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Special Report 316

# Evaluation of the Federal Railroad Administration Research and Development Program

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Special Report 316

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# **Evaluation of the Federal Railroad Administration Research and Development Program**

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Committee for Evaluation of the Federal Railroad Administration Research and Development Program

TRANSPORTATION RESEARCH BOARD  
*OF THE NATIONAL ACADEMIES*

Transportation Research Board  
Washington, D.C. 20001  
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This report has been reviewed by a group other than the authors according to the procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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## Preface

The Transportation Research Board formed the Committee for Evaluation of the Federal Railroad Administration (FRA) Research and Development (R&D) Program at the request of FRA to review the products and services that FRA's Office of R&D provides to FRA and to the railroad industry. The committee included members with expertise in mechanical, civil, electrical, and industrial engineering; safety and risk analysis; human factors; technology and R&D management; and railroad management, operations, and labor. The purpose of the review was to assist the Office of R&D in identifying research priorities, conducting successful research, and ensuring that its products find applications that contribute to railroad safety.

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's (NRC's) Report Review Committee. The purpose of this independent review is to provide candid and critical comments that assist the authors and NRC in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The contents of the review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. The following individuals participated in the review of this report: Lawrence Fleischer, Burlington Northern Santa Fe Railway, Fort Worth, Texas; Sue McNeil, University of Delaware, Newark; Gregory Mellish, CSX Corporation, Jacksonville, Florida; Louis Thompson, Thompson, Galenson and Associates, LLC, Chevy Chase, Maryland; and Paul Worley, North Carolina Department of Transportation, Raleigh. Although the reviewers provided many constructive comments and suggestions, they were not asked to endorse the committee's conclusions or recommendations, nor did they see the final draft of the report before its release.

The review of this report was overseen by Henry G. Schwartz, consultant. Appointed by NRC, he was responsible for making certain that an independent examination of the report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

Joseph R. Morris managed the study and drafted portions of the report under the guidance of the committee and the supervision of Stephen R. Godwin, Director, Studies and Special Programs. Katherine Kortum provided staff support for the committee's review of rolling stock and human factors research. Karen Febey, Senior Report Review Officer, managed the report review process. Norman Solomon edited the report, and Jennifer J. Weeks prepared the prepublication edition for web posting, under the supervision of Javy Awan, Director of Publications. Timothy Devlin assisted with meeting arrangements and communications with committee members.



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## Summary

The Transportation Research Board formed the Committee for Evaluation of the Federal Railroad Administration (FRA) Research and Development (R&D) Program at the request of FRA to evaluate the effectiveness of FRA's process for identifying research priorities and the usefulness of FRA R&D products for improving railroad safety. The committee evaluated the programs of each of the four Office of R&D divisions (Track and Structures, Rolling Stock, Train Control and Communications, and Human Factors) by examining selected projects (Table 1) and reviewed the support functions of planning, evaluation, and management.

The committee grouped the questions posed in its charge into three evaluation criteria:

- Context: Is the R&D activity based on an understanding of industry and FRA needs and priorities, institutional arrangements, and technical resources?
- Input: Does the R&D activity benefit from communication with relevant parties, including railroad and supplier industries, researchers, the FRA Office of Railroad Safety, and other government agencies?
- Impact: Are research products of high technical quality, do the results of the research find application, and do the applications have demonstrable benefits?

The first section below summarizes the committee's conclusions on the performance of the R&D office divisions with respect to these criteria. The second section presents conclusions on support functions. The final section presents recommendations.

### CONCLUSIONS ON THE R&D DIVISIONS' PROGRAMS

#### Context

- In each of the four divisions, the case studies indicated a clear understanding of rail industry safety concerns and responsiveness to the priorities of FRA's Office of Railroad Safety, industry, and workers. No instances of the R&D program overlooking a recognized important source of risk were evident, although the committee did not systematically compare risk sources with R&D resource allocation.

#### Input

- The FRA R&D divisions are engaging with the Office of Railroad Safety, industry, and researchers and are seeking their input. The case studies included examples of projects developed with input from industry and from the Office of Railroad Safety and cases in which industry demonstrated support through participation in development and testing.
- The stakeholder review panels formed to support projects in the Human Factors Division have been effective. Such external panels are a promising means of improving communication with industry and other interested parties, especially where research objectives need sharpening in the early stages of projects and where stakeholder engagement is material to success.

**TABLE 1 FRA Office of R&D Projects Selected as Case Studies**

<b>Project</b>	<b>Description</b>	<b>Status</b>
<b>Track and Structures Division</b>		
Autonomous Track Geometry Measurement	Develop a system to measure and record track geometry remotely from an autonomous rail car in regular revenue train service.	Initiated in 2006. In final development stages; scheduled to be demonstrated on short lines in 2015
Track Buckling Detection with Fiber Optics	Use buried fiber-optic cable to “listen for” and detect track buckling both under and in advance of trains.	In early stages and unfunded, but funding anticipated in 2015
Handheld Rail Flaw Tomographic Imaging System	Replicate and validate experimentally results from a previous study on reliably detecting rail flaws.	In middle stages of development
Vehicle–Track Interaction (interagency agreement with Volpe Center)	Reduce derailment risk attributable to vehicle–track interaction.	Long-established partnership
<b>Human Factors Division</b>		
Fatigue	In a series of studies, characterize railroad worker work–sleep patterns.	Begun in early 1990s; has resulted in several data collection efforts and analyses
Suicide Prevention	Collect data to improve understanding of and thus prevent train-related suicides.	Begun in mid-2000s; still in early stage
Clear Signal for Action	Develop projects to improve organizational safety culture.	Begun in late 1990s; several initiatives complete
Cab Technology Integration Laboratory	Provides a simulation laboratory to advance human factors research.	Developed in mid-2000s; several projects are using the laboratory
<b>Rolling Stock Division</b>		
Fire Safety	Develop fire safety standards for passenger rail cars.	Follow-on project in long-established area; recently started
Biobased Lubricants	Test the feasibility of using biodegradable lubricants and greases.	Work is complete and report delivered to Congress
Automated Cracked Wheel Detection	Develop new cracked wheel detection technologies.	System deployed by a Class I railroad
Hazardous Materials Risk Assessment	Identify opportunities for risk reduction.	In final stages
<b>Train Control and Communications Division</b>		
Employee-in-Charge Portable Terminal	Develop a device that allows employee control of train entry and speed in temporary work zones.	In progress
Positive Train Location	Develop a more precise system to identify train location.	In progress
Warning System and Pedestrian Behavior	Determine whether a second train warning with an auditory component lessens pedestrian crossing violations.	In process of publishing final report
Dedicated Short-Range Communications Grade Crossing	Develop a highway–rail grade crossing warning to be used in intelligent transportation systems.	In early stages; a component of U.S. Department of Transportation overall intelligent transportation systems research effort

- Some case study projects would have benefited from greater input from industry or the Office of Railroad Safety to clarify objectives or avoid duplication. An apparent low level of industry awareness of some R&D activities limits opportunities for input and indicates a need for more regular and frequent communication between R&D office staff and employees of the railroads, in particular, those responsible for R&D.
- Evaluations are a vital form of input for program guidance. The Human Factors Division is leading development of evaluation procedures.

## **Impact**

- The case studies demonstrated numerous instances of application of R&D products, including adoption of products by industry and use of research results to support rulemaking. Most current projects reviewed have prospects for producing results that can lead to safety improvements. Overall, the productivity of the R&D program appears good, and the program appears well focused on safety.
- Some projects have not produced applications. Projects that do not yield tangible results can nevertheless contribute to understanding of safety issues. Such outcomes are worthwhile and are to be expected in a research program.
- Some programs face obstacles that need to be overcome before faster progress can be achieved. Lack of data hampers progress in human factors research, particularly on fatigue and suicide prevention. The Cab Technology Integration Laboratory (CTIL) suffers from low utilization for reasons related to its location and rules governing its use and for lack of a satisfactory strategic research plan.
- Implementation of research products depends on actions of the railroads, industry suppliers, the Office of Railroad Safety, and others. Projects such as those supporting positive train control and connected vehicles are components of major industrywide systems and will yield safety benefits only as these systems come into operation. The R&D office can promote implementation through collaboration with these parties and through communication during all stages of its program.

## **CONCLUSIONS ON R&D SUPPORT FUNCTIONS**

The committee studied four R&D office support functions: communication with industry, the Office of Railroad Safety, researchers, and labor to identify priorities, recruit partners, and implement results; the annual priority-setting process; strategic planning; and program evaluation. The conclusions concentrate on communication; good communication strengthens priority setting, planning, and evaluation.

### **Communication**

- Communication between the R&D office staff and railroad employees responsible for R&D, engineering, and operations is necessary for identifying priorities, recruiting collaborators, and disseminating results. The case study projects showed good examples of collaboration with industry and with railroad professional societies, but in some instances awareness of FRA R&D activities did not appear to be high within the major freight railroads. More regular and frequent



communication with the railroads could improve FRA R&D productivity.

- The FRA Office of Railroad Safety is a primary client of the Office of R&D. FRA staff in both offices described frequent individual meetings to discuss R&D projects linked to rulemaking and periodic briefings by R&D staff for Office of Railroad Safety staff. However, it was not clear to the committee that regular, formal communication occurs between the two offices on all safety areas of mutual interest.

- In certain research areas, input from parties beyond industry and FRA is needed. In conducting and implementing research on crossing safety and suicide prevention, engagement of state departments of transportation and local law enforcement may be necessary. Communication and collaboration with the FRA regional offices could be helpful in identifying priorities or disseminating results of some projects.

- The R&D office's goal of increasing the number of R&D projects cofunded by industry is worthwhile. Industry support is evidence that a project is relevant and increases the likelihood of implementation. Cofunding leverages FRA research dollars.

### **Priority Setting**

- The R&D office's formal priority ranking tools are in a trial period during which their utility for supporting decisions is being tested. Their value has yet to be demonstrated, and they do not yet significantly influence decisions.

### **Strategic Planning**

- Development of an R&D strategic plan does not yet appear to be coordinated with established project selection and evaluation processes. Preparation of the strategic plan appears to be an occasional activity rather than an ongoing process, and the office does not track progress toward meeting plan goals. The committee understands that the 2013 R&D strategic plan is seen primarily as a public information source on the R&D program; however, a 5-year strategic plan can be a useful tool in guiding the R&D program and measuring its effectiveness.

### **Evaluation**

- The R&D office is developing an evaluation process that it intends to use routinely. The goal is for each project to be evaluated at certain stages while it is under way and its impact evaluated after completion. The office is beginning to conduct evaluations of selected projects in each division as a learning exercise. Aside from these pilot projects, formal consideration of evaluation needs or methods was not evident in the projects the committee examined.

## **RECOMMENDATIONS**

### **Communication**

1. To keep aware of industry safety priorities, generate more collaborative projects, and ensure that its products are widely applied, the R&D office should explore opportunities to increase interaction with the engineering, mechanical, operations, and research staffs of the

railroads and industry suppliers.

2. The R&D office should ensure arrangements for regular formal and informal communication with Office of Railroad Safety staff in all projects related to Office of Railroad Safety responsibilities.

3. The R&D office should establish external review panels for most projects. The composition and function of the panel would be designed to match the needs of each project. Most panels would include engineering, mechanical, operations, or research employees of the railroads and suppliers as well as independent technical experts. In research on suicide prevention, grade crossing safety, and hazardous materials safety, involvement of state and local highway and police agencies and the FRA regional offices should be considered.

### **Priority Setting**

1. FRA should continue work on adapting the Decision Lens priority-setting technique to its needs. If the technique fails to prove its worth, FRA should look to alternative objective procedures.

2. The priority-setting process should highlight the projects that hold the greatest promise. Projects lacking certain essential features, especially support of potential users, should be eliminated.

3. FRA should seek greater flexibility in the use of R&D funds provided by Congress by requesting in its annual budget proposal that R&D funding be pooled into fewer, larger categories.

4. The priority-setting process should distinguish between core functions (e.g., support of FRA facilities and programs at the Volpe National Transportation Systems Center and the Transportation Technology Center) and fully discretionary activities. Different forms of assessment may be needed for the two categories of activities.

5. The R&D office should review the research portfolio of each division to determine whether forgoing some activities to concentrate resources on activities with the greatest potential payoff could increase program benefits.

### **Strategic Planning**

1. The R&D office should regularly monitor its progress toward objectives defined in its 5-year research strategic plan and make midterm corrections in the allocation of resources to ensure that the plan's goals are met.

2. Future R&D strategic plans should be coordinated with an FRA strategic plan specifying the R&D office's role in meeting FRA objectives.

3. The R&D office should ensure that each long-term program area (such as vehicle-track interaction, safety culture, and CTIL) has a strategic plan defining measurable objectives and milestones.

4. The R&D office should undertake succession planning for long-term program areas to ensure that it retains domain knowledge. Retirements or the loss of key contractors could place retention at risk.

**Evaluation**

1. The R&D office should continue to test its evaluation process and to develop improved techniques until it settles on a method that ensures effective use of resources.
2. The R&D office should require that each project have built-in features to aid evaluation.
3. The R&D office should use the results of evaluations to improve its prioritizing procedures.
4. The R&D office should consider soliciting additional periodic reviews of its overall program, including annual review of research supporting rulemaking by senior Office of Railroad Safety staff and, for activities not driven by rulemaking, periodic in-depth technical reviews of selected areas by disinterested experts.

## Introduction

The Transportation Research Board (TRB) formed the Committee for Evaluation of the Federal Railroad Administration (FRA) Research and Development (R&D) Program at the request of FRA to review the products and services that FRA's Office of R&D provides to FRA and to the railroad industry. The committee is chaired by John M. Samuels, Jr., President of Revenue Variable Engineering, LLC, and includes members with expertise in mechanical, civil, electrical, and industrial engineering; safety and risk analysis; human factors; technology and R&D management; and railroad management, operations, and labor. Biographical information about the committee appears at the end of this report. The purpose of the review is to assist the Office of R&D in identifying research priorities, conducting successful research, and ensuring that its products find applications that contribute to railroad safety. FRA's principal strategic goal is improvement of railroad safety.

The committee reviewed the programs of each of the four R&D office divisions: Track and Structures, Human Factors, Rolling Stock, and Train Control and Communications. It also reviewed the support functions of planning, evaluation, and management.

The statement of task directing the committee's work (Appendix) identifies 11 questions to be addressed concerning the conduct and results of FRA R&D. For its review of the division programs, the committee grouped these questions into three evaluation criteria:

- Context: Is the R&D activity based on an understanding of industry and FRA needs and priorities, institutional arrangements, and technical resources?
- Input: Does the R&D activity benefit from communication with relevant parties, including railroad and supplier industries, researchers, the FRA Office of Railroad Safety, and other government agencies?
- Impact: Are research products of high technical quality, do the results of the research find application, and do the applications have demonstrable benefits?

The criteria of context, input, and impact are derived from the criteria that the R&D office has begun to apply in its own evaluations of its activities (FRA 2013a). [Box 1](#) shows how the 11 statement of task questions relate to the three criteria.

## METHOD OF THE REVIEW

To support its evaluations of the division programs, the committee examined four projects from each division as case studies. The committee formed four working groups of members, one assigned to each division. Each working group reviewed documentation of each of the group's case study projects and discussed each project with the R&D office division chief and program manager responsible for the project, researchers on the project, railroad industry employees and others outside FRA who were involved in the project or who have responsibilities closely related to the project's topic, and FRA Office of Railroad Safety staff responsible for the safety areas the project addresses. The R&D office regards the FRA Office of Railroad Safety, which is responsible for FRA safety regulation, as "a key internal stakeholder of FRA's R&D program" because "R&D provides the scientific and technological basis for rulemaking and rule

**BOX 1 Statement of Task Questions Relevant to the Context, Input, and Impact Criteria  
(Questions Are Numbered as in the Statement of Task)***Context:*

2. To what extent does R&D excel in conducting and using results from needs assessments and diagnostic studies to prioritize, focus, and plan projects and programs?
3. To what extent has R&D's planning support function defined a sound mission and associated goals and priorities that reflect assessed safety needs in the railroad industry?
4. To what extent is R&D sufficiently flexible and responsive in addressing changing economic, political, social, and technological contexts? (Question does not apply to planning and evaluation support functions.)
5. To what extent does R&D's current and planned portfolio and budget appropriately address its defined mission, goals, and priorities?

*Input:*

1. To what extent has the Office of R&D excelled in engaging, maintaining communication with, and using inputs from the full range of stakeholder groups?

*Impact:*

6. To what extent is the Office of R&D sufficiently staffed and funded in accordance with its mission and priorities to effectively carry out all of its programs and program support functions at a high level of quality?
7. To what extent is the R&D office's science and engineering work of excellent technical merit and quality, and appropriate and feasible for implementation? (Question does not apply to R&D support functions.)
8. To what extent are R&D services and products being used and/or adopted by the railroad industry both internal and external to FRA? (Question does not apply to R&D support functions.)
9. How effectively have R&D services and products helped the railroad industry improve safety and reduce fatalities? (Question does not apply to R&D support functions.)
10. To what extent does the Office of R&D evaluate its services and products prior to or during an implementation to help improve their usability and likelihood of adoption by industry?
11. To what extent is the Office of R&D effective in providing its key stakeholders with summative evaluation reports, technical reports, conference presentations, and other communications that validly assess R&D efforts, impacts, and cost-benefits?

enforcement” (FRA 2013b, 13). The working groups also reviewed documentation of the overall program of each division.

The case study projects were chosen by the working groups in consultation with the division chiefs. The committee sought projects at various stages of progress and reflecting the range of research areas within each division. The case studies include discrete research projects (i.e., with a single principal investigator, work statement, and primary product) and ongoing programs of research on a topic [e.g., vehicle–track interaction (VTI) and fatigue management]. They include projects with highly successful outcomes (or that show excellent promise of success) and some that yielded less valuable results. The committee believes that they are reasonably representative of the work of the R&D office.

The committee’s examination of each case study project was not at the depth of a technical peer review. If the committee found that it could comment constructively on the technical content or methods of a particular project, such comments are included in this report. However, the primary purpose of the case studies was to give the committee an understanding of the objectives and methods of each division’s R&D program as a whole, rather than to assess the merits of the individual projects.

To evaluate R&D support functions, a working group of the committee examined how the FRA R&D office conducts four activities: communication with industry, the FRA Office of Railroad Safety, researchers, and other constituents of the R&D office; the setting of priorities for project selection and allocation of funds; ongoing strategic planning; and evaluation of projects and of the overall R&D program. The support function review was based on R&D office planning documents and presentations to the committee by R&D office management.

The full committee supervised the working groups and reviewed and approved this report. The committee met twice to receive presentations from FRA, plan its review, and follow the progress of the working groups.

The committee succeeds a TRB committee that reviewed aspects of the FRA R&D program in a 2012 letter report (TRB 2012) and committees that reviewed the FRA research program in earlier years. The earlier committees based their reviews largely on presentations from FRA R&D office staff at committee meetings. The statement of task directing the present committee’s work differs from those of the earlier committees in requiring closer examination and evaluation of the technical content of the research programs in each of the FRA R&D office divisions.

This report was subject to an independent review according to the procedures of the National Research Council, as described in the Preface.

## **ORGANIZATION OF THE REPORT**

The first four sections below present the committee’s evaluations of the Track and Structures, Human Factors, Rolling Stock, and Train Control and Communications Divisions, respectively. For each of the three evaluation criteria of context, input, and impact, conclusions are presented on current performance and on gaps (missing elements or other weaknesses in the division’s program), and improvements are recommended. The final section presents the evaluation of R&D support functions. The summary at the beginning of this report regroups the committee’s overarching conclusions and recommendations.

## Track and Structures

The projects of the Track and Structures Division are organized in three program areas: track and components, VTI, and operations and facilities. The mission of the track and components research is to reduce the risk of derailments due to track or structure failure. The mission of the VTI research is to reduce the risk of derailments attributable to dynamic interaction between vehicles and the track. According to the R&D strategic plan, strategic priorities for the division are to develop track inspection technologies, develop models of VTI, expand use of autonomous methods for measurement of track condition, and develop methods for monitoring difficult-to-detect track safety issues (FRA 2013b, 10). To support its evaluation of the division's activities, the committee examined three case study projects from the track and components research area and the FRA-sponsored program of VTI research at the Volpe Center.

### CASE STUDY PROJECTS

#### Freight Car Autonomous Track Geometry Measurement System

The Autonomous Track Geometry Measurement System (ATGMS) project was initiated in 2006 and has been under development in a series of work phases for the past 8 years. The system is designed to measure and record track geometry remotely from an autonomous rail car in regular revenue train service. The system provides rail condition assessment continuously and at much lower cost than dedicated surveys requiring personnel, instrumentation, and a special manned vehicle. With frequently repeated assessments, time profiles of track geometry can be recorded and rail management and repair strategies developed to avoid speed restrictions and derailments. As a result of the FRA research, ATGMS hardware is now service-proven and commercially available. Demonstration of the system on short line railroads is scheduled in 2015, which will complete the project. As discussed below, further work (by FRA or the railroads) will be needed to develop procedures for applying ATGMS in the railroads' inspection programs and for managing the large volume of data that the system will provide.

#### Track Buckling Detection Using Fiber Optics

This project is in its early stages; funding is anticipated in 2015. It is a sister project to a broken rail detection project, begun in 2012, that uses buried fiber-optic cable to "listen for" and detect a lateral track shift both under and in advance of a train. Track buckling detection would use a fiber-optic cable buried adjacent to the heavy axle loop at Transportation Technology Center [a research and testing facility owned by FRA and operated under contract by Transportation Technology Center, Inc. (TTCI), a subsidiary of the Association of American Railroads (AAR)], which was installed for the broken rail detection project.

#### Handheld Rail Flaw Tomographic Imaging System

This project is in the middle stage of its development. It is based on the analytical modeling performed in a previous study completed in March 2012. The objective is to replicate and

validate experimentally the modeling and simulation results from the previous project. Traditional methods of detecting rail defects are often inaccurate and unreliable. The results of this demonstration could provide a much more reliable tool for detection of rail flaws. One concern is that the cost of the system might be too high for practical applications. The speed at which inspections may be conducted is another. The next stages of the project will seek to determine the viability and cost-effectiveness of this imaging system.

### **VTI Research**

The committee examined the program of VTI research at the U.S. Department of Transportation's (USDOT's) Volpe National Transportation Systems Center. The program has been sponsored for many years by FRA. Specific research focus areas are defined annually. Funding is about \$1.0 million annually and supports investigation in the following areas:

- Effect of track geometry irregularities, surface conditions, and vehicle speeds on safety;
- Ride quality and safety, particularly related to special track work and high cant in curves;
- Problems associated with operation of passenger and freight cars on the same track;
- Continuous evaluation of track standards in light of new conditions and to support higher passenger rail speeds;
- Participation in setting specifications for field-testing programs involving track and train;
- Participation in field investigations of train derailments; and
- Development and utilization of in-house and available computational techniques.

The results of this research have been used to develop procedures, guidelines, and standards for inspecting, maintaining, and improving track and rail equipment. New track safety standards developed on the basis of VTI research [78 FR 16052 (March 13, 2013)] apply principally to high-speed passenger rail operations but also address high-cant-deficiency passenger and freight operation.

## **CONTEXT**

### **Current Performance**

The committee's review of the case study projects provided strong evidence that the track division's program is based on a comprehensive understanding of industry and FRA needs and priorities. Primary users of the division's research are the Office of Railroad Safety, railroads, and the emerging high-speed passenger rail industry in the United States.

The Volpe VTI program, in particular, can respond to the technical needs of the industry (in supporting new rules and safety standards), rail accident investigation and analysis, and computer modeling. It is focused and administered in a way that provides track and structures technological expertise and support where and when they are most needed.



## Gaps

The committee did not observe any research gaps in the track and structures area. In fact, while all 57 current track division projects appear to have merit, whether the R&D office's Decision Lens priority ranking procedure is effective in discriminating among projects to identify those most worthy of receiving funding is unclear.<sup>1</sup> The project ratings assigned by the procedure are all within a narrow band (0.53 highest to 0.33 lowest rating on a 0 to 1 scale).

## Ways to Improve

The track buckling detection project should consider using the recently abandoned 1-mile-long Sound Transit Test Track at the Transportation Technology Center, which is adjacent to the transit test loop being used for the project and could be dedicated to track buckle testing.

The R&D office should review the track division activities to determine the relevance of each project to current industry and FRA needs and consider curtailing or dropping activities that are least relevant. The committee's sense is that the track and structures research budget might be more optimally focused on fewer projects.

## INPUT

### Current Performance

Ongoing communication occurs between the track division staff and FRA offices, industry, and international organizations concerning rail safety issues, needs, and priorities. Regular attendance of track division staff at technical conferences and industry forums provides recurring two-way communication concerning needs and research results.

### Gaps

Arrangements for regular communication between the FRA track division staff and the staffs of the Class I railroads responsible for research, engineering, and operations appear to be lacking. In addition, the committee did not see provision for formal communication between the track division and the Office of Railroad Safety on track safety research needs, although informal contacts reportedly are frequent.

In examining the case study projects, the committee observed that the railroad industry is not always fully informed of the research under way at FRA. Opportunities for industry input to FRA R&D planning are limited, and the perception exists within the engineering staffs of the Class I railroads that FRA researchers do not have strong relationships with field practitioners.

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<sup>1</sup>Decision Lens is a procedure for priority ranking of candidate projects. It is supported by proprietary software and widely used in public and private organizations. R&D staff members first compile the list of candidates and score each project on a variety of attributes, including potential safety impact, timeliness, and factors relating to the likelihood of success. Each project's final numerical score is the weighted sum of its attribute scores. The weights are determined by a survey of senior R&D staff and agency decision makers intended to gauge the relative importance they place on each attribute (Federal Railroad Administration Research and Development Program, presentation to the committee, December 9, 2013).

Travel budget restrictions have limited participation of track division staff at industry and technical meetings in recent years.

### **Ways to Improve**

Regular meetings of track division staff with Class I railroad researchers and senior engineering and operations staff would greatly improve communication and coordination of track research needs. Meetings might take the form of annual sessions with individual railroads, meetings at research needs conferences conducted by industry, or new annual regional (western and eastern U.S.) meetings. They could be supplemented with webinars on topics of broad interest to gather railroad input and identify track research gaps. The goals of the contacts should be information exchange and development of cooperative research between industry and the FRA R&D office.

Scheduling a regular (quarterly or semiannual) meeting among R&D office staff and Office of Railroad Safety staff with a formal agenda and reports from both offices on research needs and the status of ongoing research would improve coordination.

## **IMPACT**

### **Current Performance**

The evidence of the case study projects is that the track division's research products are of high technical quality and that most are being implemented and will have demonstrable benefits. New VTI track safety standards were recently promulgated in response to industry need on the basis of the track division's R&D projects over the past several years and are being implemented with FRA and Volpe Center support. Basic research into rail flaw detection, track buckling, and other causes of train derailment continues, and new track inspection technology (ATGMS) developed through FRA R&D is now service-proven and commercially available. In combination with positive train control (PTC) technology, ATGMS could greatly improve track condition assessment and track safety.

### **Gaps**

While ATGMS hardware has been fully developed and proved, software development and data analysis have lagged. Regulatory concerns also need to be resolved before ATGMS is likely to become widely used. The primary focus of the ATGMS research appears to have been on developing and demonstrating the technology, with less emphasis on implementation issues, which now require more attention. Railroads will need FRA assistance in effectively using the vast amount of real-time data obtained from ATGMS and in managing the resulting ramifications for timely compliance with track standards as currently promulgated. They will also need to determine how to integrate ATGMS with manned vehicles in their inspection procedures to target at-risk track efficiently.

ATGMS will give railroads real-time knowledge of track conditions, including the development of track faults. Regulations require timely response once faults have been

identified. Industry concern about its capacity to respond on the schedule that current regulation requires to the large volume of track condition data that ATGMS will generate may inhibit adoption of the technology.

### **Ways to Improve**

Implementation of research results could be accelerated by addressing institutional and regulatory concerns that can hamper widespread industry adoption of new technologies such as ATGMS. To help speed ATGMS adoption, the R&D office should work with the Office of Railroad Safety and with railroads to develop response time requirements that result in the greatest improvement in track quality. The problem of managing and using the great volume of data that ATGMS will generate is not unique. FRA should monitor research on the problem in other fields (e.g., artificial intelligence) for relevance to the ATGMS challenge.

During demonstration of the handheld tomographic imaging system, the R&D office should collaborate more with railroads and the Office of Railroad Safety to determine the benefits of this new technology and how it could be used to improve rail flaw detection and remediation. End users including railroads and service providers should be briefed and engaged now on the costs and benefits of this new technology to help speed its implementation if it does prove cost-effective and does not slow down the rail flaw detection and remediation techniques currently applied by railroads. This is another example of the need for collaboration with industry and the Office of Railroad Safety as a new technology is being refined.

Research into the fiber-optic detection of track buckles has yet to get under way. However, it is not too early to start communicating and collaborating with industry (railroads and service providers) on the potential for using existing fiber-optic networks to “listen” for broken rail and track buckles to ensure that the research benefits from railroads’ other ongoing efforts and knowledge in this field. Each railroad’s fiber-optic network configuration is different. Interested railroads should be engaged from the start to ensure that TTCI’s research results can be implemented if this technology proves viable and worthwhile.

Invaluable track and structures expertise and institutional knowledge have been built up over the years by the Volpe Center staff. Succession planning should be an integral part of the VTI effort to ensure that this institutional knowledge and expertise are retained.

## Human Factors

FRA's human factors research is organized in six areas, three focusing on railroad systems and operations and three on grade crossings and trespassers. Strategic priorities for the division, according to the FRA R&D strategic plan, include conduct of pilot trials to improve safety culture in railroads; research on fatigue, distraction, and ergonomics; and development of technology to minimize the potential for human errors (FRA 2013b, 10). To support its review, the committee examined four case study projects, three concerning railroad systems and operations and one concerning grade crossings and trespassers.

### CASE STUDY PROJECTS

#### Fatigue Management

FRA's fatigue research program dates back to the early 1990s. A simulator study concluded that hours of service limits for locomotive engineers were inadequate in preventing fatigue (Thomas et al. 1997). Since that seminal work, FRA has sponsored numerous studies of various railroad worker populations to characterize their work and sleep patterns. Through diary studies, FRA collected data providing a baseline against which changes can be assessed. FRA also invested in the development and validation of the Sleep, Activity, Fatigue, and Task Effectiveness biomathematical model for use in a railroad environment. That model is one of two approved for use in meeting the regulatory requirement for analysis of passenger operating crews' work schedules. FRA recently used data collected in its fatigue research to examine the relationship between work start time variability and fatigue. This analysis supports a proposed fatigue management regulation that is under consideration. The focus of the fatigue project is on providing technical support to the Office of Railroad Safety's regulatory activities.

#### Suicide Prevention

FRA suicide research began in the mid-2000s but is still in the early stage. Ongoing and planned efforts include death classification criteria, a GIS database, countermeasure development and evaluation, research on the effect of the media on suicide rates, and international collaboration.

#### Clear Signal for Action

Clear Signal for Action (CSA) is a program of FRA R&D, in collaboration with railroads and railroad employees' unions, to develop, implement, and evaluate safety risk management methods. In the late 1990s, FRA determined that the lack of a positive safety culture was slowing improvement in safety in the railroad industry. R&D was restructured to focus on organizational safety culture as a key program area, involving development of safety culture interventions, conduct and evaluation of safety culture pilot projects, and support for implementation across the industry.

A series of projects has pilot tested, implemented, and evaluated various safety culture initiatives. Some were industry-driven, with FRA participating in their evaluation; others were

initiated by the Human Factors Division staff. Active CSA projects include development and testing of passenger and high-speed rail training materials, implementation and evaluation of Amtrak's Safe-2-Safer program, implementation and evaluation of BNSF's systemwide safety culture intervention, and support of the American Short Line and Regional Railroad Association in creation of the Short Line Safety Institute.

### **Cab Technology Integration Laboratory**

FRA has established the Cab Technology Integration Laboratory (CTIL) at USDOT's Volpe National Transportation Systems Center in Cambridge, Massachusetts. The purpose of the facility is to advance human factors research associated with cab controls and display design through human-in-the-loop simulation. The facility's intended uses are assessment of technologies related to human performance and development of methods for assessing crew efficiency and operational performance.

Planning for the facility began in 2005, and funding for its establishment was first received in 2007. Subsequently, funding delays and technical limitations in the initial facility design slowed development and utilization. Active projects utilizing CTIL include efforts to reduce rule violations in commuter rail operations associated with distraction, to evaluate moving map technology and optimize trips to enhance fuel savings, and to investigate the ergonomics of the operator's workstation.

## **CONTEXT**

### **Current Performance**

FRA clearly understands the fatigue issues in the railroad industry. It documented the need for changes in hours of service limits, an action that Congress took in 2008. Throughout the program, FRA has sought input from labor and railroad management and has kept them informed of FRA's progress and research results. The success of the CSA project in moving from pilots to organizationwide and industrywide interventions demonstrates FRA's understanding of the safety culture issue in the industry and the effectiveness of interventions. The suicide work is more recent. A lack of data has hampered FRA's progress in this area, but FRA has been working with researchers since 2011 to close this gap.

CTIL has developed into a world-class simulator facility designed to support research across a number of critical human-centered issues in railroad operation. However, it appears to be underused.

### **Gaps**

The Human Factors Division program appears to emphasize maximizing the use of funds for research output. This approach may lead to inadequate investment in strategic management. For example, some activities lack a strategic research plan. This was most evident to the committee with regard to CTIL. The strategic objectives for the laboratory were written in 2007 and do not fully represent the current capabilities or use of the facility. While CSA initially lacked a strategic focus, the provisions of the Railroad Safety Improvement Act of 2008 highlighted the

necessity of such an activity, and the Office of Railroad Safety now sees it as a key component of the FRA safety program.

### **Ways to Improve**

The committee was impressed with the technical knowledge and capability of the division senior staff. However, the accumulation and retention of domain knowledge and expertise within a research management agency relying primarily on contractors are challenges. Where a program is expected or planned to last for several years (e.g., CSA), FRA should ensure that the domain knowledge remains with FRA. Retirement of key division staff may place this knowledge base in jeopardy. Succession planning for all elements of the human factors program will ensure that the organization retains essential expertise.

## **INPUT**

### **Current Performance**

The committee's examination of the case study projects indicates that the Human Factors Division, for the most part, is engaging with researchers, the Office of Railroad Safety, and industry and is seeking their input.

FRA has successfully partnered with railroads in developing CSA pilot projects. These projects demonstrated benefits and have influenced other railroad initiatives and Office of Railroad Safety regulation. The Office of Railroad Safety reported a close working relationship with the Human Factors Division on CSA.

There has been a clearly defined focus on evaluation in the Human Factors Division, reinforced by the initiative and expertise of one staff member of the division. Evaluations are potentially a highly valuable form of input into planning and management of the R&D program. In the procedure the R&D office is introducing, projects are evaluated at certain stages while in progress as well as after completion. The in-progress evaluations provide input for guiding completion, and the after-completion evaluations provide input to selection and design of future projects.

The Human Factors Division has begun using stakeholder review panels (SRPs) to guide its work, and they appear to be beneficial. Panels have been established for the CSA passenger railroads materials project and the Railroader Sleep website. SRP members may include representatives of the intended users of the results as well as others affected by the project. The SRP functions for the life of the project. SRP meetings, in person or via conference call or webinar, are held every 2 to 3 months depending on project progress and the need for SRP input.

### **Gaps**

Rules concerning employee international travel have hampered FRA's ability to facilitate collaboration with groups outside the United States in suicide prevention research. International collaboration is particularly critical because FRA has been collecting suicide data in the United States only since 2011; other countries have been working on the issue for a longer period.

Closer consultation with researchers and industry during the establishment of CTIL might

have resulted in a more accessible and flexible facility. It was not evident to the committee that FRA sought input from a wide range of potential users in developing the facility's specifications. Industry knowledge of CTIL research is limited by the dearth of published technical reports on CTIL projects. The committee understands that reports of excellent research are in draft form, but except for the report on the CTIL pilot project (Melnik et al. 2013), no final technical reports of experimental studies have been published.

More regular and frequent sharing of knowledge and informal communication concerning the division's suicide prevention research among R&D and Office of Railroad Safety staff would be beneficial for collaboration and for advancing application of research findings.

## Ways to Improve

FRA should consider seeking input from state officials in the suicide prevention research program. As the research matures and countermeasures are formulated, FRA should consider engaging more state departments of transportation and state and local law enforcement agencies.

External review panels should be used for most human factors projects, especially where overall research objectives are not clear and where engagement of industry or other parties is material to the success of the project and its implementation.

FRA should expedite agency review of CTIL reports and develop a communications plan for the facility. In addition, development of a formal channel for CTIL researchers to provide feedback to FRA may lead to improved operation of the facility.

FRA should consider forming a committee to develop a strategic research plan for CTIL. The committee would include researchers and representatives of industry and government agencies. The plan would not be constrained by the features of the existing facility.

## IMPACT

### Current Performance

FRA has documented the effectiveness of CSA. In pilot implementations, CSA produced large reductions in liability claims, injury rates, and derailments. Quantitative assessments of impacts of Human Factors Division program areas other than CSA were not available to the committee; however, the division has a research portfolio that addresses a number of core areas where human factors-related improvements can enhance safety.

Research projects with regard to fatigue have supported hours of service rulemaking, and the Office of Railroad Safety frequently distributes FRA fatigue research reports in response to industry inquiries. The Office of Railroad Safety credits CSA with significantly influencing the content of its recently issued *Collaborative Incident Analysis and Human Performance Handbook* (FRA 2014). Recommended practices for suicide countermeasures based on FRA research are under consideration by FRA and in the railroad industry. Investigators using CTIL have conducted research with clear implications for railroad operations and safety, although no result from CTIL appears to have yet influenced railroad safety.

## Gaps

Research on fatigue and on suicide prevention is hindered by data limitations. Although FRA inspectors have authority to examine hours of service records at a railroad, railroads are not required to submit hours data other than summaries to FRA, and these data are not readily accessible to FRA for research. Such data would aid FRA in studying the impact of work patterns on fatigue and allow computation of exposure measures and accident rates. Historical data on railroad-related suicides are sparse because FRA did not collect such data before 2011. Many experts believe that suicides are underreported, and criteria for declaring a death a suicide vary from state to state and are at the discretion of local medical examiners. FRA is working to improve data for fatigue and suicide prevention research.

CTIL suffers from low utilization for a number of reasons. First, as the CTIL pilot study report points out (Melnik et al. 2013, 10), there is no local population of Class I locomotive engineers to draw on in running experiments. Second, security at the Volpe Center impedes access to the facility. Third, any outside entity desiring to run an experiment at the facility must deal with the intricacies of the federal contracting process. Fourth, paperwork reduction regulations administered by the Office of Management and Budget (OMB) require that any federally funded research that includes a background survey administered to more than nine participants be subject to OMB review. Finally, technical hurdles have affected the ability of contracted researchers to provide deliverables and perform work according to plan.

The committee's examination suggested that a perceived need to utilize CTIL may be discouraging full assessment of projects' actual simulation requirements. A project should be directed to CTIL only after consideration of whether the simulator provides the best method of testing the study hypothesis. If an alternative evaluation method offers advantages over CTIL, that alternative should be selected.

## Ways to Improve

FRA should consider the following alternatives to improve the ability of CTIL to serve identified research needs: funding that allows for optimal usage of the equipment in the current location, relocation to a site that is more accessible to a suitable test population and that allows easier industry access, or transfer of the equipment to another entity that can better support FRA R&D and industry needs.

FRA should substantially increase efforts to ensure that the products of its human factors research are known and available to potential users. Promotion activities to consider include a series of webinars for selected high-profile projects and organization of FRA R&D presentations, discussions, and workshops in conjunction with major industry technical events.



## Rolling Stock

R&D in the Rolling Stock Division is organized into four program areas: hazardous materials transportation (accident consequence reduction, nonaccident release reduction, tank car structural integrity), railroad systems issues (alternative fuels, locomotive efficiency, workforce development), rolling stock and components (next-generation equipment, component safety, maintenance and inspection, risk modeling), and occupant protection (cab safety and ergonomics, emergency egress, locomotive crashworthiness, fire safety, train handling and operating practices). In the FRA R&D strategic plan, strategic priorities for the division are to investigate effectiveness of monitoring systems to detect equipment defects, analyze failure modes to identify needed improvements in materials and construction methods, conduct research to reduce the risk of transporting hazardous materials, improve safety in collisions and derailments, and conduct research to improve fire safety for passenger cars and for fuel tanks (FRA 2013b, 11). To obtain an understanding of the scope of the division's program, the committee examined four projects as case studies, one from each program area.

### CASE STUDY PROJECTS

#### Fire Safety

Fire safety research falls within the train occupant protection program area. The contractor undertaking the research is Volpe National Transportation Systems Center. This project supports rulemaking activities associated with fire safety and emergency preparedness and is aimed at developing a fire growth model that will interface with time-based performance egress standards. Future work will focus on developing alternative fire safety standards based on the potential for future fire suppression methods that could be used in design of passenger rail cars. The project will investigate and assess alternative strategies and technologies relating to evaluation of passenger rail car fire safety performance, will provide a technical basis for revising the content of FRA passenger train fire safety requirements, and will interface with industry standards. Because it deals with rulemaking for the Office of Railroad Safety, it is an ongoing effort that will produce documentation periodically as it progresses.

#### Biobased Lubricants

A study of the use of biobased lubricant technology, conducted by the University of Northern Iowa's National Agriculture-Based Lubricant Center, was a project in the railroad systems issues program area. The project was required by Congress in the Passenger Rail Investment and Improvement Act of 2008 (P. L. 110-432, October 16, 2008, Section 405). It tested the feasibility of using readily biodegradable lubricants and greases in locomotive, rolling stock, and other equipment by conducting a comparative study of biobased and conventional greases. It analyzed the lubricants' performance in a railroad environment; their health, safety, and environmental impacts; and equipment performance when these lubricants were used. This work is complete.

## **Automated Cracked Wheel Detection**

The Next-Generation Automated Cracked Wheel Detection (ACWD) System is a project in the rolling stock and components program area managed by TTCI. Its objective is to develop, demonstrate, and validate new and alternative cracked wheel detection technologies. Union Pacific Railroad has deployed a system developed through the program.

## **Hazardous Materials Risk Assessment**

The hazardous materials risk assessment project is within the hazardous materials transportation program area. It serves as a pilot project for FRA application of risk analysis for identifying readily achievable means of reducing risk in a number of domains. FRA is identifying and characterizing baseline risks and metrics associated with the operation and transportation of hazardous materials by rail. The project will determine the potential benefit of various risk reduction strategies and identify research that can support industry and governmental efforts to reduce risk.

## **CONTEXT**

### **Current Performance**

The division's program is based on a combination of outside requirements and internal priorities. Two of the case study projects were congressionally mandated, and the remaining two were based on internal prioritization of potential projects. The fire safety research program originated as a 1997 congressional mandate in response to a fire after a collision between an Amtrak train and a Maryland commuter train in 1996. It was a direct result of an industry event and a lack of adequate safety regulations for railroad passenger cars. The biobased lubricant study also was required by Congress. ACWD and hazardous materials risk assessment were both chosen by FRA in accordance with its regular project selection methods.

### **Gaps**

FRA did not fully account for private research that had been done on biobased lubricants. The Norfolk Southern and CSX railroads previously had done a great deal of work on improving their lubricants, but in response to the congressional mandate, FRA conducted a similar study. Congress's specification of the study contents left FRA little input on the research plan.

### **Ways to Improve**

An objective of FRA R&D office communication with the railroads should be to avoid duplication of research projects. FRA is obligated to respond to congressional mandates. FRA should use the budget process to convey to Congress which research areas it sees as most timely and valuable.

## INPUT

### Current Performance

Committee members' discussions concerning rolling stock research with researchers, the Office of Railroad Safety, and industry representatives indicate that the R&D office's efforts to reach out to these groups have achieved some success.

For the fire suppression project, the research team's ongoing contacts with the client and user base are a source of guidance for the work. The research team is aware that the outcome of the project will likely be regulations addressing requirements for fire detection and suppression, and it is aware of the practical challenges of accomplishing these objectives in moving and full passenger trains.

Office of Railroad Safety staff members are in close communication with the R&D office on the topic of broken wheel detection, which they consider to be a difficult problem but one with important safety implications. Most discussions are informal, but there have been some formal coordination meetings. Office of Railroad Safety staff members recognize improvement in recent years in the R&D office's decisions concerning selection of projects that have high safety value, with the cracked wheel detection project as one example.

An advisory panel formed to support the biobased lubricant project appears not to have been effective. The panel did not include a railroad maintenance manager who had significant experience with rail friction control and apparently was not involved in planning of field testing.

### Gaps

There is room for improvement in communication with industry with regard to rolling stock research. Committee member discussions with industry employees suggest that the biobased lubricant project had little visibility in industry. Similarly, FRA broken wheel research appears not to have gained a high level of industry awareness, although industry recognizes the importance of the problem.

### Ways to Improve

Railroad industry employees pointed out that they had not seen presentations on some Rolling Stock Division projects at recent prominent industry forums, which suggests that these events are a significant way of gaining visibility in the industry. Periodic webinars could help the R&D office disseminate products while limiting travel expenses of FRA and of industry.

## IMPACT

### Current Performance

The fire safety research program is well conducted, and there are reasonable expectations of continued success. Results are scientifically rigorous and have supported regulations that probably have improved railroad passenger safety, although quantitative evidence of impact is not available and would be difficult to obtain because passenger train fires are rare. The project

has resulted in three major scientific reports and has found strong agreement (by fire modeling standards) between models and full-scale tests of railroad passenger car burns. FRA has found that increasing inflammability standards for materials would be of limited additional benefit and has turned its attention to fire detection and suppression, in café cars in particular.

Results of the ACWD project are being applied by a railroad and safety benefits are expected, although the committee does not know of quantitative evidence of benefits in use. The hazardous materials risk assessment project is in progress and has not yet produced applications; however, risk assessment could improve FRA regulation of rail safety if techniques and necessary data are developed and applied.

The congressionally mandated biobased lubricant project is unlikely to lead to applications. Industry research concluded that the biobased lubricants tested do not perform consistently when produced in large quantities and therefore are impractical.

### **Gaps**

Application of results of FRA cracked wheel detection research may be hindered by lack of industry awareness of FRA work on this problem.

### **Ways to Improve**

Additional demonstration projects may be needed to promote implementation of products of successful R&D. Conducting demonstrations and other implementation activities as a project separate from the original research, with a separate budget, and possibly by a different contractor may have practical advantages.

Because cracked wheel research is such a technically difficult area, future work ideally should be undertaken jointly with the rail industry.

In general, FRA can ensure the impact of rolling stock research by identifying and concentrating resources on the equipment-related problems that are the greatest potential sources of risk reduction and by promoting application through collaboration with the Office of Railroad Safety and with industry.

## Train Control and Communications

The major program areas in the Train Control and Communications Division are PTC, grade crossing protection, communication, and modeling and simulation. According to the FRA R&D strategic plan, the division's strategic priorities include supporting the railroads in meeting statutory deadlines for implementation of PTC and improving grade crossing and trespass safety through research on technology (including intelligent transportation systems technology), pilot trials, and community outreach (FRA 2013b, 11). To support its evaluation of the division's activities, the committee selected two case study projects from the PTC area and two from grade crossing protection.

### CASE STUDY PROJECTS

#### Employee-in-Charge Portable Terminal

The purpose of this project is to enable a PTC system to provide automatic enforcement of track authority and speed limits in temporary work zones to protect workers against train operator error. The project is developing a device that would allow an employee in charge of a work zone (EIC) to regulate the entry and speed of trains in the work zone. The need for this project arose from the Rail Safety Improvement Act of 2008, which required the installation of PTC on certain tracks on Class I railroads and on passenger railroads. The act specifies that the PTC system is to prevent train-to-train collisions and overspeed derailments and to increase protection of railway workers.

The need for the EIC terminal was identified by an AAR committee. FRA R&D recognized the need, and the project was selected for funding. FRA R&D has invested about \$3 million in the project. The BNSF Railway has participated in development and testing, and a contractor who would market the device also has participated and has supported the project.

#### Positive Train Location

Positive train location (PTL) also is related to PTC. The need was identified by FRA and by the railroads working with TTCI to identify PTC-related research requirements. The PTC system being developed by the railroads uses GPS and a database of locations of signals, switches, and other features to determine the train's proximity to a location where enforcement of PTC may be required. The accuracy of the current system does not allow for precise identification of the track being occupied by the train in multitrack territory or precise location of the rear of the train. The system also suffers from inaccuracies in tunnels and urban canyons.

A more precise system will be a requirement if PTC is to evolve to provide rear-end protection to trains. The PTL system under development uses data from GPS receivers at both ends of the train augmented with data from inertial sensors to improve position accuracy, including accuracy at locations where the GPS signal is not received.

FRA R&D has invested \$4.5 million in the project and has been able to leverage its investment by involving the railroads and an industry supplier, who are contributing resources and participating in developing and testing a working system.

## **Effect of an Active Another Train Coming Warning System on Pedestrian Behavior at a Highway–Rail Grade Crossing**

This project was selected in response to a request from the New Jersey Department of Transportation after a series of trespass fatalities in late 2011. FRA R&D engaged the Volpe Center to determine whether addition of a second train warning system at a New Jersey Transit rail grade crossing would reduce the frequency of pedestrian violations when two trains pass through the crossing during a single gate activation. The research did not find a significant difference in the frequency of violations before and after installation of the warning system (Gabree and daSilva 2014).

## **Dedicated Short-Range Communications Grade Crossing Protection**

The dedicated short-range communications (DSRC) grade crossing protection project is being conducted in collaboration with the Federal Highway Administration (FHWA) as a component of USDOT's multimodal intelligent transportation systems development initiative. The project is to design a device that can be retrofitted to existing active grade crossing warning devices and that can broadcast crossing status information to DSRC-equipped vehicles. A system aboard such a vehicle would warn the driver if it determined that the vehicle was at risk of collision at a crossing.

The project is at an early stage. FRA engaged the Volpe Center to characterize crashes at grade crossings that might be prevented by an in-vehicle warning system and to define system requirements. The next phase of the project will develop a design that has the support of the railroad industry and the automotive industry.

## **CONTEXT**

### **Current Performance**

The four case study projects illustrate the diversity of pathways by which projects can enter the R&D program and show that the FRA R&D office is responsive to its constituents. PTC and EIC respond to a well-defined, high-priority need; federal law requires PTC, and a railroad industry group identified EIC and PTL as research priorities in support of PTC.

The second train coming project was undertaken at the request of the state of New Jersey out of concern for recent accidents at crossings in the state. The DSRC grade crossing protection project is a logical and necessary component of the connected vehicles R&D initiative being undertaken by USDOT and the automobile industry.

### **Gaps**

The immediate motivation of the second train coming project appears to have been a single accident in New Jersey. The project did not arise from FRA R&D's risk analysis procedure.

## Ways to Improve

The Train Control and Communications Division should continue to work with industry and with other federal and state government agencies to identify research priorities and potentially worthwhile projects for research, as a complement to its identification of priorities through risk analysis.

## INPUT

### Current Performance

In general, participants and other interested parties in the case study projects see the Train Control and Communications Division as involved, engaged, and effective in communication. The railroads and TTCI have been involved in identifying PTC-related research needs to FRA. The EIC and PTL R&D projects have railroad and supplier participation in development and testing. FRA Office of Railroad Safety staff members are engaged as subject matter experts on the PTC-related projects.

The case studies also show R&D office use of external input in its grade crossing safety R&D. The FRA Office of Railroad Safety participates with FHWA in a USDOT-wide grade crossing safety team that is a venue for communication on R&D needs and reviews some FRA R&D projects. The DSRC project was undertaken in cooperation with FHWA and with the USDOT-wide program for intelligent transportation systems development.

The New Jersey Department of Transportation was involved with FRA R&D and Volpe throughout the second train coming project.

### Gaps

The R&D Office's website states that "to facilitate the development and deployment of PTC systems, Office of Research and Development with close collaboration with FRA's Office of Railroad Safety, freight and passenger railroads, and academia have funded and continue to fund many research projects" (FRA n.d.). However, the committee did not see an indication of formal collaboration with the Office of Railroad Safety in planning stages of the PTC-related case study projects. In addition, the R&D office appears not to have established regular communication with the FRA regional office, a branch of the Office of Railroad Safety, during the planning and conduct of the New Jersey second train coming project.

The committee's information on the train control and communications case study projects is almost entirely from project participants; therefore, it cannot judge whether interested parties other than the participants are familiar with these projects or have had opportunities to provide input.

## Ways to Improve

FRA R&D efforts could benefit by involvement of the FRA regional offices in programs addressing local risks such as grade crossings. The regional offices are interested in new technology and need to be aware of developments. Better coordination and communication with

these offices could improve results and increase understanding between the Office of Railroad Safety and FRA R&D.

## **IMPACT**

### **Current Performance**

The outside participants in the train control and communications case study projects view the division's program as being of high technical quality and effective in producing results with good potential to improve safety. In particular, the PTC-related projects are viewed as pertinent to present needs. Participants expect EIC and PTL to be successful; however, much more industry work is needed to implement the PTC system of which these will be components before the benefits are realized.

Although the second train coming project did not demonstrate a safety improvement, FRA R&D staff indicated that they believed the research had benefit and would contribute to the design of practices that mitigate the hazard it addressed. The New Jersey Department of Transportation believed that the quality of the second train coming project was good. The project provided the department with good information in choosing treatments for crossings.

The participants agreed that, if implemented, the DSRC grade crossing protection system would greatly enhance safety at highway grade crossings. The project is only a component of a major technology initiative; therefore, safety improvements will not be immediately achieved. Participants noted that the DSRC system could have benefits other than safety, such as rerouting traffic around a crossing that has failed or that is tied up for a long period.

### **Gaps**

One of the interested parties with whom the working group discussed the case study projects expressed the concern that the funding of the PTC-related projects is inadequate to deliver their products when other components of PTC are being implemented. However, others noted that the funding allocated is reasonable in view of the R&D program's overall budget constraint.

### **Ways to Improve**

The effectiveness of FRA train control and communications R&D could be improved with better coordination between FRA and the railroads to sharpen the focus of the program. Continued effort by the railroad industry to identify and articulate critical issues requiring research (as the industry has identified PTC-related research needs) would aid the R&D program.

Several participants in the case study projects expressed the view that additional funding for this research area would be a worthwhile investment. The R&D office should continue to leverage the available R&D funding through collaboration with industry to get the most from its investment.



## R&D Support Functions

The statement of task instructs the committee to evaluate, in addition to the programs of each of the four FRA R&D office divisions, the R&D support functions of planning, evaluation, and management. To respond to this charge, the committee studied four R&D office functions:

- Communications with industry, the FRA Office of Railroad Safety, the research community, and labor for the purposes of identifying priorities, recruiting partners, and implementing results;
- The process of setting priorities among proposed new research projects and for allocation of funds among projects under way;
- Ongoing strategic planning and progress toward meeting the objectives of the 2013 R&D strategic plan; and
- Evaluation of individual projects and of the overall program.

The four sections below present the committee's conclusions and recommendations concerning each of these functions.

The purpose of the committee's evaluation of support functions was to identify opportunities for improving the quality, utility, timeliness, and cost-effectiveness of the R&D program through changes in practices concerning the four management functions. See [Box 2](#) for the correspondence between the questions in the statement of task and the organization of the committee's support functions review.

As the basis for its support functions evaluation, the committee studied the FRA R&D strategic plan (FRA 2013b) and the R&D evaluation implementation plan (FRA 2013a) and received presentations from FRA describing management functions at meetings on December 9, 2013 (Federal Railroad Administration's Research and Development Program), and September 8, 2014 (R&D Project Selection FY 2015). It studied the conclusions of the 2012 TRB committee that reviewed the FRA R&D program with regard to management practices (TRB 2012). The conclusions below are also based on the observations concerning project selection and evaluation of each of the committee's four technical working groups.

### COMMUNICATION

#### Conclusions: Current Performance and Gaps in Communication Practices

- Communication with three groups—the FRA Office of Railroad Safety, industry (including railroads, suppliers, and labor), and the research community—is necessary throughout the life cycle of each FRA R&D project or program, from planning and prioritizing through execution of the research and application of results.
- FRA's goal of increasing the number of R&D projects cofunded by FRA and industry is highly worthwhile. Industry support is strong evidence that a project is relevant to its needs, increases the likelihood of implementation, contributes to the quality of the work, and leverages FRA dollars. Improved communications with industry will be necessary to achieve this

**BOX 2 Correspondence Between Statement of Task and Four Management Functions**

The questions in the committee's statement of task relate to the four management functions as follows:

*Communications:*

1. To what extent has the Office of R&D excelled in engaging, maintaining communication with, and using inputs from the full range of stakeholder groups?
11. To what extent is the Office of R&D effective in providing its key stakeholders with summative evaluation reports, technical reports, conference presentations, and other communications that validly assess R&D efforts, impacts, and cost-benefits?

*Priority Setting:*

2. To what extent does R&D excel in conducting and using results from needs assessments and diagnostic studies to prioritize, focus, and plan projects and programs?

*Strategic Planning:*

3. To what extent has R&D's planning support function defined a sound mission and associated goals and priorities that reflect assessed safety needs in the railroad industry?
5. To what extent does R&D's current and planned portfolio and budget appropriately address its defined mission, goals, and priorities?
6. To what extent is the Office of R&D sufficiently staffed and funded in accordance with its mission and priorities to effectively carry out all of its programs and program support functions at a high level of quality?

*Evaluation:*

10. To what extent does the Office of R&D evaluate its services and products prior to or during an implementation to help improve their usability and likelihood of adoption by industry?

goal. However, some necessary R&D projects supporting regulation may not attract industry support.

- FRA R&D office communications with AAR and TTCI are well established and effective. However, communications with individual railroads and their R&D groups appear not to be as strong. Regular communication with railroads, and specifically railroad staff responsible for research, operations, and engineering, would help avoid duplication of effort and open a window for more field testing of FRA R&D ideas.

- SRPs that have been formed to support certain projects in the Human Factors Division are a promising means of improving communication with industry and other interested parties. SRPs can provide a reliable test of the relevance of a new project and a direct channel for putting results into the hands of parties who can apply them. The experience of conducting the panels may prove valuable to the R&D office over time in strategic planning and setting

priorities. A review panel includes representatives from railroads, labor unions, and others potentially affected by the results of the project, as well as technical experts. The panel receives periodic briefings on the FRA R&D project throughout the project's duration, and members submit their reactions concerning the project's progress and results to FRA.

### **Recommendations to Improve Communication**

1. To generate more cofunded projects and to ensure that research products are widely applied, FRA R&D should explore opportunities to increase interaction with industry and other interested parties and should consider the following actions:

- Establish an FRA R&D session on the program of the TTCI annual research review meeting.
- Hold more frequent FRA R&D presentations or an FRA R&D session at American Railway Engineering and Maintenance-of-Way Association conferences.
- Promote regular participation of FRA program managers in the technical subcommittees of the AAR Research Technology Working Committee.
- Periodically present a summary of the R&D program to the FRA Railroad Safety Advisory Committee.
- Create a regular program of public webinars to stimulate discussion of current and completed projects and to disseminate results.

The R&D office's budget should provide for the staff time needed for expanded interactions.

2. Begin to establish external review panels (as exist now for certain human factors projects) for all R&D projects that can benefit from industry engagement. The composition and function of a panel must be designed to match the needs of each project. Forming and managing review panels will add to the cost of projects; therefore, panel procedures should be streamlined as much as possible. The success of review panels in fulfilling their objectives should be evaluated, for example, by polling participants about how they benefited from the experience and by documenting collaborations that arise from panel participation.

## **PRIORITY SETTING**

### **Conclusions: Current Performance and Gaps in Priority-Setting Procedures**

- Priority setting guides three kinds of R&D office decisions: (a) what new projects to take up, (b) whether to continue ongoing activities, and (c) how much funding each activity is to receive in the year.
- Commitments to several long-standing activities limit FRA's R&D budget flexibility in any one year. These commitments include an interagency agreement with USDOT's Volpe Center that funds research on VTI and other activities in the Volpe Center's areas of expertise, a contract for maintenance and operation of the Transportation Technology Center, and a contract for maintenance and operation of R&D test vehicles (Federal Railroad Administration's Research and Development Program, presentation to the committee, December 9, 2013, 27).

Also, restrictions on funds provided for FRA R&D in the USDOT budget limit flexibility. FRA R&D funding (\$33.2 million in 2013) is divided into 10 budget categories,<sup>2</sup> each of which can be used only for projects in a specified topical area (Federal Railroad Administration's Research and Development Program, presentation to the committee, December 9, 2013, 14).

- The committee's understanding of how priorities are set at present is as follows: Allocation of the discretionary portion of the annual R&D budget begins with consultation among the R&D division chiefs and the R&D office director. Comparison of alternative uses of funds mainly occurs at this stage of the process. Special needs (e.g., to fulfill a congressional instruction, support a specific rulemaking, or respond to a current high-profile safety concern such as the growth of petroleum tank car traffic) take precedence. The consultations lead to a proposed budget specifying new projects to take up and the next period's funding level for existing projects. The proposed budget is submitted to senior agency management together with results of the formal project priority ranking techniques that the R&D office has been developing.

- The formal priority ranking tools that FRA described to the committee (the safety risk model and Decision Lens) [Federal Railroad Administration's Research and Development Program (presentation to the committee), December 9, 2013, 6, 15; R&D Project Selection FY 2015 (presentation to the committee, September 8, 2014)] are in a trial period during which their utility for supporting decisions is being tested. FRA cited only a few instances in which the Decision Lens ranking had influenced a decision about resources and no case in which the ranking influenced a decision to stop or start a project. FRA's objective is to refine the tools to the point that they can be useful in support of decisions.

### **Recommendations for Improving Priority Setting**

1. FRA should continue work on adapting the Decision Lens priority-setting technique to its needs. If the technique fails to prove its worth as a guide to decisions, FRA should look to alternative objective, data-driven procedures for setting priorities.

2. The R&D office should aim for a priority-setting process that highlights the new and existing projects with the greatest promise for contributing to safety and those with the least promise. To facilitate concentration of resources on the highest-value projects, the selection process should apply go/no-go criteria that must be met before any further evaluation takes place. That is, the absence of certain essential features in a proposed project should be considered fatal to the project. In the case of a project to support rulemaking or regulation, sponsorship of the Office of Railroad Safety should be considered essential. Projects that are not driven by rulemaking and regulation should be eliminated if they do not have demonstrable stakeholder buy-in, including a statement from stakeholders of the benefits that would be expected to follow a successful outcome of the project. Projects that do not address any of the more important sources of risk identified in the R&D office's safety risk model should be especially scrutinized.

3. To clarify the role of the priority-setting exercise, the priority-setting process should distinguish between core functions (e.g., support of Volpe and the Transportation Technology Center) and fully discretionary activities. Different forms of assessment may be needed for the

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<sup>2</sup> The 2013 categories were systems issues, human factors, track and structures, track–train interaction, facilities and equipment, rolling stock, hazardous materials, occupant protection, train control and communications, and grade crossings and trespass.

two categories of activities (for example, an annual priority ranking for discretionary projects and a periodic sunset review for the multiyear activities).

4. The R&D office should state the basis for selection of each R&D project undertaken. The statement should identify the expected users of the results of the project and define a successful outcome of the project. This initial definition of a successful outcome would aid in evaluation of the project. The external review panel for a project (as recommended above) could contribute to the drafting of this statement.

5. FRA should seek greater flexibility in the use of R&D funds provided by Congress by requesting in its annual budget proposal that R&D funding be pooled into fewer, larger categories. Ideally, most funds would be in a single budget category to be allocated across R&D activities according to the maximum potential benefit.

6. The R&D office should develop means for benefiting from external advice during project selection. The opportunities for improving communications listed in the previous section might help in obtaining such advice. The committee's review of case study R&D projects verified this need.

7. The R&D office should maintain a list of candidate projects that would receive serious consideration if more funding were available. The list would be useful in soliciting advice on prioritization and in judging the success of the prioritization process.

## STRATEGIC PLANNING

### Conclusions: Current Performance and Gaps in Strategic Planning

- FRA explained to the committee that the purpose of the current R&D strategic plan is to inform others of the direction and goals of the R&D program. The R&D office does not have an ongoing strategic planning process and is not tracking progress toward meeting the goals of the plan.
- The R&D strategic plan does not appear to be coordinated with the R&D project selection process. The project selection criteria listed in Section 3.6 of the plan do not correspond to the criteria in the prioritization procedure described to the committee. Linking the Decision Lens methodology to the goals identified in the 2013 strategic plan would be beneficial.
- FRA should specify in the R&D strategic plan how R&D will contribute to attaining the quantitative safety improvement goals stated in the USDOT strategic plan (USDOT 2014).

### Recommendations to Improve Planning

1. The greatest value of a strategic plan is as an aid in maintaining focus within an organization. Therefore, the R&D office should monitor its progress toward objectives defined in the plan on a regular basis and make midterm corrections in the allocation of resources as needed to meet the goals. The R&D office should update the plan if changes in circumstances result in changes in FRA goals.

2. Future R&D strategic plans should be coordinated with an FRA strategic plan. The FRA plan would specify safety improvement objectives and how FRA activities are expected to lead to attainment of the objectives. The R&D strategic plan would describe the R&D office's role in meeting the FRA safety objectives.

## EVALUATION

### Conclusions: Current Performance and Gaps in Evaluation Practices

- FRA described the R&D office evaluation process as a work in progress. The goal is to evaluate each project at certain stages while it is under way and when it is completed. The R&D office is beginning to conduct evaluations of one or two projects in each division as a learning exercise.
- The experience of R&D program managers across the federal government has shown the usefulness of several widely used methods of evaluation, including customer surveys, case studies, and peer review. Multiple techniques may be used in the evaluation of an R&D program (Ruegg and Jordan 2007).

### Recommendations for Improving Evaluation

1. The R&D office should continue its gradual approach to introducing formal evaluation in its procedures. A trial period is necessary to allow FRA staff to learn the process and to refine the process to match FRA needs. Because evaluation is a core requirement of the FRA R&D strategic plan, FRA should continue to test the evaluation process until it settles on a method that effectively utilizes internal resources.
2. The R&D office should require that each project have features to aid evaluation built in from inception. Sponsors and researchers should jointly define measures of success at the outset, and the project should include collection of data needed for evaluation.
3. The R&D office should limit its initial evaluation efforts to the most widely used methods that have demonstrated usefulness in R&D programs. The R&D office should consider using peer review of individual completed projects as one type of evaluation.
4. The R&D office should use the results of evaluations to improve its prioritizing procedures. Outcomes can be compared with expectations at the beginning of the project. Over time, a profile of characteristics of successful projects can be developed.

In addition to provision for evaluation of individual projects, the FRA R&D office should consider soliciting additional periodic reviews of its overall program, including an annual review of the research supporting rulemaking, prepared by senior FRA Office of Railroad Safety staff. For parts of the R&D program not specifically tied to rulemaking, FRA should consider organizing periodic in-depth technical reviews of selected major emphasis areas conducted by technical experts and industry and labor representatives.

## References

### Abbreviations

FRA	Federal Railroad Administration
TRB	Transportation Research Board
USDOT	United States Department of Transportation

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## Appendix

### Statement of Task

An ad hoc committee will conduct a review and evaluation of the Federal Railroad Administration (FRA) Office of Research and Development (R&D) of the U.S. Department of Transportation (DOT) to assess R&D products and services to the agency and railroad industry. Congress funds FRA R&D to contribute to the DOT's strategic goals, the principal of which is improved safety. Thus, the goal of this biennial review and assessment is to provide strategic feedback to the Office of R&D for program improvement and planning purposes with specific emphasis on: (1) validating FRA's process to identify new priorities for addressing emerging safety issues and trends, and (2) evaluating the feasibility, usefulness, effectiveness, and impact of R&D products and services in railroad safety. The committee will evaluate each of the four major division areas (Track, Rolling Stock, Signals, Train Control and Communications, and Human Factors), including cross-division efforts, and R&D support functions (planning, evaluation, and management).

In gathering information and conducting its evaluation, the committee will examine existing reports, documents, databases and other related material in the public domain and organize presentations from industry representatives and program managers through face-to-face meetings and conference calls. Illustrative projects or programs within each division may be used as case studies to highlight successful applications of research and to identify common lessons learned that could be more broadly applicable across divisions.

As inputs to the committee's assessment of the four FRA divisions and R&D support functions, it will address the following questions:

1. To what extent has the Office of R&D excelled in engaging, maintaining communication with, and using inputs from the full range of stakeholder groups?
2. To what extent does R&D excel in conducting and using results from needs assessments and diagnostic studies to prioritize, focus, and plan projects and programs?
3. To what extent has R&D's planning support function defined a sound mission and associated goals and priorities that reflect assessed safety needs in the railroad industry?
4. To what extent is R&D sufficiently flexible and responsive in addressing changing economic, political, social, and technological contexts? (Question does not apply to planning and evaluation support functions.)
5. To what extent does R&D's current and planned portfolio and budget appropriately address its defined mission, goals, and priorities?
6. To what extent is the Office of R&D sufficiently staffed and funded in accordance with its mission and priorities to effectively carry out all of its programs and program support functions at a high level of quality?
7. To what extent is the R&D office's science and engineering work of excellent technical merit and quality, and appropriate and feasible for implementation? (Question does not apply to R&D support functions.)
8. To what extent are R&D services and products being used and/or adopted by the railroad industry both internal and external to FRA? (Question does not apply to R&D support functions.)



9. How effectively have R&D services and products helped the railroad industry improve safety and reduce fatalities? (Question does not apply to R&D support functions.)

10. To what extent does the Office of R&D evaluate its services and products prior to or during an implementation to help improve their usability and likelihood of adoption by industry?

11. To what extent is the Office of R&D effective in providing its key stakeholders with summative evaluation reports, technical reports, conference presentations, and other communications that validly assess R&D efforts, impacts, and cost-benefits?

The committee's first letter report will include descriptive assessments and constructive comments on the evaluation questions. The letter will present a holistic assessment of the Office of R&D, the individual divisions, and the R&D support functions. The letter may provide recommendations to FRA on how to improve its processes for selecting and executing projects and delivering value from its R&D program. It may also provide direction on where the committee thinks the program should be headed in the future.

During the period of performance, FRA intends to hold a two-day public meeting to present its R&D program to stakeholders of the R&D program. The committee's second letter report will evaluate the content, organization, and delivery of the public session. In doing so, the committee will consider the evaluation of the public R&D review held in 2012 (see Summary of Evaluation Findings, 2012 FRA Research and Development Review by Fulcrum Corporation).

## Study Committee Biographical Information

**John M. Samuels, Jr. (NAE)**, *Chair*, is President of Revenue Variable Engineering, LLC, and former Senior Vice President for Operations, Planning, and Support, Norfolk Southern Railway. He previously served as Vice President for Operations Planning and Budget at Norfolk Southern and Vice President of Operating Assets for Conrail. He was on the Pennsylvania State University industrial engineering faculty from 1968 to 1978, when he joined Conrail as a Director of Shop Industrial Engineering. At Conrail he served in successive positions as Vice President, Continuous Quality Improvement; Vice President, Engineering; Vice President, Mechanical; and Vice President, Operating Assets. He joined Norfolk Southern Railroad in 1998. He was elected to the National Academy of Engineering in 1996, cited for engineering and leadership in system revitalization of rail freight transportation. He received an MS and a PhD from the Pennsylvania State University and a BS from the GMI Engineering and Management Institute (now Kettering University).

**Mehdi Ahmadian** is Dan Pletta Professor of Mechanical Engineering at Virginia Tech, where he also holds the position of Director of the Center for Vehicle Systems and Safety (CVeSS) and the Railway Technologies Laboratory (RTL). He is the founding director of CVeSS, RTL, the Virginia Institute for Performance Engineering and Research, and the Advanced Vehicle Dynamics Laboratory. Dr. Ahmadian has authored more than 200 technical publications and has made more than 100 technical presentations on topics related to advanced technologies for ground vehicles. He holds seven U.S. and international patents and has edited three technical volumes. He is currently Editor of the journal *Vehicle Systems Dynamics* and Editor in Chief of the journal of *Shock and Vibration*, and he has served as Associate Editor for the *Journal of Vibration and Acoustics* (1989–1996). Dr. Ahmadian is a Fellow of the American Society of Mechanical Engineers, a Senior Member of the American Institute for Aeronautics and Astronautics, and a member of the Society of Automotive Engineers. He holds a PhD, an MS, and a BS from the State University of New York.

**Christopher Barkan** is Professor, Executive Director of the Rail Transportation and Engineering Center, and George Krambles Faculty Fellow in the Department of Civil and Environmental Engineering at the University of Illinois at Urbana–Champaign. He is responsible for the university's railroad engineering research and academic programs. He also serves as the director of AAR's Affiliated Laboratory at the university. His research interests are in rail transportation safety and risk, train derailment analysis, hazardous materials, tank car safety, energy efficiency, rail line capacity, railroad infrastructure and operating economics, and the development and cost-effectiveness of new rail technologies. He is a member of TRB's Committees on Freight Transportation and on Railroad Operating Technologies. He previously served as chair of the TRB Rail Group and as a member of the Committees on Transportation of Hazardous Materials, Railroad Track Structure System Design, Review of the USDOT Strategic Plan for R&D, and Feasibility of a Hazardous Materials Transportation Cooperative Research Program. Before joining the university in 1998, he was Director of Risk Engineering in the Safety and Operations Division of AAR. He continues as Deputy Project Director of the Railway Progress Institute–AAR Railroad Tank Car Safety Research and Test Project, a cooperative program of the tank car and railroad industries studying ways to improve tank car safety. He completed his MS and PhD in biology from the State University of New York, Albany.

**David Connell** is Vice President of Engineering for Union Pacific Railroad. He directs the design, construction, and maintenance of all track, signal, and bridge infrastructure of the nation's largest freight railroad. He has worked for Union Pacific and predecessor companies for 26 years in a variety of field and staff positions, including Regional Vice President—Operations, Assistant Vice President—Construction, Chief Engineer—Maintenance of Way, and various engineering research positions. He chairs AAR's Heavy Axle Load Committee and is a member of the Railway Technology Working Committee at TTCI. He serves on various university-centered advisory boards. Mr. Connell holds a BS in civil engineering from North Carolina State University and attended the Harvard Business School.

**Judith Gertler** was Division Manager for QinetiQ North America from 1996 to 2012. There she managed the group conducting human factors research projects related to transportation systems. Her research involved work schedule–related fatigue, training on responding to locomotive crashes, safety rule compliance, impaired drivers, and many other transportation safety issues. Since 2012, she has been self-employed as a consultant, analyzing work schedules for fatigue risk, developing fatigue risk management programs, and facilitating focus groups for transportation safety products and issues. She holds an MS in industrial administration from Carnegie Mellon University.

**Donald Graab** is Assistant Vice President—Mechanical at Norfolk Southern Corporation. He is responsible for maintenance of Norfolk Southern's fleet of locomotives. Previously, he was Director of Transportation and Mechanical Integration and later Senior Director of the Atlanta Control Center. He joined the Norfolk Western Railway (a predecessor of Norfolk Southern) in 1978. He is a licensed locomotive engineer and a lifetime member of the Locomotive Maintenance Officers Association. He received a master's from Lynchburg College and a BS in mechanical engineering from Purdue University.

**John Harrison**, a recently retired railway engineering professional with 46 years of experience, is a former Vice President and principal project manager for Parsons Brinckerhoff (PB). He has broad experience in managing large multidisciplinary engineering and construction projects. In 2009–2010 he served as PB's deputy program director for the California High-Speed Rail project. Before that, he was deputy executive director and University Link project director for the Central Puget Sound Regional Transit Authority (Sound Transit) in Seattle, Washington. Before joining Sound Transit in 2006, Mr. Harrison worked for PB for more than two decades as a senior rail systems professional and project manager on urban and intercity rail projects, including a 1989 Los Angeles–Fresno–Bay Area–Sacramento High-Speed Rail Corridor Study, a precursor to the California High-Speed Rail Authority's current project. His experience includes planning, design, procurement, and construction management of large rail infrastructure projects, including systems engineering, operations planning, railroad application engineering, and technology assessment. Mr. Harrison was a founding member of the High-Speed Ground Transportation Association in 1982 and in the 1990s was chair of TRB's Intercity Guided Ground Transportation Committee. His professional affiliations include the American Society of Civil Engineers and the American Railway Engineering and Maintenance-of-Way Association. He holds an MS in technology management from the Massachusetts Institute of Technology (MIT) and a BS in civil engineering from Carnegie Mellon University.

**Chris Hendrickson** is the Hamerschlag University Professor of Engineering, Director of the Traffic21 Institute, and Codirector of the Green Design Institute at Carnegie Mellon University. His research, teaching, and consulting are in the general area of engineering planning and management, including design for the environment, project management, transportation systems, finance, and computer applications. Current research projects include life-cycle assessment methods, costs and greenhouse gas emissions for alternative fuels, and policy issues for connected and automated vehicles. He is member of the TRB Executive Committee and the National Academy of Engineering and is a Fellow of the American Association for the Advancement of Science. He received a PhD in civil engineering from MIT, a BPhil in economics from Oxford University, and an MS and a BS from Stanford University.

**E. Keith Holt** is the Deputy Chief Engineer, Communications and Signals, for Amtrak. He joined Amtrak in 1990. He has technical responsibility for Amtrak's PTC systems and is responsible for standards, design, planning, and management of the communications and signals capital program; maintenance of dispatching systems; and maintenance and construction oversight of communications and signals facilities. Before joining Amtrak he spent 15 years in the railroad signal supply industry. He is a member of the American Railway Engineering and Maintenance-of-Way Association and has served on its board of directors. He received a bachelor's degree in electrical engineering from Western Kentucky University in 1975.

**Anson Jack** is Director of Commercial and Strategy and Deputy Chief Executive of the Rail Safety and Standards Board (RSSB) of the United Kingdom and Professor of International Railway Research at the University of Birmingham. He was previously the Director of Standards at RSSB from 2004 to 2007, and Director of Policy, Research, and Risk from 2007 to 2012. RSSB is an industry-owned body that undertakes work in the areas of safety and standards to support all of the industry operators in Great Britain in fulfilling their legal responsibilities and to facilitate the resolution of cross-industry technical and economic issues. RSSB undertakes programs of research, development, and innovation on behalf of the UK rail industry, and Mr. Jack was responsible for all these programs until the middle of 2014. At the University of Birmingham, he is Director of the Birmingham International Railway Academy. Previously, he worked as Head of Strategy and Europe for Network Rail from 2002 to 2003. From 1993 to 2002 Mr. Jack was with Railtrack; his last position was Head of Strategy. From 1979 to 1993 he held various positions with British Rail, including National Business Manager. He also worked between 1995 and 1999 with the World Bank and the governments of Pakistan and Sri Lanka to explore and develop railway reform programs. He holds an MA and a BA from Oxford University.

**Edward La Guardia** is a professional with 34 years of experience in the railroad industry. He began his career in Conrail's engineering department and then moved to the Southeastern Pennsylvania Transit Authority, where he served in many engineering functions until retirement after 13 years as Chief Engineering Officer—Bridges and Buildings. He is currently the Chief Engineer—Rail and Transit for Michael Baker International and supports the development of rail and transit design, construction, and program management projects across the country. Mr. La Guardia is chairman of the Elevator Escalator Technical Forum, chairman of the Transit Elevator Escalator Training Consortium, and member of the Railroad and Transit Signals Training

Consortium of the American Public Transportation Association; he serves on the Transit Cooperative Research Program Project Panel on Labor–Management Partnerships. He is a professional engineer in Pennsylvania and New Jersey. He received a BS in engineering from Temple University.

**Charles Lynch** became Vice President and Southern Operations Manager for Gannett Fleming Transit and Rail Systems, a consulting engineering firm, in 2008. Previously, he was Vice President of Transportation for the Florida East Coast Railway. Earlier positions with Florida East Coast included Vice President of Maintenance and Chief Engineer of Communications and Signals. His railroad career began in 1975 with the Penn Central Transportation Company. He received an MS in electrical and computer engineering from the University of Massachusetts and a BS in electronics engineering technology from Franklin University.

**Roger McCarthy** is a private engineering consultant and a director of Shui on Land, Ltd., which is involved in large-scale urban redevelopment in China. Dr. McCarthy has substantial experience in the analysis of failures of an engineering or scientific nature. He has investigated the grounding of the *Exxon Valdez*, the explosion and loss of the *Piper Alpha* oil platform in the North Sea, the fire and explosion on the semisubmersible *Glomar Arctic II*, and the rudder failure on the very large crude carrier *Amoco Cadiz*. Previously, Dr. McCarthy was chairman emeritus of Exponent, Inc., and chairman of Exponent Science and Technology Consulting Company, Ltd. (Hangzhou, China). In 1992, he was appointed by the first President Bush to the President's Commission on the National Medal of Science. Dr. McCarthy served as a member of the National Academy of Engineering and National Research Council Committee for Analysis of Causes of the *Deepwater Horizon* Explosion, Fire, and Oil Spill to Identify Measures to Prevent Similar Accidents in the Future. He received a PhD in mechanical engineering from MIT. He was elected to the National Academy of Engineering in 2004.

**Tamara Nicholson** is the Director of the Office of Rail Transportation at the Iowa Department of Transportation, a position she has held since 2008. She has been with the department since 1990. She is a member of TRB's Standing Committee on Freight Rail Transportation and the Standing Committee on Agricultural Transportation and Chair of the Iowa State University Civil, Construction, and Environmental Engineering Advisory Committee. She holds a BS in civil engineering from Iowa State University and completed the Certified Public Manager program at Drake University in 2009.

**Andrzej Nowak** is the department chair of Auburn University's Department of Civil Engineering. He had served as the Robert W. Brightfelt Professor of Engineering in the University of Nebraska–Lincoln's Department of Civil Engineering since 2005. From 2009 to 2011, he led the department as interim chair. From 1990 to 2004 Dr. Nowak served as a professor in the University of Michigan's Department of Civil and Environmental Engineering, where he also directed the Bridges and Structures Research Center of Excellence, sponsored by the Michigan Department of Transportation. His research interests include materials, analysis and design of structures, evaluation of existing structures, and risk and reliability analysis of structures. Dr. Nowak earned a master's degree in structural engineering in 1970 and a doctorate in technical sciences in 1975, both from the Politechnika Warszawska in Poland.

**Bryan Reimer** is a Research Scientist in the AgeLab of MIT and Associate Director of the New England University Transportation Center at MIT. His research concerns the measurement and evaluation of motor vehicle driving, including how drivers are affected by in-vehicle technologies, cognitive load, and medical impairment. He is a member of TRB's Committee on Vehicle User Characteristics. He received a PhD in industrial and manufacturing engineering, an MS in manufacturing engineering, and a BS in industrial engineering from the University of Rhode Island.

**James A. Stem, Jr.**, retired in late 2014 as national legislative director of the Transportation Division of the Sheet Metal, Air, Rail, and Transportation Union (formerly the United Transportation Union). He began his railroad career as a trainman for the Seaboard Air Line Railroad and has worked as a trainman, switchman, conductor, hostler helper, hostler, fireman, and locomotive engineer. Mr. Stem has worked to improve rail operational safety, remove worker fatigue as a safety issue, and improve freight and passenger rail services and public transportation options all of his career. He served 19 years as a member of the FRA Rail Safety Advisory Committee representing the safety needs of workers. He was educated at the University of North Carolina at Chapel Hill.

**Vincent Verna** serves the Brotherhood of Locomotive Engineers and Trainmen (BLET) as Director of Regulatory Affairs, a position he was appointed to in 2011. In 2014 he was elected to the position of Alternate Vice President and National Legislative Representative of BLET. As Director of Regulatory Affairs, Mr. Verna represents BLET on numerous collaborative endeavors, such as the Rail Safety Advisory Committee (RSAC) with FRA. He represents the interests of BLET members in all regulatory matters, including those before USDOT, the National Mediation Board, the National Transportation Safety Board, and the Transportation Security Administration, among others. He prepares the union's responses to various agencies' proposals for rulemakings and proposed rules, and he prepares responses to petitions for waiver from compliance with FRA regulations. Mr. Verna served as Chairman of the Arizona State Legislative Board from 2008 until 2011. Since 2006, he has been active on various RSAC Working Groups. He holds a BS in history from California State University at San Bernardino and an MS in legal and ethical studies from the University of Baltimore.

