United States Department of Transportation
Annual Modal Research Plans FY 2021
Program Outlook FY 2022

FEDERAL RAILROAD ADMINISTRATION
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Note: The FY 2021-2022 AMRPs will be certified using the President's budget numbers and revised with enacted budget numbers after the budget passes.

Chapter 1 – Executive Summary

The mission of the Federal Railroad Administration's (FRA) Office of Research, Development and Technology (RD&T) is to ensure the safe movement of people and goods by rail through research and development of innovative technologies and solutions. Safety is the Department of Transportation's (DOT) primary strategic goal, and thus, the principal driver of RD&T's program. RD&T also contributes to other DOT Strategic Goals of Infrastructure, Innovation, and Accountability as safety-focused projects typically yield solutions affecting these goals. Further, RD&T also has an important role to play in railroad industry workforce development.

FRA's RD&T program is grounded in an understanding of safety risks in the industry. Through threat identification and risk analysis, RD&T identifies opportunities to reduce the likelihood of accidents and incidents. In addition, FRA aims 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 Regional Railroad Association (ASLRRA), Pipeline and Hazardous Materials Safety Administration (PHMSA), Intelligent Transportations Systems Joint Program Office (ITS-JPO)—and internally with FRA's Office of Railroad Safety (RRS). Moreover, RD&T works closely with OST-R and the Topical Research Working Groups to prevent the duplication of efforts. RD&T activities are non-duplicative with known prior or current projects within FRA.

RD&T is organized around 10 critical program areas: Hazardous Material (HazMat) Transportation; Highway-Rail Grade Crossing and Trespassing; Human Factors; Railroad Systems Issues; Rolling Stock Equipment and Components; Systems Performance and Analytics; Testing Facilities and Equipment; Track and Structures; Train Control and Communication; and Train Occupant Protection. 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; safe transportation of energy products; automation technology; predictive analytics; machine learning and artificial intelligence; accessibility; and workforce development.

Aligned with DOT's Office of the Assistant Secretary for Research and Technology's (OST-R) research goals, FRA research identifies and addresses safety issues across the railroad industry, including high-risk and long-term research. One example is the Autonomous Track Geometry Measurement System (ATGMS) project, where FRA identified and worked to address the need for automated track inspection. The project spanned a 15-year period (2002–2017) from proof of concept to deployment and commercialization. Sustained funding enables pursuit of specific research needs. FRA initially bears the costs and risks for research that the railroad industry is unable to pursue, but that lead to innovative solutions that may not have otherwise been realized.

Each division works 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 the modes. Research programs conduct stakeholder meetings, attend conferences and industry meetings, and facilitate program reviews to increase information sharing. RD&T publishes research to enhance T2 in the industry and inform the American public. In FY 2021 and FY 2022, RD&T will continue to mature its internal project evaluation practices. RD&T conducts internal and external project and program evaluation to inform the divisions about the effectiveness of research efforts. Going forward, RD&T will work to standardize project evaluation and integrate it with the R&D life cycle. The COVID-19 pandemic caused FRA RD&T to extend some research activities and adjust protocols related to equipment and facility.

FY 2021 RD&T Program Funding Details

RD&T Program Name	FY 2021 Enacted ($000)	Basic ($000)	Applied ($000)	Development ($000)	Technology ($000)
Railroad Systems Issues	$6,371*		$2,895	$1,534	$1,942
Track	$10,179		$3,768	$2,731	$3,680
Rolling Stock	$10,322*		$7,224	$730	$2,368
Train Control & Communication	$8,086		$3,680	$2,106	$2,300
Human Factors	$6,042*		$1,661	$3,120	$1,261
Totals	**$41,000***		$19,228	$10,221	$11,551

**Amounts include earmarks for Short Line Safety Institute ($2,500) in Human Factors, Safe Transportation of Energy Products ($2,000) in Rolling Stock and Research with Universities on Intelligent Railroad Systems ($1,000) in Railroad Systems Issues. Total amount includes $1,400 for facilities per reporting instructions. Total amount includes earmarks. Per OST-R template guidance, these numbers were not included in previous years.*

FY 2021 RD&T Program Budget Request by DOT Strategic Goal

RD&T Program Name	FY 2021 Enacted ($000)	SAFETY ($000)	INFRASTRUCTURE ($000)	INNOVATION ($000)	ACCOUNTABILITY ($000)
Railroad Systems Issues	$6,371*	$6,371			
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	**$41,000***	**$41,000**			

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Chapter 2 – FY 2021 RD&T Programs

Research, Development and Technology

Research Portfolio Overview

$41,000,000

Program Description:

The mission of the Federal Railroad Administration's (FRA) Office of Research, Development and Technology (RD&T) 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, FRA's RD&T program yields solutions that contribute to all DOT goals to advance infrastructure, innovation, and accountability.

Program Goals and Objectives:

Rail safety has improved over the last 10 years, with accidents trending downward. However, FRA remains focused on improving the safety of railways for the American public and rail workers. RD&T's main objectives are:

- To reduce incidents and accidents involving America's railroads, saving lives, and reducing environmental hazards.
- To promote innovation and facilitate leadership across the industry.
- To 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's objective has been to better understand the benefits and impacts of technology on safety and workforce development. Due to the increased impact of technology and automation on the railroad industry, RD&T has prioritized research in technology, like Positive Train Control (PTC) systems and issues, to provide needed solutions to 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. The problems FRA is solving include:

- Reducing accidents caused by human error
- Reducing track-related derailments
- Reducing incidents and accidents related to grade crossing and trespassing
- Investigating automation and technology

Critical Research Development and Technology Programs

RD&T strategically aligns its research with DOT, OST-R, FRA, and 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 innovation, infrastructure, and accountability. FRA research identifies and addresses safety issues across the railroad industry, including high-risk and long-term research. The sustained funding of FRA's research and development mission enables the pursuit of safety-specific research needs. This allows FRA to initially bear the costs and risks for research that 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, each contributing critical research, development, and technology to the industry:

- Railroad Systems Issues – Railroad Systems Issues and Research with Universities on Intelligent Railroad Systems
- Track – Track and Structures; Systems Performance and Analytics; and Research and Development Facilities
- Rolling Stock – Hazardous Materials; Safe Transportation of Energy Products (STEP); Rolling Stock Equipment and Components; and Train Occupant Protection
- Train Control and Communication – Positive Train Control and Grade Crossing/Trespassing
- Human Factors – Human Factors and 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/services. Activities that directly support technology development and implementation (Technology Readiness) are integrated with the research project life cycle through a continuum of planning, engaging stakeholders, identifying resources, and executing research activities. Over the past decade, RD&T has not seen an increase in budgetary dollars, requiring the divisions to begin working on user adoption prior to the start of research efforts, communicating the value and benefit of RD&T's research products.

Each division works with stakeholders to understand adopter (industry and stakeholder) needs and barriers to adoption. RD&T Program Managers (PMs) work internally and externally to identify and address barriers to adoption. An effective mitigation strategy used by FRA is creation of partnerships across the industry to increase the likelihood of adoption. RD&T PMs are the subject matter experts (SMEs) in their areas of research. As the SMEs in their area, each PM works with stakeholders (internal and external) in the industry to understand and develop new technology.

RD&T T2-related spend plans will be approximately $500K in FY 2021. 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 (NTL), Transportation Research Board's (TRB's) Research-in-Progress (RiP) database, U.S. DOT Repository and Open Science Access Portal (ROSA-P), and Transportation Research International Documentation (TRID) database after research is completed. This provides accessibility to the railroad industry's stakeholders and the American public. Information regarding RD&T's work can also be found on OST-R's Research Hub.

In 2017, RD&T produced 2 new products, filed 2 patents, worked with 16 small business and over 117 collaboration partners, published 29 Technical Reports/Research Results, and conducted 117 in-person webinars or presentations. In 2018, RD&T increased the production of research outputs through an improved publishing process. RD&T published 41 Technical Reports, 17 Research Results and 4 additional documents in 2018. In 2019, RD&T continued to increase public access to RD&T's research products. RD&T published 44 Technical Reports, 22 Research Results, and 3 additional documents in 2019 on FRA's eLibrary. RD&T submitted 44 Technical Reports, 22

Research Results, and 3 additional documents to the NTL, TRB 's RiP database, U.S. DOT ROSA-P, and TRID database for publishing. This table summarizes RD&T publishing efforts from FY 2017 to FY 2020.

Document Type	FY 2017	FY 2018	FY 2019	FY 2020
Technical Reports	25	41	44	52
Research Results	4	17	22	19
Other Reports	10	4	3	2
Total	**39**	**62**	**69**	**73**

The Foundations for Evidence-Based Policymaking Act of 2018 codifies the need for data to be more accessible both to the Department as well as the public. This increased access to data is intended to enable evidence-based policy making and improve transparency. As part of an intermodal collaboration across the Department, all new projects funded in 2021 under the research plan will be examined to identify if they are producing data and whether the data can be shared. To meet this end, FRA shall work with its partners in the other modes through the Data Working Group to establish consistent guidance:

- To establish standard data management plans to be incorporated into their research processes,
- To develop methods to register new research products in a timely manner under one of the existing Department catalogs (e.g. data, transportation.gov, ITS-JPO Data Hub, or equivalent modal catalog), and
- To work with partners in the modes to identify the technical assistance needed for project managers and awardees to effectively adhere to the above guidance.

In FY 2020, FRA conducted a data inventory which included collections across FRA. RD&T participated in the inventory and will identify which data can and should be shared as part of its research. Data that can be shared will be made publicly available through OST-R's Research Hub.

Collaboration Efforts

FRA's synergy with industry stakeholders and external research partners delivers accelerated information sharing and technology transfer to achieve safety goals. To guide FRA's investments, RD&T sets forth a research agenda defined by a clear set of priorities to investigate current and future safety issues.

Generally, RD&T's stakeholders are the railroad carriers, labor unions, railroad manufacturers, universities, FRA RRS, Federal Transit Administration (FTA), PHMSA, Federal Highway Administration (FHWA), ITS-JPO, and the American public (each research program will address these categories specifically). These stakeholder groups benefit from RD&T research through information sharing and transparency; development and testing of innovative technology; workforce development; 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. The beneficiaries of RD&T's research are the internal and external stakeholders, especially the American public.

Internal stakeholders, like 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 American railways and decreased fatalities over the last 10 years. External

stakeholders (e.g., railroads, labor unions) provide insights, trends, and data used to begin and prioritize research. These same stakeholders participate in research by providing expertise or equipment, providing feedback during research projects or as participants for research studies. Internal and external stakeholders consume RD&T research; implement training, establish standards, and adopt equipment suggested in RD&T research and development.

Partner Detail

Partner Name	Contribution	Benefit of Partnership
Universities across the U.S.	Expertise and research	Subject matter expertise and workforce development
American Public Transportation Association (APTA)	In-kind contribution; subject matter expertise, data	Provide data on noise emissions design features
Class I Railroads	In-kind contribution; subject matter expertise	Provide locomotive engine, duty cycle data; support testing activities
American universities	Subject matter expertise	Subject matter expertise
Railroads	Access to rail facilities	Subject matter expertise
American Short Line Regional Railroad Association (ASLRRA)	Subject matter expertise	Subject matter expertise

Benefits Detail

Beneficiary	Benefit(s) Received
FRA RRS	Improved safety standards/recommendations Improved science to improve standards and requirements in support of the Environmental Protection Agency's (EPA's) revisions to noise emissions limits for trains
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
Class I 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's program execution
- Facilitate the collection of feedback to improve project performance
- Assess achievement of target audience needs
- Assess and drive research investment decisions

RD&T's external project evaluation efforts help determine the effectiveness of research programs and their intended impact. The results inform project performance improvements and opportunities to increase RD&T's return on investment.

- In 2015, RD&T sponsored an external evaluation conducted by the TRB titled "Transportation Research Board Special Report 316 Evaluation of the Federal Railroad Administration Research and Development Program."

- RD&T is in the process of another TRB evaluation in FY 2020 and is piloting internal evaluation processes to improve its accountability to the American public.

To improve the effectiveness of performance management, RD&T conducted project evaluation training in FY 2019 to continue to grow its internal project evaluation capability and implemented new tools. RD&T remains committed to using performance measures to improve research and development throughout the life cycle process, with the goal of standardized performance measurement across the organization. As part of the pilot project evaluation practice, RD&T PMs are selecting or creating a metric to measure performance.

FRA will measure performance for T2 as part of the DOT Strategic Goal Innovation.

Development of Innovation:

- Increase the Development of Innovations in Transportation (OST)

Metric: Increase the Development of Innovations in Transportation		**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

Deployment of Innovation:

- Increase Effectiveness of Technology Transfer (OST)

Metric: Increase Effectiveness of Technology Transfer		**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 (TRL) 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 Topical Research Groups

RD&T participates in each of the OST-R Topical Research Groups to increase collaboration on research across the modes. In addition to participating in the Topical Research Groups, RD&T research impacts OST Topical Research area. This table highlights the areas that each research program addresses directly and indirectly.

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

USDOT Research Priorities

Economic Impact of Regulatory Reform

RD&T conducts research to improve railroad safety and provides data to support the activities of the RRS, including their regulatory reform efforts. Essentially, RD&T lays the foundation for regulatory reform and promotes decisions that are data-driven. Research conducted by FRA decreases the cost of complying with regulations. For example, innovations in automation resulting from FRA research enable railroads to decrease the economic burden of inspection, allowing the railroads to inspect more of the rail network for a lower cost. This reduction in burden is realized by reduced labor hours and track time, reduced equipment failure, or improved infrastructure—all resulting in fewer incidents. To maximize research resources, RD&T collaborates with RRS to align and prioritize project selection to focus research in areas of high concern and impact in support of regulatory reform.

RD&T conducts research that addresses the improvement of 49 *Code of Federal Regulations (CFR)* as outlined in this table:

Part #	Section Description
Part 213	Track Safety Standards
Part 215	Railroad Freight Car Safety Standards
Part 225.12	Rail Equipment Accident/Incident Reports Alleging Employee Human Factor as Cause
Part 228	Hours of Service of Railroad Employees
Appendix F Part 229	Recommended Practices for Design and Safety Analysis
Part 231	Railroad Safety Appliance Standard
Part 232	Brake System Safety Standards
Part 234	Grade Crossing and Signal System Safety
Part 236	Subpart I Positive Train Control Systems
Part 238	Passenger Equipment Safety Standards
Part 239	Passenger Train Emergency Preparedness
Part 270	System Safety Program
Part 924	Highway Safety Improvement Program
Appendix E to Part 236	Human Machine Interface (HMI) Design

Economic Impact of Permitting Reform

RD&T's research does not address the economic impact of permitting reform.

Performance-Based Regulations and Safety

RD&T research programs address performance-based regulations across multiple research areas. The Train Control and Communication research program develops performance-based specifications and standards for Positive Train Control (PTC) safety systems and establishes the methodologies and procedures for data collection, monitoring, and analyses to improve safety and performance. The Track research program focuses its efforts on developing the scientific basis for removing prescriptive-based regulations and moving toward performance-based regulations. Rolling Stock program staff engage stakeholders across the industry to address performance-based regulations as they relate to research, including tank cars, hazardous materials, wheel failures, high-speed rail, and glazing systems to reduce fatalities. Each research program is working with RRS and other transportation modes to research best practices and new approaches to improving safety.

Potential Impact of Asset Recycling
Research activities include the acquisition of tank cars and tank car pieces involved in derailments. These tank cars and pieces are acquired from the railroads after an incident and moved to the Transportation Technology Center (TTC) for further research and analysis to determine the potential causes of the incident. At the completion of the research, tank cars and pieces are sold as scrap materials.

Potential Impact of Value Capture
RD&T's research does not address value capture.

Improving the Mobility of Freight
Each RD&T research program improves the mobility of freight on America's railways. RD&T's research efforts help improve infrastructure and introduce innovations that contribute to improving the mobility of freight. Research by the Track and Rolling Stock programs to prevent the derailment of trains significantly affect mobility. Rolling Stock's research on the early detection of rail wheel defects reduces the risk of an accident caused by that type of defect. PTC research conducted by the Train Control and Communication division allows for the faster delivery of people and goods by rail. Research on very long trains conducted by the Rolling Stock research program supports the economic competitiveness of railroads while maintaining safe operations, improving the mobility of freight by identifying risks and developing strategies for mitigating those risks.

Feasibility of Micro-Transit
RD&T's research does not address micro-transit.

Improving Mobility for Underserved Communities
RD&T structures research to address high-priority problems wherever they may occur. Although RD&T programs impact short line railroads, which have a higher concentration in rural areas, programs have not historically been geographically focused. Autonomous track inspection programs conducted by the Track program included short lines to identify high-risk derailment locations. PTC research is improving the safety of all communities, including rural and underserved communities. RD&T research will inform FRA of rural and underserved areas' unique concerns and challenges which will aid in project prioritization and planning to consider these challenges in the future. The Research with Universities on Intelligent Railroad Systems project will provide preference for projects that implement technology in rural areas (see the Program/Activities section) to improve the mobility of underserved communities.

Cybersecurity
Train Control and Communication's research includes cybersecurity and focuses on securing the communication and ensuring authentication of sender and receiver of PTC communications. Multiple PTC research efforts address cybersecurity in coordination with the individual railroads, the railroad industry as a whole, and with the U.S. Department of Homeland Security.

COVID-19 Impacts
The COVID-19 pandemic has affected FRA RD&T research, including those conducted at TTC and Volpe, which house test facilities and equipment. RD&T is working with Volpe to define safe operating procedures for FRA simulators. At TTC, the DOTX-216 railcar was sanitized after a contractor exhibited potential signs of COVID-19. The contractor was quarantined for 14 days, delaying testing. Consequently, procedures to enter TTC have been adjusted to ensure all personnel are screened for COVID-19-related symptoms. FRA extended the period of performance end dates for all grants and over 25 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.

Safety Band Radio Spectrum

Changes to the Safety Band Radio Spectrum may impact Rail Crossing Vehicle Warning research. The Train Control and Communication research program has partnered with Honda, Inc. to conduct research on the safe traversing of grade crossings. RD&T is taking the lead on grade crossing safety for connected and automated/autonomous vehicles.

Railroad Systems Issues
$6,371,000

Program Description:
The Railroad Systems Issues (RSI) research program defines the strategy that directs the entire RD&T program toward the goals set forth by the Department of Transportation (DOT), the Office of the Assistant Secretary for Research and Technology (OST-R), FRA, and the Office of Railroad Policy and Development (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.

FRA's 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 the Office of Railroad Safety (RRS) to understand their strategic goals, safety data and trends, and requirements/needs to prioritize research to reduce safety risk.

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; TRB's independent evaluation recommendations; workforce development; RD&T-related technology transfer and travel; operations, maintenance, and equipment at the Transportation Technology Center (TTC) facilities in Pueblo, CO; and contractor support.

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:
RSI research program activities are tailored to address relevant railroad issues, spanning the spectrum from safety to workforce development.

Program Area - Railroad Systems Issues $3,521,000

Rail Safety Innovations Deserving Exploratory Analysis (IDEA)
IDEA is a project whose objective is to solicit 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
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 criteria and provides guidelines for eligibility and preparing and submitting proposals. The TRB Safety IDEA review committee will evaluate proposals on a competitive basis. The Rail Safety IDEA program committee will evaluate those proposals meeting the technical eligibility criteria. 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.

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

Project Selection

The objective of RD&T project selection is to conduct an annual prioritization to effectively manage project budgets and ensure that stakeholder and industry needs are factored into the RD&T investment planning process. In addition, DOT priorities and safety priorities, especially those provided by FRA RRS, are a major input into the process.

Anticipated Activities

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 the improved rating process to candidate research projects for FY 2022 (Oct–Dec timeframe). Each research program will use lessons learned and results to inform 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 four DOT Strategic Goals—Safety, Infrastructure, Innovation, and Accountability. RD&T strategies also align to USDOT's Strategic Goals and Related Research Topic Areas Safety (Automation, Systemic Safety Approach, and Human Factors), Infrastructure (State of Good Repair, Environmental Stewardship, and Economic Completeness), Innovation (Emerging/Enabling Technologies, Mobility Innovation, and Cybersecurity), and Accountability (Technology Transfer/Deployment, Evaluation/Performance Measurement, and Data).

Anticipated Activities

RD&T will continue implementation of its 5-Year Strategic Plan 2019–2023. The strategies build on current successes and take further steps to increase the awareness/communication of industry needs and problems, and adoption and deployment of FRA solutions, products, recommendations, and research data.

RD&T Technology Transfer (T2)

The objective of RD&T's T2 is to engage stakeholders and increase user adoption and 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 executes collaborative stakeholder engagement activities, seeking T2 and adoption of innovative concepts and methods that will enhance safety and performance for railroads.

Program Support

The objective of program support is to provide analysis; subject matter expertise; strategic planning and advice; data, records, and information management; project, program, and 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 editor team will review papers, reports, results, and other material. The editors will edit research related material and provide publishing related social media content to 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
FRA RD&T Program Managers (PMs) conduct internal and external project evaluations to assess and improve the value of research activities. PMs document the answers to critical evaluation questions throughout the life of their acquisitions. Goals of PMs' project evaluation activities include: demonstrate significance, value, and impact of RD&T's research in improving railroad safety; assess 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; assess and promote the transfer of technology to the private sector.

Anticipated Activities
RD&T will formalize its project evaluation practice. RD&T will continue project evaluation training. RD&T will use and create project evaluation tools. Each research program will continue implementation of RD&T's project evaluation methodology. As part of research activities, RD&T will conduct project evaluations and optimize RD&T's performance management metrics. RD&T will review and address TRB's Program Evaluation letter and report. RD&T may conduct follow up meetings with TRB to discuss the committee's findings and recommendations.

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 related to Broad Agency Announcements (BAAs), which support topic areas for each of the five divisions. The announcement describes the program and criteria and provides guidelines for eligibility and submitting proposals.

Workforce Development (WFD)
This research provides support and domain expertise in the areas of railroad WFD to adequately identify suitable approaches for both the management and capture of rail workforce-related trends and respond to DOT data calls. This research increases the awareness of railroad industry WFD issues by establishing and/or participating in forums and research efforts to foster and support industry collaboration. As part of this effort, FRA has an interest in the workforce development in the railroad industry and impacts of automation and emerging technologies.

Anticipated Activities
RD&T will participate in the DOT Education and Workforce Development Community of Practice (on behalf of FRA) and in FRA's strategic human capital planning and implementation activities. In addition, RD&T will conduct research and publish an update to the railroad industry workforce assessment (known as the Modal Profile). RD&T will capture and analyze workforce data on trends, skill gaps, skill demands, training opportunities, industry best practices, and cross-modal efforts.

Energy and Emissions

As new technology is developed to improve the emissions and efficiency of rail transportation, research is needed to evaluate that such technologies are not only effective but safe. Some passenger rail service providers are considering the use of hydrogen as a zero emissions, more efficient alternative to diesel fuel. Research on the structural requirements for hydrogen fuel containers and their safety features is needed. The efficacy of current Code of Federal Regulation (CFR) standards to address and ensure the safe use of such fuels will be analyzed and decisions made to adjust accordingly. The research provides FRA RRS with the scientific basis for decision-making and development of standards and requirements. FRA will collaborate with other Federal agencies to ensure safe use of the energy products.

Anticipated Activities

RD&T will continue to research the impact and applicability of alternative fuels such as natural gas and hydrogen for rail applications. RD&T will collaborate with the railroad industry to identify standards and best practices for fuel storage for a dynamic rail environment. RD&T plans to identify safety features necessary for safe use and transportation of such fuel types. RD&T will provide guidance to RRS on performance of such equipment under normal and accident scenarios.

Accessibility

Passenger rail transportation is the most optimal form of public transportation for most people who use mobility devices. Accessibility research has yielded recommendations for improved accessibility on passenger rail cars, 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 rail cars. Research will be conducted on the relative movement of wheeled mobility devices and its occupant in various seating configurations in low-speed collisions. RD&T research will also focus on further assessing the recommendations for new standards for accessibility on rail vehicles being considered by the U.S. Access Board. RD&T will engage with the U.S. Access Board and disseminate research results that can be used to inform the standards development process.

Anticipated Activities

RD&T will continue testing of rear and forward-facing wheeled mobility devices (WhMDs) and its occupant in low-speed train-to-train collision. RD&T will assess the current state of art securement systems for WhMDs on board trains. RD&T will engage with the U.S. Access Board as they consider rulemaking recommendations for improved accessibility on passenger rail equipment considering larger space, maneuverability in restrooms, and communication systems. Results from RD&T investigation—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 the efficient transportation of goods and people. This research area addresses the DOT Strategic Goal of safety and innovation and the DOT RD&T Critical Transportation Topics of promoting safety and preserving the environment.

Anticipated Activities

RD&T will complete an assessment of technological innovation using high-pressure heat exchangers in a real-world environment. RD&T plans to complete 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 subject matter expert (SME) consultation, research, data, and tools to improve railroad safety and reduce accidents and incidents. RD&T's collaboration with RRS provides insight into research needs. RD&T's support of RRS assists FRA with responding to time-sensitive safety issues.

Anticipated Activities
RD&T will continue to partner with RRS and industry on Railroad Information Sharing Environment (RISE). RD&T will conduct research of urgent safety issues identified by RRS or Congress. RD&T will continue to provide SME support to RRS.

Note: This funding will come from multiple divisions.

Public, Private, and University Cooperative Research Agreement $450,000
The objective of this research is to collaborate with industry and academia on research opportunities to fund proposals that have the potential of improving safety and performance in railroad systems in the following areas: Track, Rolling Stock, Train Control & Communication, and Human Factors. All selected proposals have the ultimate goals of improving railroad safety and performance, enhancing the infrastructure conditions and services by stimulating economic growth, productivity and workforce development, and serving the nation with reduced regulatory burden and greater efficiency, effectiveness and accountability. This effort includes a cost-share arrangement with AAR (contributing approximately $800K annually) and significant in-kind support from the railroad industry.

Anticipated Activities
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.

Note: This funding will come from multiple divisions to support their research. A total of $2M across all of RD&T will be provided to this research.

Program Area - R&D Facilities and Equipment - TTC $1,400,000
The primary objectives of this funding are to maintain the one-of-a-kind infrastructure at the TTC to accommodate the testing and evaluation of intelligent railroad systems 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, the TTC is a key enabler of national research, 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 that it can adequately support research and testing requirements.

Anticipated Activities
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. Continue the enhancement of TTC's capabilities through strategic investment to existing facilities and equipment to support upcoming research and testing needs. Continue the refurbishment of the rail system at the TTC by replacing track materials such as rail, concrete and wood ties, switch components, anchors, spikes, etc. to refurbish all major tracks and yards track at the TTC. Support environmental and green technology goals encouraging energy efficiency, use of renewable energy, reduction of toxins, recycling, reuse of materials, and water conservation.

FRA will raise awareness and encourage broader use of the TTC facilities through creative outreach efforts to other Government agencies and the private sector, while ensuring priority for FRA-sponsored activities and providing fair access to the TTC facilities.

Program Area - Research with Universities on Intelligent Railroad Systems $1,000,000
FRA will use 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. Program objectives within this project include enabling safer vehicles and roadways; enhancing mobility; limiting environmental impacts; promoting innovation; and supporting transportation connectivity. The BAA is produced in collaboration with the Intelligent Transportation Systems – Joint Program Office (ITS-JPO).

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

*This 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 2021.

Expected Program Outcomes:

Rail Safety Innovations Deserving Exploratory Analysis (IDEA)
RD&T will continue to develop new research and complete existing research (based on timelines) to deliver innovative solutions. With multiple research activities each year, the outcomes for the Rail Safety 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.

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

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 Program Managers (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 Annual Modal Research Plan (AMRP) in FY 2022.

Strategic Planning
RD&T will continue to improve research project evaluation and technology transfer reporting. RD&T will coordinate program reviews and stakeholder engagement activities to begin planning for the next strategic plan.

RD&T Technology Transfer (T2)
RD&T will increase information sharing, partnerships, and utilization of the TTC. The technology transfer activities will be focused on improving awareness and use of RD&T research, standards, recommendations, and products.

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 and outcomes.

Project Evaluation
RD&T implemented internal project evaluation practices in FY 2020. In FY 2021, all RD&T divisions will document measures such as project success and project performance, cost reduction, and railroad safety improvements. Expected outcomes include increased maturity of RD&T's project evaluation practices.

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. The outcome depends on BAA selections.

Workforce Development (WFD)
RD&T will continue to engage and collaborate with the railroad industry for a better understanding of WFD trends to address railroad industry economic competitiveness (DOT Strategic Objective 4 for Infrastructure). The work includes stakeholder outreach, collecting workforce data via surveys, and conducting trend analyses. In 2021, RD&T will complete an updated railroad industry workforce assessment (known as the Modal Profile) and publish research results. RD&T will participate in internal and external data calls and FRA workforce development and human capital initiatives.

Energy and Emissions Safety Research
RD&T will assess safety issues related to hybrid systems, including battery technology and heat exchangers and fuel cell technology in railroad application for propulsion. The assessment will identify safety research needed to progress safe use of alternative fuels to move passengers and goods. Further development of Rail Module in the GREET (Greenhouse gases Regulated Emissions and Energy use in Transportation) Model will provide the rail industry with a multi-modal tool that can be used to assess emissions and energy use of different fuel pathways.

Accessibility
Research has shown that row-to-row seating protects passengers by containing them between their seat and the seat in front of them by reducing their travel distance during sudden deceleration of the train. Such protection is not afforded to passengers in WhMDs situated in an open bay-accessible location. RD&T will conduct testing of a rear- and forward-facing WhMD and its occupant in a low-speed train-to-train collision to yield data on the relative motion of WhMDs and occupants in non-contained spaces. Data will be used to develop guidance on containment and/or securement of WhMDs.

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 obtain knowledge of 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 (RRS)
RD&T provides RRS with improved science to drive standards and requirements development, and support compliance of emissions limits for both passenger and freight equipment. All RD&T divisions support RRS by providing subject matter expert (SME) consultation, research, data, and tools to improve railroad safety and reduce accidents and incidents. Research results will analyze safety risks and identify mitigations to those risks. Collaboration and research will yield growth and maturity of the Railroad Information Sharing Environment (RISE) project.

Note: Funding will come from multiple RD&T divisions to support RRS research.

Public, Private, and University Cooperative Research Agreement
RD&T published the BAA for this research in 2019. In 2021, RD&T continues partnerships with AAR to support universities. The continued research projects focus on advanced technology, automation, and connected vehicle technologies; advancing technologies for rural application; and workforce development. In late FY 2020, RD&T will begin to award contracts using a BAA. Expected deliverables include final research reports, project management documents, and progress reports. Technology transfer of 2020 efforts (based on project schedule and duration of each effort) is also expected.

R&D Facilities and Equipment –TTC
RD&T will continue development and application of new technology at the TTC for Federal agencies and others involved in rail transportation. Use of the 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 the TTC.

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

Note: Activities and outcomes are similar to previous fiscal years because equipment and facilities assessment take place each fiscal year.

Research with Universities on Intelligent Railroad Systems
Research with universities on Intelligent Railroad Systems (IRS) focuses on advanced technology, automation, and connected vehicle technologies. The contracts in this area are starting to be awarded; the research will address intelligent transportation systems as well as technologies for rural application to enhance mobility and promote innovation. T2 of 2019 and 2020 efforts (based on project duration) is also expected. The BAA was produced in collaboration with the Intelligent Transportation Systems – Joint Program Office (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 the issues and needs of the railroad industry. RSI research collaboration partners include the railroads, labor, manufactures/suppliers, universities, non-profits, private industry, city/State/Federal Government DOTs, and DOT OAs. RSI is considering tracking stakeholder input.

Partner Detail

Partner Name	Contribution	Benefit of Partnership
TRB	TRB collaborates with DOT modes to improve innovation and technology within the transportation industry; free membership	FRA 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. Free registration, for all FRA members, to attend the TRB annual conference. Free membership to receive TRB publications and a free FRA booth at the TRB annual exhibit.
Universities across the U.S.	In-kind contributions; subject matter expertise and research	Provide locomotive engine, duty cycle data; support testing activities; subject matter expertise; and workforce development.
Amtrak	In-kind contributions; subject matter expertise, peer review	Provide data on noise emissions design features.
California High Speed Rail Association	In-kind contribution; subject matter expertise	Provide data on noise emissions design features.
American Public Transportation Association	In-kind contribution; subject matter expertise, data	Provide data on noise emissions design features.
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
California Department of Transportation	In-kind contribution; subject matter expertise	Funding; subject matter expertise
U.S. Department of Energy	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	Benefit(s) Received
FRA RRS	Improved safety standards/recommendations Improved science to improve standards and requirements in support of EPA's revisions to noise emissions limit for trains.
Rail industry	Improved safety standards/recommendations Lower operating costs Improved visibility for railroad workers and grade crossings Reduced railroad accidents and fatalities Reduced regulations

Beneficiary	Benefit(s) Received
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.
Class I railroads	Standardized matrix to determine most efficient technology for improved energy and efficiency of locomotive engines.
EPA	Improved guidelines for noise emissions limits
High-speed rail operators	Design guidance manual will permit quantifying and mitigating the aerodynamic effects of high speed trains.

Track
$ 10,179,000

Program Description:
The Track research program prepares for the future of rail transportation through applied research, development, and demonstration. As new technologies emerge, and train axle loads and speeds increase, the timely development of technical information, data, and expertise is crucial to provide a basis on which to make decisions about issues affecting the safe operation of rail vehicles on U.S. track. The Track research program supports the goals and objectives of the DOT/FRA Administration; 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. There are three primary research areas included in the program:

- Track structures and components,
- Systems performance and analysis, and
- Operation of research assets, including the DOT TTC facility.

Program Objectives:
FRA's RD&T Track research program conducts scientific and engineering research to reduce derailments and improve railroad safety. The objective of this research is to provide the scientific and engineering basis for safety rulemaking and enforcement while ensuring rules are appropriate and defendable. The program fosters collaboration with the railroad industry to develop and implement new technologies and practices to improve overall system safety and safety-related standards. The Track research program aims to prevent high-consequence derailments that result in the loss of human life and cause significant damage to property and communities.

Anticipated Program Activities:
Program Area - Track and Structures $6,551,930

Track and Structures – Rail Performance
Broken rail 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 continues to gather rail defect donations from at least three Class I railroads, characterize these defects, and adds them to the FRA rail defect library at the TTC for use by the entire research community in developing better detection systems. RD&T will refine towards commercialization and automation of detection protocol for ultrasonic rail inspection as human variability hinders the inspection consistency. RD&T will refine towards commercialization of a unique 3D rail flaw imaging technology 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 understanding and data on defect growth inside of rail welds, a frequent point of failure. RD&T will continue to collaborate with industry, researchers, TTCI, and FRA to reduce or eliminate rail performance and flaw detection issues.

Track and Structures – Track Inspection Technology and Processes
This research addresses inspection technology and processes to improve track safety and decrease derailments through technology research that yields effective methods to detect and mitigate track safety risks, the development of data-driven technologies and innovations aimed at real-time decision making, and the development of automated track change detection technologies to enhance track inspection effectiveness.

Anticipated Activities
RD&T continues R&D of change detection technology suitable for deployment on manned, autonomous, and unmanned aircraft inspection platforms. This technology will automate data analysis of track inspections to determine safety related changes to the track structure and will report this information to stakeholders with limited human intervention. RD&T will continue developing innovative approaches to imbed sensors and detection and communications technologies within the track structure to allow for a type of self-enunciation when conditions warrant remedial maintenance or pose a threat to safe rail operations. Additional research is planned to improve track component designs and to detect failures of components in track.

Track and Structures – Special Activities
This research area is focused on improving safety and state-of-good-repair of bridges, structures, track design, and special track work. The scope of this research includes collaborative projects with industry, including AAR.

Anticipated Activities
This research will continue development of technology to help categorize the type (train traffic, vehicle, maritime, etc.) and magnitude of bridge impacts to quantify the nature of bridge strikes. RD&T will continue R&D of wireless smart sensor technology to automatically assess the response of bridges to rail traffic to highlight safety issues; advance the prototype wireless bridge condition monitoring system to near commercial status; and execute technology transfer through industrialization partners. RD&T will develop intelligent robotics to inspect rail bridges, thus eliminating the safety risk to track personnel. Robotic devices can perform cleaning and other "hands-on" activities that are not possible with drone aircraft. Under this research area, RD&T is also evaluating use cases for unmanned aerial vehicle (UAV) technology to improve railroad safety. These activities are coordinated with the Federal Aviation Administration (FAA) and involve relationships with rail industry, including BNSF.

Track and Structures – Track Stability
Buckled track derailments are rare, but when they happen, they cause significant damage at a high cost. This research area focuses on understanding and preventing track buckles through applied research, awareness tools and development of rail force measurement technologies.

Anticipated Activities
To prevent buckled track derailments, RD&T will continue to develop technologies that measure rail stress without a reference. In addition, RD&T will develop video trainings and software to help the railroad industry better manage rail force and prevent track buckles. Finally, RD&T will invest in the design of a rail force test bed at the TTC in partnership with the AAR 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 seeks to conduct track research and testing aimed at preventing high-consequence derailments caused by track and structures fatigue and failure.

Anticipated Activities
RD&T is continuing revenue service testing focused on the effects of various (and often inter-related) factors on the integrity of the track system. RD&T will investigate root causes of potential issues that may arise during FY2021 affecting safe heavy axle load (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.

Program Area – Systems Performance and Analysis $3,227,070

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 artificial intelligence (AI) to improve track safety and decrease derailments.

Anticipated Activities
RD&T will continue research efforts related to establishing methodologies for the evaluation of track inspection technology effectiveness and initiate processes to incorporate as a recommended practice. In 2021, RD&T will continue research efforts focused 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 also continue with the development of automated procedures for the alignment, processing, and reporting of autonomous track geometry measurement systems (ATGMS) data for predicting areas approaching maintenance and safety limits.

System Performance and Analysis – Vehicle Track Performance
The goal of this research is to better understand how track and train interact and how infrastructure reacts with vehicles, given the industry trend toward higher loads or faster service and to provide tools and guidelines for vehicle/track qualification and wheel/rail contact condition evaluation.

Anticipated Activities
RD&T will initiate and continue construction of the curved test track. RD&T 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, and third body layer on wheel-rail contact forces. RD&T continues to examine the effects of wheel/rail contact conditions on the development of rolling contact fatigue (RCF) for wheel/rail. RD&T will conduct testing and modeling of vehicle suspension components. RD&T will continue to support building of vehicle and track models for various equipment and operating practices to be used for derailment investigations or developing safety.

Public, Private, and University Cooperative Research Agreement $400,000
See page 16 in 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 refine a prototype towards commercialization that displays 3D images of internal rail flaws. Research will yield improved capabilities of non-contact rail integrity inspection systems; expand the rail flaw library at the TTC; and improve 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. Collaboration Partners in this work include: TTCI; Lehigh University; Tuskegee University; Harvard University; University of California, San Diego; University of Texas, Austin and others (for more detail on each partner, see pages 27-28).

Track and Structures – Track Inspection

This research addresses inspection technology and processes to improve track safety and decrease derailments. In 2021, RD&T will initiate project(s) to develop beyond visual line-of-sight (BVLOS) capabilities for drone-based railroad track inspection. Research will include limited BVLOS demonstrations using drone-based track change detection technology. Other projects will include expanded field testing and demonstration of change detection technology on in-service rail lines. RD&T will begin field testing and demonstration of systems that will self-enunciate track safety issues. Spike failure research will be completed and results transferred to industry. RD&T will initiate field testing of an automated system for the detection of failed spikes in wood-tie track.

Track and Structures – Special Activities

This research focuses on improving safety and state of good repair of bridges, structures, track design, and special track work. An early prototype of bridge impact and characterization technology will be developed. Field testing and demonstration of a wireless bridge condition monitoring system will continue with cooperation and participation from railroads. Small Business Innovation Research (SBIR) projects to leverage UAVs for grade crossing inspections will progress to Phase 2 development. RD&T will initiate a new SBIR project to develop robotic technology for bridge inspections to reduce the need for human inspection in hazardous environments.

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 create rail adjustment software and trainings to reduce errors in rail adjustments that can lead to track buckles or rail breaks. RD&T will work collaboratively with industry and the AAR to design a rail stress test bed at the 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. Collaboration Partners in this work include University of Illinois Urbana-Champaign; Purdue University; University of South Carolina, Columbia; TTCI and others.

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. Outcomes further include improved inspection systems with refined criteria for detection of 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 implementation of improved quality assurance criteria and measurements for ballast consolidation after maintenance.

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 implementation of a machine vision-based ballast inspection system mounted on a moving platform capable of performing continuous track inspection

System Performance and Analysis – Predictive Analytics
In 2021, RD&T will begin to implement an automated decision-making tool that will align, segment, process, analyze and report on ATGMS data, to predict areas approaching maintenance and safety limits, in partnership with an operating railroad. As part of this effort, RD&T will also initiate subsequent field investigations into root causes on chronic degradation issues observed in the generated reports. A guidance document will be completed to establish a uniform approach for the design and execution of performance evaluation testing for track inspection technologies. Research efforts will continue to focus on the application of AI into track-related safety inspection techniques. Collaboration Partners in this work include Metro-North Railroad, Rutgers University, and TTCI. New partners will be gained through the use of SBIR and BAA acquisitions forthcoming.

R&D Facilities and Equipment – FRA Research Assets – On-Track Research and Testing
The TTC will expand testing using the "rainy section" at the facility to investigate weld strains, ballast behavior, and failures associated with progressively deteriorated track support. RD&T plans to initiate a long-term study investigating the effects of varying track parameters on rail neutral temperature loss and remediation. The TTC will conduct an evaluation of improved running-surface design for turnout frogs to improve overall dynamic performance and reduce impact loads.

System Performance and Analysis – Vehicle Track Performance
This research area focuses on all aspects of vehicle/track interaction safety. RD&T will establish root causes of RCF and wheel/rail surface damage and a method to effectively evaluate the depth of RCF to help in grinding and removal of RCF. In 2021, RD&T will publish 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 different components, friction modifiers, and suspension elements for modelling vehicles for evaluating vehicle performance. RD&T will conduct testing and simulations for RRS in vehicle qualification. RD&T will assist RRS in testing and qualification of FRA track geometry measurement systems. Also, RD&T will finish design and construction of the curved test track at the TTC and start demonstration testing using this track. Collaboration Partners in this work include, AAR, TTCI, FRA RRS, Amtrak and other passenger operators, and the APTA.

Collaboration Partners:

Partner Detail

Partner Name	Contribution	Benefit 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 (CN)	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 (WNYP)	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 (ISRR)	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	Real-world testing
Toledo, Peoria, & Western Railway (TZPR)	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	Real-world testing
Illinois and Midland Railroad (IMRR)	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 (IORY)	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	More realistic testing than in a laboratory
BNSF Railway	Track materials for test bed	More realistic testing than an average laboratory set-up
Edison Welding Institute (EWI)	Test facilities and data collection	Professional laboratory results without having to pay for new laboratory equipment
Massachusetts Bay Transportation Authority (MBTA)	Real-world on-track testing grounds and equipment	Real-world testing
Three Class I Railroads	Donations of rail defects	Real-world testing
Norfolk Southern	Test location and track time	Realistic testing environment
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	Provide 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, and test activities, reliability, and productivity	Testing and training expertise, support, and operation and maintenance of TTC

Benefits Detail

Beneficiary	Benefit(s) 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), and the safe use of alternative fuels, and new engine and energy savings technologies that focus on preserving the environment. Results of this R&D 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. 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 (HazMat) $1,448,525
The Hazardous Materials program area fosters innovation throughout the industry, helping to develop new regulations and design standards that improve the safety and integrity of tank cars and other packages carrying hazardous materials. Hazardous materials research aids the continuing growth of new research programs that satisfy the needs of industry and government.

HazMat – Tank Car Research
The Tank Car research area develops and improves the packages that carry hazardous materials, helping to reduce the release of material, and minimize the consequences during rail accidents and incidents.

Anticipated Activities
RD&T will continue to disseminate prior nondestructive evaluation (NDE) probability of detection (POD) results/findings among tank car research stakeholders and conduct a feasibility study to identify the capabilities/limitations of new and advanced NDE methods for tank car inspections. RD&T will continue to investigate the effects of corrosion on railroad tank car structures, and the potential use of state-of-the-art NDE methodologies for remaining tank car shell thickness measurement. Investigations will include gathering information on the newer types of tank cars and the common failure modes and determining if newer weld test panels are needed for future POD studies.

RD&T will continue researching industry tank car impact. This research will develop and improve test methods, provide data for improving modeling methods, design, and construct test fixtures, and

prepare and test various tank car designs. In addition, RD&T will continue to analyze and provide the data for validation of finite element analysis models and report on test and model results.

RD&T will continue research on the analysis of collected impact test data to arrive at limiting conditions for coupling speed and impacting mass. RD&T has shown that high magnitude coupling forces that occur in yard operations have the potential to exceed yield limits of mild steel. RD&T partnered with Union Tank Car and Amsted Rail to complete a comprehensive test program to characterize tank car load environments at Amsted Rail's test facility in Camp Hill, PA. Additional testing will focus on brake system performance in revenue service operations.

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

Anticipated Activities
RD&T will continue to evaluate puncture resistance of various tank cars of the DOT 113 design in standardized shell impact scenarios and examine effects of parameters such as support conditions, impactor size, etc. on shell puncture. RD&T will continue to develop computational models of tank car designs under impact conditions and compare test data with model results to validate models.

RD&T will continue to develop design strategies for improving the structural crashworthiness of passenger rail cars relative to existing designs. RD&T will continue to develop specifications and regulations and support various waiver requests and evaluations of compliance with FRA regulations. RD&T's current focus is on side structure integrity criteria and side strength requirements for various passenger equipment designs.

HazMat – Accident Consequence Reduction
The Accident Consequence Reduction Research Area studies the loading and unloading practices of hazardous material to improve the operating practices and securement of the package for safe transportation and reducing non-accident releases.

Anticipated Activities
RD&T will continue to evaluate the performance of top fittings protection used on current tank car designs, particularly those used in unit trains carrying flammable materials, under rollover conditions. RD&T will conduct this research through a series of analytical simulations and full-scale rollover tests. RD&T will continue to document (by scale testing under nominal fire conditions) pressure relief value (PRV) 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 will focus 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 (UN) standard T75 (UN-T75) portable tank to obtain experimental data, based on the results obtained on Phase I and II. Phase I provides 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. Phase II repeats Phase I test with LNG in the test tank, instead of liquid nitrogen. This will make improvements to internal instrumentation, including several floating temperature measurements which will be used for future computer model validation. Phase II test will be conducted Fall 2020.

Safe Transportation of Energy Products (STEP) $2,000,000*
The STEP program area assesses the operational safety risks associated with hazardous material unit trains and focuses on determining whether unit train operation of hazardous materials presents any unique or additional risks.

*This funding is an earmark provided annually by Congress for STEP. This is in addition to the total budget for FRA RD&T. If Congress chooses NOT to fund the $2M earmark, this activity will not be executed in FY 2021.

Anticipated Activities
Research in this area helps assess the operational safety risks associated with hazardous material unit trains and will focus on determining if unit train operation of hazardous materials presents any unique or additional risks compared with unit train operations of non-hazardous materials or mixed-freight operations involving the same hazardous materials as currently or planned for transportation in unit trains. 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 to 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. This effort will be performed according to the proposed draft AAR standard: Natural Gas Fuel Tender Specifications, M-1004.

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

Anticipated Activities
RD&T will review railroads' natural gas fuel usage programs and develop standards for a natural gas fuel tender. LNG and compressed natural gas (CNG) are viable alternatives to diesel fuel. There are prototype service utilizations of natural gas (LNG and CNG) in the railroad industry. The research provides FRA's RRS with the scientific basis for decision-making and development of standards and requirements. RD&T will collaborate with other Federal agencies to ensure use of the energy products are safe.

*This funding comes from Congress and it is not included in the FY 2021 appropriations. Funding will be spent on LNG if RD&T has carryover from the last appropriation.

Program Area – Rolling Stock Equipment and Components (RSEC) $3,406,399
Research efforts in the Rolling Stock Equipment and Components program area focus on the development and improvement of equipment defect detection and control. Both wayside and on-board detection and control systems offer diverse platforms for such research and demonstration.

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 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. Research efforts will enhance strategies to reduce adverse effects of extended train length on operational safety, crew attention issues during potentially lengthy terminal tests and train dispatch inspections, as well as, fatigue/attention issues when performing operations on long 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.

Research efforts will help identify brake systems that are functioning improperly by detecting wheels that are inappropriately hot or cold; and, assess the implementation of wheel temperature detector (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 to develop a database for maintaining pilot study data supplied by railroads for the WTD system and car maintenance as well as developing methodologies for data analysis to support the Test Waiver Committee. Research efforts will enhance data analysis to support the evaluation of the performance of the waiver pilot study as it relates to meeting the success criteria established for the waiver pilot study (including WTD alerts and associated repair records).

RD&T will continue efforts to reduce wheel failures, including researching 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.

Research efforts will study the effects of contact pressure, slip ratio, lubrication, and temperature on the development of rolling contact fatigue (RCF) cracks and wear of railway wheels. In addition, RD&T will investigate how temperature at the wheel-rail interface can affect wheel surface performance. Research efforts will investigate the properties of grease degradation related to bearing performance across all bearing types and grease types over the life cycle of in-service bearings. RD&T will also determine the best location in the bearing to sample bearing grease, as determined by the worst grease condition; and, demonstrate if it is possible to identify the grease metrics associated with bearing failure modes based on grease sampling and state-of-the-art statistical methods.

Research efforts will test the ability of the current baseline bearing rubbing lip seals versus the frictionless seals to prevent water ingress over the life of the bearing. RD&T will determine if water ingress will occur in revenue service bearing seals through environmental fluctuations and

correctly identify fretting corrosion, as differentiated from water damage, and mitigate it in revenue service.

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 volts DC interface to safety and security devices where desired. RD&T completed a full-scale field test of the EPSS on a one locomotive and eight-car freight train. RD&T will continue to develop and integrate a modern, powered, communications and control eco-system for freight vehicles. RD&T will determine communication and control platforms that might be applicable for railroad use. RD&T will continue to design and build a three-car test rack for studying the selected prototype ecosystem platform and utilize the EPSS test rack to minimize build costs and utilize the test rack for in-lab testing/development. RD&T will continue 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.

Research efforts will promote development of a draft performance specification template for AAR review. Successful prototype testing and validation have been accomplished. Long term field exposure testing on prototype electrically driven handbrakes (EDHBs) installed on freight cars at the Facility for Accelerated Service Testing (FAST) at the TTC is completed as well as testing of initial wireless control system prototype. RD&T will continue efforts to optimize the controller/motor interface design and efficiency and implement an improved means for feedback of chain load for communications and control of application and release functions.

RSEC – Rolling Stock Maintenance and Inspection

The Rolling Stock Maintenance and Inspection research area will evaluate and demonstrate the effectiveness and efficiency of automated inspection and maintenance procedures and equipment. 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.

Anticipated Activities

RD&T will continue to partner with Metro-North Railroad (MNR), Long Island Rail Road (LIRR), and 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. RD&T will document wayside system installations at MNR, LIRR, and NYA, and detect threshold analysis to help the railroads establish detection thresholds for inspection alarm and emergency level actions balanced against the shop capacity and commuter service demands. Research efforts will identify best practices for implementation and revise the Wayside Implementation Guide.

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

RSEC – Train Handling and Operations

The Train Handling and Operations research area will develop simulation scenarios to evaluate different network and capacity related parameters with electronically controlled pneumatic (ECP) brakes and Positive Train Control (PTC) technologies. Both technologies will be compared to the

conventional signaling and braking applications. Simulation scenarios include network topology, traffic type, ECP scenarios, and PTC scenarios (with and without ECP scenarios).

Anticipated Activities
RD&T will continue to conduct 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 in North America's network. Research 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 develop network simulation scenarios based on adjusting train braking algorithms with certain daily traffic volume out of the entire network. 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 (TOP) $3,067,076
The Train Occupant Protection program area conducts research on structural crashworthiness and interior safety of locomotives and intercity and commuter rail cars. The research focus is to improve the survivability of rail passengers and crewmembers in accidents.

TOP - Fire Safety Research
The Fire Safety Research program will focus on improving current Federal regulations and industry standards for crashworthiness of passenger locomotive fuel tanks, and fire performance of materials and components used in passenger rail equipment through research activities.

Anticipated Activities
Validation of computer models with data from executed RD&T diesel multiple unit (DMU) fuel tank impact tests will allow for expansion of knowledge surrounding performance of such equipment under various loads. Computer modeling will be utilized to design new dynamic impact test setups. Data collected from past research efforts will be disseminated to rail industry standards development groups for improvement of industry standards for DMU fuel tanks. 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 rate.

TOP – Emergency Preparedness Research
The Emergency Preparedness research area will investigate and develop innovative safety technologies that improve emergency preparedness and egress features of 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 to conduct testing and modeling to demonstrate reduced-scale floor assembly fire resistance compliance testing. Further, activities include an evaluation of methods to quantify smoke toxicity and recommendations for criteria to limit harmful gases that can contribute to passenger injuries/death in a fire event.

Research efforts will promote communication with industry through the National Fire Protection Association 130 Committee to revise and update standards, compare egress modeling software and

evaluate evacuation concepts, strategies, and techniques for applicability to U.S. rail passenger cars. This collaboration will help investigate fire suppression technologies for effectiveness in passenger rail environment.

RD&T will continue to develop crashworthiness standards for alternative fuel tender cars, evaluate structural performance, puncture resistance, and fitting integrity with simplified analyses of natural gas fuel tenders. Additionally, RD&T will continue to evaluate safe speeds in accident scenarios, impact testing of M-1004 LNG tender car, and evaluate the merit of utilizing hydrogen fuel cell in railroad application and assess safety requirements for hydrogen fuel tender cars.

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, & 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
Anticipated Activities
RD&T will continue to develop strategies for improved passenger railcar occupant protection. This work will include the conduct of full-scale testing to develop data to corroborate the current FRA regulations related to the crash pulse used to evaluate attachment strength of railcar components including seats, trucks, and other components. This testing will also provide the opportunity to assess the deceleration environment to which passenger car occupants in wheeled mobility devices (WhMDs) are exposed and efficacy of various means to secure these devices in passenger trains. Results of dynamic testing of passenger seats and workstation tables will be reviewed and presented to the APTA Construction and Structural Working group to inform potential revisions to the relevant APTA standards.

TOP – Glazing Standards
Anticipated Activities
RD&T will develop realistic test protocols and evaluation metrics for glazing retention capacity. This information will inform potential Federal regulations or industry APTA standards related to glazing integrity. RD&T will aggregate industry recommendations for passenger car design alternatives to improved protection of glazing in derailments which are achievable and practical.

Research and testing to develop secondary impact protection for locomotive engineers will be completed and the results presented to industry for consideration in the design of new or retrofitted locomotive cabs.

Public, Private, and University Cooperative Research Agreement $400,000
See page 16 in Railroad Systems Issues for more details on this research.

Expected Program Outcomes:

HazMat – Tank Car Research
RD&T will provide FRA with information on the survivability of tank cars under fire conditions in case of train derailment accident, determine cars' behavior and failure modes under normal transportation of tank cars, and provide a foundation for modifying, eliminating, or creating standards by leading research and capturing the results. RD&T will disseminate information to the rail and tank car industry, so it can 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 and projects that can be proactive for existing and future safety equipment and packages. RD&T will provide information on the performance and durability of safety equipment for tank cars and portable tanks, so DOT has the required information to justify, modify, eliminate, and 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 and 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 increase understanding of the structural performance of LNG tenders and tank cars.

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

*Safe Transportation of Energy Products (STEP)**
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 test of LNG fuel tender and develop guidance documents to Office of Railroad Safety (RRS) on natural gas fuel usage by nation's railroads.

RSEC – Rolling Stock Equipment and Components
RD&T will continue research, development, and technology transfer of components and systems that reduce the risk of rail incidents and accidents. RD&T will reduce the likelihood of derailments from equipment failures and mitigate the consequences should derailments occur through these or other causes. Strategic priorities include investigation of the effectiveness of wayside and onboard monitoring systems to detect equipment defects and analysis of component failure modes to identify necessary improvements in materials and construction methods.

RD&T will design, develop, and demonstrate prototypes of effective wayside and onboard technologies that can provide component health monitoring and increase understanding of equipment failure mechanisms 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 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. RD&T will develop advanced detection of failing equipment and component systems, including improved performance leading to more efficient and safe train operations. Advanced equipment and component inspection and detection can lead to improved safety and will reduce in-service defects.

RSEC - Train Handling & 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 conduct simulations to improve safety of train operations and improve the network topology to have the topological structure to offer robustness, resiliency, efficiency, and effectiveness. RD&T will improve passenger truck designs that can provide superior equalization and curving performance to better handle rough track geometry.

TOP - Fire Safety Research
During the fiscal year, it is anticipated that the data from fire safety related RD&T activities will be disseminated to appropriate industry standards groups for utilization. Research results will be disseminated at conferences and through standards committee meetings. Further, RD&T plans to make recommendations and provide guidance on measurement and method of toxicity of rail car interior materials and components.

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 DMU under dynamic loads.

TOP – Emergency Preparedness Research
RD&T will identify modern effective evacuation modeling tools for rail applications and develop a plan for integration of evacuation simulation tool and fire dynamics models.

TOP - Cab Displays, Controls, & 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 and critical HazMat 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 results from a planned train-to-train test with respect to override inhibition. Assessments of the performance of retrofit crashworthiness features and concepts will be incorporated in the test program.

RD&T will assess results from the 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 of means to improve the integrity of glazing (window) securement will be available which will provide insight on means to improve passenger containment in train accidents in which cars derail and roll over. These results 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 Detail

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 which include tank cars, valves, and engineering consultation.	Equipment, subject matter expertise
Transportation Technology Center	Data analysis, test support, actual testing, resources, and modeling. In-kind equipment contribution.	Subject matter expertise
Class I freight railroads	Donations of railcars for using in testing (including destructive testing).	Equipment, subject matter expertise
Passenger rail equipment manufacturers and component suppliers	Donations of equipment or components (e.g., window glazing samples, prototype seats and passenger workstation tables).	Equipment for testing
Passenger and commuter railroads	Donations of railcars for using in testing (including destructive testing).	Equipment for testing
Passenger and freight industry associations	Donations of railcars for using in testing (including destructive testing).	Equipment for testing
BNSF Railway	Access to Bearing/Wheel Shop Facilities, Operator time, Allow Sample Collection. In-kind contributions included.	Equipment/material
Norfolk Southern Railroad	Access to Bearing/Wheel Shop Facilities Operator time, Allow Sample Collection. In-kind contributions included.	Equipment/material
Progress Rail	Access to Bearing/Wheel Shop Facilities, Operator time, Allow Sample Collection. In-kind contributions included.	Equipment/material

Partner Name	Contributions	Benefits of Partnership
Union Pacific Railroad	Access to Bearing/Wheel Shop Facilities, Operator time, Allow Sample Collection. In-kind contributions included.	Equipment/material
Indiana North Eastern Railroad	In-kind contributions: Provide labor and access to their cars and locomotives for test installation and feedback.	Equipment, subject matter expertise
Metropolitan Transportation Authority (MTA) (Metro-North Railroad and Long Island Railroad)	In-kind contribution: Provide access to their 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 which include 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

Benefits Detail

Beneficiary	Benefit(s) Received
FRA RRS	Improved safety recommendations and innovative solutions
Rail industry FRA 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	Reduced railroad accidents and fatalities Lower operating costs Reduced railroad accidents and fatalities Improved service life for its rolling stock equipment Improve railroad performance

Beneficiary	Benefit(s) Received
Small businesses, and university research centers	Improve their 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 to rolling stock research initiatives.

Rolling Stock Research Partners are Members of the following Organizations	
American Railway Association (ARA)	University of Nebraska
APTA	Southwest Research Institute
PHMSA	Sandia National Laboratories
National Railroad Passenger Corporation (Amtrak)	Friedrich Research
Southeast Pennsylvania Transportation Authority (SEPTA)	Transport Canada
Transportation Technology Center Inc. (TTCI)	U.S. Access Board
Progress Rail	Next Generation Equipment Committee
General Electric Transportation Services	Transportation Review Board
Trinity Rail	EPA
Chart Industries	U.S. Department of Energy (DOE)
Michigan Technical University	National Transportation Safety Board (NTSB)
Oregon State University	California Department of Transportation
Taylor-Wharton of America	

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

Program Objectives:
The 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 the research through technology transfer. 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) $6,045,527

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

Anticipated Activities
RD&T will conduct testing of enhanced track circuit technologies to increase the safety and throughput, development of technologies to safely increase the capacity of freight and passenger trains through densely populated areas, and testing of improved PTC adaptive braking algorithms.

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

Anticipated Activities
RD&T will continue development of Interoperable Lifecycle Management (ILM) network.

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 train location and positioning system, and standardization of new rail communication security techniques.

Intelligent Transportation Systems (ITS)
RD&T's research of ITS improves *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 continue 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.

Program Area - Grade Crossing and Trespass $1,640,473

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 detection of trespassing activities within any given railroad, continuing new work on artificial intelligence (AI) applied 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 public sector in exploring new areas where technologies (such as PTC) and innovative devices can play a role in increasing safety at grade crossings.

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 and techniques to improve pedestrian safety at rail grade crossings, and continuing to explore enforcement and educational tools to reduce accidents at grade crossings involving pedestrians.

Grade Crossing Modeling and Simulation
RD&T will continue working on the new accident prediction and severity model for grade crossings, 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 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 results in 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 listening sessions planned during FY 2020, continued collaboration with organizations such as Operation Life Saver and others, and formation of an international working group on railroad trespass prevention.

Public, Private, and University Cooperative Research Agreement $400,000
See page 16 in Railroad Systems Issues for more details on this research.

Expected Program Outcomes:

PTC Technology
RD&T will continue to assist railroads in meeting the congressional mandate for PTC while maintaining safe and efficient rail operations. 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 continue to validate increased 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 continues interoperability research to ensure railroads' compliance with the Rail Safety Improvement Act of 2008. FRA will continue to 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 railroads' PTC systems through FRA's review of centralized test facilities.

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 must be mirrored by 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 the number of 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. Collaboration Partners in this work include the Michigan Technological University and Rutgers University.

Grade Crossing Technology
RD&T will continue its collaboration to develop and test 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, its 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 safety for pedestrians at crossings. RD&T will 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 continue development of the new accident prediction and severity model for grade crossings, as well as developing models for studying behavior in general at grade crossings. This research will explore new modeling and simulation to reproduce real scenarios of human behavior at crossings. Simulation and modeling can provide insight on how safety can be improved once the solution simulated or modeled 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 in the railroad environment when interacting with grade crossing and trespass prevention. In addition, RD&T will support RRS in examining and documenting the effectiveness of the presence of law enforcement along the railroad right-of-way. Collaboration Partners in this work include the Operation Lifesaver.

Collaboration Partners:

Partner Detail

Partner Name	Contribution	Benefit of Partnership
FHWA	FRA collaborates with these partners on intelligent transportation systems research	Stronger products through engagement with highway and automaker stakeholders
Federal Motor Carriers Safety Administration (FMCSA)	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	Rail industry coordination and project advisory group support; subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.

Partner Name	Contribution	Benefit of Partnership
BNSF Railway	System software development and supplier contracts; field test data and subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
Norfolk Southern	Subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
Union Pacific	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.
Canadian National	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	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
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	Right of way access; subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
Oklahoma DOT	Subject matter expertise	Better product deploy ability
Metropolitan Transportation Authority (MTA)	Subject matter expertise	Better product deploy ability

Partner Name	Contribution	Benefit of Partnership
Town of Bedford, NY	Subject matter expertise	Better product deploy ability
Town of Belmont, MA	Subject matter expertise	Better product deploy ability
Massachusetts Bay Transportation Authority (MBTA)	Right-of-way access; subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
Brunswick 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	Right-of-way access; subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
City of Orlando	Cameras and instillation	Better product deploy ability
SunRail	Right-of-way access; subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.

Benefits Detail

Beneficiary	Benefit(s) Received
FRA RRS	Improved safety regulations and innovative solutions
Large Railroads	Reduced PTC operational impact, workforce health & safety, specialized test facilities. Efficiency, increased safety, 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.
American Public	Increased safety, improved transportation infrastructure, economic benefit, fewer accidents, reduced congestion and fuel related environmental impacts.
Universities	Publicly available research and data sets
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
Town of Brunswick	Innovative solutions, increased safety
City of Orlando	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 safety of employees
Railroad workers	Increased on 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 also conducts research and development related to Railroad Technology, Automation & Systems Design; Railroad Organizational Culture and Safety Performance; Railroad Worker & Operator Performance; and Highway-Railroad Grade Crossings, and Railroad Trespass and Suicide Prevention.

Program Objectives:
The HF research program objective is to improve rail safety by reducing the potential for human error in railroad operations. FRA develops decision support and planning tools, eLearning initiatives, and assessments of automation and human machine interface designs; advocates for human-systems integration within the railroad industry; and works with railroads to improve safety culture.

Safety is the primary driver of HF research. The outcomes yield innovation—i.e., researching, creating, and deploying the latest technology while utilizing lessons learned and best practices from other modes.

Anticipated Program Activities:
Program Areas – Human Factors $3,192,000
And
*Program Area: Short Line Safety Institute $2,500,000**

Railroad Technology, Automation & 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
In association with the Head-Up Display (HUD) concept, RD&T will develop a library of symbols indicating track status, vehicle status, important messaging and communications, and other symbols that could be displayed on the HUD.

RD&T will develop a capability with an associated Human-Machine Interface (HMI), using an array of sensors or high-definition cameras to detect and identify objects on the right-of-way. Machine vision technology will be used for object detection; artificial intelligence will be used for object identification and programmed system reaction.

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

RD&T will maintain the Cab Technology Integration Laboratory (CTIL) website, communicating to the public the latest activities and research accomplished in FRA's CTIL. The website provides

recent technical reports and briefings related to automation research and meeting notes from stakeholder review panels.

RD&T will continue research support activities for CTIL, which include operating the simulator, conducting human subjects research, and furnishing expert advice on experimental methodology.

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.

Anticipated Activities
RD&T will provide grant management and program support of the Short Line Safety Institute (SLSI). The SLSI provides safety culture assessments and training to small railroads, which are largely located in rural areas. Funding for the SLSI is an earmark grant provided annually by Congress. Specific SLSI activities include: continuing safety culture assessments; finalizing a process for conducting follow-up assessments to measure safety culture change over time; providing leadership training curriculum for Class II and III railroads; and determining whether additional commuter railroads can participate in SLSI safety culture assessments.

RD&T will conduct a review data regarding Positive Train Control (PTC) operations, from FRA's Confidential Close-Call Reporting System (C3RS) anonymous near-miss and safety issue reporting system.

RD&T will support RRS by providing subject matter expert consultation, research, data, and tools to improve railroad safety and reduce accidents and incidents. Examples of the HF division's support of RRS include developing and pilot testing of the Rail Information Sharing Environment (RISE) and supporting railroad safety working groups, including Fatality Analysis of Maintenance-of-Way Employees and Signalmen (FAMES) and Switching & Operations Fatality Analysis (SOFA).

Railroad Worker & 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 identify those that have significant impacts on job performance and safety and to suggest strategies to enhance safety and job performance.

Anticipated Activities
RD&T will support development of a plan that addresses human fatigue detection and countermeasures, and railroad scheduling policy based on results of scientific studies in human fatigue. RD&T will conduct research on the Information and Communications Technology (ICT) Needs Assessment, providing context evaluation to understand the knowledge, skills, and attitudes of railroaders for best types of technology suited for railroader communication and information processing.

In collaboration with FRA RRS and several commuter railroads, RD&T will conduct research to evaluate the effectiveness of railroad scenario-based training 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 as well as considerations for how to effectively assign those depending on the level of automation or capabilities of the technology.

Highway-Railroad Grade Crossings, Railroad Trespass, and Suicide Prevention
This research area examines these factors to identify those that have significant impacts on grade crossing behavior and safety and to suggest 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
Representatives from FRA RD&T and FRA RRS will hold six free, 2-day Railroad Trespass Prevention and Grade Crossing Technology summits planned across the United States. The goals of these summits are 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. FRA is holding the summits in 6 of the top 10 U.S. counties with the highest frequency of trespass fatalities on rail ROWs. For more information or to register, please visit https://www.fra.dot.gov/conference/2020/trespassing/.

The Motorist Behavior at Grade Crossings project will collect and design various In-Vehicle Auditory Alerts (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.

RD&T will begin to work with industry partners and tech companies to determine the best way to include grade crossing locations on maps (e.g., Waze, Google Maps), as well as develop and test the most appropriate warning to be given to a motorist when approaching a grade crossing.

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. FRA will assist railroad partners to identify ways to use data to effectively identify mitigation strategies. RD&T will coordinate with international colleagues through the Global Railway Alliance for Suicide Prevention (GRASP). The goal of this group will remain to gather information related to railroad trespass and suicide prevention efforts being undertaken by leading experts from around the world. 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 discussion of railroad suicide incidents.

RD&T will conduct research to better understand the root cause of rail suicide and trespass incidents to develop strategies to prevent future incidents or mitigate their consequences. RD&T will also develop a Trespass and Suicide Prevention Toolbox, which summarizes best practices and lessons learned related to trespass and suicide prevention.

*This funding is an earmark provided annually by Congress for SLSI. This is in addition to the total budget for FRA RD&T. If Congress chooses NOT to fund the $2.5M earmark, this activity will not be executed in FY 2021.
Public, Private, and University Cooperative Research Agreement $350,000
See page 16 in Railroad Systems Issues for more details on this research.

Expected Program Outcomes:

Railroad Technology, Automation & Systems Design

The expected outcome for the HUD research is a prototype conceptual example of a HUD in a locomotive to minimize distraction and improve the engineer's situational awareness.

Expected outcomes for the HUD symbology research includes a standardized set of symbology that could be used in the design of the human interface across systems. Outcomes of the research will reduce training needs and reduces risk of human error.

Expected outcomes for the down-range detection capability research include a system with HMI, to improve the engineer's situational awareness and to help avoid collisions.

Expected outcome for the CAWS research is to demonstrate the need for a consistent standard of CAWS across systems to reduce risk of human error and misinterpretation, improve engineer situational awareness, and reduce required training.

Outcomes from the CTIL research support activity yields quality automation research in CTIL conducted in a timely manner. The CTIL website will be the main vehicle for communicating all HMI and related automation research activity to the American public. Research outcomes lead to a better-informed rail industry on human factors and advancement of automation issues research.

Railroad Organizational Culture and Safety Performance

Expected outcomes from the review of C3RS data include policy and procedure recommendations, technology evaluations, 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 & Operator Performance

Human Fatigue expected outcomes include reduction in risk of human fatigue-related accidents and incidents.

ICT Needs Assessment expected outcomes 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 better understanding of how to integrate new technology into legacy operations where best use of human and automation capabilities can be allocated to enhance teaming and improve efficiency in the track inspection task. Additionally, outcomes include a safer track, inspected more efficiently.

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

Expected outcomes will provide critical information to developers interested in incorporating rail crossings and IVAAs in their applications. Expected outcomes will provide a data-based approach to

design optimized IVAAs for rail crossings and help with standardizing the warnings across platforms.

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 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.

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.

Collaboration Partners:

Partner Detail

Partner Name	Contribution	Benefit of Partnership
DOT Human Factors Coordinating Committee (HFCC)	Share Human Factors research/information with each DOT mode.	As mentioned in 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.	As mentioned in 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 (OST).
FRA RRS	Subject matter expertise, collaboration, and recommendations.	HF PMs work closely with their counterparts in FRA RRS. As a primary customer, FRA RRS's research needs and priorities helps shape the division's research plan.
FRA 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	Collaboration, subject matter expertise, stakeholder engagement	Working closely with TC&C PMs, conduct jointly sponsored research

Partner Name	Contribution	Benefit of Partnership
		projects. HF and TC&C provide an engineering and human factors approach to grade crossing and trespassing research.
Union Pacific	Subject matter expertise, collaboration, data, and recommendations.	Stakeholder engagement/understanding of human error situations
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
Long Island Rail Road	Subject matter expertise, collaboration, data, and recommendations.	Stakeholder engagement/understanding of human error situations
SEPTA	Subject matter expertise, collaboration, data, and recommendations.	Stakeholder engagement/understanding of human error situations
Caltrain	Subject matter expertise, collaboration, data, and recommendations.	Stakeholder engagement/understanding of human error situations
Metrolink	Subject matter expertise, collaboration, data, and recommendations.	Stakeholder engagement/understanding of human error situations
BNSF Railway	Subject matter expertise, collaboration, data, and recommendations.	Stakeholder engagement/understanding of human error situations
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
Short Line Safety Institute	Subject matter expertise, collaboration, data, and recommendations.	Improved safety and safety culture in Class II and Class III freight railroads

Partner Name	Contribution	Benefit of Partnership
Massachusetts Institute of Technology	Subject matter expertise, collaboration, data, and recommendations.	
Michigan Technological University	Subject matter expertise, collaboration, data, and recommendations.	HF expertise.
University of Connecticut	Subject matter expertise, collaboration, data, and recommendations.	HF expertise

Benefits Detail

Beneficiary	Benefit(s) Received
FRA RRS	Improved safety requirements, standards, recommendations
Rail 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 Workforce development opportunities

Chapter 3 – FY 2022 RD&T Programs

Railroad Systems Issues

Program Description:

The Railroad Systems Issues (RSI) Research program defines the strategy that directs the entire RD&T program toward the goals set forth by the Department of Transportation (DOT), the Office of the Assistant Secretary for Research and Technology (OST-R), FRA, and the Office of Railroad Policy and Development (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.

FRA's 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 the Office of Railroad Safety (RRS) to understand their strategic goals, safety data and trends, and requirements/needs to prioritize research to reduce safety risk.

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; TRB's independent evaluation recommendations; workforce development; RD&T-related technology transfer and travel; operations, maintenance, and equipment at the Transportation Technology Center (TTC) facilities in Pueblo, CO; and contractor support.

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:

RSI research program activities are tailored to address relevant railroad issues, spanning the spectrum from safety to workforce development.

Rail Safety Innovations Deserving Exploratory Analysis (IDEA)

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 preparing and submitting proposals. The TRB Safety IDEA review committee will evaluate proposals on a competitive basis. The Rail Safety IDEA program committee will evaluate those proposals meeting the technical eligibility criteria. 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.

Note: 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 (Oct–Dec 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 2019–2023 and continue development of its 5-Year Strategic Plan 2024–2028.

RD&T Technology Transfer (T2)
Utilizing RD&T's T2 methodology, collaboration, and stakeholder engagement activities yield T2 and adoption of innovative concepts and methods that will enhance safety and performance for railroads.

Program Support
As part of RD&T's technology transfer and publishing process, the technical editor team will review papers, reports, results, and other material. The editors will edit research related material and provide publishing related social media content to Public Affairs for RD&T's social media campaigns. RD&T contractors will continue to provide program management, analyst, and subject matter experts for project, program and portfolio management support.

Project Evaluation
RD&T will standardize and enhance project evaluation tools. Each research program will continue implementation of RD&T's project evaluation methodology. As part of research activities, RD&T will conduct project evaluations and work with PMs to optimize RD&T's performance management metrics.

Facilities and Equipment - Transportation Technology Center (TTC)
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. RD&T continues the enhancement of TTC's capabilities through strategic investment to existing facilities and equipment to support upcoming research and testing needs. Refurbishment of the rail system at the TTC will continue by replacing track materials such as rail, concreate and wood ties, switch components, anchors, spikes, etc. to refurbish of all major tracks and yards track at TTC. RD&T continues to support environmental and green technology goals encouraging energy efficiency, use of renewable energy, reduction of toxins, recycling, reuse of materials, and water conservation.

RD&T will continue to raise awareness and encourage 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 to TTC's facilities.

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

Workforce Development (WFD)
RD&T will continue its participation in the DOT Education and Workforce Development Community of Practice (on behalf of FRA) and support implementation of FRA's Strategic Human Capital Plan

2020–2024. In addition, RD&T will conduct research and publish an update to the railroad industry workforce assessment (known as the Modal Profile). RD&T will capture and analyze data on trends, skill gaps, skill demands, training opportunities, industry best practices, and cross-modal efforts.

Energy and Emissions
RD&T will continue impact and applicability study of hydrogen for rail applications. RD&T will collaborate within the railroad industry to identify standards and best practices for hydrogen fuel usage for rail applications. RD&T will maintain the Rail Module in the GREET model so that the tool is updated, relevant, and useful for rail industry.

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 locomotive in a real-world environment. RD&T plans to complete development and prototype demonstration of hybrid systems.

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

Note: This funding will come from multiple divisions to support their research.

Public, Private, and University Cooperative Research Agreement
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.

Note: This funding will come from multiple divisions to support their research.

Research with Universities on Intelligent Railroad Systems
FRA will 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. The BAA will be produced in collaboration with the ITS-JPO. RD&T will review university proposals and select prospective research projects. RD&T will award funding and begin selected projects.

*This 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 2021.

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

Track

Program Description:

The Track research program prepares for the future of rail transportation through applied research, development, and demonstration. As new technologies emerge, and train axle loads and speeds increase, the timely development of technical information, data, and expertise is crucial to provide a basis on which to make decisions about issues affecting the safe operation of rail vehicles on U.S. track. The Track research program supports the goals and objectives of the DOT/FRA Administration; 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. There are three primary research areas included in the program:

- Track structures and components,
- Systems performance and analysis, and
- Operation of research assets, including the DOT TTC facility.

Program Objectives:

FRA's RD&T Track research program conducts scientific and engineering research to reduce derailments and improve railroad safety. The objective of this research is to provide the scientific and engineering basis for safety rulemaking and enforcement while ensuring rules are appropriate and defendable. The program fosters collaboration with the railroad industry to develop and implement new technologies and practices to improve overall system safety and safety-related standards. The Track research program aims to prevent high-consequence derailments that result in the loss of human life and cause significant damage to property and communities.

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 also will advance automation of detection and sizing of defects in rail.

Track and Structures - Track Inspection Technology and Processes

RD&T continues research, development, and demonstration of change detection technology. RD&T anticipates that first-generation commercial systems will be deployed and a cooperative program will begin to demonstrate the efficacy of change detection technology for automation of manual inspection requirements. RD&T will continue developing innovative approaches to imbed sensors and detection and communications technologies within the track structure to allow for a type of self-enunciation when conditions warrant remedial maintenance or pose a threat to safe rail operations. Additional research is planned to improve track component designs and to detect failures of components in track.

Track and Structures – Special Activities

RD&T will continue development of automated bridge inspection and impact detection technologies. Additional research will focus on UAV applications for rail safety, including developing technologies to allow for beyond visual line of sight operations over railroads. This research will include FAA and rail industry participation.

Track and Structures – Track Stability
RD&T will refine towards commercialization of technology to measure rail stress without a reference and initiate build of a rail stress and rail neutral temperature test bed at the 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.

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 FY2021 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 establishing methodologies for the evaluation of track inspection technology effectiveness and initiate processes to incorporate as recommend practice. In 2022, 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 automated procedures for the alignment, processing, and reporting of ATGMS data for predicting areas approaching maintenance and safety limits. Additionally, RD&T will conclude and report on the subsequent field investigations into the root causes of track geometry degradation associated with observed/predicted accelerated deterioration trends.

System Performance and Analysis – Vehicle Track Performance
RD&T will finish the design of the curved test track at the TTC and start building a test bed that can be used to validate the accuracy of track geometry measurement systems used by FRA and the industry.

Rolling Stock

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), and the safe use of alternative fuels, and new engine and energy savings technologies that focus on preserving the environment. Results of this R&D 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. 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 to conduct research on developing and improving packages that carry hazardous materials. Research efforts will reduce the release of hazardous material 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 methodologies for remaining tank car shell thickness measurement. RD&T will continue research efforts to gather information on the newer types of tank cars and the common failure modes and determine if newer weld test panels are needed for future POD studies.

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

RD&T will continue research to develop design strategies for improving the structural crashworthiness of passenger rail cars relative to existing designs. RD&T will continue research to develop specifications and regulations and support various waiver requests and evaluations of compliance with FRA regulations.

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 used in 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.

*Safe Transportation of Energy Products (STEP)**
RD&T will continue this research to help assess the operational safety risks associated with hazardous material unit trains and determine if unit train operation of hazardous materials presents unique or additional risks compared with unit train operations of non-hazardous materials or mixed-freight operations involving the same hazardous materials as currently or planned for transportation in unit trains. 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**
RD&T will continue research to review the railroads natural gas fuel usage programs and to develop standards for natural gas fuel tender. The research provides FRA with the scientific basis for decision-making and development of standards and requirements. FRA will collaborate with other Federal agencies to ensure use of the energy products are 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 brake systems that are not functioning properly by detecting wheels that are inappropriately hot or cold, 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.

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

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 determine the best location in the bearing to sample bearing grease, as determined by the worst grease condition. RD&T will continue research to demonstrate if it is possible to identify the grease metrics associated with bearing failure modes based on grease sampling and state-of-the-art statistical methods.

RD&T will continue research to test the ability of the current baseline bearing rubbing lip seals versus the frictionless seals to prevent water ingress over the life of the bearing. RD&T will continue research to determine if water ingress will occur in revenue service bearing seals through environmental fluctuations and correctly identify fretting corrosion, as differentiated from water damage, and mitigate it in revenue service.

RD&T will continue to research, design, prototype, and test an EPSS DC access/battery charger that provides a standard 24 volts DC interface to safety and security devices where desired. RD&T will continue research to design and build a three-car test rack for studying the selected prototype ecosystem platform and utilize the EPSS test rack to minimize build costs, and utilize the test rack for in-lab testing/development. 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 promote development of a draft performance specification template for AAR review. RD&T will continue research to optimize the controller/motor interface design and efficiency and implement an improved means for feedback of chain load for communications and control of application and release functions.

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 defects in railroad rolling stock. 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 the 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 system, assist involved organizations with development of DTL, and explore wireless extension to DTL. RD&T will continue research to work closely with the Next Generation Equipment Committee, Association of American Railroads, American Association of State Highway and Transportation Officials, 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 in

North America's network. 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.

TOP - Fire Safety Research

RD&T will continue research to validate computer models with data from executed DMU fuel tank impact tests for expansion of knowledge surrounding performance under various loads. RD&T will continue research to evaluate and develop alternative fire performance criteria for passenger railcars, and develop models and scaling laws to reduce test article size for quantifying fully-developed rail car fire heat release rate.

TOP – Emergency Preparedness Research

RD&T will continue research to conduct testing and modeling to demonstrate reduced-scale floor assembly fire resistance compliance testing and evaluate methods to quantify smoke toxicity and recommendations for criteria to limit harmful gases that can contribute to passenger injuries/death in a fire event. RD&T will continue research to investigate fire suppression technologies for effectiveness in passenger rail environment.

RD&T will continue research to develop crashworthiness standards for alternative fuel tender cars, evaluate structural performance, puncture resistance, and fitting integrity with simplified analyses of natural gas fuel tenders. RD&T will continue research to evaluate safe speeds in accident scenarios, impact testing of M-1004 LNG tender car, and evaluate the merit of utilizing hydrogen fuel cell in railroad application and assess safety requirements for hydrogen fuel tender cars.

RD&T will continue research 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, & Environment

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

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 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 efficacy of various means to secure these devices in passenger trains.

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 industry APTA standards related to glazing integrity. 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 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 of the next generation of train control safety systems to improve the safety and efficiency of rail operation.

Program Objectives:

The 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 the research through technology transfer. 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:

PTC Technology

RD&T will support the design and development of innovative systems to ensure PTC interoperability and reliability continue to evolve with the pace of technology 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 and assist industry in improving testing protocols and centralizing/streamlining testing and validation of PTC systems. FRA will support development of a centralized PTC network monitoring and analytics facility at the Transportation Technology Center as well as a PTC test lab that will standardize version control testing for large railroads and ease interoperability compliance of smaller railroads.

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.

Intelligent Transportation Systems

RD&T will continue to conduct research on new sensor, computer, and digital communications for train control, braking systems, grade crossing, and defect detection; and new, innovative technologies in automation, AI, and unmanned aerial vehicles to improve safety and reduce incidents around railroad operations. Activities include research into feasibility of a vital connected vehicle communication protocol for rail grade crossing accident mitigation, 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; and without this research, the number of accidents on railroad property due to trespass will likely not decrease. RD&T will continue advancing the research on how AI algorithms, related technologies and other innovative solutions can be used in reducing trespass occurrences along the railroad's right-of-way.

Grade Crossing Technology
Grade crossings, along with public railway station platforms, are the locations where the railroad is most exposed to interaction with 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 right-of-way's that involve pedestrians. Simulation and modeling offer a non-invasive and non-destructive method 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 other professional industry partners in developing new prediction models to reduce risk and improve safety at grade crossings.

Grade Crossing and Trespass Outreach and Education
Education and awareness are the best tools to have the public understand and be aware of the risks involved when near a railroad property. RD&T will continue to educate the general public to the dangers of grade crossings, in collaboration with Operation Lifesaver and other organizations.

Human Factors

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 also conducts research and development related to Railroad Technology, Automation & Systems Design; Railroad Organizational Culture and Safety Performance; Railroad Worker & Operator Performance; and Highway-Railroad Grade Crossings, and Railroad Trespass and Suicide Prevention.

Program Objectives:

The HF research program objective is to improve rail safety by reducing the potential for human error in railroad operations. FRA develops decision support and planning tools, eLearning initiatives, and assessments of automation and human machine interface designs; advocates for human-systems integration within the railroad industry; and works with railroads to improve safety culture.

Safety is the primary driver of HF research. The outcomes yield innovation—i.e., researching, creating, and deploying the latest technology while utilizing lessons learned and best practices from other modes.

Anticipated Program Activities:

Railroad Technology, Automation & Systems Design

RD&T will continue to conduct HUD symbology library research to develop a library of symbols indicating track status, vehicle status, important messaging and communications, and other symbols that could be displayed on the HUD.

RD&T will continue to conduct research to develop a capability with an associated HMI, using an array of sensors or high-definition cameras to detect and identify objects on the right-of-way. RD&T will continue research to catalog and survey the various CAWS associated with rail automated systems and displayed to engineers and operators.

RD&T will continue to maintain the CTIL website, communicating to the public the latest activities and research accomplished, recent technical reports and briefings related to automation research, and meeting notes from stakeholder review panels.

RD&T will continue support activities with the CTIL simulator including operating the simulator, conducting human subjects research, and furnishing expert advice on experimental methodology.

Railroad Organizational Culture and Safety Performance

RD&T will continue to provide grant management and program support of the SLSI, providing safety culture assessments and training to small railroads located in rural areas. RD&T will continue finalizing a process for conducting follow-up assessments to measure safety culture change over time; providing leadership training curriculum for Class II and III railroads; and determining whether additional commuter railroads can participate in SLSI safety culture assessments.

RD&T will continue to review data regarding PTC operations, from the C3RS anonymous near-miss and safety issue reporting system.

RD&T will continue providing subject matter expert consultation, research, data, and tools to improve railroad safety and reduce accidents and incidents. This includes developing and pilot testing the RISE and supporting railroad safety working groups, including FAMES and SOFA.

Railroad Worker & Operator Performance
RD&T will continue to develop a plan of research that addresses human fatigue detection and countermeasures, and railroad scheduling policy based on results of scientific studies in human fatigue.

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

RD&T will continue research to evaluate the effectiveness of railroad SBT and make recommendations for improvement.

RD&T will continue research 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 depending on the level of automation or capabilities of the technology.

Highway-Railroad Grade Crossings, Railroad Trespass, and Suicide Prevention
RD&T will continue research 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. RD&T will continue to develop railroad trespass prevention and grade crossing technology summits.

RD&T will continue to collect and design IVAAs and conduct subsequent empirical experiments involving driving simulators to evaluate their effects on motorist behavior and, more broadly, grade crossing safety.

RD&T will continue to work with industry partners and technology companies to determine the best way to include grade crossing locations as well as develop and test the most appropriate warning to be given to a motorist when approaching a grade crossing.

RD&T will continue to 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.

RD&T will continue to coordinate with international colleagues through the GRASP to gather information related to railroad trespass and suicide prevention efforts undertaken by leading experts from around the world. RD&T will continue 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 discussion of railroad suicide incidents.

RD&T will continue to conduct research to better understand the root cause of rail suicide and trespass incidents to develop strategies to prevent future incidents or mitigate their consequences.

RD&T will continue to develop a Trespass and Suicide Prevention Toolbox, which summarizes best practices and lessons learned related to trespass and suicide prevention.

- END -