United States Department of Transportation
Annual Modal Research Plans FY 2023
Program Outlook FY 2024

FEDERAL RAILROAD ADMINISTRATION
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Executive Summary

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

RD&T is grounded in understanding industry safety risks. Through threat identification and risk analysis, RD&T identifies research opportunities to reduce the likelihood of accidents and incidents and to limit the consequences of hazardous events should they occur. Key research and development strategies include stakeholder input and engagement and partnerships with external organizations – such as the Association of American Railroads (AAR), the American Short Line and Regional Railroad Association (ASLRRA), the Pipeline and Hazardous Materials Safety Administration (PHMSA), the Environmental Protection Agency (EPA), the Intelligent Transportation Systems-Joint Program Office (ITS-JPO), and labor unions, as appropriate – and internally with the FRA Office of Railroad Safety (RRS). RD&T works closely with the Office of the Assistant Secretary for Research and Technology (OST-R) and Topical Research Working Groups to prevent the duplication of effort. RD&T activities are non-duplicative with known prior or current projects within FRA.

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

FRA research identifies and addresses safety issues across the railroad industry, including high-risk and long-term research. Its work aligns to DOT Objectives and Strategies as well, as RD&T has been working with stakeholders to formulate a robust research agenda that may take years to see a return on investment. For example, RD&T has been engaged in research that examines the impact of climate change and its implications for efficient and sustainable rail operations. RD&T WFD research has identified diversity, equity, inclusion, accessibility, and belonging, for over a decade and is currently piloting programs to encourage young people in under-represented communities to consider careers in rail. RD&T continues to increase its outreach to minority-serving institutions (MSIs) and historically Black colleges and universities (HBCUs) to increase participation in its research. Overall, sustained funding enables the pursuit of specific research needs. FRA initially bears the costs and risks for such research that the railroad industry cannot; the payoff comes in the form of innovative solutions that may not otherwise be realized.

RD&T divisions work closely with stakeholders throughout research and development (R&D) life cycles to understand adopter (industry and stakeholder) needs and barriers to adoption. As part of its Technology Transfer (T2) efforts, RD&T participates in OST-R Topical Research Groups to collaborate on research across DOT modes. Research programs conduct symposia, stakeholder meetings, attend conferences and industry meetings, and facilitate program reviews to increase information sharing. RD&T publishes T2 research to inform the public and advance the practical application of new technology. In FY 2023, RD&T will continue to monitor and update its internal project evaluation practices and conduct internal and external project and program evaluation of research effectiveness.

Table 1 – FY 2023 RD&T Program Funding Details

RD&T Program Name	FY 2023 President's Budget Request* ($000)	Applied ($000)	Technology Transfer ($000)	Facilities ($000)	Experimental Development ($000)	Major Equipment, R&D Equipment ($000)
Railroad Systems Issues	$19,771*	$15,649*	$580	$1,762	$780	$1,000
Track	$11,679	$10,741	-	-	$938	-
Rolling Stock	$10,672*	$9,987*	-	-	$685	-
Train Control & Communication	$9,086	$8,556	-	-	$530	-
Human Factors	$6,792*	$6,082*	-	-	$710	-
Totals	**$58,000***	**$51,015***	**$580**	**$1,762**	**$3,643**	**$1,000**

Amounts include congressional directives for the Short Line Safety Institute ($2,500) in Human Factors; Energy Products Research ($2,500) in Rolling Stock; Research with Universities ($1,000), Workforce Development ($1,000), Rail Research and Development Center of Excellence ($2,500), and Emissions Reduction and Alternative Fuel Locomotive ($2,500) in Railroad Systems Issues.

Table 2 – FY 2023 RD&T Program Budget Request by DOT Strategic Goal

RD&T Program Name	FY 2023 President's Budget Request ($000)	Safety ($000)	Economic Strength and Economic Competitive-ness ($000)	Equity ($000)	Climate and Sustainability ($000)	Transformation ($000)	Organizational Excellence ($000)
Railroad Systems Issues	$19,771*	$19,771*					
Track	$11,679	$11,679					
Rolling Stock	$10,672*	$10,672*					
Train Control & Communication	$9,086	$9,086					
Human Factors	$6,792*	$6,792*					
Totals	$58,000*	$58,000*					

Amounts include congressional directives for the Short Line Safety Institute ($2,500) in Human Factors; Energy Products Research ($2,500) in Rolling Stock; and Research with Universities ($1,000), Workforce Development ($1,000), Rail Research and Development Center of Excellence ($2,500), and Emissions Reduction and Alternative Fuel Locomotive ($2,500) in Railroad Systems Issues.

While maintaining a safety focus, FRA's RD&T program yields solutions that contribute to all DOT Strategic Goals.
The funding request in the FY 2023 AMRP and the President's Budget are identical and fall under the category of Safety. The funding provided to RD&T is for safety research, and through safety research RD&T addresses all other DOT Goals.

Since the final updates made to this document, the FY2023 enacted budget has been released and the FRA RD&T budget for FY2023 is $44,000,000.

The AMRP reflects funding as found in the FY 2023 President's budget request per 49 U.S.C. Chapter 65 Sec. 6501 Research Planning. The FY 2023 enacted numbers will be posted as part of the FY2024 President's budget request.

Section 1 – FY 2023 RD&T Programs

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

Program Description

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

Program Goals and Objectives

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

- Reduce incidents and accidents on U.S. railroads – saving lives and mitigating environmental hazards.
- Promote innovative technologies and facilitate leadership across the industry.
- Improve its understanding of the impact of technology on safety and the industry workforce.

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

- Reducing accidents caused by human error
- Reducing track-related derailments
- Reducing incidents and accidents related to grade crossings and trespassing
- Investigating automation and technology
- Collaborating and sharing information on industry WFD challenges
- Investigating safer practices for the use and transportation of energy products

Critical Research, Development, and Technology Programs

FRA research identifies and addresses safety issues across the railroad industry, including high-risk and long-term research. The sustained funding of FRA R&D enables the pursuit of safety-specific research needs. This allows FRA to initially bear the costs and risks for research the railroad industry is unable to pursue. Without this investment, significant safety-related research (especially in human factors) and innovative solutions would not occur, and the benefits would not be realized.

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

Program	Program Area
Railroad Systems Issues	Railroad Systems Issues (RSI); Research with Universities on Intelligent Railroad Systems; Research and Development Facilities
Track	Track and Structures; Systems Performance and Analytics
Rolling Stock	Hazardous Materials; Energy Products Research; Rolling Stock Equipment and Components (RSEC); Train Occupant Protection (TOP)
Train Control and Communication	PTC; Grade Crossing/Trespassing
Human Factors	Human Factors; Short Line Safety Institute (SLSI)

Technology Transfer Deployment

Partnerships and stakeholder engagement form the foundation of RD&T's T2 methodology. Each Division works closely with stakeholders throughout the R&D life cycle to increase user adoption of research products and services. RD&T Program Managers (PMs) directly support technology development and implementation (Technology Readiness Level) and are integrated with the research project life cycle through planning, engaging stakeholders, identifying resources, and executing research activities. Understanding stakeholder needs and potential barriers to adoption allows PMs and stakeholders to effectively communicate the value and benefit of RD&T research products.

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

RD&T T2-related spend plans will be approximately $580,000 in FY 2023. T2 implementation costs include:

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

RD&T will continue to share information with the railroad industry through conferences, working groups, seminars, webinars, symposia, and summits. In FY 2022, the Track Division conducted its first Track Support and Substructure Symposium, a virtual, all-day event, providing academia, suppliers, researchers, and industry the opportunity to learn more about RD&T research. RD&T plans to conduct another symposium in FY 2023. RD&T also held stakeholder meetings with labor to

better understand safety concerns for railroad workers, as railroad worker safety is included on the NTSB's Most Wanted Top 10 List of needed transportation improvements. Both stakeholder meetings are examples of RD&T sharing research data and gathering insights to inform research planning for FY 2023 and FY 2024.

Most RD&T research projects become Technical Reports – published on FRA's eLibrary, the National Transportation Library, the Transportation Research Board's (TRB's) Research-in-Progress database, the DOT Repository and Open Science Access Portal, and the Transportation Research International Documentation database – after research is completed. Technical Reports range from 30 to 500 pages in length, while Research Results are much shorter – 3 or 4 pages. The publications are accessible to railroad industry stakeholders and the public. Information regarding RD&T's work can also be found on the OST-R Research Hub.

Over the last 5 years, RD&T publications have steadily increased in number, with FY 2022 expected to continue the trend. RD&T has implemented an improved review system with RRS for potentially sensitive reports, drastically reducing the times between report submission and publication. RD&T is also developing a tool to manage and track research products to further improve the publication process. The table below summarizes RD&T publishing from FY 2018 to FY 2022 (from October 2021 through May 2022).

Document Type	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022
Technical Reports	41	44	52	41	43
Research Results	17	22	19	29	29
Other Reports	4	3	2	6	7
Total	**62**	**69**	**73**	**77**	**79**

Collaboration Efforts

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

RD&T stakeholders include railroad carriers, labor unions, railroad manufacturers, universities, RRS, the Federal Transit Administration (FTA), PHMSA, EPA, the Department of Energy (DOE), the Federal Highway Administration (FHWA), ITS-JPO, the Transportation Security Administration (TSA), and the public. FRA partners internationally on suicide prevention, climate and energy research, and hazardous materials research. These stakeholder groups benefit from RD&T research through information-sharing and transparency; developing and testing innovative technology; WFD; safety recommendations; improved safety culture; safety tools; improved infrastructure; safety training; research risk mitigation; exploring automation and the impact of automation on transportation; and safer transportation of goods and passengers on U.S. railroads.
Internal stakeholders, such as RRS, provide safety data for RD&T research. Conversely, RRS uses RD&T research to support safety standards and requirements. RRS use of RD&T research has improved the safety of U.S. railways and decreased fatalities over the last 10 years. External stakeholders (e.g., railroads, labor unions) provide insights, trends, and data used to initiate and prioritize research. These same stakeholders participate in research by providing expertise, equipment, or feedback during research projects, or as participants in research studies. Internal and external stakeholders consume RD&T research, implement training, establish standards, and adopt equipment suggested in RD&T research and development.

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

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

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

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

Evaluation and Performance Measurement Efforts

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

- Guide and strengthen RD&T program execution.
- Facilitate the collection of feedback to improve project performance.
- Assess achievement of target audience needs.
- Assess and drive research investment decisions.

For better performance measurement, RD&T continues to update its internal evaluation capabilities and formalize the project evaluation process and procedure. Aligning to the recently released DOT Strategic Plan and learning agendas, the evaluation process will be modified to best-implement evaluation capabilities that add value to RD&T research objectives and results. Evidence-based performance measures will be used to improve research and development approaches and improve performance measurement across the organization.

Involvement in OST-R Topical Research Groups

RD&T participates in OST-R Topical Research Groups to increase collaboration on research across the modes. RD&T strives to ensure collaboration across the divisions to maximize research impact and efficiently expend research funding. All divisions recognize the benefits of collaboration and gain from the collective experiences and expertise from their inter-division peers.

Potential Progress Made toward Achieving Strategic Goals: RD&T Alignment to USDOT Priorities, FY 2022

Following FRA's *Moving Rail Forward* motto is a key factor to ensure the relevance, alignment, and agility in RD&T's strategy. RD&T leadership reviewed the work of each Division and considered FRA's role and commitment in executing Department priorities. The following table highlights how RD&T's research activities aligns with DOT's Economic Strength and Global Competitiveness, Equity,

Climate and Sustainability, Transformation, and Organizational Excellence priorities.

DOT Priority	RD&T Research Activities
Safety	RD&T focuses on new technologies and methods to reduce derailments and improve safety in rail operations through research. It will continue its research to better understand the root causes of rail grade crossing, trespass incidents, and suicide prevention to develop strategies to prevent future incidents or mitigate their consequences. Additionally, research will improve the safety and interoperability of PTC.
Economic Strength and Global Competitiveness	Since 2009, FRA has conducted research on rail industry WFD to understand workforce trends and challenges. In FY 2021, RD&T initiated three science, technology, engineering, and math (STEM) education pilot programs in collaboration with universities, including two MSIs. In FY 2023, RD&T will expand its STEM initiatives to generate more interest in railroad careers.
Equity	In FY 2021, RD&T began developing a strategy to cultivate relationships, research partnerships, and collaborations with MSIs/HBCUs. In FY 2022, RD&T continued developing a comprehensive contact list and strategic communications plan. In 2023, RD&T plans to increase awareness of research funding opportunities and build research partnerships with MSIs/HBCUs and other associations. In FY 2023, RD&T plans to fund research to increase the recruitment and retention of under-represented groups in the railroad industry.
Climate and Sustainability	RD&T is focused on quantifying track structural conditions that can have a positive impact on climate change by reducing energy consumption during safety-related maintenance. Research is also investigating the efficacy of clean energy and advanced motive power technologies to improve energy efficiency and reduce rail transportation emissions. RD&T plans to test clean energy to build on rail's competitive advantage in energy efficiency and reduce the transportation sector's greenhouse gas emissions. In FY 2022, RD&T will partner with RRS to host a transcontinental workshop on the advancement of safe, clean fuel and motive power technologies for railroad applications.
Transformation	RD&T's infrastructure investments consider generational impact and will be developed with a holistic approach to create shovel-ready, durable, safe, equitable, and sustainable rail projects. The Transportation Technology Center (TTC) in Pueblo, Colorado, provides RD&T, the railroad industry, and other DOT modes a facility to conduct infrastructure research and share information.
Organizational Excellence	RD&T continues improving research publication, project evaluation, and project selection processes. Project evaluation activities include demonstrating the significance, value, and impact of RD&T research in improving railroad safety. RD&T conducts an annual prioritization to ensure stakeholders and industry needs are factored into the RD&T investment planning processes.

Bipartisan Infrastructure Law (BIL)

The Bipartisan Infrastructure Law (BIL) provides RD&T directions to expand existing initiatives and create a new center.

Initiative	New/ Existing	Impact of BIL	AMRP Section/Page
Transportation Technology Center	Existing	Construction authority	RSI, p.11
Workforce Development	Existing	Enhanced	RSI, p. 13

Energy and Emissions	Existing	Enhanced current initiatives; planned future initiatives	RSI, p. 14
Rail Research and Development Center of Excellence	*New*	Provided direction for its creation	RSI, p. 16

Chapter 1 – FY 2023 RD&T Programs

Railroad Systems Issues
$19,771,000

Program Description

The Railroad Systems Issues (RSI) research program comprises the advanced strategic initiatives that ensure RD&T alignment with national priorities and areas of technological need. The program addresses initiatives that support industry transformation by investing in research and innovation to meet the challenges of the present and modernize a transportation system for the future. RSI activities include projects aligning with congressional, DOT, OST-R, and FRA strategic objectives as well as exploratory research areas. The principal focus and goal of the RSI program is safety; however, the program's activities contribute to all DOT Strategic Goals – advancing Equity, Climate and Sustainability, Economic Strength and Global Competitiveness, Transformation, and Organizational Excellence.

Major Program Objectives

The major program objectives of the RSI program include 1) identify safety improvements that address areas of national priority; 2) identify new program areas to advance broad rail industry safety risk; and 3) gain insight into the viability of new approaches and solutions to improve system-wide railroad safety.

Program Area – Railroad Systems Issues

Program Area – Transportation Technology Center

Program Area – Intelligent Railroad Systems

Safety – Rail Safety Innovations Deserving Exploratory Analysis (IDEA)

- TRB and FRA will issue an IDEA Program Announcement to solicit and select proposals for Rail Safety IDEA program exploratory research projects.

Outputs: Expected deliverables include final performance reports and final research reports. T2 of 2019–2023 efforts (based on project duration) is also expected.

Outcomes: Develop new research and complete existing research to deliver innovative solutions.

Impacts: The Safety IDEA program will increase safety through innovative research. IDEA funds innovative entrepreneurs and small businesses. The program aims to increase innovation in transportation by funding new and unproven concepts and evaluating novel applications of technologies.

Note: Activities, outputs, and outcomes are similar to previous fiscal years because new projects are selected, executed, monitored, and completed each fiscal year. Project topics vary and are not included in this narrative.

Organizational Excellence – Project Selection

- FRA will renew the Decision Lens software license for an additional option year to continue using the prioritization software to aid project selection and budget decisions.

Outputs: RD&T will identify project safety risks and prioritize its project portfolio.

Outcomes: Decisions Lens helps RD&T make project safety risk decisions, improve efficiency in project spending, and update its project portfolio prioritization methodology for investments. RD&T plans to renew the software license for Decision Lens for an additional option year. Prioritization results from FY 2022 will inform FRA Spend Plan selections and priorities.

Impacts: RD&T will improve efficiency in project spending and update its project portfolio prioritization methodology for investments.

Note: Activities, outputs, and outcomes are similar to previous fiscal years because new projects are selected and prioritized each fiscal year.

Organizational Excellence – Program Support

- Technical Editors will review Technical Reports, Research Results, conference papers, and other material, and provide report-related social media content to the FRA Office of Public Affairs for RD&T social media campaigns.

- Contractors will provide program management, analysis, and subject matter expertise to support project, program, and portfolio management.

Outputs: The number of published Technical Reports and Research Results will continue to increase. The program support team will continue to review and edit reports and other materials posted on the FRA eLibrary.

Outcomes: RD&T will continue with strategic planning, project management, project evaluation, and the editing and publishing of technical reports.

Impacts: The railroad industry will have immediate access to RD&T research; thus, it will have insights to improve railroad safety.

Organizational Excellence – Project Evaluation

- Each research program will continue implementation of RD&T's project evaluation methodology.

- RD&T will continue to align evaluation practices to FRA's learning agenda and the Office of Management and Budget's (OMB's) direction.

- RD&T will conduct project evaluations and optimize its performance management metrics.

Outputs: RD&T will develop training for the updated project evaluation tools and practices.

Outcomes: RD&T will review evaluation data to understand trends and verify project success criteria. Project evaluation practices will yield standardized performance measurements that allow agency-wide performance baselines to be set.

Impacts: Leadership anticipates that FRA's R&D life cycle will include the measurement of project success and performance, cost reduction, and railroad safety improvements by all RD&T divisions. The divisions will utilize project evaluation findings to adjust and prioritize research activities.

Transformation – Facilities and Equipment – Transportation Technology Center

- RD&T will provide facilities and equipment intended for railroad research and development, testing, and training to enhance the safety, security, and efficiency of rail systems and operations.

- RD&T continues the enhancement of TTC capabilities through strategic investment in existing facilities and equipment to support upcoming research and testing needs (e.g., the refurbishment of its rail system).

- RD&T continues to support environmental and green technology goals encouraging energy efficiency, renewable energy, the reduction of toxins, recycling, the reuse of materials, and water conservation. RD&T will complete Transportation Technology Center, Inc. (TTCI – not to be confused with *TTC;* the former is a company owned by AAR, and the latter is the Federal facility in Colorado) contract closeout activities.

- RD&T will continue to purchase equipment and instrumentation needed for the new ENSCO, Inc. (ENSCO) contract, based on the RD&T facilities maintenance plan.

- RD&T will continue to raise awareness and encourage the broader use of 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.

- RD&T will continue strategic research planning on how TTC will be used over the next 5 years. TTC will continue to develop new capabilities, such as human factors research.

Outputs: The new ENSCO contract began in Q1 FY 2023.

Outcomes:

- Human factors research will begin at TTC in collaboration with multiple RD&T divisions.

- RD&T continues to develop and apply new technology at TTC for governments and others involved in rail transportation.

- RD&T and the railroad industry will continue to research, test, and evaluate track- and vehicle-based safety standards and performance guidelines that enhance the safety and security of rail systems. These activities will complement the rail transportation technology, development, testing, standards development, and training at TTC.

- RD&T will continue to address climate and sustainability requirements at TTC. RD&T will establish cross-modal partnerships with PHMSA and FTA, which will use TTC for training and research.

- TSA will continue security training at TTC. (TSA has worked at TTC for over 10 years.) TSA has identified rail cybersecurity as a worthwhile pursuit. TSA is considering the impact of threats to PTC and other autonomous systems, such as the Rail Crossing Violation Warning (RCVW) system.

- The new ENSCO contract will help expand research, testing, and training activities at DOT and other Government agencies.

- RD&T will continue to purchase heavy equipment and instrumentation needed for the new ENSCO contract, based on RD&T's facilities maintenance plan. RD&T will continue to maintain buildings on TTC's campus, provided funding is allocated as part of RD&T's FY 2023 Presidential Budget request.

Impacts:

- RD&T will continue to expand the use of TTC for the railroad industry and the Federal Government.

- The facility will continue to enhance transportation safety, security, innovation, and infrastructure to improve the safety of U.S. railroads and help transform aging infrastructure.

- Funding spent on equipment will improve research capabilities – especially research related to infrastructure.

- Increased information sharing, partnerships, seminar/conference participation, and use of TTC will expand the reach of RD&T research, standards, recommendations, and products.

Safety/Transformation – Railroad Systems Issues

- RSI will conduct research related to Broad Agency Announcements (BAAs), based on proposals accepted by RD&T.

Outputs, Outcomes, and Impacts: Outputs, outcomes, and impacts will depend on BAA selections in FY 2022 and FY 2023.

Economic Strength and Global Competitiveness/Equity – Workforce Development

- RD&T will continue WFD research activities, stakeholder engagement, MSI/HBCU outreach and relationship-building, STEM projects, and the expansion of programs supporting industry efforts to increase the recruitment, retention, and training of under-represented populations.

- RD&T will collaborate with the railroad industry for a better understanding of rail workforce trends and provide relevant data and insights to support sustainable initiatives.

- RD&T will support the third phase of programs aimed toward engaging youth (pre-kindergarten [Pre-K] through 12th grade and college) and under-represented populations in rail transportation and STEM topics.

- In addition, RD&T will fund the first year of 2021 BAA research topics: 1) Addressing Equity Challenges in Evolving Railroad Workforce Training Trends and Best Practices; 2) Workforce Recruitment – Attracting and Retaining Women in Rail; and 3) Influencing Successful Practices in Knowledge Management within the Railroad Industry.

- RD&T will fund research proposals from the following research topics published in FRA's Research with Universities – Research Initiatives in Support of Railroad Safety BAA: 1) Pre-college STEM Rail Transportation Club to Increase Racial Equity in Rail Workforce Recruitment; 2) Workforce Recruitment – Attracting and Retaining Women in Rail (new contract); 3) Racial Equity in Rail Workforce Recruitment – Identifying and Training Leadership for Succession Planning; and 4) LGBTQ+ Equity and Inclusion in the Railroad Industry.

Outputs:

- Work includes stakeholder outreach, collecting survey data, and conducting trend analyses.

- In FY 2023, FRA will update the railroad WFD survey package and submit the updated package to OMB for review and approval.

- In FY 2023, FRA will publish its WFD research results. RD&T will participate in WFD data calls.

- RD&T will continue outreach to MSIs/HBCUs by implementing its MSI/HBCU Strategic Plan. RD&T will increase funding to MSIs/HBCUs as outlined in the MSI/HBCU Strategic Plan.

- RD&T will publish reports related to WFD initiatives.

Outcomes:

- Stakeholder engagement will facilitate the establishment of stakeholder forums for the exchange of best practices and information.

- RD&T will conduct strategic outreach to build research partnerships with MSIs/HBCUs and increase awareness and interest in railroad careers.

- 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 Goals – Equity and Economic Strength and Global Competitiveness).

- RD&T will conduct an updated railroad industry workforce assessment (Railroad Industry Modal Profile).

- RD&T Outreach and Education initiatives include public/private partnerships with MSIs/HBCUs and associations to increase diversity in the railroad industry.

- The third year of RD&T's STEM initiative will be completed.

- FRA will fund topics published in the BAA: FRA's Research with Universities – Research Initiatives in Support of Railroad Safety. Topics include: 1) Pre-college STEM Rail Transportation Club to Increase Racial Equity in Rail Workforce Recruitment; 2) Workforce Recruitment – Attracting and Retaining Women in Rail (new contract); 3) Racial Equity in Rail Workforce Recruitment – Identifying and Training Leadership for Succession Planning; and 4) LGBTQ+ Equity and Inclusion in the Railroad Industry.

Impacts:

- Outreach will increase the diversity of FRA partners and collaborators while encouraging a new generation of students to select careers in rail.

- RD&T will help increase the number of under-represented people, especially MSI/HBCU graduates, in the railroad industry workforce.

- HBCUs/MSIs will increase research in the railroad industry, establish training/education programs, and increase support of students/faculty conducting rail industry research.

Climate and Sustainability – Energy and Emissions

- RD&T and RRS will jointly plan and execute a second conference to include international participants on the advancement of safe, clean energy and motive power technologies for railroad applications.

- RD&T will continue impact and applicability studies of hydrogen for rail applications.

- RD&T will maintain the Rail Module in the Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model so the tool is updated to provide relevant and useful data to the rail industry.
    - RD&T will provide feedback and direction to RRS on the performance of such equipment under normal and accident scenarios.

- RD&T will provide Year 2 funding to select BAA topics: Rail's Contribution to CO_2 Emissions and Modal-Shift Impacts; Energy and Environmental Sustainability; and Climate Change and Resiliency Planning.

Outputs: GREET module data will be available for railroads, rail planners, and other practitioners to conduct emissions and energy use assessments. These hybrid systems will be

tested in railroad applications for locomotive propulsion. This assessment will identify safety research needed to advance U.S. hydrogen and fuel cell technologies.

Outcomes:

- The second climate workshop will bring together experts, end users, manufacturers, academia, international partners, and Federal agencies to discuss technologies for the decarbonization of rail.

- Research collaboration and cost-sharing with DOE and national laboratories will continue to advance clean energy technology.

- RD&T and RRS will broaden their interaction with experts and international practitioners who are implementing decarbonizing technology in the rail space to gain new knowledge and understanding.

- RD&T will assess safety issues related to hybrid systems, including batteries, heat exchangers, and fuel cells.

- RD&T will expand clean energy, climate, and sustainability research.

Impacts: RD&T research will help industry select more sustainable energy options to reduce carbon emissions.

Equity – Accessibility

- RD&T will support the development of new and improved accessibility standards for rail vehicles, ensuring standards are safe and technically feasible.

- RD&T will begin development on a mobile application to improve the accessibility of railroad communications.

Outputs:

Data from testing will inform new U.S. Access Board accessibility requirements for rail vehicles. RD&T will further develop more advanced analyses of the dynamic interaction between wheeled mobility devices (WhMDs) and railcar equipment on board passenger railcars, and use test data to evaluate additional scenarios for protecting passengers. RD&T will assess various accident loading and containment strategies for passengers using WhMDs.

RD&T will assist the passenger rail industry in developing an accessible application (APP) that can be used for transit, commuter, and intercity rail networks. The APP will provide accessible train travel information and the ability for passengers to purchase tickets and passes across multiple rail systems.

Outcomes: RD&T expects testing to produce data on the relative motion of WhMDs and occupants in non-contained spaces.

Impacts: Increase protection to passengers in WhMDs in an open-bay-accessible location. Improve communications to the hearing-impaired.

Climate and Sustainability – Locomotive Safety

- RD&T will assess new and innovative technologies to improve the safety and efficiency of locomotives in a real-world environment.

Outputs: In collaboration with Class I railroads, RD&T will also assess high-pressure heat exchangers in a real-world environment. RD&T will develop and prototype a demonstration of hybrid systems.

Outcomes: RD&T will ensure the safety of emerging locomotive engine efficiency technologies.

Impacts: RD&T will gain knowledge to safely integrate hybrid systems into the industry.

Safety – Office of Railroad Safety Support

- RD&T will continue to partner with RRS and industry on the Railroad Information Sharing Environment (RISE) project.

- RD&T will continue to provide SME support by conducting research on urgent safety issues identified by RRS or Congress.

Outputs: Research results will analyze safety risks and identify mitigations to those risks.

Outcomes: Collaboration and research will yield growth and maturity of the RISE project. RD&T provides RRS with the science that drives standards and requirements development and supports emissions compliance for both passenger and freight equipment.

Impacts: All RD&T divisions support RRS by providing SME consultation, research, data, and tools to improve railroad safety and reduce accidents and incidents.

Note: RRS research funding will come from multiple RD&T divisions.

Economic Strength and Global Competitiveness – University Research Initiatives (University Cooperative Research Agreement and Research with Universities on Intelligent Railroad Systems)

- As part of RD&T's MSI/HBCU outreach strategy, RD&T will increase outreach to MSIs/HBCUs to establish research collaborations/partnership opportunities.

- RD&T will collaborate with ITS-JPO to publish a BAA to solicit applied technology research projects in support of DOT and FRA goals to advance automation and connected vehicle technology adoption in the rail industry.

- RD&T will publish the request for proposals and select prospective research projects to fund.

Outputs: RD&T will publish a BAA, soliciting applied technology research projects to support DOT and FRA goals to advance automation and connected vehicle technology adoption in the rail industry. Expected deliverables include progress reports, project management documents, and final research reports. T2 of FY 2020–2022 efforts (based on the project schedule and duration of each effort) are expected.

Outcomes: Ongoing research projects focus on advanced technology, automation, and connected vehicle technologies; advancing technologies for rural application; and WFD. RD&T continues to expand BAA notifications through inclusion of MSIs/HBCUs to increase diversity of university partners and racial equity participation in the rail sector.

Impacts: RD&T will help MSIs/HBCUs expand as community assets by supporting students, faculty/staff, and STEM programs. RD&T will increase support of American universities and encourage students to pursue careers in railroading or research. RD&T will increase railroad safety and improve railroad infrastructure.

Transformation – Rail Research and Development Center of Excellence

- Publish a Notice of Funding Opportunity (NOFO) to establish the Rail Research and Development Center of Excellence (COE) consortium.

- Select an entity or entities to participate in the COE. The COE will:

    o Conduct research to understand the needs and implications of emerging transportation technologies. Potential research areas include:

- Transformative technologies

- Unmanned aerial systems

- Transportation system use and operations

- Infrastructure design

- Clean energy

- Rolling stock

- Positive Train Control

- Human factors

- Grade crossings

- Remote sensing

- Rail systems maintenance

- Network resiliency

  o Provide technical assistance and other outreach and engagement to conduct and sponsor prioritized research.

  o Build STEM competencies of the local/future workforce through rail programs to meet emerging local, regional, and national economic interests.

  o Develop rail-focused curricula and training programs.

  o Expand and improve employer-led rail training practices and programs through the establishment of partnerships.

Outputs:

- Innovative and transformational railroad-related research

- Rail focused curricula and training programs

- Prioritization of climate and clean energy research related to the railroad industry

- MSI/HBCU participation in rail research

- Expanded pipeline of rail professionals

- Increased technology transfer of prioritized research

- Exploratory research and experimentation, translating developments from other fields into transportation

- University partnerships that bring new science into practice

Outcomes:

- Expanded talent pool with STEM or rail-related skills

- Increased capacity for research at underrepresented and historically underserved academic institutions

Impacts:

RD&T will engage with the COE to prioritize basic and applied research (per the Bipartisan Infrastructure Law, section 22413) for evaluation, education, WFD, and training efforts. RD&T

research topics will include train control, human factors, rail infrastructure, shared corridors, grade crossings, inspection technology, remote sensing, rail systems maintenance, network resiliency, operational reliability, energy efficiency, and other advanced technologies. The COE will address all DOT Strategic Goals and have a lasting impact on training and educating a changing rail workforce.

Potential Economic and Societal Impacts

RSI research will improve the American quality of life and ensure equitable access to and use of the Nation's rail infrastructure. This research will facilitate the development of an accessible, mobile application specifically for rail. It will also address all the strategic drivers for DOT and FRA.

RSI will expand its research in WFD. For over a decade, FRA has researched WFD trends to better understand the rail industry. FRA launched three equity-focused initiatives in FY 2021 for Indigenous, Black, Spanish-speaking, and female students to learn about math, science, and railroading.

In FY 2022, RD&T funded four research initiatives that address equity. The projects examine industry restructuring performance measurement systems designed to increase diversity in the railroad industry, recruit women in rail, enhance equity in workforce training, and prepare minority students for the railroad-highway safety workforce.

RSI will also expand its collaborations and partnerships with MSIs and HBCUs. RD&T has drafted an MSI/HBCU Strategic Plan and will begin implementation in FY 2023. RD&T seeks to increase the participation of underrepresented groups in RD&T research.

Potential Progress Made toward Achieving Strategic Goals

RSI research will continue to push toward achieving DOT/FRA Strategic Goals. The initiatives and activities listed below directly support these goals and influence the development of an inclusive and equitable rail accessibility model.

Research Activity	DOT/FRA Goals Alignment
WhMD/Mobile Application	Equity
WFD Research	Equity, Economic Strength & Global Competitiveness, Transformation
Climate Summit	Economic Strength & Global Competitiveness, Climate & Sustainability
University Funding	Economic Strength & Global Competitiveness, Transformation
STEM Initiatives	Equity, Economic Strength & Global Competitiveness, Transformation
MSI/HBCU Strategic Plan	Equity, Economic Strength & Global Competitiveness, Transformation

The RSI research program is continuing research that will achieve the DOT Strategic Goal of Organizational Excellence through its support, evaluation, and prioritization of the four RD&T divisions. This effort includes TTC maintenance, administering project evaluations, prioritizing research through Decision Lens, and coordinating with RRS. The program is also committed to Economic Strength and Global Competitiveness and Transformation; funding university research, widening the pool of rail researchers, and growing the U.S. economy through their innovations will pay dividends well into the future.

RSI is developing research to achieve the DOT Strategic Goals of Equity, Economic Strength and Global Competitiveness, and Transformation through its K-12 STEM initiatives, which aim to broaden rail industry opportunities and awareness to under-represented populations. This program will increase U.S. Economic Strength and Global Competitiveness by increasing the number of candidates aware of careers in rail and will help transform the Nation's rail by increasing the number of researchers working on rail-related projects.

RSI is pursuing the DOT Strategic Goals of Equity, Economic Strength and Global Competitiveness through its WFD research program, designing research on rail workforce trends and then using that research to support sustainable initiatives. The result will be an increase in U.S. Economic Strength and Global Competitiveness through greater awareness of workforce issues.

The program is addressing the DOT Strategic Goal of Equity through efforts to make passenger rail more accessible to people who use WhMDs, making railroads accessible to a wider group of people.

RSI is also working toward the DOT Strategic Goals of Climate and Sustainability and Economic Strength and Global Competitiveness through its 2nd International Climate Summit on safe, clean energy and motive power technologies for railroad applications. The summit will give American researchers the opportunity to collaborate with global industry leaders and learn global best practices.

And finally, RSI research will achieve the DOT Strategic Goal of Safety through its locomotive safety research area, which will the make U.S. railroads safer by assessing innovative technologies to improve the safety and efficiency of locomotives in real-world environments.

Collaboration Partners

RSI relies on stakeholder input to establish research needs and priorities. PMs are members of industry organizations and regularly engage stakeholders at meetings throughout the year to remain current on industry challenges and needs. RSI research collaboration partners include railroads, labor unions, manufacturers and suppliers, universities, nonprofits, city/State/Federal DOTs, and DOT Operating Agencies. The establishment of partnerships and collaborations with MSIs/HBCUs is a priority for FY 2022 and beyond. Stakeholder engagement with these institutions will increase the diversity and equitable participation of under-represented stakeholder groups.

Partner Detail

Partner Name	Contributions	Benefits of Partnership
TRB	TRB collaborates with DOT modes to improve innovation and technology within the transportation industry.	RD&T receives a biennial review of its research, stakeholder engagement, strategic planning, priority setting, evaluation work, and recommendations on how it can improve.
U.S. Universities (University of New Mexico; Michigan Technical University; California State University, Fresno; University of Maryland; and Morgan State University)	In-kind contributions; subject matter expertise and research	WFD insight and research data; subject matter expertise, research collaborations and partnerships
EPA	Guidance on the current regulatory environment; subject matter expertise	Input and feedback on the boundaries of the tool as it relates to the new noise emissions limits.
Railroads	In-kind contribution; subject matter expertise; access to rail facilities	Provide locomotive engine, duty cycle data; support testing activities; subject matter expertise; funding
Industry	Product commercialization	Subject matter expertise; funding
AAR	Funding, in-kind contribution; subject matter expertise	Subject matter expertise; insight into safety trends and challenges and research needs

Partner Name	Contributions	Benefits of Partnership
DOE	In-kind contribution; subject matter expertise	Funding; subject matter expertise
U.S. Access Board	Subject matter expertise	Provide guidance on accessibility research.
Locomotive OEM	Subject matter expertise, in-kind contribution	Subject matter expertise, funding
PHMSA	National policy and standards related to the transport of hazardous material; subject matter expertise	Subject matter expertise
TSA	Guidance related to securing the U.S. transportation system; subject matter expertise	Subject matter expertise
FTA	Guidance related to public transportation systems; subject matter expertise	Subject matter expertise

Benefits Detail

Beneficiary	Benefits Received
RRS	Improved safety standards/recommendations Improved science to improve standards and requirements in support of EPA.
Industry	Improved safety standards/recommendations Lower operating costs Improved visibility for railroad workers and grade crossings Reduced railroad accidents and fatalities Reduced regulations
Public	Reduced railroad accidents and fatalities High-speed rail transportation, safety, reduced noise emission
Small Businesses and University Research Centers	Improved railroad research resources and capabilities
Rail Equipment Manufacturers and Suppliers	Standardized matrix to determine cost of noise emission mitigation technology for high-speed rail.
Railroads	Standardized matrix to determine most efficient technology for improved energy and efficiency of locomotive engines. Accelerated development of clean energy technologies for rail.
EPA	Improved guidelines for noise emissions limits
Labor Unions	Increased employee safety
Railroad Workers	Increased railroad worker safety

Track
$11,679,000

Program Description

The Track program drives research that improves the safety and state-of-good-repair of railroad track. This work helps ensure U.S. track and structures meet the Nation's transportation needs – today and in the future. It focuses on reducing track-caused derailments by improving the industry's technical understanding and by applying advanced analyses and technologies in innovative yet practical ways. While the emphasis is on DOT's Safety and Transformation goals, the program also advances DOT's Economic Strength and Global Competitiveness, Climate and Sustainability, and Organizational Excellence goals. The program includes two primary research areas: track structures and components, and systems performance and analysis.

Major Program Objectives

The Track research program has four broad objectives:

- Understand the root causes of track-related derailments and develop ways to prevent these derailments.

- Improve how the FRA and the industry inspects track and structures.

- Improve how FRA and the industry assess safety risk for track.

- Develop a more productive, knowledgeable, and capable workforce.

Anticipated Program Activities

The Track program's anticipated activities for FY 2023 support the major program objectives. Because the two research areas are so interdependent, the upcoming program activities are discussed in relation to the program objectives rather than the individual program projects.

Safety – Track Safety

The Track program's research provides the scientific and engineering basis for rulemaking while ensuring rules are appropriate and defensible:

- RD&T will pursue multiple projects related to better understanding what constitutes safe track. To be safe, track strength must exceed the applied loads from both train operations and the environment. Research will investigate both the forces applied to the track and the response of rail vehicles, and especially passenger cars, to track irregularities. It includes finding ways to identify and monitor track at risk of damage or failure from climate change.

- Research will also explore what factors contribute most to track strength and attempt to quantify how quickly track performance degrades. To get the necessary information, the work will not only include laboratory and field testing but will also use advanced computer simulation, analytics, and machine-learning methods.

Related Program Projects: Track Stability, Vehicle and Track Performance, Rail Performance, Predictive Analytics, FRA Research Assets, and Special Activities

Outputs: Outputs include a better understanding of the minimum state-of-good-repair needed for track to sustain safe railroad operations.

Outcomes: This research develops information for FRA's Office of Safety and industry to assess changes to Subparts B, C, D, and G of 49 CFR Part 213 (Track Safety Standards). This information

then guides how railroads fix and invest in track, ensuring the infrastructure can safely and effectively handle growing rail traffic.

Impacts: This information contributes to reducing track-caused derailments, which reduces fatalities and protects communities and the environment.

Transformation – Track Inspection

RD&T will pursue multiple projects related to improving how track is inspected:

- Research includes finding and developing new sensors or platforms that measure and assess track conditions that current equipment cannot.
- Work will also quantify and aim to improve the accuracy and reliability of current inspection equipment.
- Several procurements address how to better present inspection data to inspectors so they can make more effective use of this information.

Related Program Projects: Track, Inspection, Track Stability, Vehicle and Track Performance, Rail Performance, Predictive Analytics, FRA Research Assets, and Special Activities

Outputs: These include a better understanding of the state-of-the-art inspection methods, best practices for data analysis and presentation, and minimum inspection frequencies needed to ensure railroad track is safe for daily operations.

Outcomes: This research develops information for RRS and industry to assess changes to Subpart F (Inspection) of 49 CFR Part 213 (Track Safety Standards). RD&T expects FY 2023 projects may lead to updates to Part 213. The research also encourages industry to adopt new technologies for inspecting the track structure.

Impacts: This information contributes to reducing track-caused derailments, which reduces fatalities and protects communities and the environment from harm.

Transformation – Risk Safety Assessment

- The Track program will drive new and better ways of assessing safety risk. The work will draw on the research results from its track safety and inspection objectives.

- This research aims to devise a framework to quantify how the risk of a given safety problem varies as operating practices and inspection methods or frequencies change, and as track components improve.

Related Program Projects: Track, Inspection, Track Stability, Vehicle and Track Performance, Rail Performance, Predictive Analytics, FRA Research Assets, and Special Activities

Outputs: Research will develop evaluation tools that consider how often a safety issue occurs, how likely that issue is to be missed by a given inspection method, and how likely the safety issue may cause an accident before the next inspection. The tools will allow what-if risk analyses of combining different inspection methods and frequencies.

Outcomes: FRA and industry can make fact-based decisions about how changes to maintenance practices, inspection methods and frequencies, and track components improve overall safety instead of relying on isolated, short-term trials or anecdotal evidence.

Impacts: The work will not only ensure that risk of a track-caused derailment does not increase when operating changes are made but will also allow industry to implement more efficient inspection methods that improve operations sooner.

- The Track program's research also contributes to the development of a more capable industry workforce. RD&T expects to award half of the anticipated FY 2023 projects to 17 different universities, creating a talent pool of more knowledgeable students who can fill industry research and staffing needs. The research results and developed technologies also help develop a more knowledgeable and effective maintenance workforce.

- RD&T expects its sponsored research in the safe track, improved inspection, and safety risk assessment to provide unique, hands-on learning opportunities at the Transportation Technology Center for academic researchers and students, industry personnel, and FRA inspectors.

Related Program Projects: Track, Inspection, Track Stability, Vehicle and Track Performance, Rail Performance, Predictive Analytics, FRA Research Assets, and Special Activities

Outputs: Research, education, and development opportunities for those new to or just starting in the railroad industry.

Outcomes: Development of a more diverse and capable workforce

Impacts: The learning opportunities create a deep pool of more knowledgeable personnel able to meet the employment needs of the railroad industry.

Potential Economic and Societal Impacts

The Track Division provides a significant societal benefit by ensuring U.S. railway track and structure are safe, minimizing the risk of derailments which affect the environment and public. It improves the reliability and resilience of the railroad network that forms the backbone of the U.S. supply chain. It contributes both economic and environmental benefits by increasing the life of track components and promoting safer and faster passenger rail. The program also provides equity benefits by continuing to grow the number of MSI and HCBU institutions involved in its research projects.

Potential Progress Made toward Achieving Strategic Goals

While the Track research program contributes to progress toward all DOT Strategic Objectives, its most significant contributions are in three areas. It significantly advances FRA and DOT progress toward their Safety goals, since track issues are the second-leading cause of derailments. It will also contribute to the Economic Strength and Global Competitiveness goal by clarifying the minimum state-of-good-repair needed for a robust supply chain and safe, efficient passenger rail service. Finally, it makes major advances toward the Transformation and development of the next generation of railroad operations.

Track Research Progress toward DOT Strategic Objectives	
Safe public, workers, designs, and systems	Experimentation
High-performing core assets	Collaboration and competitiveness
Resilient supply chains	Flexibility and adaptability
System reliability and connectivity	WFD
Infrastructure resilience	Data-driven programs and policies
Matching research and policy to advance breakthroughs	Oversight, performance, and technical assistance

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Collaboration Partners

Partner Detail

Partner Name	Contributions	Benefits of Partnership
ASLRRA	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	More realistic testing than a laboratory
Canadian National Railway (CN)	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	More realistic testing than a laboratory
Canadian Pacific Railroad	On-track testing, data, and in-kind support (e.g., intellectual resources)	Real-world data and revenue service testing
Genesee and Wyoming Railroad	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	Critical samples for research and expert advice
Western NY and Pennsylvania Railroad	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	Professional laboratory results without having to pay for new laboratory equipment.
Indiana and Southern Railroad	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	Real-world testing
Toledo, Peoria, & Western Railway	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	Real-world testing
Illinois and Midland Railroad	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	Realistic rail defects for validating new detection technologies.
Indiana and Ohio Railway	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	More realistic testing than in a laboratory
BNSF Railway	Testing site and feedback on research projects	Research that is more realistic for industry application.
Edison Welding Institute	Professional support in welding research	Research that is more applicable to improving safety in the industry.
Class I Railroads	Donations of rail defects	Real-world testing
AAR	Relevant data, on-track support, intellectual resources, and, in some cases, supporting funds	Materials, expertise, and funding
Rutgers University	In-kind support	Subject matter expertise
Amtrak	Data, track time, intellectual resources, and, in some cases, supporting funds	Materials, expertise, and funding

Partner Name	Contributions	Benefits of Partnership
New Jersey Transit Authority	Data, track time, intellectual resources, and, in some cases, supporting funds	Materials, expertise, and funding
Metro-North Railroad (MNR)	Data, intellectual resources, and, in some cases, supporting funds	Materials, expertise, and funding
Port Authority of Trans-Hudson	Data, intellectual resources, and, in some cases, supporting funds	Materials, expertise, and funding
American Public Transportation Association (APTA)	Data, track time, intellectual resources, and, in some cases, supporting funds	Materials, expertise, and funding
TTCI/AAR	Transportation research, development, security, training, test activities	Testing and training expertise, support, and TTC operation and maintenance
Sperry Rail, Inc.	Data and in-kind support (e.g., intellectual resources)	Critical data for research and expert advice
CSX	On-track testing, data, and in-kind support (e.g., intellectual resources)	Real-world data and testing
Utah Transit Authority	Access to track for long-term monitoring and testing	More realistic testing and research that is more applicable to industry.
Union Pacific Railroad (UP)	In-kind support activities: manufacturing support, access to track for testing, materials, and expert analysis	More realistic testing and research that is more applicable to industry.
Norfolk Southern Railway (NS)	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis; test location and track time	More realistic testing than a laboratory
Analogic Engineering Inc.	Enhanced Acoustic Birefringence Method for Measuring Longitudinal Rail Stress	Small business support, research & development support, and expertise on rail stress measurement, and better technology to prevent buckled track derailments
ENSCO	A wide variety of R&D contributions to improve rail safety.	Improved operating practices and inspection tools
Lehigh University	Better understanding of defect growth in modern rails and recommended inspection intervals	Training the next generation of railroad professionals, expertise on defect growth in rails, and potentially more informed inspection intervals to prevent train derailments.
Purdue University	Conceptual Design of a Facility for Testing New Technologies that can Determine the Longitudinal Stress in Rail	A better rail longitudinal stress test bed which can help develop technologies to decrease buckled track derailments.

Partner Name	Contributions	Benefits of Partnership
Thornton Tomasetti Inc	Automated Rail Head Flaw Characterization and Rail Remaining Life Prediction Technology	This technology will help reduce operator error and assist with finding rail defects.
Tuskegee University	Better Understanding of Defect Growth in Welds	Supports an HBCU, training the next generation of railroad professionals, and expertise on defect growth in welds – one of the weakest parts of the track system
University of California, San Diego	Developing technologies to better image rail flaws, and also to detect them in revenue service trains.	Training the next generation of railroad professionals, expertise on defect inspection, and new technologies to better detect flaws
University of Illinois at Urbana-Champaign	Quantify Parameters Influencing Longitudinal Resistance to Rail Movement and Rail Neutral Temperature Estimation Using Local Track Vibration Measurements and Machine-Learning; Ground Hazard Database and Risk Mitigation System	Training the next generation of railroad professionals, expertise on rail restraint and stress measurement, and better methods to prevent buckled track derailments; expertise on ground hazard and risk mitigation.
University of Sheffield	Longitudinal Rail Stress Measurement Using Ultrasound	Expertise on rail stress measurement, and better technology to prevent buckled track derailments.
University of South Carolina	Non-contacting System for Longitudinal Rail Stress Measurements; Satellite Radar Imagery for Ground Hazard Risk Monitoring.	Training the next generation of railroad professionals, expertise on rail stress measurement, and better technology to prevent buckled track derailments; expertise on radar imagery for risk monitoring.
University of Pittsburgh	Image Processing and Machine-Learning Algorithms to Measure Axial Stress in Rails	Training the next generation of railroad professionals, expertise on rail stress measurement, and better technology to prevent buckled track derailments.
University of Texas, Austin	Rail Defect Detection by Noncontact Vibration Measurements	Training the next generation of railroad professionals, expertise on defect inspection, and new technologies to better detect flaws.
University of Tennessee, Knoxville	Radiographic Weld Inspection	Expertise in radiographic inspection
State University of New York at Stony Brook	Subject-matter expertise for rail integrity research, namely vision-based inspection for rolling contact fatigue.	Expertise in machine-learning applications as it relates to railroad inspection.

Partner Name	Contributions	Benefits of Partnership
KLD Labs, Inc.	Data, intellectual resources (e.g., subject-matter expertise)	Critical data for research and expert advice
University of Utah	Subject-matter expertise for AI-based rail integrity research, namely for ultrasonic rail inspection interpretation	Expertise in machine-learning applications as it relates to railroad inspection.
Virginia Tech	Subject-matter expertise for AI-related research, namely for risk-based assessment of track condition using track geometry	Expertise in machine-learning applications as it relates to railroad inspection.
Wi-Tronix, LLC	Subject-matter expertise for AI-related research – namely, vision-based inspection systems	Expertise in machine-learning applications as it relates to railroad inspection.
Volpe	Track research, technical and evaluation support	Supports OST-R to maintain railroad track expertise and provide unbiased program and research support.

Benefits Detail

Beneficiary	Benefits Received
Public	Increased safety and more efficient train operations
Rural and Urban Communities	Improved safety, infrastructure, and reduced environmental impact
Industry	Improved safety and operational efficiencies
Other Transportation Modes	Increased exposure of adaptive technologies to improve safety and operations.
Labor Unions	Increased employee safety
Railroad Workers	Increased railroad worker safety

Rolling Stock
$10,672,000

Program Description

The Rolling Stock research program studies ways to reduce railroad accidents and incidents due to rolling stock-related causes. The program develops strategies and hardware to reduce fatalities and injury severity to passengers and crewmembers involved in passenger train accidents and incidents. The program leads the research, development, and evaluation of advanced rolling stock inspection techniques, materials, and components. The program conducts hazardous material (HazMat) research to improve its safe transportation by rail (includes crude oil, ethanol, flammable liquids, cryogenic liquids, toxic inhalation hazards, and related service equipment), the safe use of clean energy fuels, and new engine and energy savings technologies designed to preserve the environment. Results of this research directly support the development, implementation, and refinement of safety operations, reduce risks, and enhance industry and Government safety-related standards and performance-based regulations.

Major Program Objectives

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

Anticipated Program Activities and Potential Program Outputs, Outcomes, and Impacts

Program Area – Hazardous Materials

Program Area – Energy Products Research

Program Area – Rolling Stock Equipment and Components

Program Area – Train Occupant Protection (TOP)

Climate and Sustainability – HazMat – Tank Car Research

- RD&T will inform stakeholders on the survivability of the United Nations (UN)-T75 portable tank car under fire conditions in a train derailment accident scenario.

- RD&T will investigate and determine tank car behavior and failure modes under normal transportation conditions, thus informing the development, modification, or elimination of safety standards.
- RD&T will investigate the impact performance of tank cars carrying cryogenic ladings.

Outputs: These include data and technical reports that improve the understanding of tank cars in fire and derailment scenarios.

Outcomes: These include the development or modification of safety standards for the safer manufacture and operation of HazMat railcars.

Impacts: This research area will improve the production and operation of tank cars carrying HazMat, leading to a safer railroad with fewer HazMat incidents and accidents.

Climate and Sustainability – HazMat – Structural Integrity

- RD&T will study defects found during inspections that affect the structural integrity of safety equipment and packages.

- RD&T will provide information on the performance and durability of safety equipment for tank cars and portable tanks to ensure DOT has the required information to justify, develop, modify, or eliminate safety standards.

- RD&T will conduct studies on crash energy management (CEM) to increase the understanding of tank car puncture resistance.

Outputs: Outputs include information on the performance and durability of safety equipment for tank cars and information to improve the understanding of tank cars under fire conditions and derailment. These outputs will include data, technical reports, and recommendations.

Outcomes: This research will result in a better understanding of tank car risks and safety, ensuring DOT has the required information to create, modify, or justify safety standards.

Impacts: This research will ensure DOT has the necessary information to create, modify, or justify safety standards that improve HazMat tank car safety, leading to safer operations. These impacts include increased knowledge of safe cryogenic material transportation for alternative fuels will ultimately lower greenhouse gas emissions.

Safety – HazMat – Accident Consequence Reduction

- RD&T will learn more about how failures occur and how to mitigate those failures through improved equipment design. RD&T will evaluate and document damage to railroad tank cars and study the release flow from pressure relief valves.

- RD&T will conduct research to better understand the structural performance of fuel tenders and tank cars that transport cryogenic liquids.

Outputs: Outputs from this work will include data and technical reports on accidents involving HazMat, as well as safety recommendations to prevent similar accidents in the future.

Outcomes: This work will result the creation, modification, or justification of safety standards that will improve HazMat tank car component safety.

Impacts: This program will make HazMat transportation safer.

Safety – HazMat – Risk Analysis

- RD&T will finalize its risk analysis studies on unit trains carrying hazardous materials. Research will include evaluating tender survivability during different accident scenarios.

Outputs: This research will produce data and technical reports on the risks associated with unit trans carrying HazMat.

Outcomes: This research will lead to a better understanding of the risk unit trains carrying HazMat and enable mitigation.

Impacts: This research will improve safety by providing DOT with the required information to create, modify, or justify HazMat unit train safety standards, leading to a safer railroad.

Climate and Sustainability – Energy Products Research

- RD&T will finalize its risk assessment of transporting large HazMat quantities. Understanding the risks associated with hydrogen fuel will be the Energy Products Research team's main focus in FY 2023.

- Using knowledge developed in the Natural Gas Safety Research project, FRA will evaluate the safety of hydrogen fuel technology for rail.[1]

Outputs: Results from this research will include a better understanding of potential alternative fuel release events and new maintenance operations to mitigate those events.

Outcomes: This research will result in understanding alternative fuel technology risks. The results of this research will be used to engage with the rail industry to ensure the safe introduction of alternative fuels.

Impacts:

- The research will improve safety by ensuring the safe introduction of clean energy technologies in the rail industry.

- The research will also affect Climate and Sustainability by giving the railroads a safe way to reduce rail transportation emissions while maintaining efficiency.

Climate and Sustainability – Clean Energy/ Alternative Fuel Transportation Safety Research

- RD&T will perform research on the fabrication and use of fuel tenders in different accident scenarios, and document U.S. railroads' alternative fuel usage for RRS.

- Small-scale impact tests on safety components used in alternative fuel tenders and fuel storage cylinders will be conducted to understand the performance of these technologies under loads expected in the rail environment.

Outputs: The outputs of this program will be data and technical reports on the safe design of alternative fuel tender cars and fuel storage cylinders.

Outcomes: The outcome of this research will be changed, modified, or justified DOT safety standards, resulting in better-designed alternative fuel tender cars and fuel storage cylinders.

Impacts: This research will result in the safer storage and transportation of alternative fuels, benefitting rail safety. This research will also produce explicit standards for transporting and using alternative fuels, providing railroads with better guidelines to reduce emissions.

Transformation – RSEC – Rolling Stock Equipment and Components

- RD&T will conduct stationary and dynamic very long train (VLT) tests to research advanced equipment and components, wheel failures, brake system performance, in-train forces, and train handling of 200-car (or longer) trains.

- Through simulation testing and validation, RD&T expects to gain increased knowledge of multiple operating conditions. RD&T research will assess the implementation of wheel temperature detector (WTD) technology and its effectiveness in detecting air brake system defects on moving trains.

- RD&T will continue to develop a database for WTD system pilot study data and develop methodologies for data analysis to support the Test Waiver Committee.

Outputs: This research will generate technical reports, data, and safety recommendations on VLTs, brake systems, and WTDs. It will also produce a database for maintaining railroad car maintenance and WTD system data and methodologies for analyzing that data.

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

Outcomes: The outcome of this research will be better safety recommendations for VLTs, brake systems, and WTDs. Another outcome will be a more accurate understanding of car and WTD maintenance schedules.

Impacts: The impact of this research will be a safe and efficient railroad network due to safe operation of VLTs, better operating brake systems, and improved maintenance procedures.

Safety – RSEC – Rolling Stock Maintenance and Inspection

- RD&T will develop a system to power advanced detection devices (technologies to monitor rolling stock conditions and defects). Finite element (FE) analysis wheel research, in collaboration with industry, will continue to focus on wheel fatigue to help mitigate wheel failures.

- RD&T will establish an implementation plan for wayside technology pilot demonstrations. In addition, RD&T will quantify the effects of tread braking on wheel damage.

- RD&T will develop and conduct vehicle dynamics simulations.

Outputs: Outputs will include test data, analysis, and technical reports on advanced detection devices and wayside detection technology. They will also include additional data, analysis, and technical reports on wheel failures, plus updated vehicle dynamics simulations.

Outcomes: The outcomes of the research will be results to improve railroad safety through systemic research.

Impacts: The impact of this research will be a safer rail network due to the more accurate inspection and the mitigation of wheel and rolling stock defects.

Safety – RSEC – Train Handling and Operating Practices

- Research efforts will improve proactive maintenance, reducing derailments and improving operational safety. RD&T will develop truck designs with superior equalization and curving performance.

- The Train Energy and Dynamics Simulator (TEDS) will support accident investigations and facilitate the identification of safety risks in train operations and equipment.

- RD&T will continue to engage the National Fire Protection Association (NFPA) and APTA for the advancement of fire safety requirements in passenger rail vehicles. Research will focus on toxicity, cost-saving alternative test method development, and the advancement of fuel tank standards.

Outputs: The research program will deliver primary data on train accidents and incidents, better train simulations with TEDS recommendations, and recommendations on train handling, operations practices, and truck designs.

Outcomes: The outcomes will be better train handling procedures, operating practices procedures, and truck designs that lower the rate of incidents and accidents.

Impacts: The impact will be a safer railroad through a collaborative effort between NFPA, APTA, and RD&T.

Safety – TOP – Fire Safety Research

- The Fire Safety research program is engaged with APTA in assessing alternative standards for the fire safety performance of passenger rail materials and components. Research on rail components, such as railcar seats and fire safety test methodologies, will be shared with the transit sector via APTA and FTA.

- Fire Safety research will be expanded to investigate the performance of zero-emissions propulsion technology, such as batteries used to provide rail propulsion. RD&T will research ventilation and egress system designs and will apply its knowledge to better predict passenger egress.

Outputs: FRA will better understand the efficacy of using the heat release rate of burning material to predict fire safety in passenger rail vehicles. The program will produce data and alternative methodologies for evaluating passenger railcar materials and components such as floors, seats, etc. Alternative methods for showing compliance will be furthered in research and disseminated to the rail industry.

Outcomes: These include cost savings and more streamlined methods for achieving compliance for fire safety of passenger rail equipment. Collaboration with passenger rail industry and FTA on standards and recommended practices will ensure fire safe passenger railcars.

Impacts: These include an improvement in procurement and economic requirements for fire safety of passenger railcars. FRA will strengthen its relationships with the passenger rail industry and FTA through these collaborative research activities.

Safety – TOP – Emergency Preparedness Research

- RD&T will identify evacuation modeling tools for passenger rail applications.

- RD&T will integrate fire dynamics models into the selected evacuation tools and simulate egress scenarios. The coupling of fire dynamics models with railEXODUS and PathFinder is expected.

Outputs: A research team will output modeling tools for evacuations and fire dynamics to simulate egress scenarios.

Outcomes: The outcome of the research will be a more accurate model of passenger railcar egress scenarios (utilizing railEXODUS and PathFinder) during a variety of accidents, leading to better passenger cabin design.

Impacts: This research will make passenger railroads safer by making passenger cabin design safer.

Safety – TOP – Cab Displays, Controls, and Environment

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

Outputs: This research will generate recommendations on new LED locomotive light standards and regulations.

Outcomes: Increased train visibility and bulb service life will result.

Impacts: This research will improve the safety and economic competitiveness of U.S. railroads by making lights brighter and easier to maintain.

Transformation – TOP – Passenger Locomotive Crashworthiness and Occupant Protection

- In FY 2023, RD&T will evaluate the results from a train-to-train collision test, to be conducted in Q3 FY 2022. This test will demonstrate the effectiveness of retrofit crashworthy components that inhibit vehicle-to-vehicle override. In addition, this test will provide collision data on the deceleration and secondary impact of passengers seated WhMDs, reaffirming that the deceleration profile required by current regulations is based on sound engineering data.

- RD&T will develop a technical report on different passenger car side strengths and their implications on passenger safety in the event of a side impact.

Outputs: The research team will create recommendations to retrofit existing passenger equipment and develop new equipment.

Outcomes: The retrofitted existing passenger equipment and new equipment will provide better CEM in the event of an incident or accident.

Impacts: These new technologies will make passenger railroads safer by ensuring that existing passenger railroad cars are safer in collisions. These new technologies will also advance equity by making the railroads safer for people who use WhMDs.

Safety – TOP – Glazing Standards

- In FY 2023, RD&T will continue testing on glazing (window) securement that, in FY 2022, successfully resulted in minor improvements in glazing retention capacity with retrofit-capable technology. Additional testing is required to evaluate alternative design approaches which may not be as easily retrofitted to existing passenger rolling stock.

- In FY 2023, RD&T will simultaneously test how to derive estimates of coupler torsional strength and the effects of coupler torsion on the potential for car rollover. The FY 2023 test results will verify preliminary results that the likely torsional failure mode of the coupled connection is the coupler attachment to the carbody and not the coupler shank itself.

Outputs: The first set of outputs of this research are data, technical reports, and recommendations on glazing processes that can be either retrofitted onto existing passenger trains or incorporated into new train designs. The second are data, technical reports, and recommendations on car rollover failure modes.

Outcomes: The outcomes of this research are new manufacturing and operational processes that make windows less likely to break and passenger cars less likely to roll over.

Impacts: This research will improve safety by making train windows stronger and by making passenger cars less likely to roll over.

Potential Economic or Societal Impacts

The economic and societal impacts of the Rolling Stock program include helping the U.S. develop a more competitive, safer, and more advanced transportation network. Rolling Stock makes the U.S. railroad industry more competitive by researching and designing railcars and railcar components with lower maintenance and failure rates without compromising safety. The program's work also lowers the overall incidence of railcar accidents and derailment – which subsequently lowers costs as well. Rolling Stock makes the U.S. safer by studying ways to reduce railroad accidents and incidents, thus improving public and transportation worker safety. Rolling Stock is working toward transforming national infrastructure into a more resilient and sustainable network by developing and refining more resilient and sustainable railcar technologies, including tank cars, passenger cars, and all associated equipment and components. Rolling Stock is contributing to enhanced train travel for all passengers, including those with mobility disabilities, by supporting the development of reasonable and inclusive requirements for railcar accessibility.

Potential Progress Made toward Achieving Strategic Goals:

Climate and Sustainability, Equity, Safety

The Tank Car research area reduces the costly and environmentally destructive effects of HazMat railcar derailments, reducing environmental harm, and contributing to the PHMSA goal of

reduced fatalities caused by the release of hazardous materials Transported via Surface Transportation Conveyance documented in the FY 2023 DOT Performance Plan.

The Energy Products research program ensures the safe introduction of clean energy for the purpose of decarbonizing rail transportation. Even with existing technology, rail transportation provides a sustainable, safe, equitable, relatively low-emission, and high-efficiency option for moving people and goods. New technologies such as hydrogen and batteries provide zero-emissions, but research is needed to ensure their safe introduction into the rail sector.

The Passenger Locomotive Crashworthiness and Occupant Protection research area advances equity by ensuring that people of all ability levels are safe on passenger trains.

Collaboration Partners

Partner Detail

Partner Name	*Contributions*	*Benefits of Partnership*
Tank Cars Owners	In-kind contribution, including tank cars, valves, engineering consultation	Equipment, subject matter expertise
Tank Car Shops	In-kind contribution, including tank cars, valves, engineering consultation	Equipment, subject matter expertise
Sharma & Associates, Inc.	Data analysis, test support, actual testing, resources, and modeling; in-kind equipment contribution	Subject matter expertise
TTC	Data analysis, test support, actual testing, resources, and modeling; in-kind equipment contribution	Subject matter expertise
Class I Railroads	Donor railcars for testing (including destructive testing)	Equipment, subject matter expertise
Passenger Rail Equipment Manufacturers and Component Suppliers	Donor equipment or components (e.g., window glazing samples, prototype seats, passenger workstation tables)	Equipment for testing
Passenger and Commuter Railroads	Donor railcars for testing (including destructive testing)	Equipment for testing
Passenger and Freight Industry Associations	Donor railcars for testing (including destructive testing)	Equipment for testing
BNSF	Access to bearing/wheel shop facilities, operator time, allow sample collection; in-kind contributions of $6,000	Equipment/material
NS	Access to bearing/wheel shop facilities, operator time, allow sample collection, in-kind contributions of $6,000	Equipment/material
Progress Rail	Access to bearing/wheel shop facilities, operator time, allow sample collection in-kind contributions of $6,000	Equipment/material
UP	Access to bearing/wheel shop facilities, operator time, allow sample collection; in-kind contributions of $6,000	Equipment/material
Indiana North Eastern Railroad	In-kind contributions of $6,000: Provide labor and access to their cars and locomotives for test installation and feedback.	Equipment, subject matter expertise
Metropolitan Transportation Authority (MTA) (MNR and LIRR)	In-kind contribution: Access to data and operational information, allowing FRA access to data that is difficult to gather,	Data

Partner Name	Contributions	Benefits of Partnership
	which can then be used to evaluate the safety efficacy of these wayside systems.	
Railway and Industrial Specialists	In-kind contribution: Access and data on wheel failure types and defect details, allowing for accurate modeling of defects.	Data
Penn Machine Co. (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
KEA Technologies	Data analysis, test support, actual testing, resources, and modeling.	Subject matter expertise
TTC, APTA, AAR, and TTCI	Passenger rail equipment manufacturers (e.g., Siemens, Alstom, Stadler Rail) have donated window glazing for the ballistics test program.	Equipment for testing
DOE	Co-funding of research related to alternative fuels and decarbonization of rail	SME, co-sponsoring of research
Wabtec	Cash-contribution, in-kind support (personnel, facilities, equipment) may be provided for development of safe alternative fuels introduction; 40% cost-sharing.	Equipment/material

Benefits Detail

Beneficiary	Benefits Received
RRS	Improved safety recommendations and innovative solutions
Rail Industry RRS Tank Car Owners Tank Car Manufacturers Leasers Tank Car Shops	FRA will acquire: • In-depth knowledge of the performance of tank cars and the different service equipment of tank cars and portable tanks • In-depth knowledge of the crashworthiness of different types of tank cars and the failure modes to improve the performance of HazMat packages.
Public	• Fewer railroad accidents and fatalities • Lower operating costs • Fewer railroad accidents and fatalities • Improved service life for rolling stock equipment • Improve railroad performance
Small Businesses; Universities	Improved railroad research resources and capabilities
Labor Unions	Increased employee safety
Railroad Workers	Increased railroad worker safety

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

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

Train Control and Communication
$9,086,000

Program Description

The Train Control and Communication (TC&C) research program focuses on improving railroad operational safety, operational efficiency and economic competitiveness, network capacity, and climate change impact. It helps the railroad industry address current and future technical and economic challenges by developing interoperable system standards and specifications. TC&C's other focus area is grade crossing safety and trespass prevention. The program conducts pilot studies, provides safety best practices, creates prototypes, and demonstrates safety and security systems, including intelligent rail systems. It also provides scientific research and data to support FRA regulations. This research program collaborates with stakeholders to build on existing TC&C technology to adapt and incorporate new software and hardware technologies to develop the next generation of train control safety systems.

Major Program Objectives

The TC&C research program objectives are to improve railroad operational safety, including reducing roadway and at-grade crossing collisions, trespass countermeasures, and finding the right level of automation to optimize asset utilization and fuel consumption to reduce environmental impact. This program's goal is to transform railroad operations by anticipating and adapting innovative and emerging technologies to future-proof TC&C technologies and provide stakeholders the benefits of the research through T2.

Anticipated Program Activities

Program Area – Train Control and Communication

Program Area – Grade Crossing and Trespass

Transformation – PTC Next Generation Technology

- PTC technology research will collaborate with railroad stakeholders to develop next generation train control technologies, including Quasi-Moving Block (QMB) and Full Moving Block (FMB) architectures.

- Interoperability research will ensure compliance with the Rail Safety Improvement Act of 2008 (RSIA) and assist industry in improving testing protocols and centralizing/streamlining the testing and validation of PTC systems.

- FRA will support the development of interoperable train automation technologies, hazard-sensing solutions, and associated industry standards.

- In FY 2023, TC&C will continue to develop tools which streamline PTC interoperability and ensure compliance with the RSIA.

- PTC Next Generation will consider 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 FMB and Line-of-Road Remote Locomotive Control (RCL). RD&T will also research advanced methods of track-circuit-based rail break detection to support moving block operations.

Outputs: Research will provide evolutionary and innovative technologies to ensure PTC interoperability and reliability. The Track Data Auditing System (TDAS), in coordination with PTC-implementing railroads, will be developed. Advanced train control concepts such as Quasi-Moving Block and Full Moving Block will be further developed. Virtual block track circuit technologies will be tested and evaluated for implementation feasibility

Outcomes: The capability to improve interoperability of PTC systems: Increase rail operational and energy efficiencies; enhance capabilities to reduce PTC burden and improve safety; ability to develop efficient and reliable interoperability controls and automated interoperability verification among railroads. A primary goal of QMB and FMB is to specify a method of train control that builds upon PTC technology to enhance safety, capacity, and reliability.

Impacts: This research will continue to improve rail network capacity and safety while reducing life cycle costs for railroads and streamlining regulatory compliance.

Safety – PTC Interoperability

- FRA staff will collaborate with railroad stakeholders to develop next generation train control technologies, including Quasi-Moving Block and Full Moving Block architectures.

- RD&T will research solutions for improving the reliability and maintainability of conventional PTC systems.

- TC&C Division will continue to develop tools which streamline PTC interoperability and ensure compliance with RSIA.

- Software tools and systems will be developed to monitor the health and maintenance of interoperable PTC communication systems and TDAS.

Outputs: The products of this research will address passenger and freight delays related to the reliability, availability, and maintainability of PTC.

Outcomes: The research will provide new tools, capabilities, and procedures to improve interoperability and maintenance of PTC systems. **Impacts:** The overall improvement to PTC capabilities and operations will provide increased safety and operational efficiency.

Transformation – Intelligent Transportation Systems (ITS)

- TC&C will conduct ITS research on new sensor, computer, and digital communications for train control, braking systems, grade crossings, and defect detection; and innovative technologies in automation, AI, and unmanned aerial vehicles (UAVs) to improve safety and reduce incidents around railroad operations.

- Activities include research into the feasibility of a connected vehicle communication protocol for grade crossing accident mitigation.

- ITS research will continue to facilitate collaboration among railroads and automotive industry stakeholders to develop coordinated solutions for automated transportation systems.

- Research will support the testing and evaluation of cellular vehicle-to-everything communication protocols.

- Activities include the public demonstration of the feasibility and performance of a RCVW system.

- Research activities will include work with the ITS-JPO to coordinate programs to better reach stakeholders.

Outputs: Research will provide newly developed technologies across the railroad infrastructure and operations.

Outcomes: The rail industry will have enhanced capabilities to improve safe operations through the application of new technologies.

Impacts: Innovative technologies will provide for safer railroad operations and improve public safety.

Safety – Trespassing Countermeasures

- RD&T will work with all relevant partners and stakeholders to research solutions that reduce trespassing along railroad rights-of-way (ROWs).

- TC&C will continue to work with stakeholders to develop new tools and technologies that address trespassing on railroad ROWs. Research in this area will continue to develop and implement a near-miss database for trespassing events.

- Stakeholders will assist the Division with new trespassing prevention research ideas with the aid of the trespass summits planned throughout FY 2022.

- RT&T will also plan a national trespass research workshop based on the outcomes of the individual summits.

Outputs: Research will provide new solutions to address trespassing on railroad property.

Outcomes: Collaboration with stakeholders will increase solution development and implementation to reduce railroad trespassing. Facilitate the development of site-specific strategies for rail trespass and suicide mitigation, thereby improving rail safety.

Impacts: New solutions will lead to fewer trespassing incidents and improve public safety.

Safety – Grade Crossing and Trespass Outreach

- The Grade Crossing (GX) and Trespass Outreach and Education research area will address pedestrian safety.

- TC&C will develop and disseminate educational tools to the public, including local and State governments, law enforcement agencies, and schools.

- TC&C will continue to collaborate with organizations such as Operation Lifesaver (OL) to establish an international working group on railroad trespass prevention.

- The Grade Crossing Pedestrian Safety research area will explore measures (such as channelization, gate skirts, and enhanced electronic signs) to address accidents at-grade crossings and along railroad ROWs that involve pedestrians.

- RD&T will continue to evaluate scenarios for possible safety improvements at grade crossings through modeling and simulations.

- In collaboration with OL and other organizations, RD&T will continue to educate the public to the dangers of grade crossings.

- FRA will organize additional outreach summits, listening to community concerns to identify research needs. FRA will then develop new research ideas based on the outcome of the trespass summits held in FY 2023.

RD&T will develop technologies and tools to improve warning devices and integrate grade crossing locations into mapping devices. RD&T will continue developing the GX toolkit – guides, noteworthy practices, and research results on the implementation of a wide range of grade crossing safety treatments.

Outputs: Research will provide improved technologies and increased information on pedestrian grade crossing safety and improve collaboration with stakeholders. Research will create educational tools on grade crossing and trespass challenges. Trespass summits will provide insight into new research opportunities. Research will provide standardized metrics for analyzing grade crossing incidents. Educational enforcement methods will be defined, and the Railroad Crossing Elimination Program will be implemented and monitored.

Outcomes:

- The research will result in improved communication, techniques, and technologies to reduce pedestrian incidents at grade crossings.

- GX communication and education will improve, and trespass issues and FRA will gain a better understanding of areas of research.

- FRA will have an improved capability to analyze GX incidents and the ability to improve enforcement of grade crossing training.

- FRA will facilitate the development of site-specific strategies for grade crossings, thereby improving rail safety. FRA will provide partners with information on technologies and/or strategies for GX safety.

- Facilitate the development of site-specific strategies for trespass mitigation at the top

- 10 counties with the most trespass casualties nationwide, thereby improving rail safety.

- TC&C will gather stakeholder feedback to create research ideas and follow up with stakeholders after initial meetings.

Impacts: This research will reduce pedestrian incidents at grade crossing, improve safety for the public and the rail workforce, inform behavioral changes at grade crossings, and reduce trespass incidents. Research results will lead to increased overall safety in the railroad environment at grade crossings and increased trespass prevention awareness.

Safety – Grade Crossing Technology

- RD&T will develop grade crossing technology and expects to deliver new safety tools to assist stakeholders that improve grade crossing safety.

- In addition, RD&T will further investigate and expects to deliver new methods to assess the risk at humped crossings by, for example, establishing a rating system to indicate their relative potential danger.

- New methods of accident data analysis from FY 2022–2023 will also be explored further to determine if researchers are asking the right questions when researching solutions to improve safety at grade crossings.

- RD&T will develop a grade crossing database that will house the 3D grade crossing scans collected by the Automated Track Inspection Program car.

Outputs: Research with universities will provide a grade crossing toolbox and grade crossing assessment and analysis techniques.

Outcomes: The industry will gain new tools and techniques to address grade crossing capabilities to address safety concerns.

Impacts: The implementation of these tools and techniques will lead to safer grade crossings and fewer incidents.

Safety/Transformation – Grade Crossing Modeling and Simulation

- In collaboration with the RRS, educational institutions, and other organizations, this research is designed to validate the new accident prediction and severity model for grade crossings as well as to develop models for studying behavior in general at grade crossings.

- This research will explore new modeling and simulations to reproduce human behavior at crossings. This research will be conducted in collaboration with the Human Factors Division.

Outputs: Research will provide a model for accident prediction and severity at grade crossings and general behavior. New simulation and modeling capabilities will be explored and analyzed.

Outcomes: FRA will have an increased capability to predict accidents at grade crossings and their severity through modeling and simulation tools.

Impacts: Research will assist the railroad industry with an overall improvement in safety at grade crossings.

Potential Economic or Societal Impacts

The TC&C research program has positive impact on the U.S. economy and society by advancing the reliability, efficiency, and safety of its railroad system. By preventing train crashes, PTC research improves rail passenger and railway worker safety while mitigating the environmental impact of HazMat spills and infrastructure damage. TC&C research in grade crossing and trespassing technology benefits society by lowering the number of injuries and fatalities that occur on U.S. railroads. TC&C research in interoperability benefits the economy by making the train network less expensive.

Potential Progress Made toward Achieving Strategic Goals

The TC&C research program advances the DOT Strategic Goals of Safety, Economic Growth and Global Competitiveness, and Transformation. The program partners with U.S. railroads to develop and deploy advanced automation and train control systems. These systems are designed to allow the safe movement of more trains on existing track and realize a higher capacity and more globally competitive U.S. rail network. Transforming the rail network with modern, interoperable automation and train control systems will benefit all U.S. citizens through improved geographic mobility and reduced shipping costs.

Collaboration Partners

Partner Detail

Partner Name	Contributions	Benefits of Partnership
FHWA	FRA collaborates with these partners on intelligent transportation systems research.	Stronger products through engagement with highway and automaker stakeholders
Federal Motor Carrier Safety Administration	FRA collaborates with these partners on intelligent transportation systems research.	Stronger products through engagement with freight and trucking stakeholders

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

Partner Name	Contributions	Benefits of Partnership
FarmRail System, Inc.	ROW access; subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
Oklahoma DOT	Subject matter expertise	Better product deploy ability
MTA	Subject matter expertise	Better product deploy ability
Town of Bedford, NY	Subject matter expertise	Better product deploy ability
Town of Belmont, MA	Subject matter expertise	Better product deploy ability
Massachusetts Bay Transportation Authority (MBTA)	ROW access; subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
Brunswick, ME, Police Department	Police department facilities; subject matter expertise	Better product deploy ability
Michigan Technological University	Subject matter expertise	Better product deploy ability
Rutgers University	Subject matter expertise	Better product deploy ability
DecisionTEK, LLC	Subject matter expertise	Better product deploy ability
PanAm Railways	ROW access; subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.
City of Orlando, FL	Cameras and instillation	Better product deployability
Carnegie Mellon University	Subject matter expertise	Enhanced basic research portfolio
SunRail	ROW access; subject matter expertise	Enhanced technology transfer success. Solutions that integrate seamlessly with railroad operations.

Benefits Detail

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

Beneficiary	Benefits Received
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 Unions	Increased employee safety
Railroad Workers	Increased railroad worker safety

Human Factors

$6,792,000

Program Description

The Human Factors (HF) research program addresses the DOT Strategic Goals of Safety and Transformation. HF seeks to optimize human performance in railroad operations and to understand the causal factors of human error, including fatigue and distraction. HF also conducts research related to highway-railroad grade crossing safety, and trespass and suicide prevention.

HF studies:

- Railroads from a human-centered perspective
- How the entire railroad system influences the way people behave and interact with it
- 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

Major Program Objectives

Safety and Transformation are the primary drivers of HF research. The strategic priorities for this work include:

- Understanding and managing worker fatigue and distraction
- Addressing human error through improved human automation interaction
- Developing, implementing, and evaluating strategies to mitigate trespass and suicide incidents
- Investigating technologies to improve grade-crossing safety
- Strengthening the safety and organizational culture of railroads

HF employs several methods to carry out this research, including survey research, human subject simulator experiments, technology demonstrations, and pilot studies.

Anticipated Program Activities and Potential Outcomes, Outputs, and Impacts

Program Area – Human Factors

Program Area – Short Line Safety Institute

Transformation/Safety – Railroad Technology, Automation, and Systems Design

- HF will conduct research on human-machine interfaces (HMIs) with automated systems and assess the effects of new technologies on human behavior and performance.
- The program will continue to lead research on new HMI design (and systems engineering more broadly), while exploring partnerships with labor, railroads, and academia.
- The program will collaborate with other Divisions to complement their systems engineering research with human factors expertise.

Outputs: RD&T will prototype a head-up display (HUD) system, resulting in a technical report. Design recommendations for a HUD interface will generally follow successful research efforts involving modeling and simulation, as well as lab testing of prototyped technology. Anticipated

activities for FY 2023 also include joint studies with other RD&T Divisions such as Track and TC&C.

Outcomes: Research on in-vehicle auditory alert systems and rail vehicle warning systems is expected to improve grade-crossing safety. Human interfaces that support human-automation teaming will be further developed.

Impacts: Expected positive impacts on operator situational awareness and distraction issues on all HMI-related research.

Safety – Railroad Organizational Culture and Safety Performance

- SLSI activities include continuing SCAs; providing training for Class II and III railroads that aligns with safety culture opportunities for improvement.

FRA will continue to build the RISE program. Next steps include selecting a railroad safety issue that can be informed by individual stakeholders' datasets.

Outputs: SLSI will continue to develop follow-up SCAs of shortline and regional railroads to measure safety culture change over time. SLSI will continue to develop training and educational materials for Class II and III railroads to address common safety gaps. HF will continue to build the RISE program and assess its feasibility as a data trust for the railroad industry.

Outcomes:

- SLSI helps improve safety and safety culture in shortline and regional railroads.

- HF will collaborate with RRS and railroad stakeholders to build the RISE program.

Impacts: The SLSI program will result in safer shortline and regional railroads by raising awareness of safety issues and addressing gaps in workforce training. RISE will improve railroad safety by identifying previously unknown safety risks.

Safety – Railroad Worker and Operator Performance

- HF will assess railroad worker incident reports to evaluate the role job stress and fatigue played in the incidents.

- RD&T will work with stakeholders to identify new studies, tools, and strategies to support human fatigue detection and countermeasures.

- RD&T will support RRS in developing strategies to assist implementing fatigue risk management plans across the railroad industry.

- RD&T will also collaborate with labor, industry, and the National Academies of Science to identify safety issues related to train length.

Outputs:

- HF will provide recommendations to assist workers following acutely stressful incidents.

- HF will update the Railroaders' Guide to Healthy Sleep (RGHS) website with information and best practices.

- HF will support research on factors contributing to degraded or enhanced cognitive and behavioral performance of rail personnel.

Outcomes: Fatigue research will help reduce accidents caused by distraction or loss of situational awareness. This research will aid new locomotive engineers with varying degrees of experience in maintaining attention and staying engaged in train-driving tasks. Research into

critical incidents will help identify potential post-incident gaps in resources for workers to deal with acute stressors.

Impacts: First, this research will make railroads safer by reducing human error, updating key safety innovations, and providing a better understanding of human factors that affect the dynamic railroad work environment. Second, it will make railroads safer by increasing positive performance outcomes for railroaders. Finally, this research will make railroads safer by leading to industry-wide, streamlined, and consistent risk management plans that readily and holistically address fatigue risk.

Safety/Transformation – Highway-Railroad Grade Crossings, Railroad Trespass, and Suicide Prevention

- RD&T and RRS representatives will collaborate to conduct trespass prevention outreach activities, including an examination of potential risk mitigation strategies and lessons learned from regional trespass summits organized in FY 2022 and FY 2023. The public summits provide RD&T insights into areas for research.

- RD&T will analyze existing data to identify rail-related incidents and develop an understanding of risk factors and socioeconomic influences on trespass and suicide that have the potential to influence economic, social, and environmental equity.

- RD&T will advance existing efforts to encourage responsible reporting about suicide and trespass incidents in the media, working with Operation Lifesaver and other organizations.

- RD&T will continue to facilitate the sharing of information on research, intervention, and implementation activities among U.S.-based commuter railroad members through FY 2023 through the Suicide Prevention in U.S. Rail (SPUR) working group.

Outputs: The data quality and analysis, countermeasures, and outreach work performed under this research area will produce enhanced processes and methods, updates to research tools including for the Trespass and Suicide Prevention Toolkit developed in Q2 FY 2022, countermeasures and strategies, data, AI, and other technological innovations.

Outcomes:

- Collaboration between RD&T and RRS on trespass and suicide prevention outreach activities will assist in identifying potential risk mitigation strategies for targeted hotspots across the country.

- HF will advance innovative technologies and integrated driver systems to help reduce accidents at or around highway-rail grade crossings.

- RD&T will participate with international colleagues at conferences and in working groups to better understand trespass and suicide mitigation strategies, including strategic communications, signage, AI, and data quality improvements.

- HF will provide a platform for shared information among rail carriers on suicide and trespass prevention.

- Increased understanding of the root causes of rail suicide and trespass incidents will inform the development of strategies to prevent future incidents or mitigate their consequences.

- HF will improve strategic communications with stakeholders, carriers, and the public.

Impacts: Rail carriers can share best practices, innovative solutions and lessons learned, and interact with other agencies that experience similar challenges to understand the breadth of

solutions available. The long-term impacts of this program are to make the public safer by reducing the number of motorist and pedestrian accidents and to prevent trespassing and suicidal behaviors at highway-rai l grade crossings and ROWs.

Potential Economic and Societal Impacts

Human Factors research in grade crossing, trespassing, and suicide prevention has a direct impact on the safety of the American public. HF collaborates with organizations and local communities to increase awareness of countermeasures that can reduce grade crossing, trespass, and suicide fatalities on railroad rights-of-way. Research, in collaboration with Track and Rolling Stock, contributes to the understanding of challenges faced by railroad workers and leads directly to a safer working environment for the Nation's rail workforce. Additionally, HF has conducted fatigue research for over 10 years, resulting in recommendations to RRS. The program's RGHS website provides industry a vehicle for education and community.

SLSI increases shortline and regional railroad safety by providing training and education that would otherwise not be available. Shortline and regional railroads help maintain freight rail services in rural America and economically connect the U.S. rail network. Moreover, SLSI SCAs provide iterative qualitative and quantitative data to ensure shortline and regional railroads continue to maintain high safety standards.

Potential Progress Made toward Achieving Strategic Goals

The Human Factors research program focuses on increasing public safety through research on grade crossing, trespassing, and suicide prevention; and factors contributing to railroad workers performance. The program investigates human-automation teaming and conducts research on safe systems and design. The program has advocated the use of HSI principles within the industry a. SLSI continues to increase the safety culture of Class II and Class III railroads through assessments and training. HF leads FRA's development of RISE, a safety data trust, in partnership with a university, to increase the understanding of safety trends and challenges within the industry.

Collaboration Partners

Partner Detail

Partner Name	Contributions	Benefits of Partnership
DOT Human Factors Coordinating Committee (HFCC)	Share HF research/information with each DOT mode.	Per the *U.S. Department of Transportation Strategic Plan for FY 2018-2022* (p. 34), HFCC "serves as a collaborative, multimodal team with Federal Government-wide liaisons to address crosscutting human factors issues in transportation." HFCC includes representatives from every DOT operating administration (OA).
DOT Safety Council	HF provides financial support to the DOT Safety Council.	Per the *U.S. Department of Transportation Strategic Plan for FY 2018-2022* (p. 16), DOT Safety Council provides leadership and establishes a departmental commitment to improving transportation safety through improved safety culture. The Council is composed of the heads of

Partner Name	Contributions	Benefits of Partnership
		each DOT OA, their senior safety officers, and senior officials from the Office of the Secretary.
TRB Committee on Railroad Operational Safety (AR070)	Subject matter expertise, collaboration, and recommendations	Stakeholder engagement/understanding of human error situations
RRS	Subject matter expertise, collaboration, and recommendations	HF PMs work closely with their counterparts in RRS. As a primary customer of RD&T, RRS research needs, and priorities help shape HF research plan.
RRS's Highway-Rail Crossing and Trespasser Programs Division	Subject matter expertise, collaboration, and recommendations	HF PMs supports staff in RRS Highway-Rail Crossing and Trespasser Programs Division.
TC&C, Rolling Stock, and Track Divisions	Collaboration, subject matter expertise, stakeholder engagement	HF works closely with PMs from other RD&T research programs to conduct jointly sponsored research projects. Integration of HF PMs ensures engineering solutions include consideration of the operator's perspective. Integration of HF principles and HMI design considerations at the beginning of developing new technologies help reduce the potential for human error once those technologies are deployed. HF will collaborate with Rolling Stock at TTC.
Amtrak	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
Metra	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
New Jersey Transit	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
Keolis/ MBTA	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
FAMES	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of fatalities and lessons learned
SEPTA	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
MTA (LIRR and MNR)	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
The Switching Operations Fatality Analysis (SOFA)	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of fatalities and lessons learned

Partner Name	Contributions	Benefits of Partnership
Brotherhood of Locomotive Engineers and Trainmen	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
International Association of Sheet Metal, Air, Rail, and Transportation Workers	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations
ASLRRA	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement
AAR	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement
GE Global Research	Collaboration, research studies	Stakeholder engagement
SLSI	Subject matter expertise, collaboration, data, and recommendations	Improved safety and safety culture in Class II and Class III freight railroads
GRASP	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement
SPUR	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement
Operation Lifesaver	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement
Massachusetts Institute of Technology	Subject matter expertise, research studies, collaboration, data, and recommendations	HF expertise
Michigan Technological University	Subject matter expertise, research studies, collaboration, data, and recommendations	HF and AI expertise
University of Connecticut	Subject matter expertise, research studies, collaboration, data, and recommendations	HF expertise
University of New Mexico	Subject matter expertise, research studies, collaboration, data, and recommendations	HF and AI expertise
Rutgers University	Subject matter expertise, research studies, collaboration, data, and recommendations	HF and AI expertise
University of South Carolina	Subject matter expertise, research studies, collaboration, data, and recommendations	HF and AI expertise
FRA IT	Collaboration, IT expertise and support, recommendations	IT expertise
OST IT	Collaboration, IT expertise and support, recommendations	IT expertise
Harvard University	Subject matter expertise, research studies, collaboration, data, and recommendations	HF and fatigue expertise
University of Alabama	Subject matter expertise, research studies, collaboration, data, and recommendations	HF, data, and AI expertise

Benefits Detail

Beneficiary	Benefits Received
RRS	Improved safety requirements, standards, recommendations
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; Universities	Improved railroad research resources and capabilities WFD opportunities
Labor Unions	Increased employee safety
Railroad Workers	Increased railroad worker safety

Chapter 2 – FY 2024 RD&T Programs

The AMRP FY 2024 outlook year chapter in the annual plan is not developed in alignment with the President's budget request of the same year due to the AMRP development schedule per 49 U.S.C. Chapter 65 Sec. 6501 Research Planning.

Railroad Systems Issues

Program Description

RSI research program comprises the advanced strategic initiatives that ensure RD&T alignment with national priorities and areas of technological need. The program addresses initiatives that support industry transformation by investing in research and innovation to meet the challenges of the present and modernize a transportation system for the future. RSI activities include projects that align with congressional, DOT, OST-R, and FRA strategic objectives as well as exploratory research areas. The principal focus and goal of the RSI program is safety; however, the program's activities contribute to all DOT Strategic Goals – Equity, Climate and Sustainability, Economic Strength and Global Competitiveness, Transformation, and Organizational Excellence.

Major Program Objectives

The major program objectives of the RSI program include 1) identify safety improvements that address areas of national priority; 2) identify new program areas to advance broad rail industry safety risk; and 3) gain insight into the viability of new approaches/solutions to improve system-wide railroad safety.

Anticipated Program Activities

Safety – Rail Safety Innovations Deserving Exploratory Analysis

- TRB and FRA will issue an IDEA Program Announcement to solicit and select proposals for the Rail Safety IDEA program exploratory research projects.

- TRB and FRA will collaborate to select and manage the projects to completion.

Organizational Excellence – Project Selection

- FRA will renew the Decision Lens software license for an additional option year to continue use of the prioritization software.

Organizational Excellence – Program Support

- Technical Editors will review and edit documents and provide report-related social media content to the FRA Office of Public Affairs for RD&T social media campaigns.

- Contractors will provide program management, analysis, and subject matter expertise to support project, program, and portfolio management.

Organizational Excellence – Project Evaluation

- RD&T will continue to align evaluation practices to FRA's learning agenda and OMB's direction.

- RD&T will conduct project evaluations and optimize RD&T performance management metrics.

Transformation – Facilities and Equipment – Transportation Technology Center

- RD&T will provide facilities and equipment that can be used to perform railroad research and development, testing, and training to enhance the safety of rail systems in both safety and security operations.

- RD&T will continue to enhance and expand TTC capabilities through strategic investment in existing facilities and equipment to support upcoming research and testing needs (e.g., the refurbishment of its rail system).

- RD&T will continue to support environmental and green technology goals encouraging energy efficiency, renewable energy, the reduction of toxins, recycling, the reuse of materials, and water conservation. RD&T will complete TTCI contract closeout activities.

- RD&T will continue to purchase equipment and instrumentation needed for the new ENSCO contract based on RD&T's facilities maintenance plan.

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

- RD&T has begun research planning on how TTC will be used over the next 5 years. TTC will continue to develop new capabilities, such as human factors research.

- TSA/FRA/RRS will refurbish a building to conduct safety and security training at the Federal Training Center. Construction will begin in FY 2023 and be completed in 18 months, in FY 2024.

- RD&T will place a solar array at TTC to improve sustainability of the center's resources. When completed, FRA will have the largest solar array in DOT.

Safety/Transformation – Railroad Systems Issues

- RSI will conduct research solicited from BAAs, based on proposals accepted by RD&T.

Economic Strength and Global Competitiveness/Equity – Workforce Development

- RD&T will continue WFD research activities, stakeholder engagement, MSI/HBCU outreach and relationship-building, STEM projects, and expanding programs that support industry efforts to increase the recruitment, retention, and training of under-represented populations.

- RD&T will engage and collaborate with the railroad industry for a better understanding of rail workforce trends and provide relevant data and insights to support sustainable initiatives.

- RD&T will support the third phase of programs aimed at engaging youth (Pre-K through 12th grade and college) and under-represented populations in rail transportation and STEM topics.

- In addition, RD&T will fund 2021 BAA research topics: 1) Addressing Equity Challenges in Evolving Railroad Workforce Training Trends and Best Practices; 2) Workforce Recruitment – Attracting and Retaining Women in Rail; and 3) Influencing Successful Practices in Knowledge Management within the Railroad Industry.

- RD&T will fund research proposals from the following research topics published in FRA's Research with Universities – Research Initiatives in Support of Railroad Safety BAA: 1)Pre-college STEM Rail Transportation Club to increase Racial Equity in Rail Workforce Recruitment; 2)Workforce Recruitment – Attracting and Retaining Women in Rail (new

contract); 3)Racial Equity in Rail Workforce Recruitment – Identifying and Training Leadership for Succession Planning; and 4)LGBTQ+ Equity and Inclusion in the Railroad Industry.

Climate and Sustainability – Energy and Emissions

- RD&T and RRS will expand bilateral discussions with international partners from a 2023 clean energy workshop to identify opportunities to collaborate and share knowledge.

- Working with the locomotive OEM, RD&T will continue to develop and evaluate clean energy for rail transportation.

Equity – Accessibility

- RD&T will support development of new and improved accessibility standards for rail vehicles, ensuring they are safe and technically feasible.

- Research will be conducted as needed to develop science-based knowledge in support of standards.

   o Data from past R&DT research in this area will be applied for more complicated and advanced scenarios.

- RD&T will continue T2 of its research products to U.S. Access Board as regulatory language for new accessibility requirements for rail are developed.

Climate and Sustainability – Locomotive Safety

- RD&T will assess new and innovative technologies to improve the safety and efficiency of locomotives in a real-world environment.

- RD&T plans to complete development and prototype demonstration of hybrid systems.

Safety – Office of Railroad Safety Support

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

- RD&T will continue to provide SME support to RRS.

Economic Strength and Global Competitiveness – University Research Initiatives (University Cooperative Research Agreement and Research with Universities on Intelligent Railroad Systems)

- RD&T will publish the request for proposals and review university proposals.

- RD&T will select prospective research projects to fund and begin selected projects.

- FRA will collaborate with ITS-JPO to publish a BAA to solicit applied technology research projects that will support DOT and FRA goals to advance automation and connected vehicle technology adoption in the rail industry.

Transformation – Rail Research and Development Center of Excellence (COE)

- Universities selected in FY 2023 will plan and start new research and training initiatives.

- RD&T will work with universities to strategically plan and launch new research and training efforts.

Track

Program Description

The Track research program drives research that improves the safety and state-of-good-repair of railroad track. This work helps ensure U.S. track and structures meet the Nation's transportation needs – today and in the future. It focuses on reducing track-caused derailments by improving the industry's technical understanding and by applying advanced analyses and technologies in innovative yet practical ways. While the emphasis is on DOT's Safety and Transformation goals, the program also advances DOT's Economic Strength and Global Competitiveness, Climate and Sustainability, and Organizational Excellence goals. The program includes two primary research areas: track structures and components, and systems performance and analysis.

Major Program Objectives

The Track research program has four broad objectives:

- Understand define what makes up safe track.

- Improve how the FRA and the industry inspects track and structures.

- Improve how FRA and the industry assess safety risk for track.

- Develop a more productive, knowledgeable, and capable workforce.

Anticipated Program Activities

The Track program's anticipated activities for FY 2024 support the major program objectives. While the activities for FY 2024 are very similar to those of FY 2023, the emphasis for several research projects will shift to TTC.

Infrastructure – Transportation Technology Center

- RD&T expects to begin construction on test beds at TTC; when finished, they will be used to better evaluate and develop inspection technologies and to quantify the effect of different factors on track strength.

  o This change in emphasis will allow RD&T to collaborate better with other transportation modes and provide access to more advance technologies and analysis methods.

  o The test beds will allow RD&T to pursue more WFD opportunities by offering FRA inspectors, academic researchers, and industry personnel hands-on access to train with the latest technologies in a safe "sandbox."

Safety – Safe Track

- RD&T will pursue multiple projects related to better understanding what constitutes safe track. To be safe, track strength must exceed the applied loads from both train operations and the environment.

- Research will investigate both the forces being applied to the track and the response of rail vehicles, and especially passenger cars, to track irregularities. It includes finding ways to identify and monitor track at risk of damage or failure from climate change.

- Research will also explore factors contributing the most to track strength and attempt to quantify how quickly track performance degrades. To get the necessary information, the

work will not just include laboratory and field testing but also use advanced computer simulations, analytics, and machine-learning methods.

Innovation – Track Inspection

- RD&T will also pursue multiple projects related to improving how track is inspected. The research includes finding and developing new sensors or platforms that measure and assess track conditions that current equipment cannot.

- Work will also quantify and aim to improve the accuracy and reliability of current inspection equipment.

- Several procurements address how to better present inspection data to inspectors so they can make more effective use of this information. Supporting these efforts requires the same hands-on testing, combined with AI, as the safe track research.

Safety –Safety Risk Assessment

- The Track program will drive research to develop new and better ways of assessing safety risk.

- This research aims to devise a framework to quantify how the risk of a given safety problem varies as operating practices and inspection methods or frequencies change and as track components improve.

- The work will draw upon the research results from the safe track and improved inspection projects.

Economic Strength and Global Competitiveness – Workforce Development

- The Track program continues to develop a more capable industry workforce. In FY 2024, RD&T expects to continue expanding university projects to create a talent pool of more knowledgeable students.

- The research results and developed technologies are expected to promote a more knowledgeable and effective maintenance workforce.

Rolling Stock

Program Description

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

Major Program Objectives

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

Anticipated Program Activities

Climate and Sustainability – HazMat – Tank Car Research

- In 2024, RD&T will continue providing stakeholders with information on fire studies, tank car impact testing, and analyses of different tank car designs.

Climate and Sustainability – HazMat – Structural Integrity

- In 2024, RD&T will continue to identify potential studies to address defects that affect the structural integrity of tank cars and portable tank safety equipment.

Safety – HazMat – Accident Consequence Reduction

- In 2024, RD&T will continue to learn about how failures occur and how to prevent or manage the consequences of failures through improved equipment design and protection, evaluate and document damage to railroad tank cars, and study the liquid/vapor release flow on pressure relief valves.

- RD&T will also develop new tank test panels to continue studies of non-destructive evaluation techniques.

Safety – HazMat – Risk Analysis

- In 2024, RD&T will finalize its risk analysis studies on unit trains carrying hazardous materials.

Climate and Sustainability – Energy Products Research

- In 2024, RD&T will finalize its risk assessment of transporting large quantities of hazardous materials. Research will develop an alternate mechanism for rapid brake signal propagation – to be used on unit trains transporting energy products (high-hazard flammable trains).

Climate and Sustainability – Alternative Fuels Safety Research

- In 2024, RD&T will perform analyses and small-scale and full-scale impact testing of alternative fuel tenders and ancillary equipment, and develop documents for RRS on U.S. railroads' natural gas fuel usage.

- FRA will engage the rail industry in testing and standards development for clean energy storage media.

Safety – RSEC – Rolling Stock Equipment and Components

- In 2024, RD&T will continue to research and develop components and systems that reduce the risk of rail incidents and accidents. VLT study efforts, in collaboration with industry, will continue.

- RD&T will also continue to identify malfunctioning or poorly performing equipment and components, including brake systems with WTD detector technology.

Transformation – RSEC – Rolling Stock Maintenance and Inspection

- In 2024, RD&T will continue to develop a system to power advanced detection devices (technologies to monitor conditions, detect rolling stock defects, and prevent failures).

- RD&T will also, in collaboration with industry, continue and improve FE analysis wheel research, wayside technology pilot demonstrations, tread braking research, and vehicle dynamics simulations.

Safety – RSEC – Train Handling and Operating Practices

- In 2024, RD&T will continue to improve truck designs that can provide superior equalization and curving performance by continuing to improve TEDS.

- RD&T will also continue passenger rail research to advance fire safety requirements in U.S. passenger rail vehicles.

Safety – TOP – Fire Safety Research

- In 2024, RD&T will continue working with APTA to assess alternative standards for the fire safety performance of materials and components used in passenger rail vehicles, including passenger locomotive fuel tanks, railcar seats, and ventilation systems.
  - This research will be applied to egress prediction models that better predict passenger egress.

Safety – TOP – Emergency Preparedness Research

- In 2024, RD&T will continue to improve evacuation modeling tools for rail applications.

Safety – TOP – Cab Displays, Controls, and Environment

- In 2024, RD&T will validate new LED headlights and assist in adopting new standards and regulations for LED lights on locomotives.

Transformation – TOP – Passenger Locomotive Crashworthiness and Occupant Protection

- In FY 2024, RD&T will continue passenger locomotive crashworthiness research.

Safety – TOP – Glazing Standards

- In 2024, RD&T will continue to study new glazing methods to improve glazing retention capacity.

- RD&T will also continue studying the passenger railcar failure modes in rollover events.

Train Control and Communication

Program Description

The TC&C research program focuses on improving railroad operation safety, operational efficiency and economic competitiveness, network capacity, and climate change impact. It helps the railroad industry address current and future technical and economic challenges by developing interoperable system standards and specifications. TC&C's other focus area is grade crossing safety and trespass prevention. The program conducts pilot studies, provides safety best practices, creates prototypes, and demonstrates safety and security systems, including intelligent rail systems. It also provides scientific research and data to support FRA regulations. This research program collaborates with stakeholders to build on existing TC&C technology to adapt and incorporate advancement in software and hardware technologies to develop the next generation of train control safety systems.

Major Program Objectives

The TC&C research program objectives are to improve railroad operational safety, including reducing roadway and at-grade crossing collisions, trespass countermeasures, and finding the right level of automation to optimize asset utilization and fuel consumption to reduce environmental impact. This program's goal is to transform railroad operations by anticipating and adapting innovative and emerging technologies to future-proof TC&C technologies and provide stakeholders the benefits of the research through T2.

Anticipated Program Activities

Safety – PTC Technology

- RD&T will continue to support evolutionary and innovative technologies to ensure PTC interoperability and reliability evolve with the pace of technological development.

- TC&C will continue industry coordination to develop solutions to improve the reliability, availability, and maintainability of deployed PTC systems.

Safety – PTC Interoperability

- RD&T will continue interoperability research to ensure compliance with RSIA and assist industry in improving testing protocols and centralizing and streamlining the testing and validation of PTC systems.

- FRA will support the development of interoperable train automation technologies, hazard sensing solutions, and associated industry standards.

Safety/Transformation – PTC Next Generation

- RD&T will continue research into advanced PTC concepts and architectures that support 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.

Transformation – Intelligent Transportation Systems

- RD&T will continue research on new sensor, computer, and digital communications for train control, braking systems, grade crossings, and defect detection; innovative technologies in

automation, AI, and UAVs will improve safety and reduce incidents around railroad operations.

- Activities will include continued research into the feasibility of a vital, connected vehicle communication protocol for grade crossing accident mitigation, and the development of novel concepts for integrating road vehicle active safety systems into rail crossing infrastructure systems.

Safety – Trespass Countermeasures

- RD&T will work with relevant partners and stakeholders to research solutions that can reduce trespassing along railroad ROWs.

Safety – Grade Crossing Technology

- RD&T will develop technologies and tools to improve warning devices and integrate grade crossing locations into mapping devices.

Safety – Grade Crossing Pedestrian Safety

- RD&T will continue to explore measures to address accidents at grade crossings and along railroad ROWs that involve pedestrians.

- RD&T will collaborate with industry partners in researching and testing new methods to reduce the risk of accidents involving pedestrians.

Safety/Transformation – Grade Crossing Modeling and Simulation

- RD&T will continue to evaluate scenarios for possible safety improvements at grade crossings without the need to perform field testing.

Safety – Grade Crossing and Trespass Outreach and Education

- In collaboration with OL and other organizations, RD&T will continue to educate the public on the dangers of grade crossings.

Human Factors

Program Description

The Human Factors (HF) research program addresses the DOT Strategic Goals of Safety and Transformation. HF seeks to optimize human performance in railroad operations and to understand the causal factors of human error, including fatigue and distraction. HF also conducts research related to highway-railroad grade crossing safety, and trespass and suicide prevention.

HF studies:

- Railroads from a human-centered perspective
- How the entire railroad system influences the way people behave and interact with it
- 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

Major Program Objectives

Safety and Transformation are the primary drivers of HF research. The strategic priorities for this work include:

- Understanding and managing worker fatigue and distraction
- Addressing human error through improved human automation interaction
- Developing, implementing, and evaluating strategies to mitigate trespass and suicide incidents
- Investigating technologies to improve grade-crossing safety
- Strengthening the safety and organizational culture of railroads

HF employs several methods to carry out this research, including survey research, human subject simulator experiments, technology demonstrations, and pilot studies.

Anticipated Program Activities[2]

Safety/Transformation – Railroad Technology, Automation, and Systems Design

- HF will continue to maintain the Cab Technology Integration Laboratory and driving simulator. These simulators provide facilities to conduct human subjects research.
- HF will continue research on in-vehicle auditory alerts for automobiles approaching grade crossings and pilot testing of HUDs in the locomotive cab.
- HF will continue to collaborate with the DOT Virtual Open Innovation Collaborative for Safety program, where the FRA driving simulator will have a role as a "node" in the system.

Safety – Railroad Organizational Culture and Safety Performance

- SLSI will continue to work with Class II and III railroads to improve safety and safety culture.
- Continue to support RRS by:

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[2] Specific research will be identified from the FY 2024 BAA.

- o Providing subject matter expertise, and research, data, and tools to improve railroad safety

- o Developing the RISE program and serving on railroad safety working groups, including FAMES and SOFA

- o Conducting human performance testing at TTC

- o Using TTC facilities to test SOFA recommendations and best practices

Safety – Railroad Worker and Operator Performance

- RD&T will continue to study issues related to railroad worker and operator performance, such as fatigue.

- RD&T will continue to support RRS in of its audit of engineer and conductor training programs. RD&T will continue to conduct research on Human-Automation Teaming, to better understand and describe the possible roles that humans and automation can play in detection, analysis, and decision-making.

- RD&T will assess worker responses to critical incidents and evaluate the role of these incidents in job stress and fatigue. RD&T will analyze worker fatigue and commute data to identify risk factors to operator performance and present findings with recommendations to RRS.

Safety/Transformation – Highway-Railroad Grade Crossings, Railroad Trespass, and Suicide Prevention

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

- Continue to identify, collect, and design various in-vehicle auditory alerts, and conduct subsequent empirical experiments evaluate their effects on motorist behavior, grade crossing safety.

- Continue to analyze GX/trespass data to identify rail-related incidents and develop an understanding of risk factors and socioeconomic influences on trespass and suicide that could influence economic, social, and environmental equity.

- Continue coordination with international and domestic colleagues through GRASP, Operation Lifesaver, and SPUR to facilitate information-sharing on research, intervention, and implementation of activities related to suicide prevention.

- RD&T will also continue to investigate how accidents, trespass, and suicide affect the rail system (including rail employees) and communities.

For More Information on DOT's Research see https://researchhub.bts.gov/search