Quadrant House
Sutton SM2 5AS
Great Britain
Telex 892084 REEDBP G
Fax +44 1 661 3738
24 h Phone +44 1 661 8608

Editor in Chief
Richard Hope, C Eng, MIEE, MIMechE
Phone +44 1 661 3740

Editor
Murray Hughes, BA
+44 1 661 3056

Production Editor
Chris Jackson, BSc, MCIT
+44 1 661 3743

Advertisement Manager
K P Mackenzie +44 1 661 3280

Assistant Advertisement Manager
Gareth Pask +44 1 661 3278

Publishing Director
James Blazeby +44 1 661 3337

Front cover:
Rolling stock for the rapidly-expanding metro in Washington DC has been supplied in several batches by Breda Costruzioni Ferroviarie of Italy

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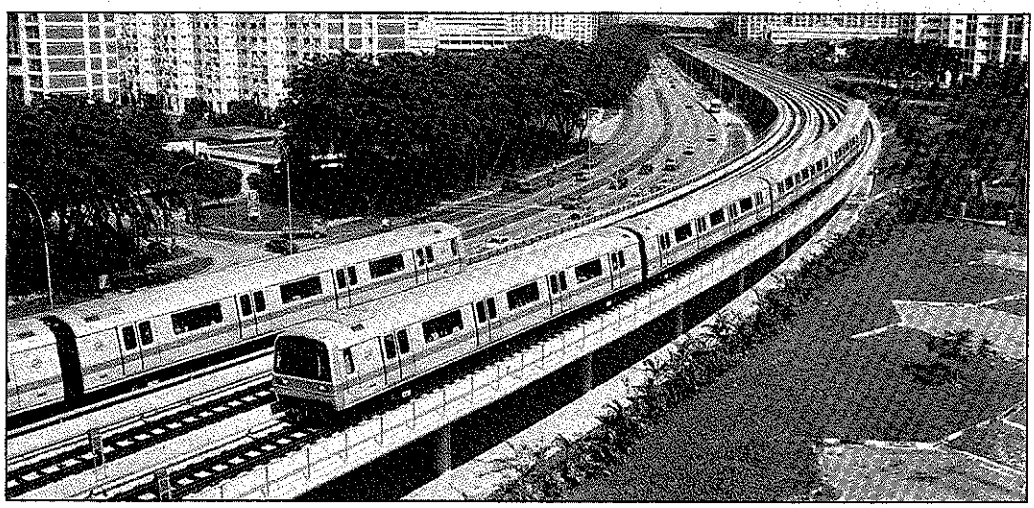
DEVELOPING METROS 88

METROS
TRAMS
LIGHT RAIL
COMMUTER RAIL

Welcome to the second edition of *Developing Metros*. First launched in 1985, this addition to the *Railway Gazette International* family of publications was enthusiastically received by urban rail operators and the rail transit industry. Our selection of reports from city rail managers and chief executives this year provides a broad overview of the urban rail spectrum with heavy metros, trams, light rail and the automated minimetro all represented.

To meet the expectations of a world population attuned to the instant availability of the private motor car, the rail transit operator's aim must be a combination of frequent services and low operating costs. Whether it be in relating how that can be achieved or in combatting the ravages of vandalism and graffiti, our authors have experience to share.

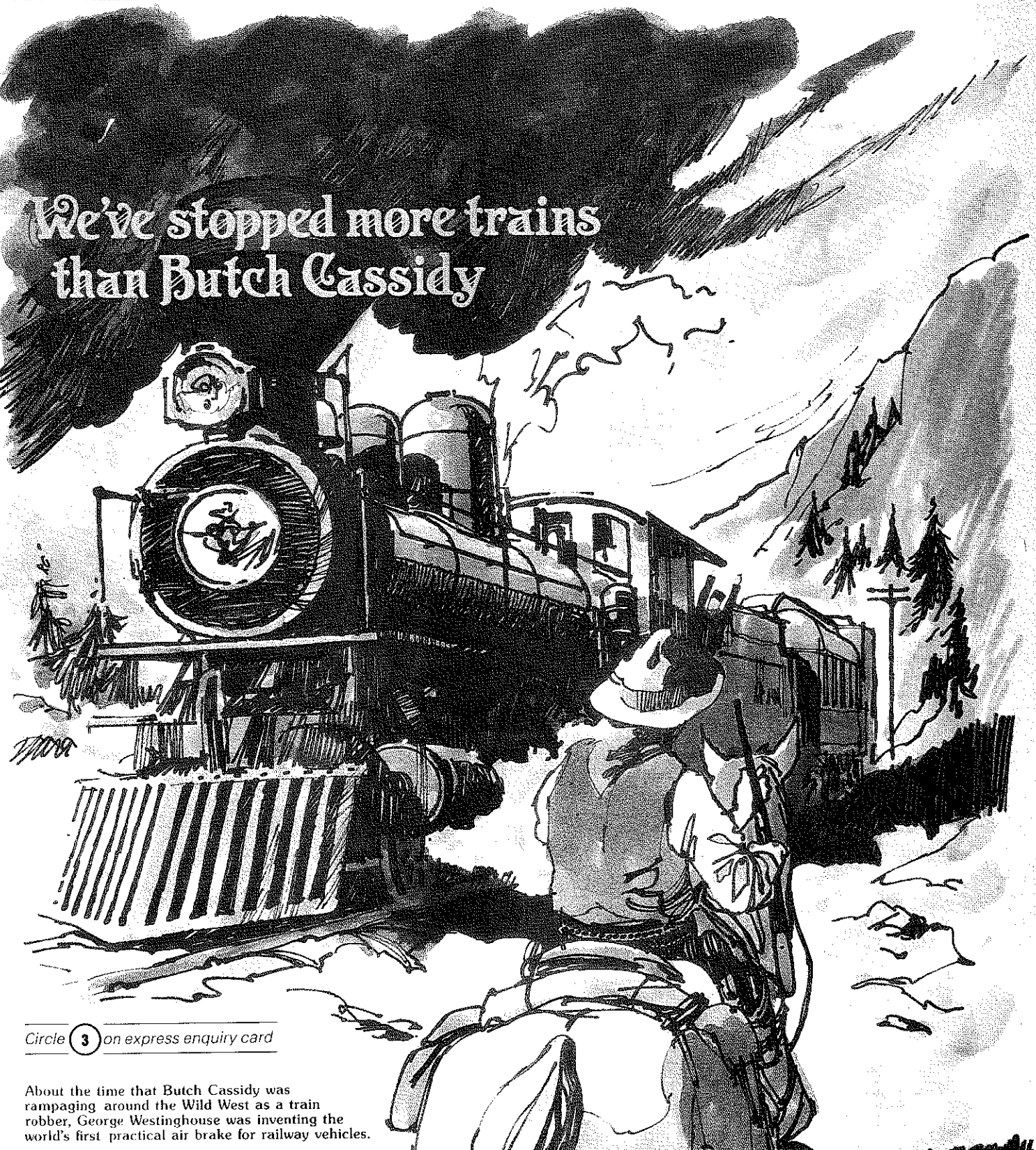
We believe that *Developing Metros* can help in this exchange of information — it offers a unique forum for urban rail managers to discuss both achievement and adversity. The next edition will be published in June 1989.



SPECIAL FEATURES

REPORTS

We've stopped more trains than Butch Cassidy



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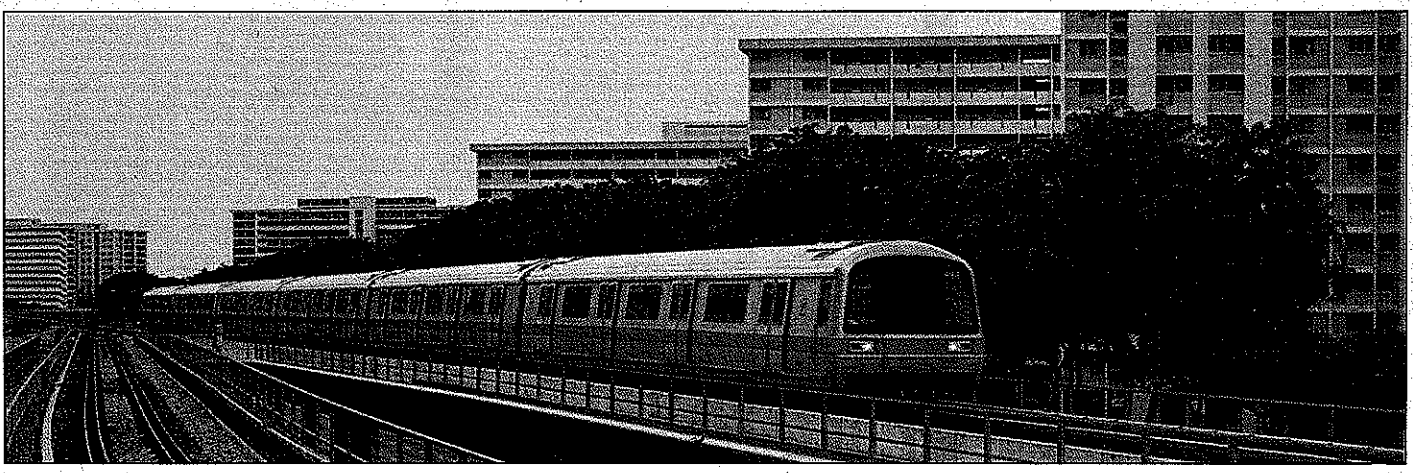
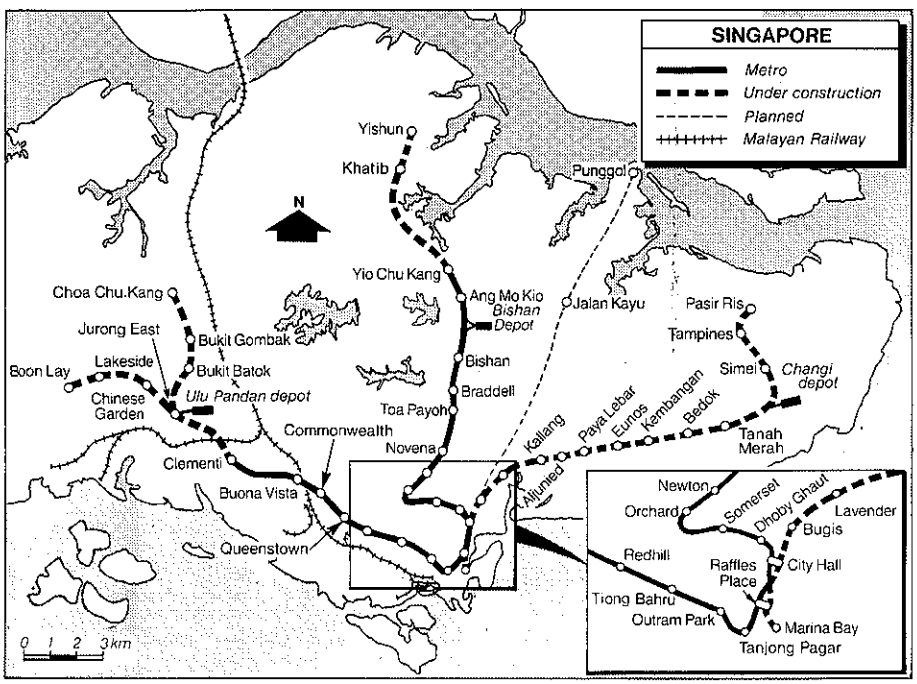


TREMENDOUS GROWTH in the booming cities of southeast Asia has prompted the International Union of Public Transport (UITP) to stage the special City Transport conference and trade exhibition (p76) in Singapore on October 11-13. In a region where industrialisation is forcing the pace of development, UITP considers it has a responsibility to ensure that public transport know-how and experience is made available to city planners and government agencies.

Among those offering their expertise at the conference will be Ingemar Bäckström, UITP President and General Manager of Storstockholms Localtrafik, UIC Secretary-General Jean Bouley and President of Teito Rapid Transit Authority Shiro Nakamura. Other leading figures are Seoul Metropolitan Subway Corporation President Kim Jae-Myong who is presiding over one of the world's fastest growing metro networks, while representatives of long-established metros will include London Underground Ltd's Chairman & Chief Executive Dr Tony Ridley who oversaw the setting up of Hong Kong's mass transit railway.

Like Hong Kong, Singapore foresaw that neglect of public transport would lead in the long term to the familiar problem of serious road traffic congestion with its attendant noise and air pollution, and a consequent deterioration in the quality of life. Singapore first examined the case for a high capacity urban railway in the 1970s, and groundbreaking ceremonies for the Mass Rapid Transit network took place in October 1983.

It is a remarkable tribute to the MRT project management team, to the Singapore government and the contractors that the first revenue-earning train rolled just four years later on November 7 1987 when the 6·5 km section from Yio Chu Kang to Toa Payoh was commissioned. Work has since forged ahead on the rest of the network, and Singapore Prime Minister Lee Kuan Yew took part in opening ceremonies at Raffles Place station on March 12 1988 to mark the start of services from Outram Park to Clementi, the Toa Payoh – Outram Park section having been completed in December 1987. Opening from Clementi to Jurong is due later this year, with the Yio Chu Kang – Yishun section of the north-south line due to follow in early 1989. The City Hall – Pasir Ris, Jurong – Choa Chu Kang and Marina Bay sections should all be carrying passengers by the end of 1990, bringing the network to nearly 70 km with 42 stations. Traffic could amount to a million passengers a day.



Masterminding the MRT is Board Chairman Mr Michael Fam whose keynote address at the UITP conference on October 11 will outline the MRT's development plans. These include the $2·2bn north-east line to Jalan Kayu and Punggol agreed in principle by Communications Minister Dr Yeo Ning Hong on August 6. Lines to serve Woodlands in the northwest from Jurong and Yishun are being studied.

Crucial to the future is Mr Fam's strategy for privatisation. Reflecting Singapore's expertise as a hothouse of Far East finance, privatisation of the MRT hinges on the setting up in August 1987 of Singapore Mass Rapid Transit Ltd as the precursor of the future private company. The achievement of building the initial network ahead of schedule and below the S$5bn budget augurs well for MRT trains to operate at a profit. The intention is that SMRT will demonstrate its ability to spin money from the metro web before the share offer is made to the public; the government has already agreed to shoulder the burden of infrastructure costs, leaving the future private company free to make realistic operating profits. □

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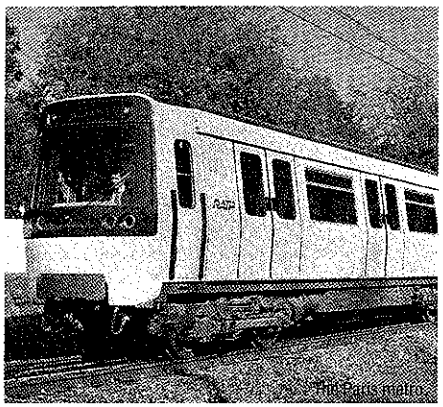
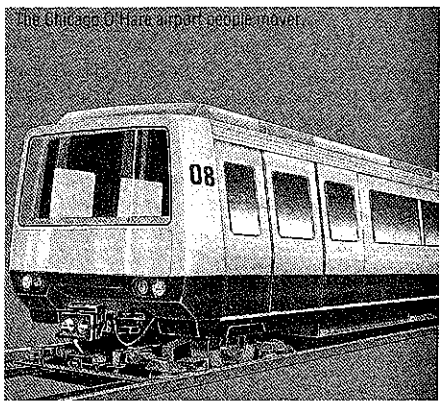
The Lille metro.


The Paris metro.

The Atlanta metro.



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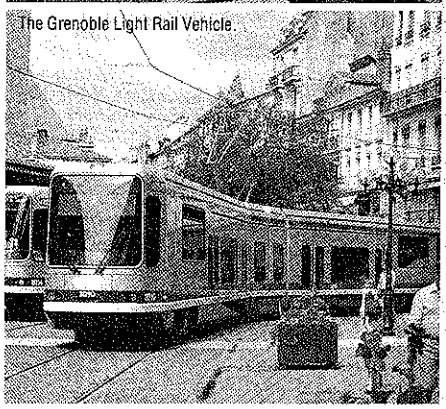
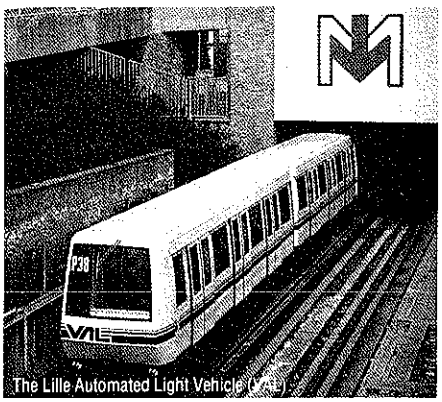
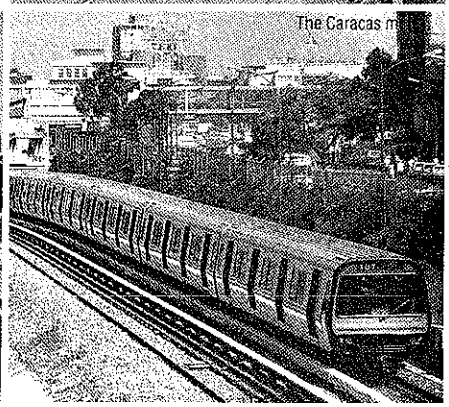

The Grenoble Light Rail Vehicle.



The Lille Automated Light Vehicle (VAL).

The Nantes Light Rail Vehicle.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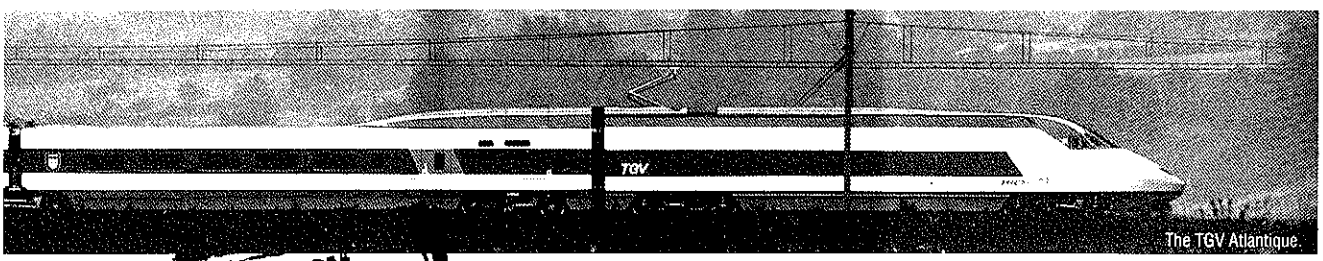

The TGV Atlantique.

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SUBWAY RETURNS TO A STATE OF GOOD REPAIR

THREE-AND-A-HALF years have passed since I wrote in the January 1985 issue of *Railway Gazette International* about my early experiences on becoming President of the New York City Transit Authority in February 1984. The thrust of that article was the changes that had been made, primarily the creation of a management structure where none had previously existed, and our plans and goals for the future.

Today, many of those plans have been accomplished and most of the goals achieved. This is not to say the job of turning around one of the world's largest metros has been completed — we still have an awfully long way to go — but the truth is we are now in much better shape than we were in 1984.

One real measure of improvement is the fact that ridership, which had been on a downward trend for more than a decade, has rebounded sharply. Average weekday ridership increased by 216 000 passengers between 1984 and 1987, and in January of this year surpassed 3·7 million for the first time since 1974.

Significantly, weekend ridership also rose, demonstrating that people are choosing the Subway at times when they are not forced to do so by road traffic congestion, for example. On an average Sunday in January the Subway carried 1 038 000 passengers, a 13·2 per cent increase over the same month in 1987. By way of comparison, Boston's MBTA carried 569 000 passengers on an average weekday last year.

David L Gunn
President
New York City Transit Authority

That is said not to brag, but merely to indicate the size of our operation. With 370 route-km, 463 stations, 6 300 cars and 23 lines, it is one of the largest, oldest and most complex urban rail networks in the world. NYCTA also operates 3 600 diesel buses over 220 local and express routes, but that is another story.

Much has been written about the state of disrepair which had befallen the complex rail network that New Yorkers refer to as the Subway — even though 190 of our stations are above ground. Trains failed mechanically or caught fire with alarming frequency; in-service derailments were commonplace — in 1983 they occurred once every 18 days. The Subway had become a symbol for uncontrolled filth and squalor in a city never renowned for its cleanliness.

Symbols and perceptions are important. One of our first publicly announced goals, in February 1984, was to clean the graffiti off our rolling stock. You might have thought we were promising mass transit to the moon from the response. Almost nobody, inside or outside the Authority, believed it could be done.

Graffiti first started to appear in 1970 on trains serving Line 1, which runs along the west side of Manhattan. Vandals proliferated, and soon not a single graffiti-free car rode the rails.

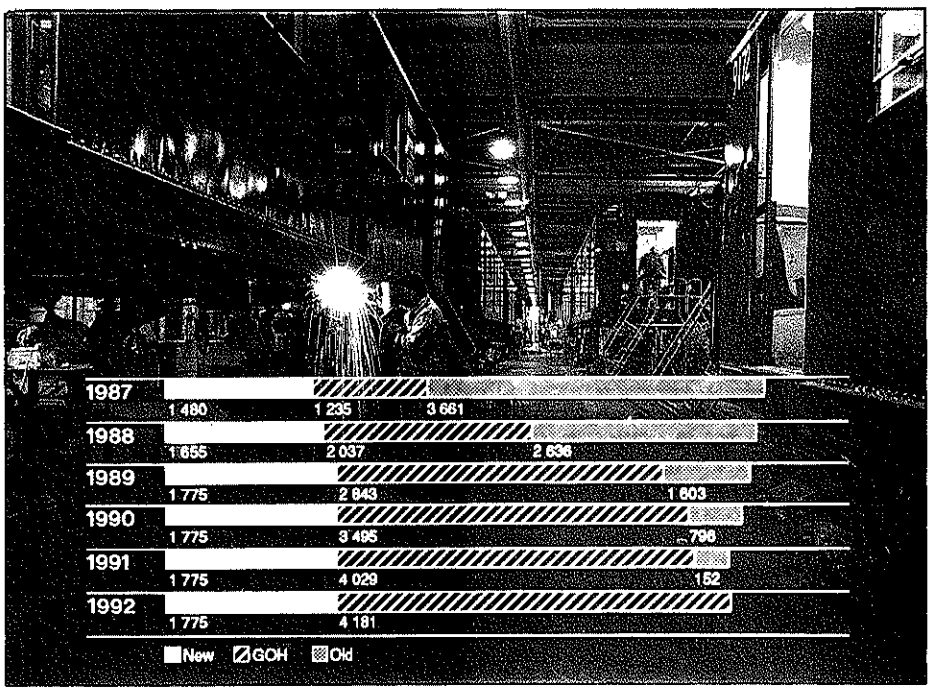
By 1984, both cars and stations were literally covered inside and out with these squiggles. Graffiti and filth gave passengers the impression that anarchy ruled and no-one was in charge.

The strategy to get rid of the graffiti was simple in its execution. We hired cleaners to wipe it off. Keeping it off required some extensive organisational manoeuvres that were to prove effective in accomplishing other goals.

The reason for these manoeuvres lies in our size. The Authority is a very large organisation with more than 50 000 employees; the majority are split between Surface (bus) and Rapid Transit divisions, which are in turn subdivided into departments.

Rapid Transit's organisation chart includes five large operating departments: Transportation (known internally as RTO for Rapid Transit Operations), Car Equipment, Track & Structures, Electrical, and Stations. Over the years these departments had come to function as quasi-independent fiefdoms, at times devoted to parochial concerns at the expense of the Subway as a whole.

Representatives from each department



Delivery of 825 R62A cars from Bombardier is virtually complete, but 800 cars are due for general overhaul next year and the whole fleet should have been modernised by 1992. Overhaul work is split between re-equipped NYCTA workshops and outside contractors

Left: R36 cars dating from 1964 were refurbished by Morrison-Knudsen in 1985

Below: 325 of these R62 cars were supplied by Kawasaki in 1984-85

were brought together, along with members of the Property Protection department and the 4 000 strong Transit Police Department to form a committee charged with maintaining cars in a clean and graffiti-free condition.

Did a fence in a lay-up yard need repairing? If so, the Car Equipment representative told the person from Structures who was charged with mending the break. Were cars going to be kept underground on the main line because of cold weather? Then RTO told police so that they could be kept secure from vandals. And so on, with the departments all working together toward a single institutional goal.

Did it work? In February of 1984, we did not have a single car that was being kept clean on a day-to-day basis. Four years on, 5 000 cars were being maintained in a clean, graffiti-free condition. By the end of 1988, that number will be 5 946, and next year Subway car graffiti in New York City will pass into the history books as the last of 6 200 cars is cleaned.

Goals extended

Rebuilding our infrastructure and restoring our rolling stock, as well as creating an internal management structure where none had previously existed, were the primary tasks of the past four years. While continuing our efforts in these areas, we have now begun to focus on other aspects. These include the condition of our 463 stations, and relationships with both customers and employees.

We have a station modernisation programme in place under which 41 stations will be completed by 1994 at a cost of about $5m each. This programme has proved slow, cumbersome and expensive, requiring outside contractors. At this rate, it would take more than a century and cost over $1·5bn to cover all 463 stations.

For this reason we have begun two additional programmes using in-house labour, one to restore stations to their original architectural purpose, and the other to upgrade stations through a process of painting and cleaning as well as removing obsolete fixtures. This will allow us to improve conditions in virtually all our stations by 1996.

Management reforms

Of course, none of the programmes I have written about would have been possible were it not for the management reforms instituted back in 1984-85. For example, four years ago only two of 15 shops in our Rail Car Equipment department had full-time managers. Today all the shops have managers In fact, since early 1984 we have added 190 managerial and 123 professional/technical employees to this 6 700 person department.

Results have been impressive. Mean distance run by each car between failures rose from a low point of 11 260 km in August 1981 to 23 420 km by 1987. I am proud to say that MDBF exceeded 30 500 km in April 1988 — the best performance in recent memory. Nearly 1 500 new cars were absorbed into the fleet over a relatively short period, and what is probably the largest heavy overhaul programme in the industry's history will have produced 2 049 rebuilt cars by the end of this year.

Equally impressive both in this department and throughout the Authority are productivity gains. Between 1985 and the end of 1987 we eliminated (via attrition) 3 169 jobs through better productivity. Of these, 2 242 were reinvested to meet specific production and service goals.

Our clean-car programme has succeeded because of the creation of slots for 892 more cleaners, and our various station improvement initiatives will produce results because we were able to hire 250 people in various job titles.

Another important change was the creation of an Operations Planning Department, which allows us to examine rationally our service needs today and in the future. This systematic approach led us to revise running times on all 76 Subway schedules last year.

Increased ridership was met with increased service, but effective scheduling and planning enabled us to provide more service with a concomitant reduction of 103 train crews. No magic was involved here — just faster running and more efficient use of each employee's time.

Another underlying factor to the NYCTA's overall improvement has been the decentralisation of decision making. Our policy has been to hire and promote good people, and then to get out of their way and let them do their jobs.

Goals are no longer established by a centralised bureaucracy but by the departments that will have to accomplish those goals. The same goes for budgets. If a manager decides that his or her area must spend funds to buy certain equipment or to build something, he or she makes the decision and takes the responsibility.

$12·4bn investment

All these changes have been taking place during a 10 year $12·4bn capital programme extending from 1982 to 1991, the largest single public works project in New York State's history. Several of our 23 rail routes have been undergoing heavy reconstruction with minimal disruption to service, and extensive rebuilding has been going on in many of our support facilities.

In-house forces have made important contributions to this programme. Last year NYCTA track gangs rebuilt 120 km of track — 41 km with continuous welded rail — and major car overhaul production lines were in operation at our two main rail repair shops.

Training has also been afforded a higher priority than ever before. A state-of-the-art chemical safety course, using interactive videos (right), is being given to 40 000 of our employees who may come in contact with toxic substances. This is part of a dramatic increase in training time dedicated to safety and customer relations, which together represented 6 per cent of all training in 1986, but will take 21 per cent this year.

A three-day workshop for our 3 800 clerks who sell tokens to operate entry gates gives them basic training in courtesy and communications. At the conclusion of the course they are issued uniforms, maroon blazers and blue trousers or skirts, that project a positive attitude to wearer and passengers.

Looking ahead, we have some exciting projects planned for the near future. Earlier this year we began testing automatic fare collection using hardware and software from two competing vendors, Alta/CGA and Cubic Western Data. This pilot programme will continue for 6 to 12 months and then we will evaluate the results.

Currently we have a flat $1 fare, with access through gates provided by a brass token with a steel bull's-eye. This bimetal token was adopted in April 1986 to cut down on fraudulent use of metal slugs that was costing us $250 000 a month; by last January slug usage cost us only $13 268.

Major car orders

Modernisation of the Authority's car fleet, including air-conditioning, will be achieved by 1991 through a programme of heavy overhaul and new purchases. Improved reliability allows the size of the fleet to be reduced despite extra ridership, and in 1991 we expect to have 4 181 rebuilt cars plus 1 775 purchased new since 1984.

In completing the overhaul programme and ordering new cars, the Authority has as a matter of policy tried to keep the technology simple. Our maintenance forces face a large enough task as it is without at the same time having to master the complexities of advanced electronics.

Looking ahead to the 1990s, however, we may purchase as many as 1 500 new cars, and obviously we want to take advantage of the latest technology to reduce energy consumption and maintenance. The Authority has therefore invited proposals from manufacturers to develop one or more prototype test trains that apply advanced technology components used successfully in other systems.

In December of this year, NYCTA will be adding its first new stations in 20 years when service is inaugurated to three stops in an area of Queens (one of the city's five boroughs) known as Archer Avenue. Next year we plan to open a new tunnel connecting Manhattan with Queens that will add another three stations. That will give us 469 stations — 201 more than the London Underground.

But the main thrust of our efforts is not towards new lines or stations, but to putting an already very extensive network into a state of good repair.

The next four years are going to be every bit as exciting as the last four. If things work out well, I may write another article for *Developing Metros* that marks completion of the long haul back from the slough of despond to a metro of which New Yorkers can once again feel proud. □

Training protects graffiti fighters

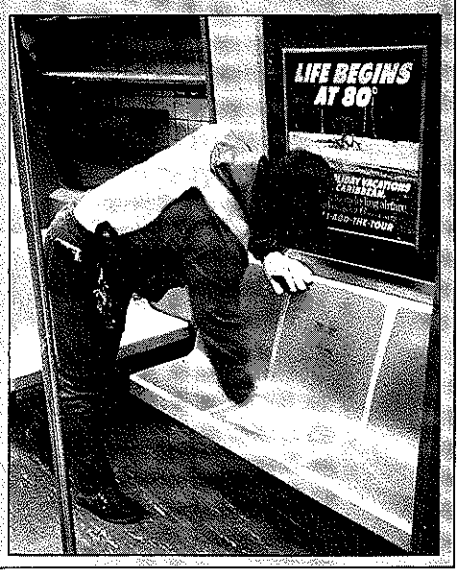
PICTURED here is one of the small teams stationed at each end of every line who use a cocktail of chemicals to remove graffiti during the layover time at the terminus. By tackling the job quickly, often before paint has dried, it is much easier to get surfaces clean.

NYCTA has achieved a significant drop in chemical related accidents at a time when rapid modernisation of workshops and depots, along with the anti-graffiti campaign, has resulted in an influx of new and potentially hazardous substances.

Devised to comply with recent legislation requiring employers to inform staff about the risks posed by chemical substances like paint and solvents, NYCTA's chemical safety programme has three basic elements: uniform labelling of all containers, the ready availability of data sheets covering all chemicals held in stock, and training in the proper use of these aids.

The training programme uses interactive video. The trainee sits in front of a VDU, and is taken step-by-step through the risks he personally could face at work. He is told how to obtain from labels and data sheets the information he needs to avoid injury — for example, by wearing protective clothing.

At every stage, he responds to questions by touching the screen, prompting either the next stage of the course, or a more detailed explanation of the previous stage if he has failed to understand it properly. The use of laser video discs makes it possible to select any part of the recorded lesson for instant display, thus allowing each trainee to go at his own pace.



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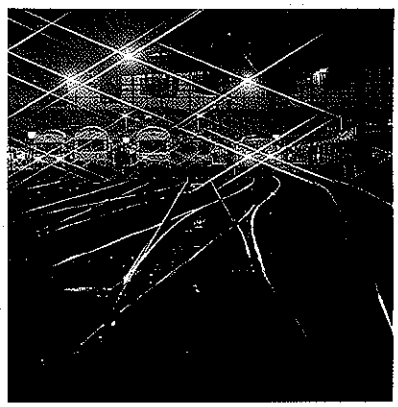

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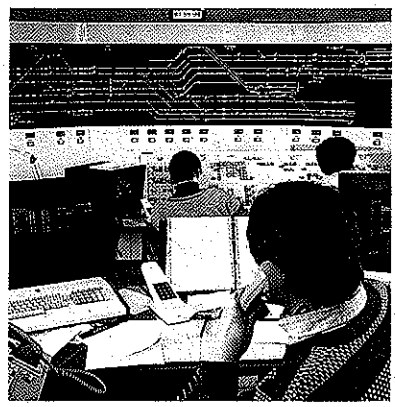

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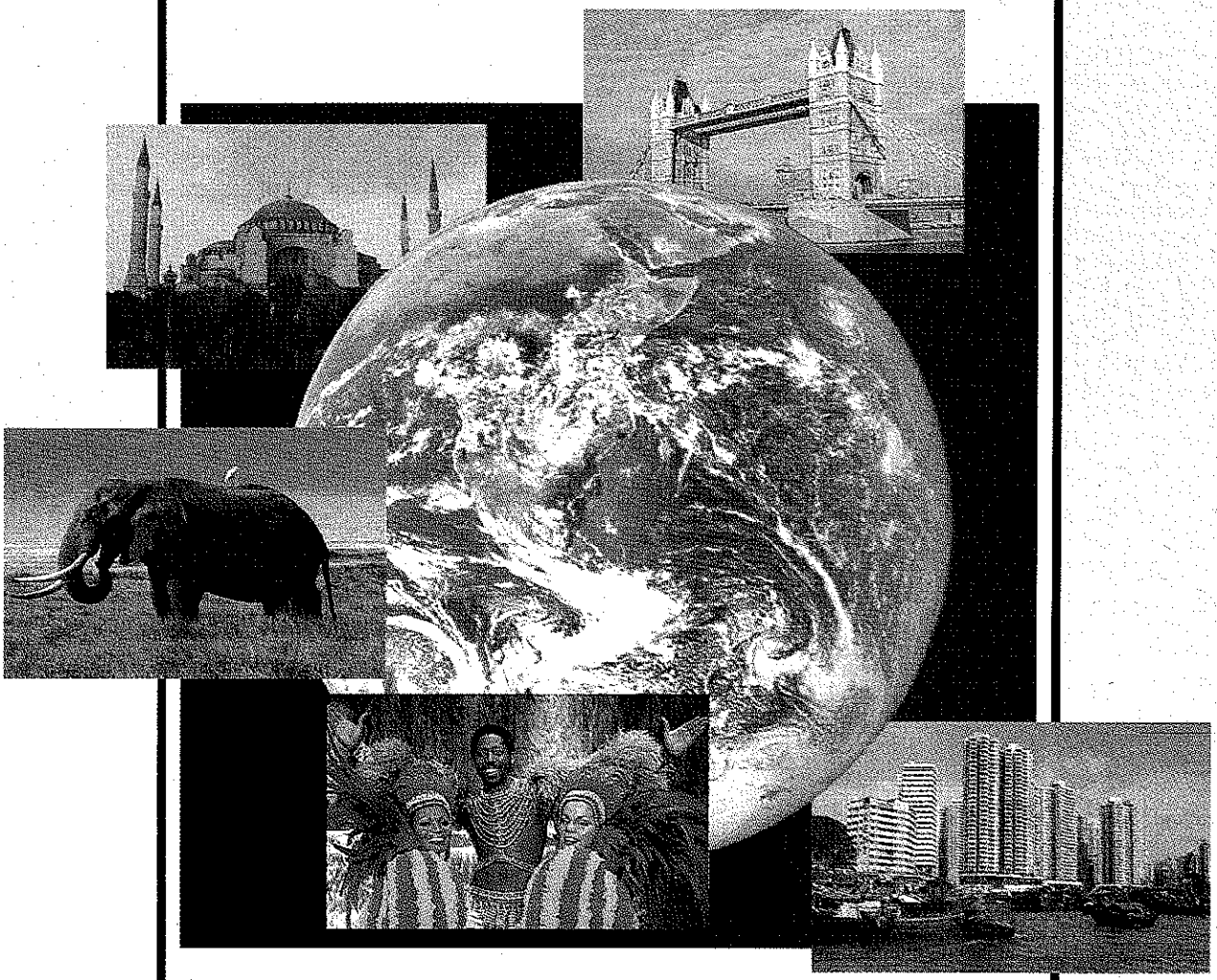

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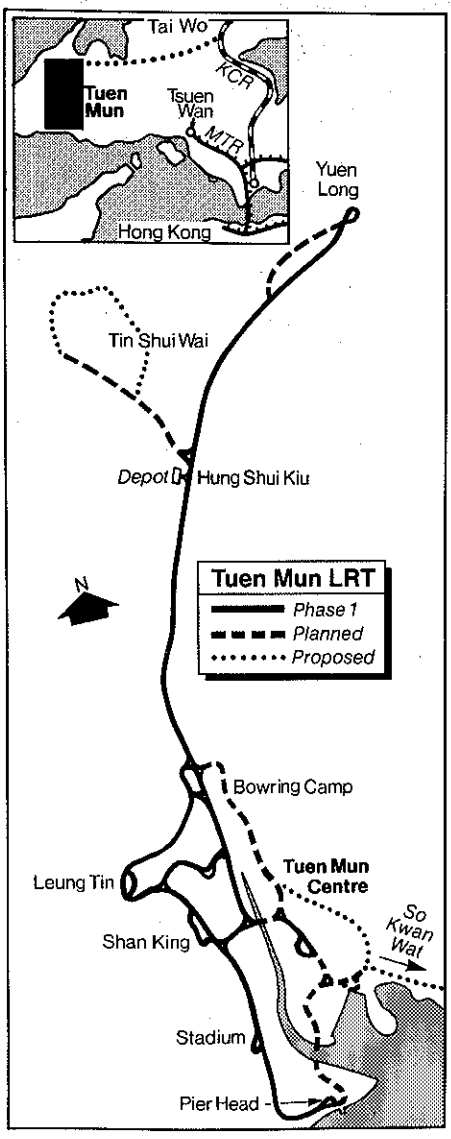
TUEN MUN READY TO

THE LIGHT RAIL transit system serving the northwestern New Territories in Hong Kong, constructed and operated by the Kowloon-Canton Railway Corporation (KCRC), was formally handed over as planned on August 7 1988, and was expected to begin revenue service in September.

The northwestern part of New Territories, which embraces Tuen Mun, Yuen Long and the Castle Peak Road corridor linking the two towns, has been developing rapidly in recent years. The idea of introducing light rail into the region goes back as far as 1972, when Hong Kong Tramways Ltd proposed building a circular LRT route in Tuen Mun, then known as Castle Peak New Town. This overture was premature, because the outline plan of the town had still to be determined. In 1978, a study was undertaken to examine the best use for the exclusive public transport right of way.



After detailed examination, the consultants recommended light rail rather than conventional buses because in the longer term it would prove cheaper to the community. LRT would also be preferable in environmental and safety terms.

The Hong Kong Government accepted the consultants' recommendations, and in 1979 negotiations began with the Hong Kong & Kowloon Wharf & Godown Co Ltd, owner of Hong Kong Tramways and the Star Ferry, which had expressed interest in building and running the LRT routes in Tuen Mun. After three and a half years of debate, the Wharf Co withdrew in January 1983 owing to a decline in the property market.

In November of that year, the Hong Kong government invited the Kowloon-Canton Railway Corporation to build and operate the LRT, which during the previous negotiations developed from a Tuen Mun town network into a regional system for the northwestern New Territories serving Tuen Mun, Yuen Long, Castle Peak Road Corridor and the proposed new town of Tin Shui Wai. The government is projecting that these areas will have a population of 800 000 by the mid-1990s.

In July 1984, KCRC decided to accept the offer. Tender documents were issued in early 1985, and by August of that year, a HK$1bn contract to design, build and put Phase One into operation had been awarded as a turnkey project to the Leighton-MTA Consortium, a joint venture between Leighton Contractors (Asia) Ltd and Metropolitan Transit Authority of Victoria, Australia. KCRC at the same time had employed Transurb, Freeman Fox and Scott Wilson Kirkpatrick & Partners to control quality and to act as 'Engineer' under the contract.

Before deciding to proceed, KCRC sought assurances from the government about the co-ordination of public transport modes in the area. Recognising that all modes will have a part to play, KCRC asked for the roles of different modes to be carefully defined so that competition with the LRT routes was kept to sensible levels. This particularly applies to services potentially in direct competition with LRT. It would be bad planning to create this system and then not allow it to be economically used. Hence a Transit Service Area (TSA) in the region was created through legislation.

The LRT will form the backbone of the public transport network within the TSA. The Corporation was also awarded control of bus services in the Area. Existing internal franchised buses have to withdraw after the LRT is commissioned.

Phase One consists of 23 km of double track, which operates at street level with 41 stops and three termini where there is interchange to other modes. Seven routes are provided with three running between Tuen Mun and Yuen Long and another four running within Tuen Mun, together with eight feeder bus routes.

Peter Quick
Managing Director, Kowloon-Canton Railway Corporation

A fleet of 70 LRVs was ordered for the Phase One commissioning, and these are being supplied by Comeng (Victoria), a division of ANI Corporation of Australia; propulsion equipment is by AEG, control equipment by Siemens, braking equipment by Knorr, bogies by Duewag, all from Germany. Air-conditioning is being supplied by Sigma of Australia and the doors by Stone Peters of Hong Kong. Each car is 20 m long and can accommodate 60 seated and 130 standing passengers. Cars can operate singly or in pairs.

Power equipment for Phase One is designed and supplied by Hawker Siddeley Power Engineering Ltd of Hong Kong, and the 750 V dc catenary is by Balfour Beatty Power Construction Ltd. Power is supplied by two infeed substations from the China Light & Power Co which are linked to 10 rectifier stations along the line.

Communications and control equipment is supplied by Cable & Wireless System Ltd using Plessey of Great Britain for vehicle control. The operation is closely integrated with the central computer at the depot along with the communication system and traffic lights. The Operations Control Centre can communicate by radio with each driver and by public address to passengers in cars or at the 41 stops, each of which offers shelter from the weather.

Each stop has at least two 910 mm high platforms 40 m long and 3 m wide. As we have adopted an open fare collection method,

OPEN FIRST PHASE

there will be no gates or turnstiles at stops. Passengers may hold a monthly pass or buy a single ride ticket from machines located on platforms. 'Heavy' ticket inspection work will be carried out along the network and a fare evader is liable to a maximum fine equal to 50 times the highest adult single fare.

Ticket vending machines are supplied by Autelca of Switzerland, and central control, fault indication, data acquisition and reporting are the responsibility of Cable & Wireless System Ltd.

Operating hours on weekdays and Saturdays are from 05.30 to 00.30 and from 06.00 to 24.00 on Sundays and holidays.

Daily patronage forecast for Phase One is around 270 000 passenger trips in 1988. This will rise to 360 000 in 1991 and to about 530 000 in 1996 for the full regional network.

Being a public corporation wholly owned by government, KCRC can view viability in the context of a public service investment with long-term community benefits rather than quick profits. The Corporation applied three key viability tests in the study: that revenues have to cover operating costs from day one; that loans can be serviced and ultimately repaid in about 12 to 15 years; and that in the longer term, reserves can accrue to provide for expansion and replacement of equipment.

Regarding further expansion, KCRC has identified six regional links that will be built in the coming years. Tender documents for these will be issued in the second half of 1988:

- ⋆ Tuen Mun Ferry Pier to Yau Oi, 2·3 km;
- ⋆ Yau Oi to Sam Shing, 0·3 km;
- ⋆ Town Centre to Tuen Mun (Northeast), 2·3 km;
- ⋆ Tin Shui Wai section one, 1·4 km;
- ⋆ Tin Shui Wai section two, 0·7 km;
- ⋆ Yuen Long (northern bypass), 2·1 km.

These links could be put into service progressively from 1990 onwards.

There are five other possible regional extensions identified by the consultants which will complete the final leg at Tin Shui Wai and serve southeastern Tuen Mun and So Kwan Wat. Present thinking is that all five could be completed by the mid-1990s, forming the full regional network.

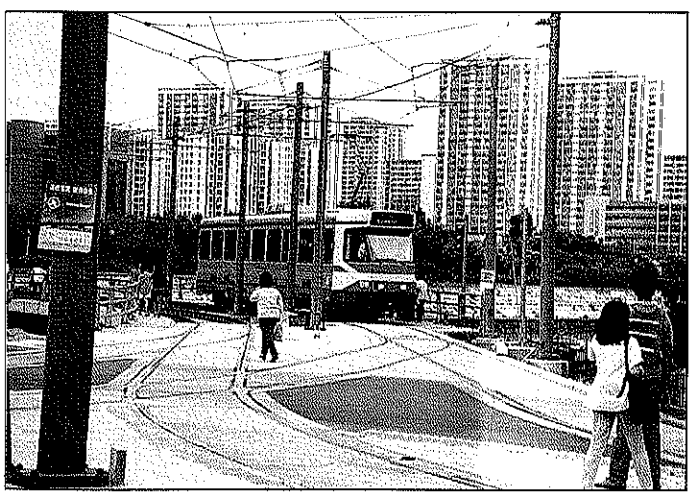
KCRC undertook a consultancy study in April 1986 on a possible rail link connecting the regional LRT with urban areas. Four alternative routes, either linking with the Kowloon-Canton Railway (KCR) or the Mass Transit Railway (p24) were studied:

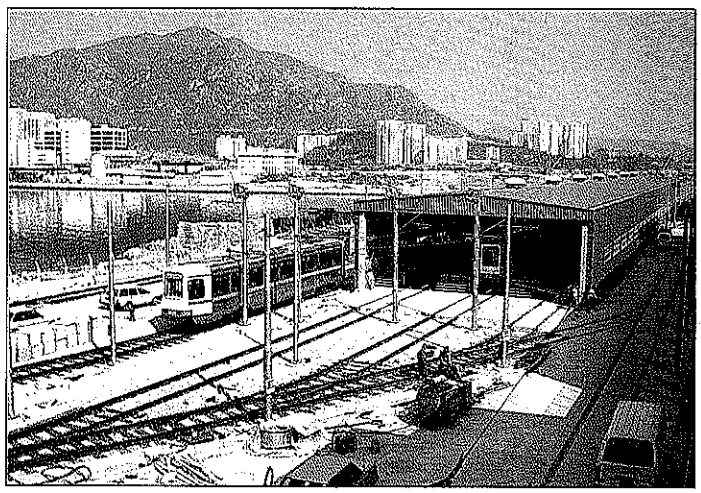
- ⋆ Yuen Long to Sheung Shui/Fanling KCR station;
- ⋆ Yuen Long to Tai Wo KCR station (a new station north of Tai Po Market);
- ⋆ Yuen Long to Tsuen Wan MTR station;
- ⋆ Tuen Mun to Tsuen Wan MTR station.

Typical of the reserved track sections through Tuen Mun is the Ming Kum Road route through the Shan Kin estate

After a nine-month study, KCRC accepted that the most commercially viable option was Yuen Long to Tai Wo, and a submission has been made to the Hong Kong Government for consideration. The final decision on whether, where and when an LRT urban link will be built depends on the result of the Comprehensive Transport Study which is being carried out by the government for release later this year. □

Street running is a feature of routes in central Tuen Mun, such as the lines in Pui To Road feeding the Nullah bridge (left). The inspection shed at the depot (below) is already surrounded by new housing





HEADING FOR 2 MILLION

Dipl-Ing Dumitru Zvoristeanu
Manager, Bucuresti Metro

BUILT WITHOUT any foreign assistance, Bucuresti's metro is the symbol of the town and of Romania's era of spectacular urban renovation. And with the opening of the first 9 km of Line 3 next year it will be handling some 2 million passengers a day — that is 50 per cent of all daily public transport journeys in the capital.

Construction of the metro needed considerable material resources, intelligence and technical talent. First surveys for the introduction of underground railways in Bucuresti were made as far back as the beginning of the century, but many specialists decided that the ground was not fit for such a project.

Despite these prognostications, Romanian engineers started construction of the first East-West metro line in April 1975, relying solely on national scientific work. All of Romania's research and design institutes were involved, together with a large number of rolling stock, plant, and electrotechnical companies, trusts, ministries and higher education institutes. Close co-operation was vital, while the use of high quality Romanian-made equipment contributed to the operation starting ahead of schedule.

Network development

Construction of the first section commenced in April 1975, and this 8·1 km route between Timpuri Noi and Semantoarea opened in December 1979 with four intermediate stations. Two years later, in December 1981, the initial East-West line was extended by a further 9·5 km with six stations from Mihai Bravu to Republica, and in August 1983 a third stage of 8 km with four stations was opened between Eroilor and Iremoas. The construction of this main line was completed in December 1984 when an initial total route length of 26·9km was achieved with the addition of the extension to Cringasi bringing the total number of stations at that time to 17.

As the East-West line neared completion, work began on the first two sections of the second North-South route from Universitatii via the Piata Unirii interchange with Line 1 south to IMGB. These sections opened in January 1986, giving a length of 10·4 km and seven stations. In October 1987 the third and fourth sections of Line 2 came into operation over 8·5 km with five stations extending northwards to Pipera.

In December 1987, a spur line was opened between Line 1 at Cringasi and Gara de Nord, Bucuresti's principal main line station. This spur will form part of Line 3, which is now under construction eastwards from Gara de Nord via an interchange with Line 2 at Piata Victoriei.

Although only 12 years have passed since construction started, Bucuresti metro has over 50 km of double track route with 30 stations, each of which has a distinctive architectural style, three depots, a maintenance plant and enough coaches to marshal two- and three-unit trains which can handle about 50 000 passengers per hour in each direction with headways as short as 90 sec.

Specialist companies from throughout Romania have been involved in equipping the metro with electric and electronic remote control equipment, computerised signalling, safety and traffic control circuits and other warning devices.

Construction techniques

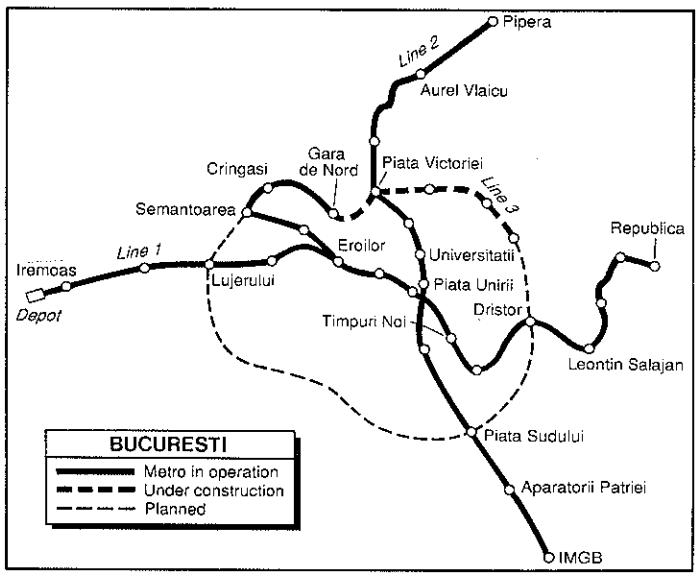
Two basic techniques are used in construction. The primary method uses cut-and-cover for stations, with reinforced concrete tunnel sections in enclosures protected by tied or supported precast walls and drained by deep wells. Where this was not practical, shield-bored tunnelling was adopted, together with other techniques because of the argillaceous and sandy geomorphology of the ground. Some of these techniques were used for the first time in Romania, for example soil consolidation and freezing, lowering of the water table, and injection technology. Perhaps the most important of these, however, is the use of tunnel shield construction with concrete which sets under ground water without sealing.

Together, these two basic techniques and the various special works make Bucuresti metro unique. They also resulted in one of the fastest average work rates in the world, nearly 4 km of fully equipped double track line being completed each year.

The metro was designed for a capacity of 800 000 to 1 million passengers per day. A totally computerised operations control centre ensures safety, comfort and speed of transport.

All the rolling stock has been designed and built in Romania. The trains are usually composed of two or three units, each of which has two permanently coupled cars. Each car is rated to carry 200 passengers at 5 persons per m², with a crush load of 300 passengers at 9 persons per m². The trains are modern and equipped with pneumatic secondary suspension. □

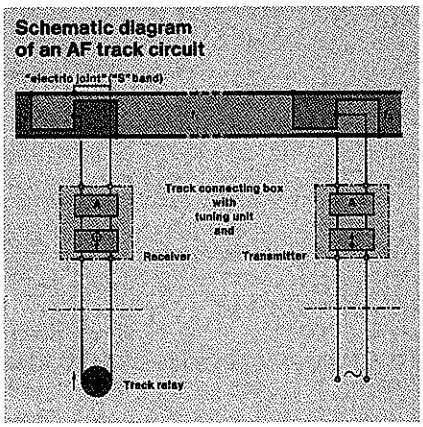
The Line 1 platforms at Piata Unirii are designed to accommodate heavy flows of interchange traffic to and from Line 2



SIEMENS

An Economic Alternative – FTG S from Siemens

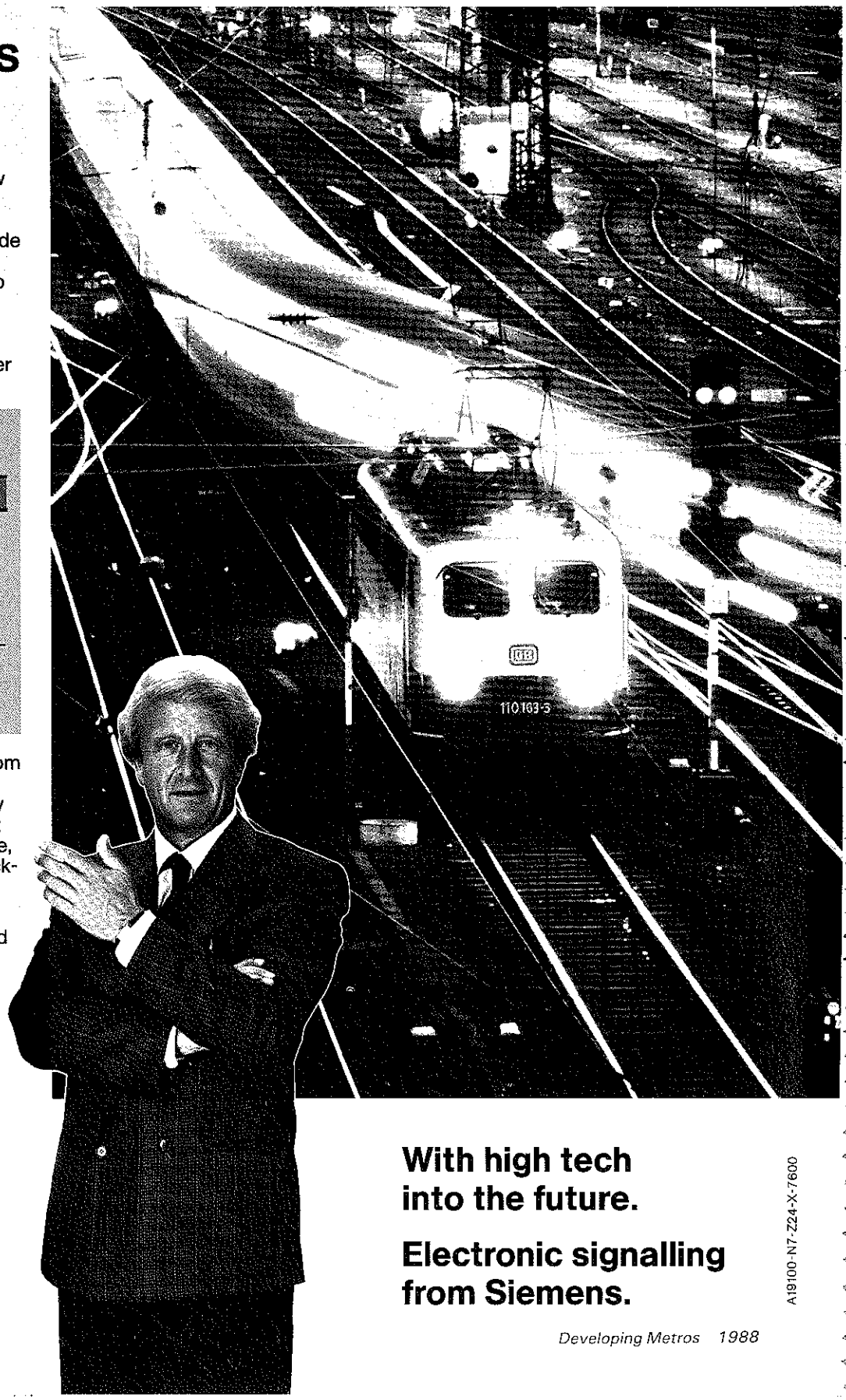
Higher economic efficiency and safety – on balance, these are the decisive advantages of the new Siemens FTG S, remote-fed audio frequency (AF) track circuits with "electric joints". There is no trackside electronic equipment. With the FTG S, insulated block joints are no longer used. The advantages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



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

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

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



With high tech into the future.

Electronic signalling from Siemens.

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CALCUTTA COMPLETE BY 1991

INDIA'S first metro became a reality on October 24 1984 with the start of commercial services over a distance of 4 km between Esplanade and Bhowanipur.

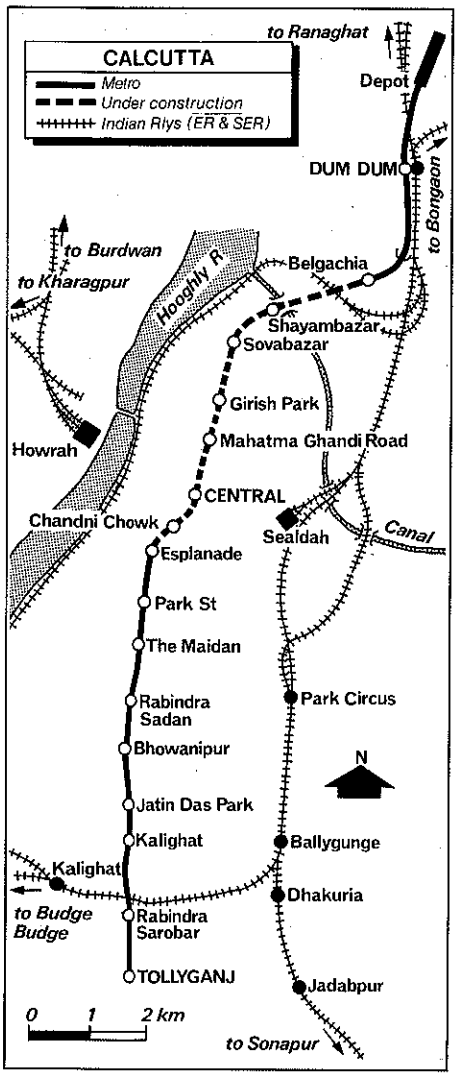
Shortly afterwards, on November 12, a further 2 km were opened in the north of the city between Dum Dum and Belgachia. Within 1½ years services were extended from Bhowanipur to the southern terminus at Tollyganj. This brought the length of line in use to 10 km, leaving a further 6·4 km between Esplanade and Belgachia to be completed. So far, 11 out of 17 stations are in service.

Construction of Calcutta's metro has been a complex and demanding task, requiring Indian engineers to tackle a whole range of techniques with which they were not familiar. Despite the difficulties, innumerable hurdles were overcome, and the metro is already making an important contribution to the city's transport.

Transport in eastern India's principal city, described by Job Charnock as 'chance directed and chance erected', became critical at the time of the country's partition in 1947; the consequent influx of refugees had a tremendous impact, and it soon became obvious that public transport was inadequate. It was Dr B C Roy, then Chief Minister of West Bengal, who conceived the idea of an underground railway in 1949, but his brainchild did not materialise until much later. The Metropolitan Transport Project (Railways) was launched in 1969, and detailed studies concluded that there was no alternative but to construct an underground line along the city's busiest north-south corridor from Dum Dum to Tollyganj. The foundation stone was laid by Indira Gandhi on December 29 1972, and construction got under way in 1973-74.

Our engineers, using their own experience and with the help of studies abroad, succeeded in adopting advanced techniques in many disciplines for the first time in India. Cut-and-cover construction was used with diaphragm walls and sheet piling; extensive decking kept the traffic flowing overhead while construction took place beneath. Shield tunnelling under normal atmospheric pressure, and in some cases with compressed air, was used where cut-and-cover was not suitable. A design of ballastless track with elastic fastenings, rubber pads and nylon inserts was developed.

Tunnels and stations featured air-conditioning and ventilation plant to control the underground environment. Third rail current collection was adopted, fed from underground substations with dry transformers, vacuum and SF6 circuit breakers.



A S Agarwal
General Manager
Calcutta Metro

Continuous automatic train control with cab signalling was developed, and VHF radio designed to operate in tunnels was installed. Microprocessor-based train control and supervisory remote control for the substations was devised, and tickets were sold and checked by machine.

At present trains run on the Esplanade –Tollyganj section from 08.00 to 21.30 from Monday to Saturday, services being limited to the period between 15.30 and 21.30 on Sundays. On weekdays 106 services carry about 60 000 people, with trains running at 10 min intervals in the peak and at 20 min intervals off-peak. Three sets of eight cars and four sets of four cars are available for the Esplanade – Tollyganj section. On the isolated northern part of the line there are 32 services every weekday.

Trains average 30 km/h, with the maximum set at 50 km/h. It takes 16 min to cover the 8 km from Tollyganj to Esplanade compared with 45 min by surface transport.

Esplanade has acted as a temporary terminus since the first section of Line 1 opened in 1984

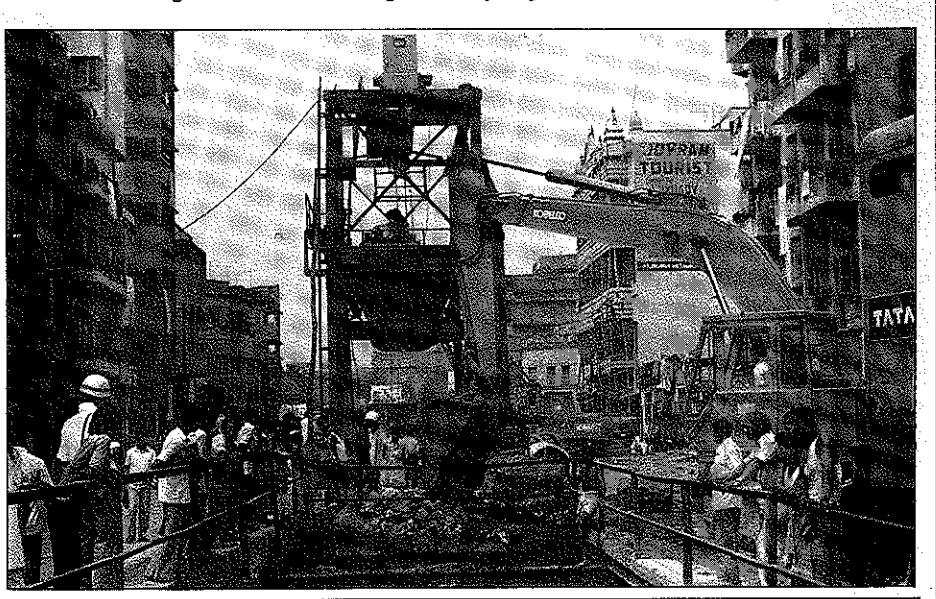
Tickets can be bought in carnets of 12 for the price of 11.

The clean look and aesthetics of the metro stations have been highly praised by visitors from other parts of India and from abroad. The fusion of sophisticated technology with artistic decor has been successful, with some of the stations featuring murals and terracota works. There are plans to decorate all stations, and this work has been entrusted to Viswabharati university. Soft music is played to create a congenial atmosphere.

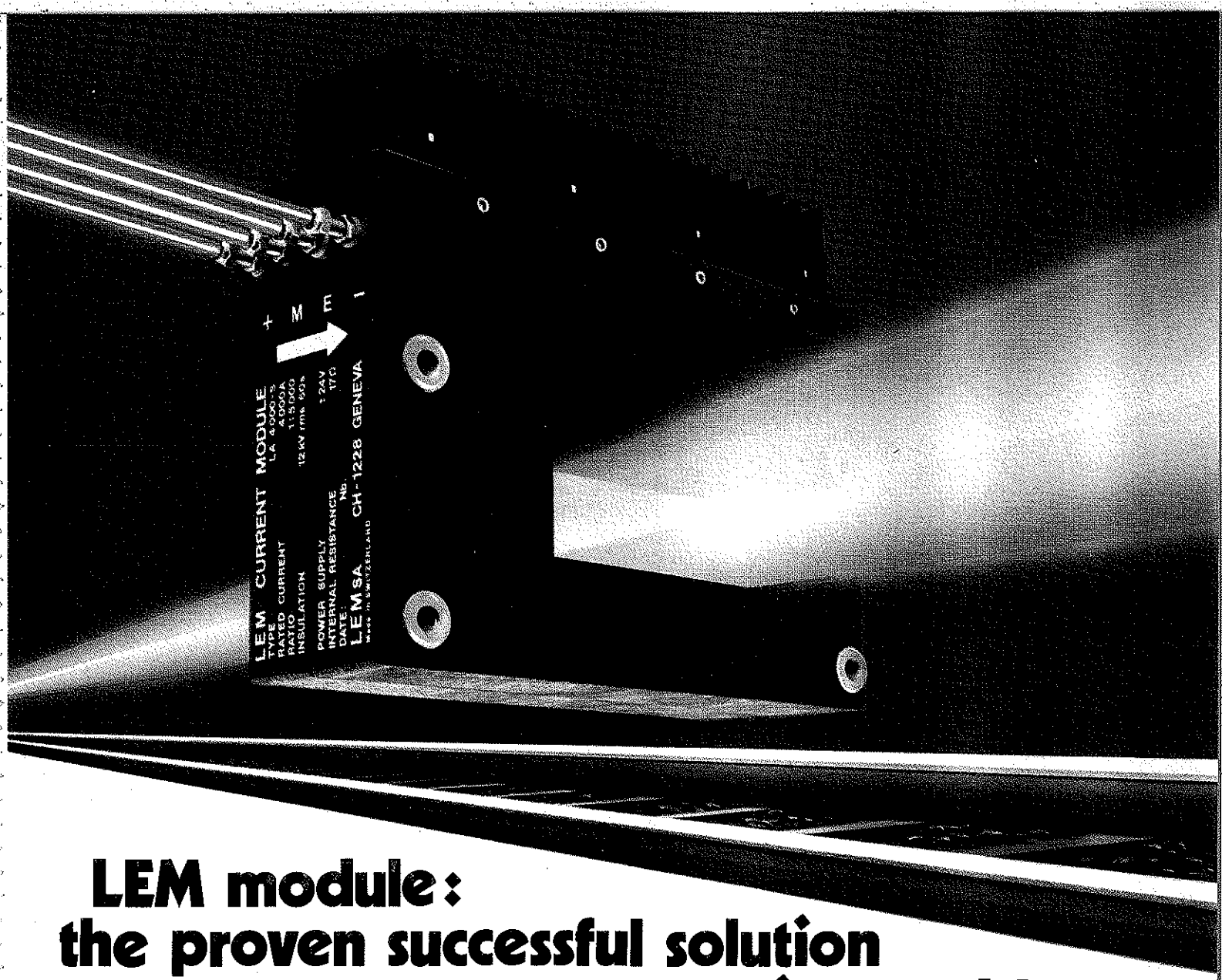
All possible measures have been taken to ensure the safety of passengers. In the near future automatic train control will be introduced. Fire-fighting measures, including formation of a special fire-fighting squad, have been taken to ensure that any incident can be handled on a train or in stations.

So far about 70 per cent of construction has been completed. Efforts are being concentrated on completing the entire scheme by mid-1991. By then the metro will be carrying 1·73 million passengers a day in a dust and pollution free atmosphere, providing a comfortable travelling environment and offering considerable savings in journey times compared with other city transport modes.

A notable feature is the metro's indigenous character — it has been conceived and built by engineers of Indian Railways. □



Construction work is continuing apace on the northern section with the aim of opening the line throughout by 1991



LEM module: the proven successful solution to power current measuring problems

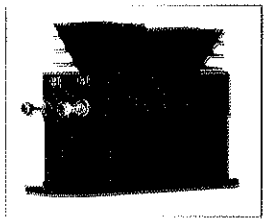
The LEM module is the perfect isolating interface between power current and electronic control. It has been developed in collaboration with, and for, traction specialists to exceed the performance of conventional systems. It is both accurate and easy to use.

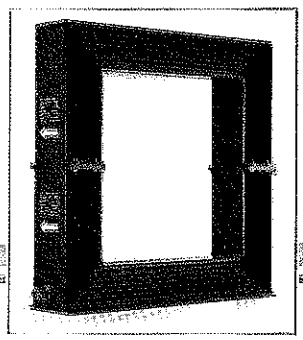
Working principle:
The concept is based on an electronic closed loop system realizing a zero flux regulation into the magnetic circuit of a transformer. The secondary ampere-turns are equal to the primary ampere-turns but with opposite polarity. The output current is isolated and represents a perfect image of the current to be measured.

Product benefits:
- Measuring of DC, AC, and pulsed currents (bandwidth from DC to 100 kHz)
- Wide range of measure and large overload capacity
- High isolation between primary and secondary circuits
- Response time below 1 µs
- Accuracy better than 1%, stability and linearity are warranted for life
- High reliability (proved by use in hostile environments)

Typical applications:
For over 15 years, the LEM module has been used in transportation applications (trains, subways, trolleybuses, rapid transit) as well as fixed substations.

For further information please ask for our data sheets or samples.


LEM voltage module 1000 V


LEM current module 50 kA

LEM

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CARACAS EXPANDS TO

Above: The trainsets are designed to provide high standing capacity, but off-peak loadings are substantial too

Below: Unlike the first line, much of Line 2 is on an elevated alignment through new housing developments

OCTOBER 1988 will see yet another important stage in the programme to build a metro network in the Venezuelan capital. This will be the opening of the final 4·2 km of Line 2, linking with Line 1 in the city centre.

Caracas is home to 3·3 million people. The city is built in a valley ringed by mountains, and about 65 per cent of the available surface is already fully developed, the density of the population being around 150 people per ha.

The need for good public transport in the city is pressing, and already 22 per cent of public transport journeys are by the metro, whose first section opened between Propatria and La Hoyada on January 3 1983. Other public transport needs are met by privately-owned buses which operate on fixed routes but with no specific stops.

The state owned Caracas metro company is responsible for planning, building and operating. The completed sections of Line 1 total 17 km with 18 stations. On an average weekday about 660 000 passengers use the line.

On the 14·4 km of Line 2 open so far, about 60 000 people pass through its nine stations each weekday. Once the extension to the city centre is commissioned, traffic will rise to around 260 000 passengers/day.

Work is still in hand on the final section of Line 1, the last 4·4 km to Palo Verde being due to open in early 1990. We estimate that the line will then be carrying 900 000 passengers a day.

Ing José González Lander
President, Caracas Metro

Most of Line 1 is underground, either bored or cut-and-cover, although some sections are at grade or elevated. About 28 per cent of the route is through soft ground, and here both single and double track tunnels were cut using a shield. About 5 per cent of the route was in hard rock, so other excavation methods were necessary.

On Line 2 about 20 per cent of the route already in service is on an elevated alignment,

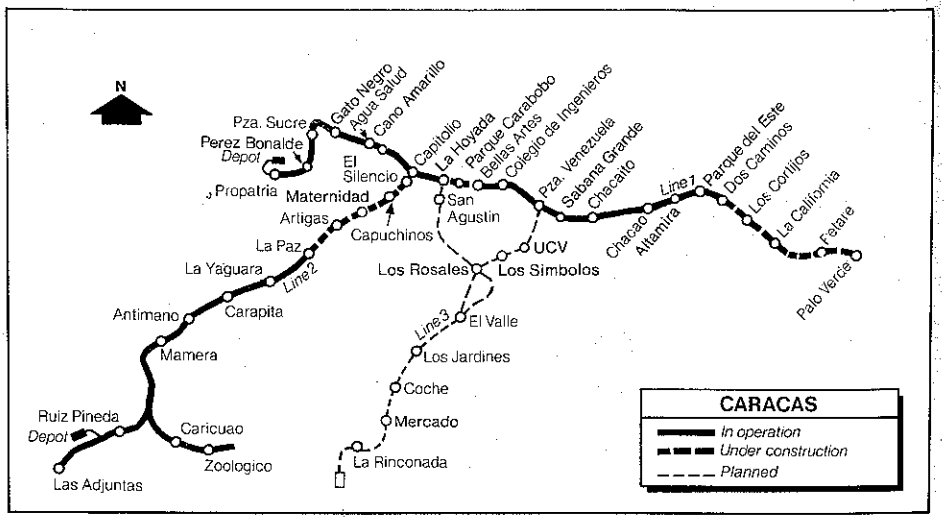
MEET GROWING DEMAND

36 per cent at grade, with the rest being in cutting.

Stations have 185 m long platforms and are built on two levels; one is a mezzanine and the other a ticket concourse. Designs cater for large flows of passengers.

Trains of seven cars are 149·5 m long, providing accommodation nominally for 1 236 passengers, of whom 408 are seated. Thanks to automatic train operation, they can run at 90 sec headways, giving a capacity of 50 400 passengers/h in each direction on the busiest section.

Commercial speed is 35 to 40 km/h, with a maximum of 80 km/h. Trains accelerate at up to 1·35 m/s², with braking at up to 1·1 m/s². Manual over-ride is provided in conjunction with the ATO.



Chopper control

Track of 1 435 mm gauge has a third rail 750 V dc power supply. This is fed through chopper control on the trains, which feature regenerative braking which is blended with the friction brakes. All cars are air-conditioned, with a cooling capacity of 52 000 fg/h. Two types of car are in service, a seven car set having two A cars and five B cars; the main difference is that A cars have driving cabs.

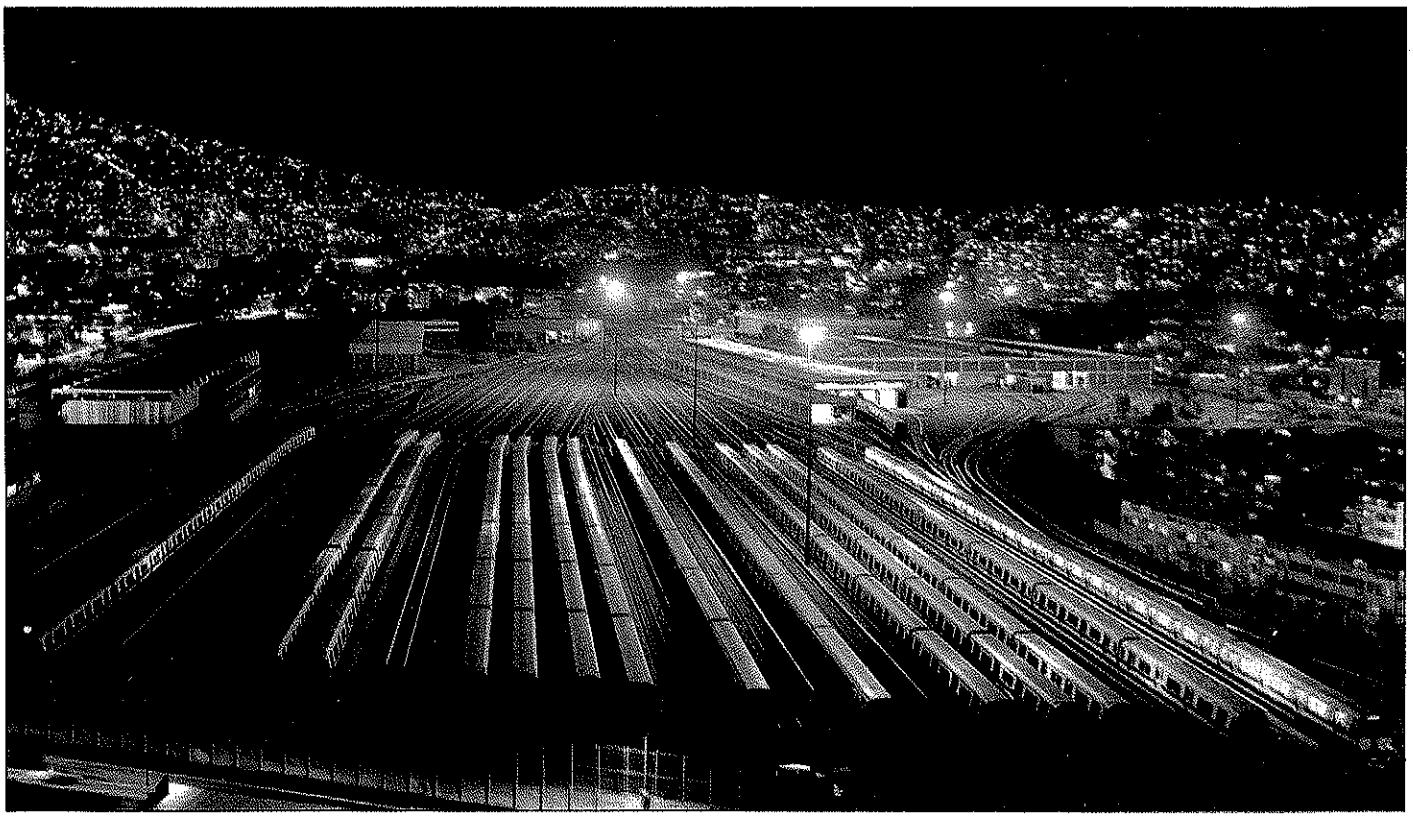
In a length of 21·4 m, each car has four 1·37 m wide doorways on each side. Car height is 3·52 m and width 3·05 m.

The third metro line has reached the engineering design stage. It will run from La Rinconada in the south to El Valle, where it will fork, one branch continuing to meet Line 1 at La Hoyada, the other running further west to meet the first line at Plaza Venezuela, where there will be a spur allowing inter-running.

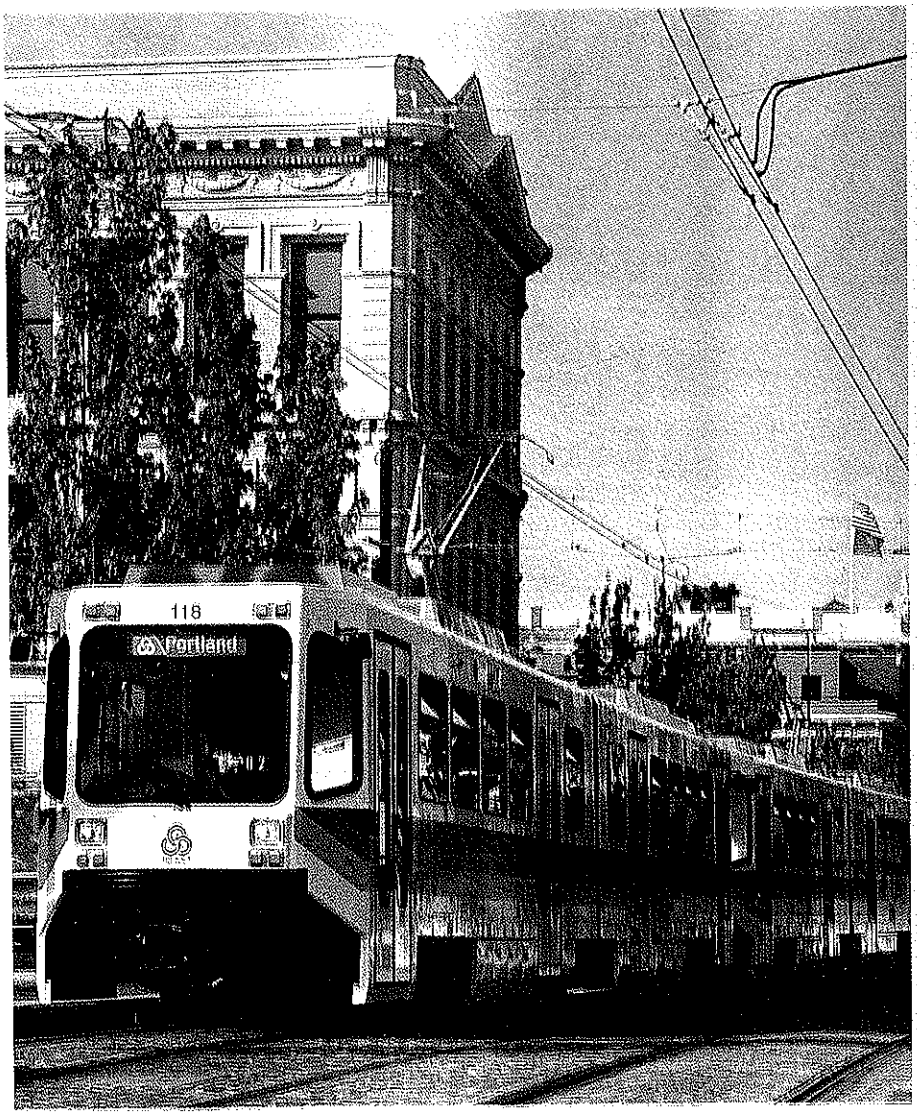
Two further lines are proposed, one of urban and the other of suburban character. The urban route consists of two sections totalling 12·7 km with 10 stations. 1993 has been set as the target date for putting it into service; we expect it to carry 270 000 passengers/day.

The suburban route would link Caracas with Los Teques, capital of the neighbouring state of Miranda. This line, also expected to open in 1993, would be 9·5 km long with two stations; initial demand is put at 130 000 passengers/day. □

The main depot for the network and home of the Line 1 fleet is located at Propatria, at the western end of the east-west route



Asea Brown Boveri have the Ideal Drive System for any Mass Transit Vehicle.



Articulated LRV Nos. 101–126 of the Tri-County Metropolitan Transport District of Oregon/USA (Tri-Met) for the urban mass transit system of Portland. Bi-directional operation with 750 V d.c.

DC direct motor drive with ABB contactor control, starting rheostat, serie/parallel regrouping and motor field-weakening. Two separate self-excited rheostatic braking circuits with pre-excitation. Constant acceleration and deceleration or downhill speed control by ABB's programmable control system (axle arrangement B'2'B', tare weight 42 t, hourly rating 420 kW, top speed 89 km/h). Mechanical equipment: Bombardier Inc., Canada/USA.

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EDMONTON HEADS SOUTH

APRIL 1988 marked the 10th anniversary of Edmonton Transit's launch into the light rail mode. Officially opened on April 22 1978 with 7·2 km of route and a ridership projection of 12 000 passengers per weekday, the light rail line has since grown to 10·3 km with a weekday ridership of 25 000 passengers. Work is presently under way on a 2·5 km extension from Corona to the University of Alberta campus.

The latest extension will take the LRT southward underneath 110 Street to 98th Avenue where Grandin Station will be located. From Grandin the line will continue underground and emerge on to a bridge across the North Saskatchewan river. Once across the river, the line will continue underground to the University. Original plans which called for the new line to be single tracked between the Corona crossover and the north bridge portal have now been modified to provide for double track.

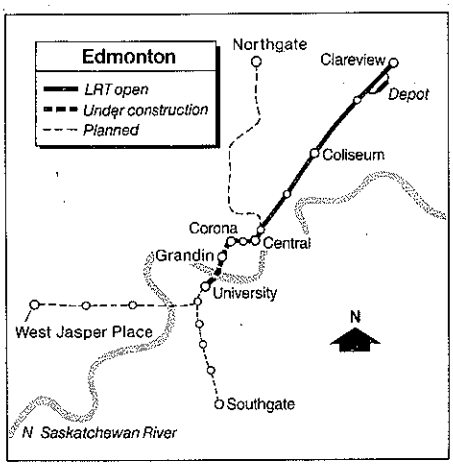
The first stage of the extension to Grandin will be ready for service in August 1989 with the University extension opening in mid-1992. Total funding for the project has been approved at C$143m.

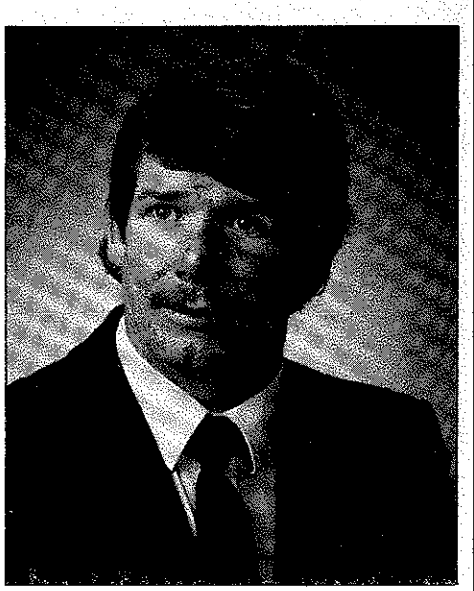
Future plans beyond the present commitment to the University include extensions to Southgate and West Edmonton, but their implementation will depend largely on the level of financial assistance offered by the provincial government.

Operation of the existing line has seen several improvements during the past two years. Peak hour train consists have been divided between two and three cars to match peak hour passenger flows, achieving significant savings in both power consumption and maintenance costs.

The self-service fare collection system has been improved in terms of equipment and customer convenience. The original ticket issuing equipment has been replaced with machines that are less vandal prone and more flexible in terms of fare structure. As a result, vandalism has dropped from approximately 12 to less than one incident per month per machine. Change machines and equipment modifications to accept new Canadian dollar coins have also made ticket purchase easier for our customers.

Passenger information signs which incorporate customer assistance telephones have been added to the stations, and passengers now have direct contact with Edmonton Transit's information service to obtain route information. A direct link is also available should passengers need assistance with the fare collection equipment.





G G Atkins
Manager of Transit
Edmonton Transit

A programme is at present under way to equip the light rail fleet with data recorders. These are analogous to the black box used on aircraft, and they will provide valuable information in the event of an accident. They will also allow us to evaluate line profiles in terms of running times, layovers and distance run. Other benefits include evaluation of technical changes to cars as well as maintenance trouble-shooting. So far 12 vehicles have been equipped with the recorders, and all should be fitted by the end of 1989.

Two new ac-motored cars are joining Edmonton Transit's fleet in 1988 for a year of testing as part of a joint project between the Province of Alberta, Siemens AG and the City of Edmonton. They are based on the successful U2 design, but they will be equipped with asynchronous three-phase drive featuring freon cooling, gate turn-off thyristors and microprocessor control.

Testing will concentrate on energy consumption in comparison with the existing fleet of cars with dc motors, but reliability and maintainability of the ac equipment will also be evaluated. □

First of two prototype three-phase-motored light rail cars developed by Siemens in conjunction with the Province of Alberta was unveiled on July 6 by Minister for Economic Development & Trade Larry Shaben; they will be tested in both Edmonton and Calgary

PROFITS BRING EXPANSION

D B G Barraclough
Operations Director
Hong Kong MTR

HONG KONG Mass Transit Railway is the only underground mass transit railway in the world which earns unsubsidised fare revenue sufficient to cover all costs, including depreciation, plus a useful operating profit margin.

The network comprises three lines: the Kwun Tong line completed in 1980, the Tsuen Wan line opened in 1982 and the Island line which was commissioned in 1986. Together they total 38·6 km with 37 stations. On the Kwun Tong and Tsuen Wan lines, trains of eight cars run at 2 min intervals in the morning peak, every 2½ min in the evening peak, and every 4 min at other times. On the Island line morning and evening peak frequencies are currently every 3 min, which will be stepped up in spring 1989 to every 2½ min. On Mondays to Fridays an average of 1·75 million journeys are made, rising on Saturdays to 1·9 million. Sunday traffic amounts to 1·3 million.

In 1986 the railway carried 532 million passengers, rising to 593 million in 1987. Traffic is forecast to grow by about 9 per cent annually in the years ahead.

Built at a cost of nearly HK$25bn, the project was partly financed by property developments along the lines. Many of these will be completed during 1988, with the last three at Tin Hau, Sai Wan Ho and Heng Fa Chuen being finished in 1989.

Severe overcrowding southbound in the Nathan Road corridor between Mongkok and Tsim Sha Tsui in the morning peak had become a serious problem by early 1988. As many as 81 000 passengers/h were being carried, although the crushload design capacity was 75 000 passengers/h. This necessitated the introduction from the end of May 1988 of peak congestion fares between 08.00 and 08.45 for passengers using this corridor.

A pricing policy was used as the most effective method of persuading a limited number of passengers to make their journeys at other times to help reduce the severity of the overcrowding. The alternative of physically restraining entry of passengers during the critical period at certain north Kowloon stations was rejected as discriminatory and impractical — about 50 per cent of passengers starting their journeys at these stations during this period do not travel along the Nathan Road corridor.

Completion of the Eastern Harbour crossing in early autumn 1989 will provide a degree of relief, and an alternative route for many passengers travelling between Kwun Tong line stations and Hong Kong Island. It will also raise the Corporation's current 52 per cent market share of all public transport journeys across the harbour.

The extension will run from Kwun Tong via a new station at Lam Tin and then through a 1·8 km immersed tube to terminate at low-level platforms at Quarry Bay, 17 m below the existing Island line. A batch of 49 more cars has been ordered from Metro-Cammell for delivery by April 1989 to cater for the Eastern Harbour traffic and to raise the Island line frequency to 2½ min intervals.

After extensive trials, a contract was placed in September 1987 for electrical equipment for the 38 power cars included in this total. They will feature gate turn-off

IN BOOMING HONG KONG

thyristors and auxiliary inverters from GEC Traction of Great Britain instead of the camshaft equipment and motor alternators with which 450 of the 470 power cars in the existing fleet are fitted. The new equipment will offer significant reductions in maintenance and energy costs.

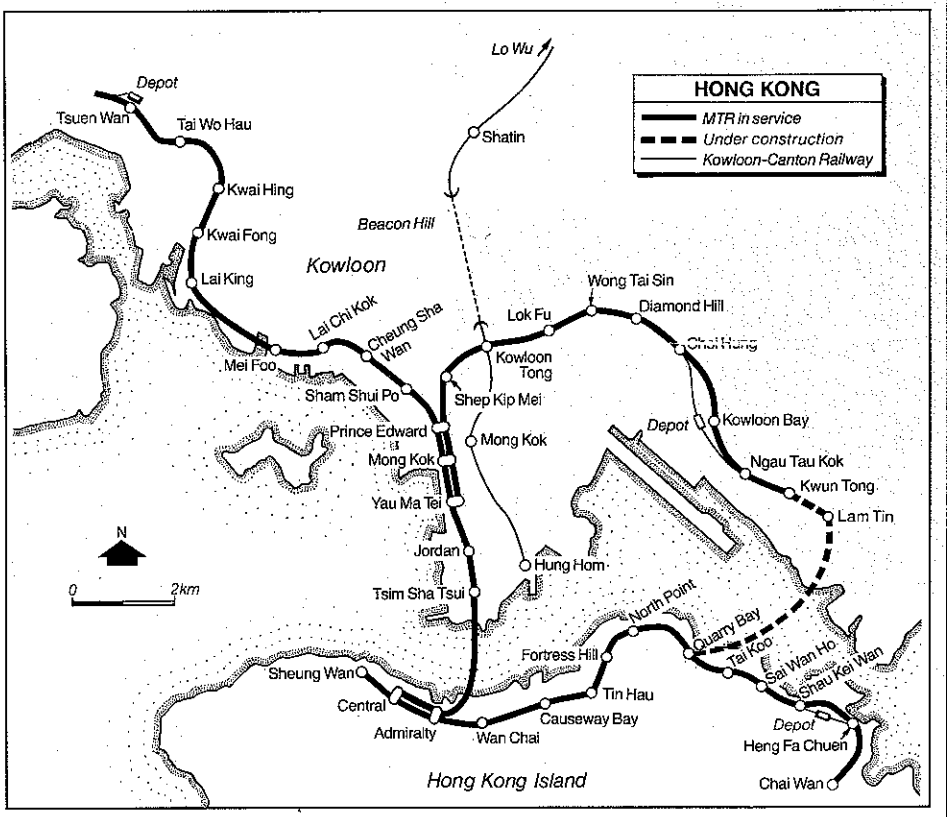
In 1989 the Corporation will commence further trials of traction equipment to evaluate potential for mid-life enhancement of the existing conventionally-fitted power cars.

The tragic fire which occurred at King's Cross on the London Underground in November 1987 led to a thorough review of emergency procedures and training on the MTR. This was to ensure that our standards matched the critical demands that can be placed on equipment and staff in such circumstances. While training to combat the potential dangers inherent in such an emergency remains an on-going requirement, the high standards of design, installation and fire protection incorporated throughout the MTR since its inception provide a degree of safety for passengers greater than any other mass transit network in the world.

Technical progress is in hand on several fronts. During the summer of 1988 a contract was to be let for automatic train regulation, initially on the Island line; it will be installed over the next three years on the Tsuen Wan and Kwun Tong lines, enhancing reliability and thus raising capacity, as well as cutting energy costs.

MTRC has developed a 10 year signalling programme which includes replacement of standard track circuits with jointless track circuits. Solid-state interlocking, which is incorporated in the Eastern Harbour crossing, may be extended to other parts of the network. Much work was carried out in 1987 with British Rail and Westinghouse Signals to adapt standard SSI for mass transit requirements.

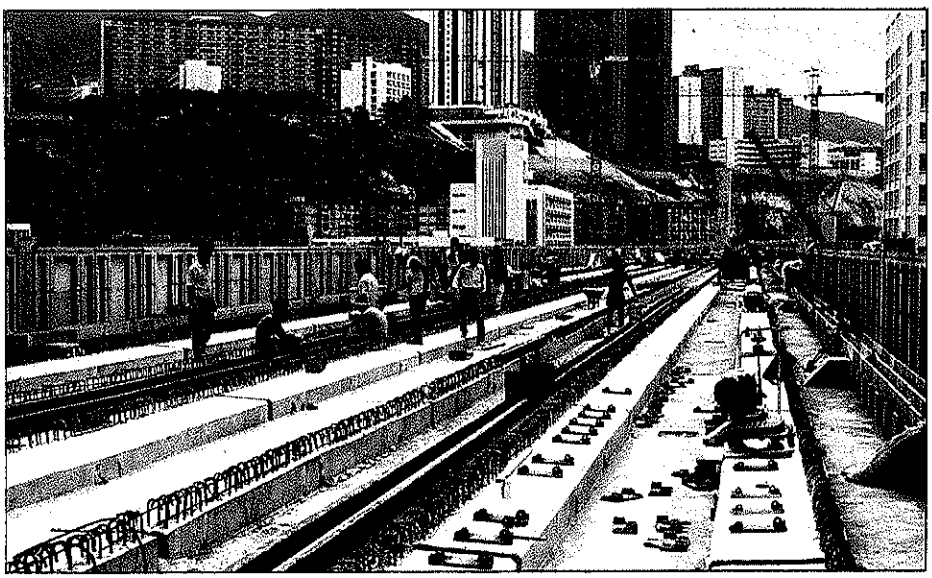
A contract will be let in autumn 1988 for automatic fare collection on feeder bus services provided by Kowloon Motor Bus and Citybus, an independent operator. This will allow MTR passengers to use stored value tickets for both rail and bus journeys. The concept may later be extended to other operators in Hong Kong.



Over the next three years expansion of the network will necessitate the replacement of the computers associated with the automatic fare collection system. At several stations a limited number of stored value ticket machines which allow passengers to purchase tickets using credit cards are being installed.

Improvements to passenger facilities at Tsim Sha Tsui and Central stations have been carried out in the past 18 months. Similar improvements are planned for Mongkok, Admiralty and Jordan stations over the next two years. The work at Admiralty is linked to the completion of major commercial, residential and office developments there in 1988-89.

The Hong Kong government and its consultants are currently undertaking the Comprehensive Transport Study II, which is due to be published in November 1988. This will examine the requirements for public transport throughout Hong Kong in the next 10 years or so, and will include a potential extension of the MTR by 1996 to serve the developing new town of Junk Bay, adjacent to the existing industrial and residential area of Kwun Tong. □



The East Harbour crossing extension from Kwun Tong to Quarry Bay, now under construction, is due to open in the autumn of 1989

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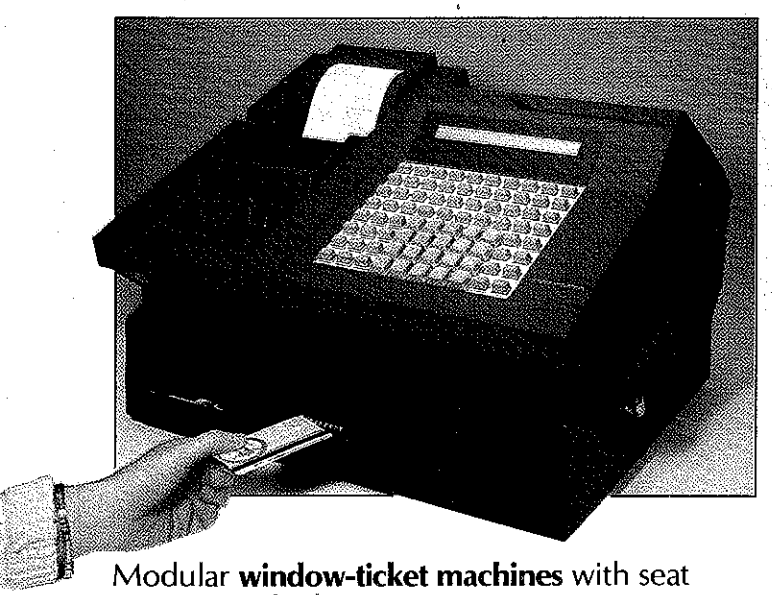
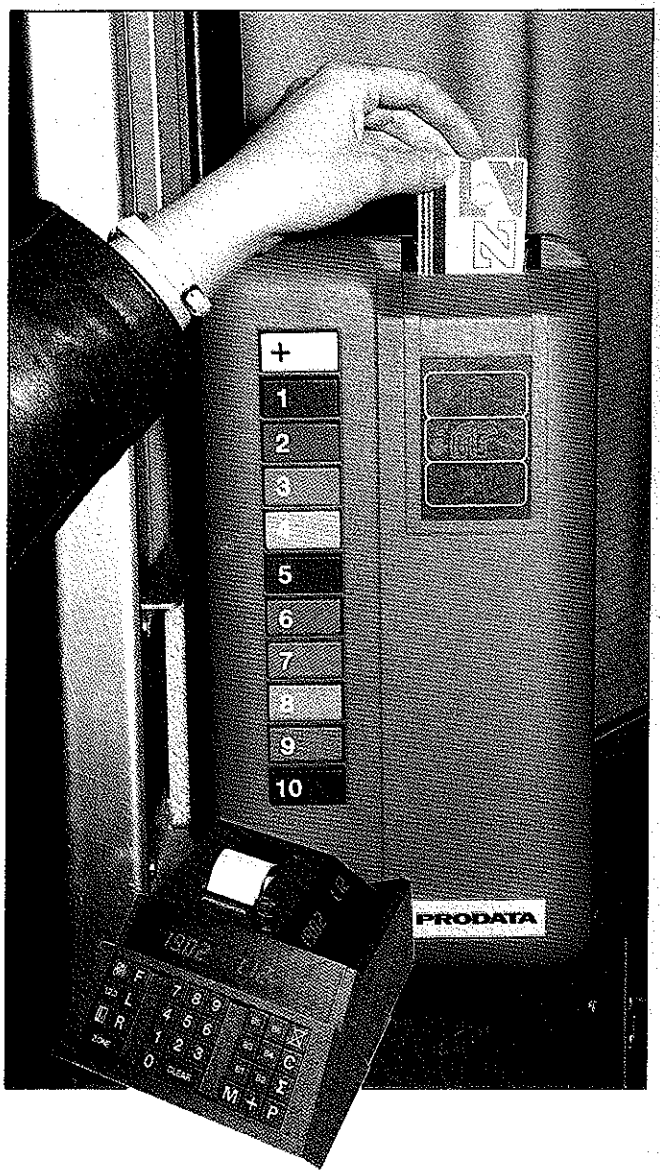


Modular **window-ticket machines** with seat reservation facilities.



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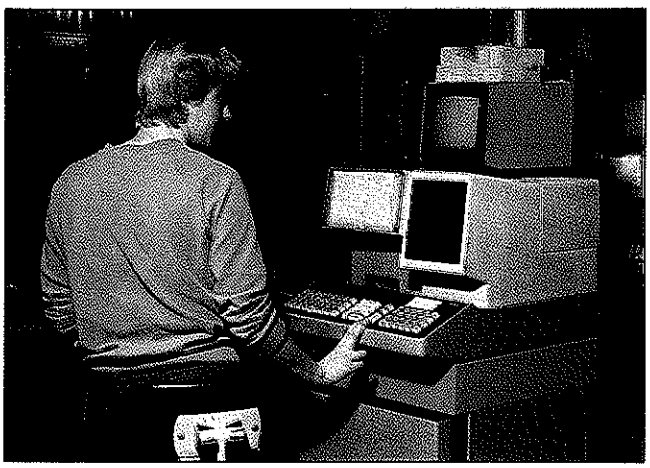

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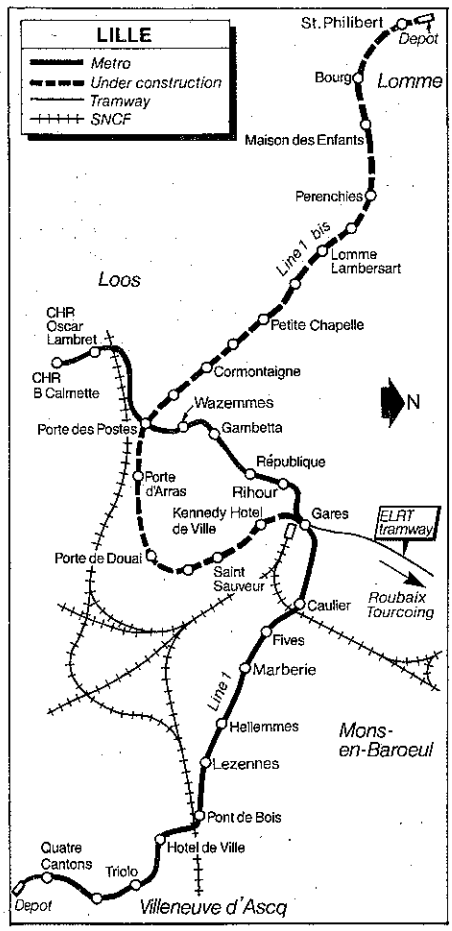
FIVE YEARS' AUTOMATION



The success of Lille's first 13·5 km VAL line over the past five years has spawned worldwide interest in rubber-tyred automated peoplemovers

ON MAY 16 1983 the world's first unmanned metro opened in Lille. VAL is a fully automated light transit system developed by Matra. After five years we can confidently say it is a great success.

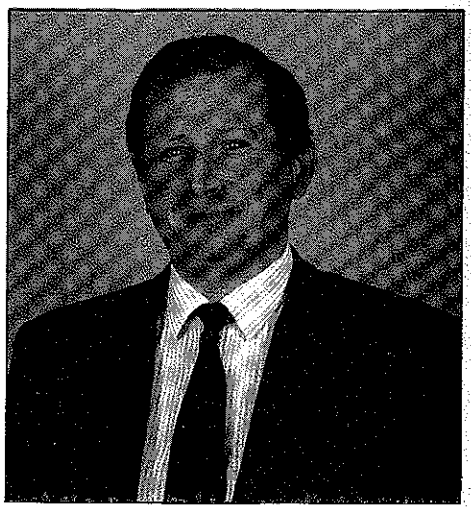
The initial line was 9·5 km long and consisted of 13 stations, each with its own style and decor. The lack of driver seemed to be of no concern to passengers, 13 million of whom rode VAL trains in the first 12 months with only part of the line in service. The line was soon extended a further 4 km to 13·5km, and five stations were added.

Each VAL train consists of two cars, each 13 m long, 2·06 wide and 3·25 high. Rubber tyres help to keep down noise and vibration levels up to the maximum speed of 80 km/h.

A fleet of 52 two-car trains is now in operation compared to 38 four years ago. During peak periods trains run at 1 min intervals, so reducing the level of overcrowding. Off-peak services run every 2 or 3 min, so that waiting time is minimal.

Access to stations is eased by escalators and lifts for prams and wheelchairs. Information about current events is displayed to passengers at 257 locations, and five information kiosks are provided. Since December 1987 a special information bus has been in operation, visiting the surrounding suburbs. A phone-in service is also available, receiving some 200 calls a day.

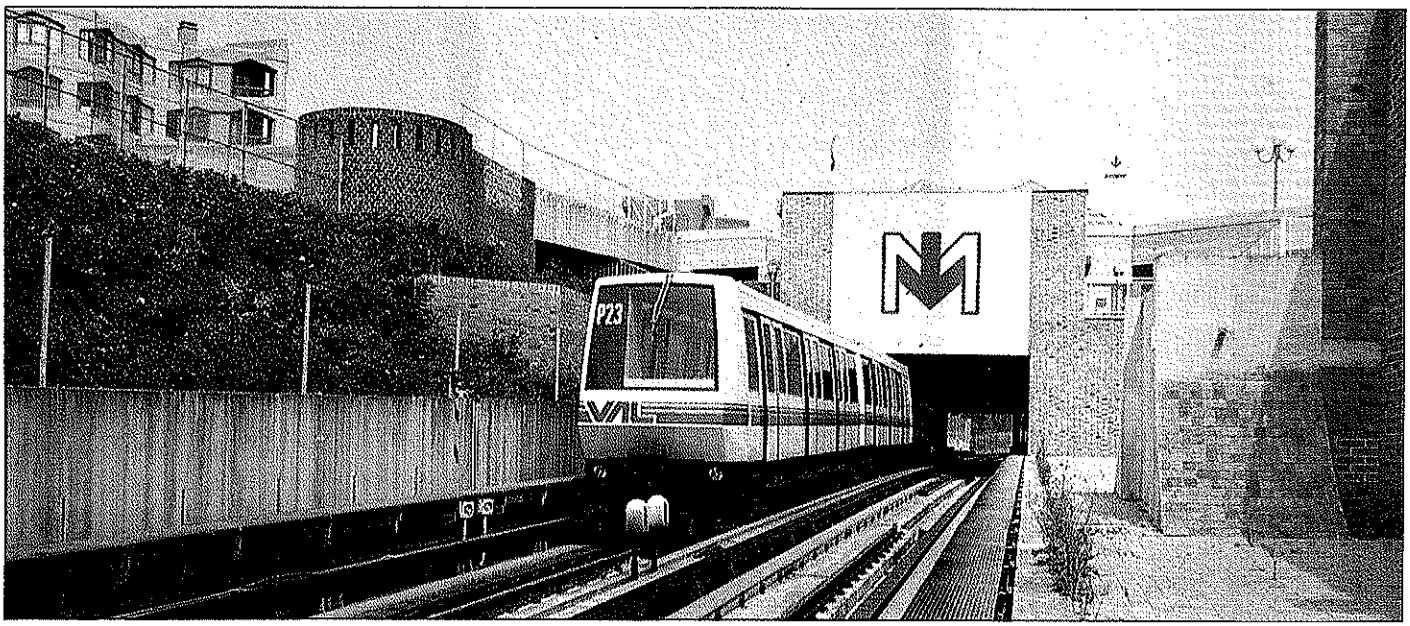
VAL is operated by Compagnie du Métro de Lille (Comeli). Public transport throughout the Lille area is provided by Compagnie des Transports de la Communauté de Lille (Cotrali). Cotrali holds regular meetings to listen to suggestions from customers as well as carrying out regular market surveys. The latest survey revealed that 93 per cent of VAL passengers were satisfied with the short waiting time for trains, while 88 per cent said they were sure of being on time; 81 per cent considered they were satisfied with the cleanliness of the metro, and 94 per cent said interruptions to journeys were rare, while 84 per cent were satisfied with safety.



Dominique Daulmerie
Director
Lille Metro Co

Vandalism quashed

Measures to reduce vandalism have been very successful. The metro has its own special police force which patrols stations throughout the day and night. Graffiti is removed from station walls as soon as it is discovered thanks to a daily cleaning service,



and trains are taken out of service immediately to remove any signs of graffiti, so discouraging further attempts.

A special environmental department deals with the cleanliness of each station. The staff are aware of particular groups of society hanging about in different stations, and by close contact with local social organisations they aim to reduce the concentration of such groups where a build-up could lead to trouble.

Safety

Much attention is paid to safety. Cars undergo a one-day overhaul every 15 000 km, and after 105 000 km they are subjected to a more thorough check lasting five days. Every 300 000 km a major overhaul taking 20 days is carried out; all mechanical parts are checked, the automatic system is verified and the interior and exterior are resprayed.

If a train breaks down in service or develops a technical fault, it is automatically brought to a halt, as are all other trains on the line. Trains can be driven manually if necessary.

At the construction stage considerable attention was paid to eliminate fire risks. Cars are built of non-flammable materials which do not emit toxic gases. The escalators are also non-flammable, and each is fitted with its own fire detector, which is connected to the local fire station. A network of telephones and video cameras in every station provides for rapid communications in an emergency.

Fire extinguishers are located in all cars, and an alarm allows passengers to contact central control to stop the train. Doors can be unlocked to permit rapid evacuation; if this occurs, the power supply is cut off and the train comes to a halt. Emergency exits are located between all stations, and special tunnels have been provided so that the fire brigade can reach the scene as quickly as possible.

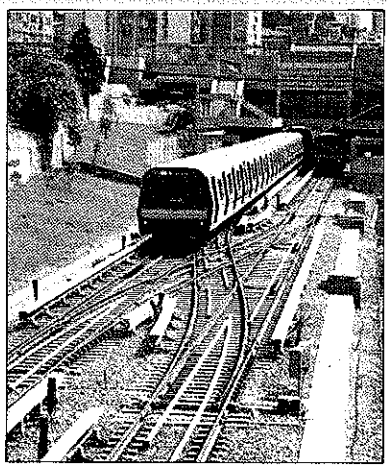
A sophisticated smoke control installation has been installed in each tunnel and station. Reversible ventilation fans can extract air at the rate of 32 m^3/s or blow it away from passengers needing to reach an emergency exit.

Other safety devices include platform doors which open automatically when a train has stopped at a station, so eliminating the risk of a passenger falling on to the track in front of a train.

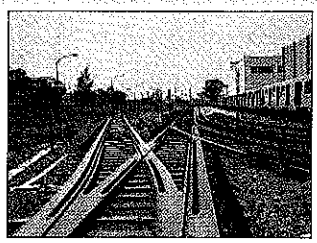
On April 17 1985 work began on an extension of the existing line. Forming a 12 km branch from Gares, Line 1bis connects with Line 1 again at Porte des Postes and then runs northwest to St Philibert, adding 18 stations to the network; 29 trains will join the existing cars. Line 1bis is due to open in March 1989. In the meantime plans are at a preliminary stage for a second line which could open in 1995.

Not long ago Lille was a city in decline with its economy based on coal mining and textiles. Now it is back on the right track thanks to the ultra-modern technical advance of its driverless metro.

VAL's success has spread. A similar system is to link Orly airport to the Express Metro in Paris, and second VAL airport link is to open in 1990 in Chicago. Jacksonville is another US city that has chosen to install VAL, while in France Toulouse, Strasbourg and Bordeaux are to have their own VAL lines by 1994. □



Caracas metro (Steel wheels)



Mexico metro (Rubber tyres)

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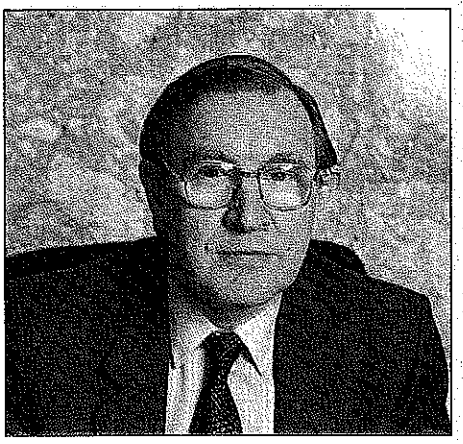
RAPID GROWTH FORCES



Dr Tony M Ridley
Chairman & Chief Executive
London Underground Ltd

HAD SOMEONE told me when I took over as Managing Director of London's Underground network in 1980 that eight years later we would be carrying more passengers than ever before, and that I would be actively considering with British Rail and the government the construction of new Underground lines, I would have doubted their sanity.

When I initiated the Underground's first five year Strategic Plan (1983-87) in 1982, London Transport, as it then was, had been subject to two fares changes within nine months; the first reducing fares by about one third, the second, following a Law Lords ruling on the Greater London Council's fares policy, doubling fares.

These enormous fluctuations, combined with an unparalleled level of political involvement in LT's day-to-day matters, provided a confused background for such a task. Demand had broadly been on the decline for the previous 20 years. The main thrusts of the Plan were a strong marketing strategy to stem further decline. Much investment was directed into renewals and improvements in the station infrastructure and environment, and much management resource geared to improving the regularity and reliability of the service — less than 92 per cent of the scheduled service was operated in 1982.

The rise in passenger numbers since then has been dramatic — 812 million journeys were made in 1987-88, 63 per cent more than in 1982. Much of this success has been due to simplified ticketing and in particular the Travelcard and Capitalcard tickets, which give wide zonal availability on the Underground and London's buses, as well as on British Rail.

At the same time, there has been a sizeable injection of capital investment in the Underground, much of it directed at badly needed station refurbishment, but with provision for a large-scale lift and escalator renewal programme, which has improved the condition and appearance of many stations.

The 1983-87 strategy was hardly under way before London's public transport was reorganised under the London Regional Transport Act of 1984. The newly created London Regional Transport (LRT) required its subsidiary companies, including London Underground Ltd (LU), to operate efficiently, safely and economically and gave LU strict budget guidelines and cost targets. The remaining years of the 1983 Plan (1983-87) saw the company achieve a 15 per cent reduction in unit costs from a number of measures including the conversion of many lines to driver-only operation, streamlining of the overhaul and maintenance functions and the increase in competitive tendering.

The cost reductions and the massive increase in ridership have resulted in London Underground becoming one of the four major metros in the world making a revenue surplus on its day to day operations.

But in 1988 there are problems. Despite the station refurbishment programme, concentrated largely in the busy central area, many stations remain shabby and neglected — a reflection of decades of under-investment. Behind the scenes much of the equipment vital to the operating efficiency of the Underground is becoming life expired.

More noticeably, increased ridership has placed the system under enormous strain, particularly from overcrowding, despite the introduction of improved services on many lines. Trains are running full, not just in the recognised rush hours, but at many other times of the day as well. This increases station dwell times, resulting in slower journeys and gaps in service which disrupt carefully planned schedules.

Moreover, many of our customers experiencing higher standards of customer care in other service industries do not consider LU sufficiently consumer orientated. The overall effect has been a decline not only in quality of service, but more significantly, in customers' opinion of the Underground as a provider of fast, efficient urban travel.

It was against this background of continuing growth intermixed with a rapidly tarnishing image that in September 1987 I initiated a major review of strategy to take us into the 1990s and to set the organisation on course for the 21st century.

This review must now take into account the issues arising as a result of the tragic fire at King's Cross last November. Although the Underground is a far safer mode of travel around London than the motor car, LU has adopted a wide range of measures to ensure that, as far as is possible, there is no recurrence of such a disaster.

The review enhances the detailed analysis of demand forecasts and examines the company's organisation. It also looks at the impact of the Underground on London's economy. and considers the inter-relationships between capacity, quality of service, fares levels and the risks associated with different levels of financial investment.

Its first major conclusion was that the growth experienced in the last five years would continue well into the 1990s, albeit at a reduced rate with higher increases in the off peak (30 per cent 1988 to 1997) compared with the peak (19 per cent).

Installation of dot-matrix 'next train' indicators is part of a revolution in passenger information provision on London Underground

STRATEGY RETHINK

Although car ownership will continue to rise, its impact will be small in relation to the predicted continuing increase in tourism (about 25 per cent of LU's revenue in 1987) and employment, particularly in areas served by the Underground.

Thus there is little doubt that, not only have we got to improve the existing infrastructure — better signalling, more rolling stock, and so on — to increase its capacity, but major civil engineering works are required to relieve key congestion points and ease passenger flows.

Plans are shortly to be put to government for the complete re-equipping of the Central Line, and measures are in hand to improve major pinch points at Angel, Liverpool Street, Victoria and Bank stations.

Consideration is being given to splitting the Northern Line into two separate lines with interchanges at Kennington and Camden Town and some small extensions.

Quality of service depends primarily on frequency, speed and reliability, but there are numerous other important factors such as cleanliness and staff behaviour.

As well as streamlining the organisation by reducing the number of layers of management and making managers more commercial in their outlook, radical changes are being introduced at station level.

A new station staffing structure is being drawn up with an individual becoming responsible for a station, including all its staff and facilities, so establishing a clear line of responsibility relevant to both customers and employees. These arrangements should also give employees greater job satisfaction, with promotion on merit rather than seniority. It will also help the Underground to provide a more friendly and caring service, and at the same time achieve cost savings over and above those already gained from the introduction of computerised ticket issuing and collection at present being implemented throughout the network.

The three 1986 stock prototypes are the forerunners of new fleets planned for the Central and Northern lines in the 1990s

A more selective recruitment and selection process is a key element of the strategy, but station improvements retain a high profile.

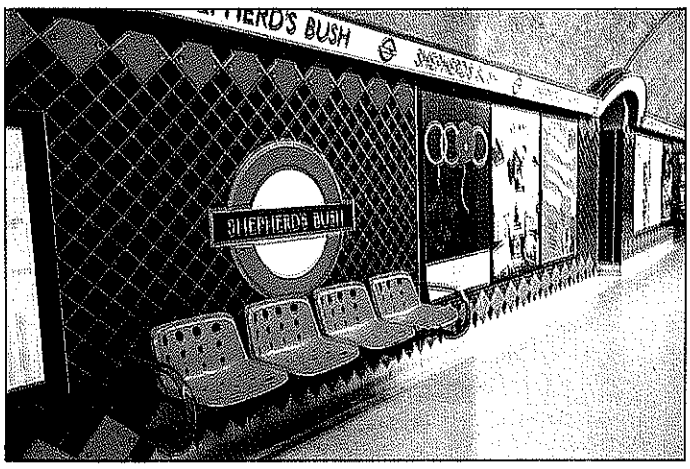
Adherence to a robust financial performance, retaining the ability to fund a significant proportion of our investment through fares revenue and at the same time increasing the quality of the service to our customers, is likely to be the cornerstone of the new strategy.

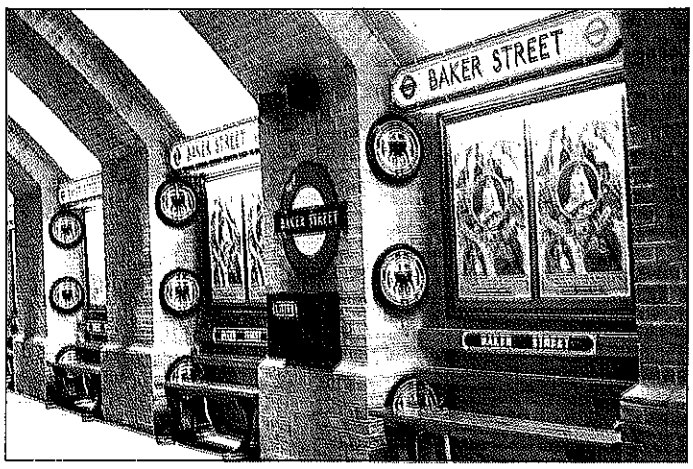
In 1992, the European Community removes its internal trade barriers and London will be under considerable pressure if it is to retain its pre-eminence as the financial and business centre of Europe. London as a city will have to function efficiently if it is to be successful, and I believe that without a good Underground network with significantly higher capacity and customer comfort than exists today, this will not be possible.

London Underground has welcomed the initiative of the Secretary of State for Transport to set up a study to look at radical rail solutions to central London's congestion problems. Along with British Rail's Network SouthEast, LRT and the Department of Transport, we are active members of this study group and are inputting much of the analytical work already carried out for our strategic review.

There is no doubt in my mind — and I write as a former researcher in the Highway & Transportation Department of the GLC — that there is no longer a road solution for central London. I hope we move quickly to ensure there is a rail solution before the Parisians can start claiming the superiority of their city as Europe's centre. □

The massive station facelift programme includes new decor, as at Shepherds Bush on the Central Line (below), and refurbishing of historic structures like Baker Street's Circle Line platforms (right)





LYON PREPARES TO START

AT THE END OF 1990 Lyon will open its fourth metro line. Called Line D, it will be 12 km long with 13 stations. Line D will be distinguished from the other lines in Lyon by being fully automated with driverless trains. As part of the Fr5bn investment package, Lyon's two funicular railways are being renovated and automated too.

The decision to build a metro in Lyon, a city of 1·2 million people, was taken in 1971. To serve the 450 km² managed by the Lyon Public Transport Authority (Sytral), three initial routes were envisaged. Lines A, B and C totalling 16 km with 24 stations were opened in stages from 1978 to 1984. In today's money, this investment amounted to Fr5bn.

Lines A and B have a common fleet of 32 three-car rubber-tyred trains, and Line D will be worked by a batch of 38 two-car sets, also rubber-tyred. Line C is a rack railway which climbs at 18 per cent for 500 m; rolling stock consists of five two-car trainsets.

The fourth line will complete the basic network, providing connections between the four main stations at Part-Dieu, Perrache, Gorge de Loup and Vénissieux. In 1990 the

A Boller
Head of Planning, Lyon Metro

85 urban bus routes will be linked to the metro, mainly at 10 bus-metro interchanges. The bus and metro network is managed by one company with a single tariff, transfers being free of charge.

Around 251 000 trips are made daily on the three existing lines, and Line D will add another 195 000 in 1990. The two funicular lines to Fourvière and St Just, known as Lines F1 and F2, together carry 17 000 people a day. Over a year the public transport network accounts for 205 million journeys, with the metro handling about 40 per cent of these. This proportion will grow to 58 per cent once Line D is open.

Before the metro was built the average number of public transport trips made by a Lyonnais was 113 a year. This figure had grown to 185 in 1986, and we anticipate an increase to 240 trips a year with opening of Line D.

The fourth line is already having a significant effect on urban development; numerous estate transactions are under way along the route between Vénissieux and Gorge de Loup.

We anticipate a favourable effect on operating costs when Line D opens as considerable savings will be made on bus operations. The extra Fr100m revenue a

AUTOMATED OPERATION

year will help to improve overall financial results.

Other benefits will accrue for Lyon's inhabitants. Metro services will be three times faster than buses, so we expect public transport customers to save 7 million hours a year, with 5 million hours a year saved by motorists thanks to a reduction in road traffic.

Line D construction

In the eastern part of Lyon's built-up area the ground is characterised by coarse permeable alluvial deposits. Lines A and B were therefore built at shallow depth or on the surface.

Line D, in contrast, had to cross the Rhône and Saone rivers in quick succession. This factor, together with the sensitive nature of the central area of the city and the discovery of important archeological remains, led to a decision to use a bentonite tunnelling machine for a 1·3 km section.

It was the first time that the bentonite method with a continuous lining of extruded concrete had been used in France. Construction of the twin tubes was carried out from 1984 to 1987.

The success of the VAL metro in Lille prompted Sytral to examine the possibility of automation in Lyon, and only in 1985 was the decision taken to automate Line D. Advantages include annual savings in running costs of Fr12m a year, a frequent off-peak service and a reduction in maintenance time thanks to on-board fault diagnosis.

The automated Line D will use a batch of rubber-tyred cars very similar to the existing Line A/B fleet (above)

Development of the automation equipment, which is based on a hierarchy of computers located on the trains, in stations and at the main control centre, was entrusted to a group embracing Matra, Alsthom and CSEE. Automation is based on the flexible moving block principle, with each train determining its own speed according to the distance from the train in front or from the next station. Trains will be similar to those in use on Lines A and B, but there will be no driving cabs.

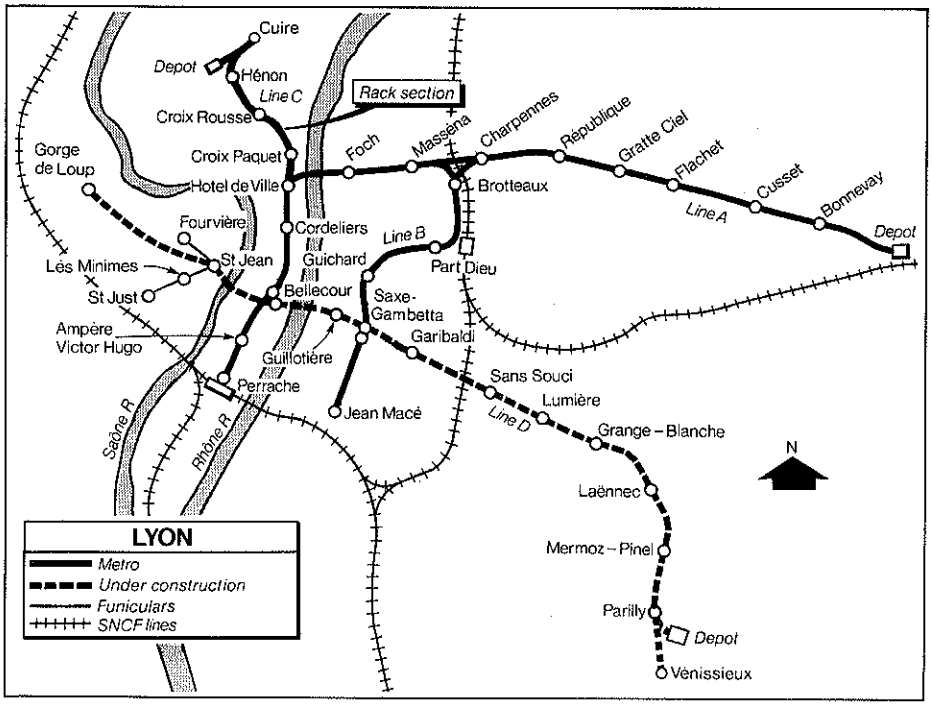
There will be no platform doors as there are on stations in Lille. Instead, an infra-red beam system will be able to detect a passenger falling on to the track. Train doors will be equipped with sensitive edges so that passengers' clothing or other items do not become trapped.

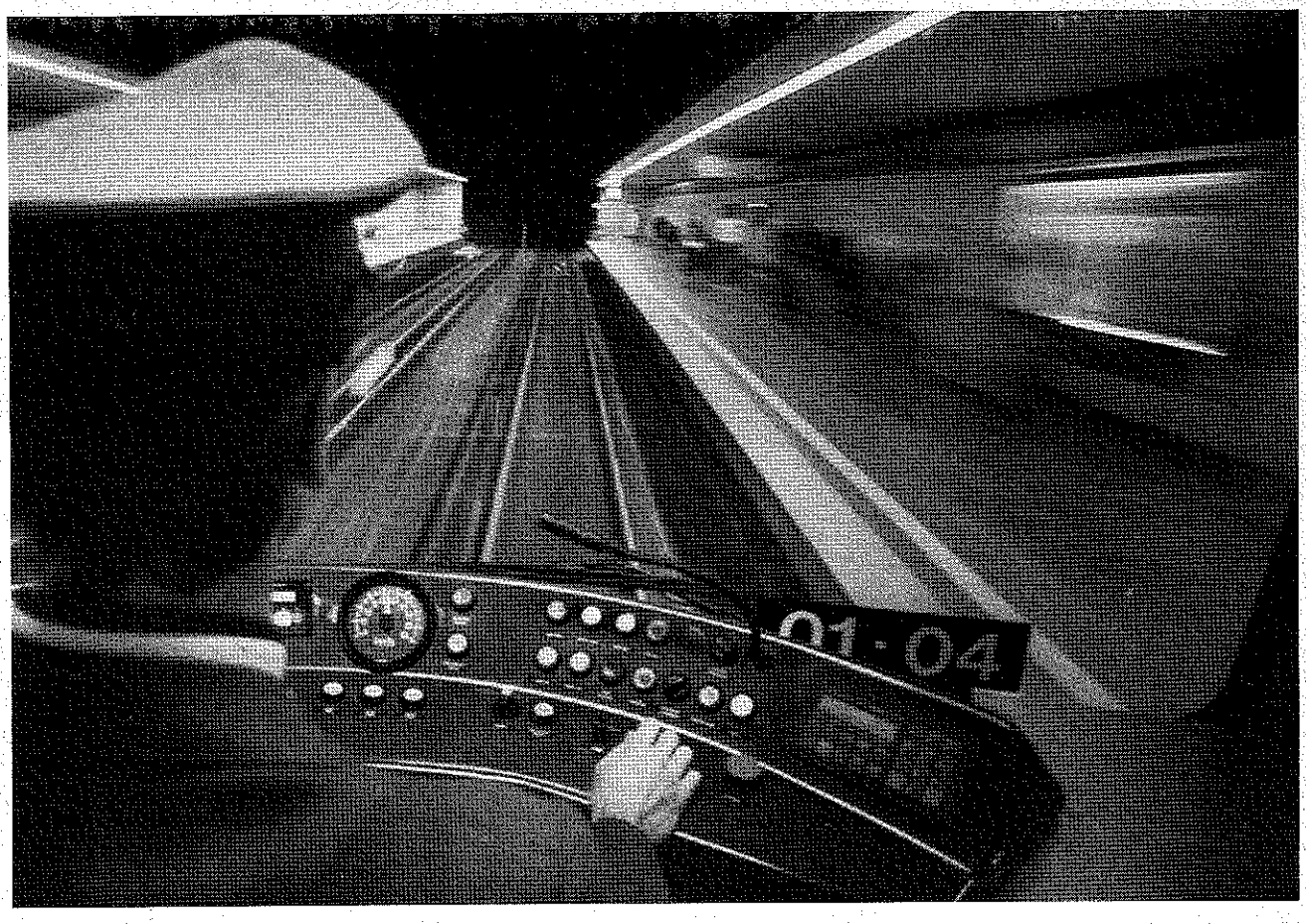
Once Line D is open, efforts will be concentrated on maximising the potential of the metro network by reshaping the bus network so that it feeds the metro more effectively.

Metro extensions under consideration run east from Laurent Bonnevay and south from Perrache on Line A, south from Jean Macé on Line B, and possibly towards Villeurbanne from Charpenne where Line B meets Line A. In due course Line D may be extended at both ends, and a short extension of Line C from Cuire to Caluire is also proposed.

Where traffic does not justify extension of the metro, lighter transport systems may be used. Efforts will also be made to develop suburban services on the existing main line railway network, and a common fares system is another objective.

In the long term a suburban rail link or regional express metro will be built to serve Satolas airport. □





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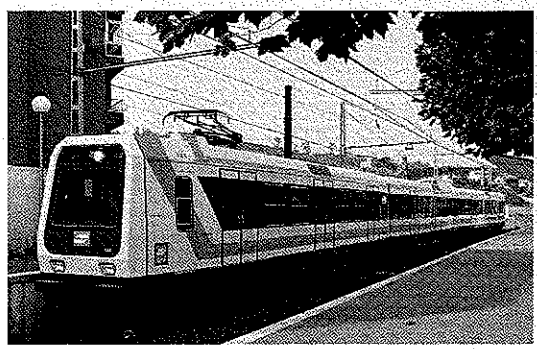

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MADRID WINS BACK

THE METRO in Madrid existed as a private company from its inception in 1919 until 1978, when the state intervened and transferred it to the Ministry of Transport. At present the municipality owns 75 per cent of shares and the Autonomous Community of Madrid the other 25 per cent.

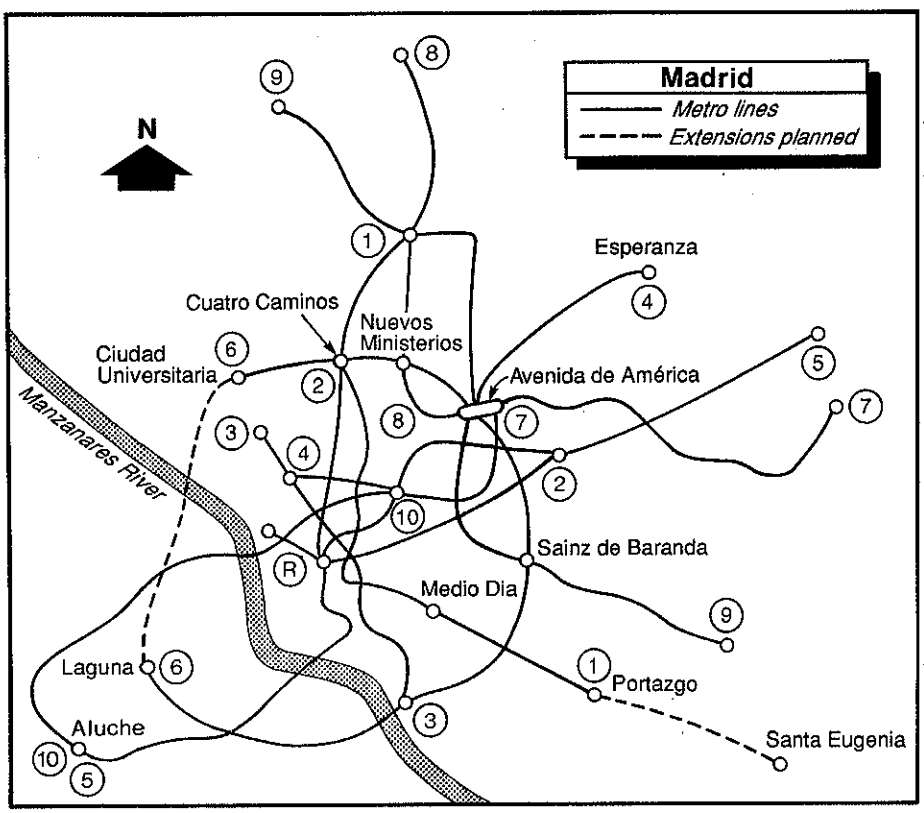
Both organisations have relinquished their shares to the Regional Consortium for Madrid Transport, which reports to the Autonomous Community. Its purpose is to co-ordinate all transport in the region.

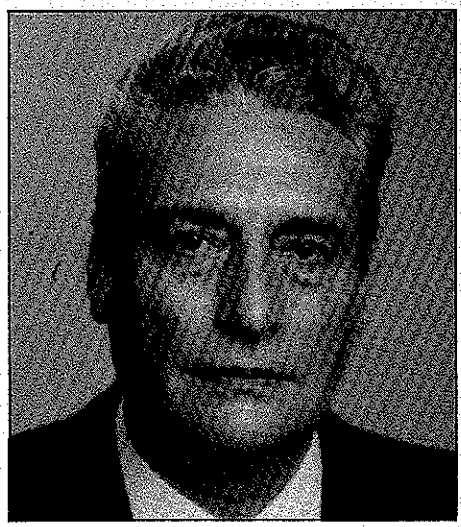
The current length of the metro is 112·5 km with 10 lines and one short branch (shown as Line R on the map) serving a total of 154 stations. An important characteristic is the existence of small and large profile lines. Lines 1, 2, 3, 4, 5 and 10 and the branch from Opera to Norte are built to a small profile, having been constructed before 1970, apart from a few short extensions; their total length is 64 km.

The large-profile Lines 6, 7, 8 and 9 built since 1974 have a total length of 48·5 km. At present no new line is under construction, but in 1989-92 Line 1 is to be extended from Portazgo to Sandi. During the same period Line 6 is to be completed as a circular route by construction of the section from Laguna in the southwest to Ciudad Universitaria in the northwest; the final alignment has still to be fixed.

As with many other city transport networks, the Madrid metro experienced a steep decline in patronage during the 1970s. Annual traffic fell from 527 million trips in 1972 to 321 million in 1985, mainly because of increased use of private cars and the introduction of continuous working hours with no mid-day siesta. A reduction in

Station refurbishment, such as the 1986 renewal of Sol on Line 2, has helped bring passengers back to the metro





Dr R López-Mancisador del Río
Chief Planning Engineer
Madrid Metro

Saturday working and economic recession in Spain were contributory factors.

In sharp contrast, 1986 and 1987 witnessed a rise in traffic to 329 and 340 million trips respectively. The trend is continuing in 1988, and we expect to have carried 354 million people by the end of the year. The reversal can be traced to an improvement in Spain's economic fortunes and inauguration of several new sections of line.

Another reason for the rise in traffic is the effort made by the Regional Transport Consortium to integrate the different modes of transport in Madrid. In particular, Spanish National Railways' suburban development plan includes metro interchanges at Atocha, Embajadores, Méndez Alvaro, Banco, Colón, Pirámides and Delicias, as well as the existing interchanges at Chamartín, Nuevos Ministerios, Aluche, Laguna and Norte. In some cases interchange is already provided to bus routes.

The rolling stock fleet consists of: 210 cars built before 1942; 232 cars of Series 2000 built in the last four years (a few have still to be delivered); 188 Series 1000 cars built about 20 years ago; and 270 of Series 5000 (130 of these date from 1975 and the rest from 1981-87). There are a further 78 cars of Type 300, of which 26 were built in 1961 and the rest in 1980-82.

The Series 2000 cars have three-phase drives, air suspension, resilient wheels and microprocessor control of traction equipment. Further orders for this type of car will be placed in 1989-92 to replace all the stock constructed before 1942.

Lines 2, 5, 6, 7, 8, 9 and 10 and the Opera – Norte branch have automatic train protec-

ITS PASSENGERS

tion with driver-only operation. The same system is being installed on Lines 1, 3 and 4, while Lines 6, 7, 8 and 9 have automatic train control. All lines have train radio with the drivers in contact with the central control at Pacifico. Control of the 35 substations supplying power to the metro is regulated from Quevedo.

The most serious problems afflicting the metro at the moment are the huge demand in the peak hours and a rise in vandalism and delinquency. Overcrowding in the peak is being tackled by introducing automatic train regulation to ensure even intervals between trains, which thanks to modernisation of signalling equipment will be reduced to a minimum of 2 min.

Although the increase in vandalism has been serious in the last few years it is still less than that experienced by many other networks. A corps of vigilantes is contracted to operate on the metro, but a police commisariat dedicated to the metro is to be established.

The metro staff is being trained to handle a range of new equipment so that routine tasks which were contracted out can be absorbed into the metro. In the future we are contemplating the introduction of expert systems which will assist driving personnel when they have to deal with a fault on the train.

Together with increasing use of electronics, expert systems will permit the introduction of maintenance for the rolling stock fleet and fixed equipment which is based on accurate predictions rather than simply on preventive maintenance as has been the case in the past. □

Over 200 new cars of Series 2000 have been put into service in the last four years and another 200 are planned

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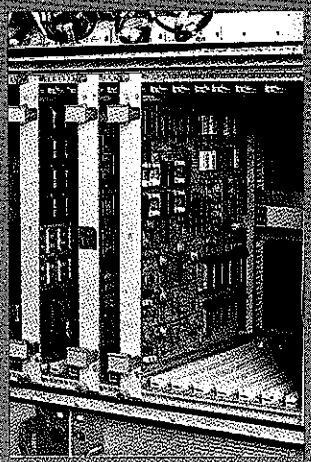

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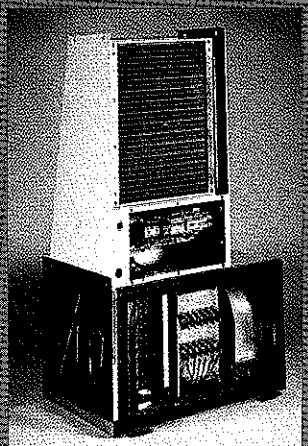

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MEDELLIN SEEKS MOBILITY

Jorge Mario Gómez
Technical Director
Aburrá Valley Metro

A FREQUENT service of trains is due to start on the first section of the Aburrá Valley metro in the Colombian city of Medellin on May 1 1990. Trains will run over the central section of the first line between Acevedo and Poblado, and services will be extended to cover all other stations in July 1991.

The project to build two lines totalling 29 km will transform mobility for the city's two million inhabitants. During the construction phase it will help to regenerate local industry, creating hundreds of new jobs, and in the long term it will help to stimulate development along the Aburrá valley. Work is in the hands of the Hispano-German Metromed consortium, with consultancy being masterminded by three Colombian firms and Electrowatt of Switzerland.

Work on the project is already well in hand. Civil engineering being carried out by Entrecanales y Tavora SA, Dywidag and Construcciones y Contratistas SA is already 25 per cent complete, and around 90 per cent of track contracts have been let; both lines are double track with 54 kg/m rail laid on prestressed concrete sleepers. Some 60 per cent of the electrical engineering has been finished. All the auxiliary rolling stock has been delivered to site, and production of the fleet of 42 three-car trainsets is 30 per cent complete.

One of the major construction jobs was to relocate the 914 mm gauge National Railways of Colombia tracks between Exposiciones and Envigado; at the other end of Line A major work was needed to divert the River Medellin.

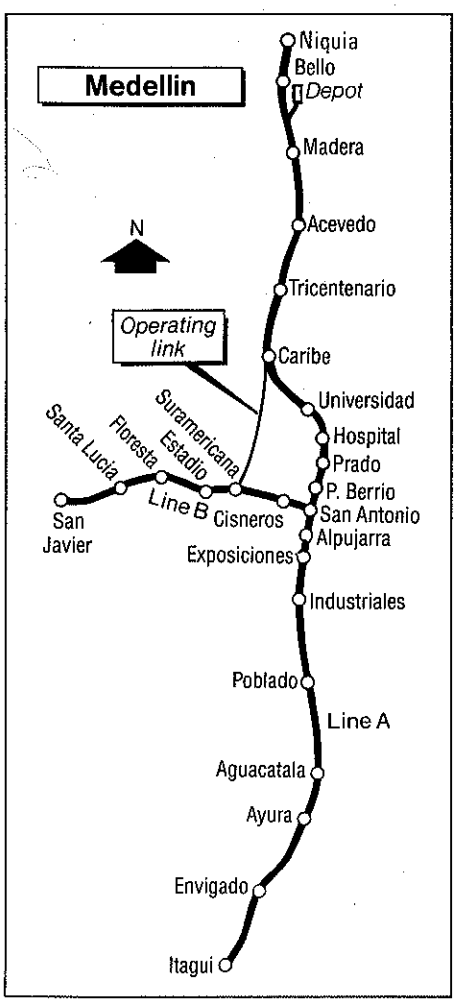
Line A is on a 23 km north-south alignment from Niquia to Itagui, with Line B running at right angles to the valley for 6 km from an interchange at San Antonio to San Javier. San Antonio will be the site for the management offices and a control centre. A 3 km link between the two lines is provided to allow rolling stock movements to and from the depot and workshops sited at Bello near Niquia on Line A.

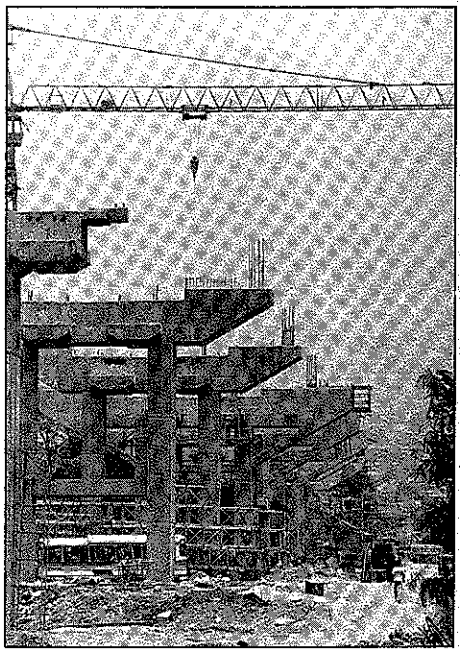
About 16 km of Line A is at grade and the rest on viaduct; 4·6 km of Line B are elevated, as is a short section at the southern end of the link between the two lines.

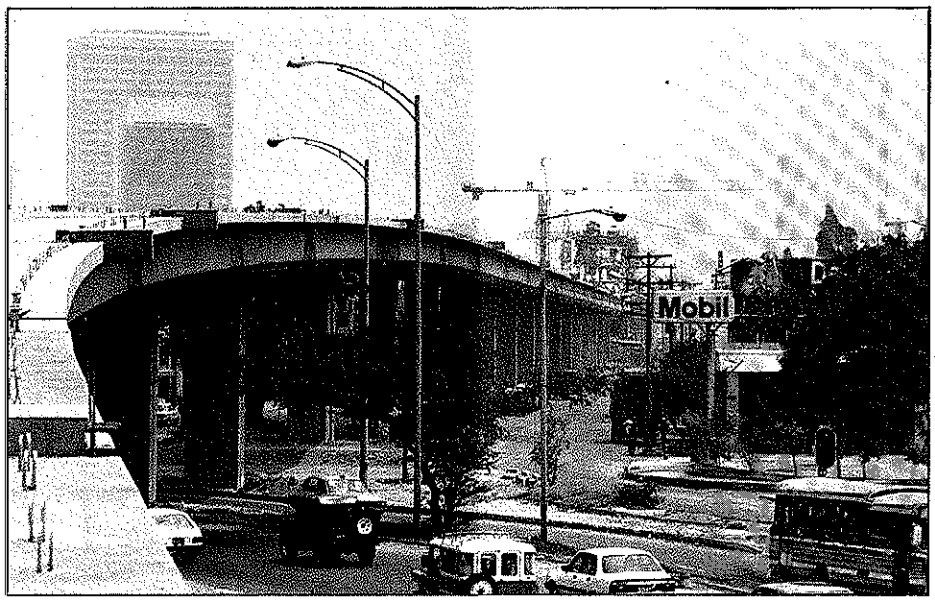
Of the 25 stations, 19 are on Line A, 11 being at ground level and the rest elevated; five of the six stations on Line B are elevated too.

On opening, the metro will feature a 5 min interval peak hour service, with trains running every 10 min off-peak. In due course services will be stepped up to every 2½ min in the peak and every 5 min at other times. Trains of six cars will load to a density of 8 passengers/m² in the rush hour, which should allow 60 000 passengers an hour to be carried in each direction. Demand is expected to grow from 900 000 passengers a day in 1990 to 1·25 million 10 years later.

Rolling stock is being supplied by three companies: MAN and Siemens in West Germany and Ateinsa in Spain. The first car is due to start track trials in March 1989. Each trainset will have two power cars and one trailer. Aluminium bodyshells will have four double doorways on each side. Operation will be at 1·5 kV dc with overhead current collection; regenerative braking is provided, and a microprocessor-based fault diagnosis unit will facilitate the task of maintenance. □







MEXICO CITY MATCHES

Ing Gerardo Ferrando Bravo
Director General
Mexico City Metro

TRANSPORT in Mexico City has always been a major concern for the city's huge population. Occupying an area of 1 500 km², of which 600 km² forms the urban district, the city and surrounding area is home to more than 17 million people — a figure which surpasses the population of 80 per cent of all countries. It is the most densely populated area of the American continent with 10 600 people sharing each km². The population is growing by around 600 000 people a year, which aggravates the already serious transport problem as well as being at the root of difficulties with housing, education, and supply of food and water.

In the 1960s buses, trolleybuses, trams and taxis were unable to cope adequately with the demand for moving people about the conurbation, and this led to a disproportionate rise in car ownership, strangling further the already slow-moving traffic flows. Attempts to tackle the problem centred mainly on controlling car movements, but they proved useless — provoking traffic jams, air pollution and noise.

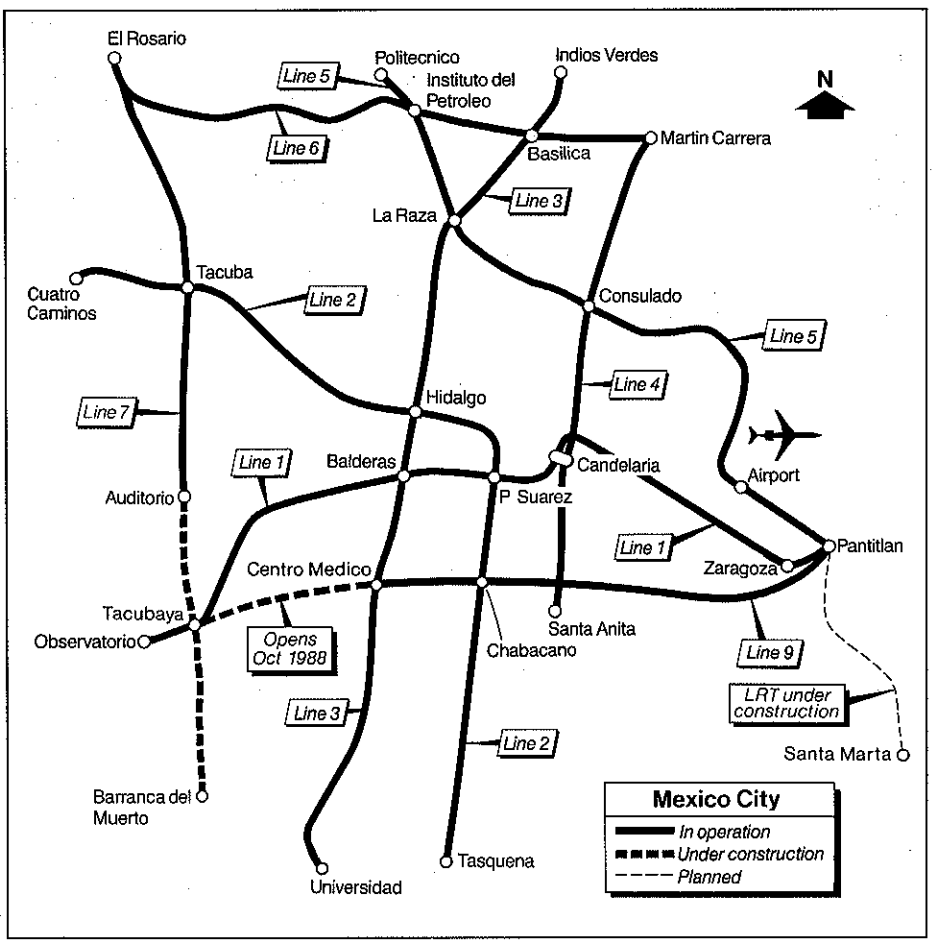
The city authorities had recognised the need for an underground rapid transit network, but the characteristics of the subsoil under Mexico City — the site of the city was once an enormous lake — presented insuperable tunnel construction problems for the technology available at the time. It was necessary to develop special methods suited to the peculiar characteristics of the ground. Not until 1966 did studies for the first metro lines get under way; these led swiftly to the creation of the STC (Sistema de Transporte Colectivo, or metro) by federal decree in April 1967.

Experience elsewhere had shown that there are no instant answers to city transport problems, and that a plan for developing a metro network can only be implemented gradually based on the results of construction and operation of each line. Before deciding the alignment of the first three lines forming Phase 1, a range of options was analysed to determine where the metro could best contribute to reducing traffic congestion.

Two options were retained. The first was a cross-shape with a north-south and an east-west line; the second was a ring shaped network which covered practically all the central area. It was agreed that passengers should generally not have to walk more than 500 m to a metro station. The conclusion was that a ring-shaped network offered more advantages, although this meant serving the central area with three lines rather than two.

Construction ran up against enormous technical problems because of the peculiar subsoil which had an 80 per cent water content with argillaceous materials that compressed too easily for cementation and construction work. This ruled out conventional tunnelling, so a caisson method was adopted, although this too had to be specially adapted to suit the soil conditions.

Choice of construction methods was preceded by exhaustive studies by the Engineering Institute at Mexico's National University, with theoretical results being checked regularly against site progress. Particular care was needed to deal with subsidence risks, which meant special designs of structures and track for the rubber-tyred trains.



Construction phased

Work started in June 1967, and the first line, 12·7 km long with 16 stations, carried its first passengers just over two years later in September 1969. The initial phase consisting of three lines totalling 40·8 km with 48 stations was completed in June 1972.

Line 1 runs east-west across the centre, with Line 2 running from the south to the east; Line 3 runs north-south. A control centre was constructed to serve all three lines, and maintenance depots were established at Zaragoza for major work and at Tasqueña for minor repairs and inspections.

By 1976 the three lines could no longer meet demand, and extensions and new lines had to be built against the clock.

At this time the Urban Transport Commission was established as a new political body with a brief to draw up and implement a Master Plan for the metro. It was responsible for the second phase of the metro which began in 1977 with extension of Line 3 from Tlatelolco to La Raza. Another extension of Line 3 with three stations was commissioned in December 1979, and the northern terminus at Indios Verdes was developed as an interchange designed to avoid the need for suburban buses to come into the city centre. Line 3 was extended again in 1980 to Zapata in the south, reaching a length of 16 km with 16 stations.

The next two years saw Lines 4 and 5 enter service. Line 4 with 10 stations runs for 10·7 km on a bold elevated alignment 20 m above ground level. Line 5 with 13 stations in a length of 15·7 km uses caisson-tunnel construction with some sections at grade.

POPULATION GROWTH

These two routes brought the network to 79·4 km.

The third phase of Mexico City's metro programme took in yet another southern extension of Line 3, and extension of Line 1 to the east and Line 2 to the west. It also embraced construction of the first sections of Lines 6 and 7, bringing the network length to 114·7 km with 105 stations, 20 of which were interchanges.

Now the fourth phase is under way. This saw inauguration of a 4·7 km section of Line 6 in July 1986, followed by opening in August 1987 of the initial 11·7 km section of Line 9. Line 7 was extended northwards in August 1988, and in October this year Line 9 will be lengthened by 3·6 km, bringing the network to 140·9 km with 125 stations.

The growth of the network demanded matching expansion of the main control centre which now handles the first six lines. Lines 7 and 9 are controlled from a new centre which provides for future lines included in the Master Plan.

Two more depots were added, at Ticomán for major overhauls and repairs and at El Rosario for work of a more minor nature.

The Master Plan is based on a wide-ranging strategic planning process involving several government departments and taking in the requirements of the city area development programme. Among its objectives is a reduction in the use of private cars thanks to high quality public transport. This may include development of light rail corridors where a full metro cannot be justified in suburbs; the first light rail scheme is already under way between Pantitlan and Santa Marta. □

In the two decades since Line 1 went into service seven further routes have been opened to cope with the city's mushrooming population

MILANO MOVES THE CITY

Dr-Ing Piero Ogna
Director-General
Milano Metro

IN A SPACE of 10 years Milano will have built a metro network of 80 km with 100 stations. The city is in the throes of a major redevelopment programme aimed at rehabilitating disused industrial areas. This forms the basis for a city renewal concept that will one day allow the serious problems of traffic congestion, urban decay and lack of 'green areas' to be overcome so that the quality of city life is improved. Key to this project is the development of an integrated suburban rail and metro network that offers an attractive alternative to the private car.

The inhabitants of Milano own around 730 000 cars, but there is a shortage of over 300 000 parking spaces. And every day between 250 000 and 400 000 cars are driven into the city from the surrounding area. So Milano has turned into one big parking-lot.

A further 250 000 people arrive in the city every day at the various railway termini and then disperse by public transport. Over 4 million journeys are made every day in the city, around 63 per cent by the resident population and the rest by those who live outside the city.

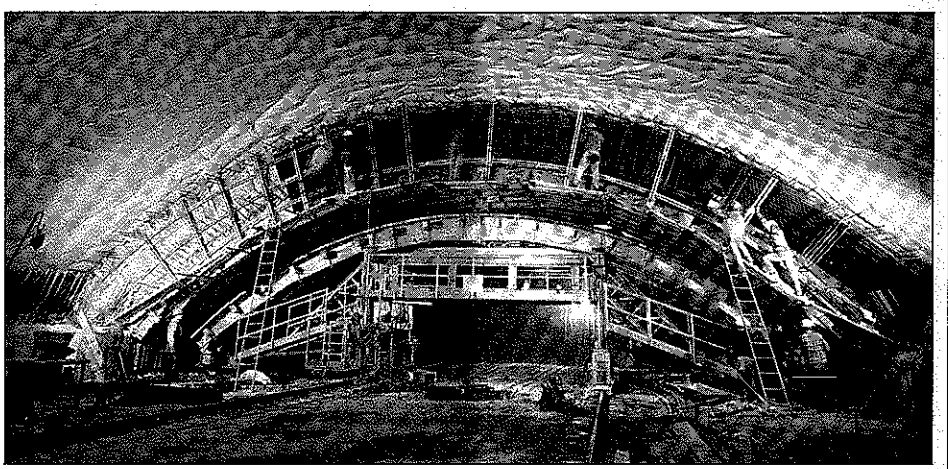
Of these 4 million trips, 61 per cent are made within the city. About 60 per cent are by public transport and the rest by car.

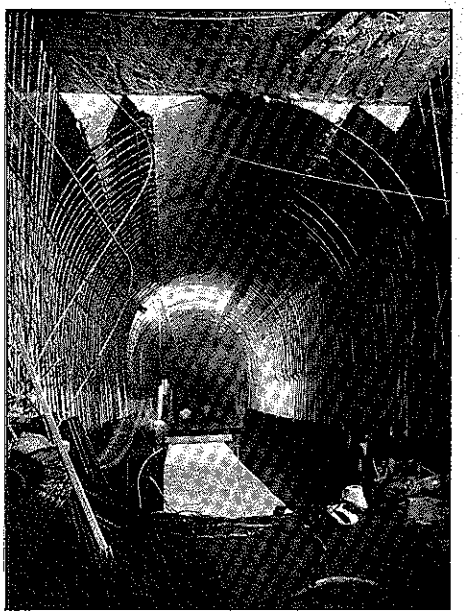
The Milano metro accounts for 700 000 journeys a day — about one third of all public transport trips. To ease the problems of moving about the city the metro network needs to be further expanded, and the project for developing the main line rail network around and through the city must be completed. The programme foresees establishment of major interchanges, together with construction of large car parks for residents and commuters; the road network is also to be remodelled.

At present the two metro lines in operation total 56·3 km with 66 stations. There is a third line under construction which will pass under the old city centre. With 15 stations, it will be 11·3 km long.

The third line has already reached an advanced state of construction, and it should be ready in 1990 when it will be able to carry 36 000 passengers/h in each direction.

Other developments planned at the moment include extension of Line 1 by 900 m; work on this project is about to start. Line 2 is to be lengthened by 2·9 km, adding three stations to the network. This work is due to begin by the end of 1988. Line 3 is to be extended northwards for 9 km, putting 14 more stations on the metro map. This line will also have a short branch running westwards.





Construction of Line 3 and the cross-city link involves a massive cavern to take the Reppublica interchange station (above) and special tunnel linings where Line 3 passes under the Scala opera (right)

We are examining a longer-term project for a fourth line. This could be on a southerly alignment, taking in a branch of Line 1 and extending from Pagano to Porta Genova, Porta Romana, Porta Vittoria and Linate airport. There are, however, other projects competing for priority, and these include a circular route around the old area of the city. These are now being evaluated.

Another area of investigation is the light underground or mini-metro which can carry 12 000 to 15 000 passengers/h in each direction. As experience has shown in other countries, this may be a winner in specific situations, for example linking a commercial or residential development area to the heavy metro or a suburban railway.

Cross-city link

Reconstruction of the main line rail network around Milano has been under way for some time. The aim is to link the regional railways of northern Lombardy into a uniform network. The present radial routes terminating in various parts of the city will be welded together to create an integrated service hinging on a cross-city line that will allow suburban trains to serve the city centre and then continue into the suburbs on the other side of the city.

When this cross-city link is in service, the whole public transport network in Milano will be transformed. Trains running at 20 or 30 min intervals will unite towns north and west of the city with other towns to the south and east. The five routes which will feed the link will combine to offer a 3 min interval service across the central section between Porta Garibaldi and Porta Vittoria at peak periods and a 6 min service off-peak. Train frequency on the link will thus be comparable with the metro. The cross-city line will be operated by Italian Railways, and will run for 9 km through the city centre, serving stations at Bovisa, Certosa, Lancetti, Porta Garibaldi, Repubblica, Porta Venezia, Dateo and Porta Vittoria.

Particular traffic problems occur when there are trade fairs, for example. In a bid to alleviate this car drivers are being encouraged to park outside the centre and use public transport to travel into the city. Large car parks are under construction at the termini of the metro lines; with the extensions planned, all the motorways and major roads leading to the city will be linked to metro stations with large car parks.

With the help of the road programme, the construction of these car parks serving metro lines should prove a key element in solving Milano's traffic problems. □

TECHNOLOGY & DESIGN

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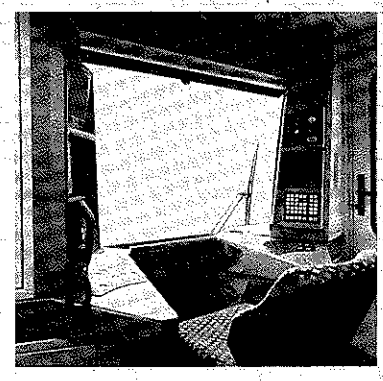
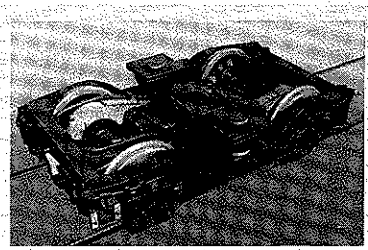
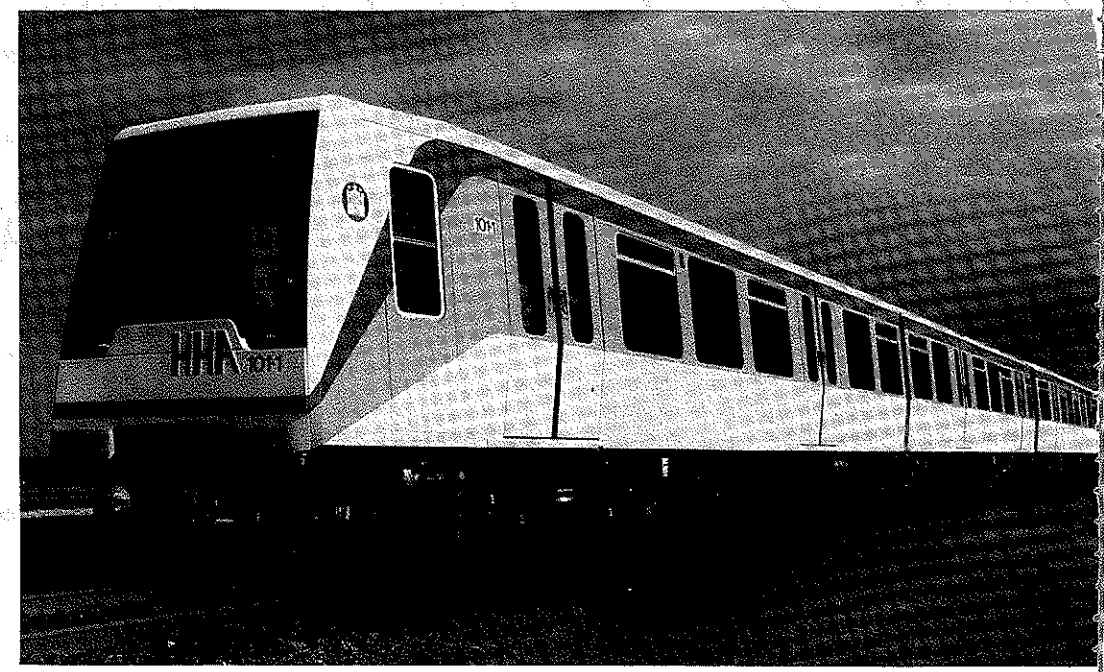






The vehicles are distinguished by an advanced steel lightweight construction using stainless steel for the body structures. The specially designed cross sectional shape, and the use of flush sliding plug doors and sidelights optimizes the interior width of the new cars. Therefore, in spite of the narrow tunnel dimensions on the Hamburg underground system, it has been possible to obtain a 2 + 2 seating arrangement.

The vehicle configuration is based on an economical design concept which meets both the requirements of passengers and the service conditions of the operator. The characteristically modern appearance of the vehicle serves to demonstrate its advanced technical standard.

THE UNDERGROUND CITY

IN JUNE 1988 Montreal Urban Community (STCUM) unveiled a 15-year programme of expansion for the city's metro and commuter lines. Although this is subject to approval by the Quebec government, it is testimony to the progress achieved since Montreal's first metro car pulled into a brand-new station on October 14 1966. Nearly 22 years have elapsed, but the metro is still impressive. Its safety, technical innovations and architecture are just some of the reasons why it has earned international fame.

Approval for the metro construction programme came on May 23 1962, and the first two lines totalling 16 km, one running east-west and the other north-south, were handed over to the Montreal Transport Commission in 1966. The Bureau du Métro, a group of architects and engineers, was created to prepare plans, specifications, tenders, and oversee construction. More than 5 000 people were involved over a five-year period.

A third line opened in 1967 linking the South Shore to the Island of Montreal. This line was built 55 m under the St Lawrence River, and completed the initial 22·1 km phase of the metro, with 26 stations.

Berri-De Montigny, where the three initial lines intersect, became the main interchange station.

Between 1976 and 1986, the first two lines were extended a further 29·1 km. In January 1988 a fourth line with 10 stations and two interchanges was completed and opened. Running for 13 km on an east-west alignment, it takes the number of metro stations to 65.

Louise Roy
President & General Manager
Montreal Urban Community
Transport Commission

Because of Montreal's harsh winters, it was decided at the outset that the entire network would be underground; it was the first in the world to use only rubber-tyred cars. Among advantages cited for rubber tyres, which in Montreal are nitrogen-inflated, are rapid acceleration and the ability to take grades of up to 6·5 per cent. Rubber tyres also reduce noise levels and minimise vibrations transmitted to nearby buildings.

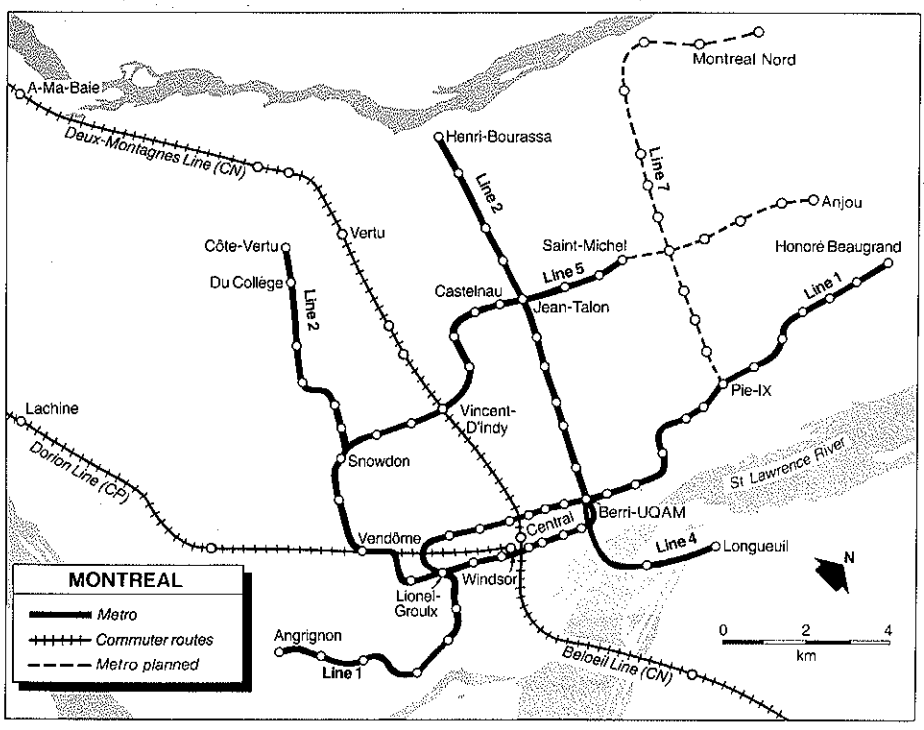
In addition to the tyreways and guides carrying the 750 V dc power supply, the track has conventional rails serving as a conductor for the return of negative current, as an antenna for the continuous speed control signals, and as support for safety wheels should the tyres deflate. Two tracks fit in a 7·1 m wide tunnel.

Stations are high vaulted where the tunnel is bored through rock, but have a smaller vault where cut-and-cover construction is used.

The mean distance between stations varies according to population density, the street pattern, and ridership, but never exceeds 1 km. Almost all stations have two 152 m long, 4 m wide platforms, and are equipped with stairs and escalators. At Beaudry there are two moving sidewalks which take passengers to street level.

Each station is designed to be one-of-a-kind, making the Montreal metro unique in North America. This concept hinged on each station being individually designed by a different architect, which helped to stimulate creativity and gave talented young architects the chance to gain public recognition. Staff engineers and architects worked closely with private firms to ensure that each station had its own character in keeping with the general concept.

The metro is equipped with emergency power sources to ensure maximum passenger safety at all times; in case of power failure, generators cut in to supply power to ventilation, pumping, lighting and signalling plant.



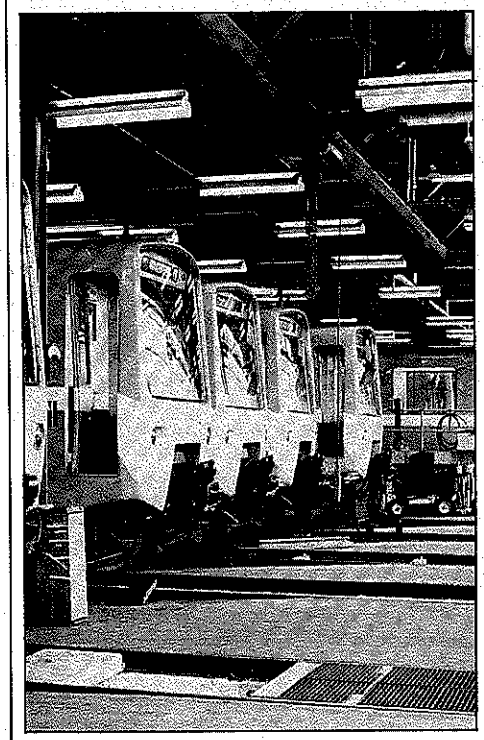
Three-car units

Trains are formed of up to three sets, each set consisting of two end power cars and a centre trailer. Each car can accommodate 160 passengers.

The 759 strong fleet comprises MR63 cars with rheostatic braking and the MR73 series with regenerative braking.

There are four two-leaf sliding doors 1·3 m wide on each car. Door closing is controlled by the train operator who initiates a command for the train to leave the station. The speed control signals, received and decoded by the train, not only adjust the train's speed, but also check the distance from the train ahead.

The control centre is located in Providence Centre, near the Berri-UQAM interchange. Providence houses the communication centre, the power control centre, and the train control centre (TCC). It also contains the



communication centre for the bus network, whose 142 routes nearly all lead to a metro station.

Train departures, route set-up and timings are regulated by the computers in the TCC. Regulators monitor operations on each line with the aid of sophisticated electronic equipment and an illuminated track display giving an overall picture of the network.

At the power control centre regulators oversee the three main parts of the system's electrical installations: incoming Hydro-Québec lines, distribution of traction power and support facilities power, and the low-voltage auxiliary systems.

At peak periods trains operate on 3 min headways, and at other times, including weekends and public holidays, passengers wait less than 7 min. For a single fare, passengers have access to buses and the metro anywhere in the Montreal Urban Community.

Montreal's rubber-tyred metro fleet is made up from two series of three-car units: the MR63 and MR73. Rubber-tyred units were preferred because of the need to climb grades of up to 6·5 per cent

In 1982 the bus and metro networks were complemented by the transfer of responsibility for two commuter train lines from CN and CP. STCUM has renovated several old stations, and two now have direct access to the metro.

The Central Station – Deux-Montagnes line, maintained by Canadian National and comprising 13 stations, carried 4·3 million passengers in 1987. It is badly in need of renovation, and the 15-year investment programme announced this year includes provision for this work. The Windsor Station – Rigaud line with 17 stations, run by Canadian Pacific, last year transported 3·1 million passengers.

Over the years, an entire underground city has developed around the metro's infrastructure, meeting the needs of the 750 000 people who use it every day. Some stations have direct links to shopping centres, hotels, restaurants and office buildings. McGill station is now one of the largest integrated shopping complexes in North America. In the dead of winter, passengers

can walk from the Place d'Armes station through the Palais des Congrès, Guy-Favreau complex and Place des Arts without setting foot outside. More than 11 km of underground passageways are available to the public.

Throughout its existence, the metro has contributed to the development of the city and neighbouring municipalities. Construction, business, shopping, socio-cultural, sports, and tourist activities served by the metro lines have developed and prospered.

Since the 1960s, Montreal has steadily upgraded its metro and adapted it to the harsh North American climate. Its reputation for efficiency and reliability, and the growing interest of other cities in our public transport expertise resulted in the creation of BTM International, a consultancy selling our services internationally.

Montreal's metro is noted for its dramatic station architecture, with every station individually designed by a different architect. A Line 1 train is seen here arriving at the Angrignon terminus

NANTES TO START WORK

DURING 1988 Nantes is taking delivery of eight more cars for its 10·6 km tram route across the city. The line opened in 1985, 27 years after the funeral rites for the last of the old Nantes tramways which were electrified in 1913. Earlier, the city was home to Louis Mekarski's compressed air tramways, first developed in 1879.

Withdrawal of the old tram services in 1958 led to stagnation of public transport. Only in the 1970s did things start to change. Gradual constriction of city life because of rising motor traffic was recognised by the authorities who introduced a levy paid by employers to help fund investment in public transport and reduce its operating deficit. At the same time a government initiative encouraged French cities to consider greater use of electricity to reduce dependence on oil, the transport ministry offering to pay 50 per cent of the infrastructure costs for new tram or metro lines.

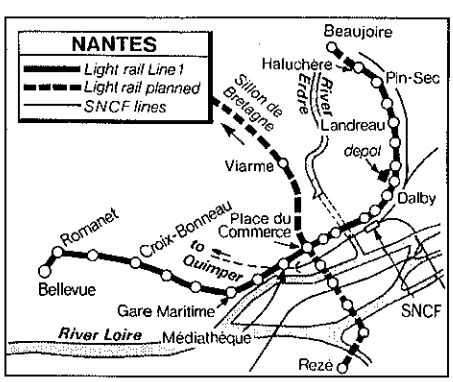
An east-west route with a segregated right of way was put forward in Nantes, the only interference with motor traffic being at crossroads. The local authority adopted the plan in 1979, and two years later the ministry agreed to a financial contribution. Work began in 1981 and the prototype tramcar was delivered in April 1984.

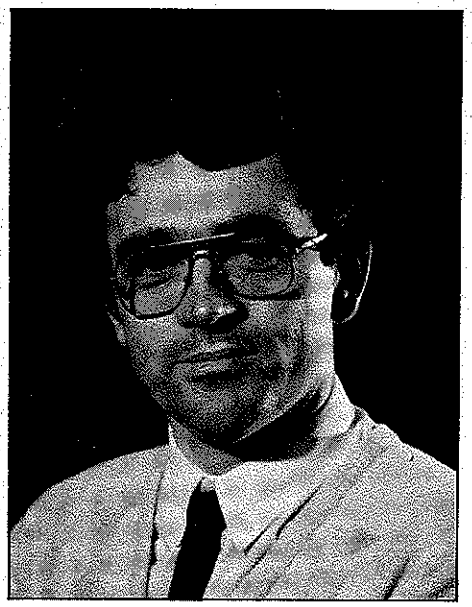
Rail transit returned to Nantes in the following year, and the bus network was remodelled to feed the trams, with 80 per cent of bus routes connecting with one or more tram stations.

Vacant land

The tram route runs from Bellevue to Haluchère, where bus transfer and park-and-ride is offered. Much of the right of way consisted of vacant land and did not require heavy earthworks or massive property acquisitions. All road junctions with the segregated right of way are protected by traffic lights.

On the western two-thirds of the route tracks are laid in the middle or at the side of wide thoroughfares, but at the eastern end the line uses 3 km of SNCF alignment.





Joel Pitrel
Operations Manager
Semitan

Grooved rails are used in the street sections and ordinary rails on the SNCF part of the route.

There are 22 stations, three of which serve the city centre, including Commerce which gives easy access to pedestrian precincts and to the central bus station. Trams also serve the main railway station and the cultural centres at Médiathèque and Manufacture. Platforms are 60 m long to accommodate pairs of trams working in multiple; simple access is provided from each pavement. At each station automatic ticket machines are provided, and passengers must validate their tickets on boarding a tram.

A depot is located at Dalby, together with a common bus and tram workshop and the administrative buildings for Semitan, the city transport company. Power at 750 V dc overhead is supplied from four substations.

The initial fleet of 20 chopper-controlled six-axle articulated cars with a cab at each end was built by a consortium led by Alsthom. Each is 28·5 m long and 2·3 m wide with two single and four double pivoting doors on each side.

Light alloy bodies are mounted on two end monomotor bogies and a central unpowered bogie. Seating capacity is 58 with room for 112 standing passengers at a density of 4/m^2. Dynamic braking is blended with discs which are complemented by electromagnetic rail brakes for emergency use.

Services start at 04.30 on weekdays and the last run is at 00.30. At peak periods cars run at 5 min intervals, with services every 7 to 8 min at other times. Late in the evening and on Sundays a 10 to 30 min interval service is operated. End-to-end journey time is 30 min, which will be reduced if the trams are given priority at road intersections at some future date.

A control centre oversees operations and regulates services, co-ordinating transfers with buses, ensuring regular interval service is maintained and checking departure times; passengers at the main stops can be given information relating to their journeys in real time.

Levy on employers

Cost of the project was Fr630m at 1987 prices. Of this, Fr164m was for infrastructure, Fr87m for tracks, power supply and overhead equipment, Fr66m for the depot, workshops and administrative buildings, Fr175m for rolling stock and Fr52m for radio, signalling and other technical equipment. The ministry of transport contributed 35 per cent of the total, the rest coming entirely from the levy on employers. Construction finished under budget.

On a typical day in October 1987 the trams carried 46 000 people, more than 20 per cent of all public transport trips in Nantes. From market research in 1986 we estimate one third of tram passengers to be new to public transport. Around 64 per cent of tram passengers walk to and from the tram stations, and 27 per cent transfer to and from buses.

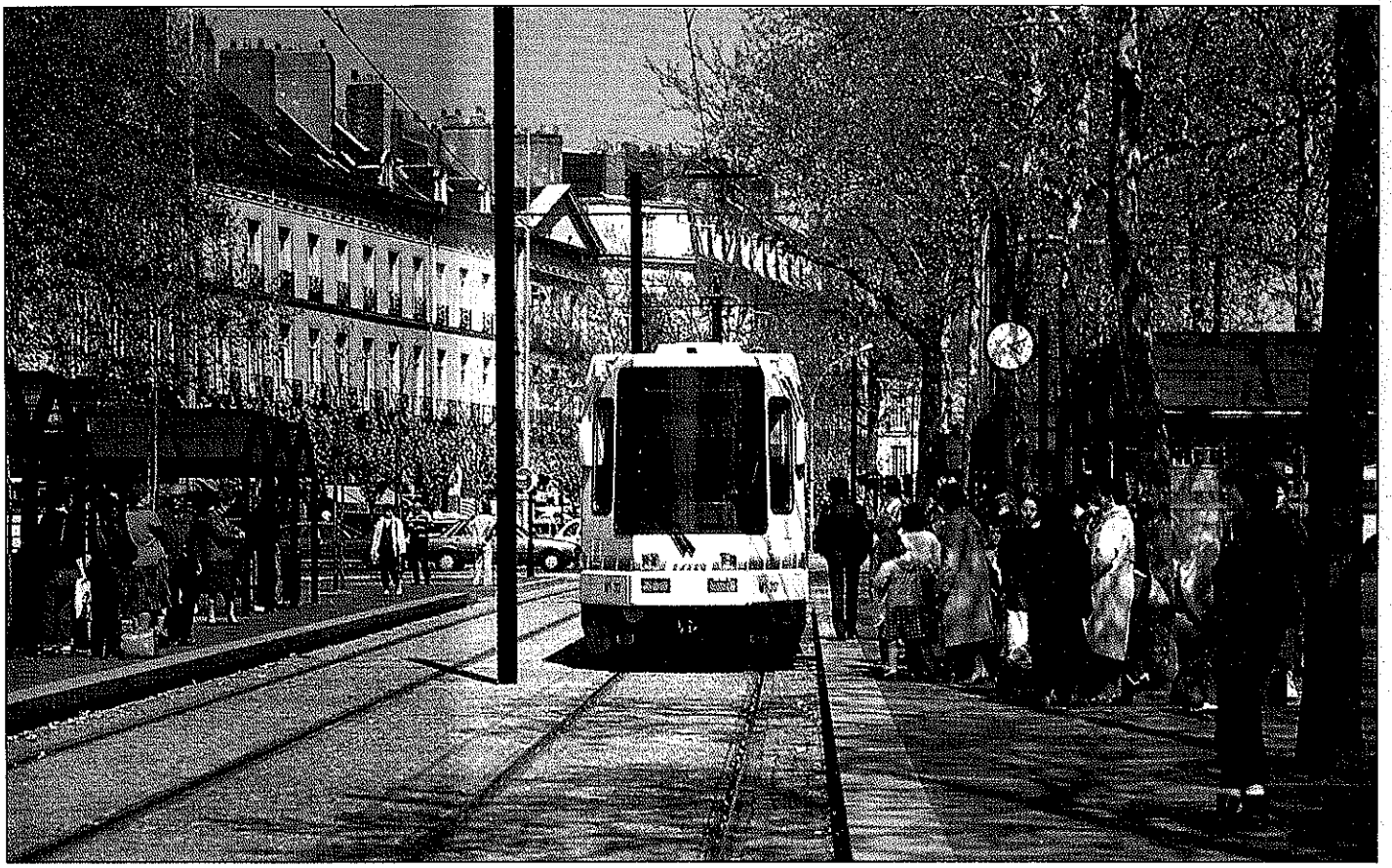
We are now planning to run at 4 min intervals at peak times, and to operate pairs of cars in multiple to raise capacity.

Introduction of tram services in Nantes has improved productivity. While the number of staff did not increase between 1984 and 1986, seat-km rose by 6 per cent. The first full year of tram operations brought a 19 per cent increase in through journeys and a 14 per cent improvement in revenue, while operating costs only rose by 3 per cent.

Operating cost of the tram services over a 12 month period in which the cars together ran 900 000 km is Fr22·7/km at 1987 prices; Fr12·3 goes on staff costs. For comparison it costs Fr14·5/km to operate a standard bus, but in terms of the cost per seat-km the tram requires only 13·4 centimes compared with 20·7 centimes for the bus. Alone, the trams make an operating profit with a cost recovery ratio of 113 per cent, and in the first full year of tram operations the cost recovery ratio for the bus and tram network together improved from 48·6 per cent to 53·8 per cent; multiple-unit operation will bring further improvements.

Considerable efforts were taken to ensure that the tram route blended in with the

ON SECOND TRAM LINE



environment with the stations forming an integral part of the urban landscape. It has made a favourable impression on both lay and professional visitors, and public transport customers and politicians too have recognised the benefits it has brought to the city.

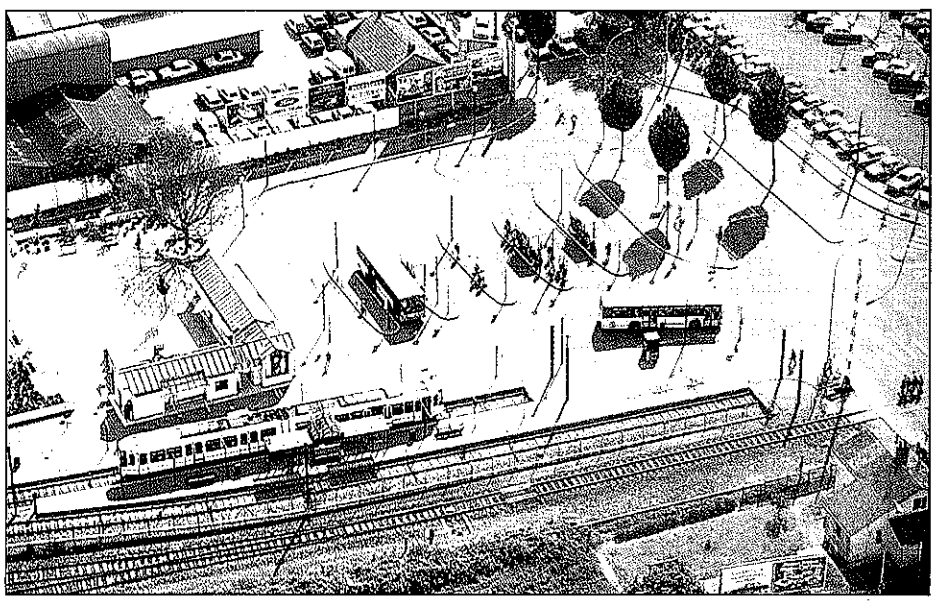
In March 1987 the city council approved a 2 km extension from Haluchère to Beaujoire where the football stadium and an exhibition site are located. If the ministry of transport agrees to contribute to the cost, this addition to the route will open in 1989.

Plans are being prepared for a second route which will run on an 11 km north-south alignment from Sillon de Bretagne to Chateau de Rezé. The case for this line is particularly good as it serves more people than the first line.

Detailed design is already complete for the 6 km southern section with 16 stations from Viarme to Chateau de Rezé, and approval was granted by Nantes city council in September 1987. Six articulated bus routes already run on part of the route on a segregated right of way including bridges over the Loire and Sèvre rivers, which will help considerably in keeping down the cost of building the route. Cost of the first section, excluding 11 tramcars, is Fr294m at 1987 prices. The cost per km is only Fr29m compared with Fr43m for the first route, partly because depot and workshop facilities are already available.

We plan to open the first section in 1991, and the second section from Viarme to Sillon de Bretagne in 1994. □

Most of Line A is laid on reserved track, either a roadside alignment or a paved pedestrian mall (above). Considerable emphasis has been put on tram feeders, with both park-and-ride and bus interchange facilities at the Haluchère terminus (below)



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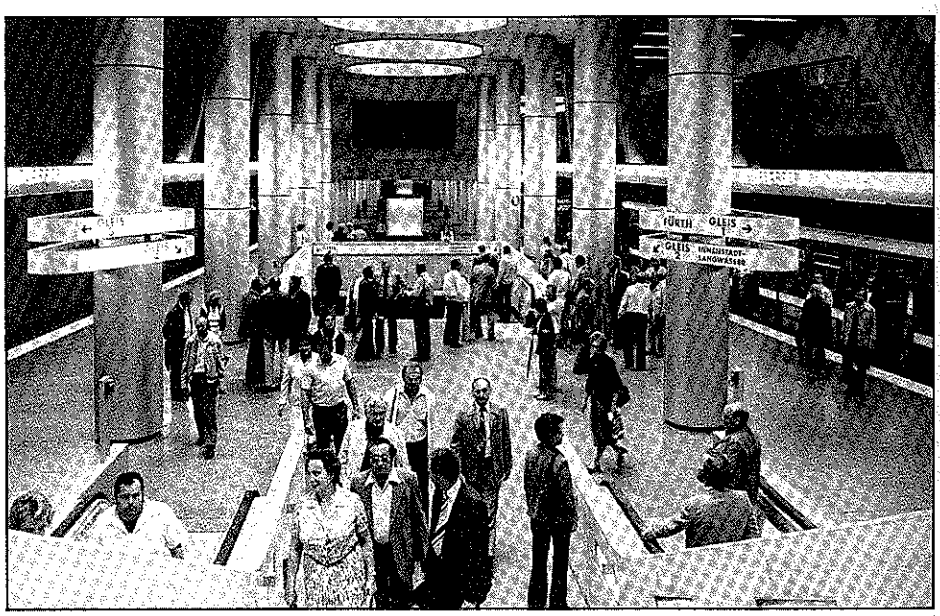
ITALY HAS ONE OF THE WORLD'S MOST TORTUOUS AND CONSTANTLY BRANCHING RAILWAY NETWORKS. AT LAST, THIS PROBLEM HAS BEEN TACKLED WITH SUCCESS AS THE ONLY GOAL. THE ANSWER, IN FACT, IS FIAT FERROVIARIA'S NEW TILTING BODY HIGH SPEED ELECTRIC TRAIN: THE ETR 450. ITS VARIABLE ATTITUDE, I.E. ITS ABILITY TO TILT ITS BODY SECTIONS TOWARDS THE INSIDE OF CURVES, ALLOWS IT TO MAINTAIN A HIGH SPEED EVEN ON CURVED TRACK SECTIONS. THE RESULT IS MUCH SHORTER JOURNEY TIMES OVER SOME OF THE CLASSIC ROUTES ON THE NATION'S NETWORK. THE ETR 450 IS FAST, TOO. ITS MAXIMUM SPEED OF 250 KPH HAS BEEN MADE POSSIBLE BY WEIGHT-SHEDDING ALL ROUND, BY INCREASED ACCELERATION AND BRAKING PERFORMANCE AND BY APPLICATION OF FIAT FERROVIARIA'S ADVANCED TECHNOLOGIES AND KNOW-HOW. SPEED AND FINE PERFORMANCE, HOWEVER, MUST TRAVEL HAND IN HAND WITH COMFORT. THE ETR 450's PASSENGERS CAN ENJOY THE BENEFITS OF AIR CONDITIONING, RECLINING AND SWIVELLING SEATS, HIGHLY EFFICIENT HEAT AND SOUND INSULATION, A BAR AND A RESTAURANT, A NEWSPAPER AND TOBACCO COUNTER AND A PUBLIC TELEPHONE BOOTH. THE FIRST ETR 450's WILL BE BROUGHT INTO SERVICE THIS YEAR. THEY WILL REDUCE THE TRAVELLING TIME BETWEEN MILAN AND ROME TO ONLY 3 HOURS AND 55 MINUTES.

NÜRNBERG BUILDS LINE 2

Dr-Ing Werner Siegloch
Operating Manager
Nürnberg Transport Co



The junction of Lines U1 and U2 at Plärrer is laid out for convenient cross-platform interchange in both directions

ON SEPTEMBER 24 1988 Nürnberg U-Bahn opens the 1·3 km section of Line 2 from Plärrer to the main station. The southern part of the line from Plärrer to Schweinau opened in January 1984, and the section from Schweinau to Röthenbach was commissioned in September 1986.

Construction is now in progress from the main station to Rathenauplatz, and services are due to start at the end of 1990. Still to be built is the northern part of Line 2 from Rathenauplatz to Herrnhütte and the airport. If construction proceeds as planned, Nordostbahnhof will be reached in 1992 and Herrnhütte in 1993.

Plans for a three-line core network totalling 42·1 km were approved by the city council in September 1971, and the last section of the 15 km Line 1 running from Langwasser in the southeast to Nürnberg's neighbouring town of Fürth was opened throughout on December 7 1985. Average distance between the 23 stations is 686 m, and the end-to-end journey takes 29 min with trains running at an average speed including stops of 31 km/h. An extension is planned in Fürth from the main station to the Stadthalle and Würzburger Strasse.

On a typical weekday 410 000 people use public transport in the city, and more than 200 000 of them make use of the U-Bahn for at least part of their journey.

A fleet of 63 two-car trainsets supplied in four batches is sufficient to work services on the present network. The latest batch of 32 aluminium bodied two-car trainsets conforms to the same mechanical design as earlier builds, but features three-phase drive and regenerative braking able to save up to one-third of energy costs. Electronic control of traction current also ensures that passengers enjoy a jerk-free ride. Each set has 98 seats and space for 192 passengers at 4/m^2.

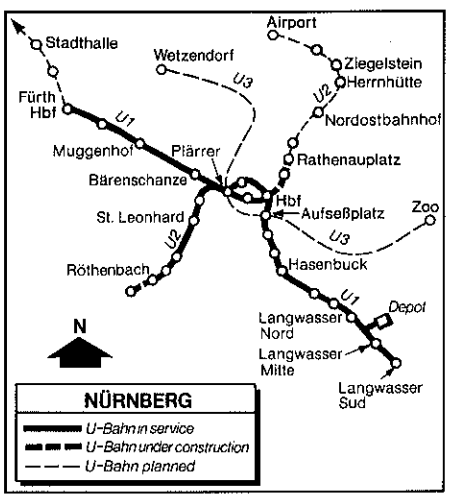
Plans are now being drawn up for the next build, but orders have yet to be placed.

Line strategy

It has always been Nürnberg's policy to build short sections of new line and commission them as soon as they are ready. In this way the benefits are brought to the largest number of people as early as possible, and at the same time there is no risk of the city being cluttered with an unfinished U-Bahn construction site that could quickly become a ruin.

The third line, on which a start has yet to be made, is to have 18 stations in a length of 12·4 km. It will run from Wetzendorf in the northwest to Johannis and then swing west of the city centre before running round the densely populated south of the city to terminate at the zoo in the east. There will be interchange with the other two lines at Plärrer and with Line 1 again at Aufseßplatz.

The main station will become a particularly important interchange with Lines 1 and 2 of the U-Bahn meeting main line, suburban and S-Bahn services operated by German Federal Railway. The first stage of the extensive S-Bahn network was opened in September 1987 with commissioning of the route to Lauf. A total of 67 km of S-Bahn routes are planned with trains operating at 20 min intervals in the peak and every 40 min off-peak. □



Gostenhof station on Line U1 is typical of the intermediate stations on both lines

MAX SPARKS URBAN

James E Cowen
General Manager, Tri-County Metropolitan Transportation District of Oregon

TRI-MET'S Metropolitan Area Express (MAX) exemplifies the impact a single investment in rail transport can have in reducing transit operating costs, stimulating community development and civic pride.

Since opening on September 5 1986, light rail service is pushing Portland's urban revitalisation, begun in 1972, into the 21st century. It is hard to believe that just two years ago there were some sceptics who described MAX as a white elephant, suggesting that we 'leave the keys in it and hope someone steals it.'

The opening had the air of a festival; politicians of every persuasion and thousands of citizens participated in three ceremonies at major stations along the 24 km route. Over 200 000 people showed up for free rides over a weekend which featured entertainment at five locations. The Oregon Symphony, Dixieland bands, clowns, rock groups and scores of volunteers combined to create a three day celebration.

The real test was revenue service. In its first year, MAX carried more than twice as many riders as predicted. Approaching the end of its second year, ridership is closely tracking year one — about 7 million journeys annually with the 15 millionth passenger expected in November 1988.

MAX set a record for paid ridership on June 6 1987 when 70 000 passengers took MAX to Portland's Rose Festival events. Weekday average is 19 000 riders.

Saturdays on MAX are a ridership phenomenon. In spring, summer and autumn, more people ride MAX on Saturdays than on weekdays. A survey of riders suggested that most were sightseers or shoppers; fewer than half of MAX rides were work-related.

It costs Tri-Met half as much to carry a light rail passenger as it costs to carry a bus passenger. As a result of lower operating costs, light rail passengers pay half the cost of their ride, bus riders less than a third.

MAX has attracted many new riders to Tri-Met. Most of the 1 600 spaces in five Park & Ride lots along the line are already filled, and ridership on feeder bus lines has increased slightly since MAX opened.

Eleven MAX drivers carrying 2 000 peak-hour commuters every rush hour do the work of the 27 bus drivers who would be needed to carry the same number of passengers. MAX carries 15 per cent of Tri-Met's total annual traffic using only 8·5 per cent of the operating budget.

Thanks to electric power, MAX is assisting with the regional clean air plan and is better insulating the region from energy-related economic shocks.

Since its opening, MAX has raised the morale of the Tri-Met workforce. Employee attendance is up, and accidents are down.

MAX has invigorated retail and commercial activity from suburban Gresham to downtown Portland. Initial evidence came during the first Christmas shopping season when sales substantially exceeded previous years. Christmas 1987 was even better.

Gresham retailers, traditionally closed on Sundays before MAX opened, now claim Sunday as their busiest day. In downtown Portland, 73 retailers are investing in FreeRide whereby merchants offer custom-

DEVELOPMENT BOOM

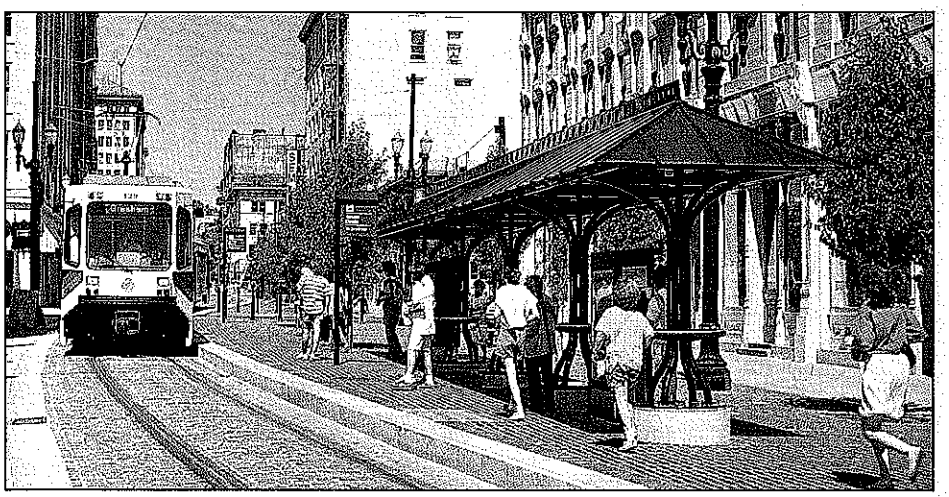
ers a free ride home on Tri-Met in return for a minimum purchase.

MAX is part of a broad regional strategy to co-ordinate transport investments and land use decisions. An early decision to locate it in the middle of key development areas rather than along the fringes was crucial in its success. Development took off in some places even while the line was under construction; the $85m Oregon Convention Center is now being built beside the route.

At Gateway Transit Center where MAX meets a dozen bus lines, a major Northwest grocery chain invested $20m in a new outlet and is rebuilding a large shopping centre. Lloyd Center, one of America's major shopping facilities, is earmarked for a $30m expansion and renovation. The speed of MAX's influence on development is surprising, considering that the major response in terms of development usually occurs five to seven years after a rail line is in place. By the time MAX opened, private development along the line amounted to $214m. Another $300m is already planned.

The next MAX move is to the West. Tri-met Met is conducting preliminary engineering on a 19 km extension to serve suburban Washington county, the state's fastest growing area and home of Oregon's developing hi-tech industry in a corridor dubbed the silicon forest.

Preliminary studies will be completed early in 1990. If approved, MAX could be operating on the West side by the late 1990s, alleviating severe congestion on already overburdened roads.



It has not all been an easy ride. There is a short list of 'Achilles Heel' items that demand continuing attention. For example, Tri-Met decided at the outset against buying air-conditioned LRVs because of Portland's moderate climate. That didn't sit well with riders when a heat wave arrived in the summer of 1987; extra ventilators were added.

MAX's success resulted in 40 per cent more vehicle-km being operated than anticipated in the first year, leaving only four cars as spares in peak hours. Purchase of extra cars is being pursued.

Passengers in the second car are concerned about not being able to contact the driver, and we are studying equipment allowing them to do this.

Traditional cast-iron waiting shelters bring character to the line, as at Yamhill on the outbound line of the city centre loop

Yet there are important signs of success. While the west takes priority for the next route, there is enthusiasm for lines to connect Portland International Airport with the Oregon Convention Center and a major shopping mall in suburban Clackamas County to the south.

The future challenge will be funding construction and operation to consolidate progress achieved to date. □

Brick-paved transit malls introduced with the light rail line have made Portland's city centre more habitable

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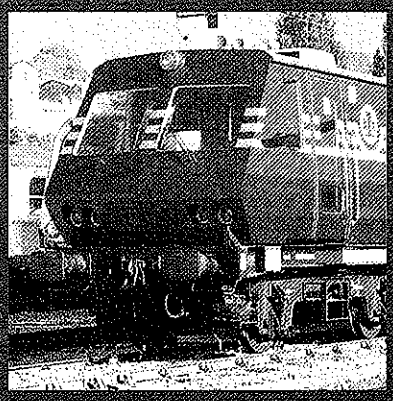


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SAN JOSE GOES DOWNTOWN

James Reading
General Manager
Santa Clara County Transit

ON JUNE 17 1988 Santa Clara County Transit's $421m light rail route moved one step closer to completion. On that day citizens first enjoyed direct service from industrial Santa Clara in the north to the central area of San Jose where a downtown transit mall offers instant access to shops and offices. Now 14·5 km of the 32·2 km route is in service.

Ironically, the area's first electric streetcar service began 100 years ago, along the same route as today's light rail line, but that era ended 50 years ago in 1938. Development of the streetcar network peaked with 203 km of route. Now we are bringing back the rail transit heyday with all the benefits of modern technology.

The centre of San Jose is the site of a major urban renewal project. Along the extension, riders are steps away from the Fairmont hotel and the Retail Pavilion — an elegant shopping complex — as well as from state and federal buildings, numerous offices, shops, restaurants and cultural attractions. Each of the 20 stations features stylish benches and canopies, public telephones and ticket machines.

Still under construction along the downtown segment are the San Jose Convention Center and Children's Discovery Museum, both scheduled for completion next year.

Festive community celebrations took place at the opening. Morning dedication ceremonies were followed by an inaugural ride for officials and free rides for the public for 2½ days.

During the celebration weekend, the local Downtown Association sponsored a food fair and special merchant sales. Music, circus performances and amusement park discounts for all light rail riders were among the highlights.

The 26·8 m light rail vehicles are manufactured in Canada by the Urban Transportation Development Corporation. Each $940 000 car weighs 49·8 tonnes and can carry 167 passengers. The fleet of 50 currently provides service every 10 min for most of the day.

The 14-block downtown transit mall is the hub of San Jose's redevelopment programme. It features red and green granite paving, antique street lamps, glass canopy transit shelters, decorative fountains and hundreds of sycamore trees.

The Mall presented both new opportunities and challenges for the Transit District. For the first time in 50 years, pedestrians, private cars and LRVs met in one central location, and safety awareness in the mall remains one of our primary concerns.

The District has carried out an extensive campaign to inform the community about transit mall safety. More than 200 000 Santa Clara County movie-goers received handouts and saw public service slides before movie showings at 60 theatres. Handouts distributed on board all County Transit vehicles, through direct mail and at major public events helped spread the word, as well as advertisements in English, Spanish and Vietnamese, circulated in 20 local newspapers and publications.

The county's younger population is learning about light rail and transit mall safety through slide presentations and a colouring poster. Safety materials have been given out to 120 000 kindergarten children by sixth-grade students.

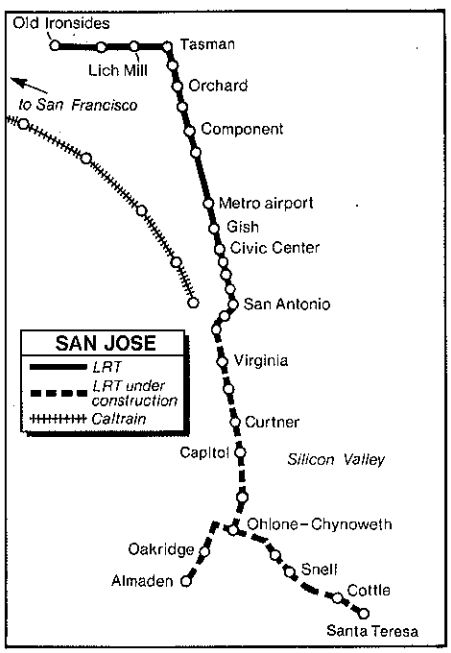
From June 17 the line has been fully accessible to disabled passengers. Lifts are in place at all stations; a series of training sessions was held to familiarise potential users with both the lifts and the cars. For the visually handicapped, station ticket machine instructions are in Braille. In addition, the District has produced a riders' guide designed specifically for elderly and disabled persons.

Together with a 15·5 km freeway, the mall and light rail route form the Guadalupe Corridor Project, named after the nearby Guadalupe river. It is Santa Clara county's largest ever public works project.

To integrate the 79-route bus network with light rail, the District has streamlined and restructured bus routes, resulting in more convenient transfers between bus and rail; 31 routes now connect directly with light rail services.

We anticipate that the downtown segment opening will spark substantial increases in ridership because we shall be serving residential areas for the first time, as well as shops, restaurants, cultural facilities and businesses.

As construction heads south, the next milestone is the 1990 opening at Alma Street, 3·2 km from downtown and the site of a proposed Peninsula Caltrain station. LRVs will roll into residential South San Jose by late 1991. □



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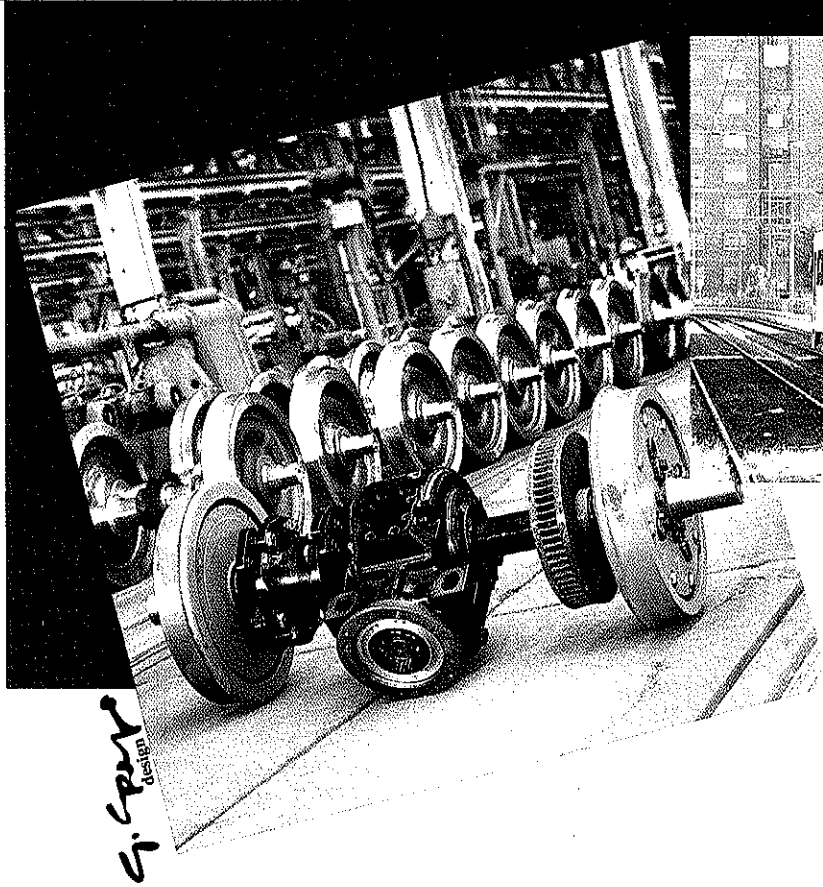

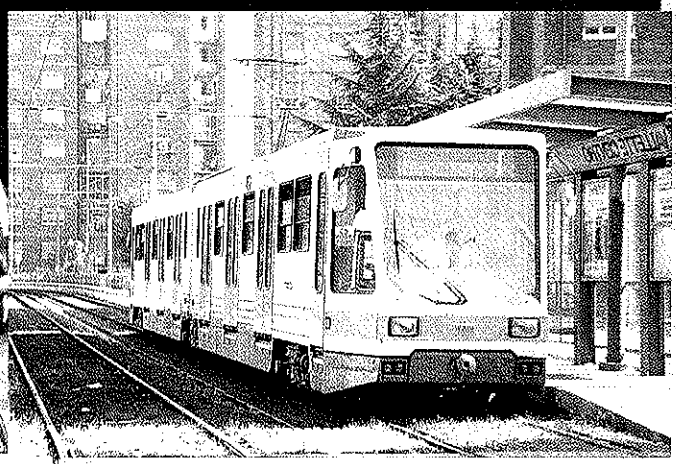

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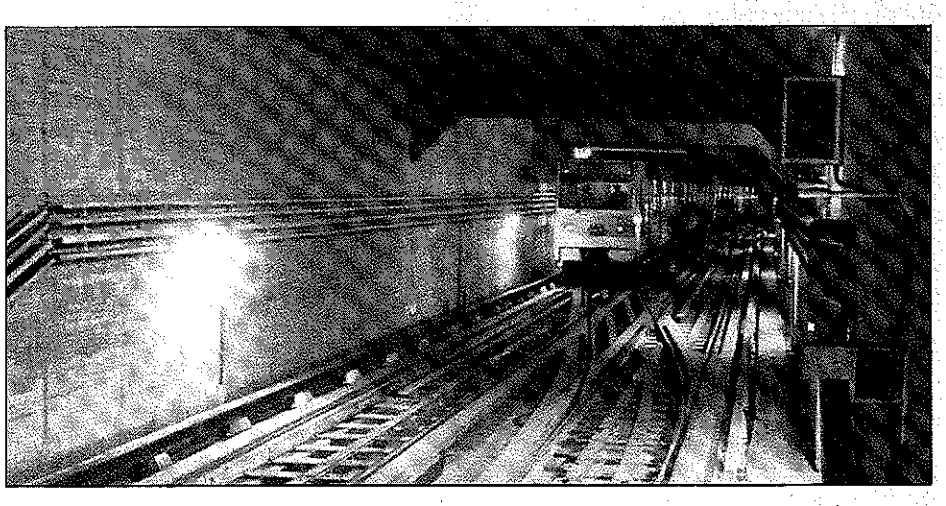
SURVIVAL IN A DEREGULATED MARKET

Luis Iriarte Garcia
Chief Planning Engineer
Santiago Metro



THE RUBBER-TYRED metro in Santiago is the only state owned public transport in the city, which has a population of 4·3 million. Every day the metro carries around 500 000 passengers, representing 12 per cent of journeys in the city. Shared taxis account for another 6 per cent, with 65 per cent of trips being made by 45-seat bus or 22-seat minibus. There are 9 000 buses and 20 000 taxis, all owned by small private companies.

Government policy in the transport sector is total deregulation of routes and fares, which has led to the large number of road vehicles, many of them operating on main thoroughfares parallel to the metro lines. The consequent over-provision of transport has led to fares increases, congestion in the streets and a high pollution index.

Faced with this situation, the Metro management decided to introduce in August 1987 a combined metro-minibus service called Metrobus. The aim was to improve the efficiency of transport within the city by raising the proportion of journeys by metro, partly by offering fares concessions and partly by cutting journey times, so leading to a reduction in road congestion and to a less polluted atmosphere.

At present there are 16 Metrobus routes which connect into the metro at eight stations; about 1 million people use these buses every month.

Extension completed

The most important event in 1987 for the metro was the inauguration on September 15 of Puente Cal y Canto station on Line 2. This completed the 1·8 km extension with two stations begun in December 1984, bringing the length of Line 2 to 11·4 km with 13 stations. Line 1 has 24 stations in a length of 15·9 km.

The latest extension has already brought a 7 per cent rise in traffic — 133 million passengers were carried in 1987, 98 million on Line 1 and 35 million on Line 2.

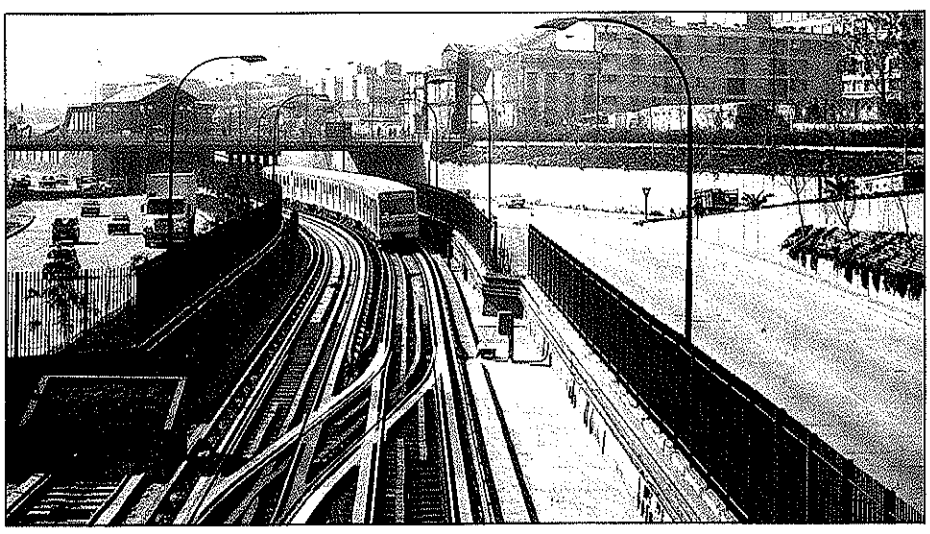
The rolling stock fleet consists of 45 five-car trains. A staff of 1 800 are employed.

Fares are differentiated by line, with that for Line 2 being half the fare for Line 1. An additional payment must be made for transfer to Line 1, equivalent to the rest of the Line 1 fare. Using one of the lowest fare levels in the world, the metro covers all its operating costs, including depreciation for rolling stock and equipment. The ratio of revenue to costs (without depreciation) in the last three years has been 1·6.

The future will see construction of the 16 km Line 3 with 20 stations. This will complete the basic network with three lines serving the whole of the central area and covering the city's main transport corridors; three interchanges will be provided. Extensions to Line 2 running north and south are envisaged, together with an eastern extension of Line 1.

The Metrobus service will also be expanded; this will entail reconstruction of some stations so that they are more suitable for bus-rail interchange. □

The Line 2 extension to Puente Cal y Canto runs at grade through Santa Ana (below) before diving into the terminus (above), which will provide interchange to Line 3 and FFCCE's Mapocho station



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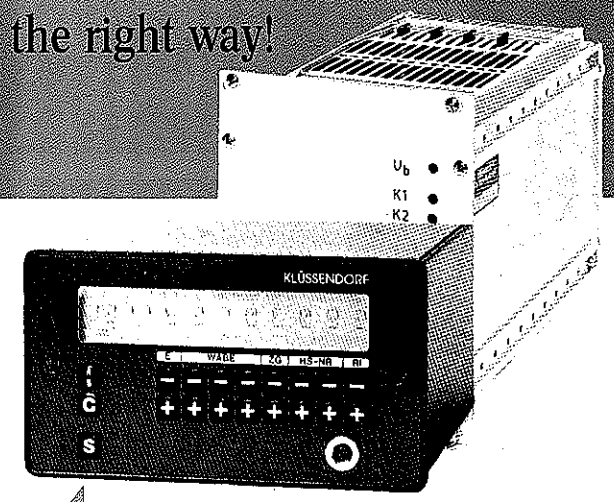

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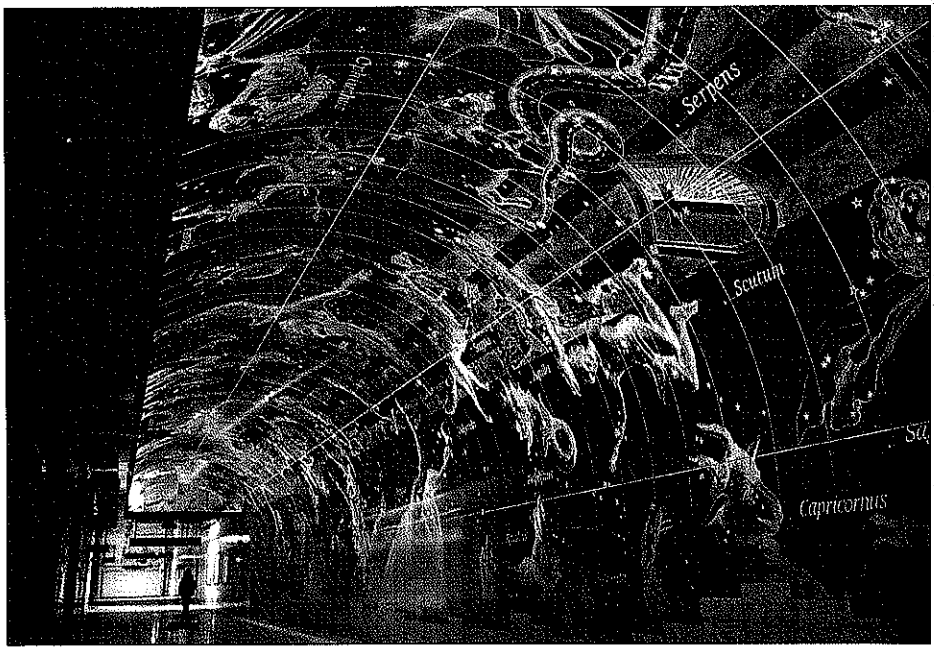
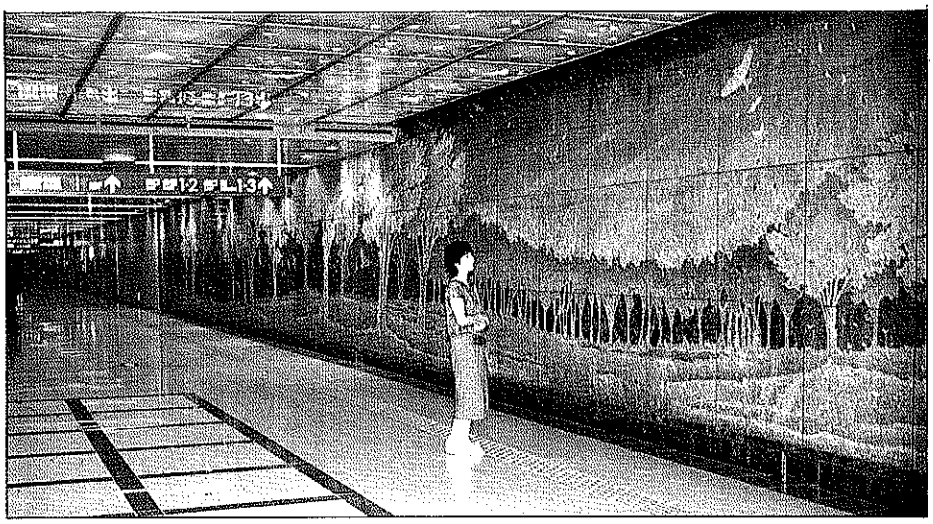
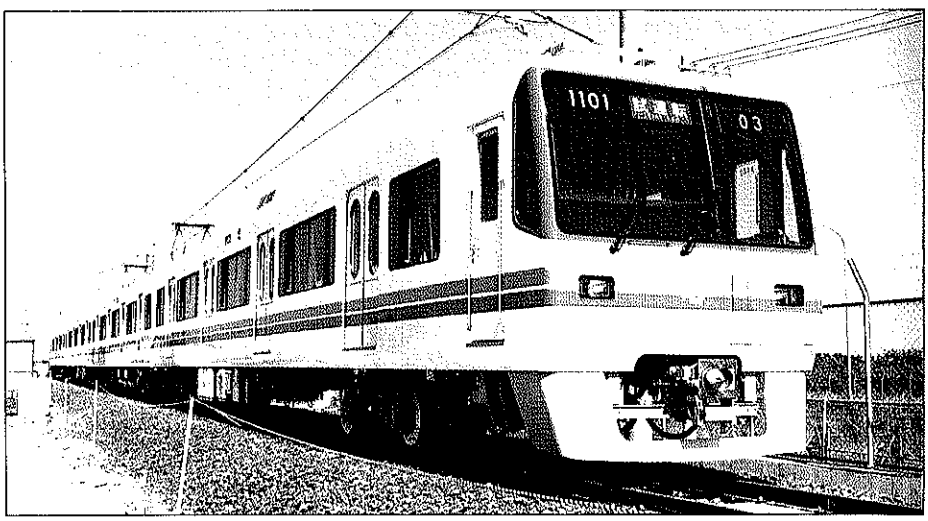
SENDAI SUBWAY SERVES







Hiroyuki Kurata
Sendai Transportation Office

SENDAI CITY, the core metropolitan area of the Tohoku area, is in a phase of remarkable growth, with the population becoming more concentrated and business activity intensifying. As the city centre develops, housing estates are springing up around the city in what is known as the 'doughnut phenomenon'. The sphere of urban activity has overflowed the city boundaries into the surrounding districts. Already the population of the metropolitan area has reached 1·23 million, and demand for transport between the central business district and peripheral housing developments is increasing steadily year by year.

Under these circumstances roads joining the centre to the dormitory towns north and south of the city have become badly congested during the morning and evening rush periods, causing great inconvenience to the inhabitants. To remedy this, Sendai embarked on construction of a mass rapid transit system.

Plans were first discussed in 1967, after which construction proposals were reviewed and refined by various committees. In 1978 Sendai City Council approved the programme. Priority went to a north-south line, and in 1980 a construction licence was granted by the ministry of transport. Work began in May 1981, and the city's first subway route opened for business in July 1987.

At present, trains run every 4 min in peak hours and every 6 min at other times. Every day about 120 000 people use the service.

Starting at Yaotome station in the northern part of the city, the line crosses a hilly area where housing estates are located before it enters the central business district. Passing 36 to 50 m under the city streets, the line serves Atagobashi and then a well-established business and residential area. It tunnels under the Hirose river and traverses dormitory towns in the south before arriving at the Tomizawa terminus where the depot and maintenance area is located.

The 1 067 mm gauge route is 14·3 km long, of which 11·8 km is underground and 2·5 km on the surface. To minimise disruption to the urban fabric, the alignment follows roads for 7·8 km.

Known as the Milky Way because of its dramatic murals (top), the Sendai metro has many other flamboyant works of art in its stations (centre)

Sendai's fleet of 19 four-car trainsets was built at Kawasaki Heavy Industries' Hyogo works

THE MILKY WAY

There are 16 stations, 12 of which are below ground. The longest distance between stations is 1·5 km from Nagamachiminami to Tomizawa, the shortest being the 570 m from Hirosedori to Sendai; average distance between stations is 900 m. End-to-end journey time is 27 min.

Stations are based on a two-level design with separate platform and concourse levels. Sendai station has three levels because of underground gas pipes and electricity cables. Island platforms are provided in all cases, with access by escalator and lifts. Facilities for elderly and handicapped people include special flagstones and wall tape with tactile bumps to guide the blind, special toilets, ticket gates that allow passage of wheelchairs, ramps in the concourses and provision of telephones at strategic locations.

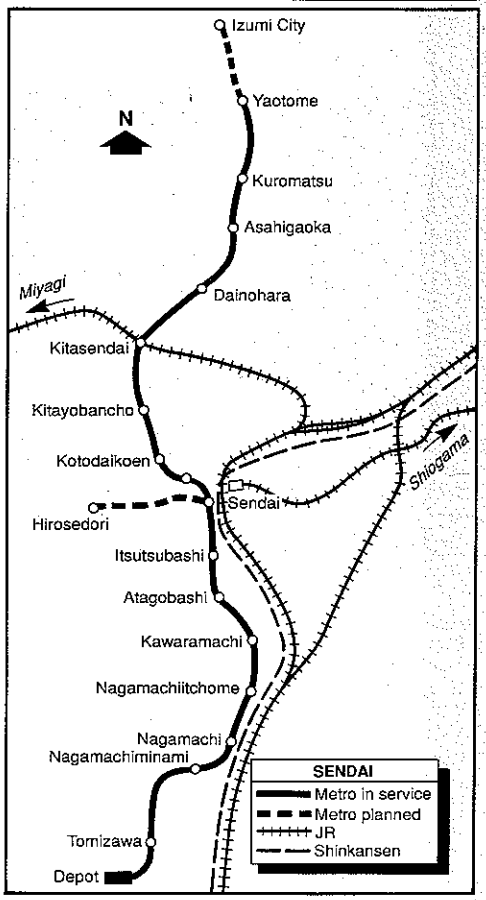
Each station was designed to reflect the character of the surrounding area. In the three central stations, Kotodaikoen, Hirosedori and Sendai, the themes chosen for the concourse decor are particularly striking. Walls and ceiling are decorated in designs that depict zelkova trees, constellations of stars, and scenes from the four seasons, bringing to life and displaying Sendai's image as 'the city of trees.'

The rolling stock fleet consists of 19 four-car trainsets which operate at 1·5 kV dc. Chopper control ensures economic use of electricity and a jerk-free ride up to the maximum speed of 75 km/h. Cars have aluminium alloy bodies and are painted in white with a two-tone green stripe at waist level. Each car can hold 144 passengers.

Designed to be crewed by only one person, the trains are equipped for automatic train operation; a video link is provided for communication with the control centre.

The depot and maintenance yard is sited near the terminus at Tomizawa, occupying an area of 88 000 m^2 on the left bank of the Natori river. Spoil generated by the underground construction was used to level the site.

The yard houses the Total Operations Control Centre, the general offices, inspection sheds, workshops and wheel turning bay. There are six tracks with inspection bays, eight car storage sidings and two wash tracks. Siding capacity allows for expansion to 24 trains of six cars. □



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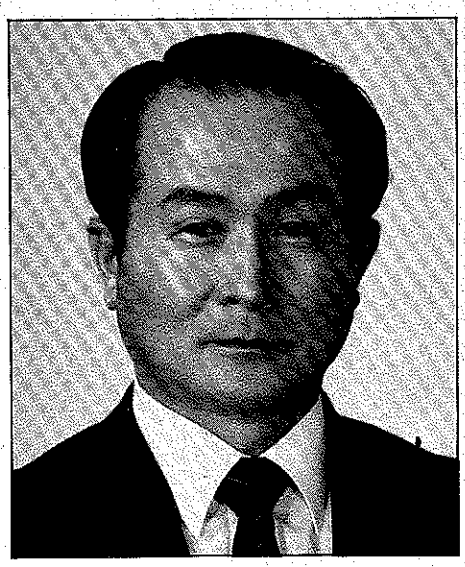
SEOUL CITY government announced details on May 4 1988 of a programme for developing the metropolitan area which includes construction of nine more subway lines amounting to 132 route-km by 2001. Such dramatic expansion of the subway network typifies the progress Seoul has already made in improving mobility for the population.

In the central area of 627 km² live 10 million people at a density of 24 500 per km². Eight small satellite cities are linked to the capital, and the whole urban and suburban area houses over 36 per cent of South Korea's total population. Over 17 million people travel in the area every day, and the Seoul metro already handles more than 17 per cent of these journeys.

Construction of Line 1 from Seoul main station to Chongryangri (9·5 km) began in April 1971; 10 local companies undertook the job and commercial operations taking the form of joint services with Korean National Railroad started in August 1974. A start was made on the second line in March 1978; this forms a 54·3 km circular route round the city opened in May 1984.

Construction of Lines 3 and 4 totalling 59·2 km was carried out from February 1980 to October 1985 by 23 companies. These lines cross under the city centre, so complementing the circular Line 2 by balancing the capital's development pattern.

Construction of Lines 3 and 4 at the same time as Line 2 was a prodigious feat which attracted the attention of the *New York Times*. In its October 13 1984 edition it lauded South Korea as being the first country in the history of subway construction to build subway lines extending to a total of 105 km at the same time.



Kim Jae-Myong
President, Seoul
Metropolitan Subway Corp

This experience was a useful factor for local companies tendering for contracts in other countries. It also enabled members of SMSC and Seoul Subway Construction who supervised and monitored the works to develop a technical and managerial capability which has proved invaluable in planning other projects.

Construction of the underground sections in the city centre required national treasures like the Dongade-Mun gate and the Namdae-Mun gate to be protected from damage, for example by using cork or other anti-vibration materials. The New Austrian Tunnelling Method was used where there was fragile ground or weak foundations, with conventional methods being used in hard rock. The cut-and-cover process was also used.

Special efforts were made to provide a pleasant environment at stations, and the architectural features at each station are unique in displaying Korea's culture. Each station has its own number and signboards colour coded by line. Many have unique murals to help with identification.

In the heart of the city, underground areas are air-conditioned and passengers can enjoy a comfortable environment in exhibition halls, waiting rooms, escalators, shops, restrooms, and shops.

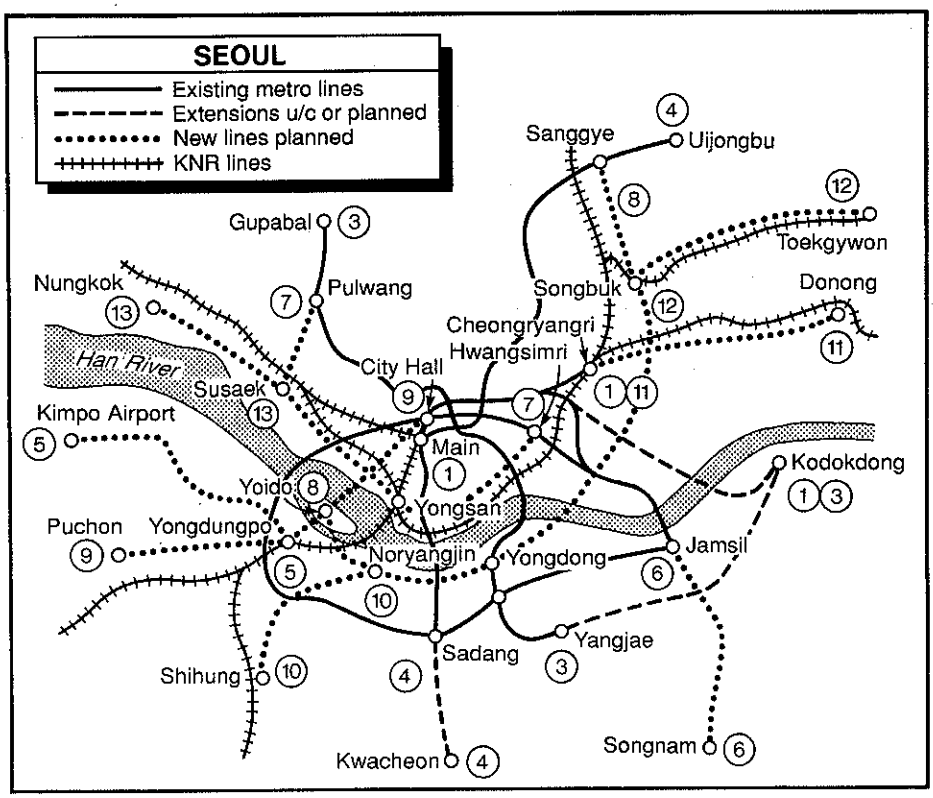
Rolling stock was built while the civil engineering was under way. In 1974 when Line 1 opened, 140 cars were put into operation. By 1984 the fleet had reached 344 cars, increasing to 720 by 1987.

At the moment train headways range from 3 to 10 min. In 1987 over 810 million passengers were carried, with 223 million passengers a day. To increase capacity, a further 142 cars will be added in 1988. An additional car depot is under construction for Line 2 trains.

Line 1 trains are equipped to operate at 1·5 kV dc on the subway section in the city centre and at 25 kV 60 Hz on KNR tracks. Trains on Lines 2, 3 and 4 use dc. Stock on Lines 3 and 4, painted in traditional Korean colours, features chopper control, regenerative braking, air suspension and air-conditioning.

Total Traffic Control enhances efficiency and safety, with trains being regulated automatically and their progress monitored by computer. Each station has centrally controlled clocks and a public address system; electronic signboards are in use for passengers to identify their trains. At stations with curved platforms, cameras are installed for safety, and radio contact is maintained between the incoming train, a line controller and the station control room. Intra-station TV ia also available.

Substations fed by the Korea Electric Power Corp are sited at 3·5 to 5 km intervals, supplying dc for traction and ac for lighting,



TO SUBWAY EXPANSION

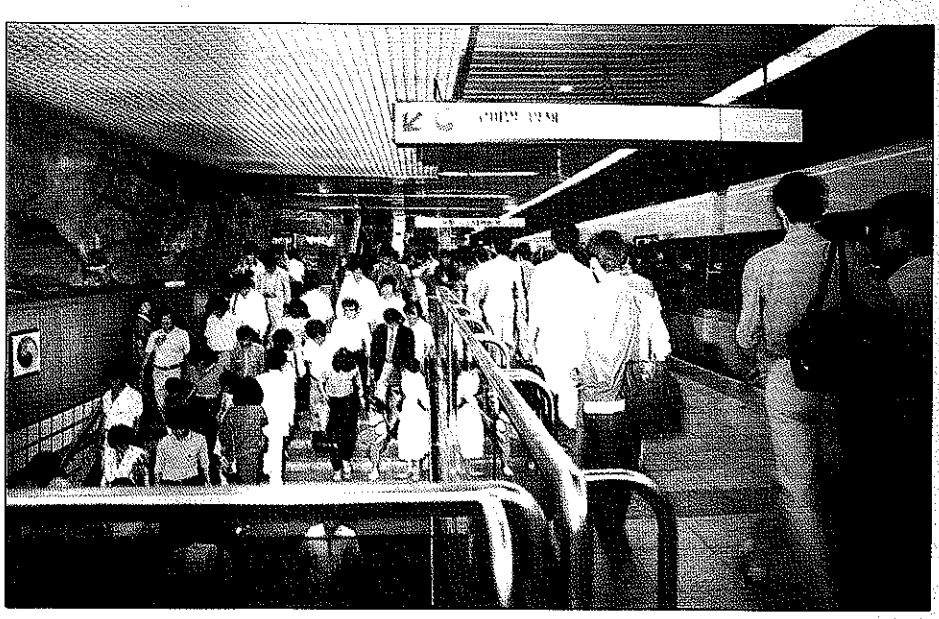
ventilation, signalling and communications.

High priority is placed on safety management during construction and operation; safety is monitored by an inspection team of professional members from the Seoul Metropolitan Government, universities, construction associations and the SMSC.

When the number of passengers per day exceeded 3 million, the fare collection system had to be automated. A central computer collects and analyses all transactions on a daily basis, and counts the number of journeys and revenue earned through ticket machines at 102 stations.

Since the subway opened, there have been remarkable changes in the public transport network in Seoul. The bus network has been reshaped to feed into the metro, which has resulted in the metro taking an ever larger share of daily movements. Riders have also been attracted by large car parks which have been built at strategic locations.

The subway has an important role to play when the Olympic stadium and sports complex is in use. During the Asian Games in 1986, 850 000 passengers or 65 per cent of spectators used the subway to travel to the stadium. Now we are preparing to transport 60 per cent of the 3·13 million visitors expected to visit the 1988 Seoul Olympics. □



Interchange between SMSC's four lines is clearly marked by the red, blue and yellow TaeGuk symbol, with other signs colour coded by line

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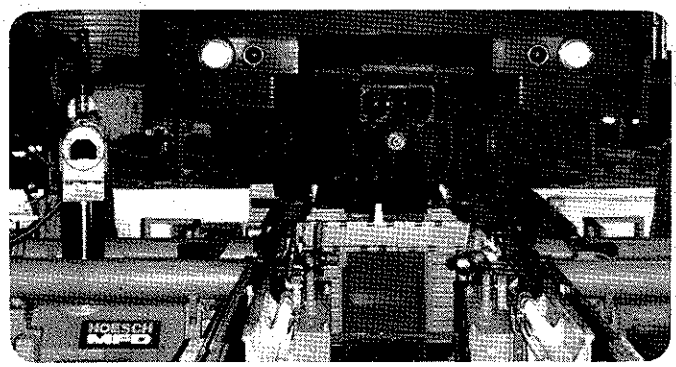
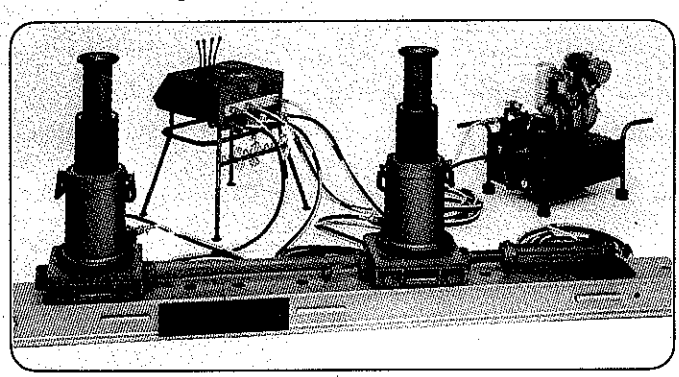
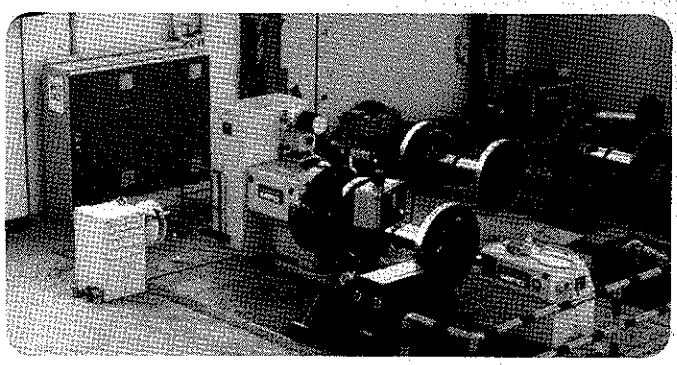


Hoesch MFD-Universal Wheel Lathe for all machining jobs around the wheel set ▼





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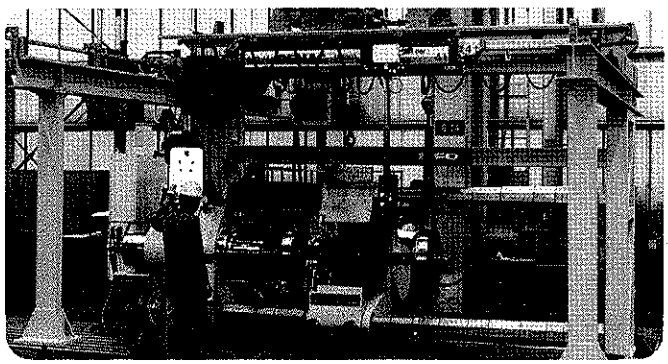

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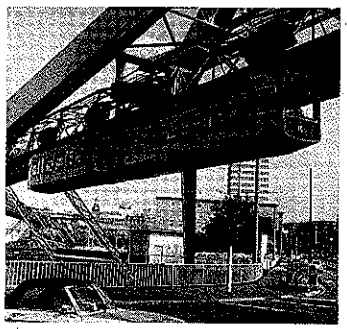

To cope with mass transport problems, municipal and regional authorities have to adopt different concepts depending on the expected passenger volumes, size of area to be served, and topographical conditions.
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H El-Beji
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SERVICES BEGAN on the first line of the 1 435 mm gauge Tunis light rail network in October 1985. Running for 9·5 km from Place Barcelone in the city centre to Ben Arous in the south, Line 1 carried 20·5 million passengers during 1987.

A section which is also used to gain access to the depot runs from Place Barcelone east along the rue du Portugal to serve Farhat Hached and Tunis Marine, where there is interchange to the Tunis – La Marsa Railway, also operated by the Tunis Light Metro Company. Interchange to the main line and suburban routes of Tunisian National Railways is provided at Place Barcelone, where Tunis main station is located.

Three more light rail routes are planned, and all should be in service by the end of 1989. First of these will be the northern route from Place El Fath to Ariana (8 km). It will be followed by the 7 km line from Place El Fath to Bardo and Den Den in the west, and the 4·1 km branch to the north-west suburb of Cité Ettahrir.

A common city centre section runs from Place Barcelone to Place El Fath. This was the subject of some controversy with demands being made for it to be in tunnel. A government decision was taken in 1983 that it would run on the surface along the Avenue de Carthage and Avenue de Paris and in tunnel between Place de Barcelone and Place de Rome under the Rue de Hollande.

Work on the three new lines is well advanced with tracklaying, power supplies and civil engineering about 70 per cent complete.

The rolling stock fleet of 78 eight-axle articulated cars is maintained at a depot common to the Tunis – La Marsa Railway at Tunis Marine. The cars were built in West Germany by Duewag and MAN, and also by Austria's Bombardier-Rotax in Wien, to a design based on the cars in service in Hannover. Duewag monomotor bogies are fitted, and electrical equipment for 750 V dc operation was supplied by Siemens. Maximum speed is 70 km/h.

Light steel bodies have five sets of double doors on each side and seats for 52 passengers are provided; standing space is available for 235 passengers at a density of 6/m². A cab occupies the full width at each end, and a conductor's booth is located in each end saloon.

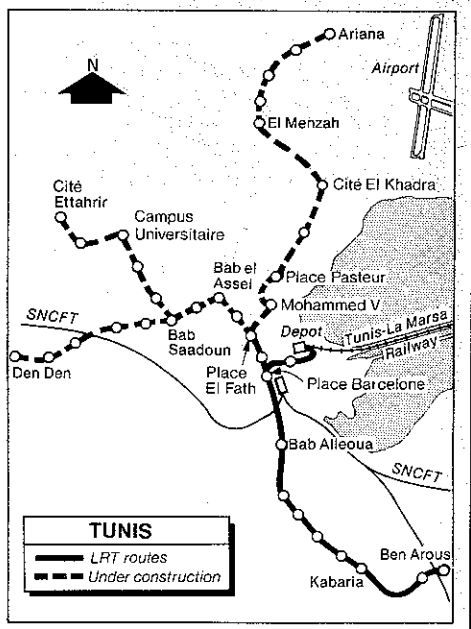
For the moment the cars and other equipment are still under guarantee. Regular testing is carried out to measure performance parameters and to detect faults that may occur in the future.

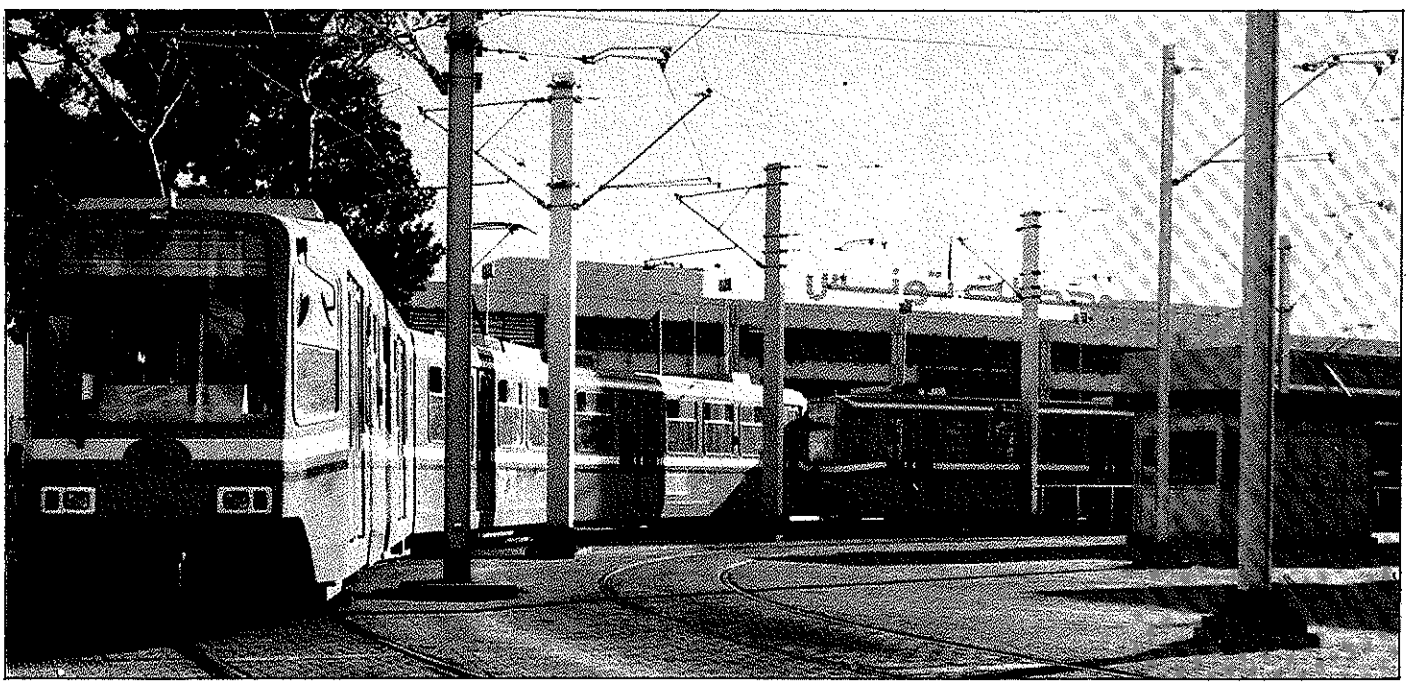
Publicity

Considerable emphasis is placed on keeping the citizens of Tunis informed of developments; this service is mainly targeted at passengers. The Information division has opened a direct telephone line for information and complaints, while suggestion boxes have been provided at all stations, the aim being to deal with dissatisfied customers as early as possible.

The 19 km Tunis – La Marsa Railway carried 20 million passengers in 1987. Since 1978 the line has been completely modernised and the MAN built rolling stock fleet of 18 two-car trains is maintained to excellent standards. This year will see completion of the project to convert the line from third rail to overhead catenary operation.

The light rail network is having a profound effect on transport in the city and its suburbs, and a study has been carried out on the Ben Arous line to determine priorities for light rail cars and road traffic at intersections. The bus network is also being reshaped so that it complements the light rail lines. □





1991 OPENING AWAITED

PROPOSALS FOR a metro in Warsaw were first put forward because of fundamental changes taking place in the city and its suburbs. The city centre needed to be made more accessible from the large residential areas in the suburbs, but prospects for further development of surface public transport in the central area were limited.

A revamped tram network and a pre-metro with underground trams were among the systems considered, as was an underground suburban rail network. In comparison with a metro these were all inferior, particularly as a metro would be entirely independent of other city transport modes. We concluded that a metro was the only socially acceptable answer.

To provide satisfactory links with the suburbs and the main employment areas in the centre a four-line network totalling 105 km is planned. Interchanges will be located at strategic sites so that rail, suburban and interurban bus as well as air passengers have easy access to the metro.

Line A will have 24 stations in a length of 23·1 km, and Line B will have 21 stations and be 25 km long. The 33 km Line C is to have 20 stations, and Line D will run for 24·5 km with 16 stations.

We estimate that metro traffic will amount to 9 million passenger-km a year with an average length of journey of 5·3 km. During the rush hour we expect metro services to carry 42 per cent of all public transport traffic. Depending on the time of day and location, traffic flows will vary from 14 000 to 35 000 passengers/h in each direction.

The government decided to build the metro in December 1982, and construction of Line A was launched in 1983. Work

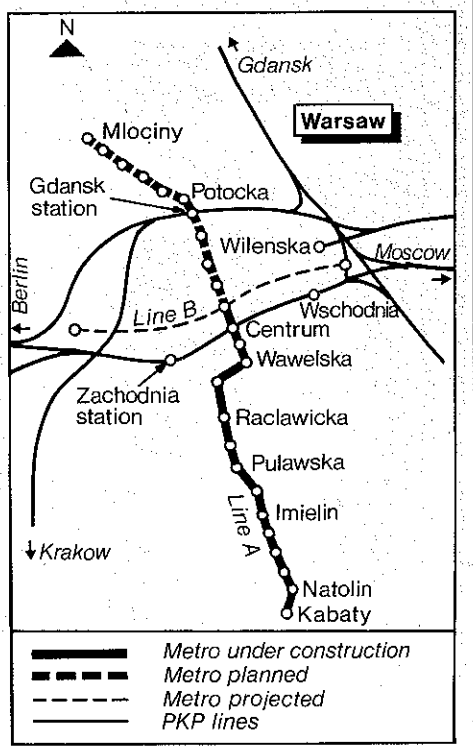
Jerzy Brzostek
General Director, Construction
Warsaw Metro

includes a depot and sidings for 360 cars at Kabaty, and provision of a single track 7 km connection to Polish State Railways.

Stage one forming the southern 12 km of Line A is scheduled to open in 1991, with the central 5 km section following in 1994. The final 6 km section in the north will be commissioned in 1996.

Construction is at a shallow depth of 9 to 15 m below the surface in strata consisting of clays and dusty sands. Open cut is used for stations and certain sections of tunnel. In other locations it was necessary to use the Greathead shield method so as to leave the surface undisturbed. Steepest gradient is 3·1 per cent and the sharpest curve radius was set at 300 m.

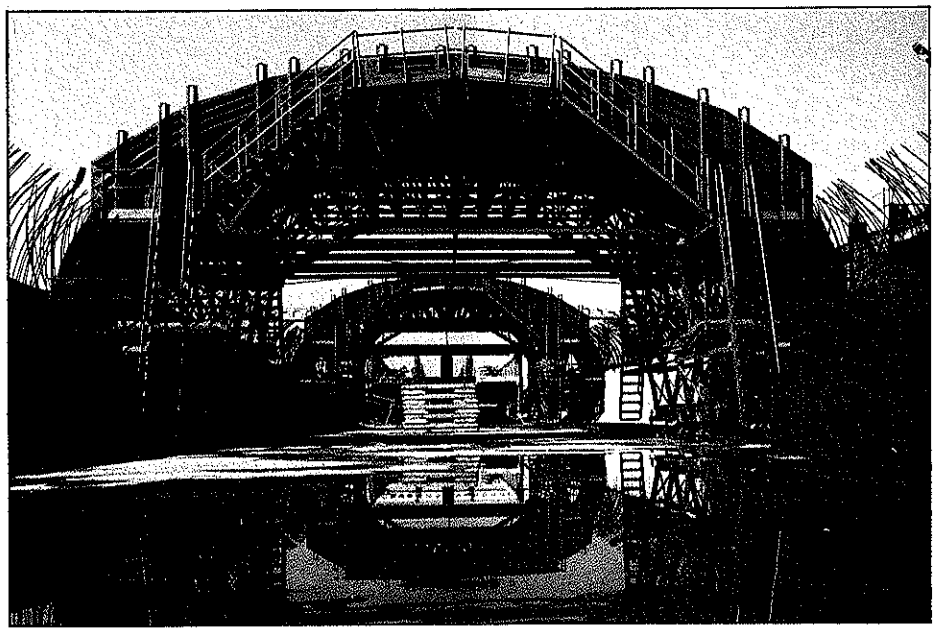
Stations are designed with prefabricated arched or flat roofs supported by columns



located centrally on island platforms 120 m long. Passenger subways are located at each end of the platforms, connecting with subways which provide access to both sides of the street under which the line runs. Longest distance between stations is 1·3 km and shortest distance 610 m.

The six-car trains built in the USSR will operate at 825 V dc third rail at a maximum speed of 110 km/h, with average speed including stops being 36 km/h. In peak periods trains will run on 90 s headways. By the end of 1987 the shell of the first 2·4 km had been completed while the remaining tunnels and the depot inspection site had reached an advanced stage. Installation of station equipment was under way at five stations with finishing work due to start shortly afterwards. Track assembly and laying is due to commence by the end of 1988, and this year will also see a start made on the construction of the metro in the central area.

Passenger information will include public address to individual stations and long-line announcements; information will be provided from the central control room, station control offices and by train drivers. Provision is also to be made for announcements to be made in the tunnels should other means of communication not be available. Closed circuit TV will monitor passenger flows at strategic locations in stations. □



Construction work is now well advanced on the first stage of Line A

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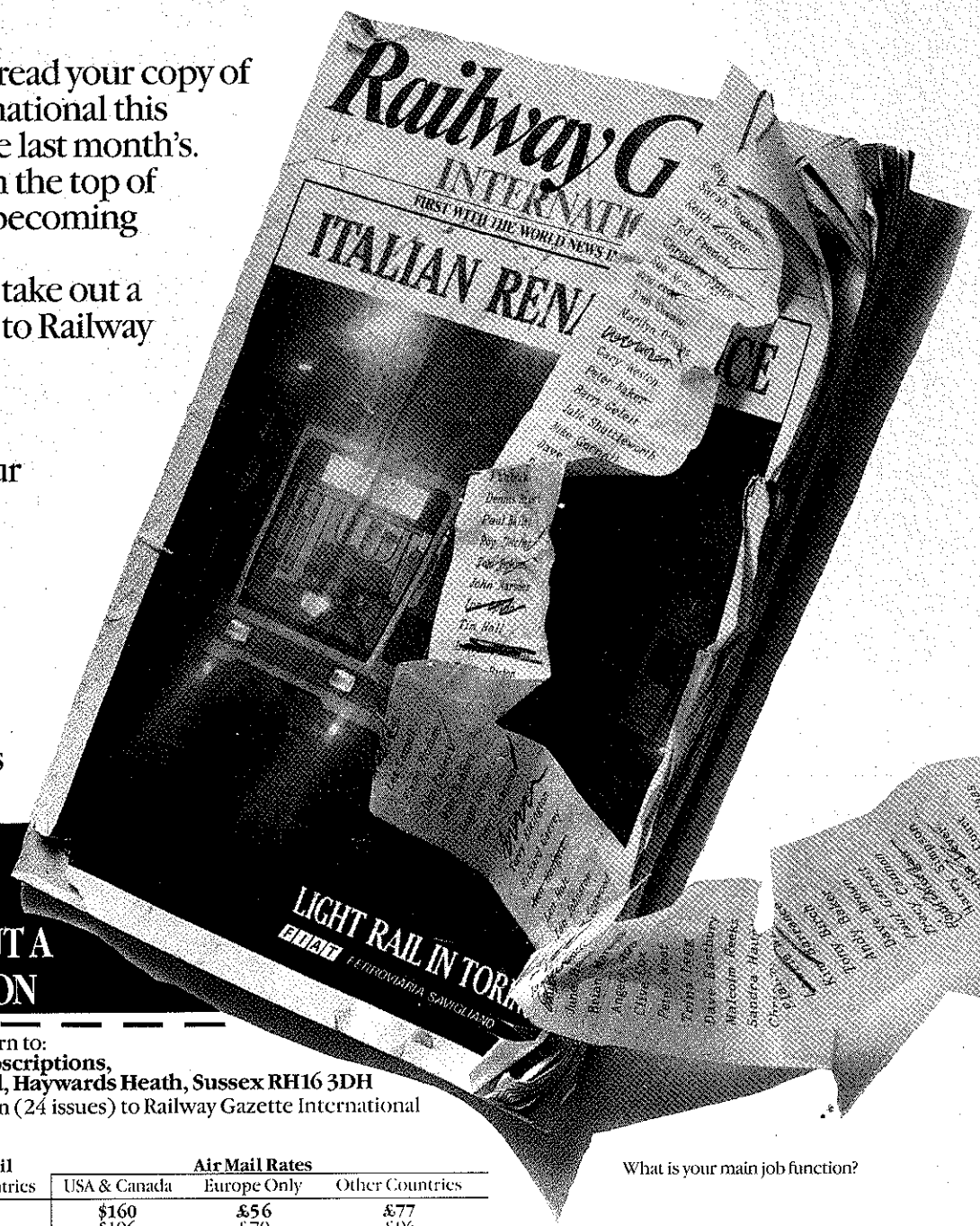

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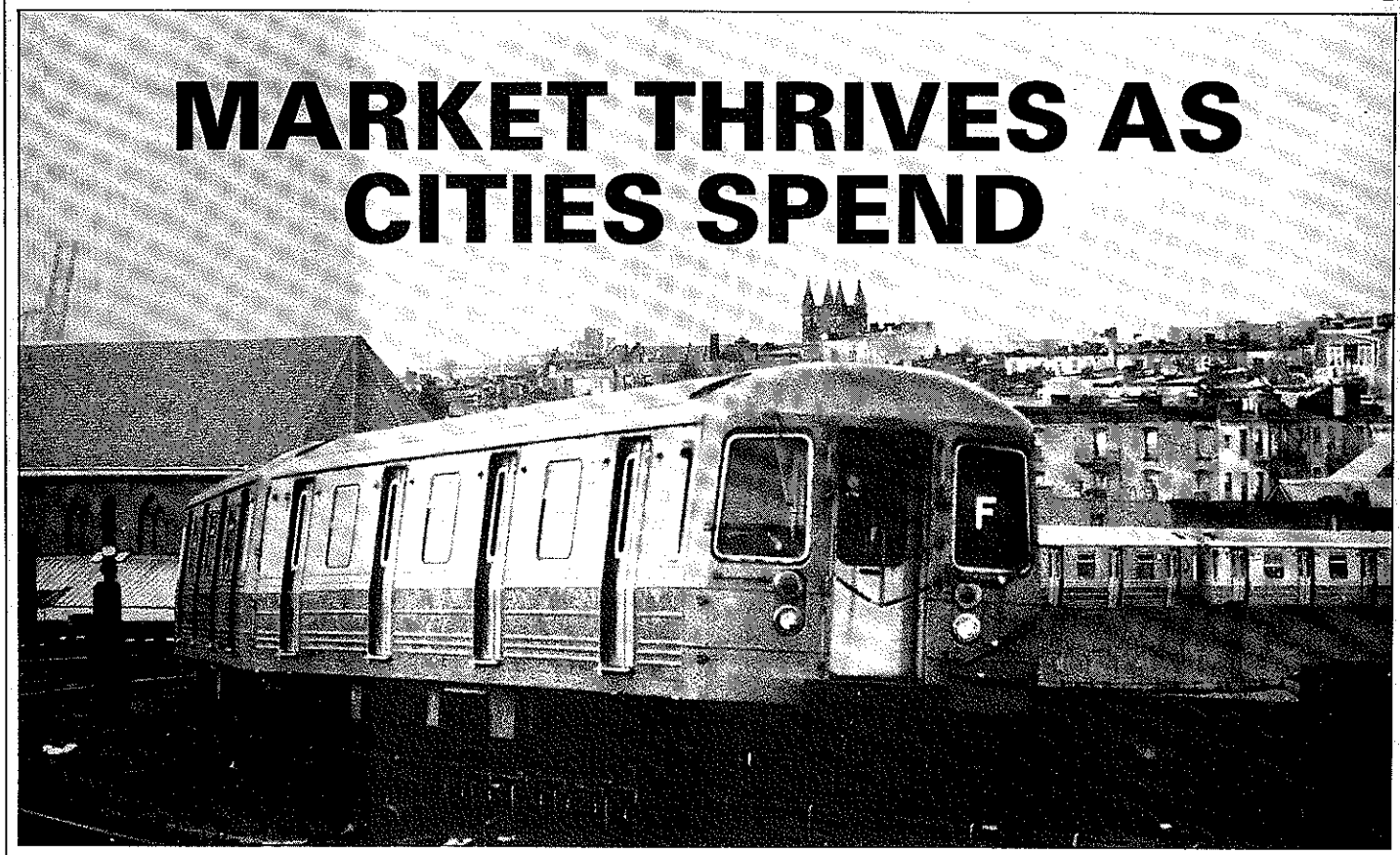


DURING the last two years well over 7 000 urban rail cars have been delivered or ordered. This figure excludes the USSR and most of eastern Europe, but it provides an indication of the scale of rail-based activity as cities face up to the chronic problems generated by rising populations and a legacy of unfettered expansion of urban roads. More enlightened attitudes are even evident in Britain, where trams were driven from all city streets bar the Blackpool seafront in the 1950s and 1960s. Now Birmingham, Bristol, Manchester, Sheffield and Leeds are all looking to light rail as the future backbone of their public transport networks, and it may soon make a comeback in the London suburbs.

London is witnessing remarkable growth in commuter traffic, with orders about to be placed for 1 500 suburban coaches. Some will replace stock dating from the 1950s, but a significant proportion is to handle new traffic. Seating capacity is at a premium, but because of a restrictive loading gauge British Rail cannot exploit the advantages of double-deck cars now so ubiquitous in Continental European cities. Latest addition to the European double-deck fleet is a series of Z2N electric multiple-units for Paris suburban services built by **CIMT-Alsthom** (Express Enquiry Form No 100) with three-phase asynchronous traction motors; trials with the first set began in July.

Australia has long been a stronghold of the double-decker, and delivery of the first of 450 strikingly styled Tangara cars for State Rail Authority of New South Wales from **A Goninan** (101) continues the tradition; **Mitsubishi** (102) is supplying the electrical equipment.

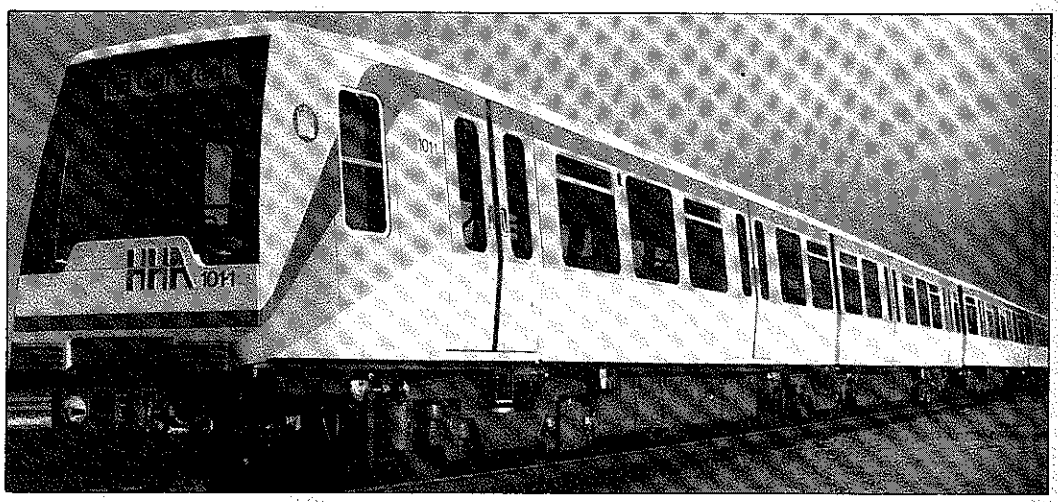
True double-deck commuter trains rather than gallery cars could soon be rolling again on US commuter tracks too if Long Island Rail Road's plans come to fruition; several groups submitted bids last March for 12 pre-series cars due to enter service in 1990: **Alsthom** (103), **Mitsui** (104) and **Comeng** (105), **Sumitomo** (106) and **Nippon Sharyo** (107).

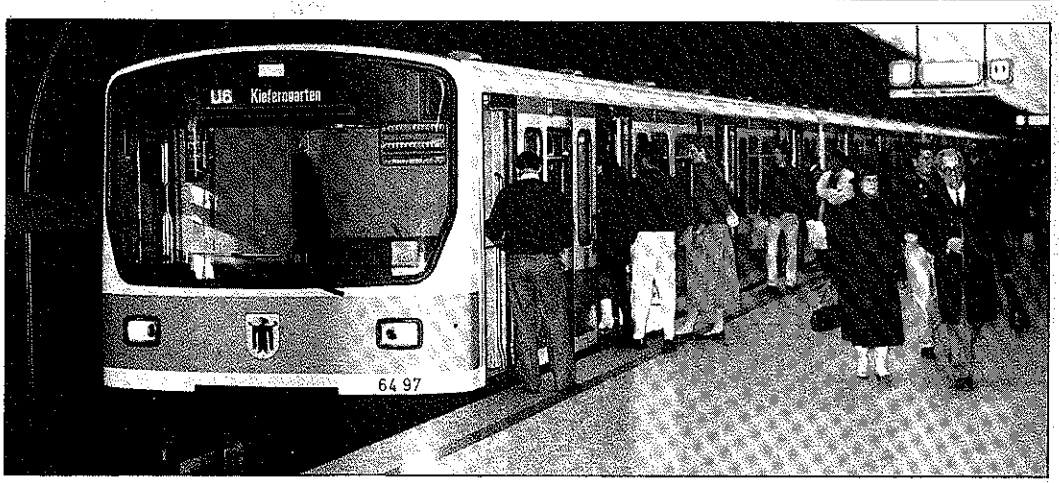
US cities are likely to award contracts for around 1 500 commuter, metro and light rail cars over the next five years. Jackpot prize is a rolling programme in New York which will see 200 cars a year placed in service from the mid-1990s onwards. To win it, bidders must first compete in a run-off of up to four prototype trains

Westinghouse-Amrail delivered these R68 cars to New York City Transit Authority

A Goninan is building 450 double-deck Tangara cars for State Rail Authority of New South Wales

Both the DT4 sets for Hamburger Hochbahn built by LHB (top) and the latest cars for the München U-Bahn from MBB are pioneering progress in electrical design





for which tenders were submitted earlier this year.

Although there is no domestic US car builder left in business, 'Buy America' legislation effectively demands that contractors use assembly plants within US shores. Suppliers who have successfully arranged this include **Breda Costruzioni** (108) of Italy, **UTDC** (109) and **Bombardier** (110) of Canada, **Hitachi** (111), **Tokyu Car** (112), **Nippon Sharyo** and **Kawasaki** (113) of Japan, **MBB** (114) and **Siemens-Duewag** (115) of West Germany, and **Alsthom** and **ANF-Industrie** (116) from France, ANF forming the French arm of **Westinghouse-Amrail.**

While the US market is open to European, Canadian and Japanese builders, Europe remains something of a closed shop with domestic manufacturers almost always taking priority. But the barriers are due to fall in 1992, and already suppliers are regrouping in a bid to secure a share of the market. Asea and Brown Boveri first pooled their resources to form **ABB** (117), and this grouping has just acquired an interest in Denmark's **Ascan Scandia,** which is now known as **Scandia Randers A/S** (118). ABB has also expressed interest in British Rail's subsidiary **Brel (1988) Ltd** (119) which is up for sale to the private sector.

Ansaldo Trasporti (120) is also seeking to secure its position in the marketplace; it has signed a co-operation agreement with Britain's **GEC** (121) and has bought **Union Switch & Signal** (122) in the USA.

Eastern promise

The Far East continues to offer enticing opportunities with long-term expansion of the metros in Hong Kong and Singapore likely as dormitory cities mushroom in peripheral areas. Slow progress is evident with plans in Bangkok and Kuala Lumpur, but a light rail route has been identified in Singapore.

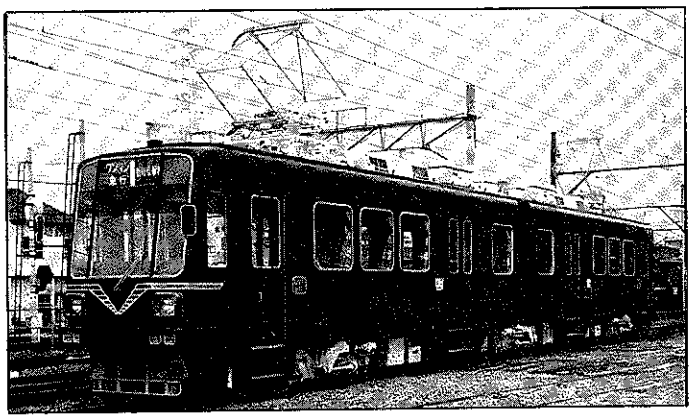
Japanese cities provide a steady stream of contracts for local manufacturers, who are also well placed for business in the Asean countries and China, where Shanghai looks set to move from the planning to the construction phase in the near future.

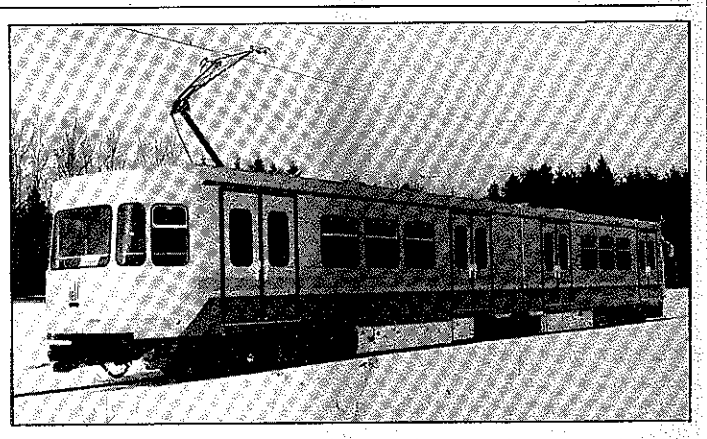
Turnkey contracts remain a sought-after prize. Much effort during the last year has centred on the 44 km Bogota metro with the Italian Intermetro group embracing **Fiat Ferroviaria** (123), **Breda** (124) and **Ansaldo** being designated by the Colombian transport minister as the victors; 156 cars are needed.

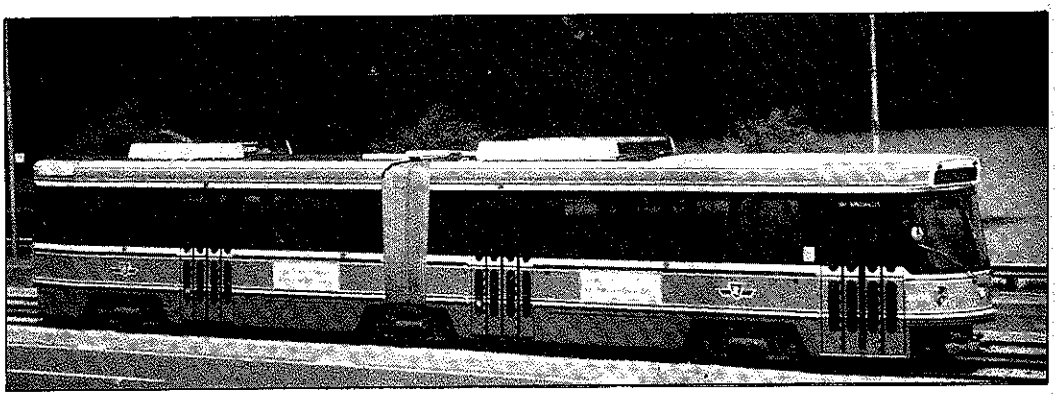
Ankara was another city where bidders congregated until the mayor announced in July that **UTDC** had been chosen to build the 14·5 km first line of the metro under a build-operate-and-transfer deal. As the terms of loans and credits take on increasing importance in bidding contests, BOT seems set to become more common, but it does depend on contractors being allowed the freedom to set fares at realistic levels.

Light rail cars have seen rapid development in recent months with the emergence of the first generation of low-floor vehicles. Switzerland's **ACMV** (125) has made much of the running with its designs for Genève and Bern, but **Alsthom** and **De Dietrich** (126) of France have produced an innovative tram design for Grenoble which this summer saw trials in Rotterdam. German builders **Linke-Hofmann-Busch** (127), **MAN-GHH** (128) and **Duewag** (129) are also developing low-floor cars which should see revenue service within the next two

Paris Transport Authority is experimenting with steerable axles and full-width inter-car gangways on its Boa metro prototype







Top left: Nagoya Railroad has taken delivery of these 1 067 mm gauge LRVs for 600 V dc operation from Nippon Sharyo

Above: One of 105 LRVs for Istanbul from Asea Brown Boveri, with bodyshells by Simmering-Graz-Pauker

Left: Toronto Transit Commission accepted the first of 52 six-axle LRVs from Can Car Rail last January

years. Italian suppliers **Fiat Ferroviaria** and **Firema** (130) have yet to see experimental vehicles yield series orders.

Progress in electrical design has centred on rapid advances in solid-state technology and power conditioning with the advent of gate turn-off thyristors in main traction circuits, which according to **ABB** may soon incorporate optic fibres too. Asynchronous three-phase motors are now penetrating the British and North American markets, having already conquered much of Continental Europe. Setting the trend in West Germany are the DT4 trainsets for Hamburger Hochbahn which feature water cooled asynchronous traction motors and self-commutating static converters with reverse conducting thyristors. Built by **Linke-Hofmann-Busch**, these advanced four-car units are due to enter service from mid-1989.

Similar progress in Japan promises long-term cost savings for operators with the introduction of microprocessor controls and freon cooling. **Mitsubishi Electric** for example has developed 16-bit microprocessors for a wide range of applications; the company is also using optic fibres for gate signal transmission as a means of eliminating mafunctioning or misfiring of the thyristors.

Among export orders notched up by Japanese builders are nine knock-down kits for Heliopolis trams in Egypt, due for delivery this year from **Kinki Sharyo** (131). The same company is supplying 30 LRVs to Boston's MBTA this year.

GEC Transportation Projects Ltd (132) of Great Britain is another leader in electronic development, with microprocessor controls and on-board

Exhibition draws Far East traders

OVER 40 companies supplying equipment to urban railways will be present at the exhibition being staged by the UITP at Singapore's World Trade Centre on October 11-13. Due to be opened formally by Singapore's Minister of Communications & Information Dr Yeo Ning Hong, the show will be a leading attraction for city transport specialists gathered at the UITP congress.

Most exhibitors are from Europe. Belgium's ministry of transport will have a joint display with **ACEC, BN Constructions Ferroviaires et Métalliques** and the Hainault Research Centre. **Automatic Systems, Prodata** and consultants **Transurb Consult** will also be represented.

The French Commission for Overseas Exhibitions is co-ordinating a display embracing rolling stock, fare collection and component suppliers: **Alsthom, CGA-Camp Alcatel, Crouzet** — which will be concentrating on its Magbus equipment —**Delachaux, Domange-Jarret** and **Ferraz, Montcocol, Sambre et Meuse, Sodeteg-TAI, Soulé, Sycafer** and **Schlumberger Industries.**

The **Federation of French Railway Industries** and the **Equipementiers Ferroviaires Français** groups will both be present; associated with the EFF stand will be seat suppliers **Compin** and **Sablé** and the **Saft** company.

Britain will be represented by rolling stock builders **Brel (1988) Ltd, Metro-Cammell, Leyland Bus** and **Walter Alexander**, with air-conditioning specialists **Stone International** also taking space.

Luxembourg's **SA Metallurgique et Minière de Rodange-Athus** will have a stand, and **Ansaldo Trasporti** will lend an Italian presence.

From West Germany **Linke-Hofmann-Busch, Duewag** and **Waggon Union** will form the car builders' contingent, while electronics and electrical equipment supplier **Siemens** of Erlangen is also planning to participate. **Thyssen Engineering, Bergische Stahl Industrie, Voith** and **Klöckner Stahl** make up the rest of the German manufacturers, but **Light Rail Transit Consultants** and the **Studiengesellschaft für Nahverkehr** will have representatives on hand.

Swiss exhibitors will be **ABB-Sécheron** and monorail specialists **Von Roll Transportsysteme.**

From Hong Kong and Australia the **Leighton-MTA Consortium** which put together the Tuen Mun light rail package will be exhibiting. Other countries due to be represented are the USA, Sweden and Korea.

fault diagnosis giving important savings in maintenance costs. GEC's recent contracts include GTO equipment for BR's Thameslink trains and for the Docklands Light Railway cars, 10 more of which are being built by Brel (1988) Ltd under LHB licence; an option for 10 more may be exercised. GEC has also supplied electrical equipment for Madras suburban EMUs being built by **Integral Coach Factory** (132) and for London Underground's prototypes for replacement of the Central and Northern line tube stock fleets.

Docklands also gave GEC an opportunity to demonstrate an automated minimetro, bringing the British supplier into the same field as **Matra** (133) of France, whose VAL system pioneered in Lille is being adopted in Toulouse, Bordeaux and Strasbourg.

UTDC is negotiating to build an extra 16 cars for Toronto's Scarborough minimetro line, while an extension of Detroit's downtown peolpemover to an island casino could bring more business for the company.

Automation is certain to spread to heavy metros in the next few years, with Lyon Line D being the first candidate and Paris expecting to convert one line as a pilot project.

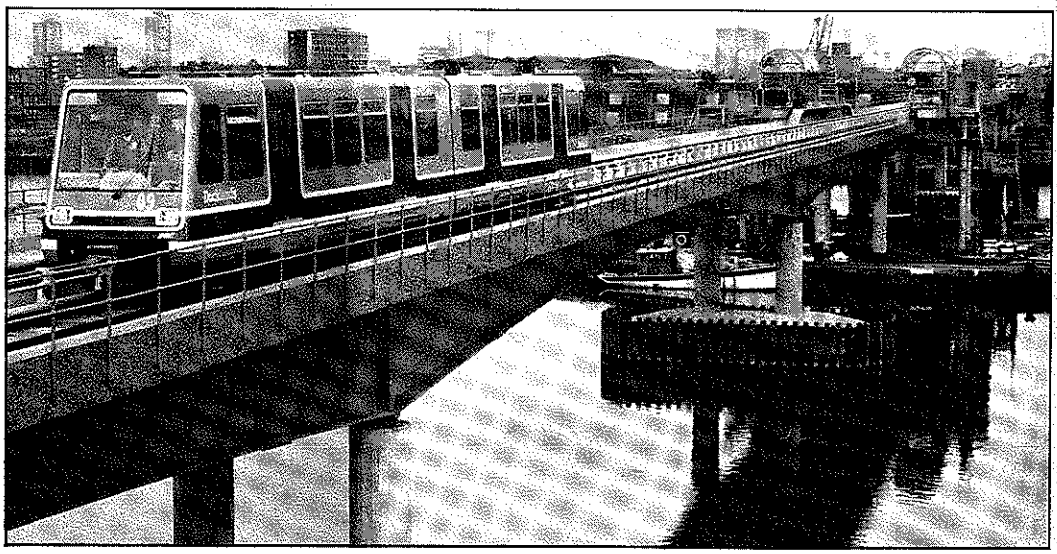
Special-purpose small-profile vehicles for metro maintenance provide a steady demand for suppliers such as **Plasser & Theurer** (134) which has developed scaled-down versions of its main line track machines. **Speno** (135) has just delivered a small-profile grinding train to Paris Transport Authority.

Tunnel and track cleaning vehicles are also in demand, and **Zweiweg-Fahrzeug** (136) exhibited its ZW100S unit based on a Unimog U1650 for cleaning grooved rails at this year's Hannover fair. The operator can chose chisel, water jet or suction nozzle as he needs.

Another approach has been adopted by **Bombardier-Rotax** (137) of Wien for the city's U-Bahn with the development of a twin-section vehicle featuring recess and gully suction devices. The company has also supplied rail-carrying cars for use on the Hamburg U-Bahn. Some of the most impressive vehicles to emerge from this firm's stables are the 10-axle L10 light rail cars recently delivered to Linz.

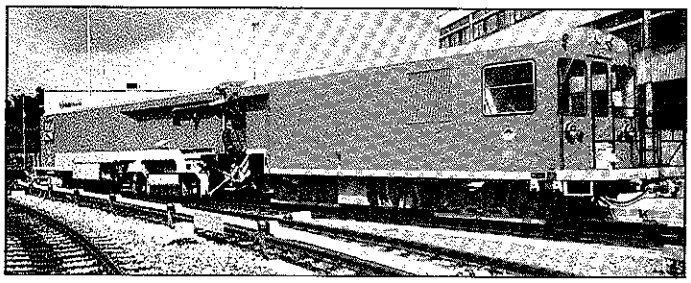
Advances in electronics are bringing rapid changes in the field of automatic revenue collection, and intelligent machines able to interface with customers can now perform complex tasks. At the same time advances in equipment for change giving and note verification are helping to reduce the workload at booking offices. Computer networking techniques allied to microprocessors are simplifying accounting tasks and offer management the ability to monitor and assess revenue more effectively.

Similar progress is evident in passenger information systems where flap, dot matrix or liquid crystal displays can be linked to signalling systems to provide passengers with real time information. This is a discipline that is attracting newcomers from the computer field into the railway market.

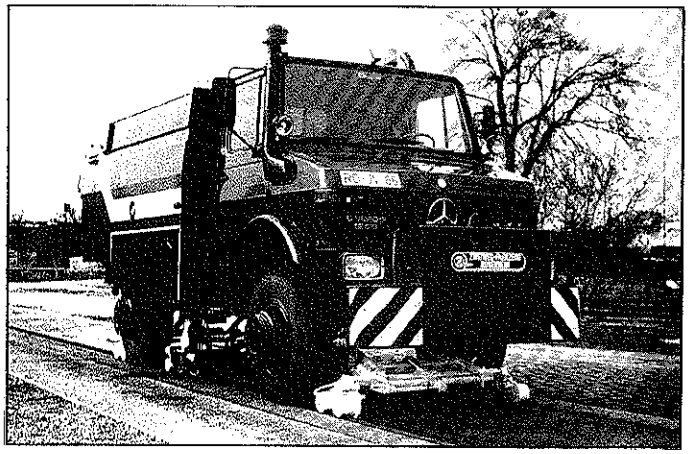


Above: GEC was main contractor for the automated Docklands Light Railway cars; LHB supplied mechanical parts; 10 more are being built by Brel (1988) Ltd

Right: This 10-axle Type L10 LRV for Linz with Sibas 16 microprocessor control was built by Bombardier-Rotax



Centre right: Bombardier-Rotax built this track cleaning vehicle for the Wien U-Bahn



Right: Based on a Unimog U1650, Zweiweg-Fahrzeug's ZW100S grooved rail cleaner has road and rail capability

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