Safety Management of Maglev Transportation Focusing on Risk Identification & Control

Dr. Wu Tao
Shanghai Maglev Transportation Engineering R&D Center, Shanghai, China

ABSTRACT: On the basis of practice of safety management over the past ten years since construction and operation of Shanghai Maglev Demonstration Line, the paper puts forward that safety management of maglev transportation should focus on risk identification and control, which should be carried out throughout of the life cycle of Maglev application project. In the prophase of the project, the importance should be laid upon risk identification and safety measure establishment. During the construction phase, the priority should be on realizing safety measures. Coming to the operation period, maintaining and improving the existing safety measures as well as identifying the new risks and building corresponding safety measures should be on the top priority.

1 WHAT'S RISK IDENTIFICATION AND CONTROL?

1.1 Concept of Safety, Hazard and Risk

a) Safety: Freedom from unacceptable risk of harm.
b) Hazard: A physical situation with a potential for human injury.
c) Risk: The probable rate of occurrence of a hazard causing harm and the degree of severity of the harm.

1.2 Risk Identification Method

Step 1: Identify all possible hazards to the system;
Step 2: Analyze and estimate the possibility of occurrence of hazardous events, and then decide the category of frequency of occurrence of hazardous events;
Step 3: Analyze and estimate the likely impact of hazardous events, and then decide hazard severity level;
Step 4: Evaluate the risk by combining the frequency of occurrence of a hazardous event with the severity of its consequence by means of "frequency-consequence" matrix, and then decide the category of risk.

1.3 Risk Control Approach

Safety measures which are researched and built include:

a) Prevention measures: to eliminate or lower the probability of occurrence of hazardous events.
b) Protection measures: to lower the severity of the consequence of hazardous events.

2 HOW TO PERFORM THE SAFETY MANAGEMENT OF MAGLEV TRANSPORTATION FOCUSING ON RISK IDENTIFICATION AND CONTROL? – TAKING SHANGHAI MAGLEV DEMONSTRATION LINE AS EXAMPLE

2.1 Prophase of the Project

2.1.1 Risk Identification

We identified almost all possible hazards to the system of Shanghai Maglev Demonstration Line by means of absorbing experience of experts, using experience of other transportation projects for reference and discussing by "brain storm". At system level the hazards were decomposed to fourteen categories as followings:

a) fire ;

b) explosion；
c) impact/collision;
d) falling;
e) tripping and slipping;
f) electric shock;
g) asphyxiation/poisoning;
h) heat;
i) pressure system;
j) non-lonizing radiation and electro-magnetic interference (EMI);
k) structure failure;
l) earthquake;
m) violent storm or hurricane;
n) Flooding.

The fourteen categories of hazards were decomposed two times according to the cause or situation. Finally more than one hundred and seventy small categories of hazards were identified. For example, "impact/collision" was firstly decomposed to twelve categories, such as collision of vehicle with other vehicle, impact with or due to switch, over passing end of guideway, impacts in station, collision of persons inside vehicle, collision with guideway, collision of vehicle with obstacles etc... Among them the cause of "collision of vehicle with other vehicle" was decomposed further to six small categories as following:

a) loss of operation control system (OCS) control;
b) loss of braking capability of vehicle;
c) incorrect location of OCS;
d) incorrect location input of vehicle;
e) incorrect conduct of operations or maintenance staff under maintenance operation mode;
f) Propulsion fault or loss of propulsion control.

2.1.2 Establishment of Safety Measures

Safety measures mainly include technical measures, i.e. safety technical requirements of system/sub-system/equipment, and operation management measures, mainly including Rules & Regulations for Operation, Rules & Regulations for Maintenance.

Firstly technical safety measures shall be established to eliminate or lower the probability of occurrence of hazardous events, or lower the severity of the consequence of hazardous events. Such as:

a) design of vehicle in accordance with German Standard DIN5510 level 4;
b) safety control of battery onboard ventilation;
c) train and route protection function of OCS;
d) safe propulsion shut-off；
e) short circuit winding at the end of tracks;
f) door control release function of OCS;
g) measures against falling, tripping and slipping at platform;
h) design of vehicle in accordance with relevant standards for EMC, earthing and lightning protection;
i) no poisoning materials in vehicle;
j) field strength of vehicle equipments below international limits;
k) structural parts of vehicle body according to specified loads and safety requirements;
l) design of guideway structure against 7 degree of earthquake;
m) consideration of historical maximum wind speed in Shanghai area in design of guideway structure;
n) Design of drainage system of stations according to related Chinese standard.

Secondly in case risk level of a certain hazard is still comparatively high after technical safety measures have been considered operation management measures shall be established to make further reduction of the risk level. For example, the following requirements were stipulated in Rules & Regulations for Operation:

a) switch off in case of failures of the equipment under the floor of vehicle;
b) check passenger baggage at station;
c) interrupt operation of one track during evacuation on another track in case of emergency;
d) during evacuation the vehicle door shall be opened only when the escape tube is in the right position;
e) during evacuation the operation control center shall switch off the power supply of related power rail, staff on site shall additionally earth the power rail as soon as possible;
f) Interrupt operation while specified wind speed limit exceeded.

The analysis and establishment for the technical safety measures is a "top-down" phase. Firstly the technical safety measures shall be established for each hazard at system level. Secondly the technical safety measures at system level shall be decomposed to the corresponding sub-systems, and then the technical safety measures at sub-system level are established. Lastly the technical safety measures at

sub-system level shall be decomposed to the corresponding equipments, and then the technical safety measures at equipment level are established.

2.2 Construction Phase

2.2.1 Realization of Safety Measures

It is the responsibility of the supplier/manufacturer of system/sub-system/equipment to establish and realize the safety measures.

It is vital for establishment and realization of the safety measures that the supplier/manufacturer insures the standardization of the manufacture. Standardization here means that the procedure of manufacture must be strictly abided by and the technical standards of system /sub-system/equipment shall be established at the beginning of the manufacture.

2.2.2 Check of the Realization of Safety Measures

The check of the realization of safety measures includes four aspects as following:

a) safety verification of the first party (supplier/manufacturer);
b) safety acceptance of the second party (user);
c) safety assessment of the third party;
d) Safety approval of the authority.

Safety verification of the first party is one link of the procedure of manufacture. It includes calculation, test and review etc...

Safety assessment of the third party shall be carried out through out prophase, construction period and operation period of the project.

The frame of safety approval of the authority includes the type approval of the special products of maglev, the approval of the batch process and application of such products and the commercial operation of system/sub-system of maglev.

The relation of the four aspects above-mentioned can be described as following:

a) The four aspects all belong to conformity assessment in nature. The purposes of them are all to assess the safety of the objects. The bases of them are all safety measures (safety requirements).
b) Safety verification of the supplier/manufacturer holds the main workload of the check.
c) Safety assessment of the third party is executed by independent experts authorized by the authority. The experts carry out the safety assessment in the parallel with check of the safety verification of the supplier/manufacturer. Safety assessment of the third party represents the interests of the public and is authoritative, equitable and real-time.
d) Safety approval of the authority is mainly on the basis of the result of safety assessment of the third party.

2.3 Operation Period

2.3.1 Maintenance and Improvement of the Existing Safety Measures

The main means of maintenance and improvement of the existing safety measures include safety check, analysis of accidents/incidents, safety education and training, safety reform.

The following are two cases from Shanghai Maglev Demonstration Line:

a) We improved the safety measures against the equipments stolen by the thefts who enter the maglev area, including the installation of monitor, introduction of the police dog and reinforcement of patrol etc...
b) We installed the removable railing at the position on platform in front of the vehicle door against the falling of passengers to guideway from platform.

2.3.2 Identification of New Risk and Establishment and Realization of Corresponding Safety Measures

The main means of identification of new risk and establishment and realization of corresponding safety measures include safety check, analysis of accidents/incidents, safety education and training, safety reform.

The following are two cases from Shanghai Maglev Demonstration Line:

a) We identified the new risk that the operation is impacted by the fall of insulation or earthing of the brake resistor in substation or transformer station under violent storm. The window blinds were installed later.
b) We identified the new risk that the operation is impacted by the interruption of the cables because of the bite of mice. The measures of killing mice

were taken later.

3 CONCLUSION

a) Safety management of maglev transportation should focus on risk identification and control. It will help to grasp the train of thought and the emphases of work.

b) Risk identification and control should be carried out throughout of the life cycle of Maglev application project.

- In the prophase of the project, the importance should be laid upon risk identification and safety measure establishment.
- During the construction phase, the priority should be on realizing safety measures.
- Coming to the operation period, maintaining and improving the existing safety measures as well as identifying the new risks and building corresponding safety measures should be on the top priority.

4 REFERENCE

– *EN 50126 1999 Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)*
– *EN 50129 2003 Railway applications – Communication, signalling and processing systems – Safety related electronic systems for signalling*