

The Transrapid Munich Airport Link Operation, Safety and Approval

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Abstract

The Transrapid system layout has to be developed carefully taking into account the system parameters and reflecting the specific project requirements. The operation of the Transrapid Munich Airport Link is defined by a minimum headway of 10 min with a trip time of maximum 10 min. The trains consist of three vehicle sections carrying a maximum of approx. 400 passengers in circulation operation. For the convenience of airline passengers, check-in including baggage service is provided at Munich Central Station. The certification and approval process for maglev transportation systems in Germany is performed by the German Federal Railway Authority (Eisenbahn-Bundesamt) in accordance with the Maglev System Planning Law (MBPIG) and the Maglev System Construction and Operation Ordinance (MbBO). As required by the MbBO the safety of the system shall be proved by a safety concept considering the safety of the technical system as well as project-specific safety measures. Based on the proof of safety and on the performance during the trial operation an operating license for the commercial operation will be granted by the EBA.

1 Transrapid Project – General Purpose

The Munich Airport has the largest growth of all the German airports. By the year 2015, the number of air passengers is expected to grow from currently 22 million to 48 million per year. These growth prospects will be increasingly hampered by the already overloaded road connections to the airport.

The airport is currently connected to the city of Munich by the suburban rail lines S1 and S8. With intermediate stops, both lines require approx. 41 minutes to travel from the airport to the central rail station in Munich.

To meet the expected ridership demand, a significant improvement in the public transportation connection between the airport and Munich city centre is required. A 10 minute journey time is desired for this connection. In this case, a maglev link between the Munich central rail station and the airport as a fast,

high-performance, regional transportation connection, is the best possible way to fulfil the requirements for transport capacity, journey time, safety, and comfort.



Figure 1: The Transrapid Munich Airport Link

2 Project Requirements

Project Requirements

Plenty of project requirements form the basis for the planning and the system layout, as there are

- transportation requirements (ridership),
- operational requirements,
- requirements for the route,
- legal, regulatory and safety requirements.
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Divided into seven sections, the Maglev System Construction and Operation Ordinance, MbBO regulates:

- the procedure for obtaining general certification, official supervision, and maintenance,
- the requirements on execution of construction work,
- the safety requirements on the operating facilities, i.e. guideway, stations, maintenance facilities, substations, and propulsion and control equipment along the route,
- the safety requirements on the vehicles,
- the requirements on operation including the safety concept,
- the requirements on personnel, and
- the aspects of public safety.

The essential requirements and project specific data concerning ridership volume, the route, and the operation are outlined as follows.

Furthermore the operation concept and the safety concept and the respective layout results are explained in detail in Chapters 3 and 4.

2.1 Ridership Volume

The ridership volume for the Transrapid was derived from a ridership prognosis taking into account all transportation means in the corridor between Munich Downtown and Munich Airport.

Ridership Prognosis for the Corridor

	Year 2000	Year 2015 without Maglev	Year 2015 with Maglev
Public Traffic	6,5 Mio	11,1 Mio	15,0 Mio
Individual Traffic (Road)	20,3 Mio	35,9 Mio	33,0 Mio
Total	26,8 Mio	47,0 Mio	48,0 Mio

(Passengers travelling between Munich Airport and Munich Main Station)

Transrapid Ridership Volume in the Year 2015

Shifting of demand from S-Bahn	2,9 Mio
Shifting of demand from airport-busses	1,0 Mio
Shifting of demand from private cars and taxi	3,0 Mio
New induced demand	0,4 Mio
Additional demand from distant regions	0,6 Mio
Total for Transrapid	7,9 Mio

(Passenger Trips)

2.2 Route

The preferred route (West Route) runs on a raised guideway from the Central Rail Station to the tunnel entrance at Hacker Bridge and from here under ground to the Landshuter Allee and the Olympic Park. It then runs above ground in a northerly direction and then moves into a tunnel in the Feldmoching area before passing under the Munich-Landshut railway line. Once it re-emerges, the route runs parallel to the A 92 highway and on to the airport where it reaches its final destination, Munich Airport Station. No intermediate stops are planned.

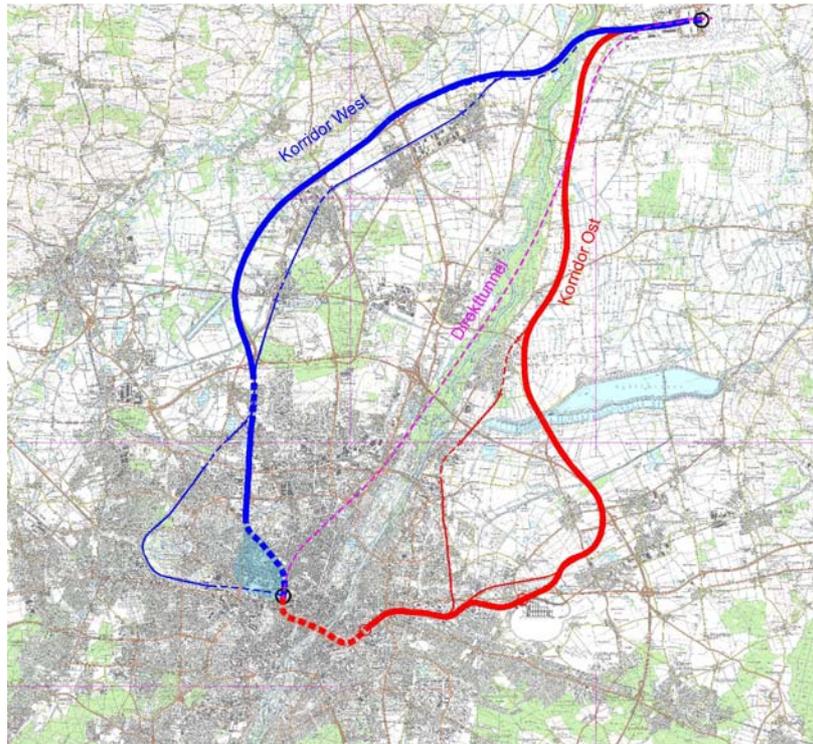


Figure 2: Preferred Route (West Corridor)

Route statistics

Total route length	approx. 38 km
At-grade / In cut < 2.0 m above ground level	approx. 18 km (47 %)
Elevated guideway > 2.0 m above ground level	approx. 12,5 km (33 %)
Tunnel (each track with its own bore)	approx. 7.5 km (20 %)
Parallel to highway	approx. 19 km (50 %)
Parallel to railway	approx. 3 km (8 %)

2.3 Operation Data

Operation Data

Stations	Central Station and Airport Station
Vehicle fleet	5 vehicles each with 3 sections
Travel speed	350 km/h
Trip time	10 minutes
Minimum departure frequency	10 minutes
Daily running time	20 hours
Trips / day / direction	115
Baggage service	Baggage check-in at Central Station

3 System Layout

3.1 Track Scheme

The Transrapid maglev project Munich is planned as a high-speed transportation line connecting Munich Central Rail Station and the airport via a 38 km route of double track. Figure 3 shows an example of the track scheme. The maglev station in the central station is built in the +1 level. Four guideway switches are installed near the central station and a special pivot beam behind the airport station. The transition to the maintenance facility is provided by a guideway switch from track B nearby the airport station. Three tunnels with a total length of 7,5 km are utilized for the Munich Airport Link. They are designed according to the newest tunnel standards concerning safety and aerodynamics.

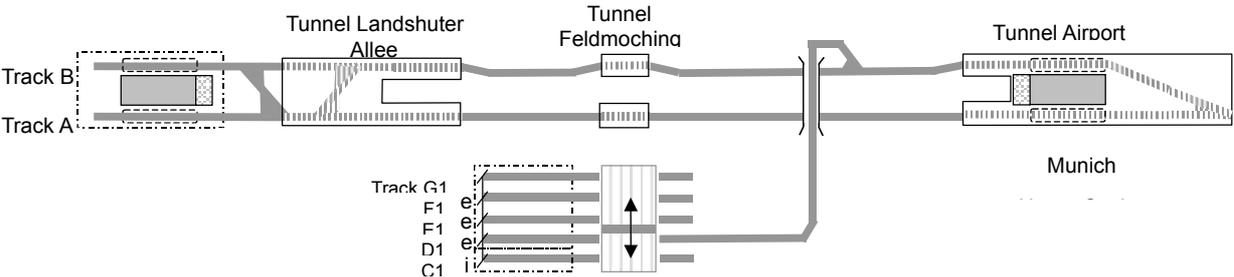


Figure 3: Track Scheme (example)

3.2 Stations

The Munich Airport Link connects the Central Rail Station with the airport. The Airport Station is planned to be an underground station which is located under the plaza of the Munich Airport Centre between Terminal 1 and Terminal 2. The Central Station shall be build either +1 Level above the railway platform 11 and 12 (see Figure 4) or underground at level -1,5. In any case, the check-in service area for airline passengers shall be located in an intermediate level. The stations are equipped with platform doors to control the access to the vehicles.

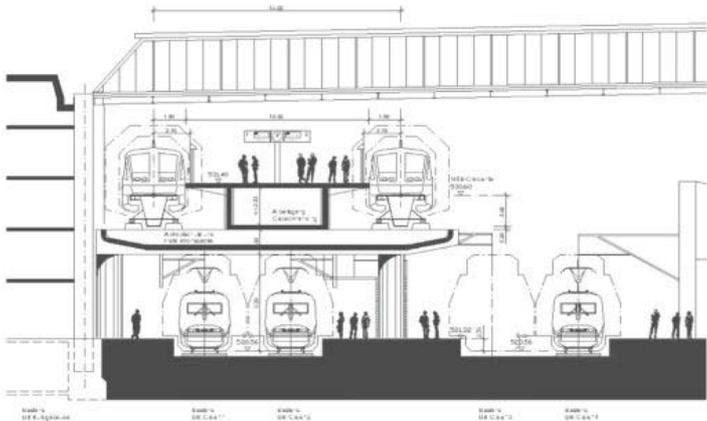


Figure 4: Example for the layout of the Central Station at +1 level

A passenger management concept is prepared for the project considering

- the volume of traffic,
- the signing concept in the station,
- the transition time from different public transportation systems to the Munich Airport Link,
- the location of the ticket terminals
- and the access to the platforms.

An access gates system is installed near the station platform to control the traffic flow to the vehicles. The gate terminals are designed to meet the requirements of the safety concept concerning emergency modes and provide the space required by handicapped passengers. The ticket reader which is integrated in the gate terminals is connected via high speed data link to the ticket terminals and the main server unit and guarantees a fast ticket control process of approx. 3 sec. The ticket reader supports the newest technologies of electronic ticketing (see Figure 5).



Figure 5: Example for Access Gates

3.3 Check-in and Baggage Handling Service

The Munich Airport Link provides a check-in and baggage handling service for airline passengers at Munich Central Station. For this reason a check-in area with a number of check-in counters and self check-in terminals are integrated in the station layout. While the passengers receiving their boarding pass for almost all carriers the baggage is transported in the baggage area of the central station which has the same security standard as the airport including baggage reconciliation and tracing system. The baggage is stowed in special containers in the baggage compartment of the Transrapid vehicle to be transported from the Central Station to the airport where the baggage is transferred into the airport baggage distribution system (see Figure 6).

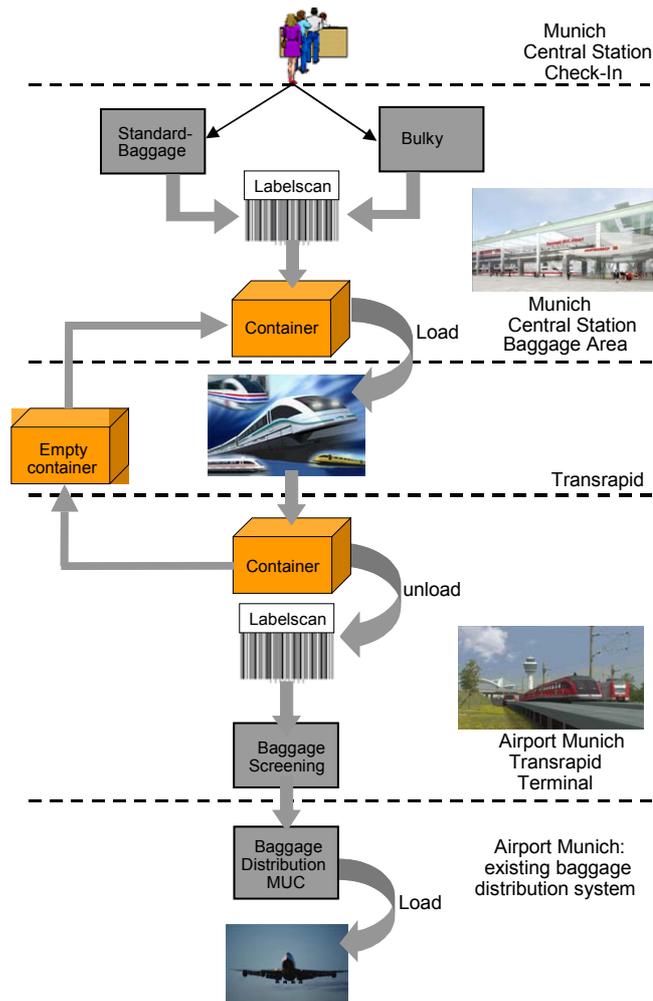
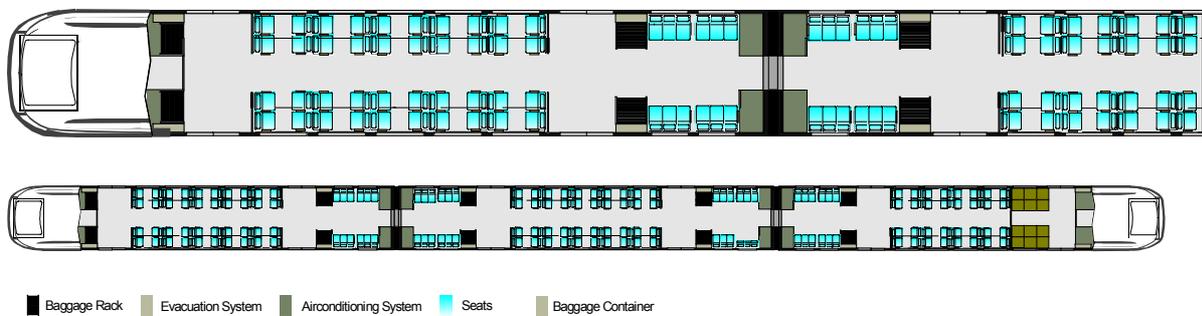


Figure 6: Process of the baggage handling service

3.4 Vehicle Configuration and Layout

The fleet of the Munich Airport Link consists of five vehicles, each with three vehicle sections and a length of approx. 75 meters. .

Figure 7 shows the vehicle layout providing 148 seats and a total capacity of approx. 410 passengers. The baggage compartment provides the capability to stow up to seven special baggage containers with a total



capacity of 70 pieces of baggage.

Figure 7: Example for vehicle layout

3.5 Propulsion Layout

In addition to the operations concept, the speed profile is the main characteristic of the propulsion layout in the Munich Project. It is limited by the route alignment constraints and by the speed limitation due to the design and the diameter of the tunnel sections. The investigations conducted during the regional planning process show that the maximum speed to meet the requirements of the operation concept can be limited to 350 km/h with regard to economical and ecological aspects.

Figure 8 shows an example for a propulsion layout consisting of six propulsion segments which are powered by six high power propulsion blocks for the main tracks A and B and one low power propulsion block for the maintenance facility.

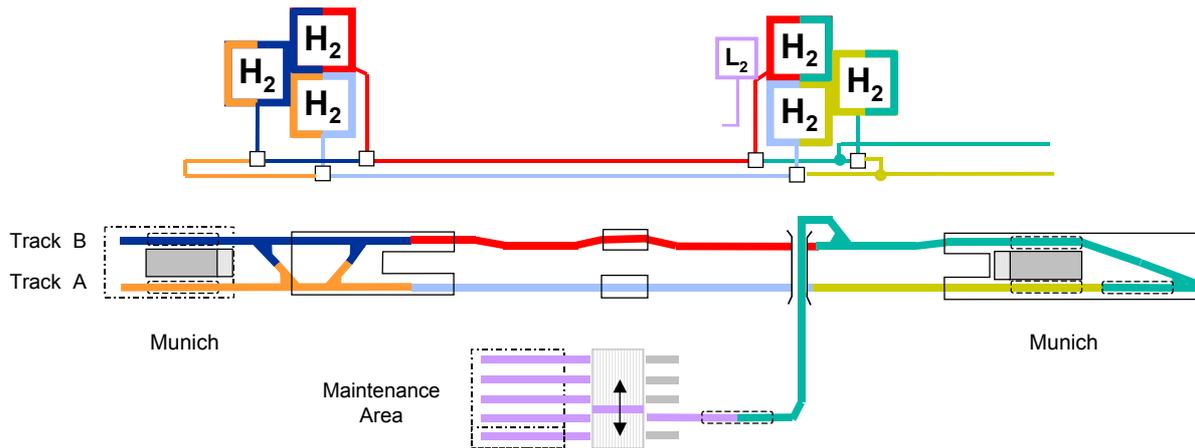


Figure 8: Example for propulsion layout

3.6 Operations Concept

The operations concept is developed as part of the planning process summarizing all technical and operational parameters of the project and defines the travel time and schedule. The concept is based on the propulsion concept, track layout, speed profile, the technical trip time, the boarding time and the ridership prognosis for the period between 2015 and 2030. In addition to the operational requirements of the operator, the operation programs and the modes of operation are defined. They are to be verified by simulations including normal, degraded and irregular operation. The results of the simulation, such as buffer times per circulation run, reduction of delays during irregular operation, are used by the track designer and the operator to define effective measures to optimize the operation.

The operations concept is prepared to provide a service from 05:00 to 23:00 hrs. with a headway of 10 min and a trip time of 10 min. The maximum headway is planned to be 20 min in the time from 04:00 and 05:00 hrs. and also between 23:00 and 24:00 hrs.

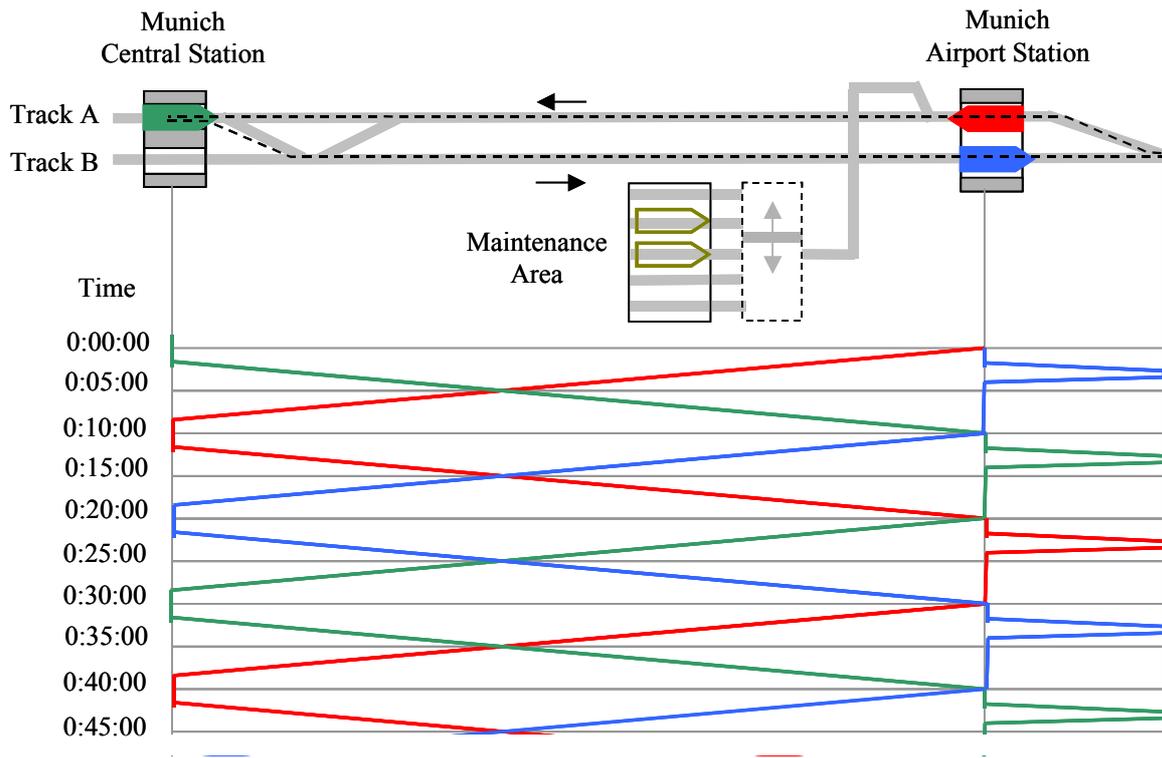


Figure 9: Example of an operations simulation with three vehicles in circular mode

4 Safety

As required by the Maglev System Construction and Operation Ordinance (MbBO), the safety of the system shall be proved by a safety concept considering the safety of the technical system including project specific safety measures. This safety concept is based on the European standard EN 50126 (RAMS) and consists of a hazard analysis, a risk assessment and the definition of appropriate and effective safety measures for risk reduction. These measures consist of technical, structural, organisational and operational measures. The safety concept considers the risk of the technical system as well as the risk derived from other transportation means, e.g. railway, aircraft or motorways. Structural measures are defined to protect the Transrapid system against damage to the guideway through accidents of other transportation means. The safety measures are defined in the safety concept with special regard to the emergency management as well as to evacuation and rescue specifications. The safety of the technical system is shown by a project-specific safety case on overall system level.

The infrastructure of the tunnels is designed to meet the international safety and fire protection standards as well as the special regulation for the construction and operation of maglev tunnels issued by the German Federal Railway Authority (EBA). As part of the certification process, the safety concept will be updated and supplemented during all phases of the project including Risk-Re-Assessment and hazard log.

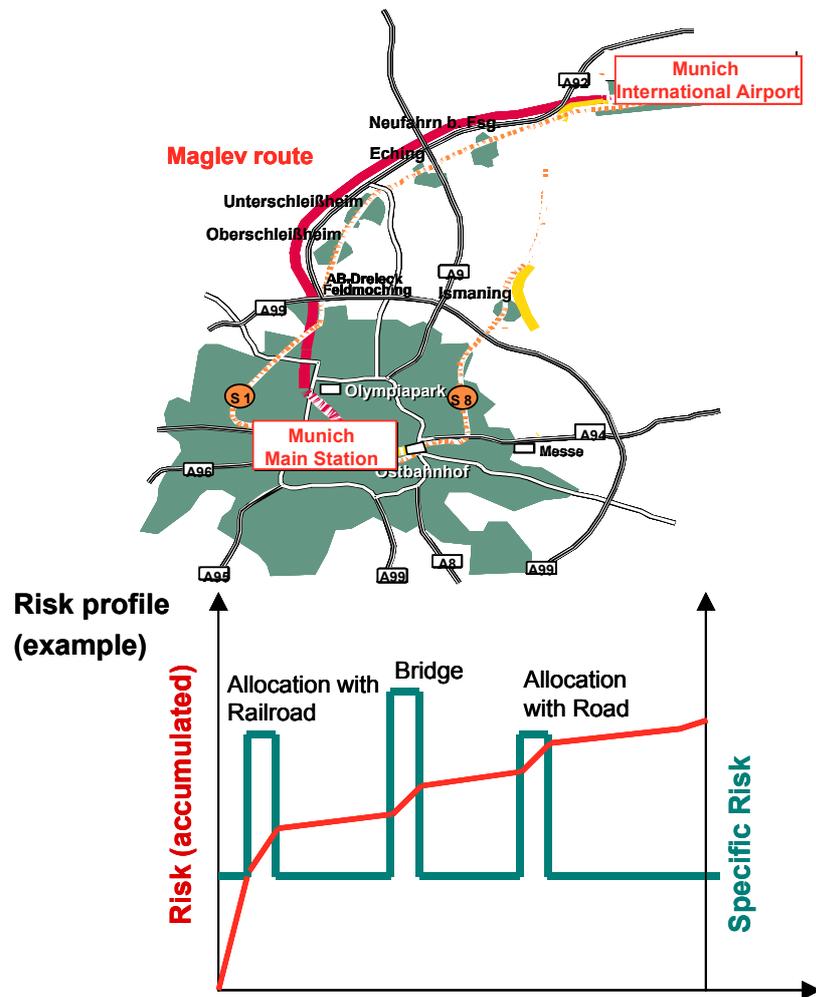


Figure 10: Example for risk description by a risk profile

Based on the requirements of the EN 50126, a quantification of the project specific risk is performed and compared with predefined risk acceptance criteria. Different methodologies, such as ALARP (as low as reasonable possible), GAMAB (globalement au moins aussi bon) or MEM (minimum endogen mortality) are used to define a risk level which is accepted. In Germany the MEM criteria, derived from the mortality rate of a young girl (5-15 years old) is used to assess the resulting risk. Figure 10 shows an example for a risk profile showing the accumulated risk concerning the project route and identifies the areas of the route with an increased risk.

Additional to the safety of the system, the safe operation of the system is ensured by a maintenance concept, the rules and regulations, an emergency management plan and by personal training on a regular basis.

The safety assessment is based on the proof of safety, on document basis as well as on the performance during the trial operation.

5 Approval

Legal Basis

The legal basis for an application of the Transrapid system in Germany was created in 1996 by the General Maglev System Law (Allgemeines Magnetschwebbahngesetz, AmbG), the Maglev System Planning Law (MBPIG) and in 1997 by the Maglev System Ordinance [4] with consists of

- Art. 1: Maglev System Construction and Operation Ordinance (Magnetschwebbahn Bau- und Betriebsordnung, MbBO) and
- Art. 2: Maglev System Noise Protection Ordinance (Magnetschwebbahn-Lärmschutzverordnung)

The General Maglev System Law and the Maglev System Planning Law regulate the responsibility of the Federal Railway Authority (EBA) for planning permission, approval, and as supervisory authority for maglev systems in Germany. EBA is an authority subordinate to the Federal Ministry of Transport, Building and Housing (Bundesministerium für Verkehr, Bau- und Wohnungswesen, BMVBW).

The MbBO demands fulfilment of the defined protection objectives. However, it does not regulate how and with which means these objectives are to be achieved and in particular contains no constructive requirements. According to the MbBO, it is the responsibility of the maglev project owner/entrepreneur/operator to identify and assess all detectable safety risks by means of risk assessment and to describe them by kind, frequency, and effects. The project owner has to define the necessary construction, operational, and organisational safety measures must be incorporated into a safety concept which to be approved by EBA.

The Transrapid Maglev System technology is subject to a systematic analysis and permanent testing with special regard to safety and availability. Continuously as part of the further development of the system, test runs and proofs are conducted at the Transrapid Test Facility in Emsland, Germany (TVE).

Technical Standards

Apart from existing Norms and Standards, Technical Standards for the Maglev System will be developed to serve as a basis for the approval of the Transrapid technology. EBA will check the project layout against the requirements stated in the Technical Standards.

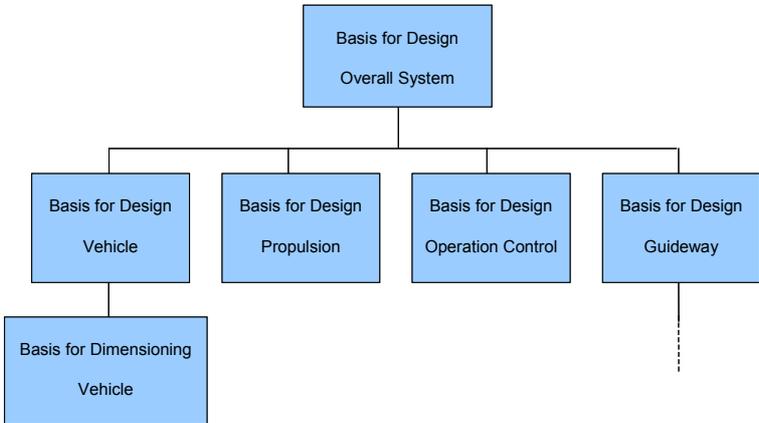


Figure 11: Technical Standards for the Maglev System

Verification and Validation

Within the Munich Project, verification documents have to be created which document the project-specific layout. Tests, verifications and safety cases will be carried out during project implementation, initially at the subsystem level. In the final phase of the project, the overall system integration takes place involving the whole system.

Certification and Operating License

Essential for the acceptance and certification of the system is the safety verification. The verification for the individual safety measures and their effectiveness in relation to the individual risks is based on the safety concept. The assessment of the safety is carried out by the EBA or acknowledged experts approved by the EBA. Based on the proof of safety, on the rules and regulations, and on the performance during the trial operation, an operating license for the commercial operation will be granted by the EBA.

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