attracting more traffic and increasing revenue. The key to achievement of these objectives is higher productivity, allied to a continuing policy of providing more and better services.

For two decades, with government help, RATP has been carrying out a huge programme of network extensions and modernisation. Most of this work is now complete, for example the major part of the RER. These projects make an important contribution to regional policy under the Land Use



**Michel Rousselot**  
Director General  
Paris Transport Authority

& Urban Planning Programme managed by the Ile de France Region.

Two events in 1988 saw culmination of another phase of RER development. In February the interchange at St Michel Notre Dame was opened in the heart of Paris. Providing connections between RER Lines B and C (Line C is operated by SNCF), this

has simplified many cross-Paris journeys.

In May the West Interconnection project was completed when SNCF's Cergy branch was connected to RER Line A. Through services are now provided between the new town at Cergy Pontoise west of Paris and its matching twin in the east at Marne-la-Vallée. May 1989 saw another phase of this project completed with the integration of Poissy line services with RER Line A.

## Extensions

During the ninth National Plan period (1984-89) several projects were initiated under an agreement between the government and the Ile de France Region. In February this year Prime Minister Michel Rocard announced that they would be completed during the 10th National Plan (1989-93).

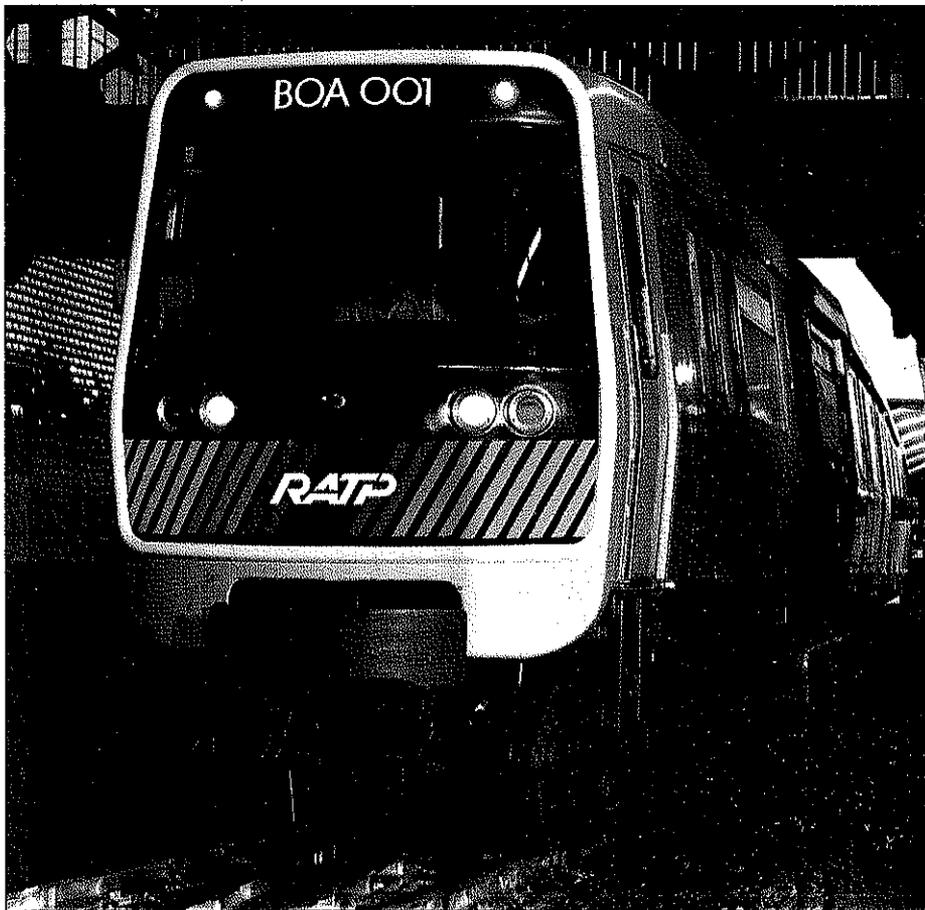
Well under way is the 2.4 km extension of urban metro Line 1 from Neuilly across the River Seine to the business centre at La Défense, already served by RER Line A. Due to open in early 1992, it will include an intermediate station at Puteaux-Courbevoie on the left bank of the Seine.

Also due to open in 1992 is an 11 km extension of RER Line A east from Torcy to the Eurodisneyland site at Chessy. The same year should see completion of the 9 km light rail route in the northeast Paris suburbs between St Denis and Bobigny Préfecture via La Courneuve. This will have 21 stations, of which three will provide interchange to urban metro lines.

Another project with a similar timescale is construction of an automated rubber-tired light metro from Orly airport in the south of Paris to Antony station on RER Line B. To be known as Orlyval, this project will be finished by late 1991. RATP is undertaking this scheme in partnership with the Matra company, which is using the technology it developed for the VAL metro in Lille.

Another phase of major investment in Paris transport is planned to get under way in 1989-93. The main objective is to relieve overcrowding on the busy central section of RER Line A between Châtelet-les-Halles and Gare de Lyon. An initial step was taken earlier this year when the Sacem (Système d'Aide à la Conduite et à la Maintenance) speed control and cab signalling system was introduced. It will permit capacity to be raised by a quarter thanks to reduction of peak hour train headways from 2½ min to 2 min. However, we are well aware that it will not be a permanent cure — we anticipate that the line will once again become seriously congested by 1995.

*Eight metro trainsets based on RATP's Boa prototype will be delivered in 1992*



# REGIONAL POLICIES

It is for this reason that RATP has for some time been studying the Meteor project, an automated rubber-tyred small profile metro which would link Gare de Lyon to St Lazare. It would run via Gare de l'Est and Gare du Nord. For people living in the west, north, east and southeast of Paris, Meteor would form an excellent means of access to the main employment areas in the west of the city. High standards of service would be provided with trains running at a commercial speed of 40 km/h; easy interchange to several suburban rail networks will be possible. A decision on whether to proceed with this project or a rival SNCF scheme is awaited in the next few months.

Among the medium-term priorities is a better public transport service to the 12th and 13th districts of Paris. This could be achieved by extending Meteor eastwards to Maison-Blanche, and would facilitate development in the Southeast Seine sector, which has been designated as a development zone for the late 1990s.

## Rolling stock renewal

To complete this broad-brush panorama of the future, RATP is planning progressive replacement in the medium term of that part of its rolling stock fleet which is 30 or more years old. So 1992 will see commissioning of the first eight trains of a new design derived from the Boa metro prototype. It will feature steerable axles and independent wheels, full-width gangways between cars, asynchronous traction motors and coded transmission of data to and from wayside installations. Considered as prototypes for the eventual replacement of the MF67 units, they will first run on the short Line 7b between Louis Blanc and Pré Saint-Gervais.

Later this year we will order the first two five-car trains of rubber-tyred stock for use on Line 11 between Châtelet and Mairie des Lilas, at present worked by four-car trains. A fleet of 20 five-car trains will be needed to replace stock put into service in 1956-58, and eventually the same design of train will replace rubber-tyred stock on other lines too.

So it can be seen that RATP has been actively preparing for the future for some years. In so doing, it is meeting two objectives: improving the quality of life for Parisians and helping Paris to compete in the Europe of tomorrow.

## Fighting graffiti and vandalism

Underground life is a reflection of what takes place on the surface. This is just as true for the problems of security (or perceived insecurity), vandalism and graffiti as it is for anything else.

For some time now RATP has been tackling these two phenomena. A passen-



*Peak hour traffic on RER Line A at Châtelet has reached saturation levels*

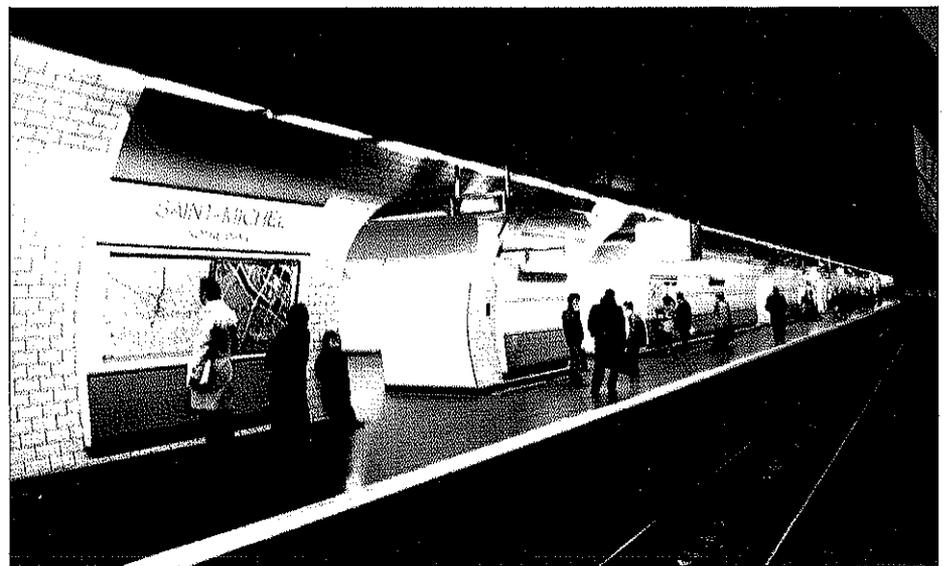
ger's feeling of insecurity is aggravated by being in a closed environment. Nonetheless, the figures show that in 1988 attacks on passengers on the RER and metro dropped by 18 per cent from 2 686 incidents in 1987 to 2 196 in 1988, with the number of pickpocketing incidents reducing by just over 3 per cent to 2 788 in 1988 compared with 2 879 the year before.

During 1989 the Paris police and RATP are restructuring their organisation to be able to tackle crime more effectively. Several commissariats will have special departments dealing with metro crime. With regard to vandalism and graffiti, the rise in this unwelcome phenomenon cost RATP Fr30m in 1988. A two-pronged strategy to fight it has been developed. A preventive policy includes the development of materials less vulnerable to graffiti and guarding more

effectively a number of yards and stations where rolling stock is likely to be vandalised.

The cure policy is to clean off graffiti as rapidly as possible. RATP and its cleaning contractor Comatec are both working on this problem. Another string to our bow is punishment of the vandals. During 1987 we caught 395 people in the act of defacing metro property, whereas only 77 were caught in 1986. Rapid judicial processes are then applied. □

*The RER Line B station at Saint Michel was opened in February 1988 to provide interchange with Line C*





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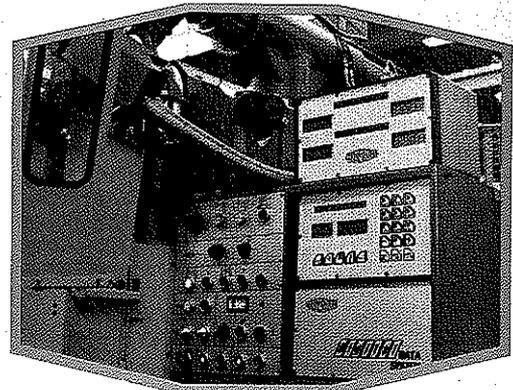
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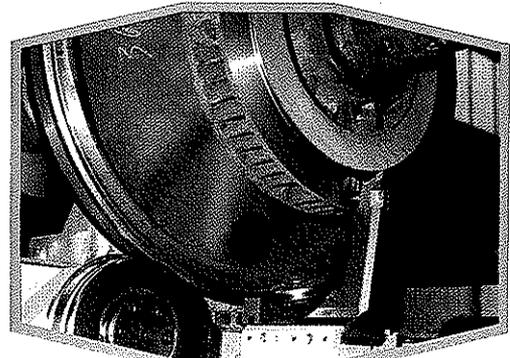
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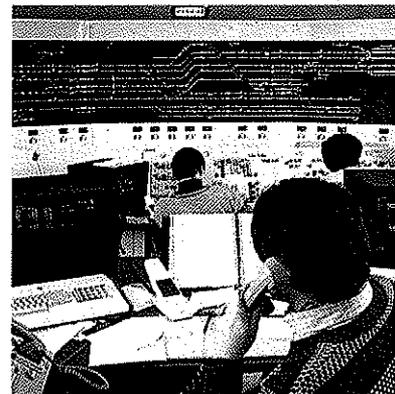
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# PRAHA ENTERS SECOND

AT THE END of last year the Praha metro extended its network by 5 km when a section of Line B was opened between Smíchovské and Dukelská. This saw the completion of the first project in the second phase of metro development in Czechoslovakia's capital.

Adding three stations to the network, the westward extension of Line B provides a high capacity link to the edge of the new Southwest City development zone from the city centre. It will be followed in 1990 by a 4.5 km section of Line B from Sokolovská eastwards to Zápotockého with four stations. In the same year another 1.5 km will be added at the eastern end of Line A to take in Skalka, bringing the total length of this route to 10 km with 12 stations.

In 1993 Line B will be extended 5 km further west through the Southwest City to Zlicín, lengthening the line to 19.8 km.

Line C, which runs 14.6 km on a north-south alignment with 15 stations from Dáblice to Kosmonautu, is not being lengthened at present; further extension is not planned until the third phase starts in 1995.

## First construction phase

The first phase of construction began in 1967. The objective was a core network of three lines, which would reduce road congestion in the historic city centre. First section to open was the 6.9 km from Sokolovská to Kacerov in May 1974; this linked the centre to housing estates in the south.

Next, in August 1978, the first part of Line A was opened for 4.9 km from Náměstí Miru in the centre to Leninova in the northwest, with the 2.8 km section from Náměstí Miru to Zelivského in the east of

*Each station has a central control room from which passenger security and fire safety can be monitored, and where train information can be issued*



**Ing Rudolf Medo**  
Director, Praha Metro

the city following in December 1980. In the previous month a 5.4 km section of Line C to the present southern terminus of Kosmonautu had been inaugurated.

Quite early during this period the various organisations and suppliers involved in construction set up a successful project management structure. This served as a model for later stages of construction.

November 1984 saw 2.3 km added to the north end of Line C between Sokolovská and Fucikova to reach a residential area. In the same year Line A was extended to serve an industrial zone in the east. The final project in the initial construction phase was completion of a 5 km addition to Line B from Sokolovská to Smíchovské Nádraží, connecting the centre to an important industrial area in the west. This gave Praha a network totalling 30 km with 32 stations.

With interchanges in the city centre, this network put all parts of the historic city centre on the left and right banks of the Vltava river within 10 min walk of a metro

station, including the important area of the Praha Kremlin, the Hradshin. It was thus possible to exclude surface transport from the centre and create a pedestrian zone as part of the renewal of the central area.

Aim of the second stage of construction is to lengthen the lines to serve the most densely populated satellite towns. The opportunity will be taken to improve depot and maintenance facilities; depots at Kacerov and Hostivar will be complemented by a third depot now under construction. A main repair shop is being built at a site in the east of the city.

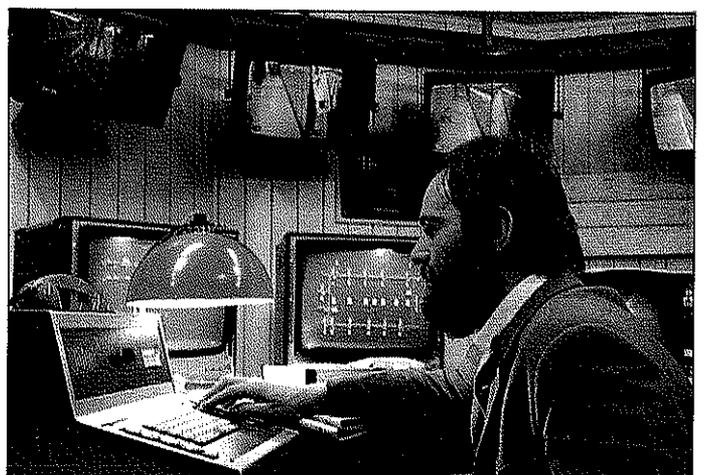
The metro already has high technical standards which are achieved with the help of fault diagnosis equipment for the rolling stock. Inspection and repair is carried out at intervals determined by the distance run, with a minor inspection after every 12 h in service, usually at termini where maintenance access is provided on selected tracks.

## Fire prevention

The demand for mass transport between the city and its suburbs makes it imperative that high safety levels are maintained. Fire prevention receives considerable attention with sensors located in all parts of stations where staff are not present. The status of these sensors is indicated to station supervisors and also to the central operations room of the special metro fire brigade.

Each station has a control room which is linked to the metro fire brigade's operations centre. This holds details of the layout and construction at each station. Should a fire break out, a computer in the operations centre prints out all relevant details for that station including access routes and technical information.

As the frequency of services has been stepped up — design capacity is 40 trains/h in each direction — it has been necessary to modernise signalling and train control



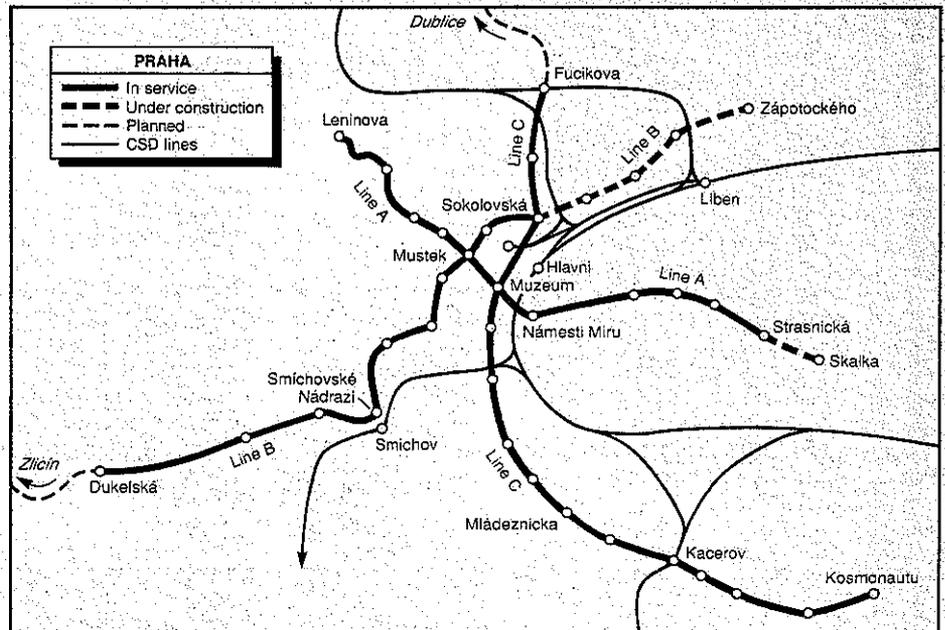
# PHASE OF CONSTRUCTION

technology. When the Smíchovské Nádraží – Sokolovská section of Line B was inaugurated in 1985, the traditional signalling panel was superseded by a computerised signalling and train control system. Computers are also used to monitor energy consumption and the status of escalators and other equipment. A hierarchy of station processors and minicomputers operating in tandem controls both train operations and monitoring tasks.

### Rolling stock

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In November 1986 we carried out a weekday survey among passengers from 05.00 to 20.00, helping us to optimise traffic flows at stations and interchanges. The metro is now handling 1.2 million passengers a day, and in 1990 we estimate that it will



be carrying half of all public transport passengers in the city.

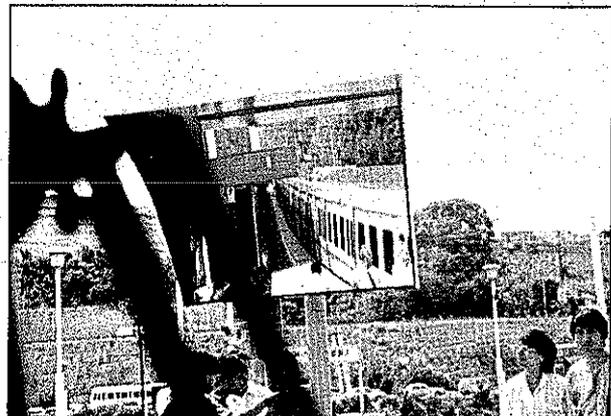
During 1987 only four out of 10 000 sched-

uled services were cancelled or late. Both visitors to Praha and the people who live there are happy with their metro. □

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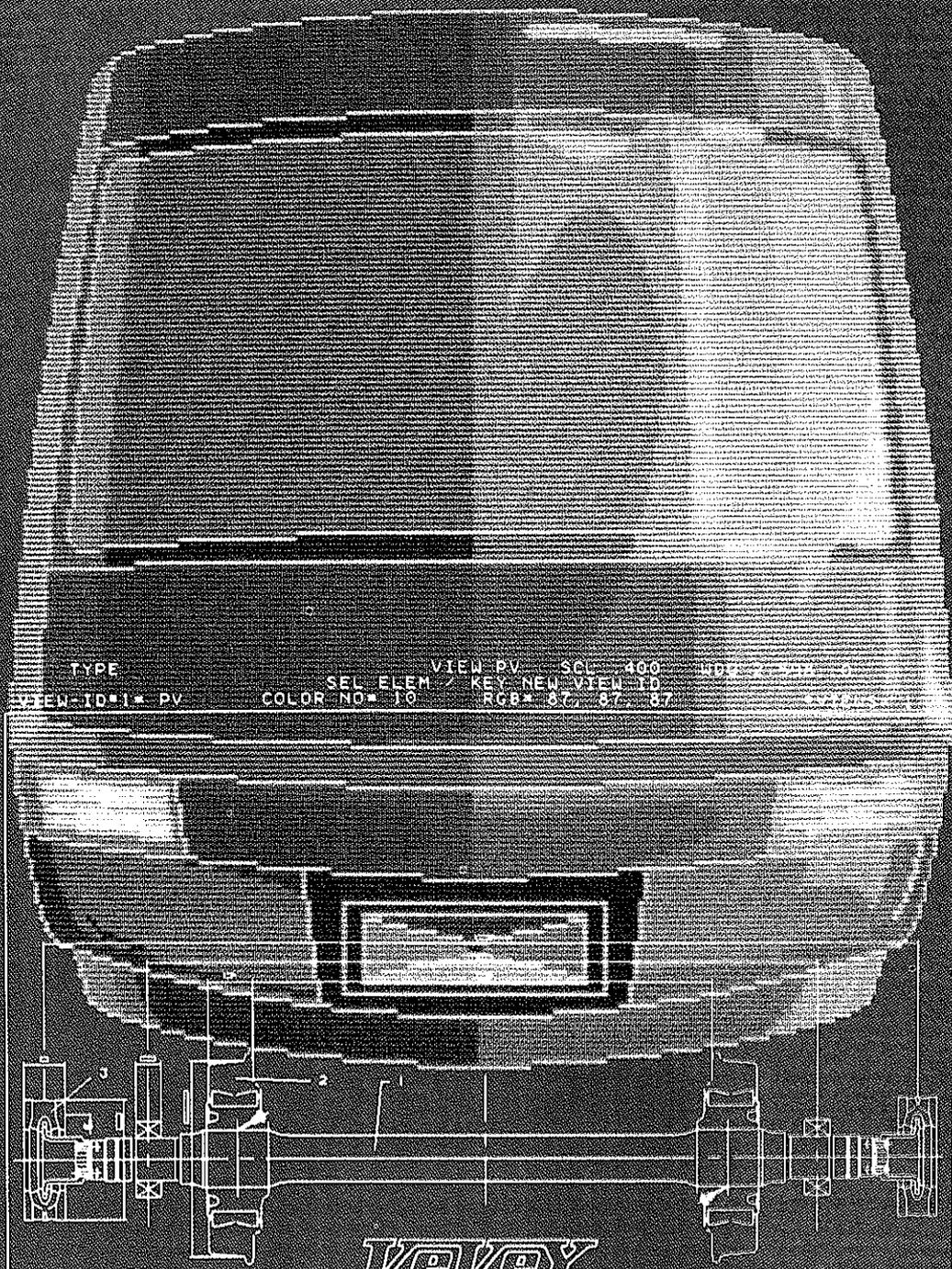
Craswell Platform Mirrors in 3 designs and 4 sizes. Taken at Tai Po Market.

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# RECIFE READY TO EXPAND

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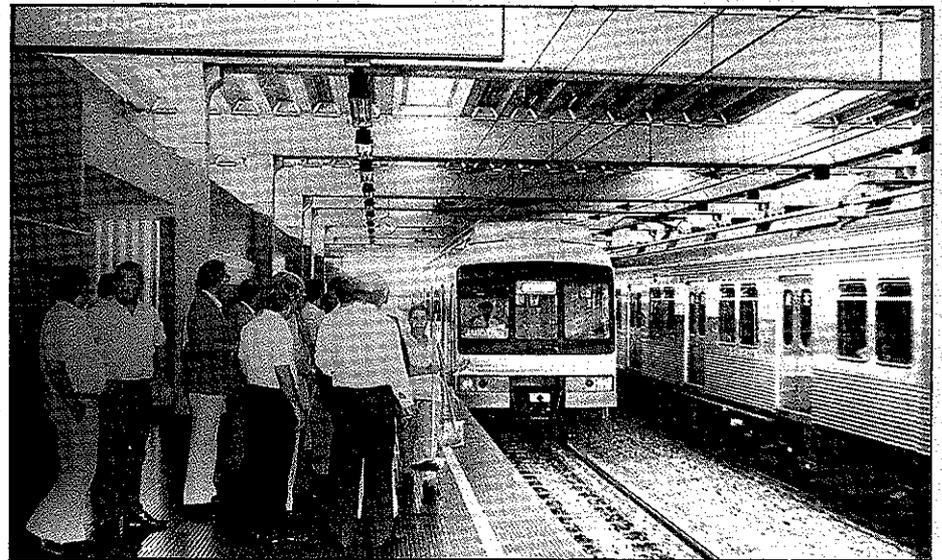
METROREC is the name of the consortium set up by the Brazilian Ministry of Transport to build and manage the city's regional metro. Metrorec was originally a subsidiary of the Federal Railway (RFFSA) and the Brazilian Urban Transport Company (EBTU). RFFSA was responsible for purchase of land and for finding staff to oversee implementation of the project, while EBTU was in charge of financial management.

After the Brazilian Urban Railways Company was set up in February 1984, Metrorec was reorganised into its present form with effect from January 1985.

Metrorec's origins date back to 1974 when a regional development corporation was set up. The corporation drew up a master plan for transport in which a mass transit system was considered to be fundamental to the process of urban development. Lines linking the east, centre and south of the conurbation were envisaged.

A 1980 census put the population of the Recife region at 2.4 million people, 38 per cent of whom lived in the central area. The city has since expanded mainly towards Jaboatão in the east and southwards in the direction of Cabo. Expansion eastwards was particularly dramatic in the 1970s, with the population in the suburbs of Jaboatão and São Lourenço growing at an average rate of 7 and 10 per cent a year respectively. It was this which dictated the route of the first metro line from central Recife to Jaboatão, with a branch from Coqueiral to the long-distance bus station at Rodoviária. Total length is 20.5 km.

Civil engineering work that required 1.25 million m<sup>3</sup> of earthworks started in January



1983. First task was construction of a freight bypass to release space along RFFSA's metre gauge alignment on the approaches to the city. Extensive track remodelling was needed to make way for the 1 600 mm gauge regional metro. Laying of double track with TR-57 rail resiliently mounted on concrete monobloc sleepers was swiftly followed by erection of the 3 kV DC catenary which was to be fed by five 9 MW substations.

In the meantime civil engineering contractors began building 17 stations, on average 1.2 km apart. A maintenance depot was constructed at Cavaleiro, and 25 four-car trains were ordered from a consortium led by Santa Matilde of Rio de Janeiro; electrical equipment was supplied by GEC of Great Britain and local company Villares. Each set is able to carry a crushload of 1 524 passengers at up to 90 km/h.

Passengers were carried on the first 6.5 km between Recife Central and Werneck

in March 1985, but to begin with services only ran between 06.00 and 13.00. In May 1986, the stations at Tejipto and Coqueiral were opened, and on September 24 the next 3.9 km section to the bus station at Rodoviária was commissioned; the bus terminal had been built eight years earlier, but it remained out of use until October 1986.

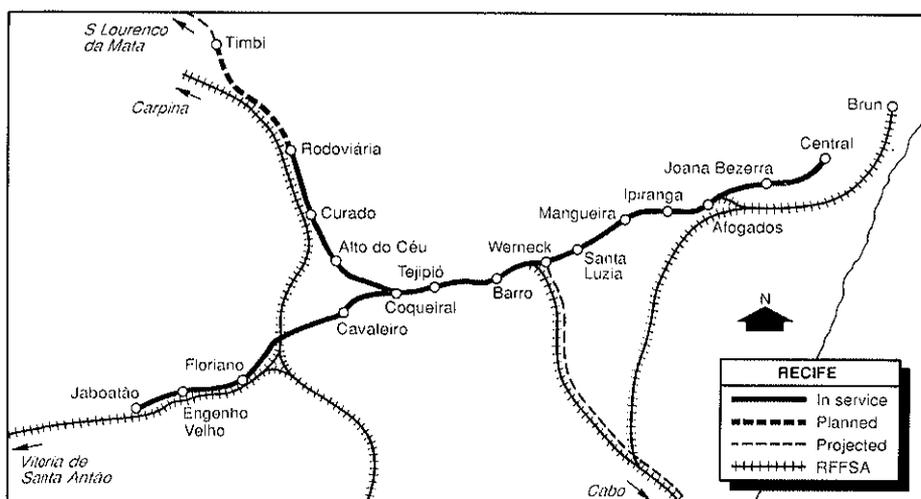
On September 30 the full timetable was introduced, and trains started to run throughout the day between 05.00 and 23.00. Journey time from Central to Rodoviária was 22 min.

Traffic grew rapidly, reaching 42 million trips a year in 1986. This put Recife's metro in the same league as the European metros of Amsterdam and Marseille. New stations at Barro and Alto do Céu opened in January and March 1987 respectively.

The final section of the initial route between Coqueiral and Jaboatão was completed in August 1987; journey time to the end of the line from Recife Central was 27 min.

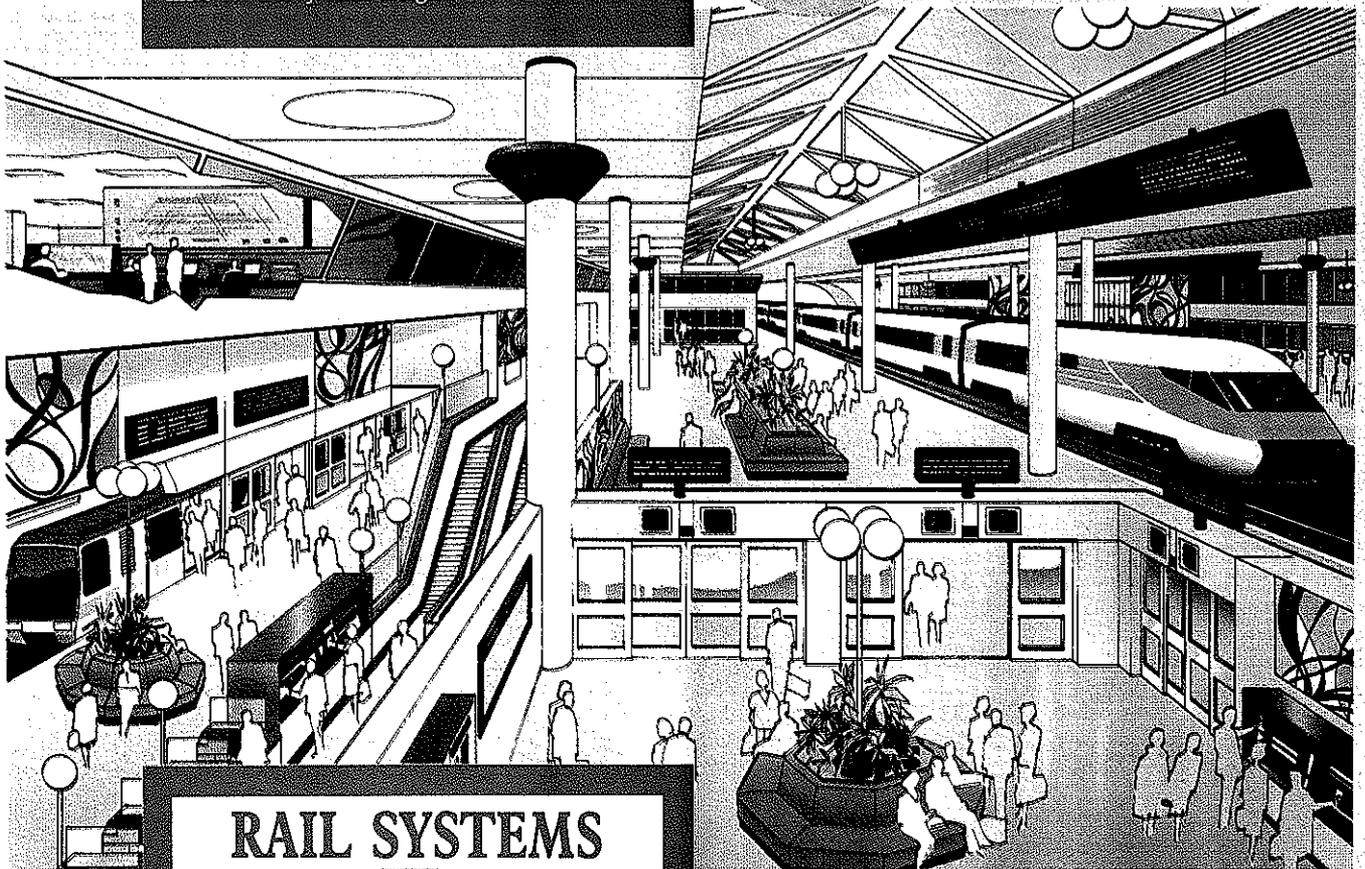
Following a series of extensive studies, efforts are being made to integrate the metro with RFFSA's services to Carpina and Vitoria de Santa Antã, as well as with urban bus routes. Station car parks have been provided at Jaboatão, Barro and Recife Central, and a number of stations also have cycle parks.

We are already looking at another phase of expansion, and studies for engineering design of a 4.5 km extension from Rodoviária to Timbi as a first priority are in hand. Construction of this section would add 45 000 passengers a day. Next step would be a continuation of this route to São Lourenço de Mata. By 2000 another line running from Werneck south to Cabo is to be constructed. □



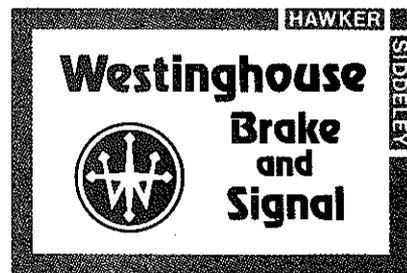
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# RIO RESTARTS LINE 2

THE FIRST SECTION of Line 1 of the 1 600 mm gauge Rio de Janeiro metro was inaugurated between Praça Onze and Glória on March 5 1979. For the first two weeks passengers did not have to pay at the five stations, and revenue service began on March 19. The line has since been extended to a length of 11.6 km between Botafogo and Saens Peña. A new station at Tijuca at the north end of the line is due to open on December 15 this year.

This year also marks an important stage in the development of Line 2, which since its first short section opened on November 19 1981 between São Cristóvão and Maracanã, has been plagued by difficulties.

At that time trains ran from 06.00 to 20.00, but the service due to be worked by metro cars built by Mafersa immediately encountered problems. The Automatic Train Operation system as used on Line 1 was never installed, and the cars were unable to operate, with the result that Mafersa finally suspended deliveries in 1984.

In the meantime some of the Cobrasma built pre-metro cars which had been destined for the Maria da Graça - Pavuna route at the north end of Line 2 were pressed into service. Thus from March 12 1983 Line 2 was operated in two sections with manual driving: from Estácio to Maria da Graça, which ran from 06.00 to 20.00, and from Maria da Graça to Irajá, with two intermediate stations at Del Castilho and Inhaúma; this section was open only from 09.00 to 15.00. This arrangement continued until December 1985 when a major leak in a pipeline adjacent to the track forced closure.

It was left abandoned for nearly two years, and no further work was carried out until 54 contracts for works on Lines 1 and 2 were reactivated with a tranche of funds totalling Cr\$4 bn from the Brazilian National Development Bank. The contracts included completion of the Tijuca turnback with three 360 m long tracks at the north

**José Maria Siqueira de Barros**  
President  
Rio de Janeiro Metro

end of Line 1 and repairs to damaged substations and cabling. The funds also allowed purchase of 28 metro cars in addition to the present fleet of 96, together with 22 more articulated pre-metro cars.

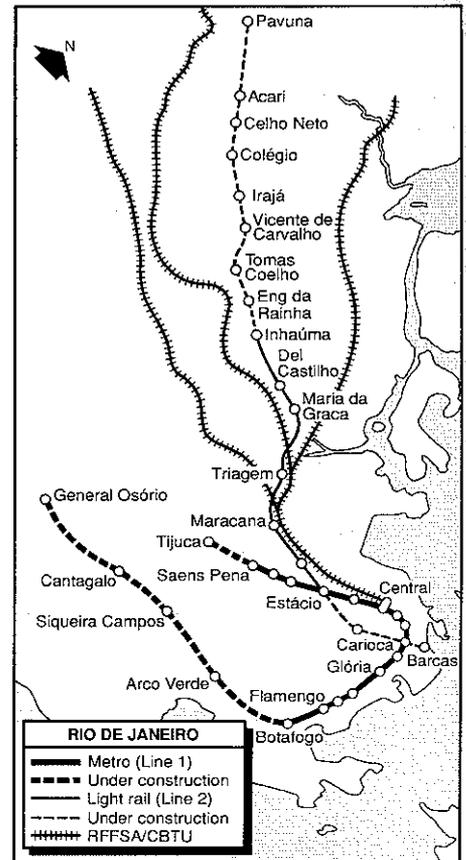
A programme of station reconstruction began on Line 2 with platforms being lengthened to take future trains of eight metro cars. The overhead current collection system was dismantled and replaced by 750 V DC third rail. This meant that six level crossings had to be replaced by bridges.

A section of Line 2 was reopened on December 24 1987 when the stations at Del Castilho and Inhaúma once again welcomed passengers. The civil works as far as the station at Engenho da Rainha have been completed, and this section will open soon.

Next year should also see substantial progress made with the southern end of Line 2 to give much improved access to the city centre. The 2.8 km section of Line 2 from Estácio to Carioca and Barcas is considered essential to relieve overcrowding on Line 1; due to open in early 1991, it will also allow Estácio station to assume its intended role as an interchange rather than the Line 2 terminus which has given rise to a bottleneck effect. An intermediate station at Cruz Vermelha will help to distribute traffic in the busiest area.

Early 1991 should also see Line 1 trains start to run on the 4 km extension from the present southern terminus at Botafogo to General Osório. They will call at new stations sited at Arco Verde, Siqueira Campos and Cantagalo. This section of the line has been designed to handle 64 000 passengers/h in each direction with trains operating on 2 min headways.

We expect an extra 500 000 passengers/



day when this section opens, and the network should then be carrying around 2 million passengers/day. At the moment traffic amounts to nearly 90 million passengers/year on Line 1 and 6 million on Line 2.

Medium term plans call for the network to be expanded to a length of 41.5 km, while long term plans envisage construction of a third line from Cocotá on Governador island to Maria da Graça, Nova Ipanema and Jóquei. A fourth line may one day run from Nova Ipanema to Barra Sul and Pontal. □



# UNCLOGGING JAMS IN THE

LAST YEAR the São Paulo metro reached the age of 20 — a magic age which leads man to define what his life would be when he is 30 or 40. Having reached this age of majority, the São Paulo metro too is planning for its future.

By the end of the century São Paulo is set to become the world's second largest city. With a population of over 12 million, it has already outstripped New York and Tokyo. In comparison with those two cities, which have long established metros with a dense network of lines covering the urban area, the 1 600 mm gauge metro in São Paulo is still in its infancy. Only two lines are in operation.

Traffic has grown rapidly in the last few years. In 1987 the number of journeys was 16 per cent more than in 1986, reaching 540 million; 1.76 million trips were made on an average weekday. Last year saw the number of journeys rise to 565 million.

At the start of 1987 there were only 11 stations on the east-west line, and morning peak traffic inbound from the eastern suburbs reached 54 000 passengers/h. On August 27 stations at Vila Matilde and Guilhermina Esperança were opened, with those at Patriarca and Artur Alvim following on September 17. Itaquera station, the present eastern terminus, was inaugurated on October 1.

The extension to Barra Funda at the western end was opened on December 17. Traffic rose dramatically, and the line is now being used by 1 million passengers/day.

*Trains on the east-west line are carrying 70 000 passengers/h in the direction of peak flow*



**Antonio Sergio Fernandes**  
President  
São Paulo Metro

Inbound morning traffic on the east-west line peaks at 70 000 passengers/h, giving some indication of what may in future be our most pressing problem — how to move 100 000 passengers/h along a single track. Fortunately, the pattern of demand on the 16.5 km north-south line is different, and although 1.1 million trips are made every day, peak travel does not exceed 45 000 passengers/h in one direction.

Regularity of services has improved on the east-west line following introduction in August 1987 of automatic train operation. The programmed headway between trains

is now 107 sec. Further improvements came at the end of the year when the last of a fleet of trains specially built for the east-west line entered service, allowing the last of the north-south line stock to be returned to its original route.

Several changes were incorporated in the design of the east-west trains to remedy problems which emerged during operation of the north-south line stock. Trainsets on the east-west line have no intermediate cabs, but the cabs in the end cars are full-width. A bogie with better suspension characteristics was chosen, and blended regenerative and rheostatic braking has been introduced. Thanks to a powerful ventilation system, windows are fully sealed to reduce interior noise levels in tunnels. Chopper control of power supplied to the traction motors from the 750 V DC third rail is retained.

## New construction

December 1987 saw the start of work on the Paulista line which will run from Vila Prudente to Oratório. This 16.5 km route with 17 stations will serve the Paulista avenue district where important administrative and commercial centres are located, together with some of the city's major hospitals. Interchange to the north-south line will be provided at Paraíso, Ana Rosa and Vila Mariana.

For the moment construction work is limited to the 4.8 km Paraíso - Clinicas section, where the New Austrian Tunnelling Method is in use. This section is expected to carry 250 000 passengers a day; another 500 000 passengers a day will use the rest of the line. As on the other lines, considerable attention will be paid to integration with other modes. About 100 bus services will feed into the 10 bus-metro interchanges along the line, and connection will be made with suburban rail services on the Santos - Jundiaí line at Tamanduateí.

The Paulista line will run underground from Vila Madalena to just beyond Vila Mariana, except for the section where it crosses Sumaré Avenue. For the short section from Imigrantes to just before Olinda the line will be elevated; the crossing of the Agua Funda Creek valley will require a large viaduct. From Olinda it is underground again for a few hundred metres to Nazaré, and elevated again from Sacomã to Oratório; a bridge will have to be built over the Tamanduateí river.

Although the first section of the Paulista line will open using existing trains, a third generation of rolling stock is on the drawing-board. Taking advantage of recent technical advances, it will have three-phase asynchronous induction motors and a fault diagnosis and monitoring system. Except for the end



# SAO PAULO MEGALOPOLIS

cars, all vehicles will be motored to ensure high levels of adhesion and rapid acceleration. A stainless steel body with slightly curved sides is envisaged, and the front end will reflect the latest thinking in industrial design. Paulista line stock will be maintained at a workshop to be built at Delamare near Sacomã.

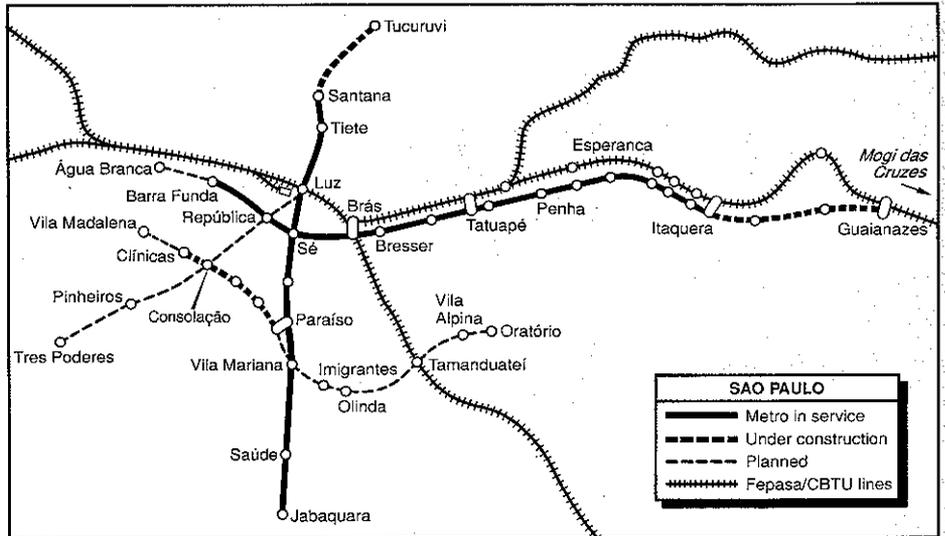
Work is also in progress on a 3.5 km extension, mainly in bored tunnel, of the north-south line from its present northern terminus at Santana to Tucuruvi; intermediate stations are being built at Jardim São Paulo and Paulicéia, and a stabling yard is under construction north of Tucuruvi.

### East line problems

Further work is under way in the eastern sector where the city's transport problems are most serious. This area is home to 3.2 million people, most of whom have very low incomes. Travelling by bus to and from work in the city centre may absorb up to 5 h a day. Although construction of the metro to the east of the city eased travel problems, it later exacerbated them because more people chose to move to areas through which the metro would run.

The east-west line is being extended by 5.5 km from Itaquera to Guaianazes; intermediate stations will be built at Pêssego and José Bonifácio.

It is on the same axis that the Brazilian Urban Railway Company (CBTU) is planning to upgrade the suburban line to Ferraz de Vasconcelos, Poa, Susano and Mogi das Cruzes in a bid to cope with the huge demand for travel into the city from the eastern suburbs. Reaching out about 100 km from the city centre, this line would become a



regional metro with frequent services meshing in with the east-west metro at the inner end of the route.

Under consideration at present is closure of the CBTU stations at Patriarca, Vila Matilde, Carlos de Campos and Gualberto. This would allow suburban trains to run non stop from the metro interchange at Itaquera into the city centre. Later, the Itaquera - Guaianazes extension would become a separate shuttle service.

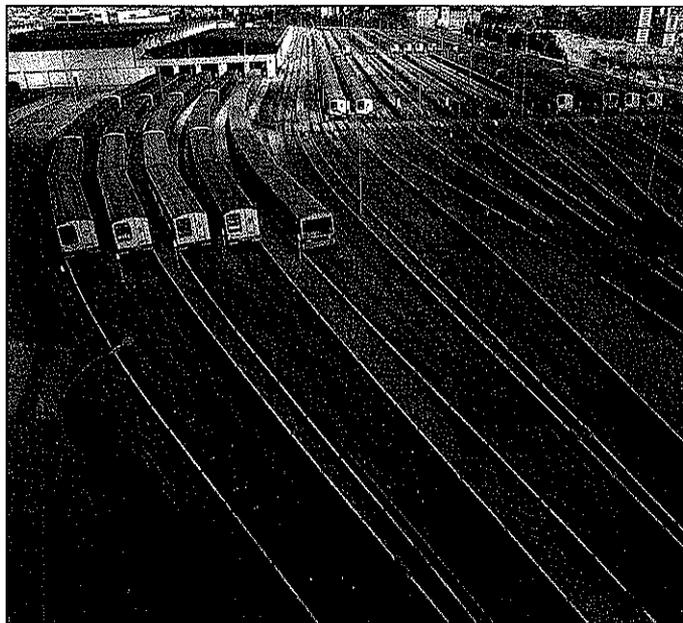
Another extension to the urban metro network is planned in the medium term. This is a fourth line with 12 stations that will run from Tres Poderes in the west to Luz main station in the city centre, where it will connect with the north-south route, and main line and commuter rail services. Interchange to the east-west line will be

made at República, and an interchange station with the Paulista line will be provided at Consolação.

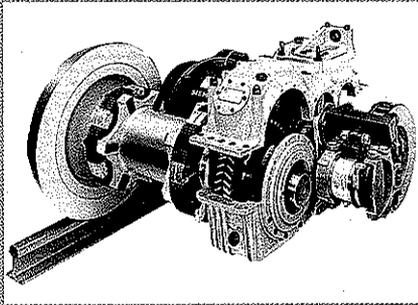
From a depot at Caxingui beyond Tres Poderes, the line will follow Eliseu de Almeida avenue on elevated alignment to Pinheiros, where interchange to Fepasa's suburban rail services is envisaged. From here to the centre the route will be underground. □

*Below left: A line-up of trains for the north-south line at Jabaquara includes east-west line sets with full-width cabs*

*Below: Crowds wait to board a northbound train to Santana*

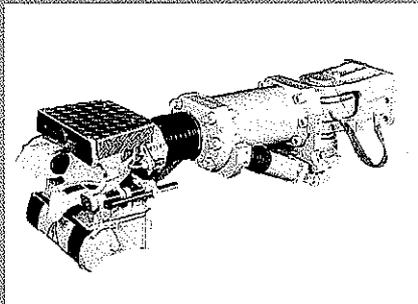
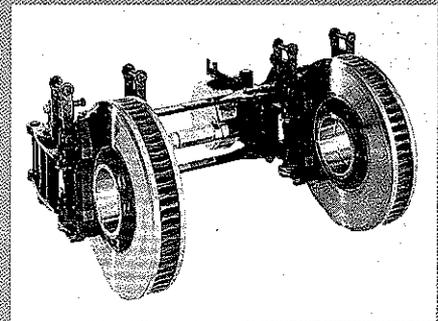


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# SAPPORO OPENS TOHO LINE



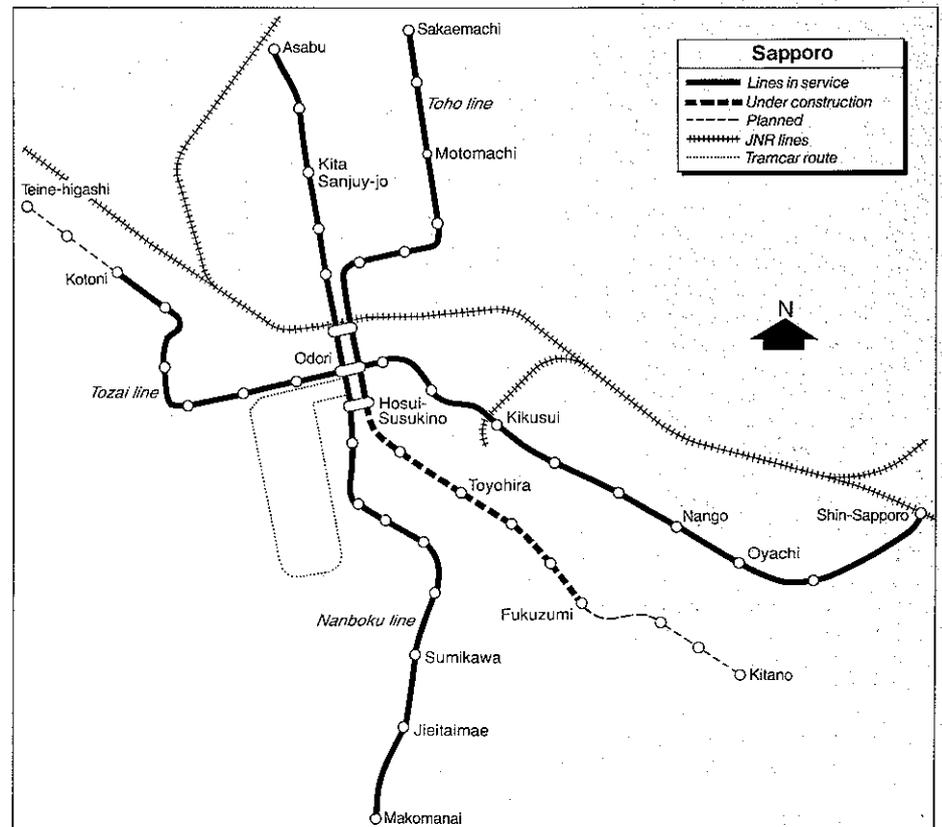
**Tadayoshi Akiyama**  
Director

Sapporo Transportation Bureau

ON DECEMBER 1 last year Sapporo opened its third subway route. Known as the Toho line, it has been long awaited by the city's rising population which last year topped 1.6 million.

Located in the southwest of Hokkaido, Sapporo is one of the most important cities in northern Japan. It has made remarkable progress as a centre of international commerce, and already it is Japan's third largest city in terms of surface area — the distance from the northern city limit to the southern fringe is more than 45 km, while an east-west journey is only slightly shorter.

Rapid growth in the 1960s changed the appearance of the city as well as the



circumstances affecting public transport. In 1963 the city authorities began research on how best to reorganise the public transport network. The subway was chosen as the mainstay of the network, both as a means of increasing transport capacity for the rapidly growing population and also to

alleviate congestion on major roads.

On the basis of a report submitted to the mayor in 1967, the 12.1 km Nanboku line from Kita Nijuyo-jo to Makomanai was given top priority. Construction began in 1968, and in December 1971, a few months before the Winter Olympics, the line opened for business. So Sapporo became the fourth city in Japan to open a subway after Tokyo, Osaka and Nagoya, using the unique formula of a covered guideway protecting rubber tyred trains from snow and ice.

In June 1976 the 9.9 km Tozai line between Kotoni and Shiroishi was opened. In March 1978, the Nanboku Line was extended northward by 2.2 km from Kita Nijuyo-jo to Asabu. In March 1983 a 7.4 km eastward extension of the Tozai line between Shiroishi and Shin-Sapporo was completed. No other Japanese city has developed a subway network so swiftly.

After more than five years of construction, which started in July 1983, the Toho Line running 8.1 km from Sakae-machi to Hosui-Susukino went into operation on December 1 1988, bringing the network to 39.7 km.

Cost of building the Toho line amounted to ¥237bn. The work was divided into 26



*The Toho line is worked by Series 7000 cars built by Kawasaki Heavy Industries*

lots, construction being much more difficult than the Nanboku and Tozai Lines because of the nature of the geology. Loose soil prevalent along the route was a major problem. South of the intersection with JR's Hakodate main line the Toho line runs through alluvial gravel deposits of the Toyohira river. To the north is soft peat.

Working in clay soils had presented difficulties during construction of the Nanboku line, but the soft peat deposits on the Toho line demanded novel methods such as grout injection of the soil.

Another difficulty was the large number of underground services encountered along the route. Average depth of construction was 18 m, considerably deeper than the first two lines. At Odori, where interchange is provided to the Nanboku and Tozai lines, construction depth reaches 27 m, and the underground shopping mall had to be underpinned. Computer-controlled hydraulic apparatus was used so that any subsidence under the existing buildings would be detected immediately.

Other construction techniques included the 'pipe-roof method' (picture, p23) where horizontal steel pipes support structures over the excavation beneath JR's Sapporo station yard. Shield construction was used to drive the tunnel for a link under Odori Park which gives subway trains access to the Nishi maintenance yard on the Toho line.

Toho line trains connect the downtown area with Sakae-machi in the East ward in 14 min. Each of the nine stations has escalators, lifts and toilets designed for wheelchair users.

Series 7000 cars for the Toho line were manufactured by Kawasaki Heavy Industries in its Hyogo works. Developed using experience gained from Series 6000 cars on



*'City in Nature' murals adorn the walls of Odori station where the three lines intersect*

the Tozai line, Series 7000 offers higher capacity, a lighter body and better energy efficiency.

The car body length of 18 m, width of 3 080 mm and height of 3 915 mm are the same as Series 6000. However, the structure was redesigned to provide enough extra space to accommodate 138 instead of 126 passengers per car.

The hexahedrally shaped front end has a curved windscreen to give good visibility and an impression of speed. Design contours were maintained by ensuring that the emergency exit from the driver's cab had a sliding plug door flush with the body.

To create an original and bright image, the cars are finished in an ivory white livery, with a sky blue band below the windows. Blue has been chosen as the identifying

colour to guide passengers to the Toho Line.

A fleet of 15 four-car trains is in use, but multiple-unit operation will allow eight-car trains to run in the future when demand warrants it. Services start at 06.15 and finish at 23.59.

Trains are controlled from a signalling centre at Oyachi in Shiroishi ward. Both train operations and control of other facilities — previously separate functions — are integrated here. Operating data are transmitted on line via optical fibres. The cause of a malfunction can be quickly identified and, should an accident occur, prompt emergency action can be taken. Sapporo's Comprehensive Control System is the first of its kind to be adopted by a subway in Japan.

### Future plans

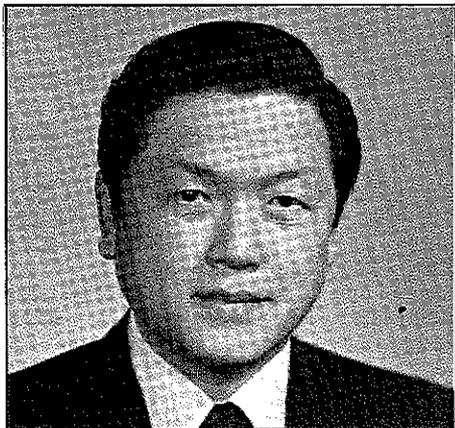
Based on a report by the Sapporo Comprehensive Transport Network Plan Research Committee, the city authorities have drawn up several subway construction projects that are to be implemented by 1995. These include the 2.8 km westward extension of the Tozai line from Kotoni to Teine-Higashi and the 8.8 km extension of the Toho line southeast from Hosui-Susukino to Kitano.

Construction work authorised by the government covers the first part of the Toho line extension, 5.6 km from Hosui-Susukino to Fukuzumi, which is expected to begin in fiscal 1989. □

*Underpinning of buildings in progress at Nijuyo-jo*



# SHANGHAI IN FULL SWING



**Cai Jun Shi**  
Director, Shanghai Public Utilities Bureau\*

vehicles work 368 routes totalling 17 440 km; the number of routes is being constantly expanded, and buses now operate in almost all urban streets where conditions permit. In 1988 the number of passenger journeys was a record 5.6 billion. On some routes buses are dispatched at intervals of less than 1 min in peak hours, with peak flows topping 13 000 passengers/h in one direction.

Various measures have been adopted to try and relieve congestion, but the traffic jams are still there and in some cases the problem has become worse. It has thus become necessary to introduce high capacity rail rapid transit in the busiest corridors. This has long been an aspiration of the people of Shanghai, and the municipal authorities have already devoted considerable effort to get the project under way.

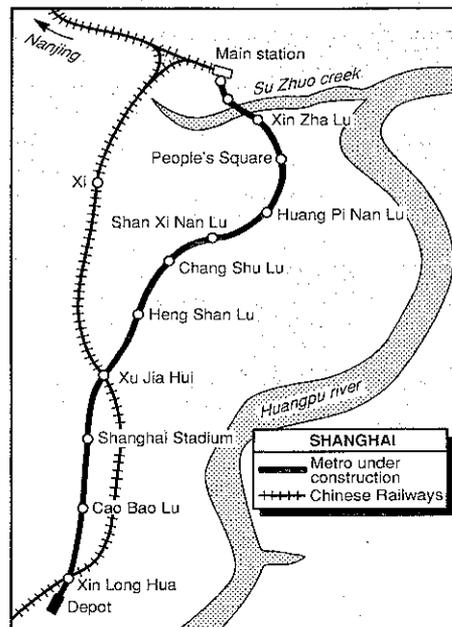
WHEN VISITORS step across the threshold of this Far Eastern coastal metropolis they are frequently surprised and puzzled by the traffic in the streets. They soon discover that many downtown streets are crushingly packed with all kinds of motor vehicles, countless bicycles and oceans of pedestrians. People commuting to and from work or rushing to social engagements often find themselves helplessly and dejectedly trapped in traffic jams on the main thoroughfares.

Shanghai is a super-cosmopolis with a population of 12.5 million people. As the national economy has grown, so has the patronage of public transport in Shanghai — the network of buses and trolleybuses handles on average more than 15 million journeys a day. Private transport consists in part of bicycles, around five million of which are registered with the authorities.

Nearly 75 per cent of the 6 000 strong bus and trolleybus fleet is articulated. These

Under the Shanghai Master Plan for Municipal Development, the city is to have a magnificent metro. When completed, this very ambitious project will have seven lines totalling 176 km; radial, circular and diagonal routes will be provided so that a wide range of journeys is possible.

The first line, pictured below, runs on a north-south alignment. It connects Shanghai's main railway station with Xin Long Hua station in the south of the city. Its 14.6 km route was carefully chosen on the basis of a series of travel surveys. From the main station it will cross the Su Zhou Creek and pass through the People's Square in the heart of the city. It will serve busy shopping centres and the 18 000 seat municipal indoor



stadium where important sporting events and other public gatherings are held.

All but one of the 12 stations will be underground and average distance between them will be 1.3 km. The southern terminus at Xin Long Hua will be constructed on the surface, although during a later construction phase it may be necessary to relocate it below ground. The depot will be immediately to the south.

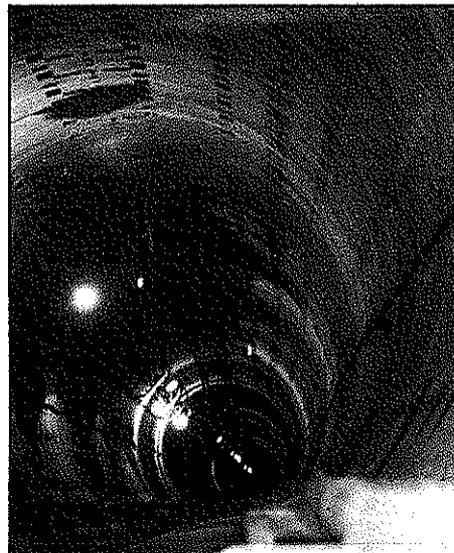
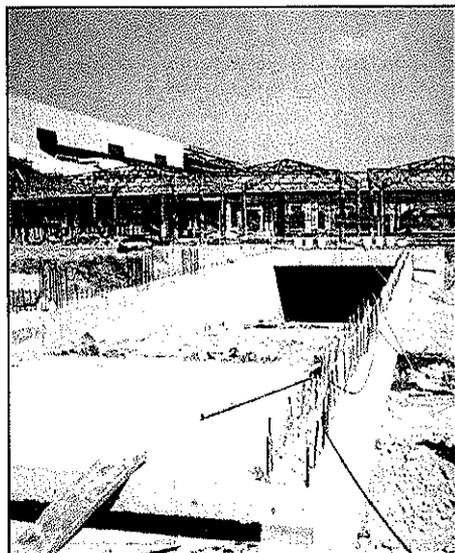
### Tough challenge

It is public knowledge that construction of the metro in Shanghai poses tough civil engineering problems. The tunnels are having to be cut in soft ground, and the water table is only 1 m below the surface. The situation is further complicated by some of the tunnels having to be constructed below narrow streets where a maze of pipes and cables carry the city's services. One of the most difficult requirements is that street traffic flows must be maintained throughout the construction period.

Shanghai first drove an experimental tunnel in the 1960s, and the results of this trial led to the conclusion that the earth pressure balanced shield method of boring was most suitable for the prevailing ground conditions. This is because it allows the amount of ground settlement to be controlled within acceptable limits, so ensuring that buildings, pavements, road surfaces and underground utilities are not damaged. Tunnel linings of reinforced concrete segments with special rubber joints that swell in the presence of water have been chosen because of their waterproof qualities.

The first line largely follows existing

\* Mr Cai Jun Shi is also Chairman of the Public Transport Society of China



## Developing Metros 89

roads. The twin running tunnels will have a bored diameter of 6.2 m. Stations will be built using cut-and-cover methods with diaphragm walling. Each station will be designed as a two-storey box structure with a concourse level on top where information counters, ticket offices and machines, telephones and retail stalls will be accommodated. Below this will be a 186 m long island platform, the width of which will vary from 8 to 14 m. Electrical and mechanical plant at each end of the platform means that the overall station length will be 260 m.

Civil construction work for the northern terminus at Shanghai main railway station is already complete. Located immediately in front of the main station, it occupies 18 000 m<sup>2</sup>. We envisage that we shall have to cater for a passenger flow of 40 000 passengers/h in each direction by 2000, rising ultimately to 60 000 passengers/h.

For this reason we have selected a rolling stock design that has 3 m wide bodies. Each 22 m long car will have five 1.3 m wide doorways on each side. Seating will be provided for 56 passengers, and there will be room for 244 standees. By the end of the

century six-car trains will operate on 2½ min headways. Extra capacity will be achieved by adding two cars to each train and reducing headways to 2 min. Power supply will be at 1.5 kV DC; overhead current collection is preferred to third rail because in the future some of the network will be at grade.

Chopper controlled cars with a maximum speed of 80 km/h will be used; this will permit an average speed of 34 km/h on the assumption that dwell times can be kept to less than 30 s. Trains will be automatically operated, although train operators will be employed to intervene in emergencies.

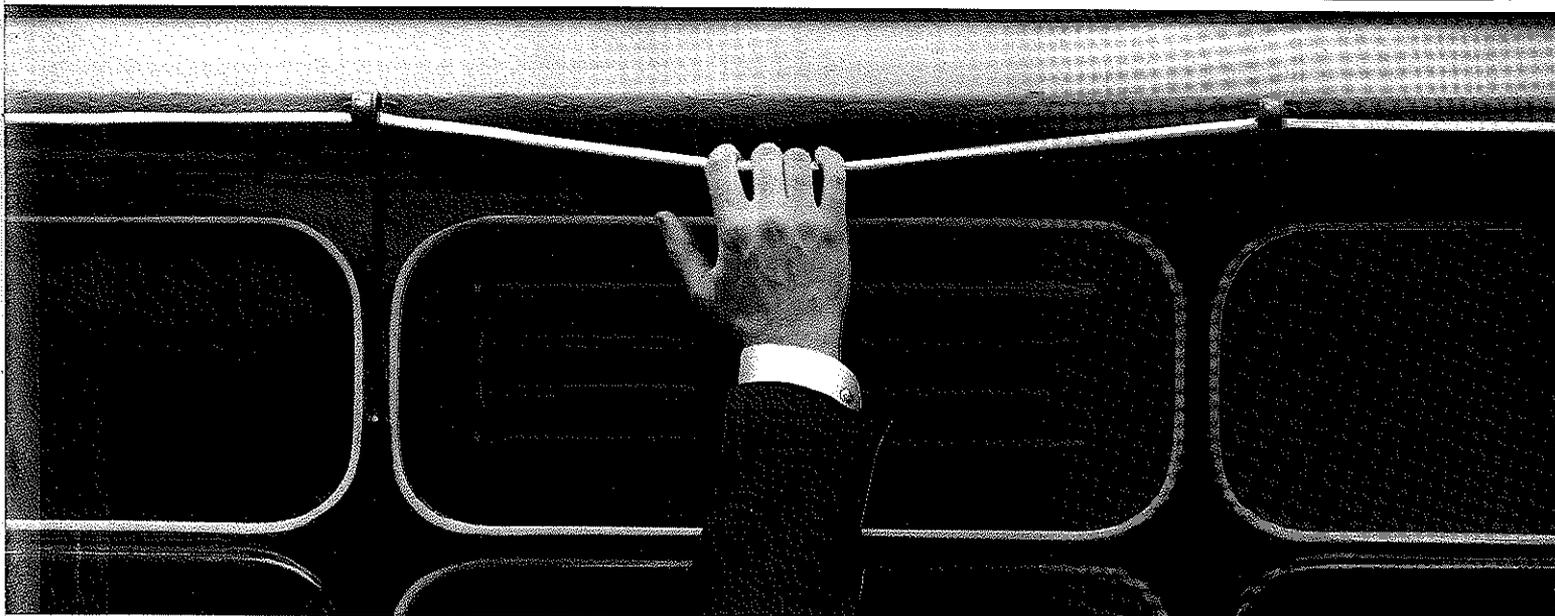
In the summer Shanghai is hot and humid, and trains and stations will be air-conditioned. Thanks to environmental controls, ambient temperatures in stations will not exceed 30°C. In the single track running tunnels, the piston effect of the trains will be used to provide ventilation, although fans will be installed to augment this if necessary.

The State Council has already approved Shanghai's proposals and it has also agreed to permit the city to draw on foreign funds for construction in a bid to accelerate the project and to allow advanced technology to

be incorporated. We have already decided that rolling stock and some other electrical and mechanical equipment will be sought from foreign manufacturers.

In conclusion, I should like to draw readers' attention to the controversy that surrounds implementation of metro projects. I believe that a debate between those who strongly advocate a metro as a panacea for public transport problems and those who suggest that rapid buses or freeway flyers are a satisfactory alternative would be a draw. I would suggest that it is better to treat each case individually as each city has different characteristics. It is important for proper feasibility studies to be carried out before the first shovel of earth is turned.

With construction of our first line in full swing, a pre-feasibility study for the second route, which runs on an east-west alignment, is under way. Several feasibility studies have already been carried out in Shanghai by Chinese and foreign consultants, and it is not a fortuitous coincidence that they have unanimously reached the same conclusion — which is that the city is badly in need of a metro, and the sooner the better. □



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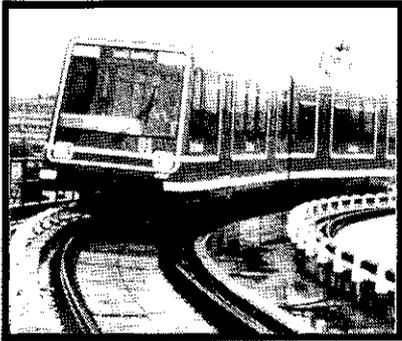


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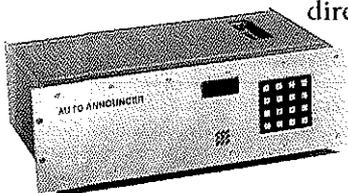
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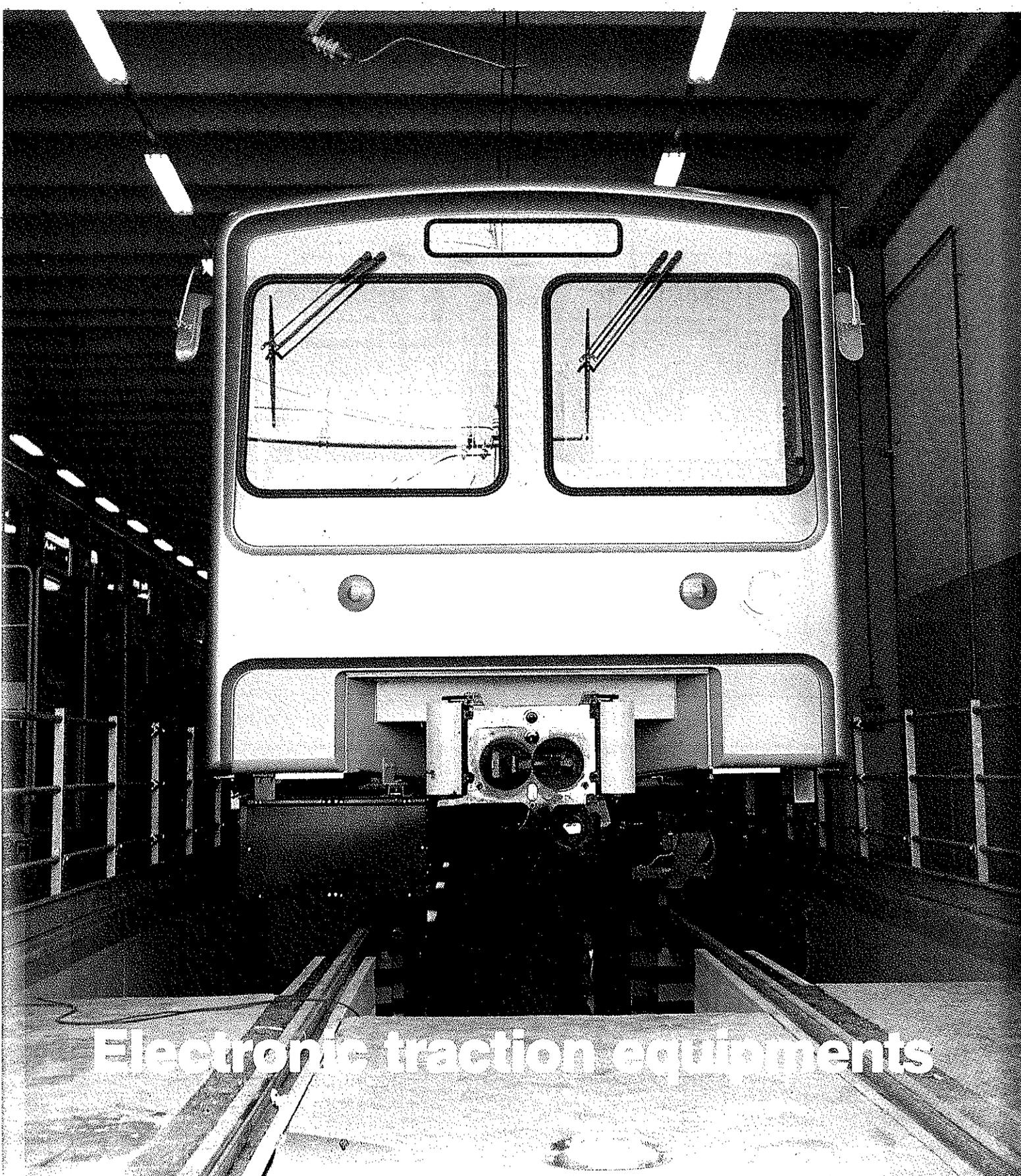
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# STOCKHOLM MANAGES BY OBJECTIVES

IN THE 40 years since the first section of Stockholm's metro opened, the network has been expanded to 108 route-km serving 99 stations. The three lines, opened in 1950, 1964 and 1975, split into various branches at the outer ends. The service pattern gives 11 basic routes which are overlaid to provide intensive services in the city centre.

The Green line, the oldest, uses former tramway alignments and premetro tunnels to link Hässelby in the west to Bagarmossen, Farsta and Hagsätra in the south. The Red line runs from Mörby and Ropsten in the northeast to Fruängen and Norsborg in the southwest, while the Blue line links Akalla and Hjulsta in the northeast to Kungsträdgården in the city centre. The three intersect at T-Centralen where there is interchange with Swedish State Railways' Central station.

The last section of the Blue line was opened in 1985, and the only section of metro now being planned is a 2 km spur which will extend the Green line by 1 km from Bagarmossen to Skärpnäck; this is to open in 1994. A further extension to Skrubba and Bollmora is being considered, as is a prolongation of the Blue line from Hjulsta to Barkarby airport and another Green line extension from Fruängen to the SJ station at Flemingsberg.

Since 1967, Stockholm Transport (SL)

**Gunnar Rehnström**  
Director, Rail Division  
Storstockholms Lokaltrafik

has been responsible for the suburban rail services from Märsta and Kungsängen in the north to Södertälje, Gnesta, Västerhaninge and Nynäshamn in the south, although these are worked under contract by SJ. The latest agreement, which runs from 1984 to 2010, includes a capital investment programme of SKr2.8bn over the eight years to 1992.

SL's responsibility also covers the Alvik - Nockeby light rail line, which is all that remains of the city's tramways. Subsidiary companies operate a light rail line from Ropsten to Lidingo island, the Saltsjobanan local railway and the narrow-gauge Roslagsbanan suburban lines.

### Council support

SL is directly responsible to the Greater Stockholm County Council for all public transport within the county. Half of the managing board are political appointees, and the council sets guidelines under which SL operates. Tariffs and service levels are set by an executive committee within these guidelines, and any shortfall between revenue and costs is met by the county council from local tax revenues.

The past decade has seen a slow but steady decline in public transport patronage as more and more cars have been coming into the city. Car use is reaching the point where some form of legislation may be required to reduce congestion, but for now we must compete for market share through better and cheaper services.

This has led to a worsening of SL's financial results; the farebox ratio is currently running at 37 per cent and operating support accounts for 19 per cent of the council's annual budget. While we are under pressure to cut costs by efficient operations, our objective is to win more passengers by running better services, so we are not cutting services to reflect declining patronage. I am confident that the trend will soon be reversed, as there is a growing recognition here that unrestricted car use cannot continue. This is reflected in the city council, where the environmental 'green' group holds the balance of power.

### Management by objectives

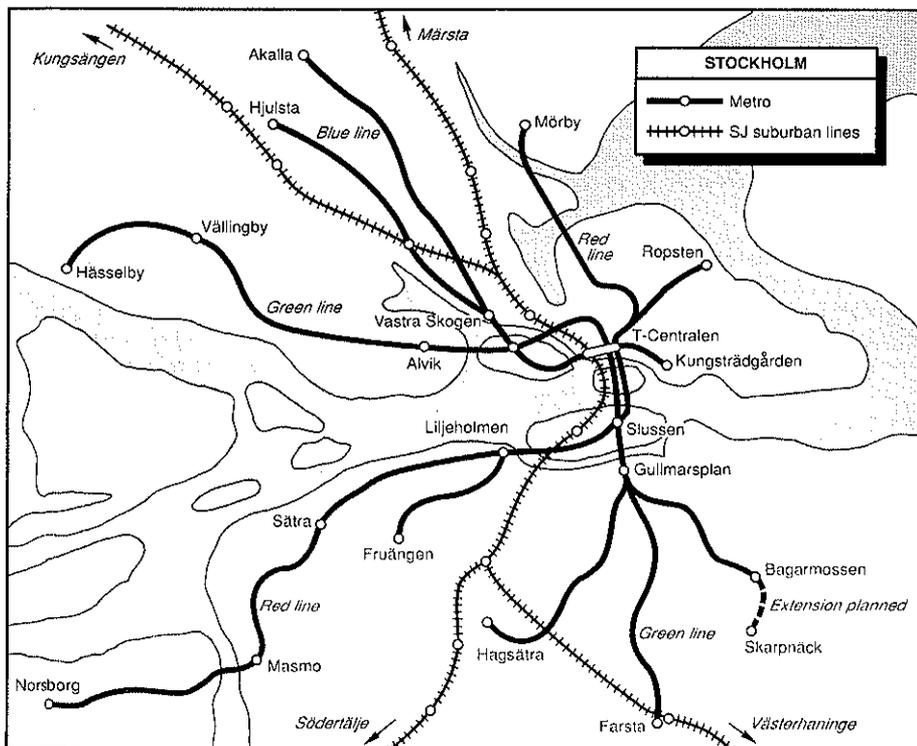
Since it was set up in 1986, SL's Rail Division has been looking at ways of restructuring operations to devolve more authority to local management and to improve staff performance.

A project team was set up to oversee these changes, which are known as MBO (Management By Objectives). The team spent several months studying our operations in detail. Next step was to set specific objectives for each part of the organisation and find effective ways to monitor and evaluate performance.

Overall divisional objectives were to improve the level of self-financing, reduce operating costs per passenger-km, improve job satisfaction, and reverse the recent decline in market share. But beyond these we had to restructure operations so that meaningful objectives could be set for every member of the work force.

Greater efficiency should come through closer co-ordination, better identification of priorities, and a clearer overall goal. Job satisfaction is coming from a greater openness within the organisation, confidence of managers in their staff, clearer common objectives and personal goals, and a realistic method of assessing and rewarding results.

To implement MBO, the Rail Division has divided itself into two main profit centres, Metro and Suburban. The Metro group is supported by four sub-centres covering permanent way, electrification, rolling stock, and structures. The headquarters staff will be split into Economics,





Planning & Development, and Personnel units. Each group has the task of defining its own structure, with budgets, skills supply and inter-departmental links arranged to suit its particular role.

Operational planning throughout the rail division is to be devolved to the individual profit centres, right down to permanent way gangs, so that a realistic range of achievable improvements is set, rather than over-optimistic targets imposed from above. We expect each group to put forward positive plans; merely resting on one's laurels is seen as letting the side down, and each group is motivated by a sense of competition with other groups.

We now have a framework for long-term planning, with a rolling 15-year investment budget and a five-year operations programme which are constantly updated to suit short-term changes. But with a much clearer idea of our objectives, analytical decision making becomes easier.

### Practical benefits

An early example of the benefits to be obtained was shown on the commuter rail services, where punctuality reached an all-time low in 1985. A comprehensive train reporting network is being installed, with displays at all stations and key management points. These displays are open to the public so passengers can see how their trains are running. Closer scrutiny and personal involvement of the staff in their performance led to a turnaround in punctuality in just 18 months. In the first two weeks of 1989, 94 per cent of trains ran within 3 min of time.

On the metro, passenger information will be improved by the installation at all stations of dot-matrix indicators showing the time, destination, and length of approaching trains. The Red line equipment was fitted

last year, although not fully functional yet, and the other lines will be equipped soon.

Skip-stop working is being introduced on two metro lines to reduce journey times, and I hope this will also improve punctuality. Better co-ordination of services should result from commissioning of a network control centre in 1993-94 to replace the four centres that regulate traffic at present. The plans for the new centre draw on the design of various recent installations elsewhere, including Montreal's new control room, to which we sent a team of inspectors last year.

We are looking at ways of countering the emerging problem of vandalism and graffiti. Cars with external graffiti are removed from service and cleaned before re-use. The total cost of removing internal and external graffiti last year was SKr35m. One attack in January defaced 40 cars stabled overnight; there were severe repercussions as services were reduced for several days while they were cleaned.

Internal scrawlings disturb the passengers most, and we are looking at introducing roving guards to travel on all off-peak and night trains. With additional cleaning, this would bring the total cost of anti-graffiti measures to at least SKr105m a year, and we are seeking government funding towards tackling what is essentially a social problem.

### Rolling stock development

We have almost 900 metro cars of the same basic design. Older cars have contactor or camshaft controls, but more recent builds have thyristor choppers. Over 250 of the older C1, C2 and C3 vehicles have been rebuilt with new bodies and underframes, retaining the bogies and traction equipment. These are redesignated C12 and C13. In addition, a build of chopper-controlled C15 stock is being delivered by ABB Traction.

*Above left: The Red and Green lines have cross-platform interchange at T-Centralen in one direction and Slussen in the other*

*Above: The Blue line is known as Stockholm's longest art gallery, with each station decorated by a well-known artist*

We have recently started development of Car 2000, the next generation of stock. Design concepts are being examined with the aim of completing a specification by the end of the year. Rather than seeking a state-of-the-art car offering every latest gadget, we want to take a reliable step forward that benefits from the best of modern ideas. Main aims are lower operating costs through reduced car weight, regenerative braking, and modular design for easy maintenance. Higher speeds with better acceleration and braking will cut journey times. As with the present cars, weather conditions dictate that all axles are driven, but we hope softer suspension will enhance the ride and reduce track wear.

At the same time as the new stock is introduced, we plan to update our signalling and install automatic train protection. We are looking at replacing the present coded track-circuits for 15, 50 and 80 km/h by a new version using 10 different speed levels, which would give better safety and easier regulating, at the same time opening the way to fully automatic operation in the future.

SL's Rail Division Planning & Development Manager Johnny Karlsson began discussing Car 2000 with manufacturers at the end of January, and we hope to invite bids for prototypes during 1990. These would begin running in 1993, with the series fleet arriving at the rate of 40 vehicles a year from 1995. □



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# TEHRAN BACK ON TRACK

**A Ebrahimi**  
 Chairman & Managing Director  
 Tehran Urban & Suburban  
 Railway Co

CONSTRUCTION of the Tehran metro began in 1977, but work was suspended in 1982. Public transport in the city remained poor, and a growing population exacerbated the problem of rapidly increasing road traffic, leading to serious air pollution. Because of this it was decided to restart the metro project in 1985.

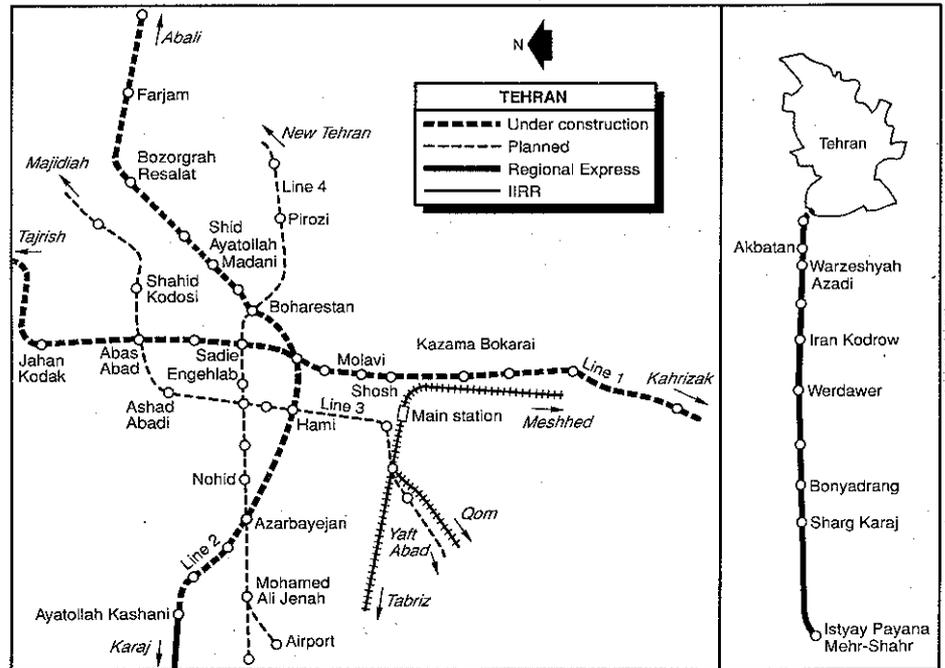
The first phase consists of two lines intersecting in the city centre. Line 1 will run for 28 km on a north-south alignment, and 12 km of this will be underground. This line will have 24 stations.

The 20 km Line 2 will be entirely underground. It will run east-west and have 19 stations.

Both lines will have standard gauge double track electrified at 750 V DC third rail. The steepest gradient on Line 1 will be 5 per cent, but on Line 2 it is only 3.5 per cent.

When work restarted, tunnelling resumed at 22 sites (below and opposite). Since then about 40 per cent of the work has been completed.

We have set up an Electrical & Mechanical Engineering Department to investigate and evaluate the earlier plans. Once this work is complete, it will be possible to design the equipment on a new basis and to prepare the tender documents. We envisage that the main mechanical and electrical tender covering rolling stock, signalling, power supply,



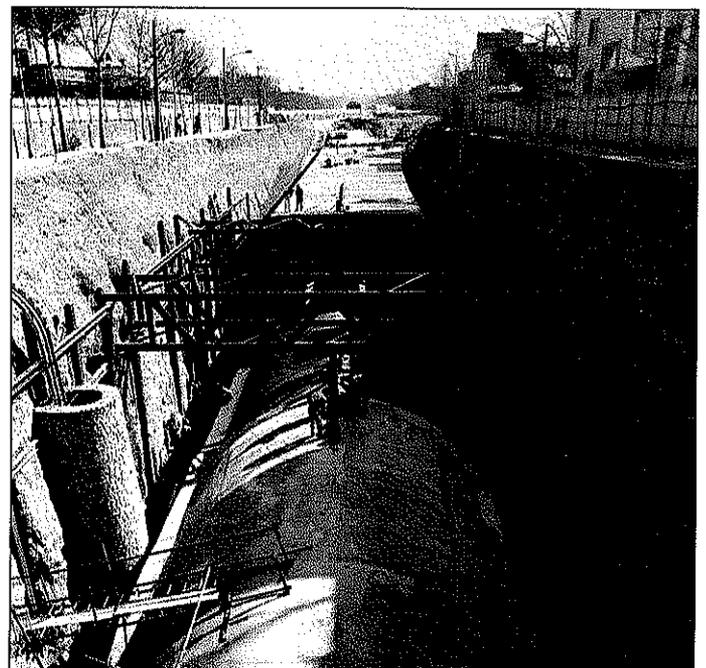
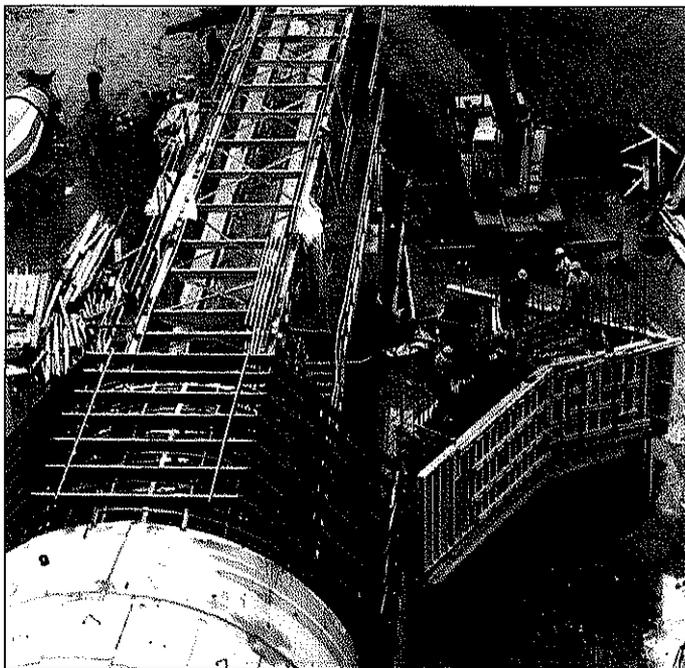
control equipment and maintenance facilities will be issued by October this year. The Electrical & Mechanical Engineering Department will be responsible for overseeing installation and commissioning, and we expect the first part of the metro to open at the beginning of 1992.

Around 90 trains, each formed of a pair of four-car units, will be needed for Lines 1 and 2. An eight-car train will have seats for 304 passengers and standing room for 1 052. With services operating on 2 min headways

in peak hours, line capacity will be 40 000 passengers/h in each direction.

Trains will run at a maximum speed of 80 km/h, with average speed being 35 km/h. On level track trains will accelerate at 1.2 m/s<sup>2</sup>, with braking rate also averaging out at 1.2 m/s<sup>2</sup> from maximum speed to zero.

Automatic train operation will be provided, and trains will be regulated from a single control centre from where the traction power supply and other equipment will also be remotely monitored and controlled.

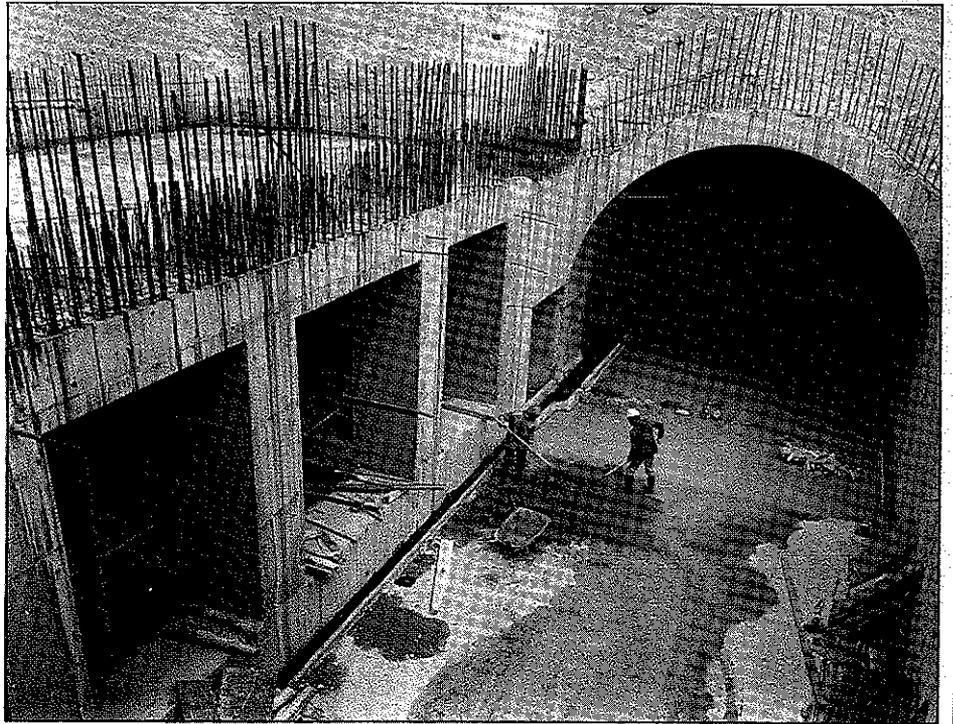


In the long term there are plans to build two more lines. Line 3 will run from the northeast suburbs to the southwest of the city and will have 17 stations. Line 4 will form a second east-west route with 18 stations; at its western end it will have a branch to serve Tehran airport.

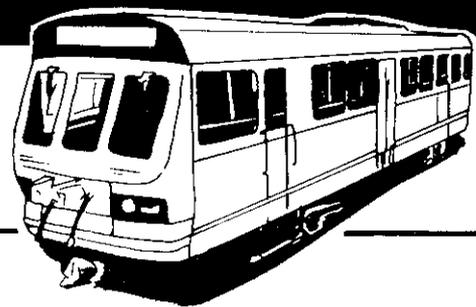
In addition to the metro, the Tehran Urban & Suburban Railway Co is working on a regional express line that will run west from the terminus at the end of Line 2 to Karaj and Mehr-Shahr. In a length of 42 km it will have 10 stations.

Like the metro, the express route will have 1 435 mm gauge track, but in this case it will be laid out for 160 km/h running. Electrification will be at 25 kV 50 Hz, and both automatic train control and automatic train protection will be provided to ensure safety of operation. A traffic control centre will monitor and regulate the trains.

A fleet of 20 trains, each consisting of two three-car sets, will be needed to work the express line. Minimum headway in peak hours will be 4 min, and we expect the line to be able to carry 20 000 passengers/h in each direction. □



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# TOKYO TUNNELS TO

THE METRO serving Tokyo was born in 1927 when the Ginza line's 2.2 km Ueno-Asakusa section opened — the first in Asia. The entire 14.3 km line was completed by 1939 as a joint effort by two companies.

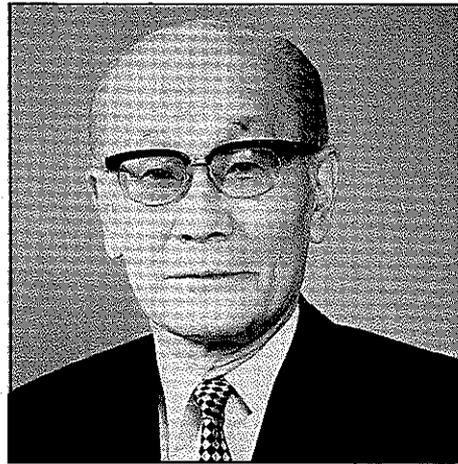
Thereafter, as the city developed, a comprehensive metro emerged as the only effective way of meeting the capital's transport problems. However, given the huge construction costs involved, the project was considered too onerous for private enterprise to undertake.

So the Teito Rapid Transit Authority was set up in 1941 as a public corporation, solely entrusted with the building and management of a metro network for central Tokyo. At the same time, guidelines were established for private railway companies to provide transport in Tokyo's suburbs.

Though devastated by war, Tokyo staged a swift recovery and its transport problems became more serious with each passing day. To speed up construction, the Transportation Bureau of the Tokyo Metropolitan Government joined forces with TRTA in 1958. Since that time, the city's metro network has been managed by the two agencies.

At present, Tokyo's metro comprises 10 lines totalling 216 km, of which TRTA controls 155 km and carries 5.6 million passengers daily.

An unusual characteristic of Tokyo's metro is the substantial amount of through running which takes place with lines owned by JR-East and the private railways. Such



**Shiro Nakamura**  
President

## Teito Rapid Transit Authority

lines effectively extend the metro by 189 km, bringing the total network to 340km.

In 1976, TRTA had a cumulative deficit of ¥26bn. A major effort by management to improve efficiency, an increase in passengers, higher fares and government subsidies gradually brought this deficit under control, and it was eliminated by the end of fiscal 1987.

### Metro expansion

All projects for urban railways in the Tokyo conurbation are co-ordinated and planned by the Transport Policy Delibera-

tion Council, an advisory body reporting to the Ministry of Transport.

In 1985, as a target for the year 2000, the construction of 530 km of railway was projected. This goal is to be fulfilled by TRTA, TMG, JR-East and seven major private railways, as well as newly-formed transport organisations.

The primary objective is to ease congestion during commuting hours. The aim is to reduce the current congestion index of over 200 per cent during the morning peak to 180 per cent.

Lines currently under construction or planned by TRTA, as well as lines which will have an impact on our existing lines, comprise the 74 km of extensions on the map.

Meanwhile, we are making efforts to replace older cars, renovate and redecorate stations, implement all-day no smoking regulations through passenger co-operation, issue new one-day open tickets and 11-ride coupon tickets, offer Metro Cards for easy ticket purchase, and generally upgrade passenger reception and service.

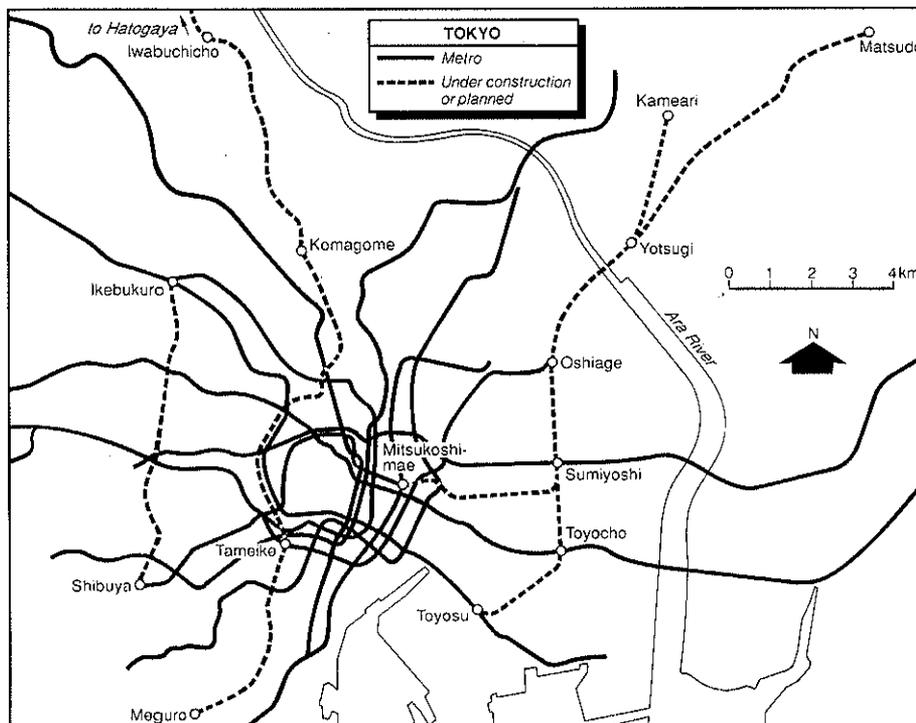
Employees are being encouraged to show more initiative in their attitudes and behaviour towards passengers as a further means of improving service. Potted palms have been introduced in stations to overcome otherwise cold or impersonal atmospheres. As another example of our new service commitment, posters subtly stressing the benefits of good commuting manners have received a positive reception from passengers as well as overseas observers.

### New and improved cars

We pride ourselves on good maintenance which ensures that our cars have a long reliable life. Nevertheless, the cost of keeping older cars operating increases with time, so we have set a limit of some 30 years for replacement. This policy also allows us to introduce improvements, further enhancing performance and comfort. Over the years, designs have become more modern and stylish, and distinctive colours have been added to the exterior.

Among many improvements designed to serve passenger needs are electronically-controlled displays above the doors inside the trains, showing the various stops, the direction of travel, and the next stop. Window levels allow passengers to see out, and glazed partitions behind the cab permit forward vision. External loudspeakers permit the train operator to address passengers on the platform. Wide aluminum extrusions improve the quality of the cars as well as reducing the man-hours required to manufacture them.

For its latest cars, TRTA has adopted



# EASE THE CRUSH

high frequency choppers with separate control of current in the armature and field of the traction motors. Offering the same level of performance as the inverter-controlled (VVVF) car adopted by the surface railways in recent years, it was found preferable to the latter despite the obvious disadvantages of maintenance costs associated with a commutator. Since its adoption, a higher level of adhesion (19 per cent) has been obtained, compared to conventional chopper cars.

Moreover, on the Tozai line, we have succeeded in changing the motor/trailer car ratio from the previous 8M+2T to 5M+5T. This represents a significant reduction in manufacturing and repair costs.

## Tunnelling technology

Japan leads the world in tunnelling technology. Within Japan, the TRTA is a pioneer in the construction of metro tunnels, displaying a technological capability which has won confidence both within Japan and overseas.

Among its many accomplishments, TRTA developed the pressurised slurry shield method for double-track tunnels and raised its technical level to the point where it can be used in various types of soil. Moreover, supplementary shield work has been kept to a minimum. At present, because of our continuing research efforts to improve the shield machine for double-track tunnels, we anticipate being able to drive on a 170 m radius curve.

## Future policy

It is vital that we continue building new lines to ameliorate traffic congestion in Tokyo. However, the cost of meeting these



needs is increasing enormously each year. Because these huge amounts have for the most part to be obtained through loans, the management of a new line must expect a prolonged period of heavy financial pressure once it begins operating. To offset this, there is a scheme under which the government can subsidise 60 per cent of the construction cost in 10 year instalments starting one year after the new line opens.

However, due to the fact that the sums actually appropriated for this purpose continually fall short of demand, we have not as yet been able to take full advantage of such subsidies.

Yet the demand for new line construction grows stronger every day. Faced with this dilemma, we are planning to ask the government for more effective construction assistance through a profit sharing scheme, and some means of deriving benefit from related property development.

*Fitting out a bored tunnel lined with bolted concrete segments to ensure integral stability in poor ground*

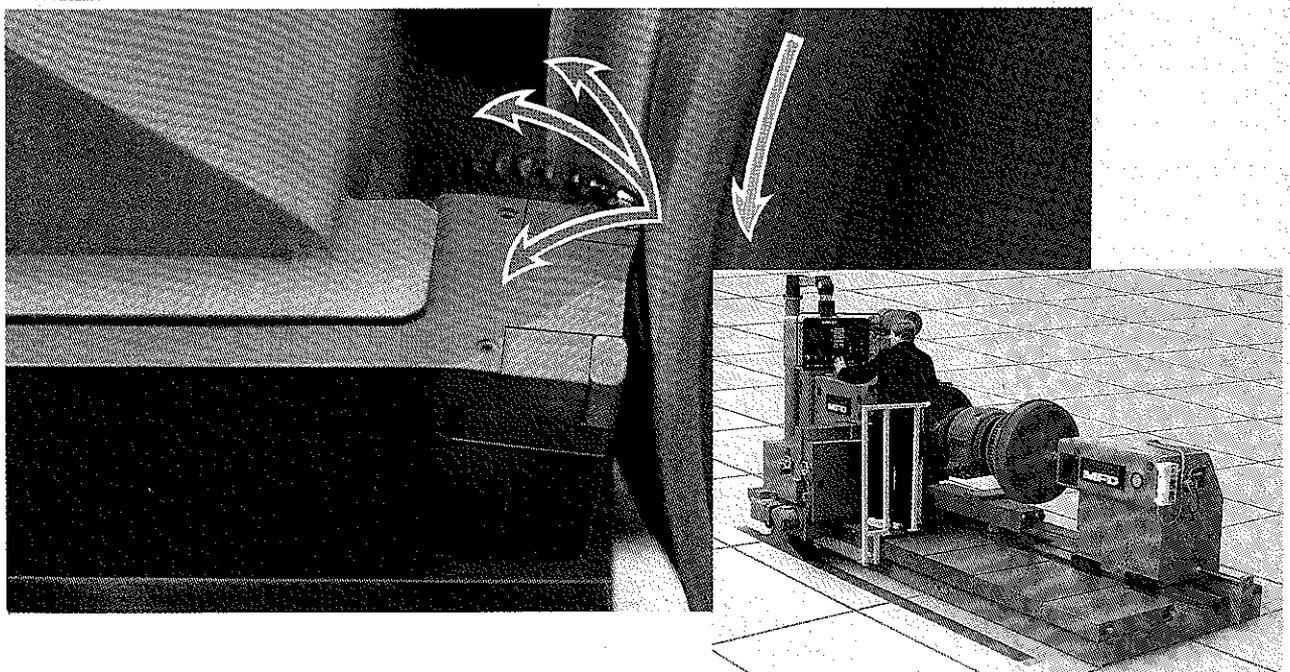
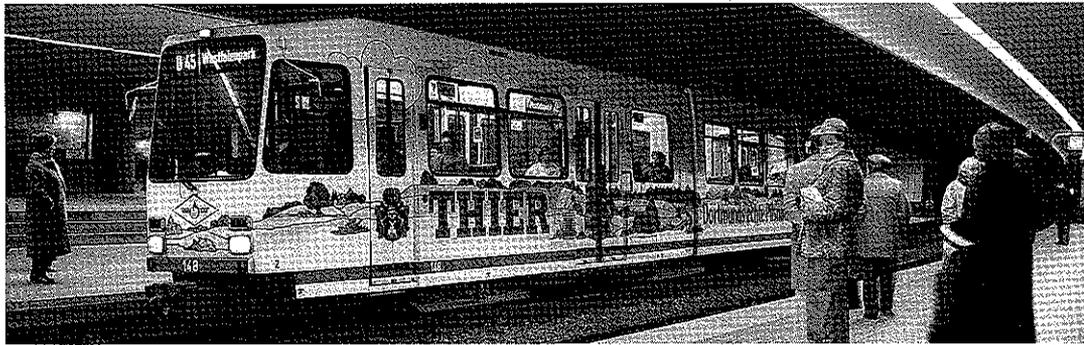
At the same time, as a means of upgrading and enhancing healthy management, we intend to strive not only to increase operational efficiency, but also to attract more people to travel off-peak, make timely revisions in fares, and otherwise implement improvements deemed necessary. In addition, we will seek to expand in related businesses as well. In these and other ways, the TRTA will continue to fulfill its role as Tokyo's most important urban transport operator. □

*Below left: Mitsukoshimae station will be the starting point for a planned extension to Sumiyoshi*

*Below: A Series 03 train on the Hibiya line*



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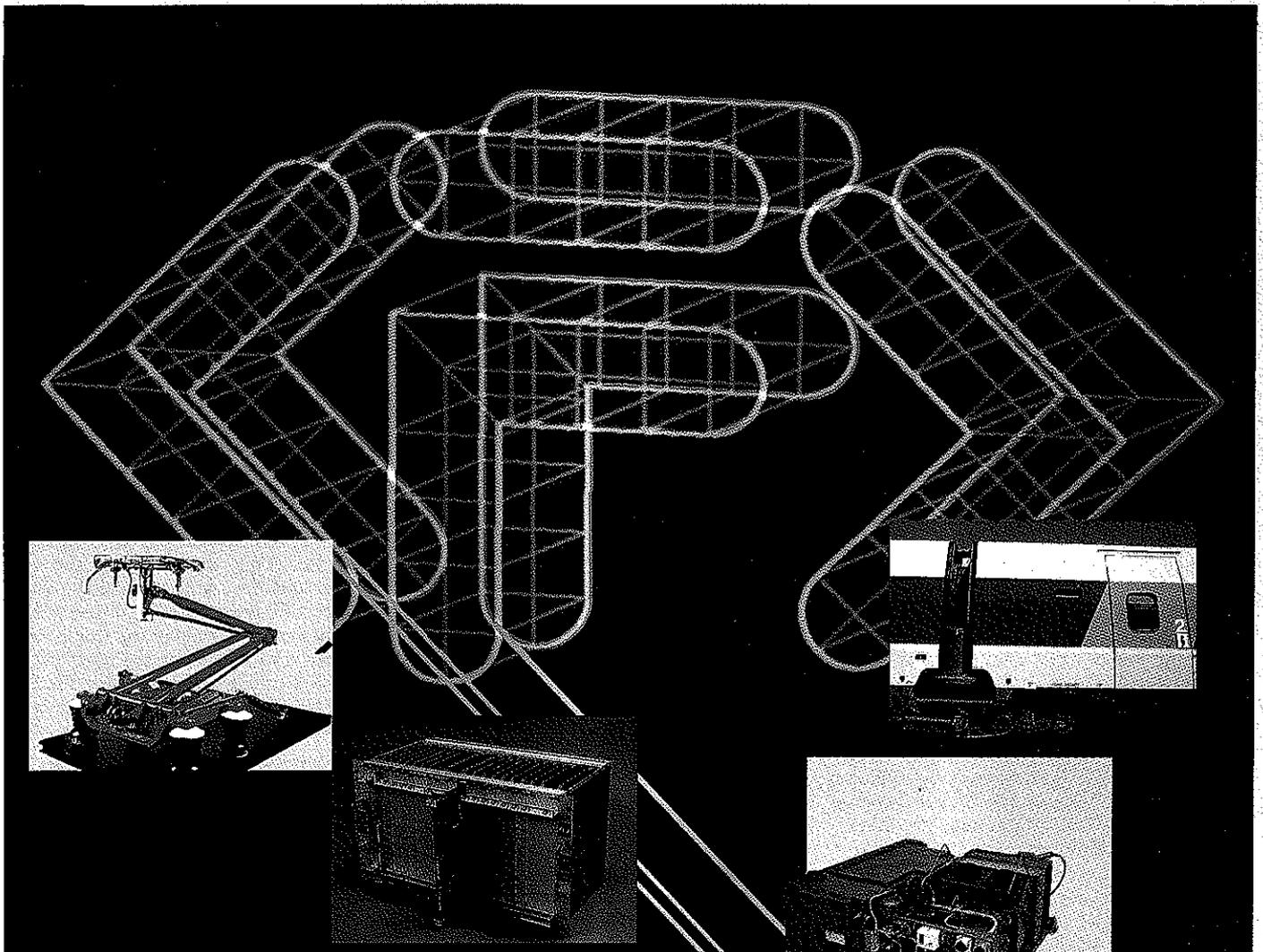
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# TORINO PREPARES TO

AT THE END of February this year Torino Transport presented to the press the prototype of a fleet of 54 light rail cars that will raise comfort standards on parts of the city's 100 km tram network. Not only do these stylish 1 445 mm gauge cars represent a dramatic improvement for our passengers, but they also foreshadow the start of a long-planned project to build two premetro lines. The cars will initially run as a dedicated fleet on existing tram routes, but later they will form the backbone of the premetro service.

Within the next few months we expect to call bids for construction of Lines 1 and 4 which will eventually run from west to south and north to south respectively across the city. Both routes will be mainly in tunnel, but only the central area tunnels will be built to start with; in the suburbs both routes will have segregated alignments.

Outline agreement for the scheme was reached last July, and now we are carrying out preliminary design work. Detailed engineering design will begin once we have received the final go-ahead from the municipality of Torino.

The 23.2 km Line 1 will run from Rivoli in the west, mainly following the Corso Francia, as far as Piazza Statuto. Here it will swing sharply south along the Corso

*Fiat and OMS are building 54 of these Series 5000 aluminium-bodied LRVs, which have a centre section where the floor height is only 350 mm*



**Dipl-Ing Pierluigi Gentile**  
Planning Director  
Torino Transport

Bolzano past Italian Railways' Porta Susa station to the Corso Vittorio Emanuele, where it will turn southeast. It will continue along this busy thoroughfare past the FS terminus at Porta Nuova before turning south to follow the Via Madama Cristina and the Via Nizza towards Nichelino. The alignment of the Via Torino will be used for the final section to the terminus at Nichelino FS station.

Line 4, which is 16.2 km long, starts in the northern suburb of Falchera from where it runs south to the FS station at Stura. It

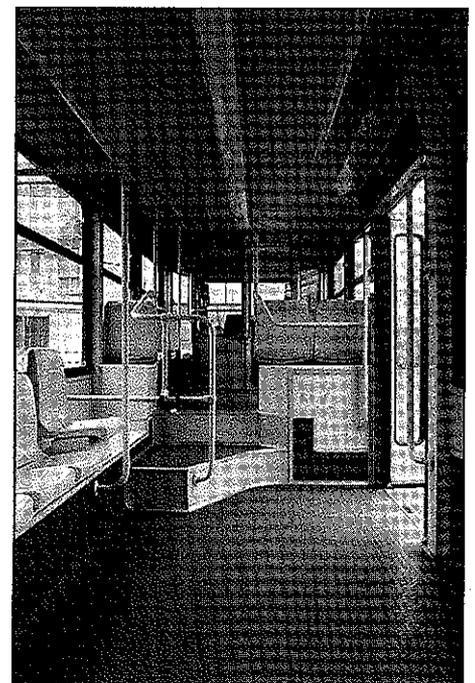
then heads southeast towards the city centre along the Corso Giulio Cesare, crossing the Stura river on the way. Passing under the Corso XI Febbraio, it reaches Piazza Castello and then runs along the Via Roma to pass close to Porta Nuova station. The route from here lies along Via Sacchi, Corso Turati and Corso Unione Sovietica. It crosses the Sangone river before reaching the terminus at Mirafiori Sud.

A separate project exists to build Line 3 from Le Vallette in the northwest suburbs to Piazza Hermada on the east bank of the River Po. This would follow the Corso Toscana before swinging south past the Amadeo di Savoie hospital. From here the route lies southeast along the Corso Regina Margherita to pass along the northern edge of the city centre before crossing the Po on the Corso Gabetti bridge. Only the central section would be in tunnel.

## Phased construction

The present scheme envisages phased construction of Lines 1 and 4. The first stage covers a 4.5 km section of Line 1 in tunnel from Bernini to Porta Nuova together with a 6.4 km section of Line 4 from Magellano to Derna. Between Derna and Falchera another 2.8 km would be at grade and 1 km on elevated alignment. At the same time the existing tramway alignment from Massaua to Bernini and from Caio Mario to Magellano would need to be upgraded to allow light rail cars to use it.

A later stage would see another 13 km of tunnel completed on Lines 1 and 4, together



# GO UNDERGROUND

with construction of an underground link at Piazza della Repubblica with the projected Line 3. The final phase would entail more civil engineering work to segregate fully the routes to Nichelino and Rivoli.

Considerable effort will be made to provide good interchange at the two main stations in the city, and also with FS local services in the suburbs. Easy connections with the Torino - Ceres Railway at Porta Milano and with other tram and bus routes are another priority.

Both premetro lines will be built to carry up to 14 000 passengers/h in each direction. Electrification at 650 V DC overhead will be compatible with the present tram routes, but the catenary design allows for uprating to 750 V.

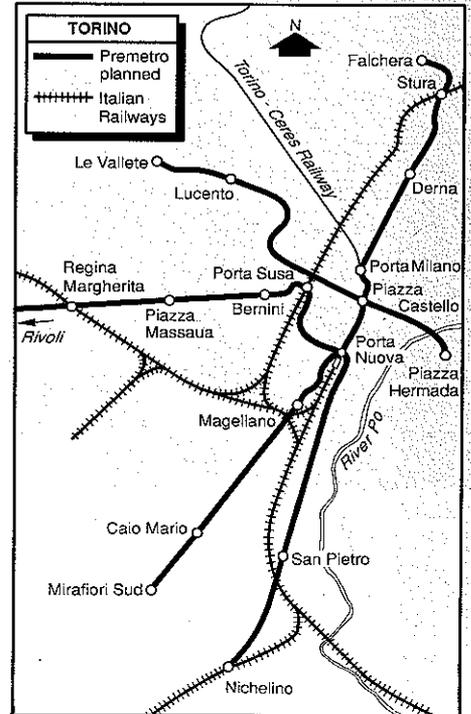
Minimum curve radius has been set at 1 000 m and steepest grade at 4 per cent. We are proposing to adopt the track design successfully used in Wien where sleepers enclosed in rubber sleeves help to absorb noise and vibration. With track centres 2.9 m apart, internal diameter of a bored double track tunnel would be 7.3 m; cut-and-cover sections would be 7.4 m wide.

On the assumption that work starts in 1990, completion of the first phase is envisaged by 1996 at a cost of 1 150bn lire.

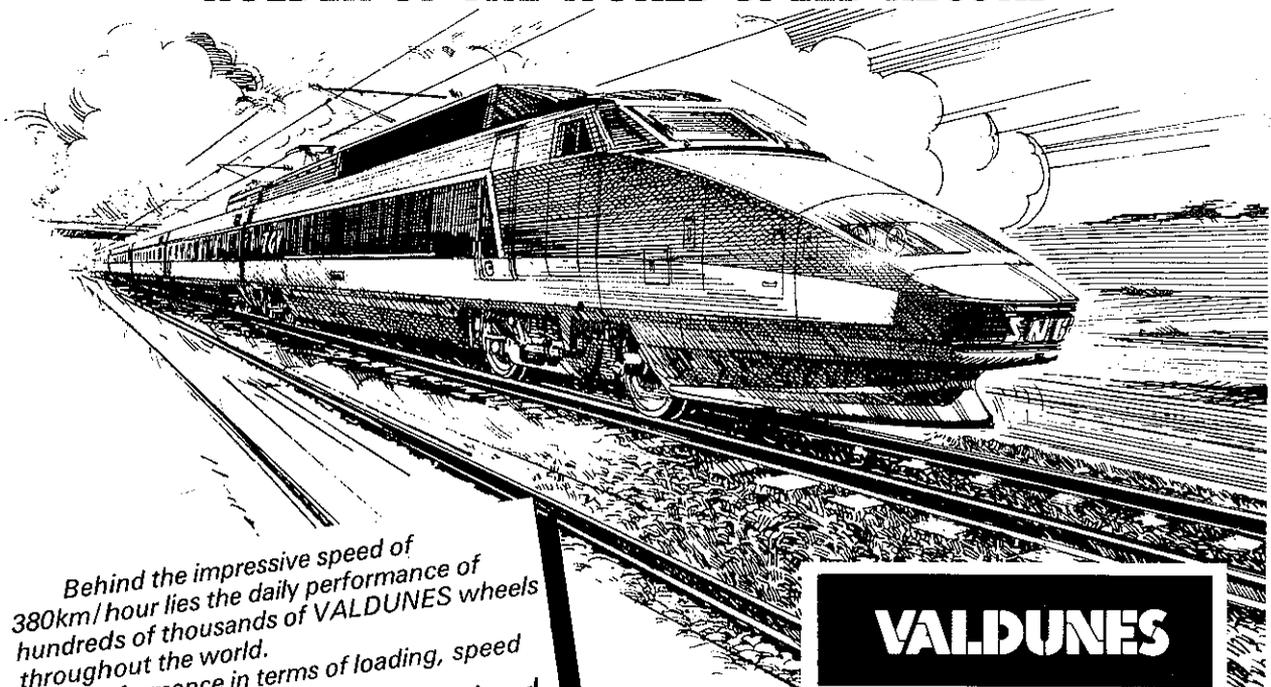
## Rolling stock

The 54 light rail cars of Series 5000 being built by Fiat Ferroviaria and OMS have a 12.4 m centre section where the floor is only 350 mm above rail top. This has been achieved thanks to Fiat's independent wheel bogie design with 680 mm diameter wheels. This novel bogie supports the articulation section which has five inward facing seats on each side. A further 41 seats are provided, and there is standing room for 129 passengers at a density of 6/m<sup>2</sup> in a car length of 22 m. The four 1 200 mm wide doorways are all located in the low-floor section.

The two main car sections each have their own chopper control for the single motor in each power bogie. Static converters with freon-cooled GTO thyristors and other electrical equipment are being supplied by Ansaldo Trasporti, although the ELO 2245 traction motors are being provided by TIBB. Average acceleration up to 35 km/h is 1 m/s<sup>2</sup> and maximum speed is 60 km/h. □



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# WASHINGTON NEARS



**Carmen E Turner**

General Manager, WMATA

THE LAST YEAR has seen a dramatic increase in traffic for Washington Metropolitan Area Transit Authority (WMATA). In August 1988 Metrorail carried its one billionth rider. The 136.7 million passenger-journeys in 1988 were 7.6 per cent up on 1987 — and that during a period which saw no extensions opening.

Contributing to this growth was Metro-rail's rigorous, yet simple, anti-graffiti programme — cars do not enter service with graffiti in or on them. Graffiti in stations is removed within 24 h, as we have found that graffiti generates graffiti. When a car is in service, employees at terminal stations pick up trash and clean up spills or messes. At night, an inspection team vacuums and spot cleans. Every 60 days, each car receives a 'spring clean' which includes carpet shampoo and hand washing of walls, ceiling, windows, lights and seats.

An aggressive and imaginative promotional campaign during 1988 was backed by reliable, on-time service achieved through a preventive maintenance policy that in two years saw the average distance run by each car between service interruptions jump by 36 per cent from 49 400 to 67 400 km.

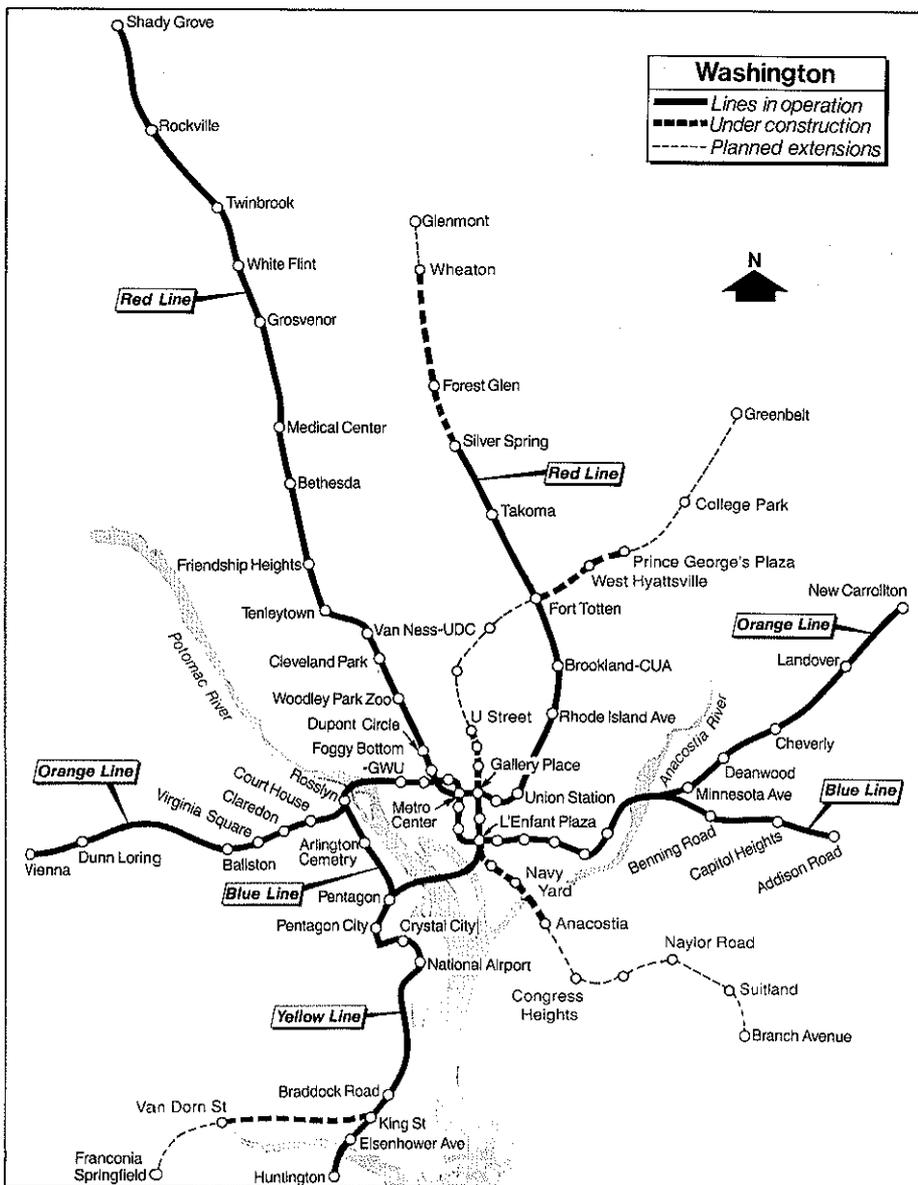
These service qualities also won recognition from North America's transit industry. The American Public Transit Association (APTA) presented WMATA with the Public Transportation System Outstanding Achievement Award for 1988.

## Network completion

With 113 km and 64 stations now in operation, WMATA looks forward to completing the planned 166 km network with 87 stations. One of our top priorities for 1989 is Congressional reauthorisation of funds to complete the last 14 km of the 166 km network — the section of the northern Green line from U Street to Fort Totten and the southern section of the same line from Anacostia to Branch Avenue.

Design and construction continues on 31.4 km. Much effort in the past year has concentrated on Navy Yard and Anacostia stations on the southern Green Line. WMATA also awarded contracts for work at Fort Totten, which will be an interchange with the Red Line, and continued work at West Hyattsville and Prince George's Plaza on the northern Green Line. The section from Prince George's Plaza to College Park and Greenbelt has reached the final design stage and is due to open in late 1993.

Construction continued on the King Street — Van Dorn Street section of the Yellow line, which should open in 1991. Engineering



# NETWORK COMPLETION

design is in hand for the short stretch from Van Dorn Street to Franconia-Springfield. Finishing work is under way at Forest Glen and Wheaton on the northern extension of the Red Line which is to be commissioned in September 1990. The final section to Glenmont is also in engineering design.

## Reliability and safety

To enhance reliability, we began a winterisation programme in spring 1987. As well as installing point and third rail heaters, we are modifying rolling stock to provide further protection against snow and ice.

Despite our good safety record, we are improving safety in corridors we share with interstate railroads operating long-distance freight and commuter trains. For example, we are implementing the recommendations of a committee formed after two major freight derailments in 1987. These caused considerable damage to WMATA's right-of-way, but fortunately caused no injuries.

We are also exploring new technology to increase productivity and improve efficiency; although people must remain ultimately in charge, computers and micro-

processors support them in the trains and in the Operational Control Center. In the OCC are three Telefile T-85 computers; one to manage train control and a second as on-line backup. The third, with less memory, is used for software development, testing, or as an emergency replacement.

The Automatic Train Control receives real-time data from remote terminal units which are sampled once a second. Of the 28 000 status points sampled by the OCC every second, 15 000 cover circuit breakers, points, signals and other equipment. Field data is routed to communications equipment which pre-processes it for the main computer. The T-85 monitors equipment status throughout the network and sends back messages from the OCC supervisors to control points, signals and train speeds, as well as peripheral plant. Real-time information for OCC staff is passed to 36 high-resolution monitors located in six consoles.

## Rolling stock

Technical advances have also seen changes to the rolling stock since we ordered the first of the fleet. The first 300 cars, built by Rohr

Industries of California, had camshaft-controlled traction equipment. The second batch of 366 cars was supplied by Breda Costruzioni Ferroviarie of Italy; most of these have chopper control with full regenerative braking. They also have 12 fewer seats to allow space for more standees, bringing the nominal car capacity to 187.

## Fare collection

WMATA has been in the forefront of AFC technology. Each item of equipment — be it an entry or exit gate, a fare card vendor, Addfare machine, or part of the enhanced data acquisition and display system (EDADS) — has microprocessors to control, monitor and diagnose its operations. The gates and fare card vendors achieve more than 98 per cent availability during the morning and evening rush hours.

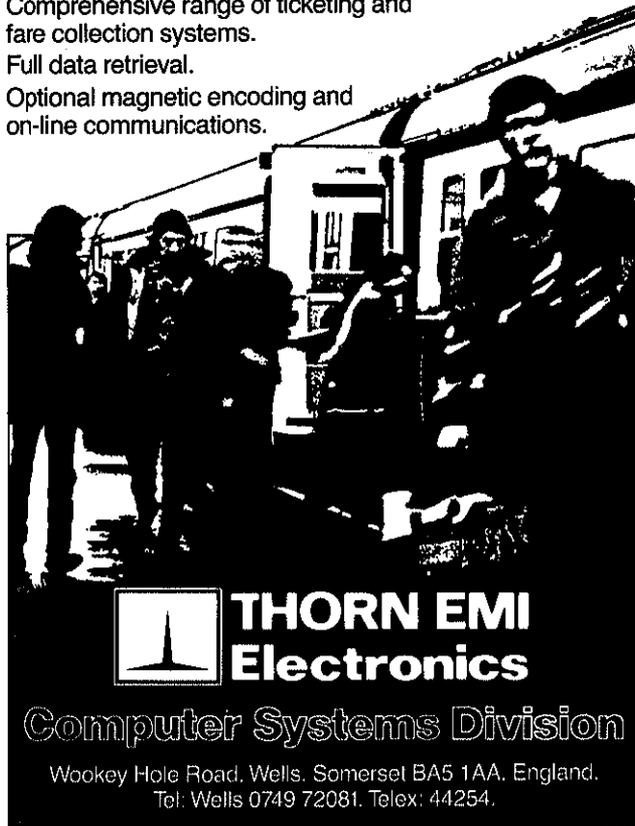
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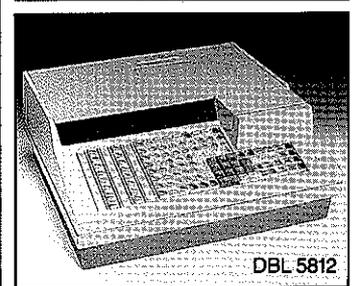
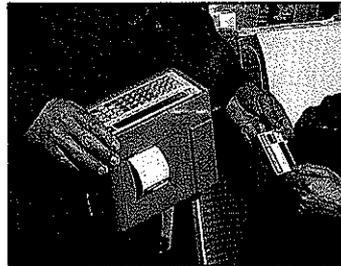
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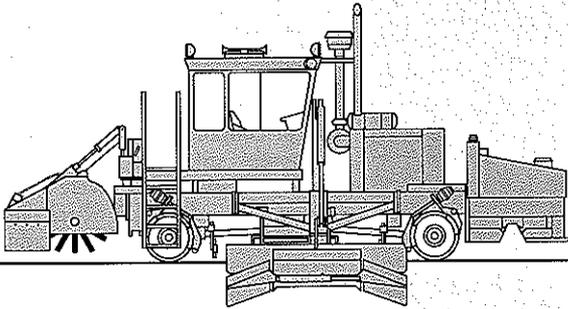
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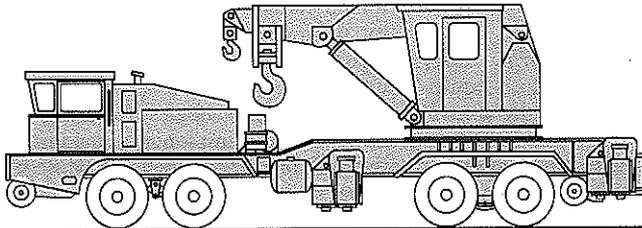
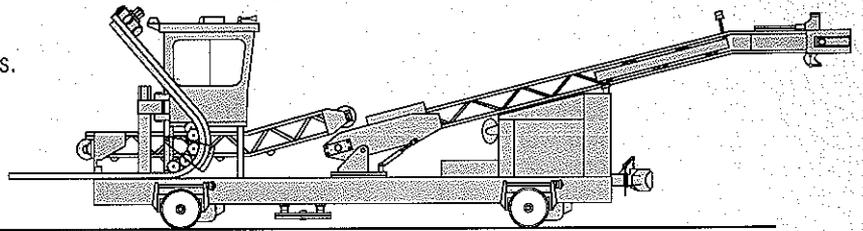


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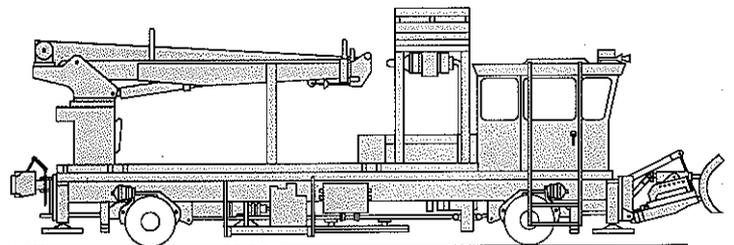


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# WIEN SEEKS ECONOMIES

AROUND 200 million journeys are made every year on the 32 km U-Bahn in Wien. Comprising Lines U1, U2 and U4, this is the core network which the city council approved in 1968. In 1980 the council decided to proceed with a second phase of construction consisting of Lines U3 and U6.

Line U6 will comprise the former Stadtbahn which runs from Heiligenstadt at the north end to a temporary terminus at Gumpendorfer Straße, just south of the Westbahnhof. This will be extended in October this year to Philadelphiabrücke. Present plans call for the light rail service from there to Siebenhirten to be modernised so that it can be integrated with the rest of the route to form the southern end of U6.

For the next two decades Line U6 will be worked by formations of Type E6 light rail cars and their matching C6 trailers built in 1979-84. The present formation is motor-trailer-trailer-motor, but it will be possible to insert an extra E6 motor car between the two trailers if demand should warrant it.

Line U3 is conceived as a through east-west route, and the first section from Erdberg to Volkstheater is due to open in March 1991. It will be extended westwards to reach the Westbahnhof in 1993, and to the terminus at Ottakring in 1996. When finished, Line U3 will have 17 stations. We have decided to order an initial fleet of 45 two-car trainsets for this line.

## Rolling stock

In drawing up the specification for these trains, our experience with the existing fleet had to be considered. To work the present service 121 out of 145 two-car sets are needed, and each runs an average of 84 000 km a year. Design of the U3 trains called for lower maintenance costs, lower energy consumption, and higher availability.

The exterior styling and bodysell were



**Dipl-Ing P Lehotzky**  
Chief Electrical &  
Rolling Stock Engineer  
Wien Transport Authority

to be retained, but all electrical equipment was to be able to withstand a 1 h thermal overload. Regenerative braking was specified to cut energy consumption and to help reduce emission of waste heat in the tunnels. Electromechanical switching had to be avoided in the power circuits, and sensitive electronic and electrical components had to be fully sealed against the warm, dusty tunnel environment. Fault diagnosis equipment was to be integrated with the control and power circuits.

Nine prototype sets with three different types of bogie were built by Simmering-Graz-Pauker for trials. Bodies are 140 mm longer to accommodate behind the cab a dustproof module with a heat exchanger to protect the electronics. The air flows for heating and ventilation have been separated so that the heating air flow can be reversed in the summer to double the amount of fresh

air blown into the car. Other changes include polycarbonate light diffusers and silicon based seat foam to improve resistance to fire.

Bogies on the existing fleet have a single longitudinally mounted motor driving both wheelsets, effectively forming a rigid mechanical coupling, with the wheelsets having relatively stiff axle guidance using Megi springs. This led to severe wear problems, especially on Line U2 where there are many curves of 100 to 190 m radius. Various techniques were adopted to reduce the wear; these included widening the gauge slightly on the curves, using a new wheel profile with higher conicity, hardening the rails by welding on a special hard steel, as well as installation of rail lubricators. These measures allowed the tyre life to be extended to around 250 000 km, but this was still considered too low.

The wheelbase of the three prototype designs was reduced from 2 100 to 2 000 mm and individual drive from a three-phase asynchronous motor to each axle was provided to ensure mechanical decoupling. Five of the prototype sets had a conventional bogie design supplied by SGP with less stiff axle guidance, again using Megi springs. Two sets received Duewag built bogies with forced radial steering of the axles achieved by using the rotation of the bogie frame relative to the car body through a system of links. The other two sets were fitted with Plasser-Scheffel bogies featuring a Watts linkage to transmit longitudinal forces across the soft primary suspension while allowing radial steering of the axles.

A programme of trials was drawn up. This embraced a lengthy period of running in revenue service on the sinuous Line U2 to allow comparison of all three designs with existing bogies. The tests also included dismantling the bogies to ascertain how they fitted in with workshop disciplines.

The conventional bogie design offered an 11 per cent reduction in flange wear resulting from the steering effect of the softer axle guidance. On the other hand, measurement of the angle of attack in sharp curves revealed that there were frequent incidences of wheelsets being poorly aligned. Both the designs with radial steering showed a 25 per cent reduction in flange wear.

One series of tests covered measurement of the forces exerted at the same speed by the three types of bogie on the outer rail of a 100 m radius curve. Whereas the vertical forces exerted by all three types fell within the same range, there were substantial

*The 45 two-car trainsets for Line U3 will be based on nine prototype sets with three-phase-motors*



# THROUGH TECHNOLOGY

differences in the horizontal forces. The Plasser-Scheffel bogie with self-steering axles gave rise to slightly lower forces than the design with forced radial steering. The forces exerted by the old bogie were around 30 per cent higher, whereas those produced by the 'new' conventional design with relatively stiff axle guidance were higher still. We therefore decided to adopt the Plasser-Scheffel design with radial self-steering.

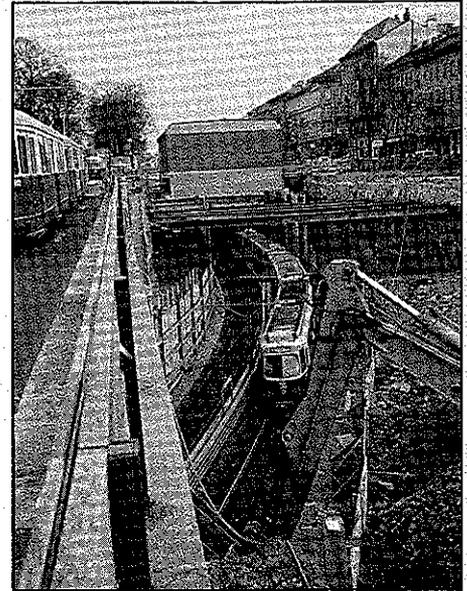
Traction equipment on each car is identical, with chokes and capacitors laid out symmetrically. Each car has its own power converter, to which the four sealed water-cooled traction motors are connected in parallel. The converter is laid out as a two-quadrant controller with an intermediate DC circuit. The arrangement allows use of electric braking almost to a standstill.

The power electronics are microprocessor-based with a control unit located in each car. Fault monitoring and logging is carried out automatically and fed to a data recorder so that information about the status of equipment at the instant of failure is retained; this can be bled off to a printer in the workshop.

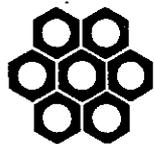
A second microcomputer system is overlaid for train control and fault reporting. On one car it also monitors the functional operating equipment as well as the position of control handles and switches. As the cars have to be able to run in multiple with older vehicles, the commands are carried on separate circuits. If only new cars are coupled, fault reporting uses a 1 200 baud 110 V train bus.

Three failure categories are identified: train can still operate in passenger service, possibly with emergency repair; train can run empty to depot after emergency repair; train is only able to run under special conditions even after emergency repair and must be shunted out of service.

We are satisfied that the tests carried out to date have shown that the design changes on the future U3 car fleet will bring the anticipated improvements. Use of the latest power electronics, traction and braking equipment will allow energy consumption to be reduced by an average of 35 per cent. We expect wheelsets to remain in service without attention six times longer than those used on the present fleet. □



*Line U6 is being created by reconstructing and extending the existing Stadtbahn; here it is being diverted through a new U-Bahn interchange station at Westbahnhof*



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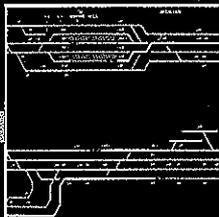
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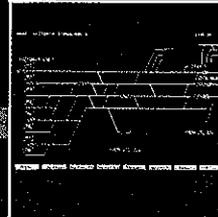
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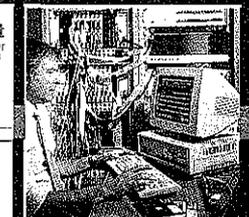
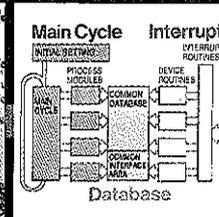
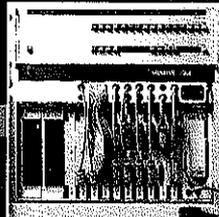
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# ZÜRICH OPENS CITY LINK

THIS MONTH sees the opening of Swiss Federal Railways' Hirschengraben tunnel across the centre of Zürich, a pivotal step in the reconstruction of the city's rail network. To be used initially by trains to Rapperswil (below), the cross-city link between Hauptbahnhof and Stadelhofen will form the core of the network of S-Bahn services which begin running in May 1990.

In the last 30 years personal mobility in Switzerland has increased sixfold. Over the same period road traffic's share of the Swiss transport market has risen from 50 to 83 per cent — not least because road investment has consistently been five times that for rail.

Despite this, the number of train journeys per head of population in a year is high; on average, the Swiss travel by rail 44 times each year, whereas their European neighbours make from 7 to 23 trips. Only the Japanese, with 66 journeys a year per head of population, use trains more often.

Shortage of land and energy, environmental damage and noise pollution have led to a recognition in Switzerland that the market share of public transport should grow again. Special low fares and more frequent services — forming part of a federal clean air strategy — have produced a 10 to 15 per cent rise in rail travel in the last three years. This has pushed SBB's ability to handle the extra traffic to the limit, and we can no longer keep pace with demand. What is more, our hands are tied by a government performance contract that only provides an hourly service on regional lines. Extra trains must be arranged and funded by the cantons.

Around 40 to 50 per cent of SBB's regional

**Dipl-Ing Fritz Kühni**  
S-Bahn Project Manager  
Swiss Federal Railways

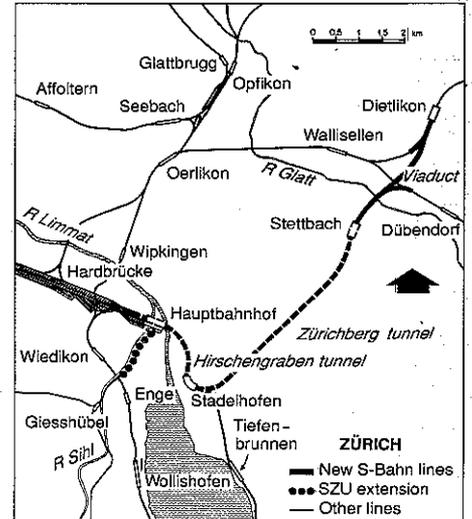
traffic originates in the canton of Zürich, which is home to one-sixth of the population. Hourly services are quite inadequate, so in 1981 the canton decided to create a 380 km S-Bahn network, mainly using existing lines, with half-hourly services on all of them.

### Costs shared

Under the terms of SBB's contract, the canton is paying 80 per cent of the SFr740m cost (1980 prices) of an 11.5 km new line under the city centre, which forms the heart of the network. It will also pay the extra operating costs not covered by fares revenue. SBB will pay the other 20 per cent of the new line costs in return for the extra capacity that it will release in Zürich main station — from 1990 there will be 20 tracks handling 1 800 trains a day compared with 1 100 on 16 tracks at present. An agreement between the canton and SBB provides for joint decisions on construction, on the type of rolling stock and the timetable.

The new line runs from Dietlikon and Dübendorf mainly on viaduct to Stettbach at the foot of the Zürichberg, and from there a 5 km tunnel continues to Stadelhofen, a station located between two tunnels on the busy suburban route to Rapperswil.

The Hirschengraben tunnel from Stadelhofen to the four new underground platform tracks at the main station was by far the most difficult to build. It runs under the old



city and the Limmat river, requiring special construction methods in tricky geological conditions. Proximity to ancient buildings and busy narrow streets posed all manner of technical and legal problems, and around 20 per cent of the construction budget had to be devoted to design and planning.

Most of the excavated spoil was removed by train. This was not cheaper for the contractors, but it did ensure that the city was spared the aggravation of tens of thousands of lorry trips. The construction schedule has been maintained, and finishing work including alterations to platforms and other structures is now in hand on the rest of the network ready for the start of services on May 27 1990. The canton is spending



## Developing Metros 89

SFr330m on this work during 1989.

Services will run at 30 min intervals for 19 h a day. No frequency reduction is planned outside the peaks, as one objective is to attract more shopping and leisure traffic, of which over 50 per cent now goes by car. Extra trains will run during peak hours, some as limited stop services, others to towns outside the S-Bahn network.

The demographic structure of the greater Zürich area generates a number of traffic flows which do not cross the centre, so the planned timetable provides for trains from each corridor to give good connections to the half-hourly or hourly long-distance services. Connections are also provided at the outer ends of the S-Bahn lines, and between different S-Bahn routes to permit transverse journeys across the region.

S-Bahn services will operate on a closely-knit network of single and double-track lines with few grade-separated junctions. Around 75 per cent of the tracks are shared with inter-city, express and freight trains. The complex operations will be regulated from a new control centre where timetable performance will be monitored. Regulating staff will

be in constant touch with signalling staff and by radio with the trains.

From the start it was clear that the core of the S-Bahn services would be provided by new trains, although some rakes of up to 12 loco-hauled coaches will be retained to work extra services in the rush hours; the operating problems of slower running were outweighed by the advantage of being able to use the motive power for other purposes.

Requirements for the new stock were rapid loading and unloading, high rates of acceleration, and plenty of seats to ensure that comfort standards were sufficiently high to attract traffic from roads.

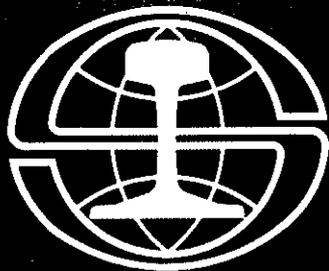
On the basis of lowest capital and annual operating cost per seat, a 100 m long double-deck trainset offering 387 seats (plus 12 fold-down seats) was the best option. Each set will be formed of a power car rated at 3 200 kW with a luggage compartment, a second class trailer, a composite trailer and a second class driving trailer. Up to three sets can be coupled automatically and operated in multiple to give a capacity of 1 200 passengers, all seated. The Schindler double-deck cars are closely modelled on the

Netherlands Railways design; roomy vestibules over the bogies have sliding-plug doors giving an opening of 1 900 mm.

Ventilation equipment will renew the interior air 60 times/h and disc-braked bogies with air suspension will give a high quality ride. A fleet of 24 sets will be available on opening, but will be doubled by 1992.

To coincide with the launch of the S-Bahn the canton is introducing a common fares policy for the Zürich region. A simple tariff structure will be introduced, with tickets also valid on inter-city services. The operating deficit will be shared by the government (50 per cent), canton (25) and local communities (25). As part of the deal an hourly public transport service will be provided to all communities with at least 300 inhabitants, meaning 40 per cent more departures from the 1 700 stations and stops in the canton. Seat-km will rise by the same proportion where S-Bahn services replace other trains.

Public transport improvements will help the canton of Zürich meet government requirements for the introduction of measures to reduce air pollution, and the S-Bahn will play a leading role in this process. □

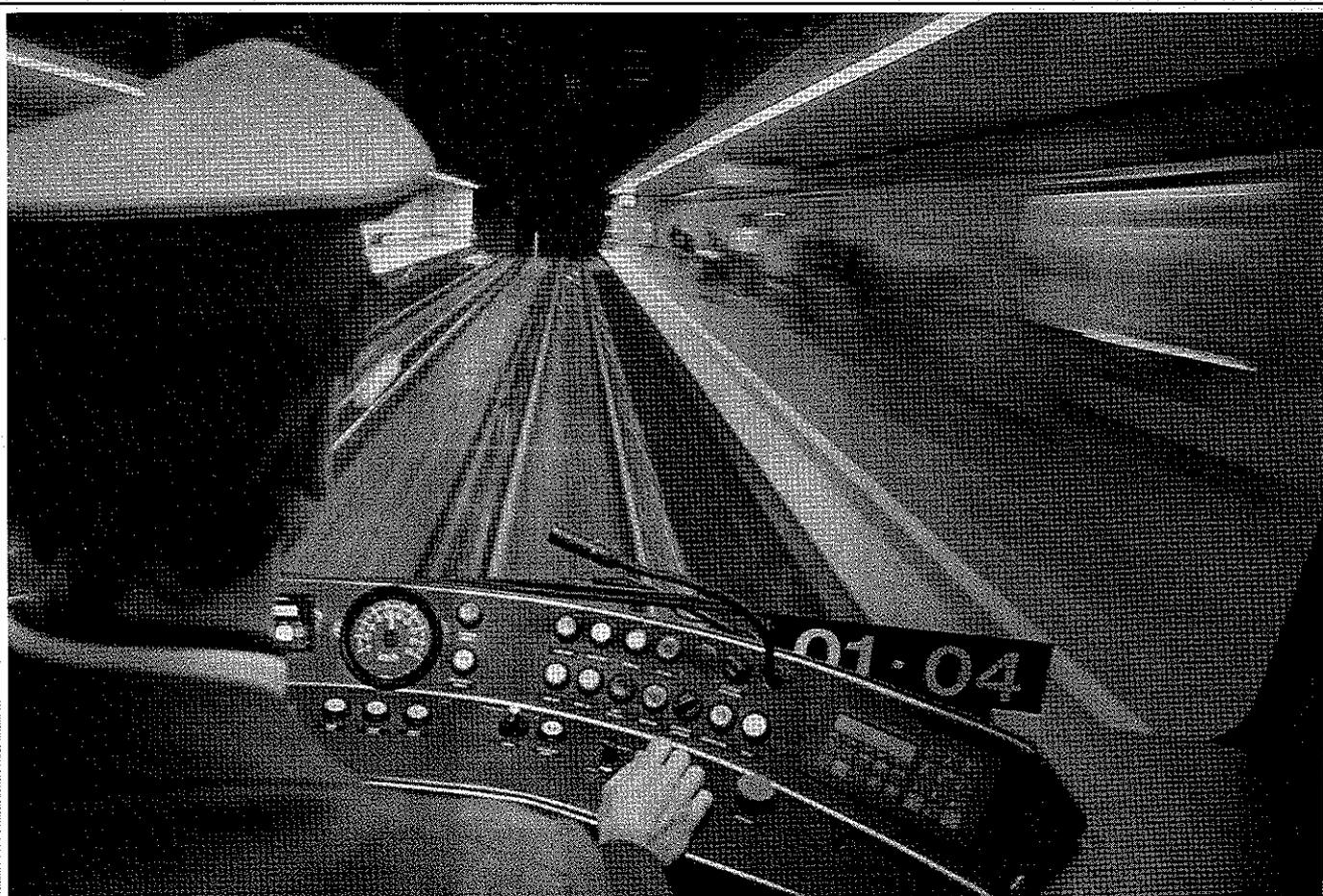


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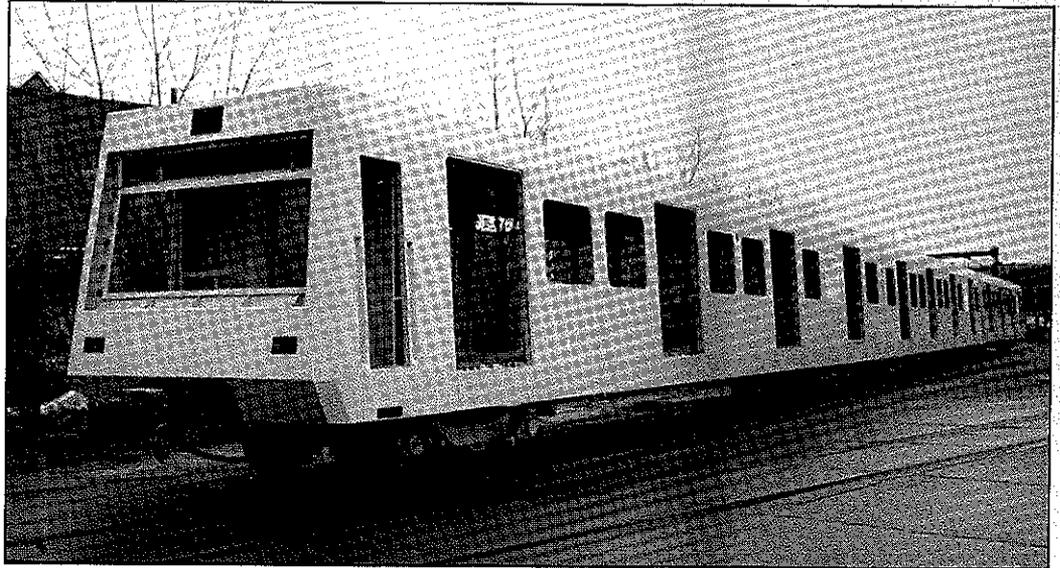
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# MARKET PLACE 89

IN PROSPECT over the next few years are orders for several thousand metro, commuter and light rail cars. Big metro projects are getting under way in Taipei and Shanghai, major expansion has been mooted in Beijing, and the four-line scheme in Tehran has been revived. Established metros are also starting to replace fleets of 1950s built stock.

Among the most innovative metro stock is that just ordered for Paris where the first Boa metro trains with steerable axles and full-width articulation sections are to be supplied by ANF-Industrie (Express Enquiry Form No 100). Self-steering axles to minimise flange and rail wear are also a feature of the Plasser-Scheffel (100) bogies being fitted to a fleet of 45 two-car units with water-cooled three-phase traction motors on order from SGP (101)



for Line U3 in Wien.

Given a tradition of conservative design, something less sophisticated is likely to be ordered for the 85 eight-car

trains needed to replace ageing stock on London Underground's Central line. This order will be followed by another 650 cars for the

Northern line. Contracts for up to 1 120 Networker cars for British Rail's Network SouthEast sector are still outstanding.

Maximum capacity remains a priority for suburban and commuter operators, and double-deck cars are being built for Zürich (Schindler, 102), Madrid (Ateinsa, 103), and Toronto (Lavalin-UTDC, 104), while Netherlands Railways' Talbot (105) design is being tried on the München S-Bahn. In the USA a trial batch of 10 double-deckers is on order for Long Island Rail Road from Comeng (106), Mitsui (107) and Tokyu Car (108), while MBTA of Boston has placed a contract for 75 with Kawasaki Heavy Industries (109) and Nissho Iwai Corp (110).

Developing countries are demanding that more manufacture and assembly work is carried out locally, and a number of suppliers have already sewn up technology transfer deals enabling quite sophisticated vehicles to be

## BUDAPEST SHOW DRAWS EAST AND WEST

THE EXHIBITION being staged at the Hungexpo Exhibition Park with the 48th UITP Congress in Budapest has attracted suppliers from both east and west. To be opened on June 12 by Hungarian Minister of Transport Mr Lajos Urbán and UITP President Ingemar Bäckström, it will provide visitors and delegates with an insight into many aspects of urban railways.

Over 30 railway equipment suppliers from the west are planning to be present, while traders from the east include local manufacturer Ganz, part of Ganz-Hunslet Holdings, and Kismotor-és Gépgyar, which in conjunction with SZIM MachineTool will be showing a range of air brake equipment, windscreen wipers and horns.

Belgian suppliers include BN Constructions

Ferrovaires et Métalliques which will be showing models of its hybrid GLT vehicle and of trams it is building for the Amsterdam - Amstelveen line, as well as an impression of the Docklands Light Railway cars to be built under subcontract to Hawker Siddeley. Alstom-owned ACEC has also registered interest, as has Automatic Systems. The Amstelveen cars will feature the Philips Vecom management and control system developed as a successor to Vetag train identification equipment used in Den Haag and on the Tyne & wear metro. Philips sees Vecom as part of its Transmation package which provides and maintains flows of information throughout a public transport network.

Among German suppliers to be represented are Knorr Bremse, Krone, MAN, MBB

and Siemens.

The Swiss contingent trading under the Swissrail banner is to include Ascom-Favag, Ascom-Radiocom, Sécheron, Sodeco and Von Roll Transport-Systeme; the German-Swiss-Swedish giant ABB also plans to be present. From Italy Ansaldo Trasporti, Socimi and Lovere plan to attend.

Fare collection equipment to be shown will include exhibits by Almex of Sweden, Scanpoint of Denmark, Camp/CGA, Scheidt & Bachmann, Prodata and Schlumberger, which will show visitors its Transpuce smart card now being tested in Paris; Établissements George Klein et Cie also plans to take space. Other railway equipment suppliers at the show include Brel, Isringshausen, Luminator and SAB-Nife.

*Top: MAN-GHH of Nürnberg has completed the first bodysells for the Aburra Valley metro in Medellín. Before shipment to Colombia, they are being fitted out in Spain by Ateinsa*

## Developing Metros 89

produced in the Third World. Semaf (111), for example, has built cars for the Cairo regional metro, and CNCF (112) in Mexico is supplying LRVs for Guadalajara.

The first metro cars for Medellin have left the West German shops of MAN-GHH (113) for fitting out by Ateinsa (114) in Spain, and Breda (115) of Italy plans to complete the first of 30 cars with ABB (116) electrical equipment for the Los Angeles metro later this year; it has an option for a further 42 cars. Breda is also sharing contracts with Fiat Ferroviaria (117) for cars to be built for Lima and Bogota.

The number of cities contemplating light rail means that there is considerable potential for contractors willing to accept small orders. Standard designs such as those by Siemens (118) and Duewag (119) should suffice for many cities, but the attractions of the rapidly proliferating low-floor designs, now offered by Linke-Hofmann-Busch (120), Alstom (121) — now merged with GEC (122), ACMV (123), Socimi (124) Firema (125) and Fiat (126) may prove irresistible. In several cities such as Nantes, capacity and accessibility of existing vehicles will be raised by adding a centre section with a low floor.

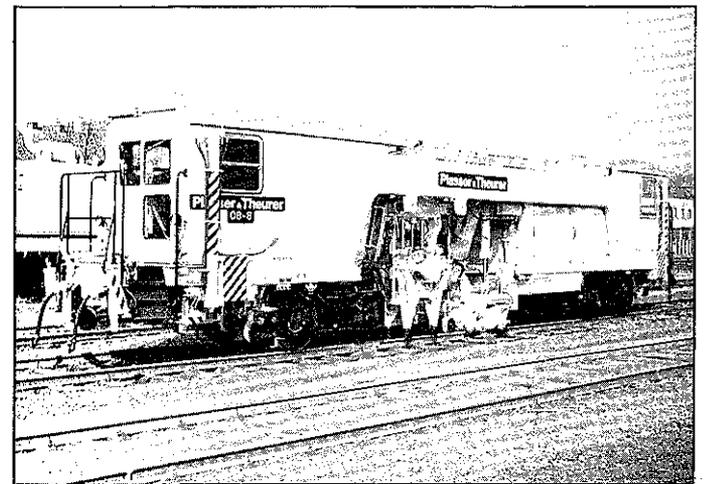
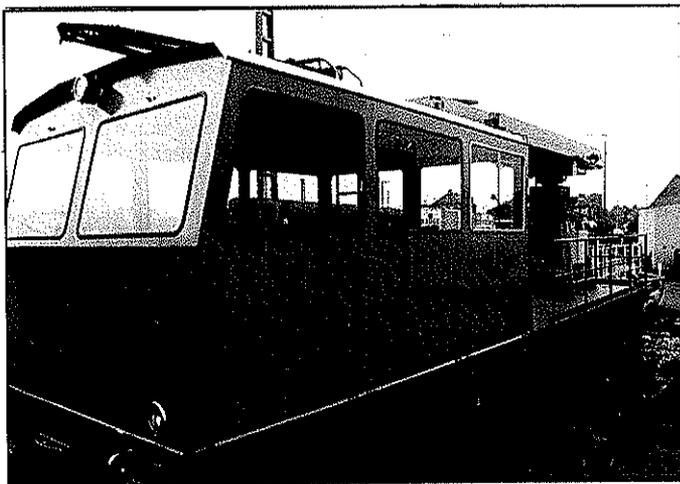
The next batch of automated cars for the Docklands Light Railway is being supplied by Hawker Siddeley which

*Right: The first Type 8M trainset built under licence from Hitachi entered service in Cape Town last February. Low floor trams being delivered this year include ACMV cars for Genève (upper centre), and Linke-Hofmann-Busch's GTW<sup>8</sup>/8s for Würzburg (lower centre) with Siemens equipment*

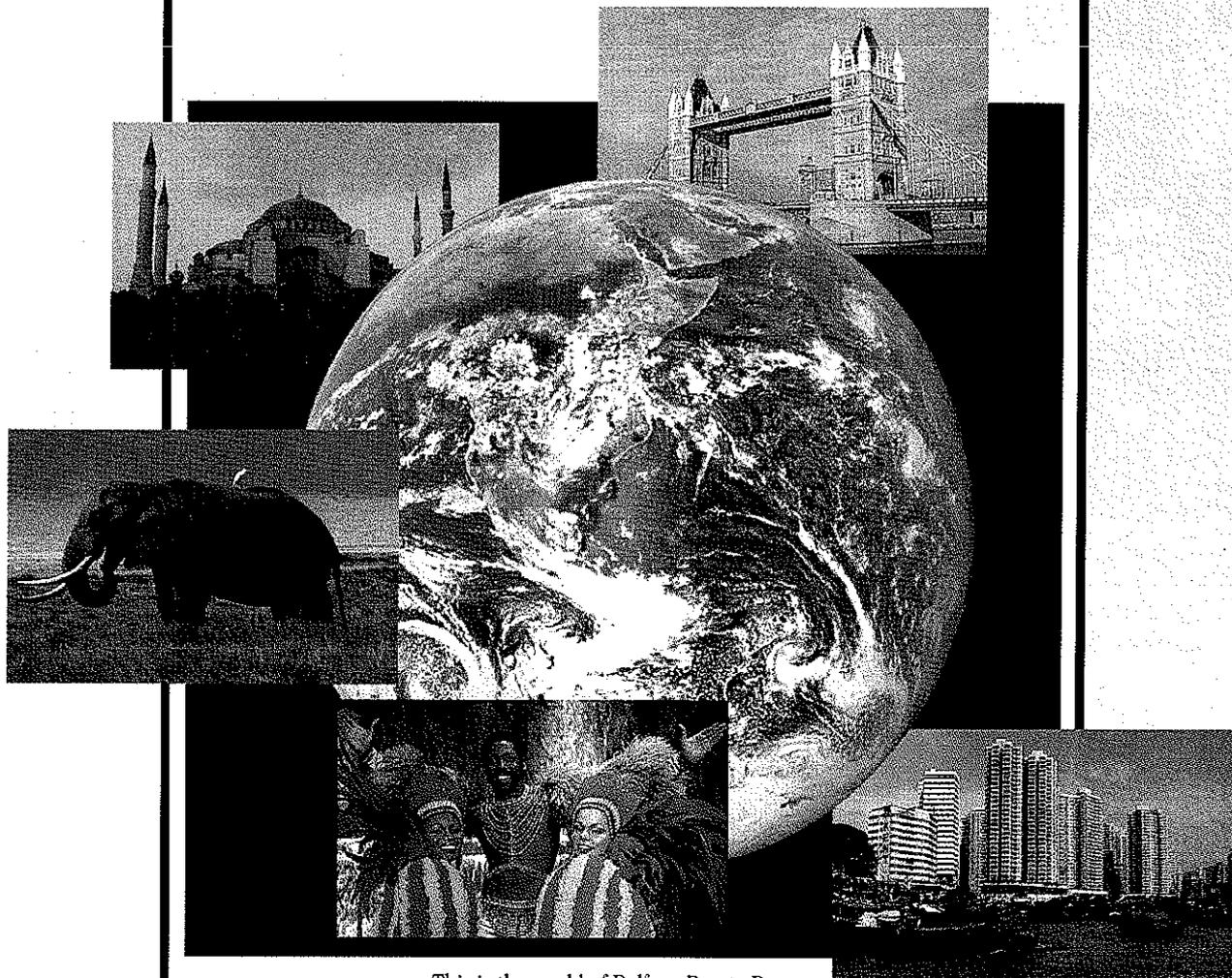
subcontracted the mechanical parts to BN Constructions Ferroviaires et Métalliques (127); Brush (128) will provide electrical equipment. Matra (129) is supplying 102 rubber-tyred VAL cars for the Mucha line in Taipei, but its prospects in Strasbourg look dim where the new mayor Mme Trautmann appears to prefer conventional light rail.

Among specialist maintenance machines for metro applications is Plasser & Theurer's 08 Metropolitan tamping and levelling unit supplied to Berlin Transport Authority. Able to work on small radius curves, this type of machine can be fitted with a low exhaust engine in a low noise housing. □

*Two Type FU45 catenary maintenance cars (below) have been supplied to Medellin by Rheiner Maschinenfabrik Windhoff. Berlin Transport Authority has bought an 08 Metropolitan levelling-lining-tamping machine (below right) from Plasser & Theurer*



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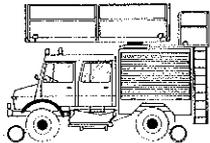
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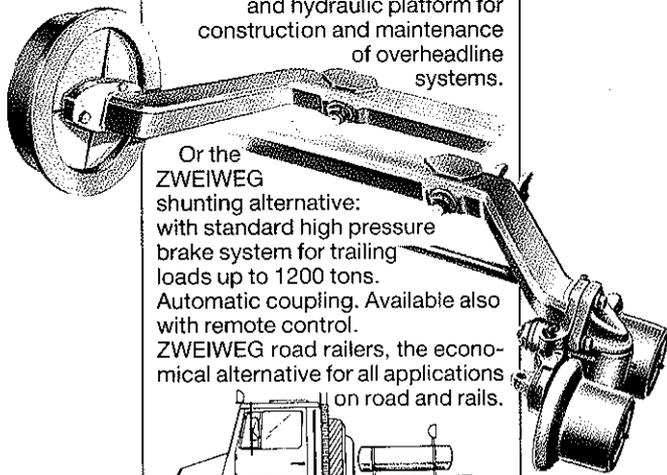
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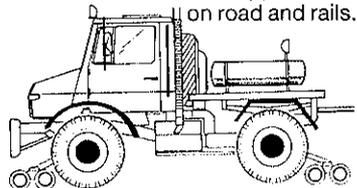
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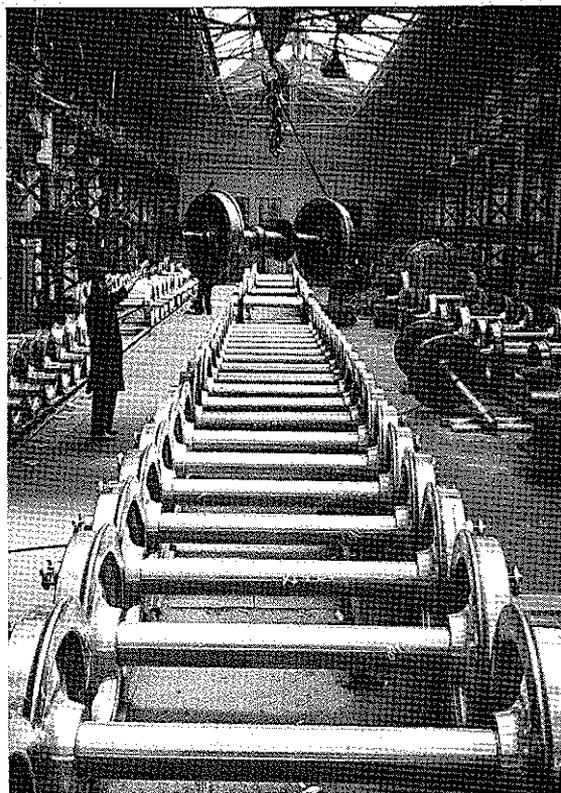
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