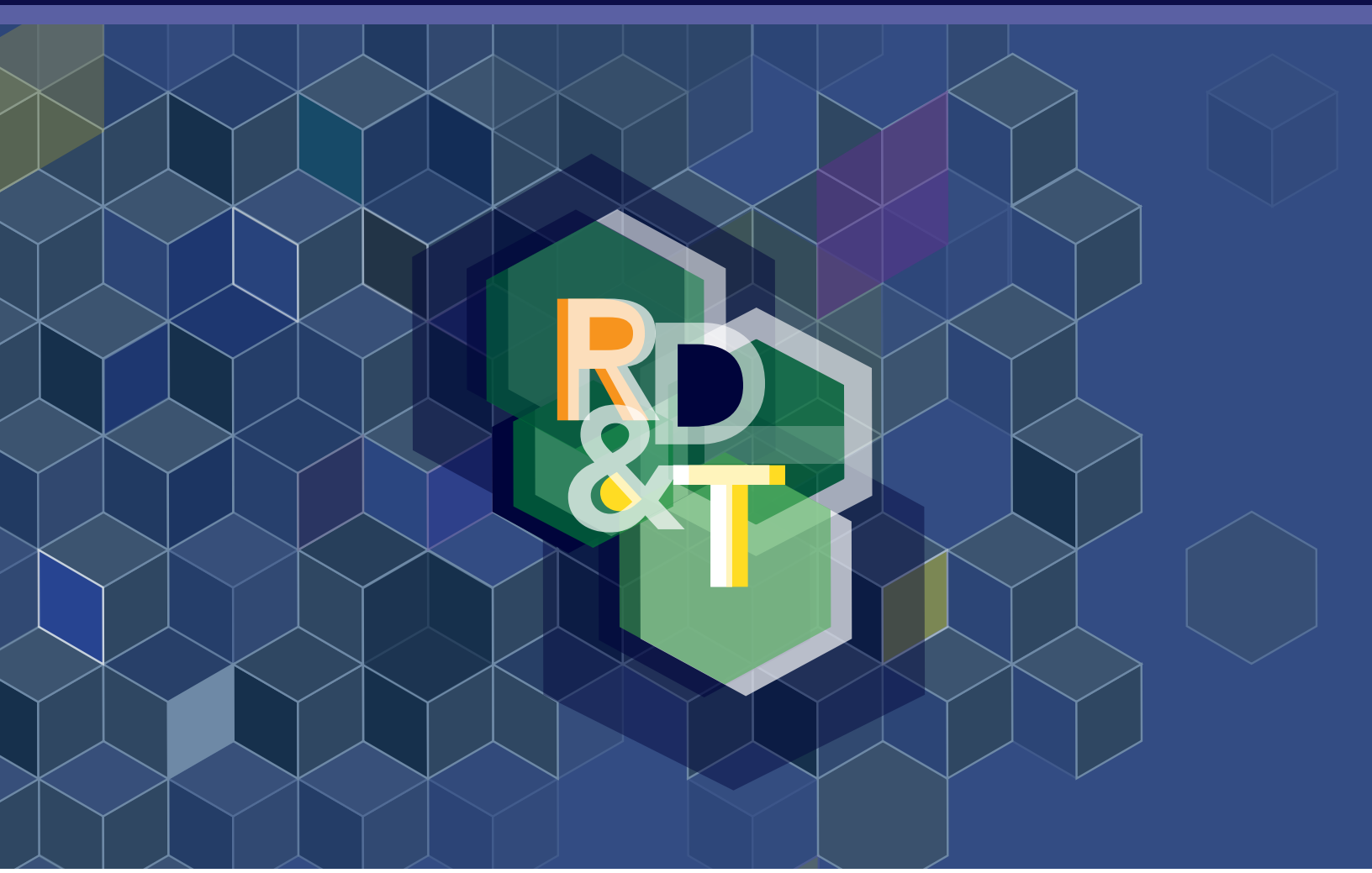
U.S. Department of Transportation

# Research, Development & Technology Strategic Plan FY 2018-2022




U.S. Department of Transportation

October 2020

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# Addendum

## USDOT Strategic Plan for FY 2018–2022 Strategic 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.

## Addendum in Response to Covid-19

The U.S. Department of Transportation (DOT) Research, Development, and Technology (RD&T) Strategic Plan presents DOT's transportation research priorities and strategies to support the goals defined in the Department's *Strategic Plan for FY 2018-2022.* This RD&T Strategic Plan update was developed as an update to the original Plan published in 2017. The coronavirus disease 2019 (Covid-19) public health emergency emerged concurrent with the completion of this strategic plan. The full effects of Covid-19 will not be known for some time, but it is apparent that the changes to transportation and to the broader economy will influence transportation research priorities over the next few years as transportation adjusts to a post-Covid-19 era.

The effects of Covid-19 on research project priorities are anticipated to be far-reaching. Early evidence suggests that the range of research initiatives could include activities such as measuring and monitoring changes in transportation systems, determining best practices for protecting the workforce and passengers from health risks, managing operations in response to disruptions such as Covid-19, understanding short- and long-term land use and travel behavior responses to Covid-19, understanding transportation performance and costs due to responses to Covid-19, and determining how transportation planning may need to adapt to integrate lessons learned from Covid-19, among others. As the Nation takes steps to recover from the public health emergency, research will be needed to understand the economics of Covid-19 and the use of transportation system investments as an economic recovery tool in the short- and long-term. DOT will prioritize research capable of providing decision makers with the data and tools needed to make informed decisions on future infrastructure investments that are economically viable and resilient, while maintaining the Department's priority focus on safety.

While these initiatives may be of value for research projects over the next few years, they will not alter the fundamental strategic goals for transportation, or alter the primary purposes of transportation research. These foundational elements of the Strategic Research Plan will remain, while the portfolio of activities may evolve as Covid-19 projects may supplement or reprioritize near-term research efforts.

The Covid-19 public health emergency has introduced significant challenges for the transportation research community. The critical nature of this issue will challenge the pre-existing research priorities and traditional processes for vetting and selecting research priorities. The desire to move expeditiously will require further emphasis in timely coordination and information sharing such that risks of research duplication can still be effectively avoided. Similarly, the desire for expeditious decisions places emphasis on ability to make further timeliness improvements in the research approval process when possible, thereby assuring the value of competitive research prioritization inclusive of new criteria and goals.

While the Covid-19 public health emergency will be a critical research agenda issue for some time, the Principles Guiding DOT Research Investments outlined in section 2 of this Strategic Plan document will continue to govern the conduct of DOT research.

The Covid-19 public health emergency represents the kind of challenge meant to be addressed by USDOT research activities; it will inevitably impact some project priorities and provide new opportunities for research to demonstrate DOT's goal of supporting policy, operations and investment decision-making for transportation. Researchers will need to balance the challenge of providing timely research to support gathering knowledge gained from the Covid-19 experience with the need to protect the integrity and efficiency of research by respecting the fundamental principles guiding DOT research investments.

### 49 USC 6503: Primary Purposes of Transportation Research

- Improving mobility of people and goods;
- Reducing congestion;
- Promoting safety;
- Improving the durability and extending the life of transportation infrastructure;
- Preserving the environment; and
- Preserving the existing transportation system.

### Principles Guiding DOT Research Investments

1. Support topical DOT priorities.
2. Avoid pitting safety and mobility against each other.
3. Focus on market failures.
4. Maximize value and avoid duplication.

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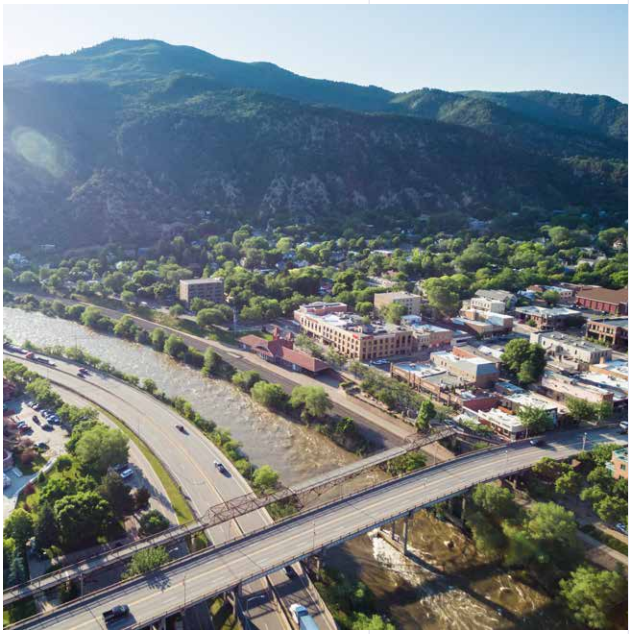
# Introduction

## Plan Purpose

This U.S. Department of Transportation (DOT) Research, Development, and Technology (RD&T) Strategic Plan presents DOT's transportation research priorities and strategies to support the goals defined in the Department's Strategic Plan for FY 2018–2022. This RD&T Strategic Plan is an update to the original plan published in 2017.[1] This plan meets the requirement set forth in section 6503 of the Fixing America's Surface Transportation (FAST) Act for the development of a five-year strategic plan to guide future Federal transportation RD&T activities.

Although the scope of the FAST Act is limited to research and development (R&D) activities, the Department includes a "technology" component in its reporting and budgeting. The technology component represents the Departmental resources and activities allocated to the deployment of R&D outputs. The Department considers this to be an important part of its role, ensuring that research results are fully leveraged in the transportation system. Thus, this plan includes the Department's strategic approach to technology deployment and is titled the "DOT Research, Development, and Technology (RD&T) Strategic Plan.



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The purpose of this plan is to improve the coordination of transportation RD&T, minimize redundancy, and guide the development of Annual Modal Research Plans (AMRPs) by each of the Department's Operating Administrations (OAs). It also describes the processes used for planning, reporting, conducting, and evaluating RD&T across the Department.

The Office of the Assistant Secretary for Research and Technology (OST-R) coordinated the development of this RD&T Strategic Plan and solicited input from the Department's OAs.

## Relationship to Other DOT Plans and Priorities

This RD&T Strategic Plan is consistent with other relevant plans and priorities that the Department's leadership has articulated.

### DOT Strategic Plan for FY 2018–2022

This RD&T Strategic Plan aligns with the Department's Strategic Plan for FY 2018–2022, which established four strategic 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.

The research deployment strategies discussed in section 3 are organized with respect to these goals.

## FAST Act: Primary Purposes of Transportation Research

The FAST Act states that the DOT five-year transportation research and development strategic plan shall describe how the Department's transportation research and development activities meet the following six primary purposes:

- Improving mobility of people and goods;
- Reducing congestion;
- Promoting safety;
- Improving the durability and extending the life of transportation infrastructure;
- Preserving the environment; and
- Preserving the existing transportation system.

Figure 1 indicates the key areas of alignment between the Department's Strategic Goals and the primary purposes of the transportation RD&T program as specified in the FAST Act.

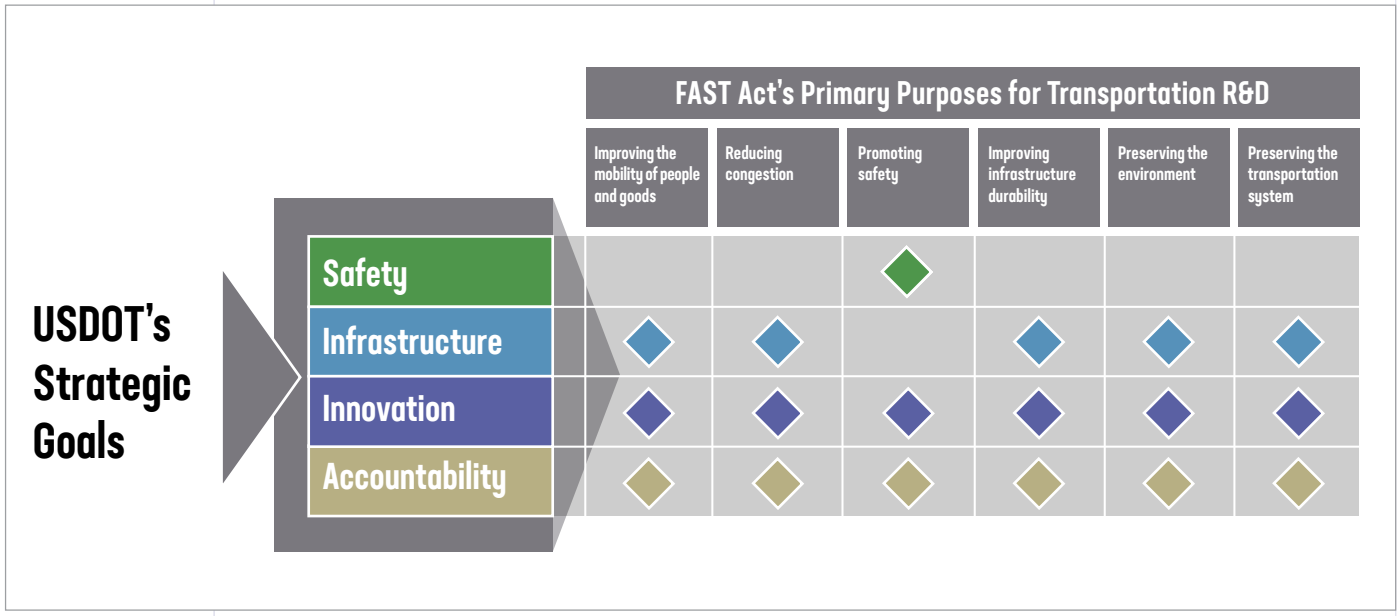



**Figure 1. Crosswalk of the FAST Act's Primary Purposes and DOT's Strategic Goals**

## DOT Research Principles

The RD&T Strategic Plan is consistent with the four research principles that help guide DOT research investments. The Department's "Principles Guiding Department of Transportation Research Investments" defined these research principles, which are described in detail in section 2 of this plan.

## Annual Modal Research Plans

The RD&T Strategic Plan serves to guide the development of Annual Modal Research Plans (AMRPs). The FAST Act requires that each Operating Administration and Joint Program Office complete an AMRP that provides a comprehensive plan for research in the upcoming fiscal year and a detailed outlook for the following fiscal year.

## Annual Department R&D Funding Reports and Performance Plans/Reports

This RD&T Strategic Plan also guides annual R&D funding reports and performance plans/reports required under 49 U.S.C. 6502. These requirements are described in greater detail in section 4.

Figure 2 summarizes the documents that guide DOT research efforts and associated reporting, as described above. These include the goals for DOT research set forth by Congress in the FAST Act, as well as the strategic goals and research priorities set forth by this Administration.

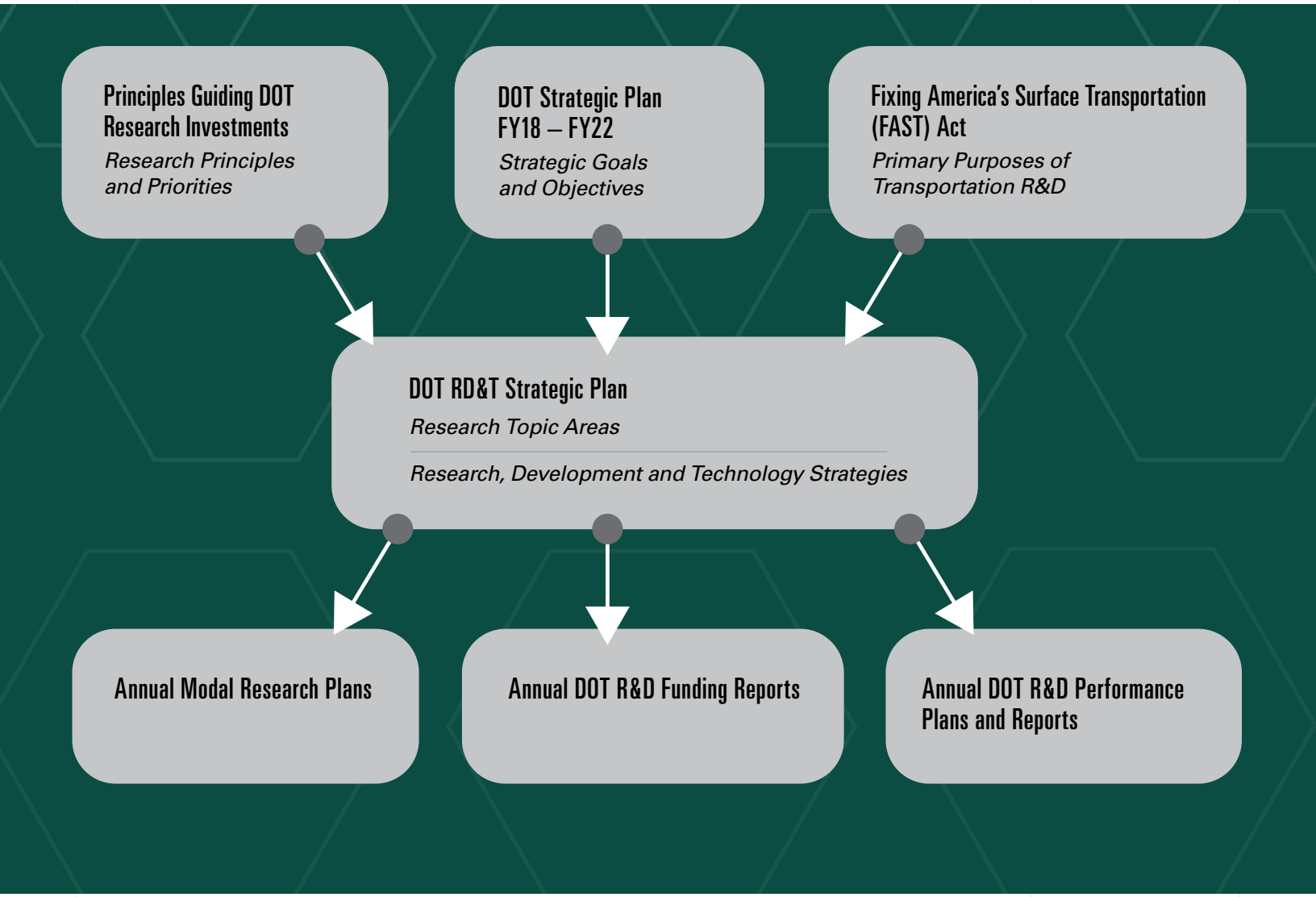
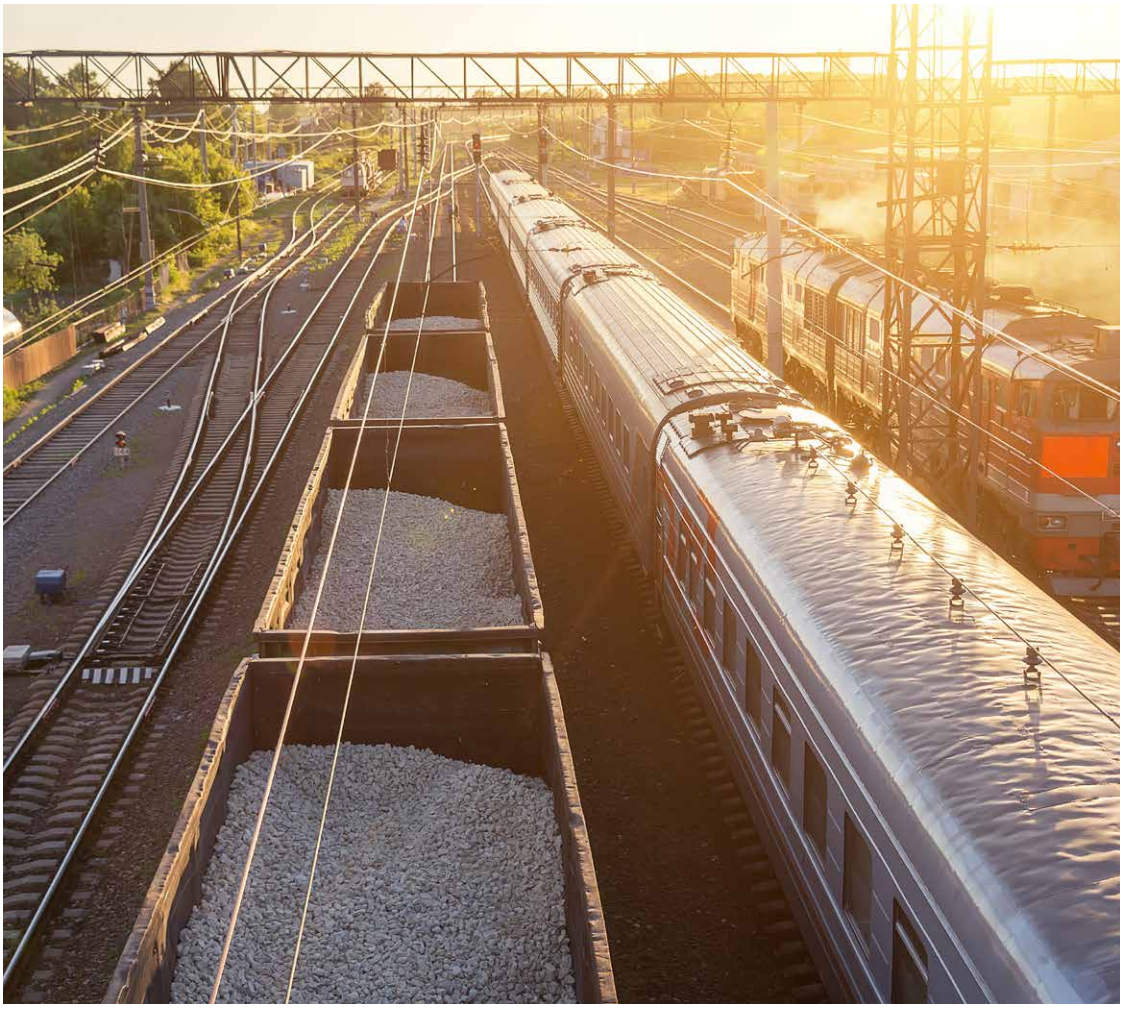



**Figure 2. U.S. DOT Research Guiding Documents**

## Plan Organization

The subsequent sections of this RD&T Strategic Plan are organized as follows:

- **Section 2** provides an overview of the Department's research programs and the principles and priorities that guide those programs.
- **Section 3** describes the RD&T strategies that the Department will use to meet its strategic goals of Safety, Infrastructure, Innovation, and Accountability.
- **Section 4** explains how the Department will implement this RD&T Strategic Plan over the next five years, through subsequent AMRPs and other FAST Act requirements, and how the Department's OAs intend to evaluate the performance of their RD&T strategies.



# DOT Research Principles and Programs

## Research Principles

The purpose of DOT's research is to identify and address issues of national significance that cannot or will not be addressed by other research sponsors, including issues that involve high-risk, long-term, research and areas of specific Federal responsibility. In this role, the DOT shapes and executes an effective national research and development, deployment, and training program that helps to solve transportation challenges. To meet this purpose, the Department has defined a set of four research principles to guide its future research investments, as defined in a memorandum titled "Principles Guiding DOT Research Investments."

1 **Support topical DOT priorities.** Where applicable, efforts should be made on areas of immediate importance. DOT topical research priorities are described in table 1 on the next page. Furthermore, each mode is expected to study the economic impact of reforming its respective regulations.[2]

2 **Avoid pitting safety and mobility against each other.** Both safety and mobility are central to the concept of transportation.[3] Projects may focus on safety or mobility or both, or seek to resolve apparent conflicts, but should avoid pitting them against each other.

3 **Focus on market failures.** DOT should avoid research that can be or already is being undertaken by private actors. DOT research should address market failures, which may include system safety; multimodal improvements; interoperability; underserved populations; long-term deliverables; and unfavorable risk profiles.[4] Also, DOT research can play a useful role on national security and national competitiveness.[5]

4 **Maximize value and avoid duplication.** DOT research should focus on efforts that are broadly useful instead of being overly applied.[6] This may include an emphasis on basic and early-stage applied research.[7] Technology transfer (T2) is also a key value-add: where possible, research should have an active commercialization or T2 component to help the research achieve its highest and best use. The performance of research investments and T2 applications should be tracked and evaluated using quantitative metrics that link directly to strategic goals and objectives, to ensure that maximum value is being maintained.[8]


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**Table 1. DOT Topical Research Priorities**

### Regulatory Reform

DOT research supports the Administration's reform goals by helping to understand the economic impact of regulations, identifying and removing unnecessary regulatory barriers, and providing tools and data to streamline regulatory oversight and compliance activities.

### Permitting Reform

DOT research seeks to understand the economic impact of delays to project delivery caused by the National Environmental Policy Act (NEPA) and permitting processes. DOT research also supports the development of tools and reforms designed to reduce delays and accelerate the delivery of transportation projects.

### Performance-Based Safety Rules

DOT research supports the use of scientific methods and data-driven processes to guide safety programs, reduce prescriptive regulations, and enable innovative approaches to improving safety.

### Value Capture

DOT research is exploring the potential impact of innovative approaches to financing transportation. Value capture is a type of public financing that recovers some or all of the value that public infrastructure generates from adjacent private landowners that benefit from the infrastructure.

### Asset Recycling

DOT supports approaches that use existing assets to fund necessary infrastructure. DOT research will assess the potential of asset recycling, which uses proceeds from the sale or lease of existing public assets to the private sector to finance public investments in infrastructure and vehicles.

### Freight Mobility

To improve the mobility, efficiency, and safety of freight movement, DOT research supports the development of innovative freight technologies, data, and processes.

### Microtransit

DOT research will explore the feasibility of microtransit, a form of public transportation characterized by flexible routing and scheduling of shared-ride vehicles operating according to passenger needs.

### Underserved Communities

DOT research is designed to improve the mobility of people with disabilities, economically disadvantaged, older persons, and to help rural and other underserved communities. DOT researches transportation needs and develops appropriate technologies and policies to meet those needs.

### Cybersecurity

DOT is pursuing research to understand and address cybersecurity vulnerabilities related to the deployment of connected and automated transportation technologies and systems.


Credit: Volpe Staff Art

## Research Program Overview

The Department's eight OAs and the Intelligent Transportation Systems Joint Program Office conduct the majority of DOT's research activities. These agencies are listed below:

- Federal Aviation Administration (FAA)
- Federal Highway Administration (FHWA)
- Federal Motor Carrier Safety Administration (FMCSA)
- Federal Railroad Administration (FRA)
- Federal Transit Administration (FTA)
- Maritime Administration (MARAD)
- National Highway Traffic Safety Administration (NHTSA)
- Pipeline and Hazardous Materials Safety Administration (PHMSA)
- Intelligent Transportation System Joint Program Office (ITS JPO)

Each OA has its own mission, statutory requirements, and funding sources. Each OA develops an AMRP that describes how it intends to address the Department's strategic goals and priorities in the coming fiscal year. As mandated by the FAST Act, these AMRPs must also align with this RD&T Strategic Plan. Figure 3 describes the missions of the Department's OAs and joint program offices and summarizes the range of entities with which they engage.

### Federal Highway Administration

The Federal Highway Administration (FHWA) is responsible for providing stewardship over the construction, maintenance, and preservation of the Nation's highways, bridges, and tunnels. Through research and technical assistance, the FHWA supports its partners in Federal, State, and local agencies to accelerate innovation and improve safety and mobility.

### Federal Motor Carrier Safety Administration

The Federal Motor Carrier Safety Administration's (FMCSA) mission is to reduce crashes, injuries, and fatalities involving large trucks and buses. FMCSA partners with industry, safety advocates, and State and local governments to keep the Nation's roads safe and improve commercial motor vehicle (CMV) safety through regulation, education, enforcement, research, and technology.

### Federal Aviation Administration

The Federal Aviation Administration (FAA) provides the safest and most efficient aviation system in the world. Annually, FAA manages over 54 million flights, approaching a billion passengers.

### Federal Railroad Administration

The Federal Railroad Administration's (FRA) mission is to enable the safe, reliable, and efficient movement of people and goods for a strong America. FRA is advancing the use of new technology in rail.

### Federal Transit Administration

The Federal Transit Administration (FTA) provides financial and technical assistance to local public transit systems, including buses, subways, light rail, commuter rail, trolleys, and ferries. FTA also oversees safety measures and helps research next-generation technologies.

### Intelligent Transportation Systems Joint Program Office

The Intelligent Transportation Systems Joint Program Office (ITS JPO) leads collaborative and innovative research, development, and implementation of intelligent transportation systems technologies to improve safety and mobility for all.

### Maritime Administration

The Maritime Administration (MARAD) promotes the use of waterborne transportation and its seamless integration with other segments of the transportation system, and the viability of the U.S. merchant marine.

### National Highway Traffic Safety Administration

The National Highway Traffic Safety Administration's (NHTSA) mission is to save lives, prevent injuries, and reduce the economic costs of road traffic crashes through education, research, safety standards, and enforcement activity. NHTSA carries out highway safety programs by setting and enforcing safety performance standards for motor vehicles and equipment, identifying safety defects, and through the development and delivery of effective highway safety programs for State and local jurisdictions.

### Pipeline and Hazardous Materials Safety Administration

The Pipeline and Hazardous Materials Safety Administration (PHMSA) protects people and the environment by advancing the safe transportation of energy and other hazardous materials that are essential to our daily lives. To do this, PHMSA establishes national policy, sets and enforces standards, educates, and conducts research to prevent incidents.

**Figure 3. Missions of USDOT Operating Administrations and Joint Program Offices**

## Research Coordination—the Role of the Office of the Assistant Secretary for Research and Technology (OST-R)

Housed in DOT's Office of the Secretary, the Office of the Assistant Secretary for Research and Technology (OST-R) plays a lead role in research coordination within the Department and with a wide range of national and international stakeholders. OST-R focuses on three priority areas:

### 1. Coordination, Facilitation, and Review of the Department's RD&T activities

By law,[9] the Secretary is responsible for coordination, facilitation, and review of the Department's RD&T programs and activities. OST-R executes this mandate by:

- Collecting, synthesizing, and disseminating information and statistics on DOT's RD&T activities and its products to ensure that all Open Science, Public Access, and other research funding and product transparency mandates are met (Open Science is the movement to make scientific research and its dissemination accessible to all. Increasing public access to scientific data and research findings generated by Federal agencies, or resulting from Federally funded research, is a U.S. policy priority).
- Reviewing modal research plans through the RD&T Review and Approval Process to ensure that the Department's research portfolio is consistent with this strategic plan and does not duplicate significant aspects of other research efforts in the Department.
- Providing the organizational frameworks necessary for effective interaction between the Operating Administrations.
- Promoting best practices for Departmental research management and technology transfer.

The core coordinating body is the RD&T Planning Team, composed of the senior research directors from each of the Operating Administrations and chaired by the Director of OST-R's Office of RD&T. The Planning Team meets monthly to discuss and coordinate research activities underway around the Department. Operating Administration representatives provide regular updates on their agency's research activities to the group, facilitating research coordination and allowing potential opportunities for interagency collaboration to be identified.

As part of OST-R, the Volpe Center also plays a key role in facilitating research coordination and collaboration, partnering with the Department's Operating Administrations on a wide range of transportation research topics.

### University Transportation Centers (UTC) Program:

The UTC program is a congressionally mandated financial assistance program that provides grants to universities to conduct research on critical transportation issues and to support education activities for the next generation of transportation professionals.

This program was funded through FY 2015 under the Moving Ahead for Progress in the 21st Century (MAP-21) Act, and was reauthorized in the FAST Act, which authorized the Office of the Assistant Secretary for Research and Technology to award $72.5 to $77.5 million in grants to UTCs annually through FY 2020. The program currently supports 35 multi-year university-based centers that conduct workforce development and basic and applied research, the products of which are judged by peers or other subject matter experts and are made available through technology transfer to the transportation industry.

With the passage of the FAST Act, U.S. DOT received authorization for the next round of UTC competition. The FAST Act authorized the competitive selection of up to 35 new centers to receive funding from FY 2016 through FY 2020 to conduct research activities that address the six primary purposes referred to in the FAST Act.

## DOT RD&T Review and Approval Process:

DOT has established a research review and approval process to ensure that the Department's research portfolio is a consistent with this strategic plan and does not duplicate significant aspects of other research efforts in the Department. OST-R is responsible for the review process in partnership with the Office of the Assistant Secretary for Budget and Programs and the Office of the Under Secretary for Policy. The AMRP documents are used for the review in conjunction with project spend plan information submitted by the DOT Operating Administrations prior to the commencement of the fiscal year.

Each Operating Administration and Joint Program Office is responsible for monitoring and evaluating the performance of their RD&T strategies. Biannual briefings from modal administrations to OST-R are conducted to review progress made on research plan implementation.

DOT has established a set of quantifiable performance metrics on research and development and technology transfer. Through the DOT Annual Performance Plan and Report, the DOT reports on these metrics, which focus on the development of innovations in transportation through DOT research and the deployment of new technologies and innovative practices to support the performance of the transportation system.

Key innovation performance metrics include the following:

- Research Laboratory Utilization Rates
- Research Outcomes Made Publicly Available in Research Hub
- Technical Reports Made Publicly Available in the National Transportation Library
- Technologies Toward Implementation (Pilots and Demonstrations)
- Success Stories (Evidence of Societal Benefits)

### 2. Aligning Departmental Research with other Secretarial Office Functions

OST-R's elevation to a Secretarial Office in 2014 facilitated a closer linkage between research and the Department's other Secretarial Office functions, such as policy and budget development. OST-R's role is to promote Departmental research within the Office of the Secretary (OST) and act as a liaison between the Operating Administrations and the other Secretarial Offices. OST-R works with OST-Budget on research budget development, and works with OST-Policy and the staff of the Secretary and Deputy Secretary to ensure that the research portfolio is effectively aligned with the Department's Strategic Goals and Administration initiatives.

### 3. Engaging External Stakeholders

OST-R represents U.S. DOT research activities to governmental groups including Congress, the White House, and other Federal agencies, and engages other transportation research entities on behalf of the Department. This role includes coordinating external requests that require a Department-level response, organizing and chairing briefings to members of Congressional Committees, formal reporting on Departmental research activities, and developing Departmental research policies in response to Executive Orders and legislative direction. This OST-R function supplements the extensive engagement activities conducted by each of the Operating Administrations. Such activities allow the Nation's transportation research enterprise to move forward coherently and economically.

## Duplication in Research:

More than $1 billion of public money is spent on Federally funded transportation research by U.S. DOT every year. The FAST Act requires the Secretary of Transportation to certify each year that there is no duplication of research directed, commissioned, or conducted by DOT except to the extent that the research:

1) Is required by an Act of Congress;

2) Is part of a contract funded before enactment of the FAST Act;

3) Updates previously commissioned research; or

4) Is necessary according to the Assistant Secretary for Research and Technology who must provide a certification to that effect with a justification.

Some duplication may be needed to validate research results. Duplication can corroborate a new result or reaffirm a prior finding. For example, several studies might be needed to find the optimal type of asphalt to reduce potholes under different weather conditions, or the optimal levels of tolls to keep traffic flowing. However, if validation is the purpose of a proposed research, it should be stated explicitly during early scoping efforts and in all documentation.

Furthermore, duplication may be less than complete, meaning that similar research projects may include some but not all the same elements. Partial duplication of research may not be wasteful when it is conducted in different contexts and likely to produce differentiated results with varying applications. It is important for people conducting similar research to be aware of what others are doing so they can adapt their research to complement one another and draw on one another's data, methods, or findings. Temporal and spatial aspects can also provide a legitimate need for work that initially appears duplicative; the same study conducted at a different time or in a different location can often yield new and valuable findings.

A key consideration is whether both the research sponsor and the research performer are fully aware of any duplicative aspects of a proposed study. If the necessary awareness exists, the likelihood of redundant research activity is eliminated. With this in mind, OST-R's role in preventing wasteful duplication is to:

1) Facilitate the widest possible awareness and coordination of research among (i) the different recipients of research funding under DOT's auspices (intramural research), (ii) DOT funded researchers and others throughout the Government, the States, and major independent research organizations (extramural research); and

2) Identify similar research projects and activities, determine whether they should continue for purposes of validation or reaffirmation, be terminated for redundancy, or whether they can be modified, integrated, or coordinated to produce incremental net benefits. The key evaluation criterion for funding research is whether it has the potential to add more value than it costs.

# Research, Development & Technology Strategies

This Strategic Plan describes the DOT's RD&T objectives and strategies by DOT strategic goal and research topic area. As indicated in figure 4, the 12 research topic areas are aligned with the four DOT strategic goals and represent common research focus areas and opportunities for future cross-modal coordination for the Department. These research topic areas and associated RD&T objectives and strategies are described in greater detail below.

## USDOT's Strategic Goals and Related Research Topic Areas

### Safety

**Automation:**
Enable the safe integration of automated vehicles and unmanned aircraft systems into the transportation system.

**Systemic Safety Approach:**
Use systemic, performance-based approaches to ensuring transportation system safety.

**Human Factors:**
Ensure the integration of human factors into the design of the transportation system.

### Infrastructure

**State of Good Repair:**
Maintain transportation assets in a state of good repair, ensure resilience to natural and man-made threats, and optimize material cost and durability.

**Environmental Stewardship:**
Preserve the environment, ensure the safety and cost-effectiveness of alternative transportation energy sources, and ensure the safe transportation of hazardous materials.

**Economic Competitiveness:**
Stimulate economic growth, productivity, and competitiveness through transportation infrastructure investments.

### Innovation

**Emerging/Enabling Technologies:**
Advance the development of emerging/enabling practices and technologies.

**Mobility Innovation:**
Use innovative business models, partnerships, and private-sector solutions to expand mobility options for travelers, including including underserved communities such as people with disabilities, economically disadvantaged, older persons, and rural residents.

**Cybersecurity:**
Develop approaches for maintaining the cybersecurity of the transportation system.

### Accountability

**Technology Transfer/ Deployment:**
Facilitate the deployment and adoption of DOT research products into the transportation system.

**Evaluation/Performance Measurement:**
Monitor and evaluate the contribution of research, development, and technology activities toward the achievement of DOT strategic goals and objectives.

**Data:**
Ensure access to high-quality data to support data-driven technologies, operations, and decision-making.

**Figure 4. DOT's Strategic Goals and Related Research Topic Areas**

DOT has established working groups within each of these 12 topical research areas. Each working group is assigned to an OA or OST office and chaired by a representative from that OA/office. Working group membership is composed of representatives from each OA and OST office working within that topical research area, with membership selections based on recognized expertise within the topic area and/or broad awareness of research activities within the topic area. The groups have been designed to raise awareness of research activities underway across DOT, and across the wider transportation research field outside DOT, in order to eliminate duplicative research efforts and to identify cross-modal research needs for future funding consideration. This "bottom up" approach to cross-modal research coordination complements the "top down" approach led by OST-R through the new DOT RD&T Research Review and Approval Process.

## Strategic Goal: Safety

Safety remains a major challenge for our Nation's transportation system, and it is DOT's top priority. Across all modes of transportation, nearly 40,000 lives were lost in 2018. The vast majority of transportation-related fatalities occurred on our Nation's roadways. In 2018, 36,560 people died in motor vehicle crashes, a decrease of almost 2.4 percent from 2017.[10] Increasing seat belt use and improved vehicle safety technology have contributed to a significant reduction in traffic fatality rates over the past 40 years; however, motor vehicle crashes remain one of the leading causes of death for Americans. Dangerous actions such as speeding, distracted driving, and driving under the influence are still putting many Americans at risk. Rural vehicle fatality rates are 2 times higher than in urban areas, while pedestrian and cyclist deaths have increased as a proportion of traffic fatalities in recent years.[11] Though fatalities in other modes are less common, safety risks persist—particularly in areas such as general aviation, highway-rail grade crossings, and railway trespassing.

Advances in technology, engineering, and human factors research are providing new insights into how DOT can address transportation safety issues. Rapidly advancing connected and automated vehicle technologies, for example, have the potential to dramatically reduce the number of crashes with fatalities or serious injuries. In aviation, runway safety improvements and technology have saved countless lives by reducing the risk and consequences of runway incursions and excursions. In addition, the Next Generation Air Transportation System (NextGen) is improving the safety of aviation by digitizing communication and navigation systems of the national airspace. The deployment of positive train control is helping to improve the safety of rail transportation. In addition, across all modes, improvements in safety data sources and analysis tools support better safety management processes.

### Research Topic Area: Automation

The integration of automation technologies across our transportation system has the potential to improve safety dramatically by reducing crashes caused by human choice or error. In recent years, the private sector has invested heavily in advancing the development of commercial automation technology. The Department's targeted research in this area aims to develop policies and other guidance and safety assessment methods to assure the safety of automation and accelerate its integration into the transportation system. Departmental research evaluates the safety and performance of automated vehicles to assess their impacts on users, infrastructure, congestion, and the environment. Due to its significant potential to improve safety, automation research supports the Department's safety goal while also contributing to achievement of the Department's innovation goal.



Research objectives supporting the Automation cross-modal topic area are as follows:

- **Automated Driving Systems:** Conduct research to support the safe deployment of automated driving systems.
  - > Assess regulatory barriers to the safe and efficient development, testing, and deployment of automated vehicles.
  - > Develop approaches to testing and certifying the safety of automated vehicles.
  - > Support field tests, pilots, and demonstrations of automated vehicles to understand how they perform in a mixed-road user environment.
  - > Test and evaluate the safety of automated commercial motor vehicles (CMVs) and truck platoons and support their deployment.
  - > Identify and evaluate infrastructure design and operational practices that address the needs of automated vehicles while ensuring the safety of all road users.
  - > Conduct research into the safe packaging, carriage, and transport of hazardous materials by automated vehicles.

### Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0

The White House and the U.S. Department of Transportation developed AV 4.0, building upon previous versions of Federal AV guidance, to coordinate efforts across the Federal government and provide high-level guidance to Federal agencies, innovators, and the public on the U.S. posture toward AVs. AV 4.0 establishes Federal principles for the development and integration of automated vehicles, consisting of three core focus areas: prioritize safety and security, promote innovation, and ensure a consistent regulatory approach.

- **Multimodal Applications of Automation Technologies:** Foster innovation and address barriers to deployment of automation technologies in rail, transit, and marine transportation.
  - > Identify and address barriers to the development and deployment of automated bus transit.
  - > Foster innovation, technology, automation, and autonomous operations in the maritime industry.
  - > Develop technologies that will leverage positive train control (PTC) system functionality to enable automated train operation.
- **Unmanned Aerial Systems:** Advance the safe integration of unmanned aircraft systems (UAS) into the National Airspace System (NAS).
  - > Support the development of regulations, policies, procedures, guidance, and standards for UAS operations.
  - > Develop UAS detection and mitigation technologies.
  - > Explore applications of UAS to improve the efficiency and effectiveness of the construction, operation, and maintenance of infrastructure.
  - > Explore the potential of UAS to improve rail worker safety in public transit.

## Research Topic Area: Systemic Safety Approach

Research and data help decision makers understand the systemic causes of transportation safety challenges and prioritize investments. Systemic and performance-based approaches to safety help ensure efficient and timely detection of critical safety hazards. However, these approaches will not work without reliable data, effective analytical tools, and a broad understanding of risk management practices. DOT research investments look to make improvements in these areas and provide a foundation for systemic, performance-based approaches to improving safety.

### Strategic Transit Automation Research (STAR) Plan

The Strategic Transit Automation Research Plan, published in 2018, outlines an FTA research agenda for transit bus automation over five years. The plan provides a framework for the transit industry to pursue transit bus automation in a safe, efficient, and economically sound manner. Built on a foundation of stakeholder engagement, use case analysis, and an extensive literature review, the plan defines activities in the areas of Enabling Research, Integrated Demonstrations, and Strategic Partnerships. The plan's continued emphasis on stakeholder engagement, knowledge transfer, and technical assistance ensures that complementary work being done by the public sector, the private sector, and academia is effectively communicated.




### Systemic Safety Approach: Safety Data Initiative

The Department's Safety Data Initiative seeks to develop new and integrated data sources, analysis, and visualization techniques to enhance our understanding of crash risk and our ability to mitigate it. The initiative seeks to build DOT's capacity to translate the successes of predictive data analytics tools used by private industry and universities to identify systemic factors contributing to serious crashes. The initiative has three goals: 1) to make data analysis and insights accessible to policy makers through clear, compelling data visualizations; 2) to integrate existing DOT databases and new private-sector data sources to answer safety questions; and 3) to use advanced analytic techniques to identify risk patterns and develop insights that anticipate and mitigate safety risk to reduce injuries and fatalities.

Research objectives supporting the Systemic Safety Approach cross-modal topic area are as follows:

- **Performance-Based Regulatory Standards and Safety Management Systems:** Support the use of safety management systems and performance-based safety standards, policies, and programs.
  - > Develop safety data collection methods, data integration and analysis techniques, and advance safety data and risk analysis techniques to support risk-based decision-making capabilities.
  - > Develop the scientific basis for performance-based regulations.
  - > Research potential voluntary standards to increase safety culture and improve safety in public transit systems.
  - > Conduct research to support potential regulatory reform and relief.

## Research Topic Area: Human Factors

Human choice or error causes or contributes to the majority of all transportation safety incidents.[12] DOT human factors research investigates sources of these human errors, such as fatigue, impairment, operator performance, and fitness for duty. In an era of rapidly evolving transportation technologies, DOT research on human factors such as distraction and interaction with technology, as well as potential misunderstanding or overestimation of the capabilities of new technologies, has also grown in importance. Human factors are a key component of DOT's automation research.

Research objectives supporting the Human Factors cross-modal topic area are as follows:

- **Accelerate Technology Integration:** Conduct human factors research to accelerate the integration of new technologies.
  - > Conduct human factors research in areas including advanced vision systems and sensor-based technologies, avionics and new technologies, physiological limitations, risk mitigation, and weather systems and displays.
  - > Study human factors such as operator impairment, team coordination, and the safe integration of people with technology.
  - > Assess how people respond to changes in roadway environments using data from driving simulators, field research vehicles, sign laboratories, test tracks, and naturalistic studies.
  - > Conduct research to support the design of effective human-machine interfaces and system design and operating procedures, and associated training, guidelines, rules, and standards.

- **Human Factors and Safety:** Study human factors in transportation safety.
  - > Conduct research on strategies for influencing operator behavior to inform national safety programs, provide guidance to State and community safety officials, and develop training and education programs.
  - > Study the effects of operator fatigue and provide educational materials to drivers to learn about how fatigue affects the safe operation of CMVs.
  - > Conduct pilot trials and studies to improve safety and organizational culture in the transportation industry.
  - > Identify performance measures to support the analysis of the safety impacts of interactions with advanced automation. Examples include driver assistance and driving automation systems, including the information needs of persons with disabilities as well as pilot control stations for unmanned aircraft systems.

### Human Factors: Trucking Fatigue Meter

FMCSA has developed the Trucking Fatigue Meter, a technology that uses existing streams of trucking data to assess driver fatigue. The tool provides objective quantitative feedback to truck drivers, dispatchers, and safety managers about fatigue stressors common in commercial motor vehicle operations (e.g., chronic sleep deprivation, extended duty hours, and night work). The tool gives safety managers an assessment of overall fatigue of drivers in their fleet. It also provides drivers with guidance on optimal times to drive, take a break, and sleep.

### Human Factors: Intermodal Collaboration on Human Factors Research

The Department's OAs coordinate human factors research through the DOT Human Factors Coordinating Committee, which serves as a collaborative, multimodal team to address crosscutting human factors issues in transportation. There are many other examples of intermodal coordination and collaboration on human factors research. FMCSA, NHTSA, and FHWA are working together to conduct a systematic review of crash factors and to develop potential crash countermeasures. Researchers will examine data from a wide range of sources to gain a better understanding of driver behaviors that precipitate a crash, such as distraction and fatigue. NHTSA, FHWA, and ITS JPO are coordinating on human factors studies aimed at improving our understanding of safe operations of connected and automated vehicles. FRA is conducting research that seeks to incorporate lessons learned from FAA's Aviation Safety Information Analysis and Sharing system. This research will promote the exchange of information to support continuous improvements to safety.

## Strategic Goal: Infrastructure

Public agencies face major challenges maintaining infrastructure in a state of good repair, ensuring the resilience of infrastructure to disruptions caused by disasters and extreme weather, and making targeted investments to support economic competitiveness and growth. This is a top priority for the Administration, as noted in Office of Management and Budget (OMB) Memo M-17-30, detailing Federal R&D priorities for FY19.[13] Insufficient and inefficient investments have led to increased congestion, deteriorating conditions, and growing maintenance backlogs.[14] Slow and inefficient environmental review and permitting processes make the delivery of infrastructure projects more costly, unpredictable, and time-consuming. Departmental research supports technologies and policies that can help transportation agencies maximize the effectiveness of transportation investments to reduce congestion, improve the state of good repair, and increase the resilience of our transportation system.


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### Research Topic Area: State of Good Repair

The Department supports research that aims to accelerate adoption of innovative materials, structures, designs, and construction methods for infrastructure. The Department also researches transportation asset management and maintenance to help extend the life of assets. This research helps to reduce maintenance costs, accelerate construction, and improve conditions. By extending the life of infrastructure and reducing the amount of time assets are under construction and repair, such research can also reduce delays and associated safety hazards.

Research objectives supporting the State of Good Repair cross-modal topic area are as follows:

- **Advanced Materials, Designs, and Technologies:** Support the development and application of advanced materials, designs, and technologies to improve durability, extend the life, and reduce the maintenance needs of infrastructure.
  - > Develop and evaluate advanced materials that enable new infrastructure designs, improve structural resilience, and accelerate construction and repair.
- **Risk-Based Asset Management:** Advance the understanding of infrastructure performance and research ways to improve risk-based asset management and maintenance practices to extend the life of infrastructure.
  - > Help decision makers assess vulnerabilities and integrate resiliency considerations into transportation planning, asset management, project development, and design processes.
  - > Assess future levels of exposure of infrastructure to extreme weather events, including changes in precipitation patterns, extreme temperatures, and cyclonic storm surges and waves.

> Assess the efficacy of "health" monitoring techniques of transit assets using advanced technologies to include sensors and the use of innovative construction techniques and new materials such as nanoparticles, recycled polymers, and composites.

- **Infrastructure System Resilience:** Infrastructure across the country faces risks associated with natural disasters, extreme weather, and security risk events. Addressing the risk of damage and disruption caused by such events is essential in ensuring the continued integrity of our transportation system.
  > Develop approaches for assessing the vulnerability of infrastructure and transportation systems.
  > Improve estimations of current and future risks to transportation systems posed by exposure to extreme weather events.
  > Assess current strategies and tools to support resilience analysis and mitigation and encourage the adoption of effective approaches across modes.
- **Advanced Inspection Tools:** Develop innovative inspection technologies that use advances in sensor systems, automation technologies, wireless communications technologies, and robotics including UAS to make inspection and oversight processes safer and more efficient.
  > Improve the use of advanced sensor systems, analytical techniques, and data visualization techniques to support early identification of structural deficiencies and infrastructure deterioration that may yield relatively low-cost solutions.

### State of Good Repair: FRA Track Autonomous Inspection Program

Decreasing derailments can significantly improve freight mobility and improve the costs of service. The industry currently uses frequent track inspections as a method of decreasing derailments, but track inspections require significant personnel time and can disrupt train operations. The FRA's autonomous track inspection program works to improve the quality and coverage of inspections using automation. This program decreases the amount of track inspection time by using revenue-service trains as the inspection vehicles and advanced analytics to process data to determine safety risk. This decreases the time and cost associated with the inspection process and increases safety through improved capability to detect defects and prioritize track repair.

## Research Topic Area: Environmental Stewardship

Through environmental research, the Department seeks to develop innovative approaches to improve the sustainability and resilience of transportation infrastructure and expedite the environmental review process. The Department aims to develop approaches that support evidence-based decision-making regarding the environmental impacts of projects. Departmental research also looks to accelerate technology maturation and deployment, integrate resilience into asset management practices, improve the energy efficiency of vehicles, and advance the use of alternative fuels in transportation.

Research objectives supporting the Environmental Stewardship cross-modal topic area are as follows:

- **Accelerated Project Delivery:** Conduct research that supports environmental analysis, strengthens environmental decision-making, and accelerates the environmental review and permitting of transportation projects.
  > Expedite project delivery and reduce regulatory costs by improving environmental review and permitting processes.
  > Develop and refine analytical tools that can help decision makers understand the impacts of transportation decisions on air quality, noise, and travel demand to support performance-based decision-making and efficient project delivery while maintaining a healthy environment.

- **Alternative Fuels and Fuel Efficiency:** Conduct research to support the use of alternative fuels and the development of fuel-efficient and electric engines.
  - > Develop methods to safely use liquefied natural gas (LNG) as a fuel for locomotives and to safely transport LNG as a commodity in regular freight service.
  - > Test, evaluate, and demonstrate the viability of alternative fuels and technologies in shipping.
  - > Support the development and adoption of alternative fuel passenger vehicles, highway infrastructure and corridors.

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  - > Support the development and adoption of more fuel-efficient aircraft engines, alternative jet fuels, and an unleaded replacement for the gasoline used in general aviation.
  - > Develop and demonstrate the viability of alternative fuels and technologies in shipping.
  - > Support the development and adoption of low- and zero-emissions buses, facilities, and related charging and maintenance technologies to support their evaluation, certification, and eventual adoption by the transit industry.
  - > Evaluate the feasibility and implications of building inductive charging capability into highway infrastructure.
  - > Support research and development of standards and inspection procedures to address safe operation and maintenance of alternative fuel commercial vehicles.
  - > Reduce energy use of transit buses, reduce harmful emissions, and increase energy efficiency.
- **Hazardous Materials Safety:** Conduct research to improve the safety of hazardous materials transportation.
  - > Support hazardous materials research that identifies emerging risks, develops technologies, strengthens industry consensus standards, and promotes the use of new lessons learned by decision makers.
  - > Identify, test, and document the performance of new materials that will improve the thermal and mechanical performance of bulk packaging containing hazardous materials, including rail-cars, road trailers, tanks, and other bulk packages.

### Environmental Stewardship: Reducing the Environmental Impacts of Aviation

FAA's NextGen Environmental Research project looks to reduce the environmental impacts of aviation by developing tools and data to inform the development of engine and airframe technologies that reduce aircraft noise, fuel use, and emissions. This project is being conducted in partnership with industry through the Continuous Lower Energy, Emissions and Noise (CLEEN) program. With the support of the CLEEN program, the aviation industry can expedite the integration of technologies that reduce noise, emissions, and fuel use in current and future aircraft. CLEEN helps accelerate technologies through a crucial phase in their maturation, culminating in full-scale ground and flight test demonstrations and showing technology readiness for product implementation.

> Examine methods for improving emergency response and accelerating access to accurate information in hazardous materials incidents.

> Test the safety of high-voltage vehicles and their charging systems and evaluate the post-crash safety of lithium ion battery systems.

### Pipeline Safety: Improving Pipeline Leak Detection Systems

PHMSA research looks to create market-ready technology for improving systems that detect pipeline leaks. Improving these detection systems is important because liquid pipeline leaks, and even some ruptures, can go undetected for long periods of time and result in large releases of hazardous materials. PHMSA research will investigate the limitations of current computational pipeline monitoring systems to understand constraints from pressure and/or flow calibration, alarm management, and filtering and/or prioritization. Findings will facilitate the use of machine learning to assist with alarm management and protocol.

## Research Topic Area: Economic Competitiveness

DOT research supports the economic growth and the competitiveness of the American economy by improving the mobility of people and goods, and by ensuring a vibrant and highly skilled transportation workforce. Economic and policy research supported by the Department is critical in helping agencies maximize limited resources to spur growth and adapt to changes in transportation technologies and travel demand.

Research objectives supporting the Economic Competitiveness cross-modal topic area are as follows:

- **Advanced Propulsion Research:** Support the growth of American transit vehicle manufacturers of fuel-efficient low and no-emission technologies through demonstration programs and through low and no-emission component testing centers.
- **Performance-Based Infrastructure Investments:** Support informed, performance-based infrastructure investments.
  > Research data, models, and planning processes that enable performance-based planning in the areas of safety, asset management, economic resiliency, freight movement, transit systems, congestion management, system reliability, and air quality.
  > Support research that builds an understanding of how investment and land use, revenue constraints, demographic trends, economic shifts, and technological innovation can affect a State or region and its transportation system performance.
  > Develop and support the use of planning practices that consider housing, land use, and rapidly emerging changes in technology and mobility services.
  > Develop tools to assess the system performance and cost-effectiveness of transportation policies, programs, and investments.

- **Innovative Project Delivery:** Support the development and use of local transportation revenues and innovative project delivery methods.
  - > Identify and support innovative approaches to funding and procuring projects and generating revenue through researching effective strategies for tolling, value capture, project finance, and public-private partnerships.
  - > Conduct research on value capture to support the development of local public transit and highway revenues.

### Economic Competitiveness: Multimodal Connectivity

FHWA is studying multimodal connectivity to develop technologies, tools, analysis methods, and performance management approaches to improve multimodal mobility for all users. Findings will help support transportation agencies as they plan and develop multimodal infrastructure. It will also allow these agencies to more effectively analyze how projects affect the environment and urban and rural communities.

- **Innovative Freight Practices:** Support the use of effective freight plans, practices, policies, and programs.
  - > Identify and support the adoptions of innovative approaches to freight planning, freight infrastructure funding and development, and freight data collection and maintenance to enhance the movement of goods and support economic competitiveness.
  - > Support research to assess the condition and performance of key freight infrastructure and develop and improve analytical tools, data collection techniques and standards, and industry data analysis methods.
  - > Develop information and tools for efficient permitting and enforcement systems to harmonize oversize and overweight permitting requirements across States.
  - > Study safe deployment of truck platooning and automated CMV-related operations as well as the deployment of virtual weigh stations.
- **Transportation Systems Management and Operations (TSMO):** Support the development and adoption of TSMO strategies that use technology and data to improve roadway operations and reduce congestion.
  - > Develop data analysis and management support tools to improve the efficiency and effectiveness of operational decision-making.
  - > Develop, test, and evaluate proactive management strategies to manage disruptions to transportation systems operations from everyday events such as work zones, traffic incidents, planned events, and adverse weather.
- **Workforce Development:** Support the development of the transportation workforce.
  - > Analyze changes in the labor market for transportation operators and the relationship between labor, management, and safety to identify trends, skill gaps, skill demands, training opportunities, and industry best practices.
  - > Examine the potential impacts of automation on the transportation workforce.
  - > Develop training and technical assistance to enhance the skills of the transportation workforces and support the integration of new technologies.

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## Strategic Goal: Innovation

Robotics, artificial intelligence, sensors, mapping, and big data are transforming how people and goods move. Innovative transportation technologies are improving safety and mobility by automating operational functions and enabling timely communications between vehicles, infrastructure, and travelers. One result is the emergence of new services and forms of mobility. In addition, the deployment of advanced sensors combined with wireless communication technologies is generating enormous amounts of information about the conditions and performance of our transportation system that have the potential to inform better decisions by vehicles, drivers, and infrastructure owners, operators, and travelers alike. To support the development and deployment of innovative technologies such as these, the Department invests in targeted research, testing, and demonstration projects.

### Research Topic Area: Emerging/Enabling Technologies

The Department's research programs help analyze emerging practices and technologies and their potential impacts. Public investments in technology research help develop potentially beneficial technologies that may not be easily commercialized and support risk assessment, strategic planning, and policy development. In areas such as Intelligent Transportation Systems (ITS) and NextGen, for example, Federal research can assist decision makers in determining needs, setting standards, and developing policies that incentivize investment in effective technologies that improve the safety and efficiency of our transportation system. In addition, in areas of emerging transportation modes and services, Federal research is required to understand the opportunities and challenges of these services on system performance such as safety, mobility, and accessibility for freight and personal travel. The Department also supports exploratory research on innovations which could potentially transform the transportation system.

Research objectives supporting the Emerging/Enabling Technologies cross-modal topic area are as follows:

- **Intelligent Transportation Systems:** Advance the development and deployment of ITS through integration of advanced information and communication technologies.
  - > Conduct research on connected data systems.
  - > Pilot deployments of infrastructure and vehicle connectivity as well as mobile device data to enable enhanced performance-based systems management.
  - > Develop cooperative automation applications and data exchanges to enable automated vehicles to safely operate in work zones, around incidents, and to enable speed harmonization on freeways.
  - > Support the accelerated deployment of ITS for providing truck parking availability information in real time to truckers on the road.
- **NextGen Technologies:** Advance the development and deployment of NextGen technologies to optimize routes and procedures, enable more precise navigation and traffic control as well as improved communication.
  - > Improve computer systems and decision support systems for air traffic control facilities, including enhanced digital communications equipment, satellite-enhanced navigation systems, and improved weather forecasting and information systems.

### Emerging/Enabling Technologies: Evaluation of Cellular Vehicle-to-Everything and Fifth-Generation (5G) Communications

ITS JPO is conducting target research to more fully evaluate the capabilities of current Wi-Fi and long-term evolution (LTE) communications and prepare for the deployment of fifth-generation (5G) communications in 2020. ITS JPO is partnering with automotive firms, tier one suppliers, and chipset manufacturers to assess new communications innovations. To assess the potential benefits of new communications technologies, ITS JPO will conduct performance testing of cellular vehicle-to-everything (C-V2X) communications. This research will also analyze and provide input as cellular communications evolve from LTE to 5G networks, which will allow the Department to better assess impacts on the transportation system.

## Research Topic Area: Mobility Innovation

Through innovative technologies and facilitating public-private partnerships, the Department seeks to improve mobility options for all travelers, including travelers with disabilities, travelers from rural areas, and lower-income travelers.

The DOT has an important role in supporting mobility service providers, State and local governments, mobility managers, providers of public transportation, and owners and operators of the transportation system, as they navigate through the dynamic, evolving mobility ecosystem. The DOT can take the lead in modernizing regulations, technical assistance, policies, and procedures and investigating these emerging technologies and new opportunities to ensure that mobility innovation continues to support strong economic growth, and that all users can benefit from high-quality mobility choices to connect with their lives, businesses, communities, and opportunities.

Research objectives supporting the Mobility Innovation cross-modal topic area are as follows:

- **New Models for Access:** Study the use of innovative business models and technologies in which public and private transportation assets expand access and improve mobility for Americans, including people with disabilities, older Americans, and rural and economically disadvantaged communities.
  - > Explore new public transportation mobility service models, how they are being implemented, and how communities can take advantage of these new technologies and service models to expand travelers' mobility while reducing operational costs.
  - > Conduct research on policies, technologies, and business models that have the potential to expand accessibility and mobility services to underserved communities.
  - > Enhance the capability of travelers with mobility, sight, hearing, and cognitive disabilities to go where they want to go safely and independently by providing wayfinding and navigation applications, pre-trip concierge and virtualization services, improved safe intersection crossing for travelers needing additional help, and assistive robotics and automation applications.
  - > Research integrated payment models to promote the adoption of multimodal payment options for transit agencies and other mobility providers at the regional and interregional levels. Such payment systems facilitate and increase seamless traveler experiences and data availability, thus improving overall systemwide mobility, efficiency, and performance.

### Mobility Innovation: Mobility Access and Mobility for All Summit

In October 2019, the U.S. DOT hosted the Access and Mobility for All Summit at its headquarters in Washington, DC. The purpose of the Summit was to raise awareness of DOT and government-wide efforts to improve access and mobility for people with disabilities, older adults, and individuals of low income. The Summit aimed to identify priority Federal and non-Federal activities and innovations that can provide more efficient, affordable, and accessible vehicles and mobility services such as transit and ridesharing. At the Summit, U.S. DOT announced several initiatives including: a Complete Trip Deployment Program to enable communities to identify and address accessibility issues; an Inclusive Design Challenge to generate design solutions to enable accessible automated vehicles; and, a Mobility for All Pilot to address transit service gaps and provide more efficient service to underserved populations in rural and small urban areas.

- **Needs of Rural Americans:** Conduct research to understand and meet the transportation needs of rural populations.
  - > Assess barriers to private-sector investment and identify opportunities for improved access, mobility, and safety for rural system users.
  - > Develop data-driven safety plans and provide tools and technical assistance to reduce rural roadway departures, which account for a disproportionate number of roadway fatalities.
  - > Conduct rural pilots and demonstrations of advanced transportation technologies, such as corridor freight platooning, curve warning systems, and animal intrusion detection and warning systems.
  - > Conduct research on technologies that enable safe and reliable general-aviation flights to remote areas.

### Mobility Innovation: Rural Opportunities to Use Transportation for Economic Success (ROUTES)

Rural Opportunities to Use Transportation for Economic Success (ROUTES) is an initiative to address disparities in rural transportation infrastructure. Improving the way that DOT engages with rural project sponsors can tangibly enhance the safety and economic competitiveness of transportation infrastructure projects throughout the country. The new ROUTES initiative will work to provide rural project sponsors with pertinent and easy-to-use information about the Department's infrastructure programs, to help overcome resource challenges that can be an impediment to competitive applications.

### Mobility Innovation: Microtransit

FTA's mobility innovation research investigates the technical and institutional feasibility of various business models and partnerships, such as microtransit. FTA recognizes microtransit as a service model that sits between traditional fixed-route transit and the new tech-enabled transportation network company (TNC) models. Microtransit is a demand-responsive service that uses ad-hoc pickup and drop-off points located within a few minutes' walk of multiple customers, generally within limited service zones. In general, microtransit uses vehicles smaller than traditional 30-ft or 40-ft transit buses but larger than the passenger vehicles commonly used by TNCs. Prices are higher than for standard transit service, but lower than a TNC ride over the same route. The hallmark of microtransit is the ability to flexibly create routes and stops in response to customer demand. In practice, the services tend to converge on a limited number of routes between dense areas of high demand, and most operate only at weekday peak hours. There may be opportunities for transit agencies to collaborate with microtransit providers to address service gaps in their mobility networks.

### Research Topic Area: Cybersecurity

Transportation systems are increasingly reliant on connectivity to communicate and exchange data. Increasing interdependencies across the transportation sector raise the potential for cyberattacks and failures that could damage critical transportation services and assets. Current defensive security practices could be outpaced by these evolving threats unless more advanced technologies are adopted to enable rapid detection, analysis, response, and prediction of cyber events. DOT is pursuing research and analysis in the area of cybersecurity for ITS and traffic management systems, NextGen, positive train control, and other transportation technologies that rely on connectivity. Federal leadership is critical to ensuring that State and local agencies adopt effective cyber risk management practices for connected infrastructure, vehicles, and devices.

Research objectives supporting the Cybersecurity cross-modal topic area are as follows:

- **Big Data Methodologies:** Conduct research on big data methodologies addressing cybersecurity to help prevent disruptive cyber incidents that may impact air traffic operations and improve resiliency in the event an incident does occur.
- **Public-Private Partnerships:** Leverage public-private partnerships to identify and assess cybersecurity risks affecting vehicle safety.
- **Cybersecurity Framework Development:** Assess, monitor, and address the cybersecurity risks associated with ITS deployments across the various modes of transportation and develop a transportation-specific cybersecurity framework for the Department.
- **Artificial Intelligence/Machine Learning Methodologies:** Support research on applications of artificial intelligence and machine learning to resolve cybersecurity challenges, including data analysis and prediction and identification of security breaches as early as possible.

### Cybersecurity: Cybersecurity for ITS

This research project will allow the ITS JPO program to work with experts from the National Institute of Standards and Technology (NIST) to develop a customized profile of the NIST cybersecurity framework. This can be utilized by ITS deployers to address today's urgent security concerns while preparing for the needs of the next generation of deployments. This project will analyze the cybersecurity needs of ITS deployments across the various modes and support the development of a transportation-specific cybersecurity framework for the Department.

## Strategic Goal: Accountability

The Department supports greater accountability of sponsored RD&T programs, which helps ensure that results are publicly available. The DOT's OAs work closely with all groups throughout the RD&T process to understand research needs, develop and pilot practical solutions, promote their adoption, and evaluate their use and effectiveness. Efforts in place to monitor DOT's activities and assess program value include: tracking and reporting RD&T, conducting performance measurement and program evaluation, and performing economic assessments of the costs and benefits of policies and regulations. These activities support enhanced accountability and efficient operation of DOT's RD&T programs and investments.

### Research Topic Area: Technology Transfer (T2)/Deployment

The DOT defines T2 as the process of transferring and disseminating transportation-related scientific information to stakeholders who may apply it for public or private use. The goal of T2 is to maximize the impact of Federally funded R&D by accelerating the transfer of new, innovative technologies from Federal agencies to the commercial marketplace. T2 is the process by which emerging technologies are moved from the lab to an adoption-ready state (see figure 5). T2 activities help stakeholders make informed decisions about whether to adopt new technologies, policies, or practices.

The DOT's current approach to T2 is diverse and unique to each mode of transportation. The DOT's OAs use a wide range of methods to support the deployment of technologies and innovations, including pilot and demonstration projects, grants for pilots and early adopters, technical assistance, and peer exchanges. To promote the adoption of innovations, OAs publish technical papers and guides, present webinars and deliver presentations to stakeholders, create websites, develop and deliver training courses and workshops, and distribute newsletters and other outreach materials highlighting research results.

U.S. DOT Image

Tracking and reporting T2 activities demonstrates the results of Federal research investment. The DOT's OAs can track measurable research elements (i.e., inputs, activities, outputs, and outcomes) to support the evaluation of DOT-sponsored research and T2 efforts (see figure 5).

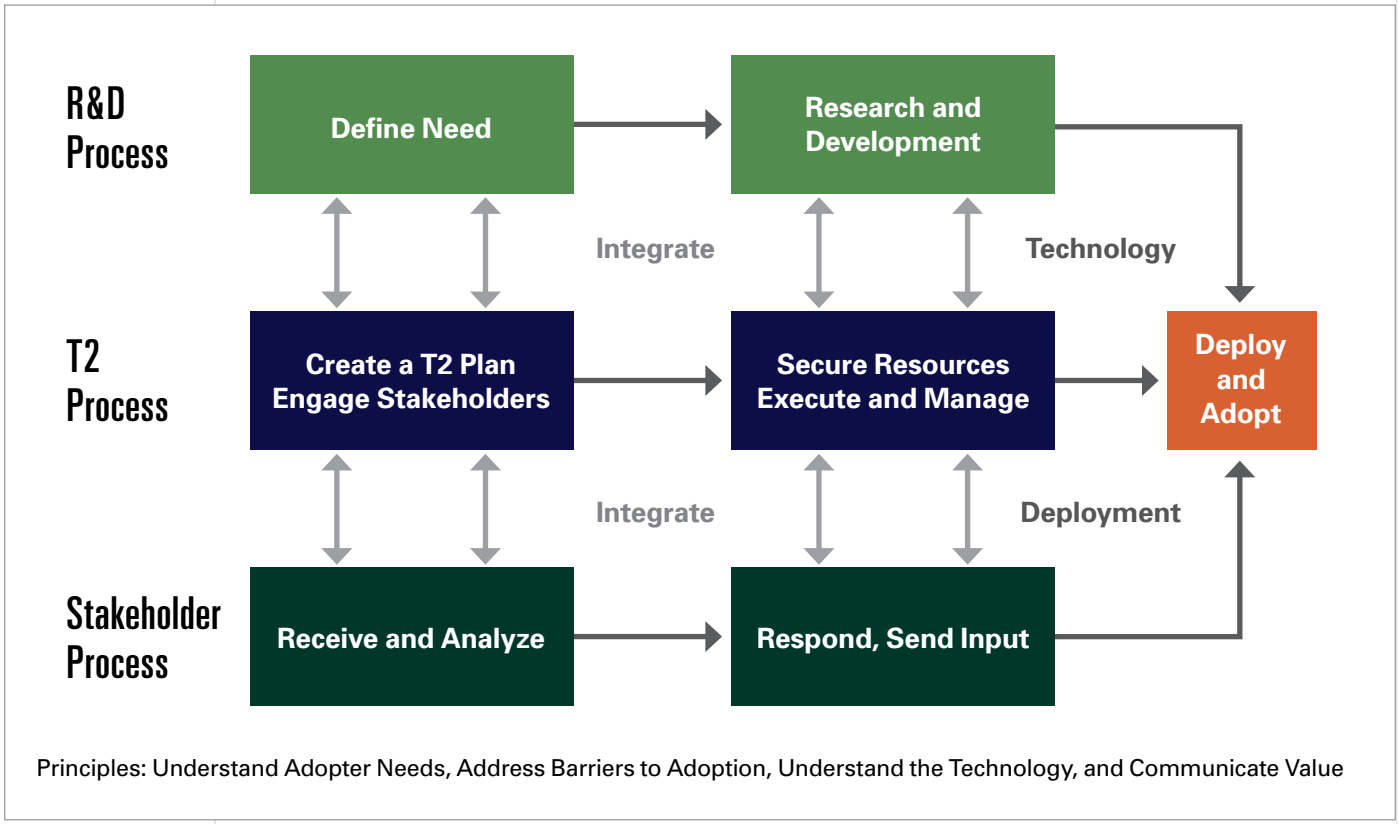


**Figure 5. Research, Technology Transfer, and Stakeholder Processes**

### Technology Transfer: ITS PCB Program

The ITS JPO's Professional Capacity-Building (PCB) Program is the primary mechanism for educating the public sector's transportation workforce about ITS. The program aims to promote technology transfer and education to accelerate deployment of ITS research and technologies. It does this through providing technical assistance to public-sector ITS deployers through peer exchanges and Talking Technology Transportation webinar programs. Increasingly, the PCB Program partners with academic institutions to train the future workforce in new disruptive transportation technologies and applications. Additionally, the program holds workshops with representatives from university, community college, and technical and trade school programs to discuss how to best incorporate relevant topics into curricula and products. The PCB Program can also provide instructors' aid in teaching about next-generation technologies.

## Research Topic Area: Evaluation/Performance Measurement

In compliance with the Government Performance and Results Act (GPRA) and the GPRA Modernization Act of 2010, DOT's OAs conduct evaluations of RD&T projects and programs to guide and strengthen research program execution. The evaluations assess the extent to which RD&T activities are meeting the needs of stakeholders, driving T2, and supporting DOT goals.

Evaluating DOT research projects can yield important information about RD&T. However, there are challenges to assessing the value of research investments. Research investment outcomes are uncertain in nature, and there is often an extended interval between research investments in technology development and technology deployment and adoption. It is also complex to separate the individual effects of a given product or innovation from the impacts of other factors upon the same goals.

DOT seeks to address these matters by strengthening its evaluation processes. The Department will work to improve how its RD&T programs track the data needed to evaluate how a program is meeting its goals. Such data should be identified as early as possible.

Evaluations generally focus on the processes and outcomes of programs. Process evaluations can provide lessons learned to improve program decision-making and inform the design of future programs. Outcome evaluations may focus on cost savings, operational efficiencies, safety improvements, or other outcomes associated with DOT strategic goals. Outcome evaluations may be used to demonstrate the public benefits of research investments. Both types of evaluations can be used to improve future RD&T initiatives.

Evaluations of T2 can provide insights on both program processes and outcomes. T2 evaluations focus on measuring how effectively DOT-sponsored research leads to the deployment and adoption of technologies. T2 evaluations can identify why certain engagement practices are more successful at persuading users to adopt an innovation or technology than others. These evaluations inform the design of T2 activities in future research programs.

Table 2 provides examples of measurable research elements (inputs, activities, outputs, and outcomes) that agencies can track to support the evaluation of DOT-sponsored RD&T efforts. The first row presents examples of the inputs, activities, outputs, and outcomes for a research program, while the second row presents examples for a T2 program that supports research deployment. The third row shows example components of an evaluation program, but it should be noted that a comprehensive evaluation will require data from both research development and deployment. Additional terminology useful for defining, tracking, and evaluating the results of DOT research and T2 activities is defined in the Appendix.

**Table 2. Logic Model for Research Development and Deployment**

| | INPUTS (EXAMPLES) | ACTIVITIES (EXAMPLES) | OUTPUTS (EXAMPLES) | OUTCOMES (EXAMPLES) |
|---|---|---|---|---|
| **RESEARCH AND DEVELOPMENT** | • Legislation<br>• Funding<br>• Technical expertise<br>• Collaborative partnerships<br>• Lab facilities<br>• Gather R&D baseline data<br>• Stakeholder engagement | • Stakeholder analysis<br>• Content development<br>• Methods development<br>• Experimentation<br>• Data collection<br>• Analysis<br>• Technology testing<br>• Development coordination<br>• Evaluation coordination | • Inventions<br>• Hardware<br>• Software<br>• Processes<br>• Methods<br>• Publications<br>• Data, databases<br>• Copyrights<br>• Patent filings | • Improved knowledge<br>• Improved processes<br>• Invention value added<br>• Project goals met, as measured by evaluation (e.g., improved safety) |
| **T2 DEPLOYMENT** | • Review of relevant T2 cases<br>• Plan for deployment funding<br>• Gather T2 baseline data<br>• Stakeholder engagement | • T2 plan development, including user and champion identification<br>• T2 outreach materials development<br>• Securing deployment funds and support<br>• Training<br>• Deployment coordination<br>• Evaluation coordination | • Publications<br>• Newsletters<br>• Briefs<br>• Website downloads<br>• Outreach events<br>• Demos<br>• Licenses<br>• Success stories | • Increased user awareness and knowledge (measured by citations, downloads, licenses, success stories, etc.)<br>• Increased usage (measured by interview, surveys, tracking systems, royalties, etc.)<br>• Project goals met, as measured by evaluation (e.g., improved safety) |
| **EVALUATION** | • Evaluation planning<br>• Evaluation funding<br>• Selection of evaluators | • Development of evaluation materials<br>• Baseline data analysis<br>• Further data collection (e.g., statistics, interviews)<br>• Data analysis | • Findings and recommendations<br>• Presentations<br>• Briefs<br>• Webinars<br>• Internal and external reports | • Improved knowledge<br>• Programs adopt recommendations to improve future processes and outcomes<br>• Programs actively include evaluation on future projects |

## Research Topic Area: Data

DOT research provides critical data regarding how well transportation systems perform and how safe and effective are new transportation technologies and policies. Today, advances in information and communications technologies are enabling more timely collection of transportation data. DOT research is exploring ways to use these technological advances to process information from such new data sources as mobile phones and automated vehicles. A number of DOT research programs focus on developing new sources and types of transportation data as well as tools and models to enable the exchange and analysis of data used to assess safety risks, support investment decisions, improve system operations, and track the long-term performance of the transportation system. DOT research continues to develop tools and strategies to help better manage collecting, storing, and analyzing massive amounts of new data.

Developing useful data often requires that transportation stakeholders cooperate extensively. DOT OAs often develop datasets in cooperation with transportation partners in State and local agencies and make these datasets available for use by researchers in government, academia, and industry, both nationally and internationally. As potential sources of transportation data expand rapidly, DOT research programs are supporting developing data standards that enable and improve the exchange of data.

Key foci of ITS JPO research are the innovative data sources and strategies enabled by connectivity. ITS JPO research results in guidance on data collection and management practices to support the evaluation of ITS technologies and the implementation of ITS strategies. For example, the ITS benefits database contains summaries from 20 years of collecting the safety benefits of deployed ITS. This is according to performance metrics including reductions in fatalities, crashes, vehicle-pedestrian collisions, and vehicle-bicycle collisions, as well as key safety indicators such as vehicle speeds, stopping distance, and braking time. ITS JPO is also focusing research on enabling data access across the automated vehicle ecosystem by supporting an integrated departmental approach to automated vehicle data.

### Data: Second Strategic Highway Safety Program (SHRP2) Safety Data

Driving behaviors cause or contribute to over 94 percent of all motor vehicle crashes, resulting in tragic loss of life and injury. In the past, research has studied driver behavior only indirectly by attempting to reconstruct the events that produce crashes. But with the creation of the SHRP2 safety data, researchers now have access to the most comprehensive database of direct observational data of real-world driving behavior ever gathered. The data provide information on the driver and driving behavior; individual trip characteristics, including events (crashes and near-crashes), non-event 'normal' driving (exposure data), and vehicle characteristics and performance. The data are geo-referenced, allowing driver behavior to be associated with the physical environment, such as signs, other roadside hardware, and road design details. Also included are transient elements of the driving environment such as work zones and weather. Research using these data is expected to answer questions about how drivers react to the environment and how they make decisions under different conditions. Answers to these questions will allow the transportation industry to develop more effective safety countermeasures, improve predictive models, design guidelines and policies, and provide a safer more reliable transportation system for all users.

# Implementation

Implementation of this Strategic Plan will take place on two levels. First, there are a number of FAST Act requirements that establish how the Strategic Plan will be used to guide and report the Department's RD&T activities over the next five years. Second, OST-R will execute its DOT research portfolio review mandate through the new DOT RD&T Review and Approval Process outlined in the "Research Program Overview" section in chapter 2. Through this process, OST-R will work with the Department's OAs to continuously track and evaluate the outputs, outcomes, and impacts of its RD&T investments, making investment adjustments and improvements as needed to maintain high levels of performance and cost-effectiveness.

This RD&T Strategic Plan is a core element of a range of measures included in the FAST Act to help ensure the most effective use of DOT's investment in RD&T activities. These elements are discussed below, along with a description of how they will be aligned and coordinated with the Strategic Plan.

49 U.S.C. 6501 requires each OA to submit an AMRP for review and approval by the Office of the Secretary (OST). The AMRP must be consistent with this RD&T Strategic Plan. One of the primary functions of the review is to identify and eliminate duplicate research performed by the different OAs.

49 U.S.C. 6502 requires DOT to provide a consolidated research database that lists the research abstracts, activities, funding, findings, and outputs of the Department's research portfolio at the project level. This comprehensive database is required for several different reasons: (1) to identify and eliminate duplicative research activities, (2) to identify multimodal research areas and subsequent opportunities for interagency collaboration, (3) to document how research findings and outputs are used to improve the efficiency, effectiveness, and safety of transportation systems, and (4) to provide the necessary level of transparency for Department's research portfolio. The Department meets this requirement using the DOT Research Hub database. The Research Hub is a public-facing, web-based database that provides a project-level summary of the Department's research portfolio and its research outputs.

49 U.S.C. 6502 requires a Department R&D funding report to be submitted in conjunction with the annual budget requests submitted by the President to Congress. The funding report will describe:

1. The amount spent in the last full fiscal year on transportation R&D with specific descriptions of projects funded at $5 million or more; and
2. The amount proposed in the current budget for transportation R&D with specific descriptions of projects funded at $5 million or more.

The contents of this funding report will follow the structure of this Strategic Plan, with the budget requests made by each OA categorized into RD&T line items.

49 U.S.C. 6502 also requires an R&D section to be included within the Department's annual Performance Plan and Report submission to Congress. This submission must include:

1. A summary of the Department's transportation RD&T activities for the previous fiscal year in each research topic area;
2. The amount spent in each topic area;
3. A description of the extent to which the RD&T is meeting the expectations described in this Strategic Plan; and
4. Any amendments to this RD&T Strategic Plan.

# Appendix A

## The Role of U.S. DOT in the Transportation RD&T Ecosystem

Our highly interconnected multimodal transportation system helps drive our economy and affects the daily lives of all Americans. As such, the transportation industry encompasses a diverse array of groups from both the public and private sector and across all modes. These groups include infrastructure owners and operators; suppliers and operators of vehicles, planes, ships, trains, and pipelines; logistics and freight firms; and, of course, American businesses, consumers, and travelers.The Department works closely with all segments of the transportation industry to identify research needs to improve the performance of the national transportation system. DOT designs research to help these entities understand trends, diagnose problems, and develop and deploy solutions that meet the DOT's strategic goals.

The DOT is the principal entity within the Federal government tasked with supporting the Nation's transportation system; however, transportation research is funded and conducted by numerous other private and public entities. Indeed, private sector R&D investment in fields such as vehicle automation is many times larger than Federal R&D funding. According to the National Science Foundation, private sector R&D spending on transportation equipment in the United States, which includes automobiles and aerospace research spending, totaled nearly $33 billion in 2016, the most recent year for which such data are available.[15] Globally, automaker R&D spending is significantly higher. Industry group estimates place global automaker R&D investment at more than $108 billion annually.[16]

Significant contributors to transportation research include State departments of transportation and universities, as well as vehicle, train, plane, and ship manufacturers, and technology companies. Equipment and facility construction and operating entities, similarly invest monies in research to support advances in products, methods, and practices. DOT partners with transportation research organizations and industry groups such as the Transportation Research Board (TRB) and the American Association of State and Highway Transportation Officials (AASHTO) to coordinate transportation research. In addition, DOT often seeks input on transportation research from Federal advisory councils and other formal and informal stakeholder engagement processes.

Other Federal departments, including the Department of Energy (DOE), the Department of Defense (DOD), the National Aeronautics and Space Administration (NASA), and the Environmental Protection Agency (EPA), also fund and conduct transportation-related research in support of their own missions. The DOT will continue to identify and pursue opportunities to meet Departmental and national research priorities through partnerships with other transportation research funders.

Examples of other non-DOT Federal research funding include the DOE's Office of Energy Efficiency and Renewable Energy (EERE), which supports research to make transportation cleaner and more energy-efficient. EERE research seeks to improve plug-in electric and other alternative-fuel vehicles, produce low-carbon domestic fuels, and increase the efficiency of vehicles through improvements to combustion engines and lightweight materials. The DOD also funds a variety of transportation-focused research activities. For example, the U.S. Transportation Command supports RD&T to improve all aspects of military transportation from

manufacture of supplies to delivery to soldiers in the field. In addition, the Defense Advanced Research Projects Agency (DARPA) sponsors revolutionary "high-risk–high-payoff" research aimed at bridging the gap between fundamental discoveries and their military applications. EPA funds research on the environmental aspects of transportation, such as the development of better emissions control technologies. Finally, the Department of Commerce's National Institute of Standards and Technology conducts a range of engineering standards research with transportation applications, such as R&D to accelerate advancements in lightweight materials for vehicles.

## Aviation

The aviation system is changing rapidly in the face of rising demand, advancing technologies, and environmental and energy challenges. The American economy relies on a safe and efficient aviation system. American aviation represents 5.1 percent of the U.S. Gross Domestic Product (GDP), yields 10.6 million U.S. jobs, stimulates $1.6 trillion in U.S. economic activity, and constitutes $59.9 billion of U.S. trade (or 8 percent of all U.S. exports).[17] Aviation is safer than it has ever been; the latest report from the International Air Transport Association showed a 35 percent decline in the all-accident rate in 2017 alone.[18] This record is the result of a collaborative, data-driven culture that allows government and industry to work together and make proactive safety improvements throughout the National Airspace System (NAS).

The United States' global leadership and unparalleled aviation safety record is supported by FAA research and development. The advancement and sharing of knowledge and the development of innovative solutions inform critical decisions the FAA makes to improve safety, increase efficiency and mitigate environmental impacts of aviation. To complement and augment the Agency's research staff and its state-of-the-art research laboratory resources, the FAA sustains a robust network of academic and industry partners to be successful.

## Rail

The U.S. economy benefits from having one of the most extensive freight rail systems in the world. The freight rail system is largely privately owned, operated, and maintained by seven "Class 1" railroads and more than 500 short line railroads. The more than $70 billion freight rail industry provides a safe and energy-efficient alternative for the movement of goods, connecting producers and consumers across the country and the world. Railroads face rising infrastructure costs to resolve choke points and to provide capacity to meet rising demand. Intercity passenger rail in the United States carries more than 30 million passengers annually and is operated by Amtrak, a quasi-public corporation subsidized by Federal and State investment.[19]

Although rail safety has improved over the last ten years, FRA remains focused on improving the safety of railways for the American public and rail workers. The main objective of FRA's research efforts is to reduce incidents and accidents involving America's railroads, to save lives, and reduce environmental hazards. Current high-priority issues for FRA include: Positive Train Control (PTC), grade crossing safety, trespass prevention, safe transportation of energy products, automation technology, and predictive analytics. The FRA's RD&T program also has an important role to play in workforce development. Research stakeholders and collaboration partners include railroad carriers and manufacturers, transit agencies, universities, as well as American businesses and the traveling public.

## Transit

The public transit industry consists of approximately 6,800 public and private providers employing more than 423,000 people. These providers operate buses, heavy and light rail, commuter rail, paratransit, and ferries in both urban and rural areas across the country. Millions of people rely on the Nation's public transit system to get to work every day. The public transit industry faces a wide range of challenges including sustaining ridership, improving deteriorating infrastructure, increasing energy efficiency, improving accessibility, and integrating new technologies and mobility innovations such as automation and on-demand mobility options.

The primary customers for FTA's research are transit agencies and their customers. FTA's research vision is that innovative technologies, projects, partnerships, and world-class infrastructure promote economic growth and improve quality of life in communities. FTA's research mission is to advance public transportation innovation by leading research and development, and implementing technologies that ultimately improve the transit rider's experience. FTA's research activities are designed to respond to issues facing public transit systems today while also laying a foundation for their transitions to the future.

## Highways

Significant trends affecting the highway industry include rising infrastructure construction and maintenance costs, rapidly advancing vehicle automation technologies, and increasing vehicle miles traveled. As demand continues to increase for use of limited highway infrastructure, traffic congestion is increasing, with delays costing drivers $169 billion annually.[20] Investments have failed to keep up with maintenance needs; 62 percent of U.S. highways are in less-than-good condition, and 25 percent of U.S. bridges are in less-than-good condition.[21] Safety remains the top priority of the USDOT. There were an estimated 36,560 traffic-related deaths in 2018.[22]

FHWA conducts advanced and applied research and coordinates and collaborates with other research organizations (both nationally and internationally) to address highway transportation needs. Working closely with States, Federal agencies, academia, and private industry, FHWA research programs seek to generate new solutions; provide better decision-support data; and build effective partnerships to optimize national investments in the transportation system. FHWA's technology and innovation deployment efforts aim to significantly improve safety, system efficiency, and infrastructure health.

NHTSA focuses research efforts on vehicle and road user safety. NHTSA research includes the study of vehicle crashworthiness, human injury/biomechanics, and crash avoidance. Crashworthiness research encompasses new and improved vehicle design, safety countermeasures and equipment to enhance occupant safety. Biomechanics research includes the development and testing of crash test dummies and other tools to understand and mitigate the risk of injury and death in motor vehicle crashes. NHTSA's crash avoidance research seeks to develop a broad base of understanding that can lead to introduction of advanced crash avoidance systems. NHTSA also conducts testing and research on the reliability and security of complex safety-critical electronic control systems, vehicle cybersecurity, and new and emerging technologies. Other research areas include the evaluation of the safety ramifications of vehicle fleet and design changes with potential safety ramifications, particularly in areas related to alternative fuel vehicles, advanced battery control modeling and analysis, and assessment of crash notification technology and emergency response.

FMCSA's mission is to reduce crashes, injuries, and fatalities involving large trucks and buses. To support this mission, FMCSA carries out R&D and technology transfer activities on the causes

of crashes, injuries, and fatalities involving commercial motor vehicles (CMV) and the means to reducing them. FMCSA also seeks to improve CMV safety and efficiency through technological innovation, improving technology for roadside inspections and investigations, and increasing the safety and security of hazardous materials.

## Pipelines

America's pipeline infrastructure spans more than 2.8 million miles, and it is used to transport nearly all of the natural gas and about two-thirds of the liquid petroleum energy products consumed domestically. Transportation of energy products by pipeline has increased more than 40 percent in recent years. At the same time, the United States is developing energy resources in areas without pipeline infrastructure, and must find ways for it to be transported safely and efficiently. Furthermore, more than 2.6 billion tons of hazardous materials are shipped annually, more than 800,000 shipments per day.

PHMSA's mission is to protect people and the environment by advancing the safe transportation of energy products and other hazardous materials that are essential to our daily lives. PHMSA operates in a dynamic and challenging environment in which changes in technology, manufacturing, and energy production all affect transportation safety. PHMSA funds research that improves safety, ensures reliability of supply, boosts business and government productivity, enhances the security of our infrastructure, and protects the natural environment. PHMSA's research objectives include identifying emerging risks, developing technologies, strengthening industry consensus standards, and promoting the use of new research insights by decision-makers.

## Maritime

U.S. DOT's maritime research focuses on identifying, evaluating, and demonstrating new technologies and processes that improve the environmental sustainability of the maritime industry. MARAD works with the maritime community to address issues related to the introduction of non-indigenous aquatic species through ballast water and hull biofouling. In response, MARAD partners with the maritime industry, academia, and other Federal agencies to develop and deploy technologies to improve fuel efficiency and reduce emissions. Air emissions from large marine engines have the potential to affect not just coastal and port communities, but also to impact populations hundreds of miles away.

# Appendix B

## Technology Transfer and Evaluation Terminology

Many of the terms used in research evaluation and technology transfer may be used interchangeably between research development and deployment teams. Critical terms are defined below.

### Evaluation and Logic Model Terms

**Evaluation:** A systematic study using research methods to collect and analyze data to assess how well a program is working and why. Evaluations answer specific questions about program performance and may focus on assessing program operations or results. Evaluation results may be used to assess a program's effectiveness, identify how to improve performance, or guide resource allocation. (General Accountability Office (GAO) 2012)

> **Formative Evaluation:** A type of process evaluation of new programs or services that focuses on collecting data on program operations so that needed changes or modifications can be made to the program in its early stages. Formative evaluations are used to provide feedback to staff about the program components that are working and those that need to be changed. (GPO.gov[23])

> **Summative Evaluation:** A type of outcome evaluation that assesses the results or outcomes of a program. This type of evaluation is concerned with a program's overall effectiveness. (HHS.gov)

**Activities:** What the program does with the resources. Activities are the processes, events, and actions that are an intentional part of the program implementation. These interventions are used to bring about the intended program changes or results. (Adapted from Kellogg Foundation, 2004)

> **Research and Development (R&D) Activities:** The creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture, and society, and the use of this stock of knowledge to devise new applications. (OMB Circular A-11)

> **T2 Activities:** Technology transfer means those activities that lead to the adoption of a new technique or product by users and involves dissemination, demonstration, training, and other activities that lead to eventual innovation. (23 CFR § 420.203)

**Inputs:** The human, financial, organizational, and community resources a program has available to direct toward doing the work. (Kellogg Foundation, 2004)

**Logic Model:** A flow diagram that describes a program's components and desired results to explain the strategy—or logic—by which the program is expected to achieve its goals. (GAO 2012)

**Outcome Measure:** Outcome measure indicates progress toward achieving the intended result of a program. Indicates changes in conditions that the Government is trying to influence. (OMB Circular A-11)

**Outputs:** The direct products of program activities and may include types, levels, and targets of services to be delivered by the program. (Kellogg Foundation, 2004)

**R&D Outputs:** The results of work performed under R&D activities. The outputs could include: processes and methods; data, hardware, software, and databases; invention disclosures, patent filings, inventions, etc.

**T2 Outputs:** The activities planned and performed in disseminating the R&D outcomes with stakeholders who are interested in using them.

**Outcome Evaluation:** Evaluation designed to assess the extent to which a program or intervention contributes to achievement of its intended outcome(s).

## T2-Specific Terms

**Champion:** A champion is an individual within an organization who occupies a key linking position and is able to promote, advocate, or represent an idea, concept, or cause as it advances toward wider adoption. A champion helps to overcome indifference or resistance to the new idea and may identify resources necessary for a technology transfer and deployment effort. (National Cooperative Highway Research Program (NCHRP 768))

**Implementation Plan:** An outline of the activities and resources (including assignment of responsibilities to personnel) to be undertaken to bring new technologies into routine practice.

**Stakeholder:** A stakeholder is a person or group involved in or having an interest in the technology transfer activities of an organization. Stakeholders may be classified as those who are the source of a technology or those who are the recipients of it. The involvement of the stakeholder may include rights, ownership or a share of ownership, or knowledge or understanding of the need for technology. (NCHRP 768)

**Stakeholder Engagement Activities:** Actions taken to connect with identified stakeholders to determine their needs, interest in and/or reactions to program activities, outputs, and outcomes.

**Success Story:** An account of successful stakeholder implementation of a research outcome with beneficial results.

**Technical Assistance:** Activities that are technical in nature, undertaken to help others achieve a desired outcome. In the context of technology implementation, technical assistance will typically take the form of expert guidance, hands on training and/or advice.

**Technology:** It is broadly defined as tangible (hardware and software) or intangible (knowledge and practices—why and how to do something novel). (NCHRP 768)

**Technology Deployment:** Activities that demonstrate, pilot, or evaluate an R&D output, and/or facilitate the transfer of an R&D output to an adoption-ready state. Technology deployment is the final phase of the T2 process.

**Technology Transfer:** The process by which existing knowledge, facilities, or capabilities developed under Federal research and development (R&D) funding are utilized to fulfill public and private needs. (Federal Laboratory Consortium)

**Technology Transfer Plan:** An outline of the people and organizations involved in the T2 process and the roles they play, the activities they undertake, and the desired outcomes to help assure that a

particular technology will be adopted. (Volpe Center – Developing and Executing Your Technology Transfer Plan, 10-point checklist)

## Legal Terms

**Commercialization:** The process through which a technology/innovation is made available for sale by a commercial entity.

**Copyright:** A form of protection provided to the authors of 'original works of authorship,' including literary, dramatic, musical, artistic, and certain other intellectual works, both published and unpublished. The 1976 Copyright Act generally gives the owner of copyright the exclusive right to reproduce the copyrighted work, to prepare derivative works, to distribute copies or phonorecords of the copyrighted work, to perform the copyrighted work publicly, or to display the copyrighted work publicly.

The copyright protects the form of expression rather than the subject matter of the writing. For example, a description of a machine could be copyrighted, but this would only prevent others from copying the description; it would not prevent others from writing a description of their own or from making and using the machine. Copyrights are registered by the Copyright Office of the Library of Congress. Source: https://www.uspto.gov/patents-getting-started/general-information-concerning-patents

**License:** A permission, accorded by a competent authority, conferring the right to do some act which without such authorization would be illegal, or would be a trespass or a tort. A licensor may grant a license under intellectual property laws to authorize a use (such as copying software or using a (patented) invention) to a licensee, sparing the licensee from a claim of infringement brought by the licensor. (Federal Laboratory Consortium)

**Patent:** A patent for an invention is the grant of a property right to the inventor, issued by the United States Patent and Trademark Office. Generally, the term of a new patent is 20 years from the date on which the application for the patent was filed in the United States or, in special cases, from the date an earlier related application was filed, subject to the payment of maintenance fees. U.S. patent grants are effective only within the United States, U.S. territories, and U.S. possessions. Under certain circumstances, patent term extensions or adjustments may be available.

The right conferred by the patent grant is, in the language of the statute and of the grant itself, "the right to exclude others from making, using, offering for sale, or selling" the invention in the United States or "importing" the invention into the United States. What is granted is not the right to make, use, offer for sale, sell or import, but the right to exclude others from making, using, offering for sale, selling or importing the invention. Once a patent is issued, the patentee must enforce the patent without aid of the USPTO. Source: https://www.uspto.gov/patents-getting-started/general-information-concerning-patents

## General Research Terms

**Demonstration:** A demonstration, or demonstration project, is an information exchange mechanism intended to show, explain, or prove the value of an innovation in a context where that innovation is new or unfamiliar. It allows hands-on experiences for participants who interact with knowledgeable peers and others experienced in the technology application. A demonstration is similar to a showcase. (NCHRP 768)

**Deployment:** Deployment of an innovation is the transformation of that innovation from a packaged, limited use to an operational state with broad usage. Deployment may include opening, arranging, installing, testing, or otherwise preparing an innovation for full, intended usage. The result of deployment is that the innovation is ready for implementation. (NCHRP 768)

**Development:** Development is defined as systematic application of knowledge or understanding, directed toward the production of useful materials, devices, and systems or methods, including design, development, and improvement of prototypes and new processes to meet specific requirements. (OMB Circular A-11)

**Impact:** The [long-term] impact of an outcome on the transportation system, or society in general, such as reduced fatalities, decreased capital or operating costs, community impacts, or environmental benefits. (DOT RD&T Strategic Plan, Jan. 2017)

**Implementation:** Implementation of an innovation is the complete execution of a plan or process to put that innovation into full effect. The result of implementation is that the innovation is fully employed by end users. (NCHRP 768)

**Innovation:** An innovation is an object, machine, process, or idea that represents a change from established methods of operation. An innovation may be a renewal or an alteration from the established norm, or may represent something new, but is generally a solution that fulfills a need. (NCHRP 768)

**Performance Measurement:** A means of evaluating efficiency, effectiveness, and results. A particular value or characteristic used to measure progress toward goals, and also used to find ways to improve progress, reduce risks, or improve cost-effectiveness. (OMB A-11 Revised)

**Pilot:** Preliminary test or application.

**Program:** An ongoing initiative composed of a group of projects and other work managed in a coordinated way to obtain benefits not obtained from managing them individually. (OMB A-11 Revised)

**Project:** A temporary endeavor to create a unique product or service with a start date, a completion date, and a defined scope. (OMB Circular A-11)

**Research:** Research is an effort to increase a body of knowledge, or to use the body of knowledge to develop new applications. Research is a creative and systematic effort that may use one or more of several research methods, depending upon the category of knowledge desired. (NCHRP 768)

- **Applied research:** Applied research is defined as systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met. (OMB Circular A-11)
- **Basic research:** Basic research is defined as systematic study directed toward fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications toward processes or products in mind. Basic research; however, may include activities with broad applications in mind. (OMB Circular A-11)

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# Acronyms and Abbreviations

| | |
|---|---|
| **5G** | Fifth-generation cellular mobile communications service |
| **AMRP** | Annual Modal Research Plan |
| **ATC** | Air traffic control |
| **AV 4.0** | Ensuring American Leadership in Automated Vehicle Technologies: Automated Vehicles 4.0 |
| **CLEEN** | Continuous Lower Energy, Emissions, and Noise |
| **CMV** | Commercial motor vehicle |
| **C-V2X** | Cellular vehicle-to-everything mobile communications |
| **DOD** | Department of Defense |
| **DOE** | Department of Energy |
| **DOT** | U.S. Department of Transportation |
| **EERE** | Office of Energy Efficiency and Renewable Energy (DOE) |
| **FAA** | Federal Aviation Administration |
| **FAST Act** | Fixing America's Surface Transportation Act |
| **FHWA** | Federal Highway Administration |
| **FMCSA** | Federal Motor Carrier Safety Administration |
| **FRA** | Federal Railroad Administration |
| **FTA** | Federal Transit Administration |
| **GAO** | Government Accountability Office |
| **GPRA** | Government Performance and Results Act |
| **ITS** | Intelligent Transportation Systems |
| **JPO** | Joint Program Office |
| **LNG** | Liquefied Natural Gas |
| **MARAD** | Maritime Administration |
| **NCHRP** | National Cooperative Highway Research Program |

| | |
|---|---|
| **NEPA** | National Environmental Policy Act |
| **NextGen** | Next Generation Air Transportation System |
| **NHTSA** | National Highway Traffic Safety Administration |
| **NIST** | National Institute of Standards and Technology |
| **OA** | Operating Administration |
| **OMB** | Office of Management and Budget |
| **OST** | Office of the Secretary of Transportation |
| **OST-R** | Office of the Assistant Secretary for Research and Technology |
| **PCB** | Professional Capacity Building |
| **PHMSA** | Pipeline and Hazardous Materials Safety Administration |
| **PTC** | Positive Train Control |
| **R&D** | Research and Development |
| **RD&T** | Research, Development, and Technology |
| **TNC** | Transportation Network Company |
| **TSMO** | Transportation System Management and Operations |
| **UAS** | Unmanned Aircraft System |

# Endnotes

[1] U.S. DOT Research, Development and Technology Strategic Plan (FY2017 – 2021).

[2] DOT Strategic Plan, 2018–2022, numerous citations.

[3] DOT Strategic Plan, 2018–2022, "DOT's top priorities are to keep the traveling public safe and secure, increase their mobility, and have our transportation system contribute to the Nation's economic growth"; and FAST Act Sec. 6019, the transportation research and development 5-year strategic plan must demonstrate how it furthers the primary purposes of "improving mobility of people and goods," and "promoting safety."

[4] EO 12866, "Regulatory Planning and Review," "Federal agencies should promulgate only such regulations as are required by law, are necessary to interpret the law, or are made necessary by compelling public need, such as materials failures of private markets to protect or improve the health and safety of the public, the environment, or the well-being of the American people"; and 23 USC 502, "delivers a clear public benefit and occurs where private sector investment is less than optimal."

[5] OMB Circular M-17-3, "FY 2019 Administration Research and Development Budget Priorities" (Mulvaney/Kratsios memo), "agencies should invest in R&D to increase the security and resilience of the Nation's critical infrastructure from both physical threats and cyber-attacks, which have increased rapidly in number and complexity in recent years."

[6] Paperwork Reduction Act of 1995, "ensure the greatest possible public benefit from and maximize the utility of information created, collected, maintained, used, shared and disseminated by or for the Federal Government."

[7] OMB Circular M-17-3, "agencies should give priority to funding basic and early-stage applied research that, supplemented by private sector financing of later-stage R&D, can result in the development of transformative commercial products and services."

[8] President's Management Agenda, Modernizing Government for the 21st Century, "CAP Goal 14—Improve transfer of federally-funded technologies from lab-to-market."

[9] 49 U.S.C. 330. Research Activities.

[10] NHTSA, Traffic Deaths Decreased in 2018, but Still 36,560 People Died, **https://www.nhtsa.gov/traffic-deaths-2018#.**

[11] Ibid.

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# U.S. Department of Transportation Research, Development & Technology Strategic Plan FY2018 – FY2022

U.S. Department of Transportation