DEVELOPING METROS 1992

A RAILWAY GAZETTE YEARBOOK

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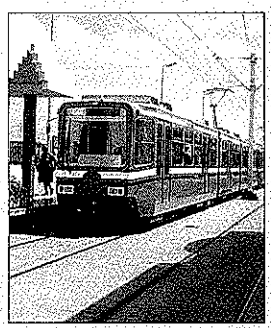

Front cover:
Under a turnkey contract, Siemens Transportation was responsible for the 78 cars, buildings, civil engineering, signalling, power supplies and communications systems for the Tunis light rail network which opened in 1985
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REED BUSINESS PUBLISHING

ISBN 0-617-00537-0

Price: £5-00

Printed in Great Britain by Williams Press (Maidenhead) Ltd

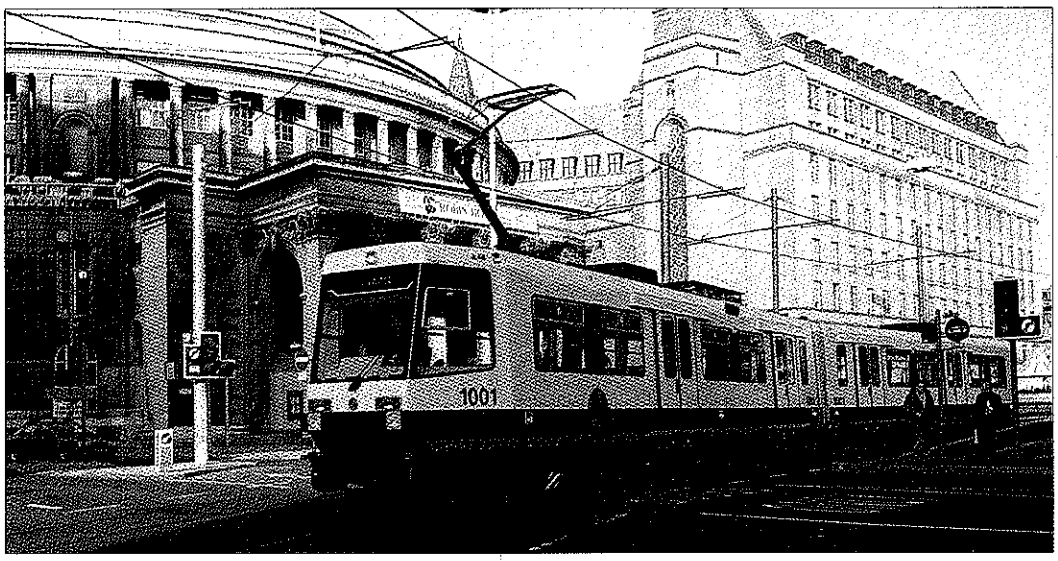
A subscription form can be found at the front of the issue, or circle 150 on Express Enquiry Form. Subscription enquiries telephone +44 444 441212

Air freight and mailing in the USA by Publications Expediting Inc; second class postage paid at Jamaica NY 11431. USA POSTMASTER: send address changes to Publications Expediting Inc, 200 Meacham Ave, Elmont, NY11003, USA.

Value for money

TWO DISTINCT but related trends can be identified from the reports in this year's Developing Metros. In both Europe and North America, the question of cost-efficiency has come greatly to the fore. Cosy relationships between local authorities and metro operators are being subjected to the chilly winds of commercial contracts in a bid to ensure that specified levels of service are provided at minimum cost. Using spare capacity for commuter rail services on existing lines is one economical approach. The selection of light rail, exemplified by the decisions of cities such as München, Frankfurt and Milano to retain and upgrade their remaining tramways, is a recognition that this mode offers a unique blend of environmental acceptability and economy. Where rail infrastructure already exists, a well-planned light rail or commuter network can generate many of the benefits of a full metro but with much lower capital and operating costs.

It is perhaps worth underlining a point made by UITP Secretary-General Pierre Laconte (p9). 'Public transport is here to provide a service for the community . . . realism and practicality must walk hand-in-hand with commercialism if the customer is to benefit.' Choice of the most appropriate rail package can be an important step in the right direction. □



April 23 saw light rail return to the streets of Manchester after 42 years when the cross-city section from Victoria to G-Mex was inaugurated. Royal opening of the first modern British LRT is scheduled for July 17

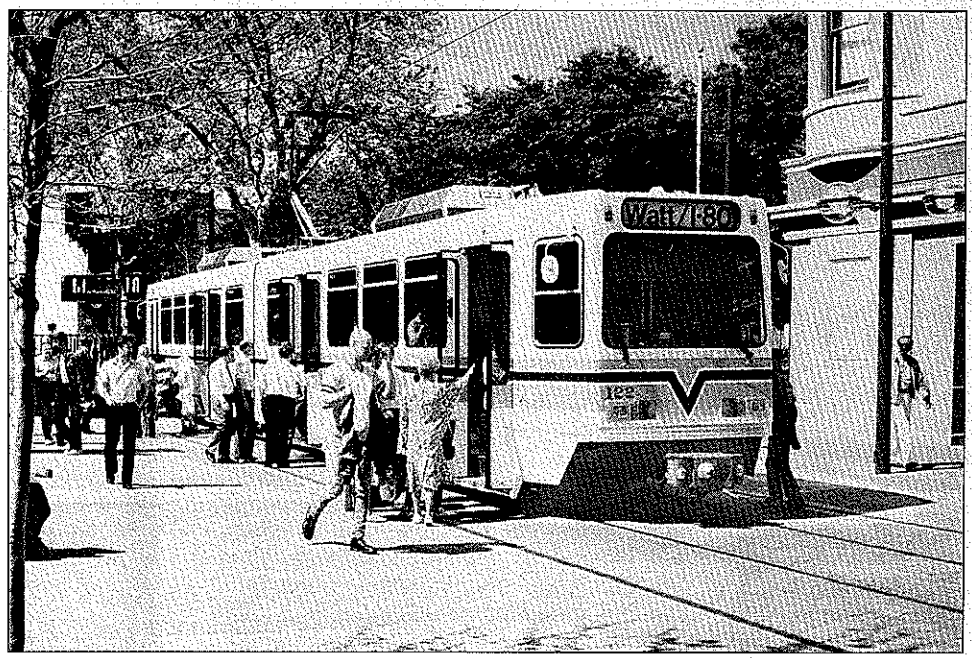
SPECIAL FEATURES

CITY REPORTS

2541

ISTEA may boost North American light rail

John W Schumann
Senior Engineer,
LTK Engineering Services*



Sacramento's 29·4 km light rail network is typical of the 'new start' networks built during the 1980s, particularly in the West Coast cities in California and Oregon

AS DELEGATES from Canada and the USA come together in Calgary for the 6th National Light Rail Conference on May 24-27, considerable interest has been sparked by the passing of the Intermodal Surface Transportation Efficiency Act. ISTEA was approved by the US federal government towards the end of last year, opening up new sources of funds for public transport development.

Light rail is well placed to bid for these funds. The technology of modern light rail became established in North America during the 1980s, which saw a remarkable resurgence following many years of neglect. The decade witnessed the opening of no less than 11 new systems: six in the USA, two in Canada and three in Mexico. All are planning to expand, and several have extensions under way.

Still setting the pace is the San Diego Trolley, which started the current resurgence and celebrated its first decade in 1991 (*Developing Metros 1991* p73). Beginning with a single 26 km route, the network now totals 55 km and is expected to reach 145 km by 2010. Los Angeles is building an extensive network, buoyed by the success of the 35 km Blue line to Long Beach opened in 1990. Portland is starting final design of its 18 km Westside line, and Santa Clara county is conducting preliminary engineering for the 19 km Tasman Corridor in San José.

The 1990s will see many more new entrants to the US light rail club. Baltimore will be the next, with the first segment of its 43 km Central Corridor line due to enter service in mid-1992. 'New start' lines are under construction in St Louis, Dallas and Denver, and preliminary engineering is in progress in Salt Lake City and Chicago. At least a dozen other US cities are actively planning light rail projects.

LRT growth in Mexico has been especially noteworthy. Implemented at a breathtaking speed compared to similar projects in the English-speaking world, three completely new systems have opened since 1989: Guadalajara, Monterrey and Mexico City. LRT serves primary trunk routes in the two provincial cities, and acts as a lower-cost feeder to the rubber-tyred metro in the Federal District. All three systems are being expanded.

ISTEA FUNDING

Welcoming the passage of the ISTE Act, Louis Gambaccini, Vice Chairman of the American Public Transit Association, said the new law 'places fresh emphasis on the benefits of mass transit and ride sharing.' He said that APTA member systems were being asked to 're-examine their plans with the goal of putting available grant money to work now, and advancing the timetable for planned purchases and projects.'

Public transport advocates worked with Congress to fashion the Act, and are elated by the results. Now, they are working just as hard to bring the promises to fruition. ISTEA increases funding for urban rail construction by US$820m (50 per cent) between 1993 and 1996 and US$1·2bn in 1997.

ISTEA offers opportunities for creative leaders to work together to obtain additional funds not previously available for public transport – but it will not be easy. Industry leaders face three challenges to effective use of ISTEA:

- **Make sure that Congress and the administration appropriate funds up to authorised levels.** By January, proposals had already been made to cut the provision of funding for the fiscal year 1992 from US$16·8bn to US$15·7bn. Conversely, an emergency public works bill introduced in the Senate would add US$1·2bn over three years for rail modernisation, capital acquisitions and implementation of the 1990 Americans with Disabilities Act (ADA).

- **Building partnerships with other modes to obtain money available under 'flexible funding' for public transport.** Officials of San Francisco's Bay Area have formed a venture called 'The Partnership' to improve co-operation and planning, in order to advance a number of short-term operations-oriented projects to ease congestion and improve air quality. With a membership of 32 participating agencies – local, regional, state and federal – plus the advice and guidance of transport industry, environmental and business leaders, The Partnership seeks to engender the high level of co-operation needed if public transport is to make the most of new flexible dollars. As such, it may serve as a model for other regions.

- **Adhering to federal regulations.** All stages of project development, from lengthy planning through to implementation are affected by regulations, such as Buy America, US shipping preference, and so on. While each was conceived to do something positive, their inevitable effect *en masse* is to add extra time and costs to schedules and budgets. Four light rail projects launched in 1975 illustrate the point. With no federal involvement, Calgary

* John W Schumann was Executive Director of Sacramento Transit Development Agency in 1981-84, responsible for planning, design and construction of the city's light rail lines between 1979 and 1984. He is presenting the keynote address at the Calgary conference

San Diego Trolley has fitted its LRVs with wheelchair lifts, but concern for disabled passengers may see low-floor cars adopted in future schemes

and San Diego were open in 1981. Portland and Sacramento had federal assistance, but took until 1986 and 1987. We must hope that the present administration's initiative to streamline regulations will lead to improvements.

LOW-FLOOR CHALLENGE

Another development which may affect North American light rail in the 1990s is the move towards low-floor cars. Most of the networks launched in the 1980s set low capital cost as a major goal, so classic high-floor cars with steps and low station platforms were selected. Access for elderly or disabled riders is achieved by the provision of lifts on LRVs or platforms, or by construction of mini-platforms at car floor height.

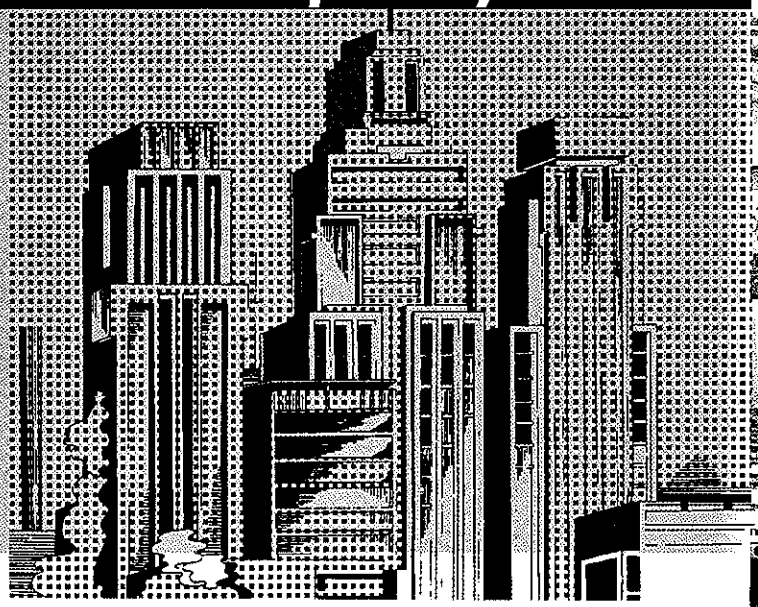
ADA requires all new cars to be accessible to disabled riders. At the same time, cities seeking low-impact rail transit cannot afford subways, and they view full-length high platforms on city streets as intrusive. As a result, several existing and planned North American light rail operations are becoming interested in low-floor LRVs, notably Boston, Toronto and Portland.

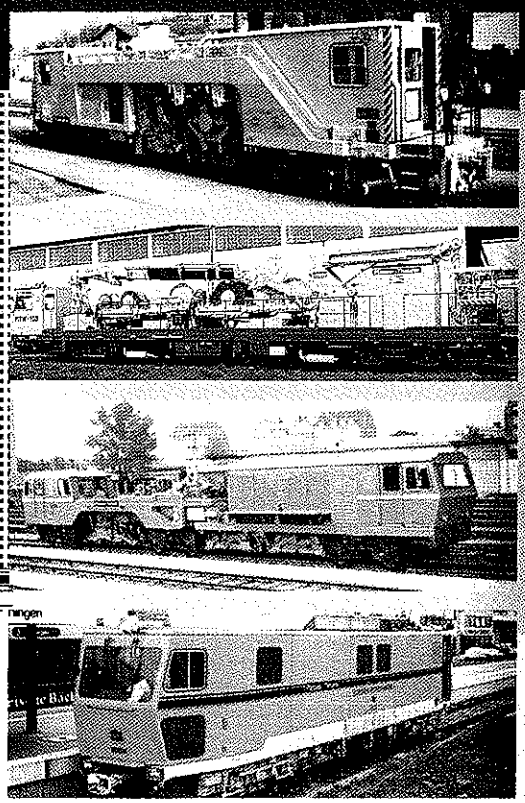
As the survey in RG 11.91 p793 established, many variations on the low-floor concept have been developed for European city tramway operations. However, there is no off-the-shelf design suitable for American style operations – high-comfort cars operating at 90 km/h on long routes linking cities and widely-spaced suburbs.

North America needs cars that provide low-level entrances but are based on technology with a proven record in American applications. This conservative approach will inevitably rule out most of the radical solutions proposed for modest-performance European trams, which are not appropriate for the higher-performance suburban LRVs required in North America. There is an opportunity here for suppliers to develop such designs, which could be applied in many cities now looking at light rail to provide a regional trunk express service. We must hope that the challenge is taken up.

New proposals continue to illustrate the flexibility and effectiveness of LRT in providing quality service at affordable prices. With increasing concern about congestion, air pollution and the quality of urban life, and with new federal, state and local funding mechanisms being put in place, the next decade should see another leap forward for North American light rail. □

Track maintenance on urban transport systems





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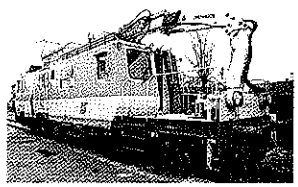

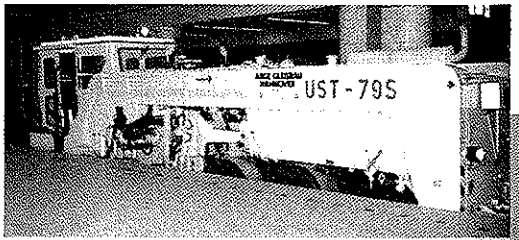

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Operators face new relationships with local authorities

FOR SOME YEARS now, there has been a steady change in the relationship between the operators of public transport around the world and the local authorities who own, control or administer them. All around the world, increasing congestion on the roads has made public transport more desirable, but at the same time the costs of providing an attractive level of service have risen. In more and more countries, the elected representatives of the public are calling for stricter economic controls and a closer definition of service quality – ensuring that the travelling and tax-paying public receive value for money.

The International Union of Public Transport has been drawing the attention of the world of public transport to these changes, which mean that the relationship between operators and local or regional authorities are irrevocably changing. Events such as the deregulation of local bus services in Great Britain are obvious landmarks, but the change in attitudes runs right around the world.

Following a request from Directorate General III at the Commission of the European Community, responsible for implementing the Single European market, UITP prepared an analysis of the organisation of public transport throughout the Community[1]. This analysis was conducted by Bill Tyson, the Planning Director of Greater Manchester Passenger Transport Executive. The report showed up a number of issues which needed to be addressed further, so we took the initiative in organising a conference in Barcelona last November to look at Public Service & Competition. Such was the level of interest in the subject that the conference was heavily over-subscribed!

The findings of the Tyson analysis can be summed up in three main categories:

There is a large variety of relationships between transport operators and local authorities. Provision of local public transport ranges across the whole spectrum from in-house local authority departments to fully commercial provision by totally independent companies.

Most relationships involve some degree of public sector control. Responses on concessions and operating agreements indicated that in most member states the various public authorities have a major role in determining routes, timetables and fares. This effectively means that the operators' role is to operate and manage the system, and in some cases to propose changes in routes and timetables to the controlling authority. Most operators do not have full commercial freedom over the level of quality and price of the service to be provided.

There is a trend towards introducing competition. However, this trend largely involves retaining public sector control over policy. So the main impact of competition for transport concessions is on management and operating skills, which are already highly mobile resources. Whilst there is a wide disparity in attitudes among the member states towards competition, Great Britain still stands alone in having open (on-street) competition between operators of bus services.

WHY ARE RELATIONSHIPS CHANGING?

Through the latter part of the 1980s and early 1990s, public transport provision has placed an increasing financial burden on the local authorities responsible. As a result, the authorities are applying greater pressure on the operators to ensure they become more competitive. Public transport is no longer regarded simply as a social service. Instead, it is increasingly being regarded as a service which has to be supplied efficiently, with a clearly defined ratio between the level of service supplied and its cost.

Reflecting this change, the European Community includes amongst its objectives the opening up of the procurement market for supplies, works and services. This includes utilities such as water, electricity, telecommunications and, most significantly for us, transport.

Addressing the Barcelona conference, David White, the head of the public procurement policy unit at DGIII, explained the Commission's reasoning for opening up public transport to greater competition. By definition, it provides a public service, it is largely, although not exclusively, publicly owned, and again largely publicly funded. The Commission felt that these three factors made public transport a crucial element in the whole economic system of the Single Market.

In opening up the public transport market, the Commission is seeking to ensure that there is:

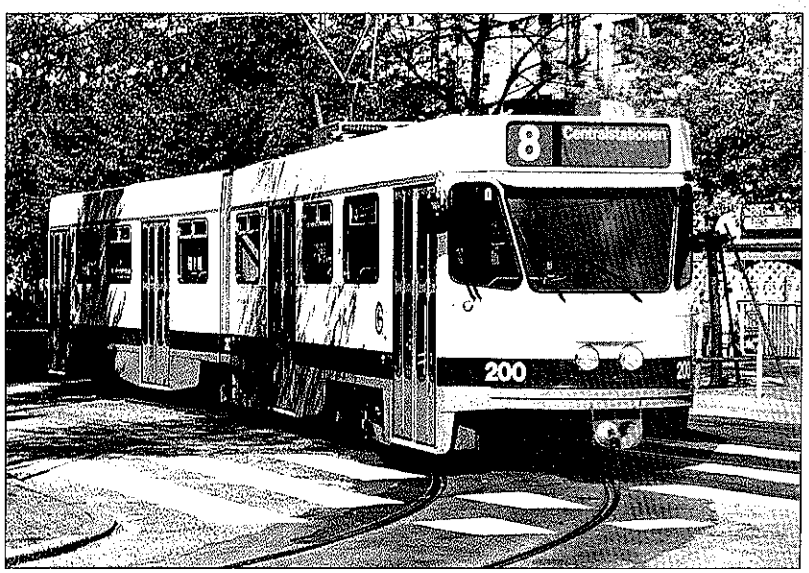
- information in and to the market;
- clear specification of the products;
- transparency in national legislation;
- a fair award of markets.

The ultimate objective of the European Community is to use competition as a means to prevent discrimination within the European Internal Market. This was recognised by the UITP in its response to the EC: *Opinion on the Enactment of a European Service Sector Directive concerning the award of Concessions for local Public Transport*. A similar opinion was also expressed by the International Road Users' Union.

Pierre Laconte
Secretary General, International Union of Public Transport

ADAPTING TO CHANGE

Given that the change in relationship between operator and local authority is becoming irrevocable, it is important for both sides to study the new situation, and the new



Swedish cities such as Göteborg are leading the way with contractual relationships between specifiers and operators of urban transport

References
1. Analysis of the organisation of local public transport in the European Community, by W J Tyson. UITP, Brussels, 1991.

ground rules, so as to achieve the best possible results from the change. Operators need to seek greater efficiency in order to retain business, and local authorities must ensure they receive the best possible level of service.

Firstly, it has to be accepted that local public transport is more than just a commodity. It is an instrument for basic existence, regional planning, protection of the environment, and the promotion of the regional economy.

For this reason, public authorities, regional governments and city administrations need to cope with both their specific statutory and social policy responsibilities and market considerations. They must be in a position to take policy decisions about how much local public transport is wanted and must be maintained, of what quality and at what price, in order to provide mobility for the entire population including people in rural areas.

On the other hand, transport operators are not only selling transport services. They are also concerned with punctuality, safety, security, staff training levels, and stability of service.

How can public authorities and operators fulfil these functions in times of change? I suggest that the only way to adapt to the new situation is to adopt concepts reflecting a **region-wide, long term** view and a mutually-matched combination of supply, prices, sales and information. This alone will enable public transport to develop effectively and achieve those of its objectives which go beyond mere transport functions.

Taking these two key points in turn, the greatest benefits can be obtained by **thinking on a region-wide scale.** Harmonised route networks, a single timetable, single fare scale and unified ticketing. This requires a large degree of co-ordination amongst the various operators, who need to be able to adapt their current procedures accordingly. This need to think on a wide scale, with all the benefits of interconnecting services, would undoubtedly be hindered if local or regional authorities were to decide to award small network or single route contracts to different operators.

Public authorities also need to **think long term.** For public transport to function well, it needs co-ordinated guidelines which have been drawn up over a long period and which have been consistently implemented. This, of necessity, means that policies must last longer than one electoral term of office. It also goes without saying that the policies should be independent of the economic power of the transport companies. It has to be borne in mind that the same timescale constraints also apply to the transport companies themselves, as they will only be able to fulfil their obligations economically by applying long-term concepts. This is particularly true as far as investment, maintenance, and staffing policies are concerned.

CHANGE IS COMING

The next year is certain to herald a period of change in the world of public transport. As far as Europe is concerned, the start of the Single Market on January 1 1993 is a clear milestone. European operators and local authorities alike need to take advantage of the internal market, whilst not losing sight of the fact that in opening up the national borders the Commission is not creating a 'fortress Europe'. The EC directives on the opening up of procurement for supplies, works and services require open tendering and publication in the EC official journal.

This effectively obliges transport authorities and operators to open up their range of suppliers. Up to now, this opening up has not been accompanied by protectionist measures in favour of EC and EFTA countries. The tendering documents have only to refer to EC norms and standards when they exist. At present, there are very few such standards in the public transport field, which in practice means the opening up of the procurement markets to the entire industrialised world. This is in direct contrast to the 'Buy America' Acts of 1982 and 1987 which specifically restrict imports to the USA in the public transport sector.

So, change is coming. Some operators are ready for it, others are not. Some authorities are prepared, others less so. The next few years will see dramatic alterations in the way that transport equipment is procured, services provided, and co-ordination achieved. There are undoubtedly great benefits to be won in terms of economical operation, cost-effective services and lower financial burdens.

But at the end of the day, public transport is here to provide a service to the community. We must not throw away our proven advantages in search of mythical savings. Realism and practicality must walk hand-in-hand with commercialism and experimentation if the passenger is to benefit. UITP welcomes the opportunity to develop better public transport, and we will be working with our members in the industry to ensure that any gains are not achieved at a greater cost to society as a whole. □

Voters back public transport

POLITICIANS IN the European Community overestimate public attachment to car use, and underestimate the electorate's willingness to shift emphasis to public transport, according to a recent study. Based on the results of a survey conducted in 1991 by INRA Europe and Socialdata of München for UITP and the European Commission, *Assessments of Mobility in Europe* suggests that the electorate is likely to criticise politicians for doing too little, rather than too much, to shift the emphasis in urban areas away from private car use.

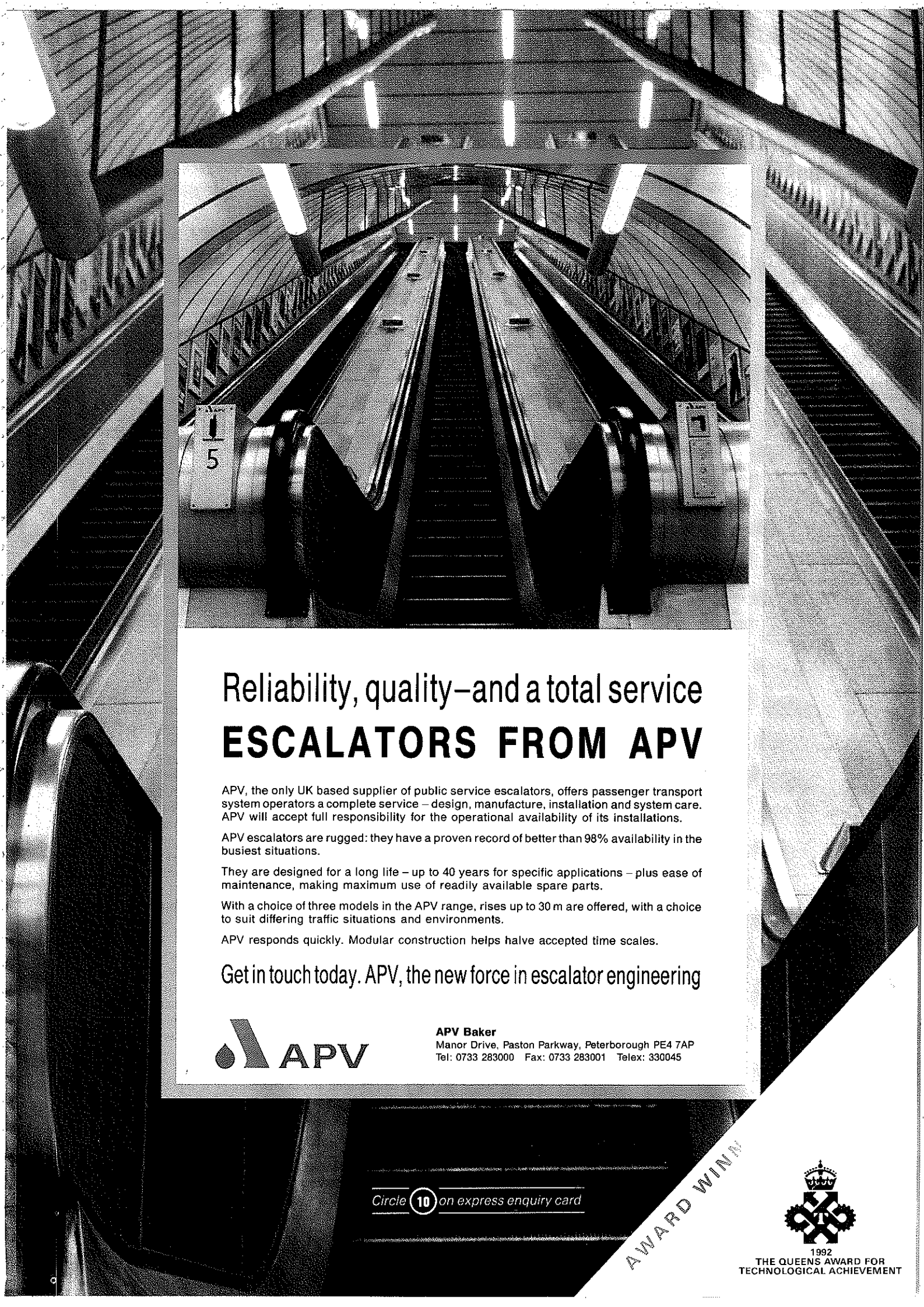
The survey found that 85 per cent of politicians favoured priority for public transport over private cars, but the same politicians believed that only 49 per cent of the public supported this view. A survey amongst the electorate showed that 84 per cent favoured public transport priority.

Discrepancies also showed in relation to traffic restraint: 80 per cent of the politicians backed the idea, but thought only 47 per cent of electors would, although this figure was actually 71 per cent. Similarly, 93 per cent of politicians wanted more pedestrian areas, but expected only 51 per cent support; in practice 75 per cent of electors backed pedestrianisation. Parking restraint was favoured by 59 per cent of politicians, and 53 per cent of electors, but the perceived figure was just 36 per cent.

Interestingly, the survey found that politicians correctly assess the level of public awareness of problems such as urban gridlock and pollution, but they do not believe that ordinary citizens are capable of drawing the right conclusions to solve them. For instance, few politicians realise that their electors are aware of the scale of risk of car-related accidents to pedestrians and cyclists.

Elected representatives throughout Europe see public transport as the solution to many urban traffic problems – 81 per cent expect the use of public transport to rise and 79 per cent see this as positive. Whilst experience suggests that declared preferences may not always be reflected in what people ultimately vote for, the UITP findings show considerable consistency. If, as the survey suggests, 84 per cent of European citizens support priority treatment for public transport, the politicians have a clear mandate to legislate and fund such developments.

If the results of this survey stiffen the resolve of politicians to act, on-street modes such as light rail, trams and buses stand to benefit first. But metro and heavy rail investment is likely to follow, because comprehensive public transport improvements are regarded as a quid-pro-quo to gain the acceptance of motorists for traffic restraint measures. We must hope that the figures will give politicians more confidence in the support of their electorate as they seek to grapple with the problems of urban mobility. □



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London's experience offers guidelines to

Professor T M Ridley
Rees Jeffreys Professor of Transport Engineering, Imperial College of Science & Technology

IN WHAT USED to be the Soviet Union, decision-making about investment in metros was rather simpler than in most countries. It went something like this – 'does your city have a population of one million, if so you get a metro'. The appraisal techniques used elswhere are rather more profound, but the addition of very expensive extensions to a metro network needs careful justification.

Metros are particular to their own cities, so that continent-wide issues do not arise as they do in the case of a European high speed rail network or international air traffic control. Nevertheless, professionals in different cities around the world have much to learn from each other. One of the most important fora for the exchange of ideas is the Metropolitan Railways Committee of the International Union of Public Transport, whose membership ranges from Hong Kong to Helsinki, San Francisco to Seoul, and Montreal to Milan.

Michael Robbins, a former Managing Director of London Underground, used to say that the Committee was the most exclusive club in the world – the entry fee was one underground railway. Nonetheless there are always new applicants. Baghdad would have had a metro today if Iraq had not spent its money on a war with Iran. Budapest, the first Continental city with a metro, is a long-time member while Singapore has joined recently.

Whilst UITP has other interests – light rail, buses, transport economics, traffic and urban planning – metros have long been a central concern. In its 100 year existence, the Brussels-based organisation has been active throughout the world, but the increasing importance of the EC has encouraged the setting up of a special unit dealing with European Affairs. This is staffed, among others, by members seconded from VDV in Germany, RATP in Paris and KNV in the Netherlands.

The Metropolitan Railways Committee is chaired by Elio Gambini of Milano, with Bill Clarke of London Underground and Antoine Lombart from Brussels as Vice-Chairmen. Its detailed work is carried out by five sub-committees – Electrical Installations, Finance & Commerce, Fixed Installations, Operations, and Rolling Stock. Together, these provide an unmatched repository of knowledge about metros.

To give some indication of the scope of research undertaken by the various committees, some of the subjects addressed in recent years have included:

- performance specifications for wire and cable;
- productivity comparisons between metros;
- financing;
- rail corrugation;
- mechanisation of track maintenance;
- passenger safety;
- operating quality;
- use of microprocessor technology.

The members of the committees are drawn from operating authorities, but some of the work finds a wider audience at the biennial UITP Congresses and in *UITP Revue*. Much of the activity of the committees is involved with existing metros, but many networks are also planning or building new extensions. In my own case, as a 'new boy' from Newcastle in the early 1970s, I found it of inestimable value to meet on an informal basis so many senior and highly experienced people in the industry – all of whom were as supportive and helpful as they could be.

On a more general level, UITP is trying to make the case for improved public transport in cities around the world. A consultation paper *Green Light for Towns*[1] looks ahead to the end of the decade and into the next century.

We are, it suggests, in a vicious circle. As more and more households own a car, private motor vehicles are starting to take up too much space in towns, so health and environment are threatened. It is necessary to reinforce the economic and social role of city centres and develop long term policies. Not surprisingly, UITP argues for priority for public transport with both better, but regulated, access to town centres.

London as an example

London offers an excellent example of the issues which face nearly all metropolitan railway authorities around the world today. Today's extensive system was founded in 1863, placing the British capital at the forefront of metro development. After a long period of restricted investment, the Central London Rail Study published in 1988 made the case for further expansion, so London is once again in an era of metro building. London Underground is pushing forward with a modernisation programme while working hard on a massive programme of extensions[2] – the Jubilee Line eastern extension, the East-West Crossrail regional metro link, and eventually the north-south Chelsea – Hackney line (RG 1.92 p34).

Challenging though these extensions are, they are in many ways no less daunting than some of the major modernisation projects now under way, such as the recently-completed Underground Ticketing System and the modernisation of the Central line. In the 1980s, a half-serious view at LU was that 'any fool can build a new metro in Hong Kong, but to upgrade an old system while carrying record numbers of passengers is a real man's job.'

Certainly, to do both together is an enormous challenge. But as all of the world's metros – all younger than London's – will one day face the same problems of upgrading and modernisation, it may be instructive to see how the world's first metro is setting about the managerial and organisational challenge.

Strategic plan

In the summer of 1988, LU completed a Strategic Plan, setting out a number of options for future development of the Underground and defining the consequences for fares, investment and ridership to 2000 and beyond.

At, Angel LU is spending £70m on a second station tunnel to replace the present cramped island platform

metro managers around the world

From this analysis came a 15-year programme divided into three equal stages. The emphasis was on internal management reform, improved service quality and safety, securing a sound financial performance, and clarification of the external framework in which the Underground must operate. Phase 1 was seen as providing a base on which to found the restoration and upgrading of the existing network in Phase 2. Phase 3 would see expansion of the network to relieve congestion and serve new areas.

A number of significant organisational changes took place during the 1980s, both prior to and as a result of the Plan. The first major departure from the Underground's historic structure was the fundamental restructuring of Engineering, decided in 1984 (*Developing Metros 1990* p20). Separate departments responsible for disciplines such as civil engineering or S&T were replaced by a concept of 'client' and 'internal contractor' relationships. These would assist competitive tendering, demonstrate value for money, and ensure control over quality. In April 1986, a Director of Engineering Operations was appointed to manage the various 'internal contractor' work forces transferred from the engineering departments.

In November 1988 a major re-organisation took place. The LU Board was restructured to emphasise corporate rather than functional responsibilities, and 10 Line Businesses were created to operate as profit centres under the direction of a Passenger Services Director. Each Line Business was headed by a General Manager, whose responsibility was to provide safe and reliable train and station services, meeting volume, quality and financial performance targets, and including responsibility for rolling stock maintenance.

This re-structuring provided clearly identified accountability for the provision of services to the customers on each Line, gave all staff a clearly identified 'chief', and sharpened accountability for income and operating costs. All other Underground activities were redefined as support roles to ensure the primary business of the Passenger Services Directorate in providing services to the customers.

The Engineering function was re-modelled again to identify the distinct roles of client engineering, with stewardship of appropriate assets and infrastructure, and a Professional Services Group to act as internal consulting engineers operating on a fee basis. The revised organisation was introduced in stages during 1989. A Development Directorate was also established to bring together major enhancement proposals and additions to the network and its infrastructure.

Recent developments

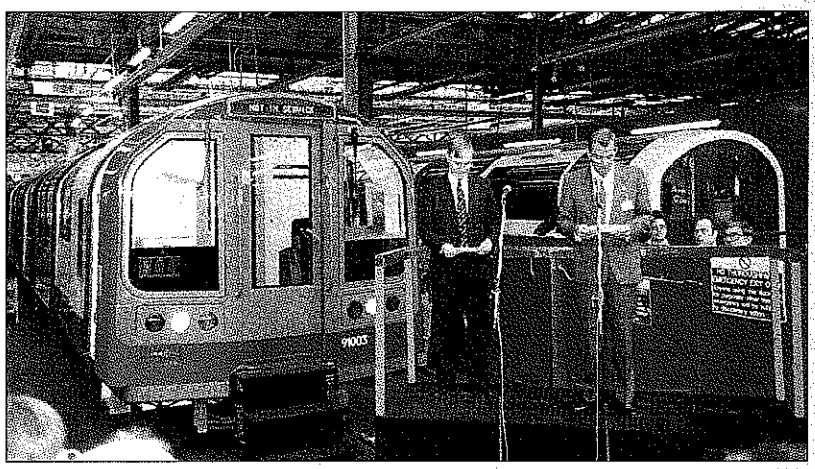
The principles underlying the three phases of the Strategic Plan were recognised in the Central London Rail Study, which recommended a major upgrading programme to address the limitations of the existing network, followed by the development of new lines. Nevertheless, much has changed since 1988, particularly as demand has fallen below projected levels owing to the economic downturn.

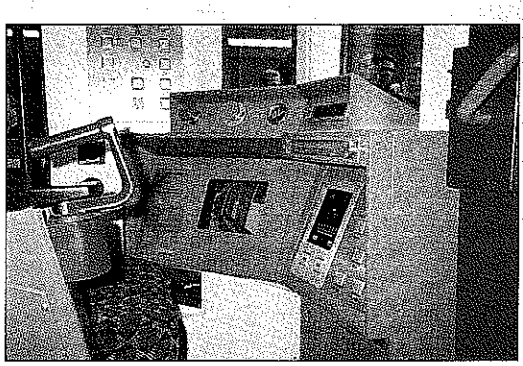
Further, government policy has not developed in line with the 1988 assumptions. A drive against inflation has precluded the real fare increases assumed in the Plan, which together with lower demand has created a pronounced gap between forecast and actual revenues.

There are roundly 130 million trips per week by all modes into or within Greater London, of which about 12 per cent are made by Underground. Journeys to work and school make up a much higher proportion of Underground trips than they do of all trips. As a result, the Underground market share is unevenly distributed, with only around 6 per cent of Saturday trips and 4 per cent of Sunday trips. This is compensated by a much larger share on weekdays.

Only 10 per cent of Londoners use the Underground five or more days per week, and 15 per cent at least once a week. A figure of 50 per cent of very infrequent users represents an important market opportunity. Eighty per cent of Underground trips are made by just 20 per cent of users, largely as a result of the Travelcard, which allows marginal trips to be made at no additional charge. This is reflected in the proportion of regular users who make leisure trips. Commuters generally account for the majority of off-peak leisure journeys.

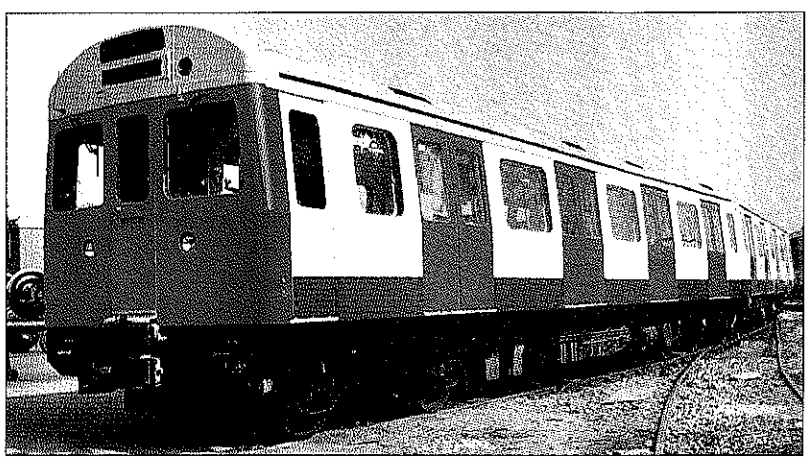
After falling by nearly 20 per cent, Underground traffic





The first of 680 new tube cars for LU's Central Line was handed over at Brel's Litchurch Lane works in Derby on May 5

Existing rolling stock is being refurbished to eliminate inflammable materials and repainted with graffiti-proof paint



A comprehensive programme during the 1980s saw the refurbishment of many stations dating from around 1900, brightening the network and attracting new users

increased dramatically during the 1980s. The decline, subsequent recovery, and further growth of traffic reflects underlying trends in the market – that is, the decline in London's population during the 1970s and, more recently, the growth of Central London employment and real incomes. It has also been influenced by fares levels and structures and by the services provided.

Demand grew particularly rapidly in the mid-1980s following a fares reduction and the introduction of Travelcards in 1983. The level of passenger demand for Underground services in recent years has been higher than at any time since 1948. Major initiatives required on safety and for asset improvement had to be undertaken against the background of unprecedented growth in demand which worsened travelling conditions and placed strains upon the network, management and staff.

The rate of traffic growth has now moderated substantially and there is currently a dip in demand, mainly as a result of the recession. The underlying trend in the travel volume still appears to be upward; the network is full during the morning and evening peaks.

Since 1988, London Underground has embarked upon a series of corporate initiatives designed to focus on change leading to improved performance. The first of these was safety. Following the King's Cross fire, the emphasis on safety led to the introduction of the London Underground Safety Management System. LU has also been developing a capability in risk analysis, to enable safety priorities to be reflected properly in investment decisions.

A second main theme was quality. A number of operating units, especially in engineering, began the path to full quality accreditation, which has been achieved in two areas. A Quality Leadership Programme was also begun as the start of a process to introduce Total Quality throughout the Underground.

The third major influence has been devolution – giving the Line General Managers both the responsibility and resources for undertaking all aspects of day-to-day and routine maintenance, and allowing them to carry out their role of managing all aspects of service delivery more effectively. In addition, devolution is designed to achieve improved working practices and better asset availability by enabling work teams to identify with their own local area of the railway.

Another influence has been competition policy. London Transport has a general obligation under government legislation to ensure that its subsidiaries, including LU, invite external parties to tender for work where appropriate. The reorganisation of engineering in the mid-1980s was designed to promote this, and competitive tendering has gradually been extended since then. In 1990 an extensive review was undertaken to identify best practice around the world and to identify opportunities for further tendering. The results of this work have formed the basis for 'make or buy' decisions.

In June 1991 the Board decided to bring these initiatives together through the creation of a new Directorate of Corporate Programmes. The current Plan[3] reinforces and accelerates this integration.

LU is still completing a programme of works arising out of previous reports into recent accidents on both the Underground and British Rail, a safety review carried out by the Railway Inspectorate and new fire regulations. As part of a regular government programme to review nationalised industries, the Monopolies & Mergers Commission was asked in October 1990 to investigate a number of issues relating to the efficiency, fares structure and investment programme of the Underground. This investigation lasted for six months and the report published in June 1991 made 114 recommendations. LU responded in September 1991, and initiated a further programme to implement agreed recommendations.

ORGANISATION STRUCTURE

As a result of the new Plan, the LU Board will now consist of the Chairman, Managing Director and Directors of Engineering, Passenger Services, Finance & Business Planning and four non-executive Members. The Executive Committee will include the Managing Director and the three Board Directors together with the Directors of Personnel, Railway Extensions, Development, Communication and Safety & Quality.

Line Business Units under the Director of Passenger Services will remain as at present. The accountability of the Line Businesses for the whole of their day-to-day operations will be reinforced, with the transfer of budgets for routine maintenance of signalling and permanent way and other activities.

The new Engineering directorate will include Engineering Operations, but the 'client' role of the existing Engineering function will be transferred to the Development directorate. A new Chief Engineer will be responsible for technical standards for engineering assets, research and development and inspection. It will be the responsibility of Engineering to ensure that project specifications include corporate standards and forthcoming technical developments, and to ensure that renewal and replacement strategies adequately reflect the existing state and anticipated life of the assets concerned.

The basic financial functions will be largely unchanged, including financial accounting and control, management accounting and internal financial audit. Payrolls will gradually move from Finance to Personnel as all employees are transferred to salaried status. Business Planning will be managed together with Finance reflecting the key task of resource allocation within Business Planning; this will inevitably be expressed in financial terms, both in operating budgets and in the investment programme. □

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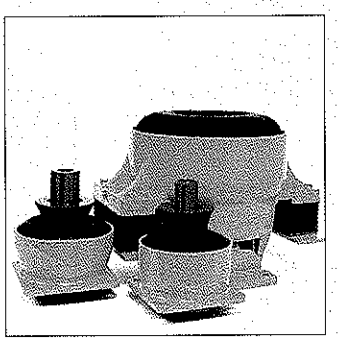
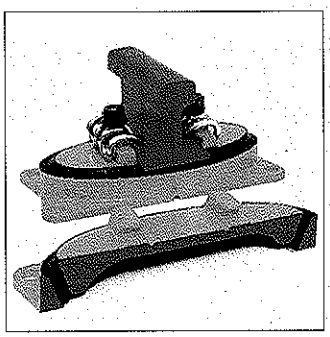
3. Company Plan. London Underground Ltd, London, 1991

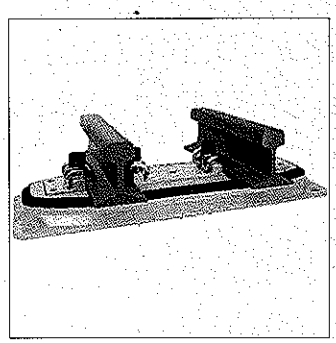
TRANSIT AND RAIL-ROAD PRODUCTS:

matured designs for reducing disturbance caused by noise and vibrations in many areas of aerial and underground rail transport.
Clouth products for transportation systems offer a wide range of designs to protect people and structures, and to improve the environment.

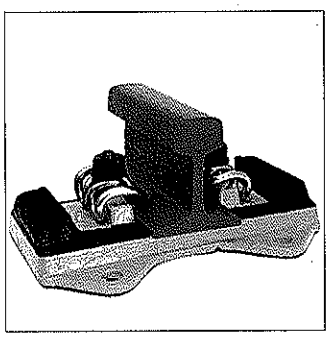


e.g. the Rolling Rubber Spring a primary and secondary suspension spring for rail vehicles.

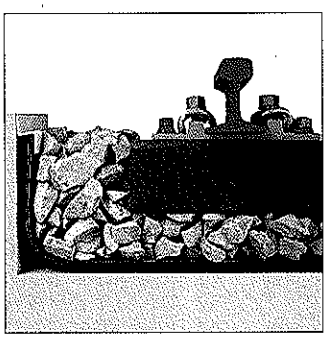


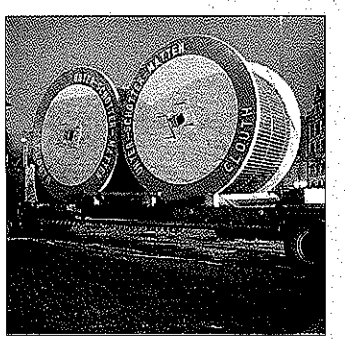


The "Cologne Egg®" and the "Cologne Egg® for switches" – highly resilient vibration-damping rail fasteners for ballastless track.



The Alternative, a rail fastener for ballastless track sections requiring less reduction in structure-borne vibration.





The Ballast Mat, a product designed for large-scale vibration damping in rail track. The Ballast Mat can be supplied for various axle loads and a wide range of applications.

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Metros should be silent servants

Dr J G Walker
Institute of Sound & Vibration Research, University of Southampton

AS MORE AND MORE cities experience traffic congestion and air pollution, the number of urban railways has increased rapidly. More than 20 cities opened new metro or light rail networks in the 1970s; almost 30 were added in the 1980s. Meanwhile, most operators are planning or building extensions, and expansion is set to continue. There are few major cities in the developed world that have not considered some form of guided rapid transit. Many innovative systems have been proposed, but the majority rely upon wheel/rail technology which is well-tried, safe, reliable and efficient.

All mechanised transport creates noise and vibration. In the case of urban railways, most is generated by the interaction between wheel and rail at moderate to high speeds. On-board equipment such as air compressors, air-conditioning fans, and so on can all create audible noise, but these sources tend to generate lower levels than the wheel/rail interface and little if any vibration.

Absence of intrusive noise is a major factor in personal satisfaction with the environment. Because of this concern, we have now developed a better understanding of the way urban railway noise is generated and propagated, and how it can be controlled. Vibration can also cause problems, but only close to the railway. A better understanding of factors causing vibration, which in turn can generate noise, is also important.

Today, methods of assessing levels of noise and vibration are available, and the attenuation necessary to provide satisfactory levels can be estimated. There is sufficient knowledge and technology available to reduce noise and vibration to acceptable levels in the majority of situations, but steps to control the impact must be addressed at the design stage. Whilst this might be costly, postponing action until the project is complete may render a solution much more expensive, if not impossible.

WHEEL/RAIL INTERFACE

When a wheel runs along a rail, fluctuating forces at the contact patch cause both to vibrate. These forces are influenced by the roughness of the wheel and the rail – smooth surfaces generate less vibration – by the distribution of axleloads over the rail, by the spacing of rail supports, and by the speed of the train.

Together, vehicle and track form a complex mechanical system generating vibrations at frequencies which depend on these factors. When one of the excitation frequencies corresponds to a natural frequency of the system, or part of it, there is a particularly strong vibration.

These vibrations cover a wide range of frequencies. In the lower part of the range, up to about 250 Hz, the vibration is propagated through the track into the ground or support structure. At frequencies from about 50 to 4 000 Hz, the vibration is radiated as audible sound from both wheel and rail; the greater the vibration of wheel and rail, the greater the noise levels. Similar levels of noise are radiated from the wheel and the rail, although the rail tends to radiate at lower frequencies. Noise is minimised if the wheels and rails are kept as smooth as possible, and if the track is designed to limit vibration.

Trains in the open air radiate both noise and vibration. Noise levels can be high and, in principle, higher speeds produce more noise; levels increase by about 9 dB when speed is doubled. Vibration is propagated through the ground close to the surface, and decays in such a way that very little is propagated effectively at frequencies above 50 Hz; little significant vibration exists beyond about 50 m from the track. Buildings, people who use them and equipment installed in them can all be affected.

Vibration from trains in tunnels is mainly below 200 to 250 Hz with maximum levels in the range 60 to 150 Hz. These frequencies can vibrate building structures, and can be re-radiated as low frequency sound. This is an increasing cause for concern in urban areas, where tunnels may be close to the basements of offices, shops or hotels.

The type and condition of the ground in the vicinity of a railway is critical in determining vibration levels away from the track. Theoretical approaches alone cannot be relied upon to predict with accuracy ground vibration at a given distance from the track. Vibration at the track can be estimated, but the influence of the ground on the transmission of this vibration is so great as to render difficult precise prediction at a distance.

It is possible to use a combination of theory and empirical data for a variety of situations (such as at-grade track or tunnels) to reach an indicative predicted level. But it should be borne in mind that the prediction will not be precise, and will vary with the amount of water retained in the ground at different times of year – wet ground propagates vibration more efficiently than dry.

Vibration induced in bridges and other elevated structures can be re-radiated as low-frequency sound – this effect is particularly obvious where non-ballasted track crosses a steel bridge.

KCR accepts need to cut noise

AS TRAFFIC has boomed on the 34 km Kowloon-Canton Railway, complaints have mounted about the noise generated by the intensive service of 12-car EMUs and less frequent diesel-hauled freights. On April 13, KCR announced that engineering consultants were being appointed to design anti-noise measures at six locations where the problem was particularly acute. These are residential zones, where thousands of people living in high-rise flats leave their windows open day and night in the tropical climate.

The results of a noise impact study commissioned by KCR were revealed on April 13. They suggest that the cost of noise abatement measures for the six worst-affected areas could amount to HK$500m over five years. The most expensive solution to be considered would be an artificial tunnel enclosing the tracks completely. High or low barriers alongside the tracks were less-costly options, and sound-absorbing concrete may be laid on the track.

On-going measures to reduce the generation of noise at the wheel/rail interface include rail grinding and more frequent turning of wheel profiles. EMU speeds have been reduced, freight operations restricted at night, and noise suppression devices applied to diesel locomotives.

The Environmental Protection Dept considers that acceptable noise levels in residential zones are 55 dB(A) by night and 65 dB(A) in the daytime. In the inappropriately named Peace Avenue near Mongkok, the worst location affected, daytime levels attributed to the trains were 63 to 76 dB(A), and the situation was even worse at night with 64 to 78 dB(A) recorded. However, general noise levels from street traffic and aircraft are also very high in this area.

The consultants will weigh the benefit of different noise reduction measures in terms of dB(A) reduction per resident against the cost of achieving them. Mr K K Lee, KCR's Head of Infrastructure & Building, said that the public would be consulted before work started on major works to supress noise. 'Any tunnels or barriers may block the views of residents, and those of passengers', he pointed out.

Another important consideration is the impact on fares. KCR receives no subsidy, and must recover the full cost of noise abatement measures out of revenue. □

Table I. Selected national standards (S) and recommendations (R) for significant levels of railway noise

		Facade level dB(A)
Denmark	$L_{Aeq,24h}$	63 (S)
	L_{Amax}	88 (S)
Norway	$L_{Aeq,24h}$	60 (R)
France	L_{Aeq12h}	65-70 (R)
Germany	$L_{Aeq,day}$	59 (S)
	$L_{Aeq,night}$	49 (S)
Netherlands	$L_{Aeq,24h}$	60 (S)
	$L_{Aeq,0700-1900}$	60 (S)
	$L_{Aeq,1900-2300}$	60 (S)
	$L_{Aeq,2300-0700}$	50 (S)
Great Britain	$L_{Aeq,0600-2400}$	68 (R)
	$L_{Aeq,2400-0600}$	63 (R)

NOISE DESCRIPTORS

Noise descriptors are used to relate community response to actual noise levels. Studies have helped to identify those which are most appropriate to particular circumstances.

It is widely accepted that L_{Aeq} (a measure of acoustic energy) is adequate for describing community response to railway noise. It has been incorporated in a number of national standards or recommendations (Table I). When a new transport development is planned, anticipated noise levels are predicted, and compared with existing standards or, if local standards do not exist, accepted noise annoyance relationships.

Wherever a new railway – or any transport corridor – runs close to buildings, there is a potential vibration problem. This may be perceived as a nuisance by occupants, or it may adversely affect sensitive equipment in those buildings. The closer the line is to buildings, the greater the need for concern. The more rigid the interface between track and ground, as in a tunnel, the more effectively will vibration be propagated into the ground.

It should be emphasised that considering vibration issues at the design stage is the most cost effective way to proceed. It is almost always more expensive – and in some cases may be impossible – to implement vibration control measures after construction has been completed.

Where the railway runs beneath a building, the vibration at the tunnel wall and in the basement of the building can be estimated. Note that vibration may not be strongest in the basement; it can be amplified at higher floors by a factor of two because the building may be free to vibrate more as the height above ground increases. Even low levels of vibration from railways, particularly those in tunnel, can be re-radiated by a building structure as low frequency noise. Relatively simple methods are available which allow this re-radiated noise to be estimated from predicted ground vibration levels.

Criteria for re-radiated train noise, sometimes known as groundborne noise, have been defined in the USA (Table II). Whilst noise that does not exceed these levels may still be audible, it should not cause significant intrusion.

If predicted noise levels are above the standards or criteria adopted, action to reduce them may be necessary. Noise control may reduce noise at source, or attenuate the noise as it is transmitted from source to receiver.

Reducing noise at source is normally the most effective and efficient method of control. Techniques that have been used with good effect include mechanical damping of vibrations set up in the wheel which reduce the noise it radiates. However, the rail radiates almost as much noise as the wheel at higher frequencies, and the overall noise reduction on tangent track is only about 1 dB. More usefully, so-called ring damping can reduce wheel squeal on curves by about 8 dB. Skirts over the wheels or bogies can be useful, although they can interfere with access for maintenance. Using articulated vehicles will also reduce the noise level because there are fewer wheels, which are the principal noise generators.

Other control options might include reducing the noise output by operational restrictions, such as reducing speed, or restricting operations to certain times of day. However, it should be noted that reducing the number of noise events by half only reduces L_{Aeq} by 3 dB(A).

The further a noise is from a receiver, the lower the noise level will be, so siting decisions are important. Obstructing the noise in its path from source to receiver is another option. Trackside barriers, in the form of walls, fences or earth banks, can reduce noise levels by up to 5 to 10 dB(A) if they are located carefully (panel p17).

Insulation of dwellings by double glazing may be the answer in some cases. The sound attenuation potential of an open window is about 10 dB(A), with single glazing achieving 15 to 20 dB(A). The standard domestic double-glazed window cuts noise by 30 to 35 dB(A), whilst sealed double-glazing with a 200 mm gap as found in modern commercial buildings can cut noise by 40 dB(A).

CONTROLLING VIBRATION

The best approach to vibration control is to minimise the vibration at source. This can be done by ensuring that the interface between wheel and rail remains as smooth as possible. Disc brakes will help, but regular grinding is now practised by most metro operators.

Vibration can also be reduced by lowering axleloads and unsprung mass. Lighter vehicles with better suspension designs will improve vibration.

It may also be necessary to isolate the track from the ground or the supporting structure, as far as possible. This can be done in a number of ways, which depend to some extent on the particular track design. For example, ballast mats (rubber sheets under the ballast) can reduce vibration levels by about 10 dB in the frequency range 30 to 100 Hz.

Ballastless track poses a different challenge; it is necessary to use elastomeric layers between the rail and the support structure. Different designs have been used for specific circumstances, but the performance depends on too many factors to quantify here.

The 'Köln Egg', so-called because of its oval shape, is designed specifically for metro and light rail track, and gives improvements over ballasted track of about 18 dB at 63 to 80 Hz. The Clouth system provides about 4 dB attenuation between 50 and 400 Hz.

The use of resiliently mounted blocks or sleepers on slab track improves vibration isolation compared to directly-fastened systems. The Stedef-VSB system, widely used by RATP in Paris, gives an improvement over ballasted track of about 12 dB between 20 and 200 Hz.

Other systems can reduce vibration by 20 to 30 dB at specific frequencies. They all basically isolate the vibrating rail from the support structure, but achieve this isolation in different ways. □

Table II. US critera and design goals for maximum groundborne noise from train operations, expressed in dB(A)

Residences and buildings with sleeping areas

	Single family dwellings	Multi-family dwellings	Hotel or motel buildings
Low-density residential	30	35	40
Average residential	35	40	45
High-density residential	35	40	45
Commercial	40	45	50
Industrial/highway	40	45	55

Special function buildings			
Concert halls and TV studios	25	Courtrooms	35
Auditoria and music rooms	30	Schools and libraries	40
Churches and theatres	35	University buildings	35-40
Hospital sleeping rooms	35-40	Offices	35-40
		Commercial buildings	45-55

Moving block signalling offers cost savings

Robert S Weir
Metro Operations Consultants Ltd

HEAVY METRO construction is extremely expensive, and a substantial proportion is accounted for by stations, both underground and elevated. Careful consideration of the relationship between operating procedures and control technology at the design stage offers scope for a significant reduction in initial costs, and may prompt a re-examination of the options for vehicle size and train length.

The ideal movement of passengers through a metro is a continuous flow. People arrive at stations in a steady flow, and while demand may fluctuate with time it will not switch to a series of discrete events. However, the inherent nature of metro technology causes the flow of passengers between stations to be divided into groups according to vehicle capacity and frequency of departure.

The efficiency of any transit system can be measured in terms of the total journey time for the average passenger. Since the actual travel time in the vehicle is a function of train performance, the efficiency of movement is mainly conditioned by the time during which the continuity of flow is interrupted – that is, the average time spent by a passenger waiting to board a train after his arrival at the station and any time spent waiting to leave the station after alighting from a train. This latter is not usually significant, as most stations are designed to process a peak alighting load without undue congestion.

It therefore follows that the overall efficiency of the system will be improved if average waiting times can be reduced by increasing the frequency of departures.

Traditional track-circuit signalling (TCS) systems are designed for a minimum headway of around 2 min, which is seen as being the most cost-effective approximation to the ideal. Although systems have been designed to cut headways to around 90 s, the cost of TCS increases rapidly when the service interval is reduced below 2 min.

This limit on conventional signalling design has resulted in the widespread adoption of relatively standard equipment from Singapore and Hong Kong to Atlanta and Miami. Metro cars are about 23 m long and 3·2 m wide, carrying around 270 passengers at 4/m^2 or up to 360 at a peak crush loading of 6/m^2. Depending on demand, such cars are formed into trains of six or eight vehicles, operating at intervals of between 2 and 3 min.

Although exact figures vary depending on the number and configuration of seats in each vehicle, such conventional metro cars can cater adequately for a travel demand of 30 000 to 65 000 passengers/h in one direction, and can cope with up to 80 000 passengers/h/direction if a degree of overcrowding is acceptable. At such times, passengers may have to wait if it is not possible to board the first available train.

Moving block

The advent of transmission-based signalling (TBS) systems, sometimes known as 'moving block', has opened up the possibility of higher frequencies of operations with smaller trains. This concept was first tried on small and medium-capacity peoplemovers such as the rubber-tyred VAL opened at Lille in 1983 and the steel-wheeled Skytrain mini-metro in Vancouver, which followed in 1985. The intensive operation and high level of passenger demand handled by Skytrain during the 1986 Expo indicated that TBS might offer scope for adoption on higher capacity metros at an economical cost.

Transmission-based signalling offers a lower cost route to higher line capacity on saturated routes handling over 65 000 passengers/h in one direction such as the Nathan Road corridor in Kowloon

Adoption of Sacem TBS on RER Line A in Paris in 1989 brought a significant increase in line capacity, and suggested that the use of TBS on a conventional heavy metro would bring similar beneficial results.

TBS does not incur the financial penalties for short time interval working that are inherent with track-circuit based systems. For service intervals of 2 min or more, TCS would cost around US$0·5m per route-km, compared to around US$1m for a typical TBS package. This advantage is declining, as the costs of conventional equipment are rising and those of TBS are falling.

At peak headways of 3 min or more, TCS retains a clear cost advantage. However, such intervals will significantly reduce total line capacity, calling into question the desirability of designing to such a standard, given the high capital and operating costs of the rest of the infrastructure.

With TBS, there is little or no extra cost in providing extra signalling capacity suitable for operation at short intervals down to the physical limitations determined by train length, acceleration and braking performance, and station dwell times (Fig 1). The difference between short and long intervals is principally a question of software in the computer operating the signalling system. With traditional signalling, the typical cost of achieving a 90 s headway is around US$1·25m per route-km.

Given an acceleration and braking rate of 0·8 m/s^2, a maximum line speed of 80 km/h and a dwell time of 30 s, the physical limit on service intervals works out at around 80 s for an 8-car train, 77 s for six, and 73 s for four cars.

Raising capacity

The introduction of Sacem in Paris has clearly demonstrated the potential benefits of the technology in raising capacity. This ability to increase the throughput of a given track offers a solution to the problems of overcrowding currently being experienced in Hong Kong, London and other cities. Replacement of block signalling by a moving block solution can increase capacity of existing infrastructure by 30 per cent, subject of course to finding sufficient rolling stock and depot space.

Hong Kong MTR's Nathan Road corridor was designed for a peak flow of 66 000 passengers/h, and is currently handling around 75 000, with an all-time peak of 82 000

in 1990. Similar or higher flows are also recorded on the east-west line in Sao Paulo. Transmission-based signalling could increase the design capacity to 88 000, reducing the present overcrowding and leaving a small margin for future growth.

DESIGN FOR ECONOMY

When applied to a new metro in the design stage, TBS offers a number of opportunities, dependent upon anticipated levels of demand.

At the top end of the design range, with one-way flows of 60 000 passengers/h or more, existing standards of train design are applicable. Looking at the concept of minimum waiting, six-car trains at 90 s headways will provide the same capacity as eight-car sets at 120 s, but offer a 15 s reduction in average waiting time.

The use of six-car trains would permit stations to be reduced in size, cutting platform lengths by 25 per cent and reducing the construction cost of a typical cut-and-cover box station by around US$6m. The reduction in volume of the passenger area of the station will also have a significant effect on operating costs, particularly where air-conditioning and ventilation is involved. On a typical metro in a tropical climate, station air-conditioning accounts for 40 per cent of all energy costs, or 25 per cent where platform screens are installed. A 25 per cent saving in this area amounts to a cut of around 6 or 10 per cent in the total energy bill for the system – or at least that proportion which is underground.

The traditional solution to a one-way peak demand of between 30 000 and 40 000 passengers/h is to provide a service of six-car trains at intervals of between 3 and 2 min. As TBS allows much closer working for similar costs, the same flows could be handled equally well by three-car trains at 90 s intervals at the bottom end of the range or four-car trains every 80 s at the higher level.

The number of cars, and therefore the size of depot required, is the same under these options as for TCS, so these factors are not critical to the decision. Equally, the amount of traction energy consumed in both options is the same. As long as it is considered necessary to keep a member of staff on each train, there will be an increase in staff costs commensurate with an increase in the number of trains. Unstaffed trains are already in service in several cities, and are likely to become the future standard, so there would be no operating cost penalty in adopting a more frequent service of shorter trains. It is notable that both VAL and Skytrain combined the installation of TBS with the use of roving passenger assistants rather than rigidly-assigned train crews.

A service of three or four-car trains using standard 23 m cars indicated a station platform length of around 70 to 93 m. If the platform is too short, the designers will face problems accommodating stairs, lifts and escalators in a configuration allowing logical passenger flows.

A 30° inclined escalator with a vertical rise of 7 m and 1·5 m horizontal levels at top and bottom has a 'footprint' of over 15 m. Add to this the 7·5 m of clear space required at each end of a bidirectional escalator bank and the total linear space is 30 m. It is usual to provide at least two escalator banks to avoid congestion on the platforms, but these would take up 60 m – difficult to achieve on a 70 m platform whilst retaining adequate circulation space.

At the upper end of the demand range, a four-car train of 92 m length is acceptable. At the lower end, operation of 70 m trains at 100 m platforms is clearly inefficient, and reduces the potential savings in construction and operating costs. If the whole platform length can be used efficiently by passengers, the total width can be reduced, whilst leaving the area available for holding passengers constant. This would allow similar savings in station volume, retaining a large proportion of the reduction in operating energy costs. This suggests the use of 100 m trains, such as four cars of 23 m, five cars of 19 or 20 m, or six cars of around 16 m.

SHORTER OR NARROWER

For a given demand level, trains of this length can be narrower – 2·75 m against 3·2 m. This allows a further 0·9 m saving in the width of civil engineering structures. A 23 m long car of narrow width could pose problems of stiffness and strength, so a 16 m vehicle might be more suitable. Shorter cars would allow a reduction in tunnel width on curves: the end and centre throws would be less than with 23 m vehicles for the same degree of curvature.

Cars of this size are similar to those used at the 'upper' end of the light rail range. Where cities follow the lead of Baltimore and Los Angeles in adopting both heavy metro and light rail technology for different parts of the network, a combination of signalling and vehicle dimensions offers the opportunity to standardise vehicle body components and traction equipment. If overhead current collection were adopted as standard, the only difference between the systems would be in signalling, and train control equipment. Maintenance savings could be considerable.

One other advantage of using longer trains of narrow cars is that the ratio of door openings to car capacity is improved. This allows a reduction in station dwell times – typically from 30 to 25 s for a reduction in width of 0·45 m. This means that for every 16 station stops on a line with an 80 s interval service, one complete trainset can be saved without reducing the capacity of the line. For a typical double-track metro line of around 16 stations this means a saving of two trains – a valuable capital cost reduction. Operating cost savings are less significant unless the trains are manned. The reduction in energy consumption in operating fewer trains is offset by the additional distance that each train runs.

Transmission-based signalling offers improved operating efficiency and capital cost savings in the design of new metros. However, planners need to take careful consideration of the relationships between anticipated demand, signalling technology, train size and station dimensions. There are significant benefits to be won by adopting the right package for any given application. □

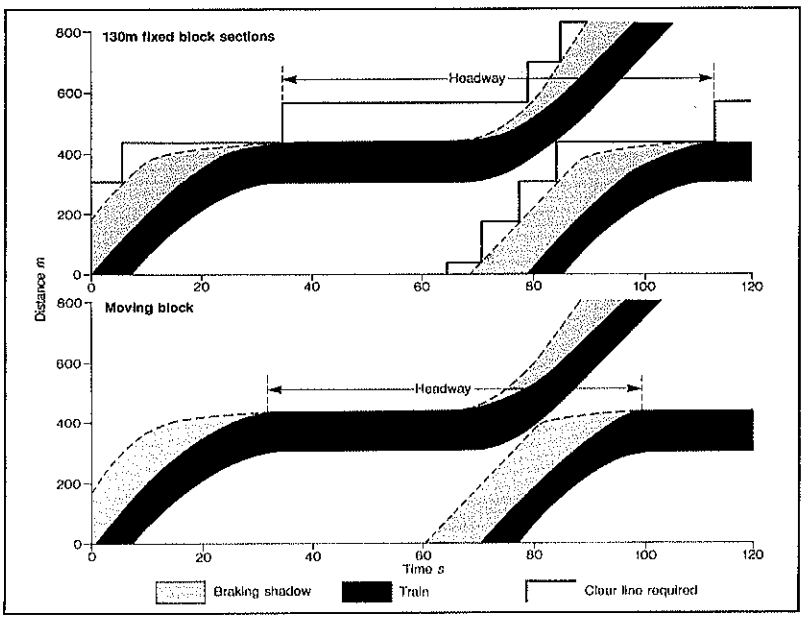
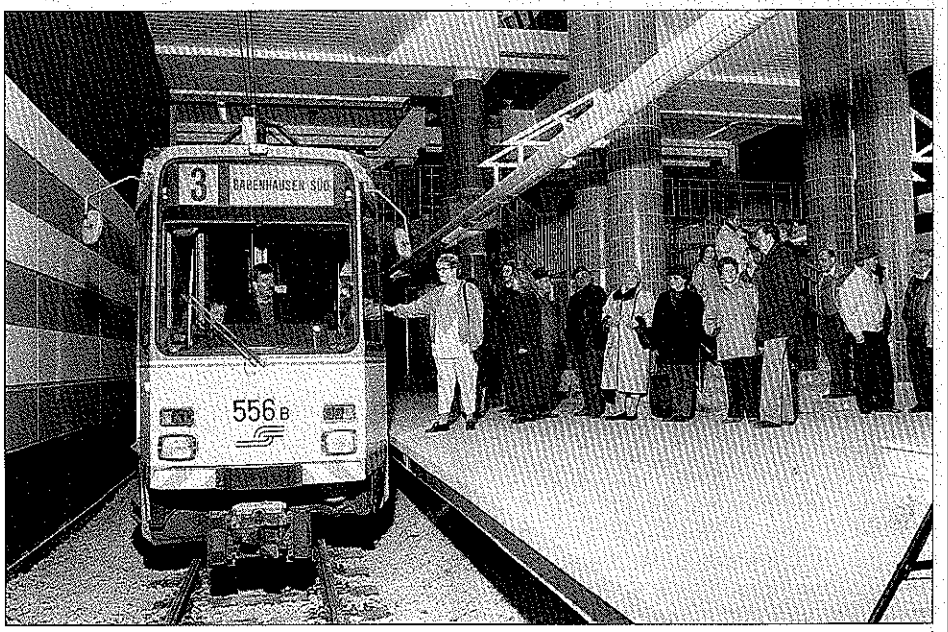


Fig 1. By abolishing the fixed block section, transmission-based signalling permits headways to be cut to a minimum that is related to the braking performance of the train

Light rail tunnel rejuvenates tram network

Dipl-Ing Manfred Weber
Tramways Manager
Bielefeld Transport

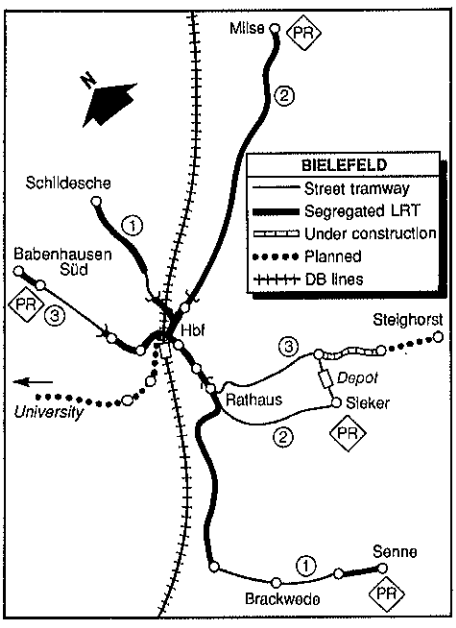


OPENING OF A 4·5 km cross-city light rail tunnel on April 28 1991 marked the culmination of a 20-year improvement programme for Bielefeld. Principal city in the eastern part of Nordrhein-Westfalen, Bielefeld has a population of around 315 000 and covers some 258 km².

Bielefeld has been served by traditional tramways for most of the 20th century, but around 20 years ago the city transport authority began a comprehensive expansion programme for the 1 000 mm gauge network. Work began in 1968, when Line 1 was extended northward from Kattenkamp to Schildesche on a 1 km dedicated alignment, the first such section of line in the city. Between 1969 and 1974, upgrading of federal highway B61 which passes through the city allowed further sections of line to be rebuilt on a dedicated right-of-way. The northern half of Line 2 was tackled first, beginning with a short tunnel as far as Beckhausstraße and dedicated alignment to the then terminus at Baumheide. To the south, the B61 is followed through the Teutoburg Forest by Line 1, which was also segregated between Bethel and Brackwede.

To work the upgraded lines, a fleet of 44 Stadtbahn-M eight-axle articulated LRVs was ordered from Duewag for delivery in 1981-84. These are based at a new maintenance depot and storage facility which was opened at Sieker in 1977. The following year, Line 2 was extended northwards by 1·3 km, again on segregated tracks, to a park-and ride interchange at Milse.

Park-and-ride facilities were also provided at Senne in 1979 when Line 1 was extended 0·6 km south from Brackwede to the new Bielefeld cemetery at Senne. Another park-and-ride interchange was opened at Babenhausen Süd, the northern terminus of Line 3, in 1980.



CENTRAL TUNNEL

The biggest single investment has been construction of the cross-city tunnel, which has removed the trams from the congested city streets. Work on the cut-and-cover tunnel began in 1977, and cost DM371m. Starting just north of the Rathaus junction where the three southern routes converge, the tunnel drops to a station below Jahnplatz, which has long been the focal point of the public transport network. The tunnel continues north to the Haupbahnhof, where comprehensive interchange between light rail and DB services is provided.

Just north of Hbf, the tunnel splits, with Line 2 curving east into the 1971 tunnel leading to Beckhausstraße. Line 1 surfaces immediately onto a short section of street track before joining its independent alignment to Schildesche. Line 3 continues in tunnel for another 1·4 km to Nordpark (above) before resurfacing; the remainder of this route is on-street.

The tunnel is built to modern LRT standards, with wooden-sleepered ballasted track and high-speed pointwork with moveable crossings. A rigid overhead copper rail of 650 mm² provides power, although conventional wires are used in the larger station tunnels. Signalling in the tunnel is controlled through an automatic interlocking at Hbf junction, which is supervised from the main network control room.

The control centre is housed in a new building at Sieker depot, and as well as the tunnel signalling panel is equipped with closed-circuit television for monitoring the underground station platforms. Another control panel monitors auxiliary supplies and equipment for lighting, lifts and the status of all ticket machines at the stations. However, the heart of the new centre is a computer-assisted command and control system to keep charge of the surface-running sections. Exchanging data with every car over a radio data link, this system allows the controllers to track the movements of each vehicle and prevent delays from building up. The system is designed for both light rail cars and buses, and we are planning to equip our bus fleet in the near future.

SURFACE PRIORITY

Having made such a substantial investment in our central tunnel, we felt that it was important that the quality of public transport was not diminished by congestion and delays on the surface routes which feed it. I have already noted that almost 70 per cent of the light rail network is now on its own right-of-way, but there was clearly scope for improvements to the remaining sections. In parallel with the construction of the tunnel, we began a programme to speed up light rail

Improvements to Bielefeld light rail routes following completion of the cross-city tunnel on April 28 1991

Line No	1	2	3
Route colour	Blue	Green	Yellow
Length *km*	11·4	10·2	6·7
Journey time before *mins*	38	33	27
after	29	25	20
Average speed before *km/h*	18·0	18·2	17·1
after	23·6	24·6	20·1
Cross-city speed before *km/h*	9·4	13·1	12·0
after	28·4	31·1	27·2
Patronage increase *per cent*	23·2	24·8	47·7

services. Infra-red detection and LRT priority has been fitted to 20 traffic-light junctions, significantly reducing road delays.

Throughout the network, conventional roadside stops are being replaced by 860 mm high loading platforms with automatic ticket machines, cutting boarding times, improving accessibility for mobility-impaired passengers, and above all speeding the service. As a result of this work, it has been possible to increase the basic service from 12 min headways to 10 min without the need to run additional cars.

Table I shows the journey time and average speed improvements resulting from the opening of the tunnel and the corresponding changes elsewhere on the network. It also shows the increase in patronage on each route – overall we have registered an increase of 28·7 per cent in average daily passenger carryings as a direct result of the improved service. Line 1 is normally worked by two articulated cars in multiple, and the others by single units, although Line 2 sees two-car workings in the peak hours.

FUTURE EXPANSION

Further expansion of the light rail network is planned, and work is already under way on two sections. Line 3 is being extended 2·5 km beyond Sieker Mitte to the nearby village of Stieghorst. The first section of this line, through existing suburbs, is now being built in a deep cutting; the second stage will have an easier run across open country, and here construction has yet to begin.

A fourth northern route is also on the drawing board, running northwest from Hbf to serve the university area and a new residential area at Lohmannshof. Most of this will be on a segregated surface alignment, but the first 1·5 km will be in tunnel. Work on this line, which is costed at DM165·8m, is expected to start at the end of 1992.

To operate the new extensions, and to accommodate further growth on the existing lines, we are planning to purchase another 16 to 20 cars from Duewag. They will be similar to the present fleet of Stadtbahn-M vehicles, but will be equipped with ABB three-phase AC motors in line with the latest energy-efficient technology. □

Wherever possible, the street-running sections of line have been provided with segregated tracks, high platforms and automatic ticket machines supervised from the control centre

Priority at traffic lights speeds trams

Dipl-Ing Friedrich Pieper
Operations Manager, Bogestra
Peter Lindner
Transport Planner, SNV

BOCHUM – GELSENKIRCHEN Straßenbahn AG (Bogestra) operates a 100 route-km network of tram services linked to 550 km of bus routes; the combined network covers 440 km^2 in the heart of the Ruhr conurbation. It was the desire to bring about a fundamental improvement in public transport services with better operating conditions that prompted Bogestra to examine a wide range of measures that might speed up tram and bus services and make them more attractive.

Tram stops are located on the approach to road junctions with traffic lights; passengers using the stops are protected from car traffic by a second set of tram-activated lights (right)

The research led to an action programme called 'Integrated Acceleration Measures for the Central Ruhr', which is currently being implemented by Bogestra and the Urban Transport Research Company (Studiengesellschaft für Nahverkehr, SNV) with financial support from the Federal Ministry for Research & Technology. The project is being overseen by the Industrial Installations Operating Co (IABG).

Journey time analysis

Starting point was a detailed analysis of journey and stopping times on five tram and seven bus routes, including time spent waiting at traffic lights; this established that around one third of journey time was spent at a standstill, and similar analyses in Wuppertal and Krefeld confirmed the results. The theoretical shortest journey times were typically being exceeded by 19 per cent. It was demonstrated that 54 to 58 per cent of lost time was spent at traffic lights and that around 25 per cent was caused by factors outside Bogestra's control.

The research also established that passengers paying cash to the driver for tickets took on average 5·9 s to board, while other passengers only took 3 s. The difference in height between platform and vehicle was another decisive factor, and the typical 3 s boarding time reduced to 2 s if same-level boarding was possible.

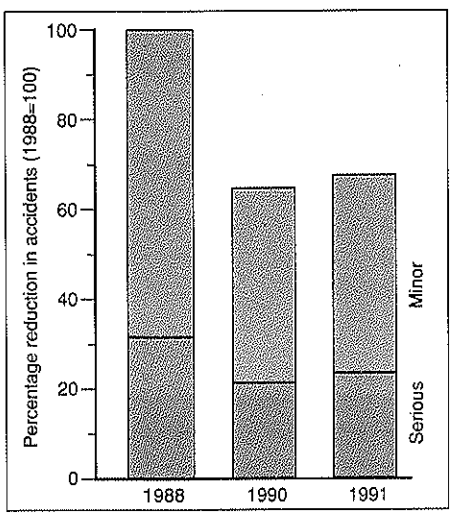


Fig 1. Percentage reduction in the number of accidents on Bochum's Hattingerstraße following introduction of traffic light priority for trams (1988=100)

The results of the analyses led to the traffic acceleration programme, which is built around the concept of trams and buses activating traffic lights to give them priority. Other parts of the programme include modifications to stops to reduce boarding height differences, introduction of low-floor vehicles, withdrawal of on-board ticket sales by the driver, better information provision at stops, and introduction of a computerised tram and bus control system. Allied to all this was the introduction of traffic lights to protect boarding and alighting passengers at stops on tracks shared with road traffic.

Trams trigger the traffic light controls through loops installed in the track, while buses use a radio system. The equipment also measures flows of ordinary road traffic on the approaches to junctions. Depending on the location, a tram requesting priority triggers one of four actions:

- no change to the timing of the traffic lights;
- green lights remain illuminated for longer than usual to allow the tram to pass;
- green phase is brought forward to avoid the tram having to slow down or stop;
- the demand is registered for implementation in the next sequence.

The logic controls at individual sets of lights take account of left turning traffic and of conflicting tram movements; in all cases the equipment is programmed to minimise delays to ordinary road traffic.

With the help of monitoring and data capturing equipment it is possible to adjust the amount of priority given to the trams and for the traffic computer to monitor automatically the time spent by trams waiting at traffic lights. The monitoring equipment also permits a close watch to be kept on punctuality, and it is linked to computers that can store information on service disruption so as to assess effectively what to do in similar circumstances. The computers also assist in a range of fleet and traffic control processes.

Passengers protected

Partly to save time but also to improve safety, we have introduced so-called 'dynamic time islands' at tram stops where tracks share the right of way with ordinary road traffic. These stops are usually located immediately before a road intersection protected by traffic lights, and a further set of lights is provided to halt road traffic before it reaches the stop.

An arriving tram is detected by a loop on its approach, and this causes the protecting lights to turn red. When the tram is ready to leave, closure of all doors results in a message being sent to clear the protecting lights, so that waiting traffic can draw forward to the main lights as soon as possible.

Waiting areas and platforms are clearly picked out in distinctive colours, and stops are being modified to reduce the boarding height; where possible same-level boarding is being introduced. To this end, 42 trams with a floor height of 320 mm were ordered in 1991, and the first is due to enter service this autumn; low-floor buses are already in service.

To reduce boarding time, drivers will in future not issue tickets. Ticket machines on board the trams and buses will be designed to accept credit card payments in the future.

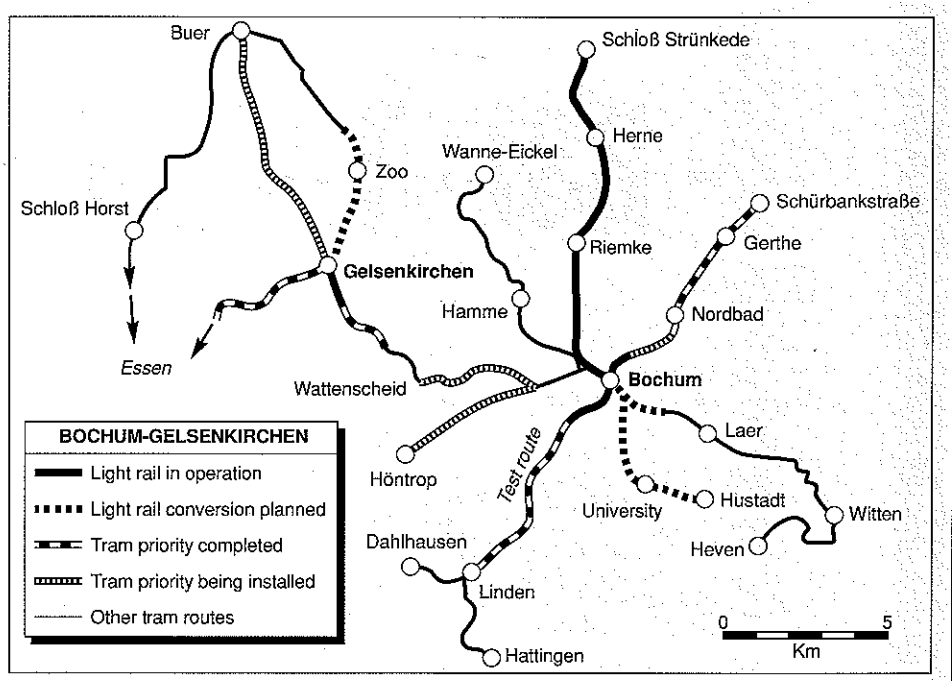
Trials have shown that two machines are needed on each vehicle, partly to avoid queues building up, but also to give a measure of redundancy. We have ascertained that there is a much lower risk of vandalism to on-board machines than to those provided at stops.

PROGRESS TO DATE

Measures designed to speed tram services affect 68 km of route, and by the start of 1992 work had been completed on 10 km in Bochum (Routes 308 and 318) and 4 km in Gelsenkirchen (Routes 127 and 302). In Bochum work is concentrated on the western sections of Routes 302 and 310; work is progressing in Gelsenkirchen in anticipation of the introduction of low-floor trams on Route 302. About 45 per cent of the programme should be finished by the end of this year, with all work completed by 1995.

To check the effectiveness of the measures, we have carried out a number of control tests on the longest completed section which runs for 6·6 km from Bergmannsheil to Linden. Despite increasing the number of sets of traffic lights from 10 to 23, the time lost at traffic lights has been reduced by 54 per cent for trams to Linden and by 70 per cent for those bound for Bochum city centre. This has given a 10 per cent cut in journey times, and schedules were initially cut by 3 min in each direction. In June 1991 it was possible to cut a further 2 min off the timings. The reduction of 5 min has allowed the service to be worked with one fewer car, and this vehicle has been used to introduce a 5 min interval service between Nordbad and Linden during peak periods.

The new or modified traffic lights have also had a beneficial effect on road traffic flows. Checks made in 1988 on the southern section of the route before the changes were made, and these were compared with traffic flows in 1990; the comparison showed that journey times for cars have not been extended, despite the higher number of traffic lights and the priority given to trams. Police records show that the number of road accidents has fallen by approximately one third on this stretch. □



Circle 20 on express enquiry card

Accessibility high on investment agenda

PASSENGERS ON Boston's Red line are starting to see the benefits of a $150m programme targeted at station and rolling stock improvements. 'The Year of the Red Line' is intended to round off a series of projects which began during the 1980s, when MBTA invested over $2·5bn in infrastructure and rolling stock.

Running from Alewife in the northwest of the city to Braintree and Ashmont in the south, the Red line has the second highest ridership of any MBTA route. Amongst the projects being undertaken in 1992 are improvements at five stations, which will make the 23 station, Y-shaped line almost completely accessible to disabled passengers. The existing rolling stock is being refurbished internally, and the first of 86 new EMU cars being built by Bombardier for $132m will come into service in mid-1993.

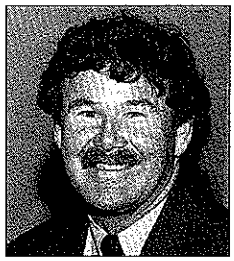
The Red line is one of three heavy metro routes belonging to Massachusetts Bay Transportation Authority. The T, as MBTA is known locally, operates the sixth largest public transport network in the United States; this includes four light rail branches and 11 commuter rail lines in the greater Boston area. Together with over 150 bus and trolleybus routes, the rail corridors carry nearly 700 000 passengers each weekday.

Another key area being targeted in 1992 is the improvement of customer information at stations. MBTA has recently introduced an automatic voice response customer service centre offering timetable and route information round-the-clock. A programme called 'Revive and Guide' is intended to rehabilitate 10 older subway and commuter rail stations with new paintwork, lighting and better signs. Operational reliability should be improved by modernisation of the downtown control centre and installation of the latest vehicle tracking equipment.

The Orange line was modernised in the 1980s, and MBTA is now moving towards final design for complete rehabilitation of the Blue line. Station and car park renovation will include provision of disabled access throughout the line, whilst platform lengthening to take six-car trains will give a 50 per cent increase in capacity.

COMMUTER RAIL

MBTA is responsible for 11 commuter rail routes which are operated under contract by Amtrak. Five routes radiate from North station to Fitchburg, Lowell, Haverhill, Rockport and Ipswich, and six from South station to Readville, Stoughton, Providence Franklin/Forge Park, Needham Heights and Framingham. These lines are largely worked by a fleet of 107 Bombardier push-pull single-deck coaches powered by General Motors F40-PH diesels. The first of 75 Kawasaki double-deckers (right) was introduced last year, and they have proved very popular.



John J Haley Jr
General Manager, Massachusetts Bay Transportation Authority

Work will begin later this year on an additional commuter rail corridor, known as Old Colony, from South station to southeastern Massachusetts. Key to this link is a new bridge over the Neponset river at North Quincy. One of MBTA's top priorities, the Old Colony route is expected to open towards the end of 1995 or early 1996. The route branches into three at its country end, serving 21 stations. All will be equipped with large car parks to encourage park-and-ride business. Daily ridership is expected to be around 15 000.

In the longer term, plans are under way to extend several commuter services over freight tracks to neighbouring cities. In 1996, the Framingham line will be lengthened 37 km to Worcester, the second-largest city in New England, and the Ipswich line will be extended 16 km north to Newburyport. MBTA is still examining the possibility of extending commuter services to Taunton, New Bedford and Fall River.

With commuter services radiating from two termini on opposite sides of the central area, there is a heavy emphasis on good connections to the rest of the city. In 1990, MBTA launched a phased project to convert North station into a multi-modal Transportation Centre. Work is currently under way on a 1 300 space underground car park, which is due to be completed in 1993. The structure incorporates a section of tunnel for the Green line, and the foundations for the new Boston Garden sports complex.

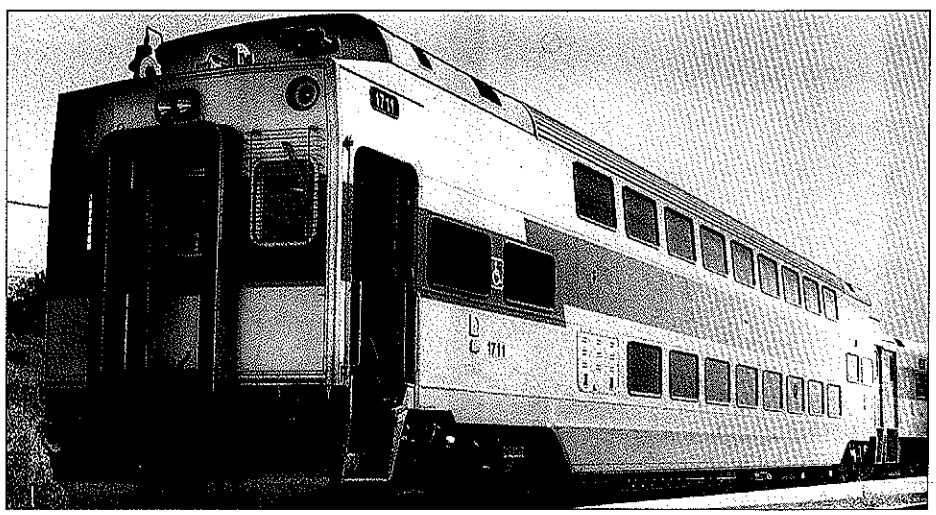
Future phases include re-siting the commuter rail platforms to give better interchange to the Green light rail route and the Orange metro line. The elevated Green station will be replaced by an underground alignment, creating cross-platform connections with Orange line services. This will allow the overhead Green line structure that blights the area to be demolished.

On the other side of Boston, the five-year $60m renovation of the South station was completed in 1989. This included total restoration of the historic terminal buildings, new platform tracks for commuter services, and direct access to the Red line. Work has just started on a $75m scheme to create an Intermodal Transportation Centre, by adding a two-level busway and two-story car park on a raft above the existing tracks.

ACCESSIBILITY

Since 1976, MBTA has been working to improve accessibility to its network for disabled passengers. In order to comply with the recently enacted Americans with Disabilities Act, MBTA is planning to buy 100 low-floor light rail vehicles and make its Green Line light rail stations and selected stops accessible for wheelchair passengers. Expansion of the 'Ride' door-to-door minibus service for the disabled is also planned.

In order to ensure rapid response to customer needs and give a clear responsibility for costs and revenues, a tightly-managed administrative structure is required. Since I took over as General Manager in September 1991, I have implemented a major reorganisation of MBTA into more compact and efficient units. In place of 15 directorates with separate directors are now six functional groups headed by Assistant General Managers. These include operations; design, construction and real estate; purchasing and administration; marketing and communications; planning and budget; and human resources. □



Turnkey deal to build 40 km in two years

AT 17.00 ON April 21 1994, the Brazilian capital will become the latest member of the world metro club. For it is then that Governor Joaquim Rorez is due to inaugurate the first line of the Brasilia metro. After many years of planning, a US$650m turnkey contract was awarded to the Brasmetro consortium on January 6 to build the 40 km Y-shaped route which will link Brasilia with its western suburbs.

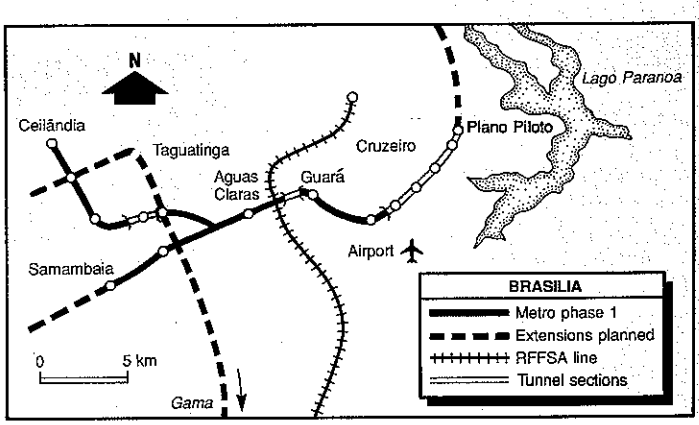
When the city of Brasilia was created by architects Lucio Costa and Oscar Niemayer, at the wish of President Juscelino Kubstichek, the new federal capital was expected to reach a population of 500 000 in 2000. In practice, the city has grown much faster. By 1991 the population had already passed 1·7 million.

Under the basic development strategy for the Federal District, around 70 per cent of all employment is concentrated in Brasilia itself, with little in the 11 suburban satellites. Only Taguatinga and Ceilândia currently include any workplaces. Not surprisingly, this has led to severe problems of transport congestion as the population has grown.

At present all transport in Brasilia is road-based, with buses accounting for 45 per cent of demand and private cars for 47 per cent; the remainder is split between taxis, bicycles and walking. Around 20 million passenger-journeys are made by bus each month, but the demand is not spread equally between the various routes. The busiest axis, leading from the city centre to Guará, Taguatinga, Ceilândia and Samambaia accounts for no less than 60 per cent of all demand. Peak hour one-way demand in this corridor is around 22 000 passengers/h, which is greater than the normally-accepted limits for bus technology.

Over the past few years, it has become increasingly clear that road transport cannot meet the growing demand for mobility. Passengers on the busiest routes are faced with journeys of up to 2 h in a bus crush-loaded at 10 passengers/m^2. The slow speeds mean that a large fleet of buses is required, with low utilisation, and increased road congestion, not to mention road damage, increased accidents, and worse pollution.

José Gaspar de Souza
Co-ordenador
Brasilia Metro



Since 1973, repeated studies pointed to the potential benefits of a rail-based solution, and in 1991 the Federal District Government voted to create a high-capacity metro to serve the principal corridors. Careful matching of the network to the natural demand flows will ensure that the metro will strengthen the city and improve the quality of life for its inhabitants without neglecting human, historic or cultural values.

Conception of a network

The principal purpose of the metro is to provide a high-capacity core in the main corridors from Brasilia to Samambaia and Ceilândia. From this, a network of feeder bus services will serve outlying suburbs, reducing demand on road space in the central area. Creation of the metro should cut the overall cost of providing public transport in the Federal District, whilst improving the quality of the service provided.

At the same time, the metro will open up travel opportunities between the various satellites, promoting more intensive land use and the spreading of employment opportunities out of the centre to these areas. As part of this policy, we are creating a new satellite at Aguas Claras, astride the metro corridor, which will eventually house 160 000 inhabitants. Aguas Claras will provide a second metropolitan centre for services and employment, reducing the concentration of jobs in the centre of Brasilia.

For the past four months, bulldozers have been hard at work in the western suburbs of Brasilia clearing the way for the first metro line

The first line will start at Plano Piloto in the heart of Brasilia, and run westwards for 8 km beneath the principal avenue, with eight intermediate stations. Surfacing at the edge of the city, the line will serve the long-distance bus station before swinging north-westwards to serve the town of Guará. There will be another tunnel here, 1·5 km long. Crossing the existing RFFSA rail line, the metro reaches the area designated for Aguas Claras, where the two branches will split. The metro depot will also be situated here.

The primary route turns north to five stations in Taguatinga, where another 1·5 km tunnel is planned to take the trains under the town centre. A long Z-shaped alignment will serve eight closely-sited stations in Ceilândia. The shorter south-western branch to Samambaia will have only four stations.

In total, the 40 km network will serve 33 stations, of which 11 will be underground, 9 in cutting and the others at ground level. Bus interchanges are planned for 10 stations, and most stations will be incorporated into commercial developments.

The tunnel sections are designed for cut-and-cover construction, but we are studying the possibility of using the New Austrian Tunnelling Method in order to avoid disruption to the trees on the surface.

Design work has already started on a 7 km extension of the first line to serve the northern half of Brasilia. Like the first phase this would be tunnelled under the main avenue, and would add nine more stations. A 48 km westward extension of the Samambaia branch is planned, with up to 30 stations.

As the western satellites continue to grow, a second line will be created to serve the areas between the existing developments and serve planned new employment zones. Starting in Ceilândia, Line 2 would interchange with Line 1 in the town centre, then loop through Taguatinga to another interchange before turning southwest towards Gama. We

expect work to begin on the first 12 km section of Line 2 between Ceilândia and Taguatinga in 1995, with opening in 1998.

FINANCE AND CONSTRUCTION

Once the decision was taken to proceed with the metro, the first priority was to arrange funding for the scheme, which is costed at US$650m, or $16·3m/km. The Federal District Government is putting up US$170m, which is being funded from sales of development land. The Federal Finance Ministry has pledged US$180m in 1992-94, and the state governor's budget allocates a further US$60m. The remainder will be funded by a long-term loan from the National Bank for Economic & Social Development (BNDES).

Tenders were invited in September 1991 for a turnkey contract to build and equip the initial line, and to operate it for the first six months. Two main groups were in contention, and towards the end of the year our choice fell on Brasmetro.

Brasmetro is made up entirely of Brazilian companies: four civil engineering firms – Camargo Correa, Norberto Odebrecht, Andrade Gutierrez, and Serveng Civilsan – rolling stock supplier Mafersa, signalling and communications company CMW, the Inepar electrical group and project management consultants TCI.

In order to have the line open by April 1994, work is progressing to a very tight timetable. The 7·5 km between Aguas Claras depot and Samambaia is due to be completed by August 1993 to provide a test track for commissioning the rolling stock. By December 1993 this section will be available for driver training, with limited staff access. The remainder of Phase 1 must be complete and tested just three months later.

Because of the need to complete the line in such a short timescale, and because we want as much of the work as possible to be undertaken by Brazilian suppliers, we are sticking to established standards. The line will be laid to 1 600 mm gauge, using conventional ballasted track on the surface sections and concrete slab track in the tunnels. Minimum curve radius is 250 m. Power supply will be 750 V third rail.

Mafersa is supplying a fleet of 80 vehicles, arranged in two-car sets with chopper control equipment. The steel-bodied cars will be similar to those used on the Sao Paulo metro: 22 m long and 3·15 m wide, with a maximum capacity of 325 passengers per vehicle. Maximum train length will be six cars. Top speed will be 100 km/h, giving a commercial average with stops of 45 km/h.

The line will be equipped with ATC, supervised from a control centre at Aguas Claras, allowing 2 min headways at peak times. The communications network will provide telephones between all stations and depots, radio communication between the control centre and all drivers, backed up by voice recording for emergencies. Public address, passenger communication points, and CCTV monitoring of platforms and booking halls will be provided.

Power for the metro will be supplied by Companhia Energia do Brasilia at 13·8 kV 60 Hz to 16 substations evenly spaced along the route. To ensure that power supplies are maintained for ventilation, lighting and communications, all feeder circuits will be duplicated; each substation will be able to feed two adjacent sections if a supply is lost.

Brasmetro will operate and maintain the line for the first six months following opening. We can therefore be confident that when the line is handed over any teething troubles will be ironed out. After many years of talking, Brasilia is on track towards a metro that a federal capital can be proud of. We have a lot to achieve in the next two years, but it is a fascinating challenge. Roll on April 21 1994! □

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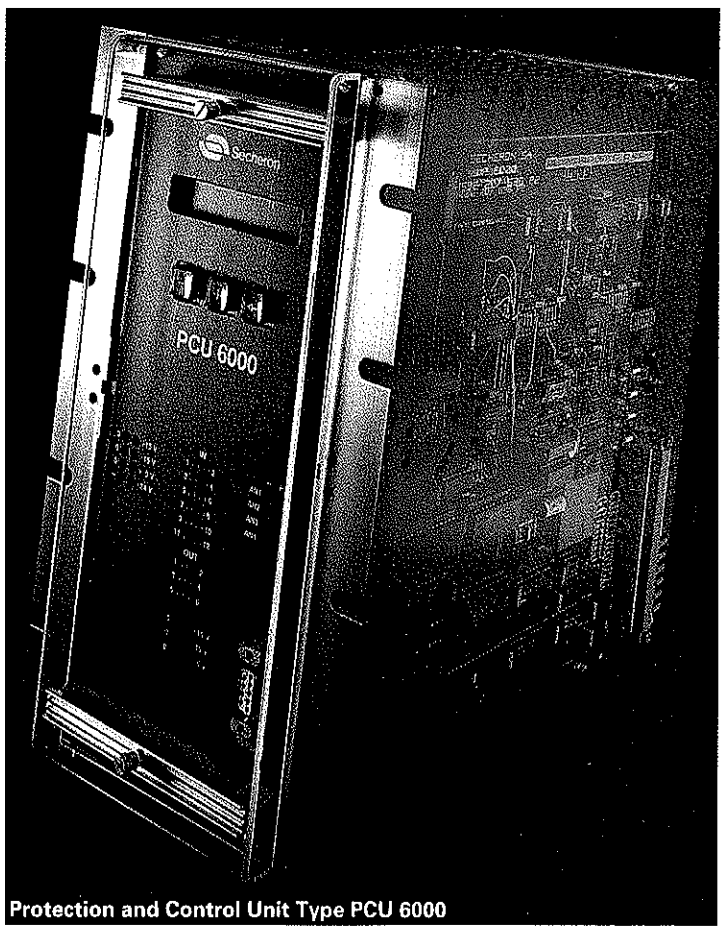

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Preparing to build Line 2

VERY SHORTLY, National Authority for Tunnels expects to place contracts for the first 10·8 km section of Line 2 of the Cairo metro. Bids have been received from consultants offering to manage the project, and from contractors willing to construct and equip Line 2.

This line will start in the northern suburbs at Shubra el Kheima, and run on the surface until diving into tunnel under the Ismailia Canal. It then follows Shubra Street to Ramses Square, where there will be interchange with the existing Line 1 at Mubarak, close to Egyptian Railways' main station. A second interchange station will be constructed at Attaba where provision will be made for the planned Line 3 running north-west to south-east across the city. Turning west, Line 2 will terminate for the time being at Sadat station under Tahrir Square where it will interchange with Line 1.

A later phase of construction will see Line 2 extended by a further 7·2 km, passing under the River Nile to serve Cairo University and the densely-populated area at Boulak El Dakrour before turning south again to reach Giza.

Eng M E Abdel Salam
Chairman, National Authority for Tunnels

LINE 1 STILL DEVELOPING

Line 1 was formed by connecting two existing commuter routes through a 4·7 km tunnel under the city centre. The line south to Helwan was already electrified at 1·5 kV DC using overhead catenary, so this power supply was used for the tunnel and the northern line to El Marg. The tunnel section was opened on October 1 1987, and electric trains began running through between Helwan and El Marg on April 12 1989.

At present, we have 100 three-car EMUs in service; these were built partly in France and partly by Semaf in Helwan. A further 20 three-car units are on order, and we plan to bring the fleet up to 204 units eventually. This will allow the current service running at 6 to 7 min intervals to be stepped up to 4 min off-peak and every 2½ min in rush hours.

At the same time, measures are being taken to speed up the service, increasing the commercial speed from 35 km/h at present to 45 km/h.

Planned capacity of Line 1 is 2 million passenger-journeys a day. Last January we were carrying about 850 000 a day, and we expect to reach 1 million some time around mid-1992.

A comprehensive control centre for the Cairo metro, now under construction at Ramses Square, will supervise train operations, signalling and power supplies including traction substations on all three lines and the 220/20 kV switching station connected to the national grid.

Also in progress is the installation of automatic train protection, which will bring trains to a stop if the driver attempts to pass a danger signal. Safety will be further improved by the construction of two road and five pedestrian overbridges to replace level crossings.

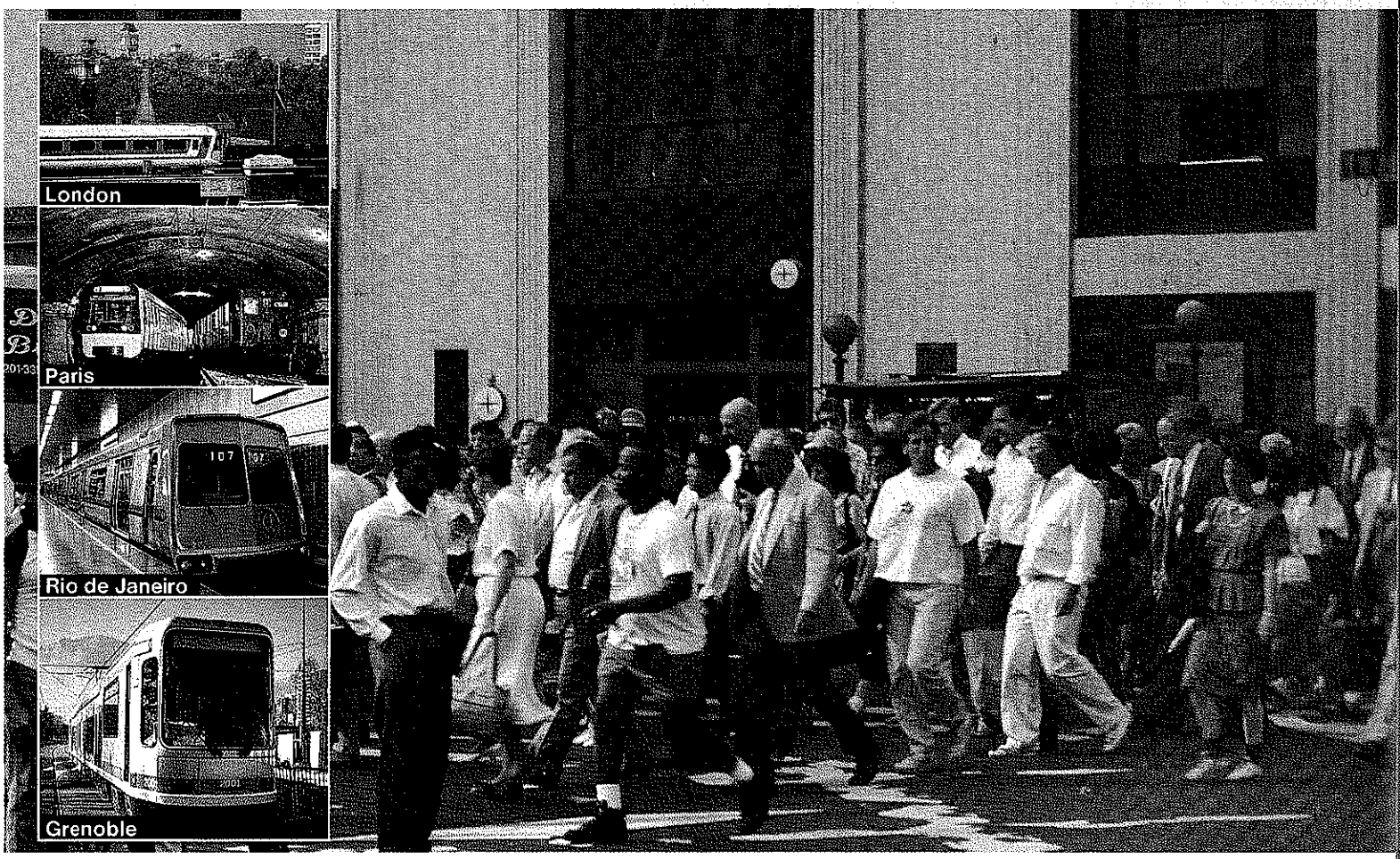
A number of stations on the Helwan line are currently being renovated.

NEW TUNNELS WILL BE BORED

Cut-and-cover construction was used for the running and station tunnels required to create Line 1, but much of Line 2 will be bored as a single 9 m diameter tunnel containing two tracks. Of the 11 stations on the first section, seven will have the platforms in bored tunnels, two will be cut-and-cover, and two will be open air.

The 15 eight-car trains required will draw power from a 750 V DC third rail, and they will be stored and serviced at a depot to be constructed at Shubra el Kheima. □

We are doing our part to keep the city on the move.



And cars in the garage.

More and more people today are taking the rails, not the roads, to work. To many the freedom of driving just is not worth fighting traffic, finding parking and adding to the pollution problem. Instead they are taking the train. To them it is the best way of getting to and from work.

SAB WABCO agrees, and wants to make everyone's journey as quick and relaxing as possible. For more than a century, the companies in the SAB WABCO group have been supplying dependable braking systems that meet commuters concerns for safety and comfort. And railway builders demands for performance and value. Which explains why SAB WABCO components have become essential parts on metros, street cars and commuter trains all over the world.

Like in London, where our disc-brakes and actuators are bringing smoother stopping power to Docklands Light Railway and British Rail's commuter cars.

And in Paris, where the city's transit authority has relied on our safety-critical equipment since the first Metro car took the tracks. Our air-over-hydraulic brake system will be fitted on the next generation of cars.

Rail authorities in Rio de Janeiro and Sao Paulo have asked our national company to deliver braking components for each city's fleet of metro coaches.

Passengers riding the new street cars in Grenoble have the security of our electro-hydraulic brake systems. So will the riders of the automatic VAL train system which is now being constructed in Taipei.

Riders of the MRTC in Singapore are also getting from place to place thanks in part to SAB WABCO engineering. So far we have delivered 1,584 brake actuators to this mass transit system.

References such as these give you an idea of the part we are playing to make city rail a better alternative. The working partnership with you will be the proof of what we can achieve.

SAB WABCO

A company in the Cardo Group

Expansion continues in centenary year

Robert Belcaster
President, Chicago Transit Authority

JUNE 6 MARKS the centenary of urban rail services in Chicago. Since the Chicago & South Side Rapid Transit Railroad Company opened the first section of its steam-worked elevated 'high line' from Congress Street to 39th Street, the city's metro has grown into a six-line network totalling 336 route-km. Chicago Transit Authority's fleet of over 1 200 cars handles over 146 million journeys each year.

After 100 years of service the technology may have changed, but the objective is the same: to give the most efficient transit service possible. To achieve this CTA is undertaking a programme of infrastructure improvements unprecedented in recent years. Over the next two years we expect to complete several capital projects that will significantly improve our quality of service.

Future investment priorities will be set by a $24m engineering analysis which is due to be completed in June. Funded by the Illinois Regional Transportation Authority (RTA), this is the most comprehensive assessment ever undertaken on a US metro network. The three-year study will analyse the present state of the network, help CTA develop a plan for future maintenance and identify capital needs for the next 40 years.

Whatever the study may indicate, CTA is pressing ahead with repairs and renewals to its rail infrastructure. Last summer, the 8 km State Street subway tunnel underwent its first major permanent way renewal since it opened in 1943. In a $19·5m project, contractors replaced nearly 15 km of running and third rail on both tracks, together with some sleepers and ballast.

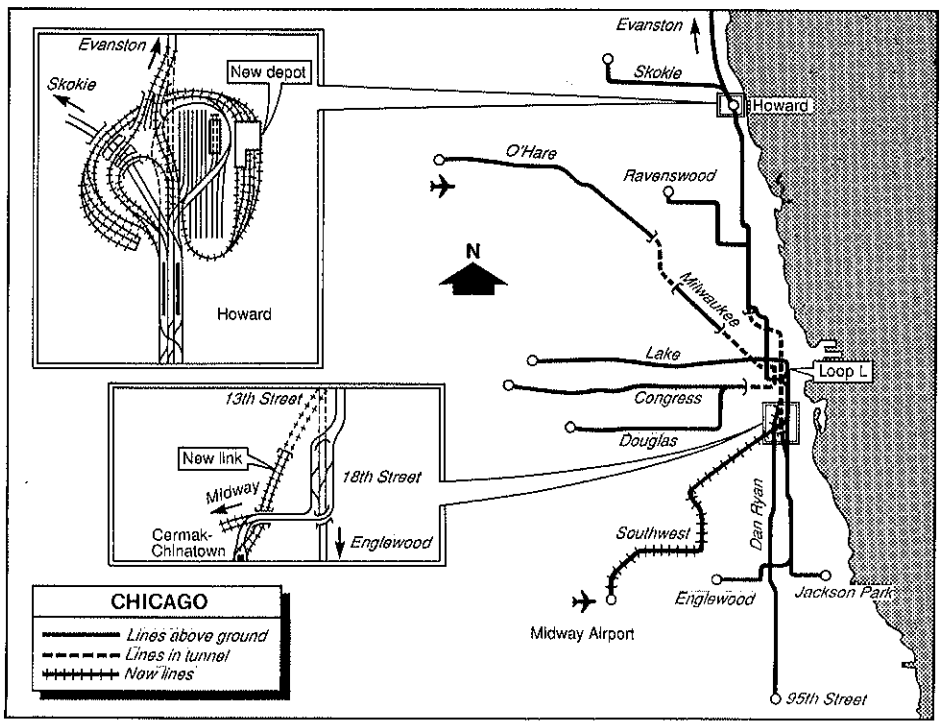
Last summer CTA completed renewal of tracks in the 50 year old State Street subway

A $15m investment on the 8 km Skokie branch was the first track renewal on the line since the CTA acquired this last remnant of the North Shore interurban route in 1963. Some 14·6 km of track were replaced, together with substantial formation renewal and reballasting, to give a faster and smoother ride. The junction layout at Howard was improved to simplify pathing.

The western branch to Douglas benefited from $8·5m for track and bridge renewal, together with some station improvements. Similar works were also undertaken on the Ravenswood line at a cost of $6m.

CTA employees continue to turn in an excellent record on both accidents and crime – 1991 was CTA's safest year ever for traffic and passenger accidents. There were only 2·37 accidents per 100 000 train-km of vehicle operation, a reduction of three per cent from the previous year's record of 2·43.

To enhance security, four of the downtown subway stations on the Howard – Englewood/Jackson Park and O'Hare – Congress/Douglas routes were equipped with CCTV monitors. Washington and Jackson stations in both the State Street and Dearborn Street subways have staffed security booths on the platforms. Each booth has 12 monitors that allow security personnel to observe the platform and connecting passenger tunnels, a public address system, and a direct line to a communications centre with provision for a link with the Chicago Police Department. The $500 000 installation was funded by the Illinois state legislature.



Expansion continues

This September should see the completion of the long-planned link-up of the Howard and Dan Ryan routes (RG 1.88 p36). Since the mid-1970s, ridership on the two arms of the north-south main line between Howard and Englewood/Jackson Park via the State Street subway have become increasingly unbalanced. A similar phenomenon has occurred on the west-south Lake – Dan Ryan line, which has been running as a through route since 1969.

Because the Lake – Dan Ryan trains operate over the elevated loop in the central business district, they must share the limited track capacity with Ravenswood and Evanston trains. This restricts the number of Dan Ryan trains that can be scheduled, causing significant overcrowding during the rush hour periods. By rerouting the less-busy Englewood/Jackson Park trains onto the elevated loop and round to Lake, space can be released in the State Street subway, allowing Dan Ryan trains to run at headways

as little as 3 min. This will enable a 30 per cent increase in the level of service.

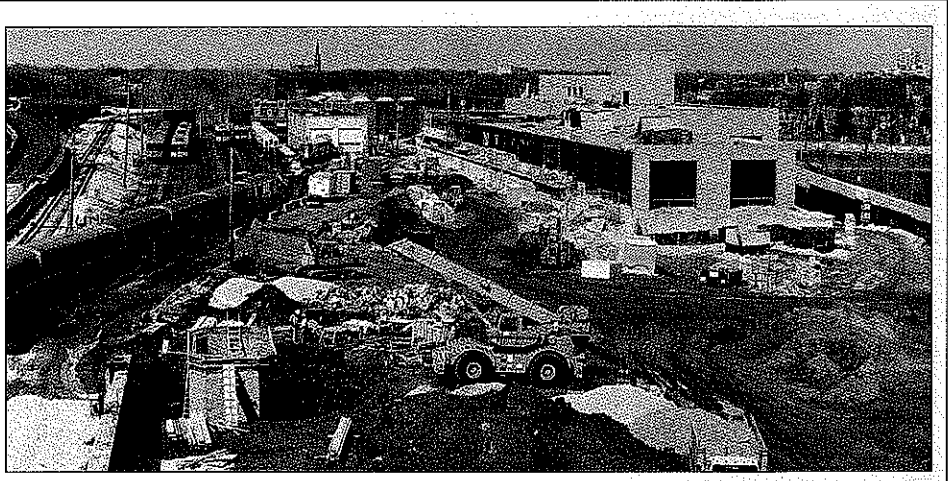
To allow the Howard and Dan Ryan services to be paired, a new link has been built between the two routes. Due to be ready for service in midsummer, the 1·4 km spur runs from the elevated Cermak station (22nd Street) to meet the subway at Roosevelt (12th Street). The two single-track ramps descend from the Dan Ryan line just north of Cermak, bridging 18th Street and enter a tunnel at 16th Street. The Lake and Englewood/Jackson Park branches will be connected at 15th Street, where Dan Ryan and Englewood/Jackson Park tracks run parallel.

A second requirement for the Howard – Dan Ryan route is increased terminal capacity. The capacity of the 98th Street yard, which serves the Dan Ryan route, was doubled to 200 cars. At Howard, CTA is replacing its 1950s depot by a new building and turning loop adjacent to the junction of the Skokie Swift and Evanston lines, one of the busiest points on the network.

An extra 1·6 ha of land has allowed the depot to be completely remodelled, increasing its capacity from 130 to 262 cars. At the same time, the junction of the Evanston and Skokie routes is being grade separated to ease pathing conflicts.

As part of the Howard remodelling, a 26-car repair shop is being built to service the fleet. An indoor washing plant able to take an eight-car train will allow year-round washing of train exteriors; this will recycle waste water. The shop will also have built-in car jacks, each capable of raising two cars about 1·5 m, to simplify the maintenance of underfloor equipment.

We anticipate that Howard shop will be ready for use in September, enabling the switch of Howard – Dan Ryan service to take place on Labor Day (September 7).



A repair shop able to handle 26 cars is due to open at Howard in September this year

SOUTHWEST LINE

Work is also under way on Chicago's southwestern side, the largest part of the city not served by a rail line. The Archer Avenue/Stevenson Expressway bus service corridor is the most heavily used in North America without a metro, handling around 150 000 daily journeys to or from the city centre. It now takes between 40 and 60 min to get from Midway to the Loop. This is set to change at the end of this year, or early in 1993 when the Midway (Southwest) Rapid Transit line opens. With trains taking just 25 min, we expect to attract almost 30 000 riders a day when the services start.

Initially, the Midway line will have seven stations, although provision has been made for another to be added. All are being built with island platforms, and every station will have a lift for disabled passengers. Each station will have a bus interchange; three will also provide parking and 'kiss-and-ride' pick-up and set-down areas.

Over 100 cars will be needed to work the Midway line, and these will come from CTA's latest build of cars. A $207m contract for 256 cars was awarded to Morrison Knudsen in December 1989, and the first four prototypes are now going through a six month type-testing programme. Once these cars have been accepted, Morrison Knudsen will start to deliver between 10 and 14 cars a month until 1994. By the time the last cars have been delivered CTA's fleet will have grown to 1 300 cars.

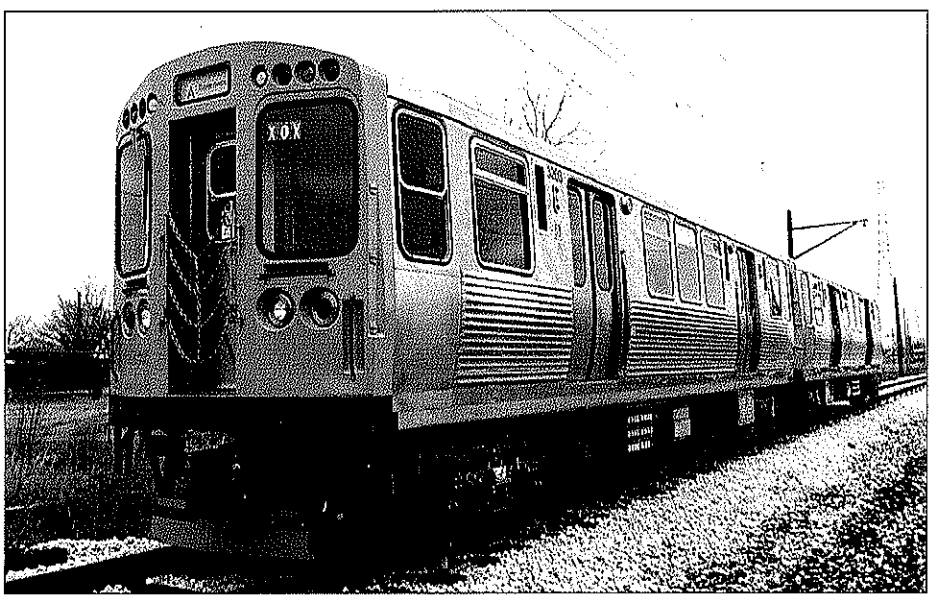
Key features of these Series 3200 cars are:

- lower exterior panels of corrugated stainless steel to reduce graffiti problems;
- self-contained underfloor air-conditioning units;
- 2+1 seating for 39 people, and wider aisles for improved traffic flow and higher standing capacity;
- wide sliding doors for rapid loading and easy wheelchair access. Each car will have space for one wheelchair, adjacent to a passenger intercom for emergency communication with the driver.

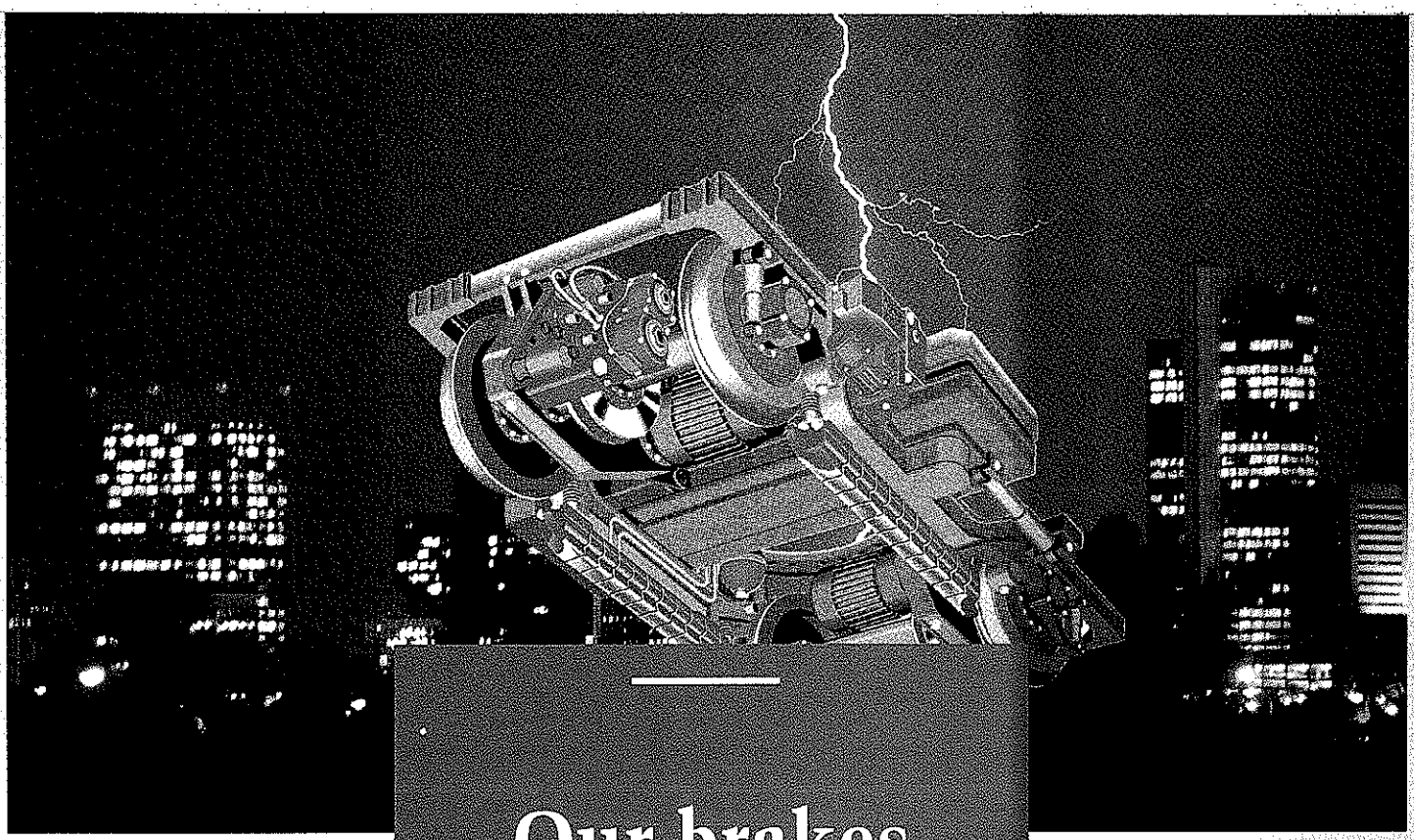
The Series 3200 cars were designed for people with disabilities, before the adoption of the Americans with Disabilities Act (ADA), as part of CTA's commitment to make rapid transit services available to all Chicagoans. CTA already has 14 wheelchair-accessible stations, and this year sees the start of a scheme to modify another 35 stations – 21 by 1996 and the rest by 2005.

As CTA looks to the future it is not neglecting its history, and this summer a set of specially painted cars will provide a focal point of the centenary celebrations of rapid transit in Chicago. Two Series 2000 cars dating from 1964 have been cosmetically transformed to resemble the first cars in use in 1892. These will run in service on the Howard – Englewood/Jackson Park line during June.

Whilst those first services on the 'high line' in 1892 gave the city new standards in public transport, the improvements set for 1992 and beyond will enable CTA to provide the highest levels of comfort on a larger and even more efficient network than ever before. □



Morrison Knudsen delivered four prototype Series 3200 cars earlier this year; bodyshells are being supplied by Mafersa of Brazil



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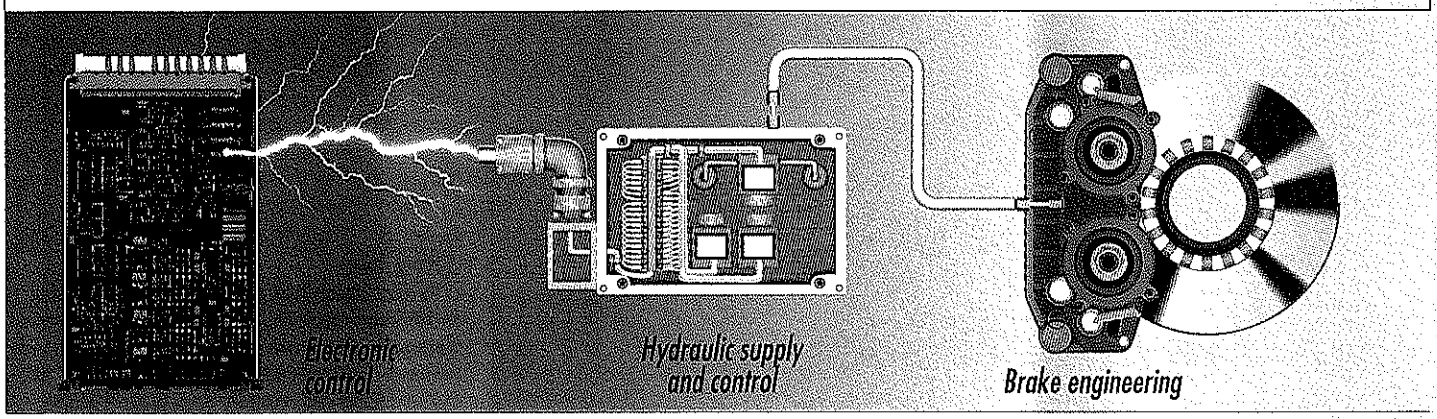

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Light rail construction gets under way

AFTER TWO YEARS of design and engineering, work began on construction of the first 32 km of the Dallas light rail network in February. Costing US$828m, the first line will link the south-western suburbs of Westmoreland and Oak Cliff to the central business district and continue north to Fair Oaks, parallelling the North Central Expressway. The line, with 21 stops, is due to open to passengers in 1996.

The present light rail project dates from 1988, when the voters in the 14 cities that make up the Dallas Area Rapid Transit district turned down a bond proposal that would have provided long-term financing to construct a 150 km light rail network originally drawn up in 1984. Sent back to the drawing board, DART planners developed a balanced scheme including 108 km of light rail routes (without the cross-city tunnels and stations planned in the first proposals), a 55 km commuter rail corridor and a 60 km network of high-occupancy vehicle lanes on key roads. This package was developed within a year of the failed vote, and survived local referenda in eight suburbs which considered pulling out of DART. The project is now scheduled for completion in 2010.

The first sections of the so-called Starter Line to be tackled are the most expensive – a 5·6 km deep-level twin-bore tunnel costing $87m on the northern section and an $18·7m bridge over the Trinity river which will connect South Oak Cliff to the centre of Dallas. Later this year, we expect to start construction of two at-grade sections of line; one on the northern route and the other in Oak Cliff. Work will also begin on a 10·9 ha LRV servicing and maintenance depot in southeast Dallas.

Final design for the remainder of the route should be complete by the end of 1993. The line will cross the city centre at-grade, using a 1·6 km Transit Mall through the historic West End district near Union station.

Charles S Anderson
Executive Director, Dallas Area Rapid Transit

Once the initial line is complete, DART will start work on a the next round of construction. Revenue service is anticipated by 1999-2001 on a further extension of the North Central line and a northeastern branch to Garland. Also scheduled at this stage is the Pleasant Grove route running south-east from the city centre.

By 2010, DART should be operating to suburban cities such as Plano, Richardson, Rowlett, Irving, Farmers Branch and Carrollton. These remaining extensions will open between 2003 and 2010 – although our long-range financial forecast indicates DART has sufficient revenues to build the entire network, the timescale is driven by cash flow, which is dependent on a local sales tax that fluctuates with local economic conditions.

In the next month or two we shall be starting the procurement process for the first 40 cars of an anticipated fleet of 120 which will be needed for the 108 km network.

Commuter rail

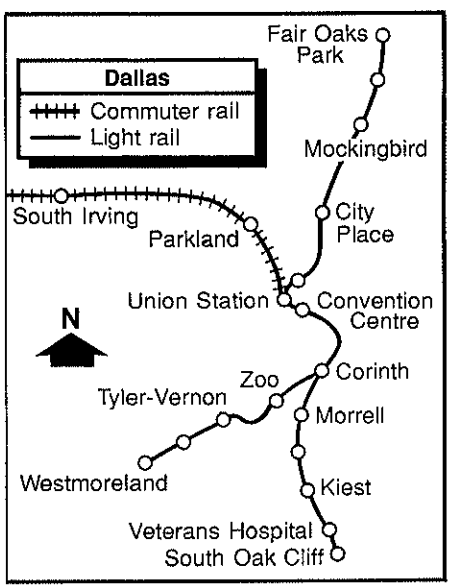
Although the light rail plan has had its share of stops and starts since DART was formed in 1984, the commuter rail element of the Transit System Plan was only approved by the DART Board of Directors in 1989. Since then, we have been faced with complex negotiations with a variety of local municipalities, so that the initial start date for the first 16 km has been put back by at least a year from the anticipated opening in 1992.

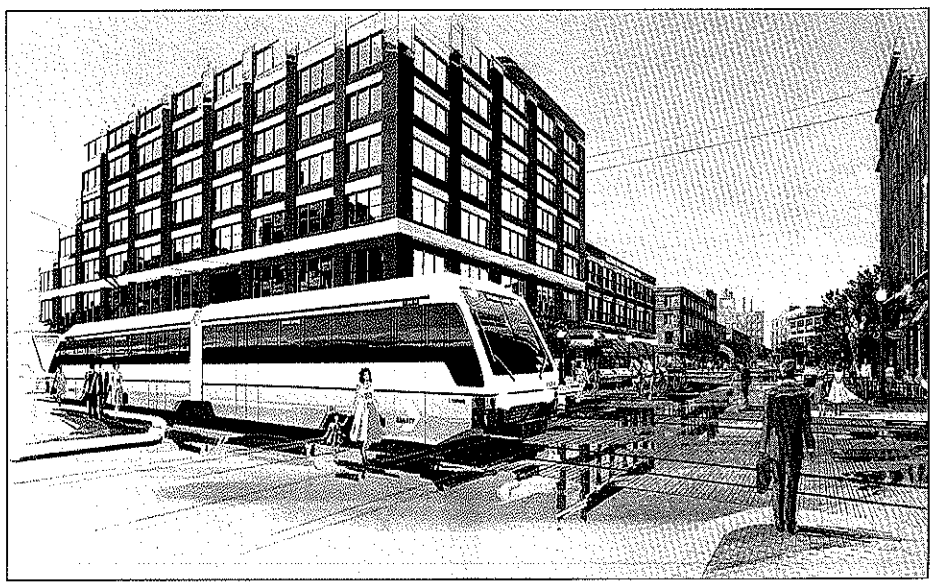
Initially, the commuter service was to operate over an existing railroad corridor from Union Station in central Dallas to the northwestern suburb of Irving, and then be extended to Dallas/Fort Worth International Airport over a new branch to be constructed by the airport authority itself. After more than a year of negotiations, DART, the cities of Dallas and Fort Worth, Fort Worth Transportation Agency (The T) and Railtran (the six-member policy committee that oversees freight traffic on the line) approved an operating agreement at the end of 1991.

Under the terms of this agreement, commuter services will run initially to Irving, probably towards the end of 1993 or early 1994. The trains will be extended to Fort Worth in 1996. The airport extension is directly linked to the expansion of the airport's southern terminal, so no specific date has been set for this part of the line.

Locations have still to be agreed for any intermediate stations outside the service areas of the Dallas and Fort Worth transport agencies. Negotiations are now under way to obtain operating rights from Union Pacific and Burlington Northern, who currently operate freight traffic over the Dallas – Fort Worth line.

DART has set aside $65m for capital expenditure on the project, and expects to receive further funding from joint development and public partnerships along the corridor. The T has offered $1m, and Railtran has earmarked $6m towards the 55 km project. DART and The T have agreed





Downtown Dallas will be served by a 1·6 km Transit Mall through the historic West End district near Union station

to pay $400 000 a year to Railtran for track, upgrading and service extensions.

Two or three coach trains, either push-pull or refurbished diesel railcars, with a capacity of 125 passengers are planned. Initially, services between Dallas and Irving would only run during morning and afternoon peak hours, but service hours would be extended later. Rolling stock procurement has not yet begun, although DART staff have made recommendations to the Board about vehicle types and the availability of diesel railcars that could be refurbished. Design and engineering has been started for Medical & Market station, which will be located between Dallas and Irving.

POLITICAL DYNAMICS

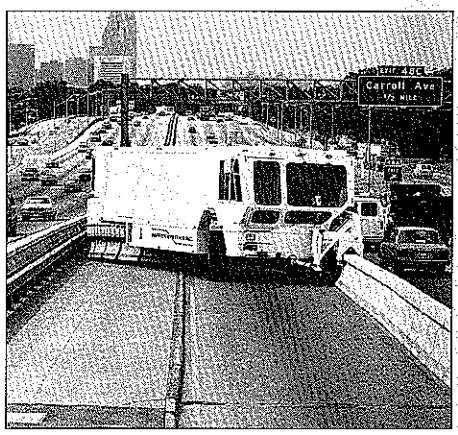
Since its inception in 1984, DART has focused on the political dynamics of creating an integrated transport network that will improve mobility over a service area of 1 200 km^2, spur economic development, improve air quality and generally benefit the urban environment.

It was clear from the outset that whilst the long-term plans were being drawn up, it would be necessary to implement more immediate measures in order to show the community that the promised benefits are real. DART has therefore focused its efforts on improvements in bus and van service, which can be implemented cheaply and quickly, yet can be seen to be beneficial.

For this reason, the light rail and commuter rail networks will be backed by 60 km of high-occupancy-vehicle lanes to be built and operated in conjunction with the Texas Department of Transportation. The first segment, on Interstate 35 East, opened in October 1991 and is already proving very successful. A 70:30 split in traffic during peak hours means DART can 'borrow' a lane from the opposite carriageway to create a designated lane for buses and multi-occupancy cars.

DART is the first transit agency in the USA to purchase a barrier moving machine which can fence off an 11 km route in the morning peak and 5·5 km in the reverse direction in the afternoon. The investment of $14·6m has improved journey times for 4 200 vehicles and 15 000 people each day by 7 to 10 min, and has also raised the average speed of the remaining traffic from 35 to 66 km/h. Ridership on the four bus routes involved has increased by 8 per cent, and reduced congestion will cut annual bus operating costs by more than $300 000.

While friction and political confrontation still pervade the construction plans, DART's growing pains appear to be diminishing. With the co-operation of the 14 member city councils, the tenacity of its staff and Board of Directors, DART has finally moved into the construction stage – and public acceptance of the need for mass transit in this growing metropolitan area has been secured. □



Twice a day, a barrier-moving machine is used to create a high-occupancy-vehicle lane on Interstate 35; a light rail line is planned for this 11 km northwestern corridor around 2005

Trams to remain in co-ordinated network

Jürgen Wann
Managing Director
Stadtwerke Frankfurt am Main

MAY 1992 sees the opening of a further section of light metro line in Frankfurt-am-Main. The Line C extension from Zoo to Bergen-Enkheim is another step in a 30-year programme to create an integrated rail network serving the city of Frankfurt and the Rhein-Main region.

With 640 000 residents in just 250 km², Frankfurt is much more compact than many European cities. However, nearly 600 000 people work here, so around 300 000 people must commute into the central area each day.

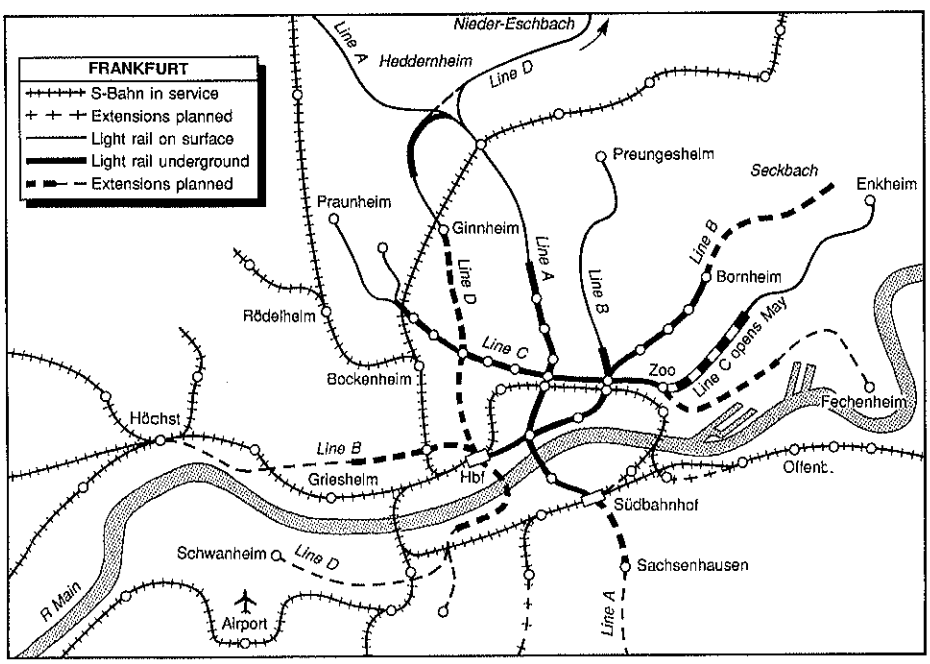
Frankfurt lies at the junction of several heavily-used motorways, with one of Europe's largest international airports and a key node in the national inter-city rail network. With the pressure of business and these key nodes, there is heavy demand for public transport.

Since the early 1960s we have created an attractive urban rail network, in which the different modes are co-ordinated into a single integrated unit with a common fare structure. German Federal Railway operates the S-Bahn network, which operates over segregated tracks for much of its length, but on some routes shares tracks with DB's long distance services. Since 1972, many S-Bahn trains have been extended beyond the Hauptbahnhof into a cross-city tunnel serving the city centre; this tunnel was projected below the Main river to Sachsenhausen in 1990. An extension to Mühlberg opens this year, and a further section to the suburb of Offenbach is expected to open in 1995.

The Stadtbahn network has its origins in a conventional tramway, which has been steadily upgraded and segregated. Three cross-city tunnels have been built, the north-south Lines A and B opening in 1968 and 1980, followed by the east-west Line C in 1986. All three routes continue into the suburbs as upgraded light rail lines.

The eastern extension of Line C creates a cross-city corridor, connecting the western and eastern suburbs. Similarly, Line B, will be extended westward from the Hauptbahnhof to the trade fair grounds and the university at Bockenheim by 1996. Once these lines have been completed, the rail network will serve every important destination in the Frankfurt area – and what is more, these destinations will all be accessible from every S-Bahn, U-Bahn or Stadtbahn stop with no more than one change en route.

Stadtbahn routes with high platform stations are worked by articulated Type P8 cars



Despite this extensive coverage, further expansion is on the cards. Line A will be continued south from the Südbahnhof to Sachsenhausen in 1999, and another eastern branch of Line C, from Zoo to Fenchenheim via the docks area is being planned. Other U-Bahn routes shown on the map, including Line D incorporating the Line A branches to Ginnheim and Nieder-Eschbach, are still the subject of political debate.

Tramway revival

In Frankfurt, as in many other cities, there has been a lengthy public debate over the future of the conventional surface tram routes. As a result, we have decided to retain the city centre tramways as feeders to the heavy rail network, in the same way as the bus routes are operated. Indeed, some of the tram routes are to be extended to serve new areas. The first will be a 700 m link from one of the northern routes to meet the east-west cross-city tram line; this should open in 1995.

As distinct to the Stadtbahn lines with their segregated alignments, 900 mm high platforms and high-floor cars, the tramways will retain street running. We have therefore decided to invest in a fleet of modern low-floor cars. The first of 20 articulated cars ordered from Siemens-Duewag is due for delivery at the beginning of 1993. These three-section cars are 27 m long, carried on three bogies of which the outer two are motored; eight hub-mounted three-phase motors will drive individual wheels. Each double-ended car will have four sliding-plug doors on each side.

The continuing use of high-floor cars on the Stadtbahn routes, dictated by the

platforms at the underground stations, can cause problems for disabled or infirm passengers where the lines are running at ground level or in the street. The new eastern section of Line C is provided with a novel pattern of station, which we hope will overcome many of these problems.

At each stop, the tracks have been lowered into a trough at least 300 mm below road level, so that the platforms themselves are between 400 and 500 mm above the ground. There are access ramps at each end of each platform, and along each side there will be no more than three shallow steps between the platform and the pavement. Passengers can leave the station and cross the road at any point. To ensure the safety of passengers, the street crossings are protected by traffic lights triggered by each approaching train.

The new terminus at Enkheim is laid out for convenient interchange between rail and bus; the two tracks are separated by a busway under extended platform canopies, allowing passengers to change modes under shelter and without negotiating any steps. A convenient park-and-ride interchange is also being provided, which we hope will tempt longer-distance commuters coming in by motorway from the east to leave their cars outside the city centre.

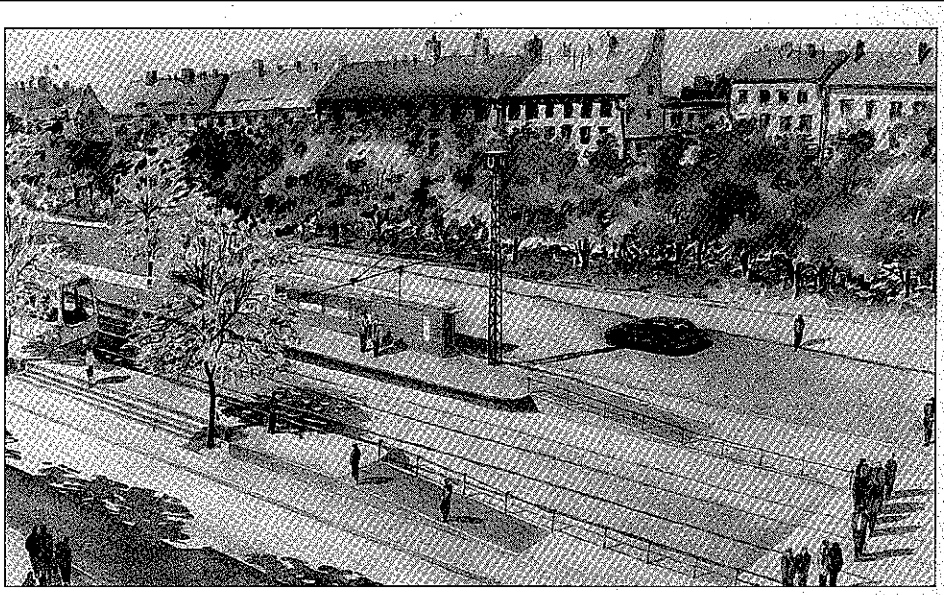


Fig 1. Depressing station tracks below road level eases access to high platforms on the Stadtbahn route for passengers with disabilities

With the rail network largely in place, it is time for us to take a comprehensive look at how public transport is to develop in the Frankfurt and Rhein-Main areas over the next three decades. The increasing burden of staff costs as a proportion of operating expenses, and recent problems in recruiting train and bus drivers, has led us to look at automation. Whilst it might be fairly easy to fit ATO on the underground sections of the Stadtbahn, which are totally segregated, there are more questions over the ground level sections which interact with road traffic.

In another area, a wide variety of people-movers and guided transport systems is now being promoted, and some of these may be suitable for low-density suburban feeders.

Clearly, there are many questions still to be answered, but for the foreseeable future, our integrated rail network will remain the central core of public transport throughout the Frankfurt region. □

Second Dnieper bridge opens in 1993

DESPITE THE upheavals caused by the break-up of the Soviet Union, construction work is progressing on an extension of the three-line metro in Kiev. Early next year, trains should start running on a second metro bridge across the Dnieper, improving links to the rapidly-growing residential suburbs in the southeast of the city.

The Ukrainian capital has always been a large industrial, scientific and cultural centre, and today its population is around 3 million people. The metro traces its history back to 1949, when the decision was taken to develop urban rail transport in conjunction with the post-war reconstruction and expansion of industrial and residential suburbs. Kiev's complicated topography precluded a satisfactory surface transport solution, but similarly slowed metro construction, and it was not until November 6 1960 that the first 5·2 km line was opened to passengers.

Over the last 30 years, the network has grown to three lines totalling 39·7 km. Another 10·1 km is under construction, and further routes are planned.

Nikolay E Balatiskiy
General Manager
Kiev Metro

CORE NETWORK

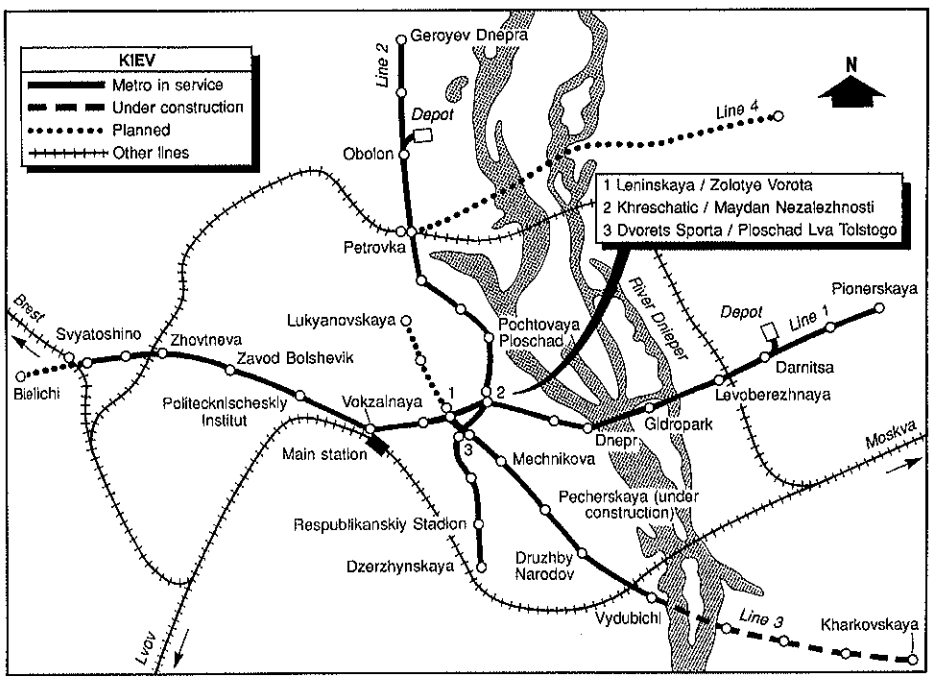
Line 1 runs east-west across the city centre, and today extends for 19·5 km from Svyatoshino in the west to Pionerskaya in the east. The western end has 3·2 km in cut-and-cover tunnel, followed by 9·6 km of deep-level tunnels under the city centre. The 6·7 km eastern section runs on the surface, crossing the Dnieper river and Rusanovka Strait on lengthy bridges. The route serves extensive residential and industrial areas on both sides of the river, and there are feeder bus services to many of the stations. In particular, a regional bus route runs from Pionerskaya terminus to the town of Brovary.

Line 2 dates from November 1976, and runs from north to south along the western side of the Dnieper. Starting from Geroyev Dnepra in the northern district of Kurenevsko, it interchanges with Line 1 at Kreschatic in the heart of the city and terminates at Dzerzhynskaya in the south. Of its 13·6 km, 4·9 km are in deep-level tunnels and the remainder is sub-surface.

Our latest addition to the network is Line 3, inaugurated in 1989. The first stage is 6·25 km long, running from an interchange with Line 1 at Zolotye Vorota southeast across the city. There is an interchange with Line 2 at Dvorets Sporta, after which the line rises from deep tunnel to sub-surface for the last 5·5 km to Vydubichi. An intermediate station is under construction at Pecherskaya on this section.

Work is now well under way on a southern extension of Line 3 to Kharkovskaya. This 6·9 km section will largely be sub-surface or ground level, and will have two intermediate stations. The line will cross the Dnieper by a lengthy bridge that will be shared with road traffic, as are the bridges on Line 1. We anticipate that construction work will be complete by the end of 1992, and that the route will be ready for passenger services to start early next year.

Further metro lines are now at the planning stage, including a northwestern extension of Line 3 from Zolotye Vorota to Lukyanovskaya and a short continuation of Line 1 west from Svyatoshino to Bielichi. A fourth line is also planned, running from the northeastern suburbs across the river to the large industrial regions on the right bank.



DIFFICULT TERRAIN

Deep-level tunnelling under the ancient city of Kiev has proved exceedingly complicated and labour-intensive because of the poor geology. The ground is littered with cavities and faults. Most of the tunnels were driven using mechanised shields, but in some sections where water-bearing layers were found it was necessary to resort to ground freezing and pressurised tunnelling at up to 1·5 atmospheres.

Running tunnels are lined with a mixture of cast iron segments and reinforced concrete blocks, depending upon local ground conditions. In the tunnels, the track is laid on wooden sleepers bolted to the concrete base slabs. The open air sections are laid on conventional stone ballast with a mixture of wooden and concrete sleepers.

The station platform tunnels, access passageways and booking halls are designed to reflect local Ukrainian traditions and are decorated with typical local materials – granites, various shades of marble, acrylics and plastics, aluminium, stainless steel, ceramics and majolics (a form of glazed ceramic). Considerable thought has been put into the decor of individual stations, in an effort to reflect the character of the surounding area. Decorative designs reflect Ukrainian culture, the ancient history of Kiev, and recent achievements.

All underground stations are air-conditioned, with a comprehensive heating and ventilation system that keeps the temperature constant at 23°C in the summer and 15°C in the winter. The 19 deep-level stations are equipped with a total of 87 escalators, which are administered from a central control room to ensure prompt attention to any failures. All underground sections are fed by a complex water main network to serve both the normal station requirements and fire fighting installations.

OPERATIONS

Train services on all lines run from 06.00 until 01.00 each day. The metro is worked by a fleet of 507 cars, which normally work in five-car trains. They were supplied by the Mytishchy and St Petersburg Carriage Works: 259 Class D cars for Line 1 in 1964-89 and 248 vehicles of Classes 81-714 and 81-717

for Lines 2 and 3 from 1980 onwards. There are two running depots: Darnitsa at the eastern end of Line 1 and Obolon at the north of Line 2. There are also separate car repair and escalator maintenance workshops alongside Darnitsa depot.

Traction power is supplied at 825 V DC via a third rail, which is fed from a number of independent substations.

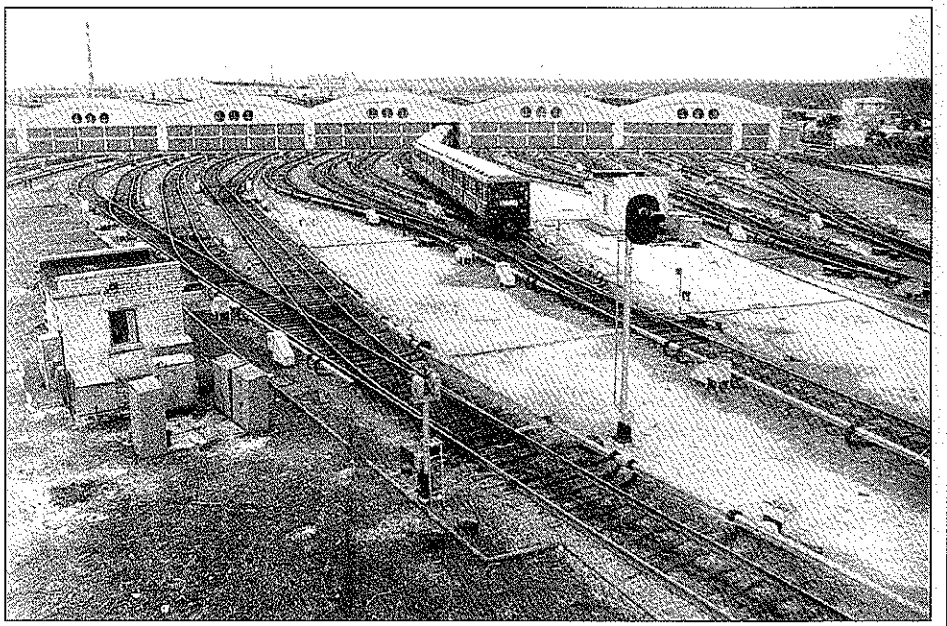
Signalling on all three lines is centralised, with the main control centre at Kreschatik. The terminal and interchange stations and the two depots have their own route-relay interlockings operating under the overall control of the main centre. From the outset, the lines were equipped with automatic train stops to prevent trains passing red aspects, but in 1989 we launched a programme to upgrade the signalling.

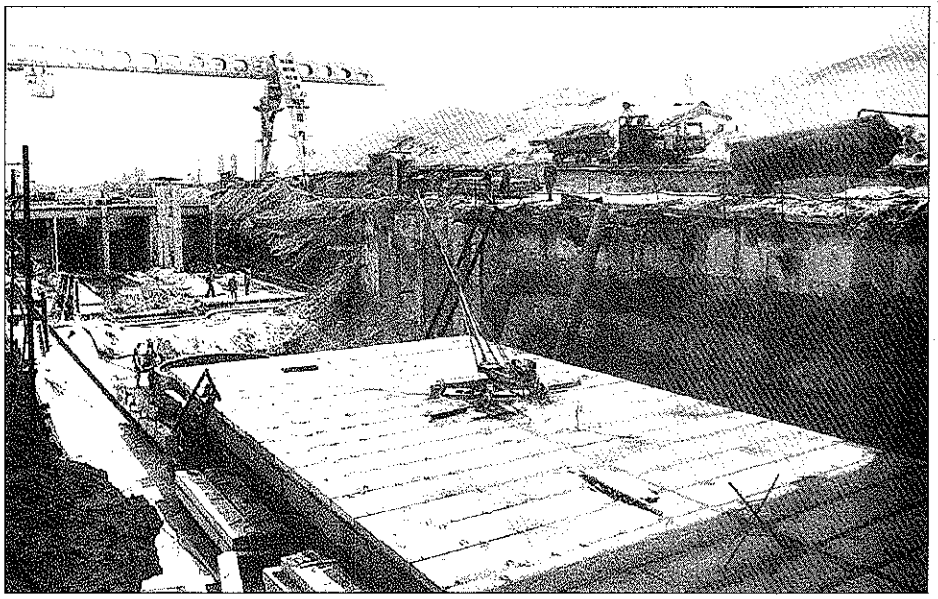
Automatic train protection has improved safety and allowed us to dispense with assistant drivers in favour of one-man operation. At the same time, line capacity has been raised to 42 trains/h each way on Line 1, 40 trains/h on Line 2 and 20 trains/h on Line 3. The next step will be to install jointless low-frequency track circuits and inductive signalling to the trains which will further improve headways.

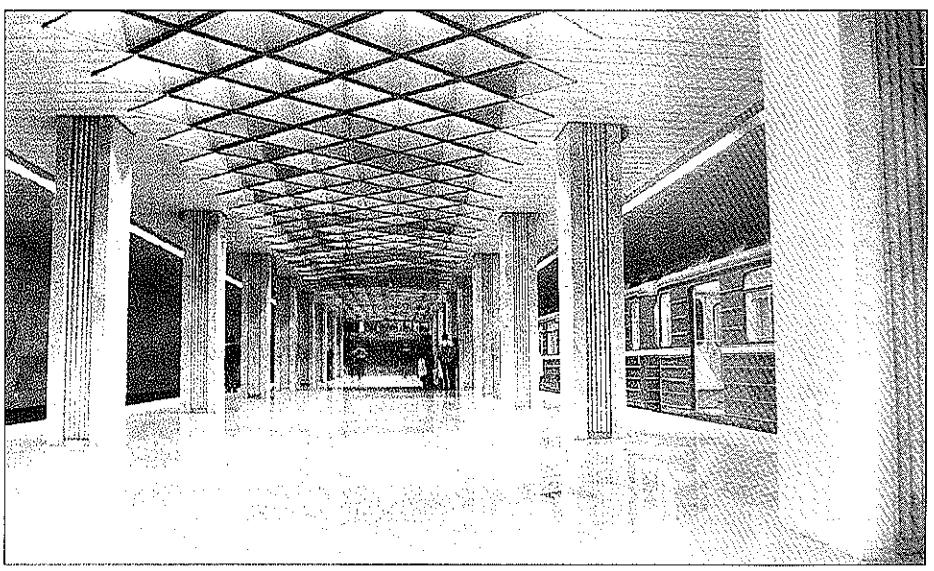
Traffic regulation has been simplified by the installation of closed circuit television from the main control centre to monitor passenger flows at the city centre interchanges; each station has its own dispatching centre with local CCTV monitors and microprocessor control of all station functions.

Fare collection is automatic, with a flat fare of 30 kopeks per ride. Access to the platforms is controlled by coin-operated photo-electric cells, and automatic change machines are provided for passengers without the correct money. Special entrances are provided for season-ticket holders.

In the 32 years since the first line opened, the Kiev metro has taken a steadily increasing proportion of the urban transport demand. With an average of over 1 million passenger-journeys per day in 1991, the metro now accounts for 25 per cent of all public transport trips. As the new extensions move closer to opening, we can be certain that this trend will continue. □



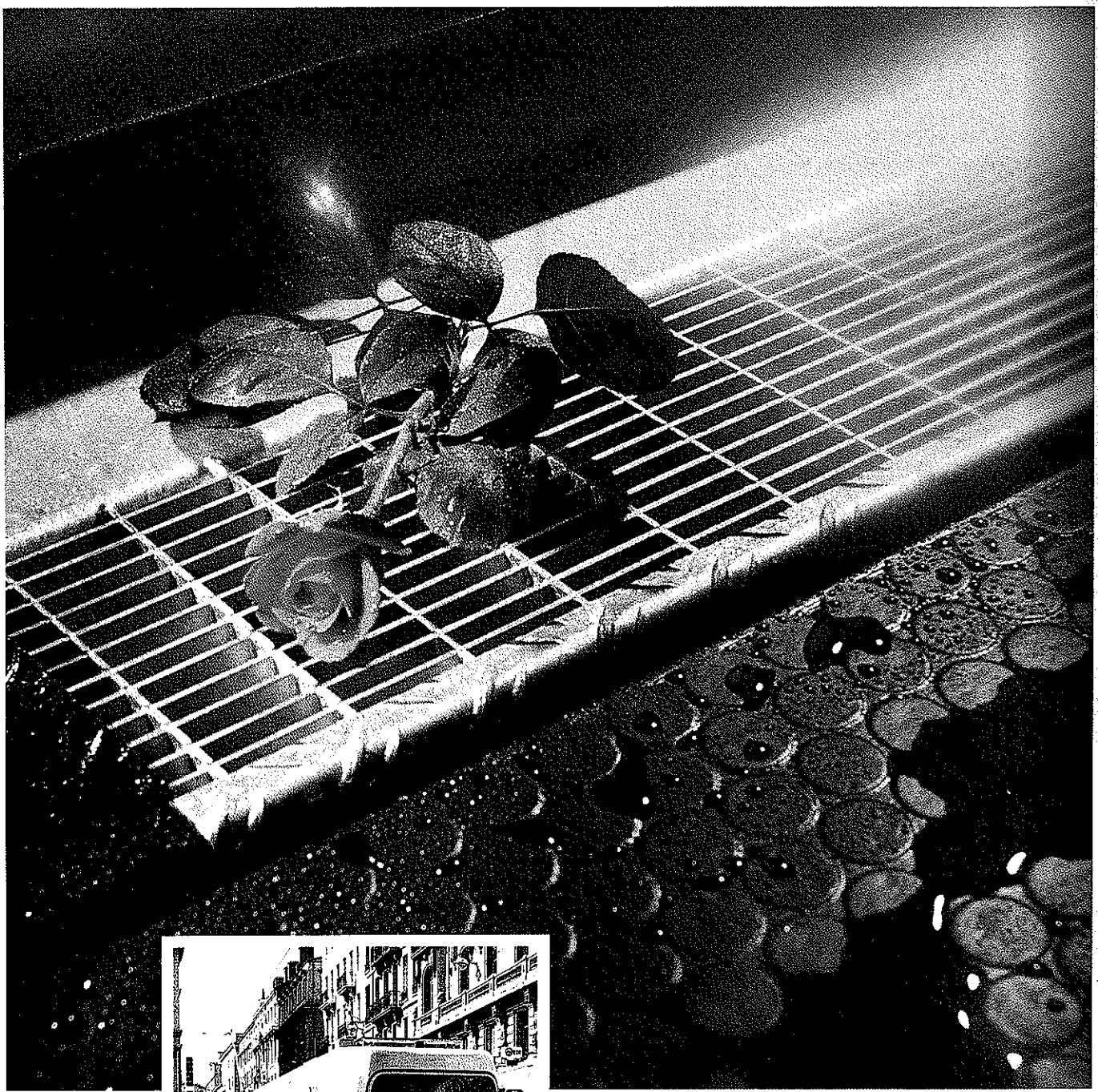




Top right: Class 81-714 and 81-717 trains for Line 2 are stabled at Obolon depot in the north of the city

Centre: Construction is well advanced on the sub-surface station at Osokorki on the south-eastern extension of Line 3 to Kharkovskaya

Right: Line 3 services currently terminate at Vydubichi, where the station decor reflects a more modern style than on the first two lines



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Métro Ouest marks successful first year

LAUNCH OF *Métro Ouest* light rail services on June 2 1991 was a milestone for public transport in the region around Lausanne – Switzerland's fifth largest city. The first nine months of operation confirmed the most optimistic traffic estimates. Around 27 000 passengers/day travelled on the line, which has become the principal mode of transport to and from the University and the École Polytechnique Fédérale de Lausanne (EPFL). We estimate that 7·5 million passenger-journeys will have been made by the end of the first year.

Jean-Pierre Kallenbach
Director-General, Transports Publics de la Région Lausannoise SA

Columns supporting the roof at TSOL's Flon station are decorated so that graffiti does not stand out

Widely known by the name of its operator, Tramway du Sud-Ouest Lausannois SA (TSOL), which is a subsidiary of Lausanne Transport (TL), Métro Ouest links the centre of Lausanne at Flon to the Swiss Federal Railways station at Renens, where the line runs briefly over ex-SBB tracks to reach its terminal bay platform. Apart from the universities, the line serves residential, industrial and business areas in the western suburbs of Chavannes, Ecublens and Renens.

There are 13 intermediate stations, of which four serve the university. This has a potential traffic of 15 000 passengers, and is reached in only 9 min from the centre of Lausanne. Interchange with TL bus services is provided at three intermediate stations. Journey time from Flon to Renens is 19 min.

The line is 1 435 mm gauge and is single track throughout, with passing loops. Overhead electrification is at 750 V DC. The route is all on segregated right of way and contains significant civil engineering works. As well as the 400 m long Flon tunnel, which contains the city terminus, there are six viaducts between 100 and 250 m in length and a 258 m cut-and-cover section. Without question, the most difficult part of the civil engineering was the Flon tunnel – because of its urban location and geological difficulties.

A fleet of 12 high-floor articulated cars built by VeVeY with ABB electrical equipment operates a 10 min interval service from 05.30 until 20.00; from then until midnight the headway is 15 min. Each two-section car has a capacity of 235, of which 66 are seated. A pair of cars can carry almost 500 people. Because the vehicles are high floor, stations have full height platforms with ramps, giving level access to the cars for elderly and disabled passengers.

Operation and signalling is supervised from a central control room. Automatic block is used and train detectors are positioned at 2 m from each signal which trigger an automatic brake application if the train fails to stop at an adverse aspect. Crossings with road traffic are controlled by traffic lights and with automatic priority for trains.

Vision achieved

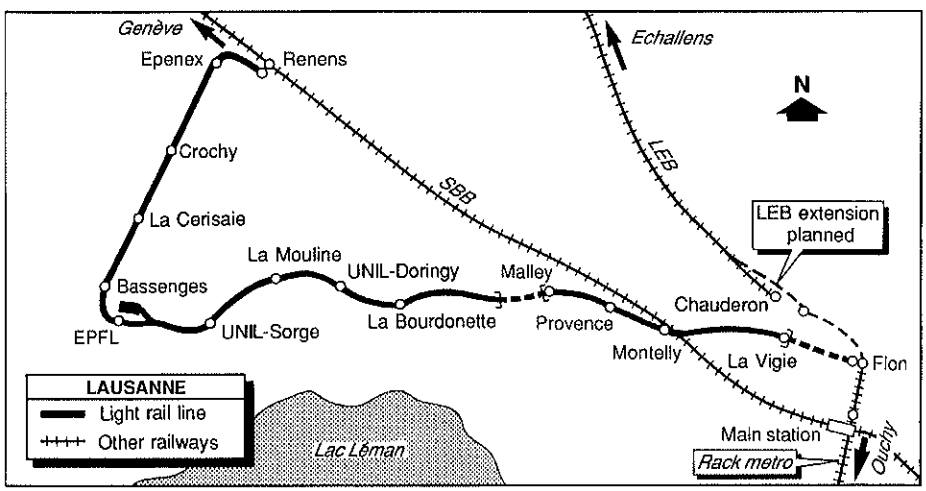
Métro Ouest represents the fruits of a handful of people who envisaged a fast and comfortable mode of transport for the area. Together with SBB's local services and the existing rack metro between Lausanne and Ouchy, the line is destined to become the backbone of the transport network in the Lausanne area, which is home to around 250 000 people. It is also a catalyst for economic development and communications improvements between Lausanne and its surrounding area. Of particular importance is the connection with SBB at Renens.

The light rail line is one of the most rapidly completed technical projects undertaken in French-speaking Switzerland in recent years. The route was devised by Philippe H Bovy, head of the Transport Institute at the Federal Technical College. Construction took three years and cost SFr192m.

Conscious of the introduction of a new mode of transport into residential areas, the Métro Ouest management initiated a safety campaign before opening, aimed particularly at local children. Visits and audio-visual presentations included a mascot known as *Museau Prudent*, which was created to get safety advice across to the children. Safety concerns led to the blocking off of several rights of way where they would have crossed the line; some road crossings have been fitted with automatic barriers.

After less than a year of operation, the favourable results have shown that light rail has responded well to the requirements of the local population. The inevitable teething troubles were quickly ironed out, and with a few minor improvements Métro Ouest has become extremely efficient. Over 99 per cent of trains run on time, and the safety record is very good. Further comfort improvements are planned.

Métro Ouest and the Ouchy metro have been integrated with TL's bus and trolleybus network, but Lausanne's topography – with a 500 m height difference between the northern part of the town and the lake shore – is not ideal for road transport. The city authorities are therefore studying further improvements to rail transport. By 2000 it is hoped that the Lausanne – Echallens – Bercher railway will have been extended in tunnel from Chauderon to Flon, which will become an interchange between all three rail routes. Plans are also being discussed for extension of the Lausanne – Ouchy metro north from Flon. □



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MAIN REFERENCES

- **Planning, design and construction management:** Lyon, Nantes, Grenoble, Strasbourg, Rouen, Saint Etienne
- **Mountain systems:** Val d'Isère, Tignes, Rocamadour
- **Regional railroads** in: Grenoble, Lyon, Toulouse
- **Planning and network analysis** in: Marseille, Strasbourg, Toulouse, Bordeaux, Maubeuge, Grenoble, Montpellier, Mulhouse, Paris area
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Line D set to start automatic operation

THIS YEAR WILL see completion of the 12 km automated metro Line D linking the centre of Lyon to the western and southeastern suburbs. The first 8 km section serving nine stations in the city centre was inaugurated on September 9 1991 following seven years of construction work. Running from Gorge de Loup to Grange-Blanche, this inaugural section provides an additional crossing of the Rhône and Saône rivers in the heart of old Lyon.

Line D connects with Line A at Bellecour and with Line B at Saxe-Gambetta. It also links at Vieux Lyon with two refurbished funicular railways serving Fourvière and St Just on the cliffs overlooking the Saône. The western terminus at Gorge de Loup interchanges with French National Railways' services from Gare St Paul to Tassin, Lozanne and L'Arbresle, which have been upgraded to form a regional commuter network. Gorge de Loup is also served by a 1·5 km busway and a 400-space park and ride terminus.

Line D is fully-accessible to disabled passengers in wheelchairs; each station is provided with lifts to the platforms, which are much deeper than on the original lines. The stations are notable for their dramatic architecture, which was a result of a widely-advertised design competition. The modern styling and wide open spaces have proved very attractive to the passengers.

Ridership on Line D has already passed 80 000 passengers/day, and is expected to reach 135 000 by the end of this year, when the extension to Vénissieux will add a further four stations to the network. If our experiences with Lines A and B are repeated, traffic on Line D should increase to about 180 000 passengers/day over the next two years.

AUTOMATIC OPERATION

Originally designed for manual operation, Line D was chosen in 1987 to become the first practical application of the Maggaly system of automatic driving developed by Matra Transport. Development work is still in progress, so the 15 rubber-tyred trainsets in use on the first section have been modified for manual driving for the first year.

Dr Hervé Chaine
Chairman & Chief Executive, Semaly

Testing of the Maggaly ATC equipment is being conducted on the southern end of Line D, which serves the light and airy station at Vénissieux

Final trials of the automation equipment are now in progress on the remaining 4 km between Grange-Blanche and Vénissieux. Maggaly is the first software-based ATO system to be developed, in which train operation and protection are entirely controlled by microprocessors on and off the train. The automatic train protection function uses a variable-length moving block, which is computed on board using information drawn from a number of sources. Information about train running is measured directly on the unit, whilst vital data about line occupation and the movement of other trains is transmitted as coded data messages by a continuous cable along the track.

Matra and its subcontractors have put in considerable efforts in developing Maggaly since the idea was launched in 1987. Their efforts resulted in a preliminary approval of the system by the Government Safety Commission in November 1990. Full scale implementation and testing is now under way to fine-tune the parameters and ensure sufficient reliability for public operation.

Assuming that the present rate of progress continues, we anticipate switching the existing section of line to ATO in September. Opening of the remaining 4 km would follow towards the end of the year when the new central control room has been completed.

With construction work on Line D drawing to a close, August 1991 saw the approval of a large programme of extensions which will carry Lyon's public transport network into the next century. Work has already started on a 1·2 km western extension of Line D from Gorge de Loup to Vaise, where a large bus terminal and 1 000 space car park are planned as well as an interchange with SNCF's Saône valley line. This will include an intermediate station at Valmy.

The twin running tunnels on the extension will be bored with a bentonite-shield machine, which is due to be delivered in October. The total cost of this extension is Fr1·05bn, which includes 2 km of busway leading to the new interchange. Opening is scheduled for the end of 1995.

Four more metro extensions are included in the programme. Line A will be lengthened 1·8 km southwards from Perrache to new stations at Sainte-Blandine and Confluent. The line will also be continued 1 km east from Laurent Bonnevay to Salengro in the suburb of Villeurbanne. A 2·5 km southern extension of Line B is planned, serving three stations on the east bank of the Rhône at Debourg, Gerland and Square Galtier before crossing the Rhône to an interchange with SNCF at Oullins. The fourth extension will continue Line D 1·5 km from the SNCF station at Vénissieux to the town centre.

Lyon's public transport authority, Sytral, will support these metro extensions by a network of 16 km of feeder busways and a trolleybus priority scheme, ensuring that the outer areas are well connected to the metro.

On the wider front, the mayor of Lyon,

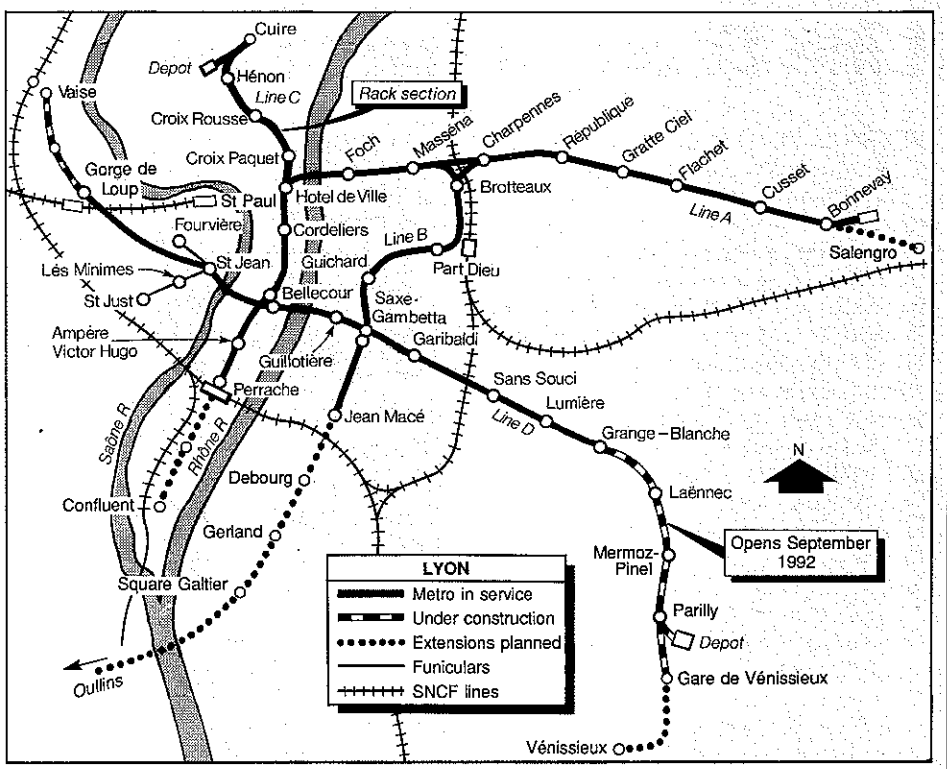
Line D stations include white tiled areas on the platforms to indicate the position of the doors on automatically-driven trains

Michel Noir, has initiated a national campaign for improving public transport throughout France. Supported by the mayors of all provincial cities of over 300 000 inhabitants – Toulouse, Marseille, Lille and Bordeaux – he has proposed the creation of a new fund to finance transport investment. This would be raised by the levying of a Fr0·1/litre tax on petrol, which would simultaneously tax the excessive use of private cars in our congested cities.

Already the cities are making their own moves towards curbing urban car use. Strasbourg banned through traffic in its central area from February 24 1991, following the lead set by Besancon some years ago. The Lyon traffic restrictions were extended in October, followed by increases of up to 50 per cent in car parking charges in January 1992.

The end of 1991 also marked a major change for Semaly, which was formed in 1968 as a public corporation to plan and manage the construction of the Lyon metro. Over the past decade, the corporation's urban transport engineering expertise has already found markets through its light rail consulting arm Metram, which has worked in Nantes, Grenoble, Strasbourg, and Rouen.

With a view to expanding Semaly's role to international business, Michel Noir decided in 1991 to privatise the operation. An agreement was reached on December 20 for a substantial capital increase and the introduction of two new private sector shareholders. A 52 per cent majority stake in Semaly is now held by Scetauroute, a road engineering specialist, whilst US engineering consultant Bechtel International has taken 15 per cent. The local authorities in Lyon retain a 27 per cent stake, with the remaining shares owned by SNCF (2½ per cent) and Semaly staff (3½ per cent). □



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Two extensions in updating programme

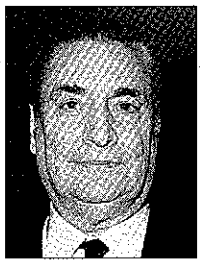
WORK IS under way to build two extensions to the 112·5 km Madrid metro, which currently has 155 stations on 10 lines. First to be completed will be the 2·1 km of Line 1 running southeast from the present terminus at Portazgo to Colonia del Sardinero; work is due to be finished in late 1993 or early 1994. Intermediate stations will be provided at Palomeras and A del Arenal, and a depot will be built at Sardinero to hold eight trains.

1994 has been set as the date for work to finish on the second scheme, which entails closing the gap in Line 6 west of the city centre to complete a circular route. This 7 km section will run from Ciudad Universitaria in the north to Laguna in the south. The first section of tunnel from Laguna to Lucero already exists, and has been used as a turnback and storage sidings since 1990.

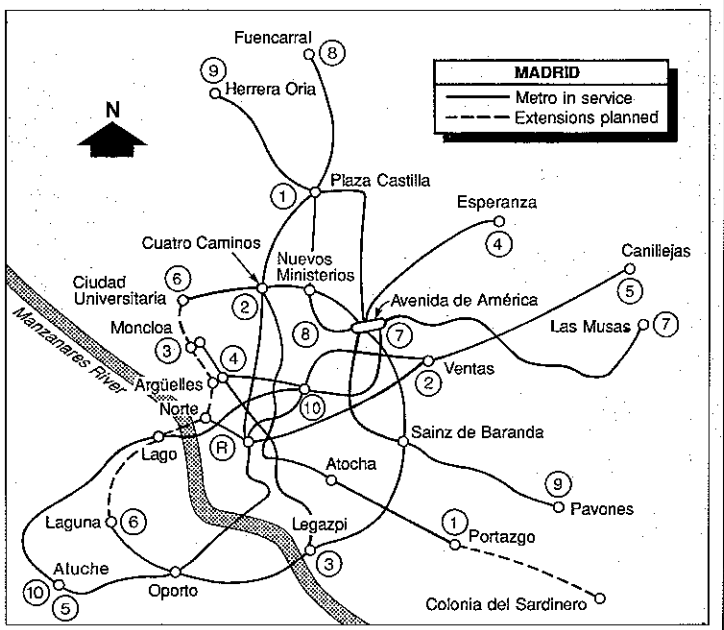
Interchange will be provided at Norte with Line 10 and the short link to Opera (Line R), at Argüelles with Line 4, and at Moncloa with Line 3. As Line 10 does not currently serve Norte station, a new section of tunnel will have to be built to bring the line close enough to give satisfactory interchange. Intermediate stations will be built at Ave de Extremadura and at Puerta del Angel. Construction work is handled by the Madrid Community, which hands the completed lines over to the metro.

The last of our historic metro cars was withdrawn from service in July 1991. Their place was taken by more Series 2000 cars which first joined our fleet in 1984; the Series 2000 design has three-phase drives and microprocessor control of traction equipment. Their introduction on the small-profile Lines 1, 2, 3, 4, 5 and 10 has been accompanied by a move to driver-only operation, which now applies on the large profile lines as well.

Currently in course of delivery is a further build of Series 2000 cars to replace the Series 300 stock on Line 10. Latest cars to be ordered are 36 two-car sets of Series 5000 cars for large profile lines. They will have chopper controls, but three-phase drives will probably not be fitted as the stock must be compatible with existing trains. CAF will start to deliver these units in 1993.



Dr Ramon Lopez-Mancisidor del Rio
President, Madrid Metro



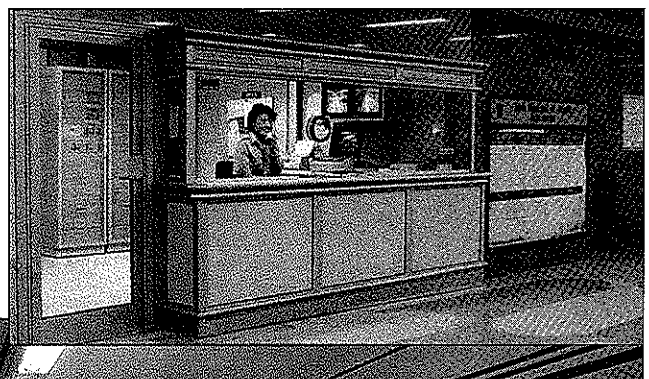
More deliveries of new vehicles for both small and large profile lines will give the metro a fleet of very modern rolling stock by 1995. The entire fleet will be maintained at a new workshops and depot complex at Canillejas, which is due to open this year.

During 1990 the metro carried 415 million passengers, but the figure was inflated because there were 22 days of bus strikes. By contrast, metro staff went on strike for 12 days in January 1991, resulting in a fall in traffic to just 400 million last year.

All lines have been fitted with automatic train protection since April 1989, the last to be equipped being Line 4. This means the traditional operating role for station staff has disappeared; they are therefore being retrained as ticket sales staff able to monitor station activities through CCTV. The programme to provide AEG monitoring and communications equipment at all stations will be completed by November 1992.

In a bid to raise productivity, the number of metro staff has been reduced; in 1989 there were 6 300 on the payroll, but this has now been cut to 5 900. □

Upgrading over recent years has brought new rolling stock, well-lit platforms and CCTV supervision from station booking offices



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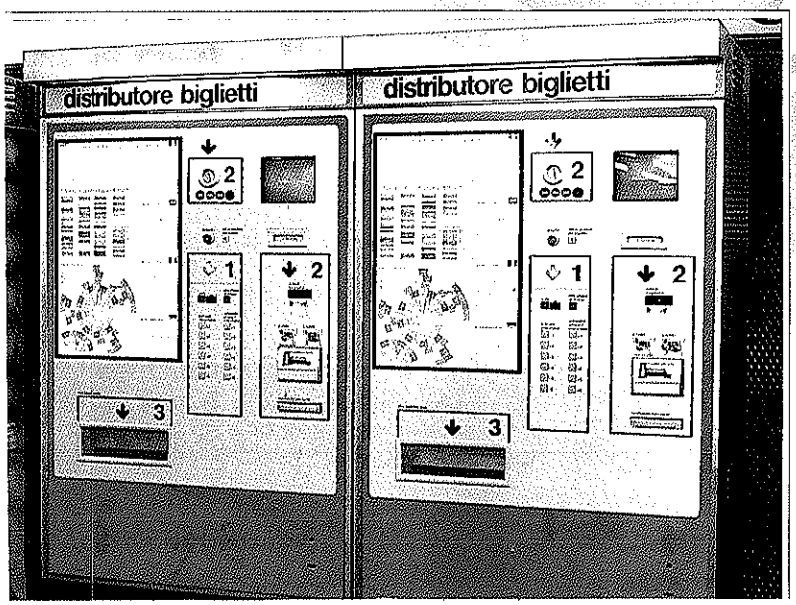
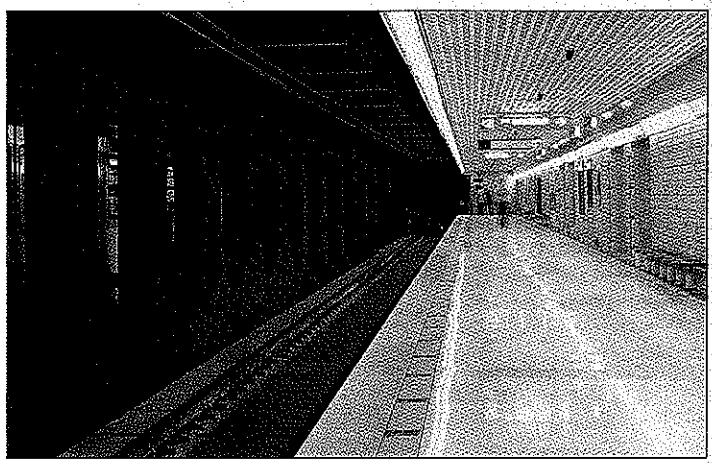


Metro spearheads transport integration

Dr Elio Gambini
General Manager, Azienda Trasporti Municipali



WITHOUT A DOUBT, the most significant development in Milano's public transport network in recent times has been the opening of the third metro line. Construction of the Yellow line has already been covered in *Developing Metros 1990* (p58), and the first 2·6 km and five stations opened on May 3 1990. Another 2 km and three stations went into service at the end of that year, and the 10·3 km line was completed on May 12 1991.

Linking Sondrio in the north of the city centre to San Donato in the southeast, Line 3 has 15 stations. It connects with Line 2 at Milano Centrale station and with Line 1 at Duomo; it will also interchange with the cross-city suburban *Passante* (RG 1.92 p40) at Repubblica. The new line serves two key Italian Railways stations with busy commuter traffic: Milano Centrale and Rogoredo in the south of the city.

Line 3 is operated by a fleet of 40 three-car EMUs supplied by Fiat, Firema and Ansaldo Trasporti, Socimi, Marelli, Parizzi and ABB. Each unit comprises two motor coaches and a centre trailer; they normally run as six-car trains. Minimum headway in the morning peaks is 4 min, and end-to-end commercial speed is 26 km/h. Trains run for 18 h a day, with a peak capacity of 20 000 passengers/h. Already traffic has reached 150 000 passengers/day, but we envisage it will reach 200 000 by the end of 1992, bringing the total weekday metro patronage to 1·2 million, or half of all public transport movements.

At present, Line 3 trains are manually driven, with the protection of intermittent ATP. However, we are about to switch over to full ATO as soon as the new central operations control room at Viale Monte Rosa has been completed. Eventually, we plan to transfer the management of Lines 1 and 2 to the same control centre, which will cut the number of operators required and ensure proper integration of the three services.

Line 3 is entirely underground, the deepest point being at Duomo where the tracks are 24 m below the surface. For this reason, considerable planning has gone into the design of stations from the view of fire prevention and evacuation in relation to recent legislation passed by the national government. Special provision has been made for visually-handicapped passengers, with escape routes marked by tactile moulded floor tiles. The Line 3 stations are the first to be equipped with bi-directional entrance gates worked by magnetic tickets. These were introduced at the end of July 1991, and are to be extended to the entire metro by the end of this year.

Line 3 platform edges are equipped with a row of yellow safety lights which illuminate when a train is approaching

Park and ride

Over the past couple of years, we have been giving a great deal of attention to better interchange with the metro. At many of the suburban stations, we have opened or enlarged park-and-ride car parks, managed by auxiliary staff. Parking charges are very reasonable, and include insurance against theft or damage – a valuable incentive in encouraging motorists to leave their cars behind. Special discount parking rates are available for metro season ticket holders.

So far we have opened 11 car parks, with a capacity for 11 000 vehicles. The newest, at San Donato on Line 3 and Bisceglie on Line 1, have capacities of 1 500 and 1 900 cars respectively. Bisceglie, in fact, is a new park and ride station specifically created at the western end of Line 1, which is served by a 700 m extension of the metro.

A similar extension is planned for the southern end of Line 2, which will be opened at the end of 1993. This 800 m extension from Romolo will serve a major park-and-ride facility at Famagosta, conveniently located near a major motorway interchange on the southern edge of the city. Famagosta will also have a new stabling depot and maintenance workshop to hold 24 six-car trains; we are now taking delivery of 20 three-car sets.

The only other extension now under way is a 1·4 km section of Line 3 running north from Sondrio to Maciachini. When completed, this will bring the Milano metro network to 70 km and 83 stations. Now on the drawing board are a 4·1 km northern section of Line 3 with five stations, running from Maciachini to Affori, and another 2·1 km of Line 2 from Famagosta to Missaglia, with two stations.

Light rail upgrading

Augmenting the three metro lines are a 160 route-km network of 17 urban tram lines, and three suburban tramways totalling 47 km. Last year, we launched a two-year plan to restructure the 1 445 mm gauge tram network following the opening of metro Line 3. Clearly, some routes are now duplicated by the metro, and these will be abandoned or re-routed to serve traffic flows. Some of

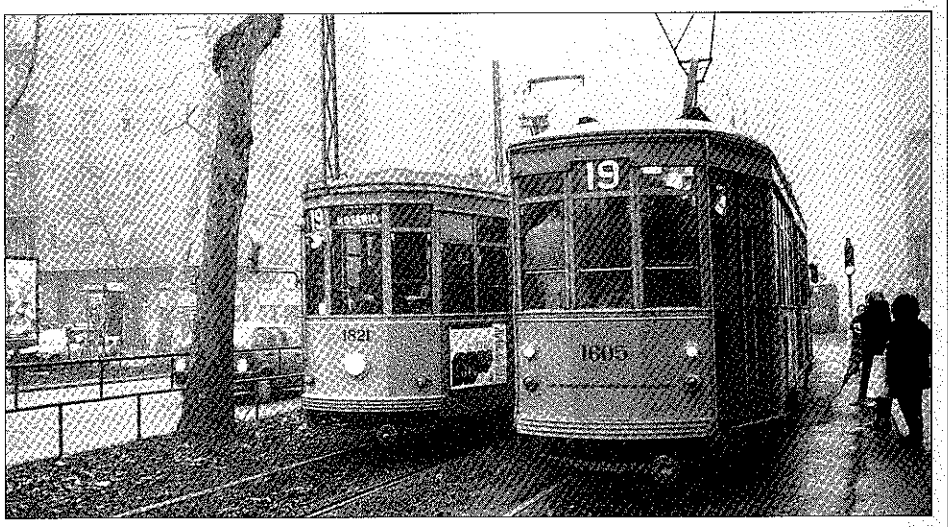
The approaches to the Line 3 ticket gates are provided with a tactile path to guide visually handicapped passengers

the trunk tram routes will be extended beyond the city boundaries to serve suburbs outside the original municipal area.

The entire tram network is being equipped with automatic vehicle monitoring, allowing operators at a central control room to watch continously the location and progress of all vehicles. This will enable them to intervene with real-time service adjustments to meet extra demand or cover for delays.

Fitting of AVM will have benefits for the passengers too. As each tram will 'know' its position, it will be possible to provide automatic announcements on board to advise of the next stop. Similarly, at key stops around the network variable message displays are being installed, showing the expected arrival time of the next car. This information will be automatically updated by radio from the control centre.

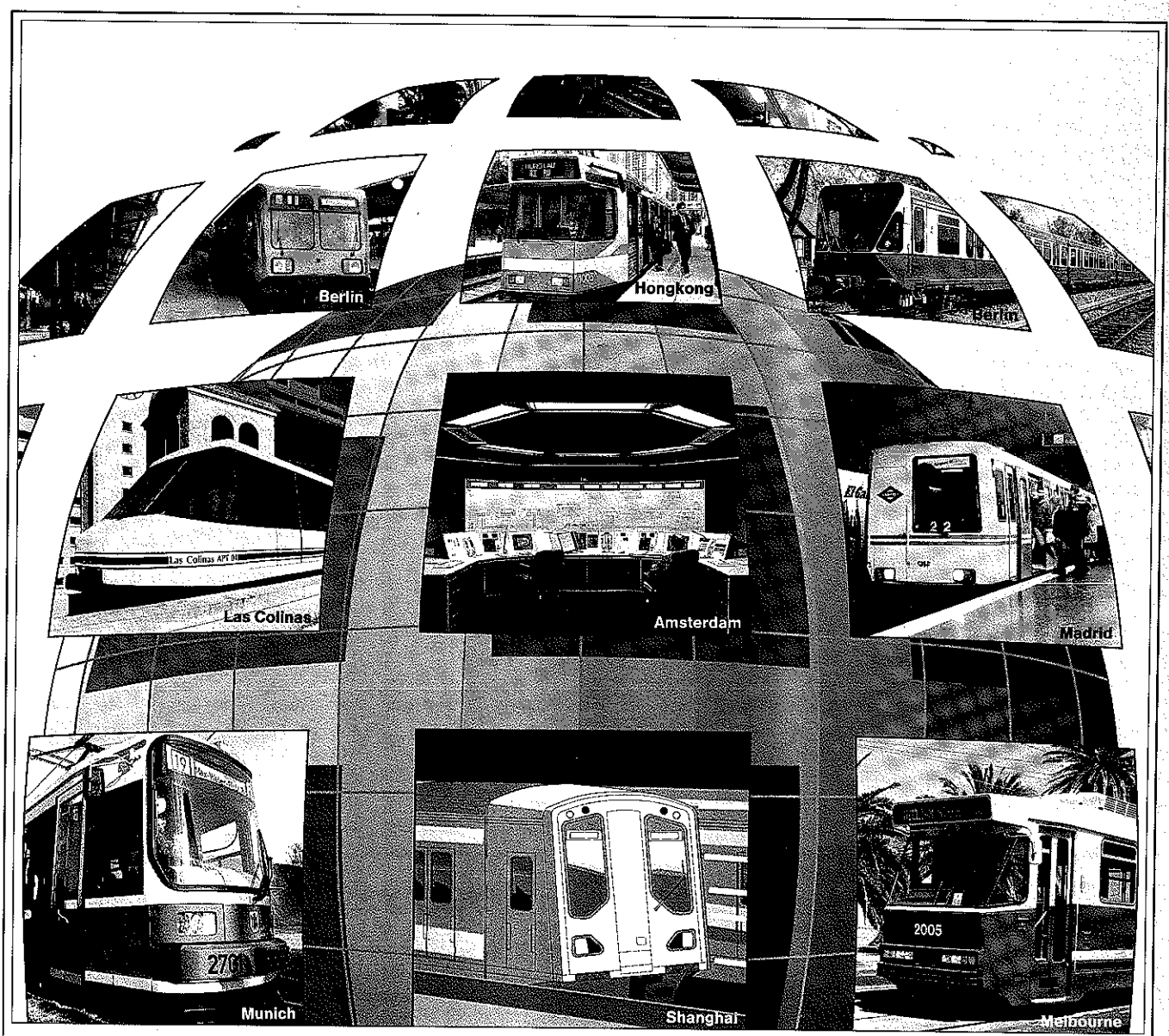
A short-term modernisation programme is now being implemented on the three suburban routes, which had previously been proposed for replacement by buses. Following the decision to retain the trams, all 117 suburban cars are being fitted with radio telephones to provide a communication link between the drivers and the control centre; this will also provide a data channel for the future installation of AVM on these routes.



Some of Milano's remaining tram routes are to be modernised and extended to act as feeders to the three-line metro

For several years passengers have been able to interchange between tram and metro using through tickets, but we have recently extended this facility. Last year we inaugurated SITAM – Sistema Integrato Tariffario Area Milanese – which created an integrated fare structure for journeys inside, partly inside or wholly outside the metropolitan area. After extensive discussions, we have been able to bring in the principal private bus networks as well.

Fares for urban journeys are determined by the Milano municipality and those outside by the Lombardy region. SITAM now provides a co-ordinated structure, reflecting the steep increase in urban and suburban journeys by metro, tram, bus and FS local trains. Since a 25 per cent fare rise on January 1 1991, the standard fare is now 1 000 lire. This allows a 75 min trip anywhere in the urban area, by any mode. In conjunction with our new park-and-ride policies, the introduction of integrated ticketing has seen a steep rise in public transport patronage as car drivers increasingly leave their cars behind in favour of rail. □



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Light rail joins the U-Bahn programme

Dipl-Ing Dieter Buhmann
General Manager
Münchener Verkehrsbetriebe

OPENING of the southern 1·8 km extension of U-Bahn Line U3 from Forstenrieder Allee to Fürstenried West during 1991 brought the total length of München's metro network to 58·3 km with 68 stations. Three sections totalling 13·3 km are under construction, with preliminary works getting under way on a further 9·1 km, and yet another 21·5 km at the planning stage.

Over the past 20 years, the U-Bahn network has become the backbone of the public transport network in the Bavarian capital, and its 1·2 million inhabitants make around 250 million journeys each year. The surrounding suburbs, with a combined population of 1·3 million, are largely served by German Federal Railway's S-Bahn network, which began with the cross-city tunnel completed for the 1972 Olympic Games; it now covers 410 route-km.

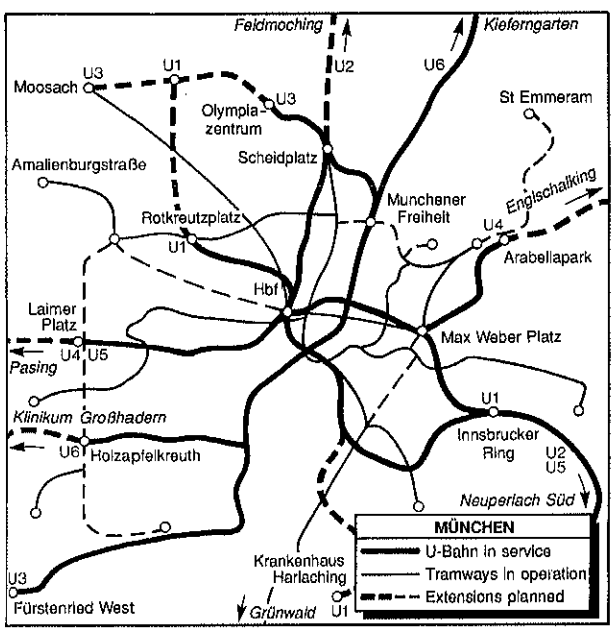
Development of these high-capacity rail routes, which radiate from the city centre, has largely superseded München's former tram network, which has contracted to around 87 km. However, the remaining tram routes continue to perform a useful role in providing orbital links between adjacent suburbs or inner city districts, interchanging with the radial U- and S-Bahn routes.

The role of the trams was formally recognised by the City Council last year; on March 6 1991 the council approved the Transit 2000' proposals for an integrated public transport network covering the whole of the inner city area. As planned, the U-Bahn will be extended to 92 km; the remaining tram routes will be upgraded and reorganised to form a complementary 82 km light rail network; the rail modes will be augmented by a 410 route-km network of buses.

Improvements to the light rail and bus routes, by segregation from other traffic, re-routing or simply modernisation, will make them faster and more attractive. The light rail routes are not going to be rebuilt to 'Stadtbahn' standards with grade segregation and high-platform stations. Around 60 per cent of the network has been converted to partial segregation from other traffic, but the remainder still operates on-street.

Several new tram routes are also planned, as shown on the map, and we have already begun the authorisation process. Objections to construction and operation must be considered and settled before authority to build is granted, and legal disputes may ensue. Completion of the new routes is therefore largely dependent upon the time taken to obtain authority for each section.

The approval process is a prerequisite for obtaining federal grants from fuel taxes, under the Community Transport Finance Law. Total investment in the new tramways will be around DM200m, and a recent revision to this law enables grants to cover up to 75 per cent of the cost. For the first time, federal grants can be used for the purchase of rolling stock; in this case we will be seeking 50 per cent.



München was one of the first European cities to introduce low-floor buses, and the success of these in attracting additional ridership led to a decision that the next generation of light rail cars will also have 100 per cent low floors. Three prototypes were put into service during 1991 (above), and following trials a series fleet of 70 cars was ordered at the end of March. The first of these cars will be delivered in mid-1994, with the order to be complete by mid-1997. This will completely replace the existing M class fleet of 157 motor and 141 trailer cars supplied by Rathgeber in 1957-65. For the foreseeable future, we expect to retain the 42 P class motors and 40 trailers built in 1967-69.

The three 1991 prototypes were supplied by AEG subsidiary MAN GHH and Siemens. They are based on the GT6N three-section cars built for Bremen (RG 11.91 p797). Built with integral-construction bodyshells in mild and stainless steel, the GT6Ns have 64 seats, many of which are mounted on plinths covering the four wheels under each section. Four pairs of double outward-swinging plug doors are fitted to each single-ended car. The leading section of each car has space for two wheelchairs. One of our three prototypes is fitted with an experimental wheelchair lift in the doorway by the driver. Internally, the bodies are finished with moulded glass fibre panels, the ceiling mouldings incorporating a row of fluorescent lights.

Each car is carried on three identical bogies; these have two free wheels with radial steering and a rigidly-connected pair powered through a right-angle drive unit. Because of the lack of space on the short stub axles, the electro-hydraulic brakes operate on a brake disc carried on the motor drive shaft. The secondary suspension uses air bags, not simply for the level of interior comfort. Adjustments to the air pressure will allow the cars to run with the bodies slightly higher in winter, so as to provide clearance above any ice and snow on the road surface.

The restricted space under the low-floors dictated the use of small, sealed three-phase induction motors. Traction power drawn from the overhead line at 600 V is converted by two inverters using GTO-thyristors; each of the three motors can be fed from either inverter to give a degree of redundancy. Service braking is largely regenerative, with the electro-hydraulic brakes blended in below 5 km/h to give a smooth stop. Spring-operated parking brakes are included, and magnetic track brakes are provided for emergency stops. □

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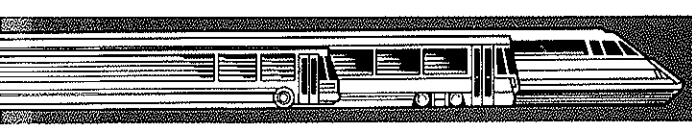

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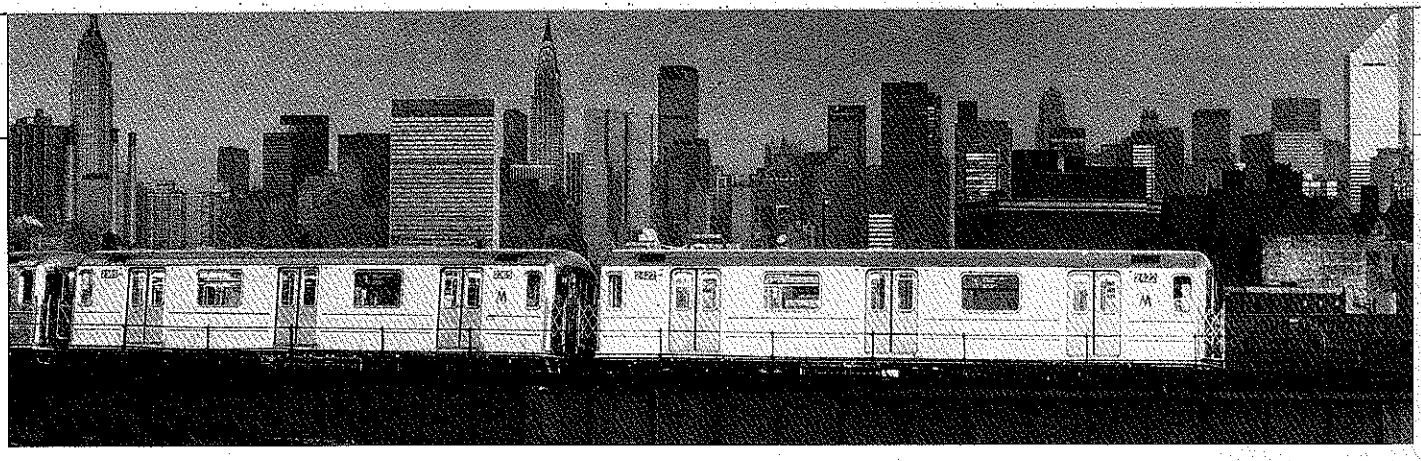


No standing still in fight to renew assets

Peter E Stangl
Chairman & Chief Executive Officer,
Metropolitan Transportation Authority

IN A NATION suffering from a growing dependence on the private car and from falling productivity caused by congested roads, there are few regions as efficient as New York in transporting large volumes of people and goods. The densely populated area of New York city and its suburbs boasts an important asset: good mobility provided by public transport. Subways, buses and commuter railways operated by agencies of the Metropolitan Transportation Authority keep New York moving.

It has not always been so apparent how much the region relies on its public transport network, which was largely built in the last decades of the 19th century and the first years of the 20th. For decades, the infrastructure was chronically neglected – routinely receiving less than 30 per cent of the funding required to keep the network in good working order. By the early 1980s, our precious asset was falling apart, ravaged by neglect and obsolete equipment. Riders faced the ever-present threat of being stranded. The subway system had become so decrepit that a total shutdown was imminent.

Fortunately, the situation was recognised just in time. The New York State legislature, recognising the crucial economic role played by public transport, declared a 'transportation emergency' in 1981. The MTA was mandated to restore the region's railways, subways and buses using state money. The last decade has seen the largest public works rebuilding programme in US history. Starting in 1982, a series of five-year phases has gradually revived basic transport services. In a decade, investment of over $16bn has brought large portions of the network back to a state of good repair.

And that investment has started to pay off. Over the eight years before economic recession struck the region in 1990-91, subway ridership rose by almost 8·5 per cent, or 84 million passenger-journeys. Amongst the MTA agencies, Long Island Rail Road ridership rose by 5·6 per cent and that of Metro North Commuter Railroad jumped by an amazing 21 per cent – proof that a dramatically improved service will draw customers back to public transport and generate business.

Above: A lengthy campaign has eradicated graffiti from NYCTA's 6 100 subway cars

Below: The 1982-91 MTA Capital Programme included complete reconstruction of the Reynolds Channel bridge which carries LIRR's Long Beach branch

Decade of investment

The 1982-91 capital investment programme reached into every corner of the MTA network. New York City Transit Authority overhauled or replaced its entire 6 100-car subway fleet, and the majority of cars are now air-conditioned. The subway's infamous graffiti has been driven off the trains, which are now maintained in a graffiti-free condition. All passenger-carrying track has been relaid; repair shops, depots and stabling yards have been rebuilt. Two new subway extensions were opened in the late 1980s – the Archer Avenue and 63rd Street lines – providing six new stations for Queens and Manhattan customers.

Unsafe passageways and dead ends at 151 stations, long the haunt of undesirables, have been eliminated. Another 63 subway stations have been completely rehabilitated, and 19 are now accessible to elderly and disabled passengers – as is 93 per cent of NYCTA's bus fleet. Staten Island's subway line fleet has been completely overhauled, and 16 of the line's platforms have been extended to take full-length trains.

Both of MTA's commuter rail networks have benefited from substantial improvements. LIRR's Main Line electrification has been extended from Hicksville to Ronkonkoma, cutting journey times to Manhattan by up to 30 min. The bridge carrying the Long Beach branch over Reynolds Channel has been completely rebuilt. Over 200 new cars have been put into service, reducing standing passengers on the crowded line west of Jamaica by 83 per cent. The new John J Caemmerer stabling yard, near Penn Station, provides extra capacity for handling these trains. A new maintenance centre has been opened at Hillside, and further capacity improvements have been started at Penn Station. The key junction at Harold has been rebuilt and resignalled, and planning is in hand for a similar rebuilding at Jamaica.

On the mainland, Metro-North's share of the capital programme has bought over 250 new and rebuilt locomotives, EMU cars and hauled coaches. MNCR's maintenance shops at Croton-Harmon have been rebuilt and enlarged. All passenger tracks have been fettled up or renewed. Electrification has been extended to the Upper Harlem line, speeding journeys into Manhattan from the northern suburbs. A major renewal of the power supply infrastructure will permit the operation of longer and air-conditioned trains with higher acceleration. A good start has also been made on rehabilitating the long

Park Avenue tunnel which leads into Grand Central station. Concrete sleepered tracks have been laid, and the structure of the tunnel itself is being refurbished with concrete roof slabs.

PHASE 3 PLANNED

Despite all that has been achieved, the restoration of New York's transport infrastructure is far from complete. Over the next five years, MTA plans to press on with crucial rebuilding work, and to introduce improvements to attract new ridership.

Phase 3 of the capital programme includes a wide range of measures, including a comprehensive review of safety in subway stations. State-of-the-art police communications will link highly-visible police offices at key stations, better lighting and emergency call points will be installed at all stations, and train radio links are planned.

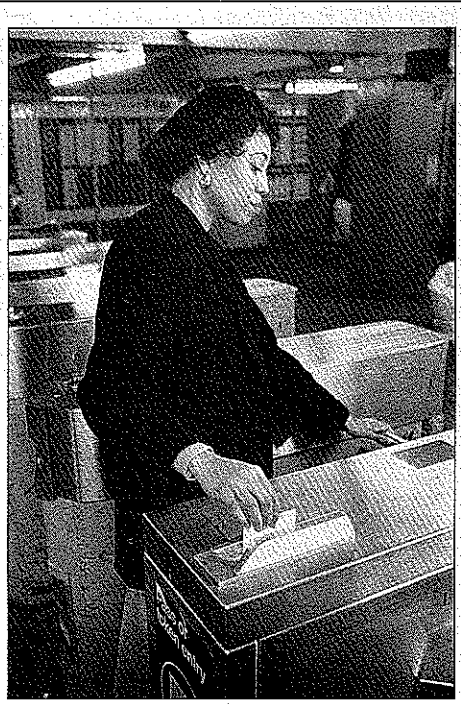
Further rehabilitation of bridges, tunnels and elevated structures is needed, together with renewal of tunnel ventilation, drainage and lighting. Substantial parts of the subway are in urgent need of resignalling. A new monitoring and control centre is planned for the IRT routes, in full communication with all trains.

To ease overcrowding, the 63rd Street subway line will be extended to connect with other lines at Queens Boulevard. LIRR's Platform 11 at Penn Station will be extended to take longer trains. LIRR will take delivery of 10 three-phase-motored electro-diesel locos and double-deck coaches.

Metro North services will be extended over existing freight lines to feed new and expanding communities. More suburban park-and-ride interchanges are planned, together with better accessibility for mobility-impaired customers. Service modifications will provide for intra-suburban and reverse-commute journeys.

Throughout New York, MTA will introduce automatic fare collection, electronic collection of bridge and tunnel tolls, and new bus-rail interchange hubs. A connection to NJ Transit rail services at Secaucus is also proposed.

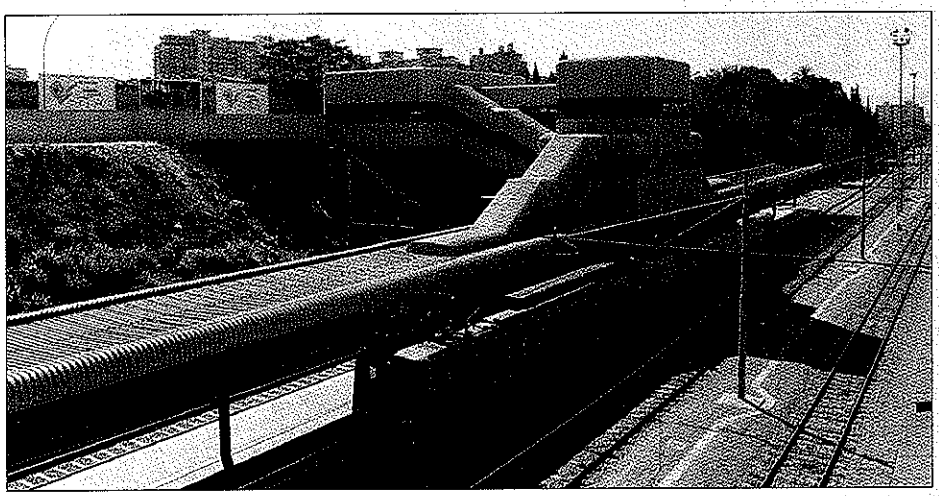
Total cost of these projects is estimated at $10·6bn, and here we face a serious problem. Capital funding has run out, and Phase 3 of the programme still awaits approval by the New York State legislature. Only about 60 per cent of the necessary funds have been identified, but even these need to be legislated. The funding gap of around $4bn poses a serious problem for the authority, and ultimately for the customers and the region as a whole. Without the capital programme, our assets and quality of service will once again begin to decay. In public transport, there is no standing still. □



Automatic fare collection is to be implemented in 1992-96, with swipe reader gates replacing token turnstiles at all subway stations

Regional metro serves Sicilian commuters

Dr-Eng Stefano Bernardi
Dr-Eng Giancarlo Laguzzi
Local Railways Division
Italian State Railways



A two-car Ale582 EMU calls at Fiera on the branch to Giacchery

INCLUDING the 23 surrounding municipalities, the metropolitan area of Palermo ranks as the seventh largest in Italy, with some 900 000 inhabitants. For many years, as with much of southern Italy, rail has played a comparatively minor role in local transport, carrying just 6 per cent of commuters compared to 45 per cent for bus and 46 per cent for private cars. Now this situation is starting to change.

At first glance, the geography of Palermo is not ideal for urban railways. The city is built on the high cliffs of the north Sicilian coast, dropping steeply to surround the busy harbour. The main station lies to the east of the city centre, but in recent years much of the development has been moving westwards around the harbour area. However, there were several sections of under-utilised rail infrastructure in Palermo with considerable potential. In particular, there was a freight branch in the western part of the city, which was built to carry goods to the harbour but in recent years had seen very little use. The line branched off the Palermo – Trapani route, which tunnels under the central part of the city. Despite their good situation, neither line had been exploited for local passenger traffic.

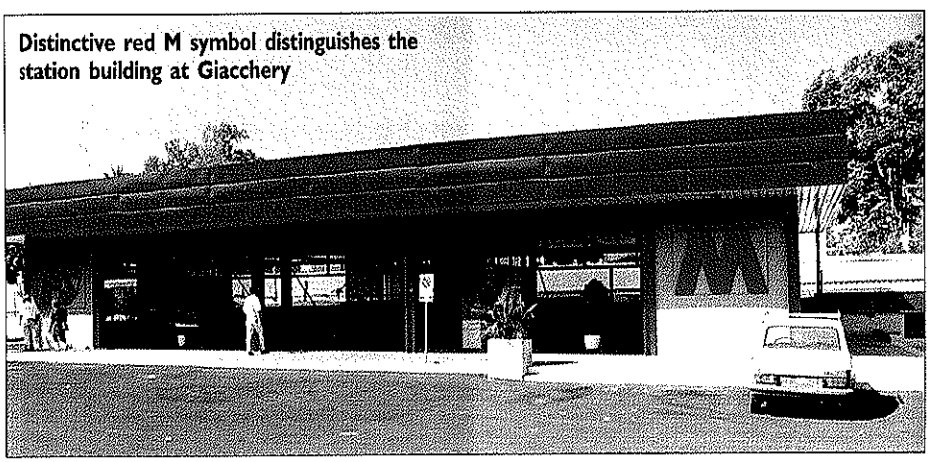
The harbour branch ran very close to the main football stadium, the trade fair district and the growing business district around the harbour. In addition, the Trapani line passes other key traffic generators, such as the Polyclinic Hospital and the residential suburbs to the west of the city. The line also runs close to Punta Raisi international airport, the most important in Sicily and the second most important in southern Italy.

With Italy scheduled to host the 1990 World Cup football championships, Palermo was clearly facing the prospect of a vast influx of extra traffic which would have swamped the available transport infrastructure. In conjunction with the local authorities, Italian Railways decided to upgrade its various routes and grasp the opportunity to weld together a passenger network which would not only serve the World Cup crowds, but would be of long-term benefit to the whole metropolitan area.

Clearly, the first priority was to achieve a link to the football stadium. During the second half of 1989 and the early part of 1990, the harbour branch from Notabartolo was completely reconstructed and electrified. This work cost 14·7bn lire, and was paid for entirely by the Italian government as part of its preparations for the World Cup events. Four new stations were opened, of which the first at Vespri is on the Trapani line; this serves the Polyclinic Hospital. On the branch, the first station is at Stadio, serving the main sports stadium, and the second at Fiera serves the trade fair. The line terminates at Giacchery, in the heart of the commercial and harbour district.

The current timetable provides 82 trains a day each way between Palermo Centrale and Giacchery, running from 06.30 to 20.00, although not yet at regular intervals. This basic service is targeted at commuters, schoolchildren and business employees, although additional trains are run when required for sports events, exhibitions or trade fairs. All trains are worked by two-car EMUs of Class Ale582.

Over a million passengers used the line during the first year, which gives an average traffic of around 3 000 passengers/day. Whilst this does not seem very many, we have recorded peaks of over 10 000 passengers/day, which is quite a respectable performance considering the small scale of the initial investment.



Distinctive red M symbol distinguishes the station building at Giacchery

BUILDING ON SUCCESS

Following the successful introduction of passenger services on the harbour branch, FS and the municipality began discussing the possibility of expanding the operation to further routes. Funding for the next stage of the project has now been agreed, and should see what we have designated the Medium-Term Service in place by 1996. This will cost around 555bn lire, of which the municipality is contributing 100bn and FS the rest.

The biggest development in this stage of the work is the construction of a branch to the airport at Punta Raisi. New stations will be opened on the existing line at Palazzo Reale, Francia, S Lorenzo and Cardillo, and the present bus services will be restructured to integrate more closely with the trains.

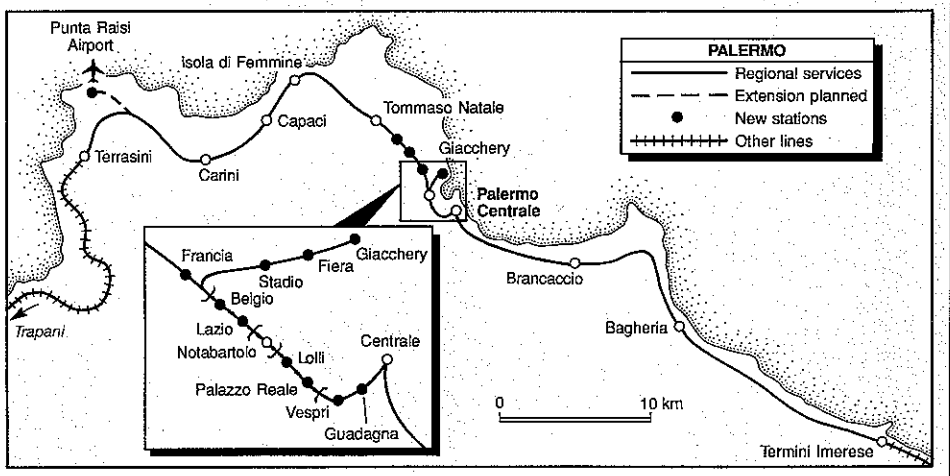
The basic service which we envisage will provide an hourly train to the airport and one to Trapani. Local services to Tommaso Natale and Giacchery will combine to give a 15 min headway on the core section between Centrale and Notabartolo.

Palazzo Reale will be a new underground station built in the existing cross-city tunnel, located close to the headquarters for the Sicilian regional government. The double-track station will provide a passing place in the centre of the long single-track tunnel,

although we are looking at doubling the whole route in the longer term. Similarly, addition of the new double-track station at Corso Francia will involve rearranging the single-track junction of the branch line to Giacchery, which leaves the main line on the Notabartolo side of the new station.

Construction of the new station at Palazzo Reale, together with similar underground stations which are proposed at Belgio and Lazio, will involve complex civil engineering work in the heart of the city centre. Further, the work must be carried out without interrupting the existing rail services. The first stage will be to underpin the buildings on each side of the tunnel using reinforced concrete bulkheads, micro-piles, and jet grouting of the surrounding ground. A hollow box can then be excavated surrounding the existing tunnel, in which the station structure will be erected. Only when this is complete will we break out the old tunnel walls and build the new platforms and loop line inside the station shell.

To the east of Palermo Centrale, a local service will be introduced along the coast to Termini Imprese, serving the neighbouring towns of Brancaccio and Bagheria. To improve journey opportunities between these eastern parts and the central area, the service to Termini Imprese will be worked by cross-city trains reversing at Centrale and continuing eastwards. As well as the new stations, the existing structures at Termini, Centrale, Notabartolo, Tommaso Natale and Carini will be refurbished and upgraded to cater for increased traffic. Redundant railway land will be transferred to the Palermo Town Council for redevelopment in exchange for investment in the regional services.



Beyond 1996, we have plans for a third stage of development which will add further stations at Guadagna, Lolli, Lazio and Belgio. Double-tracking of the entire tunnelled line under the city will allow service frequencies to be stepped up, both on the airport line and on the harbour branch. Additional regional services will link the surrounding towns into the thriving municipality.

FS is fortunate to have in place a core railway which can be used to serve the needs of Palermo's inhabitants. Now that we have established a basic urban service, there are many opportunities to expand our services and market share. The next five years promise to be extremely busy. □

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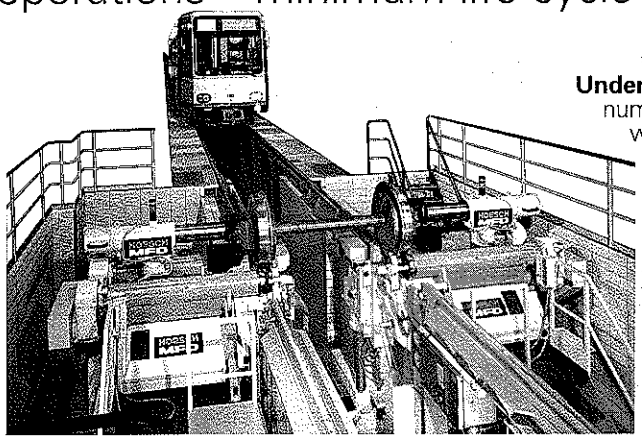

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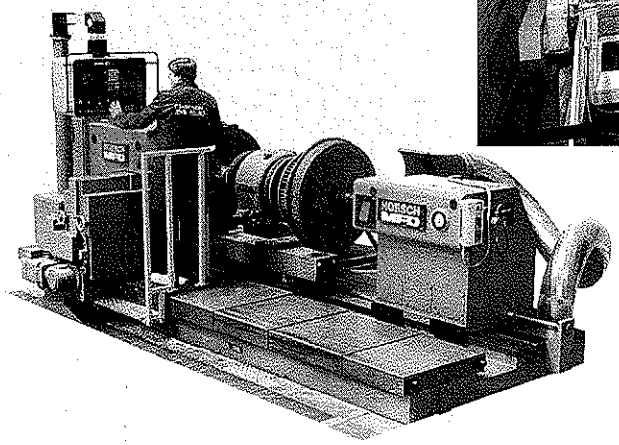

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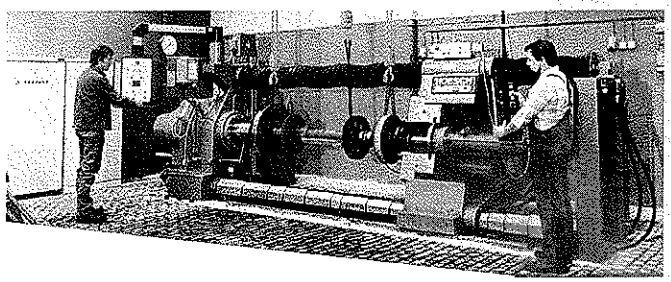

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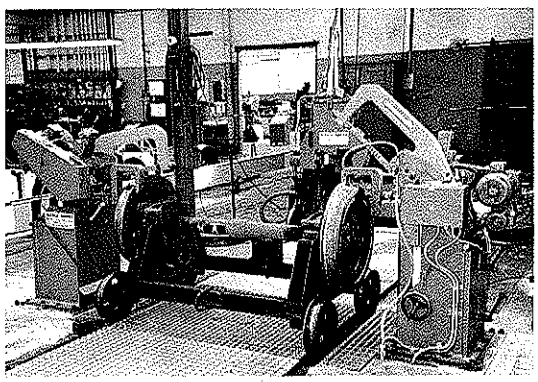

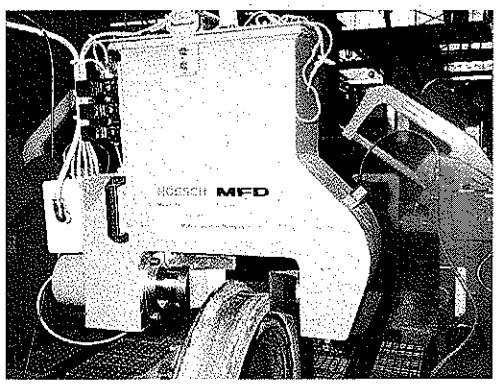

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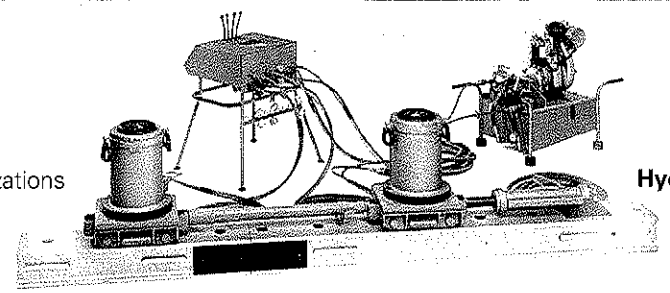

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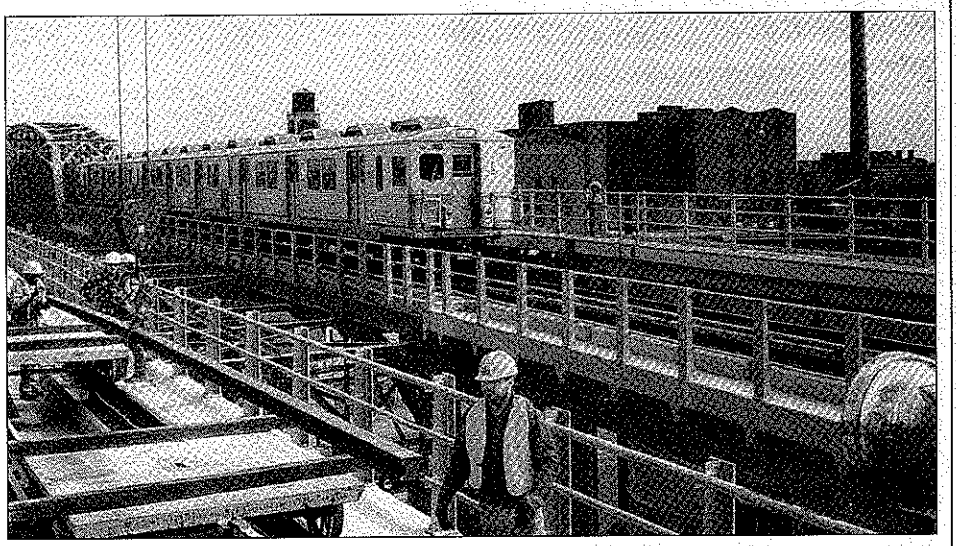
Septa epitomises a US political awakening to public transport

Louis J Gambaccini
General Manager, Southeastern Pennsylvania Transportation Authority
Vice Chairman,
American Public Transit Association



Bridge reconstruction on the Market-Frankford line has required the operation of up to 39 trains/h over a single track

THERE IS NEW HOPE for public transport in the United States because of a fundamental change of political mind and heart on what the country needs to resolve its undeniable mobility and air pollution crises. Reason has at last begun to prevail in the nation's long-running love affair with the private automobile, and perhaps this transformation is best characterised by developments in the City of Philadelphia and its four surrounding counties – a region of nearly 4 million inhabitants served by the Southeastern Pennsylvania Transportation Authority.

Septa is the fourth-largest public transport operator in the USA, providing 1·1 million passenger-journeys a day on 198 routes – including 11 light rail, two metro and seven regional rail lines.

For the first time since it was established in 1964, Septa has dedicated capital funding from the Commonwealth of Pennsylvania – a result of historic legislation enacted last August. This law allocated US$200m a year in dedicated funding for 38 transit operators thoughout the state, of which Septa will receive approximately US$135m.

On the Federal front, the US Congress reauthorised the country's Surface Transportation Act last November, which will give Septa an additional US$50m for capital investment. This is despite a decade of Administration policy to remove the Federal Government from public transport funding altogether.

The new State and Federal money – which is in addition to the 1991 level of funding – totals about US$185m annually. This means that more than US$300m will now be available as Septa reaches for an average annual spending goal of US$450m required to satisify the needs of its 10-year 'Action Plan for the 1990s'.

IMMEDIATE PROSPECTS

Thus empowered, the Plan can move forward, with a number of important milestones to be reached in 1992. A principal accomplishment in the eyes of around a quarter of Septa's regular ridership will be the ordering of a new fleet of 220 cars to replace the 31-year-old stock on the Market – Frankford line. By this summer a car builder will be selected, and according to the schedule a prototype car should be in Philadelphia by 1994. The entire new fleet should be up and running by 1996.

New rolling stock is already on order for Route 100, our Norristown High Speed Line. We have been operating the the Norristown line – which is technically somewhere between a segregated light rail route and a heavy metro – with a mixture of elderly stock for decades. In the last few years we have retired the ancient Brill cars built in 1924-29 and the famous Bullet cars of 1931, replacing them with a fleet of seven married-pairs of 1950s cars purchased from Chicago Transit Authority and five converted Budd cars from the Market – Frankford line fleet. The first of 26 three-phase motored light metro cars ordered from ABB Traction Inc was delivered in 1991 (RG 11.89 p797), and is currently being tested. A second car will be delivered in the summer, and we expect to have all 26 cars by early next year.

Seven of our 10 active streetcar lines are operating quite efficiently with 10-year old Kawasaki light rail vehicles, which have maintained their original reliability and popularity. These cars are in service on our two suburban light rail lines and five subway-surface streetcar routes which use a tunnel section to run from the city centre to the western and southwestern suburbs. However, the remaining three streetcar lines are in dire need of new rolling stock; the PCC cars on routes 15, 23 and 56 date from around 1947 and have been rebuilt several times.

The three routes also require major infrastructure renewal, and Septa's 10-year plan makes provision for this. We have

Some 25 bridges must be renewed or replaced in the $354m RailWorks project to repair the regional rail line in central Philadelphia

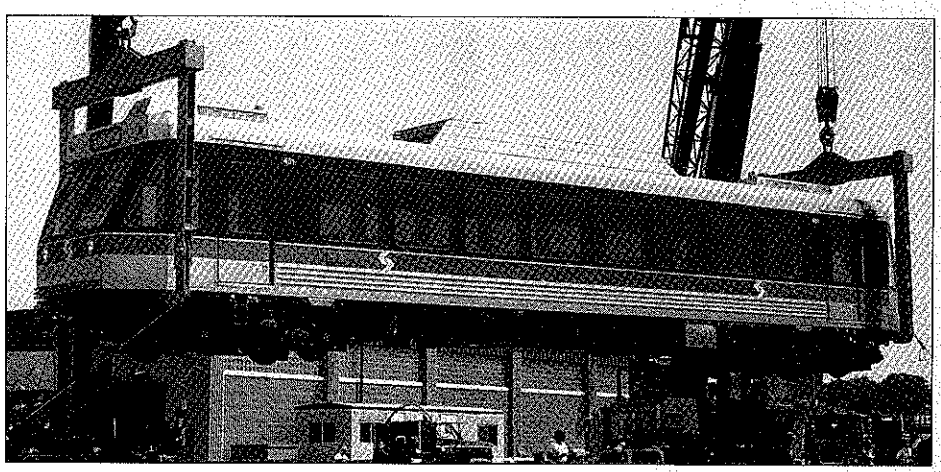
planned to invest some US$115m in the infrastructure, including the power distribution network and substations, and to buy up to 70 new LRVs at a cost of US$105m.

REGIONAL RAIL REBUILDING

One of Septa's major capital projects now under way is RailWorks. This US$353·5m effort is the most extensive railroad capital project undertaken since the authority took over operation of regional rail services in 1983. It entails taking apart and completely renewing the key four-track section between Wayne Junction and Center City, Philadelphia – the most deteriorated 6·4 km section in Septa's 362 km network of regional rail services. Whilst the major emphasis is on replacing 20 bridges and rebuilding five others, new tracks and signals are being installed, and a new station is scheduled to be built at Temple University in North Philadelphia. The heaviest construction period is now under way, requiring the stopping of rail services through the area.

The need to halt services for a total of 10 months – April to October 1992 and May to September 1993 – is the most immediate reason for construction of the new Fern Rock Transportation Center, completed at the end of 1991. Fern Rock enables regional rail riders heading for central Philadelphia to transfer easily onto express subway trains on the north-south Broad Street line. These trains cover the 59-block, five-stop run into the city centre in just 17 min.

As well as its immediate use during the blockade, Fern Rock will provide a permanent link between the regional rail services and the Broad Street line, which runs under the city's principal north-south street. The Center has opened up new travel options for Philadelphia residents reaching out for burgeoning employment opportunities in the suburbs, and suburbanites seeking convenient access to important locations along Broad Street, including two universities, several hospitals, and the city's professional sports complex.



The prototype Norristown line car was delivered in 1991, and all 26 are due by the end of 1992

On the transit front, Septa's partially-funded US$944m Frankford Elevated Reconstruction Project has moved forward on schedule. FERP is reconstructing 8·4 km of the Frankford elevated section of the double-track east-west Market-Frankford subway/elevated route which passes beneath the heart of Center City Philadelphia. The project includes the rehabilitation of 11 stations.

One of the most significant accomplishments of FERP occurred mainly during 1991, when two major bridges were completely renewed without interrupting services. The biggest challenge was operating up to 39 trains/h over temporary single track sections whilst dealing with an average daily ridership of 160 000 passengers.

Now scheduled to begin in 1993 is the reconstruction of another major bridge, carrying the route over the Amtrak main line in northeast Philadelphia. The FERP programme began in 1986, and is currently expected to be complete by 2006, but it is a priority project for acceleration as funding permits. To date, around 20 per cent of the elevated structure and superstructure has been renewed, along with one of the 11 stations. The most challenging project in the station programme will be the construction of a new Frankford Transportation Center to replace the present Bridge-Pratt terminus.

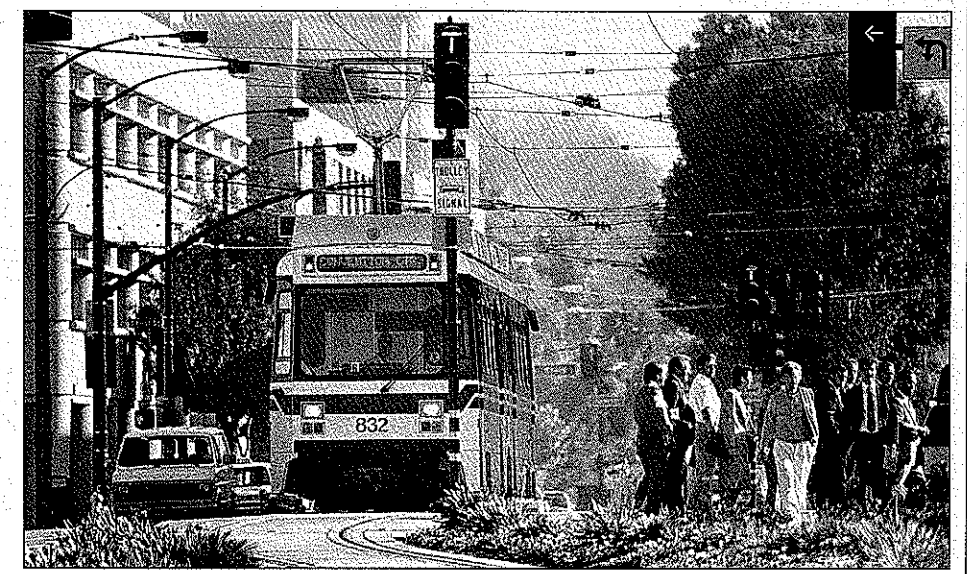
A BRIGHT FUTURE

Septa's top priority is to stop the current disintegration of the system and make sure that it is safe. Most of what we will do will not be show-stopping, ribbon-cutting type improvements. Our first priority is to save the system by renewing its old and deplorably decayed infrastructure before we find it necessary to amputate parts of the network for safety and financial reasons.

We are at the threshold of a new era. Even as we endeavour to reclaim the system from all the decades of neglect, even as we continue to seek all the funding we require to get the job done, we can dare to look forward to the 21st century with optimism. We can see that the region's vision of a future with improved mobility for all – through a renewed public transport network – is not only attainable but probable. The support which public transit has earned in just a few short years proves that. □

Light rail underpins transport network

Larry Reuter
General Manager, Santa Clara County Transportation Agency



At the heart of San Jose's business district is a 14-block transit mall

ON APRIL 25 1991, Santa Clara County celebrated the completion of its Guadalupe corridor light rail project with the opening of the southern 16·1 km segment to Santa Teresa. Over 12 000 residents turned out to mark the successful completion of the line 99 days ahead of schedule. At $550m, the 33·7 km light rail line is the largest single capital works project ever undertaken in Santa Clara, one of the longest rail lines built in the USA for 50 years, and the first to be partially funded from a 5 cent federal gasoline tax.

The Guadalupe corridor, as now operating, links the residential districts south of San Jose with a revitalised city centre and the busy industrial areas in the north of the county. Trains of up to three articulated LRVs, each with a capacity of 92, speed along the largely-segregated alignments at up to 90 km/h, carrying residents to and from their workplaces, city centre shops in the $45m 14-block transit mall, the convention centre, and many other activities.

The first cars began running in December 1987, and by the following June 14·4 km was in service, from Old Ironsides to the northern side of central San Jose. The 3·2 km cross-city section south to Tamien followed in August 1990, and the southern end in April 1991. Opening of the southern part of the route brought a phenomenal leap in ridership. During the first week, daily traffic rose by 68 per cent from 11 300 to 19 000 passengers. The year-end target of 20 000 passengers/day was passed in just two months, and ridership is still rising.

The Guadalupe corridor is owned and operated by the Santa Clara County Transportation Agency, which was established by the county Board of Supervisors in September 1974 to co-ordinate and oversee all modes of transport in the county. With an annual operating budget of $160m and around 2 500 employees, SCCTA has operating divisions responsible for rail, road maintenance, bus services, and three airports.

The Rail Operations division has 196 staff and an annual budget of $13·9m; it is responsible for operating and maintaining the light rail line, 50 LRVs, 33 stations and 10 park-and-ride installations accommodating up to 6 300 cars. It works closely with the Bus Operations division, whose 515 vehicles feed into the light rail at many points. Together, the divisions ensure that 80 per cent of the county's 1·6 million residents are within 400 m of a public transport service.

Expansion programme

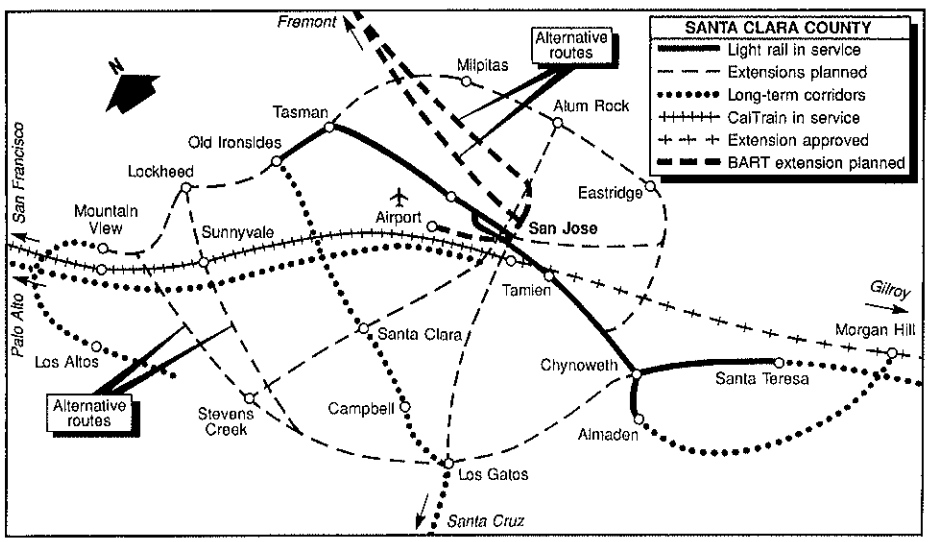
Even before the initial system was completed, the county authorities had decided to extend the benefits of light rail to a wider area. On July 23 1991, following a two-year study, the Transit District Board selected the 21 km Tasman corridor as the first extension of the network. Connecting with the northern end of the existing line at Old Ironsides, the new corridor will take LRVs west to the Lockheed works in Sunnyvale and a connection with the Caltrain commuter line at Mountain View. The route will also run east from Tasman to Hostetter Road in the suburb of Milpitas.

The current schedule for the Tasman corridor line envisages final design work starting before the end of this year, with construction getting under way in mid-1993. Opening is anticipated for early 1997.

On October 29 1991, the TDB approved a 20-year public transport development plan, designated T2010. Santa Clara County residents fully realise the vital need for improved transport, and have consistently rated transport as their number one community problem. They have also demonstrated their concern by voting for various ballot propositions which specifically allocate funds for transport.

The fourth update of a rolling programme started when SCCTA was formed in the early 1970s, T2010 provides a comprehensive multi-modal county-wide plan, covering rail, light rail, bus, car, cycle, disabled transport, pedestrian facilities and land use, together with financing for the various proposals. As well as updating the proposals to suit changing employment patterns, T2010 reflects new legal, environmental and financial conditions. Capital and operating costs for the package will amount to between $4·5bn and $6·9bn over the next 20 years.

A significant part of the package is a long-range rail master plan, giving a vision of the county's rail needs over the next 40 to



50 years. The largest single component of T2010, the rail plan envisages capital investment totalling almost $4·6bn. The rail master plan is closely integrated with land use and other transport policies.

THREE TIER STRATEGY

The master plan builds on both the rail modes currently serving the county – the Guadalupe corridor light rail and the 75·6 km CalTrain commuter corridor linking San Jose to San Francisco. Development will be phased in three tiers, to be implemented in the 1990s, 2000s and after 2010.

Tier 1 includes the Tasman corridor light rail line, and a Vasona corridor linking San Jose with Campbell and Los Gatos. An environmental study in 1991 selected light rail as the preferred mode for this 11·3 km route, but no construction schedule has yet been agreed.

Next year will see a 45 km extension of the CalTrain service south from San Jose to Gilroy, along the existing Southern Pacific route. Eight trains a day will serve new stations at Morgan Hill, San Martin and Gilroy, and connect with the light rail line at Tamien, in south San Jose.

Delivery of the 48 double-deck CalTrain coaches ordered from Morrison Knudsen in February will allow expansion of the existing service from 54 to 66 trains/day. To accommodate the extra vehicles a new servicing depot will be built in San Jose.

A third rail mode may reach the county under Tier 1 proposals in the form of a connection to BART metro services at Fremont. This year will see publication of a study of two alternative routes for this extension. One parallels SP to Milpitas and then along Interstate 880 through San Jose to Santa Clara; the other would follow a Union Pacific alignment through east San Jose to reach the city centre. Once a favoured alignment has been selected, a Federal study will compare the use of metro or light rail.

Eight more corridors have been identified as Tier 2 routes for longer-term development.

The 33·7 km Guadalupe corridor was completed in April 1991 when the 13 km section from Tamien to Santa Teresa was opened

The South County package envisages expanding CalTrain operations to both San Francisco and Gilroy, providing better reverse-commute services and electrifying the line. Extensions into central San Francisco and across the Dumbarton Bridge are proposed.

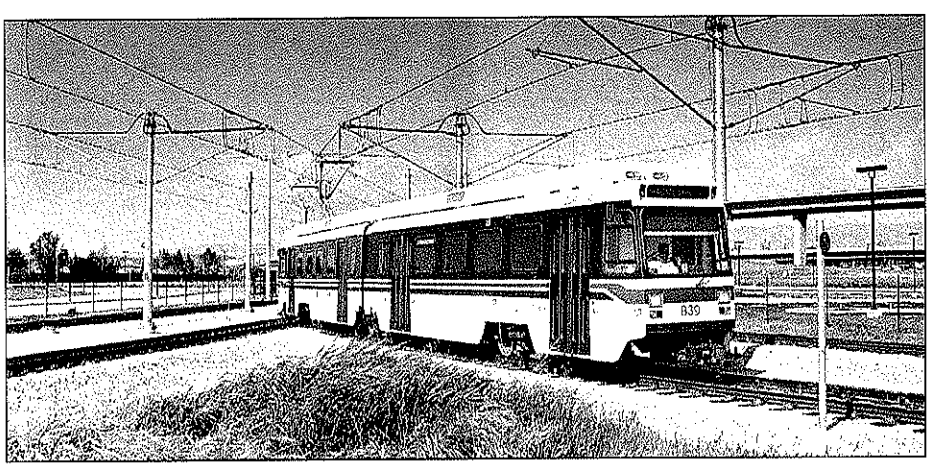
The Almaden Upgrade would double-track the existing light rail spur from Chynoweth to allow more frequent services to the Almaden valley in the southwest. Also starting from Chynoweth is the De Anza corridor, a 29 km loop through the western suburbs of Cupertino, Saratoga and Los Gatos to connect with the Tasman corridor at Mountain View. Alternatively, the line could run via central Sunnyvale, where it would connect with a short branch from the Tasman route at Lockheed.

Last year, a preliminary study was completed for the Capitol Corridor scheme, which envisages a 4·8 km extension of the eastern arm of the Tasman light rail line south from Hostetter to Eastridge. Here, it would connect with the 12·9 km Evergreen Corridor which would run back to San Jose city centre via the San Jose State University. A connection in South San Jose from Eastridge to Chynoweth would create an orbital route right round the county.

The third tier master plan proposals designate seven more corridors for long term rail development, after 2010. These would complete a comprehensive rail network for the whole of Santa Clara County, including:

- a 4·8 km extension of the Almaden LRT branch into the Almaden valley;
- an extension from Santa Teresa along the Coyote valley;
- an link from Almaden valley to the Santa Teresa corridor via Bailey Road;
- an extension of the Vasona corridor southwest from Los Gatos to Santa Cruz;
- a 32 km line along El Camino Real running parallel to the CalTrain route northwest from San Jose to Santa Clara, Sunnyvale, Mountain View and Palo Alto;
- a north-south corridor linking Los Gatos and Campbell to Great America via Santa Clara;
- a northwestern local route connecting residential and industrial areas in Los Altos and Mountain View.

Over the last five years, the Guadalupe corridor light rail line has played an ever more important part in the life of Santa Clara County. Rail will increasingly become the core of the county's public transport network, as further lines and extensions come to fruition. With the approval of the T2010 Plan and its rail development strategy, we are now set on a clear path of expansion. SCCTA has already celebrated several milestones; we have many more to which we can look forward. □



San Jose uses a fleet of 50 cars built by Canada's UTDC in 1987-88

Expansion will cut chronic overcrowding

Han Jin-Hee
President
Seoul Metropolitan Subway Corp

WHEN my predecessor Kim Jae-Myong wrote a report for *Developing Metros 1988* the four lines operated by the Seoul Metropolitan Subway Corp were handling an average of 2·2 million passengers/day. During the past four years, traffic has risen by over 50 per cent to an average of around 3·6 million – well in excess of the levels achieved even during the height of the Olympic Games in 1988.

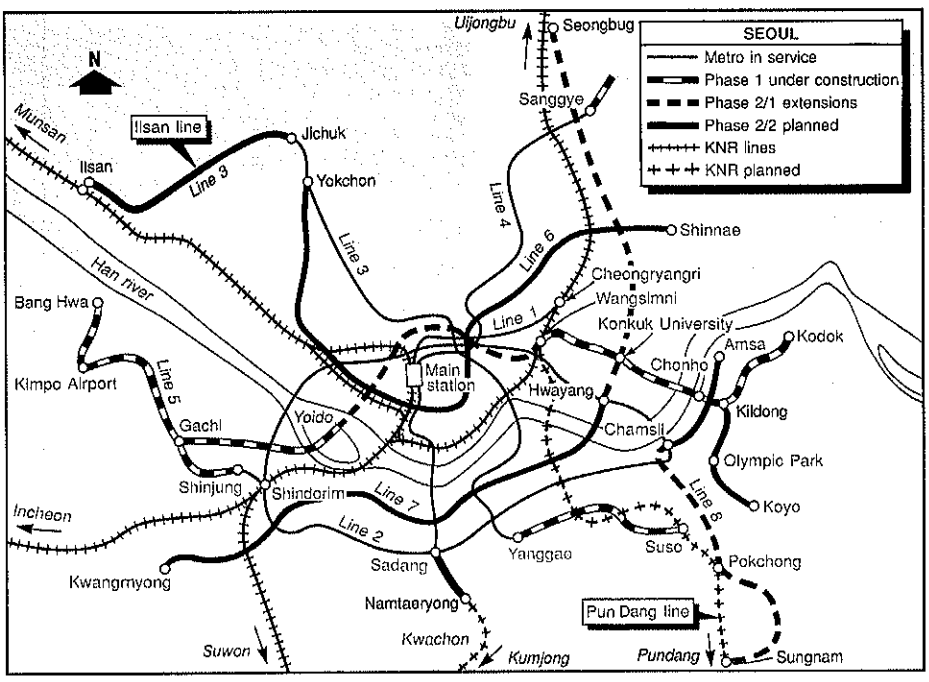
The 118 km network currently in operation is little changed from that of 1988, but we are handling 21·5 per cent of all journeys in and around the Korean capital, compared to 17 per cent before. Purchase of some additional rolling stock has allowed us to reduce the headways between trains, and lengthen some peak-hour trains. Despite these measures, congestion rates of 265 per cent of nominal capacity are not uncommon at peak times.

At the end of 1991, SMSC was operating 1 210 trains each day on its 118 km network. Headways vary from 6 min off-peak to 2½ min during peak hours, with train lengths between six and 10 coaches.

Our immediate target is to get the peak hour congestion rate down to 200 per cent by 1995. The primary means of achieving this will be the operation of 10-car trains all day and the further trimming of headways, particularly at the shoulders of the peak periods so that we can spread the worst of the crush. We are continuing a steady programme to increase the rolling stock fleet, with extra vehicles being supplied by all three domestic builders – Daewoo, Hyundai and Hanjin. The fleet of 720 cars in 1987 was increased by deliveries of 142 cars in 1989, 304 cars in 1990 and 170 in 1991 to bring the present total to 1 336. A further 202 new cars will be delivered this year, 98 in 1993, 80 in 1994 and 130 in 1995, taking the total fleet to 1 846 vehicles.

Four new lines

Despite our efforts to handle more and more traffic, urban congestion in Seoul is getting worse. So in 1988 the city government agreed a comprehensive programme to expand the metro. Around 160 km of line is either under construction or undergoing detailed design for completion by 1996, at an anticipated cost of 3 950bn won. Proposals for a further 122 km are at the planning stage.



Phase 1 of the expansion programme had already begun in 1986, and is due for completion by the end of 1993; it covers three extensions and one new line. The first scheme to begin was a 3 km branch of Line 2 from Shindorim westwards to Shinjung, where a new depot is being built. This scheme is being undertaken directly by SMSC, as is a 1 km northern extension of Line 4 from Sanggye to Shinsanggye which started in 1989. Both lines are due to open later this year.

The other two main projects in Phase 1 are on a larger scale, and are therefore being built directly by the Seoul City Government Construction Group. The first is an 8 km extension of Line 3 from Yanggae to Suso, on which work began in December 1989. This is also expected to be completed this year.

A ceremony at Naebalsangdong on June 27 1990 marked the formal start-of work on the 45 km Line 5. This is being built in three stages, with the first two due to be completed this year. Work is under way on the 17 km western end from Yoido Island to Kimpo Airport and Bang Hwa, but more rapid progress is being made in the east, where the 15 km between Wangsimni and the depot at Kodok are almost complete, ready for the start of services next year.

Phase 2 of the extension programme is split into two sections, which are each expected to take around three years. Work began in November 1990 on two more sections of Line 5. The most complicated part of the project is the 13 km central section between Yoido and Wangsimni, which provides another east-west route across the city centre, tying the eastern and western branches together towards the end of 1993. Work is also getting under way on a 7 km branch of Line 5 running southeast from Kildong to Koyo.

Phase 2 Stage 1 also includes the construction of two further metro lines

totalling 31·5 km. Work on Line 7 began in December 1990, with the aim of having it open towards the end of 1993. Line 7 will start from an interchange with Line 4 at Sanggye and run south for 16 km to meet Line 2 at Hwayang. This will relieve the northern end of Line 1, and connect with Line 5 at Neung Dong. The Line 7 depot will be built north of Sanggye, alongside Korean National Railroad's suburban line to Uijongbu.

The second new route, Line 8, was started in November 1990, and will run southeast for 15·5 km from Line 2 at Chamsil to the new suburbs of Pokchong and Sungnam, where the depot will be situated. Line 8 is also due to be completed in 1993.

As soon as these three lines have been completed, construction will commence on a further programme of extensions, designated as Phase 2 Stage 2. This covers three sections of line, totalling 61·5 km, which are due to be finished in 1996. Line 7 will be extended by another 26 km south from Hwayang across the Han river and then westwards to Kwangmyong, where another depot is to be built. Line 8 will be continued north of Chamsil along the south bank of the Han river for 4·5 km to Amsa, connecting with Line 5 near Kildong.

The third route in Stage 2 is Line 6, which will provide another east-west corridor through the city north of the Han river. Starting from Shinnae, Line 6 will loop through the northeast suburbs and parallel Line 4 into the city centre before serving the business district on the north bank of the river. Turning westwards again it will connect with Line 5 south of Seoul Main station, Line 2 at Chungchen Ro, and then turn north to meet Line 3 at Yokchon.

SUBURBAN EXPANSION

Such is the demand for housing and employment that the urban area is rapidly growing outside the metropolitan region administered by Seoul City Government. Further railway routes are needed to serve these developments, and they can be conveniently split into two forms. The first are extensions to the existing network to serve a continuous development area that has grown over the regional boundary. The others are feeder lines to serve new satellite towns which are being built at some distance from the main conurbation.

Rail development outside the metropolitan area is being undertaken in collaboration with Korean National Railroad – like metro Line 1 whose dual-voltage trainsets can operate on 25 kV 60 Hz on KNR tracks beyond the ends of the 7·5 km cross-city link. Work began in 1989 on a 16 km southern extension of metro Line 4 from Sadang to meet the KNR main line at Kumjong. This line is nearing completion, and may be ready to open in November. It will also be operated by dual-voltage EMUs.

Two satellite city links are due to open this year. The 20 km northwestern route from Jichuk to Ilsan will be worked as an extension of Line 3, but the 28 km southeastern route from Suso to Pundang will be separate. The Pundang line will connect with metro Line 3 at Suso, but from 1996, it should have its own direct route to the city. Phase 2 Stage 2 envisages the construction of a 15 km KNR line from Suso to Wangsimni, which will allow Pundang trains to connect with Line 5.

With the 122 km of additional metro schemes now on the drawing board, Seoul is well on target to have a 400 km metro and commuter rail network in operation by 1999. We envisage that rail's share of urban movement will increase from 21·5 per cent now to 60 per cent in 1996 and no less than 75 per cent by the end of the century. The metro will have a dominant role in the life of the capital. The next few years will be very exciting for all of us at SMSC. □

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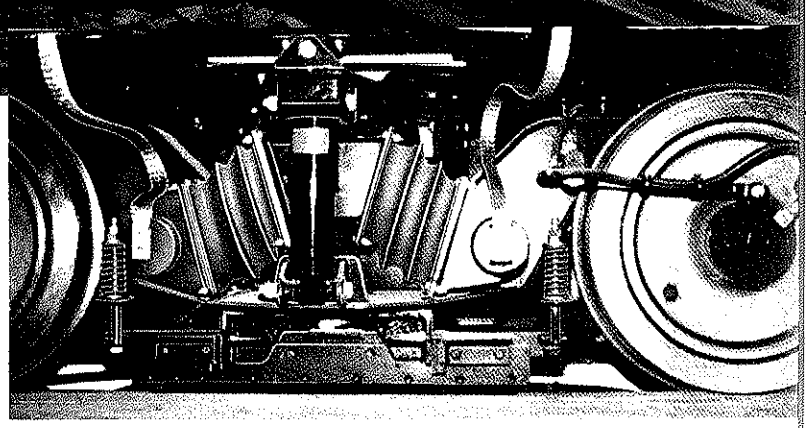

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Light rail line expands narrow-gauge metro

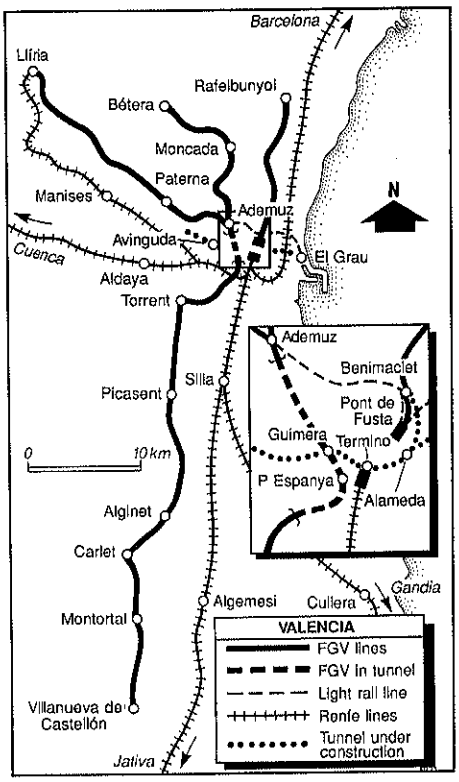
Enrique Villarreal Rodriguez
Managing Director
Ferrocarrils de la Generalitat Valenciana

OCTOBER 1993 will see the return of trams to the streets of Spain. Delivery of the first Siemens-Duewag LRV to Ferrocarrils de la Generalitat Valenciana (FGV) will mark the end of a period of around 20 years during which, barring the Tibidabo tourist tramway in Barcelona, Spain has been devoid of urban trams. The cars will operate on Line 4 of the FGV network, which will have the unusual distinction of having been converted at its northwestern end from a segregated suburban railway to a street running light rail line.

FGV was formed in November 1986, when the narrow-gauge railways in the Valencia Region, formerly operated by the state-run Feve group, were transferred to the Regional Government of the Valencian Community. The city of Valencia has a population of about 800 000, although with the surrounding area the total population served by FGV amounts to some 1·2 million inhabitants. Valencia lost its urban tramways in Spain's closure wave of the late 1960s, but suburban metre gauge lines have survived in several major conurbations, and retention of the Valencia network was assured because of its electrification in the 1920s.

FGV is owned 100 per cent by the Generalitat Valenciana, and is financed subsidies from the regional and central governments as well as fare revenues. President of the Board of Directors is the Conseller (Regional Minister) for Public Works, Urbanisation & Transport, with the General Director for Transport serving as Vice-President. The rest of the Board, up to eight Directors, is appointed by the Consell de la Generalitat Valenciana and includes worker representatives. Day-to-day operation is in the hands of an Executive led by the Managing Director, who is appointed by the Board. The management is divided into five areas: Operating, Planning & Research, Finance, Human Resources, and Commercial. There are almost 1 000 staff.

Two builds of articulated cars work the Bétera – Villanueva and Llíria – Torrent routes; they are based on LRVs supplied to Utrecht



The first stage of Line 5 will allow Line 3 trains from Rafelbunyol to be extended across the city to Avinguda

NETWORK BECOMES METRO

When FGV was formed, the Valencia suburban railways consisted of two separate groups north and south of the city. Four routes radiated from a terminus station at Pont de Fusta to Bétera, Llíria, Rafelbunyol and El Grau. The Bétera and Llíria lines shared common track as far as Empalme. A separate terminus at Jesús south of the city centre was the starting point for a line to Villanueva de Castellón.

It had been decided at the beginning of the 1980s to link these various lines together, and FGV inherited a partially-completed cross-city tunnel. This was duly opened on October 6 1988, when the network was rearranged as four linked routes. The cut-and-cover tunnel runs from Empalme, now renamed Ademuz, to Sant Isidre on the southern route, serving eight underground stations.

Services on the lines to Bétera and Llíria now run through the new tunnel, forming Lines 1 and 2 respectively. Line 1 runs to Villanueva, whilst trains on Line 2 from Llíria turn back at Torrent. At the same time as the tunnel opened, the voltage of the overhead power supply on these routes was raised from 600 V to 1·5 kV DC.

The remainder of the northern network from Pont de Fusta was redesignated as Lines 3 and 4, although these retain the original 600 V supply. Line 3 operates from Pont de Fusta to Rafelbunyol, whilst the branch to El Grau became Line 4. This latter service was extended from Pont de Fusta to Ademuz, reversing at the terminus and continuing along the old surface route vacated by Betera and Llíria trains to a bay platform at Ademuz.

This service pattern was destined to be short lived, because of a decision to go ahead with further expansion and modernisation. Line 4 was closed on January 31 1990 for conversion to a 9·2 km light rail route. In order to relieve road congestion, it was decided to rebuild some of the route from a segregated railway running down the middle of a wide boulevard and remove full-barrier level crossings across several roads, including the main coast road north from the city. As a light rail line, Line 4 will have more stops, and simple open crossings over road

junctions will facilitate the flow of all traffic. Conversion work is well advanced, and we anticipate having the line open in its new guise by the end of 1993.

Following reconstruction, Line 4 trains will still connect with Line 3 at Pont de Fusta. However, in around 18 months, Line 3 will be diverted into a second city-centre tunnel, so the interchange will be resited at Benimaclet. Construction work on the Line 3 tunnel is being managed directly by the regional Ministry of Public Works, rather than by FGV. A contract worth 8·2bn pesetas was awarded last year to a consortium of Dragados Construcciones and Cubiertas y MZOV. This covers construction of a 3·1 km tunnel from the existing Line 3 station at Palmaret to a new terminus at Alameda, which will be closer to the city centre than Pont de Fusta.

At the same time, a consortium of Comsa and Dimetronic was selected to resignal the remainder of Line 3 between Palmaret and Rafelbunyol using an improved version of the automatic block signals on Lines 1 and 2.

The Line 3 tunnel is due to open by 1995, and will be followed by the biggest development to the Valencia network since it was taken over by FGV – the construction of a fifth route. Unlike the existing cross-city routes which run north-south, Line 5 will run east-west. The first stage to be built will be a 7 km tunnel under the city costing 18·6bn pesetas; a contract for this was awarded to Entrecanales y Ocisa last summer. Starting from Avinguda, and serving Renfe's main terminus, the new tunnel will connect with Line 3 at Alameda and with Lines 1 and 2 at Angel Guimerà. The cross-city section is due for completion by the end of 1995, when Line 3 services will be extended from Alameda to Avinguda. At a later date, the route will be extended west to Nuevo Cauce and east to Cabanyal near El Grau; this will be Line 5.

The FGV lines in Valencia combine the roles of an urban metro in the city centre and an interurban network for the surrounding region; this Line 2 service is bound for Lliria

Rolling stock renewal

FGV inherited a motley collection of rolling stock, including several wooden-bodied vehicles which had been in service for over 50 years. The launch of metro services clearly necessitated a renewal of this equipment, beginning with Lines 1 and 2. These are now worked by a fleet of 40 articulated LRVs built in two batches of 30 and 10 by CAF, Macosa and MTM, with ABB electrical equipment. They are mechanically identical, although there are slight visual differences, between the 1986 and 1990 builds. The 30 m long units have a capacity of 240 passengers, 80 of them seated. They are chopper-controlled and have radios, air conditioning and doors which can be operated independently.

To supplement the new stock, a class of 10 Babcock-Wilcox three-car sets built in 1981 to a standard Feve design was modernised and equipped for 1·5 kV operation. They are 47·6 m long and have a capacity of 340 passengers, of which 83 are seated. These sets have also recently been provided with radios.

The 600 V Line 3 to Rafelbunyol is worked by 11 trainsets built in 1952, rebuilt in 1982, and refurbished again in 1989. Most services are formed of power car and trailer, giving 84 seats and a total capacity of 260 passengers. The Alicante – Denia line, which provides a commuter service out of Alicante, uses eight 2-car MAN diesel railcars built in 1967 and refurbished in 1984. They have 92 seats and a total capacity of 160 passengers.

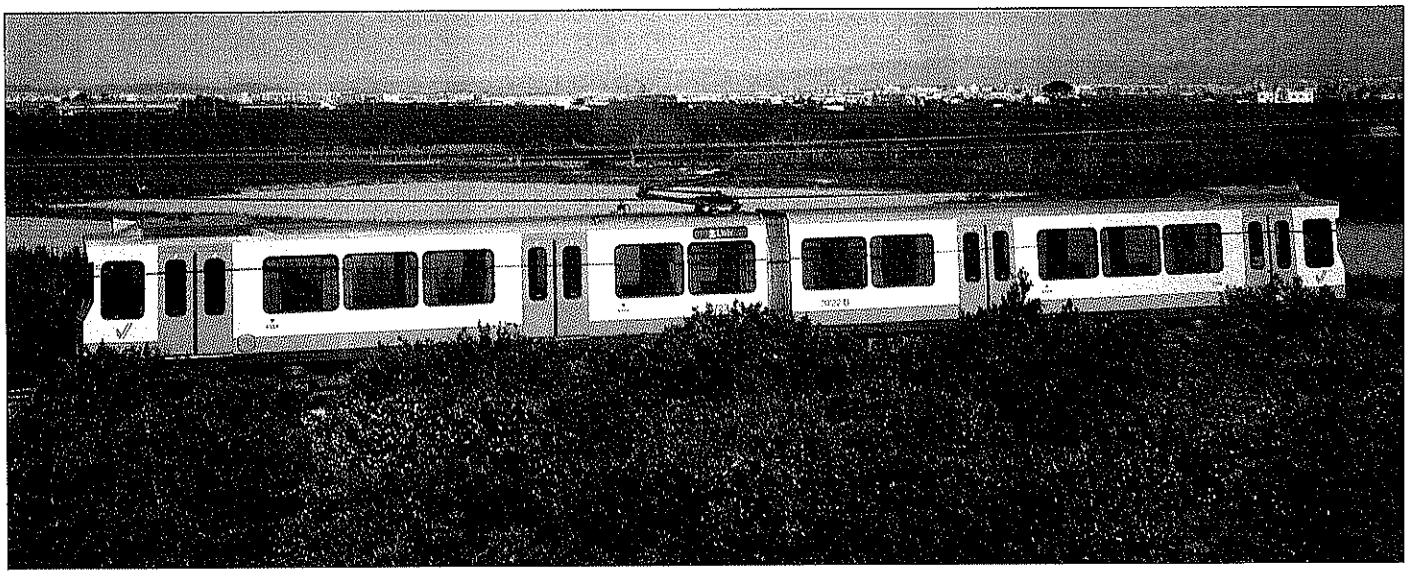
The 21 low-floor LRVs for Line 4 were ordered from Siemens-Duewag for delivery between October 1993 and Summer 1994. Seating for 65 will be provided in the three-section, six-axle articulated cars which will be 9·2 m long and have a total capacity of 190. Floor height will be 350 mm. One entrance will be fitted for disabled access.

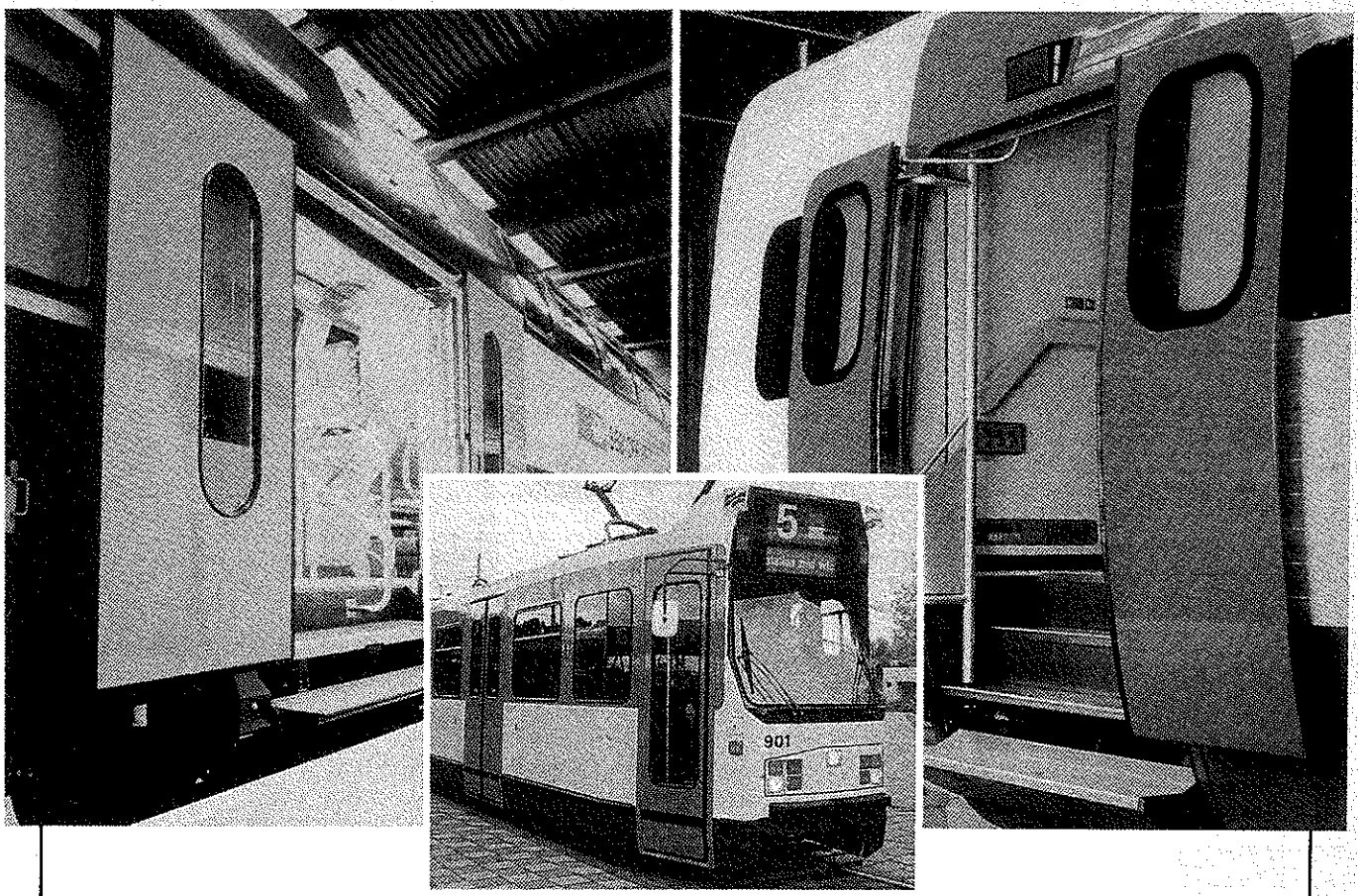
Three-phase 105 kW asynchronous motors will drive power bogies at each end of the car, with a carrying bogie under the centre section. The cars will be powered from 750 V DC overhead and have a maximum speed of 65 km/h. Control will be by Sibas 16 microprocessors. Service braking will be regenerative, backed by electro-hydraulic disc brakes on all axles. Each car will be 23 780 mm long, 2 400 mm wide and 3 370 mm high. Overall weight of the stainless steel cars will be 29 tonnes.

Income and investment

During the first four full years of FGV operation, income from fares on the Valencia network rose from 907m to 1 486m pesetas, although a substantial increase in expenditure from 2·3 to 3·6bn pesetas has kept the farebox recovery ratio at around 40 per cent. Since 1986, FGV has invested 26·9bn pesetas in its rail network, of which the bulk has gone on the cross-city tunnel.

Fares are issued on a zonal basis, with paper tickets for single journeys and magnetic cards for multi-travel tickets and the passes. Computer-based issuing and cancellation facilitates the collection of operational information. Security and service reliability are aided by an operations control centre, which allows computer-assisted monitoring of vehicles throughout the network. Closed-circuit television links enable control centre staff to monitor activity in the vehicles and on platforms at the underground stations. A comprehensive remote power supply control system allows full monitoring of the electric substations together with remote switching in and out of circuit when required. □





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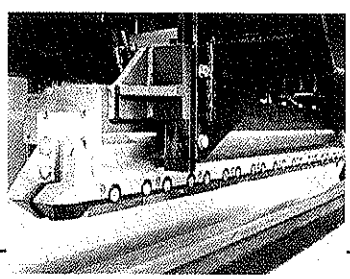

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Rolling stock dominates metro spending

PROSPECTS FOR urban railways in North America have been boosted by the passing of last year's Interstate Surface Transportation Efficiency Act (p5), with commuter rail schemes making much of the running. Northern Virginia's two routes from Washington open later this year, using 28 loco-hauled coaches supplied by Mafersa (Express Enquiry Form No 105) and diesel locos remanufactured by Morrison Knudsen (106). MK and Mafersa are also working on Series 3200 metro cars for Chicago (p38).

Chicago's commuter services are being boosted by 173 double-deck coaches from Morrison Knudsen to expand the Metra push-pull fleet. Chicago, South Shore & South Bend's interurban EMU fleet will be expanded in November by seven motor and 10 trailer coaches ordered by Northern Indiana CTD from Nippon Sharyo (107) for US$27·7m.

Morrison Knudsen consolidated its hold on the US commuter rail business in March with an order for 88 double-deckers for California Department of Transportation. Los Angeles CTC, however, has opted for the Canadian bilevel design for its commuter stock; the first of 80 vehicles arrived from UTDC (108) in April ready for the start of services in October.

Los Angeles has leased metro cars from Miami for the opening of its Red line, pending delivery of its own cars from Breda (109). The city's automated Green line suffered a setback in January when a contract to buy 41 cars from Sumitomo (110) was cancelled and tenders reopened. Boston's MBTA has ordered 86 metro cars from Bombardier (111) for delivery in 1993-94.

On the light rail front, Baltimore's newly-opened Central light rail line uses 35 three-phase motored LRVs being supplied by ABB Transportation Inc (112). Siemens-Duewag (113) is progressing a contract for 75 more LRVs to double the fleet in San Diego, whilst San Francisco's Muni has ordered 35 LRVs from Breda for US$2m each; these are due for delivery in 1995-96.

Another 24 LRVs will be required to operate the US$330m second light rail line in Guadalajara; the city's first LRVs were supplied by Concarril (114), the Mexican national builder just acquired by Bombardier. Concarril also supplied the latest rolling stock for Santiago's rubber-tyred metro, and is well placed to supply rolling stock for the 12 km Line 5 approved last August, on which work starts in 1993. Mafersa is to build 80 cars to operate the Brasilia metro.

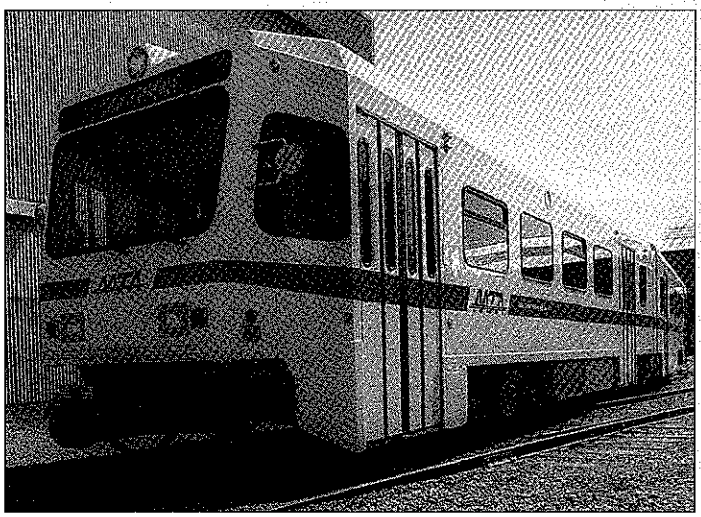


ABB Transportation Inc is supplying 35 articulated LRVs for Baltimore's north-south light rail line which opens this year

Australia's commuter networks continue to expand, with Transperth inaugurating electric services to Armadale on October 7. Two batches of 22 and 21 two-car EMUs are now being rolled out by ABB Australia (115) and Walkers (116), and a further 43 sets were ordered on April 11 for use on the Northern Suburbs line to Joondalup.

ABB and Walkers are also supplying an extra 12 three-car EMUs to expand Queensland Railways' Brisbane suburban services for A$80m. On December 11 Melbourne received a prototype double-deck four-car EMU from Goninan (117).

In Hong Kong, GEC Alsthom (118) has won a HK$669m contract to re-equip MTR's EMU fleet with updated traction equipment over the next three years. GEC Alsthom will supply a further 48 motor and 16 trailer cars from March 1994. Big orders are in prospect for the HK$22bn link to Chek Lap Kok airport.

Two routes in the second phase of the Tuen Mun light rail network opened at the end of 1991, and 30 extra LRVs are on order from Kawasaki Heavy Industries (119). These will have pneumatic doors from SMC Rail Transit (120) and pantographs from SMC Australia (121). Siemens Plessey Controls (122) has won a contract to supply road signal controls for the branch to Tin Shui Wai.

Taipei's Department of Rapid Transit Systems called tenders last year for 72 three-car EMUs for its Orange, Blue and Green heavy metro lines.

AEG Westinghouse Transport-Systeme (123) is building 96 aluminium-bodied cars for Shanghai, with another 66 cars expected to follow for the second phase. Electrification of KTM's suburban lines around Kuala Lumpur saw the ordering of 18 three-car EMUs from Hunslet TPL (124) on November 15 at a cost of £38m. Seoul's continuing metro investment (p73) was marked earlier this year when an order for 366 cars for Line 5 was placed with Hyundai (125) and ABB Traction (126).

Turkey now has three cities developing metro or light rail networks. Metro, light metro and light rail lines are all under way in Istanbul. Last summer Istanbul municipality called tenders for eight LRVs to operate a 3·7 km light rail route from Sirkeci to Araksay and a 4·9 km extension to Topkapi.

Contracts for construction of a light rail network in Ankara were awarded in the middle of last year to a consortium of AEG Westinghouse, Breda, Kutlutas and Siemens' subsidiary Sinko. Breda and AEG Westinghouse are to build the 33 six-axle articulated LRVs for DM153m.

Izmir has called prequalification bids for an initial 8·5 km light rail line following a feasibility study in 1991 which recommended a 50 km two line network.

In Egypt the established network of Alexandria's Passenger Transport Authority began a programme of track renewal and upgrading for its tram and light rail network. Three companies were shortlisted in mid-1991 to build a 376·5m riyal light rapid transit system in Makkah: UTDC of Canada, Matra (127) of France and Westinghouse Electric (128) from the USA.

Germany continues to dominate European metro development, with Linke Hofmann Busch (129) to build another 21 DT4 EMUs for Hamburger Hochbahn AG for delivery in

Transperth ordered a third series of two-car EMUs from ABB/Walkers on April 11; the A$170m deal for 86 cars will double the fleet

Hamburger Hochbahn has ordered a second series of DT4 metro cars from Linke Hofmann Busch; they have ABB electrical equiopment

1993-95. Berlin Transport Authority (BVG) has ordered 18 two-car U-Bahn EMUs from ABB Henschel Waggon Union (130) at a cost of DM35m for delivery by the end of this year; the contract includes an option for 22 more sets. ABB Henschel is also to build 40 Class 480 EMUs for the S-Bahn, with AEG Hennigsdorf (131) building 50 Class 485 sets.

Late last year DB ordered its eighth build of Class 420 three-car S-Bahn EMUs: the 46 sets will be delivered during 1994. The first of 21 dedicated units for services to München airport was rolled out earlier this year. A fleet of 75 double-deck coaches for regional services radiating from München commuter trains will be built by Waggonbau Görlitz (132) and Waggonfabrik Talbot (133) at a cost of DM170m.

Hannover is taking delivery of 20 LRVs from Linke Hofmann Busch and Siemens last year for Line C; a further 10 cars have been ordered. ABB Henschel and LHB have a contract to rebuild 97 Tatra T4 motored trams and 45 B4 trailers for Leipzig.

Kölner Verkehrsbetriebe is considering ordering up to 180 low floor LRVs to operate east-west routes. Duewag (134), ABB and Siemens are working together on 50 low-floor LRVs for Rostock, whilst Duewag and ABB are to build 69 LRVs for Mannheim, Ludwigshafen and the Rhein-Haardtbahn at a cost of DM250m. AEG Westinghouse subsidiary MAN-GHH (135) is to supply 40 four-section and 17 three-section low-floor LRVs to Bremer Strassenbahn AG at a cost of DM190m. Zwickau has ordered 12 of these GT6N metre-gauge LRVs, which have 100 per cent low-floors.

Britain's long-awaited light rail revival finally bore fruit on April 6 when the first of 26 LRVs being supplied by GEC Alsthom for Manchester's Metrolink began revenue service between Manchester and Bury; the cars were assembled in Italy by Firema (136). Resolution of funding problems last year allowed work to begin on a second scheme, Sheffield's Supertram. Civil works are in the hands of Balfour Beatty (137), with Stanton Bonna Concrete (138) supplying twin-block sleepers; the first track was laid in April. Siemens-Duewag will deliver the first of 26 low-floor LRVs early next year.

Network SouthEast's first aluminium-bodied Class 465 Networker EMUs were rolled out by Brel (139) and GEC Alsthom on December 19, with each company to supply 50 four-car trains. A further 43 two-car Class 466 sets will be built by GEC Alsthom, with bogies supplied by Brel. An order for 47 more Class 465s was awarded to Brel in April.

Dublin suburban services are to be expanded in 1994 with the delivery of 17 two-car DMUs ordered by Iarnród Éireann from Tokyu Car in April for I£18m.

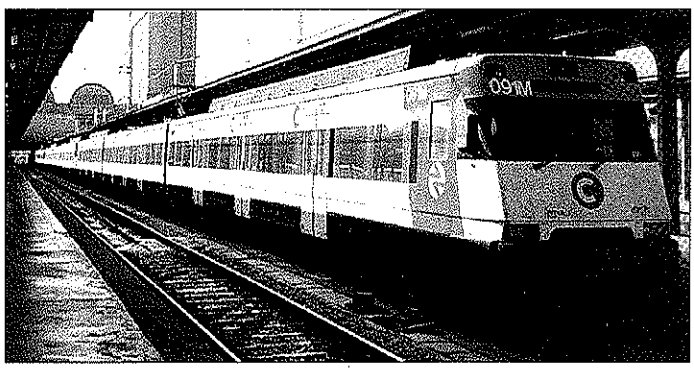
Light rail returns to the French capital in mid-July with the inauguration of part of Paris Transport Authority's St Denis - Bobigny line. The first of 17 LRVs was delivered by GEC Alsthom in February, and another 18 cars are on order to work a second 13 km route between Issy Plaine and La Défense. Delivery of the first of nine MF88 metro trainsets from ANF (140) is due at the end of this year, with the first of 665 rubber-tyred MP89 cars for Meteor and Lines 1 and 13 to follow in mid-1993.

On December 31, GEC Alsthom delivered the first of six LRVs for Nantes' second light rail line. Low-floor centre sections for these and the existing 28 cars are to follow. GEC Alsthom is to supply a further 12 three-car LRVs in September 1993 for Nantes Line 3, which is due to open in 1994.

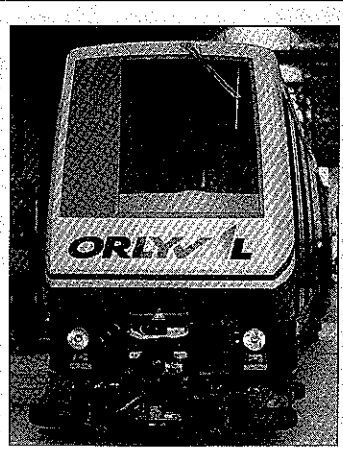
Sharing the French light rail market is ACM Vevey (141), which delivered the first of 15 LRVs to St Etienne in September. An Italian consortium of Socimi and ABB is supplying 24 five-section S350 modular cars for the first line in Strasbourg, whilst Breda and AEG Westinghouse are to re-equip Lille's metre-gauge 'Mongy' routes with 24 four-section low-floor cars.

Belgian builder ACEC (142) is supplying 51 low-floor cars to Brussels Transport. Low-floor LRVs are being developed by Simmering Graz Pauker (143) and Elin (144) for Wien, where a 5·6 km section of heavy metro Line 3 opened on April 6; SGP is supplying 45 two-car EMUs for this route at a cost of ASch1·7bn. Zürich Transport has taken delivery of a third build of Tram 2000 LRVs from Schindler Waggon (145).

Siemens and Duewag are to supply 21 low-floor LRVs next year for Valencia's Line 4, at a cost of 5bn pesetas. In May 1991, Renfe awarded a 33·2 bn pesetas contract to a consortium led by CAF (146) to build 70 Class 446 suburban EMUs. Included in the deal are Mitsubishi (147), ABB and GEC Alsthom; braking equipment is being provided by SAB Wabco (148). CAF is also building 36 Series 5000 EMUs for Madrid Metro, under a 9·5bn pesetas contract funded by the European Investment Bank.



Spanish National Railways is taking delivery of a second build of Class 446 EMUs from a consortium led by CAF for use on Madrid suburban services



The 7·3 km OrlyVal mini-metro linking Paris RER Line B and the city's second airport was inaugurated by Prime Minister Edith Cresson on October 1

On December 11 Ferrovie Nord Milano took delivery of the first of 18 double-deck coaches being built for initial services on the *Passante* cross-city line. FS and FNM are to invite tenders for an initial fleet of 40 units, with a further 120 units needed when the line is completed in 1997.

As a first step towards uniting its two metro networks in 1994, Oslo has ordered a fleet of 12 dual-system metro cars from EB Strommens Vaerksteds (149), with three-phase traction equipment from AEG. In Sweden, Norrköpings Lokaltrafik will require 10 or 12 LRVs to work a 4 km light rail extension to Navested which is due to open next year.

Göteborgsregionens Lokaltrafik AB has ordered a further three X10 EMUs from ABB Traction for SKr75m. A dual-voltage version is under consideration for a united suburban network linking Malmö and København via the planned Oresund link. DSB invited bids in February for a pre-production batch of 12 EMUs paving the way for replacement of the København S-bane fleet; DSB hopes to award the contract shortly so that test running can begin in 1994. □

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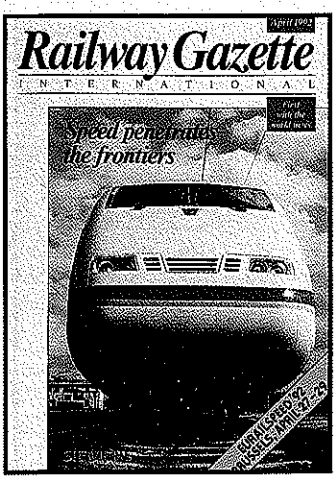

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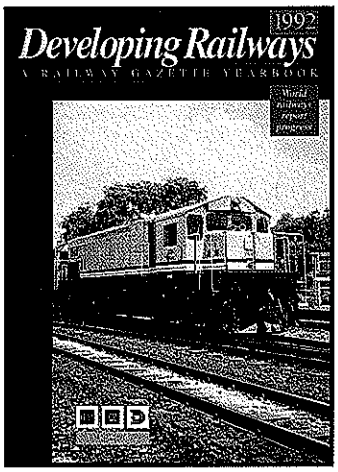

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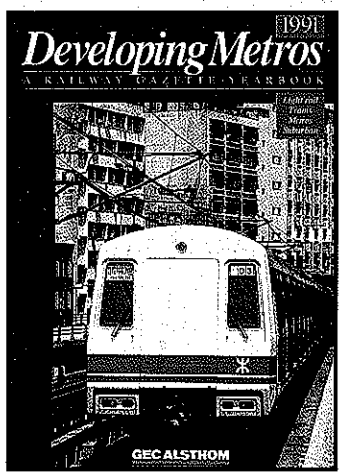

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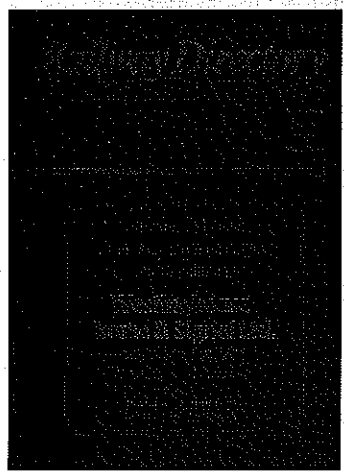

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