United States Department of Transportation
Annual Modal Research Plans FY 2022
Program Outlook FY 2023

FEDERAL RAILROAD ADMINISTRATION
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Note: The FY 2022–2023 AMRPs will be certified using the President's budget numbers and revised with enacted budget numbers after the budget passes.

Executive Summary

The mission of the Federal Railroad Administration (FRA) Office of Research, Development, and Technology (RD&T) is to ensure the safe movement of people and goods by rail through the research and development of innovative technologies and solutions. As the Department of Transportation's (DOT) primary Strategic Goal, Safety is also the principal driver of the RD&T program. Additionally, RD&T's safety-focused projects offer solutions that contribute to the other DOT Goals: Economic Strength and Modernization, Equity, Climate and Sustainability, Transformation, and Organization Excellence. RD&T also has an important role to play in railroad industry workforce development (WFD).

FRA's RD&T program is grounded in understanding industry safety risks. Through threat identification and risk analysis, RD&T identifies research opportunities to reduce the likelihood of accidents and incidents or to limit the consequences of hazardous events should they occur. Key research and development strategies include stakeholder input/engagement and partnerships with external organizations—such as the Association of American Railroads (AAR), the American Short Line and Regional Railroad Association (ASLRRA), labor unions, the Pipeline and Hazardous Materials Safety Administration (PHMSA), the Environmental Protection Agency (EPA), the Intelligent Transportation Systems Joint Program Office (ITS-JPO) as appropriate—and internally with FRA's Office of Railroad Safety (RRS). RD&T works closely with the Office of the Assistant Secretary for Research and Technology (OST-R) and Topical Research Working Groups to prevent the duplication of effort

RD&T is organized into five programs: Human Factors, Railroad Systems Issues, Rolling Stock, Track, and Train Control and Communication. RD&T strategically prioritizes research and conducts cost-effective procurement. Critical research issues for FRA include: Positive Train Control (PTC); grade crossing safety; trespass prevention; autonomous vehicles; energy products research; rail energy, environment and energy technology; automation technology; predictive analytics; artificial intelligence (AI) and machine learning; accessibility; and WFD.

Aligned with OST-R research goals, FRA research identifies and addresses safety issues across the railroad industry, including high-risk and long-term research. Its work aligns to DOT priorities as well, as RD&T has been working with stakeholders to formulate a robust agenda that may take years to see a return on investment. For example, RD&T has been engaged in research that examines the impact of climate change and its implications for making rail operations both efficient and sustainable. RD&T WFD research has identified diversity, equity, and inclusion challenges for over a decade and is currently piloting programs to encourage young people in under-represented communities to consider careers in rail. Sustained funding enables the pursuit of specific research needs. FRA initially bears the costs and risks for such research that the railroad industry cannot undertake, but that lead to innovative solutions that may not otherwise be realized.

RD&T divisions work closely with stakeholders throughout the research and development (R&D) life cycle to understand adopter (industry and stakeholder) needs and barriers to adoption. As part of RD&T's Technology Transfer (T2) efforts, RD&T participates in OST-R Topical Research Groups to collaborate on research across DOT operating administrations. Research programs conduct stakeholder meetings, attend conferences and industry meetings, and facilitate program reviews to increase information sharing. RD&T publishes T2 research to inform the public and advance the practical application of new technology. The COVID-19 pandemic caused RD&T to extend some research activities and adjust protocols related to equipment and facilities. In FY 2022, RD&T will continue to mature its internal project evaluation practices and conduct internal and external project and program evaluation of research effectiveness.

	FY 2021 Enacted ($000)	FY 2022 Pres. Budget ($000)	FY 2022 Bipartisan Infrastructure Law ($000)*
R&DT Program Total	41,000	58,826	43,000

The recently enacted Bipartisan Infrastructure Law (BIL) authorized R&DT totals differ from the detail in this AMRP. The total funding amounts are shared in this table while a continued effort is underway to assess and implement use of these funds.

Table 1 – FY 2022 RD&T Program Funding Details

RD&T Program	FY 2022 Pres. Budget* ($000)	Applied ($000)	Technology Transfer ($000)	Facilities ($000)	Experimental Development ($000)	Major Equipment, R&D Equipment ($000)
Railroad Systems Issues	$24,197*	$12,749	$280	$1,762	$1,580	$7,826
Track	$10,179	$8,141	-	-	$2,038	-
Rolling Stock	$10,322*	$8,050	-	-	$2,272	-
Train Control & Communication	$8,086	$8,086	-	-	-	-
Human Factors	$6,042*	$4,822	-	-	$1,220	-
Totals	**$58,826**	**$41,848**	**$280**	**$1,762**	**$7,110**	**$7,826**

Amounts include congressional requests for the Short Line Safety Institute ($2,500) in Human Factors, Energy Products Research ($2,500) in Rolling Stock, and Research with Universities ($1,000) in Railroad Systems Issues.

Table 2 – FY 2022 RD&T Program Budget Request by DOT Strategic Goal

RD&T Program	FY 2022 Pres. Budget* ($000)	SAFETY ($000)	ECONOMIC STRENGTH AND MODERNIZATION ($000)	EQUITY ($000)	CLIMATE AND SUSTAINABILITY ($000)	TRANSFORMATION ($000)	ORGANIZATIONAL EXCELLENCE ($000)
Railroad Systems Issues	$24,197	$14,197		$5,000	$5,000		
Track	$10,179	$10,179					
Rolling Stock	$10,322	$10,322					
Train Control & Communication	$8,086	$8,086					
Human Factors	$6,042	$6,042					
Totals	**$58,826**	**$48,826**		**$5,000**	**$5,000**		

Amounts include Congressional research for Short Line Safety Institute ($2,500) in Human Factors, Energy Products Research ($2,500) in Rolling Stock, and Research with Universities ($1,000) in Railroad Systems Issues.

Section 1 – FY 2022 RD&T Programs

Office of Research, Development, and Technology
Research Portfolio Overview
$58,826,000

Program Description

The RD&T mission is to ensure the safe movement of people and goods by rail through research and the development of innovative technologies and solutions. Safety is the principal focus and goal of the RD&T program. While maintaining a safety focus, the program also yields solutions that contribute to all DOT goals to advance infrastructure, innovation, and accountability. RD&T conducts research, development, testing, and evaluation projects to support its safety mission and enhance the U.S. railroad system as a national transportation resource. It contributes vital benefits to safety regulatory processes, freight railroads, intercity and commuter rail and their passengers, railroad employees, railroad suppliers, and labor organizations.

The Committee directs FRA to undertake research and development activities in all disciplines—track research, rolling stock, signals, train control and communications, human factors, and rail-road systems—in order to maximize gains in rail safety and directs FRA to prioritize the introduction of new technology and data analysis methods to improve safety in all areas of railroad operations.

Safe transportation of energy products.—The Committee provides $2,500,000 for FRA to research and mitigate risks associated with the transportation of crude oil, ethanol, liquefied natural gas (LNG), and other hazardous materials, including tank car research in partnership with other Federal agencies. The Committee is aware of several research and development projects FRA and the Pipeline and Hazardous Materials Safety Administration (PHMSA) are actively pursuing relating to the transportation of LNG in rail tank cars and the use of LNG as a fuel for locomotives. The Committee directs FRA, in collaboration with PHMSA, to continue to support cooperative research on the safe use of LNG in these applications which should inform rulemaking.

Note: The Rolling Stock research program continues research of energy products with PHMSA.

Emissions reduction.— FRA, the Department of Energy (DOE), and the private sector are conducting research, development, and testing on alternative fuels for locomotives, including the use of electric batteries, hydrogen, fuel cell technologies, LNG, biofuels, and renewable biodiesel. The Committee directs FRA, in collaboration with DOE, to continue to support cooperative research on innovative technology solutions for low- or no-emission alternative fuels, including zero emission technologies, engine improvements, and motive power technologies. In addition, the Committee directs FRA to conduct research, development, testing, and analysis to determine the safety of such technologies, any additional emergency response planning and training requirements relating to such technologies, related infrastructure requirements to support such technologies, and any other activities FRA deems necessary to ensure the safe operations of such technologies. The Committee provides $5,000,000 to support this research, which could improve energy efficiency, hasten the transition from traditional diesel fuel locomotives, and spur the development and deployment of low- or no-emission technologies.

Note: The Railroad Systems Issues research program continues research of electric batteries, hydrogen, fuel cell technologies, LNG, biofuels, and renewable biodiesel. Railroad Systems Issues continues to collaborate with DOE.

Workforce development.—The Committee notes that FRA's railroad systems issues program has conducted workforce development activities for several years, focusing on the recruitment, retention, and development of the railroad workforce. The Committee understands that FRA's research will focus on gathering and analyzing data on trends, skill gaps, skill demands, training opportunities, and industry best practices; identifying innovative approaches to recruiting talent, attracting and retaining a more diverse workforce, and knowledge sharing and succession planning; improving training and educational opportunities; and fostering an interest in railroad related employment through science, technology, engineering, and mathematics (STEM) programs for pre-K–12, as well as minority serving institutions, technical and vocational schools, and community colleges. The Committee provides up to $5,000,000 to support these research activities, including working with minority serving institutions (MSIs). Further, the Committee supports FRA's efforts to address diversity, equity, and inclusion in the railroad workforce through its research activities.

Note: The Railroad Systems Issues research program continues research of workforce challenges in the railroad industry. The STEM programs initiated and outreach to MSIs and historically black colleges and universities (HBCUs) in FY 2021 continue in FY 2022.

Short-line safety.—The Committee provides $3,000,000 to improve safety practices and training and develop safety management systems for Class II and Class III freight railroads. This funding supports FRA's initiative to partner with short line and regional railroads to build a stronger, more sustainable safety culture through safety culture assessments, training and education, including on the safe transportation of energy products and other hazardous materials, outreach activities, and research.

Note: The Human Factors research program continues to partner with the short line and reginal railroads to improve safety culture.

Program Goals and Objectives

FRA remains focused on improving rail safety for the American public and rail workers through research that produces data-driven prototypes, applications, and recommendations. RD&T's main objectives are:

- Reduce incidents and accidents involving U.S. railroads—saving lives and mitigating environmental hazards.

- Promote innovative technologies and facilitate leadership across the industry.

- Continuously improve its understanding of the impact of technology on safety and the industry workforce.

RD&T achieves its objectives with continuous stakeholder engagement throughout a project's research, T2, and acquisition life cycles. An additional RD&T objective is to promote innovation and facilitate leadership across the railroad industry in the exploration and use of technology and automation. For over a decade, RD&T has sought to better understand how rail technologies affect safety and WFD. To that end, RD&T has prioritized research on systems such as Positive Train Control (PTC) to solve the technology's development, implementation, and integration issues. Working with internal stakeholders, including RRS, RD&T meets industry needs and addresses safety issues as they evolve:

- Reducing accidents caused by human error

- Reducing track-related derailments

- Reducing incidents and accidents related to grade crossings and trespassing

- Investigating automation and technology

- Collaborating and sharing information on industry WFD challenges

- Investigating safer practices for the use and transportation of energy products

In early June 2021, RD&T divisions received several concept papers in response to FRA's 2021 Broad Agency Announcement (BAA). The BAA solicitation yielded its highest participation to date, with over 41 universities submitting 180 concept papers on topics that touch all five divisions. In the next few weeks, the divisions will review the papers and determine which should move forward to the proposal phase. RD&T's planned investments include topics they expect to award funding to in FY 2022 and FY 2023 based on received concept papers; however, final budgets will be determined after proposal phase evaluations are completed in early FY 2022.

Critical Research, Development and Technology Programs

RD&T strategically aligns its research with DOT, OST-R, FRA, and the FRA Office of Railroad Policy and Development (RPD) goals and strategic plans, with a focus on improving safety. Many RD&T research projects yield additional benefits in the areas of equitable economic strength and improving core assets; rebalancing investments to meet racial equity and economic inclusion goals; climate and resilience; and transformation and "future-proofing." FRA research identifies and addresses safety issues across the railroad industry, including high-risk and long-term research. The sustained funding of FRA R&D enables the pursuit of safety-specific research needs. This allows FRA to initially bear the costs and risks for research the railroad industry is unable to pursue. Without this investment, significant safety-related research (especially in human factors) and innovative solutions would not occur, and the benefits would not be realized.

RD&T includes five research programs that contribute critical research, development, and technology to the industry:

- Railroad Systems Issues – Railroad Systems Issues; Research with Universities on Intelligent Railroad Systems; and Research and Development Facilities

- Track – Track and Structures; and Systems Performance and Analytics

- Rolling Stock – Hazardous Materials; Energy Products Research; Rolling Stock Equipment and Components; and Train Occupant Protection

- Train Control and Communication – PTC and Grade Crossing/Trespassing

- Human Factors – Human Factors and the Short Line Safety Institute

Technology Transfer Deployment

Partnerships and stakeholder engagement form the foundation of RD&T's T2 methodology. Each division works closely with stakeholders throughout the R&D life cycle to increase user adoption of research products and services. RD&T Program Managers (PMs) directly support technology development and implementation (Technology Readiness) and are integrated with the research project life cycle through planning, engaging stakeholders, identifying resources, and executing research activities. Over the past decade, RD&T has not seen a significant budget increase, meaning PMs must engage stakeholders on user adoption prior to the start of research efforts. Taking these steps gives them time to understand stakeholder needs and potential barriers to adoption, and then develop strategies to communicate the value and benefit of RD&T's research products.

PMs create partnerships across the industry, increasing the likelihood of technology adoption. As the subject matter expert (SME) in their respective areas, PMs work with internal and external stakeholders to understand and develop new technology.

RD&T T2-related spend plans will be approximately $280,000 in FY 2022. T2 implementation costs include:

- Stakeholder engagement (industry conferences, meetings, presentations, workshops)
- Communications (support for publications and reports)

Most of RD&T's research projects include the production of Technical Reports and Research Results—published on FRA's eLibrary, the National Transportation Library, the Transportation Research Board's (TRB's) Research-in-Progress database, the DOT Repository and Open Science Access Portal, and the Transportation Research International Documentation database— after research is completed. The publications are accessible to the railroad industry stakeholders and the American public. Information regarding RD&T's work can also be found on OST-R's Research Hub.

Over the last 5 years, RD&T has increased research publication, with FY 2021 expected to continue that trend. RD&T is developing a tool to manage and track research products to further improve the publication process. To speed the publication process, RD&T has been collaborating with the FRA Web Team to develop and test the Research Report Tracking Tool (R2T2) solution. The purpose of R2T2 is to help the Technical Editors and Program Managers to better manage and track the publications—shortening the distance between researcher and potential user. The table below summarizes RD&T publishing from FY 2017 to FY 2021 (from October 2020 through May 2021).

Document Type	FY 2017	FY 2018	FY 2019	FY 2020	FY 2021 (as of May 31, 2021)
Technical Reports	25	41	44	52	28
Research Results	4	17	22	19	18
Other Reports	10	4	3	2	2
Total	**39**	**62**	**69**	**73**	**48**

Collaboration Efforts

FRA's relationships with industry stakeholders and external research partners delivers accelerated information-sharing and T2 to achieve safety goals. To guide FRA's investments, RD&T sets a research agenda defined by a clear set of priorities to investigate current and future safety issues. These priorities draw from the Department's priorities as well as from OST-R, FRA, and RD&T Strategic Goals—and RD&T emphasizes the relevance of those priorities in stakeholder outreach and engagement activities.

RD&T stakeholders include railroad carriers, labor unions, railroad manufacturers, universities, RRS, the Federal Transit Administration, PHMSA, EPA, the Department of Energy (DOE), the Federal Highway Administration (FHWA), ITS-JPO, and the American public. FRA partners internationally on suicide prevention, climate and energy research, and hazardous materials research. These stakeholder groups benefit from RD&T research through information-sharing and transparency; development and testing of innovative technology; WFD; safety recommendations; improved safety culture; safety tools; improved infrastructure; safety training; research risk mitigation; exploration of automation and the impact of automation on transportation; and safer transportation of goods and passengers throughout America's railroads.

Internal stakeholders, such as RRS, provide safety data for RD&T research. Conversely, RRS uses RD&T research to support safety standards and requirements. RRS use of RD&T research has improved the safety of U.S. railways and decreased fatalities over the last 10 years. External stakeholders (e.g., railroads, labor unions) provide insights, trends, and data used to initiate and prioritize research. These same stakeholders participate in research by providing expertise, equipment, or feedback during research projects, or as participants in research studies. Internal and external stakeholders consume RD&T research, implement training, establish standards, and adopt equipment suggested in RD&T research and development.

Cross-Modal Collaboration Activities

In FY 2021, RD&T and FHWA collaborated and co-funded two Small Business Innovation Research (SBIR) efforts to use AI to improve public safety at highway-rail grade crossings. Phase I was focused on feasibility and engineering design for a potential prototype. By placing forward-facing video cameras on locomotives, FRA and FHWA hope to develop an AI-based application that eventually allows real-time inspection of grade crossings for the presence and functionality of safety-related infrastructure, such as gate arms. This effort will continue in FY 2022 by way of a SBIR Phase II award.

Working Groups Activities

Public Access Implementation Working Group (DOT): As an RD&T Planning Team Topical Research Working Group, PAIWG's mission is to enable cross-modal collaboration to ensure the best possible public access to DOT scientific research through implementation of the DOT Public Access Plan, common best practices, and shared resources.

Data Access Task Force (DOT): A specialized sub-group of PAIWG, DATF is focused on supporting PAIWG regarding public access of R&D-related data sources.

AI & Privacy Working Group (General Services Administration [GSA]/Technology Transformation Service [TTS]): Engage members of the AI community of practice established by GSA's TTS to identify needs, discuss issues, and to collectively drive development of products, tools, resources, and initiatives for the Federal AI community. This group is specifically focused on privacy-related issues associated with the implementation and use of AI in the Federal environment.

AI Workforce Working Group (GSA/TTS): Engage members of the AI community of practice established by TTS to identify needs, discuss issues, and to collectively drive development of products, tools, resources, and initiatives for the Federal AI community. This group is specifically focused on WFD and worker interaction with AI systems in the Federal environment.

Partner Detail

Partner Name	Contributions	Benefits of Partnership
Universities across the U.S.	Expertise and research	Subject matter expertise and WFD
American Public Transportation Association (APTA)	In-kind contribution; subject matter expertise, data	Provide data on noise emissions design features
Railroads	In-kind contribution; subject matter expertise; access to rail facilities	Provide locomotive engine, duty cycle data; support test activity; subject matter expertise
Labor Unions	Subject matter expertise	Subject matter expertise
Associations	In-kind contributions; subject matter expertise; access to rail facilities	Support test activity; subject matter expertise

Benefits Detail

Beneficiary	Benefits Received
RRS	Improved safety standards/recommendations Improved science to amend standards and requirements in support of EPA's hydrogen fuel and batteries
Rail Industry	Improved safety standards/recommendations Lower operating costs Improved visibility for railroad workers and grade crossings Reduced railroad accidents and fatalities Reduced regulations
Small Businesses and University Research Centers	Improved railroad research resources and capabilities
Railroads	Standardized matrix to determine most efficient technology for improved energy and efficiency of locomotive engines

Evaluation and Performance Measurement Efforts

In compliance with the Government Performance and Results Act (GPRA) and the GPRA Modernization Act of 2010, the RD&T program performs project evaluations specifically designed to:

- Guide and strengthen RD&T program execution.

- Facilitate the collection of feedback to improve project performance.

- Assess achievement of target audience needs.

- Assess and drive research investment decisions.

For better performance measurement, RD&T developed an evaluation tool and conducted a pilot exercise to obtain user feedback. In 2022 RD&T will continue to develop internal project evaluation capabilities and ensure alignment to DOT learning agendas through the development of new tools, logic models, and measurement criteria. RD&T remains committed to using evidence-based performance measures to improve research and development throughout the life cycle process, with the goal of standardized performance measurement across the organization.

FRA will measure performance for T2 as part of the DOT Strategic Goal: Innovation. This will include tracking measures for the development and deployment of innovation, as represented in the table below.

Metric: Transportation Innovations		2018	2019	2020	2021
Research Outcomes Made Publicly Available in Research Hub	Targets	N/A	54	10% increase	10% increase
	Actuals	N/A	54	N/A	N/A
Technical Reports Made Publicly Available in the National Transportation Library	Targets	N/A	42.5K	44.5K	46.5K
	Actuals	N/A	42.5K	N/A	N/A

Metric: T2 Effectiveness		2018	2019	2020	2021
Technologies Toward Implementation	Targets	—	—	75	100
	Actuals	—	Baseline	N/A	N/A

| Success Stories (Evidence of Societal Benefits) | Targets | 10 | 10 | 12 | N/A |
| | Actuals | 8 | N/A | N/A | N/A |

PMs and stakeholders define metrics relating to T2, including Technology Readiness level and industry adoption (e.g., stakeholder participation, commitment, contribution, adoption levels). Based on the current readiness level and the anticipated objectives of the research project, targets and measures are established to monitor the progress of the research and the impact on the readiness of the technology for commercial adoption.

Involvement in OST-R Topical Research Groups

RD&T participates in each of the OST-R Topical Research Groups to increase collaboration on research across the modes. The following table highlights the areas that each research program addresses directly and indirectly.

OST-R Strategy	Railroad Systems Issues	Track	Rolling Stock	Train Control & Communication	Human Factors
Automation		X	X	X	X
Systemic Safety Approach	X	X	X	X	X
Human Factors					X
State of Good Repair		X	X		
Environmental Stewardship	X		X		
Economic Competitiveness	X	X	X	X	X
Emerging/Enabling Technologies	X	X	X	X	X
Mobility Innovation			X	X	
Cybersecurity				X	
Technology Transfer/Deployment	X	X	X	X	X
Evaluation/Performance Measurement	X	X	X	X	X
Data	X	X	X	X	X

RD&T Alignment to USDOT Priorities, FY 2022

Following FRA's *Moving Rail Forward* motto is a key factor to ensure the relevance, alignment, and agility in RD&T's strategy. RD&T leadership reviewed and refreshed (in some cases) the work of each division and considered FRA's role and commitment in executing the Department's priorities. The following table highlights areas in which RD&T's research agenda aligns with the Department's priorities: Safety, Economic Strength and Modernization, Equity, Climate and Sustainability, Transformation, and Organization Excellence.

DOT Priority	RD&T Research Activities
Safety	RD&T continues to focus on new technologies and methods to reduce derailments and improve safety in rail operations through research. It will continue its research to better understand the root causes of rail grade crossing and trespass incidents to develop strategies to prevent future incidents or mitigate their consequences.
Economic Strength and Modernization	Since 2009, RPD has conducted research on rail industry WFD to understand workforce trends and challenges. In FY 2021, RD&T kicked off three science, technology, engineering, and math (STEM) education pilot programs in collaboration with universities, including two Minority-Serving Institutions (MSIs). In FY 2022, RD&T plans to fund research to increase the recruitment and retention of under-represented groups in the railroad industry.
Equity	In FY 2021, RD&T began developing a strategy to cultivate relationships, research partnerships, and collaborations with MSIs. Further, RD&T plans to increase awareness of research funding opportunities and build research partnerships with MSIs and other associations.
Climate and Sustainability	RD&T is focused on quantifying track structural conditions that can have a positive impact on climate change by reducing energy consumption during safety-related maintenance. Research is also investigating the efficacy of alternative fuels and advanced motive power technologies to improve energy efficiency and reduce emissions of rail transportation. RD&T plans to test alternative fuels for use in rail and other clean energy solutions to build on rail's already superior energy efficiency and contribute to reductions in the transportation sector's greenhouse gas emissions. In FY 2022, RD&T will partner with RRS to host a transcontinental workshop on the advancement of safe clean fuel and motive power technologies for railroad applications.
Transformation	RD&T's infrastructure investments consider generational impact and will be informed with a holistic approach to develop shovel-ready, enduring, safe, equitable, and sustainable rail projects. The Transportation Technology Center (TTC) provides RD&T, the railroad industry, and other DOT modes a facility to conduct infrastructure research and share information.
Organization Excellence	RD&T continues improving organizational processes which includes research publication, project evaluation, and project selection. To speed the publication process, RD&T has been collaborating with the FRA Web Team to develop and test the Research Report Tracking Tool (R2T2) solution. Project evaluation activities include demonstrating the significance, value, and impact of RD&T research in improving railroad safety. RD&T conducts an annual prioritization to ensure that stakeholder and industry needs are factored into the RD&T investment planning processes.

Alignment to American Jobs Plan

The first prong of a larger infrastructure package, the American Jobs Plan focuses on investments in transportation, broadband, clean energy, R&D, and domestic manufacturing. RD&T research objectives align to the American Jobs Plan in supporting the improvement of reliable passenger and freight rail service. Current research priorities address the safety, reliability, and efficiency of the rail system and seek to find more climate-friendly operational alternatives. Additional, consistent investments will provide the funding streams needed to advance current research initiatives and begin research that could significantly advance new technologies, address inequities, and infrastructure resilience—by enhancing grant and loan programs that support passenger and freight rail safety, efficiency, and electrification. RD&T's WFD research agenda also supports the *broader* definition of infrastructure, to include the rail industry's *human* capital. RD&T, through its research agenda, stays current with the industry's workforce issues and challenges in preparing for the future. The research has specific focus on exposure to careers in rail and increasing funding opportunities for under-represented groups and MSIs.

COVID-19 Impact on RD&T Operations

The COVID-19 pandemic has affected RD&T research projects, including those conducted at TTC and the Volpe National Transportation Systems Center (Volpe), which house test facilities and equipment. RD&T is working with Volpe to define safe operating procedures for locomotive simulators. FRA extended the period of performance end dates for all grants and many contracts to provide researchers additional time to complete their research. RD&T will continue to look for collaborative opportunities with OST-R and other DOT modes to support safety challenges related to the pandemic.

Railroad Systems Issues

$24,197,000

Program Description

The Railroad Systems Issues (RSI) research program defines the strategy that directs the entire RD&T program toward the goals set by DOT, OST-R, FRA, and RPD. The principal focus and goal of the RSI program is safety; however, the program's activities contribute to all DOT Strategic Goals and Priorities.

The RSI research program improves railroad safety by evaluating risks and prioritizing RD&T projects to reduce safety risk and achieve DOT, OST-R, FRA, and RPD goals. RD&T works with RRS to understand their strategic goals, safety data and trends, and requirements to prioritize research to improve safety.

Statutory Requirements

Is this program statutorily mandated (Y): See page 4 for more details.

Program Objectives

RSI's objective is to determine strategic research needs and priorities through collaboration with internal and external partners and stakeholders, considering real-time safety issues requiring subject matter expertise or long-term research solutions. The RSI research program develops, facilitates, manages, and supports the following areas: RD&T's research strategy; safety risk analysis; research prioritization; strategic collaborations and partnerships; performance-based regulations; non-regulatory recommendations; railroad environmental issues; locomotive safety; project evaluation; WFD; MSI outreach; RD&T-related technology transfer and travel; operations, maintenance, and equipment at TTC in Pueblo, Colorado; and contractor support.

RD&T partners and collaborates with academia, the private sector, and the rail industry—in addition to working with other DOT modes and Federal agencies.

Anticipated Program Activities

RSI activities are tailored to address a host of railroad issues—from safety to WFD.

Program Area – Railroad Systems Issues

Rail Safety Innovations Deserving Exploratory Analysis (IDEA)

The IDEA project solicits innovation, ideas, and advanced technology applications in railroad safety. TRB initiated this effort, in conjunction with FRA, to address safety needs and advance improvements within the railroad industry.

Anticipated Activities[1]

TRB and FRA will issue an IDEA Program Announcement to solicit proposals for Rail Safety IDEA program exploratory research projects. The announcement describes the program and provides guidelines for eligibility and proposal submission. TRB selects a qualified Rail Safety IDEA review committee that will evaluate proposals on a competitive basis. The Rail Safety IDEA program committee will evaluate how well those proposals meet the technical eligibility criteria, and provide

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[1] Note for Anticipated Activities sub-headings throughout this document: Activities and outcomes may be similar to previous fiscal years because new projects are selected, executed, monitored, and completed each fiscal year.

comments for selected researchers. TRB will ensure the widespread announcement of contract opportunities for rail inventors. TRB and FRA will collaborate to manage the projects to completion. FRA and TRB will track the successful implementation of completed projects.

Project Selection

RD&T conducts an annual prioritization to ensure that stakeholder and industry needs are factored into the RD&T investment planning processes. In addition, DOT priorities and safety priorities, especially those provided by RRS, are a major consideration.

Anticipated Activities

This project includes the activities and costs associated with maintaining the Decision Lens prioritization software license and implementing the prioritization process. FRA will renew the software license for an additional option year. RD&T will use lessons learned and apply the improved rating process to candidate research projects for FY 2022 (October–December 2021 timeframe). Each research program will use lessons learned and results to inform the FY 2022 AMRP.

Strategic Planning

The objective of RD&T's strategic planning is to engage the stakeholder community in establishing research needs and assure that RD&T conducts research to meet current and future industry needs. RD&T strategically aligns with the DOT Strategic Goals. RD&T strategies also align to OST-R Strategies of Automation, Systemic Safety Approach, Human Factors, State of Good Repair, Environmental Stewardship, Economic Completeness, Emerging/Enabling Technologies, Mobility Innovation, Cybersecurity, Technology Transfer/Deployment, Evaluation/Performance Measurement, and Data.

Anticipated Activities

RD&T will continue implementation of its 5-Year Strategic Plan 2020–2024. The strategies build on current successes and take steps to increase the awareness and communication of industry needs and problems, and adopt and deploy FRA solutions, products, recommendations, and research data. RD&T staff will continue to engage internal and external stakeholders to understand industry challenges to provide solutions, research, and data. RD&T will continue to plan, assess, and execute strategies to increase partnerships and collaboration with MSIs. RD&T will also begin framing its 5-Year Strategic Plan 2024–2028.

RD&T Technology Transfer

The objective of RD&T T2 is to engage stakeholders and increase user adoption and the consumption of RD&T's innovative concepts, research, and methods—to improve safety and enhance performance for railroads.

Anticipated Activities

Utilizing RD&T's T2 methodology, each division will execute collaborative stakeholder engagement activities, seeking T2 and the adoption of innovative concepts and methods that will enhance railroad safety and performance. RD&T will test and pilot the R2T2 SharePoint application to track and manage the RD&T publication process.

Program Support

Objectives include analysis; subject matter expertise; strategic planning and advice; data, records, and information management; project, program, and strategic portfolio management; and technical editing support to RSI research, development, and T2 processes.

Anticipated Activities

As part of RD&T's T2 and publishing process, the Technical Editors will review Technical Reports, Research Results, conference papers, and other material. The editors will also provide report-related social media content to the FRA Office of Public Affairs for RD&T's social media campaigns. Contractors will provide program management, analysis, and subject matter expertise to support project, program, and portfolio management.

Project Evaluation

RD&T PMs conduct internal and external project evaluations to assess and improve the value of research activities. PMs use the SharePoint Project Evaluation tool to document answers to critical evaluation questions throughout the life cycles of their acquisitions. Goals of PMs' project evaluation activities include: demonstrate the significance, value, and impact of RD&T research in improving railroad safety; assess the achievement of target audience (beneficiaries) needs; drive sound and consistent project management practices and activities to enhance performance measurement and progress tracking; strengthen RD&T's case for needed financial support; assure the soundness and credibility of RD&T's internal evaluations in meeting external requirements and inquiries; and assess and promote T2 to the private sector.

Anticipated Activities

RD&T will update its project evaluation practice to align with changes introduced by the new presidential administration. RD&T will update the evaluation questions to align with FRA's learning agenda (expect full draft due September 2021 and final draft published February 2022). RD&T will continue project evaluation training. RD&T will use, modify, and create project evaluation tools. Each research program will continue implementing RD&T's project evaluation methodology and will establish performance management metrics and collect performance management measures.

Railroad Systems Issues

The objective of this research is to conduct research focused on safety with secondary strategic alignment to innovation, infrastructure, and accountability in the railroad industry.

Anticipated Activities

RSI will conduct research through BAAs, which support topic areas for the five divisions. The announcement describes the program and criteria and provides guidelines for eligibility and proposal submission.

Workforce Development

This research is focused on identifying, understanding, and increasing awareness of railroad industry workforce-related trends and challenges through publications, stakeholder engagement, and conferences. FRA has connected with stakeholders through surveys, conference participation, and industry dialogues, which provide a deeper understanding of workforce trends and challenges, and the data that industry uses to understand and to address common challenges. Based on past research, RD&T has emphasized expanding initiatives and programming to address railroad industry diversity, equity, and inclusion, with an eye toward cultivating future talent.

Anticipated Activities

RD&T will conduct research and publish updates to FRA's railroad industry workforce assessment, the Railroad Industry Modal Profile. Stakeholder collaboration activities include: establishing rail industry forums to identify and generate best practices and information exchange; supporting youth programs (Pre-K through 12th grade and college) and under-represented populations in rail transportation and STEM topics; expanding strategic outreach to build research partnerships with MSIs; increase awareness, capacity and interest in railroad research and careers; and STEM curriculum and learning.

RD&T will fund two BAA research proposals from the following submissions:

1) Three research topics from FRA's 2021 Research Initiatives in Support of Railroad Safety BAA:

   - Addressing Equity Challenges in Evolving Railroad Workforce Training Trends and Best Practices

   - Workforce Recruitment: Attracting and Retaining Women in Rail

   - Influencing Successful Practices in Knowledge Management within the Railroad Industry

2) Three research topics from FRA's Research with Universities—Research Initiatives in Support of Railroad Safety BAA:

   - Pre-college STEM Rail Transportation Club to Increase Racial Equity in Rail Workforce Recruitment

   - Workforce Recruitment: Attracting and Retaining Women in Rail (New Contract)

   - Racial Equity in Rail Workforce Recruitment: Identifying and Training Leadership for Succession Planning, and LGBTQ+ Equity and Inclusion in the Railroad Industry

In addition, RD&T plans to develop partnerships with rail associations to create and support programs targeting underrepresented populations to encourage them to select careers in rail.

Energy and Emissions

As new technology reduces emissions and increases efficiency in rail transportation, research is needed to evaluate the safety of such technologies. RD&T—working with RRS, DOE, and the rail industry—will evaluate various technologies aimed at the decarbonization of rail transportation. Research will assess the safety of alternative energy sources, electric batteries, and locomotive efficiency technologies. To ensure the safe use of such technologies, the research will assess the efficacy of current Code of Federal Regulations (CFR) and industry standards. The research provides RRS with the scientific basis for decision-making and the development of standards and requirements.

Anticipated Activities

RD&T, in cooperation with RRS, will plan and host a conference on the advancement of safe, clean alternative fuels and motive power technologies for railroad applications. The conference will convene experts, end users, manufacturers, academia, international partners, and Federal agencies to discuss the decarbonization of rail. Opportunities and barriers will be identified for research agenda development. Small-scale battery cell impact tests will be conducted to understand the performance of these technologies under normal and accident loads consistent with the rail environment. RD&T will provide feedback and direction to RRS on performance of such equipment under normal and accident scenarios.

RD&T will select BAA research proposals which may include the following topics: Rail's Contribution to CO_2 Emissions, Modal-Shift Impacts and Energy and Environmental Sustainability, and Climate Change and Resiliency Planning. These topics may include research related to hydrogen fuel, electric battery safety, CO_2 emissions on shortline railroads, or testing hydrogen cylinders under fire and collision simulations.

Accessibility

Passenger rail transportation is the preferred form of public transportation for most people who use wheeled mobility devices (WhMDs). Accessibility research has yielded recommendations for improved accessibility on passenger railcars, thereby enhancing the travel experience for passengers with disabilities and ultimately all rail passengers. The objective of this research is to provide safety and protections to all passengers when they ride in railcars. Research to date has focused on the relative movement of WhMDs and their occupants in various seating configurations in low-speed collisions. RD&T research has also assessed recommendations for new accessibility standards on rail vehicles being considered by the U.S. Access Board.

Anticipated Activities

RD&T will engage with the U.S. Access Board as it considers rulemaking recommendations for improved accessibility on passenger rail equipment for larger spaces, greater maneuverability in restrooms, and better communication systems. Results from RD&T investigations—on feasibility and cost associated with the Rail Vehicle Access Advisory Committee recommendations for improved accessibility—will be disseminated.

Locomotive Safety

The goal of this research is to investigate innovative locomotive engine technologies to ensure they are safe and enhance rail transportation efficiency.

Anticipated Activities

RD&T will complete an assessment of innovative, high-pressure heat exchangers in a real-world environment. RD&T plans to complete the development and prototype demonstration of hybrid systems, focusing on improving locomotive efficiency while meeting safety requirements and emissions standards.

Office of Railroad Safety Support

All RD&T divisions support RRS by providing SME consultation, research, data, and tools to improve railroad safety and reduce accidents and incidents. RD&T collaboration with RRS provides insight into research needs. RD&T support of RRS assists FRA with responding to time-sensitive safety issues.

Anticipated Activities[2]

RD&T will continue to partner with RRS and industry on Railroad Information Sharing Environment (RISE), a secure data-sharing and analysis platform. RD&T will conduct research of urgent safety issues identified by RRS or Congress. RD&T will also continue to provide SME support to RRS.

Public, Private, and University Cooperative Research Agreement

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[2] Funding will come from multiple divisions. A new contract vehicle for RISE is starting in FY 2021 for RD&T to continue to develop the RISE platform and partnerships.

The objective of this research is to collaborate with academia on research opportunities to fund proposals that have the potential of improving safety and performance in railroad systems in the following areas: Railroad Systems Issues, Track, Rolling Stock, Train Control and Communication, and Human Factors. All selected proposals have the ultimate goals of improving railroad safety and performance; enhancing infrastructure conditions and services by stimulating economic growth, productivity, and WFD; and serving the nation with reduced regulatory burden and greater efficiency, effectiveness, and accountability. This effort encourages college students to select careers in rail and expands the number of academic institutions participating in railroad research.

Anticipated Activities[3]

RD&T will publish the request for proposals and review submissions. RD&T will select prospective research projects to fund and begin selected projects.

Program Area – R&D Facilities and Equipment – TTC

The primary objectives of this funding are to maintain the one-of-a-kind infrastructure at TTC to accommodate the testing and evaluation of Intelligent Railroad Systems (IRS) technologies and to provide FRA with the type and quality of facilities and equipment needed to meet its missions in safety, infrastructure, innovation, and accountability. Focused on enhancing railroad safety, TTC is a key facilitator of national research and development, and the application of new technology for railways, suppliers, governments, and others involved in rail transportation. FRA and the Transportation Technology Center, Inc. (TTCI) are jointly responsible for the facility's maintenance and make significant capital improvements to ensure it can adequately support research and testing requirements.

Anticipated Activities

RD&T will continue providing facilities and equipment that can perform railroad research and development, testing, and training to enhance the safety of rail systems in both safety and security operations. It will also further enhance TTC's capabilities through strategic investment in existing facilities and equipment to support upcoming research and testing needs. Upgrades and refurbishment to the TTC rail system and facilities include:

- Repair, rehabilitate, and refurbish buildings and facilities that support RD&T activities.

- Maintain, repair, or replace railroad track and test infrastructure, equipment, and instrumentation used for RD&T-related research projects.

TTC will continue to support environmental and green technology goals encouraging energy efficiency, renewable energy, the reduction of toxins, recycling, the reuse of materials, and water conservation.

In FY 2021, RD&T began contract closeouts for TTCI to phase in the new contract for ENSCO, Inc. RD&T began conducting contract planning meetings with ENSCO in FY 2021 to determine instruments and equipment needed as part of the transition.

FRA will raise awareness and encourage the broader use of TTC facilities through creative outreach to other Government agencies and the private sector, while ensuring priority for FRA-sponsored activities and providing fair access to TTC facilities. The Transportation Security Administration will continue using TTC for inspector training. PHMSA is establishing research and development facilities at TTC and is expected to start using them in FY 2022.

Program Area – Research with Universities on Intelligent Railroad Systems

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[3] Funding will come from multiple divisions. A total of $2M across all of RD&T will be allocated for this research.

FRA, in conjunction with ITS-JPO, will use a BAA to solicit applied technology research proposals that will support DOT and FRA goals to advance automation and connected vehicle technology adoption in the rail industry. Program objectives include enabling safer vehicles and roadways; enhancing mobility; limiting environmental impacts; promoting innovation; and supporting transportation connectivity.

Anticipated Activities[4]

RD&T will review university proposals and select prospective research projects. RD&T will award funding and begin selected projects.

Expected Program Outcomes

Rail Safety Innovations Deserving Exploratory Analysis

RD&T will continue to develop new research and complete existing research to deliver innovative solutions to improve safety and performance in railroad systems. With multiple research activities each year, the outcomes for the Rail Safety Innovations Deserving Exploratory Analysis (IDEA) collaboration with TRB vary, based on the projects selected and the duration of research. Expected deliverables include project management documents, quarterly progress reports, final performance reports, and final research reports. T2 of 2018, 2019, 2020, and 2021 efforts (based on project duration) is also expected.

Project Selection

RD&T will continue to use Decision Lens software to support RD&T project safety risk decisions, improve efficiency in project spending, and update its prioritization methodology for investments. RD&T leadership and PMs will use lessons learned from the 2019 Decision Lens pilot to improve the rating process for FY 2022 and use the results to inform the FY 2022 AMRP.

Strategic Planning

RD&T will continue to improve research project evaluation and T2 reporting. RD&T will coordinate program reviews and stakeholder engagement activities to begin planning for the next Strategic Plan. RD&T will increase the number of MSI collaborations and partnerships. MSIs will benefit from acquisition and research training from RD&T.

RD&T Technology Transfer

RD&T will increase information sharing, partnerships, and utilization of TTC. T2 activities will be focused on improving awareness and increasing the use of RD&T research, standards, recommendations, and products. RD&T will publish more research products than in previous years. RD&T will capture user feedback for R2T2 and draft user stories documenting new requirements and areas to incrementally optimize.

Program Support

RD&T will continue with strategic planning, project management, project evaluation, and editing. In addition, RD&T aims to increase publication of research reports.

Project Evaluation

In FY 2022, all RD&T divisions will document metrics and capture measures. Expected outcomes include increased maturity of RD&T's project evaluation practices and understanding modifications

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[4] Funding has been provided by Congress for the Research with Universities on Intelligent Railroad Systems in addition to the total budget for FRA RD&T. If Congress chooses NOT to fund the $1M additional funds, this activity will not be executed in 2022.

required for FY 2023 to continue alignment to FRA's learning agenda and Office of Management and Budget (OMB) requirements.

Railroad Systems Issues

This project conducts research focused on improving safety, with a secondary strategic alignment to innovation, infrastructure, and accountability in the railroad industry. Outcomes depend on BAA selections.

Workforce Development

Expected outcomes for WFD research include increased railroad stakeholder engagement and information-sharing to enhance FRA's research and understanding of trends, and the identification of new research topics in equity across the rail industry.

Expected outcomes for WFD strategic outreach include: greater awareness and interest in rail-related careers for teens and college students; engagement in industry efforts to build a pipeline of diverse, qualified talent for the railroad industry, including increasing the percentage of women in the railroad workforce; and more research funding opportunities for MSIs.

Energy and Emissions Safety Research

RD&T will develop a robust research strategic plan focused on assessing the safety and efficacy of technologies for the decarbonization and overall "greening" of rail transportation. Cooperative research partnerships will be established to further the development of rail energy and emissions technologies. Further development of the Rail Module in the Greenhouse Gases Regulated Emissions and Energy Use in Transportation (GREET) Model will give the rail industry a multi-modal tool that can be used to assess emissions and energy use of different fuel alternatives. RD&T will also expand research in fuel technologies and establish new safety criteria for hydrogen cylinder safety.

Accessibility

RD&T will continue to work with the U.S. Access Board and the rail industry to develop guidance for securing of WhMDs on board passenger railcars.

Locomotive Safety

The goal of this research is to investigate innovative locomotive engine technologies to ensure the safe and efficient transportation of people and goods. In collaboration with Class I railroads, RD&T will complete an assessment of technological innovation using high-pressure heat exchangers in a real-world environment. RD&T will determine the performance of locomotive engine systems that improve efficiency while maintaining safety. RD&T will ensure that emerging locomotive engine efficiency improvement technologies are safe.

Office of Railroad Safety Support[5]

RD&T provides RRS with the scientific basis to drive standards and requirements development, and to support emissions limits for both passenger and freight equipment. All RD&T divisions support RRS by providing SME consultation, research, data, and tools to improve railroad safety and reduce accidents and incidents. Studies will analyze safety risks and identify mitigations to those risks. Collaboration and research will continue to yield growth, participation, and maturity of the RISE project.

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[5] Funding will come from multiple RD&T divisions to support RRS research. The new RISE contract vehicle is expected to start at the end of FY 2021, with expected outcomes still to be determined.

Public, Private, and University Cooperative Research Agreement

RD&T published the BAA for this research in FY 2021. In FY 2022, RD&T will continue to build partnerships to support universities. Projects focus on advanced technology, automation, and connected vehicle technologies; advancing technologies for rural application; and WFD. Expected deliverables include final research reports, project management documents, and progress reports. T2 of 2020 and 2021 efforts (based on project schedule and duration of each effort) is also expected.

R&D Facilities and Equipment –TTC[6]

RD&T will continue development and application of new technology at TTC for FRA, other Federal agencies, and others involved in transportation. TTC is instrumental in research, testing, and evaluation of track- and vehicle-based safety standards and performance guidelines that enhance the safety and security of rail systems. These activities will complement the capabilities of conducting rail transportation technology development, testing, standards development, and training at TTC.

RD&T will enhance the capabilities of facilities and equipment by: supporting and conducting high-speed testing; commissioning new rail equipment such as transit, passenger, light and freight rail and locomotives; refurbishing the railroad system and components around TTC; and upgrading buildings by applying High Performance Sustainable Building guidelines.

Research with Universities on Intelligent Railroad Systems

Research with universities on IRS focuses on advanced technology, automation, and connected vehicle technologies; contracts are starting to be awarded. Research will address intelligent transportation systems as well as technologies for rural application to enhance mobility and promote innovation. T2 of 2019, 2020, and 2021 efforts (based on project duration) is also expected. The BAA was produced in collaboration with ITS-JPO.

Collaboration Partners

RSI utilizes stakeholder input to establish research needs and priorities. PMs are members of industry organizations and regularly engage stakeholders at meetings throughout the year to remain current on industry issues and needs. RSI research collaboration partners include railroads, labor, manufacturers and suppliers, universities, non-profits, private industry, city/State/Federal DOTs, and DOT Operating Agencies.

Partner Detail

Partner Name	Contributions	Benefits of Partnership
Transportation Research Board	TRB collaborates with DOT modes to improve innovation and technology within the transportation industry.	RD&T receives a biennial review of its research, stakeholder engagement, strategic planning, priority setting, and evaluation work—and recommendations on how it can improve. Contract includes registration, for all FRA members, to attend TRB annual conference and receive TRB publications; and an FRA booth at the TRB conference.

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[6] Activities and outcomes are similar to previous fiscal years because equipment and facilities assessment take place each fiscal year.

Partner Name	Contributions	Benefits of Partnership
U.S. Universities	In-kind contributions; subject matter expertise and research	Provide locomotive engine, duty cycle data; support testing activities; subject matter expertise; and WFD.
EPA	Guidance on current regulatory environment; subject matter expertise	Input and feedback on the boundaries of the tool as it relates to the new noise emissions limits.
Class I Railroads	In-kind contribution; subject matter expertise	Provide locomotive engine, duty cycle data; support testing activities.
Railroads	Access to rail facilities	Subject matter expertise
Private Industry	Product commercialization	Subject matter expertise
AAR	Funding, in-kind contribution; subject matter expertise	Subject matter expertise; insight into safety trends and problems and research needs
DOE	In-kind contribution; subject matter expertise	Funding; subject matter expertise
U.S. Access Board	Subject matter expertise	Provide guidance on accessibility research.

Benefits Detail

Beneficiary	Benefits Received
RRS	Improved safety standards/recommendations Improved science to improve standards and requirements in support of EPA.
Rail industry	Improved safety standards/recommendations Lower operating costs Improved visibility for railroad workers and grade crossings Reduced railroad accidents and fatalities Reduced regulations
Public	Reduced railroad accidents and fatalities High-speed rail transportation, safer rail travel, reduced noise emission The manual will encompass both the open and tunnel environments for high-speed trains and increase the safety of passengers, train crews, track workers, and the public.
Small businesses and university research centers	Improved railroad research resources and capabilities
Rail equipment suppliers and manufacturers	Standardized matrix to determine cost of noise emission mitigation technology for high-speed rail.
Railroads	Standardized matrix to determine most efficient technology for improved energy and efficiency of locomotive engines.
EPA	Improved guidelines for noise emissions limits

Track

$10,179,000

Program Description

The Track Research program helps to ensure the U.S. railway infrastructure is safe and capable of meeting the nation's transportation needs—today and in the future. Its applied research, development, and demonstration projects provide crucial technical information and data for both regulators and industry. This information and data guides decisions about the safe operation of rail vehicles on U.S. track. It also guides investment and maintenance decisions so that track infrastructure can handle growing rail traffic effectively and be resilient to climate change. The program supports the goals and objectives of DOT and FRA; conducts safety-related research for new and in-service railroad system investments; develops and demonstrates new track condition assessment technologies; and coordinates research teams with representation from railroads, universities, technology leaders, and Government. The program includes two primary research areas:

- Track structures and components
- Systems performance and analysis

Statutory Requirements

Is this program statutorily mandated (Y): See page 4 for more details.

Program Objectives

The Track Research program conducts scientific and engineering research to reduce track-caused derailments and thus improve railroad safety. It especially aims to prevent high-consequence derailments that cause loss of human life and significant damage to communities and properties. Research results assist RRS in setting and enforcing appropriate minimum regulatory standards related to track safety. To further improve overall rail safety, the program collaborates with the railroad industry to develop and/or implement new technologies, data analyses, and maintenance practices.

Anticipated Program Activities

Program Area – Track and Structures

Track and Structures – Rail Performance

Broken rail-caused derailments and accidents cost the U.S. and its railroads about $50 million per year—more than any other track defect. FRA works with researchers and the railroads to improve rail performance and rail defect detection.

Anticipated Activities

RD&T will continue to collaborate with industry, researchers, non-destructive evaluation experts, TTCI, and FRA to reduce or eliminate rail performance and flaw detection issues. RD&T continues to collect defective rail donations from at least three Class I railroads and TTC, characterize these defects, and add them to the FRA rail defect database at TTC for use by the entire research community to develop better rail flaw detection systems. RD&T will wrap up an ultrasonic rail inspection project, a system designed to find rail defects in ways humans cannot. RD&T will evaluate and validate several new 3D rail flaw imaging technologies, as the current rail flaw

verification techniques are inaccurate. RD&T will continue to develop technology for non-contact, autonomous, internal rail flaw inspection. RD&T will develop an understanding and data on defect growth inside of rail welds—a frequent point of failure. RD&T will also advance phased array imaging technology to better detect flaws in rails with surface conditions and severe wear.

Track and Structures – Track Inspection Technology and Processes

The objective of the Track Inspection and Technology Processes program area is to improve the safe performance of the U.S. rail system through the application of advanced and emerging technologies to both track inspection tools and techniques. This objective will be achieved through applied research on inspection instruments and systems and through the development of new inspection paradigms that enable more efficient and effective condition assessment. These activities are intended to improve the state of awareness for railroad and government safety professionals and will promote improvements in track maintenance planning, reduce risks to all rail industry stakeholders, and decrease derailments and their severity.

Anticipated Activities

RD&T continues the research and develop automated track change detection technology, using industry advancements in machine learning, deep neural networks, and AI. When fully developed, these technologies will provide track inspection personnel with a more complete picture of the track elements that affect safety. This technology will augment human inspection operations and create the basis for progressive regulatory change. RD&T will continue developing innovative approaches to sensor design and wireless communication technologies to enable the self-enunciation of track conditions that warrant remedial maintenance or pose a threat to safe rail operations. Other research will focus on developing self-enunciating technologies for critical track performance issues, including ballast condition, rail wear in special track work, and train dynamics on and around grade crossings and other areas with varying vertical stiffness. RD&T will continue to research the root causes of broken spikes and will begin testing strategies to mitigate these failures. Additional efforts will be directed towards advancing automation in track inspection.

Track and Structures – Special Activities

This research area is focused on improving the safety and state-of-good-repair of bridges, structures, track design, and special track work. The scope of this research includes joint projects with industry, including AAR.

Anticipated Activities

The research in this area will use advanced and emerging technologies to improve inspection efficiency and effectiveness. Areas of concentration include developing technologies to capture and report bridge strikes and to determine the magnitude of such impacts. RD&T is also evaluating use cases for unmanned aerial vehicle (UAV) technology to improve railroad safety—in coordination with the Federal Aviation Administration (FAA) and BNSF Railway.

Track and Structures – Track Stability

Buckled track derailments are rare, but when they happen, they cause significant, expensive damage. This research area focuses on understanding and preventing track buckles through applied research, awareness tools, and the development of rail force measurement technologies. In a similar manner, track support and substructure derailments are rare yet particularly damaging, with costly and time-consuming repairs that can lead to lengthy transportation delays. As climate change has led to more extreme weather events, track support-caused derailments have increased and must be addressed to help mitigate supply chain bottlenecks associated with climate change.

Anticipated Activities

To prevent buckled track derailments, RD&T will continue to develop technologies that measure rail stress without a reference. Also, RD&T will initiate projects to create a proxy measurement for buckling risk on track, since direct measurement of this risk is impossible. In addition, RD&T will expand and improve available video trainings and software to help the railroad industry better manage rail forces and prevent track buckles. In partnership with AAR and the University of Illinois, RD&T will fund several tests to better qualify the longitudinal restraint of different track configurations. This knowledge will aid railroads in making better rail adjustments and thus prevent track buckles. Finally, in partnership with AAR, RD&T will invest in the design of a rail force test bed at the TTC for researchers and railroads across the country to develop methodologies and technologies to prevent track buckles.

RD&T will continue research in the areas of lateral stability and track support and substructure. RD&T will further develop ballast models that predict conditions and behaviors that can adversely affect track stability and advance technologies that identify, categorize, and assess risks associated with track failure and/or derailment.

R&D Facilities and Equipment – On-Track Research and Testing (FRA Research Assets)

This research aims to prevent high-consequence derailments caused by track and structures fatigue and failure.

Anticipated Activities

RD&T will continue revenue service testing focused on the effects of various (and often inter-related) factors on the integrity of track systems. RD&T will investigate root causes of potential issues that may arise in FY 2022 affecting heavy axle load (HAL) operations. RD&T will install and evaluate innovative ideas and technologies, both at the TTC and in revenue service, intended to mitigate the adverse effects HAL operating conditions pose to track system integrity. Among the experiments to be installed for long-term study is an instrumented test bed to research fastening system performance, especially those featuring spikes, as well as longitudinal rail forces in revenue service.

Program Area – Systems Performance and Analysis

System Performance and Analysis – Predictive Analytics

This research focuses on the utilization of "Big Data" sources as well as the automation of track-related data processing and analyses using AI to improve track safety and decrease derailments.

Anticipated Activities

RD&T will complete research creating methodologies for the evaluation of track inspection technology effectiveness, and initiate processes to incorporate them as a recommended practice. In FY 2022, RD&T will continue to focus on the application of AI into track-related safety inspection techniques, including advancement of AI-based track integrity risk assessment models for both freight and passenger rail lines. RD&T will evaluate the utilization of automated procedures for the alignment, processing, and reporting of autonomous track geometry measurement systems (ATGMS) data in an actual operational environment to predict areas approaching maintenance and safety limits. Additional work will be initiated to evaluate more advanced forecasting models to improve predictability within the context of this application.

System Performance and Analysis – Vehicle Track Performance

The goal of this research is to better understand how track and trains interact and how infrastructure reacts with vehicles, given the industry trend toward higher loads and faster service,

and to provide tools and guidelines for vehicle/track qualification and wheel/rail contact condition evaluation.

Anticipated Activities

RD&T will continue construction of the TTC curved test track and will use both the curve and tangent test track to test the accuracy of track geometry measurement systems. This activity will continue to support the development of procedures for both model building and model validation. RD&T will support the development of procedures to include advanced friction models that examine the effects of falling friction, speed, a third-body layer on wheel-rail contact forces, and modeling friction wedges. RD&T continues to examine the effects of wheel/rail contact conditions on the development of rolling contact fatigue (RCF). RD&T will initiate projects examining rail shape and wheelset alignment in revenue service tracks, and projects utilizing rail surface inspection systems for identifying and quantifying RCF. RD&T plans to test and model vehicle suspension components, and will continue to support building vehicle and track models for various equipment and operating practices to be used for derailment investigations or improving safety. Additionally, RD&T will continue to support RRS in the evaluation and qualification of high-speed vehicles.

Public, Private, and University Cooperative Research Agreement

See Railroad Systems Issues for more details on this research.

Expected Program Outcomes

Track and Structures – Rail Performance

Rail integrity derailments and accidents cost the U.S. and its railroads more than any other track defect. RD&T research will lead to improved automated detection for internal rail flaws. As part of this research, RD&T will identify and optimize the best technologies to generate 3D maps of internal rail flaws. Research will yield improved capabilities of non-contact rail integrity inspection systems; expand the rail flaw library at TTC; and improve the understanding and inspection of flaws inside of rail welds, a frequent point of failure. RD&T will increase its understanding of defect growth rates in modern rail steels and recommend optimal inspection intervals. Research will lead to improved technologies to detect flaws in rails with severe wear and adverse surface conditions.

Track and Structures – Track Inspection

This research addresses inspection technology and processes to improve track safety and decrease derailments. Automated Track Change Detection (ATCD) technology will be advanced through continued development and demonstration, with participation from rail operators. RD&T will begin field testing and demonstrating systems that will self-enunciate track safety issues, using the latest developments in sensor and communications technologies. In 2022, RD&T will continue developing and field testing an automated system for the detecting failed spikes in wood-tie track to support the broken spike research effort. Additional testing of mitigation strategies to solve the broken spike problem are planned with Class I rail partners through a cooperative program involving TTCI and AAR.

Track and Structures – Special Activities

An early prototype of bridge impact and characterization technology will be field demonstrated. In 2022, RD&T will initiate project(s) to assist the industry in the adoption of unmanned aircraft systems (UAS/UAV), concentrating on technologies that can assist in achieving Beyond Visual Line of Sight (BVLOS) operations over railroad track, and the adaption of terrestrial inspection technologies to drone-based operation.

Track and Structures – Track Stability

RD&T will continue to develop and test reference-free longitudinal rail stress measurement technologies to non-destructively assess the potential for a track to buckle. RD&T will develop new technologies to assess the buckling risk of track from moving platforms. RD&T will expand and advance rail adjustment software and trainings to reduce errors in rail adjustments that can lead to track buckles or rail breaks. RD&T research will better define longitudinal restraint parameters in different track conditions, thus enabling railroads to make more accurate rail adjustments to prevent track buckles. RD&T will work collaboratively with industry and AAR to design a rail stress test bed at TTC. This will allow for the evaluation of new technologies and build upon research and practices to reduce stress in rails that leads to buckled track derailments.

In addition, the resistance of track to applied lateral track buckling loads will also be assessed relative to the influence of moisture, content, fouling, and degree of ballast consolidation/compaction. Further outcomes include improved inspection systems with refined criteria for detecting problematic ballast fouling zones at risk for advanced deterioration of track structural performance, such as buckling or excessive vertical deformation as well as excessive track geometry deterioration. RD&T will also work toward implementing improved quality assurance criteria and measurements for ballast consolidation after maintenance. As more extreme weather events affect track integrity, the moisture content of the track substructure will be a key indicator of track performance. Techniques to assess the track support stiffness will provide a direct indication of the effects of moisture and fouling on the track support. This information is expected to become more important to routine inspections and to settled or soft roadbed accident investigations.

This research area will gather and provide data on the condition of existing rail infrastructure. RD&T will continue research on ground-penetrating radar (GPR) to provide quantitative and qualitative data and analysis for ballast instability—in support of multiple RRS projects. Research in this area provides improved understanding of both saturated and unsaturated characteristics of fouled ballast, including the role of different fouling materials, changing water content, and shear strength through improved understanding of the GPR response of fouled ballast during field measurements.

Research in automated, machine vision-based ballast scanning systems will develop and demonstrate a machine vision-based ballast inspection system mounted on a moving platform capable of performing continuous track inspection, including ballast condition detection and quantifying changes in fouling level.

System Performance and Analysis – Predictive Analytics

In partnership with an operating railroad, in FY 2022 RD&T will complete a revenue service demonstration of an automated decision-making tool that will align, segment, process, analyze, and report on ATGMS data to predict areas approaching maintenance and safety limits. The development and demonstration of a new, versatile approach for the design and execution of performance evaluation testing for track inspection technologies will be completed to provide the basis for future recommended practices in the industry. Research efforts will continue to focus on the application of AI into track-related safety inspection techniques. Forthcoming SBIR and BAA acquisitions will bring in new analytics partners and vendors.

R&D Facilities and Equipment – FRA Research Assets – On-Track Research and Testing

RD&T plans to initiate a long-term study investigating the effects of varying track and operational parameters on fastening system performance, including those featuring variations of spikes for hold-downs as well as rail neutral temperature loss and remediation in a revenue service

environment. This will involve an effective collaboration of research entities, including TTCI, the University of Illinois, and Penn State, Altoona. In addition to this proposed work, a new revenue service Mega Site location will be established in partnership with BNSF.

System Performance and Analysis – Vehicle Track Performance

This research area focuses on aspects of vehicle/track interaction safety. RD&T will continue to collaborate with the railroads to establish root causes of RCF and wheel/rail surface damage and a method to effectively evaluate the depth of RCF to aid in its removal. In FY 2022, FRA will continue track geometry characterization for different operations in the U.S. rail network. The research in this area will establish thresholds for individual and combined geometry irregularities based on vehicle performance. Research will also establish procedures and guidelines for creating and evaluating friction modifiers, friction wedges, and other suspension elements for modeling vehicles for evaluating vehicle performance. RD&T will conduct testing, simulations, and evaluate railroad test results for RRS in vehicle qualification. RD&T will assist RRS in testing and qualification of FRA track geometry measurement systems and will provide guidelines for testing the systems' accuracy. Also, RD&T will finish construction of the TTC curved test track and start demonstration testing. Partners in this work include AAR, APTA, TTCI, RRS, Amtrak, and other passenger operators.

Collaboration Partners

Partner Detail

Partner Name	Contributions	Benefits of Partnership
ASLRRA	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	More realistic testing than in a laboratory
Canadian National Railroad	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	More realistic testing than an average laboratory set-up
Genesee and Wyoming Railroad	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	Critical samples for research and expert advice
Western NY and Pennsylvania Railroad	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	Professional laboratory results without having to pay for new laboratory equipment.
Indiana and Southern Railroad	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	Real-world testing
Toledo, Peoria, & Western Railway	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	Real-world testing
Illinois and Midland Railroad	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	Realistic rail defects for validating new detection technologies.
Indiana and Ohio Railway	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	More realistic testing than in a laboratory
BNSF	Track materials for test bed	More realistic testing than an average laboratory set-up
Edison Welding Institute	Test facilities and data collection	Professional laboratory results without having to pay for new laboratory equipment.

Partner Name	Contributions	Benefits of Partnership
Massachusetts Bay Transportation Authority (MBTA)	Real-world, on-track testing grounds and equipment	Real-world testing
3 Class I Railroads	Donations of rail defects	Real-world testing
AAR	Relevant data, on-track support, intellectual resources, and, in some cases, supporting funds	Materials, expertise, and funding
Rutgers University	In-kind support	Subject matter expertise
Amtrak	Data, track time, intellectual resources, and, in some cases, supporting funds	Materials, expertise, and funding
New Jersey Transit Authority	Data, track time, intellectual resources, and in some cases, supporting funds	Materials, expertise, and funding
Metro-North Railroad (MNR)	Data, track time, intellectual resources, and in some cases. supporting funds	Materials, expertise, and funding
APTA	Data, track time, intellectual resources, and in some cases, supporting funds	Materials, expertise, and funding
TTCI/AAR	Transportation research, development, security, training, test activities	Testing and training expertise, support, and TTC operation and maintenance
Sperry Rail, Inc.	Data and in-kind support (e.g., intellectual resources)	Critical data for research and expert advice
CSX	Data and in-kind support (e.g., intellectual resources)	Real-world data and testing
Union Pacific Railroad (UP)	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	More realistic testing than an average laboratory set-up
Norfolk Southern Railway (NS)	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis Test location and track time	More realistic testing than an average laboratory set-up

Benefits Detail

Beneficiary	Benefits Received
Public	Increased safety and more efficient train operations
Rural and urban communities	Improved safety, infrastructure, and reduced environmental impact
Rail industry	Improved safety and operational efficiencies
Other transportation modes	Increased exposure of adaptive technologies to improve safety and operations.

Rolling Stock
$10,322,000

Program Description

The Rolling Stock research and development program conducts research to reduce railroad accidents and incidents due to rolling stock-related causes as well as research to reduce fatalities and injury severity to passengers and crewmembers involved in passenger train accidents and incidents. The program leads research, development, and evaluation of advanced rolling stock inspection techniques, materials, and components. Hazardous material (HazMat) research focuses on improving transportation processes (including those for liquefied natural gas [LNG], crude oil, ethanol, and toxic inhalation hazards and related equipment), the safe use of alternative fuels, and new engine and energy savings technologies that focus on preserving the environment. Results of this research directly support the development, implementation, and refinement of safety operations, reduce risks, and enhance the industry and government safety-related standards and performance-based regulations.

Statutory Requirements

Is this program statutorily mandated (Y): See page 4 for more details.

Program Objectives

The focus of the Rolling Stock research program is to improve railroad safety by providing the scientific and engineering basis for improved industry standards, safety rulemaking, enforcement, and the safe transport of goods and passengers. The program will investigate efficacy of alternative fuels and advanced motive power technologies to improve energy efficiency and reduce emissions of rail transportation. Research efforts involve collaboration with both internal and external industry stakeholders to develop and implement advanced technologies and practices to improve overall system safety.

Anticipated Program Activities

Program Area – Hazardous Materials

The Hazardous Materials Research program fosters innovation throughout the industry, helping to update and develop new regulations and design standards that improve the safety and integrity of tank cars and other HazMat packages.

HazMat – Tank Car Research

The Tank Car Research Area develops and improves the packages that carry hazardous materials, reduces the release of material, and minimizes the consequences during rail accidents and incidents.

Anticipated Activities

RD&T will continue research on developing and improving the packages that carry HazMat by rail. Research will reduce the non-accident HazMat releases and minimize the consequences during rail accidents and incidents.

RD&T will continue to conduct research on nondestructive evaluation (NDE) probability of detection (POD) with the tank car industry and stakeholders and identify the capabilities/limitations of new and advanced NDE methods for tank car inspections. RD&T will continue to conduct research on

the effects of corrosion on railroad tank car structures, and the potential use of state-of-the-art NDE. RD&T will continue to gather information on newer types of tank cars and their common failure modes and fabricate new weld test panels and specimens for future POD studies.

Continued research includes several side impact tests on DOT 113 tank cars: developing and improving test methods; providing data for improving modeling methods and designs; and providing test results to DOT to modify or develop new safety regulations. In addition, RD&T will analyze and provide data for validating finite element analysis models and report on test and model results.

RD&T will conduct two over-the-road testing trips on revenue trains to continue its analysis of impact test data. The goal is to arrive at limiting conditions for coupling speed and impacting mass.

HazMat – Tank Car Structural Integrity

The Tank Car Structural Integrity Research Area helps to determine the performance and durability of safety equipment and protective systems for tank cars and portable tanks. This research area focuses on the current fleet, identifying problems with current equipment and packages during routine inspections and accident investigations.

Anticipated Activities

RD&T will continue research efforts to evaluate the puncture resistance of various tank car designs in standardized side impact scenarios, conduct accident and incident investigations, and procure damaged tank cars for further research and investigation. RD&T will continue to develop computational models of tank car designs under impact conditions and compare test data with model results to validate said models.

RD&T will continue research to develop design strategies for improving the structural crashworthiness of passenger railcars relative to existing designs. RD&T will continue research to develop specifications, inform regulations, and support various waiver requests and regulatory compliance evaluations.

HazMat – Accident Consequence Reduction

The Accident Consequence Reduction Research Area studies HazMat loading and unloading practices to improve operating procedures and the securement of packages for safe transportation and to reduce non-accident releases.

Anticipated Activities

RD&T will continue to evaluate the performance of top fittings protection used on current tank car designs by testing a DOT 117 under rollover conditions and through analytical simulations. RD&T will continue to document (by scale testing under nominal fire conditions) pressure relief value performance with respect to opening pressure, reclosing, and evacuating the tank. Initial tests were performed with water as lading; subsequent tests were conducted with ethanol. Results will be used to validate detailed analytical models developed by FRA and Transport Canada.

HazMat – Risk Analysis

The HazMat Risk Analysis Research Area focuses on the design and fabrication of an LNG tender in accordance with the AAR standard in preparation for testing a highway-rail crossing accident. This research will evaluate the survivability of the cabinet that protects the valves.

Anticipated Activities

RD&T will continue to conduct phased research involving full-scale fire tests on a United Nations standard T75 (UN-T75) portable tank to obtain experimental data, based on the results obtained in Phases I and II. Phase I provided a realistic fire exposure of the UN-T75 tank on a flatcar by

conducting a computer simulation of the experiment data and using nitrogen as a commodity and a diesel fire. The fire test in Phase II will be conducted in late in CY 2021 with LNG in the test tank instead of liquid nitrogen. This will generate improvements to internal instrumentation, including several floating temperature measurements, which will be used for future computer model validation.

Energy Products Research

The Energy Products Research Area conducts research and mitigate risks associated with the transportation and use of crude oil, ethanol, LNG, and other hazardous materials; it also includes tank car research.

Anticipated Activities[7]

Research in this area helps assess the operational safety risks associated with hazardous material unit trains. The main issue is determining if unit trains carrying hazardous materials present any unique or additional risks compared with unit train operations of non-hazardous materials, and if the same risks apply in HazMat transported in mixed-freight operations. RD&T will continue to develop a risk model for quantifying risks associated with the operation of hazardous material unit trains and on risk mitigation. RD&T will continue research of Fire Performance of Alternative Fuel Tenders with Phase II of the risk analysis methodology. RD&T will continue with Phase II of Risk Analysis and Mitigation and continue with Phase II of Rapid Brake Signal Propagation on Freight Trains.

RD&T will continue to provide data to help evaluate the survivability of the valve functions that cut off supply and shut off any LNG or gas flow under certain grade crossing accident conditions. This effort will be performed according to the proposed draft AAR standard: AAR Natural Gas Fuel Tender Specifications, M-1004.

Natural Gas Safety Research[8]

The Natural Gas Safety Research Area supports the safe operation and use of such fuels through research on the safety of fuel tenders and transportation containers.

Anticipated Activities

RD&T will continue research on the safety of alternative fuels, such as hydrogen fuel and fuel cell technologies, and make recommendations to the rail industry for the safe use of cleaner fuels. Working with DOE and the national laboratories, RD&T will assess the crashworthiness of alternative fuels storage cylinders and conduct fault tree analyses of hydrogen fueled locomotives. Alternative fuels research provides RRS with the scientific basis for decision-making and the development of standards and requirements.

Rolling Stock Equipment and Components

Research in the Rolling Stock Equipment and Components (RSEC) program area focuses on the development, improvement, evaluation, and safe operation of equipment and components. Topics include defect detection, health monitoring, and the control of equipment and components. Wayside detection, onboard detection and control systems offer diverse platforms for such research and demonstration.

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[7] Funding is provided annually by Congress for Energy Products Research. This is included in the total budget for FRA RD&T.

[8] Funding comes from Congress and is not included in the FY 2022 appropriations. Funding will be spent on LNG if RD&T has carryover from the prior appropriation.

RSEC – Rolling Stock Component Safety

The Rolling Stock Component Safety Research Area proactively reduces risks through the prevention of above-track equipment and component failures (e.g., situational hazard prevention), and provides the analytical and technical basis to develop equipment safety standards while also improving safety, reliability, and respectability of rail equipment, technologies, and material.

Anticipated Activities

RD&T will continue to research train makeup, train operations, and train handling developments to develop air brake performance data, address air brake signal propagation time on very long trains' (VLTs') impact on application and release, study air brake system leakage on VLTs, and investigate brake pipe pressure on cars near the tail end of trains. Research efforts will enhance strategies to reduce adverse effects of extended train length on operational safety and train dispatch inspections. RD&T will continue to research high buff and draft forces under undulating territories, train handling of 200-car trains or longer, and individual car dynamic behavior and safety during curve negotiation.

Research efforts will help identify malfunctioning brake systems by detecting excessively hot or cold wheels and assess the implementation of wheel temperature detector (WTD) technology and its effectiveness in improving train safety and in detecting air brake system defects on moving trains.

RD&T will continue efforts to reduce wheel failures, including research on the causes of vertical split rims and shattered rims. In collaboration with the Wheel Stakeholder Working Group, RD&T will continue research on evaluating current failure modes and characteristics as well as future steps to minimize contributions to failures.

New research will investigate the properties of grease degradation related to bearing performance across all bearing and grease types over the life cycle of in-service bearings.

RD&T will continue to research, design, prototype, and test an electrical power supply system (EPSS) direct current (DC) access/battery charger that provides a standard 24-volt DC interface to safety and security devices where desired. RD&T will continue to develop and integrate a modern, powered, communications and control ecosystem for freight vehicles. RD&T will determine communication and control platforms that might be applicable for railroad use, and will continue efforts to optimize the controller/motor interface design.

RSEC – Rolling Stock Maintenance and Inspection

The Rolling Stock Maintenance and Inspection Research Area evaluates and demonstrates the effectiveness and efficiency of automated inspection technology and maintenance procedures. This research will demonstrate the ability to develop, monitor, control, and evaluate integrated, advanced components to detect defects in real time, predict and prevent future failures, improve rolling stock capabilities and performance, and improve overall rail operational safety. Research efforts will produce a better understanding of wayside system installation, calibration, threshold detection, and data communication—with a focus on threshold levels and initial installation activities. In addition, RSEC will assess the implementation and effectiveness of WTD technology in improving the safety of train operations by enhancing the detection of air brake system defects on moving trains.

Anticipated Activities

RD&T will continue to partner with MNR, the Long Island Rail Road (LIRR), and the New York Atlantic Railway (NYA) to assist and capture best practices with pilot demonstrations of wayside technology systems to detect defects and precursors to safety-critical defects in railroad rolling

stock. Along with continued data analysis and benchmarking, research efforts will identify best practices to update the Implementation Guide for Wayside Detector Systems.

RD&T will continue to investigate the current state of train line systems, assist organizations with developing a digital train line (DTL), and explore wireless extension to DTL. RD&T will continue to work closely with the Next Generation Equipment Committee, AAR, the American Association of State Highway and Transportation Officials, and Amtrak, among others.

RSEC – Train Handling and Operations

The Train Handling and Operations Research Area develop simulation scenarios to evaluate different network- and capacity-related parameters on advanced technologies such as electronically controlled pneumatic (ECP) brakes and PTC. Both technologies will be compared to conventional signaling and braking applications. Simulation scenarios include network topology, traffic type, ECP scenarios, and PTC (with and without ECP) scenarios. RD&T shall also develop the necessary technology to analyze the topology of railroad networks to quantify, assess, and improve their resilience, safety, productivity, and cost effectiveness.

Anticipated Activities

RD&T will continue to conduct research on a roadmap for next generation brake technology and develop a "mini-network" with representative characteristics of the North American rail system, including various types of traffic, tracks, signaling systems, and train configurations. The research direction will further develop next generation brake technology ruggedized for the railroad environment for improved safety, in alignment with established industry standards. RD&T will continue to conduct a comprehensive analysis of the simulated results in terms of network capacity parameters such as train delay, dwell time, train conflicts, train speed, network velocity, track occupancy level, number of meet-pass and stops, safety, and accident mitigation.

Program Area – Train Occupant Protection

The Train Occupant Protection (TOP) program conducts research on the structural crashworthiness and interior safety of locomotives and intercity and commuter railcars. The research focus is to improve the survivability of rail passengers and crewmembers in accidents.

TOP – Fire Safety Research

The Fire Safety Research program focuses on improving current Federal regulations and industry standards for the crashworthiness of passenger locomotive fuel tanks, and the fire performance of materials and components used in passenger rail equipment. Data collected from past research efforts on crashworthiness of passenger fuels tanks and fire performance of materials have been disseminated to industry groups and are being considered to update existing rail industry standards. Working with the passenger rail industry, FRA will support the evaluation of international fire safety and toxicity standards for passenger railcars for synergy and efficiency.

Anticipated Activities

The validation of computer models with data from RD&T diesel multiple unit (DMU) fuel tank impact tests will generate greater knowledge on the performance of such equipment under various loads. Computer modeling will be used to design new dynamic impact test setups. Research efforts include evaluating and developing alternative fire performance criteria for passenger railcars and developing models and scaling laws to reduce test article size for quantifying fully developed rail car fire heat release rates. FRA continues to evaluate industry methods to quantify smoke toxicity from burning materials and components and the development of recommendations for toxicity criteria. Research will be guided by input from fire safety experts.

TOP – Emergency Preparedness Research

The Emergency Preparedness Research Area investigates and develops innovative safety technologies that improve emergency preparedness and egress features in passenger rail equipment. This research supports initiatives that ensure passenger rail equipment and onboard crewmembers' training is modern, progressive, and effective. It also supports providing vital safety information in a central location for all interested parties.

Anticipated Activities

RD&T will continue comparing commercially available egress modeling software and evaluate their efficacy in determining the evacuation rate of passengers from railcars under smoke, fire, and toxic conditions. The integration of egress evaluation software and fire dynamics software will be pursued for evaluation for various egress scenarios.

FRA will investigate new and innovative technologies that can promote safe and rapid egress from passenger rail cars during emergencies. RD&T will continue to develop an underlying methodology for analyzing the topology of railroad networks, mainly to study and improve the ability of the railroad networks to offer robustness, resiliency, efficiency, and effectiveness.

TOP – Cab Displays, Controls, and Environment

The Cab Displays, Controls, and Environment Research Area will improve cab/locomotive visibility at night, provide extra alerting for track workers and attempting trespassers, provide extra visibility/alerting when approaching grade crossings, unify an optimized cab display across all railroad providers, increase freight and passenger rail safety, and reduce operating and maintenance costs for locomotives.

Anticipated Activities

RD&T will continue testing and validating the candidate light-emitting diode (LED) headlights for railroad application.

TOP – Passenger Locomotive Crashworthiness and Occupant Protection

The Passenger Locomotive Crashworthiness and Occupant Protection Research Area utilizes testing, collision analyses, and simulation techniques to develop strategies and designs for rail rolling stock to reduce injuries and fatalities resulting from rail accidents (i.e., collisions and derailments).

Anticipated Activities

This work will include the conduct of full-scale testing (which was delayed in FY 2021 due to travel restrictions imposed by the COVID-19 pandemic) to develop data to corroborate the current FRA regulations on the crash pulse used to evaluate the attachment strength of railcar components—including seats, trucks, and other components. This testing will also provide the opportunity to assess the deceleration environment in which passenger car occupants in WhMDs are exposed and the efficacy of various means to secure these devices in passenger trains. Results of dynamic testing of passenger seats and workstation tables completed in FY 2021 will be reviewed and presented to the APTA Construction and Structural Working group to inform potential revisions to the relevant APTA standards.

RD&T will also use novel collision analyses and simulation techniques along with collision evaluation criteria to objectively assess the adequacy or potential shortcoming of the modern locomotive's existing crashworthiness requirements. Advanced simulation with high-fidelity computer models and crashworthiness evaluation technology will be used to enhance freight rail

operational efficiency and safety through ensuring improved crashworthiness in the event of freight rail collisions.

TOP – Glazing Standards

The research in this area will comprehensively describe all the engineering requirements placed on glazing systems, survey existing glazing systems design strategies used throughout the world, and assess the effectiveness of these designs in meeting all the engineering requirements.

Anticipated Activities

RD&T developed realistic test protocols and evaluation metrics for glazing retention capacity. Testing was performed in FY2021 and the results will inform potential Federal regulations or APTA standards related to glazing integrity. RD&T will aggregate industry recommendations for passenger car design alternatives to improved protection of glazing and improved passenger containment in derailments which are achievable and practical. In addition, RD&T will share results from secondary impact protection for locomotive engineers with industry for consideration in the design of new or retrofitted locomotive cabs.

Public, Private, and University Cooperative Research Agreement

See Railroad Systems Issues for more details on this research.

Expected Program Outcomes

HazMat – Tank Car Research

RD&T will provide stakeholders information on the survivability of the UN-T75 portable tank under fire conditions in a train derailment accident scenario and determine tank car behavior and failure modes under normal transportation, thereby providing a foundation for modifying, eliminating, or creating standards. RD&T will disseminate information to the rail and tank car industries to be used for tank car designs. RD&T will provide a realistic fire exposure to the test assembly (tank on flatcar) and make several key measurements, including interior and external temperatures, tank pressure, blast pressure (if applicable), and heat flux.

HazMat – Structural Integrity

RD&T will identify possible studies to address defects that affect the structural integrity of safety equipment and packages. RD&T will provide information on the performance and durability of safety equipment for tank cars and portable tanks to assure that DOT has the required information to justify, modify, eliminate, or create safety standards.

HazMat – Accident Consequence Reduction

RD&T will increase understanding of how failures occur and how to best prevent or manage the consequences of such failures through improved equipment design and protection, evaluate and document damage to railroad tank cars, and study and capture the results of the liquid/vapor release flow on pressure relief. RD&T will also increase understanding of the structural performance of LNG tenders and tank cars that transport LNG.

HazMat – Risk Analysis

RD&T will enhance understanding of the structural performance of LNG tenders and tank cars.

Energy Products Research

RD&T will develop an online HazMat release probabilistic risk assessment platform for real-time, local track risk analysis. Research results will promote development of an alternate mechanism for

rapid brake signal propagation—to be used on unit trains transporting energy products (high-hazard flammable trains).

Natural Gas Safety Research

RD&T will perform grade-crossing impact testing of an LNG fuel tender and develop guidance documents to RRS on natural gas fuel usage by U.S. railroads. Small scale impact tests of safety components used in alternative fuel tender cars, fuel storage cylinders, etc. will be conducted to develop an understanding of the performance of these technologies under loads expected in the rail environment.

RSEC – Rolling Stock Equipment and Components

RD&T will continue research, development, and T2 of components and systems that reduce the risk of rail incidents and accidents. RD&T will improve and demonstrate operational safety through better understanding of brake system performance on VLTs. Through simulation testing, RD&T expects to gain increased confidence in the evaluation of multiple operating conditions.

RD&T will increase understanding of equipment failure mechanisms of wayside and onboard technologies and facilitate mitigation to reduce public safety risks.

RSEC – Rolling Stock Maintenance and Inspection

RD&T will develop a system to power advanced detection devices (technologies to detect defects on rolling stock equipment and preventable failures) and an explanation of wheel fatigue to help mitigate wheel failure. RD&T will establish a standard process for wayside technology pilot demonstrations. RD&T will quantify the effects of tread braking on wheel damage mechanisms and fatigue life, develop and conduct vehicle dynamics simulations, and demonstrate results that could be used by industry and universities to make improvements to railroad safety through systematic research.

RSEC – Train Handling and Operating Practices

Research efforts will reduce incidents and accidents through proactive maintenance, improve safety of train operations, reliability, and makeup, reduce incidents/derailments, improve operational safety, and reduce risk exposure to public.

RD&T will improve passenger truck designs that can provide superior equalization and curving performance to better handle rough track geometry.

The Train Energy and Dynamics Simulator (TEDS) will facilitate identification and quantification of safety risks in train operations affected by equipment, train make-up, train handling, operating practices, malfunctioning equipment, and track conditions.

Train Operating Practices

TOP – Fire Safety Research

RD&T anticipates that in FY 2022 the data from its fire safety-related RD&T activities will be disseminated to appropriate industry standards groups. RD&T expects ongoing collaboration with the rail industry and fire science experts on the update of fire safety standards. Recommendations on the toxicity of burning materials and components used in passenger railcars will be discussed with the rail industry to promote the development of industry standards on toxicity.

RD&T will develop validated scaling laws for modeling and simulation of rail car fire growth predictions, a list of toxicity measurement methods, and final recommendations and reporting on performance of DMUs under dynamic loads.

TOP – Emergency Preparedness Research

RD&T will identify modern effective evacuation modeling tools for rail applications and develop a plan for integrating an evacuation simulation tool and fire dynamics models. The coupling of fire dynamics models with railEXODUS and PathFinder is expected, and egress scenarios will be simulated.

TOP – Cab Displays, Controls, and Environment

RD&T will validate the new LED headlights and assist in adopting new standards and regulations for LED lights on locomotives.

TOP – Passenger Locomotive Crashworthiness and Occupant Protection

RD&T will improve the Crash Energy Management (CEM) capabilities of existing (in-service) passenger equipment through cost-effective adaptations and retrofit technology and industry standards related to passenger car safety based on sound engineering derived from research outcomes. RD&T will evaluate the results from a planned vehicle-to-vehicle test with respect to override inhibition. This test was delayed from FY 2021 due to travel restrictions imposed by the COVID-19 pandemic. Assessments of the performance of retrofit crashworthiness features and concepts will be incorporated in the test program.

RD&T will conduct the planned train-to-train test to reaffirm that the crash pulse (deceleration profile) required by current regulations is based on sound engineering data. RD&T will develop Technical Reports on side strength alternatives and implications/impacts of potential changes to the existing FRA requirements on the effectiveness of retrofit collision posts on crashworthiness of legacy locomotives.

TOP – Glazing Standards

Research and testing results on the integrity of glazing (window) securement will be presented to the passenger railcar manufacturing industry (through APTA) for its consideration in the development of new passenger car glazing system designs. Companion research and testing to assess the torsional strength of typical coupler arrangements will be performed to assess whether requirements for torsional stiffness are adequate, and the degree to which coupler torsional stiffness may prevent car rollover in derailments.

Collaboration Partners

Partner Name	Contributions	Benefits of Partnership
Tank cars owners	In-kind contribution which include tank cars, valves, engineering consultation	Equipment, subject matter expertise
Tank car shops	In-kind contribution, including tank cars, valves, engineering consultation	Equipment, subject matter expertise
Sharma & Associates, Inc.	Data analysis, test support, actual testing, resources, and modeling; in-kind equipment contribution	Subject matter expertise
TTC	Data analysis, test support, actual testing, resources, and modeling; in-kind equipment contribution	Subject matter expertise
Class I freight railroads	Donor railcars for testing (including destructive testing)	Equipment, subject matter expertise
Passenger rail equipment manufacturers and component suppliers	Donor equipment or components (e.g., window glazing samples, prototype seats, passenger workstation tables)	Equipment for testing

Partner Name	Contributions	Benefits of Partnership
Passenger and commuter railroads	Donor railcars for testing (including destructive testing)	Equipment for testing
Passenger and freight industry associations	Donor railcars for testing (including destructive testing)	Equipment for testing
BNSF	Access to bearing/wheel shop facilities, operator time, allow sample collection; in-kind contributions of $6,000	Equipment/material
NS	Access to bearing/wheel shop facilities, operator time, allow sample collection, in-kind contributions of $6,000	Equipment/material
Progress Rail	Access to bearing/wheel shop facilities, operator time, allow sample collection in-kind contributions of $6,000	Equipment/material
UP	Access to bearing/wheel shop facilities, operator time, allow sample collection; in-kind contributions of $6,000	Equipment/material
Indiana North Eastern Railroad	In-kind contributions of $6,000: Provide labor and access to their cars and locomotives for test installation and feedback.	Equipment, subject matter expertise
Metropolitan Transportation Authority (MTA) (MNR and LIRR)	In-kind contribution: Access to data and operational information, allowing FRA access to data that is difficult to gather, which can be then be used to evaluate the safety efficacy of these wayside systems.	Data
Railway and industrial specialties	In-kind contribution: Access and data on wheel failure types and defect details, allowing for accurate modeling of defects.	Data
Penn Machine Company (potential)	In-kind contribution: Design data on wheels, and access to wheel replacement data to help validate wheel life model.	Data
Siemens and Alstom	In-kind support (personnel, facilities, equipment) may be provided to perform tests which may be necessary as part of new equipment qualification.	Facilities
LED manufacturers Railroads	In-kind contribution, including halogen and tungsten light samples, meeting participation, technology requirements; in-kind support	Material for testing
TTC, APTA, AAR, and TTCI	Passenger rail equipment manufacturers (e.g., Siemens, Alstom, Stadler Rail) have donated window glazing for the ballistics test program.	Equipment for testing
DOE	Co-funding of research related to alternative fuels and decarbonization of rail	SME, co-sponsoring of research

Benefits Detail

Beneficiary	Benefits Received
RRS	Improved safety recommendations and innovative solutions
Rail industry RRS Tank car owners Tank car manufacturers Leasers tank car shops	FRA will acquire: • In-depth knowledge of the performance of tank cars and the different service equipment of tank cars and portable tanks • In-depth knowledge of the crashworthiness of different types of tank cars and the failure modes to improve the performance of HazMat packages
Public	• Fewer railroad accidents and fatalities • Lower operating costs • Fewer railroad accidents and fatalities • Improved service life for rolling stock equipment • Improve railroad performance
Small businesses; university research centers	Improved railroad research resources and capabilities

The Rolling Stock Research program benefits from the expertise, experience, and contributions of its stakeholder partners. Non-governmental partners provide cash contributions, donations of equipment and components, data, oversight, and peer review of research initiatives.

Rolling Stock Research Partner Affiliations	
American Railway Association	University of Nebraska
APTA	Southwest Research Institute
PHMSA	AASHTO
Amtrak	Friedrich Research
Southeast Pennsylvania Transportation Authority	Transport Canada
TTCI	U.S. Access Board
Progress Rail	Next Generation Equipment Committee
General Electric Transportation Services	TRB
Trinity Rail	EPA
Chart Industries	DOE
Michigan Technological University	NTSB
Oregon State University	California Department of Transportation
Taylor-Wharton of America	Sandia National Laboratories
University of New Mexico	Volpe

Train Control and Communication
$8,086,000

Program Description

The Train Control and Communication (TC&C) Research program focuses on improving railroad operation safety through the development and testing of train control and communication systems and grade crossing safety technologies. The program conducts pilot studies, creates prototypes, and demonstrates safety and security systems—including intelligent rail systems, blocked crossings, and trespass prevention. It also provides scientific research and data to support FRA regulations. This research program actively collaborates with stakeholders to build on existing research to advance train control technologies and design the next generation train control safety systems. There are two primary research areas included in the program:

- Train control and communication
- Grade crossings and trespass

Statutory Requirements

Is this program statutorily mandated (Y): See page 4 for more details.

Program Objectives

TC&C research program objectives are to improve railroad operation safety, reduce train-to-train collisions and train collisions with objects on the line and at grade crossings, and prevent trespassing. This program adapts innovative and emerging technologies from other industries to support its mission and provides stakeholders the benefits of its research through T2. Program staff collaborate with stakeholders to research, develop, and test safety systems, grade crossing protection, trespassing countermeasures, and issue best practices to communities.

Anticipated Program Activities

Program Area – Train Control and Communication (PTC)

PTC Technology

This research addresses problems associated with finalizing PTC development, deployment, and continued long-term evolution and maintenance.

Anticipated Activities[9]

RD&T will test enhanced track circuit technologies to increase the safety and throughput and develop technologies to safely increase the capacity of freight and passenger trains through populated areas, and test improved PTC adaptive braking algorithms. Railroad stop data analysis and characterization research is planned.

PTC Interoperability

Interoperability is a requirement of the Rail Safety Improvement Act of 2008 (RSIA '08), as all railroads must be able to use the national network and transport goods and people on all lines.

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[9] A reminder for the Anticipated Activities sub-headings throughout this document, and especially in this section: Activities and outcomes *may be similar to previous fiscal years* because new projects are selected, executed, monitored, and completed each fiscal year.

Anticipated Activities

RD&T will continue development of the Interoperable Lifecycle Management network and will advance development of an interoperable track data auditing system.

PTC Next Generation

This research will identify and develop the methods, facilities, equipment, and capabilities required for providing future industry PTC development.

Anticipated Activities

RD&T will conduct applied automated train operation research and development, testing of an advanced head and end of train positioning system, standardization of new rail communication security techniques, and development of a locomotive-based hazard sensing platform prototype. Additionally, requirements will be developed for a road remote control locomotive system.

Note: Activities and outcomes are similar to previous fiscal years because projects that span multiple years are selected, executed, and monitored until completion.

Intelligent Transportation Systems

RD&T's research of ITS builds on *49 CFR Part 234 Grade Crossing Safety* and *Part 924 Highway Safety Improvement Program*. FRA facilitates collaboration between railroads and automotive industry stakeholders to develop coordinated solutions for automated transportation systems.

Anticipated Activities

RD&T will evaluate development of automation technologies to improve grade crossing safety, evaluation of the effectiveness of connected vehicle technologies in a field environment, and development of rail industry-driven standards for communicating grade crossing status to connected or automated vehicles. A public demonstration of connected vehicle technologies will be organized.

Program Area – Grade Crossing and Trespass

Trespass Countermeasures

The purpose of this research area is to investigate and evaluate new technologies and their applications to mitigate the risk of accidents on railroad track due to trespassing.

Anticipated Activities

RD&T will continue working on the effectiveness of mobile systems used for the detection of trespassing activities, new work on AI as it applies to railroad trespassing, and developing new research ideas based on the input of the several stakeholders involved in trespassing issues.

Grade Crossing Technology

This research area investigates, analyzes, and tests new technologies to improve public safety at grade crossings.

Anticipated Activities

RD&T will work with universities, industry, railroads, and the public sector in exploring new areas where technologies (such as PTC) and innovative devices can play a role in increasing safety at grade crossings. In addition, RD&T will develop and implement a grade crossing toolbox and a grade crossing data portal for use by relevant stakeholders.

Grade Crossing Pedestrian Safety

This research will evaluate the effectiveness of technologies and infrastructure improvements that can mitigate the risk of accidents at grade crossings where pedestrians are involved.

Anticipated Activities

RD&T will explore new methods, techniques, and enforcement and educational tools to improve pedestrian safety at rail grade crossings and reduce accidents.

Grade Crossing Modeling and Simulation

RD&T will continue implementing the new accident prediction and severity model for grade crossings that was developed in FY 2020, as well as developing models for studying behavior in general at grade crossings.

Anticipated Activities

RD&T will explore new modeling and simulation to reproduce real-world scenarios of human behavior at crossings, which is key in creating new testing solutions without intervening on the actual railroad property or grade crossing itself.

Grade Crossing and Trespass Outreach and Education

This research is focused on the development and dissemination of educational tools to the public, including local and state governments, law enforcement agencies, and schools, among others.

Anticipated Activities

RD&T will develop new research ideas based on the outcome of the Trespass Summits organized by RRS in FY 2021. RD&T expects to continue its collaboration with organizations such as Operation Lifesaver and form an international working group on railroad trespass prevention.

Public, Private, and University Cooperative Research Agreement

See Railroad Systems Issues for more details on this research.

Expected Program Outcomes

PTC Technology

FRA staff will work with railroad stakeholders to identify technology gaps and needs in the design, development, deployment, and evolution of PTC. RD&T will produce tools and technology aimed at increasing the efficiency of PTC without reducing safety. Additionally, RD&T will facilitate increased rail capacity and throughput and increase braking accuracy for freight and passenger trains.

PTC Interoperability

RD&T will lead research to ensure railroads' compliance with RSIA '08 interoperability requirements. FRA will review centralized test facilities and work with stakeholders to: develop efficient and reliable interoperability controls and automated interoperability verification between differing railroads; enable automated file transfers between railroads to determine problem areas and corrections in testing; and, streamline testing and validation of small freight and commuter railroad PTC systems.

PTC Next Generation

RD&T research will focus on providing additional functionality, improving reliability, and supporting integration with other technologies—all of which will support the objectives of improving safety and throughput. The work will result in improved rail network capacity and

decreased delays caused by PTC, rail network safety and efficiency improvements through interoperable automation, and increased cyber security of PTC systems.

Intelligent Transportation Systems

Accelerated development of connected and autonomous road vehicles will closely follow railroad investment in rail automation and connected highway-rail grade crossing technologies. This research will enhance connected and automated vehicle technologies with a focus on grade crossing safety. In addition, RD&T's results will lead to the development of communication standards tightly coordinated between rail and automotive industry groups.

Trespass Countermeasures

The goal of this research is to develop, test, and validate methods and means to reduce casualties. RD&T expects that the tools, technologies, and lessons learned will be transferred to other stakeholders, such as railroads or local communities for further development and implementation, thus increasing public safety.

Grade Crossing Technology

RD&T will continue its collaboration to develop and test the feasibility of new technologies and solutions in this research area, with a focus on increased safety and reliability. With the wide introduction and implementation of PTC, the inclusion of a grade crossing warning system will increase overall public safety.

Grade Crossing Pedestrian Safety

RD&T will define measures to address accidents at grade crossings and along railroad rights-of-way (ROWs) that involve pedestrians to increase their safety at crossings. RD&T will continue to study new methods and techniques to improve pedestrian safety at rail grade crossings.

Grade Crossing Modeling and Simulation

RD&T has included machine learning and AI in many of its research projects. RD&T will incorporate the new accident prediction and severity model for grade crossings into GradeDEC. RD&T will continue to develop models for studying behavior in general at grade crossings. This research will explore new modeling and simulation to reproduce real-world scenarios of human behavior at crossings. Simulation and modeling can provide insight on how safety can be improved once the simulated solution or model is implemented.

Grade Crossing and Trespass Outreach and Education

RD&T will continue to expand dissemination of educational and training aids to improve public safety. Research results will lead to increased overall safety at grade crossings and trespass prevention measures. In addition, RD&T will support RRS in examining and documenting the effectiveness law enforcement personnel along railroad ROWs.

Collaboration Partners

Partner Detail

Partner Name	Contributions	Benefits of Partnership
FHWA	FRA collaborates with these partners on intelligent transportation systems research.	Stronger products through engagement with highway and automaker stakeholders

Partner Name	Contributions	Benefits of Partnership
Federal Motor Carriers Safety Administration	FRA collaborates with these partners on intelligent transportation systems research.	Stronger products through engagement with freight and trucking stakeholders
ITS-JPO	FRA collaborates with these partners on intelligent transportation systems research.	Coordinated multimodal development
AAR – Train Control Communications and Operations Committee	Rail industry coordination and project advisory group support; subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
BNSF	System software development and supplier contracts; field test data; subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
NS	Subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
UP	Field test data and subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
CSX	Subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
Amtrak	Field test data and subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
Alaska Railroad	Subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
Kansas City Southern	Subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
CN	Subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
Wabtec Railway Electronics	I-ETMS system development and insight; subject matter expertise; modifications and system enhancements	Better product deploy ability
Meteorcomm LLC	PTC 220 MHz radio design and testing data; subject matter expertise	Better product deploy ability
Metrolink	Field test data and subject matter expertise	Better product deploy ability
Sound Transit	Field test data and subject matter expertise	Better product deploy ability

Partner Name	Contributions	Benefits of Partnership
Metra	Field test data and subject matter expertise	Better product deploy ability
North County Transit	Field test data and subject matter expertise	Better product deploy ability
FarmRail System, Inc.	ROW access; subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
Oklahoma DOT	Subject matter expertise	Better product deploy ability
MTA	Subject matter expertise	Better product deploy ability
Town of Bedford, NY	Subject matter expertise	Better product deploy ability
Town of Belmont, MA	Subject matter expertise	Better product deploy ability
MBTA	ROW access; subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
Brunswick, ME, Police Department	Police department facilities; subject matter expertise	Better product deploy ability
Michigan Technological University	Subject matter expertise	Better product deploy ability
Rutgers University	Subject matter expertise	Better product deploy ability
DecisionTEK, LLC	Subject matter expertise	Better product deploy ability
PanAm Railways	ROW access; subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
City of Orlando, FL	Cameras and instillation	Better product deploy ability
SunRail	ROW access; subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.

Benefits Detail

Beneficiary	Benefits Received
RRS	Improved safety regulations and innovative solutions
Large railroads	Reduced PTC operational impact; improved workforce health & safety; specialized test facilities; efficiency, infrastructure development; reduced regulatory burden; roadway worker protection
Small railroads	Reduced cost of PTC deployment and maintenance; efficiency; increased safety; infrastructure development; reduced regulatory burden; roadway worker protection
Public	Increased safety; improved transportation infrastructure; economic benefit; fewer accidents; reduced congestion; fuel-related environmental impacts
Universities	Publicly available research and datasets
SunRail	Innovative solutions, increased safety
MTA	Innovative solutions, increased safety
MBTA	Innovative solutions, increased safety
Town of Belmont, MA	Innovative solutions, increased safety
Town of Bedford, NY	Innovative solutions, increased safety
PanAm Railway	Innovative solutions, increased safety

Beneficiary	Benefits Received
Town of Brunswick, ME	Innovative solutions, increased safety
City of Orlando, FL	Innovative solutions, increased safety
Highway motorists	Reduced delay and accident risk
Long-distance and short-haul trucks	Reduced travel time and supply chain logistics costs
FHWA	Innovative solutions, increased safety
Local communities	Innovative solutions, increased safety
FTA	Innovative solutions, increased safety
State DOTs (Oklahoma, Michigan)	Innovative solutions, increased safety
Labor organizations	Increased employee safety
Railroad workers	Increased track worker safety

Human Factors
$6,042,000

Program Description

The Human Factors (HF) Research program focuses on improving railroad safety by studying the causes of human error in railroad operations and developing new technologies, non-regulatory guidance, and programs to mitigate those causes. The program conducts R&D in the following four research areas: Railroad Technology, Automation and Systems Design; Railroad Organizational Culture and Safety Performance; Railroad Worker and Operator Performance; and Highway-Railroad Grade Crossings, and Railroad Trespass and Suicide Prevention.

Statutory Requirements

Is this program statutorily mandated (Y): See page 4 for more details.

Program Objectives

The objective of the HF Research program is to improve rail safety by reducing the potential for human error in railroad operations. The program develops decision support and planning tools, and assessments of automation and human-machine interface (HMI) designs; advocates for human-systems integration (HSI) within the railroad industry; and works with stakeholders to improve safety culture. Safety is the primary driver of HF research.

Anticipated Program Activities

Railroad Technology, Automation, and Systems Design

New technologies are changing how railroad workers perform their jobs. This research area examines the safety implications of new technology and automation from a human-centered design perspective. The primary goal of this research area is to ensure that safety is enhanced, not degraded, by new technology and automation. Prototypes may be designed and tested to benchmark the unintended human factors consequences of new technologies.

Anticipated Activities

RD&T will assess safety issues associated with (a) rail technology assessment and human performance, (b) new technology concept demonstration and the HMI, and (c) HSI as an acquisition and implementation process for new technology.

Human Automation Teaming in Track research will analyze the function of human-automation teams in the track inspection process, including the relative strengths of both humans and automation, as well as different ways they may work together.

Demonstration and Evaluation of Technology in Train Operations research will involve partners such as Amtrak and the RRS to provide support for the demonstration and evaluation of new and existing technologies that railroads adopt.

RD&T is adding support for the assessment of technology for ongoing research at TTC. Support may include providing general technical advice on HF safety issues associated with the testing and evaluation of new rail equipment. In addition, the program will examine testing and evaluation planning regarding the inclusion of human performance in the equipment test loop.

RD&T will maintain and operate the Cab Technology Integration Laboratory (CTIL) simulator as well as the driving simulator (shared with the National Highway Traffic Safety Administration)

which includes conducting human subjects research, furnishing expert advice on experimental methodology, and promoting its use and applicability to other government and rail organizations. Further, RD&T will update the CTIL website to enhance strategic communications and outreach (e.g., communicating the latest research activities to the public, recent technical reports and briefings related to automation research, and meeting notes from stakeholder review panels).

Railroad Organizational Culture and Safety Performance

This research area focuses on projects that enhance railroad safety by encouraging the development of a positive safety culture within the railroad industry. Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventive measures.

RD&T HF research supports RRS by providing subject matter expertise, consultation, research, data, and tools to improve railroad safety. The program works closely with RRS to provide insight into research needs throughout the fiscal year and support requests for research and expertise for time-sensitive safety issues.

RD&T also continues to provide program monitoring and support of the Short Line Safety Institute (SLSI), which provides safety culture assessments and training to small railroads, usually located in rural areas. SLSI is congressional directive administered as an annual grant.

Anticipated Activities

RD&T will provide oversight of SLSI's programmatic activities, including program evaluation work conducted by Volpe.

The program will also work with SLSI to pilot test the Confidential Close Call Reporting System (C³RS) Peer Review Team support services for Class II and Class III railroads. C³RS is an FRA-sponsored, voluntary program that provides participating railroads the opportunity to confidentially report unsafe events and conditions. This initiative brings together representative stakeholders from government, SLSI, and industry to work together to identify potential safety issues and proactively develop mitigation strategies in the short line railroad community. The results of the June 2, 2021 C³RS progress meeting hosted by National Aeronautics and Space Administration provided insights from locomotive engineers on PTC operations. Further research is required to gather more detailed information on PTC HMI design and operations. Therefore, C³RS will be expanded to persons outside of the original member organizations so that reporting opportunities are not restricted to only member organizations.

In partnership with RRS, RD&T will assist in RISE development, pilot testing, and support for railroad safety working groups, including Fatality Analysis of Maintenance-of-Way Employees and Signalmen (FAMES) and Switching Operations Fatalities Analysis (SOFA).

RD&T will identify stakeholders' safety concerns regarding the operation of trains longer than 7,500 feet (i.e., VLTs). FRA held an initial listening session with labor unions on May 19, 2021 to learn about and document labor's concerns regarding VLTs. The program will document themes that emerged from the listening session and present the themes to FRA leadership. In FY 2022, HF will work with other divisions in RD&T to develop a comprehensive research plan on VLTs using a systems perspective.

Railroad Worker and Operator Performance

Individuals and groups (teams) of workers perform safety critical jobs in the railroad industry under a variety of personal (age, sleep deprivation, motivation, memory, etc.), environmental (noise, temperature, vibration, etc.), and social (status, role, etc.) conditions that may affect job performance and safety. This research area examines these factors to 1) identify those that have

significant impacts on job performance and safety; and 2) suggest strategies to enhance safety and job performance.

In May 2021, the NTSB released its final Most Wanted List of Transportation Safety Improvements. "Improve Rail Worker Safety" is among the top priorities on the NTSB list. Specifically related to rail worker safety, NTSB has called for improvements in worker scheduling procedures, training practices, safety culture and technologies that facilitate safety redundancy, switching incidents, and issues related to HazMat and spacing between cars. RD&T has several ongoing research efforts that align with the recommendations on NTSB's Most Wanted List. FRA will continue to develop and expand this research area.

Anticipated Activities

RD&T will conduct research related to human fatigue. The researchers aim to better understand workload factors and their contribution to human fatigue and create human fatigue prediction models to help personnel work scheduling. FRA will publish a Fatigue Research Plan, which will describe the HF's comprehensive fatigue research efforts. HF will conduct studies and analysis on human fatigue; and develop research-based recommendations on detection of human fatigue, countermeasures, and implications for railroad scheduling policy.

RD&T will also collaborate with labor unions to identify safety concerns associated with operating VLTs.

RD&T will collaborate with RRS to develop a program of research related to employee training. This research area will focus on the quality of engineer and conductor training as it relates to new technologies, such as PTC. This research program will identify knowledge gaps in the standard of training required for engineers and conductors to sufficiently operate new technology across different terrain and territory.

In collaboration with RD&T's Track Research program, the HF Research program will continue research on track inspection to describe the possible roles that humans and automation can each play in detection, analysis, and decision-making as well as considerations for how to effectively assign those roles depending on the level of automation or capabilities of the technology.

Highway-Railroad Grade Crossings, Railroad Trespass, and Suicide Prevention

This research area examines factors that have significant impacts on grade crossing behavior and safety and identifies strategies to enhance safety and performance. This research area also explores the two leading causes of rail-related death in the U.S.—trespassing and suicide.

Anticipated Activities

RD&T will continue to partner with RRS to further its ongoing research and education activities to raise awareness of the dangers and impacts of trespassing, to seek out low-cost solutions to local trespassing issues, and to discuss practicable ideas for technological improvements at grade crossings. In this work, RD&T will continue to demonstrate its alignment with the National Strategy to Prevent Trespassing on Railroad Property.

The program will also conduct research to better understand the root causes of rail suicide and trespass incidents to develop strategies to prevent future incidents or mitigate their consequences.

The research will consider racial equity, seeking to understand how these incidents and fatalities may occur across communities of different socioeconomic status—including lower-income communities of color.

Additionally, RD&T will work directly with at least one railroad carrier to collect detailed post-incident data, with a focus on data that indicates the intent of the individual involved in a train-person collision. RD&T will continue to assist railroad partners to identify ways to use data to effectively identify mitigation strategies.

Public, Private, and University Cooperative Research Agreement

See Railroad Systems Issues for more details on this research.

Expected Program Outcomes

Railroad Technology, Automation, and Systems Design

Outcomes from CTIL research activities include prototype development, which furthers FRA's ability to benchmark safety and performance characteristics of automated technologies.

Railroad Organizational Culture and Safety Performance

Expected outcomes from the review of C3RS data include policy and procedure recommendations, technology evaluations, and operational safety issue analysis and reporting.

Expected outcomes from RISE research will improve safety by identifying a previously unknown issue or precursor from data analysis focusing on a topic of interest and monitoring data for issues, and/or identifying a topic that needs in-depth study.

Expected outcomes from work with railroad safety working groups will provide technical assistance related to data analysis and report writing to these non-regulatory stakeholder workgroups (e.g., FAMES, SOFA) in their fatality case analyses.

Railroad Worker and Operator Performance

Expected outcomes of human fatigue research include a reduction in the risk of human fatigue-related accidents and incidents.

The expected outcomes of the Information and Communications Technology (ICT) Needs Assessment include a set of software tools, websites, and email systems of information communication for railroaders. Scenario-based Training (SBT) expected outcomes include a stronger and more effective operational training utilizing the SBT approach.

Human-Automation Teaming in Track Inspection expected outcomes will yield a better understanding of how to integrate new technology into legacy operations where the best use of human and automation capabilities can be allocated to enhance teaming and improve efficiency in the track inspection task. Additionally, outcomes include safer tracks that are inspected more efficiently.

Highway-Railroad Grade Crossings, Railroad Trespass, and Suicide Prevention

Expected outcomes will provide: a data-based approach to design optimized in-vehicle auditory alerts (IVAAs) for rail crossings and help with standardizing the warnings across platforms; and critical information to developers interested in incorporating rail crossings and IVAAs in their applications.

Expected outcomes of data quality improvement efforts will be used to better understand the reliability and validity of the intent determinations that are currently used by FRA.

Expected outcomes of HF outreach include coordination and hosting of Global Railway Alliance for Suicide Prevention (GRASP) meetings and public posting of meeting minutes, including key findings. FRA will conduct outreach activities with Operation Lifesaver, mental health

organizations, and other industry groups. Also, FRA is developing a U.S.-based group similar to GRASP, in response to feedback and interest from rail stakeholders. FRA expects passenger railroads (commuter railroads) to be involved with the new group for suicide prevention.

Expected outcomes of countermeasure development and evaluation include helping railroads determine which types of countermeasures to select to mitigate their trespass and/or suicide issues and develop rail-specific guidelines for reporting.

Collaboration Partners

Partner Detail

Partner Name	Contributions	Benefits of Partnership
DOT Human Factors Coordinating Committee (HFCC)	Share Human Factors research/information with each DOT mode.	Per the *U.S. Department of Transportation Strategic Plan for FY 2018-2022* (p. 34), HFCC "serves as a collaborative, multimodal team with Federal Government-wide liaisons to address crosscutting human factors issues in transportation." HFCC includes representatives from every DOT operating administration (OA).
DOT Safety Council	HF provides financial support to the DOT Safety Council.	Per the *U.S. Department of Transportation Strategic Plan for FY 2018-2022* (p. 16), the DOT Safety Council provides leadership and establishes a departmental commitment to improving transportation safety through improved safety culture. The DOT Safety Council is composed of the heads of each DOT OA, their senior safety officers, and senior officials from the Office of the Secretary.
RRS	Subject matter expertise, collaboration, and recommendations	HF PMs work closely with their counterparts in RRS. As a primary customer of RD&T, RRS' research needs, and priorities helps shape the HF research plan.
RRS's Highway-Rail Crossing and Trespasser Programs Division	Subject matter expertise, collaboration, and recommendations	HF PMs supports staff in RRS's Highway-Rail Crossing and Trespasser Programs Division
TC&C, Rolling Stock, and Track Divisions	Collaboration, subject matter expertise, stakeholder engagement	HF works closely with PMs from RD&T's other research programs to conduct jointly sponsored research projects. Integration of HF PMs ensures that engineering solutions include consideration of the operator's perspective. Integration of HF principles and HMI design considerations at the beginning of developing new technologies helps reduce the

Partner Name	Contributions	Benefits of Partnership
		potential for human error once those technologies are deployed.
Amtrak	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
Metra	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
New Jersey Transit	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
Keolis/ MBTA	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
FAMES	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of fatalities and lessons learned
SEPTA	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
MTA (LIRR and MNR)	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
SOFA	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of fatalities and lessons learned
Brotherhood of Locomotive Engineers and Trainmen (BLET)	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
International Association of Sheet Metal, Air, Rail, and Transportation Workers (SMART)	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
ASLRRA	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement
AAR	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement
GE Global Research	Collaboration, research studies	Stakeholder engagement
SLSI	Subject matter expertise, collaboration, data, and recommendations	Improved safety and safety culture in Class II and Class III freight railroads
GRASP	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement
Operation Lifesaver	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement
Massachusetts Institute of Technology	Subject matter expertise, research studies, collaboration, data, and recommendations	HF expertise

Partner Name	Contributions	Benefits of Partnership
Michigan Technological University	Subject matter expertise, research studies, collaboration, data, and recommendations	HF and AI expertise
University of Connecticut	Subject matter expertise, research studies, collaboration, data, and recommendations	HF expertise
University of New Mexico	Subject matter expertise, research studies, collaboration, data, and recommendations	HF and AI expertise
Rutgers University	Subject matter expertise, research studies, collaboration, data, and recommendations	HF and AI expertise
University of South Carolina	Subject matter expertise, research studies, collaboration, data, and recommendations	HF and AI expertise

Benefits Detail

Beneficiary	Benefits Received
RRS	Improved safety requirements, standards, recommendations
Railroad industry	Improved safety and safety culture Lower operating costs Improved visibility for railroad workers and Grade Crossings Reduced railroad accidents and fatalities Improved training for railway workers
Public	Reduced railroad accidents and fatalities Proper implementation of technology to improve safety especially related to grade crossing and trespassing prevention
Small businesses and university research centers	Improved railroad research resources and capabilities WFD opportunities

Section 2 – FY 2023 RD&T Programs

Railroad Systems Issues

Program Description

The RSI Research program defines the strategy that directs the entire RD&T program toward the goals set forth by DOT, OST-R, FRA, and RPD. The principal focus and goal of the RSI program is safety; however, the program's activities contribute to all DOT strategic goals to advance infrastructure, innovation, and accountability—while maintaining a safety focus.

The RSI research program improves railroad safety by evaluating risks and prioritizing RD&T projects to reduce safety risk and achieve DOT, OST-R, FRA, and RPD goals. RD&T works with RRS to understand their strategic goals, safety data and trends, and requirements/needs to prioritize research to reduce safety risks.

Program Objectives

RSI's objective is to determine strategic research needs and priorities through collaboration with internal and external partners and stakeholders, considering real-time safety issues requiring subject matter expertise or long-term research solutions. The RSI research program develops, facilitates, manages, and supports the following areas: RD&T's research strategy; safety risk analysis; research prioritization; strategic collaborations and partnerships; performance-based regulations; non-regulatory recommendations; railroad environmental issues; locomotive safety; project evaluation; WFD; MSI outreach; RD&T-related technology transfer and travel; operations, maintenance, and equipment at TTC in Pueblo, Colorado; and contractor support.

RD&T partners and collaborates with academia, the private sector, and the rail industry—in addition to working with other DOT modes and Federal agencies.

RD&T partners and collaborates with academia, the private sector, and rail industry—in addition to working with other DOT modes and Federal agencies.

Anticipated Program Activities[10]

RSI research program activities are tailored to address a host of railroad issues—from safety to WFD.

Rail Safety Innovations Deserving Exploratory Analysis

TRB and FRA will issue an IDEA Program Announcement to solicit proposals for the Rail Safety IDEA program exploratory research projects. The announcement describes the program and criteria and provides guidelines for eligibility and proposal submission. The TRB selects a qualified Rail Safety IDEA review committee that will evaluate proposals on a competitive basis. The Rail Safety IDEA program committee will evaluate those proposals meeting the technical eligibility criteria and provide comments for selected researchers. TRB will ensure that there will be a widespread announcement of contract opportunities for rail inventors. TRB and FRA will collaborate to manage the projects to completion. FRA and TRB will track the successful implementation of completed projects.

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[10] Activities and outcomes are similar to previous fiscal years because new projects are selected, executed, monitored, and completed each fiscal year.

Project Selection

This project includes the activities and costs associated with maintaining the license for the prioritization software and implementing the prioritization process. FRA will renew the Decision Lens software license for an additional option year. RD&T will use lessons learned and apply improved rating process to candidate research projects for FY 2022 (October–December timeframe). Each research program will use lessons learned and results to inform the FY 2022 AMRP.

Strategic Planning

RD&T will continue implementation of its 5-Year Strategic Plan 2020–2024, continue development of its 5-Year Strategic Plan 2024–2028, and continue implementation of its MSI Outreach Strategic Plan.

RD&T Technology Transfer (T2)

Utilizing RD&T's T2 methodology (rooted in collaboration and stakeholder engagement activities), the expected outcomes include T2 and adoption of innovative concepts and methods that will enhance safety and performance for railroads.

Program Support

As part of RD&T's T2 and publishing process, the Technical Editors will review Technical Reports, Research Results, conference papers, and other material. The editors will also provide report-related social media content to the FRA Office of Public Affairs for RD&T's social media campaigns. Contractors will provide program management, analysis, and subject matter expertise to support project, program, and portfolio management.

Project Evaluation

RD&T will standardize and enhance project evaluation tools. Each research program will continue implementation of RD&T's project evaluation methodology. RD&T will continue to align evaluation practices to FRA's learning agenda and OMB's direction. As part of research activities, RD&T will conduct project evaluations and optimize RD&T's performance management metrics. RD&T will review evaluation data to understand trends and establish new project success criteria.

Facilities and Equipment – Transportation Technology Center

RD&T will continue providing facilities and equipment that can be used to perform railroad research and development, testing, and training to enhance the safety of rail systems in both safety and security operations. RD&T continues the enhancement of TTC's capabilities through strategic investment in existing facilities and equipment to support upcoming research and testing needs (e.g., the refurbishment of its rail system). RD&T continues to support environmental and green technology goals encouraging energy efficiency, renewable energy, the reduction of toxins, recycling, the reuse of materials, and water conservation. RD&T will complete TTCI contract closeout activities. RD&T will continue to purchase equipment and instrumentation needed for the new ENSCO contract based on RD&T's facilities maintenance plan.

RD&T will continue to raise awareness and encourage the broader use of TTC's facilities through creative outreach efforts to other Government agencies and the private sector, while ensuring priority for FRA-sponsored activities and providing fair access.

Railroad Systems Issues

RSI will conduct research related to BAAs, based on proposals that are accepted by RD&T.

Workforce Development

RD&T will continue WFD research activities, stakeholder engagement, MSI outreach and relationship building, STEM projects, and expansion of programs that support industry's efforts to increase recruitment, retention, and training of underrepresented populations.

RD&T will engage and collaborate with the railroad industry for a better understanding of rail workforce trends, and provide relevant data and insights to support sustainable initiatives. This engagement will facilitate establishment of forums with stakeholders for best practice and information exchange.

RD&T will support the third phase of programs aimed toward engaging youth (PreK through 12th grade and college) and under-represented populations in rail transportation and STEM topics. This will include strategic outreach to build research partnerships with MSIs and increase awareness and interest in railroad careers.

In addition, RD&T will fund the second year of 2021 BAA research topics: Addressing Equity Challenges in Evolving Railroad Workforce Training Trends and Best Practices, Workforce Recruitment - Attracting and Retaining Women in Rail, and Influencing Successful Practices in Knowledge Management within the Railroad Industry. RD&T will continue to fund research proposals from the following research topics published in FRA's Research with Universities – Research Initiatives in Support of Railroad Safety BAA: Pre-college STEM Rail Transportation Club to increase Racial Equity in Rail Workforce Recruitment; Workforce Recruitment – Attracting and Retaining Women in Rail (new contract); Racial Equity in Rail Workforce Recruitment – Identifying and Training Leadership for Succession Planning; and LGBTQ+ Equity and Inclusion in the Railroad Industry.

Energy and Emissions

RD&T and RRS will jointly plan and execute a second conference to include international participants on the advancement of safe, clean alternative fuels, and motive power technologies for railroad applications. This workshop will bring together experts, end users, manufacturers, academia, international partners, and Federal agencies to discuss technologies for the decarbonization of rail. RD&T will continue impact and applicability study of hydrogen for rail applications. RD&T will maintain the Rail Module in the GREET model so that the tool is updated, relevant, and useful for the rail industry. RD&T will provide feedback and direction to RRS on the performance of such equipment under normal and accident scenarios. RD&T will provide year two funding to selected BAA topics: Rail's Contribution to CO2 Emissions and Modal-Shift Impacts; Energy and Environmental Sustainability; and Climate Change and Resiliency Planning.

Accessibility

RD&T will support development of new and improved accessibility standards for rail vehicles, ensuring that the standards are safe and technically feasible. Research will be conducted as needed to develop science-based knowledge in support of standards.

Locomotive Safety

RD&T will assess new and innovative technologies that will improve the safety and efficiency of locomotives in a real-world environment. RD&T plans to complete development and prototype demonstration of hybrid systems.

Office of Railroad Safety Support[11]

RD&T will continue to partner with RRS and industry on RISE. RD&T will conduct research on urgent safety issues identified by RRS or Congress. RD&T will continue to provide SME support to RRS.

Public, Private, and University Cooperative Research Agreement[12]

RD&T will publish the request for proposals and review the university proposals. RD&T will select prospective research projects to fund and begin selected projects.

Research with Universities on Intelligent Railroad Systems[13]

FRA will collaborate with ITS-JPO to publish a BAA to solicit applied technology research projects that will support DOT and FRA goals to advance automation and connected vehicle technology adoption in the rail industry. RD&T will review university proposals and select prospective research projects. RD&T will award funding and begin selected projects.

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[11] Funding will come from multiple divisions to support their research.

[12] Funding will come from multiple divisions to support their research.

[13] Funding has been provided by Congress for Research with Universities on Intelligent Railroad Systems in addition to the total budget for FRA RD&T. If Congress chooses NOT to fund the $1M additional funds, this activity will not be executed in 2023.

Track

Program Description

The Track Research program helps to ensure the U.S. railway infrastructure is safe and capable of meeting the nation's transportation needs—today and in the future. Its applied research, development, and demonstration projects provide crucial technical information and data for both regulators and industry. This information and data, guides decisions about the safe operation of rail vehicles on U.S. track. It also guides investment and maintenance decisions, so the track infrastructure can handle growing rail traffic effectively and be resilient to climate change.

The program supports the goals and objectives of DOT and FRA; conducts safety-related research for new and in-service railroad system investments; develops and demonstrates new track condition assessment technologies; and coordinates research teams between railroads, universities, technology leaders, and Government. The program includes two primary research areas:

- Track structures and components
- Systems performance and analysis

Program Objectives

FRA's RD&T Track Research program conducts scientific and engineering research to reduce track-caused derailments and thus improve railroad safety. It especially aims to prevent high-consequence derailments that cause loss of human life and significant damage to communities and properties. Research results assist RRS in setting and enforcing appropriate minimum regulatory standards related to track safety. To further improve overall rail safety, the program collaborates with the railroad industry to develop and implement new technologies, data analyses, and maintenance practices.

Anticipated Program Activities

Track and Structures – Rail Performance

RD&T will develop methodologies and technologies to better inspect for internal rail flaws at high speed, in special track work, in welds and under difficult rail surface conditions. RD&T will move the rail flaw library to a more spacious and secure location for more efficient research work. RD&T will optimize 3D mapping to locate internal rail flaws. RD&T will publish new materials on how rapidly internal rail flaws grow in modern rail steels and in welds. RD&T will test non-contact internal rail integrity inspection on a major Class I railroad in the U.S.

Track and Structures – Track Inspection Technology and Processes

Research planned will advance the state-of-the-art with respect to track condition awareness and safety reporting efficiency through an extended deployment of automated track change detection technology throughout the rail industry. In addition, field deployment of self-enunciating track condition technologies will provide the foundation for real-time, remote condition assessment. Broken spike research will likely conclude, with dissemination of root cause analysis and performance data showing methods to mitigate or prevent broken spikes in wood tie track. Advances in image processing, especially in edge computing applications, will advance state-of-the-art in track inspection. Additional research is planned to improve track component designs and to detect component failures in track.

Track and Structures – Special Activities

RD&T will continue development of automated bridge and impact detection technologies. RD&T will continue to invest in rail safety applications for UAVs in the railroad and will support the technical development of safe methods to conduct BVLOS inspections. This research will include FAA and rail industry participation.

Track and Structures – Track Stability

RD&T will work toward commercializing technology that measures rail stress without a reference and finalize the design and build plans for a rail stress and rail neutral temperature (RNT) test bed at TTC—in collaboration and cost sharing with industry and AAR. RD&T will continue lateral stability and track buckling best practices research, including software development and trainings. RD&T, with the railroads, will field test RNT measurement prototypes along with moving platform measurement systems that can aid in assessing buckling risk. RD&T will further develop and refine ballast models that predict conditions and behaviors that can adversely affect track stability and advance technologies that identify, categorize, and assess risks associated with track support failure and/or derailment. A particular focus of this research is to detect track conditions that contribute to increased derailment risk, including the effect of ballast condition on track lateral resistance and track geometry deterioration. Work will also develop measurements of key track parameters such as:

- Substructure moisture content and saturation level

- Ballast resilient modulus as it relates to the degree of consolidation after maintenance as well as deterioration due to fouling

- Mechanistic track parameters such as track support stiffness that can indicate problematic weak track conditions that pose a risk for rapid deterioration.

R&D Facilities and Equipment – On-Track Research and Testing (FRA Research Assets)

RD&T is continuing revenue service testing focused on the effect that cold weather has on the integrity of the track system. RD&T will investigate root causes of potential issues that may arise during FY2023 affecting safe HAL operations. RD&T will install and evaluate new and innovative ideas and technologies, both at the TTC and in revenue service, intended to mitigate the adverse effects HAL operating conditions pose to track system integrity.

System Performance and Analysis – Predictive Analytics

RD&T will complete all research efforts related to development of a machine-vision approach for inspecting highway-rail grade crossings using locomotive-based forward-facing video. Also, in FY2023, RD&T will continue research efforts focused on the application of AI into track-related safety inspection techniques. RD&T will complete the development and testing of advanced forecasting models for predicting areas approaching maintenance and safety limits using ATGMS in a revenue service environment.

System Performance and Analysis – Vehicle Track Performance

RD&T will finish a procedure to utilize the TTC tangent and curved test track to validate the accuracy of track geometry measurement systems used by FRA and the industry. RD&T will complete research studying the effectiveness of rail surface inspection systems to quantify rolling contact fatigue in revenue service track. RD&T will complete research examining wheel/rail contact inspection and analyze the system's effectiveness in locating potential track problems. RD&T will continue to conduct research in the 3D wheel/rail contact area.

Rolling Stock

Program Description

The Rolling Stock Research and development program examines how to reduce railroad accidents and incidents due to rolling stock-related causes as well as research to reduce fatalities and injury severity to passengers and crewmembers involved in passenger train accidents and incidents. The program leads the research, development, and evaluation of advanced rolling stock inspection techniques, materials, and components. HazMat research focuses on improving transportation processes (including those for LNG, crude oil, ethanol, and toxic inhalation hazards, and related equipment), the safe use of alternative fuels, and new engine and energy savings technologies that focus on preserving the environment. Results of this research directly support the development, implementation, and refinement of safety operations, reduce risks, and enhance the industry and Government safety-related standards and performance-based regulations.

Program Objectives

The focus of the Rolling Stock Research program is to improve railroad safety by providing the scientific and engineering basis for improved industry standards, safety rulemaking, enforcement, and the safe transport of goods and passengers. The program will investigate efficacy of alternative fuels and advanced motive power technologies to improve energy efficiency and reduce emissions of rail transportation. Research efforts involve collaboration with both internal and external industry stakeholders to develop and implement advanced technologies and practices to improve overall system safety.

Anticipated Program Activities

HazMat – Tank Car Research

RD&T will continue research on developing and improving packages that carry hazardous materials. Research efforts will reduce HazMat releases and minimize their consequences during rail accidents and incidents.

RD&T will continue research on NDE, POD with the tank car industry and stakeholders and identify the capabilities/limitations of new and advanced NDE methods for tank car inspections. RD&T will continue research on the effects of corrosion on tank car structures and the potential use of state-of-the-art NDE methodologies for measuring tank car shell thickness. RD&T will continue research on newer types of tank cars and their common failure modes, and determine if new weld test panels are needed for future POD studies.

RD&T will continue tank car impact testing; developing and improving test methods; providing data for improving modeling methods, design, and construct test fixtures; and preparing and testing various tank car designs. In addition, RD&T will research efforts to analyze and provide the data for validating FE analysis models and report on test and model results.

RD&T will continue conducting research on the analysis of collected impact test data to arrive at limiting conditions for coupling speed and impacting mass.

HazMat – Tank Car Structural Integrity

RD&T will continue research to evaluate the puncture resistance of various DOT 113 tank car designs in standardized shell impact scenarios, examining the effects of parameters such as support conditions, impactor size, etc., on shell punctures. RD&T will continue efforts to develop

computational models of tank car designs under impact conditions and compare test data with model results to validate models.

HazMat – Accident Consequence Reduction

RD&T will continue research to evaluate the performance of top fittings protection used on current tank car designs, particularly those on unit trains carrying flammable materials under rollover conditions.

HazMat – Risk Analysis

RD&T will continue to conduct phased research involving full-scale fire tests on portable tanks to obtain experimental data. Research efforts will improve internal instrumentation which will be used for future computer model validation.

Energy Products Research[14]

RD&T will continue this research to help assess the operational safety risks associated with hazardous material unit trains and determine if unit trains carrying hazardous materials present unique or additional risks compared with unit train operations of non-hazardous materials, and if the same risks apply for HazMat transported in mixed-freight operations. RD&T will continue research to develop a risk model for quantifying risks associated with the operation of hazardous material unit trains and on risk mitigation. RD&T will continue to research Fire Performance of Alternative Fuel Tenders, Risk Analysis and Mitigation, and Rapid Brake Signal Propagation on Freight Trains.

RD&T will continue research to provide data to help evaluate the survivability of the valve functions or gas flow under certain grade crossing accident conditions.

Natural Gas Safety Research[15]

RD&T will continue to review railroads' natural gas fuel usage programs and develop standards for natural gas fuel tenders. The research provides FRA with the scientific basis for decision-making and the development of standards and requirements. FRA will collaborate with other Federal agencies to ensure the use of such products is safe.

RSEC – Rolling Stock Component Safety

RD&T will continue to research train makeup, train operations, and train handling developments to address air brake signal propagation time, impact on application and release, air brake system leakage on long trains, and brake pipe pressure on cars near the tail end of trains. RD&T will continue to research high buff and draft forces under undulating territories, train handling of 200-car trains or longer, and individual car dynamic behavior and safety during curve negotiation.

RD&T will continue to identify malfunctioning brake systems by detecting excessively hot or cold wheels, and assess the implementation of WTD technology and its effectiveness in improving the safety of train operations and detection of air brake system defects on moving trains. RD&T will continue research to develop a database for maintaining the pilot study data supplied by railroads for the WTD system and car maintenance, and to develop methodologies for data analysis to support the Test Waiver Committee.

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[14] Funding is provided annually by Congress for Energy Products Research. This is included in the total budget for FRA RD&T.

[15] Funding comes from Congress and is not included in the FY 2023 appropriations. Funding will be spent on LNG if RD&T has carryover from the last appropriation.

RD&T, in collaboration with industry, will continue research to reduce wheel failures, including the causes of vertical split rims and shattered rims. RD&T will continue to research the effects of contact pressure, slip ratio, lubrication, and temperature on the development of RCF cracks and wear of railway wheels and investigate how temperature at the wheel-rail interface can affect wheel surface performance.

RD&T will continue research to test the ability of the current baseline bearing rubbing lip seals versus frictionless seals to prevent water ingress over the life of the bearing.

RD&T will continue to research, design, prototype, and test an EPSS DC access/battery charger that provides a standard 24-volt DC interface to safety and security devices where desired. RD&T will continue research to initiate the development and acceptance of AAR interchange specifications/standards for an electrical power supply, electrical hand brake, and the subject eco-system platform.

RD&T will continue research to optimize the controller/motor interface design.

RSEC – Rolling Stock Maintenance and Inspection

RD&T will continue research to capture best practices with pilot demonstrations of wayside technology systems to detect defects and precursors to safety-critical rolling stock defects. RD&T will continue research to document wayside system installations at MNR, LIRR and NYA, detect threshold analysis to help the railroads establish detection thresholds for inspection, alarm emergency level actions balanced against shop capacity and commuter service demands, identify best practices for implementation, and revise the Wayside Implementation Guide.

RD&T will continue research to investigate the current state of train line systems, assist organizations with DTL development, and explore wireless extensions to DTL. RD&T will continue research to work closely with the Next Generation Equipment Committee, AAR, AASHTO, and Amtrak, among others.

RSEC – Train Handling and Operations

RD&T will continue conducting research on a roadmap for next generation brake technology and development of a "mini-network" with representative characteristics of the North American rail system, including various types of traffic, tracks, signaling systems, and train configurations. RD&T will continue to develop network simulation scenarios based on adjusting train braking algorithms with certain daily traffic volume out of the entire network. RD&T will continue research to conduct a comprehensive analysis of the simulated results in terms of network capacity parameters such as train delay, dwell time, train conflicts, train speed, network velocity, track occupancy level, number of meet-pass and stops, safety, and accident mitigation. RD&T will also develop the necessary technology to analyze the topology of railroad networks to quantify, assess and enhance their resilience and improve safety, productivity, and cost effectiveness.

TOP

TOP – Fire Safety Research

RD&T will conduct small-scale tests of various passenger rail car designs to evaluate the efficacy of smaller scaled test articles to predict the performance of full-size railcars for floor fire compliance testing. RD&T will evaluate the test layout and support of test articles to support the update of industry standards. Small-scale tests will be conducted to validate computer modeling and scaling laws to determine and quantify the heat release rate for passenger railcars.

TOP – Emergency Preparedness Research

RD&T will continue to evaluate technologies for the safe and efficient evacuation of rail passengers under emergency scenarios. Rail passenger evacuation data will be gathered and integrated into the egress models to better predict passenger evacuation. Evacuation models, coupled with fire dynamics models, will be updated to include the effect fire suppression and detection systems technologies would have on passenger evacuation.

RD&T will continue research to develop an underlying methodology for analyzing the topology of railroad networks, mainly to study and improve the capability of railroad networks to offer robustness, resiliency, efficiency, and effectiveness.

TOP – Cab Displays, Controls, and Environment

RD&T will continue research to test and validate candidate LED headlights for railroad applications.

TOP – Passenger Locomotive Crashworthiness and Occupant Protection

RD&T will continue research to develop strategies for improved passenger railcar occupant protection including the conduct of full-scale testing to develop data to corroborate the current FRA regulations related to the crash pulse used to evaluate the attachment strength of railcar components. RD&T will continue research to assess the deceleration environment to which passenger car occupants in WhMDs are exposed, and the efficacy of various means to secure these devices in passenger trains. Results from full-scale testing analytical models validated with those results will be used to evaluate safety performance under conditions for which actual testing was not performed. RD&T will also use novel collision analyses and simulation techniques along with collision evaluation criteria to objectively assess the adequacy or potential shortcoming of a modern locomotive's existing crashworthiness requirements. Advanced simulations with high-fidelity computer models and crashworthiness evaluation technology will enhance freight rail operational efficiency and safety through ensuring improved crashworthiness in the event of freight rail collisions.

TOP – Glazing Standards

RD&T will continue research to develop realistic test protocols and evaluation metrics for glazing retention capacity. RD&T will continue research to inform potential Federal regulations or APTA standards on glazing integrity as recommended by NTSB as a result of its investigations of recent passenger train accidents. RD&T will continue research to aggregate industry recommendations for passenger car design alternatives.

RD&T will continue research to develop secondary impact protection for locomotive engineers and develop findings for consideration in the design of new or retrofitted locomotive cabs.

Train Control and Communication

Program Description

The TC&C Research program focuses on improving railroad operation safety through the development and testing of train control and communication systems and grade crossing safety technologies. The program conducts pilot studies, creates prototypes, and demonstrates safety and security systems—including intelligent rail systems, blocked crossings, and trespass prevention. It also provides scientific research and data to support FRA regulations. This research program actively collaborates with stakeholders to build on existing research to advance train control technologies and design the next generation train control safety systems. There are two primary research areas included in the program:

- Train control and communication
- Grade crossings and trespass

Program Objectives

TC&C research program objectives are to improve railroad operation safety, reduce train-to-train collisions and train collisions with objects on the line and at grade crossings, and prevent trespassing. This program adapts innovative and emerging technologies from other industries to support its mission and provides stakeholders the benefits of its research through T2. Program staff collaborate with stakeholders to research, develop, and test safety systems, grade crossing protection, trespassing countermeasures, and issue best practices to communities.

Anticipated Program Activities[16]

PTC Technology

RD&T will support evolutionary and innovative technologies to ensure PTC interoperability and reliability continue to evolve with the pace of technological development. RD&T will coordinate with industry to develop solutions to improve reliability, availability, and maintainability of deployed PTC systems. This work will continue to improve rail network capacity and safety while reducing life cycle costs for railroads and streamlining regulatory compliance.

PTC Interoperability

RD&T will continue interoperability research to ensure compliance with RSIA '08 and assist industry in improving testing protocols and centralizing/streamlining the testing and validation of PTC systems. FRA will support the development of interoperable train automation technologies, hazard sensing solutions, and associated industry standards.

PTC Next Generation

Multiple areas of consideration are under review for potential development, including signaling, communications, and infrastructure enhancements to reduce PTC burden and improve safety. RD&T will conduct research into advanced PTC concepts and architectures that support higher levels of railroad automation, such as Full Moving Block and Line of Road Remote Locomotive Control. Also, RD&T will research advanced methods of track circuit-based rail break detection to support moving block operations.

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[16] Activities and outcomes are similar to previous fiscal years because projects that span multiple years are selected, executed, and monitored until completion.

Intelligent Transportation Systems

RD&T will continue to conduct research on new sensor, computer, and digital communications for train control, braking systems, grade crossings, and defect detection; and new, innovative technologies in automation, AI, and UAVs to improve safety and reduce incidents around railroad operations. Activities include research into the feasibility of a vital connected vehicle communication protocol for grade crossing accident mitigation, and the development of novel concepts for integrating road vehicle active safety systems into rail crossing infrastructure systems.

Trespass Countermeasures

Trespassing is the leading cause of incidents that occur on a railroad property; without this research, the number of accidents on railroad property due to trespass will likely not decrease. RD&T will work with all relevant partners and stakeholders to research solutions that can reduce trespassing along railroad ROWs.

Grade Crossing Technology

Grade crossings, along with public railway station platforms, are where a railroad is most exposed to other modes of transportation as well as the public. RD&T will develop technologies and tools to improve warning devices and integrate grade crossing locations into mapping devices.

Grade Crossing Pedestrian Safety

RD&T will continue to explore measures to address accidents at grade crossings and along railroad ROWs that involve pedestrians. Simulation and modeling offer non-invasive and non-destructive methods to predict traffic trends and accident reduction in a controlled environment. RD&T will collaborate with industry partners in researching and testing new methods to reduce the risk of accidents where pedestrians are involved.

Grade Crossing Modeling and Simulation

RD&T will continue to evaluate scenarios of possible safety improvements at grade crossings without the actual need to perform field testing. This work will involve collaborating with other DOT modes, universities, and industry partners to develop new simulation models to reduce the risk of accidents and improve grade crossing safety.

Grade Crossing and Trespass Outreach and Education

Education and awareness are the best tools to assist the public in understanding the risks of being near railroad property. In collaboration with Operation Lifesaver and other organizations, RD&T will continue to educate the public to the dangers of grade crossings.

Human Factors

Program Description

The HF Research program focuses on improving railroad safety by studying the causes of human error in railroad operations and developing new technologies, non-regulatory guidance, and programs to mitigate those causes. The program conducts research and development in the following four research areas: Railroad Technology, Automation and Systems Design; Railroad Organizational Culture and Safety Performance; Railroad Worker and Operator Performance; and Highway-Railroad Grade Crossings, and Railroad Trespass and Suicide Prevention.

Program Objectives

The objective of the HF program is to improve rail safety by reducing the potential for human error in railroad operations. The program develops decision support and planning tools, and assessments of automation and HMI designs; advocates for HSI within the railroad industry; and works with stakeholders to improve safety culture. Safety is the primary driver of HF research.

Anticipated Program Activities

Program Area – Human Factors

Program Area – Short Line Safety Institute

Railroad Technology, Automation, and Systems Design

RD&T will continue research to catalog and survey the various Cautions, Alerts, Warnings, and Status associated with rail automated systems and displayed to engineers and operators.

RD&T will continue operation and maintenance of the CTIL simulator, including human subjects research, providing expert advice on experimental methodology and promoting its applicability. The program will continue to explore partnerships with labor, railroads, and academia in leading research on new HMI technology and systems engineering.

Further, the program will update the CTIL website, communicating to the public the latest activities and research accomplished in FRA's simulators. The website provides recent technical reports and briefings related to automation research and meeting notes from stakeholder review panels.

Railroad Organizational Culture and Safety Performance

Specific, ongoing SLSI activities include continuing safety culture assessments (SCAs); providing leadership training curriculum for Class II and III railroads; and, determining whether additional commuter railroads can participate in SLSI SCAs.

RD&T will conduct a review of data regarding PTC operations from the C3RS anonymous near-miss and safety issue reporting system. Next steps will include focus group sessions with labor or railroad management as required by the incidents under review, as well as listening sessions.

RD&T will support RRS by providing subject matter expert consultation, research, data, and tools to improve railroad safety and reduce accidents and incidents. Support to RRS includes the ongoing development and pilot testing of RISE and collaboration with railroad safety working groups, including FAMES and SOFA.

Railroad Worker and Operator Performance

Work with stakeholders to continue to refine studies, tools, and sharing of best practices and strategies to support human fatigue detection and countermeasures.

RD&T will continue to conduct research on the ICT Needs Assessment, providing context evaluation to understand the knowledge, skills, and attitudes of railroaders to determine the best types of technology suited for railroader communication and information processing.

R&T will conduct a routine evaluation of the effectiveness of railroad SBT and make recommendations to improve the training.

RD&T will support the Human-Automation Teaming in Track Inspection to better describe the possible roles that humans and automation can each play in detection, analysis, and decision-making; it also considers how to effectively assign those roles depending on the level of automation or capabilities of the technology.

Highway-Railroad Grade Crossings, Railroad Trespass, and Suicide Prevention

RD&T and RRS representatives will collaborate to conduct trespass prevention outreach activities, including an examination of lessons learned from summits conducted in 2020 and potential risk mitigation strategies.

The Motorist Behavior at Grade Crossings project will continue to identify, collect, and design various IVAAs, and conduct subsequent empirical experiments involving driving simulators to evaluate their effects on motorist behavior and, more broadly, grade crossing safety. The project will also review and synthesize literature on the topic.

The program will continue its railroad-specific analysis and work directly with at least one railroad carrier to collect detailed post-incident data, with a focus on data that shows individual intent in a train-person collision. RD&T will assist railroad partners to identify ways to use data to effectively identify mitigation strategies.

RD&T will coordinate with international colleagues through the GRASP program. RD&T will also work to advance existing efforts to encourage responsible reporting about suicide and trespass incidents in the media, working with Operation Lifesaver and other organizations to better understand how to improve public discourse on railroad suicide incidents.

RD&T will expand its research, intervention, and implementation activities for the U.S.-based establishment of a suicide and trespass prevention group through FY 2023.

RD&T will continue conducting research to better understand the root cause of rail suicide and trespass incidents to develop strategies to prevent future incidents or mitigate their consequences. This will include transitioning to a systems thinking approach with regards to the research and improving strategic and tactical communications with stakeholders, carriers, and the public.