Munich Central Station – Airport Maglev Safety Concept

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ABSTRACT: The lecture sets out the architecture and content of the safety concept for the high-speed maglev line between Munich's central railway station and its airport. The legal foundations for drafting a safety concept are detailed and the safety objectives to be observed by DB AG explained. The systematic identification of all risks and their weighting under a procedure proposed in EN 50126 are also presented. Citing examples, an explanation is given of how individual hazards are weighted for risk analysis purposes with reference to the probability of their occurring and the extent of the damage they cause as well as of how unacceptable risk values are reduced to an acceptable level by adopting measures of a constructional, technical, organisational and operational nature as detailed in the catalogue of measures. To conclude, the rescue strategy is elucidated by describing strategies for and responses to major incidents of damage.

1 INTRODUCTION

In 2001, the Bavarian Ministry of Economics, together with Deutsche Bahn AG, decided to improve the traffic link to Munich Airport by setting up a high-speed maglev link. Work on the design and planning was carried out by Bayerische Magnetbahnvorbereitungsgesellschaft mbH (BMG), a 50 per cent subsidiary of DB AG and the Free State of Bavaria. Following completion of the regional planning process, preparation of the final planning documents began as of October 2003. Engineers began work on both the system design and the preparation of the associated safety concept for the maglev route at the same time. In 2005, DB AG decided to concentrate all its maglev activities in DB Magnetbahn GmbH. The shares owned by the Free State of Bavaria in BMG were also invested in the company. DB Magnetbahn GmbH is regarded as the maglev company in accordance with the terms of the Magnetic Levitation Train Construction and Operating Regulations (MbBO) and has already submitted applications to the Federal Railway Authority (EBA) for all the required approval procedures.

2 MILESTONES

From October 2003 to June 2005, all the tests and work relating to the safety concept were completed and subsequently approved by all those involved inside and outside the company. The safety concept itself was prepared by Transrapid International (TRI) in conjunction with Basler and Hofmann, a specialist company in the field of risk analysis for transport systems.

On 23 June 2005, it was finally submitted to the Federal Railway Authority (EBA) by the DB Magnetbahn GmbH for approval and is currently being examined by the EBA and EBA experts.

3 LEGAL BASIS

The Magnetic Levitation Train Construction and Operating Regulations (MbBO) are taken as the legal basis. The regulations specify in §23 that the maglev company is required to prepare a safety concept and submit it to the EBA for approval.

They also state that the safety concept must describe the methods used to determine and assess all identifiable safety risks in terms of the type, frequency and effects and also specify the subsequent structural, technical, operational and organisational safety measures to be taken.

Since the structural measures are already specified during the design phase, the EBA, as the design approval authority, required that the safety concept also be submitted during the design phase and that it be compatible with the final planning documents.

Besides that, the risk analysis pertaining to the safety concept, which is a key document, is an important criterion in the implementation process for the entire project in accordance with the EN 50 126 life-cycle model.

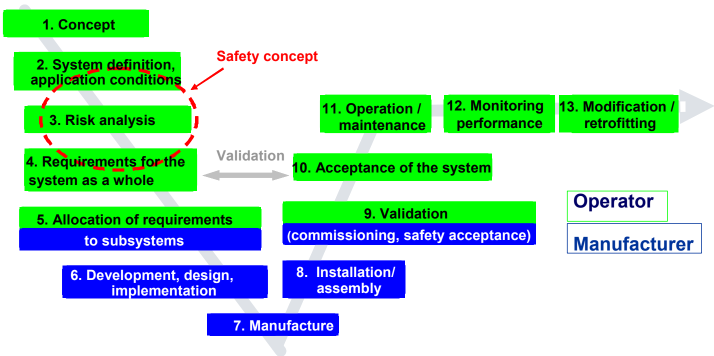

Figure 1: Life-cycle model in accordance with EN 50 126 (V–model)

4 "GOALS, METHODS AND BASIC SAFETY CRITERIA FOR THE HIGH-SPEED MAGLEV LINK"

The document entitled "Goals, methods and basic safety criteria for the high-speed maglev link" was prepared by DB AG. This implements the provisions of the MbBO and, as an integral part of the DB Magnetbahn GmbH's specification, also covers the specifications required by the manufacturers to implement the safety concept. The document was prepared in consultation with the EBA.

The document describes the basic safety goals and the safety management methodology used to implement the safety concept. It also includes details of the process required to comply with a risk acceptance criterion and provides a basis for the safety management system to be used in operations. The document was approved in consultation with the specialist departments responsible within the Group for safety, emergency management, Group safety, risk analysis, operational safety, basic operational principles and maglev system technology.

A decision on the safety goals and the approach to be taken was taken by the DB AG Board of Management on 28.06.2004. The responsibility for updating the document was assigned by the Board of Management to the specialist departments involved in the implementation of the safety concept. Major changes to the document are to be submitted to the Board of Management for approval.

The document also contains DB AG's basic safety requirements.

The safety management methodology is based on the following approach:

1. Specification of safety goals
2. Derivation of a risk acceptance criterion from the safety goals
3. Specification of the maglev system: specification of the operating facilities and vehicles, their functionality and characteristics, and the operational programme in terms of its environmental impact
4. Risk analysis
5. Examination of the extent of compliance with the risk acceptance criterion
6. In the event of non-compliance, specification of further action to be taken to reduce the level of risk

The following safety goals have been specified by DB AG:

- Safeguarding people, i.e. the health and safety of passengers, employees and third parties is the main safety goal of the high-speed maglev transport system.
- The high-speed maglev transport system must offer people at least the same level of safety offered by comparable systems currently in use. The risk acceptance criterion is determined on the basis of a comparison with long-distance wheel-on-rail systems.
- The occurrence of disastrous events is to be prevented as far as possible.
- After the Munich maglev system begins commercial operations, a continuous process must be in place to ensure that the safety, reliability, availability and maintainability levels (RAMS in accordance with EN 50126) are at least to be maintained and, if possible, improved on throughout the life cycle of the system

5 STRUCTURE OF THE SAFETY CONCEPT

The safety concept consists of four parts:

- The results are summarised in an **overall document**.
- **DB AG safety goals** contain the safety-related principles with which the Munich Central Station – Airport maglev link must comply. In addition, the safety goals contain criteria for preparing the hazard and action list that were calculated in the risk analysis and included in the catalogue of safety measures.
- All potential risks are described and assessed in the **risk analysis**, and the actions taken to reduce the risk are taken into account.
- The **catalogue of safety measures** describes in detail the actions taken to reduce the risk and classifies the actions as either structural, operational, technical or organisational in nature.

6 DETAILS OF THE RISK ANALYSIS

The risk analysis describes all the potential hazards for the maglev system and the risk of each hazard.

The normal status, including incidents throughout the entire transport facilities that are already covered by the system, is described in a system definition.

First of all, the local circumstances based on the planning documents, including any tunnels, bridges or viaducts, and the converging of traffic routes, are taken as the basis.

Descriptions of the system components used, such as the design of the propulsion system, the vehicle design, operational control technology and the design of the track infrastructure, are also included in the system definition, as are the operational criteria the system must comply with, such as the headway, track layout, vehicles, passenger volumes, staff concept and maintenance concept.

Additional requirements that also form the basis of the safety concept are included, such as vehicle fire protection, procedures in the event of collisions, etc.

In the next step, a hazard identification system for the maglev in Munich has identified 115 potential hazards to be examined in more detail that result from experience on the Transrapid test facility in Emsland (TVE), in Shanghai, and from the results of earlier studies undertaken for the planned Berlin-Hamburg maglev line. Experience gained from the wheel-on-rail sector was also included in the hazard identification system.

In accordance with EN 50126, the potential hazards that have been identified are assessed initially in qualitative terms with respect to the probability of occurrence (Classes: Frequent, Probable, Occasional, Seldom, Improbable, Unimaginable) and the extent of the damage (Classes: Catastrophic, Critical, Marginal, Insignificant) and rated on the basis of a risk category (Classes: Intolerable, Undesireable, Tolerable, Negligible).

All the hazards that were not classified as negligible were quantified and assessed in more detail.

The hazards can be broken down into the following six hazard classes:

- System-specific hazards
- Interaction with other forms of transport
- Other forms of interaction with the surroundings
- Effects from within the system
- Hazards to passengers waiting or when entering or leaving vehicles
- Hazards to third parties and staff

In the case of the 40 hazards or so that were not classified as negligible, test were performed to determine whether additional action was possible and if so, what action was to be taken to reduce the risk at reasonable cost and effort.

The result of the risk analysis with the planned safety measures showed that the previously specified risk acceptance criterion had been complied with.

The reasons for this, in addition to the system-related benefits of the maglev system, such as automatic operation, anti-derailment locking of the vehicle around the guideway, elimination of intersections at the same height, operational command and control of the guideways, are in particular protection barriers modified to meet the local circumstances when other traffic systems are encountered (embankments, walls, crash barriers) and barriers at intersections.

Frequency	**Risk classes**			
Frequent	Undesireable	Intolerable	Intolerable	Intolerable
Probable	Tolerable	Undesireable	Intolerable	Intolerable
Occasional	Tolerable	Undesireable	Undesireable	Intolerable
Seldom	Negligible	Tolerable	Undesireable	Undesireable
Improbable	Negligible	Negligible	Tolerable	Tolerable
Unimaginable	Negligible	Negligible	Negligible	Negligible
	Insignificant	*Marginal*	*Critical*	*Catastrophic*
	Hazard classes			

Figure 2: Qualitative risk assessment in accordance with EN 50 126

7 CONTENTS OF THE CATALOGUE OF SAFETY MEASURES

All the safety measures that are binding for the design and planning of the system are categorised as of a structural, technical, operational and organisational nature and listed in the catalogue of safety measures. The catalogue of safety measures is a summary of the safety measures calculated for the reduction of risk in the risk analysis.

8 RESCUE CONCEPT

The rescue concept includes strategies and responses related to potential disastrous events. Fire hazard in a maglev vehicle has been defined as a key event in this respect.

Regardless of the probability of occurrence, the sequence of events and scenarios for the response by the system engineering, staff and passengers are specified.

The technical, structural, operational and organisational conditions and safety measures for the vehicle at the stations, at the evacuation points, in tunnel sections and on open track that are of importance for the fire scenario in the vehicle are described at the start of the rescue strategy.

The following conditions apply to the vehicle:

- Operation with no crew present in the vehicles
- Fire protection class 4 in accordance with DIN 5510 (highest fire protection class)
- Fire doors between the sections with a fire resistance of at least 30 minutes
- Fire-retardant shielding for the underfloor section of the passenger cell
- Automatic fire alarm system in the vehicle
- Passenger emergency call units in the vehicle
- Automatic switching of the air-conditioning system to smoke extraction mode in the event of a fire
- Self-monitoring of power electronic devices and air conditioners
- Earth fault monitoring of on-board networks
- Automatic trip in the event of a fault
- Monitoring of battery ventilation system
- No fuels or flammable coolants on board
- At least one first aid box for each passenger area
- At least 2 portable fire extinguishers for each passenger area
- Protected and marked escape routes in the vehicle
- Escape ladders on the sides of the vehicle that will guarantee a throughput of 4 passengers a minute and can be used for heights of up to 3.50 m.

In the event that the fire cannot be extinguished, the following will take place:

After the operations control centre has been alarmed by the fire detectors installed in the vehicle or the passenger emergency call point, the vehicle will immediately travel to the next evacuation point. The passengers will then be able to leave the vehicle within a short period of time without the need for an escape ladder on the side of the vehicle.

If the vehicle has already passed the last evacuation point, it will continue to the final station, where the passengers will also be able to leave the vehicles easily and quickly.

If a two-fold event is assumed, i.e. the occurrence of a fire in the vehicle and at the same time a simultaneous technical or operational fault, the vehicle will stop at the station or on the track. If the vehicle stops in a tunnel, evacuation will take place via the catwalks in the tunnel to the next emergency exit (maximum 600 m) and from there to the surface.

According to the rescue strategy, in the event of a two-fold event and the vehicle stops at a stopping point outside the tunnel or on open track, the following approach will be taken: the passengers will be instructed by the operations control centre to leave the section that is on fire. Since the vehicles are equipped with fire doors, the passengers will find themselves in a safe area for at least 30 minutes. After the vehicle has stopped, the escape ladders on the sides of the vehicle will be activated and, depending on where the vehicle has stopped, the passengers will either climb down onto a footpath or in the event of higher gradients, the catwalk running alongside the track. The height of the escape ladder is a maximum of 3.50 m and the throughput of the means of escape on the side of the vehicle is 4 passengers a minute. Mobility-impaired passengers will use the escape ladder with the assistance of other passengers or will be rescued from the vehicle by rescue staff.

9 UPDATING OF SAFETY CONCEPT AS PART OF A SAFETY MANAGEMENT SYSTEM

Following the submission of the safety concept to the Federal Railway Authority in June 2005, it was examined by EBA experts to determine whether it was fit for approval.

Since the general conditions on which the safety concept is based (design, technical specifications, the legal basis, …) are subject to change, the safety concept, in accordance with the safety management methodology of the document entitled "Goals, methods and basic safety criteria for the high-speed maglev link" is to be updated.

10 OUTLOOK

When the approval of the safety concept is granted, an important milestone will have been reached in the design and planning of the Munich Central Station – Airport maglev link.