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TECHNICAL AND STRUCTURAL INNOVATIONS TO EUROPEAN TRANSPORT IN 21ST CENTURY

ABSTRACT

The aim of this study is to draw attention to the development opportunities presented to the population of Europe and beyond, on the threshold of the 21st century, resulting from the new geopolitical situation and available technical innovations, plus the necessary decision-making required in the field of transport politics. With the introduction of the unitary money, the Euro, giving further definition to the continental economic region, new needs arise demanding an appropriate transport system. For this a Europe-wide Maglev net is essential. It must take over quickly an increasing part of the traffic now carried in part by road, in part by the conventional railway, in part by air. It appears wise to consider critically and to amend the generally uncoordinated and partial renewals of the old system from the point of view of a continental-wide future, and with reference to the superior ecological and economic advantages of modern techniques coming to fruition in the Transrapid system. The consequences for future settlement structures and site evaluation are demonstrated by examples. The contrasts between the systems should be clear in the comparative table of data (Table 1). In addition, basic technical and political considerations are presented by various European experts in the booklet "Transrapid-Verkehr in Europa" [1].

KEY WORDS

structural innovations, European transport, 21st century, new traffic systems

1. GEOPOLITICAL FRAME AND STRUCTURAL INHERITANCE

After a century of wars and numerous dictators (the First World War 1914 – 18, the Second World War 1939 – 1945, the Cold War 1945 – 1990, and the subsequent Serbian wars), Europe is facing a geopolitical opportunity never previously enjoyed. Stemming from generally high-level of development, the whole continent can merge to a unitary economic region, and perhaps take the next steps to a wider merger with great Asian development regions. To be sure, the process will take decades, continuing at a very variable pace, and from time to time suffering inevitable setbacks. Equally, however, the perspective is encouraging. It will be entered into with a diverse inheritance. The cultural diversity so characteristic of Europe can in general be preserved. It is in relation to the infrastructure that a few adaptations are necessary to secure the future. The transport system forms an important complex. Without it, the existence of an economic region is impossible. Its efficiency has a dominant influence on the creation of value, and thereby on the well-being of the population, the levels of culture that can be maintained, and the degree of assistance that can be given elsewhere. The efficiency of the transport system plays, therefore, a key role, and demands a high order of political priority. The main factors are the highest level of reliability in all conditions, and the greatest possible economies of the main resources: *time, space* and *energy*.

In the previous four centuries, beginning with feudal-dynastic units, there have evolved in Europe, centralised, particularly over the last two hundred years, increasingly democratic nation-states. These processes have not come entirely to an end, particularly in the eastern half of the continent. Also, in the last two centuries the most important land-transport nets have evolved, and in particular in the case of the railways reflecting and confirming the contemporary settlement structures. An international standardisation has been achieved only partly. On the grounds of competition and of military requirements, the pattern of national boundaries is highlighted by certain differences in equipment (gauge, security and signalling systems, electrical supplies), differences which today impede the establishment of a Pan-European network but which, although with considerable technical costs, can be overcome. The high investment costs with which railnetworks are associated, have naturally led to a degree of fixity both in the inner structures of settlements (the importance of the location of the main sta-

Table 1 – Comparison of technical parameters (passenger trains)

System Features	Maglev Transrapid	ICE 1	ICE 2	ICE 3	TGV Duplex
Technology	Non-contact, Electromagnetic levitation, Attractive principle	Steel wheel on rail			
Train composition	max. 10 sections (length of standard platform)	2 Power cars + 12 passenger cars 645 seats	1 Power car + 1 control car + 6 pass. cars. 361 seats	8 Passenger cars 4 of them with 16 powered (à 500 kW) axles; 391 seats	
Propulsion	Synchronous longstator linear motor, mounted on guideway	Asynchronous AC motors in power cars 8 Motors à 1200 kW in 2 power cars	4 motors à 1200 kW in 1 power car		
Energy supply	110 kV, 50/60 Hz	Ac15kV, 16 2/3 Hz	AC 15 kV, 16 2/3 Hz	AC 25 kV, 50 Hz	24 kV, 50 Hz
Operation control	Fully automated communication control system, Digital radio transmission, Driver optional	Automatic train control (LBZ), driver required		Köln-Frankfurt also remote control (FZB)	
Design speed	550 km/h	280 km/h	280 km/h	330 km/h	300 km/h
Operating speeds	300-500 km/h	280 km/h	276 km/h	300 km/h	
Acceleration performance	0-200 km/h 1715 m 62 s 0-300 km/h 4340 m 104 s 0-400 km/h 8820 m 160 s 0-500 km/h 17800 m 225 s	6975 m 150 s 32204 m 567 s	7500 m 219 s 64220 m 1006 s	4200 m 129 s 21500 m 367 s	4600 m 149 s
Braking performance	200-0 km/h 1930 m 69 s 300-0 km/h 4340 m 104 s	Emergency (1.2 m/g² on level) 1290 m 46 s 2890 m 69 s			3500 m
Energy consumption Wh/P 1km[1] Constant speed	200 km/h 26 250 km/h 31 300 km/h 38 400 km/h 58 500 km/h 85	26 37	24 34	22 31	Average 35.7
Standard speed profile with maximum[2]	160 km/h 25 200 km/h 29 250 km/h 33 300 km/h 43 400 km/h 64 500 km/h 93	23 32 44 71 (280 km/h)			
Noise emission 25 m distance dB (A)[3]	160 km/h 71 200 km/h 72 250 km/h 75 300 km/h 79 400 km/h 88 non-contact – no resp. wear and tear	83 84 88 91 (280 km/h) possibly more noise due to wear and tear		89 (330 km/h)	89 92 (350km/h)
Temperature Continuous gusts Normal operation construction stability Snow Ice	- 25°C up to + 40°C up to 125 km/h up to 215 km/h 10 cm on deck plate up to10mm on Deck plate, up to 5mm on guidance rails and stator packs	- 25°C up to + 40°C	track-depending speed reductions at wind speeds over 80 km/h		
Train size[4] (End/middle section) Section length width height	 26.99 m / 24.77 m 3.70 m 4.16 m	 20.5 m / 26.4 m 3.02 m 3.84 m		 25.68m / 24.78 m 2.95 m 3.89 m	 22.10m/18.70m 2.81m/ 2.90m 4.30m

System Features	Maglev Transrapid	ICE 1	ICE 2	ICE 3	TGV Duplex
Alignment parameters Guideway/track gauge Top of guideway Double-track, Centre to centre distance	 2800 mm 1.25 m to 20 m 300 km/h 4.4 m 400 km/h 4.8 m 500 km/h 5.1 m	 1435 mm 0.40 m 4.70 m			 1435 mm 4.20 - 4.50 m
Grade climbing ability	> 10 %	4 % (Passenger traffic) 1.25 % (Mixed traffic with freight)			3.5 %
Superelevation (cant)	12° to 16°	6.9° Passenger traffic (planned) 5° Mixed traffic with freight			
Curve radii	Minimum 350 m 200 km/h 705 m 300 km/h 1590 m 400 km/h 2825 m 500 km/h 4415 m	1400 m 3200 m (Mixed traffic: 5100 – 7100 m)			150 m 125 m 4000 m
Vertical radii (crest:sag)	Minimum 600 m 200 km/h 5145:2575 m 300 km/h 11575:5790 m 400 km/h 20575:10290 m 500 km/h 32150:16070 m	1600:1400 m			1600:1200 m
Ride comfort Max. lateral acceleration Max. vertical acceleration	 1.5 m/s² Crest 0.6 m/s² Sag 1.2 m/s²	 1.0 m/s² (0.85 m/s² Mixed traffic with freight) 0.2 m/s² 0.2 m/s²			 1.5 m/s²
Route data Double track Foundation area Total ground area Earthworks during construction	 1.5-11.8 m²/m 12 - 22.8 m²/m 13.7 – 47.2 m²/m	 13.7 m²/m 31.2 m²/m (Average for new rail lines) 201.9 m²/m (Average for new rail lines)			
Tunnel profile single track double track	(<300 km/h) (<400 km/h) 39 m² 70 m² 78 m²	 56 m² 88 m²			
Max. daily circulation of trains	6000 – 8000 km	1600 – 1800 km			

A comparison of the systems shows the superiority of the magnetic levitation technique over the older wheel:rail system. With less energy consumption, less use of land and less noise, a clearly higher capacity is achieved; building and running costs are also less, the adaptation of the track to the terrain is much simpler.

1. Wh/1 Pkm = watthours per seat per kilometre; with Transrapid the energy used on board is included, with the conventional railway the on-board energy (heating and air-conditioning) is not included.
2. The "Standard speed profile" shows the time taken in normal service from stationary, accelerating to a maintained running speed and then, with braking, back to stationary.
3. In the interest of comparison this shows sound generation measurements for level track. All systems generate wind noise. This can be better controlled in the Transrapid system than by ICE, which generates less noise than TGV. The wheel:rail system (ICE 1-3 and TGV) additionally generates considerable noise from the rail:wheel contact, as well as wind and frictional noise from the electric power contacts. These two additional noise sources rise steeply with increased wear and tear. The magnetic levitation technique, with no actual contact between track and train, is free from these additional sources of noise. A rise of 10 dB (decibels) corresponds with doubling of the sound strength.
4. The trains of all systems usually consist of end and (by choice) middle sections (carriages). In Transrapid the end sections may provide space for passengers, luggage, post and/or freight. In Transrapid propulsion (and braking resp.) forces act uniformly on the entire train (each section). There is no leashing stress between the sections. The ICE 1 (and 2, one only) and TGV trains have also locomotives as endsections. ICE 3 is moved by powered axles (16 installed in 4 sections). In order to cross certain frontiers, entering into regions with different energy supply networks, these locomotives need to be variously equipped. Variations in gauge constitute another problem for cross border conventional systems. Transrapid can seat 88 persons per carriage (section), ICE 53-60.

Sources: System data for Transrapid (Thyssen Henschel Magnetfahrtechnik) Testing and Planning Company for the Magnetic Levitation system (MVP), official publications of the German Railways (DB) and the French Railways (SCNF). The SCNF has to date provided a few data for the TGV Duplex only. Much of the data from various sources revealed slight variations. Latest updating: Feb. 1, 1999. - Complied by W. Tietze and G. Wackermann.

tions) and in the hierarchical ranking of central places, the latter phenomenon further bolstered by the allocation of administrative functions within the state. This degree of fixity is further enhanced in most lands in that railways, apart from unimportant local lines, are the property of the state, and rail-workers in this sense, civil servants. Recently however, privatisation has begun to show some effects.

In the 20th century the railway has been subject to two serious competitors; road transport and air transport. The unassailable advantage enjoyed by road transport is its offer of communication virtually door to door, and virtually at all times. These advantages are additional to the speed of road transport, as yet unmatched, and its very flexible freight capacity (except for bulk goods, in any case a declining part of goods transport). In passenger traffic, road transport holds further advantages of individuality and intimacy (choice of travelling companions, air-conditioning, infotainment, extensive provision for more secure, simpler and accompanying luggage transport, generally available each and every time). Air transport cannot offer the same level of comfort. Its advantages lie in its intercontinental dimension and in speed. The advantages inherent and specific to each system of transport determine the areas of competition. In the areas of overlap, various interesting and sometimes momentous innovations have emerged. It is to be noted also that the railway and airtravel cannot in themselves lessen the usage of road traffic, being dependent upon road traffic as feeder service. This leads to another area of competition: in many cases the house to house facility of road transport is so complete and satisfactory, that integration as feeder in the air and rail transport systems is irrelevant.

2. PROBLEMS OF ADAPTATION FOR RAILSYSTEM; CONSTRAINT OF THE TOWN PLAN

How can the railway meet the challenge in the transport market? Of course there is a price war, which will not be considered here. Modern trains are introduced, more attractive, but not necessarily more comfortable. Speedier trains are introduced, linked with a better arrangement of timetables, allowing better change facilities and more rapid connections. The stations themselves can be made more attractive with an attempt to obtain a more contemporary style, often at considerable cost. In the attempt to improve comfort, the railway, vis-á-vis road transport, has only limited possibilities. It cannot provide house to house service, nor be available at all times. It is true it can compete a little in the latter respect by increased services, but only with steeply rising costs. Costs limit also the possible luggage services, in so far as one can establish the facts. From Switzerland there are encouraging signs. The Swiss railways SBB and the Post Bus lines PTT provide a convenient baggage service from terminus to terminus including the main Swiss airports. In principle, the problems of passenger traffic and freight traffic are similar; how does the passenger/freight reach the rail lines? Feeder traffic is a weak point.

It will remain a weak point because the railway companies and the local authorities, with hardly any exception, continue to use the same sites for main stations as established in the 19th century, and to rate such sites as economically of high value, even if their accessibility leaves much to be desired. An important, and at first sight reasonable basis for this conservative attitude in planning is provided by the concentration of public service routes at the main-stations. The automobile arrived too late to occupy and defend sufficient urban space in these core areas. Whilst in North America this dilemma contributed greatly to the desertion of the main-station sites, and indeed to the railways in general, in Europe the powerful railway boards, in agreement with the local authorities, have favoured access by public transport at the expense of private cars, disregarding the loss in time and the discomfort suffered by passengers, faced with the prospect of one or more changes in public transport before reaching the station for their long-distance travel. All travellers with the financial means avoid the problem by using a taxi.

The statistics for this form of access to stations are hard to come by, and this is simply overlooked in most investigations. Political decision-making in relation to this problem can be criticised as based on false premises.

Nevertheless, in all the large cities, it is very difficult to avoid, and then only at great expenses, the congestion of traffic in the vicinity of the main station. This cul-de-sac policy is being continued, although for decades a large part of retailing and of service industry, appreciated usually as a feature of high-level urbanisation, has left the city areas nearest the main station, and have been assisted in this movement by the planning authorities. This paradox is not untypical. Planning policy is determined by the state. In Europe, however, with the principle of subsidiarity, planning activity involves many complex and intriguing financial levels. The processes are therefore clumsy and lack transparency, but profit a selective political clientele, subject to political currents rather than progressive reason. These facts lead to the conclusion: strategic innovation will be successful only if linked with the necessary tactical flexibility.

3. NEW: TRANSRAPID – RENEWED: HIGHSPEED RAILWAY – PROS AND CONS

For continental-scale land transport the Maglev technique is an innovation of epoch-making dimensions [1]. It permits us to look with equanimity at the older and tested wheel:track system. The technical and economic limits imposed by the wheel:track system were insurmountable in the quest for a more modern and quicker transport system. With the Maglev technique (magnetic levitation, shortened to Maglev) as it has reached maturity in Transrapid, all three major resources; time, space and energy, are conserved in comparison with other transport systems. And in addition to these economic advantages, there are further and hitherto unachieved environmental advantages of no pollutant emissions, no vibration, less noise. None of the existing transport systems, neither by road nor by air (for distance overland of less than 2000 km), nor yet by rail, can compete. By comparison with the railtrack system (Table 1) numerous factors are made clear. The result is the overwhelming advantage of Transrapid. All that remains is a comparison of costs.

The few existing comparisons of cost are not easy to evaluate, in that it is difficult to ascertain, or even questionable, as to what is to be included in the calculations. The present rail systems cannot match the demand as shown by the enormous growth of road and air traffic, regardless of the very extensive renewals. In freight transport by rail there have been improvements in loading techniques, in better design of wagons, and improved logistics. Speeds have also been improved. In the increasing cross-border traffic, improvements have been affected by the use of multiple locomotive and wagon systems. Outstanding improvements have been made in passenger traffic. The most important term used in this context is 'high speed travel' (HST). In France, the most advanced equipment is represented by various versions of the TGV (train á grand vitesse), in Germany by the three existing versions of the ICE (intercity express), in Sweden with the trains X2000 and X3000. With these trains possible speeds extend from 200 km/h to some 350 km/h, entailing rebuilding or new building of lines with heavy foundation, large scale curvature and lower gradients, plus rearrangement of stations and other similar works. Costs vary enormously from case to case. Even in level terrain the cost rapidly exceeds the costs of construction for Transrapid, which, additionally, can cope with tighter curvatures and steeper gradients. On the other hand, the railway, by new building of stretches, frees capacity on the old lines, to the advantage of goods traffic. The railway also has to bear the costs of new or renewed stations, costs which are of the order of billions of Euro. Some of these costs, it can be argued, are unavoidable, and furthermore can be offset in part by the sale of high value land in the old city centres. Actual examples are the relocation of the former main-stations in Stuttgart, Frankfurt/Main and Munich to through-stations with kilometre-long tunnelling under the inner-city. The future importance of the inner-cities as traffic nodes in the European transport network is hardly questioned, although the ability to reach the inner-city will require permanently increasing expenditure. The urban growth along with increasing suburbanisation with not only residential areas, but also high value service industries (such as administrative headquarters of large companies) will substantially increase the demand for long distance travel. In cost comparisons these developments have been largely ignored.

4. THE BEGINNING – AND WHAT THEN?

Further inadequacy in previous cost comparisons derives from the fact that the calculations are based only on initial stretch of Transrapid or on one respective conventional high-speed line. No real clarification of the problem can be achieved by such means. A new system can only be evaluated as part of a comprehensive net. If one introduces the Maglev technique (Transrapid) with the Hamburg-Berlin (300 km) stretch, it is understandable that there is every attempt to attract to this linkage as many passengers as possible. In so far the termini will be placed near the usual inner-city main-stations of the conventional railway. This particular stretch is in fact well suited for some comparisons since both road and air transport offer real competition. Neither can it match the 53 – 55 minutes offered by Transrapid, and this is also true for the conventional railway even if it received comparable expenditure. Nevertheless, from the beginning, there should be a picture of desirable further development.

The two cities, Hamburg and Berlin are the largest between the southern coasts of the Baltic and further European hinterland. Linked with the four ferry ports Kiel, Travemünde, Rostock and Mukran (Isle of Rügen), they gather a large part of the rapidly increasing traffic between central Europe and one of the most vital growth zones in Europe, the Baltic region, with a population of over 30 million. It is obvious, therefore, that these ferry ports should be linked with the Transrapid stretch Hamburg – Berlin via the intermediate stations Hamburg-Moorfleet, Schwerin and Perleberg, especially since Moorfleet (direction Bremen and Hannover) and Perleberg (direction Magdeburg – Leipzig) offer themselves for further extensions, and only a small linkage from Schwerin would be necessary to include Lübeck. These ferry linkages could at first be single track (Figure 1) but designed for conversion to double track with the advent of a Baltic tunnel (Fehmarn Belt and/or Falster Belt) and a corresponding increase in traffic.

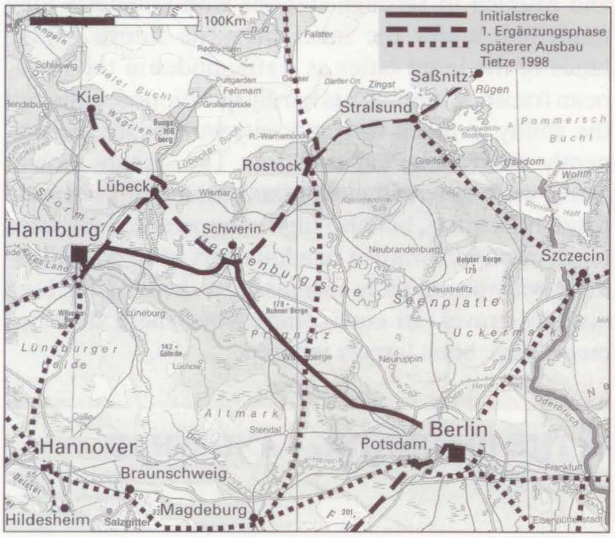


Figure 1

The first section in service of the Transrapid (Maglev) system Hamburg – Berlin, and the first extensions to connect with the ferry ports Kiel, Travemünde, Rostock and Mukran (Isle of Rügen). These extensions can initially be single track with building costs of about 10 million Euros per km. The conversion to double tracks of the sections Rostock – Schwerin and Rostock – Perleberg may become feasible if a direct linkage is established, via a Baltic tunnel from Rostock to Flaster, between Hamburg and Berlin on the one side and Copenhagen etc. on the other. Early extensions of the Transrapid net are shown: from Hamburg towards North Rhine-Westphalia (Figure 2) and from Berlin southwards to Saxony (Figure 3-5) and thence beyond (Figure 7). These extensions must be clearly defined vis-á-vis the correct planning of Transrapid installations within Berlin (Figure 6).

5. RHINE-RUHR AND RANDSTAD HOLLAND

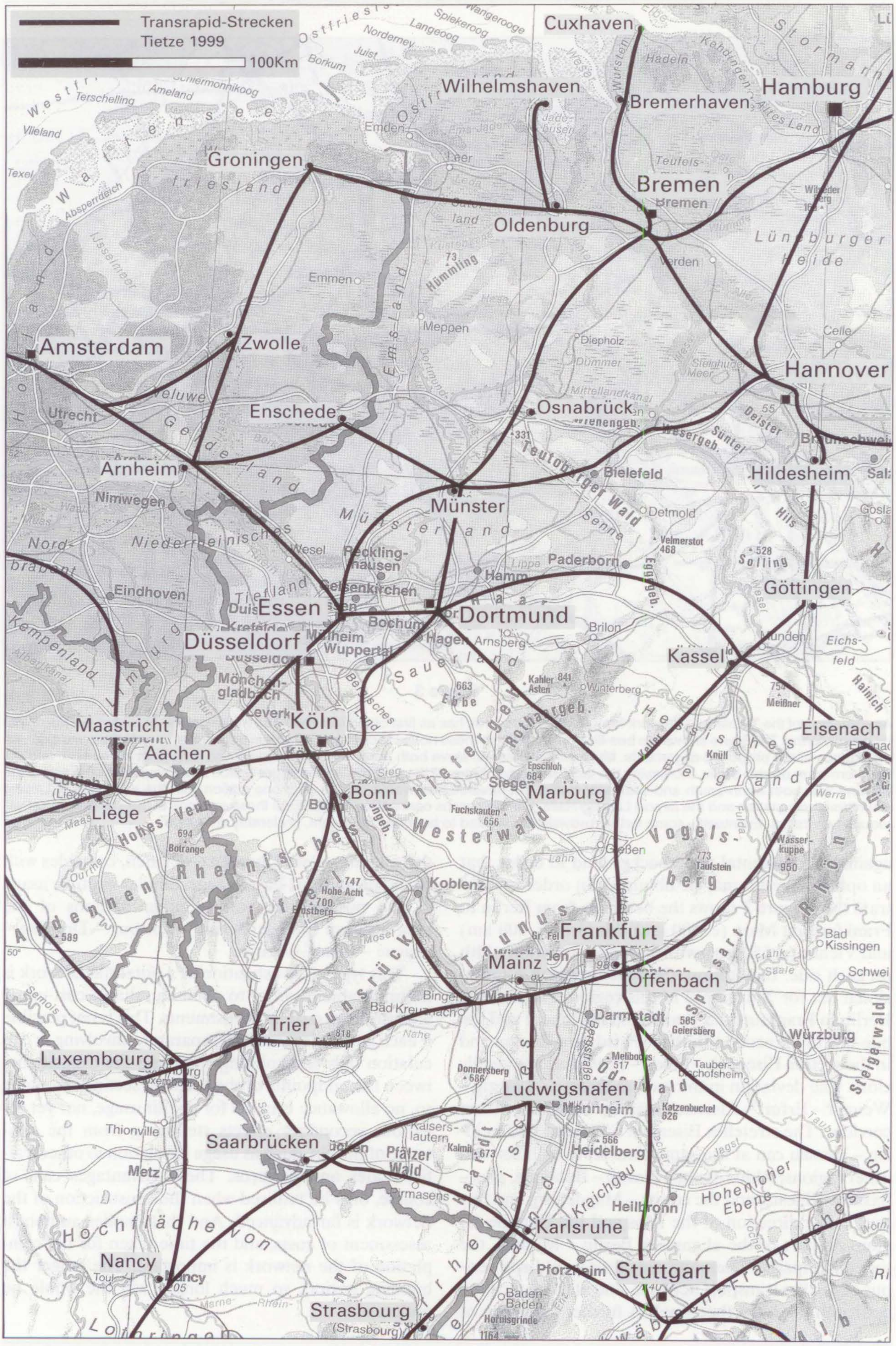
For the cost/usage evaluation of the first installed Transrapid line, that between Hamburg and Berlin, a still larger future scenario must be considered. The nearest great growth regions generating traffic to be reached from the provisional terminus at Hamburg are: North Rhine-Westphalia, the Netherlands (Randstad Holland), the European metropolises Brussels and Paris, and the Rhine-Main centre (Frankfurt). In this context, Figure 2 outlines a possible network in North Rhine-Westphalia. With a multipolar agglomeration, the decisions on the location of lines and stations is particularly difficult, and various adverse factors can be overlooked or left unconsidered. The existing sites of the main-stations in the region are relatively unimportant. They can be used if they are accessible over old railway and industrial land without a massive investment. At any event the important airports (in particular Düsseldorf, but also Cologne-Bonn, and the Dortmund, Münster-Osnabrück) should be linked with a Transrapid station. In particular, in the interest of uncomplicated access traffic, the exhibition area of Essen (Gruga) or autobahn nodes are particularly suitable for station location. It should be restated that public transport is not good at providing access to long distance traffic, in that it itself depends on access (feeder) traffic, and is poor in provision of luggage facilities. It follows that public transport should only play a limited role in the selection of sites for Transrapid stations. In a multipolar agglomeration decisions over the density of stations will inevitably provide further difficult problems. A station may be said to be well located when it serves many travellers. But station density also relates to speed. Even in an agglomeration, the distance between stations should only exceptionally fall below 30 km. This stems from the advantages of Transrapid over the conventional railway. The acceleration time is three or four times greater, with the length of track required for the acceleration correspondingly smaller; and the noise emission not half as high. In the vicinity of stations, the passage of a Transrapid train (speeds below 200 km/h) is practically soundless.

6. SAXONY AND THEN BEYOND

As the third example for an extension from the initial Hamburg – Berlin stretch, the district south from Berlin will be considered. This, it is clear, is a typical central European transit region [2], with immediate access to great traffic generating areas, and also to outer regions of Europe. That means, each and every decision as to track and station location must be taken

Figure 2

The installation of Transrapid in North Rhine-Westphalia should not be in terms of short isolated sections connecting two places of presumed transport importance (e. g. the airports Düsseldorf and Cologne-Bonn), but from the viewpoint of forming part of practical European network linking North Rhine-Westphalia with major nodes such as Amsterdam, Brussels, Luxembourg, Frankfurt, Kassel, Hanover and Hamburg. At the two regional airports, Münster-Osnabrück and Dortmund, three-way stations will be necessary; similarly on the south-west border of Cologne. In all other cases a two-way station will suffice. Dortmund provides good location for a major maintenance station. Possibly, a site can be found on the abandoned industrial land. The adaptability of Transrapid to terrain opens the possibility for Dortmund to be linked with Frankfurt (- Stuttgart – Zürich) via Marburg with journey taking only 35 minutes. The same adaptability also creates a previously unknown possibility of reaching Kassel from Dortmund, and via Wuppertal, Cologne-Bonn airport and thence Luxembourg etc.


Transrapid-Strecken
Tietze 1999
100Km
Cuxhaven
Wilhelmshaven
Bremerhaven
Hamburg
Groningen
Bremen
Oldenburg
Amsterdam
Zwolle
Hannover
Enschede
Osnabrück
Arnheim
Hildesheim
Münster
Bielefeld
Paderborn
Göttingen
Essen
Dortmund
Düsseldorf
Kassel
Köln
Maastricht
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Eisenach
Liège
Bonn
Marburg
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Frankfurt
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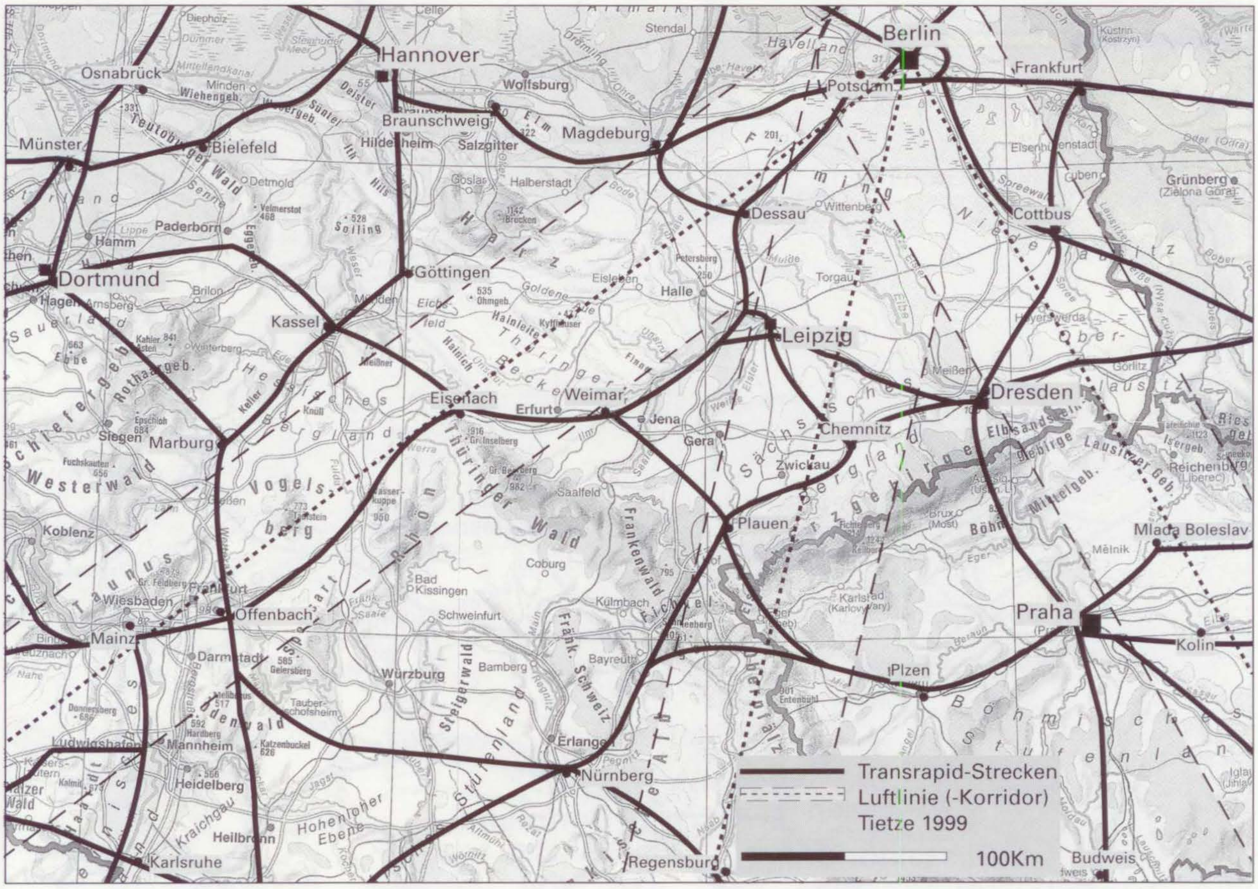

Figure 3

An extension of the Transrapid network from Berlin southwards has as first objectives the three major nodes: Frankfurt am Main, Munich and Vienna. The figure shows the bee-lines from Berlin to these nodes in corridors 40 km on both sides, in order to make clear the divergence of the proposed alignments. Much of the lines will serve both north-south movement and east-west movement, and will therefore carry double traffic, increasing the localising advantages of the stations. All the larger Saxon cities could become part of the network with both north-south and east-west traffic, but nevertheless would require only one station with the exception of Leipzig where the main-station and the airport Leipzig-Halle offer numerous connection facilities. All these sections of the Transrapid net will require two tracks. Eventually, some further provisions will need to be made for freight, preferably JiT-cargo.

against a continental scale background in order that an optimum result may be obtained. In order to illustrate this, Figure 3 shows the bee-lines from Berlin to Frankfurt am Main (c. 400 km), Munich (c. 500 km) and Vienna (c. 550 km), with a corridor of 40 km width on each side. In addition, the scheme shows a provisional net for Transrapid in this region. For the link Berlin to Frankfurt the Transrapid alignment and the bee-line in the section Berlin – Potsdam – Dessau and in the section Eisenach – Fulda – Frankfurt are ideally close. The deviation in the section Dessau – Leipzig – Weimar – Erfurt – Eisenach scarcely leaves the 40 km corridor. The stretches Eisenach – Weimar and Leipzig – Dessau can at the same time serve as links with other regions; Rhine-Ruhr – Kassel – Bohemia, plus – Saxony – Silesia, and the coasts – Magdeburg and further in the direction of the Alps and the Danube region. As part of the alignment Berlin – Munich, the section Leipzig – Chemnitz can close an old and serious gap in the transport network, and at the same time approach the ideal (bee-line). A further extension of this alignment, via Chemnitz – Plauen, coincides with an important west-east linkage. Similar multiple usage is also possible for various other sections of the long-distance linkage Berlin – Cottbus – Dresden – Prague – Brno – Vienna.

This type of investigation of a potential network is indispensable in order to obtain a reliable cost-usage analysis from current investments. This is not possible if each stretch is discussed separately, involving in calculation only the building costs and the capacity between the endpoints of the selected section. By doing so, no allowance is made for transit usage, nor yet for various secondary effects stemming from the existence of the net, such as usage in relation to other traffic modes and patterns. These advantages can, of course, only be realised when the construction of the network is far advanced. And that implies an honest assessment of costs, and the time taken for the completion of the network is important. The longer the building period, so much longer will the whole be underused.

This partial or incomplete usage would be more effective if the track and stations were built in two quality classes, with subsequent adaptation as it became possible. The higher quality trains will stop only at interchange stations, whilst the lower quality trains would also use the less important stations, and serve therefore with the feeder functions. Construction of these less important stations must nevertheless be so arranged as to allow the through train to overtake the stopping train. As an example, in Saxony the following places could be considered for these less important stations; Zwickau, Freiberg, Bautzen and also Döbeln and Hoyerswerda. These variants could be of importance as localising factors (for industry and commerce) in the development of sites.

Since the development of a new transport system, such as that of Transrapid, will require many years, it is necessary to provide as good a service as possible with the still rudimentary status systems in the beginning. The linkage between conventional railway stations and the new system is therefore important, and thus, it is to be recommended that, for example, the southern moving traffic from Berlin-Spandau station along the Avus axis leads to Postsdam main-station, and from its western exit is forked to serve future traffic in the direction Magdeburg and in the direction Dessau (main station) and Leipzig. For a metropolis such as Leipzig, two stations are necessary: one with direct linkage to the airport that is being reconstructed on an international scale (and on account of which a similar project of an airport for Berlin at Sperenberg [3] has little real chance of being built), and the other linking directly to the main-station in Leipzig, that, as the largest in Europe, has recently been subject to a fundamental modernisation. Between both stations, the old railway land can be used for the track. The Transrapid station at the old main-station can find space on the east flank thereof, if possible with the track 6 – 7 metres above the level of the railway platform. This will permit the crossing of the platform in order to join and lengthen the transverse platform of the main-station, connecting it to the Transrapid station. This can be reached by travellers by means of escalators. Since Transrapid trains need only 2, or maximum 3 minutes at a station, and can follow each other in a very rapid succession; only one platform (9 – 10 m wide) with luggage loading facilities on the outer side will be necessary for 20 trains per hour and direction. The platform must be correspondingly easy to access (capacity: 4000 passengers per hour). Southwards, the track should lead parallel to the Georgi-Ring in the direction of Augustusplatz, which can be bridged over or tunnelled beneath, via Windmühlenstrasse, (on bridge), to the railway-land of the Bavarian station and then further southwards. Bridging may well be cheaper than tunnelling.

The distance between the main-station and the Bavarian station is close to 2.5 km. Transrapid, with speed of less than 200 km/h would cover this distance in about one minute, and generate a noise level of up to 70 dB (A) near the Bavarian station. In the general traffic noise this would be imperceptible. This advantage would surpass any experience yielded from any present means of transport. In response to the anticipated objections from planning circles, attention should be drawn to this unique advantage. This alignment can lead southwards in order to branch near the S-Bahn station Markkleeberg-Grosstädteln in three directions: Erfurt – Frankfurt, Chemnitz – Nürnberg, and Dresden – Prague or Dresden – Wroclaw. This branching would entail a reduced speed of less than

Figure 4

Leipzig is one of the most important European transport nodes. This situation has been the basis over a long period for the economic importance of the city. The railway installations are at such a large scale that there is ample space for a two-track Transrapid to reach the immediate eastern flank of the existing main-station. Southwards, there should be an open linkage with the Bavarian station and beyond, on old railway land, to a fork in the vicinity of the suburb Gross-Städeln for long-distance lines to and beyond Erfurt, Chemnitz and Dresden. Northwards a second Transrapid station is needed in direct link with the airport-service buildings Leipzig-Halle. On its western exit, the track forks in the direction Dessau – Berlin, and – Magdeburg as well as in the direction Erfurt. The Thuringian section of the line must be aligned towards Leipzig on both sides because of continuing not only to Berlin (and Magdeburg) but also towards Dresden. Such an alignment is multipurpose and economical in land. On the southern margins of the city, the track can run over restored lignite workings.

Table 2 – Excerpt of one Hour only from a Fictive Timetable (10.00 – 11.00 hours) for the two Transrapid Stations of Leipzig

from Leipzig-Flughafen (Fhn)		Leipzig-Hauptbahnhof (Hbf) to
Gdansk – Szczecin – Berlin – Dessau –	09.55 > 10.00	Chemnitz – Munich – Bologna – Rome
Vienna – Brno – Prague – Dresden –	10.00 < 09.55	Magdeburg – Rostock – Stockholm
Amsterdam – Münster – Kassel – Erfurt –	10.00 > 10.05	Dresden – Krakow – Lviv – Iasi – Odessa
Genf – Zürich – Stuttgart – Frankfurt – Erfurt –	10.05 < 10.00	Berlin
Berlin – Kessau –	10.05 > 10.10	Frankfurt – Luxembourg – Paris
Kijw – Lviv – Krakov – Dresden –	10.10 < 10.05	Magdeburg – Schwerin – Hamburg
Groningen – Bremen – Hanover – Magdeburg	10.10 > 10.15	Dresden – Prague – Brno – Vienna – Budapest
Napoli – Rome – Munich – Chemnitz –	10.15< 10.10	Berlin
Paris – Luxembourg – Frankfurt – Erfurt –	10.15 > 10.20	Dresden – Warszawa – Minsk – Moscow
Bucuresti – Debrecen – Budapest – Vienna –	10.20 < 10.15	Magdeburg – Dortmund – Köln – Brussels
Berlin – Dessau –	10.20 > 10.25	Chemnitz – Munich – Zurich – Genf
Genoa–Basel–Karlsruhe–Nürnberg–Chemnitz	10.25 < 10.20	Berlin
Hamburg – Schwerin – Magdeburg –	10.25 > 10.30	Dresden – Prague – Linz – Graz – Venice
Barcelona–Toulouse–Dijon–Frankfurt-Erfurt-	10.30 < 10.25	Berlin – Szeczin – Mukran
København – Rostock – Magdeburg – Dessau	10.30 > 10.35	Erfurt – Frankfurt – Basel – Genoa
Trieste – Zagreb – Linz – Prague – Dresden	10.35 < 10.30	Magdeburg – Schwerin – Lübeck – Kiel
Berlin – Dessau –	10.35 > 10.40	Kassel – Düsseldorf – Aachen – Rotterdam
Brussel – Düsseldorf – Hanover – Magdeburg	10.40 < 10.45	Dresden – Wroclaw – Warsaw – Riga – Tallinn
Görlitz – Dresden –	10.40 < 10.35	Magdeburg – Hanover – Bremen – Cuxhafen
Milan – Verona – Munich – Chemnitz –	10.45 > 10.40	Berlin
Berlin – Dessau –	10.45 < 10.50	Chemnitz – Munich – Bologna – Rome
Hamburg – Schwerin – Magdeburg –	10.50 > 10.55	Dresden – Vienna – Budapest – Belgrade – Athinai
Madrid-Bordeaux-Dijon-Frankfurt-Erfurt-	10.55 < 10.50	Berlin
Munich – Nürnberg – Chemnitz –	11.00 < 10.55	Magdeburg – Schwerin – Hamburg
St. Petersburg – Minsk – Warsaw – Wroclaw	11.05 < 11.00	Frankfurt – Basel – Genoa – Marseilles

The two Transrapid stations at Leipzig (Airport / Fhn and Main Station / Hbf) could with 25 trains in one hour only provide direct connection with some 600 cities throughout Europe. Within only one change of trains, this number of cities would increase threefold once a continentwide net is available. Four slots (16% of capacity) are still not used. – The airport is so well situated with respect to the road net that it could receive road feeder traffic from a wide area without adding to inner-city congestion. The short-haul air services (up to some 1500 – 1800 km, except islands) could be practically dispensed with, since these are not competitive with Transrapid traffic. – Cf. figure 4.

200 km/h and therefore scarcely perceptible noise (Figure 4), (Table 2).

For the inner-city alignments in Dresden it appears desirable to erect a Transrapid three-way station over the old track-triangle Friedrichstadt and thus arrive at the old inner-city. That means that the stretch from Leipzig and from Chemnitz join at the north-west edge of the city. The alignment towards Prague leaves the city southwards over the old Tharandt route, and the Cottbus – Berlin as well as the Görlitz – Breslau line run to cross the Elbe parallel at the Marienbrücke, and reach a station at the airport before branching (Figure 5). Should it not prove possible to bring the alignment of the track so far into the old city, then it will be necessary to locate the Transrapid three-way station in the north-west of the city, and cross the River Elbe beside the crossing of the autobahn A4. It would still be possible to have a station at the airport. The Friedrishstadt solution is optimal. Also, in this case, noise generation by Transrapid is not to be feared.

For Chemnitz, one Transrapid station will suffice. The most economical location would be on the western margin of the city, immediately close to the crossing of the A72/Neefestrasse. From this point, the east, south and northern outskirts are easily accessible, and it is near a large growth area on the west of the city. But if Saxony, in an early extension of the network, can become linked with the initial Hamburg – Berlin line, then a longer period of time may be involved in order to reach continental traffic. The more initial concern is focused necessarily, on regional traffic, the more rational it will be to use established railway station sites for Transrapid stations as well. In the case of Chemnitz, it is not difficult to bring the lines from Leipzig and from Dresden to the existing main-station, perhaps 6 m above the rail tracks in order to cross them without difficulty, and at the same

Figure 5

The Saxon Land capital Dresden has been for long the meeting point of five important European long-distance routes; the north-south axis runs from Berlin (and beyond from the Baltic coast) towards Bohemia (Prague) making accessible the route for Linz through the eastern Alps to Adria, and above all, via Vienna, the diverse routes through south-east Europe to the coasts of the Aegean and the Pontus, as well as over the Bosphorus to the Near East. The east-west linkage forks many times, first in the direction Leipzig, and then once more, further as the Saxon 'Magistrale' in the direction Chemnitz – Plauen and then once more (Erfurt – Kassel or Nürnberg – Munich). Eastwards, there is the most important route through the Sudeten and the Carpathian forelands with many branching in the far regions of north-east and east Europe (St. Petersburg, Moscow and Kijev etc.). In Dresden, all these various linkages can come together in a three-way node, which could be placed best on the old railway land, on the north-west of the old city, or alternatively about 5 km further north near the autobahn. Correspondingly, the Elbe crossing would be by the Marienbrücke, or by the autobahn bridge. A second station at the airport is also possible. This ability to reach close to the heart of the city, as also in Leipzig and Chemnitz as well as Dessau, Potsdam and Berlin, will facilitate the use of the Transrapid net even whilst it is still rudimentary.

level to connect by escalator the east end of the existing transverse platform (10) (with two tracks plus luggage platforms). The southern exit must descent over a ramp to pass parallel with the rail tracks three underpasses. There is enough space at hand. The original six rail track section has been only half used since Soviet (1945) dismantling. The further exit westward will require no underpasses so that Transrapid can utilise the alignment above the existing railway, and thus no additional space is needed in this densely built up areas, and no noticeable noise generation is to be anticipated.

For the city of Plauen there are transport-geography opportunities never before enjoyed in its 750 year history, despite the fact that it occupies a classical pass-foot site. As shown in Figure 3, Plauen can continue to play its part in the north-south traffic, southwards to Nürnberg (and Stuttgart) and then forking in Regensburg to either Munich or Passau, and northward either to Berlin or more to the west via Magdeburg to the coast with its harbours and ferry ports. Plauen can also participate in the west-east traffic from the Rhine-Ruhr via Kassel – Erfurt and thence branching either towards Chemnitz – Dresden – Poland or towards Marienbad – Plzen – Prague etc. The section Plauen – Chemnitz (about 100 km, as part of the Saxon main route) serves both for north-south and for east-west traffic. With the extension of Transrapid over the whole continent, the situation of Plauen represents a centre for maintenance of the system, and as the network widens, this will gradually bring along an increasing number of high-value employment opportunities.

In so far as clarity regarding the future development of the Transrapid net around Berlin [3] is obtained, the variety of alignment necessities in Berlin it-

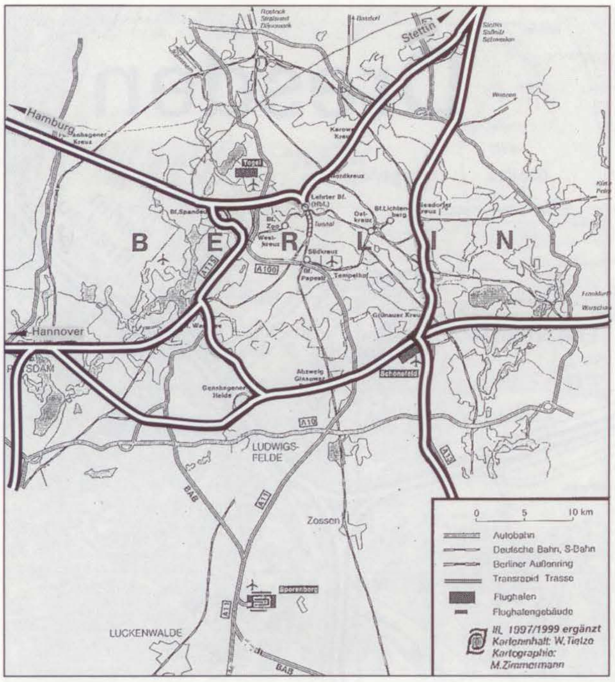

Figure 6

Transrapid network in Berlin can be clearly defined when the further central European extensions are decided upon. The first stretch from Hamburg will reach the main-station (Lehrter station) via Spandau. For through-traffic, the conventional railway will use the now realised (a century after first being planned) tunnel (the "mushroom concept") but his is useless for Transrapid. The Hamburg and Baltic traffic must thus end at a main-station. The western tangent Spandau-Potsdam can serve for through--traffic, with a branch in the south tangent Potsdam – Schönefeld, and with the airport station. The through traffic in an east-west direction will not reach the main-station, but pass through Berlin only on the southern tangent with stations at Potsdam and the airport. This is, therefore, both a suitable and a comprehensive solution.

self, becomes evident (Figure 6). A new main-station (so far called Lehrter station) is being established, and in Spandau eventually a three-way station (or alternatively a two-way station on the exhibition site/ICC). In any case, a two-way station will be required at the airport Berlin-Schönefeld. Through-traffic (West-East) may stop only here and in Potsdam.

Berlin as the leading Central-European metropolis will trigger a substantial amount of transit traffic to pass through Saxony. The destinations include (via Dresden) Silesia, Galicia, Ukraine, all major Black Sea ports, Turkey and the Near East, the Danubian Region and Greece as well as the Adriatic coasts. The south-western branch (via Leipzig, and partly via Chemnitz – Plauen) embraces destinations to Paris and the whole of south-western and southern Europe, i.e. Spain and Portugal and Italy respectively. This enormous continental region thus opened, will generate a great increase in traffic as economic integration increases, and will in turn necessitate technical innovation. Figure 7 shows a possible extension of the network through the Carpathian lands. The approximately 850 km between Berlin and the important transport node Lviv (Lemberg) can be covered by Transrapid in less than 150 min. The speed in this region will profit from the longer distances between stations than in the west-central European growth areas, as for example along the Rhine.

7. JIT-TRAFFIC OF THE TRANSRAPID SYSTEM

Whilst passenger trains are also suitable for postal and couriers services, with the transport as part of production (assembly) lines other considerations come into play. In co-operation with the interested parties in industry it has to be decided, from case to case, whether respective loading stations should be created by the community or by individual firms. Generally, JiT-transports are containerised and standardised, as part of a stringent production process, and usually moving between two production centres. JiT-transport is, in its relationships, similar to charter passenger traffic or special trains for long distance tourism. These trains collect passengers at one or few stations in the source area, and take them without any intermediate stops to their destination (and back). This type of traffic, generally much heavier at weekends, is today represented by aircraft or by coach. Transrapid could provide for a more comfortable, ecologically sound, and certainly no dearer means, but this source of possible future traffic has not been considered in the uninspired calculations made so far. For this tourist-JiT, all the traffic between (mainland) agglomerations and the coastal resorts in the Mediterranean, except for islands, can be considered, for example the Algarve in Portugal, and the Spanish Levant, Alpine resorts, as well as pilgrimage sites, such as Lourdes and Jerusalem. All in all, this represents a considerable sector of the market.

8. URBAN STRUCTURE AND SITING OF TRANSRAPID STATIONS

In can be reiterated: the Maglev technique, realised in Transrapid, is the most economic and ecologically-friendly means of land transport available on a continental scale. In comparison with the conventional railway, it is technologically uniform, and therefore more flexible and much faster. As a consequence, it can be compared and is competitive not only with the conventional railway, but also with the road transport and even air-transport (with distances of less than 2000 km in any case). For an evaluation of its competitiveness, entry to the system, that is to say, the location of the stations, plays a significant role, for, as with contemporary transport systems, acceptance by the trav-

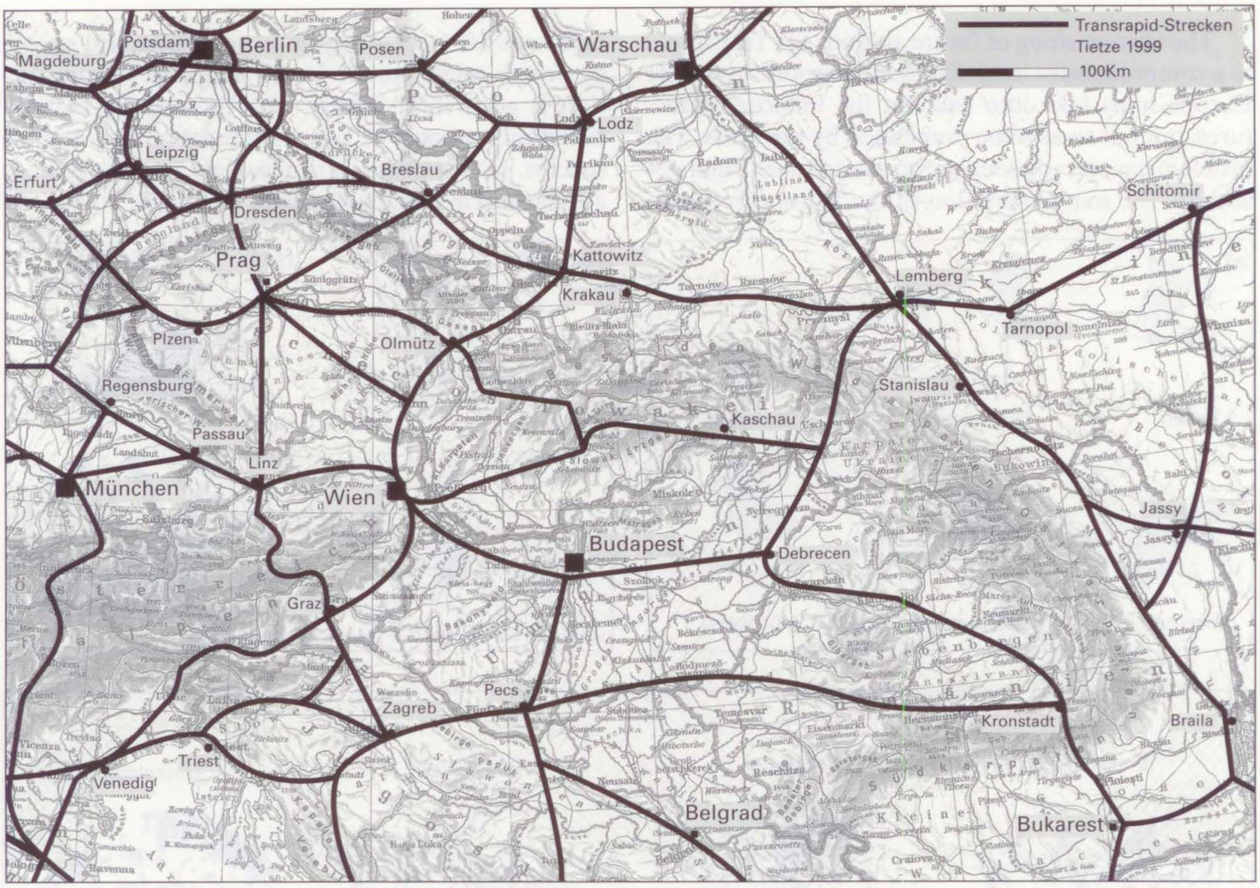

Figure 7

Proposal for the mature Transrapid network in the core area of Central Europe resulting from an exchange over many years between numerous expert transport-geographers from the region. The central triangle Berlin – Warsaw – Vienna – is embedded in a system of continental-wide transversals. The new geopolitical situation permits a considerable activation of the northern mountain foreland of Silesia and Galicia, as well as Moldovia, as connection between central West Europe and the Pontic region, in which the old city of Lemberg/Lviv plays a gateway role similar to that of Vienna. Italy and the north Adriatic harbours have access to this growth region as previously only for a short honeymoon period in the late 19th and early 20th century. Local problems such as the modernisation of the Semmering pass lose some importance. Individual stretches required to complete the net, such as in Slovakia and in Bosnia, can at first be single track. Decisions regarding details of this type may become easier as the development process continues.

elling public depends to a degree on the capacity of feeder services to the station (and conversely on return transport from the station).

The enormous growth and increased density of urbanisation in Europe as the accompaniment of industrialisation in the course of the 19th century, has at the same time led to a collectivisation of local traffic. As a consequence, the complex of local traffic has evolved as two-tiered: with local traffic to serve local traffic. Travellers, naturally, find this too complicated, with increased costs in money, time and comfort. Wherever possible, an easier solution is preferred: by car (or taxi) access becomes once more single tiered, and with that greater comfort and a saving of time achieved. But this solution was not considered, either sooner or later, in the street pattern around the main-station. In America, this lack led to the desertion of the area around the station and the adjacent district of the city, and the reduction, if not abandonment, of passenger traffic by rail, to the advantage of air travel. The airports were made accessible by large scale motorway systems and provided with parking and hire-car facilities in a perfect one tier system. On the contrary, in Europe the railway and local transport is either in the hands of the state or so constrained by regulations, so regimented, that it cannot react to the demands of the market. Instead of responding to the market, there is an increase in the regimentation, as is normal when a government department is confronted with a situation which it cannot equal. The individual transport service providing access is hindered, whilst official transport is made more 'attractive' with the help of subventions. The financing of these subventions is a burden placed on the economy in the form of taxes. Many people have long reached the conclusion that the problem cannot be solved in this manner, but unfortunately, this view is not widely shared.

Also, in science and in planning practice, this rationality is only slowly becoming evident (Figure 8) [4, 5, 6].

The correct siting of future stations for Transrapid as a comprehensive long-distance transport system for Europe must take into account the inherited structures, but not so as to be dominated by the same. The problem has already been mentioned above (Figures 4 and 5). The implementation of the European Transrapid net will necessarily be in small sections, stretch by stretch going into service. In this phase of construction, a good inter-linkage with the existing conventional railways will be very influential on the ultimate success. In this phase, it is necessary that the stations are located in conjunction with one of the stations of

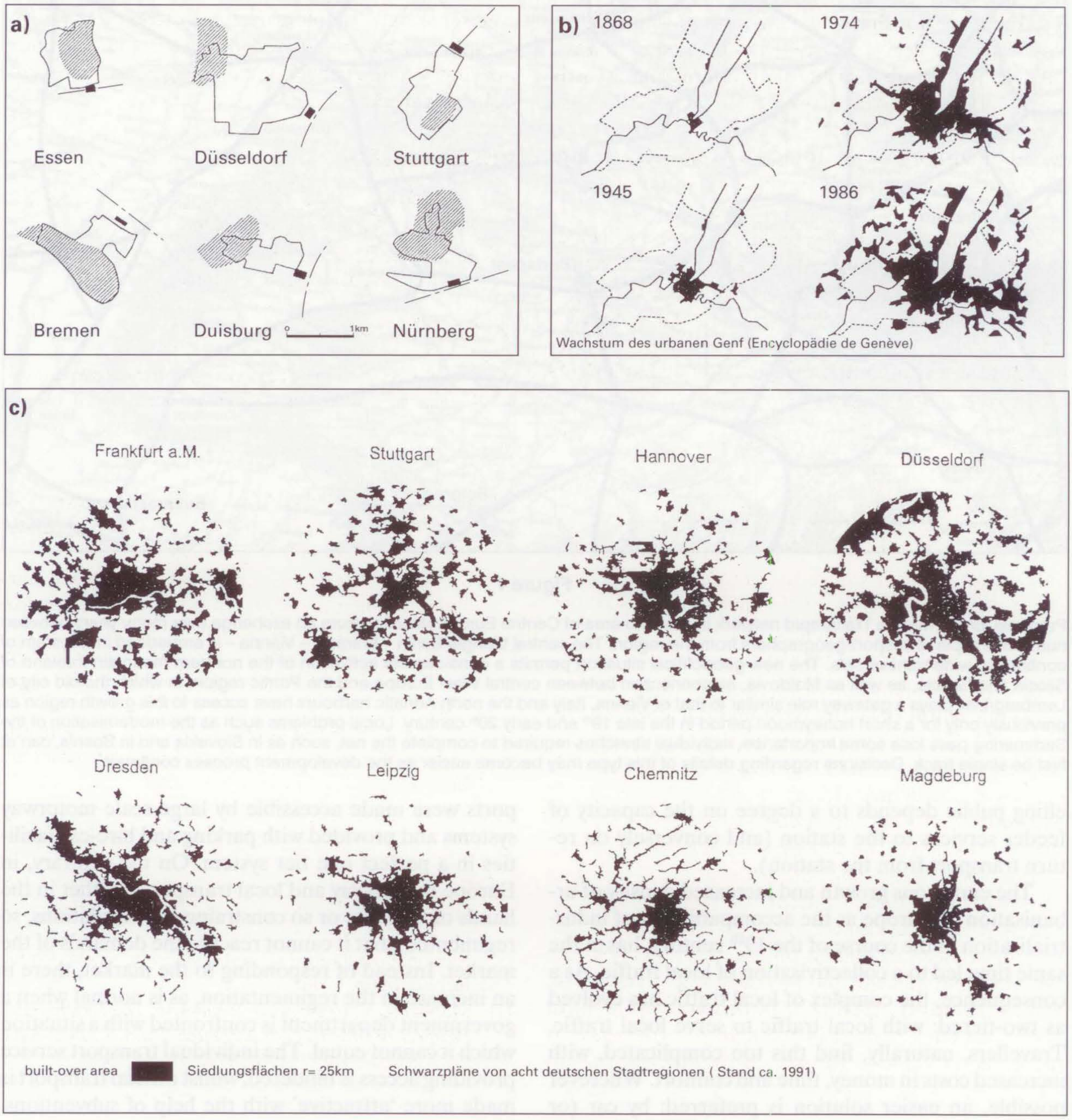

Figure 8

Figure 8 With European Union and the introduction of the Maglev transport system, a new era opens for Europe, of dimensions never before experienced. These factors, and not small economic units (and mentalities) constrained by national frontiers, set the scale for the 21st century. For the large cities, the centres of economic value - creators and generators of cultural change, this will lead to deep-seated change. Such changes have occurred before. In the 19th century the main railway stations were built outside the core areas of the cities. These locations led to a widening of the core area. A further impulse for growth was due to the recent rise in living standards. Within and without the city boundaries the built-up area has increased greatly, with marked suburbanisation, a process which in eastern Europe was distorted in 50 years of socialist policies. This suburbanisation weakens the 19th and 20th century primacy core of the city (and of the main-station as a node).

Examples a) from Lennart Amén [4]; b) Neue Zürcher Zeitung, 4/5 January 1997 [5]; c) from Stefan Siedentop, 1998 [6].

the old system. At the same time, however, it is essential that the new system has direct connection with the airports, and that in each case the feeder transport services should be as simple as it is possible to arrange. That may generally entail a tangential approach to the destination city, and not otherwise, as indeed was also the case when the older system was developed. As at that time, and for this future case, the town will grow towards the station - "die Stadt kommt zum Bahnhof". This is much more sensible than attempting a costly entry into the heart of the old city. Ideally, the tangents should be so located as to ensure the station also serves an airport, or an exhibition/conference centre or at least a major transport node, and by doing so, allows for as great a single tiered service as possible. Experience shows that for the millionaire cities or correspondingly large agglomerations, the tangent (eventually circular tangents) should touch on one of the peripheral rings. The elevated building construction of Transrapid would ensure no strangulation of urban building, as was often the case with the embankments of the conventional railway.

9. CONCLUSION

On the threshold of the 21st century, Europe is offered the opportunity for political and technical advancement which could in a few decades help overcome the disadvantages of the division into national states and the socio-economic depression and delays due to 75 years of wars and disturbances (1914 – 1989), and open the door even to the great development regions in Central Asia, the Near and Far East. The instruments for this perspective are the European Union, and the utilisation on a great scale of the magnetic levitation technique (Maglev) [7] in the form of Transrapid, to meet the need for the developing volume of transport. The conventional transport systems would not suffice; and their costly modernisation could only assist locally and for a limited time. The advantages and the disadvantages of the different systems have been examined on various occasions (see for example Tietze [ed.] Transrapid-Verkehr in Europa. Stuttgart 1998 [1]). In this article, the most important data, revised in the light of experience, is presented in Table 1. The article also discusses possible development stages in the establishment of the network linking with the first line, that between Hamburg and Berlin, with North Rhine-Westphalia and Randstad Holland as well as Saxony and ultimately east Central Europe. The closing theme in this connection, transalpine transport, and its effects on the wider regional surrounds of the Alps, will be considered separately. In this article, the effect on urban geography[1] is alternatively considered, and the interweaving with the conventional railway[2], and with public local transport.

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1 See referring to this, the contributions in this volume by G. Wackermann, and L. Bertolini.

2 For air-transport see the contribution by K. Schliephake and W. Tietze in this volume.

ACKNOWLEDGMENT

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