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TRANSPORTATION RESEARCH FORUM

THE ONLY VALID BASIS for the development of any new technology must be a systems analysis to show the need for the new development and define the aims and objects to be pursued.

Thus the development of advanced high-speed transport technologies such as the magnetic suspension principle in Germany also started with a transport analysis, which revealed the requirement for a new high-speed transport system and the need to develop unconventional suspension technique.

The economic development of a country is inseparably linked with the status and development of its transport.

For goods traffic (Figure 1), an increase of 100% in traffic volume is forecast, based on the growth of the gross national product. Similar considerations are valid for long distance passenger transportation.

This increase in traffic volume is combined with increased demands on the transport system with regard to speed, capacity and comfort and, naturally, to the economics of these systems.

In December 1971, after three years of work, Hochleistungs - Schnellbahn- (HSB) Studiengesellschaft mbH, a company founded by Messerschmitt-Bolkow-Blohm GmbH, STRABAG-BAU AG and the German Federal Railways, submitted a study of a high-capacity rapid transit system (Hochleistungs-Schnell-Bahn, or HSB for short) which had been prepared under contract to the Federal Minister of Transport.

The object of this transport analysis was to examine to what extent long-distance transport in the Federal Republic of Germany could be improved by means of a new high-capacity, high-speed means of transport, from the aspects of transport technology and economics, and how this system could be designed from the technical and operational points of view.

Route Selection and Traffic Demand

The HSB should concentrate on the main centres of long-distance transport, ensure the best possible link-up with existing and future short and medium-distance transport systems so as to cover the whole territory, provide for rapid and convenient transfer to and from these systems, and in particular make a positive contribution to the economy.

In selecting routes and terminals for the HSB, the choice will fall on those lines for which the sum of the transport costs for the total traffic out of 69 traffic centres recorded in the Federal Republic of Germany is a minimum (Figure 2). In other words, those routes are chosen for which the economic cost-benefit balance produces a maximum. This will be done by means of a mathematical simulation programme developed by Messerschmitt-Bolkow-Blohm. This simulation model for the determination of routes, also applicable for other net-optimizations, for the HSB results in a link shaped like the letter C between the major agglomerations from Hamburg via the Ruhr and Rhine-Main areas to Munich, with the following stations: Hamburg, Bremen, Bielefeld, Dortmund, Cologne, Frankfurt, Mannheim, Stuttgart, and Munich.

This C-shaped line could be regarded as a first development phase and the nucleus of a European network.

Figure 3 shows a European high-speed transportation network and traffic volume estimated by this programme.

There exist a number of proposals for European high-speed networks, but this model (Figure 3) is the only one known

		air traffic			with HSB-competition		air traffic with	
		scheduled passenger traffic	average trip length	annual increase	split to HSB	balanced after years	HSB airport link	HSB-transfer service
FRG	Domestic flights	8.7 Mio P/a	~ 300 km		40 % – 50 %	4–7 years	30 % – 45 %	
FRG	International flights of Europe	20.7 Mio P/a	~ 780 km	~ 10 % – 13 %	0	–		5 % – 10 %
FRG	Intercontinental flights beyond Europe	5.1 Mio P/a	~ 2000 km		0	–		
EUROPE	Total Domestic flights	135 Mio P/a	assumed: ~ 300 km					
EUROPE	Intraeuropean international flights	111 Mio P/a	~ 780 km	~ 10 % – 13 %	13 % – 20 %	1 – 3 years		
EUROPE	Intercontinental flights from Europe	14 Mio P/a	~ 2000 km		0			

National and European competition between passenger air traffic and surface highspeed Transport Systems (HSB) 1985

FIGURE 1

Economic Aspects of Future High-Speed Ground Transportation Systems and Their Possible Technical Solutions

by

*Dr.-Ing. F. P. Kilian**

Basic Network for Optimizing the Route

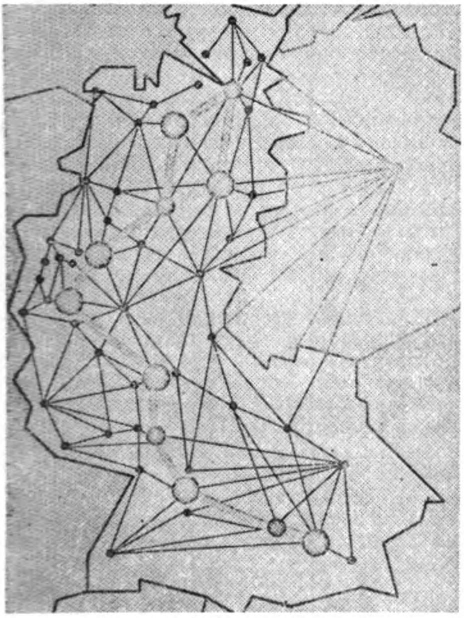

FIGURE 2

by us which is calculated by the use of socio-economic data. No doubt this model must be updated.

This simulation model also includes the calculation of the traffic demand for an HSB from a matrix of 563 traffic centres in the Federal Republic of Germany and 9 centres of transit with the remarkable feature of the HSB system in 1985, compared with similar projects in other countries (Figure 4) that not only passenger transport, but also, and to a particularly large extent (30% of total goods traffic by trucks in the Federal Republic of Germany) the transport of trucks and private cars by picka-back will show decisive improvements over existing transport systems.

**Messerschmitt/Bolkow/Blohm, Munchen.*

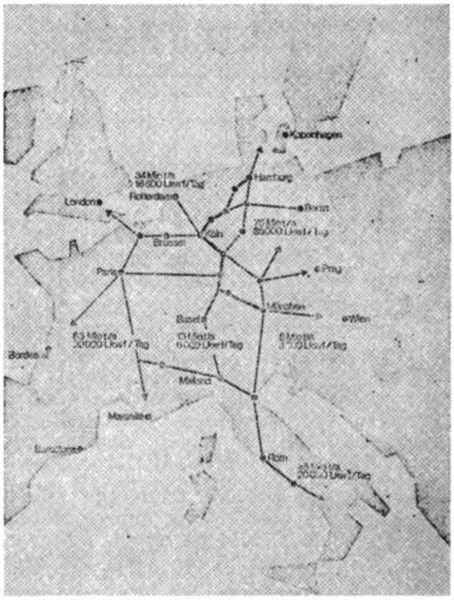

FIGURE 3

We believe that this simulation model offers the possibility to research.

1. traffic volume of a high-speed transportation system
2. optimization of traffic routes
3. optimized configuration of system (train length, frequency, tariff etc.)
4. temporal demand of users

in view of minimizing total traffic costs.

Cost-Benefit Analysis

The only basis for a technical decision is an economic cost-benefit analysis of such a system. The result is shown in Figure 5, which compares three HSB models investigated:

a) An HSB model for the carriage of trucks, cars and passengers.

b) An HSB model for the carriage of cars and passengers.

c) An HSB model for the carriage of passengers only.

It was found that the greatest benefit to the economy comes from the HSB model which offers the carriage of trucks, private cars and passengers. The

Relocation of traffic from conventional means to the HSB in 1985

	Passenger long distance traffic: total	Passenger long distance traffic: increase 1969-1985	HSB 1985	HSB 1985	long-haul freight traffic: total	long-haul freight traffic: increase 1969-1985	HSB 1985
rail traffic[1]	118000 P/day	56 %	20600 P/day	26800 P/day	504 · 10^6 t/a	33 %	3,8 · 10^6 t/a
road traffic[2]	500000 Cars/day	30 %[3]	–	24800 Cars /day	298 · 10^6 t/a	87 %	74 · 10^6 t/a
air traffic[1]	21600 P/day	370 %	8600 P/day	6800 P/day	–	–	–
domestic waterways	–	–	–	–	433 · 10^6 t/a	86 %	–
			v = 500 km/h	v = 375 km/h			v = 375 km/h

1) Airtraffic includes only originating domestic flights. Railtraffic on class A and Class B routes

2) Long haul traffic using the national high ways for distances exceeding 50 km

3) Increase of mean passenger car traffic volume

FIGURE 4

optimum speed-range from the standpoint of the economy is approximately 350 km/h. It should be noted, however, that this forecast is for 1985, the year for which the HSB is planned. As the time aspect becomes increasingly valuable in both goods and passenger transport, and transport volumes continue to grow, an increase in this optimum speed is to be expected beyond 1985.

Even on this route linking the Federal Republic's industrial agglomerations, a pure passenger transport system is not recommendable from the point of view of the economy. The passenger volume needed would have to be in the region of 18 millions a year, or more than double the figure predicted for the HSB in 1985. No such passenger volumes are

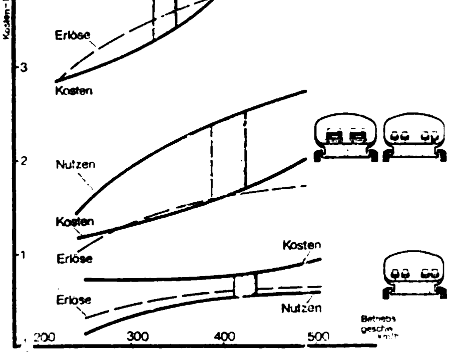

FIGURE 5

Traffic Volume Long distance traffic-volume in 1985 in the FRG 20 x 10^9 truck-km/year 85 x 10^9 car-km/year 46 x 10^8 air-km/year	Split to HSB 2.7 x 10^9 truck-km/year 3.8 x 10^9 car-km/year 16 x 10^8 air-km/year	Pollutants (in 1970) kg/km CO / C_xH_y / SO_2 / NO_x / Solids 0,0105 / 0,0035 / 0,0035 / 0,0158 / 0,0014 0,0134 / 0,0022 / – / 0,003 / 0,00016 0,034 / 0,041 / 0,004 / 0,088 / 0,1
Energy Energy demand of HSB at 400 km/h from power stations: 25 x 10^9 KWh/year Energy demand of highway traffic volume at ~ 80 km/h: ~ 25 x 10^9 KWh/year		Pollutants kg/KWh 25 x 10^9 KWh/year Power station with fossil fuel: CO_2 1, SO_2 0,01, NO_x 0,002, Solids 4 Nuclear power station: 0,5 Mcal/kWh waste heat
Area Four lane highway 2400 cars/h HSB with train sequence 1.5 minutes per 12000 cars/h	Area demand for a distance of 900 km 30 km² 30—35 km²	Noise level 75—80 dB (A) > 90 dB (A) for conventional technique, unknown for non-conventional suspension techniques

Influenc of a new surface high speed transport system (HSB) on the enviroment

FIGURE 6

likely to be reached in European transport regions. However, a passenger transport system can be super-imposed on the truck and car system without essential loss of benefit to the economy.

Moreover there are new decision criteria (comfort, security) which enable us to prove modal splits and to reach better results in analysis and prognosis of traffic demand. It may be possible that the results of passenger transport in the Federal Republic of Germany by an HSB can be improved by this new quantified criteria.

Secondary Effects

Let us now take a look on the influence of such a new high-speed transportation system on environment protection (Figure 6).

It can be assumed that

1. pollutant loadings in fare-range road traffic will be reduced proportional to the split of private cars and goods transport by truck to the HSB,

2. this reduction of pollutants must be compared with pollutant emissions of the power plants necessary for the energy demand of an HSB, but in this case better to control,

3. the area demand of such an HSB with a maximum capacity of 12,000 private cars/h is only 20% of the area demand of highways for the same capacity.

Furthermore we are often asked what consequences this HSB will have on air traffic (Figure 7).

a) In the Federal Republic of Germany 40%-50% of the domestic demand in air traffic will be split to such an HSB, but due to higher growth rate of air traffic (7%-10%) this will be balanced in approximately 7 years. A high-speed airport link could reduce this split by 10% to 20%.

b) In a European high-speed network this split will be reduced to 10%-20% due to larger trip length and will be balanced after approximately 3 years.

c) Such an HSB in connection with air traffic can take over 5%-10% of the transfer passenger volume of international flights and so reduce the cost-intensive feeder service.

It can be said that high-speed ground transportation systems as well as air traffic are necessary to meet future transport demands.

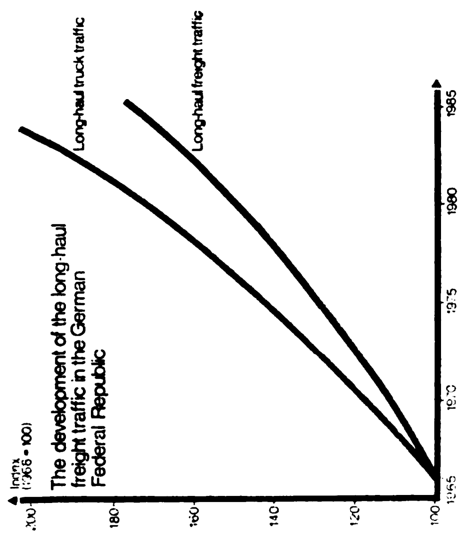

FIGURE 7

Technological Development

What kind of technology can be used for such a new high-speed ground transportation system?

1. Railway systems,
2. aircushion systems,
3. electrodynamic suspension systems
4. electromagnetic suspension systems.

For each of these technologies there exist principal vehicles in Europe.

In view of the high optimum speed of up to 450 km/h predicted for such a system and of the high operating costs together with the possibility of using conventional industrial techniques, Messerschmitt-Bolkow-Blohm decided to develop the magnetic suspension technique and propulsion by linear induction motor. The basic principles of the magnetic suspension system and its advantages are already widely known, so that I do not need to spend the short time at my disposal in describing them.

The principal vehicle of Messerschmitt-Bolkow-Blohm (Figure 8), supported, guided and propelled by electromagnetic fields and presented to the public in May 1971 is the first step towards high-speed ground transportation systems for the connection of industrial agglomerations in Europe.

Messerschmitt-Bolkow-Blohm's next step in 1973 (Figure 9) will be an experimental vehicle on a 1,300 m long track, supported and guided by electromagnetic systems and propelled by a fuel-rocket to a velocity of 400 km/h. This vehicle supports on the bottom side components to be measured like magnets, linear induction motors, current pick-ups etc.

The construction of an operational vehicle (Figure 10) is planned for 1975 for the National Research Centre in Donauried. This development programme is sponsored by the Minister of Transport and the Minister of Research and Technology of the Federal Republic of Germany.

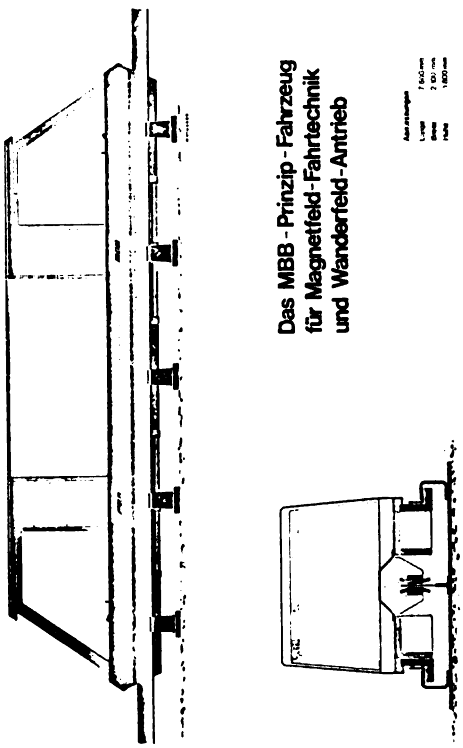

FIGURE 8

To close, I would like to show you a picture of the very first vehicle in the world to be supported, guided and propelled without contact with a track. It was exhibited at the World Fair in Paris in 1889 and was designed for a speed of 200 km/h even then. However, guidance and propulsion were provided by hydraulic fields of force, rather than by electromagnetic fields.

I should like to stress once again that a decision for or against a given system, such as the conventional railway system or air cushion system, can only be the result of transport analyses of the kind which led to development of the magnetic suspension principle by Messerschmitt-Bolkow-Blohm.

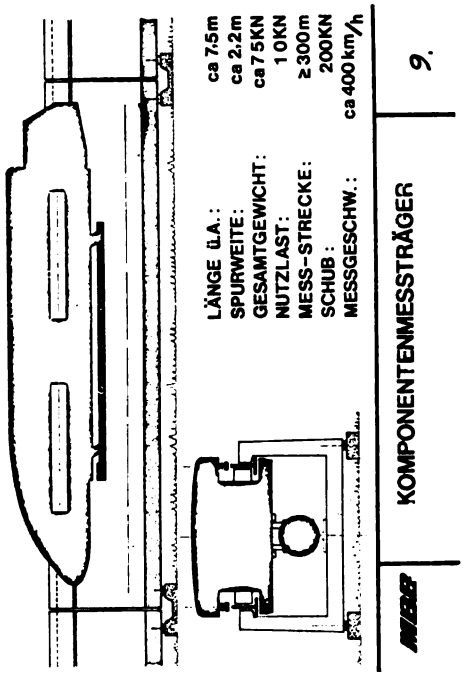

FIGURE 9