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O-Bahn, a Dual Mode Urban Transport System

Système de transport urbain "O-Bahn"

Nahverkehrssystem O-Bahn

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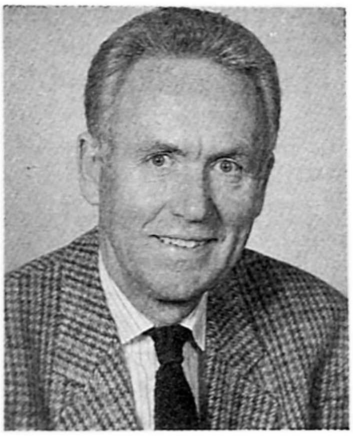

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SUMMARY
The public transport system O-Bahn, based on bus technology, can be started with buses on public roads and can be extended to the high-capacity vehicle train on separate tracks. The uniform design of vehicles of different sizes and largely standardised track components permit the extension of the transport by stages in accordance with traffic requirements and financial situation.

RÉSUMÉ
Le système "O-Bahn" de transport public est fondé sur la technologie de l'autobus. Ce moyen de transport est flexible et compatible. Il peut ainsi être exploité sur la route ou sur des voies séparées, comme un moyen de transport ferroviaire. La conception uniforme des véhicules de différents gabarits et la standardisation des éléments de voie permet une extension du réseau par étapes, en fonction de la situation financière et des données de la circulation.

ZUSAMMENFASSUNG
Das Nahverkehrssystem O-Bahn ist auf Bustechnologie aufgebaut. Kompatibel und flexibel kann die O-Bahn, beginnend mit Busverkehr auf öffentlichen Straßen, bis zum Zugverkehr auf separaten Strecken ausgebaut werden. Der einheitliche Entwurf der Fahrzeuge in unterschiedlichen Größen und standardisierte Fahrwegelemente erlauben einen stufenweisen Ausbau je nach finanziellen Gegebenheiten und verkehrlichen Vorgaben.

1. O-BARN CONCEPT

Bus operation offers a highly economical solution for urban transport as a result of a low level of infrastructural requirements and also low investment and maintenance for the bus fleet. The relatively low infrastructure costs for bus transport mainly result from the fact that buses can travel on public roads.

Traffic density, however, is a problem in all major cities throughout the world and has a detrimental effect on bus transport capacity and travelling convenience. For this reason an exclusive right of way for buses has been demanded from many transport authorities.

The improvement attained with bus lanes, marked by white lines, is not as considerable as with separate railway tracks with an exclusive right of way over the whole length of the track because there are interruptions at all road intersections. For this reason separate tracks in separate corridors for buses, too, constitute an increasingly urgent requirement.

It is an advantage in the case of separate tracks if the buses are track-guided just like a rail car, because this makes it possible to save space and costs.

Still, infrastructure costs can be kept at a relatively low level because the tracks need to be built only in areas where the extremely tight traffic density necessitates such a construction; in other areas buses can continue to use normal roads.

2. O-BAHN COMPONENTS

2.1 Benefit of guidance systems

From its principle, a track-guided system requires a more narrow track width than in the case for hand-steered vehicles. The road width for manually steered vehicles must be much larger than the width of the vehicles body itself to take the human factor into account.

For track-guided systems the vehicle clearance profile must be only a few centimetres larger than the vehicles contour - independent of the vehicle's speed.

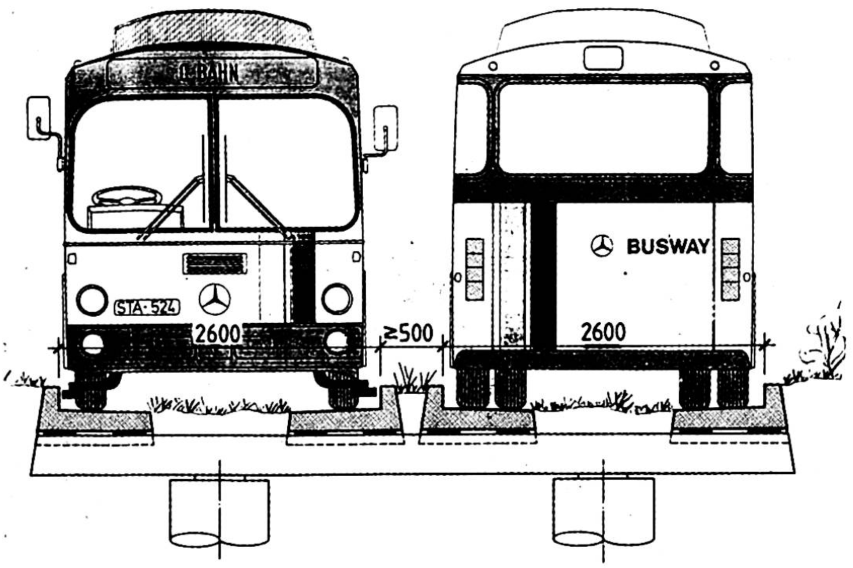


Fig. 1 Cross section of double lane

The very low lateral movement of guided vehicles allows to design the guideway itself from two running strips only the width of the vehicled tires. The remaining surface of the corridor, this means more than 50 %, can be grass land area. This guideway design leads to a higher acceptance and offers improved possibilities for easier integration of public transit corridors in sensitive city areas (Fig. 1).

Another positive effect of this design is the lower emission of the running noise on the environment. The reduction related to noise emission of a bus running on roads is approximately 6 dBA because of the lateral protection of the tires.

The mechanical guidance system chosen for the O-Bahn makes it almost absolutely impossible - even under slippery road conditions - that the vehicle can leave the guideway. This means that safety is independent of human factors and weather conditions, and in this relation it is much higher than in manually steered operations.

With track-guided systems the riding comfort is independent of the drivers action. High riding comfort is consistently ensured by high production quality and alignment accuracy of the guiding elements during a long service period. The riding comfort is comparable with well-developed rail systems.

An additional comfort effect is that guided buses can stop very exactly with a small gap at the platforms thus rendering the boarding and alighting of the vehicle very comfortable for the passengers.

The guiderails themselves and the guideway design, in general, protect the public transit corridor against misuse and prevent car drivers from trying to cross or drive along the guideway.

Finally, if necessary in a very high stage of development guided operations offer the possibility to form trains and make the transmission of electrical energy to the vehicles more reliable.

2.2 Track guided system for O-Bahn vehicles

2.2.1 Requirements, technical solutions

Wheel and rail form a simple and - up to the highest travelling speeds - very safe carrying and guidance system. However, attempts to apply this to vehicles which can be used in hand-steered operation on the road and in guided operation on tracks of their own, and where quick transition from one operation mode to the other must be ensured, have not yet led to satisfactory results.

For a mechanical guidance system with a guiding trough formed between the lateral guide rails it is easy to provide reliable guidance independent of slippery roads caused by unfavourable weather conditions.

Even with slipping road wheels, the guide rails function as an emergency guidance system, reliably preventing the vehicle from braking away from the guideway. Normally the front wheels are always steered by the guide rails via guide wheels and guide arms in such a way that the vehicle follows the centre line of the trough with only slight deviation due to minor disturbances.

2.2.2 Guideway construction methods, alignment methods

An uneven surface of the guide rails is the main source generating the lateral movements of the vehicle on the track. This means that the accuracy of the track guidance determines the riding comfort and has an important influence on the vehicles clearance profile and, finally, on the track costs, too.

These considerations resulted in establishing construction tolerances of millimetres for the guide device of mechanical track guidance. By means of prefabricated concrete components it has been possible to comply with the required narrow tolerances.

The production of the prefabricated components in a factory on site ensures the greatest possible eveness of the guide rail surfaces over the entire length (12 m) of the prefabricated component.

Efficient routing of the prefabricated components with the highest possible degree of accuracy, that is to say end offsets in the range of millimetres and very small angular deviations at reasonable cost had to be developed and can be managed today. The use of prefabricated components means that transition curves have to be constructed from arc elements whose radii increase or decrease within the course of the curve (so-called oval or basket arches), because - for reasons of cost - only a limited number of formworks can be manufactured for different radii.

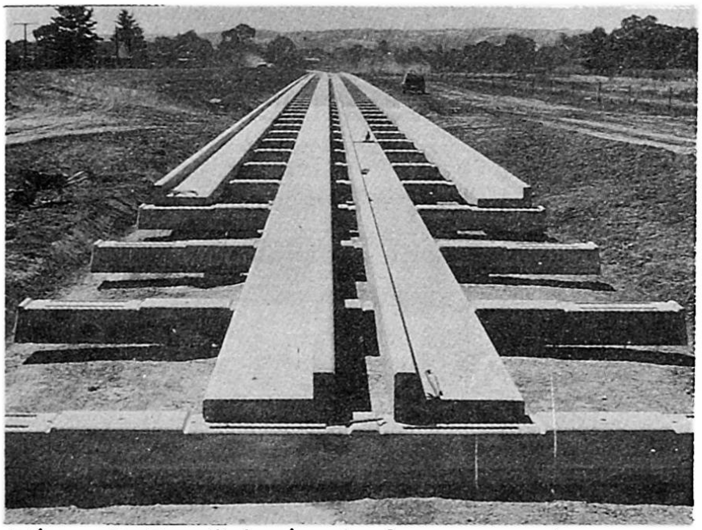


Fig. 2 Prefabricated cmponents

If only plan profile prefabricated components are used, i.e. those which are not twisted, the construction costs are positively influenced and the upslopes and downslopes of the superelevations can still be constructed by inclining the entire guideway component by component. To achieve good ride comfort, these boundary conditions require careful matching of changes in radii and degrees of superelevation.

The running strips of the guideway (with integrated guide rails) are carried by sleepers being prefabricated in factories as well (Fig. 2). The foundation of the track depends on the soil conditions. Either flat foundation or, if necessary, pile foundation is possible. In order to maintain the accuracy of the guideway the height of the sleepers on the foundation can be adjusted.

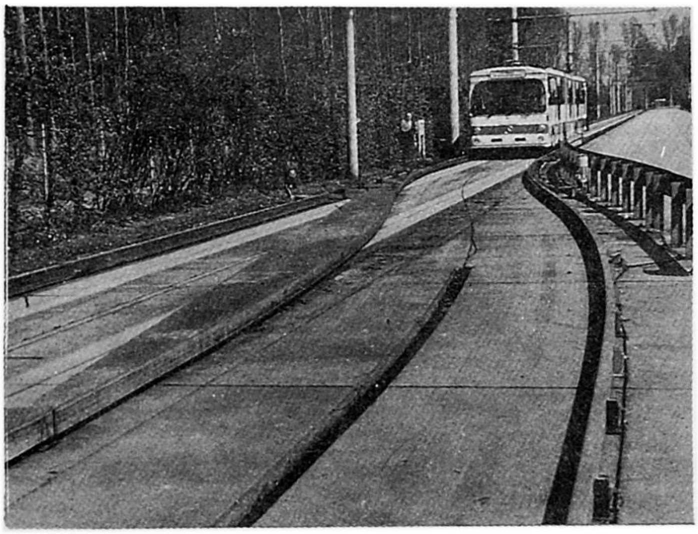


Fig. 3 Switch

2.2.3 Special guideway components

Junctions, entry areas

Switches have been developed to take all conceivable requirements into account, especially those relating to train operation (Fig. 3).

Various construction forms with alternative lowering of guide rails for branchingoff and straight-on tracks as well as with swing-type or bending guide rail sections which are especially suited for combination with rail switches were installed as prototypes and tested up to operation standards.

However, they have so far not been used in facilities built for practical operation. On these tracks, the buses are steered manually through junction areas, which on the one hand saves high costs and on the other hand achieves high operational flexibility and particularly short intervals between vehicles.

Design of the entry areas into the track-guided section behind the junction areas (and not only there) is based on aspects of driving dynamics and thus permits the driver to enter the track-guided section at a speed of 40 km/h (or more). Since the speed must be reduced anyway in most junction areas (stations, curve radii, visibility), the limited entry speed specified by the operating instructions does not represent an obstruction of the operations.

Extraction of exhaust gases

Central importance is attached to diesel operation in the O-Bahn concept because of the low system cost and considerable operating economy of diesel-powered buses. Direct extraction of exhaust gases has been developed as part of the upgrading concept to enable track-guided diesel buses to operate also in lengthy tunnelled sections with station (Fig. 4).

This allows the following system requirements to be fulfilled in a practical manner:

- no operational restrictions in respect of speed and system change
- practically no bad-smelling fumes in underground stations
- low energy consumption and
- possibility of central, catalytic treatment of exhaust gases.

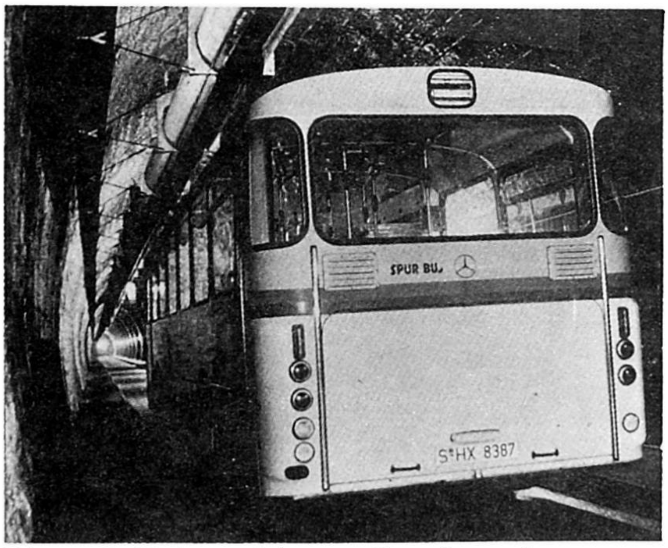


Fig. 4 Extraction of exhaust gases

System testing commenced in 1986 in a disused railway tunnel at Wertheim in Germany. The tests aimed at determining the operational design data have meanwhile been concluded.

2.3 Vehicle family

The O-Bahn system represents a family of vehicles, ranging from the standard regular service bus through the articulated bus to the double articulated vehicle. The double articulated vehicles can be operated on arterial roads and on guideways whereby the formation of trains is possible. In this way, transport volumes can be achieved which could never be managed in conventional bus transport. These vehicles can be equipped with diesel or electric drive system.

A duo bus is realised with a double drive with full operational efficiency, namely diesel engine and automatic transmission on the one hand and electric drive on the other hand. The duo bus is characterised by

- the same comfort characteristics as in the standard regular service bus, such as low and even vehicle floor, easy entry, broad aisle,
- the same passenger capacity (with corresponding number of seats) as in the diesel-powered articulated bus,
- and general availability due to independent drive systems.

In the future, the electrical components will be used as standard, on all electrically powered O-Bahn vehicles to achieve production economies from longer production runs and, in this way, to diminish the cost disadvantages of electric drive compared with diesel drive.

The aim of vehicle development is to achieve lower specific purchase costs and lower specific vehicle weights in comparison with conventional rail vehicles by basing vehicles on modern bus technology.

Lightweight design permits energy savings, notably with the close station spacing which is predominant in local passenger services.

3. GENERAL TRANSPORT CONCEPT OF O-BAHN

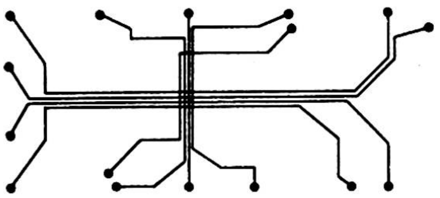
3.1 Stages of extension

The basis of the transport concept is the operation of buses as normal road users. Bus transportations offer two advantages in the attractivity for the passengers. These advantages are short walkways to and from the stops as well as a low number of transfers in the route network. Bus transportation on public roads is a very economic solution and thus another advantage for the authority.

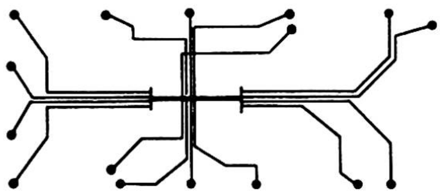
Bus transportation can be improved by constructing a guideway on certain route sections as the own right of way for buses. These measures are introduced in stages, in most cases with an immediate service benefit. Sections of route, for example, in city centres which have developed historically, can be constructed in tunnels, or, as in Adelaide lengthy at - grade sections can be established within a given corridor (Fig. 5).

For some years this stage of development of O-Bahn, called Guided Bus, has been realised in the cities of Essen and Adelaide and in revenue service in both towns.

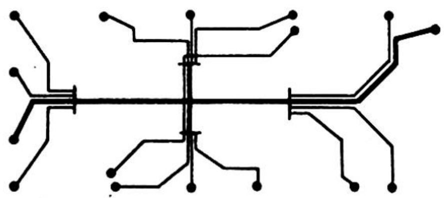
Should, in other applications, future traffic volumes necessitate the implementation of a guideway over the full length of the route, this can likewise be implemented in stages, with the final



Existing line network



Expansion-first stage



Expansion-second stage

Fig. 5 Step from bus system to O-Bahn system stage permitting the operation of large-capacity O-Bahn vehicles allowing train formation over a throughroute. In this development stage, too, full compatibility is assured between dual-mode operation and operation of vehicle trains over shared sections of routes.

The O-Bahn concept is thus based on the objective of implementing a transport network according to traffic volume, structure and investment capital available, by using largely standardised system components developed from, or adapted to, bus technology and combining the lowest possible costs with the maximum possible benefits.

3.2 System Upgrading

This objective of the O-Bahn concept requires that the system components have to permit practical system upgrading. Upgrading has to be achieved in three system sectors:

- vehicles including traction system
- guideway
- operation

Different vehicle sizes offer possibilities for an upgrading of the passenger capacity. The transition from diesel operation to electric traction or a combination of both operation methods complies much better with the requirements of higher environmental quality, especially in the city areas. The extension of the guideway network results in a higher attractivity for the users of the system and also in a higher passenger carrying capacity owing to the faster travelling speed and the shorter round trip time of the vehicles.

If required by the passenger volume, for example, a proven method is to operate a larger number of vehicles in so-called platoons. In addition to the same and as an alternative multiple off-line stations - as used in Adelaide - result in an upgrading of the passenger capacity.

4. GUIDED-BUS OPERATION IN ADELAIDE AND ESSEN

4.1 Adelaide (South Australia)

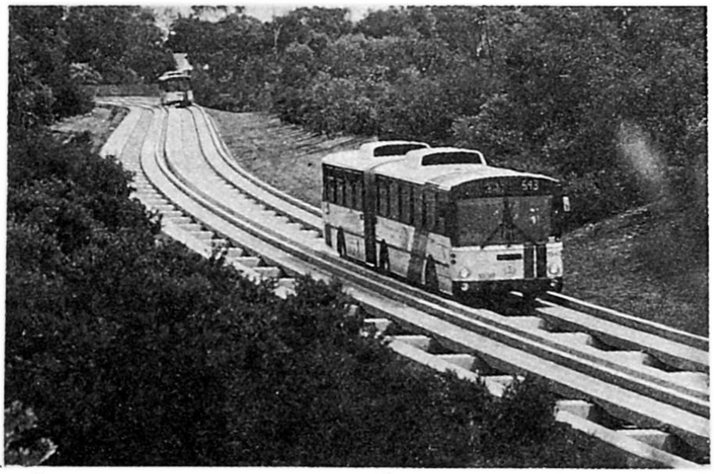


Fig. 6 O-Bahn Adelaide

In Adelaide eleven bus lines are operated with a vehicle fleet of 100 buses over a 12 km guideway between the north-eastern suburbs and the city centre. The maximum speed on open stretches is 100 km/h (Fig. 6).

Since the start of scheduled services in March 1986, the buses have covered a total of approx. 21 million kilometres, and 8 million of them were covered in track-guided operation. A total of approximately 25 million passengers were transported during the first five years of operation.

In contrast to a light-rail system, the passengers do not have to change frequently since the same buses are steered manually through the suburbs to collect the passengers and then transport them quickly to the city via the guideway.

The buses are hand-steered, too, in the area of the two intermediate stations; this allows mutual overtaking and the highest possible flexibility in operation. No signal system is incorporated. The vehicles are controlled only by the visual assessment of the driver.

In practice, extraordinarily short vehicle sequence times of 30 s are possible. In conjunction with short trip times and high vehicle speeds they add to the attractiveness and capacity of the system.

The system is very well accepted by the users. After putting the system into service the passenger volume has increased by slightly more than 35 %.

As far as the costs of the system including the vehicles are concerned, 40 % in investment was saved as compared with a light-rail system.

A comparison of the operational costs for 1986/1987 between the commuter rail systems operated by the authority of Adelaide, too, and the O-Bahn (guided bus system) results in a cost relation from approximately one to two as a cost advantage for the O-Bahn.

4.2 Essen (Germany)

As early as 1980 the first bus guideway was put into service in Essen (Fig. 7). The network has been extended gradually and in 1988 the highest extension level had been reached by taking into service the mixed-operation stretch for guided duo buses and trains in a tunnel.

On this mixed-operation stretch the duo buses are powered by an electric motor; they are also included in the light-rail protection system installed in the tunnel. This means that they have to be monitored by the protection system, and in case the drivers do not observe stop signals or exceed the maximum speed, they are automatically braked.

This required the development of absolutely reliable identification devices for tyred vehicles which cannot provide a track position indication by electric contact between the steel wheel and rail as in the case of normal trains.

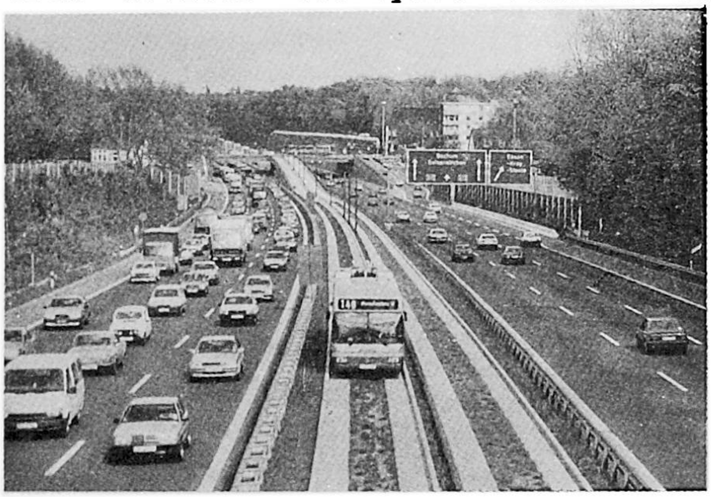


Fig. 7 O-Bahn Essen

A prolongation of this tunnel with a length of 2.5 km including three stations is approaching completion and will be put into practical operation in autumn 1991.

The guideways at ground level in Essen are all constructed on former separate tramway tracks, one to the suburb Kray with a length of 4 km with three stations and one to the suburb Haarzopf with a length of 2 km with three stations. Outside these corridors and outside the tunnel the guided buses are running on the public roads manually steered.

The guided busroutes to the suburbs have replaced the former tramway lines for reasons of economy. The operational experiences with the guided buses in Essen are basically very positive. The maintenance work for the guiding device on the vehicles is acceptably low. The amount for guideway maintenance needed over a period of more than 10 years is negligible.

For the handling of the track cleaning winter service, a guided special service vehicle was designed, manufactured and delivered to Essen and is well proven in operation.

A total of 60 buses - 18 of which are equipped with a duo drive - are operated on the guideway stretches which are currently 7 km long, 9.5 km from autumn 1991.

The vehicles in Essen have meanwhile covered a total of 20 million kilometres, 4 million of them in track-guided operation. The number of passengers now amounts to approximately 40 million.

An interview action of the passengers just being carried out has demonstrated the high acceptance of the guided bus system in Essen.

5. SUMMARY

A public transport system has been developed which can be extended in stages up to the formation of trains operation on separate guideway. The track guidance systems are essential components of the O-Bahn transport system. In addition to reducing the width required for the bus-only routes, the operational compatibility of the mechanical track guidance versions, in particular, enables supplementary system components to be developed to permit bus services to be upgraded in stages in line with requirements to create an efficient total O-Bahn transport system.

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