

## THE RAILROAD SYSTEM IN THE REGION OF STUTT GART

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### 1. FUNDAMENTAL PRINCIPLES OF PLANNING

The region of Stuttgart is one of the most prosperous regions of the Federal Republic of Germany. In 1977, the Federal Republic of Germany, The Federal State of Baden-Württemberg, the State Capital of Stuttgart, and four administrative districts bordering Stuttgart made an agreement with the aim of keeping the present high level of efficiency not only for the time being, but of securing and extending it to the future. They layed down by contract to increase the promotion and extension of the local public transport with the intention of improving the public local and area wide service, of relieving congestion in the road network, of strengthening the railroad system and of facilitating the intramodal transfer.

In a first step, the varied fares and supplies of the two main transit authorities, the state-owned Federal Railways, and the municipal Stuttgarter Straßenbahnen AG, were joined in a transport association with the aim of offering a standard fare and a coordinate supply of system performance. The two authorities set up in the Verkehrs- und Tarifverbund Stuttgart (transport and fare association Stuttgart, VVS) which took over the task of coordination for both.

In the meantime there have been negotiations to join about 40 other authorities and to develop and operate the entire public transport of the region according to identical fare and transport principles and standards.

Today the region has a population of about 2.2 million people living on an area of about 3000 square kilometres. Based on the prognosticated population shift in Federal Republic of Germany, the local demographic planning assumes that by the end of the millenium, settlements for additional 150 000 to 200 000 people will have to be provided for. There are jobs for 1.2 to 1.3 million inhabitants. At present, Stuttgart, as State Capital of the Federal State of Baden-Württemberg has about 475 000 jobs for 580 000 inhabitants. The central function of Stuttgart

leads to a large proportion of commuter service. About 210 000 commuters come to the town every day, whereas only 34 000 leave it. The region profits by the fact that it is not mono-centrally concentrated on Stuttgart, but is surrounded within a radius of 15 kilometres by a number of prosperous medium-sized centres with up to 100 000 inhabitants. A number of big as well as middle class enterprises in car industry, computer processing, electronics and electrical engineering have settled there.

In 1990 the motor vehicle density amounted to an average of 514 passenger cars per 1 000 inhabitants. In Stuttgart with an average of only 471 passenger cars, the density was considerably lower than in the surrounding communities with an average of 529. This might be a result of the attractiveness of public transport in Stuttgart.

In the last few years the local public transport has taken an enormous upswing. Compared to 1976, when, in Stuttgart, the proportion of public transport to individual transport was still 25 to 75, it changed to a proportion of 38 to 62 in 1990, and of 45 to 55 during the rush hours. At present the proportion of the surrounding communities and Stuttgart is 25 to 75, whereas it is 15 to 85 in the intrazonal movements of the surroundings.

The extension of the VVS to all transport authorities of the region is meant to lessen this discrepancy between town and surroundings significantly. It is indispensable, as the shift of population from the expensive city to the outskirts and surrounding communities is still going on and will cause a further increase of the total traffic volume. Stuttgart, however, will not be able to cope with this additional volume of individual transport, as there are no more areas for either, public parking or moving traffic. Besides, the opposition of the residential population to any further extension of motor vehicle transport is constantly growing. Stuttgart has tried to countermanage this development by the following measures.

The rail transport system was given high priority by the elaboration of separate railroads. Busses and rail systems get priority at light signals, and separate bus lanes are being built out to accelerate bus transit. New roads are generally built only, if they serve to protect the residential population from noise pollution and other reductions of the quality of life caused by individual transport. In this process it is always taken into account that

the total capacity of the road network must not increase. In built-up areas with qualified public transport connections, the existing parking space is reduced by so-called "Stellplatzbeschränkungsvorgaben", that is: instructions for the restriction of parking space. This means that parking space will only be at hand for the residential population and the necessary business transport.

The rapid transport systems of S-Bahn and Light Rail Transit are the backbone of public transport in the region. The former takes mainly regional, the latter mainly local functions.

## 2. S-BAHN

In the region of Stuttgart the Federal Railways operate the rapid transport system called S-Bahn. In 1978, when the VVS started its work, the first three lines were put into service on a network of 65 kilometres, from the terminal Schwabstraße on the southern edge of the city to the terminals of Weil der Stadt, Ludwigsburg and Plochingen. Today there are six lines on a total network of 152 kilometres. By the end of 1992 two additional sections from Böblingen to Herrenberg with a length of 16 kilometres, and the extension of the line from Oberaichen to the airport with a length of 6 kilometres will have been added. With this network the up-to-now planning projects have been realized. Various additions to this network by extensions of lines beyond the actual terminals have been conceived. Every extension, however, first requires a transport-economic cost-benefit analysis to show the economic benefit, and, secondly, a business-management-analysis to prove that the annual operating profit of the Federal Railways is not going to decrease due to the extension. If these proofs cannot be furnished, the extension of a line is only possible, if the expected financial loss is balanced by the initiator, as a rule the regional administrative body in whose administrative district the extension shall be realized.

The centrepiece and, at the same time, bottleneck of the S-Bahn in Stuttgart is the 8.3 kilometres double track tunnel below the city, stretching from the Central Station at the northern edge of the city to the Filderplateau in the south, which is topographically higher by about 200 metres. This S-Bahn tunnel has four stations in the centre and another one in the university centre in the south. The other lines already existed before the extension and were used

for local, regional, and national railroad service. They had to be adapted to the demands of S-Bahn transport by a partial extension to four tracks, the closure of level-railway crossings, crossing-free passenger access, and crossing-free merge of junctions as well as the elevation of the existing platforms to 76 or 90 centimetres. Platforms with a height of 76 centimetres are necessary on lines which are still frequented by both, the S-Bahn and the other railroad traffic of the Federal Railways. At present a project is being worked out, planning an access for handicapped persons at every station by means of elevators, sloping elevators and ramps for pedestrians.

The financing of the infrastructure of the S-Bahn railroad network is based on a Federal Law. According to this law, the Federal Republic has to finance 60% of the costs with means of the mineral oil tax receipts. The State of Baden Württemberg finances the remaining 40% with budgetary means. Part of these costs, from 12% to 15% of the total costs are, however, refinanced by the regional administrative bodies, that is, The State Capital of Stuttgart and the administrative districts. Up to now about 2 000 millions of DM have been invested in infrastructure measures for the S-Bahn. Nevertheless, this will not be enough for the long term.

During the peak-hours in the morning, relevant to the calculation of supply capacities, a twenty minutes cycle is offered on every line. In all other operating hours a 30 minutes cycle is offered, which is increased to a 15 minutes cycle in the afternoon rush-hour traffic. After 8p.m. it is reduced to a 60 minutes cycle. It is true that the latter cycle fills the conditions of the actual demand, if you do nothing but compare and calculate the corresponding figures, it does not, however, answer the demand for shorter cycles, which would in fact be desirable for reasons of attractiveness. Up to the present any improvement has failed for lack of the financial means.

The operating fleet consists of 101 of the reliable ET 420 electric multiple unit trains of the Federal Railways. During the times of greater demand, train formations of three trainset trains with a capacity of 1275 passengers, a seating capacity of 588, and four persons per square metre of standing room are put on service.

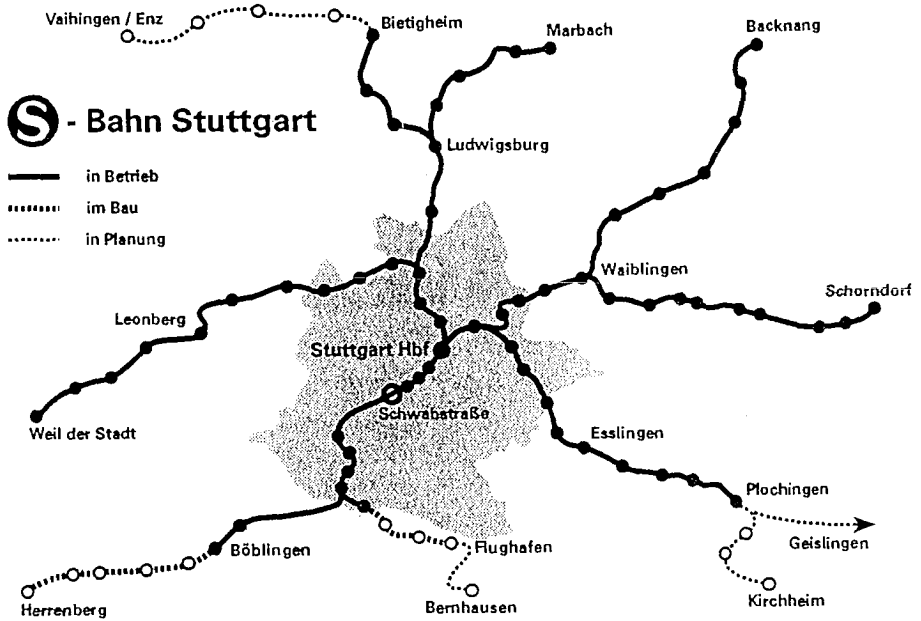


Figure 1: The S-Bahn network

Of the six S-Bahn lines three are diameter lines and three end in the Schwabstraße. As the tunnel line from this station to the Central Station requires high capacities, an underground switch back, with a siding, in form of a loop was installed at the Schwabstraße. This comparatively costly installation has entirely proved its worth in operation and is a guarantor for a satisfactory operating control.

The demand, growing constantly since 1978, has caused a shortage of capacities, which necessitates remedial measures. It has been planned to heighten the cycles of scheduled service in the morning from 10 to 15 minutes. This implies an increase of capacity by about a third.

To allow the realisation of these measures, at least twenty new multiple unit cars will have to be procured. Later on they will have to be made up by another twenty cars making possible the supply of a maximum capacity then. Besides this acquisition of vehicles, some sections will have to be done up by efficiency increasing train protection systems. It might be a matter of interest that in this case the vehicles will be partly financed by the regional administrative bodies. This has been made possible by the application of the instructions of the Federal Law on the Financing of infrastructure investments on the financing of the cars. The regional administrative bodies will probably have to pay but a third of the acquisition costs. The financing of the public rail transit of the Federal Railways by the respective regional administrative bodies is a transport political aim of the Federal Government. The achievement of this policy, however, requires a new balance of costs between the Federal Republik and the Federal States.

A further increase of capacities and the resulting higher passenger capacity cannot be achieved by conventional technical means, as the tunnel line does not allow a higher density of headways. It is possible that the use of an inductive loop train protection system would allow even that. The effects would, however, be offset by the lot of time needed for boarding and alighting in the highly frequented stations. A punctual and trouble-free transport could thus hardly be guaranteed.

Therefore some first observations are being made, how the S-Bahn can be made more efficient in view of a further increase of passenger demand, caused for example by administrative traffic management measures such as a limited transport vehicle operations as a measure against air pollution.

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These observations include new tangential connections within the S-Bahn network, the enlargement of the existing tunnel to four tracks, or the construction of a second tunnel in the city of Stuttgart on a new marked-out route.

Contrary to the field of infrastructure, all operating costs, including personnel and acquisition costs must be financed by the Federal Railways themselves. Costs which cannot be covered by fare box revenues and other revenues are born by the Federal Government as the owner of the Federal Railways. At present the revenue to cost relation is 0.5. Thus, the Federal Government must bear about 110 million DM of annual costs out of its tax receipts in order to operate the S-Bahn in Stuttgart.

### 3. STADTBahn (LIGTH RAIL RAPID TRANSIT)

Besides the S-Bahn with its mainly regional functions there is another rapid transport system in Stuttgart, the Stadtbahn, which performs mainly local functions. The Stadtbahn system is a development of the former 140 kilometres tramway network. In the past, the growing obstruction of the tramway caused by individual transport led to a reduction of the rail network to the main lines along the most important corridors of the residential and business areas. The remaining network has gradually been developed into the Stadtbahn system. At present 70 kilometres of Stadtbahn tracks with 6 Stadtbahn lines are in operation. By 1993 to 1994 another section with a length of 10 kilometres will be put into operation. Till the turn of the millenium about 13 kilometres will be added, if the financial conditions can be maintained. In addition to the Stadtbahn network there are two tramway lines with a length of about 25 kilometres. 60% of them are, however, already identical with the Stadtbahn tracks. Whether these tramway tracks will ever be extended, too, depends on the development of demand and the financial feasibility. Extensions of transport way connections beyond the basic network are conceivable. First rough analyses show that an extension of some lines by a total length of about 25 kilometres might in fact be useful. Detailed economic and business management cost-benefit analyses will, however, still have to be done. If the results proved to be favourable, a financial support similar to that of the S-Bahn would be possible. Till the completion of the whole basic network of the Stadtbahn, about 3000 million DM will probably have been invested. 85% of the infrastructure costs are born by the Federal Republic and Baden-Württemberg. The Stuttgarter Straßenbahnen Ag bears the remaining 15%.

# **U** - Stadtbahn Stuttgart

- Stadtbahn in Betrieb
- ⋯⋯⋯** Stadtbahn im Bau
- ⋯⋯⋯** Stadtbahn in Planung
- Straßenbahn

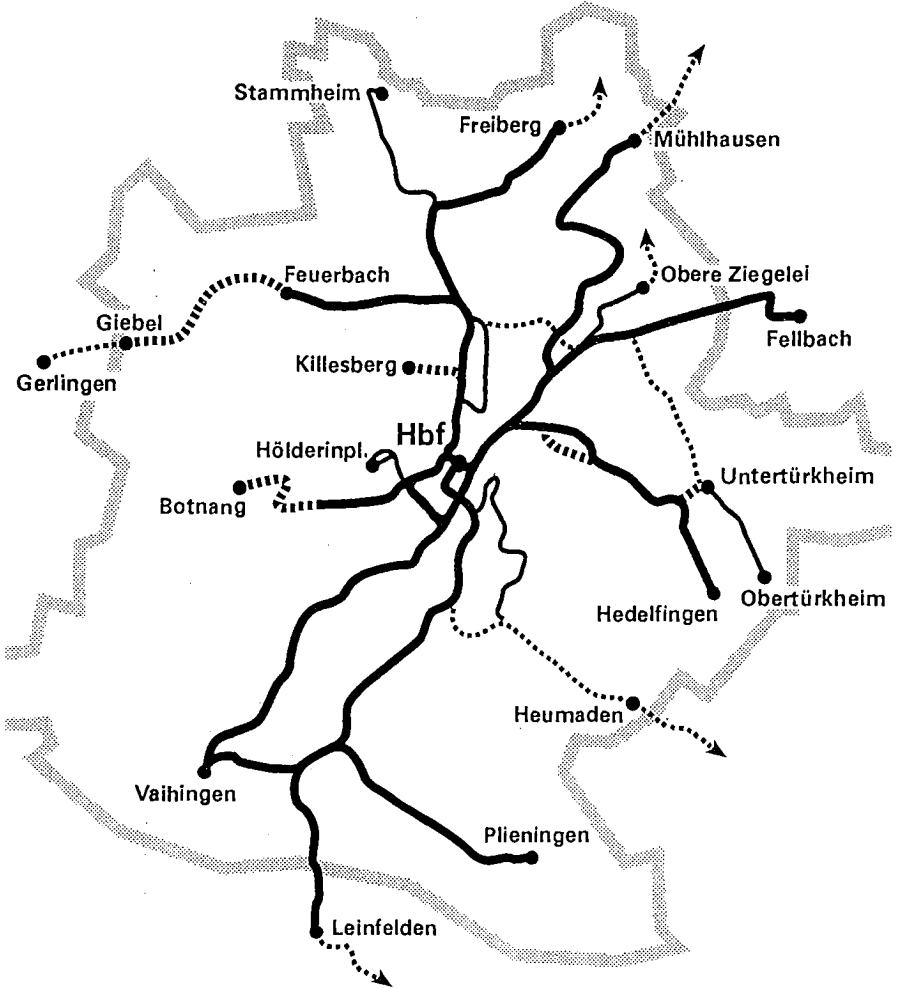


Figure 2: The Stadtbahn network



The self-financed share in infrastructure costs, the partial prefinancing of extension measures within a certain limit of time, and the acquisition of 81 Stadtbahncars from 1984 to 1991 have considerably worsened the economic balance of the Stuttgarter Straßenbahnen AG (SSB). Only 43 % of the costs are covered by fare-box revenues. By means of State balance and other returns the revenue-to-cost ratio can be bettered to two thirds of the expense. Nevertheless, Stuttgart as owner of the SSB has to balance an annual deficit of about 110 million DM.

The Stadtbahncars are short-coupled married pairs of a length of 39 metres, a width of 2.65 metres on standard gauge (1435mm), and a capacity of 234 places (112 seats). A service with two units is possible. A majority of the stations has been equipped with elevated platforms of 90 centimetres height, and with accesses, suitable for handicapped persons. A mixed service of Stadtbahn and tramway cars is possible without any problems, as the outer car limits of both are identical. This was a prerequisite for the beginning of the Stadtbahn service. As the Stadtbahn is developed out of the tramway network, it cannot be avoided that for certain transitional phases both systems must use the same tracks. This is the only way to guarantee that new track sections can immediately be put into operation and can serve to improve transport supply. Those Stadtbahncars stopping at lower platforms, as they are operated in mixed service, have got folding steps to facilitate boarding and deboarding.

Both rail rapid transit systems are operated and controlled by command and control systems of their own, which also include passenger information. This passenger information is gradually improved, for example by visual information about delays. Furthermore, the opportunities for a dynamic schedule synchronisation system are being verified, which is intended to secure the connections to other transport systems by means of command and control computers. Both measures will be tested in a large-scale research project within the framework of the project "Regionales Verkehrsmanagement Stuttgart" (STORM), which is supported by the European Community.

A planning element which is partly important for rail rapid transit systems is the determination of the demand for park and ride. Today there is space for 8100 cars at the S-Bahn and Stadtbahn stations. In the whole region of the VVS it amounts to 9600 places. An extension programme

projects an increase to 14 500 places by 1995. According to first prognoses, the extension limit will be attained with a number of about 20 000. Claims beyond this number will meet with economic limits, as the expense for building one place will then be too high to be justified with any possible benefit. The annual amortisation in this case would amount to several times the costs of a VVS network ticket. Moreover, an unacceptable competition with shuttle service transport systems would be the result.

To complete the picture, it should be mentioned that Stuttgart owns a rack railway track of 2 kilometres length, and a funicular railway of 0.53 kilometres.

#### 4. THE DEVELOPMENT OF DEMAND

At present, the transport systems of the VVS: S-Bahn, Stadtbahn/tramway, and bus transport about 220 millions of passengers annually. According to the results of a traffic flow survey, there were 728 000 passengers every day, on working days, within the VVS network in 1987. Recent information says that the number of passenger there has increased by at least 5% since that time, the share of the S-Bahn amounting to about 41%. Since the first realization of a common fare and supply, the number of passengers has even increased by 25%. This is certainly not only generated traffic but also diverted traffic caused by the integration and substitution of transport systems, and by certain fare structure measures.

The transformation of the former regional transport of the Federal Railways into an S-Bahn transport essentially improved in quality and quantity has caused an increase of passengers of about 40%. As fundamental causes of this increase, the changed responsibilities of both associations, Federal Railways and SSB as well, in different main corridors of public transport, and the changes in the development of the population in the surroundings( + 6% ), and in Stuttgart ( - 1.2% ) should be mentioned. Contrary to this development, the SSB could quote only a comparatively insignificant increase of passengers in the beginning. The start and consolidation of the Stadtbahnssystem, however, finally caused a significant increase (10 to 15% ).

In a research project on the occasion of the start up of several rapid rail transport way connections, the VVS made an investigation on how that part of the population, affected by changes in public transport supply, had changed their individual views on public transport, as well as their

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behaviour towards it. In this investigation the changes in demand before and after the extension have been compared.

The results prove that the individual estimation of the new rail rapid transit supply is in fact positive. Above all, it is the better connection to destinations in the city which is pointed to. Over 90% of the interviewed think that public transport is an indispensable municipal service. The share of public transport with regard to the total mobility has definitely increased, whereas the share of motor vehicle transport shows a falling off. Today's higher speeds have made it possible to cover longer distances without needing more time. It can, however, also be realized that the competition with parallel-running express roads has a negative effect on the amount of local public transport. On a similar section of a line, an increase could not be achieved. Nevertheless it must be stressed that an attractive public transport supply can cause a transfer from motor vehicle transport to public transport.