The TRANSRAPID Test Facility (TVE)
Experience for Start Up and Commissioning of Shanghai Maglev

METZNER, Jörg

Industrieanlagen-Betriebsgesellschaft mbH (IABG), Maglev – Test Facility
Hermann-Kemper-Str. 23 - D 49762 Lathen/Ems - Germany
Phone: + 59 33 / 62 24 FAX: + 59 33 / 62 20
E-Mail: joerg.metzner@tm.iabg.de

Keywords
Commissioning phase, organisational safety, rules and regulations, Transrapid Test Facility(TVE), verification of system parameters

Abstract
What is intended to be shown in the following is how the TVE operations, maintenance, organisation and test experience, beginning with the start of the Shanghai Maglev project, was used to be able, in the short time available, to commence punctually the commissioning of commercial operations.

1. Experience Obtained from TVE

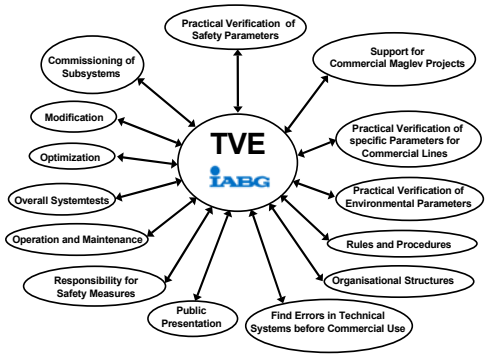

Figure 1: Tasks and Experience of the TVE Team

It became clear very early on that the experience obtained at TVE was to be used in close cooperation between German system industries, the Chinese operator and the TVE Team for the achieving of the joint aims in the Maglev Shanghai project.

For these tasks, recourse to almost 20 years' experience of the IABG test team was possible (Figure 1).

1.1 Safety Procedures

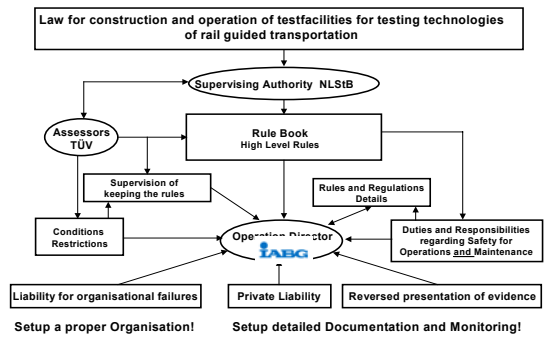

Figure 2: Legal Basis

If, at the beginning, the emphasis was on the individual system start-up, in the following years, organisation structures and procedures were developed, which were intended to facilitate safe operations of the test facility under all conditions imaginable [1], [2].
In this process, what had, in particular, to be given consideration was the fact that, as part of the tests and commisionings to be performed, what had to be expected, on the hand, were almost daily modifications to the

techncial sub-systems and, on the other hand, taking the commissioning status of the techncial subsystems into consideration, initially operations were to be performed based very much on the responsibility of the staff involved.
The necessary organisation for this was equally under scrutiny with the commensurate procedures as was the technology and could be constantly improved in running operations under continuous monitoring by licensing authorities and experts on the basis of the applicable laws and standards (Figure 2).
Particular attention in this was paid to the
safety relevance of maintenance and derived from this the close organisational from this the close organisational operations and maintenance, with overall responsibly for this in the hands of an IABG Operations Director.

The result was extremely effective safety procedures consisting of intensive quality controls and individual system releases.
The basic idea with this was always the fact that individual faults in the technology and, in particular, in human actions can occur and be recognised by independent observers in good time so that safety-oriented responses are always possible in all configurations imaginable.
on board or for operations with passengers in the magnetic levitation vehicle. The aim was always the fulfilment of the highest possible safety standard, irrespective of the type of operations or the technical boundary conditions.
With this objective and the procedures developed and tested by the IABG team, operations with passengers were unrestrictedly released by the responsible licensing authorities and the experts involved even under the specific conditions of the test facility.

Figure 3:
TVE Visit by the Prime Minister of the P.R. of China

Thus it was always possible to present the Transrapid system to high-ranking State and industry representatives from both home and abroad from the viewpoint of a passenger with the highest safety standard in running test operations.
One of the highlights was certainly the visit of the Chinese Prime Minister, Zhu Rongji (Figure 3), and numerous other visits by high-ranking delegations from the People's Republic of China.
The tested methods and procedures from TVE through to the cooperation with licensing authorities and experts were transferable with only a minimum of adaptation effort directly to the commissioning phase in the Shanghai Maglev project.
Within a very short period of time, therefore, on the assured basis and with the intensive participation of the experienced members of staff of the test facility, the regulations for the commissioning of the Maglev system in Shanghai were in place and approved by the Chinese operator.
The practical introduction and optimisation of the safety procedures were supported intensively during the running commissioning by experienced members of the TVE Test Team in operations and maintenance in-situ in Shanghai.
On the basis of the high-level safety standards and methods derived from TVE operations, it was possible, after a relatively short period of commissioning time, to undertake high speed runs on 31.December 2002 with the Prime Minister of P.R. of China, Zhu Rongji, and the German Chancellor, Schröder, on board a Transrapid, accompanied by high-ranking delegations on the Maglev track in Shanghai.

1.2 Team Structure and Training

Whilst on the test facility an experienced team was available for operations, maintenance and test performance, moulded over a number of years, corresponding structures had to be commenced for the Shanghai Maglev project both on the part of the German industrial consortium and also on the part of the Chinese operator.
Similarly here it seemed sensible to make use of the experience gained at the test facility. There, in the course of time, members of staff had been trained for all Maglev-specific functions in operations and maintenance. The test facility team could build up experience under all imaginable operational circumstances in the commissioning of individual sub-systems and in the operation of the whole system.
Even before the commencement of construction work and technical commissioning in Shanghai, the time was used to build up the operations and maintenance teams of the Chinese operator and the German Maglev consortium and to introduce them to their new tasks in the Maglev system as soon as possible. For this the TVE experienced members of staff were integrated into the running process of the team build-up at a very early stage. On the Chinese side, the future responsible staff members for operations and maintenance were given the opportunity very early on to build up and widen their knowledge and experience in the running test operations at TVE. Hereby not only were techncial details made known by the TVE team but also great emphasis was placed on the making clear of the organisational link between operations and maintenance, which is the basis for safe and reliable operating processes.
A further measure for an effective start and the performance of commissioning tasks in Shanghai based on a very ambitious time plan was the direct integration of experienced staff from the test facility into the commissioning team in Shanghai.
So, in particular, train drivers, on-board technicians, operations managers and responsible Maglev vehicle maintenance staff from the test facility were deployed in the commencing practical operations in Shanghai. The advantage in so doing was that practically no familiarisation time was required for the operation of the system based on the responsibility of the staff involved, as the important procedures could be taken over from the test facility. On the other hand, train drivers and on-board technicians were available with in-depth knowledge of the Transrapid vehicle as a subsystem. These were able to work together with the system developers of the Maglev vehicle also in critical phases of the commissioning and, based on their practical experience, be involved directly in commissioning-specific problem solutions.
In addition to the activities in important operational and maintenance functions, there was the task of the experienced test facility members of staff to pass on their knowledge and experience to the new staff in the German Maglev consortium and of the Chinese operator. The aim in this was to facilitate extended multi-shift operations, in terms of time, with increased personnel requirements in the commissioning phase.
In addition, the measures for the team structure in Shanghai and the introduction of the necessary safety procedures were supported by staff with many years' experience from the operations management of TVE.

1.2.1 The Maintenance Management System

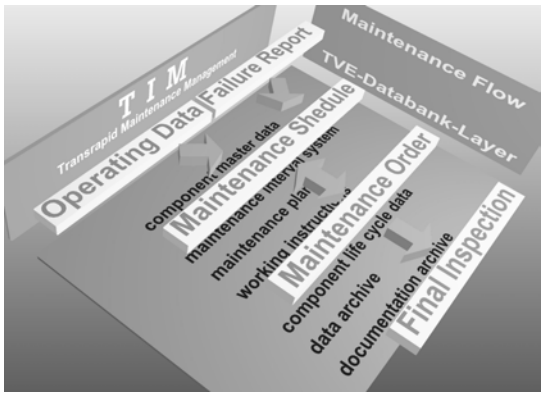

Figure 4: Maintenance-Management-System

A further high priority measure was the training and consultancy of senior members of staff of the Chinese customer into an integrated team of operational and maintenance personnel and software developers. The aim here was to make it possible for the Chinese operator to set up an own Maintenance Management System (Figure 4), based on the practical experience of the test facility and to develop the suitable software tools for this purpose.

As what had to be completed was not only the compilation of software but also to incorporate the functions of the software tools advantageously into the closely linked operational and maintenance processes, great emphasis was placed as part of the consultancy on the composition of the teams on the Chinese and on the German sides. In addition to the responsible software developers, the respective responsible persons for the technology of the subsystems Maglev vehicle, guideway, drive and operations control system were incorporated from the very beginning into the build-up of the Maintenance Management System and the appropriate organisation.

1.2.2 Emergency-Procedures and Training

Figure 5 : Emergency Training

In order to obtain the operating approval for the participation of passengers in the test operations, it had been necessary at TVE also to prepare and introduce processes and training procedures for emergencies. Included here are, among other things, the almost impossible, namely to be optimally prepared for a fire in a passenger section of the Maglev vehicle and to evacuate as quickly as possible the passengers on board with the help of the board personnel.

The emergency procedures developed and tested at TVE were transferable directly with only minor adoptions to the Maglev

.

project conditions in Shanghai and formed the basis, among other things, for the first operation runs with passengers. As part of the consultancy activities for the German Maglev consortium, these procedures were compiled by an Operations Director of the test facility, trained with on-board personnel of the operator in Shanghai and then introduced.

Particular value was placed thereby, besides on the correct handling of the techncial resources (Figure 5), also on the effective interaction of the operational staff involved in the Maglev vehicle and in the control centre.

1.3 Verification of System Parameters

Among other things undertaken at the test facility for the securing of the licensing approval, methods for the metrological verification of safety and environmentally relevant system parameters were developed [4]. During commissioning of three generations of Maglev technology, the methods and tools required for this could be continuously optimised and were available at short notice, qualitatively secured, for direct application in the Maglev project in Shanghai.
During commissioning in Shanghai, both the sound emission and also the riding comfort were examined and verified under differing operating conditions by the metrology teams from the test facility with comprehensive measurements made.
It is particularly to be emphasised in this connection that the metrological verification of the aerodynamic pressure conditions when vehicles pass each other at high speed had to be performed. Practical experience of the passing-by of trains has not existed at the test facility to date due to the single guideway.
The pressure values to be expected and specified in an actual passing-by of trains were based therefore, to a large extent, on theoretical observations and fundamental practical tests at TVE as part of a Maglev vehicle passing a stationary measurement wall. The tested and quality-assured metrological methods in this conjunction from TVE were used in Shanghai for a stepwise release of high-speed passings of trains and prepared, performed and documented in the practical application by the experienced TVE members of staff The measurement results showed no relevant deviation from the theoretical assumptions and formed the basis for the rapid processing of all release and approval procedures necessary in the safety segment .

1.4 Additional Systems and Procedures

Supplementary resources and procedures were developed and optimised by the TVE team, which do not belong to the standard delivery scope of the main systems Maglev vehicle, guideway, propulsion and operations control, but however in the sense of a safe and reliable operational process, in particular, under the boundary conditions necessary for commissioning.
In the following, the additional equipment used in the Shanghai Maglev project, developed and delivered by TVE, is to be described briefly.

1.4.1 Mobile Power Supply

Figure 6 : Mobile Power Supply for Maglev Vehicle

In regular operation, the Maglev vehicle is supplied with power during a run via its own on-board linear generators or when standing at the projected stops via power rails and collectors. For short stops on the open route outside the power rail sector the energy reserves in on-board batteries can called on for a limited period of time.
If the energy reserves of the on-board batteries are used up at a stop outside the power rail sector, these have to be re-charged at the respective stop of the Maglev vehicle by means of a mobile power supply before the journey can be continued.

For this purpose, a mobile motor generator set was developed for use at TVE, which can be transported on a special wheeled vehicle via the guideway to the stopped Maglev vehicle. As there is a service road along the whole guideway in the Shanghai project, the mobile power supply was adapted for transport on a standard lorry and used in Shanghai in that way.
Thus precautionary measures were taken for the almost impossible case in normal operations and specifically, during commissioning with even more restricted availability of the technical subsystems, the extraordinary case of a loss of energy on the open guideway was made controllable.

1.4.2 Guideway Monitoring System

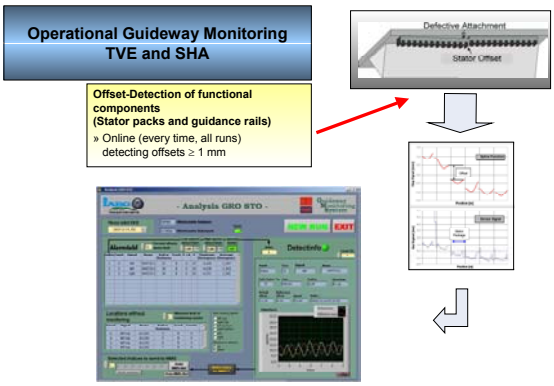

Figure 7 : Guideway Monitoring System

For the test facility, a measurement system integrated into the Maglev vehicle was developed and perfected, with which it is possible to identify geometry deviations in the stator plane and the guidance rails of the guideway with great precision during regular operations (Figure 7). Deviations at the guideway are thus identifiable without the time-consuming use of additionally special inspection or measurement vehicles during running passenger operations.
The diagnosis reports of the Guideway Monitoring System [3] are taken as the basis for the maintenance of the guideway.

The TVE Guideway Monitoring System was adapted to the special requirements of the Shanghai Maglev project and is used successfully in commercial passenger operations as an important diagnosis resource.

1.4.3 Driving with GPS- Support

For the special boundary conditions for commissioning, the procedures developed at the test facility for driving under the responsibility of the personnel were transferred to the operations in Shanghai. The procedure is based on controlling the respective actual speed at defined reference points by the train driver. For this the train driver requires free visibility at marked or prominent points along the route. Thus, initially, only operations in good visibility and in daylight were permissible. In order to be able to continue operating under the responsibility of the personnel, in poor visibility or in the dark during commissioning, a procedure was tested using the Global Positioning System (GPS) and introduced in Shanghai for the commissioning phase.
The Maglev location and speed are displayed to the train driver in a lucid manner by means of a correspondingly configured GPS. The information on location and speed are derived from diverse sources, namely from the vehicle tracking system and the GPS and an error disclosure is thus given at all times in the safety sense when driving under the responsibility of personnel without external visibility.

2. Appraisal and Consulting

The responsibility for operational safety and for maintenance at TVE always lay uniquely in the past 20 years in the hands of an IABG Operations Director named by the licensing authorities. The close cooperation between licensing approval and expert appraisers in all safety questions and in the structuring and further development of the regulations for operations and maintenance belonged to the daily tasks of

the Operations Director and the TVE team. Also this experience was used in the Shanghai Maglev project and corresponding experienced TVE members of staff were involved if required or were consulted concerning the safety appraisal process and in the finding of solutions for commissioning-caused special techncial problems.

3. Prospects

The experience of the TVE test team and its practical inclusion in the Shanghai Maglev project were an important contribution for the safe operation of the system under the conditions existing for a dynamic commissioning process and for the final licensing for commercial passenger transport.
The TVE team is ready to participate actively in the planning and commissioning of further Transrapid systems at home and abroad.
The Maglev test facility in Emsland can continue to be used sensibly for the intensive testing of new and optimised technical Maglev technology components and systems and thus continues to make a contribution to the minimisation of risk and achieve planning safety in future application projects.

4. References

[1] Metzner, J.
The Transrapid Testfacility
Testbench for Safety-Standards in Commercial Operation
Maglev 2000

[2] Metzner J.
The Transrapid Test Facility
From Components Testing to System Operation
Maglev 1998

[3] Nieters W., Snieders G., Rande H.G.
Guideway Monitoring Systems for the High-Speed Maglev Train Transport
Maglev 2000

[4] Wolters C., Schmitz K.P.
Verification of Environmental Compatibility of TRANSRAPID
Maglev 1998