From commissioning to scheduled services – the way to regular services for the maglev line between Munich Central Station and the Airport

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ABSTRACT: With its ambitious operating programme, the high-speed maglev line in Munich is required to function reliably in regular passenger operations. New parameters apply relative to previous applications with high-speed maglev systems. An integrated verification concept incorporating acceptance testing has been drawn up to this end. The requirements of the verification process are presented along with an overview of the progress achieved to date and the prospects regarding the further course of action.

0 SUMMARY

The maglev system in Munich, as Deutsche Bahn's premium product with a challenging operating programme, must operate safely, reliably and economically in regular revenue service. What needs to be done to achieve this is contained in a functional specification prepared by DB Magnetbahn.

Compared with previous applications of the maglev system, the general conditions in Munich are new:
e.g.

- Commissioning and start of operations are subject to the conditions specified in the Magnetic Levitation Train Construction and Operating Regulations (MbBO)
- Operation in tunnels
- Operation under winter conditions in Munich

To deal with the additional risks that result from this, an integrated verification and acceptance process has been developed.

This includes the following steps:

- Evidence of compliance with selected specification requirements prior to the award of contract
- Design reviews in the development phase
- Reviews in the setup phase
- Initial functional test following system integration and official acceptance by the authorising body
- Trials to simulate commercial operation
- Functional tests under all weather conditions
- Verification of correct functioning under operating conditions

This paper provides an introduction into the requirements for providing evidence of compliance, an overview of the current stage of progress and a look at where we go from here.

1 INTRODUCTION

The maglev system in Munich is to provide a first class 10-minute service every 10 minutes, as befits a premium product, taking passengers safely and comfortably from the central station to the airport.

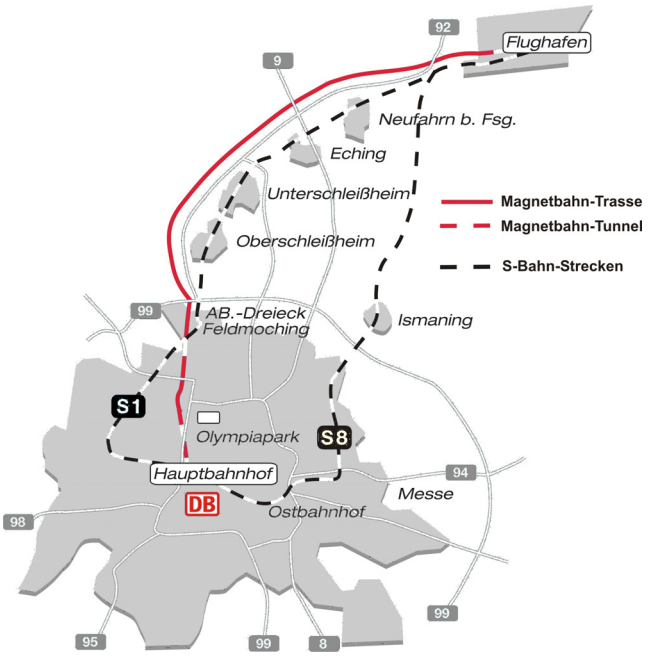


Figure 1: Overview of route

(maglev track / maglev tunnel / S-Bahn lines / Central Station / Airport)

Journey time: 10 min
Frequency: 10 min
Max. speed: 350 km/h
Max. capacity: 11 million passengers p. a.

Compared with the previous experience with the Transrapid test facility in Emsland or the airport link in Shanghai, this operating programme is an extremely challenging one.

Before the start of commercial operations, Deutsche Bahn must ensure that the system meets all the prerequisites that will enable it to provide passengers with the services as promised on a permanent basis and at a reasonable cost.

2 AIM

The aim and purpose of all the activities from the start to the completion of commissioning is to ensure that the maglev system in Munich is "fit for commercial operations".

The commissioning of the entire system will start with the first levitation/propulsion test of a vehicle on a section of the track.

It ends when the first passenger purchases a ticket and can travel on the maglev train from the central station to the airport or vice versa.

3. GENERAL CONDITIONS

Unlike high-speed rail services, an area in which Deutsche Bahn has acquired extensive experience since 1991, the commercial operation of a maglev system is unknown territory.

The fact that operations on the Transrapid test facility in Emsland were basically of an experimental nature means that, in comparison with the commercial use, it is characterised by a much lower annual transport performance.

On the Transrapid test facility in Emsland, the preproduction TR 08 maglev vehicle has travelled some 50.000 kilometres since September 1999, which is equivalent to a transport performance of around 70,000 km per vehicle and year.

In Shanghai, by comparison, with the current timetable, which is based on a 20-minute frequency of service from 8:30am to 5:30pm, some 200,000 kilometres are covered per vehicle and year.

In the Munich project, distances of at least 700,000 kilometres will be covered per vehicle and year in commercial operation. This must be achieved reliably and under additional conditions that are not found either in Shanghai or on the Transrapid test facility in Emsland.

The key requirements DB must meet with respect to the entire maglev system are contained in the tender specifications (Guideline 416.01) and focus primarily on functional aspects.

In addition, it is of fundamental importance for the commissioning phase that it must be carried out under the general conditions as specified in the General Magnetic Levitation Train Law (AMbG) and the Magnetic Levitation Train Construction and Operating Regulations (MbBO). This is also a first, since these general conditions were not found on the Transrapid test facility in Emsland or in Shanghai.

4. IMPLEMENTATION AND THE QUALITY ASSURANCE PROCESS

To achieve the commercial goals of DB Magnetbahn and subsequently bring the project to a successful conclusion, the following key aspects of the project must be completed with the right quality, on schedule and within budget:

- final project-specific development and optimisation of the maglev system
- final design (detailed engineering design and specifying design details in performance specifications)
- manufacture and assembly of all operating facilities and vehicles, incl. the associated software and integration into the DB Group
- commissioning, incl. system integration, test runs and trials
- obtaining all licences and approvals
- setting up all the structures required for commercial operation

In order to achieve the project goals with the right quality, on schedule and within budget, an integrated verification and acceptance process has been developed. This includes the definition of milestones in the development phase, when reviews are carried out. Only when these reviews have been successfully completed will the next phase begin. The process ends with functional tests on the maglev line itself. To provide intensive preparation and cost-effective completion of these reviews, a concept of development monitoring has been created, which will be discussed in more detail later.

5. DEVELOPMENT STATUS

For the first time, a commercially operated maglev system was set up in China in the city of Shanghai to provide a link to the airport. The system in

Shanghai has also been conceived as one part of long-distance applications planned for the future. The system in Shanghai is based on the technology that was formerly planned for the Berlin – Hamburg long-distance line.

In Germany, there is as yet no maglev system certified for commercial operation.

The requirements and the design submitted for the maglev system deviate in many points from the maglev system in Shanghai.

This means that, during the preparation phase and the implementation itself, additional development work or proof of compliance is necessary.

The following issues are of particular importance:

- Modifications to meet the safety and approval requirements in Germany
- Modifications to meet the transport task as an airport feeder (standing room, payload, transport of luggage, doors, cross-section, weight, etc.)
- Operation of the maglev system with stations and tunnel sections and on primary supporting structures (e.g. aerodynamics, acoustics, acceptable pressure level, operational stability, voice communications)
- Modifications to meet the local environment conditions (in particular during winter months)
- Certificate for automatic operations with no personnel in vehicles and stations
- Development and approval of an appropriate anti-vibration system for the maglev system
- Development and approval of dual-gauge equipment
- Maintenance of the maglev system only from midnight to 4:00am for a period of 30 years from the start of commercial operations
- Development of procedures and equipment required for maintenance.

6. DEVELOPMENT MONITORING

To manage the risks that arise as a result of the tougher requirements compared with the systems in Lathen and Shanghai, a concept has been drawn up for monitor the development.

Initially, we identified 30 issues by analysing existing documents and consulting experts.

These issues were then examined and classified in the course of an initial qualitative assessment of the risks involved. This will now be taken as the basis for a decision-making tool designed to identify critical issues that require special attention. For dealing with these issues, either more development work is required or more detailed evidence of compliance must be submitted.

The probability of occurrence and the possible extent of damage were estimated for the individual issues and included in a 3-stage assessment scale.

- Stage 1 = low
- Stage 2 = medium
- Stage 3 = high

The risk class is determined as the product of the stage designations (1, 2, 3) of the probability of occurrence and the stage designations (1, 2, 3) of the extent of damage.

The following risk classes result: 1, 2, 3, 4, 6 and 9. Class 9 is the class with the highest level of risk.

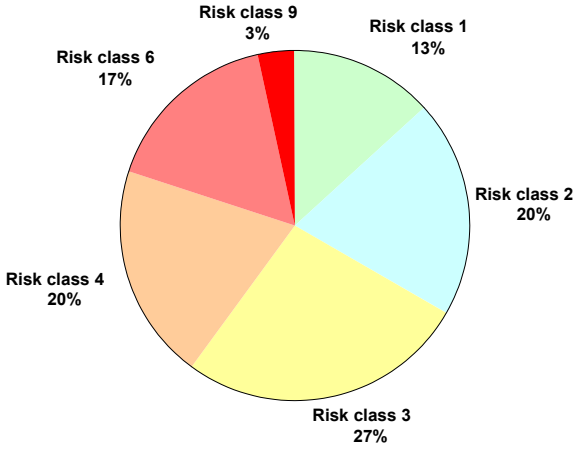


Figure 2: Overview of the breakdown of risk classes following the first assessment

In addition to this classification of the risks, an additional separate ranking was made, which indicates whether a particular issue would prevent the issuing of the operating licence if no solution were found. Risk class 9 was used for this purpose.

The result is shown in the next figure:

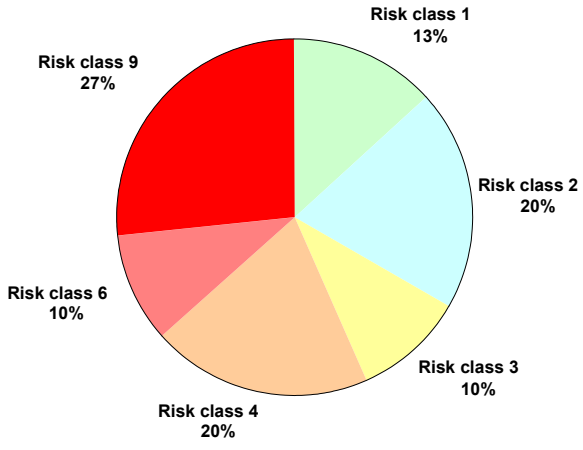
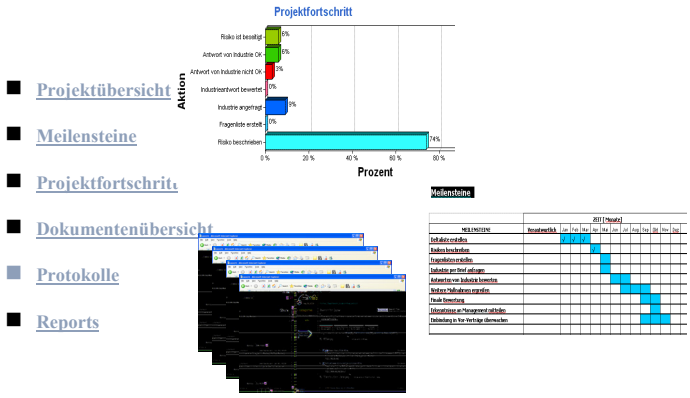


Figure 3: of the breakdown of risk classes following a second assessment regarding operating approval

A person has been appointed by DB Magnetbahn with responsibility for monitoring progress in this area and for risk assessment. The manufacturers are also urged to appoint persons with responsibility for the individual issues, so that the issues can be dealt with systematically and rapidly in a Critical Design Review (CDR) process.

The progress made in dealing with the various issues is monitored in a web-based monitoring process.



Project overview
Milestones
Project progress
Overview of documents
Minutes of meetings
Reports

Figure 4: Overview of monitoring system

The next step was to prepare 10-20 detailed questions on each of the 30 issues. The assessment of the risk was used to determine what level of quality was required for the evidence of compliance.

The 4 stages when providing evidence of compliance are as follows:

- theoretical evidence, e.g. drawings, incl. calculation, analogy comparison, etc.
- Bench tests
- Test at the Transrapid test facility in Emsland
- Any combination of the above, supplemented by the test report provided by an appropriate expert.

The evidence is finally assessed.

At the end of the process, the issues must have been dealtte with in sufficient detail that

- the risks have been completely eliminated or minimised as much as possible
- residual risks have been quantified
- residual risks can be covered by contract

Concurrently, the acceptance and test criteria for the individual requirements of the specifications are written down and the procedures to be used in the event of deviations from the expected test result specified.

7 OUTLOOK

A project as complex as the completion of the first maglev system for commercial operation in Germany, which has been the focus of public attention like no other before it, must be examined in depth at an early stage, particularly with respect to commissioning and acceptance. This is the only way to adequately minimise the risk of some nasty surprises at the start of des commercial operations.

One of the tools to do this is the analysis of shortcomings in terms of development and the provision of evidence of compliance before implementation gets underway and the monitoring of progress in a CDR process.

A sufficiently long and tough startup operation for at least one full year's cycle of the seasons is necessary to be absolutely certain that the challenging goals with respect to the product quality and cost effectiveness of the maglev system as a permanent link between Munich Central Station and the Airport can actually be achieved.