United States Department of Transportation
Annual Modal Research Plans FY 2024
Program Outlook FY 2025

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 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 also aligns to DOT Objectives and Strategies, as RD&T works 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. 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 collaborates on research across DOT modes and other Federal agencies. RD&T Program Managers (PMs) conduct symposia, participate in stakeholder meetings, attend conferences and industry meetings, and facilitate program reviews to share information. RD&T publishes research to inform the public and advance the practical application of new technology.

Table 1 – FY 2024 RD&T Program Funding Details

RD&T Program Name	FY 2024 President's Budget Request* ($000)	Applied ($000)	Technology Transfer ($000)	Facilities ($000)	Experimental Development ($000)	Major Equipment, R&D Equipment ($000)
Railroad Systems Issues	$20,611*	$16314*	$605	$1,837	$813	$1,042
Track	$11,783	$10,837	-	-	$946	-
Rolling Stock	$10,553*	$9,876*	-	-	$677	-
Train Control & Communication	$9,008	$8,483	-	-	$525	-
Human Factors	$7,045*	$6,309*	-	-	$736	-
Totals	**$59,000**	**$51,819***	**$605**	**$1,837**	**$3,697**	**$1,042**

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

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

Table 2 – FY 2024 RD&T Program Budget Request by DOT Strategic Goal

RD&T Program Name	FY 2024 President's Budget Request ($000)	Safety ($000)	Economic Strength and Economic Competitiveness ($000)	Equity ($000)	Climate and Sustainability ($000)	Transformation ($000)	Organizational Excellence ($000)
Railroad Systems Issues	$20,611*	$20,611*					
Track	$11,783	$11,783					
Rolling Stock	$10,553*	$10,553*					
Train Control & Communication	$9,008	$9,008					
Human Factors	$7,045*	$7,045*					
Totals	**$59,000**	**$59,000**					

**Amounts include congressional directives for the Short Line Safety Institute ($2,500) in Human Factors; Tank Car 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 2024 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.*

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

Section 1 – FY 2023 RD&T Programs

Office of Research, Development, and Technology
Research Portfolio Overview
$59,000,000

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 research aligns to OST-R Research Priorities and all the Grand Challenges: Zero Fatalities, Resilient Supply Chains, Equitable Mobility for All, Net-Zero Emissions, and The Future Transportation System-of-Systems. 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:

- 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:

Table 3 – RD&T Programs and Program Areas

Program	Program Area
Railroad Systems Issues	• RSI • Research with Universities on Intelligent Railroad Systems • Technology Transportation Center (formerly Research and Development Facilities) • WFD • Emissions Reduction and Alternative Fuel Locomotive • Center of Excellence
Track	• Track and Structures • Systems Performance and Analytics
Rolling Stock	• Hazardous Materials (HazMat) • Energy Products Research • Rolling Stock Equipment and Components (RSEC) • Train Occupant Protection (TOP)
Train Control and Communication	• PTC • Grade Crossing/Trespassing
Human Factors	• HF • 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 2024. 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 2023, the Track Division conducted its second Track Support and Substructure Symposium, a hybrid, 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 2024. RD&T conducted quarterly stakeholder meetings with labor to better understand safety concerns for railroad workers, as railroad worker safety is included on the National Transportation Safety Board (NTSB) 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 2024 and FY 2025.

Most RD&T research projects produce Technical Reports – published on FRA's eLibrary, the National Transportation Library, the Transportation Research Board (TRB) 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 2023 expected to continue the trend. The table below summarizes RD&T publishing from FY 2019 to FY 2023 (from October 2022 through May 2023).

Table 4 – FY 2019 – 2023 RD&T Publishing

Document Type	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023*
Technical Reports	44	52	41	42	44
Research Results	22	19	29	29	30
Other Reports	3	2	6	7	0
Total	**69**	**73**	**77**	**78**	**74**

** As of 9/29/2023*

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, Research Priorities, Objectives, and Grand Challenges – 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 HazMat 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 the impact of automation on transportation; and the 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.

Working Groups Activities

Performance Task Force Working Group: This OST working group focuses on establishing DOT's performance practices. The group is creating an integrated framework that leverages DOT performance goals. Recently, the working group completed logic models for each mode and plans to develop performance measures.

Data Access Task Force (DATF): DATF is focused on supporting public access of R&D-related data sources.

Very Long Trains (VLT) Steering Committee and the VLT Stakeholders Group: The goal of both working groups is to provide FRA input on research activities and provide in-kind support to FRA research on VLTs. Both groups include the railroads, labor unions, FRA staff, and AAR. The group expects to provide input and knowledge at meetings and while conducting reviews. These groups will continue until the VLT project has completed.

Evaluation and Performance Measurement Efforts

In compliance with the Government Performance and Results Act (GPRA) and the GPRA Modernization Act of 2010, RD&T 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.

RD&T conducts independent evaluation as part of the Human Factors research program. The evaluation efforts are included as part of FRA's learning agenda.

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 2023

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 research activities aligns with DOT's Economic Strength and Global Competitiveness, Equity, Climate and Sustainability, Transformation, and Organizational Excellence priorities.

Table 5 – RD&T Research alignment with DOT 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 2022 and FY 2023, RD&T expanded its research in STEM programs, including creating a training program at an HBCU in partnership with a state DOT. In FY 2024, RD&T will expand its STEM initiatives to generate more interest in railroad careers. Starting in FY 2019, RD&T began a concerted effort to increase funding to academic institutions. Funding to universities for all research has increased 95% between FY 2017 and FY 2022.
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. Initiatives funded in FY 2022 examine ways to increase the number of women in the railroad industry and how performance management systems affect recruitment and retention. In FY 2023 and FY 2024, 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 2023, RD&T will partner with RRS to host an international workshop at TTC 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, DOT modes, and other government agencies a facility to conduct infrastructure research and share information.
Organizational Excellence	RD&T continues improving research publication and project selection processes. RD&T conducts an annual prioritization to ensure stakeholder and industry needs are factored into RD&T investment planning processes.

Potential Progress Made toward Achieving Strategic Research Priorities and Grand Challenges: RD&T Alignment to OST-R Priorities, Objectives, and Grand Challenges, FY 2023

RD&T's ultimate goal is zero derailments – zero accidents – zero fatalities across the Nation's rail network. RD&T leadership considered FRA's role and commitment in executing OST priorities. The following table highlights how RD&T's research activities, designed and disseminated through its divisions, TTC, and the new Rail Research and Development Center of Excellence (COE), align with OST-R Research Priorities and Grand Challenges.

Table 6 – Research Activities Aligned with OST-R Priorities

Strategic Goals	Research Priorities	Grand Challenges	RD&T Research Activities
Safety	• Human Factors • Data-Driven System Safety	Zero Fatalities	Safety is the primary Strategic Goal of DOT; it is also the principal driver of the RD&T program. RD&T's ultimate goal is zero derailments – zero accidents – zero fatalities across all divisions, TTC, and the COE. The Human Factors research program conducts research in human factors in collaboration with every RD&T division.
Economic Strength and Global Competitiveness	• Resilient Supply Chains • Create Pathways to Good-Paying Jobs	Resilient Supply Chains	The Rolling Stock research program's "Improving the Resilience of Freight Railroad Networks" and the Train Control and Communication research program's "PTC-Interoperability" align to OST-R efforts to create Resilient Supply Chains. The COE and WFD provide funding to innovative projects to Create Pathways to Good-Paying Jobs.
Equity	• Equity and Accessibility Assessment • Mobility Innovation • Wealth Creation	Equitable Mobility for All	RD&T research in Accessibility helps to create equitable and accessible transportation as part of the OST-R Grand Challenge Equitable Mobility for All. Equity and Accessibility Assessment, Mobility Innovation, and Wealth Creation Research Priorities are addressed by WFD, university funding, Accessibility research, and the COE.
Climate and Sustainability	• Decarbonization • Sustainable and Resilient Infrastructure	Net-Zero Emissions	The Rolling Stock and Railroad Systems Issues research programs include two Program Areas dedicated to Decarbonization and Sustainable and Resilient Infrastructure. Both Program Areas (Tank Car Energy Products Research and Emissions Reduction and Alternative Fuel Locomotive) contribute to the Net-Zero Emissions Grand Challenge. The COE will also conduct research in Climate and Sustainability.
Transformation	• Integrated System-of-Systems	The Future Transportation System-of-Systems	Each RD&T research program conducts to research to develop connected intelligent infrastructure.

Chapter 1 – FY 2024 RD&T Programs

Railroad Systems Issues
$20,611,000

Program Description

The Railroad Systems Issues 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

Program Area – Workforce Development

Program Area – Emissions Reduction and Alternative Fuel Locomotive

Program Area – Rail Research and Development Center of Excellence

Anticipated Program Activities and Potential Outcomes, Outputs, and Impacts

Safety – Rail Safety Innovations Deserving Exploratory Analysis (IDEA)

- TRB and FRA will issue an IDEA Program Announcement to solicit and select proposals for the Rail Safety IDEA program research projects.
- TRB and FRA will collaborate to select and manage the projects to completion.
- Project selection will focus on new, innovative, and unproven ideas that have potential to improve railroad safety and efficiency.

Outputs:

- Expected deliverables include quarterly progress reports, a final performance report for each project, and a final research report from the TRB committee.
- T2 activities are expected for projects started in 2020–2023 (based on project duration).

Outcomes

TRB and FRA will collaborate to select and manage the projects to completion. The selected research projects will deliver innovative ideas and techniques to improve railroad safety and solve railroad safety problems.

Impacts:

- Support and improve new research ideas to be proven and implemented.
- Improve overall railroad safety and mitigate existing problems.

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 renews the software license for Decision Lens for an additional option year. Prioritization results from FY 2023 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: Expedited technology transfer through the implementation of continued strategic planning, project management, project evaluation, and the editing and publishing of research related reports.

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

Safety/Transformation – Facilities and Equipment – Transportation Technology Center

RD&T will:

- Continue to provide facilities and equipment that can be used to perform railroad research, development, testing, and training to enhance passenger and freight rail systems in both safety and security operations.

- Continue to address the site's aging infrastructure and deferred maintenance needs, as funding allows, for the repair and rehabilitation of buildings and facilities in FY 2024.
- Continue to enhance and expand TTC capabilities through strategic investment in existing facilities, equipment, and instrumentation to support upcoming research and testing needs (e.g., the refurbishment of its rail system and equipment).
- 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.
- 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.
- Complete 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.
- FRA and TSA will explore how industry can use drones. (TSA has worked at TTC for over 11 years).
- TSA is considering the impact of threats to PTC and other autonomous systems, such as the Rail Crossing Violation Warning (RCVW) system. TSA has identified rail cybersecurity as a worthwhile pursuit and is providing its inspectors cyber security training (through ENSCO, Inc.) at TTC. The pilot training program is complete and now additional classes have started based on planned program expansion.

  Outputs:

  - The start of a feasibility study for a grade crossing testbed.
  - Research plan identifying how TTC will be used over the next 5 years. TTC will continue to develop new capabilities, such as human factors research, that will begin at TTC in collaboration with multiple RD&T divisions.
  - TTC's capabilities will be expanded based on the purchasing of heavy equipment and instrumentation.

  Outcomes

  TTC will continue to promote the 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. TTC will encourage a broader use of the facilities to develop and apply new technology for State and local governments and others involved in rail transportation. Also, TTC will partner with local colleges and universities on a workforce development effort to retrain students.

  TSA will continue security training at TTC. Also, TTC will develop a Drone Operations, Safety, and Security program at TTC that will provide TSA additional capabilities for its security training.

  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 TTC's rail transportation technology, development, testing, standards development, and training.

RD&T will address climate and sustainability requirements at TTC. RD&T will work to establish cross-modal partnerships with PHMSA and FTA.

Impacts:

- Expanded use of TTC by 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 infrastructure research.
- 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 – TTC Alterations, Improvements, and Construction

RD&T will complete Building System, Electrical Network, External Structure, and Fire/Life/Safety projects to maintain TTC in a state of good repair.

Outputs:

- Hardware
- Software
- Data, databases
- Demonstration

Outcomes

RD&T will support and expand research and training conducted at TTC by FRA, DOT modes, governmental agencies, and industry by:

- Modernizing the facility
- Adding infrastructure as needed to support new research programs
- Replacing critical end-of-life components
- Addressing the maintenance backlog
- Improved knowledge
- Improved processes

Impacts

The repairs, replacements, and upgrades that are part of this project enable TTC to continue as a critical venue for research and training related to transportation safety and security.

Safety/Transformation – Railroad Systems Issues

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

Outputs, Outcomes, and Impacts

The Outputs, Outcomes, and Impacts of the Railroad Systems Issues research will depend on BAA selections in FY 2023. Note: RD&T is reviewing concept papers as of May 4, 2023, and proposals as of June 1, 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 expanding programs that support industry efforts to increase the recruitment, retention, and training of under-represented populations.
- 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.
- Support programs aimed at engaging youth (Pre-K through 12th grade and college) and under-represented populations in rail transportation and STEM topics.
- Seek proposals on the following topics: 1) Addressing Equity Challenges in Evolving Railroad Workforce Training Trends and Best Practices; 2) Influencing Successful Practices in Knowledge Management within the Railroad Industry; 3) Encouraging Early Interest in Railroad Careers; 4) Equity in Rail Workforce Recruitment – Identifying and Training Leadership for Succession Planning; 5) 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 the Office of Management and Budget for review and approval.
  - In FY 2023, FRA will publish its WFD research results. RD&T will participate in WFD data calls.
  - Outreach to MSIs/HBCUs by implementing its MSI/HBCU Strategic Plan. Increase funding to MSIs/HBCUs as outlined in the MSI/HBCU Strategic Plan.
  - Publish reports related to WFD initiatives.

  Outcomes:

  - 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 seek proposals on the following BAA research topics: 1) Addressing Equity Challenges in Evolving Railroad Workforce Training Trends and Best Practices; 2) Influencing Successful Practices in Knowledge Management within the Railroad Industry; 3) Encouraging Early Interest in Railroad Careers; 4) Equity in Rail Workforce Recruitment – Identifying and Training Leadership for Succession Planning; 5) LGBTQ+ Equity and Inclusion in the Railroad Industry.
- Stakeholder engagement will help create stakeholder forums to exchange best practices and information.
- 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, Economic Strength and Global Competitiveness).
- RD&T will conduct an updated railroad industry workforce assessment (Railroad Industry Modal Profile).
- Completion of the first WFD symposium on STEM education

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.

Equity – Accessibility

- Support the development of new and improved accessibility standards for rail vehicles.
- Assess the various accident loading and containment strategies for passengers using wheeled mobility devices (WhMDs).
- Conduct research to develop science-based knowledge in support of standards.
    - Data from past R&DT research in this area will be applied for more complicated and advanced scenarios.
- Continue T2 of research products to U.S. Access Board as regulatory language for new rail accessibility requirements are developed.
- Complete development of a mobile application to improve the accessibility of railroad communications.

Outputs:

- Development on a mobile application to improve the accessibility of railroad communications.

- An accessible application (APP) that can be used for transit, commuter, and intercity rail networks will be developed for the passenger rail industry.
    - The APP will provide accessible train travel information and the ability for passengers to purchase tickets and passes across multiple rail systems.
- Analyses of the dynamic interaction between WhMDs and railcar equipment on board passenger railcars
    - Test data will be used to evaluate additional scenarios for protecting passengers.
- Data from testing will inform new U.S. Access Board accessibility requirements for rail vehicles.
- T2 of research data to equipment procurement cycles for Amtrak and other passenger rail providers

Outcomes

RD&T will develop new and improved accessibility standards for rail vehicles, ensuring they are safe and technically feasible. RD&T will use its data and science-based knowledge to support standards on the relative motion of WhMDs and their occupants in non-contained spaces. Last, RD&T will conduct T2 of research products to the U.S. Access Board as regulatory language for new accessibility requirements for rail.

Impacts:

- Increase protection to passengers in WhMDs in an open-bay-accessible location. Support the development of reasonable and inclusive requirement for accessibility on board railcars.
- Improve communications to the hearing-impaired

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 original equipment manufacturers (OEMs), RD&T will continue to develop and evaluate clean energy for rail transportation.
- Develop tools to assess sea-level rise and other climate change manifestations on rail infrastructure.
- Develop tool for evaluation of effects of clean energy technology on improving emissions.

Outputs:

- Greenhouse Gases, Regulated Emissions, and Energy Use in Technologies (GREET) module data will be available for railroads, rail planners, and other practitioners to conduct emissions and energy use assessments.
- 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

Expand clean energy, climate, and sustainability research by:

- Expanding bilateral discussions with international partners, in collaboration with RRS, from a 2023 clean energy workshop to identify opportunities to collaborate
  - A third climate workshop will bring together experts, end users, manufacturers, academia, international partners, and Federal agencies to discuss technologies for the decarbonization of rail.
- Broadening interaction with experts and international practitioners who are implementing decarbonizing technology in the rail space.
- Working with the locomotive OEM, continue to develop and evaluate clean energy for rail transportation.
- Researching collaboration and cost-sharing with DOE and national laboratories will continue to advance clean energy technology.
- Assessing issues related to hybrid systems, including batteries, heat exchangers, and fuel cells.

Impacts:

- RD&T research will help industry select more sustainable energy options to reduce carbon emissions.
- FRA will establish international partnerships to continue information-sharing to improve safety.
- Greater understanding of the impact of climate change on rail infrastructure
- Greater understanding of the efficacy of advanced clean energy technologies that may benefit communities near rail yards and rail operations.

Climate and Sustainability – Locomotive Safety

- Assess 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.

Outputs:

- Collaboration with Class II and III railroads on advancing and deploying high-pressure heat exchangers in a real-world environment.
- Collaboration with shortline railroad associations to analyze the effectiveness of non-traditional energy efficiency improvements and emissions reduction technologies used by shortline and regional railroads.
- Identify and develop new technologies accessible to Class II and III railroads for near-term reductions in emissions.

Outcomes

RD&T will ensure the safety of emerging locomotive engine efficiency technologies. RD&T will work with industry to assess innovative technologies to improve the safety and efficiency of

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

Impact

RD&T will assess how to safely integrate hybrid systems into the industry.

Safety – Office of Railroad Safety Support

RD&T will:

- Continue to provide SME support to RRS.
- Continue to partner with RRS and industry on the Railroad Information Sharing Environment (RISE) project.
- 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

RD&T will conduct research on urgent safety issues identified by RRS or Congress for both passenger and freight rail. RD&T provides RRS with the science that drives standards and requirements development and supports emissions compliance for both passenger and freight equipment.

RD&T will continue to partner with RRS and industry on the RISE project. Collaboration and research help contribute to the growth and maturity of this data trust.

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)

RD&T will:

- Publish the request for proposals, review university concept papers and proposals, then select prospective research projects to fund.
- Select prospective research projects to fund and begin selected projects.
- As part of RD&T's MSI/HBCU outreach strategy, increase outreach to MSIs/HBCUs to establish research collaborations/partnership opportunities.

Outputs:

- RD&T will publish a BAA, soliciting applied research projects to support DOT and FRA goals to technology adoption in the rail industry.

- Expected deliverables include progress reports, project management documents, and final research reports. T2 for FY 2020–2022 efforts (based on the project schedule and duration of each effort) are expected.

Outcomes

Each year RD&T selects prospective research projects to fund and begins selected projects. RD&T will publish the request for proposals and review proposals to solicit applied research projects that support DOT and FRA goals to advance automation and connected vehicle technology adoption in the rail industry.

Ongoing research projects focus on advanced technology, automation, and connected vehicle technologies; technologies for rural application; and WFD. RD&T will expand BAA notifications to MSIs/HBCUs to increase university partner diversity and racial equity in the rail sector.

Impacts:

- Increase railroad safety and improve railroad infrastructure. Help MSIs/HBCUs expand as community assets by supporting students, faculty/staff, and STEM programs.
- Increase support of American universities and encourage students to pursue careers in railroading or research.

Transformation – Rail Research and Development Center of Excellence

- The entity or entities selected in FY 2024 will plan and start new transformative research and training projects to improve railroad safety and performance.
- RD&T will work with the grantee(s) to strategically plan and launch new research and training efforts to improve the overall railroad safety and performance.
- Grantee(s) will conduct basic and applied research. Potential research topics include:
    - Transformative technologies
    - Workforce development
    - Training efforts related to safety, project delivery, efficiency, reliability, resiliency, and sustainability of urban commuter, intercity high-speed, and freight rail transportation
    - Advances in rolling stock, advanced positive train control, human factors, rail infrastructure, shared corridors, grade crossing safety, inspection technology, remote sensing, rail systems maintenance, network resiliency, operational reliability, energy efficiency, and other advanced technologies

Outputs:

- Transformational, exploratory, railroad-related research
- Rail-focused training programs
- Prioritization of climate and clean energy research related to the railroad industry
- Greater number of rail professionals
- Increased T2
- Partnerships that bring new science into practice

Outcomes

The grantee(s) will conduct and deliver research and training initiatives that should improve railroad safety and performance. The COE will continue to expand the railroad talent pool with STEM or rail-related skills. The COE may increase capacity for research at under-represented and historically underserved academic institutions and has the potential to increase MSI/HBCU participation in rail research.

Impacts:

- The COE prioritizes basic and applied research (per the Bipartisan Infrastructure Law, section 22413) for evaluation, education, WFD, and training efforts.
- COE will address all DOT Strategic Goals and have a lasting impact on research and the training and educating of a changing rail workforce.

Potential Economic or Societal Impacts

RSI research will improve the American quality of life and ensure equitable access to and use of the Nation's rail infrastructure. It will also address all the strategic drivers for DOT and FRA.

RSI research will facilitate the development of an accessible, mobile application specifically for rail. This application will help the hearing impaired receive train communications on trains and increase equitable access to passenger rail transportation. RSI research will continue to expand WhMD research, testing, and analysis to ensure the safety of all passengers.

RSI will continue its WFD research. 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, FRA invested in additional initiatives that increased equity in the rail industry through training practices and STEM programs. Also, existing STEM programs expanded to include more universities to increase the students participating in the STEM programs. FRA added a new STEM program in FY 2022 at an HBCU that will create jobs, utilize AI and machine learning to improve safety.

In FY 2023, RD&T funded seven 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 use rail to teach STEM topics. All these efforts focus on under-represented students in rail, 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, to be implemented in FY 2024. RD&T seeks to increase the participation of under-represented groups in RD&T research.

The COE Program will potentially enable students to get involved with rail training and programs at an early age, leading to a more generous talent pool in rail.

Potential Progress Made toward Achieving Modal Strategic Goals

RSI research will continue to advance DOT/FRA Strategic Goals and OST-R's Research Priorities/Grand Challenges. The initiatives and activities listed below directly support these goals and help build an inclusive and equitable rail accessibility model.

Table 7 – RSI Research Activities Aligned with Modal Strategic Goals

Key Research Activity	DOT/FRA Goals Alignment	OST-R Research Priorities/Grand Challenge
WhMD/Mobile Application	• Equity	Equity and Accessibility Assessment /Equitable Mobility for All
WFD Research	• Equity • Economic Strength & Global Competitiveness • Transformation	Create Pathways to Good-Paying Jobs
Climate Summit	• Economic Strength & Global Competitiveness • Climate & Sustainability	Decarbonization, Sustainable and Resilient Infrastructure/Net-Zero Emissions
University Funding	• Economic Strength & Global Competitiveness • Transformation	Create Pathways to Good-Paying Jobs/The Future Transportation System-of-Systems
STEM Initiatives	• Equity • Economic Strength & Global Competitiveness • Transformation	Create Pathways to Good-Paying Jobs/Equity and Accessibility Assessment/Wealth Creation
MSI/HBCU Strategic Plan	• Equity • Economic Strength & Global Competitiveness • Transformation	Create Pathways to Good-Paying Jobs/ Equity and Accessibility Assessment/Wealth Creation
Decarbonization Research	• Economic Strength & Global Competitiveness • Climate & Sustainability	Decarbonization Sustainable and Resilient Infrastructure/Net-Zero Emissions
COE	• Safety • Equity • Economic Strength & Global Competitiveness • Climate & Sustainability, • Transformation	Zero Fatalities/Resilient Supply Chains/Create Pathways to Good-Paying Jobs/Equity and Accessibility Assessment/Mobility Innovation/Wealth Creation /Equitable Mobility for All/ Decarbonization/Sustainable and Resilient Infrastructure/Net-Zero Emissions/The Future Transportation System-of-Systems
Human Factors Research Capability at TTC	• Safety • Transformation	Human Factors/Zero Fatalities
SBIR Research	• Economic Strength & Global Competitiveness	Zero Fatalities/Resilient Supply Chains/Equitable Mobility for All/Net-Zero Emissions/The Future Transportation System-of-Systems
RISE	• Safety • Transformation	Zero Fatalities/The Future Transportation System-of-Systems

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 innovation 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. RSI has also launched research to identify practices to recruit women into railroading. RSI has partnered with universities (including an HBCU and an MSI) to create training programs that will increase under-represented students, staff, and workers engaged in the railroad industry. 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 and the hearing impaired, 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 3rd 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 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. Stakeholder engagement with these institutions will increase the diversity and equitable participation of under-represented stakeholder groups.

Table 8 – RSI Partner Detail

Partner Name	Contributions	Benefits of Partnership
TRB	TRB collaborates with DOT modes to improve innovation and basic and applied research and technology.	RD&T receives a biennial review of its research, stakeholder engagement, strategic planning, priority-setting, evaluation work,

Partner Name	Contributions	Benefits of Partnership
		and recommendations on how it can improve.
U.S. Universities (University of New Mexico; Michigan Technological University; California State University, Fresno; University of Maryland; University of Nebraska-Lincoln; Morgan State University; Tennessee State University; Southern Methodist University; and University of Memphis)	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 contributions; subject matter expertise; access to rail facilities	Locomotive engine, duty cycle data; testing activities support ; 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
DOE	In-kind contribution; subject matter expertise	Funding; subject matter expertise
U.S. Access Board	Subject matter expertise	Guidance on accessibility research
Locomotive OEMs	Subject matter expertise, in-kind contributions	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
Amtrak	Guidance related to public transportation systems; subject matter expertise	Guidance on accessibility research

Table 9 – RSI Benefits Detail

Beneficiary	Benefits Received
RRS	Improved safety standards/recommendations Proven applied science to improve standards, regulations, and requirements in support of EPA.
Industry	Improved safety standards/recommendations Lower operating costs Improved visibility for railroad workers and grade crossings

Beneficiary	Benefits Received
	Fewer railroad accidents and fatalities Fewer regulations
Public	Fewer railroad accidents and fatalities High-speed rail transportation, safety, reduced noise emission Improved railroad safety and performance
Small Businesses and University Research Centers	Improved railroad research resources and capabilities Support and motivate rail-research communities.
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. Improve safety and mitigate accidents.
EPA	Improved guidelines for noise emissions limits
Labor Unions	Increased employee safety
Railroad Workers	Increased railroad worker safety

Track
$11,783,000

Program Description

The Track program sponsors research that helps make the nation's railroad infrastructure more reliable and resilient. These efforts contribute to the safe movement of both passengers and commodities across the country today and in the future. The program's focus on reducing track-caused derailments relies on finding the variables involved in each type of these derailments and then developing the processes, technologies, and analytical methods needed to identify the most at-risk locations on the track and prevent future derailments.

Major Program Objectives

The Track research program has four broad objectives, listed below, that directly relate to DOT Strategic Goals and Objectives. Objectives in italics are also OST-R Strategic Objectives.

1. Understand the root causes of track-related derailments and develop ways to prevent these derailments.
2. Improve how FRA and the industry inspect track and structures.
3. Improve how FRA and the industry assess track safety risk.
4. Develop a more productive, knowledgeable, and capable workforce.

Objective 1: Understand the root causes of track-related derailments and develop ways to prevent these derailments.

- DOT Safety Goal – Safe Public; Safe Workers; Safe Design; and Safe Systems
- DOT Economic Strength and Global Competitiveness Goal – High-Performing Core Assets; *Resilient Supply Chains*; and System Reliability and Connection
- DOT Climate and Sustainability Goal – *Infrastructure Resilience*
- DOT Transformation Goal **–** Matching Research and Policy to Advance Breakthroughs; Experimentation; Collaboration and Competitiveness; and Flexibility and Adaptability
- DOT Organizational Excellence Goal **–** *Data-Driven Programs and Policies*; Oversight, Performance, and Technical Assistance

Objective 2: Improve how FRA and the industry inspect track and structures.

- DOT Safety Goal – Safe Public; Safe Workers; Safe Design; and Safe Systems
- DOT Economic Strength and Global Competitiveness Goal – High-Performing Core Assets; *Resilient Supply Chains*; and System Reliability and Connection
- DOT Transformation Goal **–** Matching Research and Policy to Advance Breakthroughs; Experimentation; Collaboration and Competitiveness; and Flexibility and Adaptability
- DOT Organizational Excellence Goal **–** *Data-Driven Programs and Policies*; Oversight, Performance, and Technical Assistance

Objective 3: Improve how FRA and the industry assess safety risk for track.

- DOT Safety Goal – Safe Public; Safe Workers; Safe Design; and Safe Systems
- DOT Economic Strength and Global Competitiveness Goal – High-Performing Core Assets; *Resilient Supply Chains*; and System Reliability and Connection
- DOT Transformation Goal **–** Matching Research and Policy to Advance Breakthroughs; Experimentation; Collaboration and Competitiveness; and Flexibility and Adaptability
- DOT Organizational Excellence Goal **–** *Data-Driven Programs and Policies*; Oversight, Performance, and Technical Assistance

Objective 4: Develop a more productive, knowledgeable, and capable workforce.

- DOT Organizational Excellence Goal – Workforce Development

Anticipated Program Activities and Potential Outcomes, Outputs, and Impacts

The Track Program consists of two sub-programs: Track and Structures; and System Performance and Analysis. Each sub-program encompasses unique research areas, discussed below.

Track and Structures – Rail Performance

In CY 2021, rail and joints failures accounted for 34 percent of all track-caused derailments and over $29 million in track and equipment damage.

The division plans to work in three areas related to rail performance in FY 2024. The first is research to better detect rail flaws. This work includes efforts to detect flaws of ever-smaller sizes and to better find and size flaws within the rail, welds, and special track work. The second area is research to improve the standards, methods, and tools used to set and assess rail flaw testing frequencies. Projects include work using physical testing, physics-based simulations, and other predictive analytic methods to predict how rail flaws grow. The third area is research to improve the quality of rail welds. This effort will continue to focus on new techniques for making stronger, longer lasting field welds and how to better inspect those welds.

Outputs:

- Data on the capabilities of current nondestructive testing equipment
- Validated laboratory and in-track rail samples for assessing the performance of nondestructive test equipment.
- AI/machine-learning algorithms for predicting the growth of internal rail flaws.
- A revised process with associated new hardware for making thermite welds
- Prototype development of new sensor technologies
- Technical reports documenting each completed project

Outcomes

RD&T will improve the inspection of rail flaws and the strength of rail welds to prevent derailments through:

- Improved production and inspection techniques for field welds.
- More accurate internal defect growth predictions for both rails and welds.

- New techniques to more accurately locate and size rail flaws.
- Criteria for more flexible yet less risky non-destructive inspection intervals.

Impacts:

- Fewer derailments caused by rail and joint failures.
- Potential regulatory changes

Track and Structures – Track Inspection

In CY 2021, accidents related to gauge, crossties, and geometry accounted for 33 percent of all track-caused derailments and over $14 million in track and equipment damage.

The division plans to advance several novel track inspection sensors and platforms in FY 2024. The first is research into novel track inspection sensors and platforms. These projects will research new technologies used in non-railcar applications such as hi-rail vehicles, drones, and wayside sensors to assess track health. The efforts will also work to identify suitable situations to use such platforms and technologies.

In addition, the division will continue efforts to promote industry adoption of automated track change technology. Several railroads have already purchased commercial systems, yet further research is required to refine what the systems look for and how this data is presented.

Outputs:

- Data from new sensor technologies
- Prototype development of new sensor hardware
- Recommended uses for new sensor technologies
- AI/machine learning algorithms for detecting and evaluating track components.
- AI/machine learning algorithms that enable drones to self-navigate using the rails as a reference.
- Recommendations as to how best allocate inspection tasks between humans and intelligent systems.
- Technical reports for each completed project

Outcomes

This research will better understand track health to reduce derailments.

- Prototype sensors and platforms for further research and development in track inspection.
- Use cases identified for non-traditional sensors and platforms.
- Continued industry adoption of change detection technologies.

Impacts:

- Fewer derailments caused by low gauge strength, defective crossties, or track geometry issues.
- Potential regulatory changes

Track and Structures – Special Activities

In CY 2021, switches, turnouts, and other causes accounted for 25 percent of track-caused derailments and over $12 million in track and equipment damage.

For FY 2024, planned activities include bridges and other structures and special trackwork issues. Research will focus on improved detection of structural bridge issues that may lead to a derailment or sudden failure. Work will also focus on research to understand, quantify, and improve how special trackwork performs and degrades.

Outputs:

- Data for track issues on bridges and in tunnels
- Further development of gages for inspecting special trackwork
- Design of a prototype rolling load machine for laboratory testing of special trackwork.
- Technical reports for each completed project

Outcomes:

- Test equipment able to performance-test special trackwork components and rail sections.
- Better standards for inspecting structural ties on timber deck bridges.

Impacts:

- Fewer derailments due to bridge or special trackwork failures
- Potential regulatory changes

Track and Structures – Track Stability

Track buckles and roadbed failures only accounted for 9 percent of the track-caused derailments in CY 2021, yet they resulted in more than $15 million in track and equipment damage.

Track stability is the most active research area in the Track research program. Among the planned activities for FY 2024 is research to measure or estimate lateral track strength (from tie down) and the ability of the track and substructure to properly spread vertical loads. These efforts address both track buckling and vertical track geometry degradation. Another planned activity is research to identify the conditions leading to sudden roadbed failures and potential locations for such failures. A third planned activity is research to measure, estimate, or manage the longitudinal force in the rail or the rail neutral temperature. These projects include work to promote technology and knowledge transfer in continuous welded rail (CWR) management.

Outputs:

- Data for the longitudinal resistance of the track structure and for the electrical and physical properties of fouled ballast
- Continued development of prototype instrumentation to measure longitudinal rail stress, vertical track deflection, and ballast water content.
- Web applications for the management of CWR
- Training materials for the management of CWR

- Technical reports for each completed project

Outcomes:

- Evaluation of multiple new technologies for quantifying the presence of water in the ballast.
- Improved understanding of how the mechanical properties of ballast change with fouling and moisture – and the subsequent effect on track strength and degradation.
- Development of new sensors to monitor longitudinal force in the rail.

Impacts:

- Fewer derailments caused by track buckles and roadbed failures.
- Rail infrastructure climate resiliency
- Potential regulatory changes

System Performance and Analysis – Predictive Analytics

For FY 2024, several research efforts will use machine-learning (AI) or other advanced analytical methods to identify or predict unsafe track conditions. Another FY 2024 focus will be to develop methods to evaluate the effectiveness and safety impact of inspection technologies, especially when combining different inspection methods.

Outputs:

- Data, processes and methods, hardware, AI/machine-learning applications and algorithms, technical reports, and industry adoption
- Data for the probability of detection of rail flaws for various nondestructive testing methods
- Continued development of methods, hardware, and test beds for quantifying the probability of detection for railroad inspection systems.
- Continued development of AI/machine learning algorithms for predicting track issues and support for demonstration projects.
- Technical reports for each completed project

Outcomes:

- Continued industry adoption of foot-by-foot track geometry predictions using time series analytical methods.
- More accurate internal defect growth predictions for rails.
- A probability-based framework for understanding the change in risk as new inspection technologies are introduced or when inspection methods are combined.

Impacts:

- Fewer derailments resulting from rail failures or track geometry issues.
- Potential regulatory changes

Track and Structures – FRA Research Assets

For FY 2024, the Track research program has two planned activities in this research area. The first supports RD&T's (and other FRA Offices) use of FRA Automated Track Inspection Program (ATIP) cars for research activities. The second activity supports TTC on-track testing for research efforts.

Outputs:

- Data from instrumentation systems
- Hardware and software development
- Technical reports, as applicable

Outcomes:

- Valuable field data that will provide science-based knowledge in support of standards and other FRA Offices.
- Industry exposure to new processes and technologies to better understand opportunities to improve safety.

Impacts:

- Data collection and testing in real-world environments

System Performance and Analysis – Vehicle Track Performance

In CY 2021, track geometry issues resulted in 10 percent of track-caused derailments and just over $5 million in track and equipment damage.

Vehicle Track Performance is another one of Track's most active research areas. One of the most important FY 2024 activities is to improve simulation and model accuracy, especially in how to predict wheel and rail contact and to account for the effects of rail lubrication. A complementary activity will study the fundamental mechanisms involved in wheel and rail contact issues using a small-scale roller rig. Yet another activity will analyze Track Geometry Measurement System and vehicle/track interaction data from FRA test vehicles to identify how often certain combinations of track geometry occur. Finally, an RD&T study will use a combination of physical testing and simulations to identify track conditions not defined in CFR 49 part 213 that pose a valid derailment risk from vehicle and track interactions.

Outputs:

- Data on wheel/rail interactions during varying contact conditions and on the overlap of different track parameters in revenue service
- New methods for assessing the probability of detection of track geometry measurement systems, including the development of hardware and test beds.
- Open-source modules for modeling changing wheel/rail contact conditions in simulation software.
- Validated vehicle models for industry use in simulation software
- Technical reports for each completed project

Outcomes:

- More accurate simulation software that completely models the wheel/rail interface.
- More accurate and completely validated vehicle models for use in simulations
- More complete understanding of mechanisms occurring at the wheel/rail interface.
- An initial set of combined track geometry parameters that can lead to a derailment even when the individual parameters are within regulatory limits.

Impacts:

- Fewer derailments from combined vehicle and track performance
- Potential regulatory changes

Potential Program Outputs, Outcomes, and Impacts on Technologies and Practices

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 Economic or Societal Impacts

The railroad industry, the national economy, and the public all benefit from more reliable and predictable rail transportation. By preventing as many derailments as possible – and especially catastrophic events – due to track and structure issues, the Track research program helps to safeguard both public health and the environment. Additionally, increasing the life of track components makes the railroad industry safer and more efficient while also promoting better environmental stewardship. Strong track infrastructure facilitates safer and faster passenger rail, providing the traveling public more environmentally friendly transportation options and promoting commerce. Finally, continuing efforts to involve more MSIs and HCBUs in track research provides equity benefits by expanding access and while also advancing WFD.

Potential Progress Made toward Achieving Modal Strategic Goals

Every Track research program activity advances the Safety goal, and most of the activities also advance both the Economic Strength and Global Competitiveness and Transformation goals. Additionally, a few specific activities further the Climate and Sustainability goal. Finally, because many activities involve university partners, including MSIs, the work contributes to the Organizational Excellence and Equity goals.

Table 10 – Track Collaboration Partners

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

Partner Name	Contributions	Benefits of Partnership
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, 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	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.
AAR	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; concrete tie failure mode investigation team member
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
APTA	Data, track time, intellectual resources, and, in some cases, supporting funds	Materials, expertise, and funding
MxV Rail (formerly TTCI)/AAR	Research, development, security, training, test activities	Testing and training expertise, support, and TTC operation and maintenance
CSX	On-track testing, data, in-kind support (e.g., intellectual resources)	Real-world data and testing

Partner Name	Contributions	Benefits of Partnership
Union Pacific Railroad (UP)	In-kind support activities: manufacturing support, access to track for testing, materials, 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, expertise on rail stress measurement, and better technology to prevent buckled track derailments
ENSCO, Inc.	Wide variety of R&D contributions to improve rail safety.	Improved operating practices and inspection tools
Thornton Tomasetti Inc.	Upgrade of the analytical rail detail fracture model	This will lead to an overall improvement of the rail life prediction and recommended inspection interval.
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	Investigation on measurement of local stiffness as a trackside method to determine longitudinal rail stress without a reference.	Training the next generation of railroad professionals, expertise on rail stress measurement, and better technology to prevent buckled track derailments.
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 Automated Track Change Detection development partner	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. Machine vision track inspection to improve efficiency and effectiveness of routine track inspection.
University of South Carolina	Non-contacting System for Longitudinal Rail Stress Measurements; Satellite Radar Imagery for Ground Hazard Risk Monitoring; Autonomous Power Efficient Track Inspection System development	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. Machine vision track inspection to improve efficiency and effectiveness of routine track inspection.

Partner Name	Contributions	Benefits of Partnership
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.
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 Track research in wheel-rail contact and gage face contact conditions.	Expertise in machine-learning applications as it relates to railroad inspection. Expertise in wheel-rail contact conditions.
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 National Transportation Systems Center (Volpe)	Track research, technical and evaluation support	Support OST-R to maintain railroad track expertise and provide unbiased program and research support.
University of Delaware	Development of a Track Buckling Risk Assessment Framework Using Comprehensive Track Condition Data	Training the next generation of railroad professionals and better technology to prevent track buckles.
University of Central Florida	Absolute and Proxy Rail Stress Measurement Using Non-contact, Mobile Photoluminescence Piezospectroscopy	Training the next generation of railroad professionals and better technology to prevent track buckles.
Kansas State University	In-Track Measurement of the State of Stress in Steel Rail Concrete tie failure research	Training the next generation of railroad professionals and better technology to prevent track buckles. Concrete tie failure mode investigation team member
University of Houston	Neutral Temperature Determination using Reliable Pressure Sensing Ceramics Thermite weld improvement research	Training the next generation of railroad professionals and better technology to prevent track buckles. Expertise in vibration-enhanced welding mechanics

Partner Name	Contributions	Benefits of Partnership
University of Massachusetts, Lowell	Feasibility of Computer Vision Measurement Techniques to Quantify Longitudinal Rail Stress	Training the next generation of railroad professionals and better technology to prevent track buckles.
University of Missouri	Development of Calibration-Free Ultrasonic Stress Measurement Technology	Training the next generation of railroad professionals and better technology to prevent track buckles.
University of Nebraska	Self-referenced Ultrasonic System for Measuring Longitudinal Rail Stress	Training the next generation of railroad professionals and better technology to prevent track buckles.
Florida East Coast Railway	In-kind support activities: manufacturing support, access to railroads and materials, expert analysis	Direct support for machine vision/AI inspection technologies Concrete tie failure mode investigation team member

Rolling Stock
$10,553,000

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. Tank car research studies their safety during and after impact and performs fire studies. 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, passengers, and energy products in tank cars. 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.

Program Area – HazMat Transportation

Program Area – Rolling Stock Equipment and Components

Program Area – Train Occupant Protection

Program Area – Tank Car Energy Products Research

Anticipated Program Activities and Potential Outcomes, Outputs, and Impacts

Climate and Sustainability – HazMat – Tank Car Research

- Provide stakeholders with information on fire studies, tank car impact testing, modeling, and analyses of different tank car and portable tank designs.
- Create a better understanding of the operational environment and root causes of fractures on tank cars.
- Develop speed and mass combination curves to mitigate tank car stub sill failures.
- Conduct over-the-road brake testing to target a variety of issues faced by the industry.
- Develop performance-based testing requirements.
- Develop methods to evaluate the crashworthiness and structural integrity of different tank car designs.
- Evaluate the crashworthiness performance of tank cars used in the transportation of HazMat.

Outputs:

- Information on fire studies, tank car impact testing, modeling, analyses of different tank car and portable tank designs, data, and technical reports
- Methods to evaluate the crashworthiness and structural integrity of different tank car designs.
- Test results on over-the-road brake testing to target a variety of issues faced by the industry.

Outcomes

RD&T will continue providing stakeholders with information on fire studies, tank car impact testing, and analyses of different tank car and portable tank designs. Also, RD&T will develop or modify the safety standards for the safer manufacture and operation of HazMat railcars.

Impacts:

- Improved safety in tank car operations.
- Better understanding of braking conditions for over-the-road rail operations.

Climate and Sustainability – HazMat – Structural Integrity

- Continue to identify potential studies to address defects that affect the structural integrity of tank cars and portable tank safety equipment.
- Develop performance-based scenarios intended to evaluate the puncture resistance of modern fuel tenders.
- Evaluate structural performance of passenger fuel tank designs in accident conditions.
- Support RRS in accident investigations and regulatory development efforts.
- Collaborate with the AAR Tank Car Committee, the American Public Transit Association (APTA), Passenger Rail Equipment Safety Standards, Communications & Signals– Fuel Tank Working Group to support standard development/revisions.

Outputs:

- Data, technical reports, and recommendations on performance and durability of safety equipment for tank cars
- Updated safety investigation processes and rules
- Industry-wide coordinated standards development and revisions

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:

- Improved safety performance of tank cars and investigation processes
- Better-coordinated rules and standards development

Safety – HazMat – Accident Consequence Reduction

- 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.
- Develop new tank test panels to continue studies of non-destructive evaluation techniques.
- Develop methods to evaluate and compare the crashworthiness and structural integrity of different tank car design features (e.g., different materials, material thickness).
- Evaluate crashworthiness performance of tank cars used in the transportation of hazardous materials.
- Develop objective methods for demonstrating validation of computational models.

Outputs:

- Data and technical reports on accidents involving HazMat and how to manage failures
- Non-destructive evaluation techniques for tank car testing
- Crashworthiness evaluation methods for HazMat tank cars
- Validation methods of computational models

Outcomes:

- Understand how failures occur and how to prevent or manage the consequences of failures, specifically on the liquid/vapor release flow on pressure relief valves.
- Improved equipment design and protection..
- New tank test panels to continue studies of non-destructive evaluation techniques.
- The creation, modification, or justification of safety standards.

Impacts:

- Improved analytical capability for HazMat incidents
- Enhanced assessment of tank car testing and evaluation methods

Safety – HazMat – Risk Analysis

- Finalize risk analysis studies on unit trains carrying hazardous materials.
- Develop performance information that can be used by the industry for standards development.
- Develop recommendations for future design and testing of fittings for industry use.

Outputs:

- Data and technical reports on the risks associated with unit trains carrying HazMat materials.
- Data and technical reports on the risks associated with transportation of cryogenic materials.

Outcomes

A better understanding of risks associated with unit trains carrying hazardous materials and with unit trains carrying HazMat and the transportation of cryogenic materials.

Impacts:

- Improved overall safety of tank car operations by the release of HazMat in tank car rollover derailments

Climate and Sustainability – Tank Car Energy Products Research

- Finalize risk assessment of transporting large quantities of HazMat. Research will develop an alternate mechanism for rapid brake signal propagation – to be used on unit trains transporting energy products (high-hazard flammable trains) and derailment models.
- Develop performance information that can be used by the industry for standards development.

Outputs:

- Better understanding of potential alternative fuel release events for rapid brake signal propagation.
- Better understanding of derailment models carrying different hazardous materials.
- Provide information on derailment models to help industry better understand the causes for railroad derailments.

Outcomes

This research will result in understanding alternative fuel technology risks.

Impacts:

- Improved overall safety of tank car operations by the release of HazMat in tank car rollover derailments
- Enhanced engagement with the rail industry to ensure the safe introduction of alternative fuels.

Climate and Sustainability – Alternative Fuels Safety Research

- RD&T will perform analyses and small-scale and full-scale impact testing of alternative fuel tenders and ancillary equipment.
- RD&T will develop documents for RRS on U.S. railroads' use of hydrogen and other clean energy for rail propulsion.
- FRA will engage the rail industry in testing and standards development for clean energy storage media and hydrogen-powered and battery-electric locomotives and multiple units.
- FRA will continue to co-fund research with DOE and locomotive manufacturers on alternative fuels for rail transportation.

Outputs:

- Data and technical reports on the safe design of alternative fuel tender cars, ancillary equipment

- Data and technical reports on dual fuel locomotive engine development for improved efficiency and emissions
- Documents for RRS on U.S. railroads' alternative fuel and battery energy storage system usage for rail propulsion

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 as well as standards for safe deployment of battery-electric locomotives.

Impacts:

- Improve the state-of-the-art knowledge on safety and efficiency of alternative fuels, such as hydrogen and fuel cell systems for rail applications and battery-electric locomotive.
- Collaborate with railroads to safely implement hydrogen fuel cell technology.
- Availability of a rail module in the GREET model, which provides a tool to assess the efficiency and emissions of alternative fuels in rail.

Safety – RSEC – Rolling Stock Component Safety

- In 2024, RD&T will continue to research and develop components and systems that reduce the risk of rail incidents and accidents. Findings from the VLT (Very Long Train) study efforts, conducted in collaboration with industry, will be distributed and discussed. Train performance modeling tools used by FRA and the industry, such as the Train Energy and Dynamics Simulator (TEDS) and the Train Operations and Energy Simulator (TOES), will review research results and be considered for modification to improve their fidelity for longer train consists and handling/braking behavior.
- RD&T will also continue to identify malfunctioning or poorly performing equipment and components, including braking systems with Wheel Temperature Detector (WTD) technology.

Outputs:

- Technical reports, data, and safety recommendations on VLTs, brake systems, and WTDs
- Database for maintaining WTD system data

Outcomes:

- Better understanding of reasons for heated wheels. Better understanding of the effects of brake shoe types on heated wheels; and better understanding of the magnitude of heat and length in time it takes to failure.
- Better safety recommendations for VLTs, brake systems, and WTDs. Another outcome will be a more accurate understanding of car and WTD maintenance schedules.

Impacts:

- Improved safety, security and efficiency in railroad operations through the use of robust and sufficient electrical power for the powering of monitoring and activation devices on freight cars.

- Decreased wheel failures attributed to overheating.
- Improved shoe and wheel life through better understanding of tread braking issues
- Provide cost saving by reducing wheel/rail wear
- Continued vehicle track worthiness due to continued and improved vehicle dynamics simulations and analysis.
- Establish a standard process for wayside technology pilot demonstrations.
- Wayside technology systems will reduce the number of incidents and accidents through proactive maintenance, driven by monitored performance of rolling stock equipment and components.

Transformation – RSEC – Rolling Stock Maintenance and Inspection

- In 2024, RD&T will continue to improve truck designs that can provide superior equalization and curving performance by continuing to improve the modeling tool TEDS (Train Energy and Dynamics Simulator).
- RD&T will continue passenger rail research to advance fire safety requirements in U.S. passenger rail vehicles.
- RD&T will also continue to explore the potential of using the 160MHz RF band to modernize its usage across the rail industry for new applications such as Wireless Digital Train Line for Passenger Trains (WiDTL) and expanding 220MHz Positive Train Control to other frequency bands.

Outputs:

- Test data, analysis, and technical reports on electrical power supply improvements, advanced detection devices and wayside detection technology.

Outcomes:

- Improved TEDS by recalibrating through field data acquisition and analysis.
- Research results to advance U.S. passenger rail vehicle fire safety requirements.
- Research results to inform the possible modernization of WiDTL with implementation of 160MHz band while possibly expanding PTC to more frequency bands.
- Better train handling procedures, operating practices procedures, and truck designs that lower the rate of incidents and accidents.

Impacts:

- TEDS facilitates identification and quantification of safety risks in train operations affected by equipment, train makeup, including free slack between couplers, train handling, track conditions, including presence of lubricators, operating practices, environmental conditions, and certain types of malfunctioning equipment, such as locomotive power drops, leaking air brakes, etc.
- Possible presentation of improved passenger rail fire safety requirements.
- Improved communications and control using WiDTL.

Safety – RSEC – Train Handling and Operating Practices

RD&T will:

- In FY 2024, continue research to improve truck designs that can provide superior equalization and curving performance by continuing to improve TEDS.
- Continue passenger rail research to advance fire safety requirements in U.S. passenger rail vehicles.
- Continue to explore the potential of using the 160 MHz RF band, to modernize its usage across the rail industry for new applications such as WiDTL and expanding 220 MHz PTC to other frequency bands.

Outputs:

- Data on train accidents and incidents, better train simulations with TEDS recommendations, and fire safety requirements
- Improved applications of WiDTL for passenger trains

Outcomes

Better train handling procedures, operating practices and procedures, and truck designs that lower the rate of incidents and accidents

Impacts:

- Improved identification and quantification of safety risks in train operations affected by equipment, train makeup, including free slack between couplers, train handling, and track conditions – including presence of lubricators, operating practices, environmental conditions, and certain types of malfunctioning equipment, such as locomotive power drops, leaking air brakes, etc.
- Decreased number of incidents and accidents related to train handling, operating practices, and truck designs

Safety – TOP – Fire Safety Research

- In FY 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.
- RD&T will evaluate whether materials passing the EN 45545-2 would also be expected to meet National Fire Protection Association and Code of Federal Regulations requirements.

Outputs:

- Improved understanding of the efficacy of using fire safety performance of materials to predict fire safety in passenger rail vehicles.
- Data generated will be inputted to the National Institute of Standards and Technology's Computational Fluid Dynamics fire model program for use by rail car manufacturers and station and tunnel designers.

Outcomes

Knowledge of the quantification of rapid and easy egress from passenger railcars as well as the determination of whether the EN standard could be used for material approval by FRA.

Impacts:

- Potential cost savings and more streamlined methods for achieving compliance for fire safety of passenger rail equipment
- Through collaboration with the passenger rail industry and FRA, advancement of fire safety policies and standards for passenger railcars

Transformation – TOP – Passenger Locomotive Crashworthiness and Occupant Protection

RD&T will:

- In FY 2024, continue passenger train crashworthiness research to improve safety for passengers and crew.
- Continue to examine train occupant protection elements and methods for securing passengers using mobility assistance devices.
- Research existing, crash energy management-retrofitted, passenger equipment and new equipment to generate recommendations to provide better performance in terms of override protection in the event of an incident or accident.
- Continue to assess the adequacy or potential shortcomings of the existing modern locomotive crashworthiness requirements.

Outputs:

- A generation of new recommendations on passenger locomotive crashworthiness based on testing and analysis shown to improve passenger locomotive crashworthiness in head-on collisions.
- A generation of recommendations for the securement of WhMDs on passenger trains to improve safety for all passengers in the event of a collision.

Outcomes

Outcomes include the development of structural elements at the forward end of a locomotive that can greatly reduce the propensity for override, ensuring crashworthiness compliance with S-580 and the cab-crew protection of modern locomotives, and new approaches to the securement of WhMDs.

Impacts:

- Reduction of overrides
- Reduction of fatalities and injuries to persons in the cab during due to collisions
- A basis for safety standards related to WhMD securement

Safety – TOP – Glazing Standards

- In 2024, RD&T will continue to study new methods to improve glazing retention capacity. Test articles are being acquired from railroads interested in participating in FRA research.
- RD&T will also continue studying passenger railcar failure modes in rollover events. This work will involve analysis of the role of coupler torsional stiffness in preventing rollover.

Outputs:

- Data, technical reports, and recommendations on glazing processes and glazing retention capacity
- Data, technical reports, and recommendations on passenger railcar failure modes and ways to prevent car rollovers.

Outcomes

New manufacturing and operational processes that make windows less likely to detach from the vehicle sidewall resulting in loss of containment of passengers and passenger cars less likely to roll over.

Impacts:

- A decrease in car rollovers
- A decrease in casualties related to improved glazing processes

Safety – TOP – Improving the Resilience of Freight Railroad Networks

- In 2024, RD&T will continue the development of a tool for assessing connectedness efficiency for intelligent rail network infrastructure.
- RD&T will continue research for enhancing railroad safety and resilience by gaining insights based on the impacts of node and link losses on network connectedness efficiency due to disruptions.
- RD&T will also continue research related to topology enhancements.

Outputs:

- Data, technical reports, and recommendations on enhancing the resilience of railroad networks.
- Data, technical reports, and recommendations to improve safety through topology enhancements.

Outcomes:

- Potential enhancements to the current generation of safety and efficiency systems within the entire railroad assets and operation

Impacts:

- Cost-effective safety and efficiency systems, including intelligent railroad systems, asset management, safety enhancements, and resource allocation in cost effective terms

Potential Economic or Societal Impacts

The Rolling Stock program enables the U.S. to develop an advanced, safe, and competitive transportation network. With advancements in key areas such as inspection techniques, materials, and components, RS research can aid the reduction of fatalities and passenger injury severity. With safety initiatives such as clean energy fuels, new engine and energy savings technologies, RS research will help better preserve the environment.

Potential Progress Made toward Achieving Modal Strategic Goals: Climate and Sustainability, Equity, Safety

The Rolling Stock program contributes toward the DOT Strategic Goals of Climate and Sustainability, Equity, and Safety through its research:

- The Climate and Sustainability research area investigates clean energy fuels and new engine and energy-saving technology.
- Passenger Locomotive Crashworthiness and Occupant Protection research area ensures that longer freight trains with higher freight capacity can operate with cab-crew safety in collisions.
- The Tank Car research area provides inspection reliability, increases safety through technological development, and addresses key industry needs such as maintenance, inspection and damage tolerance. Tank car fittings in HazMat service mitigate the release of hazardous materials in tank car rollover derailments.

Table 11 – Rolling Stock Collaboration Partners

Partner Name	Contributions	Benefits of Partnership
Tank Cars Owners	In-kind contributions, including tank cars, valves, engineering consultation	Equipment, subject matter expertise
Tank Car Shops	In-kind contributions, including tank cars, valves, engineering consultation	Equipment, subject matter expertise
TTC	Data analysis, test support, actual testing, resources, and modeling; in-kind equipment contributions	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	Equipment/material
NS	Access to bearing/wheel shop facilities, operator time, allow sample collection	Equipment/material
Progress Rail	Access to bearing/wheel shop facilities, operator time, allow sample collection	Equipment/material
UP	Access to bearing/wheel shop facilities, operator time, allow sample collection	Equipment/material
Indiana North Eastern Railroad	Labor and access to cars and locomotives for test installation and feedback	Equipment, subject matter expertise

Partner Name	Contributions	Benefits of Partnership
Metropolitan Transportation Authority (MTA) (Metro-North Railroad [MNR] and Long Island Railroad [LIRR])	In-kind contributions: Access to data and operational information, allowing FRA access to data that is difficult to gather, which can then be used to evaluate the safety efficacy of these wayside systems.	Data
Railway and Industrial Specialists	In-kind contributions: Access and data on wheel failure types and defect details, allowing for accurate modeling of defects.	Data
Penn Machine Co. (potential)	In-kind contributions: 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
TTC, APTA, AAR	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	Subject matter expertise, 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
ASLRRA	Cash contribution, in-kind support (personnel, facilities, equipment) may be provided for development of safe alternative fuels introduction; 40% cost-sharing.	Equipment/material
Progress Rail	Cash contribution, in-kind support (personnel, facilities, equipment) may be provided for development of safe alternative fuels introduction; 40% cost-sharing.	Equipment/material
CSX	Cash contribution, in-kind support (personnel, facilities, equipment) may be provided for development of guidance on rail infrastructure resiliency and sea level rise.	Equipment/material
Transportation Community Awareness and Emergency Response (TRANCAER)	Collaboration with TRANCAER of Mexico to provide regulatory updates in hazardous materials loading and unloading.	Reduction or non-accident HazMat releases

Table 12 – Rolling Stock Benefits Detail

Beneficiary	Benefits Received
RRS	Improved safety recommendations and innovative solutions
Rail Industry RRS	FRA will acquire:

Beneficiary	Benefits Received
Tank Car Owners Tank Car Manufacturers Leasers Tank Car Shops	• 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 • Improved 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.

Table 13 – Rolling Stock Research Partner Affiliations

Rolling Stock Research Partner Affiliations	
Association of American Railroads	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
$9,008,000

Program Description

The Train Control and Communication research program focuses on improving railroad operational safety, operational efficiency and economic competitiveness, and network capacity – which reduces railroad's climate impact. It helps the railroad industry address current and future technical and economic challenges by developing interoperable system standards, specifications, and technologies.

Major Program Objectives

TC&C research program objectives are to improve railroad operational safety, including reducing roadway and at-grade crossing collisions and overspeed-caused derailments, developing and testing trespass countermeasures, and optimizing 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 provide stakeholders the benefits of the research through T2.

Program Area – Train Control and Communication

Program Area – Grade Crossing and Trespass

Anticipated Program Activities and Potential Outcomes, Outputs, and Impacts

Transformation – PTC Next Generation Technology

- In collaboration with railroad stakeholders, TC&C's PTC technology research will develop next generation train control technologies, including Quasi-Moving Block (QMB) and Full Moving Block (FMB) architectures.
- TC&C will support the development of interoperable train automation technologies, hazard-sensing solutions, and associated industry standards.
- TC&C will continue to develop tools which streamline PTC interoperability and ensure compliance with the Rail Safety Improvement Act of 2008 (RSIA).
- TC&C's PTC Next Generation research will consider signaling, communications, and infrastructure enhancements to reduce PTC maintenance burden and improve safety.
- TC&C 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.
- TC&C will 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. Advanced train control concepts such as QMB and FMB will be further developed. Virtual block track circuit technologies will be tested and evaluated for implementation feasibility.

Outcomes

The capability to improve the interoperability of PTC systems:

- Increased rail operational and energy efficiencies
- Enhanced capabilities to reduce PTC burden and improve safety
- Ability to develop efficient and reliable interoperability controls and automated interoperability verification among railroads.
- QMB and FMB will specify a method of train control that builds on 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

TC&C will:

- Collaborate with railroad stakeholders to develop next generation train control technologies, including QMB and FMB architectures.
- Research solutions for improving the reliability and maintainability of conventional PTC systems.
- Continue to develop tools which streamline PTC interoperability and ensure compliance with RSIA.
- Develop software tools and systems to monitor the health and maintenance of interoperable PTC communication systems and Track Data Auditing System.
- Upgrade testing infrastructures and systems at TTC to support rail industry R&D needs.

Outputs:

- The development of QMB and FMB architectures
- PTC reliability and maintainability solutions

Outcomes

The research will provide new tools, capabilities, and procedures to improve interoperability and maintenance of PTC systems.

Impacts

The overall improvement of 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.

- Innovate technologies in automation, AI, and unmanned aerial vehicles (UAVs) to improve safety and reduce incidents around railroad operations.
- Conduct ITS research on the feasibility of a connected vehicle communication protocol for grade crossing accident mitigation.
- Continue to facilitate collaboration among railroads and automotive industry stakeholders to develop coordinated solutions for automated transportation systems.
- Support the testing and evaluation of cellular vehicle-to-everything communication protocols.
- Conduct a public demonstration of the feasibility and performance of RCVW.
- Work with FHWA, the National Highway Traffic Safety Administration, the Federal Motor Carrier Safety Administration, and FTA to coordinate programs to better reach stakeholders.

Outputs:

- Newly developed technologies across the railroad infrastructure and operations
- Improved collaboration between railroads and the automotive industry on solutions for automated transportation systems
- Coordinated stakeholder outreach among Federal agencies

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

TC&C will:

- Work with relevant partners and stakeholders to research solutions that reduce trespassing along railroad rights-of-way (ROWs).
- Continue to work with stakeholders to develop new tools and technologies that address trespassing on railroad ROWs, including the completion of the development and implementation of a near-miss database for trespassing events.
- Work with stakeholders on new trespassing prevention research ideas with the aid of the trespass summits planned throughout FY 2023 and FY 2024.

Outputs

New solutions and tools that address trespassing on railroad property.

Outcomes

Collaboration with stakeholders will increase solution development and implementation to reduce railroad trespassing, including 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

- TC&C's Grade Crossing (GX) and Trespass Outreach and Education research will address pedestrian safety.
- TC&C will continue to 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.
- TC&C's Grade Crossing Pedestrian Safety research will explore measures (e.g., channelization, gate skirts, and enhanced electronic signs) to address accidents at grade crossings and along railroad ROWs that involve pedestrians.
- TC&C will continue to evaluate scenarios for possible safety improvements at grade crossings through modeling and simulations.
- In collaboration with OL and other organizations, TC&C will continue to educate the public to the dangers of grade crossings.
- TC&C will develop technologies and tools to improve warning devices and integrate grade crossing locations into mapping devices.
- TC&C 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:

- Improved communication, techniques, and technologies to reduce pedestrian incidents at grade crossings.
- Improved GX communication and education of trespass issues..
- Improved capability to analyze GX incidents and the ability to improve enforcement of grade crossing training to address GX incidents.
- 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.
- Development of site-specific strategies for trespass mitigation at the top 10 counties with the most trespass casualties nationwide, thereby improving rail safety.
- Creation of research ideas using stakeholder input

Impacts

This research will reduce pedestrian incidents at grade crossings, 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

TC&C will:

- Design and develop a new grade crossing testbed at TTC.
- Further investigate and deliver new methods to assess the risk at humped crossings, including establishing a rating system to indicate their relative potential danger.
- Develop new methods of accident data analysis for FY 2022–2023 data and determine if researchers are asking the right questions when researching solutions to improve safety at grade crossings.
- Continue to work on the development of 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 new grade crossing assessment and analysis techniques.
- The testbed, part of a larger vision to transform TTC to a 21st century multimodal facility, will be used to perform testing and validation of new safety features at grade crossings that cannot be tested elsewhere.

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, TC&C research will 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.
- TC&C 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. 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 safety, reliability, and efficiency of its railroad network. PTC research improves freight and passenger railroad operational safety, protecting passengers, train operators, roadway workers, and infrastructure by safely controlling train movements, while also increasing reliability and network capacity. TC&C research on interoperability benefits the economy by making the train network more efficient. TC&C research in grade crossing and trespassing technology benefits society by lowering the number of accidents, injuries, and fatalities that occur on U.S. railroads.

Potential Progress Made toward Achieving Modal Strategic Goals

The TC&C research program advances the DOT Strategic Goals of Safety and Transformation. The program partners with U.S. railroads to develop and deploy advanced train control and automation systems to enable the safe movement of more trains on existing track, increasing capacity across the rail network. This research supports the DOT Strategic Goal of Economic Strength and Global Competitiveness by enabling efficient movement of people and goods on 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.

Table 14 – TC&C Collaboration Partners

Partner Name	Contributions	Benefits of Partnership
FHWA	Intelligent transportation systems research collaboration	Stronger products through engagement with highway and automaker stakeholders
FMCSA	Intelligent transportation systems research collaboration	Stronger products through engagement with freight and trucking stakeholders
FTA	Intelligent transportation systems research collaboration	Stronger products through engagement with highway and automaker stakeholders
NHTSA	Intelligent transportation systems research collaboration	Stronger products through engagement with highway and automaker stakeholders
ITS-JPO	Intelligent transportation systems research collaboration	Coordinated multimodal development
AAR – Train Control Communications and Operations Committee	Rail industry coordination and project advisory group support; subject matter expertise	Enhanced technology transfer; solutions that integrate seamlessly with railroad operations.
BNSF	System software development and supplier contracts; field test data; subject matter expertise	Enhanced technology transfer; solutions that integrate seamlessly with railroad operations.

Partner Name	Contributions	Benefits of Partnership
NS	Subject matter expertise	Enhanced technology transfer; solutions that integrate seamlessly with railroad operations.
UP	Field test data and subject matter expertise	Enhanced technology transfer; solutions that integrate seamlessly with railroad operations.
CSX	Subject matter expertise	Enhanced technology transfer; solutions that integrate seamlessly with railroad operations.
Amtrak	Field test data and subject matter expertise	Enhanced technology transfer; solutions that integrate seamlessly with railroad operations.
Alaska Railroad	Subject matter expertise	Enhanced technology transfer; solutions that integrate seamlessly with railroad operations.
Kansas City Southern	Subject matter expertise	Enhanced technology transfer; solutions that integrate seamlessly with railroad operations.
CN	Subject matter expertise	Enhanced technology transfer; 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
FarmRail System, Inc.	ROW access; subject matter expertise	Enhanced technology transfer; 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; solutions that integrate seamlessly with railroad operations.
Brunswick, ME, Police Department	Police department facilities; subject matter expertise	Better product deploy ability

Partner Name	Contributions	Benefits of Partnership
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; 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; solutions that integrate seamlessly with railroad operations.

Human Factors
$7,045,000

Program Description

The Human Factors research program addresses the DOT Strategic Goals of Safety and Transformation. HF seeks to optimize human performance in railroad operations. The program considers the railroad from a human-centered point of view by studying how the whole system influences the way people behave and interact with the railroad and develops new technologies, non-regulatory guidance, and programs to mitigate causes of human error. HF also conducts research on highway-railroad grade crossing safety and trespass and suicide prevention.

Major Program Objectives

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

- Understanding and managing railroad worker performance factors, such as fatigue and distraction
- Identifying human performance issues in new technologies and systems and recommending methods to enhance the safe deployment of these new systems (e.g., human-automation teaming).
- Developing and pilot-testing strategies to mitigate trespass and suicide incidents.
- Investigating technologies to improve grade crossing safety.
- Partnering with stakeholders to help improve 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

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

HF will:

- Continue to maintain the Cab Technology Integration Laboratory (CTIL) and driving simulator. These simulators provide facilities to conduct human performance research.
- Continue research on in-vehicle auditory alerts and RCVW for vehicles approaching grade crossings.
- Continue to collaborate with the DOT Virtual Open Innovation Collaborative for Safety program, where the FRA driving simulator, known as the Behavior and Railroad Crossings Laboratory, will have a role as a "node" in the system.
- Conduct research on incorporating user-centered design into the railroad industry by applying user interface/user experience technical solutions demonstrated in defense-related domains.
- 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.

- Continue research into the use of driver state monitoring (DSM) systems currently available in automated vehicles in the railroad industry. HF is studying whether DSM (first developed for automobiles) can aid in the detection and mitigation of states of reduced alertness by adapting the system to an in-cab rail environment.
- Conduct joint studies with the other RD&T divisions: Track, Rolling Stock, and TC&C.

Outputs:

- Published technical reports and presentations on projects related to safety and transformation
- Protype, user-centered, designed displays for enhanced operator situational awareness and reduced human error potential
- Initial testing of two selected DSM systems in a controlled environment

Outcomes:

- User-Centered Design Rail that displays the right information and functionality at the right time to manage, adapt to, or override possibly unsafe automated rail equipment control options.
- DSM technologies are useful to the rail environment to control tasks of a locomotive engineer reducing the impact of human error on locomotive engineer performance through continuous monitoring of the locomotive crew state of alertness.
- Optimized Rail Crossing Violation Warning in-vehicle audiovisual alerts (RCVW-IVAA) for grade crossings and their implementation.
- A data-based approach to design optimized, in-vehicle, audio-visual alerts for GX and standardize alerts.
- Expanded understanding of effectively using artificial intelligence in railroad operations

Impacts:

- Address alertness issues associated with increasing in-cab automation.
- Reduce distraction or fatigue-related crashes and safety events in the rail system.
- Reduce human error.
- Increase operator situational awareness and distraction issues on all human machine integration (HMI)-related research.

Safety – Railroad Organizational Culture and Safety Performance

HF will:

- Continue to provide program oversight of the SLSI, a non-profit organization that seeks to improve safety and safety culture in Class II and III railroads.
- Continue to support the study of safety concerns related to train length as directed by the National Academies.

- Serve on a Rail Safety Advisory Committee working group to develop a close call reporting system that allows all railroad employees to report safety incidents, not just employees of railroads who participate in the FRA Confidential Close Call Reporting System (C^3RS).
- HF will continue to support RRS by:
    - Providing subject matter expertise, research, data, and tools to improve railroad safety
    - Continuing to develop the RISE data trust
    - Serving on railroad safety working groups, including Fatality Analysis of Maintenance-of-Way Employees and Signalmen (FAMES) and Switching & Operations Fatality Analysis (SOFA)
    - Conducting human performance testing at TTC
    - Using TTC facilities to test SOFA recommendations and best practices
    - Providing HF subject matter expertise to support safety audits; conducting research to identify safety issues related to dispatching and consolidations

    Outputs:

    - Technical reports describing SLSI's work on Class II and Class III railroads, including themes from safety culture assessments.
    - Data from one or more safety questions informed by the RISE data trust.

    Outcomes

    These include training and educational materials that address common safety gaps, as identified in the safety culture assessment process (e.g., leadership development training). There will also be a pilot of the first RISE project through the collaboration with RRS and partnerships with the University of Maryland, Center for Advanced Transportation Technology Laboratory (CATT Lab) and multiple Class I, shortline, and passenger railroads. More railroads will be engaged in RISE. RD&T will be able to identify trends from C^3RS that may warrant future research.

    Impacts:

    - Improve job performance and safety through innovative, science-based research and pilot programs that lead to fewer events caused by human error.
    - Safer Class II and Class III railroads with an increased awareness of safety issues
    - Improved railroad safety through the identification of previously unknown safety risks

Safety – Railroad Worker and Operator Performance

HF will:

- Continue to expand its research into cognitive performance, including fatigue, stress, and sleep. HF is also investigating how safety-related work incidents affects railroad workers.
- Update content for the FRA sponsored Railroaders' Guide to Healthy Sleep (RGHS) website (launched 2012; refreshed 2016). RGHS is a non-regulatory educational resource that provides scientifically valid information on sleep and sleep hygiene.

- Continue to support the RRS audit of engineer and conductor training programs.
- 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.
- Conduct a study of critical incidents related to 49 CFR 272, which outlines the responsibility of railroads to implement Critical Incidents Stress Plans. This includes completing a literature review, including existing critical incidents stress plans, and planning future interviews to promote the safety of railroad operations and the health and safety of railroad employees, especially those who are directly involved.
- Further refine a model developed for predictive work scheduling to address unpredictable and irregular schedules that may contribute to preventable hazards within the operations environment.

Outputs:

- Progress on providing recommendations to assist workers following stressful incidents.
- Update of the RGHS website with relevant data and best practices
- Research results on factors contributing to cognitive and behavioral performance of rail employees
- Data and reports illustrating the use of predictive scheduling in the railroad industry

Outcomes

RD&T research results will identify ways to reduce accidents caused by distraction or loss of situational awareness. Also, RD&T will be able to provide insights into understanding how varying degrees of experience affect attention and engagement during train operations. Further, RD&T will be able to help address issues (related to worker burnout and fatigue, stress, hours, or service rules) and mitigate on-the-job risks for railroad employees. RD&T will expand railroad participation with FRA to further refine predicted scheduled work.

Impacts:

- Improved job performance and safety through innovative, science-based research and demonstration programs that lead to reductions in injuries and deaths due to human error.
- Decreased number of fatigue-related incidents

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

- HF will continue to analyze grade crossing/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.
- RD&T will continue coordination with international and domestic colleagues through Global Railway Alliance for Suicide Prevention (GRASP), OL, and Suicide Prevention in U.S. Rail (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.

Outputs:

- Updates to research tools such as Trespass and Suicide Prevention Toolkit
- Deployment of a new Grade Crossing Toolkit
- Preliminary design of a grade crossing testbed at TTC
- Development of an understanding of risk factors and socioeconomic influences as it relates to trespass and suicide which may impact equity.
- Collaborative effort with law enforcement agencies to collect local trespass data using questionnaires.

Outcomes

RD&T will be able to identify ways to use data to effectively mitigate trespassing and suicide on railroads. Also, RD&T will be able to better understand of the root cause of rail suicide and trespass incidents to develop strategies to prevent future incidents or mitigate their consequences. Furthermore, RD&T will transition to a systems-thinking approach on research and improving strategic and tactical communications with stakeholders, carriers, and the public. Moreover, the advancement of innovative technologies and integrated driver systems will help reduce accidents at or around highway-rail grade crossings. Lastly, RD&T will create a collective space to share information among rail carriers on suicide and trespass prevention.

Impacts:

- Increased public safety with the reduction of motorist and pedestrian accidents
- Increased prevention of trespassing and suicidal behaviors at highway-rail grade crossings and ROWs
- Increased understanding of the causal factors behind why individuals contemplating suicide consider this method to end their lives.
- Increased identification of countermeasures to prevent accidents attributable to trespassing and plan new efforts to support FRA rail trespass prevention.

Potential Economic or Societal Impacts

HF research drives Safety and Transformation for the American public. Research in railroad technology, automation, and systems design will improve job performance and safety through innovative, science-based research. Research in railroad worker and operator performance will

ensure that railroad workers can successfully mitigate risks associated with the cognitive and physical tasks of their jobs. The research in highway-railroad grade crossings, railroad trespass, and suicide prevention may help reduce such accidents. The research in human interaction in development and use of AI in railroad operations will inform the practical application of this developing technology.

In addition, the Human Factors division continues to provide program monitoring and support for SLSI. This will enable the institute to conduct safety culture assessments and provide training and education on key issues such as HazMat transportation and leadership development.

Potential Progress Made toward Achieving Modal Strategic Goals

Human Factors research has contributed to significant improvements in railroad suicide prevention, railroad trespass prevention, motorist behavior at highway-rail grade crossings, and railway worker and operator performance. The RGHS website was launched in 2012, refreshed in 2016, and its content and structural architecture is currently being updated and improved. The site is used in the industry to learn ways to prevent and manage fatigue. The PWS pilot model currently in review can create schedules for 43 railroad workers that take regulatory requirements into consideration, improving work-life balance for the railway worker. The Virginia Tech Transportation Institute study, "The Impact of Commute Times on Fatigue and Safety of Locomotive Engineers and Conductors," moves forward with union member focus groups to understand and reduce worker fatigue. SLSI has continued its efforts to further increase the safety culture of Class II and Class III railroads through assessments, training, and communications to stakeholders regarding railroad safety.

Table 15 – Human Factors Collaboration Partners

Partner Name	Contributions	Benefits of Partnership
DOT Human Factors Coordination Working Group	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 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.

Partner Name	Contributions	Benefits of Partnership
		As a primary customer of RD&T, RRS research needs and priorities help shape HF research plan.
RRS 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, and 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
SOFA	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of fatalities and lessons learned
FAMES	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of fatalities and lessons learned
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	Subject matter expertise, collaboration, data, and recommendations	Stakeholder engagement/understanding of human error situations

Partner Name	Contributions	Benefits of Partnership
Transportation Workers-Transportation Division		
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
OL	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, and recommendations	IT expertise
OST IT	Collaboration, IT expertise and support, and 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

Partner Name	Contributions	Benefits of Partnership
Virginia Tech University	Subject matter expertise, research studies, collaboration, data, and recommendations	Various technical, data analysis, and HF expertise
Virginia Tech Transportation Institute	Subject matter expertise, research studies, collaboration, data, and recommendations	Various technical, data analysis, and HF expertise
CATT Lab	Subject matter expertise, research studies, collaboration, data, and recommendations	Various technical, data analysis, and HF expertise
AASHTO	Subject matter expertise, research studies, collaboration, data, and recommendations	Stakeholder engagement
National Academies	Collaboration, research studies	Stakeholder engagement/understanding of safety concerns related to train length
Federal Fatigue Management and Research Group	Collaboration, research, and subject matter experts	Multi-agency collaboration, HF expertise, and stakeholder engagement

Table 16 – Human Factors Benefits Detail

Beneficiary	Benefits Received
RRS	Improved safety requirements, standards, and recommendations
Industry	Improved safety and safety culture Lower operating costs Improved visibility for railroad workers and grade crossings Fewer railroad accidents and fatalities Improved training for railway workers
Public	Fewer 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 2025 RD&T Programs

The AMRP FY 2025 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

The 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

Program Area – Workforce Development

Program Area – Emissions Reduction and Alternative Fuel Locomotive

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.
- TRB and FRA will follow up and provide guidance to the selected research projects.

Organizational Excellence – Project Selection

- FRA will renew the Decision Lens software license for an additional option year to continue use of the prioritization software.
- Prioritization results from FY 2023 will inform FRA Spend Plan selections and priorities.

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.

Transformation – Facilities and Equipment – Transportation Technology Center

- TTC will continue to provide facilities and equipment that can be used to perform railroad research and development, testing, and training to enhance the safety of passenger and freight rail systems in both safety and security operations.
- RD&T will:
    - Continue to enhance and expand TTC capabilities through strategic investment in existing facilities, equipment, and instrumentation to support upcoming research and testing needs (e.g., the refurbishment of its rail system and equipment).
    - Continue to address the site's aging infrastructure and deferred maintenance needs, as the funding for the repair and rehabilitation of buildings and facilities in FY 2025 allows.
    - 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.
    - Complete TTC strategic research planning on how TTC will be used over the next 5 years.
- TSA and FRA will make a joint budget request in FY 2025 for construction of a new training building at the site large enough to properly accommodate anticipated training needs.

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.
- 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.
- Support programs aimed at engaging youth (Pre-K through 12th grade and college) and under-represented populations in rail transportation and STEM topics.
- Fund research topics: 1) Addressing Equity Challenges in Evolving Railroad Workforce Training Trends and Best Practices; 2) Influencing Successful Practices in Knowledge Management within the Railroad Industry; 3) Encouraging Early Interest in Railroad Careers; 4) Equity in Rail Workforce Recruitment – Identifying and Training Leadership for Succession Planning ; 5) LGBTQ+ Equity and Inclusion in the Railroad Industry.

Equity – Accessibility

RD&T will:

- Support the development of new and improved accessibility standards for rail vehicles.
- Assess the various accident loading and containment strategies for passengers using WhMDs.
- Conduct research as needed to develop science-based knowledge in support of standards.
    - Data from past R&DT research in this area will be applied for more complicated and advanced scenarios.
- Continue T2 for the U.S. Access Board as new regulatory language on accessibility requirements for rail are developed, as well as for passenger rail service providers.
- Complete development on a mobile application to improve the accessibility of railroad communications.

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 DOE, locomotive OEMs, RD&T will continue to develop and evaluate clean energy for rail transportation.

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 the development and prototype demonstration of hybrid systems.

Safety – Office of Railroad Safety Support

RD&T will:

- Continue to provide SME support by conducting research on urgent safety issues identified by RRS or Congress.
- Continue to provide SME support to RRS.
- Continue to partner with RRS and industry on the RISE project.

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.
- Select prospective research projects to fund and begin selected projects.
- As part of RD&T's MSI/HBCU outreach strategy, increase outreach to MSIs/HBCUs to establish research collaboration/partnership opportunities.
- Publish the request for proposals and select prospective research projects to fund.

Track

Program Description

The Track program sponsors research that helps make the Nation's railroad infrastructure more reliable and resilient. These efforts contribute to the safe movement of both passengers and commodities across the country today and in the future. The program's focus on reducing track-caused derailments relies on finding the variables involved in each type of these derailments and then developing the processes, technologies, and analytical methods needed to identify the most at-risk locations on the track.

Major Program Objectives

The Track research program has four broad objectives, each directly relates to DOT's Strategic Goals and Objectives as noted. Objectives in italics are also OST-R Research Objectives.

1. Understand the root causes of track-related derailments and develop ways to prevent these derailments.
2. Improve how FRA and the industry inspect track and structures.
3. Improve how FRA and the industry assess safety risk for track.
4. Develop a more productive, knowledgeable, and capable workforce.

Objective 1: Understand the root causes of track-related derailments and develop ways to prevent these derailments.

- DOT Safety Goal – Safe Public; Safe Workers; Safe Design; and Safe Systems
- DOT Economic Strength and Global Competitiveness Goal – High-Performing Core Assets; *Resilient Supply Chains*; and System Reliability and Connection
- DOT Climate and Sustainability Goal – *Infrastructure Resilience*
- DOT Transformation Goal **–** Matching Research and Policy to Advance Breakthroughs; Experimentation; Collaboration and Competitiveness; and Flexibility and Adaptability
- DOT Organizational Excellence Goal **–** *Data-Driven Programs and Policies*; Oversight, Performance, and Technical Assistance

Objective 2: Improve how FRA and the industry inspects track and structures.

- DOT Safety Goal – Safe Public; Safe Workers; Safe Design; and Safe Systems
- DOT Economic Strength and Global Competitiveness Goal – High-Performing Core Assets; *Resilient Supply Chains*; and System Reliability and Connection
- DOT Transformation Goal **–** Matching Research and Policy to Advance Breakthroughs; Experimentation; Collaboration and Competitiveness; and Flexibility and Adaptability
- DOT Organizational Excellence Goal **–** *Data-Driven Programs and Policies*; Oversight, Performance, and Technical Assistance

Objective 3: Improve how FRA and the industry assess safety risk for track.

- DOT Safety Goal – Safe Public; Safe Workers; Safe Design; and Safe Systems

- DOT Economic Strength and Global Competitiveness Goal – High-Performing Core Assets; *Resilient Supply Chains*; and System Reliability and Connection
- DOT Transformation Goal **–** Matching Research and Policy to Advance Breakthroughs; Experimentation; Collaboration and Competitiveness; and Flexibility and Adaptability
- DOT Organizational Excellence Goal – *Data-Driven Programs and Policies*; Oversight, Performance, and Technical Assistance

Objective 4: Develop a more productive, knowledgeable, and capable workforce.

- DOT Organizational Excellence Goal – Workforce Development

Anticipated Program Activities

In FY 2025, the Track research program plans to adjust its program and research areas to better align with the specific causes of track-related derailments and to eliminate overlap between the current research areas. The following tables show the new program and research areas and how those areas map to the areas currently used.

Table 17 – Track Anticipated Program Areas

New Program Area	New Research Area	Current Program Area	Current Research Area
Derailment Prevention	Derailment Mechanisms	Track & Structures	Track Inspection
		Track & Structures	Track Stability
		Track & Structures	Special Activities
		System Performance & Analytics	Vehicle & Track Interaction
	Component Failure	Track & Structures	Rail Performance
		Track & Structures	Special Activities
		Track & Structures	Track Inspection
		Track & Structures	Track Stability
		System Performance & Analytics	Predictive Analytics
Risk Assessment and Predictive Intelligence	Technology Performance Assessment	Track & Structures	Track Inspection
		System Performance & Analytics	Predictive Analytics
	Risk Analysis	System Performance & Analytics	Predictive Analytics
		System Performance & Analytics	Vehicle & Track Interaction
Research Support	Field Testing and Technical Expertise	Track & Structures	FRA Research Assets
		Track & Structures	On-Track Research and Testing
		Track & Structures	Rail Performance
		Track & Structures	Special Activities
		Track & Structures	Track Stability
		System Performance & Analytics	Vehicle & Track Interaction

Derailment Prevention – Derailment Mechanisms

For FY 2025, the Track research program plans to study how to prevent derailments caused by gage rupture, rail rollover, track buckling, and wheel climb. For each derailment mechanism, research activities may include characterizing track strength, characterizing applied loads, determining a fitness for service threshold, quantifying track strength degradation, and determining ways to reduce applied loads.

Derailment Prevention – Component Failures

For FY 2025, the Track research program plans to study how to prevent derailments resulting from rail failures, roadbed failures, special trackwork issues, and bridge failures. For each failure type, research activities may include characterizing track strength, characterizing applied loads, determining a fitness for service threshold, quantifying track strength degradation, and determining ways to reduce applied loads.

Risk Assessment and Predictive Intelligence – Technology Performance Assessment

For FY 2025, planned activities in this area include developing ways to assess how well intelligent systems, including AI- and machine-learning-based instrumentation, can reliably detect track issues. Research will also attempt to identify the most appropriate use cases for these intelligent inspection systems and conduct field demonstrations.

Risk Assessment and Predictive Intelligence – Risk Analysis

The program plans to continue activities to determine the probability of detection for all track issues and inspection methods. These activities will in turn provide the information needed for other planned activities that include develop predictive frameworks for how the risk of an accident changes as inspection methods and frequencies are changed or combined.

Research Support – Field Testing and Technical Expertise

For FY 2025, the planned activities in this area will support work in other Track research areas and other FRA offices with field testing using FRA's ATIP fleet, on-track testing at TTC, and Volpe technical expertise.

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.

Program Area – HazMat Transportation

Program Area – Rolling Stock and Components

Program Area – Train Occupant Protection

Program Area – Tank Car Energy Products Research

Anticipated Program Activities:

Climate and Sustainability – HazMat – Tank Car Research

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

Climate and Sustainability – HazMat – Structural Integrity

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

Safety – HazMat – Accident Consequence Reduction

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.
- Continue to investigate non-destructive evaluation techniques.

Safety – HazMat – Risk Analysis

- RD&T will continue studying the risk analysis of cryogenic hazardous materials transportation.

Climate and Sustainability – Tank Car Energy Products Research

RD&T will:

- Continue its studies in fuel tenders and the transportation of cryogenic materials.
- Continue the development of 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

- 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

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.
- Continue to identify malfunctioning or poorly performing equipment and components, including brake systems with WTD detector technology.

Transformation – RSEC – Rolling Stock Maintenance and Inspection

RD&T will:

- Continue to develop a system to power advanced detection devices (technologies to monitor conditions, detect rolling stock defects, and prevent failures).
- 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

RD&T will:

- Continue to improve truck designs that can provide superior equalization and curving performance by continuing to improve TEDS.
- Continue passenger rail research to advance fire safety requirements in U.S. passenger rail vehicles.

Safety – TOP – Fire Safety Research

- 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.

Transformation – TOP – Passenger Locomotive Crashworthiness and Occupant Protection

RD&T will:

- Continue passenger locomotive crashworthiness research.
- Continue work on assessing passenger car side strength requirements to understand how sidewall strength influences the likelihood of passenger car rollover due to impacts from highway trucks at grade crossings.

Safety – TOP – Glazing Standards

RD&T will:

- Develop industry recommendation for alternative glazing attachment methods to improve glazing retention capacity for consideration in new equipment procurements.
- Continue studying the passenger railcar failure modes in rollover events.

Safety – TOP – Improving the Resilience of Freight Railroad Networks

- RD&T will continue the development of a tool for assessing connectedness efficiency for intelligent rail network infrastructure.

Train Control and Communication

Program Description

The TC&C research program focuses on improving railroad operation safety, operational efficiency and economic competitiveness, and network capacity. 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

TC&C research program objectives are to improve railroad operational safety, including reducing roadway and at-grade crossing collisions, improving 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.

Program Area – Train Control and Communication

Program Area – Grade Crossing and Trespass

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.
- TC&C will upgrade testing infrastructures and systems at TTC to support rail industry R&D needs.

Safety/Transformation – PTC Next Generation

RD&T will:

- Continue research into advanced PTC concepts and architectures that support railroad automation, such as FMB and RCL.

- RD&T will research advanced methods of track-circuit-based rail break detection to support moving block operations.

Transformation – Intelligent Transportation Systems

TC&C 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.
- Continue research into the development of novel concepts for integrating road vehicle active safety systems into rail crossing infrastructure systems.
- Seek to foster technologies which interconnect multimodal systems for improved public safety and transportation network efficiency.

Safety – Trespass Countermeasures

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

Safety – Grade Crossing Technology

- TC&C will develop technologies and tools to improve warning devices and integrate grade crossing locations into mapping devices. TC&C anticipates using the new grade crossing testbed at TTC as part of its research activities.

Safety – Grade Crossing Pedestrian Safety

TC&C will:

- Continue to explore measures to address accidents at grade crossings and along railroad ROWs that involve pedestrians.
- 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

- TC&C 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, TC&C will continue to educate the public on the dangers of grade crossings.

Human Factors

Program Description

The HF research program addresses the DOT Strategic Goals of Safety and Transformation. HF employs several methods to carry out this research, including survey research, human subject simulator experiments, technology demonstrations, and pilot studies. 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 on 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

Program Area – Human Factors

Program Area – Short Line Safety Institute

Anticipated Program Activities

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

HF will:

- Continue to maintain CTIL and the driving simulator. These simulators provide facilities to conduct human performance research.
- Initiate research on AI applications for railroad operations.
- Continue to use AI to understand systems engineering processes and their impact on rail operations.
- Continue research on in-vehicle auditory alerts for vehicles approaching grade crossings and pilot testing of HUDs in the locomotive cab.

- 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

HF will:

- Continue to provide program oversight of the SLSI.
- Continue to support the study of safety concerns related to train length, as directed by the National Academies.
- Continue to support RRS by:
    - Providing subject matter expertise, and research, data, and tools to improve railroad safety
    - Continuing to develop the RISE program data trust
    - Serving on railroad safety working groups, including FAMES and SOFA
    - Conducting human performance testing at TTC
    - Using TTC facilities to test SOFA recommendations and best practices
    - Engaging stakeholders to increase the railroads participating in RISE
    - Providing HF subject matter expertise to support safety audits
    - Conducting research to identify safety issues related to dispatching and consolidations

Safety – Railroad Worker and Operator Performance

RD&T will:

- Continue to expand its research related to railroad worker and operator performance, such as fatigue, stress, and sleep. HF will continue to investigate how safety-related work incidents affect railroad workers.
- Continue to support RRS in its audit of engineer and conductor training programs.
- Continue to 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.
- RD&T will:
    - Continue to identify, collect, and design various in-vehicle auditory alerts and conduct subsequent empirical experiments to evaluate their effects on motorist behavior and 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 to coordinate with international and domestic colleagues through GRASP, OL, and SPUR to facilitate information-sharing on research, intervention, and implementation of activities related to suicide prevention.
- Continue to investigate how accidents, trespass, and suicide affect the rail system (including rail employees) and communities.

For more information on DOT research see https://researchhub.bts.gov/search.