U.S. Department of Transportation

Federal Railroad Administration

Research, Development and Technology Strategic Plan 2020–2024

Office of Research, Development and Technology
Washington, DC 20590

July 2020

U.S. Department
of Transportation

**Federal Railroad
Administration**

Administrator

1200 New Jersey Avenue, SE
Washington, DC 20590

Dear Reader:

I am pleased to present the Federal Railroad Administration's 5-year Strategic Plan for Research, Development and Technology. This plan outlines our goals and strategies for assuring FRA's programs and activities are founded on the best available science and technology, resulting in real word impact. It supports the Department of Transportation's strategic goals, the first of which is improving safety.

A key theme in the plan is partnership with the railroad industry in our research and development activities. We plan to work together to improve safety at a time when the industry is growing and new technology is being adopted at an increasing rate.

I hope that reading this plan gives you an understanding of our research and development program's strategies and priorities. I look forward to your engagement in what is a key program for the Federal Railroad Administration. We need the results from research and development to help us achieve our mission of enabling safe, reliable and efficient movement of people and goods.

Sincerely,

Ronald L. Batory
FRA Administrator

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Executive Summary

The Railroad Research and Development program is managed by the Federal Railroad Administration's Office of Research, Development and Technology (RD&T). Its mission is to improve railroad safety. This plan describes the strategies that RD&T will use to achieve this mission and support the U.S. Department of Transportation's goals.

Consistent congressional funding for the Railroad Research and Development program has resulted in significant contributions to improving railroad safety. Continuing work is necessary to maintain this trend, especially at a time when the railroad industry is growing and changing.

The program's mission is achieved by developing and deploying new technologies in collaboration with public and private industry partners. The program maintains facilities and equipment for conducting research. Prudent financial management ensures RD&T staff are accountable for delivering value.

Examples of new technology include electronic systems for train control, and autonomous inspection of railroad assets. New technology is not only physical systems; it also includes new approaches to safety culture and new operating practices. Another example is advances in computer simulation that allow new methods of assessing safety without testing in operational service.

The program covers all aspects of the railroad system, including human factors, track, vehicles, and signaling. RD&T prioritizes research in these areas using safety data and risk analysis.

RD&T undertakes two main types of research projects. The first acts as a catalyst for new technology. The program takes the initial risk of proving a concept. Prototype development and demonstration is then conducted in collaboration with industry partners. Technology transfer is complete when the industry commercializes the new technology.

The second type of research project involves industry adoption of new technology. RD&T supports research to provide the scientific foundation for necessary waivers or regulatory reform. Understanding the complexities of vehicle-track interaction and human error, for example, are essential to developing scientifically informed regulations.

RD&T's underlying strategy over the next 5 years is to continue the methods that have led to significant successes. At the same time, RD&T will continue to improve research project evaluation and technology transfer reporting.

1. Mission, Organization, and Authorities

1.1 Mission Statement

The Federal Railroad Administration Office of Research, Development and Technology mission is to ensure the safe movement of people and goods by rail through research and the development of innovative technologies and solutions.

1.2 Organization

The Office of Research, Development and Technology (RD&T) is part of the Office of Railroad Policy and Development and works closely with the Office of Railroad Safety.

RD&T has five research areas that cover different aspects of the railway system:

- Human Factors research addresses accidents caused by human error, the most common cause of railroad accidents.
- Train Control and Communication research focuses on reducing train collisions with other trains and with objects at highway-rail grade crossings. It has long been involved in the development and implementation of Positive Train Control (PTC).
- Track research targets the prevention of train derailments. It studies vehicle-track interaction and the degradation and failure of track components.
- Rolling Stock research examines the structural integrity of trains to increase the safety of passengers and reduce releases of hazardous materials. It also targets the causes of derailments due to rolling stock component failures and improper train handling.
- Railroad Systems Issues research looks at overall system safety and prioritizes the research in the other four areas.

1.3 Legislative Authorities

The Department of Transportation Act of 1966 created FRA, which started operations in 1967. Research and development into high-speed ground transportation was one of FRA's earliest activities.

The Railroad Research and Development program is funded by Congress through annual and supplemental appropriations. The following are other major laws that influence the work performed by RD&T.

Rail Safety Improvement Act (RSIA)

Congress passed the Rail Safety Improvement Act (RSIA) of 2008 to improve railroad safety [1]. It initiated the Risk Reduction Program and mandated PTC on certain train routes.

RSIA led RD&T to further research into hours of service requirements for railroad workers, PTC implementation, standards for track inspections, certification of locomotive conductors, and safety at highway-rail grade crossings.

Passenger Rail Investment and Improvement Act (PRIIA)

The Passenger Rail Investment and Improvement Act (PRIIA) of 2008 directed FRA to develop a long-range national rail plan and authorized appropriations for intercity passenger and freight rail grants [1]. PRIIA included research into higher-speed passenger trains and the implications of operating those trains on track shared with freight trains. Congress then passed the American Recovery and Reinvestment Act of 2009 that appropriated $8 billion to improve and deploy high-speed rail systems [2].

The Fixing America's Surface Transportation (FAST) Act

The Fixing America's Surface Transportation (FAST) Act authorized $305 billion for the U.S. Department of Transportation (DOT) from fiscal years (FY) 2016 through 2020 [3]. It covered DOT's rail, highway, motor vehicle safety, public transportation, motor carrier safety, hazardous materials safety, research, technology, and statistics programs. The FAST Act prompted RD&T to expand its research into tank car and highway-rail grade crossing safety. It also required DOT to submit a 5-year strategic research and development plan and for all DOT modes to submit annual research plans.

2. Introduction

This 5-year RD&T strategic plan describes strategies that support DOT's strategic plan for fiscal year (FY) 2020 to 2024 [4]. It defines a long-term vision for the RD&T program and guides the contents of FRA's Annual Modal Research Plans for the next 5 years.

2.1 Strategic Goal Framework

RD&T strategies are aligned with the DOT goals listed below. While improving safety is the principal goal for the Railroad Research and Development program, support is also given to the other DOT goals.

- **SAFETY**: Reduce transportation-related fatalities and serious injuries across the transportation system.
- **INFRASTRUCTURE**: Invest in infrastructure to ensure safety, mobility, and accessibility and to stimulate economic growth, productivity, and competitiveness for American workers and businesses.
- **INNOVATION**: Lead in the development and deployment of innovative practices and technologies that improve the safety and performance of the Nation's transportation system.
- **ACCOUNTABILITY**: Serve the Nation with reduced regulatory burden and greater efficiency, effectiveness, and accountability.

DOT has identified strategic objectives for each of its goals. RD&T has developed strategies to help meet the DOT objectives that are within the scope of FRA's research and development program. Table 1 shows the RD&T strategies in this plan that support DOT's strategic goals and objectives.

Table 1. RD&T Strategic Goals, Objectives, and Strategies

DOT Goal	DOT Strategic Objective	RD&T Strategy
Safety	Systemic Safety Approach	• Use data to understand safety risk in the railway system. • Collaborate with public and private partners to identify safety risk. • Prioritize research to ensure the best outcomes. • Address safety risk in rural areas. • Clarify RD&T's role as research leaders in DOT and the railroad industry.
Infrastructure	Project Delivery, Planning, Environment, Funding, and Finance	• Provide tools to ensure Federal investments achieve safety improvements.
	Life Cycle and Preventive Maintenance	• Maintain RD&T facilities and equipment in a state of good repair.

DOT Goal	DOT Strategic Objective	RD&T Strategy
Innovation	Development of Innovation	• Collaborate with DOT research and development partners. • Innovate in partnership with the railroad industry. • Address safety concerns related to data and cybersecurity.
	Deployment of Innovation	• Ensure the safe integration of new technology with railroad operations. • Strengthen the technology transfer process.
Accountability	Regulatory Reform	• Participate in reforming regulations.
	Mission Efficiency and Support	• Increase staff knowledge and industry awareness. • Ensure prudent financial management and procurement. • Improve operational efficiency of the Transportation Technology Center.

Section 3 of this strategic plan gives details of RD&T's strategies listed in Table 1.

2.2 Industry Trends Affecting RD&T

RD&T creates its strategic plans within the context of an evolving railroad industry. U.S. rail intermodal freight traffic has increased steadily since 2008. Trends indicate continued growth in freight traffic, with trains getting longer and axle loads increasing. Passenger trains are expected to run more frequently and operate at higher speeds. The railroad industry is also impacted by an aging workforce and increased automation.

RD&T anticipates a quick return to rail traffic growth after the worst aspects of the COVID-19 pandemic subside. The industry is growing, and there have been significant improvements in safety in recent decades. However, major train accidents still occur, and some types of accidents are consistently common.

The industry is investing in new technology to enable growth and continue to improve safety. RD&T's strategies reflect these trends.

3. Program Goals and Strategies

RD&T strategies are described in the following four sub-sections that align with the four DOT goals. Each sub-section includes the DOT strategic objectives that are within the scope of RD&T's research areas and activities.

3.1 Safety Goal

Improving transportation safety is DOT's top strategic goal. This drives RD&T to set improving railroad safety as its primary goal. The current level of safety in the railroad industry is quantified by analyzing accident and incident data gathered by FRA [5].

Table 2 shows a breakdown of accident and incident causes, averaged over a recent 5-year period.

Table 2. Average Annual Accident and Incident Data 2015–2019

Accident/Incident Category	Fatalities	Accidents or Incidents	Accidents or Incidents/Million Train Miles
Trespass	505	950	1.38
Grade Crossing Incidents	261	2,093	3.00
Human Factors Accidents	8	699	1.01
Track-Caused Accidents		504	0.73
Miscellaneous – excluding Grade Crossings		308	0.44
Equipment-Caused Accidents		257	0.37
Signal-Caused Accidents		45	0.06

Trespassing along railroad rights-of-way is the leading cause of rail-related fatalities in the U.S. Collisions at grade crossings are the second-leading cause. The FY 2018 DOT annual performance report set the FY 2020 target for trespass incidents at 1.48 per million train miles and for grade crossing incidents at 2.84 per million train miles [6].

The total rate of accidents and incidents for causes other than trespass and grade crossings is 2.49 per million train miles. The DOT target for FY 2020 is 2.29 per million train miles.

All FRA offices contribute to reaching these targets. RD&T's contribution comes from the new technologies it helps introduce and the expert advice it gives to other offices.

3.1.1 Systemic Safety Approach

RD&T follows DOT's systemic safety approach by using data to analyze safety risk and prioritize research that best addresses program goals. Collaboration with public and private partners helps RD&T identify research needs for the railroad system as a whole.

Strategies

Use data to understand safety risk in the railway system.

RD&T has developed a Safety Risk Model (SRM) to analyze safety risk across the railroad system. The model calculates safety risk by multiplying the likelihood of accidents occurring by the consequences when they do occur. It ranks individual hazards and provides an indication of where RD&T project investments may have the greatest influence on improving safety.

The SRM uses data from FRA's Rail Accident/Incident Reporting System (RAIRS) [5]. A record is created in this system whenever an accident or incident occurs that meets a certain reporting threshold. RAIRS also contains operational data such as miles traveled, passenger miles, and labor hours. This information is used to normalize the raw safety data.

RD&T will update the SRM as new data becomes available. It will continue to use the model to make sure different safety hazards in the railroad system are considered.

Safety risk will be analyzed in detail using predictive analytics. For example, data will be gathered to predict the probability of a derailment following a broken rail.

Collaborate with public and private partners to identify research needs.

RD&T collaborates with internal and external stakeholders to understand research needs and the interest in research results. Federal stakeholders include:

- Office of Railroad Safety, for knowledge on emerging safety problems in the field
- Office of Chief Counsel, for information on upcoming regulatory reforms
- Assistant Secretary for Research and Technology (OST-R), for cross-modal research needs
- Pipeline and Hazardous Materials Safety Administration (PHMSA), for tank car research needs
- National Transportation Safety Board (NTSB), for accident investigations and its Most Wanted List of Safety Improvements

External stakeholders who help RD&T identify research needs include:

- Association of American Railroads (AAR) and its members
- American Short Line and Regional Railroad Association and its members
- Amtrak for passenger rail research needs
- American Public Transportation Association and its members for commuter, light rail, and rapid transit research needs
- Labor unions, for human factors research needs

An example of the ongoing collaboration to identify research needs is the work to improve the safe transportation of hazardous materials by rail. RD&T works with the AAR Tank Car Committee to understand emerging hazardous materials issues. RD&T staff also visit tank car maintenance and repair facilities and meet with tank car fleet owners to better understand the issues. Research needs are then discussed and agreed upon with the Office of Railroad Safety and PHMSA.

RD&T participates in selected accident investigations to see first-hand how current systems are performing and help determine research needs. This often provides evidence to help evaluate technologies developed by previous research.

FRA's successful Confidential Close Call Reporting System (C^3RS) was developed and prototyped by RD&T [7]. By allowing railroad employees to anonymously report near misses, C^3RS identifies safety issues before they become accidents. Some of the identified issues may need research by RD&T. As a follow-on from C^3RS, RD&T is collaborating with the Office of Railroad Safety to launch the Railroad Information Sharing Environment (RISE) program, which is modeled on the Federal Aviation Administration's Aviation Safety Information Analysis and Sharing program. The RISE program will be a partnership of FRA stakeholders sharing safety sensitive data for the purpose of understanding and mitigating safety problems.

RD&T periodically sponsors workshops on trespassing, grade crossing, and suicide prevention research needs. Attendees are experts from industry, universities, State and local government, and public advocacy groups. These workshops continue to provide an opportunity for industry stakeholders to gather and discuss needs, issues, concerns, priorities, best practices, and lessons learned. RD&T is planning further workshops or similar activities in collaboration with the Office of Railroad Safety.

RD&T will continue to collaborate with OST-R's Intelligent Transportation Systems - Joint Program Office on research needs for automated vehicle interaction at highway-rail grade crossings.

In identifying research needs, RD&T will continue to balance the need to solve current issues with the long-term needs of the railroad industry. RD&T subject matter experts are often called on to advise on current problems. At the same time, they remain focused on long-term objectives and goals.

Prioritize research to ensure the best outcomes.

Once research needs have been identified, RD&T uses a formal prioritization process to select research projects for funding. The process uses the following criteria to determine a project's priority:

- **Strategic Alignment** – If successful, by how much would the project reduce safety risk? Are there any expected benefits to other strategic goals?
- **Project Stage** – How far is the project along the life cycle from basic research to technology transfer?
- **Timeliness** – Does the project help a current rulemaking, concern a recent major accident, or address an NTSB recommendation?
- **Risks to Success** – Can costs be controlled? Is there industry support for the project?

RD&T staff, Office of Railroad Safety staff, and FRA senior leadership determine the criteria weightings and score the projects. Each potential project is scored against the above criteria and the weighted scores are combined to provide a prioritized list of projects.

RD&T will continue this collaborative approach to project selection and periodically update the criteria and weightings.

Address safety risk in rural areas.

RD&T programs benefit regional railroads and short lines that tend to operate in underserved rural communities. Through an annual grant authorized by Congress, RD&T will continue to monitor and support the Short Line Safety Institute. The objective is to help the short line and regional railroad industry operate at an increasingly high level of safety by improving safety culture.

RD&T will continue its research to improve safety at highway-rail grade crossings. This will include passive crossings, which are located predominantly in rural areas. In 2015, passive grade crossings (i.e., crossings that indicate to a roadway user that there is a crossing, but do not indicate whether a train is approaching) comprised 46 percent of all grade crossings in the U.S. Motorists are almost 10 times more likely to have an accident at passive crossings compared to active crossings [8].

Clarify RD&T's role as research leaders in DOT and the railroad industry.

RD&T has been an active participant on the DOT Safety Council and has helped strengthen safety culture in the Department. This participation will continue, with RD&T seeking to share its experience on safety risk reduction and to learn from the other modes.

Many of RD&T's activities demonstrate its leadership role in railroad research. Examples include grade crossing and trespass workshops and the original research and development of PTC. However, this role does not extend to funding and implementing new technology. RD&T will clearly define its leadership role and its limitations so industry partners understand when responsibility passes to them.

3.2 Infrastructure Goal

While the primary driver of the research and development program is improving safety, many projects also contribute to achieving DOT's goal of investing in infrastructure.

3.2.1 Project Delivery, Planning, Environment, Funding, and Finance

RD&T develops decision tools that are used by others to support DOT's objective to ensure Federal investments improve the Nation's infrastructure and increase safety.

Strategy

Provide tools to ensure Federal investments achieve safety improvements.

RD&T developed GradeDec.Net, a web-based decision-making tool for investment in highway-rail grade crossings [9]. State departments of transportation, local governments, metropolitan planning agencies, inspectors, and railroad companies use it to analyze the costs and benefits of

highway-rail grade crossing infrastructure investments. The tool identifies the most cost-effective investment option and quantifies the safety benefits.

RD&T will continue to invest in GradeDec.Net. Future enhancements are likely to cover the use of locomotive horns at highway-rail grade crossings and support decisions regarding autonomous vehicle fleets.

3.2.2 Life Cycle and Preventive Maintenance

RD&T will meet DOT's objective to keep its facilities and equipment in a state of good repair.

Strategy

Maintain RD&T facilities and equipment in a state of good repair.

RD&T's primary facility is the Transportation Technology Center (TTC), consisting of a 52-square-mile tract of land near Pueblo, Colorado [10]. Since its dedication as the High-Speed Ground Test Center in 1971, the TTC continues to play an important part in research, development, and testing of rail infrastructure and equipment. An example is the Positive Train Control (PTC) test bed, funded by RD&T, that enables railroads and system suppliers to test products before they enter revenue service.

Plans for using the TTC in the future include:

- Enhancing FRA's capability to independently evaluate railroad equipment and infrastructure integrity
- Developing testbeds to evaluate new track defect detection technologies
- Expanding the PTC testbed to enable the testing and evaluation of new intelligent transportation technologies
- Continuing to develop a training facility for FRA and Transportation Security Administration inspectors

RD&T and the onsite contractor share the responsibility for maintaining assets at the TTC and investing in the facility. Both parties collaborate and agree on annual maintenance and improvement plans. RD&T ensures the plans meet FRA's needs. The contractor identifies maintenance needs and selects its own investments to support commercial testing. When funding allows, the plans will contain environmental sustainability improvements toward meeting DOT's Strategic Sustainability Performance Plan goals for sustainable buildings and renewable energy [11].

FRA's Cab Technology Integration Laboratory (CTIL), developed by RD&T, supports human factors research on train operation. CTIL is a locomotive simulator configured with computer monitors, displays, and tools for analyzing crew performance. It is located at DOT's Volpe National Transportation Systems Center (Volpe Center) in Cambridge, Massachusetts.

RD&T has developed a strategic plan for CTIL [12]. It will continue to keep CTIL's technology up-to-date and will increase its usage by railroads, industry suppliers, academics, and government researchers. A stakeholder review panel was formed to guide the research direction, project selection, and evaluation of CTIL.

RD&T installed a CORYS Hybrid Research Simulator at DOT headquarters in Washington, DC. The simulator can represent three common PTC systems and provides a platform to study safer train handling, with locomotives equipped with the latest automated braking systems. It will be kept up-to-date when CORYS distributes new software.

FRA owns two research railcars, a road-rail vehicle, instrumented wheelsets, and various portable devices for inspection and measurement. RD&T will continue to use these test cars and equipment to develop and test new inspection technologies in the harsh railroad environment.

3.3 Innovation Goal

New technology is changing the railroad industry and influencing RD&T's research priorities. For example, the implementation of PTC is a major change that will improve safety and significantly affect railroad operations in the Nation. RD&T's role is to help develop new technologies, such as PTC, and show how they can be safely integrated into railroad operations.

RD&T undertakes two main types of research projects. The first acts as a catalyst to introduce new technology. The program assumes the initial risk of proving a concept. For promising concepts, this is followed by prototype development and demonstration in collaboration with industry partners. Technology transfer is complete when the industry commercializes the new technology.

The second type of research project arises when the industry seeks to adopt new technology it has developed on its own or purchased from a third party. RD&T then performs the research to provide the scientific foundation for necessary waivers or regulatory reform.

Table 3 gives examples of new technologies the rail industry is currently introducing. It shows that new technology impacts all RD&T research areas.

Table 3. Emerging Technologies and Strategy

Technology	Description	Research Area(s)	Strategy
Unmanned Aerial Vehicle (UAV)	A UAV is an aircraft piloted by remote control or onboard computers.	Track	Evaluate how an UAV may be applied in the railroad industry and determine if it can replace or enhance existing measurement and inspection technologies.
Artificial Intelligence (AI)	AI is human behavior demonstrated by machines.	Track Train Control & Communication	Evaluate how AI may be applied in the railroad industry and determine if there are unintended safety risks.
Augmented Reality (AR) and Virtual Reality (VR)	VR engineering includes the use of 3D modeling tools and visualization techniques as part of the design process.	Human Factors	Determine how AR and VR could help to train conductors and drivers and improve health and safety.

Technology	Description	Research Area(s)	Strategy
Machine Learning	Machine learning gives computers the ability to learn without being explicitly programmed.	Human Factors Track Rolling Stock	Determine how machine learning could ensure timely maintenance.
PTC	PTC is an advanced system designed to automatically stop a train before certain accidents occur.	Train Control & Communication	Monitor the development of future generations of PTC to determine if there are unintended safety risks.

More detail on RD&T's priorities for the next 5 years is provided in the Appendix.

3.3.1 Development of Innovation

RD&T conducts world-class research that meets the DOT objective to improve safety through innovation. This is most effectively done in collaboration with public and private partners.

Strategies

Collaborate with DOT research and development partners.

RD&T staff participate in many cross-modal working groups dedicated to improving safety, while also addressing innovation, infrastructure, and accountability. Table 4 lists several examples.

Table 4. RD&T Cross-Modal Collaboration

Partner	Description
Human Factors Coordinating Committee (HFCC)	Collaboration with other DOT modes to share human factors research, information, and lessons learned.
Intelligent Transportation Systems – Joint Program Office (ITS-JPO)	Collaboration with the ITS-JPO on multiple efforts, meeting regularly based on research needs. ITS-JPO has supported RD&T research through cost-sharing arrangements.
Autonomous Vehicles (AV)	Participation in the new cross-modal AV working group to discuss issues related to automation and autonomous vehicles.
OST-R Planning	Collaboration with DOT modes to improve safety, innovation, infrastructure, and accountability through the OST-R Topical Research Working Groups (TRWGs).

RD&T has established a special partnership with the Volpe Center because of the center's specialized technical expertise and relationships with the railroad industry. Research conducted

by the Volpe Center provides RD&T with scientific data to help the Office of Railroad Safety in decision-making and in supporting regulatory reform. Volpe Center staff provide support to NTSB investigators and local FRA inspectors at accident sites when needed.

Innovate in partnership with the railroad industry.

RD&T has a successful history of innovation in partnership with industry and universities. A recent example is the Autonomous Track Geometry Measurement System (ATGMS) [13]. This technology enables railroads to efficiently gather data on track conditions that are essential to maintaining safety. Several railroads provided access to vehicles and equipment for system development and installation, supported testing through complimentary train moves, and gave invaluable technical feedback on system design and data outputs.

The research and development life cycle of ATGMS provides a good example of the stages involved and collaboration with the industry in a typical RD&T project. Figure 1 shows the funding life cycle of the ATGMS project, which began in 2002 and was recently completed.

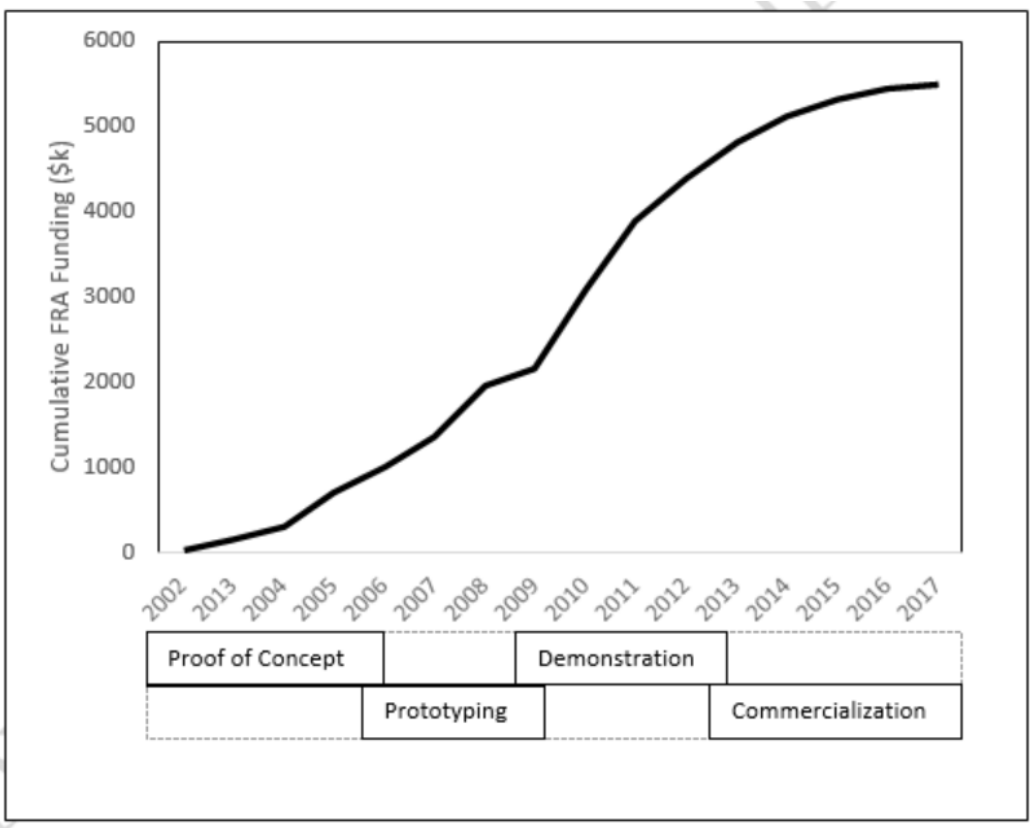

Figure 1. ATGMS Project Life Cycle

The ATGMS project was initially funded in 2002 by RD&T to test the concept of unmanned rail vehicles recording track quality. Early promise led to the development and testing of a prototype in collaboration with an industry supplier in 2006. The supplier used its experience gained from developing manned recording systems. Starting in 2009, the demonstration phase was conducted on operational main lines with support from 29 Class I, regional, and short line railroads. The system developer then commercialized ATGMS and is now supplying it nationwide and internationally. To date, 15 systems have been delivered and another 15 are on order.

Figure 1 shows how RD&T's funding of ATGMS increased in its early years. RD&T assumed the risk in the proof of concept stage. RD&T's investment leveled off as the industry became more involved and ATGMS went into production. A measure of the project's success is the significant reduction in the cost per mile of track recording. The additional track geometry data has helped railroads find and repair track defects before derailments occur.

RD&T will continue to innovate in collaboration with industry partners. Opportunities for collaboration will be identified by participation in industry forums. RD&T staff will participate in the committees that plan and monitor AAR's cross-industry research program.

RD&T has created two new research initiatives involving partnership with universities. The first is a program to support RD&T's research projects on intelligent railroad systems. This research focuses on advanced technology, automation, and connected vehicle technologies; advancing technology to improve safety in rural areas; intelligent transportation systems; and workforce development. The second initiative is a partnership with the railroad industry to provide research opportunities to universities. RD&T expects to improve rail safety, advance innovation, and improve rail infrastructure while enhancing workforce development through both efforts.

Address safety concerns with data and cybersecurity.

As digital technologies increase in power, RD&T continues to research the impact on the railroad industry. For example, in cooperation with Metro-North Railroad, RD&T is developing an automated methodology for analyzing ATGMS data. Trends in the data are being used to predict when preventive maintenance is needed. As railroads become more dependent on data for decision support, issues with data security and integrity will need to be addressed.

Cybersecurity is a concern for safety-critical systems such as PTC. RD&T will participate in industry working groups, such as the AAR's Rail Information Security Committee, and participate in the research needed to address the cybersecurity of PTC and similar systems.

3.3.2 Deployment of Innovation

RD&T strategies help meet the DOT objective to accelerate the deployment of new technologies and remove barriers to implementation.

Strategies

Ensure new technology can be safely integrated with railroad operations.

RD&T helps to develop technical standards and practices that maximize the benefits of new technology. The work with the Railroad Safety Advisory Committee (RSAC) on track safety standards is a recent example. FRA's regulations used to require all new rail vehicles be tested on tracks before they are approved for operational service. RD&T successfully demonstrated to the cross-industry committee that new methods of computer simulation could verify operational safety in many cases. The regulations have been revised to allow computer simulation instead of track testing, thereby reducing the time and cost required for rail vehicle approval.

RD&T will continue to collaborate with the industry to implement innovative technology. The technology may be an output from RD&T's own work or be something the industry wants to adopt. A recent example of the latter is the use of liquefied natural gas (LNG) as a locomotive fuel. RD&T assessed the safety risks and conducted research to provide the basis for FRA to set standards to ensure safe operation.

New technology is being introduced by railroads for vehicle and track inspection. Often, the intention is to supplement or replace human inspection. RD&T will continue to develop methods for checking these new inspection systems are at least as good as those they are intended to replace.

New technologies usually require new workforce skills as operational norms change [14]. RD&T will continue to investigate the safety aspects associated with integrating people and technology. Research will be conducted to examine the extent to which advanced technological systems in railroading affect employee training, job design, and other personnel issues.

Strengthen the technology transfer process.

RD&T participates in OST-R's Technology Transfer (T2) program. Technology transfer is defined as "the process by which existing knowledge, facilities, or capabilities developed under Federal R&D funding are utilized to fulfill public and private needs" [15]. It is how RD&T's research gets translated into real-world application and impact.

RD&T will strengthen its existing technology transfer process by continuing to collaborate with OST-R. It will follow guidance from OST-R [16] and the Federal Laboratory Commission [17].

Recognizing that the industry is the end user of nearly all the technologies and working practices developed by RD&T, there will continue to be collaboration regarding implementation. Possible barriers to implementation will be discussed early in projects and throughout their life cycles.

Where appropriate, stakeholder review panels will be set up to guide projects to implementation.

3.4 Accountability Goal

RD&T's strategies support the DOT goals of reforming regulations and improving mission efficiency.

3.4.1 Regulatory Reform

RD&T has a key role to play in reforming regulations and creating performance-based standards. New technologies developed by RD&T are often the precursors to regulatory reform. RD&T will support regulatory reform needed to adopt new technology introduced by the industry. Many of RD&T's projects lead toward less prescriptive approaches to ensuring safety.

Strategy

Participate in reforming regulations.

RD&T's program provides the scientific foundation for regulatory reform. It gives the Office of Railroad Safety an understanding of complex issues that is needed to adapt regulations to modern conditions. An example is the recent rule establishing modern, performance-based safety standards for passenger trains. Research and full-scale testing were performed to revise regulations for the crashworthiness of rail vehicles and improve safety in collisions and derailments. The final rule will be a deregulatory action under Executive Order (EO) 13771, *Reducing Regulation and Controlling Regulatory Costs*. It is expected to save more than $475 million in net regulatory costs.

RD&T staff will collaborate with FRA's Office of Railroad Safety and Office of Chief Counsel to identify regulations being considered for reform.

New technologies are constantly being introduced to the railroad industry. RD&T will identify those that are going to require regulatory changes and conduct research to help make those changes when necessary.

3.4.2 Mission Efficiency and Support

RD&T strategies will ensure progress toward DOT's objective to develop staff and increase effectiveness.

Strategies

Increase staff knowledge and industry awareness.

RD&T staff members are highly educated subject matter experts. RD&T's success depends on fostering good relationships with industry, staying aware of industry trends, and maintaining credibility with stakeholders. RD&T staff are expected to participate in industry forums, seminars, conferences, and working groups. RD&T managers will continue to support staff development and standing within the industry by:

- Assessing staff capabilities and addressing areas for improvement
- Mentoring staff and providing opportunities to broaden skills
- Encouraging staff participation in industry forums, working groups, and conferences
- Supporting professional development

Ensure prudent financial management and procurement.

RD&T is held accountable for the public funds it uses to complete its mission. Congress funds the Railroad Research and Development program through annual appropriations. The appropriations may include statutory mandates for topics such as LNG, Safe Transport of Energy Products, Research with Universities on Intelligent Transportation Systems, and Short Line Safety Institute programs.

Although the program's funds are available until they are expended, RD&T will continue to plan to use them in the first fiscal year they are made available. To comply with FAST Act requirements, RD&T will complete the following plans each year:

- Annual Modal Research Plan – A research overview spanning 2 fiscal years
- Annual Performance Plan – A review of activities for the previous fiscal year

- Annual Funding Plan – Details of acquisitions for the upcoming fiscal year

RD&T division chiefs and program managers plan acquisitions based on the performance of each research project. They decide if research will continue and how many phases or option years will be pursued.

They agree with an FRA contracting officer on the most appropriate procurement option to use for each acquisition.

The Small Business Innovation Development Act of 1982 requires a small, but increasing, portion of Government research contracts be awarded to small businesses. RD&T will continue to support the DOT's Small Business Innovative Research program in addition to meeting FRA's other targets for small business contract awards.

Improve operational efficiency of the Transportation Technology Center.

The contract for the maintenance and operation of FRA's TTC expires during this 5-year strategic plan. This creates the opportunity to further improve the efficiency of the facility.

RD&T will collaborate with other FRA offices to start a new TTC contract that meets the various needs. Potential use of the site by other Government agencies will also be considered.

The option to install a solar voltaic power system at TTC would contribute to DOT's Strategic Sustainability Performance Plan [11]. RD&T will work with the contractor at the TTC to develop such a system.

4. Program Evidence

The ability to prove the Railroad Research and Development program delivers value will allow RD&T to continue to have the funding and staffing levels necessary to achieve its mission. This proof can be provided by performance measurement and program evaluation.

4.1 Performance Measurement

Measuring the performance of RD&T activities is necessary to ensure goals and objectives are being met and to quantify the value of the research. However, the duration of a given research and development life cycle means the impact and value of the research may be hard to define. As a proxy, RD&T will identify and track performance measures that indicate the program's contribution to improving safety. For example, a tangible outcome of the ATGMS research project was a quantified increase in the annual miles of track recorded. This is an indicator of safety improvement because it assisted the railroads in identifying more track quality problems and making repairs before derailments happened.

RD&T will also measure project performance by tracking progress through technology readiness levels (TRL). These levels are standard definitions of research and development stages.

Tracking projects by TRL will identify those that are not meeting expectations and need to be reviewed. Monitoring the distribution of project TRLs across RD&T will demonstrate the program is continuing to provide a pipeline from basic research to implementation.

In addition, RD&T will track the following performance measures required by OST-R:

- Increase dissemination of DOT-funded research reports (OST)
- Research reports published on eLibrary and the National Transportation Library
- Technology transfer language in research funding agreements

RD&T reports will continue to be published on FRA's website, the DOT Research Hub and Repository Open Science Access Portal database, the National Transportation Library, and the TRB's Transport Research International Documentation database.

4.2 Program Evaluation

RD&T's earlier Evaluation Implementation Plan [18] has resulted in the publication of several reports on the subject [e.g., 7, 19]. An effort within RD&T is currently underway to further develop and implement project evaluations. The next steps are to adopt standardized processes, guides, and tools. This will help program managers to:

- Select meaningful project goals and measures.
- Create a data-driven performance improvement culture.
- Capture data to inform future research.

In addition to the evaluation of individual projects, RD&T will sponsor periodic evaluations of the Railroad Research and Development program. The TRB will conduct these evaluations using a panel of representatives from railroads, academia, and railroad associations. RD&T

will use the feedback and recommendations to set priorities, plan projects, and improve the program's performance.

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Appendix
Research Priorities

The following tables outline RD&T's 2020–2024 research priorities.

Table A1. Human Factors Research Priorities

Priority	Description
Fatigue	Identify existing gaps in research, particularly related to the railroad industry, that must be assessed and targeted using a variety of methods to study fatigue in railroad operations, including survey research, human subjects' simulator experiments, and technology demonstrations.
Human Automation Interaction	Address human error that result in accidents and fatalities; investigate the safety aspects associated with integrating people and technology. Examine the extent to which advanced technological systems in railroading affect employee training, job design, and other personnel issues.
Grade Crossing Safety	Identify knowledge gaps related to grade crossing safety; continue to investigate technologies to improve grade crossing safety and motorists' behavior at grade crossings.
Trespass/Suicide Prevention	Continue research to better understand the two leading causes of rail-related deaths in the U.S., trespass and suicide, by conducting pilot studies with rail carriers implementing strategies to mitigate trespass and suicide. Evaluate the effectiveness of these strategies.
Short Line Safety Institute (SLSI)	Continue to provide program monitoring and support of the SLSI, which provides safety culture assessments and training to small railroads, which are largely located in rural areas. Funding for the SLSI is an earmark grant provided annually by Congress.

Table A2. Train Control and Communication Research Priorities

Priority	Description
PTC Performance Monitoring and Reporting	Continue in the development and deployment of data collection and analysis tools for PTC systems under normal operating conditions to monitor and evaluate system performance.
Next Generation PTC Technologies	Enhance existing PTC technologies taking advantage of advances in automation, communication, and sensor technologies to further improve safety.
Intelligent Transportation Systems	Invest in connected vehicle technologies to ensure safe interaction of road vehicles with trains at grade crossings. Investigate levels of train automations, and develop requirements and standards.
Artificial Intelligence (AI) and Computer Learning (CL)	Incorporate AI and CL into research related to predictive analyses for PTC system performance and faults as well as identifying risky trespasser behavior around railroad tracks and crossings.

Table A3. Track Research Priorities

Priority	Description
Autonomous Inspection Technologies	Expand the use of autonomous inspection methods to provide more frequent and cost-effective measurements and quality assessments of track condition. Focus investments in the defect detecting payloads carried by the drones and revenue service railcars and the automation of data processing.
Artificial Intelligence-Based Risk Analysis	Invest in the development of a suite of technologies utilizing Artificial Intelligence (AI) to increase safety and reduce human error by improving the speed, accuracy, and consistency of inspection processes. The primary focus will be the application of predictive analytics to determine high-risk derailment locations before they exceed any safety threshold.
Safety Assurance Performance Measures	Railroads are currently testing automated and autonomous technologies to supplement or replace manual safety inspections. RD&T will develop standards and procedures to verify and validate the performance of these new systems to ensure their efficacy.
Rail Safety Simulations and Testing	In direct support of FRA Office of Railroad Safety, invest in computer modeling capabilities to improve the state of science of vehicle-track interaction, wheel and rail profiles and contact conditions, minimum track safety requirements, derailment root causes, defect initiation and crack growth rates, and evaluation methods for the qualification of new high-speed equipment.
Advanced Defect Detection Measures	Invest in research and development of improved methods to locate, monitor, and predict the performance of difficult to detect railroad track safety issues such as rail internal defects, longitudinal rail force related issues, and ballast vertical and lateral restraint.
TTC Research Facility Maintenance and Enhancement	Invest in necessary maintenance and enhancements to ensure the sustainability and efficacy of the facility for current and future activities.

Table A4. Rolling Stock Research Priorities

Priority	Description
Automated Inspection Technologies and Techniques	Partner with the railroad industry to foster further development of automated wayside and on-board inspection techniques and technologies.
Improved Materials and Component Designs for Rolling Stock Components	Invest in testing and analysis to identify materials which can provide improved performance and durability in the railroad environment.
Occupant Protection Enhancements	Invest in means for improving train occupant protection in the event of collisions and derailments by mitigating the potential for loss of occupied volume and minimizing the secondary impact velocity to which passengers are exposed.
Improving the Safety of Hazardous Materials Transportation	Continue to develop, analyze, and test means for improving the structural integrity of tank cars.
Energy and Environmental Sustainability	Investigate means for ensuring that advances in alternative fuels such as compressed and liquefied natural gas (CNG and LNG) are introduced in a safe manner.

Abbreviations and Acronyms

Abbreviation or Acronym	Description
AAR	Association of American Railroads
AI	Artificial Intelligence
AR	Augmented Reality
ATGMS	Autonomous Track Geometry Monitoring System
C3RS	Confidential Close Call Reporting System
CFR	Code of Federal Regulations
CNG	Compressed Natural Gas
CTIL	Cab Technology Integration Laboratory
DOT	Department of Transportation
EO	Executive Order
FAST	Fixing America's Surface Transportation
FRA	Federal Railroad Administration
LNG	Liquefied Natural Gas
NTSB	National Transportation Safety Board
OSHA	Occupational Safety and Health Administration
OST	Office of the Secretary
OST-R	Assistant Secretary for Research and Technology
PHMSA	Pipeline and Hazardous Materials Safety Administration
PRIIA	Passenger Rail Investment and Improvement Act
PTC	Positive Train Control
RAIRS	Rail Accident/Incident Reporting System
RD&T	Research, Development and Technology
RISE	Railroad Information Sharing Environment
RPD	Railroad Policy and Development
RSAC	Railroad Safety Advisory Committee
RSIA	Rail Safety Improvement Act
SBIR	Small Business Innovative Research
SLSI	Short Line Safety Institute

Abbreviation or Acronym	Description
SRM	Safety Risk Model
T2	Technology Transfer
TRB	Transportation Research Board
TRL	Technology Readiness Level
TTC	Transportation Technology Center
UAV	Unmanned Aerial Vehicle
VR	Virtual Reality

On the Cover:

FRA's DOTX 218/220 vehicle consist is North America's most comprehensive "single pass" inspection platform in use today. Platform inspection technologies include a Gage Restraint Measurement System (GRMS), Ground Penetrating Radar (GPR), Light Detection and Ranging (LiDAR), Track Geometry and Rail Profile Measurement Systems, a Vertical Track Deflection Measurement System (VTDMS), a Joint Bar Inspection System, a Ride Quality Measurement System, a Track Component Imaging System, and a Right of Way and Roadbed Imaging System. This technology and the data collected can be used to understand critical track support and substructure behavior, provide information that can determine root causes of track conditions and inform remedial actions, and predict future conditions and safe inspection intervals.