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WORKSHOP ON SAFETY RESEARCH RELATED TO HIGH-SPEED RAIL AND MAGLEV PASSENGER SYSTEMS

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Workshop on Safety Research Related to High-Speed Rail and Maglev Passenger Systems

Transportation Research Board
Federal Railroad Administration
October 18–20, 1993
Nordic Hills, Illinois

TRANSPORTATION RESEARCH BOARD/NATIONAL RESEARCH COUNCIL

PREFACE

In many areas of the country, potential U.S. applications for high-speed rail and maglev technologies are being considered. The Federal Railroad Administration (FRA) of the U.S. Department of Transportation has statutory responsibility to assure the safe operations of intercity high-speed rail and maglev passenger systems, but its existing regulations govern only conventional systems and do not address many unique features of the more advanced technologies. In April 1991, TRB and FRA jointly sponsored a workshop in St. Louis to identify safety factors related to high-speed rail and maglev that required additional research prior to FRA's development of safety regulations for these new technologies. The research needs identified at this workshop became input for FRA's safety research program and were published in *TR Circular 387*, "Research Problem Statements: Safety Factors Related to High-Speed Rail and Maglev Passenger Systems".

Subsequently, the TRB Committee on Guided Intercity Passenger Transportation distilled the 74 research needs statements from the workshop into 12 major areas upon which FRA's safety research program could focus. These 12 research needs statements were published in full in *TR Circular 417*, "Research Problem Statements: Design and Construction of Transportation Facilities"; a list of the statement titles appears in Appendix A, and several of them are referenced in this report.

On October 18—20, 1993, TRB and FRA cosponsored a second workshop at Nordic Hills, Illinois, to highlight progress made to date in research on safety aspects of high-speed rail and maglev passenger systems. The workshop format provided an opportunity for participants to critique completed and ongoing research, to identify gaps in the research, and to suggest priorities for future research efforts. Workshop discussion groups focused on the following topics: generic high-speed guided ground transportation safety issues; electromagnetic field (EMF) effects; power and braking systems; control systems; and structural and mechanical systems. Each of these topics is covered in a section of this report. References to published reports on completed research and project information on in-progress research are provided.

To retain the sense and spirit of participants' efforts at this workshop, the content of this report reflects no attempt to prioritize or further refine the output of each workshop discussion group. The research problem statements have been as far as possible transferred directly from the notes of the workshop session topic leaders and participants.

The steering committee acknowledges and thanks all the workshop participants for their efforts in preparing these research problem statements. A list of all workshop participants is included in Appendix B.

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PART 1: GENERIC HIGH-SPEED GUIDED GROUND TRANSPORTATION SAFETY ISSUES

Nazih K. Haddad, Session Leader

PRESENTATIONS

Maglev System Concept Definition System Safety Review, *Thomas C. Griego, Booz-Allen & Hamilton, Inc.*

Recommended Emergency Preparedness Guidelines for Passenger Trains, *Stephanie H. Markos, Volpe National Transportation Systems Center*

Collision Avoidance and Accident Survivability, *David Tyrell, Volpe National Transportation Systems Center*

Human Factors and Automation in HSGGT Systems, *Thomas Sheridan, Massachusetts Institute of Technology*

Fire Safety of Passenger Trains, *Stephanie H. Markos*

This first workshop session addressed the generic high-speed guided ground transportation issues that did not fit under any of the other four more specific sessions of the workshop. Several topics under this session related directly to research needs identified as a result of the 1991 Workshop on Safety Factors Related to High-Speed Rail and Maglev Passenger Systems. All the research reported on the above topics was conducted under the direction of the Volpe National Transportation Systems Center.

Critique

The above presentations were well received in the workshop session. Session participants went on to identify several areas requiring further research as detailed in the ten research needs statements below.

MAGLEV SYSTEM SAFETY

The first topic presented and discussed at this session dealt with a study to provide an independent review of the maglev systems safety provision in each of the four maglev system concept definitions (SCD), conducted by Booz-Allen and Hamilton for the Volpe National Transportation Systems Center. This review was directed at determining the extent to which each SCD report addressed the prevention of safety-critical hazards and unsafe conditions. It was also aimed toward finding and recommending ways to minimize the effects of such events if they do occur and investigating the responsiveness to such emergencies. The objective of this study was to ensure that potential safety-critical hazards and unsafe conditions associated with SCDs and other proposed maglev system designs are identified and eliminated early in the development process.

Research Needs

Problem Statement 1

The group identified the following issues as deserving attention: (1) determining the acceptable level of risk associated with HSGGT systems and on what it should be based, (2) determining whether the method of risk assessment for any HSGGT system is any different than that used for a passenger airline, and (3) determining what method should be used to validate that the acceptable level of risk is not exceeded.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Both.

Research Objectives

One objective is to determine the level of risk that is considered acceptable for HSGGT systems and to develop a methodology for measuring and validating risk levels for specific systems. Another objective is to

determine whether the risk assessment of HSGGT should differ from that of other transportation systems (e.g., commercial airlines).

Urgency

Medium to high.

Problem Statement 2

The safety of the levitation, guidance, and braking systems proposed by the four system concept definitions will need to be verified as more design details become available.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Maglev only.

Research Objective

The objective is to conduct a more detailed safety analysis of the maglev system concept definitions during subsequent phases of U.S. maglev development. A failure modes and effects analysis should be performed in parallel with preliminary design and prototype development of safety critical systems (e.g., levitation, guidance, braking, etc.). A thorough analysis performed by an objective third party will contribute significantly to the development of safe and robust designs.

Urgency

Low to medium.

RECOMMENDED EMERGENCY PREPAREDNESS GUIDELINES FOR PASSENGER TRAINS

The second presentation under this generic session covered recommended emergency preparedness guidelines for passenger trains. These guidelines were developed by the Volpe National Transportation Systems Center to provide methods for addressing potential situations. The objective of this effort was to enhance the safety of train passengers and crew members during emergencies. Research Need Statement Problem No. 1 from the St. Louis workshop highlighted the importance of this issue and the need to develop better emergency preparedness procedures that would lead to better emergency response capabilities by operating entities.

Research Needs

Problem Statement

Attention should continue to be directed toward evaluating specific design and operational tradeoffs of new passenger train technologies to ensure an equivalent or better level of safety.

Technology Distinction

Is research needed for high speed rail, maglev, or both?
Both.

Research Objectives

The objectives are as follows:

- Evaluate tilt systems to ensure adequate provisions for emergency egress.
- Establish requirements for speed of egress to ensure the timely evacuation of passengers under all foreseeable conditions.
- Examine and evaluate safety ramifications of elevated structures, tunnels, and guideway/trainway protection (barrier systems).
- Pinpoint alternative ways to evacuate passengers/crew to points of safety for various proposed new technologies.
- Establish emergency preparedness guidelines to cover all possible emergency situations presented by states planning to locate high-speed railways in the median of interstate highways, such as emergency stopping, firefighting, and emergency evacuation onto the highway median.

Urgency

High.

COLLISION AVOIDANCE AND ACCIDENT SURVIVABILITY

The third topic under this session covered collision avoidance and accident survivability. Research Need Statement Problem No. 2 from the St. Louis workshop identified this issue as a high priority one requiring much attention. Previous efforts undertaken by the Volpe National Transportation Systems Center developed a relationship between collision avoidance and accident survivability as well as a methodology for assessing the overall collision safety of guided ground

transportation systems. The further application of this methodology to the Northeast Corridor (NEC) and the Texas TGV system was covered under this presentation.

Research Needs

Problem Statement 1

Because attached equipment may become detached during a collision, interior design aspects of the trains must be considered so as to minimize injury to passengers in the event of a collision. The issue of seat belt requirements also needs to be addressed.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Both.

Research Objective

This objective includes investigating all aspects of passenger trains' interior designs to ensure that injury to passengers from equipment, seats, and other objects is minimized. It is also important to determine if current hardware attachment requirements are adequate and if seat belts would enhance safety on HSGGT.

Urgency

Medium to high.

Problem Statement 2

The appropriateness of the current passenger car's strength and other design requirements when applied to high-speed rail travel requires attention.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
High-speed rail.

Research Objective

The objective is to investigate whether the current passenger train car's strength (i.e., buff loads) and other design requirements are appropriate for high-speed rail. A pertinent research issue would be to determine appropriate loads and the means or methods that will be used to verify them.

Urgency

Medium to high.

Problem Statement 3

The need for full-scale collision tests to validate crushing and survivability models should be addressed.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
High-speed rail.

Research Objective

To validate crushing and survivability prediction models, full-scale collision tests will be required. However, because of the high cost associated with collision testing, this effort should be limited to planning and to assessing the feasibility of such tests at this time. A complete evaluation of the cost of such testing and any economic considerations must be performed.

Related Activities

- All topics under Session IV Safety Workshop; and
- Barrier design between HSGGT and adjoining transportation systems.

Urgency

Medium.

HSGGT HUMAN FACTORS AND AUTOMATION

The fourth presentation under this generic session dealt with human factors and automation in HSGGT systems. The objectives of this effort were to assess human operator versus computer roles and functions in high-speed train operations for both driving and dispatching. This topic relates to Research Statement No. 6 from the St. Louis workshop, which was entitled "Automation Levels and Human Factors Related to High-Speed Rail and Maglev Systems Operations."

Research Needs

This topic deals with the optimal function allocation between human operator (driver and dispatcher) and automated systems in HSGGT. The current investigation focuses mainly on where HSGGT control systems appear on a continuum going from fully manual to fully automated, with special attention given to intermediate steps with computerized driving plus design aides. Specific problem statements are as follows.

Problem Statement 1

An increase in automation often entails a shift of operator duties from active control of the train to passively monitoring the equipment. Human operators, however, are notoriously bad monitors, especially when fatigued.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Both.

Research Objective

The objective is to explore operator adjustment to the monitoring role: focussing on topics such as operator complacency, motivation, alertness, vigilance, sustained attention, and maintenance of situational awareness (keeping the driver in the loop) at different levels of automation. Alternative approaches need to be considered that keep the driver and dispatcher alert and ready to impose supervisory control in automated mode or maintain active human control when appropriate. In both cases, it is desirable to have the machine monitor human alertness.

Urgency

High.

Problem Statement 2

Cumulative or interactive effects of human and system errors can lead to catastrophic situations.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Both.

Research Objective

This objective entails exploring human/automation contingencies and redundancies, and the relative sensitivities of various accident-provoking event chains to human and/or machine error.

Urgency

High.

Problem Statement 3

There is a discrepancy between the human sensory, perceptual, and information processing capabilities, which have a limit, and the ever increasing speeds and braking distances of advance train systems.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Both.

Research Objective

The objective is to explore enhancement of human sensation, perception and processing of information, including how human operators deal with false alarms, sudden and transient increases in information processing demands, and make proper responses to alarms. This involves better integration of information in computer graphics display (instead of requiring the operator to garner information from separate displays and do all the integration mentally). It also requires aids for diagnosing failures, and better means to present appropriate procedures during critical events.

Urgency

High.

FIRE SAFETY OF PASSENGER TRAINS

The fifth issue discussed under this session dealt with passenger train fire safety. The objective of this study effort was to evaluate the different fire protection approaches used by the German and French systems and to provide FRA with the means to continue improvement of fire safety requirements for HSGGT and conventional passenger train systems.

Research Needs

Problem Statement

The existing fire safety requirements for passenger trains are dependent on outdated test methods. Considerable evidence calls into question their ability to predict real-scale fire behavior. System tradeoffs in vehicle design, detection and suppression, and evacuation have not been quantified.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Both.

Research Objective

Validation of the utility of quantitative fire hazard analysis is necessary. The suitability of new test methods must be demonstrated by comparing current materials in bench- and real-scale tests to establish acceptance criteria for heat release rates for passenger trains.

Related Activities

The National Institute of Standards and Technology (NIST) has completed a review of U.S. and foreign approaches to passenger train fire safety. NIST has developed a fire hazard computer model that could be adapted for application to passenger trains.

Urgency

High.

REPORT/PUBLICATION REFERENCES

1. Griego

Safety of High Speed Magnetic Levitation Transportation Systems: U.S. Maglev System Concept Definitions (SCDs)-System Safety Review, David L. Gilles, Wayne L. Gilles, Thomas C. Griego and John M. Simon, Booz-Allen and Hamilton, Inc. and The Canadian Institute of Guided Ground Transport
September 1993
DOT/FRA/ORD-93/22 DOT-VNTSC-FRA-93-11
Limited to U.S. Government use only

This report documents a separate system safety review to supplement the analysis described for each of the four SCD reports to identify any additional safety-critical system hazards and unsafe conditions associated with the respective design and operation of each respective SCD. The report contains a generic set of safety issues and requirements for each type of proposed maglev system design and for maglev in general.

2. Markos

Recommended Emergency Preparedness Guidelines for Passenger Trains, Stephanie H. Markos, Volpe National Transportation Systems Center
December 1993
DOT/FRA/ORD-93/24 DOT-VNTSC-FRA-93-23
NTIS#: PB94-154721/XAB Price: $36.50

The recommended guidelines in this document are intended to assist passenger train system operators to assess, develop, document, and improve their emergency response capabilities and to coordinate these efforts with emergency response organizations in a manner which best protects the traveling public and system passenger trains and facilities. The recommendations also provide a useful framework for these organizations to evaluate and, if necessary, modify or supplement their emergency preparedness plans and procedures, training, and passenger train and facility equipment.

3. Tyrell

Safety of High Speed Guided Ground Transportation Systems: Collision Avoidance and Accident Survivability - Volume I: Collision Threat, Alan J. Bing, Arthur D. Little, Inc.
March 1993
DOT/FRA/ORD-93/02.I DOT-VNTSC-FRA-93-2.I
NTIS#: PB93-205268-LL Price: $27.00

This report is the first of four volumes. This volume provides a discussion of collision scenarios to which a high speed guided ground transportation (HSGGT) system may be exposed, a description of regulations, standards and practices used by foreign railroads and HSGGT systems to protect against the incidence of and consequences of collision and other accidents, and guidelines for collision avoidance and accident survivability.

Safety of High Speed Guided Ground Transportation Systems: Collision Avoidance and Accident Survivability - Volume II: Collision Avoidance, John Harrison, et al, Parsons Brinckerhoff Quade & Douglas, Inc.
March 1993.
DOT/FRA/ORD-93/02.II DOT/VNTSC-FRA-93-2.II
NTIS#: PB93-205276-LL Price: $27.00

This report is concerned with developing safety guidelines and specifications for high speed guided ground transportation (HSGGT) collision avoidance and accident survivability. This volume describes the features of signal and train control systems used in existing high speed rail, conventional rail and mass transit systems and other measures to prevent collisions, such as prevention of right-of-way intrusions.

Safety of High Speed Guided Ground Transportation Systems: Collision Avoidance and Accident Survivability -

Volume III: Accident Survivability, Robert A. Galganski, Calspan Corporation
March 1993
DOT/FRA/ORD-93/02.III DOT-VNTSC-FRA-93-2.III
NTIS#: PB93-205284-LL Price: $27.00

This report is concerned with developing safety guidelines and specifications for high-speed guided ground transportation (HSGGT) collision avoidance and accident survivability. This volume provides a detailed discussion of survivability of HSGGT vehicles and trains.

Safety of High Speed Guided Ground Transportation System: Collision Avoidance and Accident Survivability - Volume IV: Proposed Specifications, Alan J. Bing, Arthur D. Little, Inc.
March 1993
DOT/FRA/ORD-93/02.IV DOT-VNTSC-FRA-93.2IV
NTIS#: PB93-205292-LL Price: $19.50

This report on collision safety is part of a comprehensive effort by the Federal Railroad Administration (FRA) to develop the technical information necessary for regulating the safety of high speed guided ground transportation. This volume provides a detailed specification for HSGGT system collision avoidance and accident survivability.

Safety of High Speed Guided Ground Transportation Systems: Case Studies in Collision Avoidance and Accident Survivability, Foster Miller
Due:

The objective of this work is to compare the collision safety of an existing U.S. passenger rail corridor with the collision safety of the proposed Texas TGV system.

4. Sheridan

Safety of High Speed Guided Ground Transportation Systems: Human Factors and Automation, MIT.
Due: December 1993 - other report dates to be determined.

The objective of this university research support is to study and model the roles of human operators in relation to computer-based automation and safety considerations, both on high speed rail vehicles and at centralized stationary control centers, and including planning, controlling and monitoring in normal operations as well as emergency operations.

5. Markos

Fire Safety of Passenger Trains: A Review of U.S. and Foreign Approaches, R. D. Peacock, R. W. Bukowski, W. J. Jones, P. A. Reneke, V. Babrauskas, and J. E. Brown, National Institute of Standards and Technology (NIST)

December 1993
DOT/FRA/ORD-93/23 DOT-VNTSC-FRA-93-26
NTIS#: Not currently available.

This report presents a detailed comparison of fire safety approaches used for passenger trains in the United States, France and Germany. Strengths and weaknesses of current methods for measuring the fire performance of rail transportation systems are presented. An optimum systems approach to fire safety that addresses typical passenger train fire scenarios is analyzed.

TERMINOLOGY

FRA	Federal Railroad Administration
HSGGT	High-speed guided ground transportation
NEC	Northeast Corridor
NIST	National Institute of Standards and Technology
SCD	System Concept Definition
TGV	Train à Grand Vitesse
TR07	Transrapid 07

PART 2: ELECTROMAGNETIC FIELD EFFECTS

Janie Page Blanchard, Session Leader

PRESENTATIONS

Potential Biological Effects of Electromagnetic Fields Associated with Maglev and Other Mass Transit-Type Rail Systems, *Robert B. Goldberg, Information Ventures*

Broadband Magnetic Fields: Their Possible Role in EMF-Associated Bioeffects, *Bary Wilson, Battelle Pacific Northwest Laboratory*

Maglev Spectrum EMF Exposure Effects on Pineal Indoleamine Metabolism, *Kenneth R. Groh, Argonne National Laboratory*

EMF Measurements on Various Rail Systems, *William E. Feero, Electric Research and Management*

EMF Exposures and Regulatory Overview, *Lynne Gillette, Environmental Protection Agency*

Magnet Safety and Design Studies, *Aviva Brecher, Volpe National Transportation Systems Center*

The projects examined by the EMF group were mostly finished at the time of the meeting, in contrast to the other groups, whose efforts were just being initiated. The breakout group's overall reaction to the completed research was that good characterizations of fields have been developed (except for those associated with electrodynamic system (EDS) systems, and those are expected to be distinctly different from those of TR07). However, a meaningful metric by which to characterize the fields does not yet exist. Consequently, standards and guidelines vary widely and shielding becomes difficult because there is no target at which to aim. Essentially, it appears acceptable to suspend the EMF research for now, although it is hardly completed. Research may need to be resumed when exposure metrics become better defined.

ELECTROMAGNETIC FIELD EFFECTS ISSUES

EMF Key Issues

1. What are the problems?

- Field characterization from rail sources under different operating conditions.
- Targets for reduction of AC and static fields via shielding.

2. Shielding options include the following:

- Spatial,
- Passive shielding,
- Active shielding, and
- Current path control.

3. What are the tradeoffs in cost and system performance?

SOURCE CHARACTERIZATION ISSUES

Systems characterized included the following:

- Transrapid 07 (German maglev with test facility in Emsland),
- TGV (French high-speed rail system),
- Washington, D.C., Metro,
- Boston MBTA,
- Northeast Corridor systems (25 Hz, 60 Hz, non-electric/diesel), and
- New Jersey Transit.

The group reviewed measurements of variations in magnitude and frequency taken as functions of the following: location and speed changes made within passenger cabin at four different heights, within operator

cab, in the control room, in stations, and along the wayside.

Critique

The general consensus of the group was that the magnetic fields from various electrical train systems are sufficiently well characterized and that research to date does not clearly indicate that fields from maglev (TR07) or high-speed rail (TGV) violate any existing standards. However, research on EMF health effects is going on nationally and internationally, in order to resolve which field characteristics may pose a hazard to health and at what levels and duration of exposure.

Research Needs

An electrodynamic system (e.g., Japanese system in Miyazaki) needs to be characterized at the same level as other systems have been characterized, and this is particularly needed if an EDS system is to be built in the United States.

Additionally, EMF research should continue to be monitored, particularly to identify an appropriate exposure metric by which to examine acquired data. As indicated above, we now have a great deal of potentially useful information about a wide variety of systems but no clear metric by which to measure or characterize it in terms of possible biological consequences. If one compares direct current (DC) or alternating current (AC) field levels by individual frequency bins, maglev appears to be little different than other existing electrical transportation systems. However, an alternate metric, such as the ratio of AC to DC field, might yield different conclusions.

Potentially sensitive populations requiring special consideration in or around HSGGT systems need to be identified. (For example, pacemaker wearers may be more vulnerable if the fields cause their equipment to malfunction. There may be other sensitive populations that should be warned or excluded from riding electrified high-speed transportation systems.)

Also, we need to understand whether demonstrated magnetic field influence on melatonin might have impact on operator performance (as a safety issue, not a health issue).

Problem Statement 1

A protocol for obtaining meaningful magnetic field data needs to be established, and representative data should be collected for existing systems on station and wayside magnetic fields, with and without presence of electrified train systems.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Maglev, high-speed rail, and conventional rail.

Research Objective

Earlier source characterizations focussed on fields within the trains. This would continue the analysis by defining a protocol for measuring station and wayside fields caused by the train system. Ultimately, the development of a protocol and a generic database of consistently measured and reported EMF field values would aid in more efficient development of EIS.

Related Activities

Ongoing EIS studies are being conducted in Texas and New England.

Urgency

Moderate.

Problem Statement 2

Magnetic field data should be provided to bio-effects researchers in a more immediately useful form without depending on them to interpret raw data.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
High-speed rail (TGV) and conventional rail (NEC 60 Hz section) are revenue service lines whose data may have epidemiological usefulness.

Research Objective

The objective is to prepare a technical paper to accompany the required electronic data on rail system magnetic fields that describes both the compilation methodology and the form of reported measurement results of concurrent AC and static magnetic fields, as well as how to determine the degree of polarization of the AC fields.

Related Activities

NIOSH may be working on standardization of measurement data from other sources.

Urgency

Moderate to high.

SHIELDING ISSUES

In its discussion of EMF shielding issues on the second day, the group identified several problems:

- It is difficult to translate from textbook examples to real (much more complex) fields.
- Material properties of shields are not well characterized, particularly below 1 Gauss.
- There are many magnetic field sources in any environment, some of which may not be immediately obvious (e.g., underground cables, cables in walls, and proximity to transformers). This can complicate field mapping.

The following general shielding-related needs were identified:

- Need a clear idea of shielding requirements.
- Need a better characterization of shielding materials at low field strengths.

Mitigation: implies something wrong. Reduction: implies threshold. Management: implies goal.

Research Needs

Research is needed to address AC field variations with different operating states of systems and different system environments (urban, rural, suburban, etc.) and how those variations might influence anything associated with the rest of the system or the people in or near the system (the system being either maglev or high-speed rail). Two assumptions apply here:

- Operational profile impacts on critical EMF parameters and
- Power requirements and speed impacts on critical EMF parameters.

All transit systems (maglev, high-speed rail, electrified rail, heavy rail mass transit) seem to have similar EMF characteristics based on the field intensity metric.

Alternate metrics not yet explored but suggested by some EMF researchers as possibly important are as follows: duration of exposure, time of day of exposure, flux density (units: mG), frequency (units: Hz), relative orientation between AC and DC fields and also with respect to body axes, AC/DC ratio, reversibility of effects, chronic vs. acute exposures, thresholds, and temporal variations in fields.

Problem Statement 3

Costs associated with magnetic field management for each type of electrified rail technology need to be characterized.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
If magnetic field management is found to be desirable, either scientifically or politically, it will apply to all transportation.

Research Objective

Detailed analysis of different options to manage magnetic fields associated with different types of rail technology should be undertaken in order to be prepared to answer questions or demands for field reduction or control.

Related Activities

Related activities included EPRI-supported R&D.

Urgency

Moderate to high.

Problem Statement 4

Public pressure may necessitate reducing EMF fields to extremely low values, even under current uncertainty (insufficient knowledge base for rulemaking or design guidance).

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Both.

Research Objective

The objective is to assess different shielding and magnet design options for EMF management and establish the cost/benefits for each.

Related Activities

Studies are being conducted at Electric Power Research Institute (EPRI) and by individual utilities to better understand magnetic field shielding technologies for power stations and power lines.

Urgency

Moderate to high.

Problem Statement 5

Interactions between magnets and dynamic system fields are unknown, especially for superconducting magnets.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Primarily maglev, but also for high-speed rail.

Research Objective

Modeling, verification, and validation of magnetic fields associated with EDS and electromagnetic system (EMS) maglev concepts (DC and AC fields) as used by SCD configurations to understand interactions within systems and assess possible safety implications; understand to what extent field variability is a safety problem; and learn how to better evaluate the cost/effectiveness of field minimization, mitigation, and control.

The work described here is related to research and development (R&D) efforts on electrical power subsystems, propulsion subsystems, ATCS, and all EMI/EMC requirements.

Related Activities

Field interactions within TGV and TR07 are well characterized, but little about HSST and nothing about MLU is known. Some SCD contractors supplied quasi-static analysis of their magnet designs, but this work may need to be extended to provide a more realistic magnetic field picture.

Urgency

Moderate.

REPORT/PUBLICATION REFERENCES

1. Goldberg

Safety of High Speed Guided Ground Transportation Systems: Potential Health Effects of Low Frequency Electromagnetic Fields Due to Maglev and Other Electric Rail Systems, William A. Creasey and Robert B. Goldberg, Information Ventures, Inc.
August 1993
DOT/FRA/ORD-93/31 DOT-VNTSC-FRA-93-18
NTIS#: PB94-121217 Price: $19.50

This report outlines research on the biological and health effects of electric and magnetic field (EMF) most relevant to fields generated by maglev and HSR systems. There are concerns for physical safety associated with equipment operation and high-voltage currents, and for potential adverse health effects on transportation workers and the public from the EMF produce in the Extremely Low Frequency (ELF) range (3-3,000Hz).

Safety of High Speed Guided Ground Transportation Systems: An Overview of Biological Effects and Mechanisms Relevant to EMF Exposures from Mass Transit and Electric Rail Systems, R. B. Goldberg, W. A. Creasey, and K. R. Foster, Information Ventures, Inc.
August 1993
DOT/FRA/ORD-93/32 DOT-VNTSC-FRA-93-19
NTIS#: PB94-128220 Price: $27.00

2. Wilson

Safety of High Speed Guided Ground Transportation Systems: Broadband Magnetic Fields: Their Possible Role in EMF-Associated Bioeffects, Bary Wilson, Russel Reiter, Arthur Pilla, Norbert Hankin, U.S. Environmental Protection Agency
August 1993
DOT/FRA/ORD-93/29 DOT-VNTSC-FRA-93-17
NTIS#: PB94-129780 Price: $36.50

This report reviews electric and magnetic field (EMF) exposures from electrical transportation systems, including electrically powered rail and magnetic levitation (maglev). Material also covered includes research concerning biological effects of EMF exposure, with special emphasis on broad spectrum or broadband magnetic fields.

3. Groh

Safety of High Speed Guided Ground Transportation Systems: The Biological Effects of Maglev Magnetic Field Exposures, Kenneth R. Groh, Argonne National Laboratory
August 1993
DOT/FRA/ORD-93/30 DOT-VNTSC-FRA-93-20
NTIS#: PB94-118593 Price: $19.50

This report describes selected biological effects on transformed human cell lines and on rates from

exposure to simulated maglev magnetic fields (MFs). Maglev-like MF exposures up to 7 times the intensity produced by the TR-07 had no effect on cultured growth of four human cell lines or on chemically induced differentiation compared to control, unexposed cultures. However, other tests suggest that ac component TR-07-like MFs and time-varying EMFs at superconducting maglev intensities produce biological effects, and these results should be further examined.

4. Feero

Safety of High Speed Magnetic Levitation Transportation Systems: Magnetic Field Testing of the TR07 Maglev Vehicle and System - Volume I - Analysis, Fred Dietrich, William E. Feero, Electric Research and Management, Inc.
April 1992
DOT/FRA/ORD-92/09.I DOT-VNTSC-FRA-92-6.I
NTIS#: PB92-224666/HDM Price: $27.00

This volume summarizes the experimental findings of electromagnetic field (EMF) measurements on the Transrapid maglev system and compares the results to common home, work and power lines emissions for selected spectral bands.

Safety of High Speed Magnetic Levitation Transportation Systems: Magnetic Field Testing of the TR07 Maglev Vehicle and System - Volume II - Appendices, Fred Dietrich, David Robertson, George Stein, Electric Research and Management, Inc.,
April 1992
DOT/FRA/ORD-92/09.II DOT-VNTSC-FRA-92-6.II
NTIS#: PB92-224674/HDM Price: $44.50

This volume catalogs and documents detailed magnetic field data files and their specifics (static fields, spectral waveforms, temporal and spatial information) by location for the measurements taken on the Transrapid maglev system.

Safety of High Speed Guided Ground Transportation Systems: Magnetic and Electric Field Testing of the Amtrak Northeast Corridor and New Jersey Transit/North Jersey Coast Line Rail Systems - Volume I: Analysis, Fred M. Dietrich, William E. Feero, Petros N. Papas, George A. Steiner, Electric Research and Management, Inc.
April 1993
DOT/FRA/ORD-93-01-I DOT/VNTSC-FRA-93-4.I
NTIS#: PB93-219434-LL Price: $44.50

This report provides the analysis of results (Vol. I, Analysis) and detailed summaries (Vol. II, Appendices) of representative EMF profiles for Northeast Corridor (NEC) rail technologies, facilities operating conditions and locations.

Safety of High Speed Guided Ground Transportation Systems: Magnetic and Electric Field Testing of the Amtrak Northeast Corridor and New Jersey Transit/North Jersey Coast Line Rail Systems - Volume II: Appendices, Fred M. Dietrich, William L. Jacobs, Electric Research and Management, Inc.
April 1993
DOT/FRA/ORD-93-01-II DOT-VNTSC-FRA-93-4.II
NTIS#: PB93-219442-LL Price: $77.00

This report provides the analysis of results (Vol. I, Analysis) and detailed summaries (Vol. II, Appendices) of representative EMF profiles for NEC rail technologies, facilities operating conditions and locations.

Safety of High Speed Guided Ground Transportation Systems: Magnetic and Electric Field Testing of the French Train à Grande Vitesse (TGV) Rail Systems - Volume I: Analysis, Fred M. Dietrich, Petros N. Papas, William L. Jacobs, William E. Feero, Electric Research and Management, Inc.
May 1993
DOT/FRA/ORD-93/03.I DOT-VNTSC-FRA-93-7.I
NTIS#: PB93-223071-LL Price: $36.50

This report provides the analysis (Vol. I) of results and detailed data and statistical summaries (Vol. II, Appendices) of representative electric and magnetic field (EMF) profiles on TGV-A trains between Paris and Tours for two electro-technologies (1.5 KV DC near Paris and 2x25 KV at 50 Hz AC).

Safety of High Speed Guided Ground Transportation Systems: Magnetic and Electric Field Testing of the French Train à Grande Vitesse (TGV) Rail Systems - Volume II: Appendices, Fred M. Dietrich, William L. Jacobs, Electric Research and Management, Inc.
May 1993
DOT/FRA/ORD-93/03.II DOT-VNTSC-FRA-93-7.II
NTIS#: PB93-223089-LL Price: $52.00

This report provides the analysis (Vol. I) of results and detailed data and statistical summaries (Vol. II, Appendices) of representative electric and magnetic field (EMF) profiles on TGV-A trains between Paris and Tours for two electro-technologies (1.5 KV DC near Paris and 2x25 KV at 50 Hz AC).

Safety of High Speed Guided Ground Transportation Systems: Magnetic and Electric Field Testing of the Washington Metropolitan Area Transit Authority Metrorail

System - Volume I: Analysis, Fred M. Dietrich, Petros N. Papas, William L. Jacobs, William E. Feero, Electric Research and Management, Inc.
June 1993
DOT/FRA/ORD-93/04.I DOT-VNTSC-FRA-93-8.I
NTIS#: PB94-102472 Price: $36.50

This report presents data on both static (dc) and alternating (ac) magnetic fields and on ac electric fields obtained on the Washington Metropolitan Area Transit Authority (WMATA) system (Vol. I analysis and Vol. II appendices).

Safety of High Speed Guided Ground Transportation System: Magnetic and Electric Field Testing of the Washington Metropolitan Area Transit Authority Metrorail System - Volume II: Appendices, William L. Jacobs, Fred M. Dietrich, Electric Research and Management, Inc.
June 1993
DOT/FRA/ORD-93/04.II DOT-VNTSC-FRA-93-8.II
NTIS#: PB94-102480-LL Price: $61.00

This report presents data on both static (dc) and alternating (ac) magnetic fields and on ac electric fields obtained on the Washington Metropolitan Area Transit Authority (WMATA) system (Vol. I analysis and Vol. II appendices).

Safety of High Speed Guided Ground Transportation Systems: Magnetic and Electric Field Testing of the Massachusetts Bay Transportation Authority (MBTA) Urban Transit System - Volume I: Analysis, Fred M. Dietrich, Petros N. Papas, William E. Feero, William L. Jacobs, George A. Steiner - Electric Research and Management, Inc.
June 1993
DOT/FRA/ORD-93/05.I DOT-VNTSC-FRA-93-6.I
NTIS#: PB93-227619-LL Price: $36.50

This report provides the analysis (Vol. I) of results of an EMF survey of the MBTA transit system and detailed data and statistical summaries (Vol. II appendices) of represen-tative EMF profiles on vehicles and facilities typical of electrotechnologies used in this transit system (3rd rail dc, catenary with pantograph, trolley bus).

Safety of High Speed Guided Ground Transportation Systems: Magnetic and Electric Field Testing of the Massachusetts Bay Transportation Authority (MBTA) Urban Transit System - Volume II: Appendices, William L. Jacobs, David C. Robertson, George A. Steiner, Electric Research and Management, Inc.
June 1993
DOT/FRA/ORD-93/05.II DOT-VNTSC-FRA-93-6.II
NTIS#: PB93-227627-LL Price: $77.00

This report provides the analysis (Vol. I) of results of an EMF survey of the MBTA transit system and detailed data and statistical summaries (Vol. II appendices) of representative EMF profiles on vehicles and facilities typical of electrotechnologies used in this transit system (3rd rail dc, catenary with pantograph, trolley bus).

Safety of High Speed Guided Ground Transportation Systems: Comparison of Magnetic and Electric Fields of Conventional and Advanced Electrified Transportation Systems, Fred M. Dietrich, William E. Feero, William L. Jacobs, Electric Research and Management, Inc.
August 1993
DOT/FRA/ORD-93/07 DOT-VNTSC-FRA-93-13
NTIS#: PB94-103397-LL Price: $19.50

This report summarizes and compares the results of a survey of EMF characteristics (spatial, temporal and frequency bands) for representative conventional railroad and transit and advanced high speed systems including: the German TR-07 maglev system, Amtrak Northeast Corridor (NEC) and North Jersey Transit (NJT) trains, the French TGV-A high speed rail system, the Washington, D.C. Metrorail (WMATA) transit system, and the Boston, MA (MBTA) transit system.

5. Gillette

Safety of High Speed Guided Ground Transportation Systems: Review of Existing EMF Guidelines, Standards and Regulations, Don Goellner, Barbara Zackhiem, Melissa Bockleman, Lynne Gillette, Norbert Hankin, U.S. Environmental Protection Agency
August 1993
DOT/FRA/ORD-93/27 DOT-VNTSC-FRA-93-15
NTIS#: PB94-117819 Price: $19.50

This report provides information on existing and proposed electric, magnetic, and EMF guidelines, standards and regulations at the international, national, state, and local levels. The report is comprised of information derived from both primary and secondary sources and is current as of June 1993.

Safety of High Speed Guided Ground Transportation Systems: EMF Exposure Environments Summary Report, Don Goellner, Terry Inge, Lynne Gillette, U.S. Environmental Protection Agency
August 1993
DOT/FRA/ORD-93/28 DOT-VNTSC-FRA-93-16
NTIS#: PB94-152402 Price: $19.50

This report presents an overview of U.S. exposure assessments for electric and magnetic fields in the extremely low frequency range (ELF). A commentary is provided discussing equipment and methods and they are briefly described for each study reviewed.

6. Brecher

Novel Cryogen-Free Actively Shielded Superconducting Magnets for Maglev Vehicles, M. E. Vermilyea, General Electric Co.
June 1992
DOT/FRA/NMI-92/07
NTIS# PB93-154771/XAB Price: $36.50

Safety of High Speed Magnetic Levitation Transportation Systems: Safety of Superconducting Magnets in Maglev Operations, Wright Laboratories
Due: May 1995

The objective of this interagency agreement is to conduct an engineering and safety assessment of the National Maglev Initiative, System Concept Definition concepts utilizing superconducting magnets. SCM failure mode and effect analysis for individual and configured magnet modules, failure prevention and mitigation options for SCM and magnet modules and the development of safety guidelines will be covered by this effort.

TERMINOLOGY

AC	Alternating Current
ATCS	Advanced Train Control Systems
BAA	Broad Agency Announcement
CIGGT	Canadian Institute of Guided Ground Transport
DC	Direct Current (usually refers to static magnetic field)
DOT	U.S. Department of Transportation
EDS	Electrodynamic (maglev) Suspension
EIS	Environmental Impact Statement
ELF	Extremely Low Frequency (typically >0 to 3kHz)
EMF	Electric and Magnetic Fields
EMF	Electromagnetic Field
EMI/EMC	Electromagnetic Interference/Compatibility
EMS	Electromagnetic (maglev) Suspension
EPRI	Electric Power Research Institute
ERM	Electric Research and Management, Inc.
HSGGT	High-speed guided ground transportation
HSST	Japanese EMS Maglev System
MBTA	Massachusetts Bay Transportation Authority
mG	milligauss (measure of magnetic flux density)
MLU	Japanese EDS Maglev System
NEC	Northeast Corridor
NIOSH	National Institute of Occupational Safety and Health
NMI	National Maglev Initiative
R&D	Research and Development
SBIR	Small Business Innovative Research Project
SC	Superconductor (or superconducting)
SCD	System Concept Definition study (part of NMI)
TGV	Train à Grand Vitesse (French high-speed rail system)
TR07	Transrapid 07 (German maglev with test facility in Emsland)
TSC	High-Temperature Superconductor
VNTSC	Volpe National Transportation Systems Center

PART 3: POWER AND BRAKING SYSTEMS

Richard A. Uher, Session Leader

PRESENTATIONS

Electrical Safety Regulations, *Gerard R. Deily, Federal Railroad Administration*

Safety Implications of Propulsion Power in High-Speed Systems, *Frank Raposa, Acton, Massachusetts*

Operation of Passenger Trains in Freight Railroad Corridors, *Alan Bing, Arthur D. Little, Inc.*

Advanced Braking System Safety, *David Wagner, Battelle Columbus*

Interface issues must be monitored and addressed to avoid "system aspects" from falling through the cracks. Also, coordination between various problem areas is important. For example, belt restraint requirements affect other problem areas (e.g., braking systems, mixed corridor operational issues, guideway geometry, collision avoidance, and accident survivability.).

Pertinent questions include:

- When and to what level should safety analyses be conducted?
- Should concept screening be universal?
- What project should accompany safety certification?

The question remains as to whether concepts should be killed early with safety showstopper issues or permitted to mature to some extent before being subjected to some sort of safety scrutiny.

ADVANCED BRAKING SYSTEM SAFETY

Critique

- The effort to avoid exclusion of viable technologies is important.
- Coverage of multitechnology braking systems is important.
- Interface of braking systems with train control, propulsion, etc., must not slip through the cracks.
- Depth of outlined six-month study outlined may not be adequate for useful regulatory support results.

Research Needs

- Real-time brake system status monitoring systems should be part of R&D effort.
- The effects of brake control system failure rate on overall safety needs to be studied.
- Physical issues related to energy absorption and dissipation require more research.

OPERATION OF PASSENGER TRAINS IN FREIGHT RAILROAD CORRIDORS

Critique

- The generic corridor portion of the study needs to be well focused to ensure useful results. Such a corridor must encompass all key issues to ensure the development of a useful methodology/planning guide for mixed corridor use (freight, commuter rail, etc.) for high-speed rail.
- All assumptions should be clearly stated.
- Interface with grade crossing research, although not directly addressed in this topic area, is important.
- The matrix of corridor options may become unmanageable for study.

Research Needs

- Maintenance and inspection standards need to be tracked for different traffic densities and train speeds.

- An enhanced freight equipment inspection is necessary and should be developed for trains operated over a high-speed corridor.
- Antitrespasser precautions need to be developed.

ELECTRIC SAFETY REGULATIONS AND SAFETY IMPLICATIONS OF PROPULSION POWER IN HIGH-SPEED SYSTEMS

Critique

- Foreign (international) standards, experience, regulations, and guidelines and U.S. standards, regulations, etc., should be stressed.
- On-board safety issues also need to be addressed.
- Fossil-fueled locomotives, power units, and trains must be addressed.
- Potential EMF regulations and standards may affect electrical safety.

Related research completed and planned (aside from that in the above notes) is listed under Problem No. 1, High-Speed Rail and Maglev Wayside Electric Power Supply Standards.

Research Needs

Gaps in research are addressed in the problem statements that follow.

Problem Statement 1

High-Speed Rail and Maglev Electric Power and Propulsion Standards.

The current activity in the field of high-speed rail and maglev in the United States centers around the feasibility and preliminary design studies for several intercity corridors. For high-speed rail, the next step may involve facility design and the selection of a railroad system and equipment for a specific corridor. For maglev, system concept definition studies have recently been completed, and a prototype development is currently planned. Technical information for the electric traction system and the on-board power and propulsion system safety standards, design codes, and practices reside principally with high-speed rail and maglev suppliers in Europe and Japan. A large body of U.S. codes, standards, and practices also exist for the application of electrical equipment in various industries. A need exists to assess the applicability of these safety standards and practices to U.S. operations of high-speed rail and maglev. Both high-speed rail and maglev systems will be electrified; therefore, there is also a need to ensure safe compatibility between the electric traction power supply and adjacent or nearby telecommunication and signal facilities.

Research Objectives

The objective of this proposed research is to gather information on both foreign and domestic transportation and related technologies that can be useful to regulatory agencies developing electrical standards to govern the safety and compatibility of high-speed rail and maglev systems designed for operation in the United States.

Related Activities

FRA has established a maglev/high-speed rail task force that has been collecting data on candidate foreign technologies, yet a dearth of data exists on electric wayside and on-board power and propulsion. The Volpe National Transportation Systems Center contracted for a comparison of U.S. standards (industry and government) and those specified in the German report, *Safety Requirements—High-Speed and Maglev Trains, RW-MSB*. An FRA study effort reviewing U.S. and foreign electrical safety standards is planned. This study will provide recommendations and guidelines for existing and future electrification systems.

Urgency

High.

Many technical and operational issues in the preliminary and final designs of maglev and high-speed rail systems will require the application of appropriate safety standards. To the fullest extent possible, the standards, codes, and practices to which these systems have been designed for operation in Europe and Japan should be adapted to the U.S. conditions. Furthermore, any applicable U.S. industry standards, codes, and practices also should be adapted, as appropriate, to high-speed rail and maglev systems. Otherwise, any different regulations establishing U.S. standards that may be developed after designs have been completed could require significant modification of expenditures to comply with such regulations.

Problem Statement 2

Maglev Brakes.

Because of the noncontacting feature of maglev, the specific braking equipment differs greatly from that on steel-wheel-on-rail systems. Generally, the linear synchronous motor (LSM) is the primary brake. The secondary or emergency brake may use eddy currents, skid or other friction contact devices, or aerodynamic retarders. Existing safety regulations enforced by FRA cannot be directly applied or transferred to maglev systems. The intent of these regulations—to ensure that a safe braking system is always available on any operating train—is appropriate. Because maglev systems generally operate at a height of about 4.5 to 15 meters (15 to 50 ft) above ground level, some systems feature programmed braking to the next safe evacuation location for a situation that requires an emergency stop. Because of the high acceleration and deceleration rates of maglev systems, and automatic central station control, maglev systems are being proposed with headways that are far afield from traditional ones and are possibly unsafe for high-density mixed traffic services (e.g., individual vehicles, trains, freight, local passenger service, and express). A research program to examine all of these issues is needed.

Research Objectives

The overall objective of this proposed activity is to identify and evaluate performance-based characteristics leading to a generic specification. To meet the objective, the following tasks should be performed:

- Review current, proposed, and other possible alternate maglev brakes for both primary and secondary (emergency) braking.
- Consider fault tolerance and redundancy requirements for maglev braking systems.
- Consider full emergency brake application as opposed to programmed braking to the next emergency evacuation location and operator control.
- Investigate the interrelationship of braking rates/deceleration limits, stopping distances, train separation/headway and capacities with consideration of passenger comfort and restraint, energy implications, lead train assumptions, and switch or junction assumptions.
- Consider real-time monitoring of the condition of the braking system with feedback on system condition to the train control system/train operator.
- Develop a generic set of performance criteria for primary and secondary (emergency) maglev braking systems as a function of braking rates and headways.

Related Activities

FRA is conducting an assessment of the Safety of High-Speed Magnetic Levitation Transportation Systems. To date, four reports have been issued on one system. It is understood that FRA plans to develop a Rule of Particular Applicability for the Florida Maglev Demonstration Project and, ultimately, a Rule of General Applicability for all maglev systems.

Under the National Maglev Initiative (NMI) program, four SCD contractors studied technical feasibility, performance, and capital and operating costs for new maglev systems for the year 2000. Many technical, operational, and economic issues concerning the preliminary and final design of new maglev systems will require the application of appropriate safety standards. Timely information is needed to provide the basis for rational subsystem selections.

FRA and the Volpe National Transportation Systems Center is sponsoring an assessment in which the technical and safety aspects of advanced braking concepts are examined. The study focuses on the design capabilities of various braking concepts and fault-tolerant and fail-safe design features and developing performance criteria for both service and emergency braking functions.

Urgency

High.

Problem Statement 3

Development of Standards and Guidelines for High-Speed Rail Brakes.

To ensure safety in high-speed rail travel, it is necessary to develop brake performance standards and guidelines that will establish acceptable levels of safety for high-speed train operations with multitype brake systems.

Research Objective

The objective is to identify acceptable levels of safety and performance for high-speed rail braking systems. The safety and performance criteria will define the objective to be met in the design and qualification of braking systems. This process should include a review of the foreign standards that have been used for existing high-speed rail systems and those being proposed for future high-speed rail systems.

Specific objectives are as follows:

- Review current, proposed, and possible alternate concepts for high-speed rail primary and secondary (emergency) braking.
- Consider fault tolerance and fail safety requirements for high-speed rail braking concepts.

- Investigate the interrelationship of braking rates and deceleration limits, stopping distances, train separation/headways and capacities with consideration of passenger comfort and restraint, energy implications, lead train assumptions, and switch or junction assumptions.
- Consider real-time monitoring of the condition of the braking system with feedback on system condition to the train control system or train operator.
- Develop a set of performance criteria for primary and secondary (emergency) high-speed rail braking systems as a function of braking rates and headways.

Related Activities

The FRA task force is reviewing the safety and performance standards that have already been defined and implemented by foreign high-speed rail regulating bodies.

Urgency

High.

Problem Statement 4

High Speed Rail Operation in Freight and Mixed Traffic Railroad Corridors.

Recent emphasis upon high-speed rail development in the United States has shifted to the utilization of existing freight and conventional passenger railroad corridors for high-speed service. In particular, the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) required that five rail corridors be selected for the development of high-speed services. These are called the "Section 1010" corridors. Initially, funding was provided for grade crossing improvements in these corridors. Eventually, speeds of up to 240 km/h (150 mph) may be achieved with the appropriate improvements.

Utilization of existing freight and passenger corridors is an economically attractive way of providing high-speed rail service. However, such utilization raises a number of safety and operational issues that require research. Research subjects requiring study include the need for upgraded signal and train control systems, improved track and equipment inspection, maintenance and hazard detection procedures and systems, grade crossing warning and protection systems, and antitrespasser precautions. A research program is needed to address these issues.

Research Objectives

The overall objective of the research program is to identify and evaluate safety concerns that arise when high-speed passenger trains are operated in rail corridors with other types of rail traffic, especially freight trains but also conventional intercity and commuter passenger trains, and to evaluate the means of ensuring that safety performance is at acceptable levels. The following tasks should be performed:

- Evaluate the relationships between rail traffic mix, maximum passenger train speeds, signal and train control system type, and other factors concerning the safety and efficiency of operations in a mixed-traffic rail corridor.
- Evaluate alterative strategies for eliminating or reducing the hazards presented by grade crossings on lines over which high-speed trains operate.
- Evaluate track quality standards and track inspection and maintenance techniques for their effectiveness in preventing track-caused accidents on mixed-traffic, high-speed corridors.
- Evaluate the effectiveness of enhanced freight train inspection and hazard detection techniques in reducing the incidence of accidents caused by defective freight equipment in mixed-traffic, high-speed rail corridors.
- Evaluate alternative strategies for minimizing the incidence of trespasser casualty on mixed-traffic, high-speed rail rights-of-way.

Related Activities

Several FRA research projects are currently being conducted to study grade issues, including those specifically associated with crossing safety with high-speed passenger rail operation.

Under the FRA High Speed Rail Safety Program, a study of operational and safety factors to be considered in high-speed rail operations on freight corridors was initiated in September 1993. This study will concentrate on the effects of signal efficiency, control system and hazard warning system upgrades on safety, and operational efficiency in the high-speed corridor.

Urgency

High.

REPORT/PUBLICATION REFERENCES

1. Deily

Safety of High Speed Guided Ground Transportation Systems: Safety Considerations with Electrification, contract not yet awarded, some in-house work underway Due: tbd

Guidelines may be necessary for newly emerging or proposed systems to assure that construction and operation of electrified HSGGT systems will not jeopardize the safety of the general public or transportation workers. This work will initially develop baseline information on current industry practices (to include foreign standards and practices) relative to electrification safety issues.

2. Raposa
No references

3. Bing

Safety of High Speed Rail Transportation Systems: Passenger Train and Freight Railroad Corridors, Arthur D. Little and Parsons Brinckerhoff
Due: July 1994

The objective of this task is to identify and evaluate safety concerns that arise when high speed passenger trains are operated in rail corridors with other types of rail traffic, especially freight trains but also conventional intercity and commuter passenger trains, and to evaluate means of ensuring that safety performance is at acceptable levels.

4. Wagner

Safety of High Speed Guided Ground Transportation Systems: Advanced Braking Systems, Battelle
Due: July 1994

The objective of this task is to develop quantitative information on a variety of braking systems and their technical and economic feasibility in order to assist the FRA in potential rulemaking activities related to high-speed braking systems.

TERMINOLOGY

EMF	Electromagnetic Field
FRA	Federal Railroad Administration
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
LSM	Linear Synchronous Motor
NMI	National Maglev Initiative
R&D	Research and Development
SCD	System Concept Definition

PART 4: CONTROL SYSTEMS

Paul H. Reistrup, Session Leader

PRESENTATIONS

Analysis of Railroad Signaling System: Microprocessor Interlocking, *Jeffrey Gordon, Volpe National Transportation Systems Center*

As microprocessors have been adopted in signal interlocking systems, concerns have been raised regarding maintenance and modification activities affecting integrity. One supplier's application was analyzed and changes to "signal rules" (i.e., 49 CFR Part 236, *Rules, Standards and Instructions Governing the Installation, Inspection, Maintenance, and Repair of Signal and Train Control Systems, Devices, and Appliances [RS&I])* were recommended. No review of the microprocessor system itself was made.

Sensor Systems for Monitoring Maglev Guideway Structures, *John Bower, Babcock & Wilcox*

Available technologies for continuous monitoring of physical condition and structural integrity of guideways were assessed. Criteria included monitoring of alignment, unusual vibration/motion or catastrophe failure, and also gradual degradation. Sufficiently mature technologies are available to meet these requirements, including passive acoustic method for crack growth, infrared and visible light, ultrasonics, microwave monitors, and fiber optic networks (strain gauges).

Evaluation of Concepts for Safe Speed Enforcement, *Jonathan Luedeke, Battelle Columbus*

The availability and suitability of various means of safe speed enforcement were assessed. In the case of maglev, functions and needs were arrayed for comparison. Conclusions include that the existing developmental enforcement system for maglev is generally suitable and that existing steel wheel/rail systems are not directly applicable to maglev. Some of the latter aspects and equipment are adaptable, however.

Maglev Guideway and Route Integrity Requirements, *Steve Carlton, Martin Marietta*

An effort was made to identify various risks to maglev guideway/route integrity and to estimate the probability of occurrence and likely severity. Hazards investigated included obstruction, integrity, and physical security. Sensor technology assessment included local line sensors and on-vehicle millimeter microwave radar. There was also architecture assessment for risk mitigation, including sensors, processing, and commands communication.

Methodology for Safety Validation of Computer Control Systems, *Jonathan Luedeke, Battelle Columbus*

This effort was to determine the methodology to assure the fail safety/fault tolerance of computer controlled systems. A glossary of terms (without ambiguity) relevant to computer control was developed. Both the state of the art in maglev and rail technologies plus pertinent techniques from the FAA, DOD, NASA, and NRC were reviewed. The work, ongoing at the time of the workshop, is expected to weigh the technical and economic feasibility (burden of the operation) of proposed standards that would be included in regulations.

Critique

The above presentations were well received in the workshop session and, after close scrutiny, led to suggested further research to fill existing gaps (Problem Statements 6-9). Five new research needs also were identified (Problem Statements 1–5).

SAFETY VALIDATION OF COMPUTER CONTROL SYSTEMS

Research needs

Problem Statement 1

Modes of transmission of vital data necessary for safe operation of high-speed vehicles need to be investigated. This will include transmission to and from the wayside, the vehicle, and central control.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Both.

Research Objective

The overall objective is to examine modes of data transmission and intercommunication between high-speed vehicles and their surroundings. Issues include modes of encoding, decoding, speed of data processing, and methods of error detection and correction. Also of interest are reactions of the system when transmission is lost or corrupted, including links to propulsion and braking systems and reaction times.

Related Activities

Such activities include investigation of novel strategies for data transmission and communication of vital operational data, e.g. investigating transmission rates necessary to assure safe operation at expected operating speeds while allowing greater flexibility for future increases in maximum operating speeds.

Urgency

Medium.

HUMAN FACTORS—MAINTENANCE

Problem Statement 2

Complex control systems operating in all types of weather require technically trained maintenance personnel for field repairs or changes and shop personnel to perform component repair and testing.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Both and for upgrading existing rail corridors.

Research Objective

Higher traffic levels (or close headways) between trains require that field change-outs or repairs are done promptly to minimize service delays. The primary objective is to determine technical training and capability of two types of personnel:

1. Field personnel who make immediate equipment changes and tests under all weather conditions and
2. Shop personnel who repair and test units pulled from the field.

Related Activities

Research is needed to determine the practicality of integrated distributed educational facilities such as community colleges and vocational schools in providing training on a system-wide basis, and such research should investigate distributed versus centralized training facilities.

The research should explore the various types of training available.

Urgency

Medium, as some work has been done in this area regarding corridor upgrades and high-speed rail traveling up to 125 mph.

SAFETY ASSURANCE

Problem Statement 3

A system safety development approach is needed that provides an overall proof-of-safety/safety assurance mechanism. For example, future maintenance or reuse of these systems may compromise safety without adequate documentation of safety concepts and design.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Both.

Research Objectives

The approach to assuring system safety must include the following areas: components, roles of components, and requirements.

The research should identify those components during system development that assure safety:

- Documentation—providing the safety concepts and safety design,
- Configuration management,
- Quality control management, and
- Safety management.

These are the roles of each component that are formulated to assure that the safety requirements of each component are met.

Related Activities

Related activities include some work accomplished specific to ATCS.

Urgency

High.

TRACK CIRCUIT RESEARCH

Problem Statement 4

Due to changing operating conditions with a variety of vehicles and train speeds, present track circuits may be limited regarding train detection and as a transmission medium for train control.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?

Track circuits are typically used for train detection and data transmission on railroads and transit systems, including light rail. Track circuit technology has not been applied to magnetic levitation systems.

Research Objectives

Research is needed to expand present capabilities of track circuits. For example, track circuits should be tuned, adjusted, or revised by adding electrical components to improve train detection and data transmission.

Related Activities

- Research is needed to extend track circuit length significantly from the present length of 15,000 feet.
- Research of the effects of profile grinding of rails on shunting sensitivity, composition brake shoes, rail lubrication, and contaminants or films on rails should be conducted.
- Research is needed to determine if wire loops, beacons, or transponders integrated into track circuits can improve train detection and data transmission capability to both the train and to the wayside.

Urgency

Medium to high, because the results can apply to both existing railroads and transit operations and also to high-speed rail and corridor upgrades.

Results of the research may foster practical and safe operation of mixed traffic on the same lines, such as freight, commuter, passenger, and corridor upgrades.

INFORMATION EXCHANGE

Problem Statement 5

The lack of a single international source of information or published research reports and other technical information in the control systems area (as well in the overall high-speed rail, maglev, and incremental rail arena) needs to be addressed.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?

Both plus incremental higher speed rail.

Research Objectives

- Improved information exchange,
- Increased productivity (less time required) in literature searches, and
- Related activities.

TRIS of TRB produces published research reports but does not reference and abstract all foreign and domestic railway periodicals and technical journals in the subject fields. This service could be expanded to include these sources, or another effort could be established.

Urgency

Low.

MICROPROCESSOR INTERLOCKING

Problem Statement 6

The microprocessor interlocking study conducted on the GRS VPI system needs to be expanded to include other

U.S. system manufacturers, including Harmon, US&S, and SAFETRAN.

A review of the system and an assessment of the applicability of current federal regulations from the point of view of assured safety of these microprocessor-controlled systems will be included.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?

High-speed and conventional rail.

Research Objective

The objective is to expand on previous work to include other U.S. manufacturers of similar systems that use different technologies for safety assurance of vital functions.

Related Activities

Such activities include the identification of potential failure modes of these systems and inherent characteristics that mitigate these failures. The effects of changes or modifications to these systems after field repair and revision should also be investigated.

Urgency

Medium.

INFORMATION EXCHANGE, JAPANESE SYSTEM

Problem Statement 7

A technical description of the Japanese Shinkansen high-speed passenger system needs to be developed.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?

High-speed rail.

Research Objectives

The major objectives of this research include development of a report to be added to the existing series under "Safe Speed Enforcement" on TR07, TGV, ICE, and X-2000 in order to place the Shinkansen system in the context of other high-speed systems under consideration for deployment in the United States. This report will describe the basic vehicle, its operating characteristics, guideway characteristics, and right-of-way requirements. Specific emphasis will be placed on control systems employed in this technology and how they are applied to assure safe operation at high speeds. These will include—

- ATP/ATO/ATC strategy,
- Train detection techniques,
- Communications and data transmissions strategies, and
- Provisions for fail-safety of vital control system elements, including computers.

Related Activities

Related activities include the investigation of safety assurance methodology as it is implemented in Shinkansen system design (systems approach to safety of the entire system).

Urgency

Medium.

SAFE SPEED ENFORCEMENT

Problem Statement 8

Gaps should be filled in research related to safe speed enforcement. This includes maglev vehicle and speed detection; impact of equipment, subsystem failures, and abnormal conditions; safe headways related to various operating scenarios; and operator override of speed and braking commands.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?

Both, except that vehicle and speed detection is maglev.

Research Objectives

- Identify and assess the effectiveness of various vehicle location and speed detection techniques—maglev.
- Determine the impact of vital equipment and functional failures on safe speed enforcement systems.
- Investigate the impact of safe speed approaches to operating philosophy and headways.
- Determine the role of train and vehicle operator in overriding train speed and braking commands.

Related Activities

Completed study on safe speed enforcement indicated areas of potential further investigation.

Urgency

Medium to high (failures of equipment/functions).

TRAIN/SPEED DETECTION

Problem Statement 8A

Train and speed detection is vital for safe maglev operation; proper and safe techniques need to be further evaluated.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Maglev.

Research Objective

The primary objective is to identify and assess the effectiveness of different train and speed detection techniques for maglev applications (based upon results of safe speed enforcement work).

Related Activities

- Identify techniques.
- Identify advantages and disadvantages.
- Review innovative approaches.
- Determine overall effectiveness.

Urgency

Medium.

FAILURE/ABNORMAL CONDITIONS

Research needs

Problem Statement 8B

Certain equipment and subsystem failures and abnormal conditions could be unsafe if vehicle speed is not safely controlled.

Technology Distinction

Is research needed for high speed rail, maglev, or both?
Both.

Research Objective

To determine the impact of certain equipment and functional failures on safe speed assurance.

Related Activities

- Identify failure types.
- Assess impact on safety.
- Determine impact on safe speed command generation or safe speed enforcement functions.

Urgency

High.

HEADWAY/OPERATING PHILOSOPHY

Problem Statement 8C

A wide variety of operating philosophies and safe speed approaches are being used. These need to be assessed to determine their effectiveness relative to assuring safe headway.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Both.

Research Objective

The objective is to investigate the impact of safe speed approaches relative to headway requirements.

Related Activities

- Identify safe speed approaches.
- Identify advantages and disadvantages of each.
- Determine effectiveness in ensuring safe headway.

Urgency

Medium.

OVERRIDE OPERATOR CAPABILITIES

Problem Statement 8D

Although the assurance of safe speed is becoming even more highly automated, the role of the operator (vehicle, central) relative to override capabilities (if any) needs to be defined.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Both.

Research Objective

The objective is to determine the role of the train operator in overriding train speed and braking commands.

Urgency

Medium.

SAFETY MONITORING

Problem Statement 9

Current guideway and rail monitoring is not adequate to prevent catastrophic accidents. Fail-safe systems are needed for improved hazard detection and timely reporting.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?

Maglev, high-speed rail, and conventional rail upgrade.

Research Objective

The primary objective is to demonstrate advanced sensor detection systems for maglev, high-speed rail, and improved rail applications. Recent events involving bridge structures, guideway and rail integrity, and obstacle detection suggest that improved systems are warranted. Vehicle and/or guideway and rail mounted sensor systems to detect obstacles, to monitor vibration and displacement, and to ensure guideway and rail integrity should be examined.

Related Activities

The "Sensor Systems for Monitoring Maglev Guideway Structures" and "Maglev Guideway and Rate Integrity Requirements" reports generated from the NMI Broad Agency Announcement activity show feasibility of applicable sensor systems.

Urgency

High.

REPORT/PUBLICATION REFERENCES

1. Gordon

Safety of Vital Control and Communication Systems in Guided Ground Transportation: Analysis of Railroad Signaling System: Microprocessor Interlocking, Simon Reich and Thomas Bessoir, Thomas K. Dyer, Inc.
May 1993
DOT/FRA-ORD-93/08 DOT/VNTSC-FRA-93-5
NTIS#: PB93-217339-LL Price: $19.50

This report is concerned with the safety issues associated with the application of microprocessor-based track control systems to railroad operations in the United States.

2. Bower

Sensor Systems for Monitoring Maglev Guideway Structures, J. W. Berthold, J. R. Bower, J. D. Buttram, L. R. Okes, M. O. Robertson, Babcock and Wilcox Co.
July 1992
DOT/FRA/NMI-92/12
NTIS#: PB93-154821/XAB Price: $19.50

This report is an assessment of the technologies available for continuous monitoring of the physical condition and structural integrity of maglev guideways. The technologies covered are sufficiently mature to meet the requirements, with some degree of additional development.

3. Luedeke

Evaluation of Concepts for Safe Speed Enforcement, J. F. Luedeke and R.E. Thompson, Battelle Columbus
April 1992
DOT/FRA/NMI - 92/02
NTIS#: PB93-152692/XAB Price: $36.50

This report evaluates the suitability of existing and developmental safe speed enforcement concepts/systems for application to a high-speed maglev control system in the U.S. Requirements, functions, and needs are identified and discussed for two major aspects of safe speed enforcement: 1) generation of safe speed commands, and 2) enforcement of safe speed limits as defined by those commands or otherwise imposed upon vehicles.

4. Carlton

Maglev Guideway and Route Integrity Requirements, S. Carlton and R. Whinnery, Martin Marietta Corporation
April 1992
DOT/FRA/NMI-92/04
NTIS#: PB93-154870/XAB Price: $19.50

5. Luedeke

Safety of High Speed Guided Ground Transportation Systems, Safety Verification/Validation Methodologies for Vital Computer Systems, Battelle
Due: January 1994

> The objective of this contract is to provide the substantiated technical bases for changes to existing signal, train control, and communications regulations and recommen-dations. Specifically this work will address the safety verification and validation needs to ensure the safety of modern vital computer systems that support signal, train control and communication systems.

TERMINOLOGY

ATCS	Advanced Train Control Systems
ATO	Automatic Train Operations
ATP	Automatic Train Protection
ATC	Automatic Train Control
GRS VPI	General Railway Signal Vital Processor Interlocking
ICE	Intercity Express (German high-speed train)
NMI	National Maglev Initiative
TGV	Train à Grand Vitesse
TR07	Transrapid 07
TRB	Transportation Research Board
TRIS	Transportation Research Information Service
X-2000	Swedish Tilt-train

PART 5: STRUCTURAL AND MECHANICAL SYSTEMS

Brenda M. Bohlke, Session Leader

PRESENTATIONS

Maglev Guideway Route Alignment and Right-of-Way Requirements, *Steve Carlton, Martin Marietta*

Barrier Designs Between HSGGT and Adjoining Transportation Systems, *Paul Moyer, Parsons, Brinckerhoff, Quade & Douglas, Inc.*

Highway-Rail Grade Crossings Hazard Elimination: Problem Definition, *John Bachman, Applied Systems Technologies, Inc.*

Grade Crossings in High-Speed Corridors: State-of-the-Art Survey, *Anya Carroll, Volpe National Transportation Systems Center*

Thermal Response Analysis of Transrapid-Type Guideway Structure, *Andrew Kish, Volpe National Transportation Systems Center and Steven Kokkins, Foster-Miller, Inc.*

RIGHT-OF-WAY REQUIREMENTS

Problem Statement

Comfort criteria and limits need to be defined.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Maglev.

Research Objectives

The objectives are to determine comfort criteria and limits for restrained and unrestrained passengers and to account for combined forces (accelerations) and duration and frequency of events.

Urgency

High.

INTRUSION BARRIERS

Problem Statement 1

A test program needs to be developed to validate assumptions and input to barrier design.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Both.

Research Objectives

- Review available test program results (AAR, etc.).
- Develop test program.
- Implement test program.
- Validate the computer program.
- Re-evaluate performance criteria.

Urgency

High.

Problem Statement 2

System safety analysis of intrusion barriers on shared right of way needs to be conducted.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
Both.

Research Objectives

- Establish criteria for need.
- Determine type of barrier as a function of speed, environment, vehicle.
- Provide system safety assessment.

Related Activities

The potential for noise abatement needs to be assessed.

Urgency

High.

GRADE CROSSINGS

The topic of "High-Speed Rail Highway Crossings at Grade" was identified as a high priority research need which appeared in TRB Circular 417 (November 1993), *Research Problem Statements: Design and Construction of Transportation Facilities*. This statement combined several research needs statements from the 1991 workshop and focussed on the need to identify potential grade crossing protection devices that would permit higher operating speeds and to determine the safe threshold speed for HSR operations across streets or highways.

Problem Statement 1

Selection and implementation methods for closure of at-grade crossings need to be determined.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
High-speed rail.

Research Objectives

- Review methods for closing grade crossings on all rail systems corridors.
- Apply methods to high-speed rail.
- Develop method guidelines for closing crossings.

Related Activities

Each state has established criteria and formulae for determining the need for application of various warning devises at highway-railway crossings at grade. In addition, relevant activities include FRA lessons learned, and the FRA/AASHTO model law for closings.

Urgency

Medium.

Problem Statement 2

Performance criteria and warrants for barriers should be established.

Technology Distinction

Is research needed for high speed rail, maglev, or both?
High-speed rail.

Research Objective

The objective is to define criteria for design and selection of barriers to prevent intrusion into rail operations.

Related Activities

Demonstration projects are being funded by FRA for the purpose of evaluating friendly barriers such as nets and cushioned-impact equipment. FRA is also sponsoring two related study projects: one to define problems associated with hazard elimination at highway-HSR at-grade crossings (being done by Applied System Technologies, Inc.) and the other a grade crossing safety analysis for HSR corridors (being done by Battelle). (See below for full references.) In addition, other related work includes NCHRP Report 350, *Recommended Procedures for the Safety Performance Evaluation of Highway Features.*

Urgency

High.

Problem Statement 3

Accident causation at grade crossings should be investigated to develop a public educational program and to identify infrastructure improvements to enhance safety.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?
High-speed rail (in high-speed rail and ISTEA corridors).

Research Objectives

- Identify and analyze information (data) sources (from FRA, state departments of transportation, NHTSA, etc.).
- Characterize accident influence factors.
- Define approach to define methodologies.
- Develop safety countermeasures.
- Develop implementation strategies.

Related Activities

- Operation Lifesaver educational activities.
- Other human factor safety research.

Urgency

High.

The present loss of human lives at highway-railroad crossings underscores the need to conduct research prior to forthcoming increases in passenger train speeds.

THERMAL RESPONSE

Problem Statement

Thermal deflections and stresses in elevated HSGGT structures are significant and may potentially affect safety and ride quality.

Technology Distinction

Is research needed for high-speed rail, maglev, or both?

Both.

Research Objectives

- Determine thermal responses for representative set of elevated guideway and viaducts.
- Detail horizontal deflection, ground heat reflection, eddy currents, and weather.
- Give concrete and prestress concrete highest priority.
- Conduct detailed study and tests of thermal coatings.
- Address aging, deterioration, and maintenance with accelerated testing.

Related Activities

Activities include the ongoing Transrapid steel guideway thermal program at Volpe National Transportation Systems Center/Foster-Miller, Inc.

Urgency

High for Florida Transrapid.
High to medium for Texas TGV (elevated corridor penetrations of city centers).

REPORT/PUBLICATION REFERENCES

1. Carlton

Maglev Guideway Route Alignment and Right-of-Way Requirements, S. Carlton, T. Andriola, Martin Marietta Corporation
December 1992
DOT/FRA/NMI-92/10
NTIS#: PB93-154854/XAB Price: $27.00

This report assesses the use of existing rights-of-way (ROW) for maglev systems by estimating trip times and land acquisition requirements for potential maglev corridors while meeting passenger comfort limits. ROW excursions improve trip time but incur a cost for purchasing land. The use of routes independent of existing railroad or highway ROW have trip-time advantages and significantly reduce the need for aggressive guideway geometrics on intercity corridors.

2. Moyer

Safety of High Speed Guided Ground Transportation Systems: Barrier Designs for Shared Rights-of-Way, Parsons Brinckerhoff
Due: December 1993

The objective of this contract is to develop anti-intrusion systems that will perform the function of preventing a derailed railroad car or an errant highway vehicle or some type of dislodged load from intruding into the operational space of the high speed line. In addition the situation of a derailing HSGGT vehicle being restrained from intruding into the operational space of an adjacent mode or from falling from an elevated guideway or colliding with track-side hazards will also be addressed.

3. Bachman

Safety of High Speed Guided Ground Transportation: Problem Definition of HSGGT Systems Highway Railroad Grade Crossing Hazard Elimination, Applied System Technologies, Inc.
Due: September 1994

4. Carroll

Safety of High Speed Guided Ground Transportation: Grade Crossings in High Speed Corridors: State of the Art Survey, Battelle

Due: Task 1 Signalling - February 1994
Task 2 Obstruction Detection - May 1994
Task 3 Motorist Warning Devices - Sept. 1994
Task 4 Assessment Methodology and Final Report - April 1995

5. Kish and Kokkins

Thermal Effects and Related Safety Issues of Typical Maglev Steel Guideways, S. Kokkins, A. Purple, and G. Samavedam, Foster-Miller, Inc.
August 1994
DOT/FRA/ORD-94/10

TERMINOLOGY

AAR	Association of American Railroads
AASHTO	American Association of State Highway and Transportation Officials
FRA	Federal Railroad Administration
HSGGT	High-speed/guided ground transportation
HSR	High-speed rail
ISTEA	Intermodal Surface Transportation Efficiency Act
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
TGV	Train à Grand Vitesse

APPENDIX A: LIST OF RESEARCH PROBLEM STATEMENTS FROM 1991 WORKSHOP

(Note: in TR Circular 417, these problem statements are numbered 212-223):

1. Safe Egress from Maglev Systems Under Emergency Conditions
2. High-Speed Guided Ground Transportation System Collision Avoidance and Accident Survivability
3. Maglev Brakes
4. Development of Standards and Guidelines for High-Speed Railway Brakes
5. High-Speed Rail and Maglev Vehicle Interiors
6. Automation Levels and Human Factors Related to High-speed Rail and Maglev Systems Operations
7. High-Speed Rail and Maglev Computer/Software Safety
8. High-Speed Rail and Maglev Wayside Electric Power Supply Standards
9. High-Speed Rail and Maglev Magnetic and Electric Field Effects
10. High-Speed Rail and Maglev EMF Mitigation and Shielding
11. Track Geometry, Inspection, and Maintenance Practices: High-Speed Rail in the United States
12. High-Speed Rail Highway Crossings at Grade

APPENDIX B: PARTICIPANT LIST

WORKSHOP ON SAFETY RESEARCH RELATED TO
HIGH-SPEED RAIL AND MAGLEV PASSENGER SYSTEMS

October 18-20, 1993
Itasca, Illinois

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