Transportation Research Board
Technical Activities Division

Committee Research Problem Statements
Rail Group
AR020, Committee on Guided Intercity Passenger Transportation

Preface

An important function of the Transportation Research Board (TRB) is the stimulation of research toward the solution of problems facing the transportation community. One of the techniques employed by technical committees in support of this function is the identification of problems, and the development and dissemination of research problem statements. The aim of this activity is to provide information to governmental agencies, research institutes, industry, the academic community and others in allocating scarce resources to the solution of transportation problems.

The problem statements listed below were developed by the TRB committee indicated above. Collectively they should not be considered an all inclusive recognition of research needs in the committee's technical area, but represent a portion of the overall needs identified by committee members. It is likely that some current research in progress or recently completed research was overlooked which may have altered the listings.

Statements (As of Date 08-15-2005)

Problem Number	Problem Statements
1	Crash Energy Management Design
2	Passenger Car Seat Testing
3	Vehicle Crash Testing
4	Risk Assessment Methodology
5	* Fuel Tanks
6	* Combined Track Defects
7	* Permissible Track Defect Sizes For High Cant Deficiency Operation
8	* Carbody Acceleration Limits
9	* Locomotive and Cab Car Corner Posts
10	Fire Safety Standards
11	* Automated Monitoring & Diagnostics
12	* Combined TGMS & Instrumented Wheelset System
13	Advanced Vision-Based Inspection System
14	Effectiveness Of Inspection Systems
15	Short Wavelength Track Surface Irregularities
16	* Cab Car Anti-climbing Requirements
17	* Carbody Side Impact Strength
18	* Automated Vehicle Inspection
19	Location Determination
20	* Longitudinal Rail Force Measurement
21	Inspection Test and Maintenance

*** (2005 midyear updates to these 2004 Research Statements not available by July 7, 2005)**

PROBLEM 1: CRASH ENERGY MANAGEMENT DESIGN

Passenger railroads need practical crash energy management design solutions to include in future equipment procurements and information on the implications of new designs on existing equipment and operations.

Objective

- Determine if cost effective, state-of-the-art, crash energy management designs can be developed compatible with North American carbody structural requirements.
- Determine the operational compatibility and safety of mixed operation with conventional and CEM compliant equipment.
- Increase the awareness of the benefits of crash energy management design.
- Provide guidance on writing crash energy management specifications.
- Develop tools and test techniques to validate crash energy management designs.

Related Work

- At APTA's request, FRA funded Arthur D. Little to develop a risk assessment methodology to help commuter railroads determine the costs and benefits of procuring rail passenger equipment designed with crash energy management systems.
- FRA has initiated a program through the Volpe Center to study the feasibility of and benefits of incorporating CEM in a North American passenger rail car. Further studies have focused on the operational factors of including CEM cars in a conventional consist. Preliminary results suggest that including CEM cars in a conventional consist can potentially improve, but never degrade, crashworthiness performance. Furthermore, including specific components of a CEM system, such as a deformable anti-climber and a push-back coupler, will bring about incremental crashworthiness improvements.
- The Volpe Center has completed development of a proof-of-concept CEM system for coach cars, and is currently in the process of developing a proof-of-concept

CEM system for cab cars. A full-scale test of a CEM consist which includes one cab car, four coach cars, and a locomotive will be conducted in 2006 at the Transportation Technology Center in Pueblo, Colorado.

- APTA has developed a recommended practice that gives commuter railroads guidance on how to write procurement specifications for equipment with a crash energy management feature.
- Significant R & D has been completed in Europe to incorporate CEM into UIC designed intercity and commuter cars.

Urgency

The subcommittee rated this a priority one or most urgent rail passenger safety need.

Cost

$1,500,000.

PROBLEM 2: PASSENGER CAR SEAT TESTING

Past research on seat performance in collisions, while extensive, has focused on a few varieties of seat orientation - - particularly parallel row seating. Additional test data is needed to validate the computer model that predicts seat performance and passenger motion under various collision scenarios for a broader set of seating and furniture arrangements. A better understanding of crash pulses is also needed.

Objective

- Validate assumed crash pulses used during sled tests of rail passenger seats.
- Include realistic seat to carbody attachment techniques in future tests.
- Evaluate different seat configurations (i.e. opposing facing, transverse seating, use of tables for compartmentalization).
- Under realistic crash test conditions, validate existing computer models that predict seat performance.
- Investigate improvements in seat and table designs to mitigate passenger injuries due to passenger secondary impacts.
- Develop industry standards for seating other than row-to-row style arrangements.

Related Work

- At APTA's request, FRA funded sled tests of four types of commuter rail passenger seats with instrumented crash test dummies. The results of these tests recently became available and based on the assumed crash pulse, show a few areas where seat design could be improved.
- Amtrak and the Volpe Center (funded by FRA) jointly conducted sled tests of typical inter-city passenger coach seats.
- Simula Inc. has developed a computer model that predicts seat performance and passenger motion under various collision scenarios.

- APTA standards only apply to row-to-row style seating. Further research is needed to define standards for other types of seating arrangements.
- The Volpe Center is currently conducting a study (funded by FRA) that investigates the causes of passenger injuries that have occurred in recent train accidents.
- The Volpe Center has included several occupant experiments on the series of full-scale tests that is currently underway. The following seats have been tested:
  - Forward-facing commuter seats
  - Rear-facing commuter seats
  - Forward-facing inter-city seats
  - Forward-facing inter-city seats modified to include a lap belt and shoulder harness restraint system
  - Forward-facing commuter seats with intervening workstation tables
- The Volpe Center (funded by FRA) is currently in the process of developing an improved workstation table that will reduce passenger injury risk in train accidents. This seat will be included on the upcoming train-to-train test of CEM equipment.
- The Volpe Center (funded by the FRA) is currently in the process of developing an improved commuter seat that will reduce passenger injury risk in both the forward-facing and rear-facing configurations. This seat will be included on the upcoming train-to-train test of CEM equipment.

Urgency

The subcommittee rated this a priority one or most urgent rail passenger safety need.

Cost

$1,500,000.

PROBLEM 3: VEHICLE CRASH TESTING

Detailed computer models have been developed, and the analysis results from these models have been used to form a substantial portion of the technical bases of recent FRA passenger equipment rules and the APTA PRESS Manual. To date, there is limited crash test data for North American passenger rail components and vehicle structures. There is a need to validate the modeling and analysis currently in use through component, scale and full scale testing.

Objective

The overall objective is to measure the performance of current-design equipment and improved-design equipment (i.e., crash energy management design) in various collision scenarios. These collision scenarios should include a head-on collision and an oblique collision. The test program should be designed to assure adequate technical understanding of rail equipment behavior during collisions, and to address:

- Car-to-Car Interactions
- Secondary Collision Environment
- Body Sheet Metal/Main Structure Interaction

- Large Crush Distances

The results of this testing should be used to develop/validate computer crash models and support future scale model testing for various carbody designs.

This research program should include conducting a review of foreign crash test experience.

Related Work FRA has initiated a series of full-scale vehicle tests to quantify the potential benefits of incorporating CEM features in passenger rail cars. This testing has been funded by the FRA and has been conducted at TTCI in Pueblo, CO. The matrix of full-scale in-line tests is shown below:

Test Conditions	Conventional Equipment	Crash-Energy Management Equipment
Single-car impact with fixed barrier	Nov. 16, 1999	Dec 3, 2003
Two-coupled-car impact with fixed barrier	Apr. 4, 2000	Feb. 26, 2004
Cab car-led train impact with locomotive-led train	Jan. 31, 2002	Planned for 2006

- The key results of this testing are shown below. The complete results can be found at http://www.volpe.dot.gov/sdd/pubs-crash.html
    - The single-car impact test of conventional equipment showed significant loss of occupant volume.
    - The single-car impact test of CEM equipment demonstrated the functionality of the system, highlighted by the preservation of occupant volume and negligible vertical and lateral car body accelerations.
    - The two-car test of conventional equipment showed significant loss of occupant volume, as well as significant vertical and lateral accelerations.
    - The two-car test of CEM equipment demonstrated that the occupant volume is preserved, and crush can be passed back to following cars. Additionally, vertical and lateral accelerations were significantly reduced.
    - The train-to-train test of conventional equipment showed a loss of roughly twenty feet of occupant volume, resulting in the loss of at least six rows of seating along with the operator's compartment. Additionally, the cab car overrode the locomotive, presenting significant vertical and lateral accelerations to the occupants.

- The train-to-train test of CEM equipment is expected to demonstrate the effectiveness of CEM in a full consist. The occupant volume will be preserved, as well as the operator's compartment. The cab car will not override the locomotive, and the vertical and lateral accelerations seen by the occupants will be negligible.

- Significant component and full scale crash testing has been completed in Britain, France and Japan.

Urgency

The subcommittee rated this a priority one.

Cost

$1.5 million.

PROBLEM 4: RISK ASSESSMENT METHODOLOGY

The recent move toward "performance-based safety standards" requires all railroad operators to include risk assessment in their Railroad Safety Program Plans (RSPP) or Product Safety Plans (PSP) when modifying the train control systems. Although the regulation (49 CFR 236 Subpart H) does not specify the methodology, it requires the industry to produce the complete (documentation), correct (assumption), valid and satisfactory models in risk assessment. Such models would provide decision-makers with performance measures between the base cases and alternative bases in the safety of a proposed passenger rail operation, and for estimating the return of investments in safety improvement projects.

Risk assessment methods have been applied to specific railroad safety issues on a number of occasions in recent years, but none of these methods are entirely satisfactory or have met with general acceptance in the industry. In many cases the analyses have been narrowly focused to answer a specific question, and concerns have been expressed regarding the validity of input data, identification of hazards and similar matters. A research generally accepted risk assessment methodologies and for the best analytical practices should remove these limitations and promote/facilitate a wide application of risk assessment tools in railroad safety evaluation.

Objective

The overall objective is to develop, document and review a suite of risk analysis methodologies acceptable to system users, operators, suppliers and regulatory agencies. The proposed methodologies and tools should be developed from past passenger rail safety experience and should be practical to both traditional and non-traditional infrastructure, and compatible with varied operating methods, equipment, signal and train control systems, and grade crossing applications.

Specific areas to be emphasized in the research should include:

- Choice of a risk assessment approach to address a specific question.

- Selection of appropriate safety measures that can be used to compare the safety performance under different operating conditions, and to provide readily observable indicators of ongoing safety performance.
- Use of hazards analysis techniques such as fault and event tree analysis, failure modes and effects analysis and similar methods to identify root and contributing causes of accidents.
- The references and applications of quantitative methods including mathematical, statistical, engineering and operations research techniques to analyze railroad accidents by types (causes or operating conditions), specifically to estimate the (future) probabilities and consequences of these accidents in specific scenarios.
- Documentation of data sources and their qualities to support passenger rail risk assessments.
- Interpretation of risk assessment results, including uncertainty and sensitivity issues.

The applications of risk assessment include:

- Hazards Identification: documenting all the hazards and their relationship for the system, and identifying the failure modes and rates associated with each hazard.
- Mitigation Analysis: defining the changes and restrictions of a proposed system, including component design, performance specifications, manufacturing warranty, maintenance, inspection and other operational requirements, as ways to reduce the risks.
- Risk Calculation: evaluating the levels of risk (safety performance) for both freight, passenger and mixed rail operations, including the shared use of railroad tracks, right of ways and/or corridors for conventional railroad and transit operations.
- Regulatory Support: meeting the government and industry safety performance objectives, and making the tools in compliance with existing safety standards and facilitating the development of effective and economical safety-related regulations and practices, including cost-benefit analysis.

The newly published safety standard in 49 CFR Part 236.900 Subpart H identified the following requirements in risk assessment for processor-based signal and train control systems:

- Conformance and trace ability to safety requirements;
- Submission of required documentation;
- Use of appropriate standards;
- Strength of technical justifications;
- Completeness of risk analysis (including Base Case Analysis) and level of risk;
- Adequacy and results of unit, integration, acceptance safety testing;

- Conformance to appropriate software development and test methodologies;
- Strength and accuracy of internal quality assurance, and Verification and Validation (V&V) efforts;
- Results of third party reviews (if conducted).

This new performance-based safety standard has specific timelines for the industry to document their system safety. On any proposed new train control systems, the railroads have to develop risk mitigation strategies and to prove their proposed new systems are as good as (or safer than) the old (or existing) systems; and the government need to review their risk assessment methodology in the safety case document. Planning-level analyses to support selection of safety-related features for a new or upgraded passenger rail corridor. For example, risk assessment can be used to assess grade crossing collision risks for both highway users and train occupants and estimate the benefits of a package of grade crossing improvements. Both industry and government have to come to an agreement on a variable set of risk assessment methodologies. From there the computer models/toolkits can be developed for risk assessment with user's input and modification. For example, the user must be able to import fault and event trees from other users and to customize the model for his/her own operating environment.

Related Work

Risk assessment has been widely used in chemical processing, security, defense, aviation, space, and nuclear systems. In the past decade, US railroads have adopted several risk assessment techniques for a few specific operations such as the Amtrak High Speed Rail Service in the Northeast Corridor, the formerly proposed FOX system in Florida and the operation of TALGO in the Northwest Corridor.

In support of the demonstration of Positive Train Control (PTC) systems, USDOT (FRA/FTA) sponsored a number of research projects on risk assessment toolkits. Various methodologies and software packages were developed during the following projects:

- The North America Joint PTC Demonstration Program (NAJPTC) and Illinois DOT PTC (IDOT) project;
- CSX's Computer-Based Train Management (CBTM);
- BNSF's Electronic Train Management System (ETMS);
- Grade-Crossing project evaluation in North Carolina;
- Communication Based Train Control (CBTC) projects in NYCTA and NJ Transit;
- Maglev Demonstration Lines of Baltimore-Washington and Las Vegas-Anaheim;
- Maglev Demonstration Line for Pennsylvania High Speed Maglev Project.

These projects have produced their own risk models, however their fault trees, event trees and base case results could not be cross-referenced/shared among various user/developer groups. Their methodologies have not been formally validated by or agreed on the government's technical staff, industries and academies. Therefore, there is a need, for TRB (the National Academies or National Research Council) to set an open consortium on the development of risk assessment methodology (technical standard), and the later evaluation of risk assessment results. A public forum is needed to facilitate the discussion, peer-review, user training, and data sharing.

Urgency

This effort should have a top priority. After the tests and trials in the past five years, it's time to bring all the interested parties together: finalize key methodologies, examine the various assessment results, and come to agreements on credible data and assumptions. Then, industry and government could apply these methodologies or tools with confidence in risk assessment.

Cost

$500,000.

PROBLEM 10: FIRE SAFETY AND PASSENGER EMERGENCY EGRESS

As part of the passenger equipment safety standards issued in Part 238, on May 12, 1999, the FRA now requires that rail car materials be tested and meet minimum flammability and smoke emission performance criteria. Although useful as a screening tool to eliminate particularly hazardous materials, the small-scale tests may not reflect the actual behavior of the materials in a real-world fire. As an alternative, the FRA now allows the use of heat release tests and minimum performance criteria for seat assemblies and small parts.

The FRA also requires that fire safety analysis be conducted for both existing and new equipment. Currently, the industry has no means to quantitatively measure the degree of additional safety provided by fire protection requirements, such as fire detection and suppression, and emergency egress systems.

Objective

- Revise the table of FRA tests and performance requirements for materials to permit the expanded use of heat release rate data.
- Use accident statistics and fire hazard analysis to identify potential fire hazards and scenarios for passenger rail equipment operating in various environments, including tunnels, to determine the level of risk.
- Develop detailed guidelines and recommendations, as warranted, for fire detection and suppression and egress system requirements.
- Develop a means to quantify the additional protection provided by various proposed fire protection design requirements. (See also Problem 24)

Related Work

- FRA is now funding a fire safety research program at Southwest Research Institute. This research is building upon previously completed research by the National Institute of Standards and Technology. The intent is to permit the evaluation of the fire performance of individual materials on the overall rail car fire hazard. The previous FRA-funded NIST study demonstrated the feasibility of evaluating rail car fire performance by the use of fire hazard analysis based on quantitative heat release rate data. FRA issued fire requirements in the May 12, 1999 passenger equipment safety standards, which were clarified on June 25, 2002.

- The Federal Transit Administration continues to fund an effort to update its table of tests and performance criteria. The FRA and FTA funded efforts are being coordinated by the Volpe Center.
- The National Fire Protection Association has expanded the scope of the previously existing rail transit standard for fire and life safety (NFPA 130) to now include passenger rail equipment. NFPA 130 committee work to make further revisions to the standard is ongoing and monitored by Volpe Center staff in coordination with the FRA/FTA sponsored fire safety research program.
- APTA has published a Recommended Practice for Fire Safety Analysis of Existing Passenger Rail Equipment. This recommended practice provides guidance for making determinations as to which categories and levels of fire safety risks may be unacceptable and acceptable to railroads for the purpose of regulatory compliance

Urgency

The subcommittee rated this a priority two.

Cost

$575,000

PROBLEM 13: ADVANCED VISION-BASED INSPECTION SYSTEM

The need for increased application of automated track inspection technology continues to grow as inspection territories expand and traffic tonnage continues to increase in the rail industry. Manual inspections based on the inspectors' visual verification of the integrity of the infrastructure play the critical role in directing maintenance and assuring the safety of track and structures on the nation's railroads.

It is becoming increasingly difficult for railroads to allocate the manpower and track time necessary to conduct accurate visual track inspections as traffic densities increase. Currently, individuals either walking or riding over the inspection territory perform visual inspections. This method of inspecting track limits the amount of territory that can be safely and accurately inspected. To improve the efficiency and safety of the visual inspections, the application of vision-based technology will be required to either enhance the inspectors' productivity or to provide opportunities for technology-based alternatives to current inspection strategies. In order to make more efficient use of track time and reduce the risk of injury to track inspectors, the railroad industry will need to introduce Vision-Based Inspection systems to assess track structures.

Objective

- Identify all the tasks currently performed by track inspectors from hi rail vehicles and on foot.
- Evaluate current or potential alternative inspection strategies both nationally and internationally.

- Evaluate the current status of existing automated inspections systems for track and conduct a survey of the automated inspection services industry to determine the potential for application of the technology.
- Determine the feasibility of providing inspections equivalent to current visual inspections through automated means.
- Develop and demonstrate a prototype automated vision-based inspection system that could be used to assist or replace current visual track inspection techniques.

Related Work

Other industries with distributed infrastructure, highways and pipelines most notably, have begun to make increased use of vision-based systems to detect defects and signs of structural degradation. Vision system technology for image acquisition and processing has advanced substantially in recent years to the extent that system operating speeds, resolution, cost and reliability make application in the railroad industry practical. At least one U.S. railroad is currently developing such a system to augment their visual inspection operations.

Urgency

The subcommittee has rated this a priority two.

Cost

$400,000.

PROBLEM 14: EFFECTIVENESS OF INSPECTION SYSTEMS

The new track safety standards define requirements for both new and conventional inspection techniques. Each of these inspection methods can be used to detect specific types of rail and track defects. Several of the inspection techniques monitor similar failure modes creating overlap between the inspection methods. To provide a cost effective track inspection and maintenance program, a systems approach to safety must be taken, which maximizes the benefits obtained by each type of inspection method and ensure each method is used to monitor the failure modes it is best at detecting.

Objective

- Establish a comprehensive list of all types of defects that occur on conventional and high-speed track.
- Determine the types and severity of defects that can be reliably detected by each inspection method.
- Based on statistical data and analytical models, determine the rate of occurrence and propagation of each defect type for various operational environments.
- Provide recommendations as to the required frequency of each inspection type for a cost effective track maintenance program.

Related Work

None currently known.

Urgency

The subcommittee has rated this a priority two.

Cost

$150,000.

PROBLEM 15: SHORT WAVELENGTH TRACK SURFACE IRREGULARITIES

Cross-level track variations that occur over a short wavelength (such as the truck wheelbase or less) can cause significant wheel unloading. This becomes of particular concern on curved track. There are currently no requirements in the track safety standards that address this issue.

Very short wavelength track irregularities, less than 3 feet in length down to as small as ½ inch, may also cause significant vehicle response and the rapid deterioration of track structures. Critical defect types and sizes are not well understood nor is the optimum rail and wheel profile combination. These defects are of significant concern and are difficult to find with conventional track measuring systems.

Objective

- Study the effect of short wavelength cross level and combined defect variations for conventional and high-speed vehicle suspensions.
- Estimate how to partition operating and track geometry defect regimes where cross level variations can be considered independently of other defects as they influence derailment potential, vehicle response and track deterioration, and regimens where cross level variation cannot be considered independently of these other defects.
- Develop an understanding of real-world short wavelength track irregularities and measurement techniques for same, and their effect on vehicle response and effect on track deterioration.
- Determine the practicality and potential advantages of including requirements for short wavelength track irregularities (particularly cross-level variations) in federal safety standards.

Related Work

Requirements for short wavelength cross-level variations are included in UIC track safety standards. APTA has established a committee to study the problem of wheel climb derailment associated with cross-level variations.

There does not appear to be any research being conducted on the effect of other short wavelength track irregularities on vehicle response or track degradation rate.

Urgency

The subcommittee rated the requirement to conduct research on the effect of short wavelength track surface irregularities as a priority two.

Cost

$150,000.

PROBLEM 19: LOCATION DETERMINATION

Passenger and high-speed rail services generally require more frequent inspection of track and other infrastructure to ensure continued operational safety. This inspection is more often conducted with automated systems and vehicles that move at typical track speeds to exploit ever shrinking maintenance periods due to increased traffic, especially on busy rail corridors. The implementation of satellite-based location determination technologies on such moving inspection and/or monitoring systems allows for the accurate mapping of locations where safety or maintenance exceptions may be recorded. The added exploitation of newer wireless communication technologies allow for the inspection results to be communicated in near real-time to other remote locations for timely maintenance planning and execution. Further utilization of Graphical Information Systems (GIS) mapping applications can provide for intelligent and consistent viewing of inspection results onboard the inspection cars and remotely and can provide further insight into the overall conditions of track and fleet (as in the case of data reported from multiple health monitoring sensors on multiple vehicles).

Objective

- Integrate location determination technologies in automated track inspection and fleet monitoring systems for marking safety and/or maintenance exceptions,
- Translate locations determined into rail mileposts and feet from milepost units,
- Integrate location determination with wireless communication technologies for reporting to remote sites,
- Integrate location determination (and wireless communication) with GIS mapping applications for consistent and informative presentation of inspection results or monitoring trends.

Related Work

The FRA has currently began utilizing all the three above-mentioned technologies on their T-16 high speed rail inspection car and their remote monitoring systems. Amtrak and Marc have also successfully utilized the remote monitoring systems developed by the FRA for monitoring system performance. Continued refinements are needed for a more seamless integration of all three technologies and for better utilization of the newer wireless telecommunication technologies. Further work is also needed in establishing methods for analyzing and extracting performance trends from either track inspection or fleet monitoring or both. The FRA is also developing a prototype track geometry system that will be mounted to a revenue rail car and operated autonomously to detect spots with unsafe track conditions. They system will integrate the latest location determination technology and will send a frequent report with its findings to a remote office.

Urgency

The subcommittee rated this a priority three.

Cost

$200,000.

PROBLEM 21: INSPECTION TEST AND MAINTENANCE

All intercity rail operators are actively engaged in assessing the effectiveness and efficiency of their inspection, test, and maintenance programs through the use of modern computer tracking programs, scientific and statistical methods, research institutes, and government agencies.

Objective

Develop and validate dynamic inspection test, and maintenance programs for intercity railroad systems, thus allowing the cost-effective use of maintenance resources.

Related Work

Metro North Railroad and several European high-speed rail operators currently have reliability centered maintenance programs.

The APTA PRESS Task Force adopted an industry recommended practice for using reliability data to justify changes in periodic maintenance intervals.

The Volpe Center has written a report entitled “A Comparative Analysis of High-Speed Train Inspection and Maintenance Programs.”

Urgency

The subcommittee rated this a priority three as the need is less urgent than most others.

Cost

$150,000.

PROBLEM 22: EMERGENCY COMMUNICATIONS

Some recent passenger train accidents indicate a need to make improvements to the rail passenger car emergency communication system. For maximum effectiveness, this emergency communication system should include both visual and audible means for providing passenger awareness to 1) avoid confusion and panic and 2) direct passengers in the event of an emergency. Visual means for emergency communications include signs, and other special markings, emergency lighting, and information booklets. Audible means to communicate with passengers include the car PA system, and portable amplifiers. In addition, car intercoms, radios, and cell phones provide a means for the train crew to contact each other, the dispatcher, and in serious emergencies, the local emergency response organization. The design and interaction of the various components of the emergency communication system are key to the integrity of the system. For instance, the distance at which an exit sign is visible and readable depends on the sign letter size, background contrast, and the level of emergency lighting provided. A particular issue is how to ensure PA/intercom operation in the event of a trainline break.

Objective

- Develop a knowledge base through testing or validated analytical techniques that can be used to optimize the emergency communication system.
- Develop a means to quantify the additional protection provided by various proposed emergency communication system design requirements.

Related Work

- FRA's Passenger Equipment Safety Equipment Safety Standards contain improved requirements for passenger emergency egress systems.
- The FRA is funding a research study by the Volpe Center that includes a "systems" approach to emergency communication. The study is in support of the the FRA rail equipment rulemaking and is directed at providing technical and quantitative information, which will allow the analysis of tradeoffs between benefits and costs.
- In addition, the APTA PRESS Task Force has developed standards for emergency communication, emergency signs, emergency lighting, and low location exit path marking.
- Continued PA/intercom communications after trainline break has been identified as an area requiring further study.
- FRA has established a Railroad Safety Advisory Committee (RSAC) Working Group for Passenger Rail Equipment. Enhancements to the FRA regulations for emergency systems, including emergency lighting, exit and access exits, and signs and instructions are being developed by the Emergency Preparedness Task Force. An NPRM is expected in 2006, Volpe Center is providing technical assistance to the RSAC Emergency Preparedness Task Force.
- While the APTA PRESS Task Force has developed and adopted several industry standards that provide very specific design requirements for several aspects of emergency egress systems, including emergency signs, emergency lighting, and low level exit path marking.

Urgency

The subcommittee rated this a priority three since the research activity is already underway.

Cost

$100,000 for a high-level review of issues.

PROBLEM 24: PASSENGER COACH EMERGENCY EGRESS

Some recent passenger train accidents indicate a need to make improvements to the rail passenger coach emergency egress system that includes emergency signs, emergency lighting, number and size of emergency exits. The FRA Passenger Equipment Safety Standards (49 CFR 223 and 238), published on May 12, 1999, as modified on April 3, 2002,and a related regulation, the FRA Passenger Train Emergency Preparedness regulation (49 CFR Part 239) published May 4, 1998, contain general and specific requirements for emergency planning, procedures, emergency communications, passenger awareness, crew training, as well as the size, location and operation of emergency exits.

Although very little data exists on how to optimize the passenger car emergency egress system, the FAA has conducted extensive research related to these emergency evacuation topics.

Objective

- Develop a knowledge base through testing or validated analytical techniques, including emergency egress models that can be used to optimize the time available to evacuate passengers from railroad specific vehicles.
- Evaluate the backup power needs for emergency egress systems under various accident scenarios.
- Develop a means to quantify the additional protection provided by various proposed emergency egress system design requirements.
- Provide a means for the impact of rail car orientation on evacuation time and provide a training tool for railroad crew and emergency response personnel.

Related Work

The APTA PRESS Task Force has developed and adopted several industry standards that provide very specific design requirements for several aspects of emergency egress systems, including emergency signs, emergency lighting, and low level exit path marking. APTA has used the results of FRA-sponsored research by the Volpe Center to develop the detailed provisions of these PRESS standards. However, the APTA-developed standard for emergency exit units is problematical since the provisions are theoretical and not based on actual evacuation times by passengers. FRA-sponsored research being conducted by NIST and directed by Volpe is ongoing to develop a revised standard for emergency exits based on computer modeling and actual evacuation times based on human factors experiments to provide a more supportable technical rationale.

Urgency

The subcommittee rated this a priority three as the need is less urgent than many others.

Cost

$750,000

PROBLEM 25: COMPARATIVE ANALYSIS OF THE NO-BUILD ALTERNATIVE FOR HIGH-SPEED

RAIL PROJECTS

Several previous high-speed rail projects in the U.S. were proposed, analyzed, assessed, but were not built, e.g., the "No-Build Alternative" was selected. There is a need for a comparative analysis of the key factors used for these projects to define the need for an intercity travel alternative and to characterize the baseline or "No-Build Alternative".

Objective

To provide a systematic framework for completing a comparative analysis of the No-Build Alternative for three previous high speed rail projects in the U.S. (Texas, Florida, and California), addressing:

- Factors used to define the need for a high speed rail alternative for intercity travel (congestion relief, travel time savings, mobility improvements, safety, air quality, and energy savings)
- How the baseline is defined for existing conditions and future years for the No-Build Alternative.
- How the actual data for each of the No-Build Alternative factors compares with what was estimated at the time that the high speed rail was proposed.

The research may be presented as a White Paper summarizing the results of the comparative analysis resulting from systematic data collection and comparison of factors used: (1) to define the need for high speed rail in three states and, (2) to document the actual resulting "No-Build" environmental factors to assess if the need was understated or overstated.

Urgency

Priority 3

Cost

Estimated cost $90,000.

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PROBLEM 28: TRACK TRANSITIONS

Track transitions, where changes in the track structure result in changes in track support, often cause poor track performance. Track transition locations with reported poor track performance include: bridges/tunnels, highway-rail grade crossings, turnouts, crossing diamonds, and changes in tie type and size. Track transitions are associated with increased levels of track maintenance, track geometry exceptions, and dynamic loading. Due to the location of transitions where structures and other traffic increase the potential damage during derailment, it is imperative to minimize the risk exposure by addressing the cause of poor performance. Poor performance at transitions is typically addressed by increasing maintenance, much of which requires non-mechanized, hand maintenance at high cost. Improved techniques to better design and maintain transition sections are required, since ride quality criteria dictated by higher speeds require tighter track geometry tolerances. Recommended practice to ensure that transitions are built for good performance combined with safety standards to ensure the good condition is maintained will minimize the risk exposure. Common methods to rebuild transition sections have been recently investigated on a major North American freight railroad with the conclusion that none of the improved designs performed noticeably better than the control transition of standard construction.

Objective

The main objective of the research is to develop techniques for constructing, upgrading, or modifying transitions that improve track performance. This requires investigating the mechanisms causing the poor performance at transitions and developing strategies that target the problem to improve track performance.

Related Work

The FRA has sponsored two projects focused on cost-effective solutions to improving track transition performance: one focused on a grade crossing and the other on bridge transitions.

Zeta-Tech Associates, Inc. developed an analytical technique and a modified highway-rail grade crossing to improve the stability of the track geometry near the crossing. A dynamic analysis was conducted to determine the optimum design of the modified crossing and the crossing was installed and tested. Testing and interviews with engineers indicate that the track condition has improved with the new design and the required level of maintenance was expected to be reduced.

Professor Kerr of the University of Delaware developed a technique to determine the optimum stiffness of a rail seat pad to minimize the change in stiffness across a bridge transition. Installation of the pads accompanied by profiling the track at the transition has resulted in initial ride quality and track geometry improvement. Additional testing and longer term monitoring was conducted.

Transportation Technology Center Inc. (TTCI) has also participated in a research project with the Union Pacific Railroad to investigate the track behavior and performance at several newly constructed bridge approaches. The bridge approaches were constructed using a variety of new techniques expected to result in improved performance over the control section that was constructed to the existing Union Pacific standard. The result of the research was that none of the new techniques performed substantially better than the existing transition. This indicates that better knowledge of the problems at transitions is required since the hypothesized solutions appear to suffer the same degradation as the standard bridge approach.

Urgency

The research is urgently needed. Track transitions are common locations of track geometry exceptions, which represents a potential safety concern and high maintenance costs. The basic research into the mechanisms limiting the performance of track at transitions can also be used to develop improved maintenance strategies. With increasing speeds and, the need to provide improved safety and ride quality at transitions in a cost-effective manner becomes more critical.

Cost

The cost for the research is estimated at between $300,000 and $600,000.

User Community

Individual railroads, Federal and State Departments of Transportation, Passenger rail authorities

Implementation

AREMA Standards, reports, presentations

Effectiveness

The effort is expected to produce information on the mechanisms leading to poor performance at transitions. This information will be used to define strategies to design transitions for improved track performance and maintenance, eventually leading to improved design and construction standards.

PROBLEM 29: SUBGRADE CONSIDERATIONS FOR HIGH-SPEED OPERATIONS

Under very high-speed operations currently predicted to be above any practical speeds expected in the United States in excess of 200 mph large rail displacements due to dynamic effects have been predicted by track models. The main mechanism hypothesized for these large displacements is the transfer of the wave energy, specifically the shear wave, induced by the train through the track and into the subgrade The practical mechanisms of the occurrence of this phenomenon need to be examined in the lab and in the field. Recent research from Europe combining theory and measurements indicates the critical speed above U.S. high-speed operations, however advanced deterioration of track due to this problem has been noted at speeds in the range of current U.S. operations. Lab and field investigations are required to develop new or calibrate existing track behavior models to assure the predictions correctly reflect observed track behavior and failure mechanisms.

Objective

The main objective of the research is to address the potential for advance track geometry deterioration under high-speed operations. The approach should include reviewing available literature, investigating reported occurrences and the causal mechanisms, and verifying current models of dynamic track behavior followed by a field investigation..

Related Work

Research has been conducted internationally to evaluate the possible occurrence of excessive track displacement as train speeds approach the critical speed. An academic study of the problem has been made in the U.S., but the results should be verified to assure correct representation of the dynamic soil structure interaction and accurate safety assessment.

Urgency

The research is urgently needed. Although current models indicate that this could be a concern for U.S. operations, better understanding of the problem is needed to ensure the model predictions are correct and accurate.

Cost

$400,000

User Community

Individual Railroads, Federal and State Departments of Transportation, Passenger Rail Authorities

Implementation

AREMA Standards, Reports, Presentations

Effectiveness

The effort is expected to produce information to clarify the failure mechanisms and improve modeling of track behavior. This information will be used to define strategies to ensure track safety.

PROBLEM 30: DESIGN LIFE: TRACK SAFETY AND PERFORMANCE

Many passenger rail projects are being developed in this country with a combination of public and private funds. These funds are used to rehabilitate track corridors and equipment to reinstate or start passenger services. There is a strong interdependency between initial quality and long-term maintenance (e.g., high initial quality should provide low maintenance over the design life). Using standard crosstie track, typical construction utilizes standard cross sections. Weak track locations are identified by passing traffic and fixed or maintained throughout the life of the track. In heavily traveled and high-speed corridors, track design should incorporate some expected tradeoffs between initial quality and performance to ensure that the line can be operated with reasonable maintenance requirements. The design of the Channel Tunnel Connection to London has been heavily scrutinized to ensure the track is safe and feasible to construct and operate with publications indicating need for research to define relationships between initial quality and long-term performance. Research is needed to provide guidance to passenger rail authorities on the tradeoffs between initial quality (cost) of track and on-going maintenance to ensure that informed decisions can be made regarding the use of public funds on these projects.

Objective

The main objective of the research is to investigate the design/construction stage tradeoffs on overall track performance and economics. This requires reviewing available literature, investigating track design methods, evaluating track performance models, and developing guidelines useful for groups developing rail corridors.

Related Work

Research has been conducted internationally to develop track design methods incorporating traffic and track design parameters. AAR has developed a ballast thickness design procedure that requires an estimate of the design life. These models provide initial guidance on track design, but do not provide clear guidance on design life tradeoffs between initial cost and long-term maintenance expenditures.

Urgency

The research is urgently needed. Many publicly funded or subsidized passenger rail projects have been completed such as the Amtrak Downeaster service from Boston, MA to Portland, ME, some are in progress, and others are planned. Information obtained on completed or on-going projects can guide this effort and future projects. Guidance on design and planning stage tradeoffs regarding track performance and maintenance is needed immediately.

Cost

$150,000

User Community

Individual Railroads, Federal and State Departments of Transportation, Passenger Rail Authorities

Implementation

AREMA Standards, Reports, Presentations

Effectiveness

The effort is expected to produce information to clarify the tradeoffs between initial cost and long-term performance. This information can then be used immediately on passenger rail projects to better estimate design and construction stages costs and develop comparisons of long term maintenance cost implications.