INTRODUCTION

Mobility and infrastructure are basic conditions for an operative and efficient national economy and in this way indispensable for the community. The preservation and the appropriate expansion of traffic infrastructure as well as the setup of modern transportation systems occupy considerable investments in the sum. These are, however, investments in the future because the interweavement keeps on increasing between states and national economies and allows enterprises to act globally. For the people this means to manage longer distances in increasingly shorter times.

Four significant transportation systems exist for the passenger traffic, which have to be regarded to their different advantages and disadvantages:

- the railway system with the subsystems for low-speed and high-speed traffic and for local public traffic and long-distance traffic,
- the road traffic (individual and public motor car traffic as local and as long-distance traffic),
- the maglev systems for low-speed and high-speed traffic and
- the air traffic.

A comparison of all four transportation systems would exceed the limits of this abstract. All transportation systems show different advantages in certain distance areas. Figure 1.1 shows the typical relations between the journey time and the distance for a motor car, a high-speed train, for the Transrapid and for airplanes. The listed journey times include the times for journeys to the railway station or to the airport and typical waiting times; additional waiting times caused by the limited transportation offers are not included (for example rail connection every 1 or 2 hours, flight offers only 1 or 2 times daily).
traffic with high-speed trains may hardly be distinguished in the journey time from the motor car in distances from 100 km to 200 km. The airplane displays its advantages from distances above 700 km. In the distance area between 70 km and 700 km the Transrapid is the fastest system.

The accessible average speed plays a significant role in this comparison. The individual traffic on roads does not allow an average speed more than 80 km/h up to 130 km/h for motorcars. High-speed trains with top speeds of up to 320 km/h reach an average speed of not more than 110 km/h to 150 km/h in densely populated areas with stops up to 150 km. The average speed of the airplane is estimated at 500 km/h to 700 km/h. New transportation systems may be successful only with a significant increase of the average speeds. Therefore an enormous acceleration and high final speed are needed. The Transrapid represents a technical innovation which gains the comparison with existing transportation systems in the local area (point to point) and in the long-distance traffic up to approx. 700 km.

Following, the authors discuss typical aspects of the track-guided high-speed traffic. This is based on an entire comparison of high-speed transportation systems, which the authors have published under the title „Transrapid und Rad-Schiene-Hochgeschwindigkeitsbahn“ [1]. Main aspects of the discussion are:

- technical-physical features of the two transportation systems including ecological questions,
- economical aspects and
- questions of traffic politics, national economic and industry politics.

Based on the publication of the European Strategic Environmental Assessment (SEA) directive 2001/42/EC [2], different national committees of the EU partners examine procedures and methods for traffic planning. In this directive the objectives of the environmental risk assessment are concretized. Although decision-critical checking standards related to the decision process are missing in this directive, it demands to develop the project evaluation in the direction of interlinking. On the one hand this means, that the responsible organisation of roads, railways and water lanes are supposed to carry out comprehensive and integrated transportation planning. On the other hand, aspects have to be considered concerning:

- climate gas,
- pollutants,
- noise and vibrations,
- land use, land separation and land cut off.

In the following, a comparison is provided, which is based on the different technical-physical features of the Transrapid guideway and the high-speed railway.

2 DESIGN CRITERIONS FOR HIGH-SPEED LINES

2.1 High-speed railway systems

In Germany the proven ballast bed was given up in high-speed railway traffic for the benefit of the slab track. The Deutsche Bahn AG (DB AG) builds since some years all high-speed lines only as slab track. The line Cologne-Rhine/Main, which went 1st of August 2002 after six years of construction in operation, is the first long-distance slab track. There are different systems of slab tracks, which were evaluated by the DB AG. Following, the systems of Boegl and of Rheda are presented.

2.1.1 System Boegl [3] [4]

The special feature of this system consists in prefabricated slabs of concrete with high strength, on which the rails are fixed.

![Fig. 2.1 Construction of the slab track system of Boegl](image)

The slabs are individually produced for the planned location. The supporting surfaces for the later fixing of the rails are grinded with high precision. After laying they are coupled lengthways on site and are grouted with a bitumen-cement-mortar.

![Fig. 2.2 Slab track system Boegl just before coupling](image)
2.1.2 System Rheda 2000 [6]
The system Rheda 2000 uses short sleepers, fixed on a preliminary rail, which are embedded in concrete on a hydraulically bound base course (see figure 2.3 and 2.4). It has to be noticed, that different designs are used in tunnels, in trough buildings and on bridges. Switches are principally carried out according to the system Rheda.

![Fig. 2.3 Slab track system Rheda 2000 [7]](image)

The DB AG uses heavy rails for high-speed lines of the type of UIC 60 (weight of 60,34 kg/m), which meet highest requests.

![Fig. 2.4 Aligning the preliminary rails before embedding the short sleepers [7]](image)

In addition to the construction of both systems of slab tracks, further extensive works are necessary. These are earthworks, overhead line, control- and protection technique, drainage ditches and cable troughs.

2.2 Transrapid guideway

The development of the Transrapid guideway began in the 1970th with investigations, first with different steel girders and later with prestressed concrete guideway beams. The first generation of steel girders was the basis for the Transrapid testing track in the Emsland (TVE) (see figure 2.5). Since then, a great number of beams were developed from different manufacturers and tested in reality on the TVE.

![Fig. 2.5 North horseshoe bend at the Transrapid testing track Emsland (Source: Transrapid International, Berlin)](image)

The development of the guideway beams is not finished. Technical further developments, company internal and costs-sided optimizations demand further activities on the interface between the vehicle and the propulsion system:
- evaluation of the experiences on the TVE and from the Shanghai project,
- consideration of valid standards, rules and regulations,
- judgement of ecological aspects as sound and vibrations, flora and fauna,
- requests for the guideway in tunnels and
- summary of demands from other subsystems to the guideway.

The guideway for the Transrapid may be carried out as elevated or at-grade according to terms of design. Both alternatives are subsequently presented.

2.2.1 The elevated guideway

An elevated guideway can be constructively carried out very different. It is recommended to design elevated guideways with a clearance of at least 4,00 m between ground level and the underside of the beams. So, agricultural vehicles can pass through at every place along the guideway. This fulfills an important security criterion. A typical view on the elevated guideway is given in figure 2.6.

The span length is strongly dependent on the used beams and represents a difficult optimization task. Longer and therefore heavier beams are more expansive in mounting. Shorter beams, however, lead to more columns and foundations. The beams in Shanghai have a standard span length of 24,80 m or 12,40 m [8]. Some beams, however, have a span of up to 31,00 m [9]. The overall height of the beam depends on the span. Beams with a span between
24,80 m and 31,00 m have an overall height of about 2.50 m, beams with a length of 9.30 m to 12.40 m only about 1.00 m. The length for the beams has to be a multiple of 3.10 m, which derives from the length of the stator packs.

Fig. 2.6 Example of an elevated guideway in Shanghai

The elevated guideway shows a great number of advantages in comparison to the at-grade design:

- Land separation: Animals and people can move without hindrance below the track. Interventions in the ground water balance are negligible. Drainage ditches can be dropped, even the drainage of heavy rain is not influenced. From ecological points of view, these criterions have to be evaluated very high.

- Security: The elevated guideway leads to a very high system security. Persons and animals (except for birds) can not reach the runway. Objects can almost not be thrown onto the guideway. Collisions with vehicles are impossible.

- Design of the line: The elevated guideway allows a distinctly flexible lining. Only a minimum of earth work is necessary, the adaptation of the gradient of the guideway to the topography is realised by different high columns. Existing roads are scarcely influenced, the Transrapid simply over-passes them.

- Load-bearing capacity: The loads, an elevated guideway has to bear, are smaller for the Transrapid than for the railways. The Transrapid vehicle is considerably lighter than the locomotive of the railway, because no heavy drive motors have to be carried along. In addition, the loads of the Transrapid are distributed along the vehicle and not punctual by wheels.

- Noise protection: Protection against noise at elevated guideway is very expensive. An elevated guideway is rarely used for the traditional railways because of this reason as well. The Transrapid is, however, considerably not so loud, so it can often be carried out elevated without problems.

- Costs: The construction of an elevated guideway is more expensive in comparison with an at-grade guideway. But there are smaller costs for environmental mitigation works and land acquisitions, because of the strongly reduced land use. An agricultural use of the area below the guideway may be still possible without restrictions.

2.2.2 The at-grade guideway

The Transrapid can be led as well at-grade. It encloses the carrier unit of the guideway in the same way analogously to the elevated alternative. Figure 2.7 shows a cross and a longitudinal section of a possible version of the guideway.

Fig. 2.7 Cross and longitudinal section of an at-grade guideway

Two fundamentally different construction alternatives exist for the at-grade guideway. On the one hand beams are used in an analogous mode to the elevated guideway but nearer to the ground. It is to be emphasized, that shorter and therefore much cheaper beams are mounted with a short distance to the ground surface, so for example the surface water of heavy rainfalls can pass the guideway unhindered. Extensive drainage systems including necessary retention reservoirs can be dropped. In addition, insects, reptile and small animals including game can pass through the at-grade guideway without prob-
lems. So, that a land separation under this aspect does not occur.

On the second hand, at-grade guideways can be manufactured similar to a slab track of the railway-system. A gliding-manufacturer produces a concrete wall on a foundation slab, or optional columns approx. 1.00 m high, parallel to the axis. The driving plate with the functional carriers is mounted then onto the concrete wall or the short columns as a prefabricated slab. Both construction technologies have advantages and disadvantages. It depends on many factors, which system will be used in practice. However, concrete walls should be used only along existing traffic routes for example parallel to highways or railways. In these cases the landscape has been already separated.

The guideway constructions of the Transrapid, elevated or at-graded, facilitate the route mapping unlike the railway-system. It is easy possible to cross other traffic routes or to balance the differences if ground falls or rises, because of the change option between the elevated and the at-grade construction. In addition, the Transrapid can easily overcome uphill gradients and slopes with inclinations up to 10%. The railway system allows according to the regulations of the EU only 3.5% for passenger high-speed traffic lines [20]. Embankments and incisions are necessary for the compensation of the small ability of climbing and the constructive design of the guideway. This can lead to a considerable land use. In total these affects are disadvantageous for the railway system.

2.3 Land use

The side slopes of embankments or incisions have normally an inclination between 1 : 1.5 and 1 : 2.0, which depends on the existing ground (fig. 2.8).

An embankment with a width of 12.10 m at the crest and a height of 12.00 m will have a width of 60.10 m under unfavourable conditions between the slope toes. In addition cable channels have to be arranged as well at the slope shoulder and in many cases drainage ditches at the slope toes. Thus approx. 55 m² up to 65 m² land has to be taken in use per double-track meter. Nearly the same land use is necessary to build incisions.

Furthermore, the necessary earth structures do not lead only to high land use, but also to risks caused by thunderstorms. Considerable rainfalls can lead to dangerous damages to the earth structures and to flood damages as well.

Land use of an elevated guideway is small in comparison to an at-grade construction or to a normal railway track. The land use depends on the beam span and the foundations of the columns, substations for the levitation and propulsion systems, stopping points for evacuation and access ways. The land use for these system facilities are added to about 2.0 m²/m for the elevated guideway. In addition land has to be bought for ecological compensatory measures. This will lead to 40% to 70% more land use. The requirements depend on line-specific conditions:

- to the ecological value of the used areas,
- unusable islands, for example through grouping of traffic lines,
- tree-free areas if the guideway is passing through a forest (approx. 30,00 m on both sides of the line).

In table 2.1 the land use of the railway system and of the Transrapid are shown.

<table>
<thead>
<tr>
<th>Land use condition</th>
<th>Railway system</th>
<th>Transrapid</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>at-grade, without embankment/incision</td>
<td>approx. 16.00 m²/m</td>
<td>approx. 11.50 m²/m</td>
<td>1.4</td>
</tr>
<tr>
<td>embankment/ incision 5.00 m high</td>
<td>approx. 35.00 m²/m</td>
<td>elevated</td>
<td>17</td>
</tr>
<tr>
<td>at-grade, without/ incision, in addition to 50% of compensation areas</td>
<td>approx. 24.00 m²/m</td>
<td>at-grade, including 50% of compensation areas</td>
<td>1.4</td>
</tr>
<tr>
<td>at-grade, with embankment incision, 5.00 m high, in addition to 50% of compensation areas</td>
<td>approx. 50.00 m²/m</td>
<td>elevated, including 50% of compensation areas</td>
<td>17</td>
</tr>
<tr>
<td>embankment /incision, 12.00 m high, in addition to 20% of compensation areas</td>
<td>approx. 75.00 m²/m</td>
<td>elevated, including 50% of compensation areas</td>
<td>25</td>
</tr>
</tbody>
</table>

The values vary between a factor of 1.4 (both systems at-grade) and a factor of 25 (railroad on a 12 m
high embankment and the Transrapid elevated). The actual land use can only be calculated on the base of a real route mapping. In many cases the land use of the railway system will be about a factor of 4 or 5 higher than on a Transrapid line.

2.4 Route mapping

The connection between two stations can seldom be realized by a direct straight line. There are diverse restrictions like cities, lakes, mountains or nature reserves, which have to be passed by. As well regional planning, the environment and the nature, business and economic aspects have to be considered. In addition the comfort for the passengers should be optimized. The route mapping has to consider the following distinguishing features:

- permissible superelevation in curves,
- permissible side acceleration in curves,
- permissible vertical acceleration at hilltops and in dip curves,
- climbing capability.

The different permissible horizontal curve radii and the smallest hilltop and dip curve radii can be calculated in dependence of the design speeds. Some results are compiled in the following tables 2.2 to 2.5.

Table 2.2 Minimum horizontal curve radii with a speed of 300 km/h for the railway system

<table>
<thead>
<tr>
<th>Super-elevation $u$ [mm]</th>
<th>Angle $\alpha$ [°]</th>
<th>Minimum horizontal curve radius $R_y$ [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>170</td>
<td>6,5</td>
<td>3.270</td>
</tr>
<tr>
<td>180</td>
<td>6,9</td>
<td>3.165</td>
</tr>
<tr>
<td>200</td>
<td>7,7</td>
<td>2.974</td>
</tr>
</tbody>
</table>

A reduction of the permissible minimum curve radii is possible with the tilting technique. In this case the vehicle construction leans into the curve with an angle up to 8°.

Table 2.3 Minimum horizontal curve radii at the Transrapid

<table>
<thead>
<tr>
<th>Maximum speed $v_e$ [km/h]</th>
<th>Minimum horizontal curve radius $r_y$ [m] at $a = 12^\circ$</th>
<th>Minimum horizontal curve radius $r_y$ [m] at $a = 16^\circ$</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>1.937</td>
<td>1.638</td>
</tr>
<tr>
<td>350</td>
<td>2.637</td>
<td>2.231</td>
</tr>
<tr>
<td>400</td>
<td>3.444</td>
<td>2.913</td>
</tr>
<tr>
<td>450</td>
<td>4.360</td>
<td>3.686</td>
</tr>
<tr>
<td>500</td>
<td>5.382</td>
<td>4.551</td>
</tr>
</tbody>
</table>

Table 2.4 Minimum vertical radii for the railway system

<table>
<thead>
<tr>
<th>Design speed $v_e$ [km/h]</th>
<th>Permissible vertical acceleration $a_{z, zul}$ [m/s²]</th>
<th>Minimum vertical radii $r_{K, W}$ [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>0,2</td>
<td>15.432</td>
</tr>
<tr>
<td></td>
<td>0,3</td>
<td>10.288</td>
</tr>
<tr>
<td>250</td>
<td>0,2</td>
<td>24.113</td>
</tr>
<tr>
<td></td>
<td>0,3</td>
<td>16.075</td>
</tr>
<tr>
<td>300</td>
<td>0,2</td>
<td>34.722</td>
</tr>
<tr>
<td></td>
<td>0,3</td>
<td>23.148</td>
</tr>
</tbody>
</table>

Table 2.5 Minimum vertical radii for the Transrapid

<table>
<thead>
<tr>
<th>Design speed $v_e$ [km/h]</th>
<th>Permissible vertical acceleration $a_{z, zul}$ [m/s²]</th>
<th>Minimum hilltop radius $r_{K, W}$ [m]</th>
<th>Permissible vertical acceleration $a_{z, zul}$ [m/s²]</th>
<th>Minimum dip curve radius $r_w$ [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>0,6</td>
<td>5.144</td>
<td>1,2</td>
<td>2.572</td>
</tr>
<tr>
<td>300</td>
<td>0,6</td>
<td>11.574</td>
<td>1,2</td>
<td>5.787</td>
</tr>
<tr>
<td>400</td>
<td>0,6</td>
<td>20.576</td>
<td>1,2</td>
<td>10.288</td>
</tr>
<tr>
<td>450</td>
<td>0,6</td>
<td>26.042</td>
<td>1,2</td>
<td>13.021</td>
</tr>
<tr>
<td>500</td>
<td>0,6</td>
<td>32.150</td>
<td>1,2</td>
<td>16.075</td>
</tr>
</tbody>
</table>

With the ICE T, which is equipped with the tilting technique, an enhancement of the permissible speed up to 21 % at same radii can be achieved.

In the comparison of the two systems you will notice that the hilltop and dip curve radii are smaller at the Transrapid because of the higher permissible vertical acceleration.

The few examples of the different characteristics of the two systems show the superiority of the innovative Transrapid system. A look onto the technical advantages and the ecological aspects is following.

3 ECOLOGICAL ASPECTS

An ecological comparison of different technical systems is very difficult because different ecological effects must be evaluated. The MIPS-analysis (Material Input per Service Unit analysis) represents the potentials of environmental changes for products and services.
3.1 Resource consumption

The basis of the MIPS-analysis was the design of the Transrapid project Berlin – Hamburg. By the analysis the categories of abiotic raw materials, biotic raw materials, earth works, water and air have been investigated. The construction of the guideway, of the vehicles and the operation were evaluated. In table 3.1 the results are shown for the infrastructure and for a single journey.

Table 3.1 MIPS-analyses for the infrastructure

<table>
<thead>
<tr>
<th></th>
<th>Abiotic raw-materials [g/km and person]</th>
<th>Water [g/km and person]</th>
<th>Air [g/km and person]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transrapid</td>
<td>109</td>
<td>391</td>
<td>4</td>
</tr>
<tr>
<td>ICE</td>
<td>380</td>
<td>904</td>
<td>3,5</td>
</tr>
</tbody>
</table>

for a single journey

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Transrapid 430 km/h, ICE seating</td>
<td>202</td>
<td>3.186</td>
<td>22,4</td>
</tr>
<tr>
<td>ICE 300 km/h</td>
<td>224</td>
<td>3.090</td>
<td>15,1</td>
</tr>
</tbody>
</table>

By this study it can be stated that the Transrapid is superior to the ICE in consumptions of resources. The Transrapid is inferior only in the consumption of air.

3.2 Sound emissions

It is proved that noise can damage health. Noise impairs hearing and can lead to heart defects. Newer investigations gave evidence that people subjected to environmental noise fall ill more frequently as people in quiet surroundings.

Regulations to sound immissions are determined in the German BImSchG [10] in connection with the BauNVO [11]. Further regulations are given in the “Magnetenschwebebahn-Lärmschutzverordnung” for the Transrapid and in the 16th BImSchVO [12] for the railways. On these basis the maximum permissible sound emissions are given in reliance to the build-up areas (see table 3.2).

Traffic vehicles produce sound emissions by

- Engines and fans,
- Mechanical contact between wheel and rail,
- Aerodynamic turbulence by the body, by the current collectors, the wheel and axle sets,
- Oscillations of the body and
- Oscillations of the track system or guideway.

Table 3.2 sound emission reference values in Germany

<table>
<thead>
<tr>
<th>Build-up area</th>
<th>during the day 1</th>
<th>at night 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Only industrial or industrial facilities</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td>Mainly industrial facilities</td>
<td>65</td>
<td>50</td>
</tr>
<tr>
<td>Industrial facilities and apartments</td>
<td>60</td>
<td>45</td>
</tr>
<tr>
<td>Mainly apartments</td>
<td>55</td>
<td>40</td>
</tr>
<tr>
<td>Excluding apartments</td>
<td>50</td>
<td>35</td>
</tr>
<tr>
<td>Health-resort areas and hospitals</td>
<td>45</td>
<td>35</td>
</tr>
</tbody>
</table>

1) nighttime peace is from 10.00 p.m. to 6.00 a.m.

Sound emissions can be reduced by continuous further development of the drives and the vehicles. Sound-absorbing walls can be installed at especially critical places, for example near housing areas, schools or hospitals. Additional sound-absorbing measures can be essential along noise-intense traffic lines. In table 3.3 typical sound emissions of track-guided vehicles are shown at different speeds.

The measured maximum sound levels depend on many influencing factors; for example the condition of the rails, the wheels and axle sets at the railway vehicle or the body of the vehicle. According to the DIN 45641 [13] an average sound level (Mittelungspegel Lm) has to be calculated for the evaluation of sound emissions. The permissible level is used for the approval procedure.

Table 3.3 Measured sound emissions (peak level) at a distance of 25 m [14] [15] [16]

<table>
<thead>
<tr>
<th>Sound peak level in dB (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
</tr>
<tr>
<td>km/h</td>
</tr>
</tbody>
</table>

| Freight train             | 88-92                          |
| Interurban train          | 89-91                          |
| Intercity train           | 90-95                          |
| ICE                       | 82-84                          |
| 83-87                      | 87-93                          |
| 85-88                      | 91-95                          |
| TGV                       | 95-105                         |
| Transrapid                | 73,5 74 78,5 81,5 86,5 94 96 101 |

1) Own investigations on the basis of the measurements of Schmitz/Hebbelmann with Transrapid 08, 8 sections, elevated guideway (7 m), measurement height 1,2 m, speeds above 400 km/h as prediction
2) according to Rade
3) according to Kratz
The noise emissions of high-speed trains at a speed of 300 km/h is approx. similar to those of the Transrapid at 400 km/h. However, that means that a Transrapid can run with a clearly higher speed for example along housing areas.

3.3 Vibrations

Vibrations are caused by construction works or traffic with heavy vehicles. Along subways or along high speed railways vibrations can lead to considerable damages at buildings.

In the German BImSchG [10] vibrations are qualified as harmful environmental impacts. But there are no legal regulations for the evaluation of vibrations. The German standard DIN 4150 supplies reference values for the evaluation of vibrations. General information are given in the part 1 of this standard [17]. In the part 2 [18] harmful influences on humans in buildings are listed and in the part 3 on buildings [19].

Trains produce vibrations by:

– periodic variations of the stiffness of the track,
– unevenness of the rail surface,
– deviations from the accurate location of the rails,
– defects in the roundness of the wheels and on the wheel running surfaces,
– self-oscillations of vehicle parts, for example the bogies and wheelsets,

or because of disturbances, such as

– switches,
– uneven welds on the rails or
– abutments and columns of bridges.

The speed has an essential influence on the strength and the frequency range of the vibrations. The vibrations increase with the speed up to a system-dependent upper limit. Vibrations are rather reduced when the train runs on embankments or in incisions. According to the DIN 4150 part 1 [17] vibrations can rarely not be felt at a distance more than 80 m to the rail axis.

Vibration measurements were carried out at the Transrapid test track in the Emsland. In Fig. 3.11 the vibration peak levels of the Transrapid are presented.

The limit of notice of vibrations is shown in the diagram of figure 3.1 for better orientation. Vibration peak levels below this limit are not noticed by humans. The measurements confirm that the vibrations of the Transrapid with a speed of 400 km/h normally are not noticed anymore in a distance of approx. 45 m to 55 m to the line axis.

The comparison of the measured values at the Transrapid Versuchsanlage Emsland with the provisional values of the DIN 4150 part 2 show, that the Transrapid stays below the permissible values for example in a distance of approx. 15 m in living areas at high speed at nighttime. Other studies, for example done by Rausch, came to identical results. They show that the Transrapid at a speed above 400 km/h has the same vibrations as a railway at about 135 km/h [21].

4 SUMMARY AND OUTLOOK

The presentation of some examples of the comparison of the two high-speed transportation systems have shown, that the Transrapid comes off clearly better. Already the differences in the guideway construction and the route mapping (alignment) confirm the superiority of this innovative new system.

The authors have published an entire comparison of high-speed transportation systems under the title „Transrapid und Rad-Schiene-Hochgeschwindigkeitsbahn“ [1]. In this book a lot of aspects have been discussed, for example technical-physical features, ecological questions, economical aspects and questions of traffic politics, national economy and industry politics. The Transrapid represents a technical innovation which gains the comparison with existing transportation systems in the local area (peer-to-peer) and in the long-distance traffic up to approx. 700 km.

The authors do not stand alone with their convincing arguments for the Transrapid system. But there are a great number of opponents, who have established a resistance on the basis of emotional arguments. It remains therefore to hope that a first commercial application of the Transrapid in Germany will be realised soon to strengthen the advocates of this innovative system.
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[7] Pfleiderer Infrastrukturtechnik GmbH & Co. KG, Neumarkt


