Ten years on; where do we go next?

A decade after the first purpose-built low-floor tram network opened in Grenoble, over 1 300 cars are in service and another 600 on order. Harry Hondius MSc reviews technical developments over the past 10 years and assesses where the market is heading

On May 22 Mülheim-an-der-Ruhr rolled out one of its 1982-built Stadtbahn M6D cars rebuilt with a composite low-floor centre-section from Schindler, Fiat-SIG and MGB

IT WAS IN September 1987 that the world's first low-floor tram network opened in Grenoble, with a fleet of 20 TSF-2 trams supplied by GEC Alsthom. Early in 1990 the first 100% low-floor car was unveiled to the public – the Bremen-MAN GT6N prototype. By the end of that year Duewag had supplied its first low-floor car to Kassel and the first Duewag/Vevey car had arrived in Bern.

Today, a new tram design announced anywhere in the Western world is virtually certain to be a low-floor vehicle. For new high-platform light rail networks, production of high-floor LRVs continues at about 100 to 130 cars a year.

So what has 10 years of low-floor tram development brought to the operators and to the industry? On the positive side, low-floor cars offer much easier boarding for all passengers. If door speeds are correctly selected, this can help to reduce boarding times at stops. Lower platforms can be provided more easily to further enhance the boarding comfort, without being obtrusive in the city landscape.

AC traction motors have proved very robust, and do not require the same level of maintenance and servicing as DC motors. They are also better able to stand overloading. Acceleration and braking have been greatly improved, and high regenerative braking rates almost to a standstill offer reduced energy consumption and longer life for mechanical brake components. Modern control electronics have made wheel flats a rarity. Together these developments have led to a safer vehicle which is easier to drive.

At the same time, there have been many negative experiences. The wheels are much nearer to the passenger, making it far more difficult to keep the interior noise levels as low as before. Many of the new technologies have proved noisier than expected, notably the control electronics and brakes. It seems unbelievable that electric under-seat heaters should produce the noise they do; no modern bus heating system produces such noise. Overall noise levels can often be unacceptable, given the high price paid. The industry failed to address this problem promptly or adequately; only recently have user specifications forced suppliers to start investigating noise problems seriously.

Low-floor cars are generally relatively heavy, with average weights around 20% higher than vehicles built in the 1960s. As a result, net energy consumption is not always reduced. Many of the innovative traction drives, although tested with prototypes, have caused serious, prolonged and often repeated troubles when entering service.

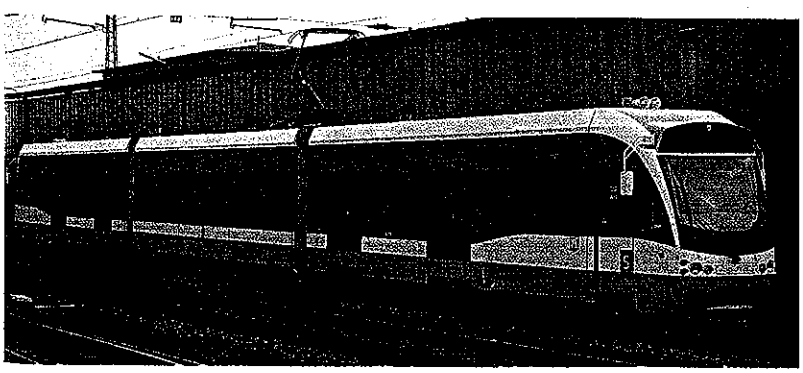
Long-standing lessons from the past about the tough steel-wheel/rail environment, with its extremely high vertical *g* values, appear to have been forgotten. Hub motors made houses vibrate. Single-wheel drives of all kinds caused high noise and high wear. Cars sometimes derailed. Having independent wheels has not stopped them shrieking in curves or really diminished wheel and rail wear.

Too many of the modern designs have proved to be particularly sensitive to the quality of the track. This applies especially to the cars using single 'axles' with individual wheels, where any deterioration in track maintenance standards can lead to noisier running. Commissioning of series-built cars has often taken up to or over a year, before the running characteristics have settled down to

Table I. Market share of low-floor trams supplied or ordered up to April 1 1997 (Western suppliers)

Mechanical parts	Orders	Options
Siemens Verkehrstechnik	652	507
Duewag	616	391
SGP	36	116
Adtranz	538	160
AEG	408	96
Variobahn	58	64
Eurotram	72	–
GEC Alsthom	357 (1)	80
TSF 1 (Nantes type)	46	–
TSF 2 (Grenoble type)	116	–
T 2000 (Brussels type)	51	–
Vevey	20	–
LHB	124 (1)	80
Breda	125	–
Vevey	73 (2)	–
Fiat	58	–
Bombardier Eurorail	45	–
Firema	43	15
Socimi	35	–
DWA Bautzen	12	10
Schindler/Fiat SIG	6	11
Total	**1 944**	**783**

1. Includes 30 trailers
2. Includes 46 middle-floor cars



Below left. The first Bombardier/Kiepe/Elin Saarbahn medium-floor two-system LRV has been tested on DB tracks around Trier

Table II. Electrical equipment for low-floor trams ordered to April 1 1997

Supplier	Total	Chopper	VVVF Inverter	GTO Inverter	Bipolar Inverter	IGBT Inverter
Adtranz	951					
ABB	(541)[1]	69	–	–	358	114
AEG (Germany)	(251)	25	–	–	–	226
AEG (USA)	(159)	34	–	25	–	100
Siemens	393	14	–	270	–	109
GEC Alsthom	248	162	–	51	–	35
Kiepe	139	–	–	127	–	12
Ansaldo	71	54	–	–	–	17
Holec	45	–	45	–	–	–
Elin	36	–	–	–	–	36
Parizzi	28	–	–	–	–	28
Marelli	2	2	–	–	–	–
Total	**1 913**[1]	**360**	**45**	**473**	**358**	**677**

1. Includes 46 middle-floor cars

Chopper: DC motors with GTO thyristor chopper controls

VVVF: Three-phase AC motors with variable-voltage, variable-frequency thyristor controls and intermediate voltage circuit

GTO: direct Pulse-Width Modulation using air-cooled GTO-thyristors

Bipolar: Direct PWM with three point water-cooled bipolar transistors

IGBT: Direct PWM using Insulated Gate Bipolar Transistors in three point air-cooled (Adtranz) or two-point water-cooled (Adtranz, Elin, GEC Alsthom, Siemens) or air-cooled arrangement (Ansaldo, Kiepe, Siemens)

levels that are acceptable to the end user.

The fierce market competition has seen too many completely new designs launched in a too short a period, overloading the engineering and testing capacity of suppliers when serious problems arose. Too much innovation in too short a period has led to high remedial costs for the builders. Few suppliers can have earned much profit from low-floor trams, and many will have made none at all. A consolidation period in development would be highly desirable, but there seems no prospect of this in the near future.

Orders grow, but market slows

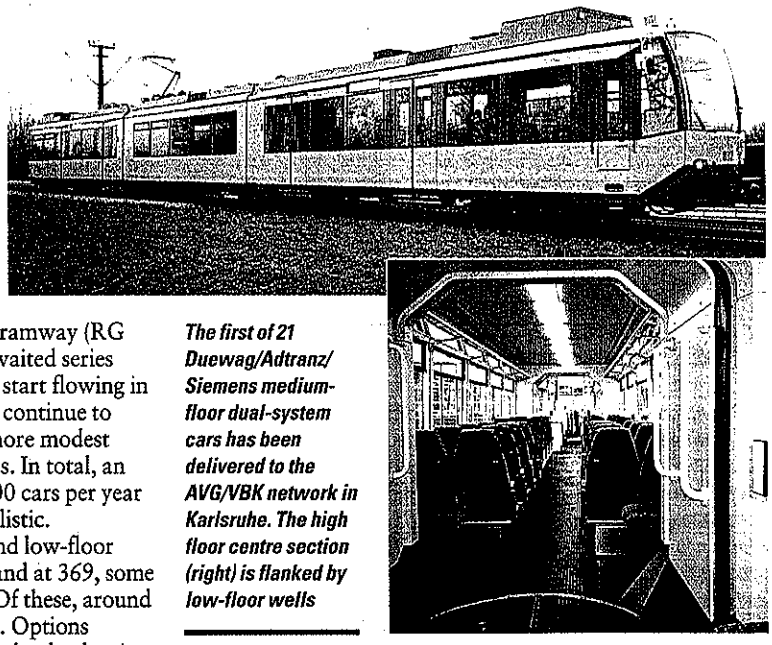
Comparing the low- and medium-floor tram car market situation on April 1 1997 (Table I), with the position a year earlier on the same basis (DM96 p23), we can see that total orders for Western European suppliers rose from 1 664 to 1 944 and the outstanding options fell from 949 to 783. Out of the 280 cars ordered, only 122 came from the 'options reserve'. Around 1 300 cars have been delivered so far, leaving some 650 firm orders on the books to keep the factories busy. In addition to these, Bielefeld proved the exception to the rule by ordering 16 high-floor trams and 8 matching trailers.

Fig 5. Dresden has bought eight 65% low-floor bi-directional cars from Siemens/ DWA/Adtranz

Adding orders and options together to give an indication of the market strength of the various groups, Siemens Verkehrstechik has 43% of the market, 1 159 out of 2 727 cars. Adtranz has 26% with 698 cars, and GEC Alsthom 16% with 437. Breda (with Ansaldo and Firema now part of the same group) has 125 cars or 5%, leaving just 10% for the other four: DWA/Vevey, Fiat, Bombardier Eurorail and Schindler.

In the electrical field (Table II) Adtranz is the clear leader with a 50% market share, followed by Siemens 20-5%, GEC Alsthom 13% and Kiepe 7%. Again there is just 10% left to divide between four groups: Ansaldo, Elin, Holec and Parizzi. Looking at the control technology, it is clear that IGBT inverters have definitively taken the lead for new orders.

Since April 1 Montpellier has ordered 28 Citadis 301 cars from GEC Alsthom (RG 5.97 p277), and Dublin has confirmed that it plans to buy 30 of the same design. However, it is extremely difficult to give any prognosis on further contracts. Orléans has also decided to build a new tramway (RG 3.97 p169), and long-awaited series orders might eventually start flowing in Italy. German cities will continue to order cars, albeit on a more modest scale than in recent years. In total, an order level of around 200 cars per year might be considered realistic.



The first of 21 Duewag/Adtranz/ Siemens medium-floor dual-system cars has been delivered to the AVG/VBK network in Karlsruhe. The high floor centre section (right) is flanked by low-floor wells

Orders for medium and low-floor LRVs (Table III) now stand at 369, some 70 more than last year. Of these, around 205 have been delivered. Options remained stationary. Market leaders in this segment are still Bombardier Eurorail and Kiepe Elektrik, although it is interesting to see the first penetration in this market by the Japanese, with Kinki Sharyo picking up an order for 45 cars for New Jersey Transit.

Industry groupings still changing

Of the 652 cars currently on order from Duewag, 219 will have bodies supplied by DWA Bautzen, which will undertake final assembly for 210 of them. Bautzen is also supplying bodies for the 15 LHB cars to be delivered to Magdeburg and 23 Variobahnen for Chemnitz, using LHB and Adtranz designs respectively.

As was to be expected, DWA Bautzen is emerging as a new player in the market, and looks likely to stay for a while. DWA has started to win orders on its own, beginning with 12 cars for Kassel in conjunction with Kiepe Elektrik (RG 5.97 p278). In early May DWA confirmed its purchase of Vevey Technologies from the Dutch-based Begemann Rail Group, adding small-wheel low-floor, VAL and Urbos technology to its competence.

Siemens Verkehrstechnik has completed its internal reorganisation, leaving Duewag in Düsseldorf and its counterpart Siemens Duewag Corp in Sacramento as the 'centre of competence' for urban rail business. Bogie design and fabrication have been concentrated at the SGP works in Graz. A similar concentration can be seen at Adtranz, where the ex-MAN Nürnberg works is the main urban transport centre, with bogies concentrated at Siegen. It may well be that in future Adtranz tram body construction will be entirely contracted out, as is happening with the Chemnitz Variobahn cars.

Following a ruling of the EU competition directorate, Adtranz has sold its stake in Kiepe Elektrik to Berlin Elektrogroup, or more specifically its Schaltbau AG subsidiary; the group already owns coach refurbishing specialist PFA of Weiden. LHB will now market GEC Alsthom electrical traction equipment in Germany. Parizzi has entered the tram field for the first time, enabling Fiat to offer a total systems package.

Table III. Market share of low- and middle-floor LRVs ordered by April 1 1997

Mechanical parts	Orders	Options
Bombardier Eurorail	187	53
Siemens Verkehrstechnik	122	–
Kinki Sharyo	45	–
Firema	15	–
Total	**369**	**53**

Electrical Equipment	Orders	Options
Kiepe (Elin motors)	68	–
Kiepe (GEC Alsthom motors)	119	53
Siemens	71	–
Japanese (supplier unknown)	45	–
Adtranz	51	–
Ansaldo Trasporti	15	–
Total	**369**	**53**

Extensions back in vogue

An interesting development in the last year has been the revival of interest in lengthening existing high-floor cars

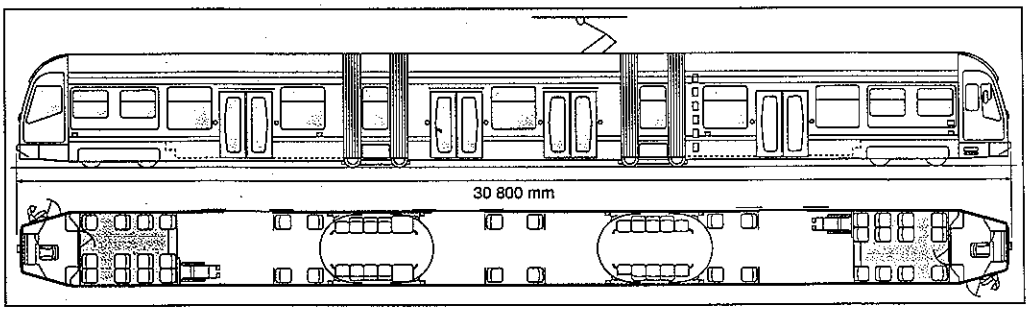


Fig 1. Roma's ATAC has selected this Fiat/Parizzi design

OEG of Mannheim has put into service its six 32 m long, 2 500 mm wide Variobahn cars with 65% low floors. Top speed is 80 km/h and the weight 38 tonnes

with a low-floor centre section. For a long time it looked that the 92 lengthened cars on four systems would be the only examples of the concept, but Duisburg's DVG has now decided to convert its 45 GT8NC cars built in 1986-93 to GT10NC by adding a 7 000 mm long low-floor section.

A joint venture of Mittenwalde Gerätebau, Schindler Waggon, and Fiat-SIG has picked up a series order to lengthen 16 Tatra KT4D cars in Cottbus with a 8 660 mm low-floor centre section offering a floor height of 350 mm over a length of 6 750 mm. These innovative centre sections are formed of a wrapped glass-fibre composite bodyshell on a galvanised steel frame, and run on two Fiat-SIG two-wheel trucks steered from the articulations (RG 5.96 p250).

The converted cars must be good for another 20 years service, so Kiepe IGBT choppers are to be installed, and the CKD motors are likely to be replaced by a more powerful version. The cost of the transformation will be around DM750 000 per car, of which DM225 000 will come in GVFG subsidy. Another nine conversions are expected to follow in 1998. On May 22 Mülheim-an-der-Ruhr unveiled a similar extension to one of its 1982-built M6D cars, which has involved more extensive changes than for the KT4Ds, at a cost of around DM650 000.

In December 1996 Basler Verkehrsbetriebe ordered 28 composite low-floor sections from Schindler Waggon and Fiat-SIG to enlarge its six-axle articulated cars bought in 1990-91. The length of the new centre part is the same 8 660 mm, with the two-wheeled trucks 4 600 mm apart. The weight is around 8 tonnes, and the cost SFr586 000 per car.

Thus for around DM34 000 per m² of floor space, it is possible to add a small low-floor area to modern cars. The riding qualities of the Cottbus car are quite acceptable, although the KT4D parts showed a tendency to light galloping at 50 km/h. As with other single axle types, the riding qualities of the centre section are directly related to the quality of the track and show a tendency to rumble.

Part-low-floor developments

Looking at the various categories of cars with 60 to 70% low floors, as defined in DM95 (p26), the number of Category A cars remains unchanged at 159. Category A2 has expanded to 61 cars with the arrival of two new designs.

The first of 15 Bombardier/Kiepe/Elin cars for Saarbrücken has been rolled out and is successfully undergoing tests on DBAG tracks between Trier and Mettlach. The riding qualities at 100 km/h on the curved track along the Mosel river valley are very good.

The first of 21 dual-system cars for Karlsruhe's AVG/VBK group has been delivered by Duewag and Adtranz. This medium-floor car is derived from the 36 all-steel dual-system cars already in service, with Adtranz bogies and Siemens transformer/rectifier. The latest cars use an Adtranz AC-drive using water-cooled 125 kW motors and bipolar transistor inverters, the same as the 20 medium-floor cars built for the city's 750 V DC routes last year.

The two dual-system cars have the same outer dimensions, but the Saarbahn versions have all axles motored, against only half in Karlsruhe. Floor height in the outer sections where the doors are located is 400 mm for the Saarbahn and 630 mm for the VBK cars. Total weight, power/weight ratio and price are similar. The VBK cars have double glazed coated windows and air-conditioned cabs. The Saarbahn cars have air-conditioning in both the centre modules and the cabs.

The Saarbahn car's end sections are similar to Bombardier's latest LRVs for Köln, with a welded steel underframe and body framing, onto which aluminium outer plating is glued. The roof has a riveted aluminium frame with glued-corrugated stainless steel plates. The tubular steel front ends covered with glass fibre mouldings are bolted to the underframe. The centre car is made of riveted aluminium. The bogies are identical to the Köln ones, but have a lower gear ratio to give a top speed of 100 km/h. The only fundamental difference is that the Elin four-quadrant controller allows regenerative braking when running on 15 kV.

Category B cars with small diameter bogies have reached 208 cars and 30 trailers. Magdeburg has ordered a further 15 cars from LHB, whilst St Etienne is buying 20 more from GEC Alsthom, Duewag and Vevey, largely identical to an earlier batch of 15, but with an Onix AC traction package.

Leipzig has decided to stop its present order for NGT8 cars after deliveries have reached 55, and is seeking bids for 50 low-floor trailers to be used with the 169 modernised Tatra T4D cars. After that Leipzig will revert to buying low-floor cars, but these will be six-axle NGT6s which can be used in multiple or to haul the low-floor trailers.

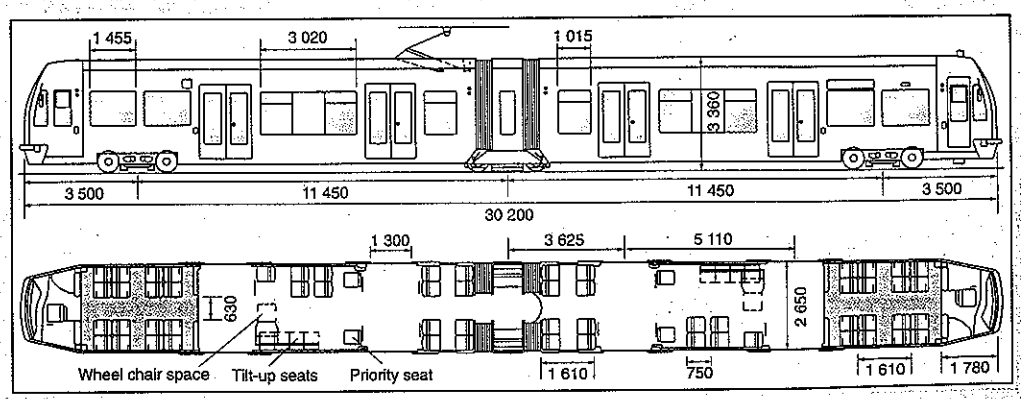
The first move by the new chairman of Rheinische Bahngesellschaft in Düsseldorf was to cancel the letter of intent for 15 low-floor trailers and its option for 44 more. As former technical director of Bremen's tramway, where he oversaw orders for 78 eight-axle 100% low-floor trams, he wants no trailers.

In the multi-articulation bracket (Category B1), there is a total of 507 cars, making it the second largest category. Dresden has increased its order from 20 to 60, which covers 52 unidirectional and 8 bi-directional cars. Belgium's De Lijn has ordered six single-ended trams for Antwerpen and three bi-directional cars for Gent. Although metre gauge, these will be very similar to the Dresden cars, but with an extra front entrance door. Over the next five years, De Lijn expects to receive 31 single and 14 bi-directional cars. Siemens is the general contractor, supplying the SIBAS 32 controls and trucks. DWA Bautzen will build the bodies, and Adtranz will supply the rest of the electrical equipment, including water-cooled motors and HITRAM IGBT inverters. Average price is around DM49 000 per m².

Signalling the beginning of the long-awaited renaissance of the Italian tram (RG 7.96 p427), Roma has ordered 28 multi-articulated cars from Fiat and Parizzi; they are a 30·8 m long bi-directional version of the Torino cars delivered in 1990. The first contract for Fiat to act as systems provider sees Parizzi supplying the four 178 kW AC-drives with IGBT inverters. Styling will be by Giugiaro, and the price is reported to be around DM45 000 per m².

Germany's OEG has put into service

Fig 2. The 65% low-floor car for Croydon to be supplied by Bombardier Eurorail and Kiepe is a lengthened version of the Köln 4000 medium-floor car, with a 70 km/h top speed and a weight of 36 tonnes



its six Variobahnen with 65% low floors; these have excellent riding qualities at 80 km/h.

GEC Alsthom has been named as the preferred bidder for the Dublin LUAS project (p36), ahead of the Siemens Combino. The 29 bi-directional Citadis 301 trams will be either 29 or 39 m long and 2 400 mm wide. The LHB-built medium-floor end bogies will resemble those of the Magdeburg cars, and the centre truck the Grenoble design. The Neermann-styled riveted aluminium body will come from Aytré, with pre-fabricated front ends bolted to the underframe.

In Category B2, multi-articulated LRVs, recent developments have seen the total jump to 240 cars. VBK of Karlsruhe has ordered 10 lengthened versions of its earlier design, of which 20 are in service (RG 6.95 p342). The 38·7 m cars have a Bo'2'2'Bo' axle arrangement and a floor height of 407 mm over 72% of the length. Weighing 48·1 tonnes (469 kg/m²), they will seat 118. With a width of 2 650 mm, the price works out at DM41 125 per m².

Bombardier and Kiepe have almost completed deliveries of the second batch of 40 K4000 cars to Köln, and have just received confirmation of the final option for another 40.

Kinki Sharyo entered the US market with an order for 45 cars for New Jersey Transit; 29 to work the new Hudson-Bergen line in Jersey City and 16 for the modernised Newark subway. The electrical supplier is not yet known. The 26·7 m long cars will be 2 680 mm wide, with 720 mm high floor ends connected by ramp to a 350 mm low-floor section where the doors are situated. Wheel diameter is 590 mm.

To the distress of the suppliers, the 15 Firema/Ansaldo cars for Birmingham will not have end sections identical to the Oslo cars as planned, nor AC drives. Centro did not want to be the first British light rail operator to adopt AC traction, and opted instead for GTO choppers and DC monomotors.

As part of the Tramtrack Croydon Ltd DBOM concessionnaires, Bombardier Eurorail is to supply 24 bi-directional cars, as a development of the K4000 type. The Kiepe electrical equipment will be identical. They will be 29·9 m long and 2 650 mm wide, with 580 and 350 mm floor heights linked by a ramp, as in the Wien T68 cars. Fixed seats for 64 are envisaged. The cars will be built in Wien by BWS, with bogies from Manage. The first will be built and tested in Wien, and the rest will be assembled and finished in the Bombardier Prorail workshops at Wakefield. The reported price of £35m would correspond to around DM4m per car, or DM50 000 per m²!

Category B3 cars with EEF-trucks have increased to 194, as Halle exercised an option for 38 cars. The total of Category B4 cars with steered two-wheel trucks now stands at 72, because the Rheinbahn order has been increased to 48. These are likely to be the last of the type. No more orders have been placed in categories B5, B6 or B7, although it is expected that Wien is to order 10 extra T 68 cars.

Düsseldorf's Rheinbahn is buying 48 Duewag/Kiepe 65% low-floor cars with steered two-wheel bogies. The 27·5 m long, 2 400 mm wide cars weigh 33·5 tonnes

This year sees a new Category B8 covering eight-axle cars, using classic motor bogies with floating articulations and four wheel carrying bogies with normal diameter wheels. Kassel has ordered 12 cars from DWA and Kiepe for around DM40 000 per m² (Fig 3).

This brings the total of low-floor cars in the 10 to 70% low-floor band to 1 178, or 62% of all orders. The part-low-floor LRV total stands at 369.

51 cars, whilst Schindler and Fiat-SIG have just 6.

In Category C2 it looks at present as if the AEG/MAN car has reached the end of its cycle; only one car was ordered in the last year, for Kumamoto in Japan. The type has been undertaking demonstration tests in 12 cities including Warsaw (RG 7.96 p547), but only Berlin finally decided to buy 120 cars of which 60 are in service. Deliveries of the other 60 will start soon. The option for 80 cars has been cancelled, as BVG plans to call tenders against a new specification. The same has happened in Augsburg, and the Bremen options have also disappeared as BSAG feels it has enough low-floor cars for the time being. Only 96 options remain.

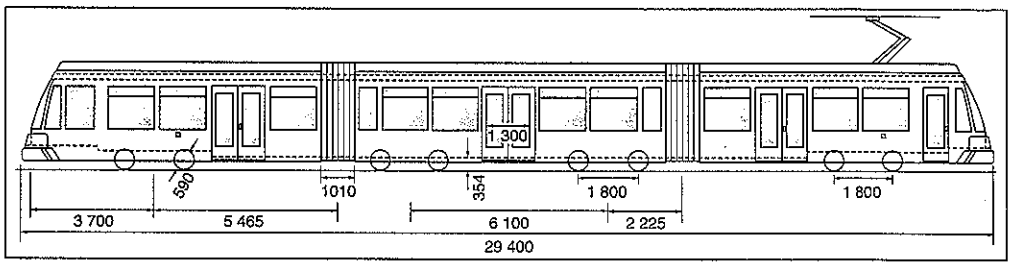


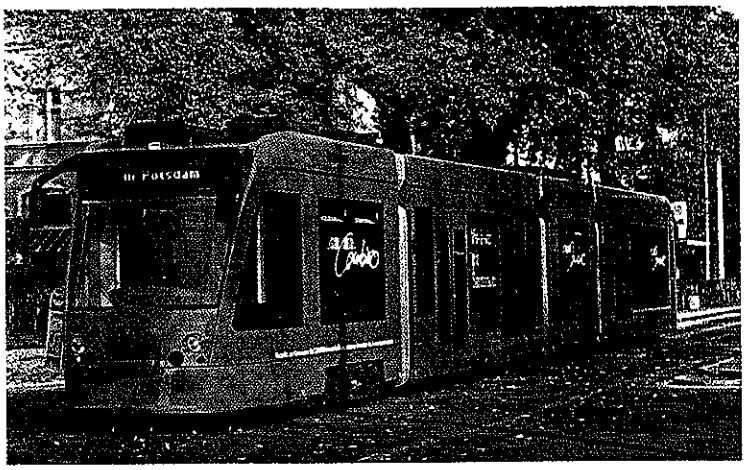
Fig 3. Kassel has ordered 12 of these cars from DWA Bautzen and Kiepe

All-low-floors

The four main categories of 100% low floor cars (C1, C2, F and G) now account for 736 cars or 38% of the total. Adtranz is the clear market leader, with 408 AEG/MAN cars, 72 Variobahnen (including the 20 Würzburg cars delivered by LHB and Siemens, which have Adtranz trucks, and clearly belong to this category), and 72 Eurotrams. Siemens follows with 49 Combinos, 36 ULF and 40 Frankfurt R-cars, for a total of 125. GEC Alsthom and Bombardier have supplied

Still to be delivered from the Nürnberg works are 26 second generation GT8N cars for Nürnberg and another 20 for München. Stadtwerke München has returned its first three GT6N prototypes in part exchange for three more GT8N cars. However, press reports suggest the design still has problems. The BVG cars are plagued with mechanical defects, with one third of the fleet out of

Below: Duisburg's 33 780 mm long and 2 300 mm wide all-low-floor Adtranz Variobahn cars are driven by 8 gearless hubmotors. Each 35·6 tonne car seats 48 passengers (left)



Following tests with the Siemens Combino prototype, Potsdam has ordered 48 cars for delivery by 2009

use. All 12 Braunschweig cars were taken out of service for 6 weeks following the discovery of bogie defects.

Variobahn orders increased by 23 with an order from Chemnitz. Duisburg has taken delivery of its Variobahn, which has a much improved design. The trucks are simplified from the Chemnitz version, as it was not felt necessary to give the wheels freedom to move sideways in curves.

Siemens has successfully tested its Combino prototype (RG 8.96 p512) in Potsdam, Düsseldorf and Austria, including 15 000 km on the Wiener Lokalbahn line to Baden. Riding qualities remain excellent up to the top speed of 68 km/h, and the next step is to tackle the noise levels.

Potsdam has ordered 48 cars to be delivered in batches of four until 2009 (RG 2.97 p75); these will be equipped with front and rear end doors. The price for the first 12 cars is around DM41 000 per m². The prototype will be exhibited at the UITP Congress in Stuttgart in June before spending two months running in Potsdam over the summer.

The new chairman of Düsseldorf's Rheinbahn wants 100% low-floor cars, and it looks as if the company's option with Duewag and Kiepe for 90 more 27·5 m cars with 65% low-floors might be converted into seven-section articulated cars to a tailor-made design by Rheinbahn using Combino elements (p39). Three long centre modules derived from Combino (of which two or three would be powered with Kiepe Elektrik equipment) would enclose two shorter non-powered modules. The two end modules would have a small wheel bogie at the outer ends, to permit double entrance doors at the front. Rheinbahn expects this 40 m vehicle to work out cheaper than a relatively conventional 27·5 m vehicle plus a 14·2 m low-floor trailer!

Wiener Verkehrsbetriebe has ordered 10 ULF type A cars 23·6 m long and and 24 of the longer 34·9 m Type B. Both will be 2 340 mm wide, giving a combined price of DM55 756 per m². These include some significant technical changes from the prototype.

The transversal steering of the non-motored axles will be simplified, allowing the individual wheels to swivel around a vertical axle. A leaf spring steers them back to the parallel course, and the whole wheelset is still steered from the articulation. Primary springing will now take 20% of total sprung weight, compared with 10% before.

Essential measures have been adopted to try and reduce the overall noise. SAB V60 wheels will be used, and the disc brakes of the powered wheels will be placed on the motor axle. The steel bodies will be supplied by BWS.

Wien has ordered 24 Type B ULF cars 34·9 m long from Siemens Verkehrstechnik SGP and Elin; the series version is expected to weigh 42·5 tonnes

Hub-motored cars

In Category F, the 20 type R cars in service in Frankfurt since 1993 and the 20 new ones, of which the first was delivered recently, will be equipped with a hydraulic device to stabilise the cars and prevent high transverse forces when braking in curves. This is intended to overcome the risk of derailing under special circumstances and in depot yards. As with the AEG design the bogies are placed centrally under each body section, with hub motors driving the outer bogies and the centre unit unpowered.

Of the 51 GEC Alsthom/Bombardier Eurorail cars supplied to Brussels, only 38 are presently diagrammed for regular service. On some routes for which the cars were intended, the hub motors were found to generate excessive levels of vibration in the houses alongside the line.

The Adtranz Eurotram continues to sell well. Strasbourg has ordered a further 26 cars, of which 16 will be the same 33·1 m as its originals, and 10 will be 43 m long. The average price is reported to be DM57 000 per m². They will be built at Adtranz, Derby, and be assembled by Lohr Industrie in Düppigheim, where the *région* has financed construction of a test track.

After testing Breda's VLC, Fiat's Torino car and the Strasbourg car (RG 4.96 p182) Milano ordered 20 unidirectional Eurotram derivatives 34 m long, with 62 seats. There will be a number of very sensible design changes. The upper end of the glass surface of the 'cupola' that houses the driver is considerably reduced. The impractical and slow single-leaf doors 1 500 mm wide are replaced by a more normal pair of 1 300 mm doors, whilst the 'bretsels' blocking the flow of passengers from the entrance platforms to the interior saloons also go. Parts of the cars will also be made in Derby, but final assembly will be in Italy. The price is reported to be DM43 000 per m².

Also in Category F, Schindler and Fiat-SIG have finally won an order after testing their Munico for over 36 000 km in Zürich, Basel, Helsinki and Augsburg. Zürich is to buy six Cobra cars, with an option for another 11. (RG 11.96 p708). The 35 470 mm long 2 400 m wide cars will be designated Be 5/6, with an axle arrangement of A'A'+ ½ A' ½ A'+A'A'. Five ABB AC motors of 80 kW will drive the car, but in the centre powered module, only the inner two wheels are driven.

Using essentially the same concept as the composite centre sections for Cottbus and Basel, the 96-seat cars have a calculated weight of only 35·87 tonnes or 421·2 kg/m², which would be an all time low! The price is also low, at DM41 970/m². Schindler, Fiat-SIG and MGB look certain to continue to market this car for German metre gauge systems such as Augsburg.

After tests with its radially-steered Urbos two-wheel bogie in Rotterdam during 1995, Vevey established that it could not fulfil the requirement of a fully-loaded axleload of less than 10 tonnes, and abandoned the two-wheel bogie. Vevey subsequently developed a 100% low-floor design using bogies with 560 mm wheels and a wheelbase of only 1 000 mm. A transverse AC motor will drive two wheels on each side through gears and flexible couplings. Use of bogies means eight seats per bogie must be placed on boxes.

This solution was offered to De Lijn in collaboration with CAF and Holec. A Bern four-axle tram is to be equipped with two Urbos bogies and four Holec AC motors, and tests should start this autumn. If the Leeds light rail project

accessibility

Widespread distribution network

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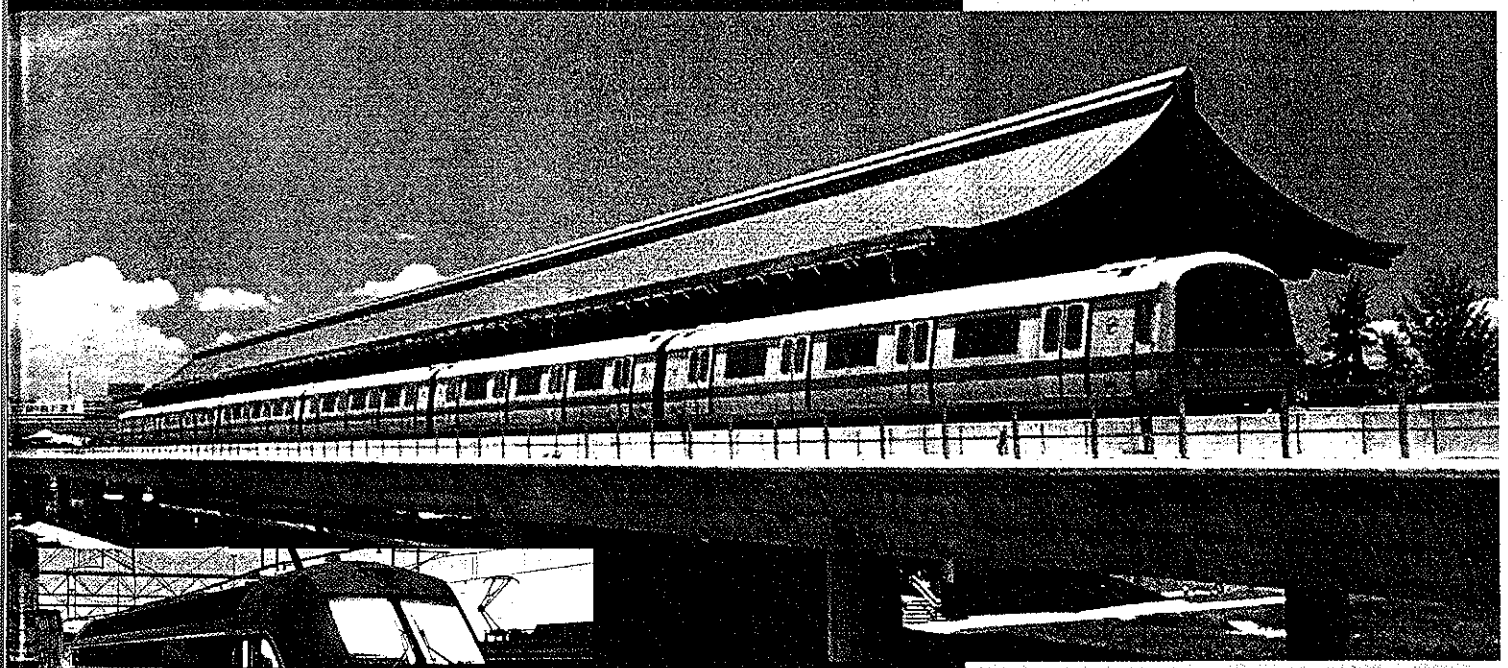

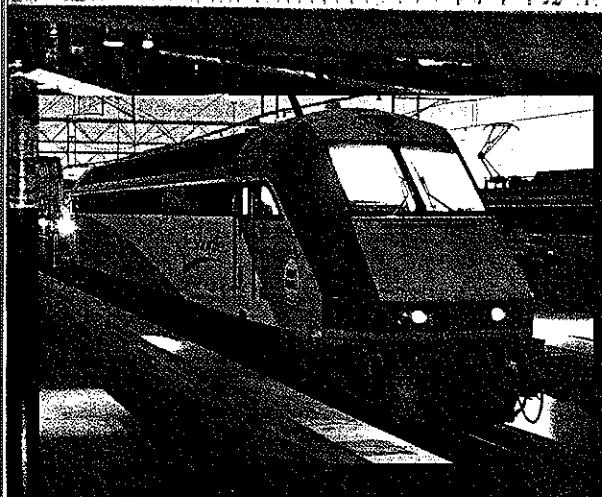

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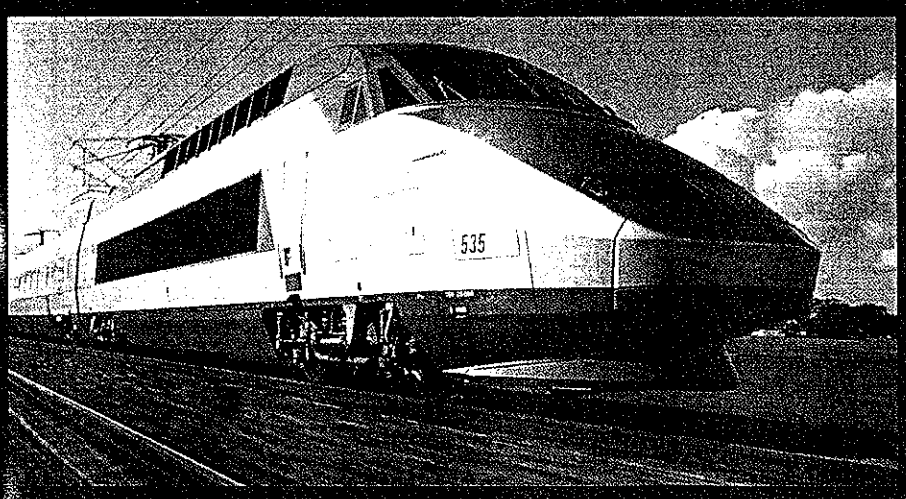

The new SAB WABCO Group

On January 1st, 1997, the railway operations of the Swedish Cardo Group and the German Thyssen Industrie AG were united into one multi-national company called SAB WABCO.

SAB WABCO operates under the following well-known trade names: SAB WABCO, BSI, Tebel Technologies, Davies & Metcalfe and Gutehoffnungshütte Radsatz. The combined programme embraces a complete range of brake products and systems, couplings, wheelsets, wheels, automatic doors and electronic control systems for the railway industry.

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A company in the Cardo BSI Rail Group

On April 26 Montpellier ordered 28 Citadis 301 cars from GEC Alsthom for Fr300m, with delivery starting in December 1998. The 65% low-floor car will look very similar to the all-low-floor Citadis 202 design currently being promoted

goes ahead, Vevey is in line to supply 13 cars 25·75 m long and 2 500 mm wide cars on three bogies, similar to the Genève arrangement, but with all wheels driven.

Business outlook

As the world's operators appear to have deliberately rejected the only way to obtain substantially lower tram prices and good, widely proven vehicles – pooling purchases – the constant drive for new and possibly 'cheaper' solutions seems set to continue. The latest attempt to build a sturdy, simple and low-maintenance car, the Combino, which cost Siemens around DM20m, is already struggling to meet all the detail wishes of different operators. What is perfectly normal for buses seems impossible with trams! Düsseldorf is a particularly graphic case.

Above all, it seems that every operator now wants a car to its own tailor-made design, but at an 'off-the-peg' price. For the time being it looks as if this tendency is partly successful, for example Kassel's order for DWA and Kiepe. Whether the suppliers can actually build such designer cars for economic prices remains a moot question. The lowest price for 2 300 m wide 30 m long cars seems to be settling at around DM40 000 per m².

The only low-cost designs ordered so far are Combino and Cobra. GEC Alsthom is continuing to promote its Citadis 202 all-low-floor car with two trucks powered by hub motors of the Brussels type. This 22 m car with two articulations would seat 50. It would use a riveted aluminium bodyshell and pre-assembled cab end modules.

The next step in this 'race to progress' is likely to be the introduction of synchronous hub motors with permanent magnets, which will allow much higher torque and much lower weights, down to just 1 kg/kW. Such motors have recently been introduced in trolleybuses and diesel-electric buses, but it remains to be seen whether such light machines are able to withstand the rail environment, including vertical accelerations in the order of 10 to 20 *g*. Light motors would help to overcome the heavy unsprung loads which have been associated with hub-motors and if produced in greater volumes could help reduce the present high costs of the hub motor option.

US operators have traditionally been prudent and are well advised to stay with 60 to 70% low-floor solutions utilising classic drive packages in order to guarantee robust and simple vehicles.

Another interesting question is whether the European international open tendering rules will really succeed in opening up the borders? So far three French cities have bought non-French designs: St Etienne with 35 Vevey/Duewag cars, but using a GEC Alsthom drive, Lille has 24 Breda/Westinghouse cars and Strasbourg has opted for 52 cars to an Italian design, built in Britain using German/Austrian electrics. Of 273 cars ordered by French cities, 162 were from GEC Alsthom. Will Siemens and Matra stand a chance with Combino?

Bombardier Eurorail's plants in Wien, Brugge and Manage have broken into the German market with 80 cars for Köln and 15 for Saarbrücken, albeit with Kiepe electrics and AC motors from France. Oslo has ordered 17 cars from Ansaldo and Firema, whilst De Lijn has gone for German technology with 45 cars from Siemens, DWA and Adtranz. Will this trend continue? ❑

High-speed gates speed Seoul throughput

THE FIFTH metro line in the South Korean capital was officially opened on December 31 1996. Line 5 has been equipped with automatic fare collection equipment by Thorn Transit Systems International, but required modifications to the standard gate design in order to handle a projected throughput in excess of 60 passengers per gate per minute.

For several years Seoul Metropolitan Subway Corp has standardised on Edmonson-sized magnetic strip tickets with a plasticised thermal print surface. Unlike earlier installations, the Line 5 gates have been designed to accept and read tickets inserted in any of the four orientations, avoiding any risk of delays caused by wrongly-inserted tickets.

The gates on Line 5 stand 'normally open', with electrically-powered flaps closing only if a passenger tries to pass without inserting a valid ticket. Sensors located at various heights within the gates prevent more than one person seeking to gain access with a single ticket, but can differentiate between a person and a large item of luggage. For safety reasons the barrier flaps do not move if a passenger or item becomes trapped. The flaps will automatically lock in the open position in the event of an emergency requiring evacuation of the station.

The revised gate design allows for retro-fitting of readers to handle contactless smart cards, which are under consideration for future ticketing policy. Thorn has also been contracted to provide fare collection equipment on Lines 7 and 8, which are now under construction, and has demonstrated various smart card options to SMSC. ❑