The Moscow – Warsaw – Berlin Project: A High-Speed Maglev for long distance transport

Martin Retzmann, Kenji Eiler, Johannes Klühspies, Daniel Wiegand
International Maglevboard e.V., Guido-Schneble-Str. 32, 80680 Munich, Germany, martinretzmann@web.de

ABSTRACT: The concept of a maglev Moscow – Warsaw – Berlin is a proposal which was made by the International Maglevboard from June 2010, but the origins of this project go back as far as to the 1980s. The paper defines preliminary figures and theoretical foundations for the Moscow – Warsaw – Berlin maglev line and its infrastructure, based on currently available and proven maglev technologies. The concept was officially presented during the Russian-German "Petersburg Dialogue" conference in October 2010 in Yekaterinburg, Russian Federation, and drew considerable attention. A detailed feasibility study is about soon to be determined.

1 INTRODUCTION

The concept of a maglev Moscow – Warsaw – Berlin is a proposal which was made by the International Maglevboard from June 2010, but the origins of this project go back as far as to the 1980s.

The project is based on a two-lane high-speed maglev link from Moscow to Berlin via Minsk and Warsaw, with a total length of 1,750 km and a design speed of 600 km/h (370 mph). The Moscow – Berlin maglev line can be superior in its performance and safety, in comparison to all wheel/rail systems. Maglev infrastructure can turn out as a highly efficient, effective and convenient transport link between major economic and cultural regions in Europe, thereby boosting the economic perspectives of the entire European continent.

The paper defines preliminary figures and theoretical foundations for the Moscow – Warsaw – Berlin maglev line and its infrastructure, based on currently available and proven maglev technologies.

2 THE AIM OF THE INTERNATIONAL MAGLEVBOARD AND ITS RELATION TO THE PROPOSAL

Maglev systems represent a revolutionary transport innovation. At the same time, they can also function as a technology development platform (e.g., superconductors, new materials). They can, in certain cases, bring positive economic benefits through the optimization of spatial networking, travel time reduction and resource efficiency. A meaningful use of the technology also brings collective social advantages as well as a good image and prestige.

Maglev should be promoted in places and situations where its use is meaningful, based on an objective weighing of the available facts. Especially important evaluation criteria for all systems, in addition to their technical and operational benefits, are their long-term economic effects and life-cycle costs.

The International Maglevboard e.V., or "The International Society for Maglev Transportation", is an international non-profit organization. It is made up of internationally known transport scientists, engineers, experts as well as members of citizens' movements.

The International Maglevboard is oriented to the public interest, works independently and, as a basic tenet, does not represent any commercial interests. It is oriented toward interdisciplinary and scientifically based support of long-term social well-being, especially in relation to sustainable mobility. One focus of our attention concerns the prospects and limitations of magnetic levitation transport technologies.

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By and large, modern maglev technology is ignored or misrepresented in the media and public discussion. In addition, the few presentations on the potential of maglev that appear in the media often seem unscientific and biased toward more conventional technologies. The intention of the recent project proposal is to contribute positive, accurate information about maglev technology along the Moscow – Warsaw – Berlin corridor to help overcome the existing misrepresentations against maglev technology in both scientific and public discussion as well as the media.

It is our intention to strongly support the proposal of a maglev link from Moscow to Berlin via Minsk and Warsaw as we believe in positive results of highly efficient, effective and convenient transport modes boosting the economic perspectives of the entire European continent.

3 TECHNICAL OUTLINE OF THE PROJECT

3.1 Core Data of the Project Proposal

The proposal is based on a maximum design speed of 600 km/h in order to have sufficiently reserves for the future and to offer competitive travel times compared to the air transport. Intermediate stations along the route from Moscow to Berlin can be seen in Figure 1 and will be provided in Smolensk (Russian Federation), Minsk, Baranovichi (both in Belarus), Brest, Warsaw, Lodz, and Poznan (all of them in Poland) in order to connect as many metropolitan areas in the new corridor as possible.

Figure 1. Intermediate stations along the route from Moscow to Berlin [8].

How many and which intermediate stations are finally chosen along an optimal line, will be the subject of the coming economic calculations.

The project is furthermore based on an operational concept, in which both super-express maglev high-speed trains will link only the capital cities Moscow, Minsk, Warsaw, and Berlin, as well as maglev high-speed trains, which will in addition stop at every relevant intermediate stations along the route.

Passenger numbers dependent on the operational concept, the technology, and the passenger load factor of the trains. To operate such a system without subsidies it is strongly seen necessary to have at least several few million passengers per year as a lower limit. Currently, the number of passengers in air transport along the proposed route is still less than the sum of 1 million passengers per year [1]. However, it is assumed that the existence of new highly attractive travel links will enormously increase the number of passengers. This is due to the acquisition of transport between regions along the route as well as the general increase in traffic due to the attractiveness of the connection but also due to an induced increase because of economic development along the route. These effects have to be evaluated by means of complex traffic models and to be verified by empirical values.

3.2 Travel Times

A cruising speed of 500 km/h (up to 600km/h as an option) for the super-express maglev high-speed trains and the maglev high-speed trains stopping at all stations will result in the following travel times (Distances [2] and number of inhabitants [3]):

Table 1. Travel distances and travel times [8].

Route	km	Travel time for Express	Travel time for Super-Express	Inhabitants
Moscow	0	0:00	0:00	10,800,00
Smolensk	374	0:48		320,000
Minsk	687	1:34	1:27	1,830,000
Baranovichi	820	1:57		170,000
Brest	1,017	2:27		300,000
Warsaw	1,199	2:56	2:36	1,710,000
Lodz	1,319	3:17		740,000
Poznan	1,504	3:46		560,000
Berlin	1,750	4:22	3:54	3,440,000

Figure 2 on the following page shows the travel distances and travel times in a diagram. Thanks to the flat topography an operation speed of 500 km/h can be reached nearly along the whole route.

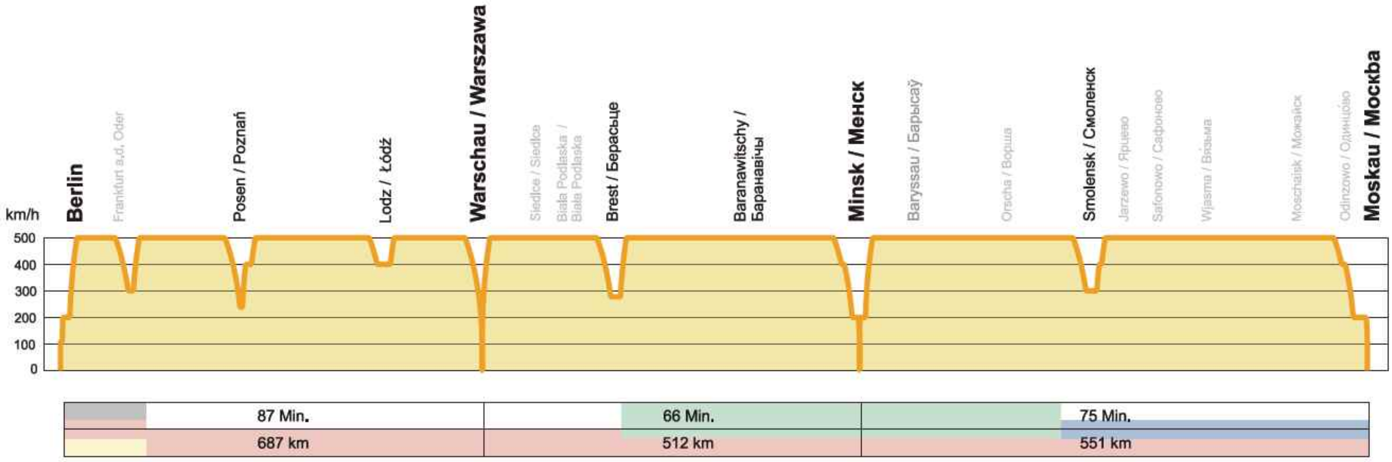

Figure 2. Travel distances and travel times along the route from Berlin to Moscow [8].

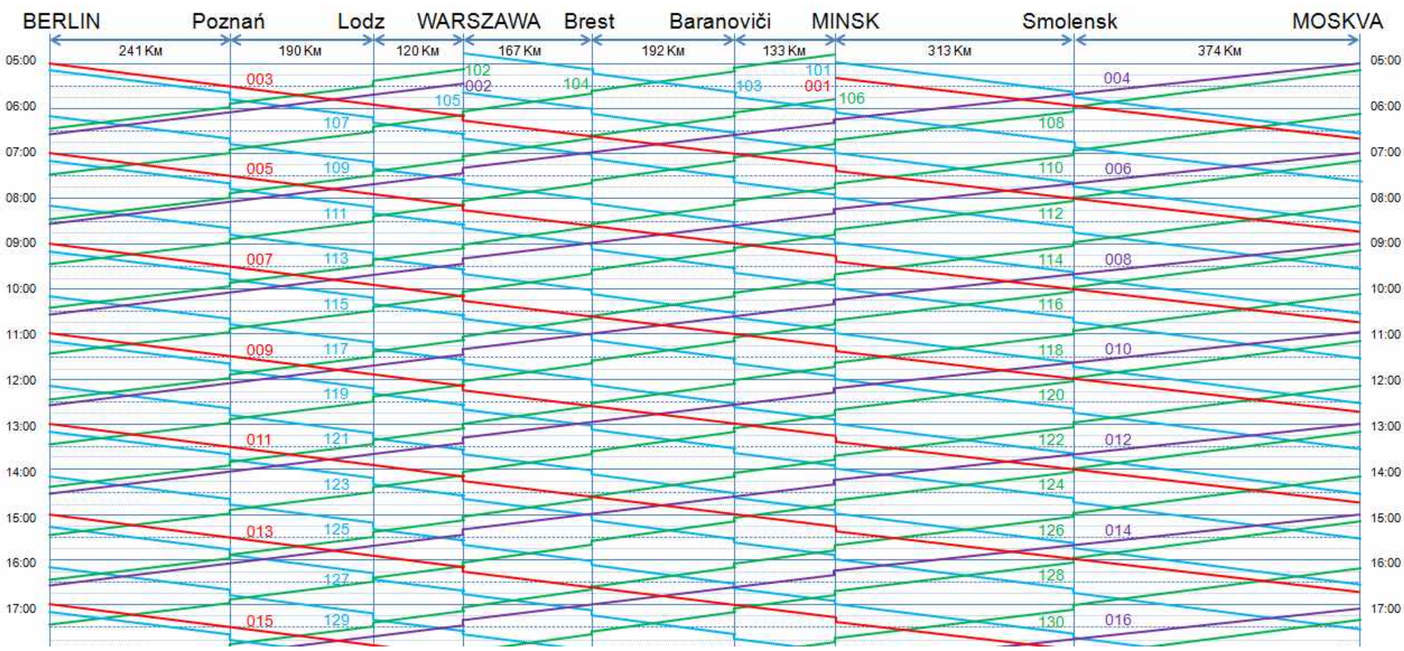

Figure 3. Operationally meaningful headway of 120 minutes for the super-express maglev high-speed trains and 60 minutes for the maglev high-speed trains based on 20 hours operating time per day [8].

Red lines indicates the train as an east-bound (from Berlin to Moscow) super-express train, violet lines are west-bound (from Moscow to Berlin) super-express trains. Therefore, blue lines indicates the train as an east-bound (from Berlin to Moscow) express train stopping at every station, green lines are west-bound (from Moscow to Berlin) express trains stopping at every station.

The Transrapid maglev system was chosen in a very first stage as it has shown its technical steadiness and reliability since many years both at the Emsland Test Track Line, Germany, as well as in Shanghai, P.R. of China.

A Transrapid maglev high-speed train may consist of up to 10 sections [4]. This will result in a passenger capacity of about 1,200 seats per train (economy class) by using a standard seating layout. Alternatively, approximately 600 to 800 seats at a world-unattainable level of travel comfort in high-speed traffic might be offered by using a possible luxurious interior design which is due to the large vehicle width of 3.4 m [4]. To buckle up is not necessary in any case, the passengers can move freely and unhindered in the vehicle. In addition the introduction of an on-board restaurant or a lounge would be possible.

A maximum capacity of around 29 million passengers per year for both directions seems to be possible assuming an operationally meaningful headway of 120 minutes for the super-express maglev high-speed trains and 60 minutes for the maglev high-speed trains based on 20 hours operating time per day. See Figure 3 on the previous page for details. Technically, the system allows a minimum headway of 5 minutes (!) [4], whereby the maximum capacity could theoretically be over 200 million passengers per year (!). In order for a further increase in demand sufficient capacity will be available.

With special maglev cargo trains it will additionally be possible to realize the use of free slots for time-sensitive freight (similar to air freight). A feasibility study will determine whether the use of free slots will be economically reliable or not, and how it can be done.

3.3 The basic technological Principle and its Benefits

Maglev is the only track bound transport system that has practically no mechanical friction during operation [4 and 6]. All the weight, propulsion and lateral guidance forces of the vehicle are transferred contact-free to the guideway, including the braking forces. As a result, maintenance costs of some maglev systems are only a fraction of the costs of traditional wheel/rail systems [4].

Maglev systems can operate at very high speeds almost without deterioration and are therefore more economical to operate than wheel/rail rapid transit systems that require regular intensive maintenance and experience exponentially increasing erosion with increasing speed. The fundamental freedom from mechanical erosion is one of the main advantages of maglev high-speed systems. Especially this important property makes it possible to trace out a proposed link between Moscow and Berlin to offer economically high travel speeds.

Wheel/rail systems are not to operate economically at speeds above 300 km/h and also need an unattractive travel time of about 7 to 8 hours for the proposed distance (of about 1,750 km). That's why and because of the above mentioned fundamental facts on mechanical friction maglev systems are currently the only capable technology to cover the route in a travel time of about 3.5 hours. Thus, the proposal appears to compete with air transport at this distance while providing much greater comfort, much better operational reliability, and significantly shorter travel frequency.

The Transrapid system is currently designed for operating speeds of up to 550km/h [4 and 5] and shows, in comparison to conventional wheel/rail high-speed trains, a superior acceleration performance, resulting in significantly shorter travel times. The acceleration of the Transrapid is much higher than conventional trains. Acceleration from standstill to 300 km/h will only lasts 98 seconds, while the distance is only 4.3 kilometers. [4]

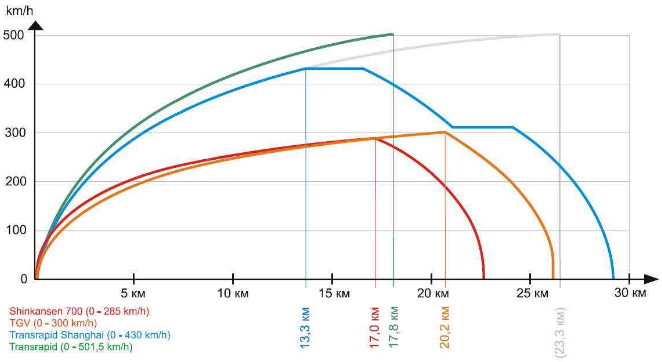

Figure 4. A superior acceleration performance is resulting in significantly shorter travel times [8].

The energy consumption related to the usable ground floor of a vehicle is above 300 km/h lower than for conventional wheel/rail trains [6]. The main reasons are much better aerodynamic properties of the maglev vehicle body, which are primarily due to the absence of bogies and wheels.

3.4 Infrastructure Construction Costs

The capable magnetic side guidance of the trains in operation allows maximum lateral inclination of 16° and encounter rides on relative speed of up to 1,100 km/h [5]. The high superelevation at the same time makes it possible to operate at much smaller horizontal curve radii than conventional trains. The Transrapid maglev system is designed to be elevated, so that the space available underneath the route can be still used by agriculture, migration of animals, and street crossings, as can be seen in Figure 5. Of course, even ground level and tunnel sections are possible. The guideway beams are normalized to a length of 24.9 m and fulfill a life cycle of 80 years.

Figure 5. The space available underneath the route can be still used by agriculture, migration of animals, and street crossings [8].

For topographically demanding routes, maglev trains already offer clear advantages in the cost of infrastructure construction. Some maglev systems can manage ascending longitudinal gradients of up to 10% (Transrapid maglev), while traditional wheel/rail high-speed railroads are limited to gradients on the order of 4%. Maglev systems adapt more easily to the landscape and therefore require fewer tunnels [4 and 6]. This offers enormous cost savings in infrastructure construction, particularly in hilly landscapes.

Construction of the 30 km two lane track line in Shanghai costs around EUR 30 million per km. This sum includes the construction costs of two stations [4]. Based on this experience the 1,750 km-long route between Moscow and Berlin would cost approximately EUR 54 billion. This can be seen as a realistic upper limit due to the proposed route's ideal topography, which requires only few elevated track sections, bridges, and tunnels compared to the Shanghai maglev route. New manufacturing processes in track construction, for example, the spun concrete construction technique (MMF-Schleuderbetonträger System Flessner / Schwarz) and other modular production concepts make it possible to reduce the costs of mass production to around EUR 25 million per km [7]. In hilly landscapes, maglev guideways on pier foundations - spaced tens of meters apart - are considerably more economical than the massive, expensive embankments and causeways usually required for the entire length for most wheel/rail systems. Furthermore, in a long-distance project are expected significant cost savings through economies of scale in mass production. These are usually at up to 30%. However, for a project of this size, more development work on cost reduction will be necessary.

3.5 Impact on the Environment

Maglev trains do not create direct pollution emissions and are always quieter in comparison to traditional systems when operating at the same speeds [6]. In the area of noise emissions, maglev trains are superior in every way to wheel/rail systems, not to mention airplanes. Comparisons made at the same speed show that all rolling friction noises, every track screech, all shocks from wheel-on-rail contact are eliminated in maglev systems that use magnetic forces rather than physical contact to keep the vehicle upright. Noise generated by air turbulence is also greatly reduced with maglev high-speed trains, making them clearly superior to all wheel/rail high-speed vehicles. In particular, the noise from the conventional train's pantograph is replaced in maglev by a process of induction and the required energy is transferred without physical contact. At speeds under 200 km/h (125 mph), maglev systems can hardly be heard, especially in an urban environment – an important advantage for populated areas (Figure 6).

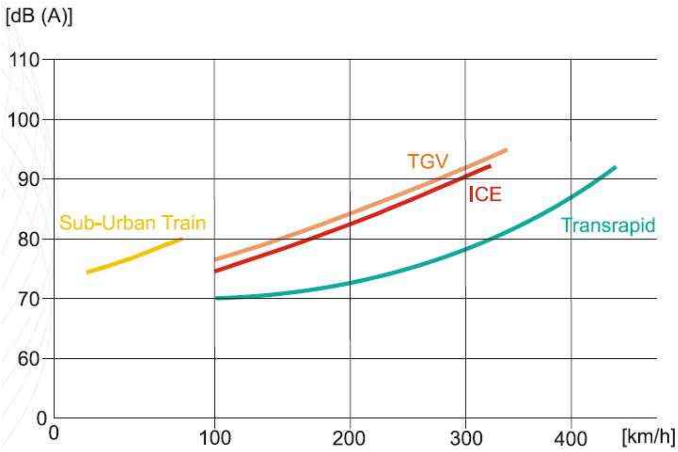

Figure 6. Maglev trains are always quieter in comparison to traditional systems when operating at the same speeds [8].

Maglev routes also do not "divide the landscape" as highways, train tracks and waterways typically do. Animals can cross under elevated maglev guideways, which they do without hesitation, and farmers can till the land undisturbed, as shown by observation and experience at the test facilities in Japan's Yamanashi Prefecture and Germany's Emsland town of Lathen.

3.6 Vehicles

The outlined concept of operations will require the acquisition of 18 to 20 six-section maglev trains, 4 of them as super-express maglev high-speed trains, 12 as maglev high-speed trains, and 2 to 4 trains as standby, which will be stationed in the stations of major cities. A detailed feasibility study of the proposal will finally show a precise indication of the exact number of required trains. Benchmarks are as follows: The four Transrapid TR08 maglev trains for the proposed Munich line, which were planned to built in Germany, should cost an average of EUR 14.3 million per each section [4]. This result in total cost of approximately EUR 1.7 billion for 20 trains of which each consists of six sections. However, this sum is based on the cost structure of manufacturing prototype and small batch production. A substantial cost reduction through economies of scale in mass production might be possible.

The interior of the Transrapid train can be freely designed according to customer specifications. Seating arrangements are both available as a highly efficient 3 + 3 seating, as well as extremely comfortable 2 + 2 seating due to the large interior width of 3.4 m. The outline can be seen in Figures 7 and 8. The trains have continuous strips of windows, and provide toilets to bistros, bars and restaurants, everything that belongs to a modern and comfortable high-speed train. The luxurious spaciousness of the maglev trains could be also used for possible attractive conference rooms, sleeping and relaxing compartments. Of course, all compartments are air-conditioned by a sophisticated ventilation system. A continuous spacious aisle will connect all parts of a train. Restrooms, overhead compartments, spacious wardrobes, and vending machines might be also a possible option over long distances. The Shanghai maglev train configuration could be suitable for regional routes for up to 200 km individual travel distances. Nevertheless, an optimal seat allocation may increase the passenger capacity.

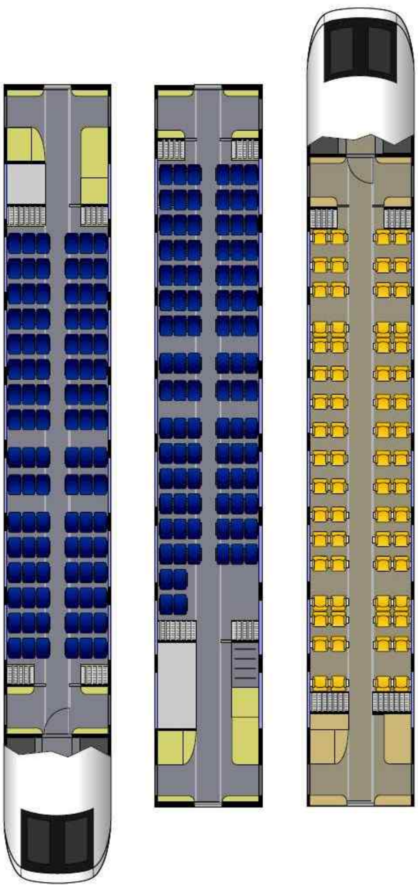

Figure 7. Seating arrangements of the Transrapid TR08 as an example of long-distance transportation for super-express trains [8].

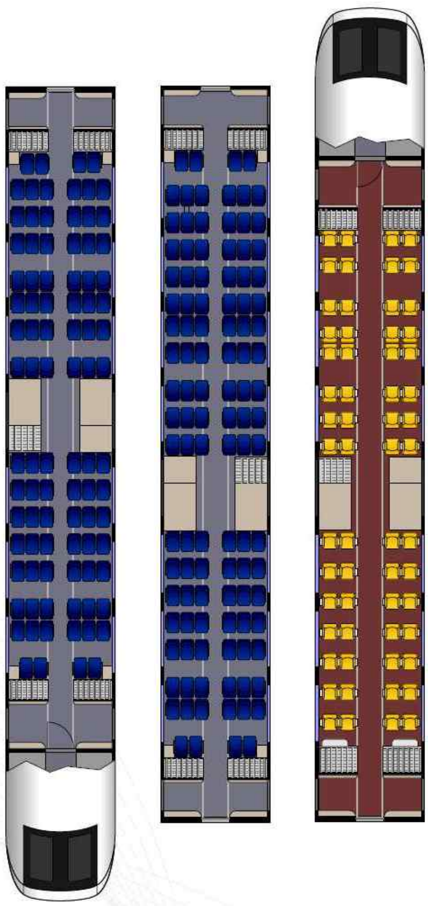

Figure 8. Seating arrangements of the SMT Shanghai Transrapid as an example of short and regional-distance transportation [8].

3.7 Re-financing of Investment Costs

Because of comparative low operation expenses maglev systems are suitable to cover a portion of their infrastructure costs of subsequent operating income, so that even investors may be involved during the construction of the route. In addition to the directly affected countries, which will bear the main burden of financing, it can be assumed that the European Union will significantly contribute towards funding by their programs of the Trans-European Networks (TENs). A detailed feasibility study should focus on this topic as a main topic.

4 CONCLUSIONS AND PROGRESS OF THE PROPOSAL

The Concept was officially presented during the Russian-German "Petersburg Dialogue" conference in October 2010 in Yekaterinburg, Russian Federation, and drew considerable attention. A detailed feasibility study is about to be determined. After considering the interests and the position of the participating states (territories) it is proposed to organize a conference of representatives of the participating States to discuss the possibilities and conditions for the project implementation.

5 REFERENCES

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