

DB AG Operator Requirements for High-Speed Maglev Railways as Regional Services

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The Transrapid high-speed maglev railway was conceived and optimised as a means of long-distance conveyance. Its use as a fast regional carrier for population centres or airport feeder services involves different and in some respects greater demands than for long-distance workings, in respect of which DB AG has produced operator requirements. The aims DB AG is pursuing and the ensuing focus areas for further development of the high-speed maglev railway are extrapolated having regard to the system's use in regional services. How these aims translate into functional requirements is set out together with the methodological tools adopted and a Requirement Database.

1. Summary

DB AG examined five high-speed maglev services in Germany in a preliminary study carried out in 2000 [1]. Four of these services were short lines (max. 100 km) of a regional nature or else airport feeder routes. It soon became apparent that, to ensure optimum operation and layout of the system, the existing technology requires adaptation.

Regional services in Germany display the following characteristics relative to long-haul traffic:

- very pronounced traffic demand profiles with a tendency towards lower vehicle utilisation ratios; demand during the morning commuter-traffic peak can exceed average ridership by up to 400 %;
- no reservation system with which to channel the admissible vehicle payload;
- lower average speed due to shorter intervals between stops and lower maximum speeds as a rule;
- greater punctuality requirements on the part of customers;
- lower specific earnings per passenger as a rule due to participation in transport associations;
- higher specific staff expenses due to shorter distances between stations and lower average speed;
- higher energy consumption due to frequent starts and stops;
- greater specific number of vehicles owing to slower turn-round rate;
- greater forces exerted on material due to more frequent starts and stops, rapid passenger entry/egress and external impacts in densely populated conurbations;
- lower investment costs per seat.

Given these differences, the following focus areas were defined with a view to further developing the system for deployment in regional services:

- increasing ridership by means of demand-optimised operating and vehicle concepts for adaptation to the traffic demand profile
- coping with peaks in demand (peaks during the rush hour) by permitting standees as a means of increasing payloads;
- increasing journey speeds by reducing dwell times, optimising the number and width of doors, reducing technical running times and reducing acceleration and braking distances;
- great reliability as regards all environmental provisions so as to meet the punctuality target and reduce the amount of reserve stock;
- high resilience of systems to impacts from without (vandalism for instance);

- optimising economics of operation through full automation with no staff on vehicles or in stations and use of automated, central diagnostics systems to minimise staff input, cutting energy costs by recuperating energy and reducing vehicle weight;
- reducing system costs by at least 25% by increasing reliability and efficiency, simplifying the system and making the greatest possible use of standardised systems to prevent the superior performance of the high-speed maglev railway being negated by overly high initial capital expenditure.

DB AG has been discussing these focus areas with manufacturers since the beginning of 2000 and is applying itself to them in, amongst other things, the “Further Development Programme for Regional Applications” initiated by the Federal Ministry for Transport, Building and Housing. DB AG is producing functional specifications for the deployment of high-speed maglev in regional traffic.

2. DB AG’s Aims as regards Application in Regional Traffic

DB AG aims by supporting the development of the high-speed maglev railway system (HSMR system) to run a forward-looking and efficacious transport system. Within the framework of the German high-speed maglev projects in Bavaria and North Rhine-Westphalia (NRW), DB AG is pursuing the following aims:

- substantial improvement of the existing transport offering on the respective route
- higher cost recovery ratio than with wheel-on-rail (W/R) systems
- integration of HSMR into existing DB AG services and systems
- first fully automated train operations in Germany

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DB AG’s ”Orderer’s Specifications for HSMR”
Conditions for deployment in regional traffic

- high ridership (travel to and from work)
- limited access with reservation schemes not acceptable
- short journey timings between stops
- numerous changes of speed
- numerous stops
- numerous departures
- numerous impacts by third parties
- numerous passenger entry/egress events

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All requirements are to be geared to meeting these aims, there being a need in the process to reconcile (seemingly) contradictory objectives in optimum fashion (Figs. 1 and 2).

Fig. 1: Conditions for deployment in regional traffic

DB AG's "Orderer's Specifications for HSMR"
Greater requirements for HSMR in regional traffic

- loading capacity
- train headway
- durability
- ride comfort
- availability
- staff requirements
- stopping accuracy
- energy consumption
- evacuation system
- passenger entry/egress times

Fig.2: Greater requirements for HSMR in regional traffic

3. Specific Requirements for the German Projects

At present, two projects are being discussed and planned in Germany, namely Munich's airport feeder service from her central railway station (München Hbf) and the Düsseldorf Hbf – Dortmund Hbf line. At the current stage of planning, the two projects have the following characteristics:

		München Hbf – München Flughafen	Düsseldorf Hbf – Dortmund Hbf
Traffic Volume	million trips/yr	6 – 8	24 – 34
Traffic Performance	billion passenger km	240 – 290	860 – 950
Peak Service Frequency	min	10	10
Length of Line	km	37	78
Stops		2	7
Journey Time	min	10	37 – 39
Mean Distance Carried	km	37	28 – 35
Commercial Speed	km/h	220	120 – 130
Customer Breakdown		80 % flyers	80 % domestic traffic

The Düsseldorf Hbf - Dortmund Hbf project is determined as being a "standard" regional service for commuters, shoppers and leisure travellers. The Munich airport feeder, by contrast, will primarily carry airline passengers.

Given the nature of its customers, the airport feeder is to feature a luggage service. Passengers will check in for flights and check in their luggage at the railway station. Luggage will be conveyed in containers on the train. Thus, Munich central station will become a satellite of the airport.

The focus areas for further development of a high-speed maglev railway for regional traffic as set out in the Summary are corroborated by the specifics of the lines involved (Fig. 3)

They need to be supplemented in two respects:

- consideration to be given to the specific requirements of an airport feeder in the form of an accompanying luggage service;
- thorough-going reworking of the safety concept drawn up for long-distance traffic (especially the rescue concept);



However, the line characteristics reveal that the technical challenges, too, are considerable. This applies particularly for the line in North-Rhine Westphalia. Here, a total of seven stations are to be served at 10-minute intervals and for large numbers of passengers. This poses the same challenge for the HSMR system as that faced by advanced local/suburban transport systems.

Fig.3: High-speed maglev railway for regional traffic

4. DB AG's (Orderer's) Specifications for High-Speed Maglev Railways

Only the entity that subsequently operates the system can define comprehensive requirements for a high-speed maglev railway. Under the German Maglev Railway Regulations, the operator is required to obtain operating approval and needs, therefore, to be able to confirm that safe operation is feasible with the high-speed maglev system from the conceptual phase. The suppliers industry needs the operator's requirements in order to adapt the high-speed maglev train to the exigencies of day-to-day operation. DB AG declared in mid-2001 that it is prepared to operate the two high-speed maglev projects in Germany. This was when work commenced on drawing up requirements for regional application of the system.

Exhaustive solutions for deployment at the cutting face of everyday operation have yet to be demonstrated for some functions. Accordingly, the operator should not have the task of ordering technical solutions from suppliers but as far as possible of formulating functional requirements, i.e. it is primarily a case of setting out WHAT the system is to deliver and not HOW the supply industry is

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DB AG's "Orderer's Specifications for HSMR"
HSMR Orderer's Specifications are basis for

- contractor's specifications produced by all-in system supplier
- checking application readiness and fitness for function
- quality assurance during planning and development
- quality assurance during construction and manufacture
- further development of HSMR system
- operating instructions
- operating manual and training
- safety management system
- putting into service and entry into service
- test runs and trial operation
- testing, acceptance and licence to operate

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to implement anything. This leaves manufacturers with the requisite scope as well as with responsibility for developing fit-for-function solutions within the overall system. Developing such solutions is their most central task. Deutsche Bahn AG will actively support the process of developing technical solutions by means of a formalised review process.

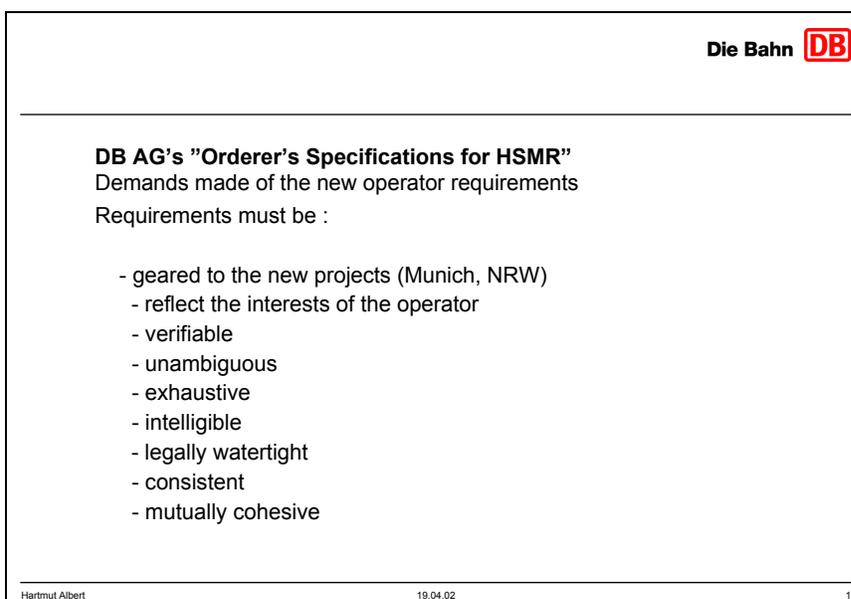
Fig. 4: Uses for HSMR Orderer's Specifications

5. Quality Criteria for Requirements

The “high-speed maglev railway” system needs to be considered as a holistic entity even more than is the case for the “wheel-on-rail” system. Hence, requirements need to be geared towards the entire system and not just towards any single part thereof.

Several subsystems are involved in almost all functions. There is involvement in the closely interconnected carriage, guidance and drive functions by the track, drive, traffic-management and maglev-vehicle subsystems.

Specifications need to meet a series of quality criteria so as to provide the orderer and the maker with assurances concerning the product being delivered. Specifications need to be geared towards specific projects. They need to be unambiguous, legally watertight, verifiable, well-founded, exhaustive, consistent, intelligible and mutually cohesive (Fig. 5).



The image shows a document page with the 'Die Bahn DB' logo in the top right corner. The main heading is 'DB AG's "Orderer's Specifications for HSMR"' followed by the subtitle 'Demands made of the new operator requirements'. Below this, it states 'Requirements must be :'. A bulleted list follows: '- geared to the new projects (Munich, NRW)', '- reflect the interests of the operator', '- verifiable', '- unambiguous', '- exhaustive', '- intelligible', '- legally watertight', '- consistent', and '- mutually cohesive'. At the bottom left, it says 'Hartmut Albert' and at the bottom center, '19.04.02'. A small '1' is in the bottom right corner of the page.

With regard, in particular, to the quality criterion of “intelligibility”, natural language is often the only means of communication amongst all project participants when formulating requirements.

Since, however, the complex qualities of natural language (scope for interpretation for example) can lead to non-comprehension amongst outside parties - whilst the above-mentioned quality criteria nevertheless need to be met - orderer’s functional specifications

Fig. 5: Demands made of the new operator requirements

for the “High-Speed Maglev Railway” were jointly drawn up with the SOPHIST GROUP of Nuremberg, in compliance with the “Rules of natural language” devised by them [4], in a process defined by the C.A.R.E. 3.0 Requirement Database.

As unified a syntactic structure as possible was selected for formulation of requirements. All requirements are substantiated, all terms open to interpretation defined. This ensures that requirements are intelligible, unambiguous and legally watertight.

6. Methodological Tools and a Requirement Database

The various requirements combine to form Deutsche Bahn AG’s functional specifications for “High-Speed Maglev Railways”. The C.A.R.E. 3.0 requirement database produced by SOPHIST GROUP of Nuremberg [4] was chosen as the basis for processing the sizeable quantities of information involved. C.A.R.E. 3.0 enables all requirements and their life-cycles to be captured, processed, monitored and administered along with any other documents needed to produce orderer’s functional specifications for “High-Speed Maglev Railways” (Fig. 6).

Cohesions between Informations

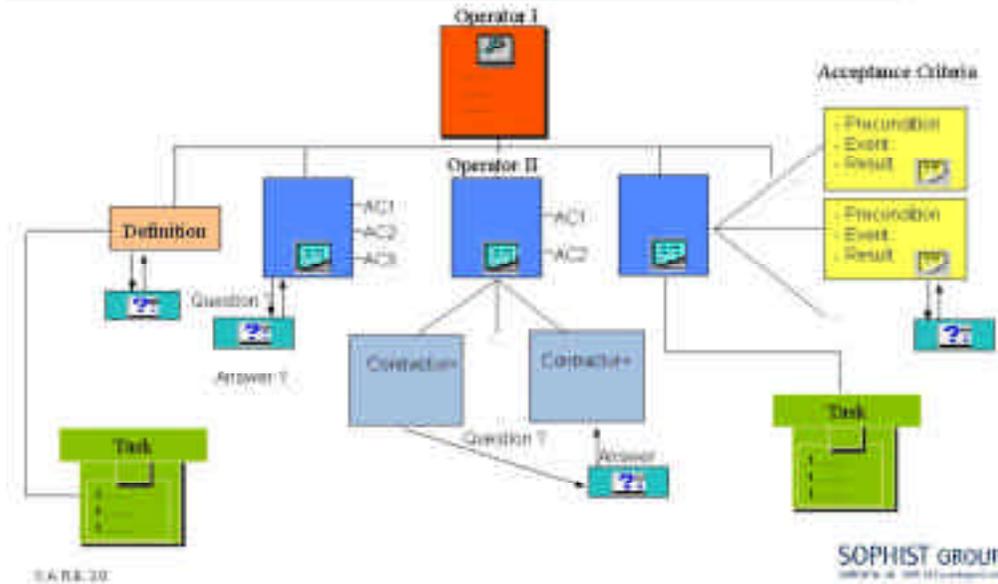


Fig.6: Cohesion between Information

Whenever a specification is amended, a new version of that specification is produced. All previous versions remain accessible in C.A.R.E. 3.0. A record is simultaneously made of the date of the amendment and the reason for it being made. This enables a dependable historical record to be kept. Should a given specification cease to be justified, checks can be conducted as to whether it should be amended or deleted altogether.

Applicable focus area topics, processes and subsystems are listed for each specification, which has the effect of interlinking requirements. Further indirect links between the individual requirements are additionally possible.

C.A.R.E. 3.0 allows a variety of reports to be accessed. Specifications can be classified and printed by subsystem, but also by process. Thus, it is easier to run integrity and consistency checks.

Deutsche Bahn AG and SOPHIST GROUP have prepared the orderer's functional specifications for "High-Speed Maglev Railways" using C.A.R.E. 3.0 with a view to enabling the supplier's solutions to be added to the corresponding Deutsche Bahn AG requirements and guaranteeing traceability over several levels.

In addition, C.A.R.E.3.0 has been prepared in such a way that, for each specification, the attendant test methods and criteria are formulated. The following graphic contains an excerpt from the C.A.R.E. 3.0. Requirement Database (Fig. 7).

7. Sources for Requirements

The first thing done when setting up the collection of requirements was to establish what is required of the high-speed maglev railway and by whom.

Naturally enough, focus centres on future passengers, though consideration also needs to be given to the aspirations of those commissioning regional transport services. In the final instance, the latter determine which route is to be served with which stops. Added to this are DB AG's requirements in

respect of the operative sphere, the Federal Railway Office's requirements and also those of associations and other organisations.

What is required of a high-speed maglev railway by customers

Customer requirements relate in the first instance to the service offering, access to the system, and accompanying information.

Questions of interest here are:

- What journey times are desired?
- What dwell times/passenger entry/egress times are accepted?
- How are stations to be fitted out?
- What form is passenger accommodation to take?
- What services are considered desirable and worth paying for?

Suitable consideration also needs to be given to the concerns of persons with impaired functions when designing stations and passenger accommodation. In day-to-day running, issues of ride comfort, ease of access, air conditioning, punctuality and safety are important for passengers. Meeting aspirations voiced by customers is an important precondition for the economic success of a transport enterprise.

What is required of a high-speed maglev railway by DB AG

DB AG's own requirements regarding the high-speed maglev railway are, in the final instance, likewise geared towards satisfying customer aspirations. Of particular interest here are operating safety, transport safety, productive efficiency, reliability, availability and cost-effectiveness. Requirements relating to operating safety simultaneously constitute requirements whose implementation is examined within the framework of approval by the Federal Railway Office. Further internal needs concern issues such as industrial safety, work structuring, plant safety and building security, ease of operation of controls, servicing capacity and resilience to external interventions.

Ultimately, the economics of a transport service are the key. Decisive here are issues such as investment costs, operating costs, maintenance outlay, staff requirements and service life.

What is required of a high-speed maglev railway by third parties

Over and above the focus area issues listed, which cover requirements from a customer and operator perspective, there are also justified interests of third parties to consider. This particularly concerns focus areas such as external noise, noise control, environmental compatibility, environmental friendliness and environmental protection. These are the most crucial aspects as regards the ability to implement infrastructural planning procedures in densely populated regions and as regards acceptancy of the system and are, therefore, an important objective for the operator.

8. Correlations between Requirements

Like any other guided transport system, the high-speed maglev railway is a very complex system.

The basic carriage, guidance and drive functions are, for instance, connected with numerous other functions directed towards the safety, availability and cost-effectiveness of the high-speed maglev railway. Upon closer examination of the "Carriage" function alone, answers are needed to such as the following questions:

- How many passengers need to be carried during peak hours?
- How many trains are to be run during peak hours?
- How long and wide are trains to be?
- How much utilisable space are trains to have?
- What payload do trains need to be able to cope with?
- How is the term "navload" to be defined?

- Do the internal appointments on maglev vehicles count as payload?
- If yes, which items can be classified as internal appointments?
- Are excess amounts to be factored in when calculating permissible payloads?
- How is it to be ensured that the permissible payload is not exceeded?
- Is there a need to restrict access to trains?
- What payload is to be carried per sqm of vehicle floor space?
- What is the total weight of a train including payload?
- What forces impact on the track per train movement and day of running?
- What influence does the payload have upon investment costs?

As the example of the “Carriage” function shows, there are countless interdependencies between requirements. All requirements have equal status. Any one of them can impact on any of the others.

9. Requirements for Processes, Responsibility for System as a Whole

Besides requirements for the high-speed maglev railway, requirements are also formulated in respect of planning, development, construction, manufacture, commissioning and acceptance.

Deutsche Bahn AG demands that the high-speed maglev railway be planned, developed, built, manufactured, put into service and accepted as an all-in system. To this end, it is necessary that responsibility and performance targets for these processes be assumed by one all-in system supplier.

This party also bears responsibility for drafting all key system-related documentation as well as for its exhaustiveness and accuracy. This covers items such as the operating programme, the maintenance programme, the safety concept and instructions for use. Said party is also responsible for demonstrating the safety of the system as well as for all approvals by the Federal Railway Office.

10. Contractor’s Specifications, Quality Assurance, Acceptance and Warranty Agreement

The “High-Speed Maglev Railway” orderer’s specifications will underpin all further activities up to entry into service. The all-in system supplier is called upon to draft contractor’s specifications corresponding with Deutsche Bahn AG’s orderer’s specifications. These are obliged to provide in written form solutions to each and every requirement cited. Where there are several options, the more economical is to be proposed to the operator. The economics of solutions is to be assessed by DB AG. When assessing solutions, it is not investment costs alone that are decisive, rather the entire operating cycle needs to be considered. As well as operating costs, non-conformance costs arising from non-availability or the assessment of customer appeal have thus also got to be borne in mind.

The contractor’s specifications produced by the all-in system supplier shall be responded to by Deutsche Bahn AG. Specialists at Deutsche Bahn AG will check the plausibility of every single solution contained in the contractor’s specifications, i.e. whether a given solution is capable of satisfying the applicable requirement.

The orderer’s specifications will form the basis for all contracts between the all-in system supplier and Deutsche Bahn AG. They will, therefore, also form the basis for quality assurance conducted by Deutsche Bahn AG in the course of planning, development, building, manufacture, and commissioning. Furthermore, the orderer’s specifications will also form the basis for acceptance of the high-speed maglev railway and for all warranty agreements between the all-in system supplier and Deutsche Bahn AG.

11. Drafting Orderer's Specifications for High-Speed Maglev Railways

Working as a team

Given the complexity of the task and the multifarious correlations involved, orderer's "High-Speed Maglev Railway" specifications can only be drafted with the aid of a defined process in a team-based context. Likewise, any amendments to requirements, substantiations and definitions will only ever be carried out by the "HSMR Orderer's Specifications" working party, which will simultaneously also act as an Amendments Committee as a result. The first phase of drafting involved a working group comprising approx. 20 specialists from different disciplines.

Team-based working procedures have proved to be a success. Existing knowledge has been consolidated and new insights have been acquired. Team-based work has enabled many correlations between individual requirements to become even more clearly visible than before.

From long-distance to regional traffic

Operator requirements have already been formulated for the Berlin-Hamburg long-distance route [2, 3]. These contain a great deal of current knowledge of the "high-speed maglev railway" system. Despite their having been drafted for long-distance applications, the relevant documents (approx. 1,000 pages) are eminently suitable as a basis for drafting new requirements.

The documents for the Berlin-Hamburg project were structured on a triple-tier basis.

The first tier embraced the elemental documents "Safety Concept", "Operating Concept" and "Principles of Track Layout". The second tier involved the cross-system documents "Operation - Safe Implementation", "Operation - Regulation and Control", "Availability", "Maintenance" and "Environment/EMC". The third tier covered concrete operator requirements for individual subsystems, specifically "Vehicle", "Track", "Drive", "Traffic Management" and "Operating Equipment".

The documents set out the requirements for and technical descriptions of systems, rules of action for service staff, explanations of technical and operating correlations and sundry background information. Content matter was not strictly segregated but was, rather, textually intermixed. Requirements contained in the copy were often no longer recognisable as requirements as a result. The textual material contained a large number of descriptions of concrete solutions. Latently concealed behind these solutions were the corresponding functional requirements. During the systematic elaboration of requirements, these were adapted to the exigencies of local transport services. Numerous completely new requirements were additionally developed. By year-end 2001, 639 requirements were in place.

As a means of making requirements more readily comprehensible, they have been assigned to 150 different thematic focus areas. The collection of requirements is as yet incomplete. It will be completed in the course of the process in hand by means of targeted reviews and a methodological-iterative approach.

Deutsche Bahn AG aims to develop orderer's functional specifications for the "high-speed maglev railway" system in its entirety by 30 June 2002.

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