

Safety Assessment & Approval System of Shanghai Maglev Demonstration Line and its Practice

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Abstract:

The safety assessment & approval work of Shanghai Maglev Demonstration Line has basically come to an end. The paper summarizes the system and practice of the safety assessment & approval of the Shanghai Maglev Line. First the paper summaries the safety assessment & approval system for maglev transportation in 4 respects, i.e. the concept of safety assessment & approval, the basic methods and flow of the third-party safety assessment, the contents of government safety approval and the flow of safety assessment and safety approval. Finally it describes the practice of the safety assessment & approval of Shanghai Maglev Line, including organizational structure, safety assessment, safety approval and the international cooperation in the work.

From the very beginning of the construction of Shanghai Maglev Demonstration Line, on the basis of “taking human-being as the foundation” and “being highly responsible for people’s life and property and maintaining the national benefit”, Shanghai High-Speed Transrapid Project Construction Headquarters(hereinafter referred to as SHTPCH in short), Shanghai Maglev Transportation Development Co., Ltd. (SMTDC in short) and National Maglev Transportation Engineering R & D Center (NMTC in short) introduced the advanced European concept. In the light of international prevailing rule, the safety assessment & approval work was carried out actively for the first commercial operation line of maglev in the world and a set of safety assessment & approval system for maglev transportation was established gradually. The safety assessment & approval obtained the active cooperation of the supplier – the German Consortium for Shanghai Maglev Project (hereinafter called CONS in short) and the forceful support of the Chinese and German governments.

1. System of Safety Assessment & Approval for Maglev Transportation

1.1 Concept of Safety assessment & approval

In accordance with the summary of the practice of Shanghai Maglev Demonstration Line, the safety assessment & approval for maglev transportation is the abbreviation of third-party safety assessment and the government safety approval. The third-party safety assessment means that a third-party

assessment organization or expert that is independent of supplier and user and has been recognized by the approval authority makes assessment of system/subsystem/products and make a judgment they conform with the specified safety requirements by means of document inspection and on-site inspection. The government safety approval refers to that on the basis of the third-party safety assessment, the approval authority makes a strict review of the system/subsystem/products and see if they are up to the safety requirements before it gives an approval of the system and put it into (trial) operation with passengers. The so-called conformity to specified safety requirements refers to the conformity of specified safety requirements of relevant laws, rules and regulations, generally accepted technical standards or the state of arts as well as the Safety Concept of a specific engineering project.

1.2 Basic Methods and Flow of the Third-party Safety Assessment

1.2.1 Basic Methods

The basic methods of the third-party safety assessment are the document inspection and on-site inspection.

Document inspection refers to that the assessment expert checks the proof documents produced by suppliers' safety verification. Generally, the inspection is done in two fields: the first is to use the inspection list to inspect the formation of documents (including document identification, document structure and format); the second is to adopt a problem list to check the contents of a document according to the following criteria.

- Validity
The given information must be free from errors.
- Completeness
The given information must cover all aspects to be taken into consideration.
- Unambiguity
All definitions of terms, statements and descriptions must be unambiguous.
- Consistency
All statements and descriptions must be consistent to the document itself and in relation to other documents. Terms must be used uniformly according to their definitions.
- Inspectability
Sufficient information must be given in a clearly organized way. The inspectability is influenced by readability, scale, clarity, complexity and the contents.
- Comprehensibility
The comprehensibility is determined by a concise description of facts and relationships and a precise/uniform definition of terms.

On-site inspection generally includes the witnessing of the verification tests, visual inspections and functional tests.

The basic methods of the above safety assessment are shown as Fig. 1:

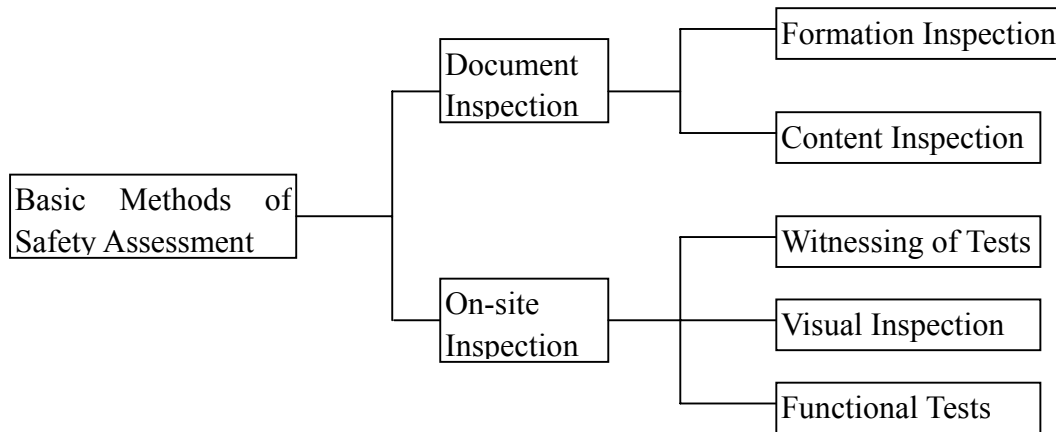


Fig. 1 Basic Methods for Safety Assessment

1.2.2 Basic Flow

The basic flow of the third-party assessment is “supplier safety verification – the third-party safety assessment – rectification and correction by supplier according to assessment comments – re-assessment by the third-party” which accompanies the entire process of research, development, manufacture and commissioning of system/subsystems/products, as shown in Fig. 2. By means of the repeated and cyclic working flow or mode, a lot of safety problems or hidden faults are found and solved.

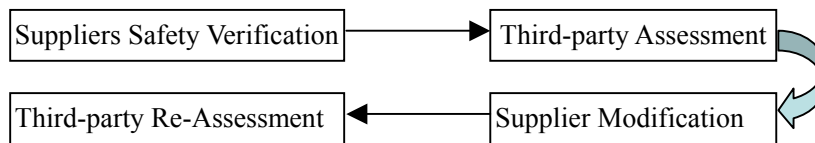


Fig. 2 Basic Flow for Safety Assessment

1.3 Contents of Government safety approval

Main contents of government safety approval include the following:

- Examine and recognize the qualification of the third-party assessment organization /experts;
- Check and evaluate on site the work of assessment experts;
- Witness or participate the tests related to safety;
- Examine the expert reports;
- Request experts to answer or explain problems in the reports;
- Request suppliers to answer questions and provide proof documents for examination;
- Supervise suppliers to make rectification according to the comments of assessment experts;
- Supervise suppliers and/or operator to compile Safety Concept and Rules & Regulations for Operation and Maintenance and update them continually;
- Supervise suppliers and/or operator to do the system safety verification , etc.;
- Safety approval for (trial) operation with passengers.

1.4 Work Flow of Safety assessment & approval

In accordance with the practice of safety assessment & approval of Shanghai Maglev Line, the work flow of the safety assessment & approval for maglev transportation is shown in Fig. 3.

In Fig. 3, the “overall system hazard analysis” and the “proof of safety measures” comprise the Safety Concept of an engineering project. It can be seen from Fig. 3 that the safety assessment of maglev transportation begins from system – overall system hazard analysis and the third-party assessment and ends at the system – proof of safety measures, system safety verification and the third-party assessment.

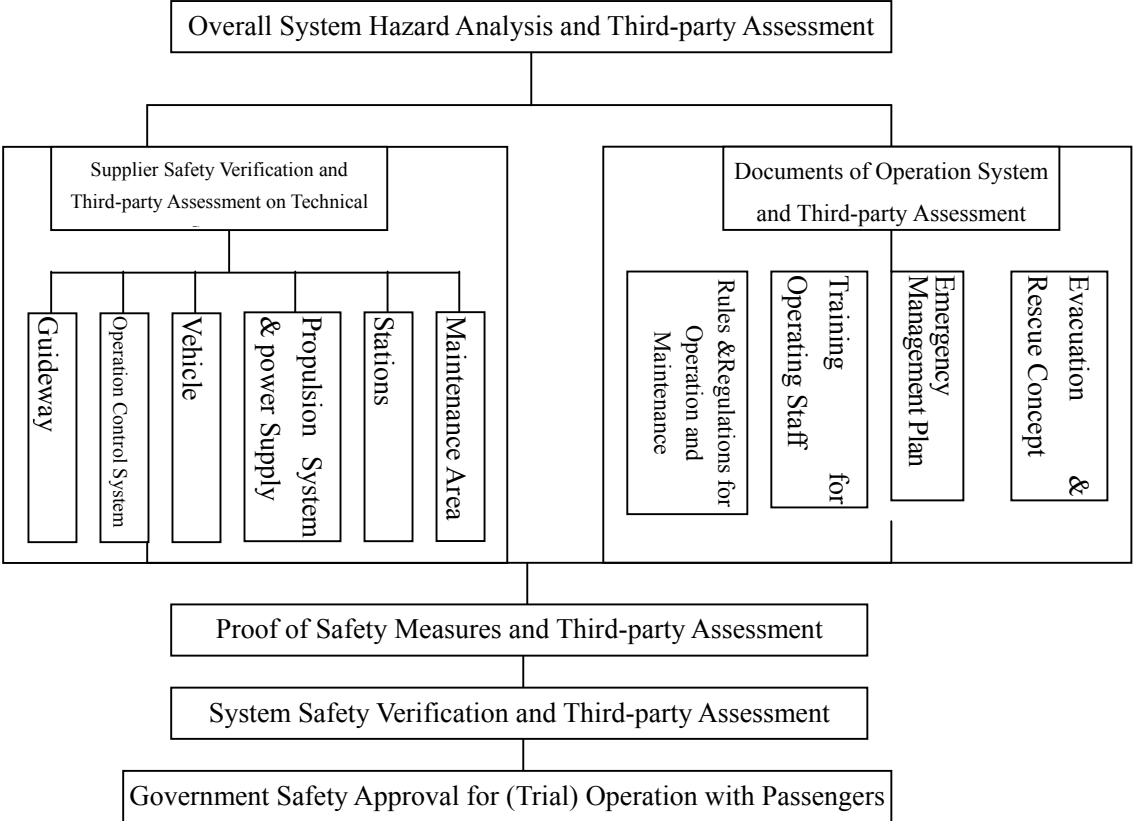


Fig. 3 Work Flow of Safety Assessment & Approval for Maglev Transportation

2. Practice of Safety Assessment & Approval for Shanghai Maglev Line

2.1 Organization Structure

The safety assessment work was organized and coordinated by the NMTC, a third-party organization recognized by SHTPCH. Inside NMTC, safety assessors of the guideway Research Department, the Operation Control Research Department, the Vehicle Research Department, the Propulsion & Power Supply Department and the Operation & Maintenance Research Department are organized by the Safety Assessment Center to form an assessment team. Besides, a number of third-party assessment organizations and experts recognized by the Federal Railway Authority (Eisenbahn-Bundesamt, EBA) of Germany – the supervision and approval organ of German Maglev Line – were invited to participate the safety assessment work of Shanghai Maglev Line.

The work of safety approval of Shanghai Maglev Line was done by SHTPCH – the approval authority authorized by Shanghai municipal government, while assistance was rendered by EBA, an advisor of

SHTPCH for the approval under the frame of cooperation in the maglev area between the governments of China and Germany.

Refer to Fig. 4 for the detailed organization structure of the safety assessment & approval of Shanghai Maglev Line.

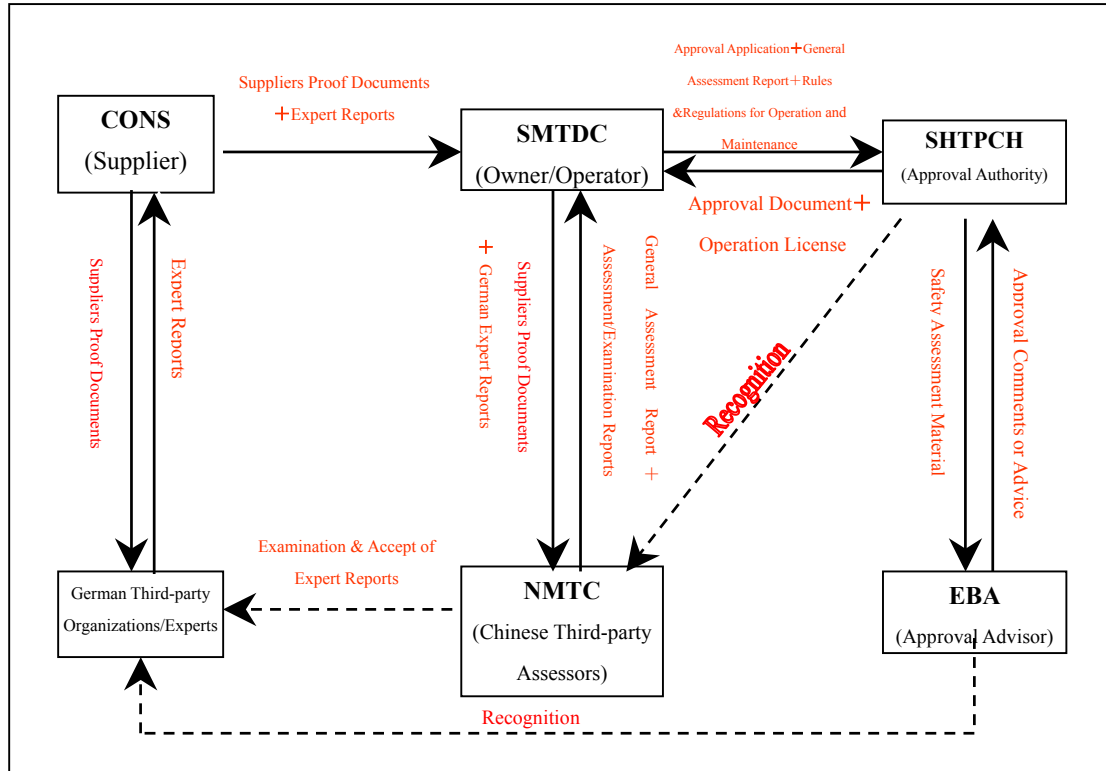


Fig. 4 Organization Structure for Safety Assessment & Approval of Shanghai Maglev Line

2.2 Overview of Safety Assessment

Refer to Fig. 3. The safety assessment of Shanghai Maglev Line is divided into 4 parts, the safety assessment of the Safety Concept, the safety assessment of the technical system, the safety assessment of the operation system and the safety assessment of system safety verification. Among the four parts, at the system level, the assessment of Safety Concept and the assessment of system safety verification were jointly done by NMTc and German third-party organizations/experts. In the technical system, the safety assessment of stations, the maintenance area and the guideway structure were done by NMTc. The safety assessment of rest subsystems and the operation system were done by German third-party assessment organization/experts first, and then NMTc made examination and accept of the German expert reports.

2.2.1 Assessment of Safety Concept

The Conception of Safety Concept comes from German Maglev Law “Verordnung über den Bau und Betrieb der Magnetschwebbahnen (MbBO)”. The core is the risk analysis and safety measures. The Safety Concept of Shanghai Maglev Line was jointly compiled by CONS and SMTDC. Documents include 3 parts, the safety procedure, overall system hazard analysis and proof of safety measures. The Safety Concept is an overall concept to guarantee the whole system.

The second part “overall system hazard analysis” is the hazard analysis of the whole system of Shanghai Maglev Line according to prevailing international standards (EN50126).

The third part “proof of safety measures” includes hazard resolution sheets pin-pointing to each item of safety measures. The sheet lists the corresponding hazards, giving out the list of supplier proof document and expert reports concerning the safety measure.

The assessment expert adopts mainly the method of document inspection to make assessment of the three parts of Safety Concept, including inspection the completeness of hazard analysis, the correctness and effectiveness of safety measures. Based on the comments of experts, the Safety Concept has been revised and updated several times.

2.2.2 Safety Assessment of the Technical System

Safety assessment of the technical system is composed of the following 3 cases:

(1) Being assessed as a new system, e.g. the Operation Control System (OCS), Propulsion and Power Supply System (PPS) and the Guideway Structure. Take OCS as an example, system composition structure and function requirements being considered comprehensively, OCS is broken down to 15 working packages for assessment. See Fig. 5 for details.

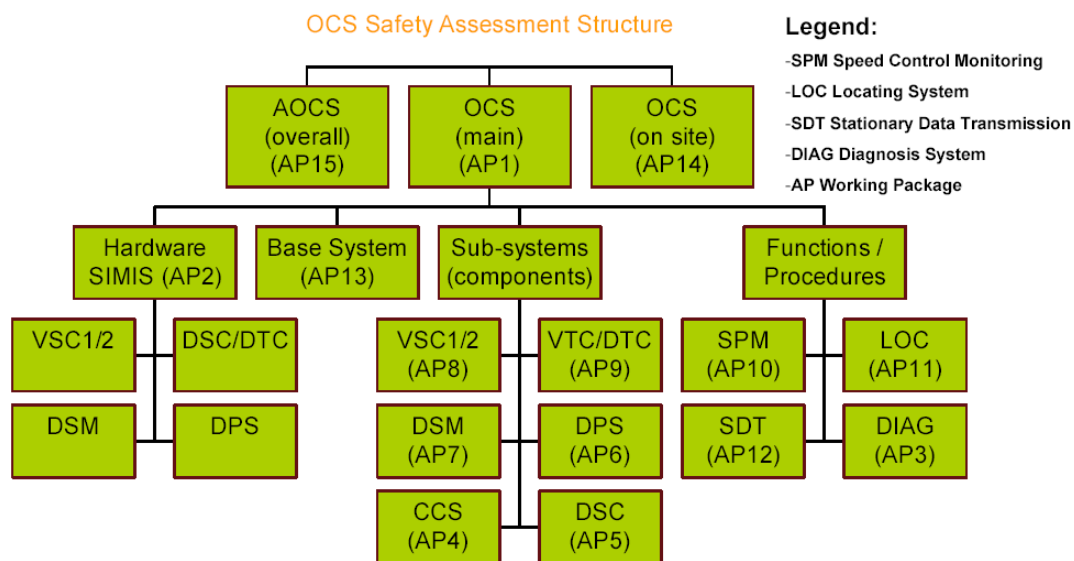


Fig. 5 OCS Safety Assessment Structure

(2) Make supplementary assessment on the basis of German Type Approval. This mainly refers to Vehicle, Guideway Switch, and Long Stator. They have already passed the type certification in Germany and have obtained the “Assurance for Type Approval” issued by EBA. Moreover, the supplier (TKT-TR) provided SMTDC the Declaration of Conformity. Therefore, the supplementary safety assessment of Vehicle, Guideway Switch, and Long Stator of Shanghai Maglev Line is first to fulfill those stipulations related with Shanghai Project in the “Assurance for Type Approval” of the a.m. three subsystems. The second is to assess the safety influence caused by the design modifications of the a.m. three subsystems in Shanghai Project.

(3) Safety Assessment of Conventional Civil Facilities, including stations and the Maintenance Area.

2.2.3 Safety Assessment of Operation System

Here operation system is defined as far as the Rules & Regulations for Operation and Maintenance, the Emergency Management Plan (EMP), Evacuation and Rescue Concept (ERC) and the Training for Operating Staff. As the operation safety is concerned, the operation system has equal importance as the technical systems. In safety assessment of Shanghai Maglev Line, all the four parts of the operation system were assessed. For example, in the assessment of the training for operating staff, the assessment experts gave their assessment statements respectively concerning the qualification of trainers, trainees, language exchange, training methodology, training organization and environment, training plan, training documents and training courses etc. According to expert's statement, the Rules & Regulations, EMP, ERC were amended and updated several times. And the training for operating staff was also adjusted and perfected.

2.2.4 Assessment of System Safety Verification

The system safety verification and assessment means the verification and assessment of the safety of the overall system on the basis of the above-mentioned safety verification of the supplier and the third-party assessment so as to provide recommendations to the approval authority for granting a license for the (trial) operation with passengers. There is rare experience in this respect in the world up to now. The system safety verification of the double-track circulation trial operation with passengers of Shanghai Maglev Line comprises two steps, i.e.

(1) Document Inspection

All the safety related conditions or open points given by the expert reports on Safety Concept, technical system and operation system were listed and examined item by item to see whether they had been either satisfied or solved.

(2) On-site Inspection

It comprises visual inspection and functional tests, totaling 22 activities, such as short-circuit winding braking functional test, interaction Guideway-Vehicle test, eddy-current brake test etc.

The assessment experts assessed the system safety verification plan, process and report. In the conclusion of the experts' report 73 restrictions and 9 remarks and recommendations were put forward with regard to the issuance of a trial operation license by SHTPCH. It should be pointed out that a.m. restrictions had taken into account almost all safety-related conditions or open points which remained unsatisfied or unsolved in the expert reports on the Safety Concept, the technical system and operation system.

2.3 Brief Account of Safety Approval

Based on the large number of daily approval work as described in section 1.3, SHTPCH conducted the safety approval of single-track trial operation with passengers and double-track circulation trial operation with passengers respectively at the end of December, 2002 and at the end of December, 2003 and issued to SMTDC the approval document and the license for trial operation with passengers. The approval also stipulated the restrictions that operation must observe (mainly originated from the assessment report on system safety verification). The operation license for double-track circulation

trial operation with passengers is shown in Fig. 6. SHTPCH will conduct the safety approval for commercial operation of Shanghai Maglev Line by the end of 2004.

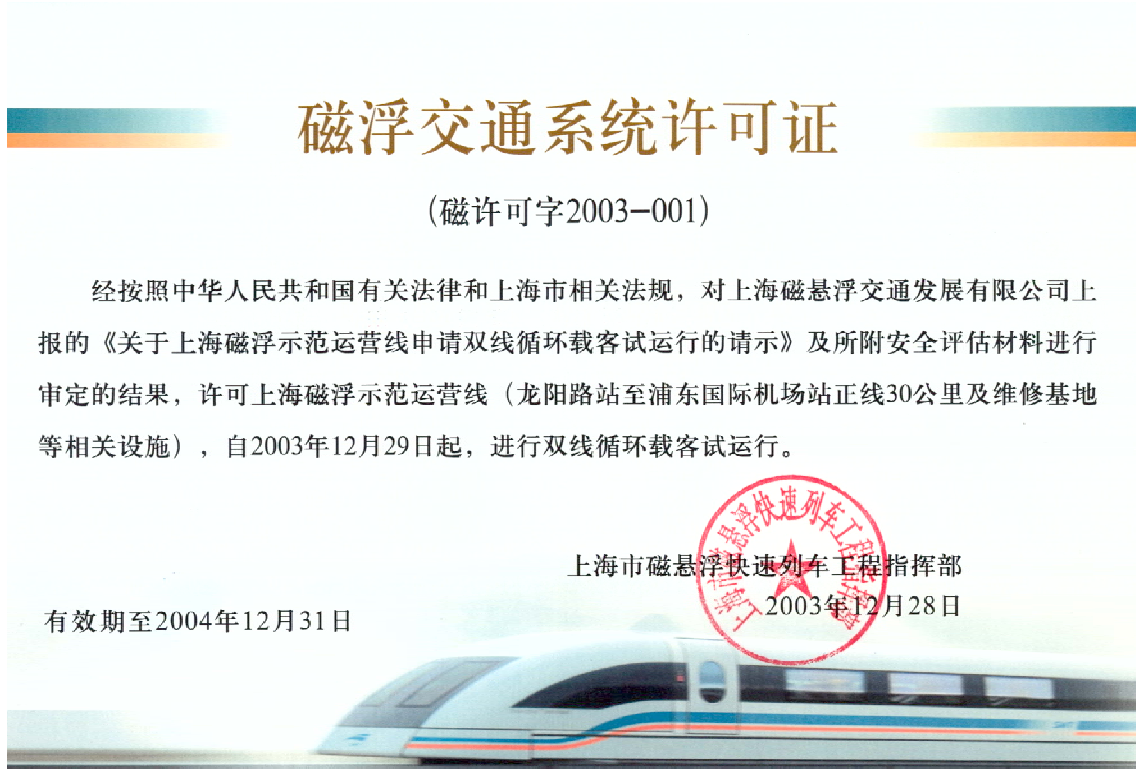


Fig. 6 Operation license for double-track circulation trial operation with passengers

2.4 International Cooperation on the Safety assessment & approval of Shanghai Maglev Line

The successful construction and putting into operation of the Shanghai Maglev Demonstration Line is the fruit of Sino-German cooperation. In the course of the safety assessment & approval, extensive cooperation was performed at various levels between the enterprises, assessors and governments of the two countries.

At the level of enterprises, SMTDC and CONS jointly carried out large quantities of safety verification work in accordance with the requirement of the safety assessment & approval and provided a large amount of proof documents required by the safety assessment & approval (according to preliminary statistics, a total of over 800 documents, including the proof documents for the purpose of German Type Approval and the safety certificates for the general purpose products with OCS and PPS).

At the level of assessors, NMTC and German third-party organizations /experts cooperated in the assessment work and generated a large number of expert reports (according to preliminary statistics, a total of more than 400 reports, including the reports for German Type Approval).

At the level of governments, in June, 2002 the Ministry of Science and Technology of China and the Ministry of Transportation of Germany listed the safety approval of Shanghai Maglev Project as the first specific cooperative project under the framework of cooperation between the two governments in the field of Maglev Technology, the subject of which was to let EBA provide SHTPCH with support and consultancy in safety assessment & approval of the Shanghai Maglev by making use of its professional advantage and experience accumulated in the course of approval of Berlin - Hamburg Transrapid Project. Both parties performed highly effective cooperation in about two years that followed it. EBA assisted in examining a batch of safety assessment material. Project Manager Maglev of EBA came to Shanghai respectively in mid-December 2002 and mid-December of 2003 to support SHTPCH with the safety approval of trial operation with passengers. The final written approval comments given by he becomes the important basis for the issuance of the two licenses for trial operation.

3. Conclusion

The safety assessment & approval of Shanghai Maglev Demonstration Line is the first complete safety assessment & approval of a commercial operation line of maglev in the world and the first complete safety assessment & approval of a big transportation project in China. The system and practice of the safety assessment & approval of Shanghai Maglev Line has a creative significance and is also an example of Sino-German cooperation. The safety assessment & approval of Shanghai Maglev Line played an important role in guaranteeing the safety of the line. From the start of trial operation at the end of 2002 to the end of July, 2004, the safe operation days of Shanghai Maglev Line amounted to 580, the trains have covered a total distance 0.96 million km and carried passengers totaling 1.25 million passengers and not a single accident affecting safe operation has occurred in the period. We believe that the safety assessment & approval system of Shanghai Maglev Line will find better applications in new maglev projects in the future.