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Adapting the S-Bahn concept to suit a medium conurbation

FOR MANY years there had been talk about an S-Bahn for Nürnberg. However, it was only last year, on November 2, that an agreement was finally reached between the Federal government, the Bavarian regional government, the city authorities of Nürnberg and German Federal Railway. It provides for three routes covering 67 km with 35 stations at a cost of DM746m (panel page 628).

The S-Bahn in Nürnberg will serve the surrounding towns of Fürth, Erlangen, and Schwabach. Even so, the population in the area is only 1.1 million—substantially less than that of other conurbations where S-Bahn networks have been established.

The S-Bahn concept originated in the 1920s in Berlin (page 630), which then had a population of 4 million. Later S-Bahn networks in Hamburg, München, Frankfurt, Stuttgart and the Rhine-Ruhr all serve metropolitan areas with populations ranging from 2.1 to 7.7 million. The decision to add Nürnberg to the S-Bahn club therefore prompts a question. 'Is Germany now so rich that expensive S-Bahn networks can be built in smaller cities?' The answer is no. The Nürnberg S-Bahn is a tailor-made network suited to a medium-sized conurbation.

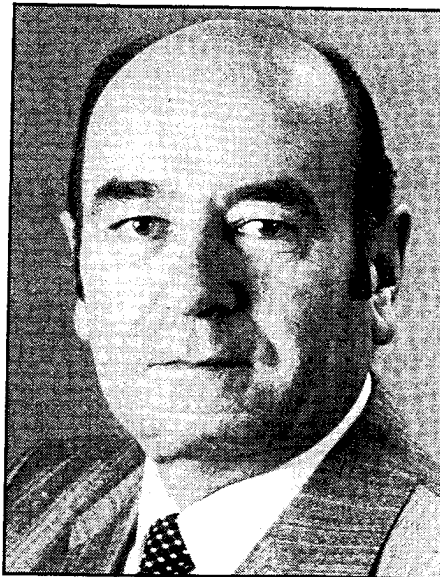
It is essential to stress that finance for major projects of all kinds in West Germany is rapidly drying up. Secondly, DB only builds and operates S-Bahn networks on the instructions of the Minister of Transport. It is the Minister's job to ensure that S-Bahn operation does not worsen the financial situation in comparison with existing suburban services. To understand why the S-Bahn must be tailored to fit in smaller cities, it is helpful to analyse the position of the S-Bahn within the family of urban and suburban railways (Table I).

The flexibility of the S-Bahn and its adaptability to widely varying traffic conditions stems from its evolution out of the existing rail infrastructure. The starting point is a suburban railway, usually with loco-hauled trains running to an irregular timetable on ordinary tracks, taking their place in the succession of main line passenger and freight trains. Stations are generally spaced well apart, and there is usually only one terminus in the city centre.

München sets example

The classic example of evolution from suburban railway to S-Bahn is München. A short underground link in the city centre transformed 14 radial routes into cross-city lines; with four stations in the city centre, excellent coverage of the main business and shopping areas was provided.

Thus many passengers were spared the tiresome and time-consuming change from railway to inner-city transport—be it metro, bus, tram or taxi.



When a 67 km network of routes planned for Nürnberg is completed in 1990, the city will become the seventh German conurbation to enjoy the benefits of S-Bahn services. Thanks to the flexibility of the original concept, it is possible to select operating parameters for a smaller city that fall within the broad S-Bahn framework and do not prejudice the type or quality of service offered. Careful choice of timetable pattern, use of existing tracks on less-busy routes, unmanned stations and automation of ticket sales are all significant factors that will help to keep down operating costs

Dipl.-Ing. Horst Weigelt
President
Nürnberg Region
German Federal Railway

Other measures designed to make transport to and from the city easier and more comfortable included introduction of EMUs with high rates of acceleration, and therefore shorter journey times, and construction of platforms matching the floor height of the trains, so making boarding and alighting quicker and simpler.

The final change—introduction of a regular timetable—was also the most difficult. The problem was to discover which lines and sections of line could accept a regular-interval timetable with a mix of traffic—in both the short and long term—and where segregated S-Bahn tracks would have to be built because of the density of long distance passenger services and freight trains. Of the 400 route-km used by S-Bahn trains in München in 1972, only 24 km (6 per cent) had segregated S-Bahn tracks. By the beginning of 1982 the proportion had risen to 10 per cent, but it is clear that mixed operation predominates.

Other characteristics of the S-Bahn can be summarised as follows:

- vehicles resemble U-Bahn cars;
- commercial speed is higher than on a U-Bahn because of wider station spacing and faster maximum speed;
- as with a U-Bahn, segregation from street traffic is total;
- because of the mix of traffic on tracks used by other trains it is often necessary to compromise on the operating pattern and with the timetable, although these disadvantages are considerably offset by a shorter construction period and lower first costs.

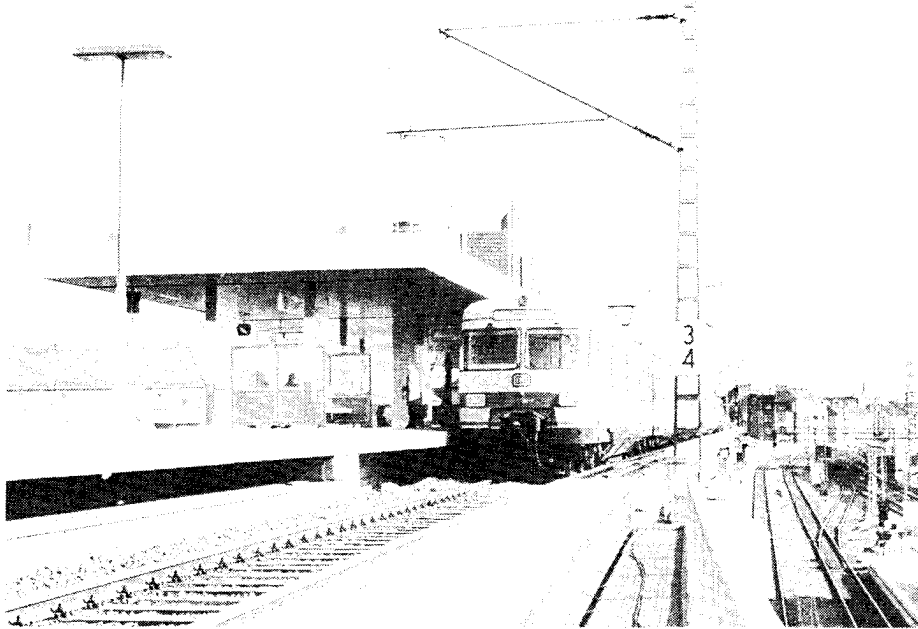
It is important to make a distinction between the S-Bahn and totally new regional railways such as Bart in the USA which are completely

independent of existing lines. In such cases new infrastructure results in high costs and a lengthy construction period.

Only the S-Bahn was capable of achieving in München what amounts to a world record—in a mere six years and at a cost of only DM1 000m a 400 km network of lines was established with regular-interval services

Steeply graded S-Bahn tunnels demand powerful EMUs such as this Class 420





Additional tracks and new stations on S-Bahn features typified by this view of Frankfurt

Central sup
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operation

One factor influencing the choice was the existence of four U-Bahn stations in the city centre - Hauptbahnhof, Lorenzkirche, Waser Turm and Plärrer. The other factor was the need to minimise capital expenditure. Given that a relatively large proportion of S-Bahn passengers would therefore have to change to and from U-Bahn and tram services we deem it essential to have a common fare structure.

Planning the timetable

Mere imitation of lines in other countries with a 2 min interval service on the central tunnel sections is not sufficient to determine a timetable for the S-Bahn. The timetable for each S-Bahn network is carefully calculated on the basis of the traffic potential.

As far as Nürnberg is concerned, maximum traffic is forecast on the line to Lauf (9.2

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worked exclusively by modern EMUs. This achievement improved the quality of suburban services to such an extent that all forecasts of traffic were beaten. Currently the München S-Bahn carries 560 000 passengers on a typical working day.

Traffic on West Germany's S-Bahn lines varies from 5 000 to 35 000 passengers/day in each direction. Corresponding headways between services range from 5 to 20 min in peak hours and from 10 to 40 min off-peak.

In the case of Nürnberg with its basically low or average traffic level we clearly needed a low-cost S-Bahn which would nevertheless offer passengers a regular-interval timetable, more stations, and high commercial speeds. This boils down to making the suburban rail option more attractive, without incurring unnecessary costs. In particular:

- it was possible to avoid the cost of building a city centre tunnel because Nürnberg's main station is not a terminus;
- the interval between services will be strictly matched to the level of traffic;
- existing tracks will be used wherever possible;
- careful dimensioning of civil engineering structures will ensure construction costs are kept low;
- stations will be largely unstaffed;
- low-cost trainsets will be used;
- trains will be one-man operated.

Planning criteria

Using Nürnberg as an example, the planning criteria for a tailor-made S-Bahn can be drawn up for other medium conurbations.

A wise choice of site for Nürnberg's main station was made in the last century: it is immediately adjacent to the mediaeval city wall and the central business area. Of course the city area coverage would be better if we had decided to build a tunnel underneath the old city, in which case the number of passengers changing from S-Bahn trains to inner-city modes would be substantially reduced.

First stage of Nürnberg S-Bahn covers 67 km

THREE S-Bahn lines will converge on Nürnberg main station in 1990. Lines to Lauf (17 km), Altdorf (24 km) and Roth (16 km) will form the first 67 km stage of the scheme. The second stage will put Fürth, Siegelsdorf and Erlangen on the S-Bahn map. This will bring the total length of German Federal Railway's S-Bahn routes in the Nürnberg area to 100 km.

Nürnberg differs from other S-Bahn schemes in West Germany by not needing a city centre tunnel section as the main station is not a terminus. In most cases, S-Bahn tracks will parallel existing lines. In the central area the S-Bahn will provide interchange with the U-Bahn at a number of locations; the U-Bahn will act as a distribution and feeder network, but it will also serve suburbs through which the S-Bahn does not pass.

All the S-Bahn routes are at present served irregularly by ordinary suburban trains. The S-Bahn will bring more trains, regular interval services and better punctuality because of reserved tracks. For example, there are 66 weekday suburban services on the Nürnberg-Schwabach route; future S-Bahn services on the same line will total 106, with 10 ordinary suburban trains augmenting the timetable.

The agreement covering the financial arrangements for the DM746m scheme signed at the end of last year (RG January page 16) specifies frequency of weekday services on particular routes:

- Nürnberg-Schwabach, every 20 min;
- Nürnberg-Feucht, every 20 min;
- Feucht-Altdorf, every 40 min;
- Schwabach-Roth, every 20 min;

- Nürnberg-Lauf, every 20 min in peak hours and every 40 min off peak with slight variations.

Nürnberg-Roth and Nürnberg-Lauf S-Bahn trains will be augmented by ordinary suburban services in the peak. At weekends and during holiday periods DB has agreed to provide at least a 40 min interval service.

There will be 35 S-Bahn stations on the routes covered by the first stage. Of these 11 will be new, giving an average distance between stations of 2 km. Platforms served exclusively by S-Bahn trains will be 950 mm high, reducing to 760 mm where other trains will use the same platforms.

Push-pull rolling stock

Experience with push-pull trainsets in the Rhine-Ruhr area has confirmed DB's decision to abandon use of Class 420 electric multiple units for new S-Bahn schemes; because all axles are powered, they are expensive to build and to maintain. The push-pull concept offers a cheaper alternative, and it has been selected for Nürnberg.

New coaches will be built to form three or five-car sets offering 220 and 380 seats respectively. In contrast with the Rhine-Ruhr S-Bahn, where new Class 111 locomotives have been chosen, no new motive power units will be needed in Nürnberg. Instead, existing Class 141 electric locos will be modified for push-pull operation. This decision also minimises DB's rolling stock outlay.

As it would be relatively difficult to build two new tracks alongside the existing line from Nürnberg to Schwabach and Roth-

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Central supervision of station platforms and dispatching of trains allows one-man operation of S-Bahn services in Hamburg



passengers/day and on the Feucht - Nürnberg - Roth route (12 500 passengers/day in each direction). For both lines a 20 min peak interval is planned, with a 20 min off-peak interval for the Feucht - Roth section and 30 min on the Nürnberg - Lauf section. Difference in demand will also be reflected in the use of three-car and five-car trainsets. This careful choice of timetable patterns explains why we shall be able to manage for the first phase of the scheme with only 12 trainsets.

Segregated tracks

Having established the likely timetable pattern, the next job was to ascertain to what extent segregated tracks would be needed. The Nürnberg - Schwabach - Roth line is already used by 200 trains a day in both directions, and of these 30 are Intercity and

fast trains running at regular intervals. There is no question that separate S-Bahn tracks are needed right from the start.

The Nürnberg - Feucht section of the line to

Regensburg is a similar case. Although there are fewer Intercity trains, Nürnberg's status as a major Intercity interchange requires widespread co-ordination of connecting services. Freight traffic to Austria is also very important on this line

On the Nürnberg - Lauf line and the Feucht - Altdorf section a different picture emerges. On the Lauf line with both directions taken together there are only 33 semi-fast passenger and freight trains. When this is double-track, the S-Bahn trains will mesh in quite satisfactorily with existing services. On the single track Feucht - Altdorf line a single pair of freight trains will be the only other traffic.

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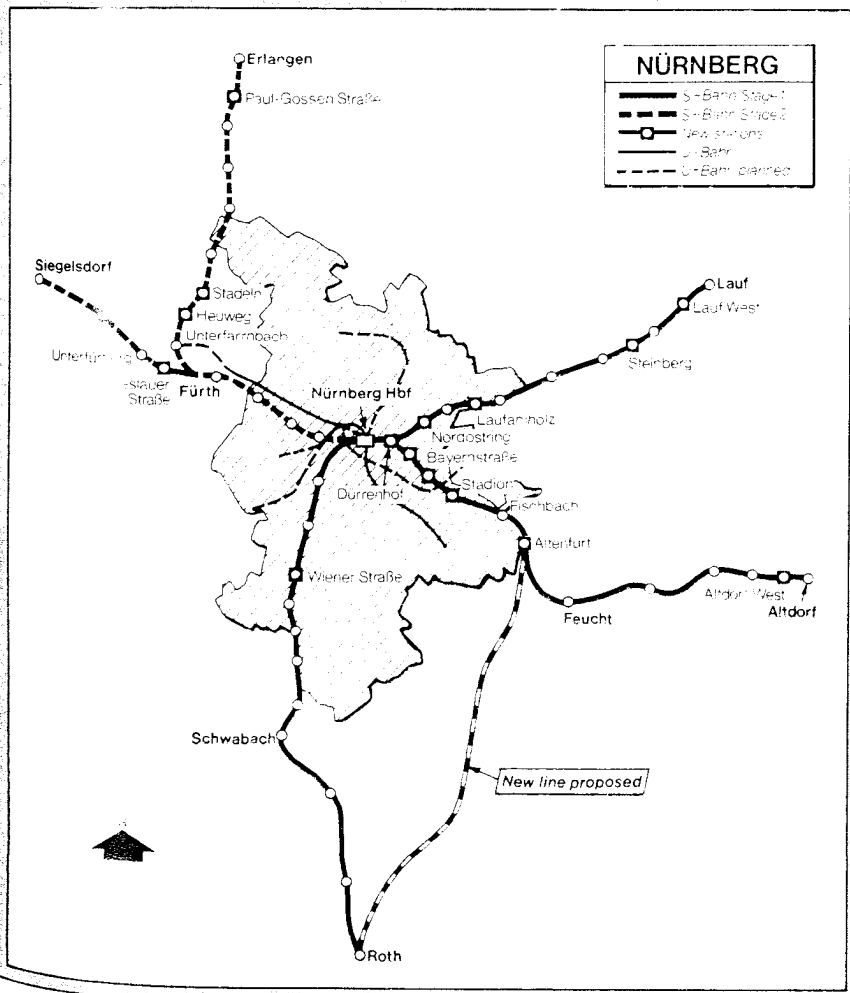
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DB is proposing to construct a 21 km new route from Roth to Fischbach on the line to Feucht; main line trains would be diverted over this line, leaving the existing tracks free for S-Bahn trains. Partly because the alignment would run through the Lorenzer Reichswald, opposition to construction of a new line has arisen. The Federal Minister of Transport has therefore asked

DB to examine in more detail its proposal to quadruple the existing Roth - Schwabach - Nürnberg line and compare it more closely with the new line alternative.

DB hopes that by the time the S-Bahn is in operation a standard tariff will be in force for all public transport in the greater Nürnberg area. □



Station design

In contrast to S-Bahn stations in München and Hamburg where the platform length is 210 m, platforms in Nürnberg will be only 160 or 90 m long. Every opportunity will be explored to save costs. For example, existing railway-owned property will be used to avoid land purchase as much as possible. As far as possible new subways will be avoided by using road underbridges and tunnels to provide access to platforms. Simple structures that merely provide protection from rain and wind will be built for less busy stations, and in Nürnberg main station no new platforms will be necessary.

Under normal circumstances there will be no station staff at S-Bahn stations—as is already the case on other S-Bahn networks. This means that single tickets will be sold only from automatic machines. Season ticket and long distance ticket sales will be restricted to Nürnberg main station and a few other major locations

Rolling stock

A characteristic of large conurbations is that the S-Bahn lines all converge on a single cross-city route. This means that headways of 2 min or even less may be required. It is often the case that steep access ramps to the city centre tunnel are needed to avoid widespread disturbance of surface structures. All this means that the rolling stock has to be powerful and capable of rapid acceleration. The only type of train fitting these conditions is an EMU with all axles driven such as Class 420.

Nürnberg is fortunate in not having that

Table 1. How the regional metro (S-Bahn) fits into the family of rail transport in medium and large conurbations

	Regional rail systems				Urban rail systems		
	Regional express trains	Railway suburban trains	Regional rapid transit		Full metro	Light rail	Street tramway
			S-Bahn	Independent railway			
Segregation from street traffic	100%	100%	100%	100%	100%	30 to 80%	0 to 40%
Segregation from main-line trains	0%	0%	10 to 50%	100%	100%	100%	100%
Operating speed km/h	75 to 90	40 to 50	40 to 60	40 to 70	35	25	12 to 20
Central stations	1	1	3 to 6	3 to 6	5 to 10	7 to 12	10 to 20
Station spacing km	10 to 30	3 to 6	0.7 to 4	0.7 to 6	0.6 to 2	0.4 to 1	0.3 to 0.5
Train type	Loco hauled	Loco or push-pull	MU or push-pull	MU	MU	MU	Tram plus trailer
Timetable type	Irregular	Irregular	Regular interval	Regular interval	Regular interval	Regular interval	Regular interval
Headway min	30 to 120	10 to 90	2 to 40	3 to 30	1.6 to 20	1 to 10	1 to 10
Proportion in tunnel	0%	0%	0 to 10%	5 to 10%	50 to 90%	20 to 30%	0%
Construction cost million DM/km	—	—	2.6 to 12	20 to 30	40 to 50	20 to 25	—
Construction time years	—	—	7 to 20	10 to 30	30 to 40	15 to 20	—
Operator	National railway system			Independent	Local transport authority		

type of S-Bahn—there is no tunnel section and no steep gradient. Mainly for this reason we were able to angle the rolling stock specification more towards lower costs, and we decided to use a type of locomotive that already hauls suburban passenger services.

Our choice fell on Class 141 matched with coaches of the type used on Rhine-Ruhr S-Bahn services. This option is considerably cheaper than the Class 420 EMU. A further advantage is that the less-busy routes will be worked by three-car and the busier routes by five-car sets. On the other hand there will not

be time to change train formations during the day.

One-man operation

Experience in Hamburg, München and Frankfurt has encouraged efforts to operate S-Bahn trains with a single member of staff on board.

In Nürnberg door control will be from the driver's cab. The only problem is dispatch of trains from platforms without jeopardising the safety of passengers.

In Hamburg, where headways are

particularly short, the answer was to dispatch the trains from a control centre where operators monitor platforms on TV screens, they announce the imminent departure of trains and transmit the start signal to the driver. They also monitor departures to ensure, for example, that a passenger's coat is not trapped in a door. The high cost of equipment for a similar system in Nürnberg rules this out. It is only cost-effective for short headways.

There is no doubt that short trains of up to three coaches can easily be dispatched by the

Revival of Berlin S-Bahn hangs on east-west accord

GRANDMOTHER to all the systems in Germany, the Berlin S-Bahn has suffered for many years from the effects of the city's unique political situation. With 142 km of the S-Bahn network that lies in West Berlin boycotted by West Berliners because it is operated and administered by the German State Railway (DR), sections of the U-Bahn operated by West Berlin's own transport authorities are being built parallel to S-Bahn tracks.

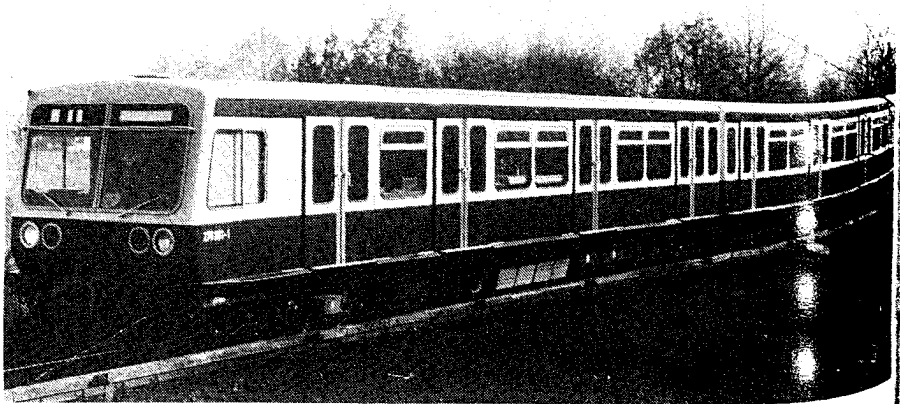
To end this absurd paradox, the Berlin Senate has put forward proposals for modernisation of 102 km of the neglected West Berlin S-Bahn network with a view to eventual administration from the West. The decision will involve DR, the West Berlin Transport Authority (BVG), the political authorities on both sides of the wall, the Allied powers responsible for Berlin and the West German Transport Ministry in Bonn.

Although DR wishes to rid it itself of the West Berlin tranche of the S-Bahn—it closed all but 45 km of the network in September 1980—there will be a hefty political price to pay. The exceptionally thorny nature of this

problem means that the Senate's wishes are not likely to be implemented speedily.

What the Senate envisages is creation of a through north-south S-Bahn route from Frohnau to Lichtenrade via Wittenau,

Introduction of modern S-Bahn trains to West Berlin such as this DR prototype Class 270 is not likely unless a comprehensive agreement on the Berlin S-Bahn is reached



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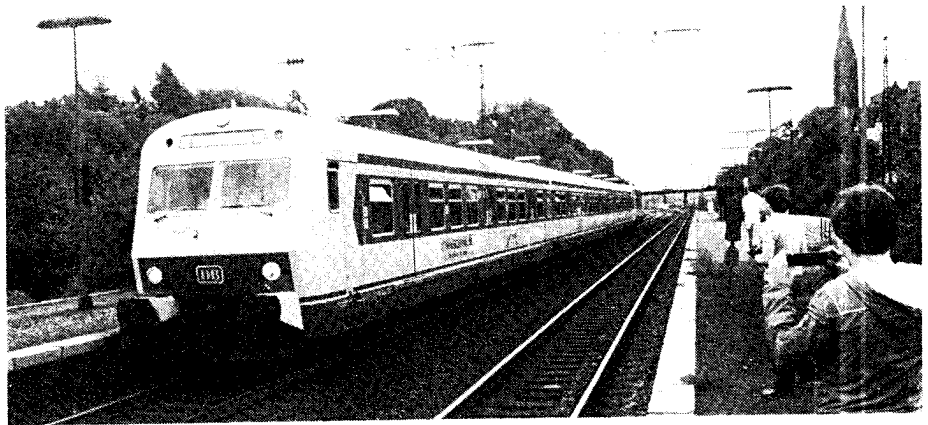
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Increasing use is being made of push-pull trains such as this Rhine-Ruhr set being propelled by a Class 111 locomotive



driver. For five-car trains we are looking at other possibilities.

No similar avenue for cutting costs on the planned S-Bahn in Nürnberg has been ignored. Even so, it does not fulfil the Transport Minister's requirement that the financial situation of local rail transport in this area be made no worse.

It is therefore essential to maximise traffic and hence revenue, and to ensure that there are good interchanges to feeder buses on the outer sections of the network. Similarly, more interchange with inner-city modes will be needed in the central area of Nürnberg and also in Fürth.

Interchange must be kept as simple as

possible and so standardisation of the fares structure among all operators will be essential.

For these reasons, studies covering the future fares structure in the whole Nürnberg area are being carried out in parallel with preparations for civil engineering work. The first

stage, before the start of S-Bahn services, will be to offer season ticket holders a single reasonably priced transfer ticket that permits use on the U-Bahn and on tram services. We hope to introduce this before the end of the year. □

Adaptation du RER pour convenir à une ville Moyenne. Lorsque le réseau de 67 km projeté pour Nuremberg sera complété en 1990, la cité deviendra la septième conurbation allemande à profiter des bénéfices apportés par les services de RER. Grâce à la souplesse du concept original, il est possible de sélectionner des paramètres d'exploitation convenant à une ville Moyenne qui se situent dans le vaste cadre du RER, sans cela pour autant porter préjudice au caractère ou à la qualité du service. Le choix circospect des configurations d'horaires, l'utilisation des voies existantes sur les itinéraires moins occupés, les stations sans personnel et l'automatisation des ventes de billets représentent tous des facteurs significatifs qui contribuent à maintenir les coûts d'exploitation au minimum.

Die S-Bahn wird an den Bedarf einer Mittleren Stadt angepaßt. Nachdem im Jahr 1990 in Nürnberg ein geplantes Streckennetz von 67 km vollendet sein wird, zählt Nürnberg als 7. deutsches Ballungsgebiet, welches die Vorteile eines S-Bahnverkehrs ausnützt. Dank der großen Elastizität des ursprünglichen Konzepts ist es möglich, Betriebsparameter für eine Mittlere Stadt zu wählen, die im breiten Rahmen einer S-Bahn liegen und weder Art noch Qualität des Betriebs beeinträchtigen. Eine sorgfältige Selektion der Fahrpläne, die Inanspruchnahme von vorhandenen Gleisen für die Strecken mit weniger Verkehr, unbemannte Bahnhöfe und automatischer Fahrkartenverkauf sind eindrucksvolle Faktoren, welche die Betriebskosten in der Zukunft niedrig halten werden.

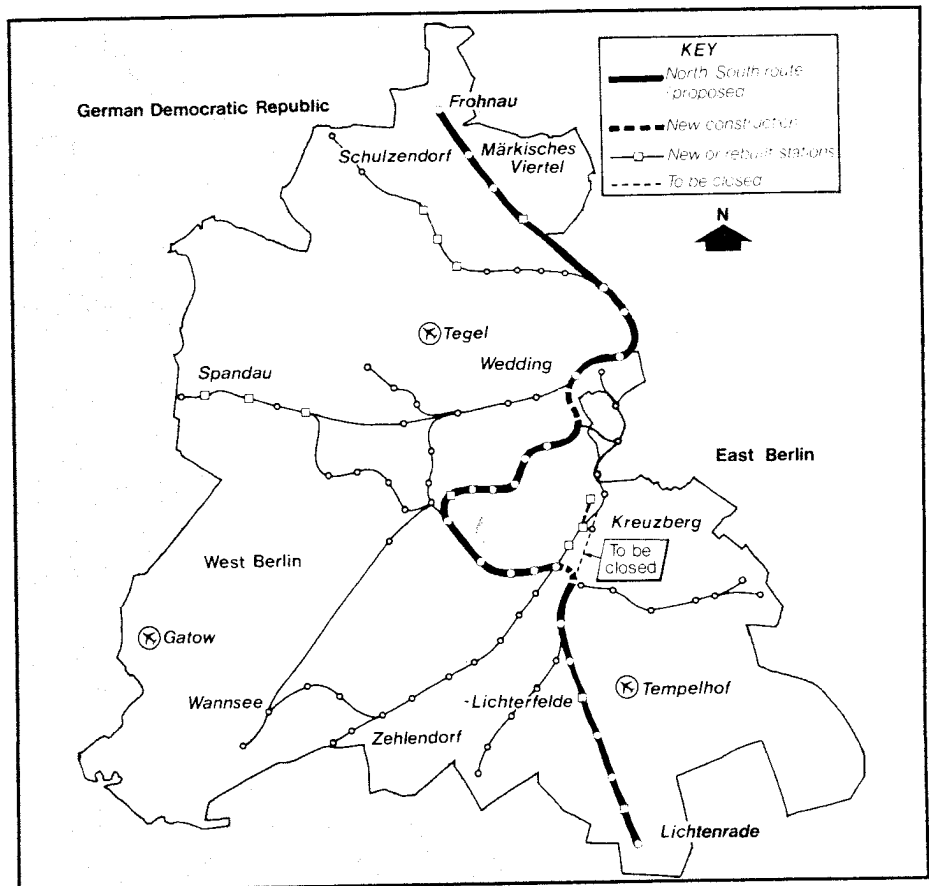
Adaptando los S-Bahn a las peculiaridades de una ciudad menor. Cuando se termine de construir, en 1990, la red viaria de 67 km planeada para Nuremberg, esta ciudad se convertirá en la séptima aglomeración urbana alemana que goce del beneficio que representan los servicios S-Bahn. Gracias a la flexibilidad del concepto original, es posible elegir, para una ciudad menor, parámetros operacionales comprendidos dentro del amplio marco de los S-Bahn y no determinantes del tipo ni de la calidad del servicio ofrecido. La cuidadosa elección del modelo de los horarios, la utilización de vías ya existentes en las líneas menos transitadas, las estaciones que funcionen sin personal y la automatización de la venta de billetes son todos ellos factores significativos que contribuirán a mantener bajos los costes.

Gesundbrunnen, Wedding, Tiergarten, Zoo, Charlottenburg, Schöneberg and Marienfelde. This would entail about 5 km of new construction, in particular a chord line at Gesundbrunnen between the S-Bahn tracks of the Nordbahn and those of the Ring railway, and a second chord line between Wedding and Lehrter stations, mainly on existing railway property.

Other changes in the southern part of Berlin are already planned because of a new freight depot. This necessitates a new link from Schöneberg to Priesterweg for freight, and it would be a relatively simple matter to electrify it for use by S-Bahn trains.

This would complete the proposed north-south route (map, right). Its principal advantage would be that it serves nearly all the main areas of the city on one line, as well as tapping the new dormitory area in the Märkische Viertel.

Forecasts put traffic on a modernised West Berlin S-Bahn operated by BVG at 300 000 to 400 000 passengers/day. At the moment there are a mere 14 000. □



The effect of the border upon the Berlin S-Bahn is clear; the new spurs would enable the western system to be operated independently