Current Status of Maglev Development Programme

No. 25
Gunter Nissen
Dornier Consulting GmbH, Transportation / Infrastructure, Platz vor dem Neuen Tor 2, D-10115 Berlin, Germany, gunter.nissen@dornier-consulting.com

ABSTRACT: This paper discusses the status of the German Ministry of Transport, Building and Urban Affairs (BMVBS) Maglev Development Programme with which the BMVBS has entrusted the German systems industry with the task to technically optimize the subsystems guideway, vehicle, propulsion, operations control system and power supply to achieve significant cost reductions compared to the existing Maglev System Transrapid in the development projects focusing on cost-optimised guideway beams and the further development of system technology. The status of the programme was previously discussed at the Maglev 2006 conference in Dresden, Germany. Due to the accident with the maglev train Transrapid on September 22nd 2006 the permission to operate the Testing Facility at the Emsland in Germany (TVE) was withdrawn and the Maglev Development Programme slowed down. A new permission to operate the TVE has been granted in July 2008 so that operation with the new maglev train TR09 did commence end of July. Programme activities since recovery of operation permission and the next steps in the development programme moving towards completion will be discussed.

1 INTRODUCTION

Originally the magnetic levitation (maglev) technology has been developed for long distance travel. Investigations of future markets for the application of maglev technology have shown that besides the long distance option other application areas exist, i.e. high-performance point to point connections with a premium product. And this appeared to be true not only for applications in Germany. In other countries such as the U.S.A. such applications also seemed to offer sound marketing opportunities.

In order to encourage these new application opportunities the BMVBS has established a research and development programme with the main emphasis on system technology and guideway. Specific issues were investigated with the main goal of achieving the following items in the vehicle, propulsion and power supply subsystems, the operations control system and guideway subsystems:

- Adjustment of the maglev technology to regional transport requirements.
- Reduction of the capital and operational costs.
- Elimination of remaining development problems.

Figure 1. German maglev technology Transrapid

The research and development programme for cost-optimised guideway beams started in 2002. The consortium of BGmU has designed and build a Type II guideway beam as a straight and curved section and the Ed. Züblin AG has build the same two sections of a Type III guideway beam. These beams have been integrated into the Emsland Test Track (TVE).

The research and development programme for the Transrapid maglev system technology commenced in 2003 and has recently gone in to phase IV - preparation for Type Certification.

Figure 2. The new vehicle TR09 on the Emsland Test Track.

Since recovery of operation permission at the TVE in July 2008 the German maglev development programme has gained speed again and is moving towards completion. On-going and planned activities include finalisation of initiation of the subsystems and the Commissioning and Certification of systems functionality.

2 TECHNOLOGY DEVELOPMENT

2.1 Objectives of the Development Programme

In light of an international marketing of German technology it seems justified to contract a project to safeguard the functionality of a technically and economically optimised maglev system by the public authorities. Technical improvements through fewer components, ease of change of components, a more robust design against environmental influences, an increase of passenger comfort and an adjustment to higher traffic loads as well as the implementation of potential cost reductions both for the investment costs of the operational system and the guideway and for operational and maintenance costs over the life cycle of the maglev system describe the main objectives fort his contract. As a result a long-lasting, durable and world-wide applicable maglev system will be developed, which will among other things afford longer reinvestment cycles.

2.2 Cost optimized Guideway Beams

The phases Concept, Development and Construction have been completed. Summer 2006 the four beam segments have been integrated into the Emsland Test Track (Fig. 3), the curved ones in the south loop and the straight ones near the Operation Control Centre. Since 2006 the environmental long-time tests have been run. Testing with regard to the Certification process will be completed in the 2nd half of this year and include:

- Trials of guideway components on the test track
- Theoretical and practical verification (structural testing of the track types)
- Preparation of type certification documents (drawings and reports)
- Assurance of type certification in accordance with Paragraph 6 of the MbBO

It is expected that the project will be completed at the end of 2008.

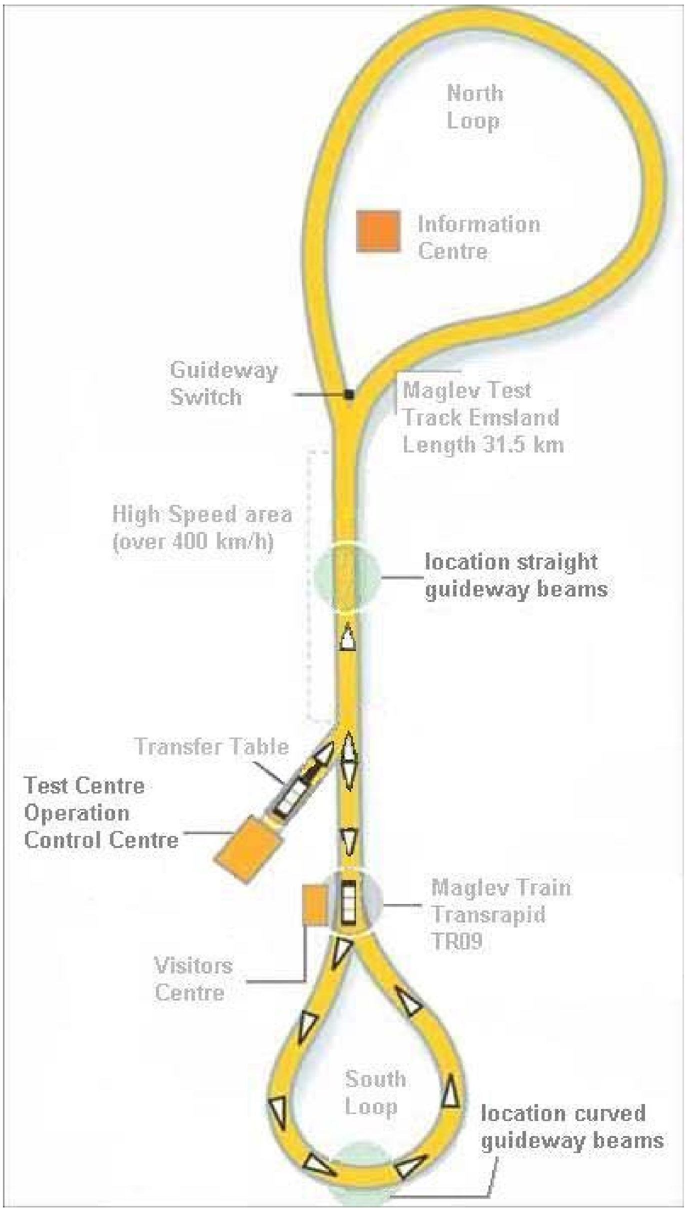

Figure 3. Maglev Emsland Test Facility (TVE) with location of new guideway beams.

2.3 Further Development of System Technology

In the context of further development of system technology, the entire system, including its subsystems, needs to be modified to suit its application as high-performance point to point connection, i.e. the linkage of airports to the city.

With the Factory Acceptance Tests of the newly developed components of the propulsion and power supply subsystems, the operations control system and the new vehicle the phases Concept, Development and Construction have been completed. The components have been shipped to the TVE where the main testing and verification will be conducted to assure system functionality and gain operation data. Due to the inability to run tests as planned on the TVE the expected completion date of the project has shifted to the 3rd quarter of 2009.

3 CONTENT OF THE DEVELOPMENT PROGRAMME

3.1 Cost optimized Guideway Beams

This program contributes to the main goal of significant cost reduction by the following intended improvements:

- reduction component complexity and number
- optimization of maintenance
- minimization of temperature effects
- reduction of noise emission
- increase of load bearing capacity
- reduction of investment cost
- reduction of maintenance cost

The track designs (see Fig. 4 and 5) have been manufactured and integrated into the TVE by the consortium BGmU and the Ed. Züblin AG. Initial testing has been done with the TR08 and since the TR09 has its operation permission testing has been pursued so that certification of the two guideway beam types by the German federal railway authority EBA has almost been accomplished.

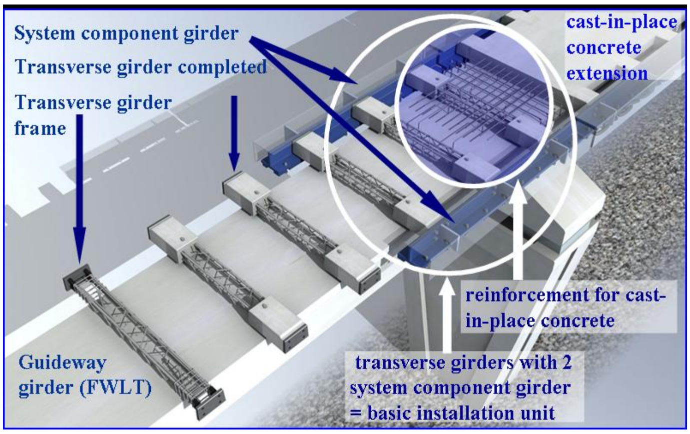

Figure 4. Track of Type II, BGmU design (Source: BGmU)

The three possible types of Maglev guideway beams are shown in Fig. 6. For the type classification the matter out of which the beams are made is not important.

Figure 5. Track of Type III, Züblin design (Source: Ed.Züblin)

The design for guideway beam type II is more or less based on the rigid track concept known by wheel-on-rail systems. Single sleepers are fine positioned and then cast with concrete to a rigid plate. The design offers cost reduction due to separated requirement levels for production, assemby and observation of tolerances. The detachment of structure and guideway allows therewith two different requirement levels with two individual components in a modular system in stack design. The monolithic bond between the two levels, using cast-in-place concrete, permits fast assembly while meeting rigid tolerance criteria.

The type III design mounts rigid true to size precast plates on an endless reinforced concrete girder simply founded on the soil. The main advantage of this system lies besides the easy and inexpensive manufacturing in the potential to apply it nearly everywhere. The guideway plates can be utilized with a girder modified as appropriate in every kind of tunnel, on bridges and with at grade girders.

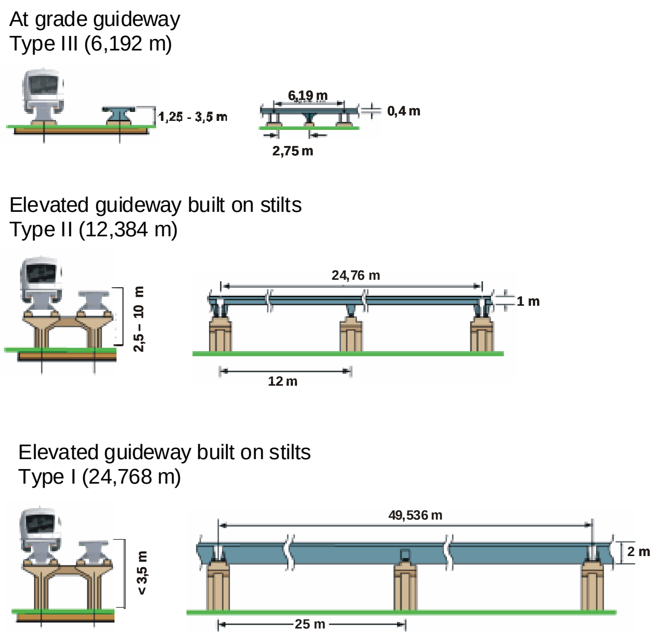

Figure 6. Types of Maglev Guideway Beams

3.2 *Further Development of System Technology*

Important requirements of modern means of mass transport are the support of a swift boarding/deboarding process and the ability to adjust the transport capacity to the distinctive transport demand curve. By comparison of the new requirements typical for regional transport with existing maglev technology originally designed for long distance transport and subsequent prioritisation of necessary improvements, the content of the further development program of the system technology has been determined.

All improvements made in the identified development measures have to contribute to the main objectives of the programme – technical advancement and realisation of cost-reduction potentials.

The identified development measures will be illustrated in the following sections.

3.2.1 *Reduction in length of safe stopping segment and reduction in false acceleration*

A paramount objective to improve operation and aid cost savings is the qualification of a technical solution to reduce the length of the safe stopping segment, which either enables shorter safe stopping segments in the terminal stations, maintenance and parking facilities, or achieves travel time savings through minimisation of the time lack from command prompt until command execution.

The relevant parameters for reduction in length of safe stopping segment and reduction in false acceleration are:

- Close control of the propulsion current
- Increase of safe breaking force
- Increase of electronic telegram speed for propulsion shutdown
- Electronic propulsion shutdown
- Increase in accuracy of vehicle position signals
- More precise calculations of motion profile

3.2.2 *Guideway switches*

In view of the creation of a more than twice as long lasting, low maintenance and durable product it was determined that the in Shanghai installed low speed switches cannot fulfil the technical requirements of regional transport. As part of the development, the type catalogue of guideway switches and track-changing facilities (transfer tables and pivot tables) has been expanded.

The switches and track changing facilities need to be designed for higher operating load. Furthermore the increases in availability and also in reliability are important criteria. Finally the reduction of the maintenance and inspection efforts to enable night operations and thereby improvements in economic efficiency have been important development tasks.

In the development program the theoretical basis for dimensioning of switches and track changing facilities had to be defined. To achieve the doubling in life span for such devices the main emphasis had to be laid on dynamic behaviour of the pivoting beam of the switch.

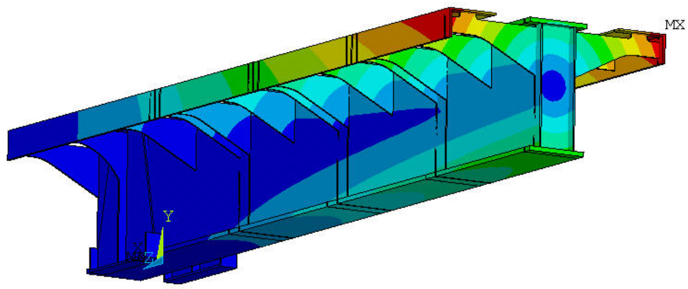

Figure 7. Finite Element Modelling of Guideway Switch bending beam and table (Source: ThyssenKrupp)

3.2.3 *Standardised converter unit*

The objective of the further development of the converter unit, being a central function of the propulsion block, has been the development of a standardised conversion unit, with the following improvements to functions and interfaces while retaining the type-certification:

- Expansion of the existing converter unit concepts with the power network regeneration function.
- Replacement of the Transrapid-specific power section of the converter unit, through integration of an industry-standard power converter on the basis of integrated gate commutated thyristors (IGCTs) into the existing converter unit.
- Consideration of requirements stemming from the concept for overlapping propulsion sections (segment boundary overlap) and new concepts for safe stopping segments, respectively.

The new converter unit has been integrated into the TVE in 2005 and is since this date in operation.

3.2.4 *Hardware Innovation Propulsion Control*

The new generation of Maglev power supply with its new converter unit disposes of additional functions, such as power regeneration, section overlap and track turnouts, which need to be integrated in the propulsion control software. Since the formerly used SIMADYN D software is out of date, hardware availability and software support can not be guaranteed anymore. The transfer to a new standardised platform was a must.

Following successful further development now a system is available, which stands at the beginning of its product life cycle and because of the use of industry computers will be less susceptible to product recalls. The performance of the system SICOMP meets the requirements of short and long distance travel and offers numerous advantages:

- Better communication enables new line concepts and a simpler remote maintenance and diagnosis of the facility,
- Open technology, which enables easier adjustments to new requirements,
- Reduction of elements with retention or improvement of the MTBF for individual elements, resulting in an increase of availability of control systems and simpler maintenance and provision of spare parts.

3.2.5 Segment boundary overlap

The operations control system (OCS) including the radio control system is based on a hierarchical structure, containing central and decentralised facilities as well as vehicle components, and for the radio frequency system radio base stations. The operations control system has been expanded to include the functions segment boundary overlap and safeguarding of the safe stopping segments.

The segment boundary overlap has the purpose of assigning a vehicle at a section border or in close proximity of the section border to the neighbouring section so that a vehicle can be registered in the neighbouring section earlier and it is possible to reduce the time between trains.

Segment boundary overlap will be used where the dwelling time of a vehicle in one section is longer than in other sections, for instance in stations or at the entrance to long sections along the line. Another application results from the coupling of stations at section borders to reduce the number of auxiliary stopping areas and thereby reduce the expense of track equipment (for instance, external vehicle power supply).

3.2.6 Radio communication system

With future Transrapid applications it is to be expected that the track will be at least partly in deep cuts and next to high noise and view protection barriers, or in tunnels.

The objective of the development program for the radio communication system is the optimisation of characteristics of the radio communication system, i.e. base stations (higher air pressure and vortices at tunnel entrance), regarding its use along lines with tunnels. The program includes maintenance and diagnosis aspects, since maintenance is difficult in tunnels due to restrictions in space.

Through an optimisation of the diagnosis system (independent fault detection) and the maintenance concept of the guideway equipment of the radio communication system, negative effects on the operations by urgent maintenance requirements in the tunnel can be largely avoided so that a comparable availability of the radio communication system in tunnel sections is guaranteed.

3.2.7 TR09 three-section vehicle

The requirements in the context of the development programme are a resulting combination of, firstly, typical characteristics of regional transport (wide entrance doors in the middle of the car, accordingly adjusted design of air-conditioning ducts, increased operating load with use of standing spaces) and, secondly, the requirements of high-speed long distance transport (pressure-sealed design of the car with corresponding integration of air-conditioning units, low level of interior sound and sound emission to the exterior, consideration of luggage transport, as well as running resistance and power demand).

At the same time an economically-efficient use of the vehicles, on the basis of transport capacity and the kilometres driven per vehicle per year should be achieved.

The Transrapid TR09 represents a new generation of vehicles which is especially tailored to the requirements of regional transport. Higher load for the transport of more passengers, wider doors to speed up alighting and boarding, bigger interior vehicle height to provide a pleasant journey for standing passengers, new air conditioning technology.

The prototype vehicle TR09 has been delivered to the TVE in 2007 and obtained its operation permission End of July 2008. After its initiation it is now a vital part for the test, evaluation and commissioning of the complete Transrapid system.

3.2.8 OCS for the TR09 vehicle

The supply of an operations control system for the TR09 is directly linked to the development and realisation of the maglev vehicle in the development programme. The objective of this development program measure was the manufacture, assembly and implementation of the operations control system for the TR09, so that the vehicle can be secured for the operation on the Emsland Transrapid Test Facility. The OCS has been built in the TR09 at the vehicle factory in Kassel, Germany prior to delivery of the vehicle to the TVE.

3.2.9 Inductive power supply (IPS)

Taking into account the economical use of the available on-board network batteries (life cycle, maintenance interval, maintenance effort) it is necessary to prevent stressing the batteries, if possible, with discharge-charge-cycles during normal operations of the Transrapid vehicle. Consequently an external stationary on-board power supply is required in the station areas and in parking and maintenance facilities.

Until now, external power supply was realised by conventional technology (collector, feeder power rail). Known problems of conventional systems (wear and tear, noise, sparks) as well as the break of the system philosophy (contactless levitating inductive train system) are remedied by the use of inductive power supply (see Fig. 8) with which the needed energy is transferred via electromagnetic fields even without relative movement between vehicle and track.

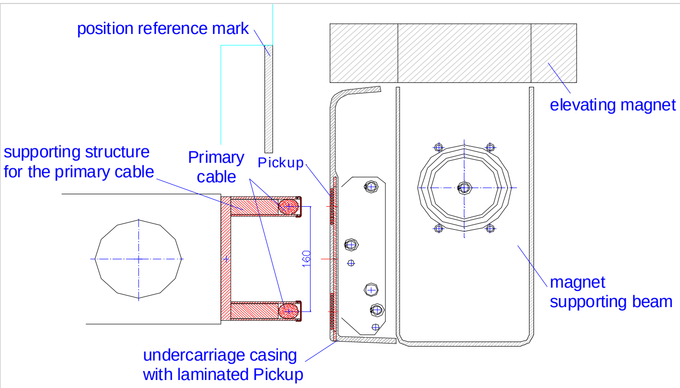

Figure 8. Detail of the IPS system (Source: ThyssenKrupp)

4 SUPPORTING ACTIVITIES

The realization, approval and operation of transport systems are based on generally accepted technical standards. Since there have been no comprehensive regulations for Maglev at the beginning of the Maglev Development Programme the BMVBS initiated the development of state-of-the-art regulations for Maglev. The formed committees functioned under the leadership of the German Federal Railway Authority. The state-of-the-art standards for maglev systems will define the technical and operational specifications of maglev systems and will form the basis for planning, design, implementation and the operation of maglev projects.

All activities in the further development program of the systems technology which concern more than one subsystem have been bundled in a measure called Systems Integration. This measure includes adjustments of operational data of the Emsland Transrapid Test Facility based on the changed input data, which were derived from development program measures.

Documents, which were produced during the development programme on a subsystem level, are being verified on the systems technology level from a comprehensive systems viewpoint as well as for conformity to the other developments within the programme and for interface compatibility.

The further development program of system technology will be finalized with the proof of system functionality of the Transrapid system on the Emsland Transrapid Test Facility.

5 CONCLUSIONS

With the Maglev Development Programme the BMVBS significantly supports the development and optimisation of many components of the maglev subsystems for an application as premium product in regional and point-to-point travels. Thereby it is possible to open up new opportunities on a worldwide market to use this innovative, technically mature product.

Design, construction and integration have successfully been completed and testing and commissioning are well under way on the test track so that overall functionality of the newest generation of Transrapid system can be demonstrated shortly.

6 LIST OF ABBREVIATIONS

BMVBS Bundesministerium für Verkehr, Bau und Stadtentwicklung (German Ministry of Transport, Building and Urban Development)

BGmU Bietergemeinschaft mittelständischer Unternehmen (Bidding consortium of medium-sized companies)

MbBO Magnetbahn Bau- und Betriebsordnung (German standards for construction and operation of Maglev systems)

EBA Eisenbahn-Bundesamt (Federal Railway Authority)

TVE Transrapid Versuchsanlage Emsland (Emsland Transrapid Test Facility)

IGCT Integrated Gate Commutated Thyristor

MTBF Mean Time Between Failure (mittlere Zeitdauer bis zum Ausfall der Komponente)

TR {09} Fahrzeug Transrapid {laufende Versionsnummer} (Transrapid vehicle {consecutive numbering of versions})

IPS Inductive Power Supply (Berührungslose Bordenergieeinspeisung)