

**United States Department of Transportation
Annual Modal Research Plan FY 2026
Program Outlook FY 2027**

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. In addition, RD&T's safety-focused projects offer solutions that contribute to the other DOT Goals: Infrastructure, Innovation, and Efficiency.

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 interagency 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 DOT Working Groups to prevent the duplication of effort. RD&T activities are reviewed to confirm they are non-duplicative with known prior or current projects within FRA and the railroad industry.

RD&T is organized into five programs: 1) Railroad Systems Issues (RSI), 2) Track, 3) Rolling Stock, 4) Train Control and Communication (TC&C), and 5) Human Factors (HF). RD&T strategically prioritizes research and conducts cost-effective procurement. Critical research issues for FRA include supporting enhancements to Positive Train Control (PTC); Next Generation Train Control (NGTC); grade crossing safety; trespass prevention; autonomous vehicles; safe transportation of hazardous materials in rail tank cars; emerging rail propulsion technology; automation technology; predictive analytics; artificial intelligence (AI) and machine learning; and workforce development (WFD).

FRA research identifies and addresses safety issues across the railroad industry. RD&T works with stakeholders to develop a robust research agenda that is sustainable and will progressively build upon successful projects to improve railroad safety through technology transfer. FRA research prioritizes safety while industry research often seeks operational and economic benefits. Absent FRA RD&T safety research, objective data to define safety requirements and address accident causes and trends would be missed.

As advanced safety inspection technologies are developed for industry, RD&T, in cooperative partnership with the railroads and the supply industry, develops and tests these technologies, providing insight into their capabilities and effectiveness. With this knowledge, RD&T provides tools and training for inspectors to better understand the technologies and help them perform their duties. For example, RD&T PTC development and testing resulted in establishing hands-on training for train operators and inspectors in the train handling under PTC control. In addition, building on the PTC technology, RD&T in cooperation with the railroad industry, will enhance PTC capabilities and integration into various levels of train automation technologies and be part of the highly anticipated Next Generation Train Control (NGTC). Lastly, RD&T supports automation through projects that include developing high-speed, revenue-track rail and profile inspection systems and remote bridge structural health monitoring technologies.

RD&T research supports FRA's ability to conduct safety oversight and advance new technologies. RD&T research results in the development of industry standards, best practices and compliance

guidelines. For example, in the tank car research program, RD&T research evaluates improved structural and thermal designs for tank cars carrying hazardous and flammable materials. Data from the research is used to develop industry standards, regulations, and specifications that ensure safety and interoperability. In many cases, RD&T research of novel and emerging technologies improves the safety and efficiency of rail transportation. RD&T research advances new technologies to a Technology Readiness Level (TRL) where it is economically beneficial to the rail industry to further develop and commercialize.

Leveraging its expertise in new technologies, RD&T supports RRS through participation in RRS's Rail Safety Training (RST), a weeklong gathering of rail safety inspection professionals from across the U.S. that include FRA Inspectors and Specialists, State inspectors, Class I and short line rail inspectors, and industry stakeholders. RD&T also presented at industry workshops on vehicle train/track interaction, and most recently on track support and substructure and vehicle derailment investigations. These workshops provide rail safety professionals with greater understanding of derailment investigations and subsequent prevention, in addition to previewing the latest research tools and techniques used for rail and roadbed inspections.

FRA's RD&T program builds the foundation for safety improvements through pilot tests and program development. There may be a lag between RD&T outputs and operational implementation when emerging and innovative technologies are being proven. While an increase in research funding is not a linear relationship to a decrease in fatalities, RD&T's research has a direct impact on finding the appropriate solutions to reduce fatalities. From 2020–2024, when normalized by per million train miles, there has been a 20 percent decrease due to rolling stock-related causes, 18 percent decrease due to train control-related causes, 5 percent decrease due to track-related causes, and 0 percent change due to human factors-related causes. RD&T's research has real-world impact. For example, building on PTC technologies, RD&T, in partnership with the rail industry, continued to advance the development of the locomotive centric Next Generation Train Control (NGTC) and automation technologies to precisely locate and track train movements on the U.S. rail network, which will increase safety, efficiency, and track capacity. Track Research's Autonomous Power-efficient Track Inspection System (APTIS) project invests in infrastructure by significantly improving track safety through automated, real-time detection and evaluation of track component conditions and leads in innovation by deploying a compact, power-efficient system with integrated

AI for on-site analysis that enables fully automated, high-accuracy detection of track anomalies.

STRATEGIC GOAL

STRATEGIC OBJECTIVE

SAFETY

Reaffirm that safety is the Department's top priority.

- 1.1 Improve aviation safety
- 1.2 Reduce surface transportation-related fatalities and serious injuries
- 1.3 Improve transportation worker safety
- 1.4 Develop improved safety management systems across transportation modes

INFRASTRUCTURE

Invest in high-quality transportation infrastructure capacity to unlock American prosperity.

- 2.1 Accelerate project delivery
- 2.2 Construct projects to expand system capacity
- 2.3 Improve system condition and reliability
- 2.4 Position the U.S. transportation sector for economic competitiveness at home and abroad

INNOVATION

Lead the world by bringing the best of American ingenuity to transportation.

- 3.1 Reduce regulatory burden
- 3.2 Enable transportation technology development and adoption
- 3.3 Invest in transformative technologies

EFFICIENCY

Improve efficiency and accountability across the Department.

- 4.1 Modernize DOT operations

Table 1— FY 2026 RD&T Program Funding Request Details

RD&T Program Name	FY 2026 President's Budget Request* (\$000)	Applied (\$000)	Technology Transfer (T2) (\$000)	Facilities (\$000)	Experimental Development (\$000)	Major Equipment, R&D Equipment (\$000)
Railroad Systems Issues	\$10,560	\$1,590	\$1,670	\$3,000	\$2,500	\$1,800
Track	\$10,120	\$10,120	-	-	-	-
Rolling Stock	\$11,000	\$8,500	-	-	\$2,500	-
Train Control & Communication	\$6,600	\$5,850	-	-	\$750	-
Human Factors	\$5,720	\$4,570	-	-	\$1,150	-
Totals	\$44,000	\$30,630	\$1,670	\$3,000	\$6,900	\$1,800

*Amounts include congressional directives for Transportation Technology Center (TTC) Improvements (\$3,000) in Railroad Systems Issues and Short Line Safety Institute (\$2,500) in Human Factors.

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 2026 RD&T Program Budget Request by DOT Strategic Goal

RD&T Program Name	FY 2026 President's Budget Request (\$000)	Safety (\$000)	Infrastructure** (\$000)	Innovation** (\$000)	Efficiency** (\$000)
Railroad Systems Issues	\$10,560	\$10,560	-	-	-
Track	\$10,120	\$10,120	-	-	-
Rolling Stock	\$11,000	\$11,000	-	-	-
Train Control & Communication	\$6,600	\$6,600	-	-	-
Human Factors	\$5,720	\$5,720	-	-	-
Totals	\$44,000	\$44,000	\$0	\$0	\$0

**Amounts include congressional directives for TTC Improvements (\$3,000) in Railroad Systems Issues and Short Line Safety Institute (\$2,500) in Human Factors.*

****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 2025 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.

Table of Contents

Executive Summary	2
Program Description	9
Program Goals and Objectives.....	9
Critical Research, Development, and Technology Programs	9
Technology Transfer Deployment.....	10
Collaboration Efforts	11
Evaluation and Performance Measurement Efforts	12
Potential Progress Made toward Achieving Strategic Goals: RD&T Alignment to USDOT Strategic Goals, FY 2026.....	12
Chapter 1 — FY 2026 RD&T Programs	13
Railroad Systems Issues	13
Program Description	13
Major Program Objectives	13
Anticipated Program Activities and Potential Outcomes, Outputs, and Impacts.....	13
Potential Economic Impacts.....	17
Potential Progress Made toward Achieving Modal Strategic Goals	17
Collaboration Partners	17
Track	21
Program Description	21
Major Program Objectives	21
Anticipated Program Activities and Potential Outcomes, Outputs, and Impacts.....	21
Potential Program Outputs, Outcomes, and Impacts on Technologies and Practices	25
Potential Economic Impacts.....	25
Potential Progress Made toward Achieving Modal Strategic Goals	25
Collaboration Partners	26
Rolling Stock	30
Program Description	30
Major Program Objectives	30
Anticipated Program Activities and Potential Outcomes, Outputs, and Impacts.....	31
Potential Progress Made toward Achieving Modal Strategic Goals	41
Collaboration Partners	41
Train Control and Communication	45

Program Description	45
Major Program Objectives	45
Anticipated Program Activities and Potential Outcomes, Outputs, and Impacts.....	45
Potential Economic Impacts.....	49
Potential Progress Made toward Achieving Modal Strategic Goals	49
Collaboration Partners	49
Human Factors.....	52
Program Description	52
Major Program Objectives	52
Anticipated Program Activities and Potential Outcomes, Outputs, and Impacts.....	52
Potential Economic Impacts.....	56
Potential Progress Made toward Achieving Modal Strategic Goals	56
Collaboration Partners	57
Chapter 2 — FY 2027 RD&T Programs	60
Railroad Systems Issues	60
Program Description	60
Major Program Objectives	60
Anticipated Program Activities	60
Track	62
Program Description	62
Major Program Objectives	62
Anticipated Program Activities	62
Rolling Stock	64
Program Description	64
Major Program Objectives	64
Anticipated Program Activities	64
Train Control and Communication	67
Program Description	67
Major Program Objectives	67
Anticipated Program Activities	67
Human Factors.....	69
Program Description	69
Major Program Objectives	69

Anticipated Program Activities 69

Office of Research, Development, and Technology

Research Portfolio Overview

\$44,000,000

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: Infrastructure, Innovation, and Efficiency. 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 — save lives and mitigate 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, Technology Transfer (T2), and acquisition life cycles. An additional RD&T objective is to promote innovation across the railroad industry in the exploration and use of technology and automation. RD&T has prioritized research on systems to solve the technology's development, implementation, and integration issues. Working with internal stakeholders, especially 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. The sustained funding of FRA RD&T enables the pursuit of safety-specific research needs. This allows FRA to initially bear the costs and risks for research the railroad industry does not pursue. FRA research results are widely distributed through publications, industry and academic forums, and government interagency working groups. Without this investment, significant safety-related research 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	Technology Transportation Center Intelligent Railroad Systems Rail Research and Development Center of Excellence Workforce Development
Track	Derailment Prevention Risk Assessment & Predictive Intelligence Research Support
Rolling Stock	Hazardous Materials (HazMat) Tank Car Energy Products Research Rolling Stock Equipment and Components (RSEC) Train Occupant Protection (TOP)
Train Control and Communication	Train Control and Communication Grade Crossing/Trespassing
Human Factors	Railroad Technology, Automation, and System Design Railroad Organizational Culture and Safety Performance Railroad Worker and Operator Performance Highway-Railroad Grade Crossings, Railroad Trespass, and Suicide Prevention 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 (TRL) 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 study the development of new technology.

RD&T T2-related spend plans will be approximately \$546,000 in FY 2025. 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 2025, the Track Division conducted its third 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 2025. 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 2026.

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. By making this information publicly available, RD&T shares its work and findings with railroad industry stakeholders and the public. Information regarding RD&T’s work can also be found on the OST-R Research Hub.

From FY19 through FY22, RD&T publications steadily increased in number with a slight decrease in FY23 and FY24. The table below summarizes RD&T publishing from FY 2019 to FY 2024.

Table 4 — FY 2019 - 2024 RD&T Publishing

Document Type	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
Technical Reports	44	52	41	42	44	53
Research Results	22	19	29	29	30	15
Other Reports	3	2	6	7	0	3
Total	69	73	77	78	74	71

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 potential safety issues.

RD&T stakeholders include railroad carriers, labor unions, railroad manufacturers, universities, RRS; interagency partners such as 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, emerging propulsion technologies, and HazMat research. International collaboration increases access to emerging and innovative concepts and technologies being developed outside the U.S. that may have applications to improve transportation safety in the United States. 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, advancing FRA’s mission of improving railroad safety.

Working Groups Activities

RD&T participates in DOT Working Groups and other communities of practice to increase collaboration on research across the modes and to reduce the likelihood of duplication in research activities. RD&T collaborates across other DOT offices to maximize research impact and efficiently expend research funding. All DOT offices recognize the benefits of collaboration and gain from the collective experiences and expertise from their inter-division peers. Some examples of the DOT working groups that RD&T participates in are the Automation Research Working Group, Lithium-ion Battery Safety Interagency Working Group, Artificial Intelligence Community of Practice, and the Human Factors Coordination Working Group.

RD&T also participates in the 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.

Potential Progress Made toward Achieving Strategic Goals: RD&T Alignment to USDOT Strategic Goals, FY 2026

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 reviews the work of each division and considers FRA's role and commitment in executing Department priorities. The following table highlights how RD&T research activities aligns with DOT's Strategic Goals: Safety, Infrastructure, Innovation, and Efficiency.

RD&T relies on several factors such as, safety trends and statistics, industry research needs, and DOT goals and priorities for research project selection. RD&T project selection prioritizes the safety implications of new technology deployment and the tools and training for inspectors to perform appropriate and effective safety oversight.

Chapter 1 — FY 2026 RD&T Programs

Railroad Systems Issues

\$10,560,000

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 invests in research and innovation to meet the challenges of the present and modernize freight and passenger rail for the future. RSI activities include projects aligning with congressional, DOT, OST-R, and FRA strategic objectives as well as exploratory research areas. Safety is the principal focus and goal of the RSI program.

Major Program Objectives

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

Program Area — Transportation Technology Center (TTC)

Program Area — Intelligent Railroad Systems

Program Area — Rail Research and Development Center of Excellence (CoE)

Program Area — Workforce Development (WFD)

Anticipated Program Activities and Potential Outcomes, Outputs, and Impacts

Rail Safety Innovations Deserving Exploratory Analysis (IDEA)

- FRA funds the TRB to issue an IDEA Program Announcement to solicit and select proposals for the Rail Safety IDEA program research projects.
- TRB selects a committee of railroad experts to meet (with FRA representation) and select three proposals to be funded (for up to \$130,000 each).
- TRB and FRA manage the awarded projects to completion.
- Project selection focuses on innovative, yet unproven ideas that have the potential to improve railroad safety and efficiency.
- Recently completed projects include a computer vision-based track component detection system, innovative LED signal lights, an AI-aided trespass detection system, and a drone inspection technology for track that operates without having to rely on GPS.

Outputs:

- Expected deliverables for all projects 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 all projects.

Outcomes

The selected research projects will deliver innovative ideas and techniques to improve railroad safety and solve existing problems.

Impacts:

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

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.
- Address the site's aging infrastructure and deferred maintenance needs; as funding allows, repair and rehabilitate buildings and facilities in FY 2026.
- Enhance and expand TTC capabilities through strategic investment in existing and new facilities, equipment, and instrumentation to support upcoming research and testing needs (e.g., the refurbishment of its rail system and equipment).
- Raise awareness and encourage expanded use of TTC facilities, including multi-modal projects, through creative outreach efforts to other Government agencies and the private sector, while ensuring priority for FRA-sponsored activities and providing fair access.

Outputs:

- Repairing and rehabilitating buildings and facilities will ensure a safe operating environment.
- Purchasing needed equipment and instrumentation will expand TTC capabilities.

Outcomes

RD&T will continue to promote 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. Through this outreach, RD&T 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.

With technology upgrades of the active crossings and adding auto industry standard communication capabilities and protocols, FHWA, FTA, and ITS Connected/Automated Vehicle (CAV) researchers can conduct research to advance safety and mobility. Currently, these crossings are used to further develop and test the cloud-based Rail Crossing Vehicle Warning (RCVW) to calculate train arrival and departure times and alert approaching vehicles and traffic management systems, improving safety and mobility around grade crossings. TSA will continue security training at TTC (TSA has worked at TTC for over 10 years). TSA is considering the impact of threats to PTC and other autonomous systems, such as the RCVW system. TSA has identified rail cybersecurity as a critical pursuit and is training its inspectors in cyber security (through ENSCO, Inc.) at TTC. The pilot training program is complete; additional classes have now started, based on planned program expansion.

FTA has established a new transit-related research program at TTC. Over the next fiscal year, FTA will initiate multiple research projects, advancing safety for our Nation's transit systems. This will expand utilization of the site initially with rail-focused transit applications before pursuing other transit modes (e.g., buses), bringing with it the potential expansion of TTC's research and testing capabilities. Further, these new activities will potentially draw interest from both public and private entities wishing to explore transit-related safety.

RD&T and the railroad industry will continue to research, test, and evaluate track- and vehicle-based safety standards and performance guidelines. These activities will complement TTC's rail transportation technology, development, testing, standards development, and training.

RD&T will also work to establish cross-modal partnerships with PHMSA and the National Highway Traffic Safety Administration (NHTSA) for work at TTC.

TTC has the capacity to test best practices for transportation of hazardous materials on rail, as well on other modes of transportation, such as highways and pipelines. At TTC, the Rolling Stock Research program and the rail industry can evaluate dynamic ride and structural performance of all varieties of tank cars, especially those that transport hazardous materials. Current testing includes the investigation of the dynamic forces placed into a tank car as the car traverses over different types of track defects and perturbations. The data collected provides insights into how the wheel-rail interaction forces can affect the life and performance of tank car structural components such as the stub sill.

Impacts:

- Expanded use of TTC by the railroad industry, including Federal agencies, State and local transportation providers, suppliers, shippers, and railroads.
- The facility will continue to enhance surface transportation safety, security, innovation, and help transform the Nation's aging infrastructure.
- Funding spent on testing equipment will improve and expand research capabilities — especially rolling stock and 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.

Broad Agency Announcement (BAA)

- RD&T will conduct research solicited from its annual BAA, based on proposals accepted by RD&T.

Outputs, Outcomes, and Impacts

These will depend on BAA selections in the current fiscal year. Note: RD&T has been reviewing concept papers as of January 16, 2025, and proposals on a rolling basis.

Workforce Development

RD&T will:

- Build partnerships with industry to address critical workforce needs and increase in-demand skills of workers.
- Continue to engage and collaborate with the railroad industry for a better understanding of rail workforce trends and provide relevant data and insights to support various initiatives.
- Support programs aimed at engaging youth (Pre-K through 12th grade and college) and American workers in skilled trades to develop a pipeline for railroad transportation and STEM careers.

Outputs:

- Stakeholder outreach, trend analyses, and programmatic planning.
- WFD Technical Reports and data calls.

Outcomes:

- RD&T will continue WFD research activities, stakeholder engagement, STEM projects, and expanding programs that support industry efforts to increase the recruitment, retention, and training of the railroad workforce.
- RD&T will support additional programs aimed at engaging youth (Pre-K through 12th grade and college) and workers in skilled trades for rail transportation and STEM careers.
- RD&T stakeholder forums will be a vehicle by which to exchange best practices and information.
- Invest in the upskilling of incumbent workers to meet rapidly evolving skill demands of their industries, including the use of AI in the workplace.
- Identify strategies for alternative credentials and assessments to the 4-year college degree that can be mapped to the specific skill needs of prospective employers.
- Conduct program evaluation to improve transparency on the performance outcomes of workforce development programs.

Impacts

Outreach has the potential to increase FRA partnerships and collaborations while encouraging a new generation of students and workers to select careers in rail.

University Research Initiatives (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.

Outputs:

- RD&T will publish a BAA, soliciting applied research projects to support DOT and FRA goals to encourage technology adoption by the rail industry.
- Deliverables include progress reports, project management documents, and final research reports. T2 is expected.

Outcomes

Each year RD&T selects prospective research projects for award. RD&T will publish the request for proposals and review proposals to solicit applied research projects that support DOT and FRA goals, including advancing automation and connected vehicle technology adoption by the rail industry.

Ongoing research projects focus on rail neutral temperature of track, trespassing, emerging propulsion technologies, broken rail detection, and WFD.

Impacts

Increase railroad safety and improve railroad infrastructure.

Rail Research and Development Center of Excellence (CoE)

- The National University Rail Center (NuRail) consortium of universities will conduct research and training projects to improve railroad safety and performance pursuant to 49 U.S.C. 20108(j). The CoE was awarded in May 2024.
- RD&T will work with the grantee to help launch new research and training efforts to improve overall railroad safety and performance.

- Grantees will conduct basic and applied research. Potential research topics include:
 - o Transformative technologies
 - o Workforce development
 - o Training efforts related to safety, project delivery, efficiency, reliability, and resiliency, of urban commuter, intercity high-speed, and freight rail transportation.
 - o Advances in rolling stock, advanced PTC, human factors, rail infrastructure, shared corridors, grade crossing safety, inspection technology, remote sensing, rail systems maintenance, network resiliency, operational reliability, and other advanced technologies.

Outputs:

- Transformational, exploratory, railroad-related research
- Rail-focused training programs
- Greater number of rail professionals
- Increased T2
- Partnerships that bring new science into practice

Outcomes

Grantees will conduct research projects and training initiatives that will improve railroad safety and performance. The CoE will continue to expand the railroad talent pool with STEM or rail-related skills.

Impacts:

- The CoE prioritizes basic and applied research, consistent with the law, for evaluation, education, WFD, and training efforts.
- CoE will have a lasting impact on research — and on the training and education of the rail workforce.

Potential Economic Impacts

RSI research will improve the safety and efficiency of passenger and freight rail leading to economic benefits that improve Americans' quality of life. It will also address the strategic drivers for DOT and FRA.

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

Potential Progress Made toward Achieving Modal Strategic Goals

RSI advances the DOT Strategic Goals of Safety, Infrastructure, and Innovation by providing the TTC facilities and equipment that can be used to perform railroad research, broadening rail industry opportunities and awareness, and launching research to expand recruitment.

The RSI research program supports the four RD&T divisions and coordinates with RRS. The program is also committed to funding university and intelligent railroad systems research, widening the pool of rail researchers, and growing the U.S. economy through innovation that will pay dividends well into the future.

Collaboration Partners

RSI relies on stakeholder input to establish research needs and priorities. FRA PMs are members of industry organizations and regularly engage stakeholders at meetings throughout the year to remain current on industry needs. RSI research collaboration partners include railroads, manufacturers and

suppliers, universities, nonprofits, Federal/State/municipal DOTs, labor unions, and DOT Operating Agencies.

Partner Detail

Partner Name	Contributions	Benefits of Partnership
Intermodal FTA TSA PHMSA	Guidance related to public transportation systems Subject matter expertise	RD&T receives guidance and policy standards in relation to securing public transportation systems.
Industry Organizations AAR American Public Transportation Association (APTA) ASLRRA TRB Albuquerque Rocket Society	Product commercialization Subject matter expertise	RD&T receives periodic review of its research, stakeholder engagement, strategic planning, priority-setting, evaluation work, and recommendations on how it can improve.
Labor Unions BLET SMART-TD TTD BMWED TCU Brotherhood of Railroad Signalmen (BRS) IAM NCFO	Subject matter expertise	Collaboration with labor union organizations yields further insight in specific subject matters.
Railroads and Local/Regional Partners BNSF Garland ISD CN Railway New Mexico Rail Runner Los Alamos County North Carolina DOT Illinois DOT Tennessee DOT Oak Ridge National Laboratory	Facilities management ROW access Subject matter expertise Field test data	RD&T receives support and access to testing facilities for higher quality testing.

Industry Suppliers and Engineering Firms High Water Mark, LLC Air Force Research Laboratories Explora! KEA Technologies, Inc. HILE Group Fairpointe Planning, LLC American Railway Engineering and Maintenance-of-Way Association (AREMA) National Railroad Contractors and Maintenance Association	In-kind contributions Subject matter expertise Field test data	Collaboration with industry suppliers and engineering firms yields further insight in specific subject matters as well as increased field test data.
Universities Southern Methodist University Texas State University Stanford University Florida A&M University Michigan Tech University of Illinois at Urbana-Champaign University of Illinois University of Nebraska University of Tennessee Knoxville University of Texas at Austin Michigan Technological University North Carolina Central University University of North Carolina at Charlotte University of Memphis Southeast Tennessee State University Vanderbilt University Penn State Altoona University of New Mexico University of South Carolina California State University, Fresno Colorado State University Pueblo University of Michigan Transportation Research Institute	Universities act as principal investigators on research projects. As such, they provide further subject matter expertise.	The universities produce knowledgeable graduates that form the next generation of employees for railroads, suppliers, and engineering firms.
Federal Partners NASA EPA TSA DOE DOD U.S. Access Board	Regulatory guidance In-kind contributions Subject matter expertise	RD&T receives regulatory guidance from agencies not found within DOT.

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 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	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 train noise limits
Labor Unions	Increased employee safety
Railroad Workers	Increased railroad worker safety

Track

\$10,120,000

Program Description

The Track research program conducts scientific and engineering research to reduce track-caused derailments and improve railroad safety. In doing so, the Track research program helps make the Nation's railroad infrastructure more reliable and resilient, contributing to the safe movement of passengers and commodities across the country. The program's focus on reducing track-caused derailments relies on finding the variables involved in each type of these derailments. This information then drives research into the processes, technologies, and analytical methods needed to identify the most at-risk locations on the track and prevent future derailments. The resulting new methods and technologies — including new AI applications — increase the efficiency of the industry and the knowledge of its workforce. The Track research program's current research is positioned to address the growth of new technologies in the rail industry, including the integration of automated inspection technologies into railroad operations. FRA's Track research program goals include plans to further investigate track strength characterization, applied load impacts, fitness-for-service thresholds, track strength degradation, rail neutral temperature limits, and methods to reduce loads on rail and ballast. Research activities will utilize FRA's Automated Track Inspection Program (ATIP) fleet as data collection sources that will investigate non-destructive and non-rail contact measurements systems to advance program goals.

Major Program Objectives

The Track research program strives to provide the scientific and engineering basis for safety rulemaking and standards while ensuring rules are appropriate.

The Track research program has four broad objectives:

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

Anticipated Program Activities and Potential Outcomes, Outputs, and Impacts

The Track Program consists of three sub-programs: Derailment Prevention, Risk Assessment and Predictive Intelligence, and Research Support. Each sub-program encompasses unique research areas, discussed below. They position the agency to deal with the explosive growth of new technologies in the rail industry.

In FY 2025, the Track program began using the Stress State model to guide research planning for both the Derailment Mechanisms and Component Failures research areas. As a result, both areas have similar planned activities. The railroad industry has used this model since the early 2000s, so it provides a familiar and logical model for the industry to understand the research. It is based on capability analysis concepts used throughout the quality field. The widespread use of these concepts may allow researchers who have not worked in the rail industry to contribute to the research efforts.

Derailment Prevention — Derailment Mechanisms

In CY 2024, dynamic mechanisms accounted for 382 derailments and over \$115.7 million in track and equipment damage.

The division plans to focus on four derailment mechanisms in FY 2026:

- Gage rupture
- Rail rollover
- Wheel climb
- Track buckle

These four mechanisms are the primary ways that track can cause a derailment, excluding the component failures discussed below. Research into each mechanism will seek to answer two basic questions at the time of inspection: “Are there currently any conditions related to the mechanism that would cause a derailment?” and “When does the track need to be inspected again to ensure it is still safe?” Research activities will attempt to identify all the relevant variables — including interactions between variables — and determine how much each one contributes to causing a derailment. This work may need to develop or improve test beds, measurement systems, simulations, and analytical methods. Activities will also try to define the loads applied to the track and determine ways to reduce those forces. Other activities will try to quantify how quickly the strength of the track degrades with rail traffic and local conditions.

Outputs:

- Data on wheel/rail interactions during varying contact conditions and on the overlap of different track parameters in revenue service.
- Validated vehicle models for industry use in simulation software.
- Development and refinement of test beds to aid in identifying important variables and their contributions.
- Data from new sensor technologies.
- Prototype development of new sensor hardware.
- Field studies on rail longitudinal resistance.
- Continued development of prototype instrumentation to measure longitudinal rail stress.
- Training materials for the management of continuous welded rail.
- AI/machine learning algorithms for detecting and evaluating track components.
- Technical Reports documenting 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.
- Better technology to monitor and measure rail stress.
- Better training materials to prevent track buckles.

Impacts:

- Fewer derailments caused by low gage strength, defective crossties, track geometry issues, or track buckles.

- Potential regulatory changes or standards development.

Derailment Prevention — Track Component Failures

In CY 2024, accidents related to component failures accounted for 248 derailments and over \$93.4 million in track and equipment damage.

The program plans to focus on four types of component failures in FY 2026:

- Rail failures
- Roadbed failures
- Special trackwork issues
- Structural bridge issues

Component failure research will seek to answer two basic questions at the time of inspection: “What is the currently likelihood that one of the above components will fail and cause a derailment?” and “When does the track need to be inspected again to ensure the above components are still safe?” This research will attempt to identify all the relevant variables — including interactions between variables — and determine how much each one contributes to causing a failure. This work may develop or improve test beds, measurement systems, simulations, and analytical models. Activities will attempt to define the loads applied to the components and determine ways to reduce those forces. Other activities will try to quantify how quickly component strength degrades with rail traffic and local conditions.

Outputs:

- AI/machine-learning algorithms for predicting the growth of internal rail flaws.
- Data on the capabilities of current nondestructive testing equipment.
- Data for mechanical properties of ballast when fouled, wet, or both.
- Continued development of prototype instrumentation to measure ballast fouling, vertical track deflection, and ballast water content.
- Data from new sensor technologies.
- Prototype development of new sensor hardware.
- AI/machine learning algorithms for detecting and evaluating track components.
- Further knowledge of failure methods in special trackwork.
- Design of a prototype for laboratory testing of special trackwork.
- Technical Reports for each completed project.

Outcomes:

- Improved 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.
- More accurate internal defect growth predictions for rails.
- Criteria for more flexible yet less risky non-destructive inspection intervals.
- Test equipment able to performance-test special trackwork components and rail sections.
- Better standards for inspecting structural ties on timber deck bridges.
- 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.

Impacts:

- By coordinating with industry, fewer derailments caused by rail or joint bar failures, roadbed failures, special trackwork issues, or bridge collapses.
- Opportunities to build robust rail infrastructure that is better able to withstand extreme weather events.
- Provide RRS with necessary information to evaluate potential regulatory changes.

Risk Assessment & Predictive Intelligence — Technology Performance Assessment

For FY 2026, planned activities 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.

Outputs:

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

Outcomes:

- Use cases identified for non-traditional sensors and platforms.
- Recommended uses for new sensor technologies.
- Continued industry adoption of change detection technologies.

Impacts

Better understanding of both the capabilities of and most appropriate use cases for new and existing inspection technologies; potential regulatory changes or standards development.

Risk Assessment & Predictive Intelligence — Risk Analysis

The program plans to use probability of detection information gathered during the Technology Performance Assessment and use activities to develop data-driven frameworks and predictive models to analyze how variations in inspection methods and frequencies affect accident risk.

Outputs:

- Augmented manual inspection processes for seamless integration with emerging autonomous technologies.
- Recommendations for optimal allocation of inspection tasks between human operators and intelligent systems.
- Validated laboratory and in-track rail samples for assessing the performance of nondestructive test equipment.
- Technical Reports for each completed project.

Outcomes

A probability-based framework for understanding the change in risk as new inspection technologies are introduced or when inspection methods are combined.

Impacts:

- Mitigate safety hazards by optimizing inspection methods and frequencies.
- Provide RRS with the information necessary to evaluate potential regulatory changes.

Research Support — Field Testing and Technical Expertise

For FY 2026, 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 National Transportation Systems Center (Volpe) technical expertise.

Outputs:

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

Outcomes:

- Valuable field data
- Industry exposure to new processes and technologies

Impacts

Data collection and testing in real-world environments.

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

The Track Division research program provides a significant benefit by ensuring U.S. railway track and structures are safe, minimizing the risk of derailments which affect the public. It improves the reliability and resilience of the railroad network that forms the backbone of the U.S. supply chain. It contributes economic benefits by increasing the life of track components and promoting safer and faster passenger rail.

Potential Economic 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 public health while increasing the life of track components. Strong track infrastructure facilitates safer freight and passenger rail, providing public-friendly transportation options while promoting commerce.

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 Infrastructure and Innovation goals.

The Track research program is responsible for technology innovations that improve track infrastructure. The research program generates solutions for a wide range of rail flaws, wheel/rail interface problems, ballast and sub-surface defects, track geometry flaws, and bridge issues. The

program fulfills DOT Strategic Goals through field-testing, modeling, AI/machine learning algorithms, and risk analyses.

- Track Research’s Autonomous Power-efficient Track Inspection System (APTIS) project invests in infrastructure by significantly improving track safety through automated, real-time detection and evaluation of track component conditions and fosters innovation by deploying a compact, power-efficient system with integrated AI for on-site analysis that enables fully automated, high-accuracy detection of track anomalies. In addition, APTIS enhances efficiency by augmenting and improving traditional human track inspection activities.
- Track Research’s Ground Hazard Monitoring project, in collaboration with the University of Illinois, promotes innovation and infrastructure by leveraging satellite imagery to assess slope stability along railway embankments and tracks that results in the detection of ground movement before safety failures. This approach enhances efficiency by pinpointing precise inspection sites and effectiveness by focusing monitoring on the most critical track segments.
- Track Research’s Inspection Fleet Support project invests in infrastructure to ensure safety in that multiple innovative research technologies are affixed to ATIP research vehicles to predict, detect, and prevent safety critical conditions that may result in derailments and loss of life. The project further increases efficiency and effectiveness of FRA inspectors in locating and addressing the safety critical conditions.

Collaboration Partners

Partner Name	Contributions	Benefits of Partnership
Industry Organizations AAR APTA AREMA ASLRRA TRB NRC	Data Standards and recommended practices Industry committees Subject matter expertise	FRA gains information on current accepted industry practices. Partnerships promote two-way exchanges about industry issues, research needs, and research findings.
Railroads Amtrak BNSF Brightline Canadian National Railway CPKC CSX Genesee and Wyoming Railroad Metro-North Railroad Norfolk Southern (NS) Union Pacific Red River Valley and Western Railroad Northern Plains Rail Services	In-kind support activities which may include: Data Access to track and rolling stock Donated materials Manufacturing support Subject matter expertise and analysis Matching funds	Principal investigators gain access to real-world data and a revenue service environment. Railroads provide industry input on the nature of the safety challenges being researched. Railroad involvement increases the likelihood that they will adopt the new methods, processes, and technologies being developed. High speed vehicle qualifications

Labor Unions TTD BMWED	Subject matter expertise	Collaboration with labor union organizations yields further insight in specific subject matters.
Industry Suppliers and Engineering Firms Analogic Engineering Inc. ENSCO, Inc. KLD Labs, Inc. Thornton Tomasetti MxV Rail Volpe Wi-Tronix, LLC Insight Rail LLC MERMEC Inc. FTS Rail Ltd. voestalpine Nortrak Amsted Rail Alstom Graham White OceanIt Rhombert Sersa U.S. Harsco/Protran Correlated Solutions Inc. Sol Solutions Vtech CMCC Vehicle Dynamics Group LLC	Industry suppliers and engineering firms may act as principal investigators or project partners providing support. That support may be in-kind and may include: Data Donated materials Manufacturing support Subject matter expertise and analysis Matching funding	FRA, the industry, and university partners gain access and exposure to the latest industry technology and methods. These firms provide industry input on the nature of the safety challenges being researched.

Universities Kansas State University Oklahoma State University Rutgers University State University of New York at Stony Brook University of California, San Diego University of Delaware University of Illinois at Urbana-Champaign University of Houston University of Nebraska, Lincoln University of South Carolina University of Tennessee, Knoxville University of Texas, Austin University of Utah Virginia Tech University of Sheffield Michigan Tech University of Arkansas Jackson State University University of North Dakota Texas State University	Universities typically act as principal investigators on research projects. As such, they may provide: Data Manufacturing support Project management Subject matter expertise Matching funding	FRA, railroads, suppliers, and engineering firms gain exposure to the latest technologies and analytical methods, some of which may be adapted from other industries or transportation modes. Universities produce knowledgeable graduates who form the next generation of employees for railroads, suppliers, and engineering firms.
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Benefits Detail

Beneficiary	Benefits Received
RRS	Improved safety recommendations and innovative solutions, inclusive of Track Safety Standards updates and guidance, FRA inspector training, and ATIP technology improvements.
Federal Agencies: Volpe Army Corp of Engineers (ERDC) FHWA	These partnerships allow for further research and intergovernmental collaboration on emerging technologies for rail safety and technology transfer opportunities.
Public	Fewer railroad accidents and fatalities, lower operating costs, improved passenger railroad performance, improved freight railroad performance.

Rolling Stock

\$11,000,000

Program Description

The Rolling Stock research program (RS) focuses on improving the safety of the Nation's rail network by providing the scientific and engineering basis for updated industry standards, performance-based safety regulations, enforcement, risk reduction, and technology development to improve the design, maintenance, and operation of rail equipment.

RS 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. The program leads the research, development, and evaluation of:

- Advanced defect detection and inspection techniques for rolling stock materials and components performance.
- Improved designs of rail equipment to withstand crash loads and fire conditions associated with high-energy train derailments and collisions.

The HazMat research program focuses on improving transportation processes and the safety and reliability of moving HazMat (crude oil, ethanol, toxic inhalation hazards, et. al) by rail. The research program also investigates the safe use of emerging technologies such as battery energy storage systems and hydrogen, where such technology is proposed by industry for deployment. The program studies tank car safety performance during and after impact and performs fire studies.

The Emerging Technologies Safety research area evaluates technologies in the railroad environment and promotes innovation by developing models as tools to create safer, more cost-effective system designs and test programs.

Major Program Objectives

Rolling stock defect detection is critical for the safe operation of trains. RS focuses on supporting the development of modern on-board and wayside equipment defect detection technologies; research supports RRS reviews of railroads' applications for wider use of such technologies. Fiscal year 2026 will see continued investment in wayside detection technologies and methods, resulting in improved safety requirements and a decrease in accidents and incidents. The strength and fire safety of the materials and components used in rolling stock will also be targeted. The program will also investigate the efficacy of emerging technologies to provide sufficient motive power for rail transportation, as well as understand the safety performance of these new technologies under accident loadings. 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 — Hazardous Material Transportation

Program Area — Rolling Stock and Components

Program Area — Train Occupant Protection

Program Area — Tank Car Energy Products Research

Anticipated Program Activities and Potential Outcomes, Outputs, and Impacts

Hazardous Material — Tank Car Research

RD&T will provide critical data on tank car performance through focused research efforts, including:

- Evaluating the effects of track geometry and dynamic perturbations on tank car stub sills.
- Analyzing the effectiveness of “breakaway” stub sill attachment designs.
- Developing finite element models of tank car head impacts and assessing alternative head protection systems.
- Estimating puncture speeds through parametric modeling across a range of impact scenarios.
- Assessing weld performance during impact through simulations and scaled pendulum testing.
- Characterizing the mechanical properties and fracture behavior of steels used in tank cars.

Outputs:

- Industry insights on the root causes of stub sill failures.
- Puncture resistance data of tank cars under diverse operating conditions and varying parameters.
- Technical Reports and performance data on tank car materials and welds.

Outcomes

RD&T will enhance understanding of tank car structural risks and performance, enabling informed updates to safety regulations and engineering design standards for RRS, PHMSA and the railroad industry.

Impacts:

- Improved safety in tank car design and operations.
- Better characterization of material properties across the tank car fleet, supporting baseline assessments of structural performance.

Hazardous Material — Tank Car Crashworthiness Evaluation

RD&T will assess the crashworthiness of tank cars used to transport HazMat, including toxic inhalation hazard (TIH) substances and cryogenic liquids. Focus areas include DOT-113, DOT-105, DOT-112 tank cars and fuel tenders. Activities include:

- Developing computational models of tank car responses under impact conditions.
- Evaluating puncture resistance under standardized shell impact scenarios.
- Conducting full-scale impact tests to validate model accuracy.
- Performing post-test simulations to compare experimental and computational results, improving modeling methods.
- Supplying technical findings to support regulatory decision-making and standards development.

Outputs:

- Technical Reports and data on the performance and durability of tank cars and tenders during an accident.
- Industry-wide recommendations for revising tank car standards and regulations.

Outcomes

RD&T will provide validated test data and impact performance assessments to inform manufacturing practices and regulatory development for RRS, PHMSA and the railroad industry.

Impacts:

- Enhanced safety and reliability of tank cars and fuel tenders.
- Increased understanding of tank car performance under derailment conditions.
- Availability of experimental data to guide design improvements.
- Enhanced modeling validation for industry and regulatory stakeholders.
- Expanded technical knowledge base for the rail safety community.
- More unified and effective safety standards across the industry.

Hazardous Material — Accident Consequence Reduction

RD&T aims to understand the root causes of tank car failures and advance safety through improved design and accident mitigation strategies. RD&T will work closely with RRS and PHMSA to address NTSB recommendations and gaps in current standards and designs.

Outputs:

- Technical Reports on HazMat tank car accidents and mitigation techniques.
- Support for accident and incident investigation and root cause analysis.
- Data identifying failure modes and contributing factors in tank car accidents.

Outcomes

RD&T will enhance accident prevention and consequence management capabilities through research-driven improvements in design, testing, and assessment practices.

Impacts:

- Understanding the cause of accidents and identifying improvement to design or regulations to prevent similar accidents or reduce consequences in the future.
- Strengthened assessment frameworks to guide tank car design improvements.

Hazardous Material — Fire Performance of Tank Cars

The objective of this research is to evaluate and improve tank car fire resistance. Improving the fire performance of tank cars in the event of a train derailment or collision will provide public safety benefits by reducing the likelihood of tank car fires and the potential requirements for emergency response activities. Key activities include:

- Modeling failure modes of thermal protection systems (TPS) during fire exposure.
- Enhancing TPS performance for conditions such as pool and torch fires.
- Developing and applying non-destructive evaluation (NDE) tools to assess tank car fire performance.

Outputs:

- Technical Reports on existing and next-generation thermal protection systems.
- Predictive tools and simulation models for tank car fire performance.
- Fire scenario modeling data to inform safer tank car designs.

Outcomes

RD&T will advance fire performance standards by identifying vulnerabilities and proposing improvements to tank car thermal resilience and safety systems.

Impacts:

- Increased survivability of tank cars in fire scenarios.
- Improved predictive tools to inform TPS design and materials selection.

Tank Car Energy Products Research

RD&T will perform analyses and small-scale and full-scale impact testing of fuel and energy storage packaging and tenders and ancillary equipment. FRA will engage with PHMSA and the rail industry in testing and standards development for energy storage packaging and fuel tender technologies.

Outputs

Data and Technical Reports on the safe design and loading of emerging energy storage packaging and fuel tenders.

Outcomes

This research will inform DOT safety standards, resulting in better-designed energy storage and fuel tender technologies for transporting energy products as a commodity and as a rail fuel.

Impacts

Improved understanding of the safety and efficiency of transporting energy products by rail and as a rail fuel.

Emerging Technologies Safety Research

- RD&T will support RRS in technical reviews of the proposed use of battery energy storage systems, hydrogen, other alternatives to diesel fuel, or a combination of these technologies, where such technologies are proposed by industry for deployment.
- RD&T will fund research to evaluate the safety of emerging technologies in the railroad environment. Research will focus on understanding their fire safety and crashworthiness performance.
- RD&T and RRS will continue bilateral discussions with international partners to identify opportunities to collaborate and share knowledge.
- FRA will continue to co-fund research with DOE and locomotive manufacturers on energy storage and tenders technologies and the advancement of fuel flexibility for rail transportation.
- More research is planned on how well a battery's protective housing perform in containing heat and flames when a thermal runaway event occurs. Research data will inform best practices and guidance for the design of these protective housings.

Outputs:

- Data on the performance of emerging technologies under accident scenarios that can cause catastrophic damage to the equipment, injuries, or fatalities.
- Data to support RRS discussions with rail equipment suppliers on safety of emerging technologies.
- Technical reviews of and recommendations to RRS on U.S. railroads' request to use emerging technologies for rail propulsion.

- Emerging technologies will be safety-tested in railroad applications for locomotive propulsion.
- Useful models to make emerging energy storage propulsion systems safer, in addition to making them more cost effective to design and test.

Outcomes:

- Broaden interaction with experts and international practitioners who are implementing emerging propulsion technology in the rail space.
- Working with locomotive original equipment manufacturers (OEMs), continue to evaluate emerging technologies, such as hydrogen, for rail transportation.
- Research collaboration and cost-sharing with DOE and national laboratories will continue to advance emerging technologies for rail propulsion.
- Assess issues related to batteries, heat exchangers, and fuel cells.
- Designers will use models as tools create safer and more cost-effective system designs and test programs.

Impacts:

- RD&T research will help the railroad industry understand the safety performance of the emerging technologies the industry puts into revenue service.
- Safer energy storage propulsion systems for the rail industry, both freight and passenger.

Accessibility

- Review 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 RD&T research in this area will be applied for more complicated and advanced scenarios.
- Continue T2 of research products to passenger rail industry and U.S. Access Board as regulatory or standards language for new rail accessibility requirements are developed.

Outputs:

- Analyses of wheelchair securement and occupant restraint systems for efficacy in compartmentalizing wheelchairs on passenger railcars.
- Analyses of the dynamic interaction between WhMDs and interior fixture 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 recommendations 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. RD&T will also conduct T2 of research products to the U.S. Access Board as regulatory language for new accessibility requirements for rail.

Impacts:

- Increased protection to WhMD passengers in an open-bay-accessible location.
- The development of reasonable and inclusive requirements for railcar accessibility.

RSEC — Rolling Stock Equipment and Components

In FY 2026, RD&T research will build on recently completed studies to develop components and systems that reduce the risk of rail incidents and accidents. Findings from the Very Long Train (VLT) study, conducted in collaboration with industry, will be discussed to determine new research opportunities. The continuous improvement of train performance modeling tools used by FRA and the industry, such as the Train Energy and Dynamics Simulator (TEDS), will be modified to improve fidelity for longer train consists, running gear improvements, and handling/braking behavior. Over-the-road data will be collected on a conventional-length train consist, generally accepted to be less than 7,500 feet, to get a better understanding of the differences between VLT and conventional train consists. This will add to FRA's baseline data on in-train forces, accelerations, and displacements the agency shares with industry.

RD&T will also continue to identify malfunctioning or poorly performing railcar equipment and components, using wheel, axle, and bearing defect detectors (WABDDs), including wheel temperature detectors (WTDs). Research in FY 2026 will focus on advancing acoustic, vibration, and temperature measurement technologies for bearing defect detection. In addition, RD&T will continue to focus on braking issues, including compressed-air leaks and the effects of cold weather and aged components on air-braking.

Outputs:

- Technical Reports, data, and safety recommendations on VLTs.
- Technical Reports, data, and safety recommendations for brake systems performance.
- Development and recommendations for standards on wayside and the on-board standardization of defect detection technologies for wheel, axle, and bearing defects.
- Database for maintaining detector system data.

Outcomes:

- Improved TEDS modeling tool for improving train operational safety.
- Better understanding of:
 - The effects of hot wheels due to braking issues.
 - Improvements in bearing defect detection based on novel inspection and monitoring, including vibration and acoustic and temperature state-of-the-art detectors.
 - Component age and cold weather on air-brake system performance.
- This research will result in better safety recommendations for VLTs, brake systems, and WABDDs. Another outcome will be a more accurate understanding of rolling stock maintenance needs.
- Electrical power supply opportunities for freight cars.

Impacts:

- Fewer wheel, axle, and bearing failures.
- Improved wheel life through a better understanding of applied tread braking issues.

- Cost saving by reducing wheel/rail wear.
- Continued vehicle track-worthiness improvement due to improved vehicle dynamics simulations and analyses.
- A standard process for wayside defect detector technology pilot demonstrations.
- Wayside and on-board defect detection systems will reduce the number of incidents and accidents through proactive asset maintenance capabilities, driven by the monitored performance of rolling stock equipment and components. This includes a better understanding of the spacing between wayside defect detectors — for more robust and timely notifications of incipient failures well before catastrophic events can occur.

RSEC — Rolling Stock Maintenance and Inspection

In FY 2026, RD&T will continue to improve truck designs, through superior equalization and curving performance. These designs will be validated by field testing and simulations using vehicle dynamics modeling software such as Vampire and NUCARS. In addition, RD&T will improve train makeup and car positioning through field testing and by continuing to improve the TEDS modeling tool.

Outputs:

- Data analysis and Technical Reports on truck/vehicle dynamics testing and modeling, train makeup and handling modeling, electrical power supply implementation, and advanced WABDDs, including wayside and on-board detection technologies.
- Technical Reports on time required to conduct inspection activities on a per-car basis and a plan to build additional phases for studies related to inspection resources.

Outcomes:

- Improved TEDS capabilities; this will be achieved by recalibration through field data acquisition and analysis and with new capabilities.
- Better train handling procedures, operating practices, and truck designs that lower the rate of incidents and accidents.
- Improved detection and communication of wheel and bearing incipient failures to reduce related derailments and incidents.
- Improved understanding of inspection resources required for federally required inspection activities.

Impacts:

- TEDS facilitates the identification and quantification of safety risks in train operations affected by equipment, train makeup, helper locomotive placement, free slack between couplers, train handling, and track conditions. It also includes identifying the presence of lubricators, operating practices, environmental conditions, and certain types of malfunctioning equipment — such as leaking air brakes, etc.
- Improved communications and control using Wireless Digital Train Line (WiDTL).
- Reduced potential of derailments and incidents due to better wheel and bearing defect detection.

RSEC — Train Handling and Operating Practices

In FY 2026, RD&T will:

- Continue research to improve train makeup recommendations that will provide safer performance. Building upon previous research on stationary and moving VLTs, this research will include different geographic territories and environments to improve TEDS capabilities and modeling effectiveness.
- Continue researching VLT effects on train handling, train dynamics, and blocked crossings.

Outputs:

- Improved makeup recommendations and more accurate TEDS simulations will result in better train operations.

Outcomes:

- Better train handling and operating practices and procedures that lower the rate of incidents and accidents.

Impacts:

- Improved identification and quantification of safety risks in train operations affected by defective equipment, train makeup, helper locomotive placement, slack between couplers, train handling, and track conditions — including the effects of lubricators, environmental conditions, and certain types of malfunctioning equipment such as locomotive power drops, leaking air brakes, etc.
- Fewer incidents and accidents related to train handling, operating practices, and train makeup.

TOP — Fire Safety Research

FRA's Fire Safety Research program area aims to improve outcomes for passengers and railroad employees involved in an incident by reducing the likelihood of fire ignition, propagation, and off-gassing. FRA evaluates new passenger vehicle designs and evaluates potential fire risk. FRA also evaluates current regulatory requirements for longevity and impact over the life of a vehicle.

RD&T will continue to advance fire safety requirements in U.S. passenger rail vehicles. Research will focus on investigating the longevity of fire safety performance in the materials used for passenger rail car designs. FRA will test and evaluate materials subjected to in-service rail life against new vehicle materials to determine the effectiveness of materials and requirements over time. RD&T will provide support to APTA in the development of recommended practices for conducting fire safety analysis.

- 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 systems, railcar seats, and ventilation systems.
- RD&T will continue research on the fire safety performance of emerging technologies for rail propulsion. Battery energy storage systems and fire safety design features will be evaluated to better understand the related hazards, subsequently making the systems safer and more cost effective to design and test.

Outputs:

- Improved understanding of the efficacy of using the fire safety performance of materials to predict fire safety in passenger rail vehicles.

- Improved understanding of the efficacy of fire suppression/extinguisher technologies for rail applications.

Outcomes:

- Knowledge of the quantification of rapid and easy egress from passenger railcars as well as a determination of whether the European Norms standard could be used for materials approval by FRA.
- Quantify the usefulness of smaller-scale floor test specimens for qualifying compliance tests.
- Knowledge of the fire risk of materials over the life of a vehicle.
- Improved outcomes of various types of fuel systems in non-ideal conditions.

Impacts:

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

TOP — Passenger Vehicle Crashworthiness and Occupant Protection

The overall objective is to develop design strategies for improving passenger rail vehicles over existing designs. Research is designed to improve the outcomes for passengers in the event of a derailment or collision involving a passenger train. FRA develops strategies to protect the occupied spaces in a rail vehicle, limit secondary impacts with the vehicle interior, mitigate the effective deceleration forces imparted on a passenger, reduce passenger ejections from normal seating positions through compartmentalization, and provide window solutions that both prevent unintended removal and provide access and egress when necessary. FRA works collaboratively with Volpe, public and private research organizations, and industry groups such as APTA, railroads, and manufacturers. This program has been ongoing for several decades and has resulted in improved designs, crash energy management components, and regulatory improvements, resulting in increased passenger safety.

In FY 2026, FRA will:

Outputs:

- Complete and validate a finite element analysis (FEA) model of an Arrow III passenger car. A compression test to 800,000 lbs will be conducted at TTC to confirm the accuracy of new computer models, allowing researchers to confidently use simulations for design, analysis, and engineering studies.
- Evaluate side impact and static side load cases on passenger cars to evaluate the practicability of research associated with recent NTSB recommendations.
- Analyze the performance of simulated crash energy management components in non-ideal (offset) collision scenarios against international design requirements for collision scenarios. FRA will use this analysis to create a modeling plan for future testing that may lead to improved safety standards for new designs.
- FRA will validate passenger seat FEA models to improve the design of and research efforts related to passenger containment, including wheeled mobility devices.

- FRA will investigate the causes of injuries in the event of a passenger rail incident, in coordination with other investigative teams from the industry and NTSB. Data gathered from these incidents will advance future research and regulatory efforts.
- FRA will publish research results on assessing the adequacy of existing modern locomotive crashworthiness requirements and establish recommended practices for new designs.
- Publish reports and disseminate information to RRS related to the root causes of passenger injuries in railroad incidents.
- Acquire perishable evidence and obtain witnesses testimony from rail incidents to ensure that potential research information is not lost.

Outcomes:

Outcomes include the development of head-end locomotive structural elements that can greatly reduce the propensity for override, provide FRA with constructive responses to NTSB recommendations, improve regulatory performance requirements for new passenger vehicles in non-ideal collision scenarios, improve window systems, and gather critical data from field investigations.

Impacts:

- Improved outcomes from passive safety systems, such as vehicle structure and window systems, in the event of a collision or derailment.
- Reduced the likelihood of rail vehicle override.
- Improved design requirements and standards.
- Improved safety outcomes for passengers using wheeled mobility devices.

TOP — Glazing Standards

This program area is focused on window systems, called “glazing,” in the railroad industry. In addition to providing clear-sight pictures for passengers and crew, glazing is expected to have impact resistance, emergency egress and access, fire resistance, and occupant containment safeguards. The program supports the development of engineering strategies for meeting all of these competing design requirements. RD&T will collaborate with Volpe, private and public research entities, and respondents to BAA proposals.

Outputs:

- FRA will continue to develop new technologies, collaborating with Volpe to provide technical reviews.
 - An SBIR project was awarded to develop a novel design for glazing retention system that does not rely on traditional securement methods (zip strip).
 - Two extra components are added to the emergency rescue access window glazing system:
 - An operable shear key that locks in the aluminum window frame to the carbody but allows it to be removed by emergency responders
 - A transparent adhesive film is applied to the glazing and the carbody
 - For a non-emergency access window, the adhesive film is applied to glazing and carbody.
 - Proof-of-concept is being conducted to demonstrate performance through testing and modeling
 - Collaborate with APTA working groups to improve glazing standards.

- Publish a technical document to analyze accident data to assess the risk of injury due to glazing design.

Outcomes

New manufacturing and operational processes that make windows less likely to detach from the vehicle sidewall, thus improving passenger containment and making passenger cars less likely to roll over.

Impacts:

- A decrease in accident consequences in car rollovers.
- Fewer casualties related to compromised glazing performance.

TOP — Improving Freight Railroad Network Resilience

RD&T will:

- Continue to develop a tool for assessing connectedness efficiency for intelligent rail network infrastructure using attribute weights from waybill information.
- Continue research to enhance railroad safety and resilience by studying the impact of node and link losses on network-connectedness efficiency.
- Continue research to enable distributed train management that avoids a single point of failure by ensuring topology enhancements reflect waybill information.

Outputs:

- Data, Technical Reports, and recommendations on enhancing railroad network resiliency.
- Data, Technical Reports, and recommendations to improve safety through topology enhancements.

Outcomes

The main goal of this research is to improve the safety and efficiency of the national freight railroad network and reduce delays that could occur due to accidents or severe weather conditions. The research should also provide performance measures for risk and asset management and for enhancing the resilience of the U.S. freight railroad network. Results from this research should:

- Improve the overall safety, efficiency, and resilience of the national freight railroad network and enhance economic prosperity.
- Support and inform planning and decision-making practices for intelligent railroad systems, making the technology more accessible to rail.
- Significantly reduce the delay times in supply chains caused by railroad accidents by choosing an efficient and reliable alternate route within the railroad network, thereby improving the overall railroad efficiency and cost-effectiveness.

Impacts:

- Improved efficiency and resilience of the national freight railroad network.
- Reduce the delay times in supply chains caused by railroad accidents.

Potential Progress Made toward Achieving Modal Strategic Goals

The Rolling Stock program contributes toward the DOT Strategic Goals of Safety, Infrastructure, Innovation, and Efficiency through its research in the following areas:

- The Emerging Technologies Safety research area evaluates technologies in the railroad environment and promotes innovation by developing models as tools to create safer, more cost-effective system designs and test programs.
- Passenger Locomotive Crashworthiness and Occupant Protection research area ensures that passenger rail cars are designed for safe operations at higher speeds and improved cab-crew and passenger safety in collisions.
- Rolling Stock Equipment and Component research area ensures that longer freight trains with higher freight capacity can operate with improved locomotive and freight car train handling and braking performance. Research investigating in-train forces utilizing over-the-road-tests can also provide data that informs wheel loading on the rails and track system. In addition, research is being conducted on the strategic placement of wayside detection systems along the railroad right-of-way infrastructure and the systems' ability to timely and effectively detect and report defects.
- 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.
- A testbed for the development of next generation innovative wayside and on-board sensors for rail rolling stock will be developed at TTC. The planned testbed will vigorously interrogate the performance of new and innovative sensor technologies to ensure their effectiveness in detecting failure in the railroad environment.
- RD&T will support the development of new innovative sensors, both for on-board and handheld applications, that uses non-traditional sensing technologies such as acoustics and ultrasound.

Collaboration Partners

Partner Name	Contributions	Benefits of Partnership
Industry Organizations AAR ASLRRA APTA TRANCAER	Facilities access Funding In-kind support	RD&T gains further guidance on regulatory updates and new equipment qualification.

Railroads and Local/Regional Partners Massachusetts Bay Transportation Authority (MBTA) Northeastern Railroad Tank car owners Tank car shops Class I railroads MTA MNR LIRR Passenger/commuter/railroads Passenger rail equipment and manufacturers and component suppliers Brightline West CAHSRA Amtrak	Donor railcars and equipment In-Kind Contributions Subject matter expertise	RD&T receives access to local railroads as well as equipment for testing.
Labor Union Organizations BLET SMART-TD TCU-BRC BRS	Subject matter expertise	Collaboration with labor union organizations yields further insight in specific subject matters.
Industry Suppliers and Engineering Firms BNSF NS Progress Rail CSX UP Wabtec AV (formerly BlueHalo Labs) IEM Harsco Rail Siemens Alstom Jensen Hughes ENSCO, Inc. Sharma & Associates, Inc. Ambipar SwRI Redstone Technologies LLC Forcing Function	Equipment and testing materials Subject matter expertise	RD&T gains access to research and testing expertise on topics such as fire safety, resonant ultrasound spectroscopy, advanced acoustic bearing detection, and battery thermal runaway management.

Federal Partners DOE Volpe Center PHMSA TRB U.S. Naval Research Center	Co-funding Subject matter expertise	This partnership allows for further research and intergovernmental collaboration on emerging technologies for rail propulsion.
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Benefits Detail

Beneficiary	Benefits Received
RRS	Improved safety recommendations and innovative solutions
Tank car owners Tank car manufacturers Leasers tank car shops Wheel manufacturers Axle manufacturers Bearing manufacturers Braking component manufacturers Coupler and draft gear manufacturers Running gear manufacturers	FRA will acquire: • In-depth knowledge of the performance of tank cars and the different service equipment of tank cars and portable tanks • In-depth knowledge of the crashworthiness of different types of tank cars and the failure modes to improve the performance of Hazardous Materials packages. • In-depth knowledge of the performance of rolling stock component defects detection • Increased knowledge on in-train forces and the impact on safety • Better understanding of cold weather and aged components on a train's braking capacity • Improved knowledge on rolling stock equipment performance in navigating safely across rail tracks under various scenarios
Public	• Fewer railroad accidents and fatalities • Lower operating costs • Improved service life for rolling stock equipment • Improved railroad performance
Universities: Michigan Tech Virginia Tech Colorado State University-Pueblo University of Maryland University of Nebraska-Lincoln University of Hawaii University of Illinois Urbana-Champaign University of Texas, Rio Grande Valley San Jose State University Penn State University	Improved railroad research resources and capabilities
Labor unions, e.g., BRS	Increased employee safety
Railroad workers	Increased railroad worker safety

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.

Train Control and Communication

\$6,600,000

Program Description

The Train Control and Communication research program (TC&C) focuses on improving railroad operational safety, efficiency, economic competitiveness, and network capacity. 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 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 assets and fuel consumption. 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

PTC Next Generation Technology

- Invest in TTC to support the development, testing, and evaluation of advanced PTC technologies.
- Support RRS and the industry to address NTSB recommendations for PTC enhancements.
- Integrate grade crossing safety systems with PTC and Next Generation Train Control (NGTC) systems.
- In collaboration with railroad stakeholders, TC&C's PTC technology research will support the development of NGTC technologies, including Quasi-Moving Block (QMB) and Full Moving Block (FMB) architectures.
- TC&C will work to facilitate the development of interoperable train automation technologies.
- TC&C will research advanced methods of rail break detection to support moving block operations.

Outputs

Research will provide innovative technologies to ensure PTC interoperability and reliability. Advanced train control concepts such as QMB and FMB will be further developed.

Outcomes

The increased capacity to improve PTC interoperability:

- Enhanced capabilities to improve safety.
- Ability to develop efficient and reliable interoperability controls and automated interoperability verification among railroads.
- Increased rail operational efficiencies.

- QMB and FMB standards and specifications that build on PTC technology to enhance safety, capacity, and reliability.

Impacts

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

PTC Interoperability

TC&C will:

- Collaborate with railroad stakeholders to develop NGTC technologies.
- Research solutions for improving the safety, reliability and maintainability of conventional PTC systems.
- Upgrade testing infrastructures and systems at TTC to support rail industry R&D needs.

Outputs:

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

Outcomes

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

Impacts

The overall improvement of NGTC capabilities and operations will improve safety and operational efficiency to critical rail transportation networks.

Intelligent Transportation Systems (ITS)

TC&C will:

- Conduct ITS research on new sensors, computers, digital communications, and grade crossings.
- Innovate technologies in AI and automation to improve safety and reduce rail-grade crossing accidents.
- Conduct ITS research on the feasibility of a connected vehicle (CV) communication protocols 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 (C-V2X) communication protocols.
- Work with FHWA, NHTSA, the Federal Motor Carrier Safety Administration (FMCSA), and FTA to coordinate programs to better reach stakeholders.

Outputs:

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

Outcomes

The rail industry will be able to improve safe operations by applying FRA-sponsored technologies.

Impacts

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

Trespassing Countermeasures

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

Outputs

New solutions and tools that address trespassing on railroad property. For example, augmenting the Best Practice technical report, multimedia and educational material for school-aged children in collaboration with Operation Lifesaver, Inc. (OLI).

Outcomes

Collaboration with stakeholders will increase solution development and implementation to reduce railroad trespassing, including site-specific strategies for rail trespass and suicide mitigation, thus improving rail safety.

Impacts

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

Grade Crossing and Trespass Outreach

TC&C will:

- Continue to collaborate with organizations such as OLI to establish an international working group on railroad trespass prevention.
- Continue to address grade crossing safety through its Grade Crossing (GX) and Trespass Outreach and Education research.
- TC&C's Grade Crossing Pedestrian Safety research will continue to explore measures (e.g., channelization, gate skirts, and enhanced electronic signs) to address pedestrian-related accidents at grade crossings and along railroad ROWs.
- Continue to evaluate scenarios for possible safety improvements at grade crossings through modeling and simulations.
- Continue maintaining and updating content on the GX toolkit — guides, noteworthy practices, and research results on the implementation of a wide range of grade crossing safety treatments.

Outputs:

- Research will continue to provide improved technologies and information on pedestrian grade crossing safety and improve collaboration with stakeholders.
- Research will create educational tools on grade crossing and trespass challenges.
- Research will provide standardized metrics for analyzing grade crossing incidents.

Outcomes:

- Improved communication, techniques, and technologies to reduce incidents at grade crossings.

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

Impacts

This research is expected to reduce incidents at grade crossings, improve safety for the public and the rail workforce, and decrease the number of trespass incidents. Research results will lead to increased overall safety in the railroad environment at grade crossings and increased trespass prevention awareness.

Grade Crossing Technology

TC&C will:

- Use LiDAR technologies to assess the risk of vehicle hangups at high vertical profile crossings. Develop new methods of accident data analysis for researchers to improve safety at grade crossings.
 - Continue to develop a grade crossing database that will contain the 3D grade crossing scans.
- TC&C will lead a group of subject matter experts from several DOT modes (FHWA, FTA), all Class I railroads, the American Association of State Highway and Transportation Officials (AASHTO), State DOTs, and academia to develop engineering design criteria and guidelines for highway approaches to grade crossings and the placement of Manual Uniform Traffic Control Devices Low Ground Vehicle Clearance (W10-5) signs.

Outputs:

- Research with stakeholders will provide new grade crossing assessment and analysis techniques.
- New, safer highway grade crossing vertical approach designs.
- LiDAR scans of U.S. grade crossings.

Outcomes

The industry will gain new tools and techniques to address grade crossing safety concerns. LiDAR scans will provide 3D representations of grade crossings, and the working group expects to deliver new design guidelines applied to the AASHTO Green Book.

Impacts

The implementation of these tools and techniques will lead to safer grade crossings and fewer incidents. The updated guidelines to the AASHTO Green Book will improve safety at both new and existing grade crossings.

Grade Crossing Modeling and Simulation

- TC&C will continue to collaborate with both the HF division and the Data Analysis and Geospatial Systems division within the FRA Office of Research, Data, and Innovation or other DOT modes to research modeling and simulations on human behavior at grade crossings.
- Explore the applicability of count and duration models to grade crossing incident analysis.

Outputs

New simulation and modeling capabilities will be explored and analyzed.

Outcomes

Modeling and simulation tools will help FRA predict accidents and their severity at grade crossings.

Impacts

Research will assist the railroad industry with an overall improvement in grade crossing safety.

Potential Economic Impacts

The TC&C research program has a 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 rail network more efficient. TC&C research on grade crossing and trespassing technology benefits the American people by lowering the number of accidents, injuries, and fatalities that occur on U.S. rail system.

Potential Progress Made toward Achieving Modal Strategic Goals

The TC&C research program advances the DOT Strategic Goals of Safety, Infrastructure, and Innovation. The program partners with U.S. railroads to develop and test advanced train control and automation systems to enable the safe movement of trains. Building on PTC technologies, TC&C, in partnership with the rail industry, continued to advance the development of the locomotive centric NGTC and automation technologies to precisely locate and track train movements on the U.S. rail network, which will increase safety, efficiency, and track capacity.

TC&C developed the Connected/Automated Vehicle (CAV) technology and demonstrated prototypes of the Rail Crossing Vehicle Warning (RCVW) safety system around the U.S to help connected vehicles safely interact with grade crossings. TC&C developed a Cloud-based version of RCVW to provide blocked crossing status to traffic management centers, first responders, and other subscribers to improve safety, mobility, reduce traffic congestion and potential traffic violations.

TC&C improves safety at grade crossings and reduces right-of-way trespassing by developing, testing, and prototyping countermeasure technologies, while also providing education and best practices to stakeholders and affected communities.

Collaboration Partners

Partner Name	Contributions	Benefits of Partnership
Intermodal FHWA FMCSA FTA NHTSA ITS-JPO AASHTO	ITS research collaboration	FRA gains stronger products through engagement with freight, automaker, trucking, and highway stakeholders.

Railroads and Local/Regional Partners Amtrak BNSF NS UP CSX CPKC CN Rail North County Transit Florida DOT Oklahoma DOT MBTA City of Orlando, FL Illinois Commerce Commission Metra Mass DOT SunRail Metrolink MTA Brightline	Facilities management ROW Access Subject matter expertise Field test data	Enhanced technology transfer and solutions that integrate seamlessly with railroad operations.
Labor Unions BMWED BRS	Subject matter expertise	Collaboration with labor union organizations yields further insight in specific subject matters.
Industry Suppliers and Engineering Firms Wabtec Railway Electronics Meteorcomm LLC Sound Transit FarmRail System, Inc. DecisionTEK LLC QuestRail ENSCO Siemens AG	Facilities management ROW access Subject matter expertise Field test data	TC&C relies on these partnerships for better product deployment.
Universities Michigan Technological University Rutgers University Carnegie Mellon University University of South Carolina	Subject matter expertise	Universities produce knowledgeable graduates that form the next generation of employees for railroads, suppliers, and engineering firms.

Benefits Detail

Beneficiary	Benefits Received
General public	Improved public safety at grade crossings. Increased awareness of Emergency Notification System (ENS) signs. Reduced travel delays due to train-occupied crossings. More efficient (faster & lower cost) movement of freight.
RRS	Additional precise parameters derived from grade crossing scans (e.g. vertical profile, angles). Enhanced promotion of the ENS sign. Safety and performance analyses of next generation train control systems. FRA inspector training capabilities at TTC.
Intermodal partners AASHTO Volpe Center FHWA State DOTs Class I RRs and other RRs Police Departments	Improved safety at grade crossings. New design guidelines and criteria for highway approaches to grade crossings. New knowledge on new parameters derived from grade crossing scans (e.g. vertical profile, angles). Highway-rail communication standards development.
Academia	Use of TTC for research and testing. Enriched rail-specific curriculum development.
Freight and Passenger Railroads	Reduced operational delay due to grade crossing and trespasser accidents. Reduced rail and equipment damage due to grade crossing accidents. Higher likelihood of technology interoperability between railroads. Defrayed R&D costs to meet government rules and requests. Use of TTC for conformance testing and standards development. Improved rail network capacity
Rail Industry Suppliers	Use of TTC for product development and testing. Opportunities to take research outcomes to be productized rail industry desired technologies

Human Factors

\$5,720,000

Program Description

The Human Factors research program (HF) seeks to optimize human performance and reduce the risk of human error 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. HF identifies human performance safety issues in new technologies and systems and recommends methods to enhance the safe deployment of these new systems. The program develops and demonstrates new technologies, non-regulatory guidance, and programs to mitigate the causes of human error. HF also conducts safety research on highway-railroad grade crossings and trespass and suicide prevention.

Major Program Objectives

Safety is the primary driver of HF research. HF conducts research in four Research Areas to achieve its program objectives: Railroad Technology, Automation, and System Design; Railroad Organizational Culture and Safety Performance; Railroad Worker and Operator Performance; and Highway-Railroad Grade Crossings, Railroad Trespass, and Suicide Prevention. HF employs multiple methods to carry out this research, including surveys, human subject simulator experiments, technology demonstrations, and pilot studies.

Anticipated Program Activities and Potential Outcomes, Outputs, and Impacts

Railroad Technology, Automation, and Systems Design

This Research Area examines the safety implications of new technology and automation from a human-centered design perspective. The primary goal of this Research Area is to ensure that safety is not degraded by new technology and automation. Prototypes may be designed and tested to benchmark the unintended human factors consequences of new technologies.

HF will continue to conduct research in the following areas:

- Human-System Interface Design: Research how interface design affects operator comprehension, decision-making, and error rates in complex rail systems, and conduct research on incorporating user-centered design into the railroad industry by applying user interface/user experience technical solutions demonstrated in defense-related domains. This research seeks to examine methodologies to test and evaluate safe human interaction with rail software systems that contain/utilize AI.
- Automation and Human Oversight: Analyze the impacts of automation and AI systems on operator tasks, trust in technology, and human intervention in automated systems. HF will also continue to research human-automation teaming.

HF maintains the Cab Technology Integration Laboratory (CTIL) locomotive simulator and the Behavior and Railroad Crossing (B-RX) driving simulator. These simulators allow FRA to conduct human performance research.

When long-standing job functions—visual or mechanical inspections—are shifted from human to machines or sensors, there is potential tension. To manage and mitigate the tension, RD&T has a multi-prong approach: a monthly meeting with labor unions to brief on current research project and receive feedback; a notification to labor leaders ("Notice of Planned Research") before

beginning a research project that would be of interest to labor; and an upcoming publication of best practices that offer suggestions for human-automation teaming.

Outputs

HF publishes Technical Reports, Research Results reports, and presentations on projects related to safety and transformative technology. HF may develop and/or test actionable prototypes and user-centered displays for enhanced operator situational awareness and reduced human error potential.

Outcomes

HF publications provide information on how to responsibly design and implement new technologies in railroad operations.

Impacts

HF research may reduce the risk of human error, address the safety of operator attentiveness and situational awareness, and issues associated with new technologies.

Railroad Organizational Culture and Safety Performance

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

HF will continue to conduct research in the areas of:

- Organizational and Safety Culture: Studies explore how leadership, policies, and peer dynamics influence safety behaviors and reporting practices.
- Crew Communication and Coordination: Research evaluates communication protocols and teamwork dynamics to improve efficiency and reduce miscommunication.

HF will also continue to:

- Partner with stakeholders to help improve the safety and organizational culture of railroads.
- Provide program oversight of the Short Line Safety Institute (SLSI), a non-profit organization that seeks to improve safety and safety culture in Class II and III railroads.
- Support FRA's voluntary, non-punitive railroad safety working groups, including Confidential Close Call Reporting System (C3RS), Fatality Analysis of Maintenance-of-Way Employees and Signalmen (FAMES) and Switching & Operations Fatality Analysis (SOFA), and Railroad Information Sharing Environment (RISE) program
- Conduct research on switching/shoving practices; develop training to aid yardmasters' knowledge and skill acquisition.

Outputs

HF publishes Technical Reports, Research Results reports, and presentations related to projects in this Research Area.

Outcomes

Outcomes include training and educational materials that address common safety gaps. RISE may produce deliverables that allow industry stakeholders to better understand systemic railroad safety issues.

Impacts

HF research may improve railroad safety through the application of lessons learned from projects in this Research Area.

Railroad Worker and Operator Performance

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

HF will continue to conduct research in the following areas:

- **Fatigue Management:** Research explores physiological and operational contributors to fatigue and evaluates countermeasures to enhance crew alertness and performance.
- **Workload and Situation Awareness:** Research examines cognitive demands in rail operations to optimize workload distribution and support situational awareness.
- **Training and Skill Retention:** Investigations focus on developing evidence-based training methods and understanding how skills degrade over time without practice.
- **Human Performance Monitoring and Analytics:** Research uses biometric and behavioral data to identify risk factors and support real-time performance feedback.
- **Researching root causes of switching and shoving safety issues** and investigating the impact of human factors engineering solutions to minimize safety risk.
- **FRA will continue to develop new human factors capabilities at TTC.** Efforts to be executed at TTC will include development of a training course on safe switching and shoving.

HF will continue to:

- Expand research into cognitive performance, including fatigue, stress, sleep, and total worker health. HF will also investigate the effect of safety-related work incidents on railroad workers perceptions, performance, and health.
- Ensure content for the FRA sponsored *Railroaders' Guide to Healthy Sleep* (RGHS) website is up-to-date and dynamic. Integrate social media to perform outreach activities for the site. RGHS is a non-regulatory educational resource that provides scientific information on sleep and sleep hygiene. 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.
- Work on research related to 49 CFR Part 272, which outlines the responsibility of railroads to implement Critical Incidents Stress Plans (CISP). RD&T will work to identify actionable programs or resources that could be used to mitigate critical incident stress.
- Progress on providing recommendations to assist workers following stressful incidents and develop research to understand how acute and long-term stress affect railroaders.

Outputs

HF publishes Technical Reports, Research Results reports, and presentations related to projects in this Research Area.

Outcomes

HF research results will identify ways to reduce accidents caused by distraction or loss of situational awareness. HF research may provide insights into understanding how varying degrees of experience affect attention and engagement during train operations. HF research may address issues related to worker burnout and fatigue, stress, hours of service rules, and mitigate on-the-job risks for railroad employees.

Impacts

Projects in this Research Area may lead to improved job performance and railroad worker safety.

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

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

HF will continue to conduct research in the following areas:

- Grade Crossings: Research will develop and pilot-test strategies to mitigate risky human behavior around grade crossings and railroad ROWs; research on road users' response to grade crossing warning systems to improve grade crossing design and reduce collisions.
- Trespass and Suicide Prevention: Research will develop and pilot-test strategies to mitigate risky human behavior on railroad ROWs; studies to identify behavioral indicators to evaluate intervention strategies and environmental design to deter suicide attempts on rail property.

HF will continue to:

- Collaborate with RRS to conduct trespass prevention outreach activities, including risk mitigation strategies and lessons learned from research on countermeasures.
- Engage with communities (e.g., Palm Beach County, FL) to build partnerships with local representatives to address rail trespassing and suicide-related issues.
- Continue to refine the Community, Analysis, Response, and Evaluation (CARE) model and expand the research to include other areas around the country experiencing trespass and suicide-related issues on the railroads. Develop interagency partnerships to address rail safety, trespassing, and suicide-related incidents — including human trafficking, homelessness, vandalism, and accidents and incidents at grade crossings.
- Analyze grade crossing/trespass data to identify rail-related incidents and develop an understanding of risk factors.
- Coordinate with international and domestic colleagues through the Global Railway Alliance for Suicide Prevention (GRASP), OLI, and Suicide Prevention in U.S. Rail (SPUR) to facilitate information-sharing on research, intervention, and implementation of activities related to suicide prevention.
- Investigate the impacts of accidents, trespass, and suicide on the rail system (including rail employees) and communities.

Outputs

HF publishes Technical Reports, Research Results reports, and presentations related to projects in this Research Area. HF also provides updates to the Trespass and Suicide Prevention Toolkit and Grade Crossing Toolkit. Data from law enforcement agencies receiving Consolidated Rail

Infrastructure and Safety Improvements grant funding provides information about grantees' railroad ROW trespassing hotspots.

Outcomes

HF research will enhance the public's understanding of risk factors, demographics, disability status, and geospatial, sociopolitical, and socioeconomic influences as they relate to trespass and suicide on railroad ROWs. HF will use data to inform trespass and suicide mitigation strategies. HF will create a collective space to share information among railroad carriers and other stakeholders on suicide and trespass prevention. The advancement of innovative technologies and integrated driver systems will help reduce accidents at or around highway-rail grade crossings.

Impacts

HF research will increase public safety on and around railroad ROWs.

Potential Economic Impacts

HF research improves railroad safety through innovative, science-based research that seeks to reduce human error. HF research helps ensure that railroad workers can successfully mitigate risks associated with the cognitive and physical tasks of their jobs. Research in highway-railroad grade crossings, railroad trespass, and suicide prevention may reduce such accidents. HF research conducted from a human-centered point of view helps ensure that new technologies are deployed in a manner that helps optimize human performance in railroad operations.

In addition, HF continues to provide SLIS with program monitoring and evaluation support. This enables SLIS 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

HF research contributed to the DOT Strategic Goal of Safety in its grade crossing safety research area by publishing a report assessing the safety benefits of a real-time railroad crossing information system for emergency responders. The study focuses on reducing first responder delays at rail crossings.

HF contributed to the DOT Strategic Goal of Safety in its railroad worker and operator performance research area by presenting at the February 2025 *Critical Incidents Stress Plan* Railroad Safety Advisory Committee working group meeting and at the January 2025 TRB Conference. The presentations provided a multi-faceted view of traumatic exposure in the rail workforce and the support currently available to those affected, based on a series of discussions with relevant stakeholders, including representatives from rail labor unions, railroads, and several groups of Train & Engine railroaders. Findings address the types and impacts of critical incidents and potentially traumatic events common in railroading; current processes that fulfil the requirements of railroad CISPs, and limitations of current supports.

HF research has contributed to the DOT Strategic Goal of Safety by publishing an evaluation of FRA's C3RS program, which assessed program effectiveness and suggested modifications to sustain and institutionalize the program. C3RS is a program that supports the *Cooperative Information Sharing* element in the DOT Office of General Counsel's *Memo Procedural Requirements for DOT Enforcement Actions*.

In addition, HF continues to provide program support and program evaluation (supporting the DOT Goal of Safety) services to the SLSI, a non-profit organization that helps to improve safety and safety culture in short line and regional railroads through voluntary, non-punitive safety culture assessments of small railroads with limited resources. SLSI uses assessment findings to develop training and educational resources to help small railroads perform at an increasingly high level of safety. An independent evaluation of SLSI's programs assesses the extent to which SLSI adheres its safety culture assessment model and helps FRA and SLSI determine value to inform the future of program and for funding accountability and to inform ongoing program improvement.

Collaboration Partners

Partner Name	Contributions	Benefits of Partnership
Intermodal FRA IT OST IT FRA RD&T Train Control & Communication Division FRA RD&T Rolling Stock & Equipment Division FRA RD&T Track Division DOT Human Factors Coordination Working Group DOT Safety Council RRS Highway-Rail Crossing and Trespasser Programs Division	Subject matter expertise Stakeholder engagement Collaboration Financial support Information sharing	HF works closely with other DOT modes and, with support from the IT offices, integrate HF principles and HMI design considerations for developing new technologies.
Industry Organizations & Working Groups ASLRRA AAR APTA AASHTO OLI SLSI GRASP SPUR SOFA FAMES	Data Standards and Recommended Practices Industry committees Subject matter expertise	HF gains more insight into human error situations as well as further stakeholder engagement.

Labor Unions ATDA BLET BRS SMART-TD TTD	Subject matter expertise Collaboration, data, and recommendations	Collaboration with labor unions allows HF to engage with stakeholders and gain a further understanding of human error situations.
Railroads and Local/Regional Partners State DOTs, including: Missouri DOT Illinois DOT Florida DOT Georgia DOT Maryland DOT New Jersey DOT North Carolina DOT Tennessee DOT California DOT Texas DOT Passenger/Commuter Railroads, including: Amtrak Metra New Jersey Transit Keolis/MBTA MTA (LIRR and MNR) SEPTA BART Brightline Metrolink	Subject matter expertise Collaboration, data, and recommendations	Collaboration with national railroads as well as State/regional/local DOTs allows HF to engage with stakeholders and gain a further understanding of human error situations.
Industry Suppliers and Engineering Firms AtkinsRealis ENSCO, Inc. TiER1 Redstone Technologies LLC	Collaboration Research studies	Industry vendors allow HF to further engage with stakeholders.
Universities Michigan Technological University University of Maryland's CATT Lab Tennessee State University University of Memphis	Subject matter expertise Collaboration, data, and recommendations	Collaboration with universities yields expertise for HF.

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 2027 RD&T Programs

“The AMRP FY 2027 outlook year chapter in the annual plan is not developed in alignment with the Presidents’ budget request of the same year due to the AMRP development schedule per 49 U.S.C. 6501, Research Plan.”

Railroad Systems Issues

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 invests in research and innovation to meet the challenges of the present and modernize freight and passenger rail for the future. RSI activities include projects aligning with congressional, DOT, OST-R, and FRA strategic objectives as well as exploratory research areas. Safety is the principal focus and goal of the RSI program.

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 — Transportation Technology Center

Program Area — Intelligent Railroad Systems

Program Area — Rail Research and Development Center of Excellence

Program Area — Workforce Development

Anticipated Program Activities

Rail Safety Innovations Deserving Exploratory Analysis (IDEA)

- FRA funds the TRB to 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.
- TRB and FRA will follow up and provide guidance to the selected research projects.
- Forthcoming work includes projects on AI-enabled motion assessments of continuous welded rail, a robotic system for detecting rail anchor failures, and an Industrial Internet of Things approach to monitoring rail turnout degradation.

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.

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 FY 2027 funding allows, to repair and rehabilitate buildings and facilities.
 - 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.

Broad Agency Announcement

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

Workforce Development

RD&T will:

- Continue WFD research activities, stakeholder engagement, STEM projects.
- Support programs aimed at engaging youth (Pre-K through 12th grade and college) in rail transportation and STEM topics.

University Research Initiatives (and Research with Universities on Intelligent Railroad Systems)

RD&T will:

- Publish the request for proposals and review submissions.
- Select prospective research projects to fund and begin selected projects.
- 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 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. This information then drives research into the processes, technologies, and analytical methods needed to identify the most at-risk locations on the track and prevent future derailments. While improving safety is the priority, the program also leads to more reliable infrastructure that is resilient to extreme weather conditions. The resulting new methods and technologies — including new AI applications — increase the efficiency of the industry and the knowledge of its workforce.

Major Program Objectives

The Track research program conducts scientific and engineering research to reduce derailments and improve railroad safety. This research strives to provide the scientific and engineering basis for safety rulemaking and enforcement while ensuring rules are appropriate and defensible.

The Track research program has four broad 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.

Anticipated Program Activities

Derailment Prevention — Derailment Mechanisms

For FY 2027, the Track research program plans to continue studying 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 2027, the Track research program plans to continue its study of 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 2027, planned activities 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

For FY 2027, the program plans to continue developing predictive frameworks for how the risk of an accident changes as inspection methods and frequencies are changed or combined and develop the probability of detection using information gathered during the Technology Performance Assessment and Use activities.

Research Support — Field Testing and Technical Expertise

For FY 2027, planned activities include supporting work in other Track research areas and other FRA offices with field testing using FRA's ATIP fleet, full-scale testing at TTC, and Volpe technical expertise.

Rolling Stock

Program Description

The Rolling Stock (RS) research program focuses on improving the safety of Nation's rail network by providing the scientific and engineering basis for updated industry standards, performance-based safety regulations, enforcement, risk reduction, and technology development to improve the design, maintenance, and operation of rail equipment.

RS 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. The program leads the research, development, and evaluation of:

- Advanced defect detection and inspection techniques for rolling stock materials and components performance.
- Improved designs of rail equipment to withstand crash loads and fire conditions associated with high-energy train derailments and collisions, protecting passengers and crew.

The Hazardous Material research program focuses on improving transportation processes and the safety and reliability of moving HazMat (crude oil, ethanol, TIH, et. al) by rail. The research program also investigates the safe use of emerging technologies such as battery energy storage systems, hydrogen, or both, where such technology is proposed by industry for deployment. And the program studies tank car safety performance during and after impact and performs fire studies.

Major Program Objectives

Rolling stock defect detection is critical for the safe operation of trains. RS focuses on supporting the development of modern on-board and wayside equipment defect detection technologies; research supports RRS reviews of railroads applications for wider use of such technologies. Fiscal year 2026 will see continued investment in wayside detection technologies and methods, resulting in improved safety requirements and a decrease in accidents and incidents. The structural performance and fire safety of the materials and components used in rolling stock will also be investigated. The program will also investigate emerging technologies to understand the safety performance of these new technologies under accident loadings. 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 — Hazardous Materials

Program Area — Rolling Stock and Components

Program Area — Train Occupant Protection

Program Area — Tank Car Energy Products Research

Anticipated Program Activities

Hazardous Material — Tank Car Research

RD&T will continue providing stakeholders with critical data to help improve the safety and reliability of tank cars through targeted research on tank cars.

Accessibility

RD&T will:

- Support the development of improved 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 where new regulatory language on accessibility requirements for rail is developed, as well as for passenger rail service providers.
- Complete development on a mobile application to improve the accessibility of railroad communications.
- RD&T and RRS will continue to identify opportunities to collaborate on research and share knowledge.
- Working with DOE and locomotive OEMs, RD&T will continue to develop and evaluate the safety of emerging rail propulsion technologies.

Hazardous Material — Crashworthiness Evaluation

RD&T will continue to assess the crashworthiness of tank cars used to transport HazMat, including TIH substances and cryogenic liquids.

Hazardous Material — Accident Consequence Reduction

RD&T will evaluate and assess the root causes of tank car failures and advance safety through improved design and accident mitigation strategies. RD&T will work closely with RRS and PHMSA to address current and future NTSB recommendations and gaps in current standards and designs.

Hazardous Material — Tank Car Fire Performance

RD&T will continue to evaluate and improve tank car fire resistance through targeted research.

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 research, in collaboration with industry, will continue. Efforts to identify malfunctioning or poorly performing equipment and components, including wheels/axles/bearings and brake systems with wayside and on-board defect detector technology will be expanded in FY 2027. The wayside and on-board defect detection test bed that will be developed in FY 2026 at TTC, will be used by both FRA and safety monitoring device manufacturers to develop and evaluate state-of-the-art systems, including communications, for reducing the risk of catastrophic derailments. Data from evaluating these technologies can be use by rail industry to better standardize failure and condemning limits for rolling stock components.

RSEC — Rolling Stock Maintenance and Inspection

RD&T in collaboration with industry, will continue and improve wheel research, wayside technology, air and tread braking research, train makeup and handling, and vehicle dynamics research. The wayside and on-board defect detection test bed that is planned for development at TTC will be used to further improve inspection techniques, combining the use of automated systems with railroad employees for more efficient and effective inspection processes. Finally, RD&T will continue to build on the results of research on inspection times. RD&T expects to expand into additional phases that will introduce more real-world variables such as longer trains and varying environmental conditions.

RSEC — Train Handling and Operating Practices

In FY 2027, RD&T will continue research to improve truck designs that can provide superior equalization and curving performance by field testing and continuing to improve TEDS. Field testing and TEDS will be used to further improve FRA's understanding of the train makeup and handling of VLTs, especially component performance under extreme cold weather.

TOP — Fire Safety Research

RD&T will continue working with stakeholders, including APTA, to assess alternative standards for the fire safety performance of materials and components used in passenger rail vehicles, including passenger locomotive fuel systems, railcar seats, and ventilation systems. The research will also identify the effects of service over the life of a vehicle and assess the effectiveness of current regulations and standards. Finally, the fire performance of battery energy storage systems and other emerging technologies will be evaluated through scaled testing in FY 2027.

TOP — Passenger Vehicle Crashworthiness and Occupant Protection

RD&T will continue research on passenger rail vehicle and locomotive crashworthiness research to improve outcomes in occupied volume preservation, occupant containment, emergency egress and access, and the reduction of severity from secondary impacts. New research on assessing passenger car side strength requirements to understand how sidewall strength influences the likelihood and severity of passenger car rollover and occupant injury due to impacts from highway vehicles at grade crossings and analyses of effectiveness of potential improvements will continue. Investigating lateral stability and lateral offset in collision scenarios for improving crash energy management components will be initiated. Finally, RD&T will continue to investigate the root causes of occupant injuries in railroad accidents to effect mitigation strategies aimed at protecting passengers and crews.

TOP — Glazing Standards

Research on glazing retention and safety will be completed in FY 2027. New product designs to improve window glazing outcomes in accident scenarios, focusing on both emergency egress/access and retention of the window systems in rollover events will be developed. In FY 2027, RD&T will develop industry recommendations for alternative glazing systems to improve glazing retention capacity for consideration in new equipment procurements and will work with industry partners to improve glazing certification standards. Research will continue quantifying the risks of passenger ejection from various egress glazing designs and accident scenarios by studying the passenger railcar failure and occupant injury modes in rollover events.

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, thus improving railroad safety and efficiency.

Train Control and Communication

Program Description

The TC&C research program focuses on improving railroad operation safety, efficiency, 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 AI and connected vehicle systems. It also provides scientific research and data to support streamlined FRA regulations. This research program collaborates with stakeholders to build on existing TC&C technology to adapt and incorporate advances in software and hardware technologies to develop the next generation of train control safety systems.

Major Program Objectives

The TC&C research program improves 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. This program's goal is to transform railroad operations by anticipating and adapting innovative and emerging technologies such as locomotive-centric, communications-based train control and automated train operation.

Program Area — Train Control and Communication

Program Area — Grade Crossing and Trespass

Anticipated Program Activities

PTC Next Generation Technology

- TC&C will support the development of enhanced PTC safety functions such as restricted speed enforcement.
- TC&C will continue industry coordination to develop solutions to improve the reliability, availability, and maintainability of deployed PTC systems.

PTC Interoperability

- RD&T will continue interoperability research to ensure compliance with the applicable legal requirements 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.

PTC Next Generation

RD&T will:

- Continue research on advanced PTC concepts and architectures that support NGTC and railroad automation such as FMB and remote control locomotives.

- Research advanced methods of track-circuit-based rail break detection to support moving block operations.

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 on novel concepts for integrating road vehicle active safety systems into grade crossing infrastructure systems.
- Foster technologies which interconnect multimodal systems for improved public safety and transportation network efficiency.

Trespass Countermeasures

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

Grade Crossing Technology

- TC&C will develop technologies and tools to improve warning devices and integrate grade crossing locations into mapping devices.
- Continue the collaboration with the HF division on grade crossing safety matters.

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.

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.

Grade Crossing and Trespass Outreach and Education

In collaboration with OLI and other organizations, TC&C will continue to educate the public on the dangers of grade crossings.

Human Factors

Program Description

The Human Factors research program seeks to optimize human performance and reduce the risk of human error 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. HF identifies human performance safety issues in new technologies and systems and recommends methods to enhance the safe deployment of these new systems. The program develops and demonstrates new technologies, non-regulatory guidance, and programs to mitigate the causes of human error. HF also conducts safety research on highway-railroad grade crossings and trespass and suicide prevention.

Major Program Objectives

Safety is the primary driver of HF research. HF conducts research in four Research Areas to achieve its program objectives: Railroad Technology, Automation and System Design; Railroad Organizational Culture and Safety Performance; Railroad Worker and Operator Performance; and Highway-Railroad Grade Crossings, Railroad Trespass, and Suicide Prevention. HF employs multiple methods to carry out this research, including surveys, human subject simulator experiments, technology demonstrations, and pilot studies.

Anticipated Program Activities

Railroad Technology, Automation, and Systems Design

This Research Area examines the safety implications of new technology and automation from a human-centered design perspective. The primary goal of this Research Area is to ensure that safety is not degraded, by new technology and automation. Prototypes may be designed and tested to benchmark the unintended human factors consequences of new technologies.

HF will continue to conduct research in the following areas:

- Human-System Interface Design: Research how interface design affects operator comprehension, decision-making, and error rates in complex rail systems, and conduct research on incorporating user-centered design into the railroad industry by applying user interface/user experience technical solutions demonstrated in defense-related domains. This research seeks to examine methodologies to test and evaluate safe human interaction with rail software systems that contain/utilize AI.
- Automation and Human Oversight: Analyze the impacts of automation and AI systems on operator tasks, trust in technology, and human intervention in automated systems. HF will also continue to research human-automation teaming.

HF maintains the CTIL locomotive simulator and the B-RX driving simulator. These simulators allow FRA to conduct human performance research.

Railroad Organizational Culture and Safety Performance

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

HF will continue to conduct research in the following areas:

- **Organizational and Safety Culture:** Studies explore how leadership, policies, and peer dynamics influence safety behaviors and reporting practices.
- **Crew Communication and Coordination:** Research evaluates communication protocols and teamwork dynamics to improve efficiency and reduce miscommunication.

Railroad Worker and Operator Performance

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

HF will continue to conduct research in the following areas:

- **Fatigue Management:** Research explores physiological and operational contributors to fatigue and evaluates countermeasures to enhance crew alertness and performance.
- **Workload and Situation Awareness:** Research examines cognitive demands in rail operations to optimize workload distribution and support situational awareness.
- **Training and Skill Retention:** Investigations focus on developing evidence-based training methods and understanding how skills degrade over time without practice.
- **Human Performance Monitoring and Analytics:** Research uses biometric and behavioral data to identify risk factors and support real-time performance feedback.
- **Researching root causes of switching and shoving safety issues and investigating the impact of human factors engineering solutions to minimize safety risk.**

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

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

HF will continue to conduct research in the following areas:

- **Grade Crossings:** Research will develop and pilot-test strategies to mitigate risky human behavior around grade crossings and railroad ROWs; research on road users' response to grade crossing warning systems to improve grade crossing design and reduce collisions.
- **Trespass and Suicide Prevention:** Research will develop and pilot-test strategies to mitigate risky human behavior on railroad ROWs; studies to identify behavioral indicators to evaluate intervention strategies and environmental design to deter suicide attempts on rail property.

Additional information about DOT research can be found at <https://researchhub.bts.gov/search>.