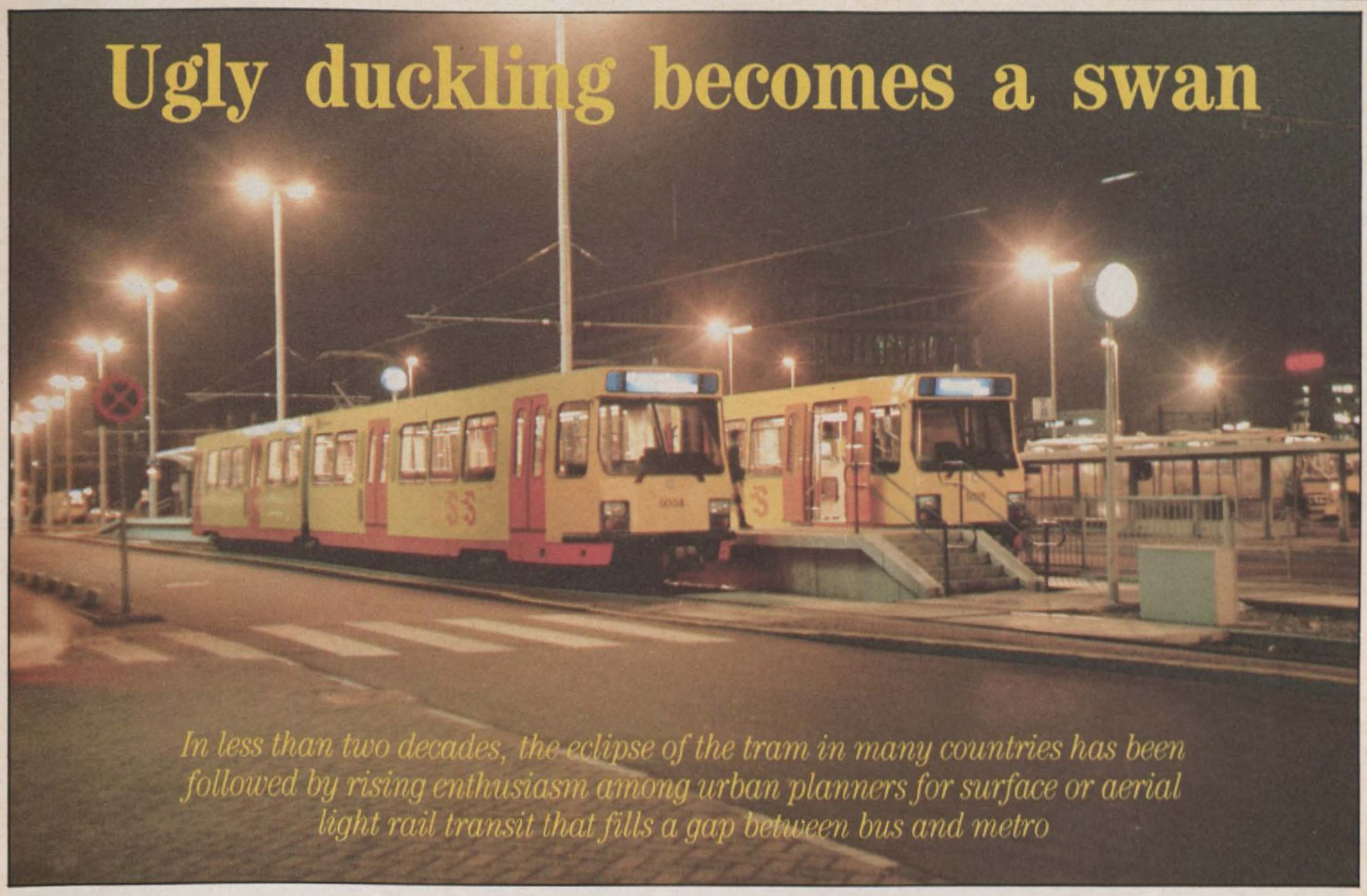
Ugly duckling becomes a swan



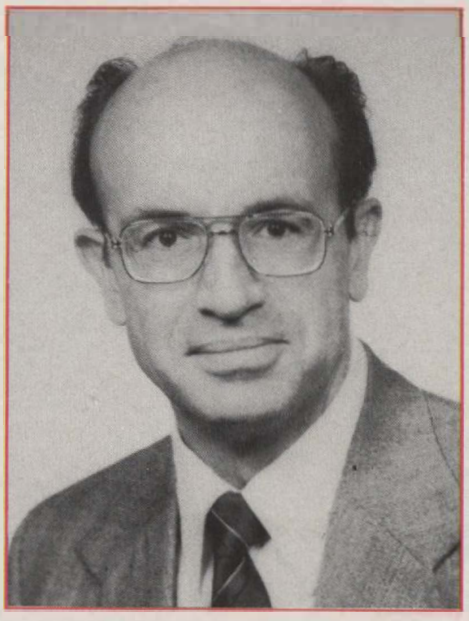
In less than two decades, the eclipse of the tram in many countries has been followed by rising enthusiasm among urban planners for surface or aerial light rail transit that fills a gap between bus and metro

PLANS PREPARED during the 1960s for transit improvements in such diverse cities as Pittsburgh, Seattle, Edmonton, Amsterdam, Johannesburg and Bangkok considered only the enhancement of bus services and construction of a conventional metro.

Similar plans prepared today include a greater number of potential modes, with light rail transit (LRT) increasingly selected as a favoured choice for busy corridors and networks. New LRT lines or networks are already operating in Buffalo, Calgary, Edmonton, Manila, Nantes, Newcastle-upon-Tyne, Rio de Janeiro, San Diego, Torino, Tunis and Utrecht—a list that could no doubt be extended depending on accepted definitions of 'new' and 'LRT'.

At least a dozen entirely new networks are under construction, as in Sacramento and Grenoble, and many more are being adapted from existing tramways as in Charleroi. A similar number of LRT systems are at the planning stage, including the 258 km Dallas network and lines in such cities as Los Angeles, Buenos Aires and Kuala Lumpur.

What has brought about such a drastic change in transit planning in less than two decades?



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Emergence of LRT

Tremendous pressure to accommodate the rapidly increasing number of cars in cities, which peaked during the 1950s and 1960s, had a major impact on urban structures, character, and on the role and type of transit systems. Suffering low speeds and long delays from street congestion, tramways were proclaimed in some countries as 'obsolete in the automobile era'. Buses were considered 'more flexible' and therefore better suited to the new conditions, while an increasing number of cities embarked on construction of metros which were completely segregated from street traffic.

By 1970, the majority of cities in the United States, Great Britain, France, Canada, Scandinavia and many other countries had abandoned trams. Transit consisted of buses and, in a few cases, metros.

A commonly expressed opinion was that rail-based transit must be completely separated from all other traffic, from which it was concluded that metro and regional commuter lines were the only rail modes suitable for modern cities. Moreover, the theory was expressed that for economic reasons a city should not have more than two transit modes. London's elimination of trolleybuses was based on that curious rationale.

Such thinking was not universally accepted. In West Germany, Switzerland, the Netherlands, Belgium and some other countries the concept of an 'automobile-dictated city' was rejected as not just undesirable, but infeasible. To create a livable city, it was argued, public transport must provide a high-quality service that can only be achieved if transit is separated from general traffic and street congestion.

As separate transit rights-of-way become available, the relationship between buses and trams changes considerably in favour of the latter. The manoeuvrability of the buses becomes irrelevant, while much higher capacity, electric traction and superior riding comfort make rail modes more desirable wherever passenger volume justifies their higher investment and lower operating costs.

Dozens of West German cities, as well as Zurich, Rotterdam, Den Haag, Göteborg, Brussels and other central European cities embarked on improvement rather than replacement of their tramways. The change was gradual, but very significant. By the 1970s these cities had high-capacity, comfortable, quiet articulated cars with many doors used simultaneously (due to self-service fares) running on tracks which were largely separated from other traffic. They offered high-quality service, in many respects competitive with the automobile.

Eventually, the rail systems one could see in

Köln, Göteborg or Frankfurt were more similar to a small-scale metro than to the old-fashioned two-axle trams with two trailers travelling along streets at 10 to 12 km/h.

A new name had to be coined to describe them, so the terms 'light rail transit' in English and 'Stadtbahn' in German were introduced. Although the public — and even some experts — still confuse these concepts, and there are systems which fall somewhere between the two modes, a typical tramway such as that found in Vienna, Milano or Hong Kong is very different from LRT systems operated in Hannover, Göteborg, Calgary and San Francisco.

Medium-capacity modes needed

If transit modes are presented on a diagram of performance (consisting of travel speed, capacity, reliability, safety, service quality and other elements) relative to investment costs, as in Fig 1, buses on streets occupy the region of low performance and low investment while metros rate much higher in both respects.

As the diagram shows, there is a large gap between buses and metros. Cities relying on these two modes, or on buses alone, eventually began to realise that there are many corridors which need much better service than conventional buses can provide, but cannot justify the cost of a fully grade-separated metro.

To fill this gap between buses and metros, several solutions (listed in order of increasing investment) have been tried in the last 10 to 15 years:

- **Reintroduction of trolleybuses:** Used in Belgrade, Sao Paulo, San Francisco and several other cities, this solution increases identity of transit and improves its environmental characteristics through electric traction, but does not increase capacity or speed.
- **Semi-rapid buses:** Provision of reserved or exclusive bus lanes and busways for sections of a route was given much attention in the USA, as well as in many European and some Latin American countries. Reserved lanes have had acceptable results in cities with police enforcement and traffic discipline; they have failed where these are weak. The most successful example of improved bus performance is the corridor in Sao Paulo where, by reserving up to four parallel lanes, bus capacity of 20 000 to 25 000 passengers/h has been achieved; (the frequently quoted bus capacity in New York's Lincoln Tunnel is irrelevant because this highway section has no stops along its length). Busways can provide a substantial improvement of bus service with a corresponding increase in investment costs, but its entire concept has been seriously damaged by recent developments in the USA where busways have been opened to non-transit buses, vans, car pools and various other vehicles. This 'increase in utilisation' reduces bus service reliability and safety, encourages major competitors, and (perhaps most important) weakens the image of a distinct, independent transit facility.
- **Bus with optional guidance:** Developed recently in Germany as the O-Bahn, this dual-mode bus has increased riding comfort and safety on a guideway which physically prevents mixing of other vehicles. Disadvantages of O-Bahn in comparison with conventional busways are lower capacity and reduced flexibility (no overtaking except at off-line stations) and higher investment costs. O-Bahn appears promising in rather special situations, as in narrow rights-of-way in street medians or with dual propulsion in short city centre tunnels.
- **Modernised tramways or streetcars:** By reserving special street areas for tracks and stops using physical barriers such as kerbs and corresponding police enforcement, several cities such as Amsterdam, München, Toronto and Zurich, have shown that even without the major right-of-way separation characteristic of LRT, tramways can provide very attractive service. For longer lines transition to LRT operation is needed to achieve higher speeds.
- **Light rail transit:** Operating one- to four-car trains of articulated vehicles on predominantly separate rights-of-way, LRT can provide a great variety of performance elements up to 20 000 passengers/h and a commercial speed of 35 km/h. With this diversity LRT has in recent years proven to be the most promising solution for medium-capacity transit.
- **Automated guided transit (AGT):** After a long period of experiments with various unconventional technologies and operational concepts, such as on-call operation and headways of a few seconds, the AGT mode has now been built in several cities. VAL operates in Lille and New Tram in Osaka, with similar systems in a few other Japanese cities, while a Skybus line is to open soon in downtown Miami. Compared to LRT, AGT systems generally have lower capacity but higher speed and frequency during off-peak hours. However, their automatic operation necessitates fully separated rights-of-way which makes AGT expensive to build. AGT thus represents an appreciably higher investment mode than LRT but it offers all the advantages of fully-automated operation which

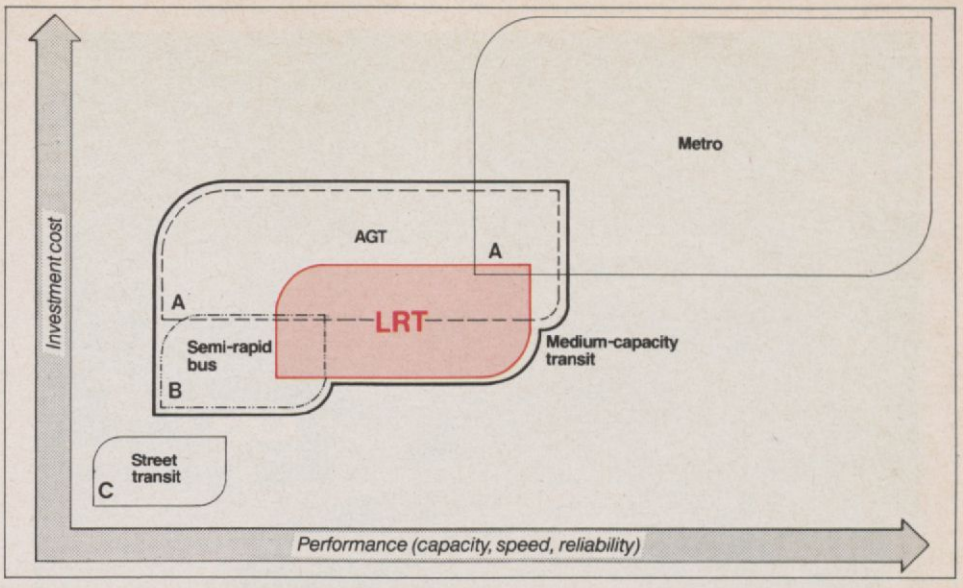


Fig 1. The generic classes of transit mode can best be considered in terms of the investment cost needed to generate a package of performance characteristics

Where it has proved possible to remove road traffic to adjacent streets and create a transit mall, the quality of city life undergoes a major improvement which makes shopping and other activities a pleasurable experience. This street in Calgary is shared by light rail and buses so that both modes benefit by avoiding downtown traffic congestion

Transition from the tram

TYPICAL OF the West German approach to LRT is that displayed by the Baden-Württembergische city of Freiburg im Breisgau, where opening of a 2·2 km extension on June 14 marked the latest stage in a 15-year programme to upgrade an existing tram network.

The line from Paduaallee to Landwasser is the final section of a new segregated LRT route serving the western suburbs which was started in April 1976.

From a junction with the north, east and south lines at Bertholdsbrunnen in the city centre, the west route crosses the DB station on a 329 m bridge incorporating an interchange station.

The first 3·5 km of line, as far as Paduaallee, opened to traffic in December 1983, but since then a new junction has been laid at Runzmattenweg. A new flyover carries the LRVs over a major road junction, and the 219 m bridge also forms a flying junction with a new 300 m spur to Bissierstrasse.

The 2·2 km extension beyond Paduaallee to Landwasser includes several rural stretches where the line passes through woodland to serve a bike-and-ride interchange at Moosgrund. Elsewhere, roadside sections of the route have been grassed over to improve the local environment. A five-minute interval service using 32 m long articulated LRVs connects at the Landwasser terminus of Moosweiher with feeder buses to several outlying districts. Moosweiher is also equipped with a car park for 130 cars.

The inner end of the western route will see extra services from 1987, when the existing tram route between Hauptbahnhof and Friedrich-Eburt Platz is replaced by a new 1 km LRT line from Technisches Rathaus. A 2 km extension from Bissierstrasse to the Transport Authority's West workshops is currently in the planning stage, and this will be followed by a 4 km link from the works to Johanneskirche on the existing south line to Gunterstal which will complete the southwestern ring. An extension of the north line from Zähringen as far as Gundelfingen is also planned.

metro operators have been unjustifiably reluctant to recognise as desirable, and to use.

- **'Advanced' or 'automated' LRT:** The system recently opened to serve Scarborough in suburban Toronto, and its twin under construction in Vancouver, consists of bogie rail cars, similar to LRT vehicles, operated on fully segregated right-of-way in a fully automatic mode, and powered by linear motors. Consequently, this system represents a hybrid between LRT and AGT. Strictly speaking, the designation 'ALRT' used in Vancouver is incorrect, since LRT is defined as a mode capable of using rights-of-way which are partially separated (B) or with mixed road and rail (C), as well as fully-separated (A). ALRT can use only rights-of-way in category A.

Although most AGT systems have rubber tyres, there is no reason why they should not use steel wheels, maglev or any other support. ALRT is therefore an AGT rail technology. Alternatively, it can be considered as an automated mini-metro, or automated light rail rapid transit (ALRRT).

Two major tests of this mode will be observed in the foreseeable future. As well as UTDC's projects in Toronto and Vancouver, London Regional Transport is building in Docklands a somewhat similar system with conventional motors. If present projections and expectations are fulfilled, the ALRRT should outperform other AGT systems in capacity, and offer such advantages of rail technology as simple guidance and switching as well as high riding comfort of spacious, bogie-supported vehicles.

LRT characteristics

The concept of modern LRT was introduced to North America with UMTA's assistance in the 1970s through several reports[1,2] and specialised conferences on that subject organised by the Transportation Research Board[3]. That publicity reached professional circles in many other countries. Descriptions of LRT emphasised the potential diversity of this mode in technical and operational characteristics and its possibilities for deployment in stages.

Developments since that time have fully confirmed that claim,[4,5] so it is now possible to set out the characteristics of modern LRT.

Rights-of-way should be separated from street traffic as much as possible. Though most lines are category B, category A is not unusual, as in Manila where street congestion is severe, and category C is acceptable where traffic is light and separation would be very expensive. Street medians, railway rights-of-way and green areas are commonly used; viaducts — as in Charleroi and Manila, but with even lighter structures in future — will be used increasingly, particularly in developing countries. While tunnels are common for short sections in urban centres (Hannover, Boston, Edmonton), there has been a trend towards pedestrian malls — a very popular solution in Mannheim and Calgary (shared with buses) as well as in Portland and Sacramento where LRT is under construction.

Stations vary from simple paved areas along the tracks with a small shelter (San Diego) to small-scale metro stations above or below ground. A key factor affecting the design is platform height relative to the car floor. They may be high (Edmonton), low (San Diego), a

combination of high and low with automatic change on the car (San Francisco), or low steps with intermediate-height platform (Den Haag).

Signalling is not needed on open air sections because the maximum speed is generally 70 to 80 km/h and magnetic track brakes provide emergency braking rates of up to 3 m/s^2. Block signalling is used in tunnels, and traffic lights at major road intersections.

Probably the best example of the diversity in infrastructure and type of operation LRT can have is found on Line 16 running between Köln and Bonn, and into the heart of both cities. The line uses viaducts, tunnels, medians and street running with and without signals, and has stations with low and high platforms.

The vehicles have also seen many innovations recently. Four-axle single-body cars have virtually disappeared: Melbourne, Philadelphia, Toronto and Buffalo have been among the few western cities which recently purchased them. Six-axle cars with body lengths of 18 to 23 m are most popular, followed by 27 to 30 m long eight-axle cars. Widths on existing networks vary from 2·20 to 2·50 m. For new or reconstructed systems, such as Newcastle, Utrecht and most North American systems, a larger version of six-axle cars has been the predominant choice: length varies from 23 to 28 m and width from 2·50 to 2·65 m. Tunis and Manila opted for eight-axle 29 to 30 m long cars; the extra bogie does increase weight, but it allows negotiation of sharper curves which is a desirable feature. Most new systems have bidirectional vehicles and multiple-unit operation. Hannover and Manila operate two eight-axle cars in a train; Calgary and San Diego run one to three and San Francisco up to four six-axle cars.

Mechanical and electrical innovations have been numerous. Pantographs have replaced trolley poles. Choppers and regeneration capability, with substantial energy savings, are becoming standard. Resilient wheels, rubber inserts and air bellows ensure soft and quiet running. Large windows are popular because they increase the sense of contact with surrounding urban or suburban scenery.

An important feature of any well planned light rail service is good interchanges where passengers can be fed into the network by bus and car. This example in Hannover underlines the advantage offered by light rail in enabling passengers to transfer between modes without the delay and exertion involved in a change of level

Cost variations

Costs are a function of infrastructure and vehicle types. Surface lines in Edmonton, San Diego and Sacramento involve investments of $3m to $5m per kilometre, but Pittsburgh, Buffalo and some future lines in Los Angeles are expected to cost $20m to $30m per kilometre due to difficult urban conditions and tunnelling. Justification for such high investment is not only in benefits to riders but also decreased street congestion, environmental improvement and attraction of property development.

The greater complexity of modern vehicles has tended to increase maintenance costs, but labour productivity has improved remarkably during the last 25 years. Fig 2 shows the evolution from typical tramways found in some European cities up to 1960 to the present LRT vehicles. If we take account of the fact that operating speeds have at least doubled due to improved rights-of-way, one can conclude that one operating person on a modern LRT system produces about 20 times more space-km than his predecessor in an old fashioned tram! This is worth pointing out to people who still fail to see any difference between tramways and LRT.

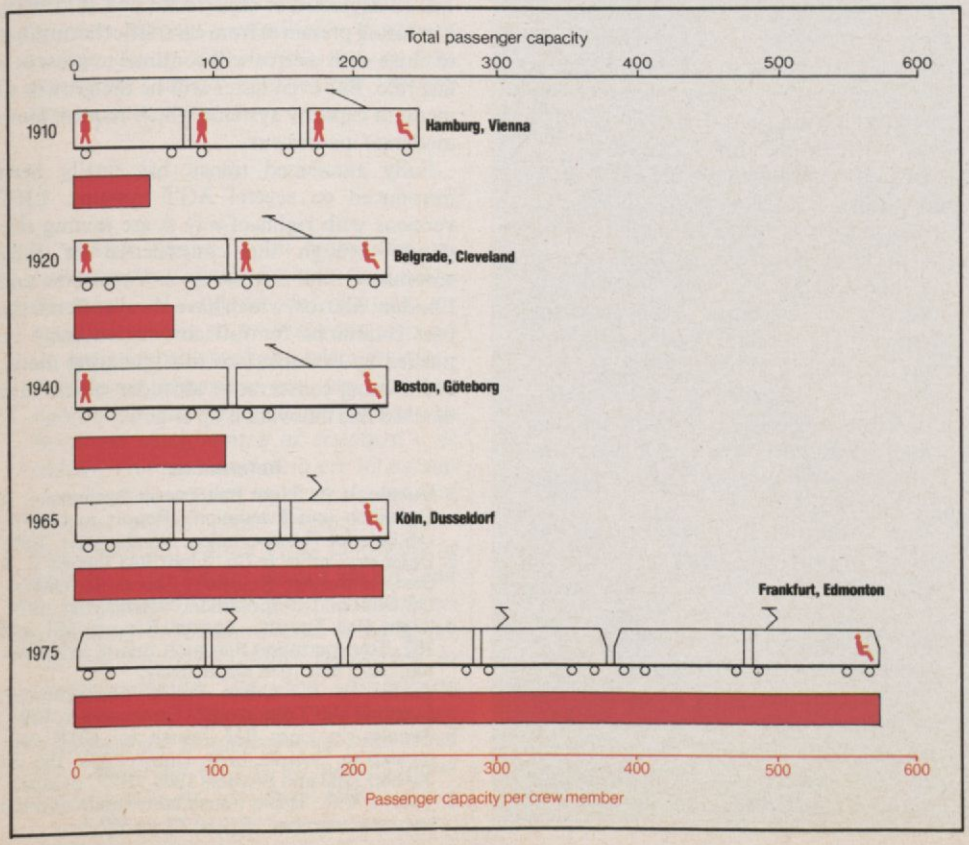


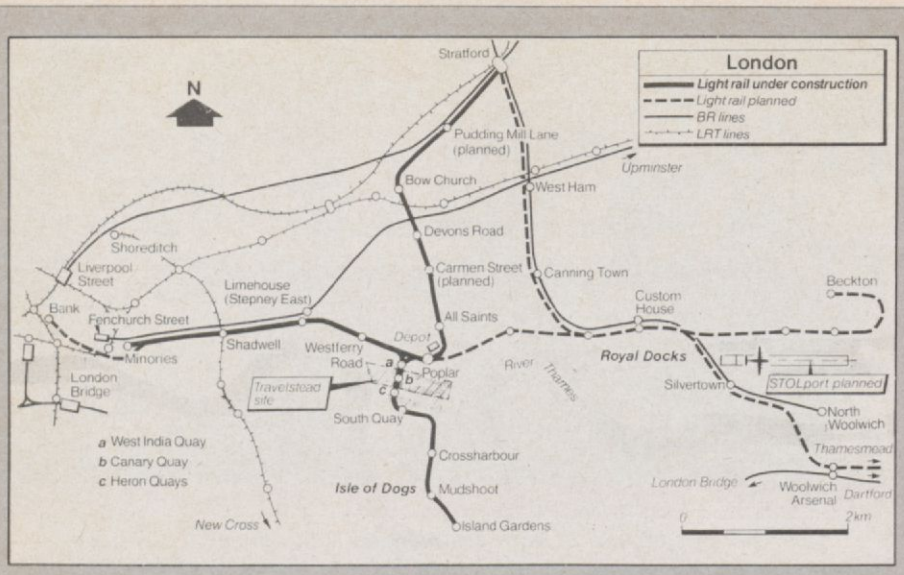
Fig 2. Labour productivity of trams has increased dramatically thanks to the transition to light rail in terms of rolling stock and operational innovations; the productivity gain is further enhanced by a substantial rise in commercial speed over the period 1960-85

Attractive features

Wide recognition of the LRT mode came in the 1970s because of the excellent service and moderate costs (as compared to metros) demonstrated on modernised former tramway networks in such cities as Bremen, Göteborg and Boston. During the 1980s, the acknowledged success of newly-built LRT systems, such as those in San Diego, Calgary, Newcastle and Utrecht, have further dispersed negative misconceptions about this mode.

Freed from prejudices, LRT has become the dominant solution for medium-capacity systems because of several unique features:

- It is the only transit mode which combines the advantages of guidance (train operation = high capacity, comfort and safety) and electric traction (good dynamic performance, environmentally superior, tunnel operation easy), with



Developers swallow the bait

BILLS ARE to be deposited next month for two extensions of the Docklands Light Railway: the first will run eastwards to Beckton, and the second west to Bank in the heart of the City of London.

The 7 km Beckton extension had been planned from the outset (RG 10.84 p796), but the 1·5 km extension to the City is a recent development which has thrown the London Regional Transport team responsible for getting the initial three-pronged 12 km network into service by July 1987 into confusion.

Plans to build the City extension were revealed on September 26 by a consortium comprising affiliates of Financière Crédit-Suisse First Boston, Morgan Stanley International and First Boston Docklands Associates.

This consortium is willing to pay for the £30m extension because it believes Docklands could be developed into a major banking and commercial centre. On October 17 the London Docklands Development Corporation approved in principle a huge project promoted by G Ware Travelstead of New York which would employ 45 000 office workers, some of them occupying the three tallest skyscrapers in Europe (see map).

October 18 saw the first rail laid at the depot for the initial DLR network, and the first of 11 cars is under construction at Linke-Hofmann-Busch's Salzgitter works. Running singly, these were to provide a service at 7½ min intervals from Island Gardens to Minories station, which is well separated both horizontally and vertically from LRT's Tower Hill station.

John Mowlem, the civil engineering contractor building DLR in partnership with GEC, has been asked by the consortium to prepare a scheme for the City extension in co-operation with LRT, which is preparing the Parliamentary bill at its own expense. The favoured solution is to bore twin single-track tunnels 1 500 m long under the District line, and terminate close to Bank station on the Northern and Central lines.

Problems for the DLR team start at Minories, where a station is already under construction above street level. The extension will have to drop down into tunnel east of this point, but a developer is already putting up the building to house Minories station in the confident belief that DLR passengers will be using the commercial facilities he has planned.

To handle the much greater volume of traffic now envisaged, three-car trains at 3¾ min headways would have to replace the single cars envisaged. Mowlem has designed the new viaducts and structures for single cars, so these might have to be strengthened as well. The stations are too short for three-car trains and some could not easily be extended. A hasty investigation is under way to determine whether the triangular junction at the heart of the DLR network could be grade-separated.

Part of the problem for the DLR planning team stems from uncertainties about future service patterns. An alignment for the Beckton extension has been agreed, but the LDDC is still considering branches to Canning Town and the Stolport. The Greater London Council came up with another scheme in September for converting BR's Stratford – North Woolwich line into another arm of DLR, and extending it under the Thames to serve Woolwich Arsenal station and Thamesmead.

It is already clear, however, that the strategy of providing Docklands with its own automated light rail system is paying off. Latest estimates (excluding Stratford – Thamesmead) put rolling stock requirements at 60 to 70 six-axle cars.

Most significant of all is the fact that international banks and finance houses have now made it clear that they would not have been prepared to invest in Docklands without a high quality rail service.

the ability to use B or C rights-of-way;

- It can be built or upgraded section by section, using each as it is completed;
- The great diversity in station and right-of-way design, vehicle type and operations allows adaptation to many different applications.

It is interesting to review the types of application which LRT has found recently, which indicated where it is likely to expand in the future.

- Cities with existing tramway/LRT networks will continue to upgrade and in some cases expand them (Belgrade, Stuttgart, Oslo, Charleroi, San Francisco);
- North American low-density cities which have recently built their first LRT lines are planning to expand their networks (Edmonton, Calgary, San Diego, Portland);
- West European cities which are now without urban rail systems but are committed to transit improvements appear likely to use LRT increasingly (Grenoble, Manchester).
- Very large super-cities often retain tramways (Moscow, Cairo), or build new ones even when they have extensive metros (Paris, Hong Kong); Los Angeles will have LRT before it gets a metro;
- Soviet and east European cities, extensive users of tramways, have been more oriented towards metros than to LRT, but the latter has been recently introduced in a few cities (Kiev);
- Cities in developing countries are rapidly growing and desperately need higher quality transit than jitneys and buses can offer. LRT introduction has been slow (Rio de Janeiro, Manila, Tunis). However, with sharpening problems of extreme congestion and difficulties in financing metros, it is possible that developing countries will become the greatest users of LRT in the coming years.

This review does not imply that other modes will be neglected or superseded by LRT. With increasing pressures from car traffic the number of cities with metros will continue to grow at a fast rate. But even faster will be the growth of medium capacity systems which require more moderate investment.

Fully automated transit has finally been introduced on several AGT systems. LRT versions with rights-of-way A are joining this group through the construction of fully automated mini-metros, as in Vancouver and London. Metros, which have always offered the best conditions for full automation, may be pushed by example into this operating mode, overcoming conservative attitudes which have blocked this innovation up to now.[6] □

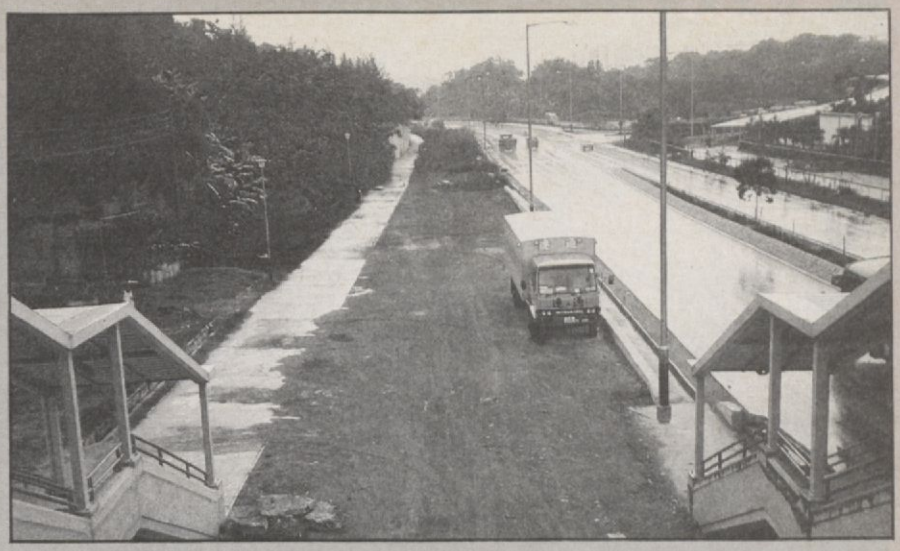
References

1 Vuchic, V R. 'Light Rail Transit Systems — A Definition and Evaluation'. Report to UMTA, US Dept of Transportation, Washington, 1972
2 DeLeuw, Cather & Co. 'Light Rail Transit — A State-of-the-Art Review'. Report to UMTA, US Dept of Transportation, Washington, 1976.
3 'Light Rail Transit'. Special Reports 161 and 182, Transportation Research Board, Washington, 1975 and 1978 respectively.
4 Vuchic, V R. 'Urban Public Transportation Systems and Technology'. Prentice Hall, 1981.
5 Reports on Light Rail Transit for UITP congresses in Helsinki 1979, Dublin 1981, Rio de Janeiro 1983 and Brussels 1985. UITP, Brussels.
6 Vuchic, V R. 'Rapid transit automation and the last crew member'. RG 10.73 pp 382-5.

Métro léger — le vilain caneton devient un cygne. *En moins de deux décades, l'éclipse des tramways dans de nombreux pays a été suivie par un enthousiasme croissant parmi les urbanistes en ce qui concerne les métros légers de surface ou aériens qui remplissent le vide entre l'autobus et le métro. Des réseaux de métros légers entièrement nouveaux sont déjà exploités dans 10 agglomérations, et un grand nombre est en cours de construction. La planification est bien avancée dans plusieurs autres villes. Les avantages du métro léger ont été reconnus quand d'anciens tramways ont été convertis pendant les années 70. Les impressions favorables ont été renforcées par le succès des nouveaux réseaux ouverts pendant les années 80*

Die Stadtbahn — das häßliche Entlein wird ein Schwan. *In den letzten zwei Jahrzehnten trat in vielen Ländern die Straßenbahn mehr und mehr in den Hintergrund, während sich die Städteplaner immer stärker für auf den Boden oder hochliegend geführte Stadtbahnen einsetzten, welche die Lücke zwischen Autobus und Metro füllen. Ganz neue Stadt- und Vorortnetze bedienen schon den Personenverkehr in zehn Großstädten und viele weitere befinden sich im Bau. In vielen anderen Großstädten sind die Planungsarbeiten schon weit fortgeschritten. Die Vorteile der Stadtbahnen erregten allgemeine Anerkennung, als die ehemaligen Straßenbahnen in den siebziger Jahren umgebaut wurden. Dieser vorteilhafte Eindruck wurde durch den Erfolg der in den achtziger Jahren eröffneten neuen Netze untermauert*

El metro ligero — el pato feo se convierte en cisne. *En menos de dos décadas, el eclipse del tranvía en muchos países se ha visto seguido de un entusiasmo creciente entre los planificadores urbanos por los metros ligeros de superficie o elevados que llenan el vacío entre el autobús y el metro. Ya hay en servicio en 10 países redes enteramente nuevas de metros ligeros, y hay otras tantas en construcción; en varias otras ciudades la planificación se encuentra ya en fase bastante avanzada. Se reconocieron ampliamente los beneficios de los ferrocarriles ligeros cuando se realizó la transformación de los anteriores tranvías en los anos 1970, y las impresiones favorables se han visto reforzadas por el éxito de nuevas redes inauguradas en los años 1980*



Starting from scratch

WORK HAS begun on the 34 km light rail network which is to serve Hong Kong's Western New Territories, including the new city of Tuen Mun. Subcontracts are being placed for the $HK1·1bn first phase covering 22 km with 41 stops, which is to be completed by mid-1988. The entire network should be in service by 1993.

After years of debate and negotiations following a 1973 decision to reserve rights-of-way for the exclusive use of public transport, it was finally agreed in July 1984 that Kowloon–Canton Railway Corporation should organise the building of a high capacity light rail network serving Tuen Mun and Yuen Long, where 840 000 people are expected to be living by 2001.

KCR called bids in 1984 on the basis that the contractor would have to design, finance and build the light rail network. On July 15 1985 KCR announced that an Australian consortium comprising Leighton Construction (Asia) Ltd and the Metropolitan Transit Authority of Victoria had won the order.

The 70 four-axle light rail cars will be built at the Dandenong works of Comeng (Victoria). These cars will be 20 m long and will normally run singly or in pairs, although three-car trains will be possible. Cars will be unidirectional which means that the complex layout of 15 routes has to include turning circles. GTO thyristors will be used to control traction power and the cars will be air-conditioned.

Power will be supplied at 750 V dc from overhead catenary or trolley wire; Balfour Beatty Power Construction has been awarded a £3·3m subcontract to design, supply and erect the 51 track-km required under the first phase. Contact wire height will normally be 5·6 m. In built-up areas where speed is limited to 60 km/h the overhead will consist of a 120 mm^2 contact wire with two 120 mm^2 stranded copper conductors to act as parallel feeders. On open sections where speeds of 80 km/h are permitted, the two stranded conductors will act as a catenary supporting the contact wire. Sidings and loops will have a single trolley wire. Power from the overhead line will be used to drive point machines, operated by the drivers of approaching cars.

Another successful subcontractor is Vickers Designs & Projects. Indeed, Vickers has won every recent contract placed for the supply of workshop equipment by Mass Transit Railway Corporation and KCR, in the latter case working with Leightons on extensive reconstruction of the workshops at Shatin.

Vickers' contract for Tuen Mun is worth nearly £3m, and it embraces the design, supply and commissioning of depot and workshop plant needed to maintain, service and clean the fleet of 70 cars at the 5·7 ha depot which is to be built north of the Butterfly estate.

There will be no signalling as such on the Tuen Mun network, but communications are being provided by Cable & Wireless (Hong Kong). All of the lines are at ground level with numerous road crossings, but there will be very little street running as roadside reservations are already available; many footbridges linking future station with adjacent flats are already in place (above). Stations will have 800 mm high platforms with shelters. Tickets are to be sold off the cars from automatic machines at stations.

Track will be 1 435 mm gauge with 54 kg/m rail on sleepers in ballast, but 60 kg/m grooved rail will be used in paved areas. Minimum curve radius has been set at 20 m.

The consortium is responsible for recovering its investment by operating the LRT system at a profit — hence the need to include MTA, which operates one of the world's largest tramways, in the consortium. Patronage is expected to be 318 000 passengers/day on opening the first phase in 1988, rising to 746 000 by 2001.

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R H Christeller · Switzerland
C Hastings · Thailand
John Edgar · United States

Front cover
Cars on Line A of the Roma metro have been equipped by Ansaldo Trasporti with ATO for automatic operation

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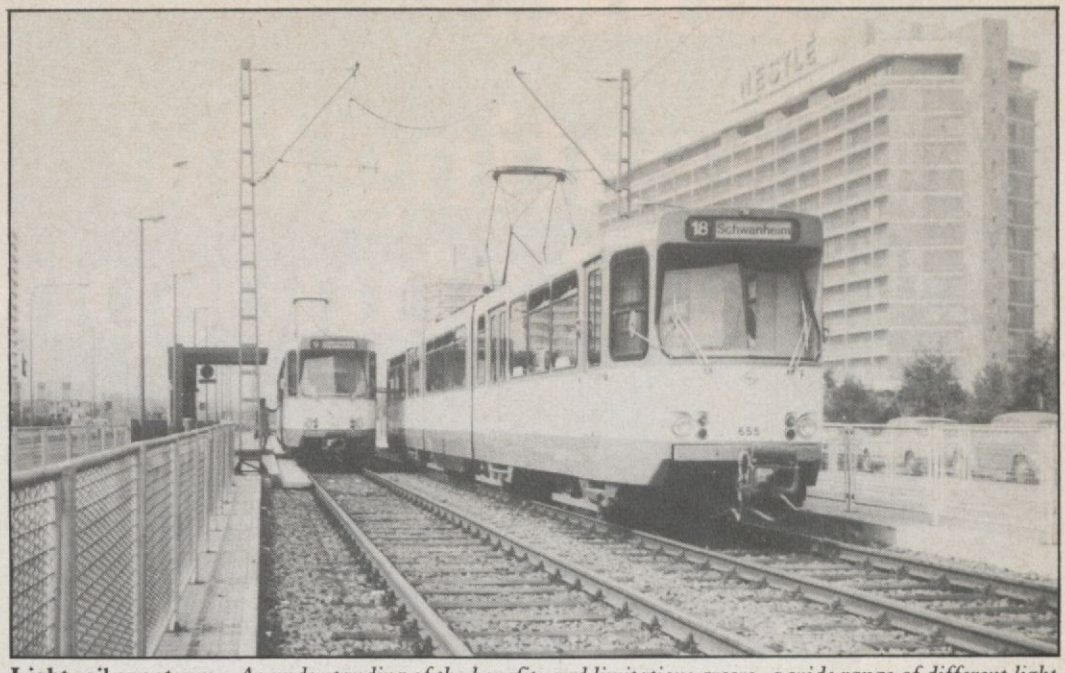

Light rail spectrum—*As understanding of the benefits and limitations grows, a wide range of different light rail projects is taking shape; each scheme can be individually tailored to meet the needs of its own city. Suppliers are putting together comprehensive packages embracing everything from civil engineering to cars and ticket machines, particularly for the rapidly growing market in automated light metros which combine LRT and heavy metro technology*

Ugly duckling becomes a swan
Eclipse of the tram has been followed by rising enthusiasm among urban planners for light rail transit to fill a gap between bus and metro **829**

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Developers swallow the bait **834**

Starting from scratch **835**

Grenoble moves towards 1987 opening
France's second new tramway is taking shape after the start of tracklaying **838**

Trams in the metro
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Liège plans its light metro
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Second Arab conference to debate safety
UACF's second scientific symposium will be held in Damascus this month **857**

Oder trunk line electrified
Poland's new north-south trunk line will carry international traffic to the Baltic ports clear of Warsaw **859**

Rebuilding Mexico's ruins
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NEXT MONTH

Latin Renaissance—January 1 sees the long awaited separation of Italian State Railways from the Ministry of Transport. A new management structure will help in the drive for greater efficiency and productivity, but the high level of investment in infrastructure and new rolling stock seems set to continue. Several cities have plans for expanding or modernising their urban rail networks, with both light rail and metro construction forging ahead.

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