State of the Art of bus, hybrid bus, trolleybus and intermediate systems

by Mr. H. Hondius, ing. Dipl. ETHZ,

This article is based on a paper presented at the UITP Conference on "Intermediate Transport Modes" in Bruges on 29 August 1995

Version française, voir 5F en deuxième partie
Deutsche Fassung, Siehe 5D im dritten Teil

Diesel bus development

The "motor bus" is still the backbone of public transportation in the world. It developed rapidly between 1923 and 1960 to the detriment of the tram, because enough road space was then still available. This road space has since been snapped up by the private car, lorries, etc. rendering the bus slower and thus less and less attractive. In the past 10 years the diesel bus has gone through an unprecedented technical evolution, comparable with the one between 1930 and 1940, when steel bodies replaced wooden ones and the diesel engine largely started replacing the petrol engine.

After years of standardisation, or the production of a very limited number of bus types by the makers of buses in each country, the introduction of the low-floor bus in 1988 opened the floodgates of new development. By the end of 1995, 14 European and 3 North American bus producers will be producing 44 and 3 different low-floor bus types respectively, with no end yet in sight. The top developments include a twin-articulated low-floor bus (lit.1) with all entrances at 330 mm (fig.1) and a 15 m bus with all three axles steered (lit. 1,2,3) and equally all entrances at 320 mm (fig.2).

The diesel bus might well have reached a stage where a further important breakthrough could be achieved in the next 5-10 years. Diesel-electric drive with hub-motors (2,4) with Euro 3 engines in combination with a magnetic-dynamic vacuum operated flywheel energy accumulator may well produce an environmentally friendly vehicle, consuming up to 25% less energy than today, and still at a reasonable price per m² (fig.3). A few vehicles with all-wheel steering are running in Herten (FRG). Volvo even presented for the participants of the conference it's Environmental Concept Bus (ECB) (fig.4), which is equipped with a gas turbine-electric drive and a battery.

Battery or Hybrid buses

Battery buses have, after costing a fortune in international development subsidies, not yet fulfilled any real promise to any practical extent. After the NA-S flop suffered by ABB, the only readily available battery still seems to be the lead acid variety (fig.5), although Varta has high hopes for its Nickel Metal-Hydride (NiMH) battery (2) which equips the ECB. So people like Neoplan have entered the development of quick battery-changing systems (5) to be operated by the driver (fig.6).

In order to make hybrid town buses more versatile they are often equipped with a modern petrol engine which, once the city centre is left behind, can be started up to charge the batteries.

Bus systems

The first serious alternative to the standard bus run on public road space is the creation of the bus lane, making the bus part of a bus system. A few examples:

Nagoya: Key-Bus system (6,7): the Shindeki route (fig.7), opened in 1985, 9.4 km long, provides 15 stops at 650 m distance and has two interchange points with the metro. 41 trips per direction per hour at an average speed of 18 km/h. 16.500 passengers are transported per direction per day .

Paris Trans Val de Marne (8), opened 10/93. Length 12.5 km, cost 47.8 MM FF, or 3.8 MM FF/km. 19 articulated RVI PR 180 buses run from 05:30-0:00 hrs. There are 23 stops at 600 m distance. A 3-4 minute service is run during rush hour, after which a bus runs every 8 minutes. Average speed is 22 km/h. The result is approx. 12.000 passengers per day per direction.

Trolley- and hybrid buses

If the diesel bus is not considered to be attractive enough, the trolleybus (9) is the next, more expensive but higher quality, alternative. Trolleybuses are by far the most environmentally-friendly vehicles, be it from the pollution angle or from the energy consumption point of view. Unfortunately, their operational advantages only truly come to light in a hilly environment (Nancy, Seattle, San Francisco, Solingen, Lausanne). They need the same electrical overhead system as trams, and the vehicles

Van Hool
H. Hondius

▲ *Left: 1. Van Hool AGG 300 24.6 m twin-articulated 100% low-floor bus, 47 seats, max. capacity up to 200 passengers.*
Right: 2. Neoplan N 4020 15 m 100% low-floor bus with all-wheel steering.

● *Gauche: 1. Autobus Van Hool AGG 300 à plancher 100% surbaissé et à double articulation, 24,6 mètres, 47 sièges, capacité maximale: 200 passagers. Droite: 2. Autobus Neoplan N 4020 à plancher 100% surbaissé, toutes roues orientables, 15 mètres de long.*

■ *Links: 1. Doppelgelenkbus AGG 300 24,6 m von Van Hool mit 100 % Niederflur, 47 Sitzplätze, Fassungsvermögen max 200 Fahrgäste. Rechts: 2. Neoplan N 4020, 15 m, 100 % Niederflurbus mit Allradlenkung.*

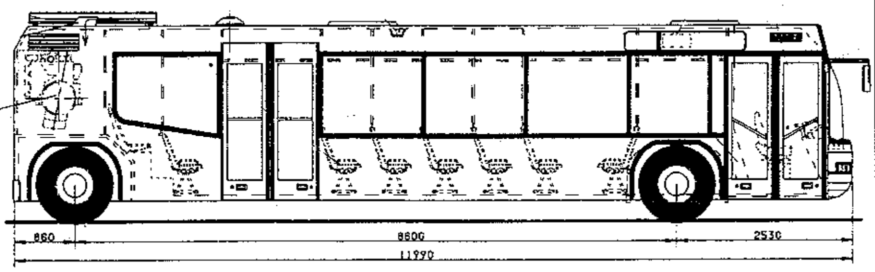
may cost twice the price of diesel buses. In examining trolleybus systems one can clearly see demonstrated the discrepancy between "words" and "deeds". Everyone talks about the need for electric public transport systems and flirts with their introduction. And what do we actually see? Between 1993 and 1995, Weimar, Hoyerswerda, Potsdam, Hamilton and Toronto all decided to scrap their "trolleys", with the Oporto system soon to follow. The "modern" manager may not like electric buses, citing economical reasons for this, or the CNG bus as potentially a more acceptable alternative, etc. Often the electricity prices charged are completely unrealistic. The fact remains that it is quite unbelievable that, here in 1995, trolleybus systems can be closed down on the strength of arguments that were being used in the sixties.

Quito now has a new system and **Zurich** has converted two bus lines over to trolleys; a purely political decision taken somewhat against the wishes of the operator, VBZ. New low-floor trolleys, with all or nearly all entrances at 330-350 mm, have recently been bought by Basle (fig. 8), Montreux (fig. 9) and Salzburg (fig.10).

There remain in the Western world about 70 systems with some 5300 vehicles. The hope is that if the introduction of diesel-electric bus drives is successful and series production of electrical drives gets going, the cost price of the electrical equipment may substantially fall, thereby reducing the overall cost of the trolleybus.

Its energy consumption based on fossil fuel-fired power stations is practically identical with the consumption of diesel buses. Environmentally, the trolleybus solution is the best possible: on NOx, CO, HC it is incomparably better than the best diesel version and practically identical on SO^2; however, it is 25% worse on CO^2. That being said, in many industrial countries 30% or more electricity (Argentina: 14%, Belgium: 56,4%, Bulgaria: 45,6%, Canada: 19%, Czech Republic: 22%, Finland: 29%, France: 75%, Germany: 33%, Hungary: 42%, Japan: 30%, Korea: 35,5%, Russia: 11%, Slovakia: 49%, Slovenia, Croatia: 23%, Spain: 33%, Sweden: 51%, Switzerland: 36%, Taiwan: 30%, Ukraine: 43%, USA: 20% (10)) is generated by nuclear reactors or hydro-electric power. So in reality the trolleybus scores better on all environmental fronts.

There are however a few drawbacks that have to be mentioned. Although external noise is quite low, many motors and cardan shafts produce noise at unacceptable levels. The hub motor could bring about an improvement here. The catenary and

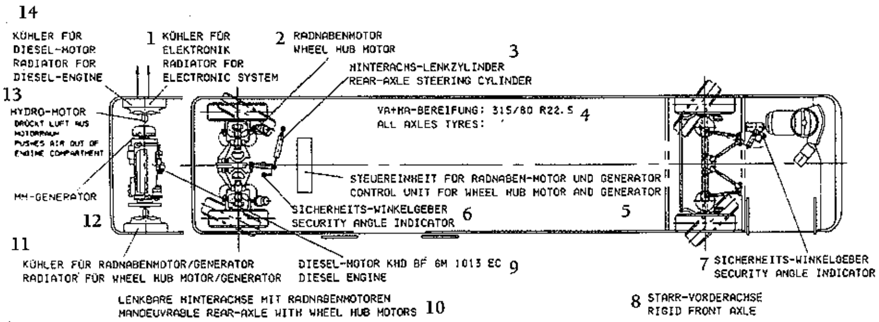


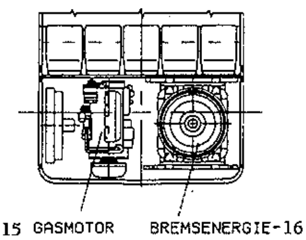
Neoplan

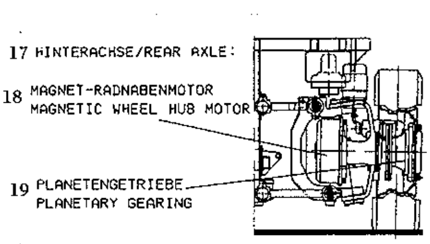
▲ *3.Neoplan N 4114 DES, 12 m bus of the year 1995, with all-wheel steering.*

● *3. Autobus Neoplan N 4114 DES de 12 mètres de long à roues orientables, sacré autobus de l'année 1995.*

■ *3. Neoplan N 4114 DES, 12-m-Bus des Jahres 1995 mit Allradlenkung.*







● *1. refroidisseur du système électrique - 2. Moteur-moyeu - 3. cylindre de direction de l'essieu arrière - 4. pneus - 5. module de commande du moteur-moyeu et de la génératrice - 6. indicateur de l'angle de sécurité - 7. indicateur de l'angle de sécurité - 8. essieu avant rigide - 9. moteur diesel - 10. essieu arrière orientable avec moteur-moyeu - 11. refroidisseur du système électrique / génératrice - 12. régénérateur - 13. hydro-moteur - 14. radiateur du moteur diesel - 15. moteur au gaz - 16. stockage de l'énergie de freinage - 17. essieu arrière - 18. moteur-moyeu - 19. boîte à engrenages planétaires.*

current collection system have not really progressed any further since the sixties. Overhead wires in town centres are often rejected by elected officials. To that extent, the trolleybus is operationally more vulnerable than the normal bus.

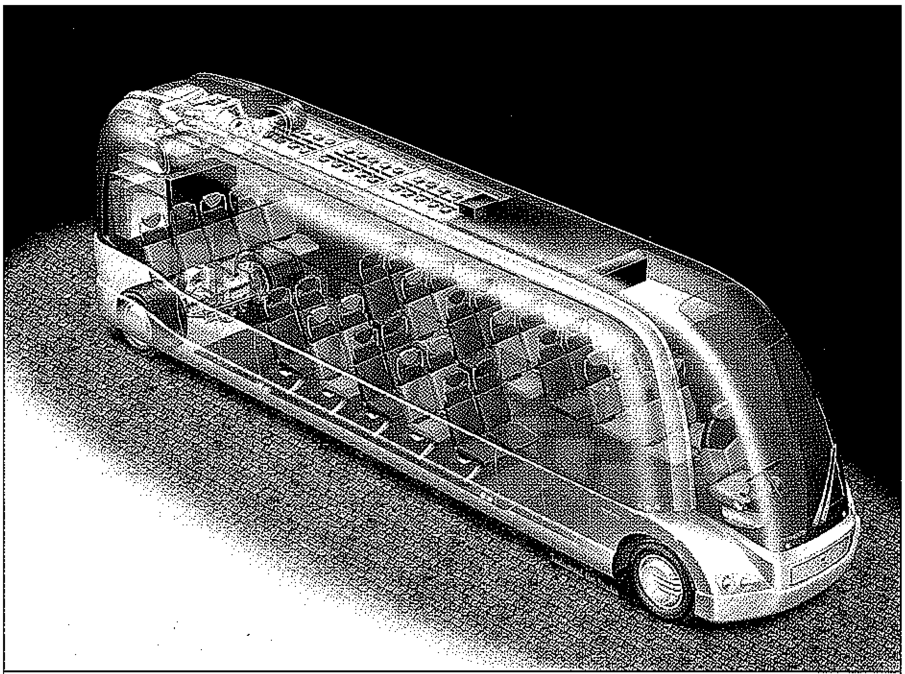
Trolleybuses can run on their own bus lanes and thus form a trolleybus system.

Arnhem: open since 1949, 55 km network, 52 trolleybuses. Trolley lines 5 and 9 use a separate bridge with a length of 2.2 km (fig.11). The centre of the city also has a through-running trolleybus lane.

Hybrid buses

The next step-up in quality could be the hybrid ("dual") bus system (11). Buses operate in densely populated areas like trolleybuses and under diesel power outside those areas. A few interesting dual systems have been created:

Nancy has had a hybrid bus system in operation since 1982. 25.5 km electrified, 48 hybrid buses, 9.31 km separate routes, average speed 17.5 km/h. Three lines carry 11.6 million passengers per year. Investment: 4 million DM per km.



Volvo

▲ 4. *Volvo gas turbine-electric / battery 10.7 m Environmental Concept Bus with all-wheel steering.*

● 4. *"Environmental Concept Bus" de Volvo avec propulsion par turbine à gaz / électricité et par batterie, roues orientables, 10,7 mètres de long*

■ 4. *Experimentier-Versuchsbus von Volvo, Gasturbine-elektrisch / Batterie, 10,7 m, mit Allradlenkung.*

Esslingen, a small system in Germany (4), **Bergen** in Norway, and a test line built in **Copenhagen. Bologna**, with its 20 two-axle hybrid buses, might want to replace these with articulated trolleybuses.

Seattle: a 2 km transit tunnel running (12) from Convention Plaza to the international district, constructed for use by 236 Breda / AEG hybrid buses (fig. 12) and equipped for light rail use. There are five stations, built between 1985 and 1990. The total cost is reported to have been US $ 500 million. (The cost of the 236 hybrid buses at 1985 prices was US $ 103 million).

Of course, the dual vehicle is more costly than the trolleybus and heavier than both the diesel bus and trolleybus. A very interesting development is taking place in **Zurich.** VBZ has ordered 48 MB O 405 GTZ high-floor trolleybuses with an ABB/ Siemens DC-chopper drive on axle 3 and a 66 kW hydro-mechanical auxiliary drive on axle 2, of which 43 are now in service. Vehicles are nearly identical to the 56 delivered earlier to Winterthur and Zurich. The last five vehicles will now be built as 100% low-floor hybrid buses of type O 405 GNTD (fig. 13) with ZF hub motors in the wheels of axles 2 and 3. They will be exhibited at the Palexpo exhibition in Geneva in January 1996. This could be the start of a very promising development whereby the actual drives of diesel-electric and electrically-driven buses would be identical.

High-capacity bus or trolleybus systems

If the simple bus, trolleybus or hybrid bus system does not perform well enough, bus or trolleybus systems have been developed which potentially offer virtually the capacity of tram systems in a format that could be considered as "new".

- **Curitiba** (Brazil): "Surface Subway"; Boqueirao route, opened since 12/92, 11 km, 30 stops at 500 m with "tubular" high platforms (fig. 14), ticketing facilities and controls, and four integrated network transportation terminals served by high-platform buses (13-15). 33 Volvo B58 twin-articulated buses (fig.15) have replaced 66 other vehicles. 5000 passengers per direction per hour are transported at an average speed of 20 km/h. The investment is reported to be worth US $ 18 million, or $ 1.63 million per km. The top speed of the buses is 55 km/h.

Curitiba also operates 14 "rapid" routes with 88 similar "tubular" stations, carrying 300.000 passengers per day. These have been served since 11/92 by 156 standard buses equipped with left side high-platform doors only. The average speed on these routes is 30 km/h.

- **Bogota** (Colombia): Set to have a similar system (16) which is being developed jointly by the Volvo Bus Corporation and Stage Coach.
- **Quito** (Ecuador): A city that lies at an altitude of 2,850 m has decided to install a 23 km trolleybus system with high-floor platforms to combat air pollution. 44 stops are planned and 54 articulated trolleybuses (actually semi-hybrid buses) of type MB O405 GTD/Kiepe (fig.16) with a 100 kW auxiliary engine will be used. The vehicles are being completed in Spain. The system will open in early 1996.

Guided bus systems

The next step might be when a community decides that only "something different" may be attractive enough to push forward powerfully the role of public transport, but where the step-up to tramway may be considered too obtrusive or costly. The guided road vehicle system may then be a consideration.

All the vehicles described here are road vehicles, being subject to road codes and under the supervision of road inspection authorities. A "tram on rubber tyres" may be an interesting marketing expression, yet bears little relation to reality. A tram runs on rails and is governed by the railway inspectorates of this world. A GLT or Translohr will always be a road vehicle!

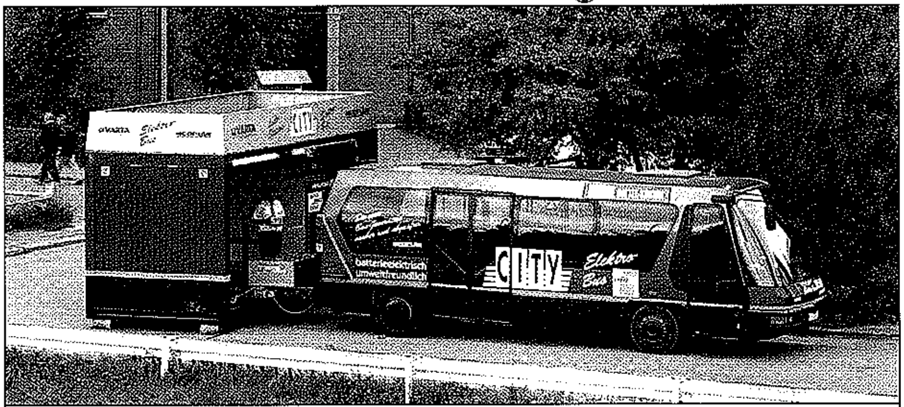
A real advantage of guided road vehicle systems compared to classic bus lanes is that they effectively need less road space. A two-lane reserved site for guided buses does not need more than around 6 m width, whereas a normal double bus lane would need something up to 7.5 m. Furthermore in low-floor systems the gap be-

H. Hondius

▲ 5. *DAB/Scania Delphi hybrid bus with a Saab petrol engine and lead-acid batteries for the city of Luxembourg.*

● 5. *Autobus hybride DAB/Scania Delphi équipé d'un moteur à essence Saab et de batteries plomb-acide, pour la ville de Luxembourg.*

■ 5. *Hybridbus von DAB/Scania Delphi mit Benzinmotor von Saab und Bleisäurebatterien für Luxemburg-Stadt.*

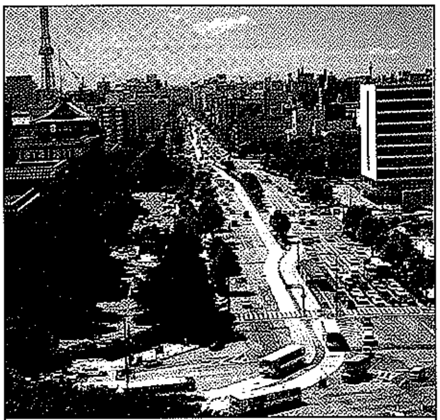


Zimmerman

▲ *6. Neoplan MIC N 8008 E with Varta automatic battery-changing installations.*

● *6. Autobus Neoplan MIC N 8008 E avec dispositif Varta d'échange automatique des batteries.*

■ *6. Neoplan MIC N 8008 E mit automatischer Batteriewechselvorrichtung von Varta.*



Nagoya

▲ *7. Nagoya Key-Bus system.*

● *7. Système "Key-Bus" de Nagoya.*

■ *7. Nagoya-Key-Bussystem.*

tween the vehicle floor and the stop may be minimal, at about 50 mm.

There are various modes of guided road vehicle in service, at the latest planning stage or still at the proposal stage:

The MB-Spurbus system

This system, also known under the name of O-Bahn, is well known, with 12 km in operation in Adelaide, 9 km in Essen (17), 1 km in Mannheim and 0.8 km in Ipswich. The MB solution has a great advantage in that normal buses are used. As long as a straight axle design is used, all makes of bus can be equipped with the system. It is fully proven, fits well into the environment, can run together with trams, etc. Yet after 15 years, there are only 4 systems operating on some 23 km. However, even a system such as the one in Essen has never contemplated going any further than subsidised test tracks to create more "Spurbus" lines. Leeds is reported to have installed a stretch following this idea, albeit without MB components. Nowhere else has any decision been taken yet to install such a system, despite an abundance of visits and plans.

H. Welter

Above: 8. BVB, Basle, Neoplan N 6020 100% low-floor trolleybus with MM-hub motors on axles 2 and 3 and a flywheel energy storage system. Below: 9. VMCV, Montreux, one of 18 100% low-floor Van Hool trolleybuses with Kiepe AC-equipment driving axle 2. Axle 3 is steered.

Ci-dessus: 8. BVB - Bâle: trolleybus Neoplan N 6020 à plancher 100% surbaissé, équipé de moteurs-moyeu MM sur le 2e et le 3e essieu et d'un système de stockage d'énergie avec volant d'inertie. Ci-dessous: 9. VMCV - Montreux: un des 18 trolleybus Van Hool à plancher 100% surbaissé équipé d'un moteur CA Kiepe sur le 2e essieu; 3e essieu orientable.

Oben: 8. BVB Basel, Neoplan N 6020 100 % Niederflur Obus und MM-Radnabenmotoren an den Achsen 2 und 3 und einem Schwungrad-Energiespeichersystem. Unten: 9. VMCV, Montreux: einer der 18 100 % Niederflur-OBusse von Van Hool mit Kiepe-Wechselstromausrüstung für den Antrieb der Achse 2; die Achse 3 ist gelenkt.

H. Hondius

The GLT system from Bombardier-Eurorail

This system (18,19) was developed from 1985 initially by the BN Division alone, then together with Spie Energietrans to devise the infrastructure. A 4 km former railway line between Jemelle and Rochefort was converted for this system (fig. 17) in 1988 and for a few years a commercial operation was conducted using two twin-articulated vehicles, which then continued their runs as "hybrid buses" on to Han. After many years of hard work Bombardier finally found the city of Caen willing to take a firm interest in the system. It calls the system TVR ("Transport on reserved track"). The TVR system comprises 13.8 km of track. The earliest opening is planned for 1998. It is a low-floor system with 27 stops. The price will be 71 million FF per km. The ambition is to transport 150 passengers per vehicle (at 4/m²) during peak hours at a 3.5 'service headway leading to 2600 passengers per hour per direction at an average speed of 21 km/h using 20 TVR vehicles of 24.5 m in length and 2.5 m wide.

The TVR system has the advantage of offering "something new", at overall less cost than a new tram system. The investment savings are entirely on the civil-engineering side: fewer initial km need to be constructed, no depot, etc. The cars have large wheels, which take up a fair amount of space. The TVR car's cost per m² is the same as for a tram car. We will have to wait and see whether this system will meet the noise standards today required of new transportation systems. The required car weight of 400 kg/m² is light for a tram, but heavy for a road vehicle.

The Translohr system

The "Translohr", the rival challenger in Caen, will be built more along road-vehicle lines and should weigh around 350 kg/m². It has the flatter floor, because of the different drives. Its rail guidance system (fig. 18) is far less proven than the one used by the GLT. Profiles need further scientific specification.

The GLT and Translohr have all-wheel steering, bringing the advantage that curves of 12 m can be negotiated by the complete vehicle.

It is not excluded that De Dietrich/ Neoplan / Cogifer will introduce the TLP, the "tramway léger sur pneus" or "Light Tram on Tyres", a vehicle that can run on tram tracks and continue its way on roads; effectively a new version of the "Roadrailer" that was introduced in 1933 in the UK.

Costs

Although costs are calculated differently in practically every country or region we will try to give some indication as to vehicle costs, the costs of running them per vehicle kilometre and the costs of the various modes per passenger kilometre.

Vehicle costs

The calculations here were based on the price per m² of low-floor vehicles (car length times car width, where car width in all cases was set at 2.5 m):

1 The 17.5 - 18 m articulated diesel bus's cost is assumed to be 100%;

2 The articulated trolleybus with single axle drive and an auxiliary engine 150-180%;

3 The articulated trolleybus with twin-axle drive 180-200%;

4 The articulated hybrid bus 180-200%;

5 The 27.5 m single direction 65% low-floor tram with six axles, four motors 340-360%;

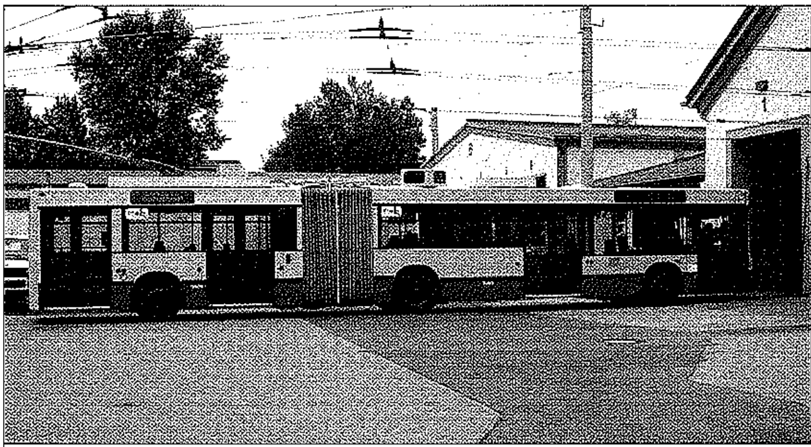
6 The TVR, single direction but doors on both sides 365%.

NB: 1: Series product. 2-4 and 6 mostly ordered in small series, around 20 vehicles per batch. 5: Prices for orders of 120 vehicles. At smaller orders and different specs prices may be higher.

These ratios may vary from country to country. In the FRG 100% corresponds with approx. 12,000 DM/m².

Costs per vehicle kilometre

Arnhem, Nancy and Zurich supplied cost details to the author (9,11). The limited picture is as follows:


Kiepe

H. Hondius

▲ *Left: 10. Salzburg: 16.5 m low-floor trolleybus from MAN/ÖAF with Kiepe AC-equipment driving axle 2. Axle 3 is steered, all entrances at 340 mm. Right: 11. GVM, Arnhem, trolleybus lanes on Rhine bridge.*

● *Gauche: 10. Salzbourg: trolleybus MAN/ÖAF à plancher surbaissé équipé d'un moteur CA Kiepe sur le 2e essieu (3e essieu orientable). Il mesure 16,5 mètres de long, et toutes les entrées sont situées à 340 mm du sol. Droite: 11. GVM - Arnhem: un pont réservé aux trolleybus sur le Rhin.*

■ *Links: 10. Salzburg: 16,5 m Niederflur-Obus von MAN/ÖAF mit Kiepe-Wechselstromausrüstung für den Antrieb der Achse 2. Die Achse 3 ist gelenkt. Alle Türen mit 340 mm. Rechts: 11. GVM, Arnheim, Obusspuren auf der Rheinbrücke.*

Breda

▲ *12. Metro, Seattle: one of 236 Breda/AEG high-floor hybrid buses at the underground station of Pioneer Square.*

● *12. Métro de Seattle: 1 des 236 autobus bimodes Breda/AEG à plancher haut, à la station de Pioneer Square.*

■ *12. U-Bahn in Seattle: einer der 236 Hochflurbusse von Breda/AEG an der U-Bahn-Haltestelle Pioneer Square.*

Diesel bus	100%
Trolleybus	114-116%
Hybrid bus	122-130%

Costs per passenger kilometre

Here data was hard to come by. GVB Amsterdam operates metro, tram and bus services.

Data available for 1994 and 1988

In 1994 the system (20) revealed the following:

16 tram lines,.totalling 134 km, using 252 articulated 8-axle trams, transporting 500 000 passengers per weekday, 143 million per year or 342 million passenger kilometres. Over 365 days, the average tramline carries 25 000 passengers per day.

Two metro and one light rail line(s), totalling 40 km, using 44 + 25 vehicles, transported 50 million passengers per year or 262 million passenger kilometres. Over 365 days, each line carries 45,500 passengers per day.

The bus system has a route length of 422 km, uses 170 12 m buses and 85 articulated vehicles. It transported 170,000 passengers per weekday or 57 million per year, producing 250 million passenger kilometres.

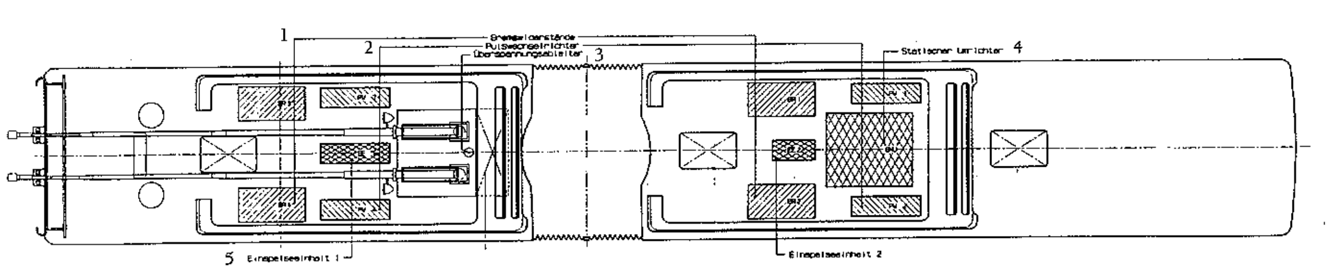
In 1988 the passenger kilometre values were: tram, 287 million; metro, 196 million and bus, 229 million and at that time the costs per passenger kilometre were indicated (21) as follows: for tram Hfl 0.58, metro 0.38, bus 0.64.

This underlines the well-known fact that, in order to install high capacity systems, one needs to be sure of heavy passenger loads, which in Amsterdam for the rail line seems to be the case. A study (22) underlines this and offers a view on the costs of trams and trolleybuses and the merits of the various systems.

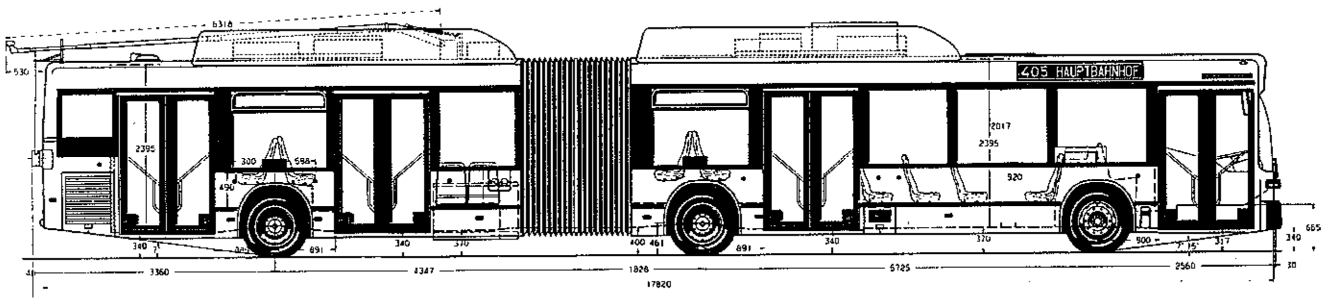
Life cycle costs are worth a chapter in their own right. There is as yet no practical data available on this subject.

Conclusion and outlook

- *We have seen that diesel bus development is still in full swing. In the next ten years the bus will progress and become a more environmentally-friendly vehicle with less noise production and air pollution. If the diesel-electric drives for town buses were indeed introduced on a large scale, energy recuperation would be possible as well as a jolt-free acceleration process.*
- *Operators would be well-advised to look more closely into the possibilities*



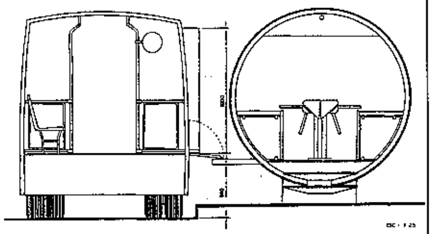
1. Braking resistors - *résistances de freinage* - Bremswiderstande / 2. Pulse inverter - *onduleur à impulsion* - Pulswechselrichter / 3. Peak voltage suppressor - *protection contre la surtension* - Überspannungsableiter / 4. static inverter - *convertisseur statique* - statischer Umleiter / 5. Power supply unit - *unité d'alimentation* - Einspeiseeinheit

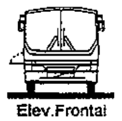


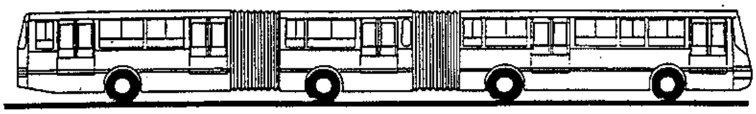
▲ *13. VBZ, Zurich, the MB O 405 GNTD 100% low-floor hybrid bus with ZF-hub motor drives on axles 2 and 3.*

● *13. VBZ, Zurich: autobus bimode O 405 GNTD à plancher 100% surbaissé doté d'un moteur-moyeu ZF sur les 2e et 3e essieux*

■ *13. VBZ, Zürich: der MB O 405 GNTD 100 % Niederflur Duobus mit ZF-Radnabenmotor an den Achsen 2 und 3*







Curitiba

▲ *Left: . 14. High-platform bus stop with ticketing facilities.*
Right: 15. Curitiba, Volvo B 58 twin-articulated, high-floor 24.7 m bus, 2.6 m wide, with axle 2 driven by a 210 kW diesel engine. 49 seats, total capacity 270. Axles 2, 3 and 4 have twin-tyre sets

● *Gauche: 14. Arrêt à quai haut avec point de vente de billets.*
Droite: 15. Curitiba: autobus Volvo B 58 à double articulation, à plancher haut et avec propulsion du deuxième essieu à l'aide d'un moteur diesel de 210 kW. Long de 24,7 mètres et large de 2,6 mètres, il compte 49 places assises et affiche une capacité totale de 270 passagers. Les essieux 2, 3 et 4 sont équipés de jeux de roues jumelées

■ *Links: 14. Hochflurbus-Halstestelle, in der Fahrausweise verkauft werden.*
Rechts: 15. Curitiba: Volvo B 58 Doppelgelenk-Hochflurbus, 24,7 m lang, 2,6 m breit. Achse 2 angetrieben durch 210 kW-Dieselmotor. 49 Sitzplätze, Gesamtkapazität 270. Die Achsen 2, 3 und 4 haben Zwillingsreifen.

of using twin- articulated buses. Presently they are found only in Bordeaux and Curitiba, while Utrecht is seriously contemplating the building of a bus system with twin-articulated low-floor buses after plans to build a tram system were scrapped. The authorities should collaborate to enable the wider deployment of these cost-effective vehicles.

- *Battery buses will only take off if batteries that are less costly and can be recharged more quickly become readily available on the market. Until then subsidies will be spent on all sort of "trials".*

- *The trolleybus is a very "green" vehicle that deserves more attention from operators than it currently attracts. Those who operate a system should certainly continue to do so, and town networks should give careful study to the introduction of trolleybuses. More orders for trolleybuses would mean lower prices. If diesel-electric technology were indeed to progress, electrical installations could equally profit from lower costs.*

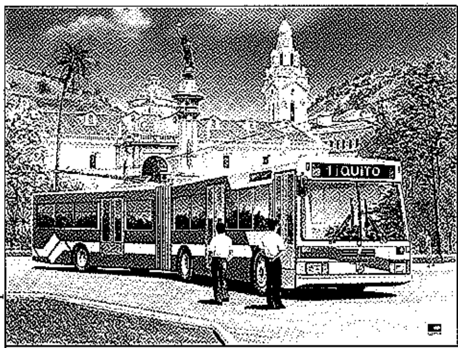
The trolleybus and, for that matter, the hybrid bus are the least costly options for operators to "upgrade" their bus systems via the introduction of an electrically-driven vehicle.

- *Every attention should be paid to trying to win space for separate bus lanes in order to turn the bus into a genuine bus system. This is the most effective and cheapest way to improve* *the position of public transport. The "Spurbus" is certainly another system that deserves more attention than it is getting today.*

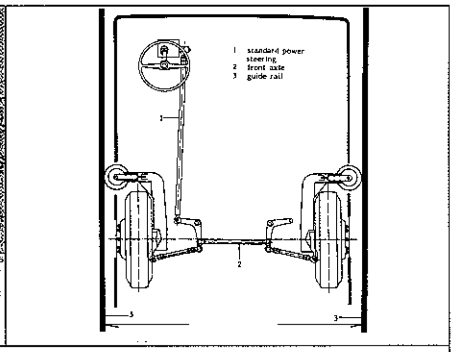
- *Operators would be well advised to keep a weather eye on all possibilities for bus or trolleybus systems before entering the sphere of special systems with all their axles guided. Caen has taken a courageous step in planning the TVR system. It is now up to the TVR system to prove itself.*

Literature

1. **H. Hondius**, Car & Bus 1993 in Kortrijk. "Stadtverkehr" 1/94.
2. **H. Hondius**, IAA-Nutzfahrzeuge, Hanover. "Stadtverkehr" 11-12/95
3. **H. Hondius**, UITP City-Transport '95 Exhibition, Vehicle Development, PTI 1995/4, "stadtverkehr" 8/95.
4. **E. Hoepke et al.**, Omnibusse im Verkehrssystem von Ballungsgebieten. ISBN-8169-1164-1.
5. **H. Hondius**, Neoplan MIC N 8008E Niederflur-Elektrobus. "Stadtverkehr 11-12/93.
6. The Nagoya city-bus and subway system, 1985/7. Nagoya municipal transportation bureau.
7. Plan for a Key Route bus system in Nagoya and the effects of implementation. Expert's Report, SEATAC '86.
8. **R. Viennet**, Trans Val Marne: le bus en liberté. Transport Public, 10/93.
9. H. Hondius, O-bus, eine Bestandsaufnahme. "Stadtverkehr", 2/94.
10. ENS World Yearbook 1995. Nuclear Europe Worldscan, 7/8-1995.
11. **H. Hondius**, Duobus - eine Bestandsaufnahme, "Stadtverkehr" 3/94.
12. Trolleybusmagazine 193.



Kiepe

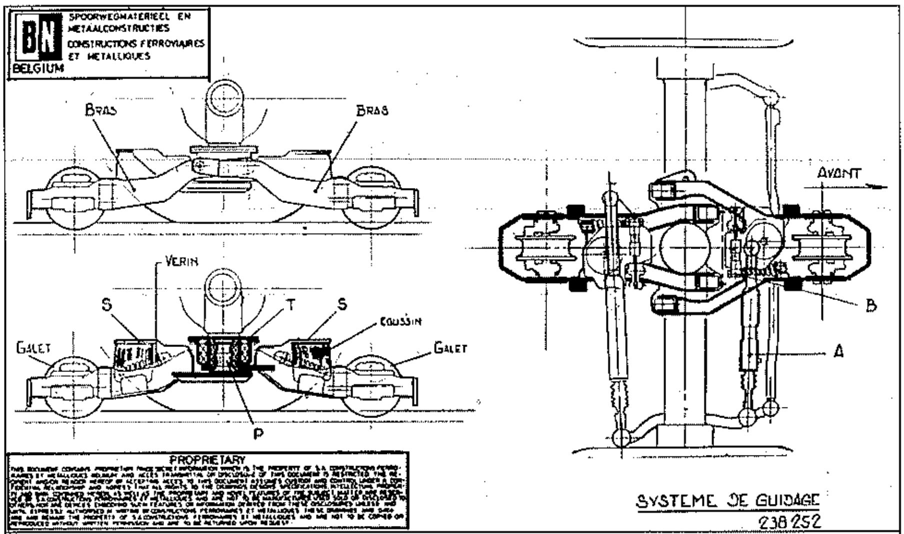


EVAG

▲ *Left: 16. Quito, artist's impression of MB O 405 GTD semi-hybrid bus with Kiepe AC-equipment for a high-platform trolleybus system.*
Right: 17. The MB guidance system used for the Spurbus and O-Bahn system.

● *Gauche: 16. Représentation graphique de l'autobus "semi-bimode" MB O 405 GTD doté d'un moteur CA Kiepe qui circulera sur le réseau de trolleybus à plancher haut de Quito. Droite: 17. Le système de guidage de MB: "Spurbus" et "O-Bahn".*

■ *Links: 16. Quito: Eindruck eines Künstlers vom MB O 405 GTD Semi-Duobus mit Kiepe-Wechselstromausrüstung für ein Hochbahnsteig-Obussystem. Rechts: 17. Das Spurführungssystem von MB für Spurbusse und das O-Bahnsystem.*



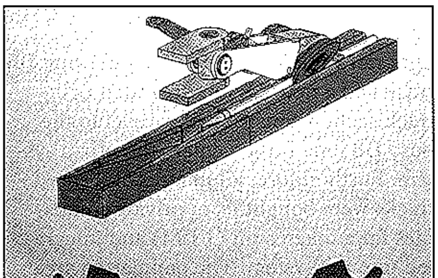
BN

▲ *18. Guidance system for the TVR/GLT from Bombardier Eurorail.*

● *18. Le système de guidage du GLT/TVR de Bombardier-Eurorail.*

■ *18. Das Spurführungssystem des TVR/GLT von Bombardier Eurorail.*

13. Solving the problems in Latin America. PTI, 2-1992.
14. Integrated Transport Network 1993. Urbânizaçao de Curitiba S.A.
15. **G. Fronemann**, Mindre än en procent. Resor & Trafik 3.4.95.
16. Symposium on Curitiba, Brazil, Bogota, 1.11.93.
17. **H. Ahlbrecht**, Das Duo-Spurbussystem in Essen. Elektrische Bahnen 2/1992.
18. **H. Hondius**, Caen bestelt "tram op banden". Nederlands Vervoer 11/12-1995.
19. **M. Scallet**. GLT: The tramway on tyres. PTI, 1995/3.
20. GVB, Amsterdam, Annual report 1994.
21. Ontwerp Verkeers-en Vervoerplan Amsterdam 1990. DRO, 1990.
22. **M. Benz**, Noch Chancen für den O-bus? Der Nahverkehr 9/95.



Lohr

▲ *19. Guidance system for the Translohr system.*

● *19. Le système de guidage du système Translohr.*

■ *19. Das Spurführungssystem des Translohrsystems.*

Version française, voir 5F en deuxième partie
Deutsche Fassung, Siehe 5D im dritten Teil