

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

Pipeline and Hazardous Materials Safety Administration

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Executive Summary

The Pipeline and Hazardous Materials Safety Administration’s (PHMSA or the Agency) mission is to protect people, property, and the environment by advancing the safe transportation of energy products and hazardous materials that are essential to our daily lives. The Agency operates in a dynamic and challenging environment wherein changes in technology, manufacturing, and energy production affect transportation safety. PHMSA anticipates that the scope and complexity of our safety mission will continue to grow to protect people and the environment, serve environmental justice, and support climate and sustainability efforts.

PHMSA oversees the safe design, construction, operation, and maintenance of more than 3.4 million miles of pipelines that are used to transport nearly all the natural gas and about two-thirds of the hazardous liquid petroleum energy products consumed domestically. According to the U.S. Energy Information Administration, oil furnishes 36 percent of our energy, natural gas 32 percent, coal 11 percent, nuclear 8 percent, and renewables 12 percent.¹ Adaptation of the existing pipeline infrastructure to support alternative energy sources and the need to better protect underserved communities will drive the demand for innovation in the coming decade. PHMSA also confronts safety challenges posed by the increased transportation of hazardous materials across all modes—more than 3.3 billion tons annually and more than 1.2 million shipments per day.² The routes taken by these shipments must be chosen in an equitable and environmentally sustainable manner. Unexpected circumstances continue to arise, and the Agency must prepare for any emerging issues. Research and development (R&D) activities provide critical solutions to these ongoing challenges.

Due to the significant contribution of energy and hazardous materials to our economy and standard of living, as well as their potential safety and environmental impacts, research projects promoting the safety, resilience, and performance of our transportation system are essential. PHMSA will fund research that improves safety to reduce potential human and environmental impacts. This kind of research will enhance the security of our infrastructure, our people, and our environment. In Fiscal Year (FY) 2024, PHMSA will pursue research, development, and technology (RD&T) goals through a variety of projects carried out by its Office of Pipeline Safety (OPS) and the Office of Hazardous Materials Safety (OHMS).

PHMSA supports evaluation and performance measurement efforts related to the Foundations for Evidence-Based Policymaking Act of 2018 (Pub. L. 115-435). In support of the U.S. Department of Transportation’s (DOT or the Department) strategic objectives as identified in *Figure 1*, PHMSA’s performance goals will be monitored for trends and reported DOT-wide, serving as a guide for both R&D and operational performance.

¹ <https://www.eia.gov/energyexplained/us-energy-facts/>

² <https://www.phmsa.dot.gov/>

Figure 1 also identifies the performance goals for which PHMSA is the lead Agency, as well as those DOT-wide goals that PHMSA supports.

Figure 1 Performance Goals

Strategic Goal	Strategic Objective	Performance Goal
PHMSA Lead Agency		
Safety	Safe Public	Reduce Fatalities Caused by the Release of Hazardous Material Transported via Pipeline or Surface Transportation Conveyance (PHMSA)
Economic Strength & Global Competitiveness	High-Performing Core Assets	By 2036, Repair, Replace, or Rehabilitate 1,000 Miles of High-Risk, Leak-Prone, Community-Owned Legacy Gas Distribution Pipeline Infrastructure, as well as an Estimated Reduction of 1,000 Metric Tons of Methane Emissions and a Reduction in Fatalities/Serious Injuries
Economic Strength & Global Competitiveness	Resilient Supply Chains	Reduce the Number of Hazardous Materials Incidents that Resulted in a Road Closure of One Hour or More
Equity	Power of Community	Increase the Percentage of Community Outreach Activities Directed Toward Underserved Communities to Increase Hazmat Transportation Awareness, Preparedness, and Response
Climate & Sustainability	Path to Economy-Wide Net-Zero Emissions by 2054	Reduce the Gross Volume Spilled from Crude Oil and Refined Products' Pipeline Systems
PHMSA Support of DOT-Wide Goals		
Equity	Proactive Interventions, Planning, and Capacity Building	By 2025, Increase by 5 Percent the Number of U.S. DOT Discretionary Grant Applicants from Disadvantaged Communities Who Have Never Applied for U.S. DOT Funding Before (Office of the Secretary for Transportation Policy) (OST-P), All Operating Administrations) KPI, BIL
Climate & Sustainability	Path to Economy-Wide Net-Zero Emissions by 2054	Reduce Transportation Emissions in Support of Net-Zero Emissions Economy-Wide by 2050 (Office of the Secretary for Transportation (OST), All Operating Administrations) KPI
Climate & Sustainability	Climate Justice and Environmental Justice	Ensure that the Benefits of at Least 40 Percent of U.S. DOT Investments in the Areas of Clean Energy and Energy Efficiency, Clean Transportation, and the Remediation and Reduction of Legacy Pollution Flow to Disadvantaged Communities (OST-P, All Operating Administrations) KPI
Transformation	Matching Research and Policy to Advance Breakthroughs	Double the Number of Research and Deployment Projects Centered on Breakthrough Discoveries that Introduce New Technologies or Approaches Not Currently Deployed in the Transportation System (Office of the Secretary, Research and Technology (OST-R), All Operating Administrations) KPI

PHMSA remains focused on collaboration with all stakeholders to leverage investment and successes to date. PHMSA makes continual efforts to remove unnecessary duplication while engaging a wide range of stakeholders, including advanced technology providers and academia, to fund and co-fund critical research that develops new technology, products, and knowledge. PHMSA's RD&T activities are non-duplicative with known prior or current projects within the Agency and outside of the Agency (e.g., other federal agencies and research organizations).

Figure 2 illustrates the contribution of PHMSA’s research activities in support of the six DOT strategic goals. The table demonstrates how PHMSA-specific research activities, such as research in alternative fuels, liquefied natural gas (LNG) safety, and pipeline threat prevention, align with the Office of the Secretary, Research and Technology (OST-R) programmatic goals and working groups’ (Transportation Research Working Group (TWRG), Center for Climate Change, and Equity Task Force) objectives. The table below includes all the projects that have been awarded in FY 2022 and research topics we are currently soliciting for in FY 2023.

Figure 2 Strategic Goals

DOT Goal	OST-R Linkages: TRWG Center for Climate Change Equity Task Force	Alternative Fuels	LNG Safety	Underground Natural Gas Storage Safety	Pipeline Anomaly Detection	Pipeline Threat Prevention	Pipeline Repair/ Rehabilitation	Risk Management and Mitigation	Emerging Technology	Technical Analysis to Aid Risk Assessments
Safety	Automation		x		x	x		x	x	
	Systemic Safety Approach	x	x	x	x	x	x	x	x	x
Economic Strength & Global Competitiveness	State of Good Repair	x	x	x	x	x	x	x		x
	Technology Transfer/Deployment	x	x	x		x	x	x	x	x
	Economic Competitiveness	x	x				x		x	
Equity	Equity Task Force	x	x			x	x	x	x	x
Climate & Sustainability	Environmental Stewardship (Chair)	x	x	x	x			x	x	x
	Center for Climate Change	x	x	x	x		x	x	x	
Transformation	Emerging/Enabling Technologies	x	x	x	x	x	x	x	x	x
Organizational Excellence	Evaluation/ Performance Measurement	x	x	x	x	x	x	x	x	x

Table 1 below includes FY2024 RD&T program funding details for PHMSA’s R&D activities. In the FY 2024 Budget (see Table 2 below), PHMSA’s funding by strategic goal is allocated solely to safety; however, the impact of PHMSA’s R&D activities will extend to all strategic goals (see

Figure 2 above). While PHMSA's primary mission is safety, its research programs also support key Administration priorities, such as *Climate and Sustainability, Economic Strength and Global Competitiveness, and Equity*.

For instance, PHMSA plans to invest significantly in hydrogen and carbon dioxide research, methane emissions reductions, and lithium battery safety advancements. While these research activities focus on improving safety, they also will help reduce the climate impacts of fossil fuels, stimulate innovative research, and thereby improve economic strength and global competitiveness. To further enhance PHMSA's ability to analyze equity impacts, PHMSA plans to invest in a modeling framework that analyzes equity implications for hazardous materials routing and exposure.

PHMSA's investment program is designed to improve equity and stimulate innovation by increasing stakeholder engagement with minority serving institutions (MSIs) and small businesses to increase participation in upcoming grant and research awards.

Table 1 - FY 2024 RD&T Program Funding Details

Budget Account	FY 2024 President's Budget	Applied	Tech Transfer	Facilities	Experimental Development	Major Equipment, R&D Equipment
Pipeline Safety	\$15,000	\$15,000				
<i>Safety</i>						
Liquefied Natural Gas (LNG)	6,000	6,000				
Underground Natural Gas Storage (UGS) Safety Research	1,500	1,500				
Pipeline Anomaly Detection/ Characterization	1,000	1,000				
Pipeline Leak Detection	1,500	1,500				
Pipeline Threat Prevention	1,500	1,500				
Repair/Rehabilitation	1,500	1,500				
Climate Change Solutions/Hydrogen	2,000	2,000				
Hazardous Materials Safety	7,570	7,570				
<i>Safety</i>						
Risk Management	1,500	1,500				
Technical Analysis	1,000	1,000				
Package Integrity	2,500	2,500				
<i>Innovation</i>						
Emerging Technologies	2,570	2,570				
Administrative Expenses						
Pipeline Safety	1,363	1,363				
Hazardous Materials Safety	846	846				
Total	24,779	24,779				

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

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

DOT STRATEGIC GOALS							
Account/Program	FY 2024 President's Budget Request* (\$000)	Safety (\$000)	Economic Strength & Global Competitiveness (\$000)	Equity (\$000)	Climate & Sustainability (\$000)	Transformation (\$000)	Organizational Excellence (\$000)
Pipeline Safety	\$15,000	\$9,000		\$1,000	\$5,000		
<i>Safety</i>							
Liquefied Natural Gas	6,000	6,000					
Underground Natural Gas (UNGS) Safety Research	1,500	500			1,000		
Pipeline Anomaly Detection/ Characterization	1,000	500			500		
Pipeline Leak Detection	1,500	500			1,000		
Pipeline Threat Prevention	1,500	1,000			500		
Repair/Rehabilitation	1,500	500		1,000			
Climate Change Solutions/Hydrogen	2,000				2,000		
Hazardous Materials Safety	\$7,570	\$4,560	\$750	\$500	\$1,760		
<i>Safety</i>							
Risk Management	1,500	1,000		500			
Technical Analysis	1,000	525			475		
Package Integrity	2,500	1,750	750				
<i>Innovation</i>							
Emerging Technologies	2,570	1,285			1,285		
Administrative Expenses							
Pipeline Safety	1,363	1,363					
Hazardous Materials Safety	846	846					
Total	\$24,779	\$15,769	\$750	\$1,500	\$6,760		

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

Chapter 1 – FY 2024 RD&T Programs

Hazardous Materials Safety (\$8,416,000)

Program Description:

Hazardous materials are essential to our daily lives. They are used in countless industries including manufacturing, agriculture, our power grid, and consumer products, to name a few. Every day, there are more than 1.2 million shipments of these hazardous materials, totaling more than 3.3 billion tons shipped annually. There are continuous new developments in hazardous materials. Some of these developments include new products, such as new lithium-ion battery chemistries or sodium-ion batteries, and new packaging and methods of transportation. Research, therefore, provides critical solutions to both ongoing and new challenges that make transporting these essential goods around the country safe for all.

PHMSA’s Hazardous Materials Research & Development, Analysis & Technical Assessment Program (HMR-DATA) Fiscal Year 2024 initiatives explore ways to reduce the risks associated with the transportation of hazardous materials, and identify and evaluate new technologies to facilitate the safe, secure, and efficient transportation of hazardous materials. These goals are supported through four core areas of research in FY 2024: Risk Management and Mitigation; Package Integrity; Emerging Technologies; and Technical Analysis to Aid Risk Assessments. Each core area is described below.

Risk Management and Mitigation: Researching risk reduction strategies to lower the likelihood of transportation-related injuries and fatalities; increase packaging and operational safety; and improve system reliability. The primary Department Strategic Goal in this program area is Safety, with a secondary goal of Equity.

Packaging Integrity: Researching innovative, novel packaging materials and ways to improve safety and reliability of current packaging design and integrity. The primary Department Strategic Goal in this program area is Safety, with a secondary goal of Economic Strength and Economic Competitiveness.

Emerging Technology: Researching and evaluating emerging materials, processes, transport operations, energy products, and packaging technologies to keep pace with an ever-evolving transportation system. This research will leverage new technology to reduce and mitigate risks of hazmat transportation systems. The two primary Department Strategic Goals in this program area are Safety, and Climate and Sustainability.

Technical Analysis to Aid Risk Assessment: Researching evaluation methods for hazardous material transportation activities, events, and incidents. This type of research will aid in understanding packaging failures and hazmat anomalies. The primary Department Strategic Goal in this program area is Safety, with a secondary goal of Climate and Sustainability.

In FY 2024, HMR-DATA will continue to pursue its goals through its various research solicitation programs: Small Business Innovative Research (SBIR), Inter-Agency Agreements (IAAs), and Subject Matter Expert initiated projects. HMR-DATA also initiates research projects with academia and industry. These self-initiated research projects are from stakeholder input from our research forum as well as HMR-DATA subject matter experts. These research solicitations enable HMR-DATA to engage with a variety of stakeholders, including modal partners and small businesses. They are designed to take innovative research ideas, incorporate them into new technologies, and assist with potential regulatory changes.

Major Program Objectives:

HMR-DATA remains committed to the safe transportation of energy products and other hazardous materials. Through our research projects, we will continue to focus on identifying risk management and mitigation tools, improving packaging technologies and designs, and developing new and emerging transportation technologies.

HMR-DATA's main objectives are to:

- Reduce the number of injury- and fatality-related incidents that involve hazardous material transportation.
- Continue to engage and collaborate with our modal partners on joint research projects and review studies.
- Work with small businesses to promote emerging technologies and innovative risk mitigation techniques, such as leak detectors and sensors.
- Identify and address the challenges and research gaps in transporting hazardous materials and support projects that will advance the Department's strategic goals.

The program achieves these objectives through partnerships with stakeholders and small businesses, and intergovernmental agreements to execute research projects. To develop research proposals into potential technology transfers or regulatory outcomes, we announce solicitations through the SBIR program and IAAs. HMR-DATA will continue to engage with existing partners at the Transportation Research Board, the Interagency Advanced Power Group, and Naval Research Laboratory, and build new relationships with other federal partners.

Anticipated Program Activities:

In FY 2024, HMR-DATA will work with our subject matter experts, stakeholders, and modal partners to continue activities within the four research areas: Risk Management and Mitigation, Packaging Integrity, Technical Analysis to Aid Risk Assessment, and Emerging Technology. To further the Department's strategic goals, HMR-DATA will focus on lithium batteries, climate change and sustainability, and equity across its research focus areas.

Risk Management and Mitigation

Research in risk management and mitigation is essential to reduce the number of injury- and fatality-related incidents that involve hazardous material transportation. HMR-DATA's objective is to reduce and prevent these incidents through research projects that identify and analyze safety gaps with high-consequence materials and rapidly developing industries. Such research areas include delay costs, thermites, and evaluation of modal choice and hazardous materials routing.

Cost of Delays from Hazardous Material Rail Incidents

Hazardous materials incidents by rail can cause a variety of delays. This research estimates the cost of delays by using a standard bottleneck model that factors in the duration of closure, traffic level, and the capacity of the closure site. The research explores various network locations with different levels of traffic and capacity, and differentiates non-accident releases (NARs) and accident releases (ARs) since a significant portion of ARs is due to the accident itself. Derailments and collisions can result in the need for cleanup, emergency response, evacuation, environmental remediation, and transportation delays. Currently, it is unknown how different factors such as weather, types of track or train consist, rail traffic, etc. impact the monetary and social cost estimates for each rail delay. RD&T will research these factors and estimate the monetary costs of delays due to hazardous materials rail incidents.

Thermite

Thermite is a diverse group of pyrotechnic materials that are used in fireworks, welding, metal refining, and more. PHMSA has been actively researching the proper classification of thermite material since 2016 when it received questions related to thermite classification from multiple PHMSA-approved explosive test labs. Based on PHMSA's initial research efforts, PHMSA determined that thermite substances meet the definition of a Class 1 explosive, and so require classification testing from a PHMSA-approved laboratory. PHMSA believes that further oversight is necessary to properly manage the hazards thermite poses in transportation. HMR-DATA will research different compositions of thermite (varying concentrations of metal oxides and additives) and the corresponding hazards to better understand how these materials meet Class 1 criteria. Accurate classification is critical to managing risk during transportation.

Modal Choice and Hazardous Materials Routing

The safe transportation of hazardous materials relies on careful mode and route selection. Unfortunately, current transportation models prioritize limited metrics, such as cost, emissions, mileage, and time, and do not consider safety and other societal and environmental risks. This lack of information makes it difficult for freight carriers and logistics companies to evaluate the risks and benefits of different transportation options. Additionally, there is a need for a comprehensive approach for evaluating and prioritizing risks associated with transporting hazardous materials through sensitive communities and environments.

In FY 2024, HMR-DATA is collaborating with the Volpe Center to incorporate risk factors into the Freight and Fuel Transportation Optimization Tool (FTOT) to address this issue. Including these risk-based factors will allow for the optimization of freight and supply chain flows and routing over the transportation network. The development of the proof-of-concept version of FTOT is expected to be the first phase of a broader effort to incorporate risk into the model.

Packaging Integrity

Packaging Integrity research helps inform standards that ensure hazardous materials remain within original packaging during transportation. HMR-DATA continues to research different packaging solutions as novel packaging techniques are being developed. Research in this area includes fiber-reinforced plastic portable tanks, nurse tank fatigue, and autonomous leak detectors.

The international community is deciding whether to adopt new United Nations provisions for fiber-reinforced plastic (FRP) portable tanks. Other international communities, like the European Union, have already approved them for use. Canada is also evaluating the provisions for regulatory

harmonization. In FY 23, HMR-DATA and the Volpe Center conducted a review to identify concerns and challenges related to using FRP portable tanks. They identified recurring issues, such as fatigue and commodity compatibility, to potentially establish performance criteria to evaluate FRP portable tank safety equivalency to existing metallic tanks.

In FY 24, HMR-DATA will conduct performance testing on FRP portable tanks, such as using a pool fire test to determine when an FRP portable tank fails under standardized fire test conditions. HMR-DATA is concerned that the 30-minute survival time in the UN Model Regulations may not be adequate for FRP portable tanks. Additional testing may be needed to evaluate the tank's fatigue and frame impact, and conduct nondestructive testing on tanks.

HMR-DATA is conducting research on nurse tank fatigue over its life cycle. Nurse tanks are widely used in the agricultural industry as bulk packaging to transport anhydrous ammonia fertilizer. However, the factors that contribute to nurse tank packaging failure and consequent leakage are not fully understood. This research will use finite-element modeling to understand the nurse tank design properties that impact fatigue life.

As autonomous vehicles become increasingly popular, there is a growing demand to use autonomous vehicles for commercial shipments. Shipments on autonomous vehicles could include household hazardous materials, which creates a need for novel approaches to packaging safety. HMR-DATA funded a project on compact broadband leak detectors for autonomous vehicles to address this need. This compact detector can be affixed to a drone and detect a wide array of common hazardous materials, such as paint thinner, butane, mercaptans, methane, and more. In FY 24, HMR-DATA will continue to fund this work in Phase II to further develop the technology towards commercialization.

Package integrity research will also explore how hazardous materials packages can be safely reused and recycled to reduce emissions associated with the manufacture of new packages. This research includes identifying strategies for reducing per- and polyfluoroalkyl substances (PFAS) and other harmful materials. This research will also address how the research program can help reduce climate change impacts.

Technical Analysis to Aid Risk Assessment

The DOT Hazardous Material Incident Reporting Program collects information about a hazmat-related incident. HMR-DATA will use incident data, including root cause, pattern, and anomaly analyses, to inform its research agenda with the longer-term goals of developing safer and more efficient inspection, testing, classification, and certification methods. Additionally, HMR-DATA will examine novel methods of commodity flow tracking in FY 24.

HAZMAT Incidents and Commodity Flow

To minimize safety risks, it is essential to understand where hazmat accidents occur relative to where they are typically transported. Adding a yearly hazmat packaging commodity survey to the existing U.S. Census Bureau Commodity Flow Survey has been an ongoing research project within the program. The yearly hazmat survey provides more granular data on shipping performance, packaging performance, quantity, and mode of transportation for each of the different hazmat packaging types. This detailed packaging survey helps PHMSA determine new packaging requirements or the need for potential rulemaking for packaging standards.

Novel Commodity Flow Tracking

Information on type and quantity of hazardous materials for hazards and vulnerability assessments is critical to develop plans for preventing, mitigating, responding to, and recovering from hazardous materials incidents. However, common methods of collecting information on type and quantity of hazardous materials involve manual data collection (e.g., individuals observing placards periodically and documenting the information). Manual data collection can be inefficient, prone to human error, and not continuous. In FY 24, HMR-DATA will partner with Pacific Northwest National Laboratory to evaluate the capability and feasibility of a novel hazardous materials monitoring system for identifying, tracking, and analyzing the movement of hazardous materials.

Emerging Technology

The DOT FY 2022–26 Strategic Plan states that Operating Administrations (OA) should "invest in purpose-driven research and innovation to meet the challenges of the present and modernize a future transportation system that serves everyone today and, in the decades, to come." HMR-DATA has a well-established history of researching emerging technologies. HMR-DATA will continue to support and pilot projects to analyze new materials for innovative packaging and other emerging technologies to aid in the transportation of hazardous materials.

Small business partnerships advance the development of innovative emerging technology. In FY 23, HMR-DATA oversaw ongoing work on its first Phase II SBIR project, the Battery Logistics Integrated Safety System (BLISS). The BLISS project is in the prototype testing phase now and is planned for commercialization by the end of FY 24. Additionally, HMR-DATA funded a new Phase II project on a compact leak detection system for autonomous vehicles. HMR-DATA solicited proposals for four new Phase I SBIR topics: Bioremediation for Hazardous Material Spills; Integrated RFID Trackers and Sensors for Hazardous Material Communication in Transportation; Portable State-of-Charge Sensor for Lithium Batteries; and Wearable PPE-Integrated Sensors for First Responders.

Bioremediation for Hazardous Material Spills

Over the past decade, there have been close to 200,000 hazardous material incidents. Such incidents can result in human injuries, fatalities, economic losses, and environmental damage. To reduce these negative consequences, HMR-DATA asked small businesses to develop a bioremediation solution for first response and ongoing treatment of hazardous materials spills. Bioremediation is a technique that uses living organisms, such as plants, algae, bacteria, or fungi, to treat contaminants. This solution will emphasize treatment, rather than just initial containment and removal of hazardous materials.

Integrated RFID Trackers and Sensors for Hazardous Material Communication in Transportation

To transport hazardous materials, packages must be appropriately labeled and marked as specified by the Hazardous Materials Regulations. The safe transportation of hazardous materials hinges in part on the visibility of hazardous communication labels and markings. To prevent hazardous communication from being obscured, removed, or inaccurate, HMR-DATA asked small businesses to develop an integrated radio frequency identification (RFID) and sensor system that would accurately communicate the hazard and detect packaging failure.

Portable State-of-Charge Sensor for Lithium Batteries

Current regulations require Lithium-Ion Batteries to be at 30 percent State of Charge (SOC) or less when transported by air. However, this regulation is very difficult to track and enforce. HMR-DATA will be working with a small business to develop a portable SOC Sensor. Current methods for detecting SOC are either dependent on high quality information from the manufacturer or a lengthy

process of discharging and charging. The goal of this project is the development of a sensor that can have a relatively quick and easy SOC detection for a variety of lithium-ion batteries. This will give carriers as well as investigators information to ensure the cargo is in compliance, thus reducing risk.

Wearable PPE-Integrated Sensors for First Responder

First responders to hazardous material incidents face many safety risks daily. Some risks, such as exposure to hazardous chemicals and toxic gases, can be difficult to detect. Without information on real-time exposures, first responders are at a higher risk of injury or harmful exposure. HMR-DATA tasked small businesses with developing novel sensor technologies that are wearable and integrated into clothing or personal protective equipment. The sensor would be able to monitor exposure to hazardous materials and provide notifications in advance of dangerous exposure levels.

As a critical component of emerging technology research, HMR-DATA will continue to establish partnerships with small businesses in FY 24. HMR-DATA plans to solicit SBIR topics in critical emerging technology areas, such as machine learning/artificial intelligence, novel sensor technologies, green/sustainable packaging, and processes to leverage the “Internet of Things.”

Lithium Batteries

Ensuring the safe transportation of lithium batteries continues to be a priority for HMR-DATA and PHMSA. Recently, PHMSA has observed a significant increase in lithium battery fires in transportation and storage incidental to movement. This trend is likely to continue based on increased lithium battery shipments due to advancements in personal electronic devices, micro-mobility, and electric vehicles.

Research in the safe transportation of batteries has been an ongoing project area for HMR-DATA since FY 2019. This research will continue in FY 2024 as the electrification of our transportation system continues to grow. To address the increase in battery-related incidents, HMR-DATA will continue researching strategies for lithium-ion battery risk management and mitigation. Such strategies include end-of-life battery management, lithium-ion battery alternatives, and SOC evaluation techniques.

HMR-DATA will continue its research collaboration with the United States Naval Research Laboratory (NRL) to develop strategies for de-energizing end-of-life lithium-ion batteries, such as pouch packs and 18650s. This project is multi-year and wrapping up its first year of the project. NRL has been evaluating saltwater solutions as a possible method to de-energize end-of-life batteries. In FY 24, NRL will look at cost-effective ways to de-energize end-of-life batteries at consumer collection points (e.g., Home Depot) and determine if other ideal solutions provide a maximum discharge rate without corroding the cell.

HMR-DATA’s second project with NRL tests sodium-ion batteries as a potential alternative or complement to lithium-ion batteries. HMR-DATA wants to understand sodium-ion battery properties and whether they act like lithium-ion batteries. NRL procured two different types of sodium-ion batteries to use for thermal stability testing. In the future, NRL will conduct nail-penetration testing and toxicity, and relative concentrations of off gases from the two sodium-ion battery types. Going into FY 24, the goal is for NRL to document the test findings and provide recommendations on how PHMSA might regulate sodium-ion batteries.

On March 6, 2019, PHMSA published an interim final rule, “Transportation of Lithium Batteries” (HM-224 I). This rule requires lithium-ion batteries to have a SOC of 30 percent if transported via

aircraft. However, we do not know, nor do we currently have methods to confirm, SOC if aircraft-transported batteries are at or above 30 percent SOC. In FY 24, HMR-DATA will evaluate the SOC of new 18650 and pouch cell lithium-ion batteries shipped by air. The evaluation of 30 percent SOC in lithium-ion batteries will determine if these batteries shipped by air are at or below 30 percent SOC. The research will also identify a potential method to determine if pouch packs and 18560 batteries are at 30 percent SOC and gather knowledge on the physical limits of lithium-ion batteries above 30 percent SOC before thermal runaway occurs.

In addition to understanding the consumer market, HMR-DATA will be soliciting a SBIR Phase I project to help design a portable device to detect the SOC on batteries being shipped. This will give shippers, carriers, and regulators a tool to help determine the safety of batteries before they are shipped.

HMR-DATA continues to plan and conduct packaging research to address the risks and issues with batteries that go into thermal runaway while they are in their packaging. Notably, HMR-DATA's first ever successfully funded SBIR Phase II project is developing an intelligent packaging solution aiming to predict and contain the hazardous effects from batteries in a thermal runaway. Under Phase II, small businesses will continue developing and refining intelligent packaging.

Equity

One of the Department's strategic goals is to reduce inequities across the transportation system and the communities they affect. HMR-DATA, in collaboration with the Volpe Center, has developed an equity measurement case study that will look at PHMSA's activities. In FY 23, Volpe used a logic model framework to analyze the equity implications for various HMR-DATA program activities. The models traced inputs and activities to outputs, outcomes, and impacts. Select programs within PHMSA were assessed to determine the degree to which outcomes and impacts are equitable, mindful of the possibility of existing inequities.

In FY 24, case studies will then be developed to demonstrate the practical application of the measures and metrics to PHMSA activities. The project began by researching many of PHMSA's activities. In FY 24, the project will develop a method for selecting activities based on the importance of the particular activity for equity issues; the feasibility of developing specific equity measures; and the difficulty of implementing the measure.

The research will include identifying and reviewing data needed to understand PHMSA activities, evaluate baseline conditions, or develop equity measures and metrics. The resulting analysis will include actionable measures and metrics that can be applied to existing risk models and other decision-making activities. The analysis may also result in guidance and recommendations for data collection efforts to establish and implement proposed equity measures. This study will communicate information gaps but attempt to leverage the available information to provide practical and actionable measures and metrics.

In FY 24, HMR-DATA will collaborate within PHMSA to research the current registration fee structure and its equity impacts. PHMSA registration fees are collected from persons who offer for transportation certain hazardous materials in commerce. These fees fund Emergency Preparedness Grants that also provide emergency response and hazardous materials employee training. This research will model and analyze the risks of registration fee structures and provide an equity assessment.

In FY 24, HMR-DATA will continue to identify equity information gaps and analyze the equity metrics to determine areas of improvement in the program. Research in FY 24 could include

projects that assess equity impacts of technologies HMR-DATA have funded. Additionally, HMR-DATA will collaborate with stakeholders to explore new research grounded in equity in transportation of hazardous materials.

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

Risk Management and Mitigation

The program will continue to invest in research to manage and mitigate the risks associated with transporting hazardous materials. For example, PHMSA will continue to research the cost of delays from rail incidents. Research outcomes on delay costs of derailments and collisions will provide a more thorough understanding of key factors and how they influence the delay cost of incidents. The impact of this work will inform the areas that should be prioritized to reduce delay and increase safety. The output of the FTOT project would be a framework to update FTOT by incorporating risk into the tool. The outcome could be an updated tool and insight on responsible delivery options of hazardous materials instead of a cost-based approach to route optimization. The impacts encompass environmental, social, and economic factors if the new tool becomes widely used, as route optimization would encompass risk factors that result in impacts to those areas. The output of the thermite project would be data on the hazards of different thermite compositions. This would inform thermite classification in regulations and result in safer transportation of thermites based on evidence-driven classification.

Packaging Integrity

Hazardous materials packaging failures pose a significant threat to public safety and continue to occur within our transportation system. Our research investigates ways to reduce packaging failures through non-traditional materials like fiber-reinforced plastics on portable tanks and cargo tank motor vehicles. These lightweight materials would reduce the overall weight of the packaging while keeping the hazardous material inside the packaging. The outcome of these research projects would be new packaging, promoting a safer transportation system, and enhancing economic strength and global competitiveness. The impact of the research should improve the safety of all hazmat transportation while informing future rulemaking.

Planned research on using recycled plastic as a packaging material will investigate how increased use of recycled plastic will impact packaging safety. The outcome of this research would be increased manufacturing using recycled materials for packaging. This research could decrease carbon emissions and materials usage from packaging manufacturing and inform ongoing discussions about how to regulate recycled plastic packaging.

Technical Analysis to Aid Risk Assessment

Using incident data and identifying root causes, patterns, and anomalies to inform HMR-DATA's research agenda would set longer-term goals of developing safer and more efficient inspection, testing, classification, and certification methods. The output of the annual hazardous material commodity flow survey would allow timely data on the current shipping landscape of hazardous materials. The outcomes of this survey may also help inform the buildout of frameworks using geo-spatial mapping to determine the risk of hazmat incidents during the in-transit transportation phase. The impact of the commodity flow survey could establish frameworks that could help predict where routing might have a higher or lower risk to the public.

The output of the novel commodity flow tracking project will be more accurate and timely methods of standard commodity flow tracking. The outcomes would be informing state governments of the

quantity and type of hazardous materials moving through their communities. The impact of these new tracking methods would be the potential for systematic change in tracking hazardous materials commodities, better risk communication to the public, and better collection and management of commodity data.

Emerging Technology

In FY 23, the program invested heavily in emerging technology. Partnerships with small businesses enabled the program to discover innovative and emerging technologies that could assist in safely transporting hazardous materials. Through the SBIR program, HMR-DATA has observed many innovative projects. Through the four new Phase I SBIR topics, small businesses will develop technologies that range from portable state-of-charge sensors for lithium-ion batteries to green bioremediation solutions for hazardous materials spill treatment. These feasibility studies will determine if there is a pathway to proof of concept. The outcome of these projects would be the development and commercialization of technologies that enhance the safety of hazardous materials transportation. The impact of emerging technology on the hazardous material transportation system would update safety standards and find non-traditional ways of safely transporting hazardous materials.

Lithium Batteries

As consumer demands for personal devices continue to grow, so does the use of lithium-ion batteries. HMR-DATA and PHMSA have recognized the need to continue researching lithium-ion batteries, their chemistry, their impact on transportation systems, and risk. The outputs include continued research collaboration projects with the Naval Research Laboratory (NRL), Federal Aviation Administration (FAA), Environmental Protection Agency (EPA), and Department of Energy (DOE) to study lithium-ion battery properties. The outcome of these collaborative research efforts would be better informing the lithium-ion battery users throughout the entire supply chain and reducing the risk these batteries pose. This includes new batteries that aid in fire protection and firefighting as well as help reduce the risk of transporting end of the life batteries to recyclers. The additional outcome would be identifying other battery chemistries, such as sodium-ion batteries. The impact would provide more information and guidelines on how hazardous material carriers and shippers should handle, dispose of, and ship this kind of battery. This research will also inform future regulatory changes related to batteries.

Equity Measurement

HMR-DATA will research ways to reduce inequities across our transportation systems and the communities they affect. With the ongoing research efforts between HMR-DATA and the Volpe Center, the outputs will be the identification of equity metrics that will support PHMSA's activities. While the outputs will identify the level at which PHMSA's activities are equitable, the outcome of this research will empower PHMSA with the necessary tools for program managers to adjust their programs and activities accordingly to ensure each activity is equitable. This research will ensure that PHMSA's internal or external activities avoid imposing inequities that affect underserved communities and transportation systems.

The output of research on registration fee structures will be a risk assessment, evaluation, and model of registration fees. The outcome of this research can help inform the rulemaking process, as there is an advance notice of proposed rulemaking on adjustments to registration fee structures. In turn, this impacts the equitable implementation of new registration fees on the numerous people and businesses the registration fees affect.

Potential Economic or Societal Impacts:

Hazardous materials are transported through thousands of communities in every state, every day. Congress has entrusted PHMSA with protecting the safety of millions of Americans who live and work around hazardous materials transportation routes. It is anticipated that continued R&D investments will have a positive impact on communities and improve hazardous materials safety and environmental protection. To that end, continued investments in hazardous materials safety research will provide PHMSA with science-based solutions and resources to support the safe delivery of hazardous materials via highway, rail, vessel, or air. This will protect the environment, reduce GHG emissions, promote economic growth, and create jobs. This program continues to pursue groundbreaking and evidence-based R&D that improves existing hazardous materials packages, explores new packaging solutions, and develops technologies that could improve the safe transportation of hazardous materials. PHMSA believes this research will transform the hazardous materials industry and make hazardous materials transportation even safer. Transformation in the hazardous materials industry will further enhance safety, environmental and climate change management, and reduce harmful community impacts from hazardous materials incidents.

HMR-DATA supports DOT's strategic goal of transformation through continuous improvement of hazardous materials safety and reliability, and identification of the best technology for commercialization. This enhances the protection of people, property, and the environment from hazardous materials incidents, while allowing for reliable transportation for industries relying on hazardous materials to manufacture goods.

HMR-DATA will continue to conduct outreach that increases awareness of research funding opportunities and build research partnerships. These efforts will help advance the strategic goal for Equity, as we evaluate PHMSA activities and develop tools and metrics to ensure PHMSA's activities are equitable. In support of the strategic goals for Safety and Economic Strength and Global Competitiveness, HMR-DATA will continue to promote topics under the SBIR program, work with our federal partners, and seek input from our stakeholders to address the research gaps within the hazardous material transportation community.

Potential Progress Made Toward Achieving Modal Strategic Goals:

HMR-DATA is making strides towards research that aligns with the Department's strategic objectives, with a primary focus on Safety. The program's main objective is to reduce incidents involving fatalities and significant injuries caused by hazardous material transportation. To achieve this, the program concentrates on risk management, mitigation, technical aid, and packaging integrity. However, the program also contributes to the Department's broader goals of Equity, Climate and Sustainability, Economic Strength and Global Competitiveness, and Innovation.

The program is working with the Volpe Center to create equity measures and metrics that can be applied to its activities, allowing PHMSA program managers to evaluate scenarios and adjust their programs and activities accordingly. The program is also working with Volpe to add a risk assessment to Volpe's existing Freight and Fuel Optimization Tool to identify highly vulnerable areas and underserved communities.

To address Climate and Sustainability concerns, HMR-DATA will also research recycling and reusing plastics that carry hazardous materials to minimize carbon emissions and used plastic packaging. Additionally, HMR-DATA will research ways to reduce PFAS in the packaging supply chain and first-responder exposure to PFAS. PFAS are an environmental concern due to their

persistence in the environment and the negative health effects they can have. Minimizing the impact of PFAS in commerce can help support the agency's goal of Climate and Sustainability.

In line with the Economic Strength and Global Competitiveness department goal, HMR-DATA continues to invest in the SBIR program to collaborate with small businesses and support the commercialization of innovative technology. Within the past few years, HMR-DATA has increased the investment in SBIR by funding more Phase I projects. In this way, HMR-DATA is building the foundation for new American technology that could have a widespread impact on the safe transport of hazardous materials.

Collaboration Partners

Hazardous materials are transported daily by all modes of transportation (air, rail, highway, and water), so HMR-DATA needs to take every opportunity to collaborate with our modal partners on joint work.

HMR-DATA has collaborated with the Federal Railroad Administration (FRA) on several current and past projects related to impact and fire testing on tank cars and portable tanks, and the transportation of liquefied natural gas.

In FY2024, HMR-DATA will continue to develop new partnerships. In FY2023, HMR-DATA planned and entered into an agreement with Pacific Northwest National Lab for novel hazardous material commodity flow measurement. In this way, HMR-DATA continues to prioritize building relationships that leverage the expertise of federal partners.

The program continues to partner with the Volpe Center on several projects, including the equity measurement case study, fiber-reinforced plastic portable tanks, costs of delay in freight transportation incidents by rail, and the Freight and Fuel Optimization Tool.

In FY 24, the program hopes to partner with the Federal Aviation Administration (FAA) on several lithium-ion battery projects, including reviewing SOC on batteries shipped by air, and methods for classifying damaged, defective, and recycled batteries.

Like PHMSA, HMR-DATA and its projects also touch every aspect of transportation by air, rail, highway, and water. HMR-DATA collaborates with modal partners, e.g., Federal Railroad Administration on tank car research, Federal Aviation Administration on unmanned aerial systems research, Federal Motor Carrier Safety Administration on nurse tank research. HMR-DATA also collaborates with a broad range of external stakeholders and partners who want to engage and solve the same objectives HMR-DATA has identified. HMR-DATA collaborates with academia; small businesses; and other federal partners such as the National Labs, Department of Energy, the National Institute of Standards and Technology, the Environmental Protection Agency, the Naval Research Lab, the United States Coast Guard, and the National Academy of Sciences. HMR-DATA also works with a variety of small businesses through the SBIR program. These partnerships help HMR-DATA identify knowledge gaps and innovative research topics and promote new knowledge to inform potential regulatory changes. HMR-DATA also helps to facilitate the transfers of knowledge between these organizations that help our multiple federal partners achieve their own strategic goals.

Pipeline Safety Research Program **(\$16,363,000)**

Program Description:

PHMSA's OPS RD&T FY 2024 initiatives will continue to address ongoing safety and environmental risks and challenges while increasing focus on the transportation of new energy products. New RD&T will continue to increase as we transition to new energy sources that reduce greenhouse gas (GHG) emissions and transportation-related pollution. This process will include investments in research on hydrogen, carbon dioxide, and biofuels to ensure safe and effective regulation of the transport of new energy products—particularly as volumes scale up.

PHMSA oversees the safe design, construction, operation, and maintenance of more than 3.4 million miles of pipelines that transport nearly all the natural gas and about two-thirds of the liquid petroleum energy products consumed domestically. Research and development, therefore, provide critical solutions to ongoing and unexpected challenges.

In FY 2024, OPS' Pipeline Safety Research Program (PSRP) will continue to pursue its RD&T goals through four sub-programs: the Competitive Academic Agreement Program (CAAP); the Pipeline Core Research Program (Core); Small Business Innovative Research (SBIR); and Inter-Agency Agreements (IAAs). The PSRP is executed through competitive awards, cost-sharing agreements, grants, and IAAs. The sub-programs address different research requirements and are designed to develop concepts from their initial stages to industry or government adoption.

Major Program Objectives:

In FY 2024, the PSRP will remain focused on improving pipeline safety through research that provides engineering solutions, applications, and recommendations for advancement of the safe transportation of energy products. The PSRP achieves its goals through Core program demonstrations, deployments, and commercialization; research partnerships with universities through CAAP; small business-focused innovation through SBIR; and expertise from federal agencies and national labs through IAAs. The PSRP's main objectives are to:

- Help advance a safe and reliable pipeline transportation system for the American public by providing the scientific and engineering basis for improved industry standards and rulemaking.
- Promote emerging technologies for implementation within the pipeline industry.
- Identify and address pipeline safety challenges and research gaps and invest in research projects that address the Department's FY 2022 through FY 2026 strategic goals.

The PSRP achieves its objectives by establishing public-private RD&T partnerships with pipeline stakeholders. In addition, PHMSA sponsors RD&T projects focused on providing near-term solutions that will improve safety, reduce negative environmental impacts, and enhance the reliability of the nation's pipeline transportation system. PHMSA avoids unnecessary research duplication through extensive public outreach and by working closely with interagency partners from federal agencies, research organizations, private research consortiums, academia, public advocacy groups, and other pipeline stakeholders. Together, these efforts aim to fund and share the cost of critical research to develop new technologies, products, and knowledge while promoting stakeholder engagement and transparency.

PHMSA uses its own pipeline data and the information gained from Pipeline RD&T public forums and meetings to establish future research funding agendas and solicitations. On November 15 and 16, 2022, the PSRP hosted a public meeting and forum to invite stakeholders to focus on research gaps and challenges specific to the LNG industry. Approximately 156 participants from governmental, international, and non-governmental organizations attended the virtual forum, and more than 20 presentations were given. The public meeting and forum identified 23 priority research gaps related to LNG facilities, specifically in design and construction, siting, fire protection system design, and operation and maintenance. These gaps were incorporated into the FY 2023 R&D solicitations for the CAAP and the Core Research Programs.

PHMSA hosted a public meeting and forum in Houston, Texas, from December 13 through December 15, 2022, with nearly 850 combined in-person and virtual attendees, which included both public and industry participation. PHMSA had the opportunity to present and discuss its ongoing initiatives to improve safety; its efforts to reduce methane emissions; and its current role in regard to carbon dioxide and hydrogen pipelines. Additionally, PHMSA presented and discussed initiatives involving the update and use of advisory bulletins and lessons learned from failures, such as the recent geohazard-related failure of a carbon dioxide pipeline in Sartoria, Mississippi; a natural gas failure involving a hard spot in Danville, Kentucky; and a crude oil spill caused by a ship anchor striking an offshore pipeline near Long Beach, California. The meeting also allowed the PSRP to highlight success stories of the programs' technology transfers and gather input from both industry and public stakeholders on research topics.

Anticipated Program Activities:

Research activities lead to the development of new or improved tools and technology to aid in the prevention and reduction of pipeline failures and incidents. Research investments also assist with the early identification of pipeline defects (before they lead to catastrophic ruptures) and the identification of issues related to the transportation of alternative fuels, which may be used to reduce GHG emissions. Investments in these areas are aimed at preventing or lessening the release of hazardous materials into the environment. The PSRP is designed to be a collaborative program with stakeholders. Research funding is derived from pipeline operators through user fee assessments and from Oil Spill Liability Trust Fund contributions.

A comprehensive research strategy is developed systematically through RD&T forums, research gap ideas submitted by stakeholders, PHMSA initiatives, and collaborative partnerships with government organizations (GOs) and non-government organizations (NGOs). OPS coordinates and collaborates on R&D topics through workgroups, conferences, and meetings with international partners, other federal and state agencies, and pipeline stakeholders.

PHMSA will continue building research and innovation partnerships with universities, industry, and research organizations that specialize in advancing pipeline safety and bringing technology to market. An important programmatic component is PHMSA's funding of cooperative research projects through the CAAP with colleges and universities, which spurs innovation by enabling and supporting academic research. The CAAP is focused on theoretical and high-risk projects that have high promise of success to a wide range of pipeline safety challenges. Promising CAAP theoretical research results may be shared with the Core program for further development. The CAAP also exposes students to both the pipeline industry and common pipeline safety challenges to show them how highly valued and needed their engineering and technical disciplines are in the pipeline field. The Protecting Our Infrastructure of Pipelines and Enhancing Safety (PIPES) Act of 2016 (Pub L. 114-183) requires a 20 percent cost share from non-federal sources for university research projects. Historically, PHMSA has awarded \$2 million of CAAP projects annually. However, to

increase CAAP participation, PHMSA issued its FY 2023 Notice of Funding Opportunity (NOFO) for the CAAP on March 19, 2023, through the grants.gov web page³, with anticipated research awards of up to \$4 million and federal funding not exceeding \$1 million per award.

PHMSA ensures that the CAAP is more inclusive through outreach communication of funding opportunities to all higher education institutions, including MSIs, such as Historically Black Colleges and Universities; Hispanic-Serving Institutions; and Asian-American, Native American, and Pacific Island-Serving Institutions. PHMSA strongly encourages universities to partner with MSIs in their grant proposals. In late March and early April 2023, PHMSA conducted two informational sessions with MSIs on the CAAP. PHMSA will continue to plan, assess, and execute strategies to increase research partnerships and collaboration with MSIs; increase awareness, engagement, and interest in pipeline safety research and careers; and learn through CAAP research partnerships.

In addition, on April 12, 2023, PHMSA issued its FY2023 Safety Research Announcement No. 9 (RA9) for the Core Program through sam.gov.⁴ RA9 identified 19 topics, covering various research topics, such as threat prevention, underground natural gas storage (UNGS) safety, anomaly detection and characterization, hazardous liquid tanks, LNG, climate mitigation, and materials. Total research awards are anticipated at approximately \$9 million.

Collaboration with other government agencies continues to be a priority for PHMSA as demonstrated through ongoing IAAs totaling approximately \$2 million for FY 2023. Areas of research under these agreements support the transition to a low-carbon economy. The research includes examining steel weld qualifications and performance of pipelines in the presence of hydrogen, and a recently awarded project stemming from the 2021 R&D Forum investigating the safe conversion of existing natural gas storage reservoirs to hydrogen service. Additional research within these cooperative agreements includes the investigation of vintage pipe materials; impacts of geomagnetic disturbance events on pipeline safety; and detection of difficult to locate plastic pipes. PHMSA looks forward to new partnerships with other federal agencies in support of the Administration's climate solution initiatives and PHMSA's pipeline safety mission.

PHMSA continues to support small businesses via the SBIR Program, which will award more than \$4 million in fully funded research projects in FY 2023. SBIR projects focus on bringing developing technology to commercialization through American-owned and operated businesses of 500 or fewer employees. Projects awarded in FY 2023 include a fiber-optic system to provide real-time detection of excavation activities near pipelines; smart particles to repair leaks in underground natural gas storage wells; and tools to non-destructively measure fracture toughness of in-service pipelines. These technologies will directly benefit pipeline safety by helping pipeline operators detect safety issues and respond to them more effectively.

For FY 2024, PHMSA plans to invest in the following pipeline safety focus areas:

Liquefied Natural Gas (LNG) Safety

The recent growth in the production and export of LNG has required PHMSA to provide clear regulatory guidance within the changing energy landscape and update its regulations for LNG facilities to address the mandates in the PIPES Acts of 2016 and 2020 (Pub. L. 114-183 and Pub. L. 116-260, Division R). PHMSA hosted an LNG R&D Public Meeting and Forum on November 15 and 16, 2022, with interactive working groups to assist in developing upcoming research topics for

³ <https://www.grants.gov/web/grants/search-grants.html?keywords=CAAP>

⁴ [Research & Development Program: PHMSA Safety Research Announcement #693JK323RA0001 \(dot.gov\)](#)

funding consideration. Upcoming research topics, based on inputs during the 2022 LNG Forum, will address safeguards, process hazard management, hazard modeling, and emerging technologies. The close coordination with LNG sector stakeholders will seek research solutions to address performance-based risk reduction at every type of LNG facility during site location, design, construction, operations, maintenance, and fire protection activities.

In addition, in the FY 2023 appropriations, Congress allocated up to \$8.4 million to PHMSA for the creation of an LNG Center of Excellence (Center) aimed at positioning the U.S. as the leader and foremost expert in LNG operations. The Center offers a unique value proposition for all LNG stakeholders and will enable PHMSA to be a centralized active collaborator with the LNG sector stakeholders, as defined in Section 111 of the PIPES Act of 2020. This collaboration will result in cooperative research with academic and private sector partners, as well as national laboratories and nongovernmental organizations, to further LNG safety technology development and implementation. As required by the Act, the Center will also create an electronic repository for sharing information on best practices for LNG facility operators and all stakeholders.

Development of the Center is in process and PHMSA anticipates it will be operational within the next year.

Underground Natural Gas Storage (UNGS) Facilities Safety

In October of 2015, a containment failure of stored natural gas from Aliso Canyon's Gas Storage Field resulted in an atmospheric release of 97,100 metric tons of methane.⁵ This event prompted Congress to provide PHMSA with significant new statutory authorities to regulate underground natural gas storage. In 2018, PHMSA began funding research and building a portfolio of solutions to develop integrity management programs applicable to more than 17,000 wells associated with UNGS facilities in the U.S. PHMSA will pursue additional UNGS research gaps in FY 2023 for risk assessments, well casing integrity investigations, subsurface safety valve testing, subsurface and facility-level equipment analysis, and knowledge generation on maintenance practices for UNGS wells. On May 16–17, 2023, PHMSA held a public meeting on UNGS (<https://primis.phmsa.dot.gov/meetings/MtgHome.mtg?mtg=164>) in which various stakeholders, such as Kinder Morgan and the Pipeline Research Council International, participated. In addition to the information gleaned from this meeting, PHMSA will use lessons learned from facility inspections and investigations conducted over the past few years to identify research gaps in UNGS.

Pipeline Anomaly Detection/Characterization

Detecting and characterizing anomalies in pipeline systems requires advanced solutions that integrate people, processes, and technology into a comprehensive program. Detection capability must progress past simple corrosion to complex anomalies, such as a mixture of dents, gouges, and corrosion. Incident data for calendar year 2022 shows corrosion as a cause of 20 percent of significant pipeline incidents. Therefore, corrosion as a threat will remain a focus of pipeline safety research investments. Ongoing research includes such topics as improved detection tools to identify critical anomalies; alternative methods for protecting hazardous liquid tanks from corrosion; advanced methods like Bayesian modeling, a statistical modeling method well suited for

⁵ Ensuring Safe and Reliable Underground Natural Gas Storage, Final Report of the Interagency Task Force on Natural Gas Storage Safety, October 2016.
<https://www.energy.gov/sites/prod/files/2016/10/f33/Ensuring%20Safe%20and%20Reliable%20Underground%20Natural%20Gas%20Storage%20-%20Final%20Report.pdf>

predicting and classifying pipeline anomalies; and artificial intelligence (AI) to more accurately predict, characterize, and prioritize anomalies. The PSRP has five active projects utilizing either AI or Bayesian modeling for risk assessment, including a project awarded in FY 2022 for the development of AI-enabled pipeline risk management tools utilizing machine learning, Bayesian Neural Network, and an innovative Reinforcement Learning approach.⁶ Future research will further support improvement of detection and characterization of defects and develop technology that will more effectively manage pipeline integrity. PHMSA's R&D research forum planned for this fall⁷, will have five working groups including carbon dioxide, hydrogen, leak detection of pipeline and LNG facilities, threat prevention, and anomaly detection, repair, and rehabilitation. All five working groups will consider incorporation of AI and machine learning in these areas with consideration for any security and associated risks.

Pipeline Leak Detection

Leaks and fugitive emissions continue to present a challenge. Based on data from the 2023 Environmental Protection Agency (EPA) Inventory of U.S. Greenhouse Gas and Sinks (GHGI), natural gas transmission, storage, and distribution systems accounted for 28 percent of all GHG (methane, carbon dioxide, and nitrous oxide) emissions from natural gas systems.⁸

The PSRP recently funded research focused on operational and maintenance functions that cause the release of GHGs, including:

- Development of new and improved tools and technology to prevent or reduce damage to pipelines, thereby preventing or mitigating releases into the environment, including advanced pipeline right-of-way monitoring and artificial intelligence tools to predict leaks.
- Further development and prove-out of continuous leak detection monitoring and identification systems for both gas and hazardous liquid pipelines.
- Development of new technologies and methods that will allow for the detection of smaller leaks and/or less time to reliably detect larger leaks than can currently be performed with existing leak detection systems, resulting in less product lost from the pipeline and improving safety and reducing environmental impacts.
- Improvement of leak detection for pipelines carrying hydrogen and natural gas/hydrogen blends by gathering information on required sensing specifications and detection procedures for integration into next-generation leak detection equipment.
- Field validation of an advanced leak detection system to accurately identify, without false positives, spontaneous pipeline leaks in real time with accurate Global Positioning System (GPS) locations, which will advance leak detection beyond current capabilities, allowing for quicker detection of smaller leaks and, in turn, reducing fugitive emissions.

PSRP is planning further research on such topics as preventing fugitive emissions from UNGS wells and recapture of fugitive emissions from pipeline equipment.

⁶ <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=954>

⁷ <https://primis.phmsa.dot.gov/meetings/MtgHome.mtg?mtg=166>

⁸ US EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2021, published April 13, 2023, Table 3-65. <https://www.epa.gov/system/files/documents/2023-04/US-GHG-Inventory-2023-Main-Text.pdf>

Pipeline Threat Prevention

Excavation, natural force, and other outside force damage to pipelines continue to be the cause of serious, environmentally-damaging, and injury-causing pipeline incidents.⁹ Preventing or reducing this damage would greatly increase pipeline safety and reduce damage to the environment and GHG emissions. PSRP recently funded projects include developing equipment to help detect unsafe excavations and tools to locate strain in buried pipe caused by earth movement.

In addition, the PSRP recently funded research focused on pipeline threat prevention, including developing a scalable, cloud-based, GIS-enabled recommendation tool for identifying and assessing the impact of geohazards on cast iron and non-cast iron pipelines by utilizing industry standards and best practices, and incorporating satellite-based radar geohazard detection and monitoring.

Repair/Rehabilitation

Damaged coatings, corrosion, and other pipeline damage or defects are major risks to pipeline safety. Improving existing repair methods and creating new, reliable repair methods are critical to the safe operation of pipelines. The PSRP will focus on enhancing repair materials, techniques, processes, tools, and/or technology to support this objective. Ongoing and upcoming projects include a tool to internally repair pipe defects; advanced polymers and adhesives for use in repair; and development of a risk-based approach to remediating gas distribution pipes. Research priorities may be identified to further support PHMSA efforts to help repair, replace, or rehabilitate 1,000 miles of aging, leak-prone, municipality- and community-owned natural gas infrastructure, supported by the Natural Gas Distribution Infrastructure Safety and Modernization Grant Program.¹⁰ The degrading nature of iron alloys, the age of the pipelines, and weak pipe joint designs will receive higher focus since these areas increase the risk of accidents and climate damaging methane emissions. In FY 2021 and FY 2022, PHMSA funded three research projects related to rehabilitation and repair of aging pipelines, including the development of a cured-in-place pipe structural liner for natural gas pipelines with trenchless technology and integrated AI risk assessment.¹¹ Funding has also been awarded in FY 2022 for research into welding performance and requirements for pipelines carrying emerging fuels such as CO₂.¹²

Climate Change Solutions/Hydrogen/Carbon Capture and Underground Storage (CCUS)

The 2023 EPA GHGI data reports that natural gas systems accounted for 22.9 percent of total U.S. methane emissions in 2021, a reduction from 25.4 percent in 2020.¹³ Transmission and storage (e.g., LNG and UNGS) facilities accounted for 24.5 percent of methane emissions from natural gas systems, gathering and boosting accounted for 23.9 percent, while distribution accounted for 8.5 percent.¹⁴

⁹ <https://www.phmsa.dot.gov/data-and-statistics/pipeline/national-pipeline-performance-measures>

¹⁰ [Natural Gas Distribution Infrastructure Safety and Modernization Grants | PHMSA \(dot.gov\)](https://www.phmsa.dot.gov/natural-gas-distribution-infrastructure-safety-and-modernization-grants)

¹¹ <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=990>

¹² <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=996>

¹³ US EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2021, published April 13, 2023, Page 47. <https://www.epa.gov/system/files/documents/2023-04/US-GHG-Inventory-2023-Main-Text.pdf>

¹⁴ US EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2021, published April 13, 2023, Table 3-67. <https://www.epa.gov/system/files/documents/2023-04/US-GHG-Inventory-2023-Main-Text.pdf>

PHMSA will address climate solutions by funding research projects that identify methods to reduce methane emissions on its regulated infrastructure, which will be done in coordination with its stakeholders and interagency partners. Significant research investments at the federal and international level have been conducted on alternative renewable fuels, such as hydrogen and/or hydrogen blends, and carbon capture and underground storage (CCUS). PHMSA continues to identify research gaps for hydrogen gas and/or various hydrogen blends in natural gas pipeline facilities and carbon dioxide transport and storage. Furthermore, PHMSA will continue to prioritize RD&T topic areas based on future usage projections and need.

In addition, the PSRP recently funded research focused on hydrogen and carbon dioxide, including:

- Determining the potential impact radius for carbon dioxide pipelines, using a computational fluid dynamics model for use in risk estimation and emergency response planning in the event of a carbon dioxide pipeline rupture.
- Developing innovative tools to accelerate the conversion of the existing pipeline structure to hydrogen service, including artificial intelligence-powered software and data analytics-based compatibility assessment models.

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

Research investments into pipeline-, LNG-, or UNGS-related challenges may result in published analytical outcomes, small scale tests, and, in some cases, full scale demonstration projects that lead to new technology and scientific methods that improve pipeline safety. The results from each completed project are provided in final reports shared publicly on the PHMSA website and/or the National Transportation Library. Researchers are required to disseminate their findings through presentations and publications at conferences or in peer-reviewed journals. Completed technology development projects may result in new patents or new products for commercialized adoption. PHMSA plans to continue tracking each project's performance using metrics to monitor the progress of the research and the readiness of the technology for commercialization or potential application in the field.

The PSRP has specific annual performance goals to support the priorities and objectives of the Department and PHMSA. These performance goals demonstrate the program's outputs, outcomes, and impacts across multiple research areas, as described below, in support of PHMSA's safety mission and the Department's strategic goals.

Liquefied Natural Gas (LNG) Safety

PHMSA will continue to invest in LNG safety research to address the safety risks and operational challenges from LNG facilities, as well as foster development of new technologies and alternative designs for LNG storage and piping systems. For example, hydrogen could be introduced into LNG facilities in the future as part of the feed gas supply for liquefaction. There are currently no industry standards that identify the design, installation, construction, operation, maintenance, and fire protection requirements for LNG facilities that process and store hydrogen-enriched natural gas. Future research projects will study the impact of hydrogen-enriched natural gas on existing LNG facilities. Research outputs will yield recommendations for safely processing and storing hydrogen-enriched natural gas. Outcomes from upcoming research projects may lead to changes to federal regulations or industry standards in terms of design, construction, operation, maintenance, and fire protection to reduce operational safety risks to employees and the public.

Underground Natural Gas Storage (UNGS) Facilities Safety

PHMSA will continue research to improve the safety of UNGS facilities over their full life cycle with a focus on design and reliability improvements to storage well equipment and maintenance practices. Research outputs from UNGS projects will provide reliability-based methodologies focused on well integrity management and corrosion protection practices while evaluating the effectiveness of real-time, continuous pressure monitoring systems for well surveillance and leak monitoring. PHMSA will encourage incorporating research project outcomes into industry standards or best practices as minimum requirements and/or guidance for storage well casing integrity management. Furthermore, the research outcomes will provide operators with improved efficiency in managing casing corrosion, thereby potentially reducing delayed maintenance-driven well casing incidents. The impacts from UNGS research results will support new policy development on the safe operation of these facilities and reduce uncontrolled releases of gas into the atmosphere.

Pipeline Anomaly Detection/Characterization

PHMSA will continue to fund research to improve pipeline anomaly detection, characterization, prediction, and prioritization in steel and non-metallic pipes. Research outputs are designed to more consistently and accurately identify critical defects within pipelines, and provide PHMSA and pipeline operators with effective instrumentation, methodologies, and processes to locate, evaluate, and predict manufacturing defects and in-service anomalies in pipe. Research outcomes will better inform PHMSA and pipeline operators to make integrity management decisions on steel and composite pipe systems to support safer operations and aid in determining a pipeline's fitness for service. Impacts from the research results will increase stakeholder confidence in pipeline technologies and the accuracy of improved decision-making tools for integrity management. Furthermore, the research impacts will provide pipeline operators with effective instrumentation for detection, allowing for accurate remediation measures that reduce the likelihood of pipeline failures harming the public or environment.

Pipeline Leak Detection

PHMSA will continue investing in research projects to develop new or improved tools and technology solutions to locate, quantify, and repair hazardous liquid or natural gas pipeline leaks. Project outputs will develop processes to more accurately predict leaks, and develop, test, and deploy advanced leak detection platforms (ground-based, aerial, and satellite) and protocols under real-time field conditions to provide pipeline operators with critical knowledge on gas behavior and real-time data to help locate and quantify natural gas leaks. Research outcomes will provide the ability to quantify leaks by utilizing real-time data, which can reduce the risk of an incident caused by migrating gas to a residence or a prolonged release of methane into the environment or predict where leaks are likely to occur before they happen. Impacts from the research findings will lead to further development of advanced leak detection monitoring, identification, and measurement systems for gas and hazardous liquid pipelines. This research will enable operators to expeditiously repair leaks, thereby limiting the duration of methane emissions. Ultimately, this safety improvement will also help to advance the Administration's strategic goal to tackle climate change by lowering the U.S.' cumulative methane emissions.

Pipeline Threat Prevention

Excavation, natural force, and other outside force damage to pipelines continue to be the cause of serious, environmentally-damaging, and injury-causing pipeline incidents. PHMSA will continue to

invest in research to prevent pipeline threats and damage. Research outputs in this focus area will refine tools to identify and predict geohazards and other natural threats; develop sensing platforms to help operators map existing pipelines; make existing unlocatable plastic pipes locatable in advance of planned excavations; develop markers to locate new plastic pipes without the need for a separate tracer wire; or alert operators of possible excavation damage to pipelines. Research outcomes will allow operators to utilize technologies to mitigate excavation pipeline damage, and to quickly detect and respond to damages and leaks in the pipeline system. Impacts from the research findings will help improve safety by developing better methods to detect underground pipelines, helping to prevent excavation damage to buried pipelines and improving detection of hard-to-identify geological hazards. This will ensure an effective, efficient, and reliable underground utility network, and reduce GHG emissions caused by natural force, other outside force, and excavation damage.

Repair/Rehabilitation

PHMSA will continue to invest in improving anomaly repair, and pipe remediation and rehabilitation. Research outputs will provide reliable methods to repair damaged pipe or coatings, manufacturing defects, and corrosion damage, as well as develop testing protocols needed when using composite repair materials. Research outcomes will provide the pipeline industry with validated and safe solutions to rapidly repair and return pipelines to service, reducing economic losses and customer inconvenience, and more effectively make preemptive repairs to prevent accidents or shutdowns from occurring. Impacts from these research investments would advance technological solutions and have longstanding impacts on: 1) safety, with the repair of aging pipelines; 2) equity, with the provision of better service to often underserved communities; and 3) climate change solutions, with pipeline rehabilitation, replacement, or new pipeline installation that will minimize methane emissions.

Climate Change Solutions/Hydrogen/Carbon Capture and Underground Storage (CCUS)

PHMSA will continue to invest in research initiatives to promote the Administration's strategic goals related to climate change solutions and decarbonization. Hydrogen can serve as a sustainable power-generating fuel and could reduce GHG emissions by blending hydrogen into natural gas pipelines. Research outcomes in this focus area will work to remove technical and safety barriers to expand the development of safe transportation by pipeline of emerging fuels, such as hydrogen, and other commodities critical to decarbonization, like carbon dioxide. Hydrogen and carbon dioxide are integral to increase the production of green hydrogen, which is developed from renewable fuels, and blue hydrogen, where the climate impact is decreased through carbon dioxide capture and storage, or capture and utilization.

Specific research related to climate change will identify solutions to safely store hydrogen gas and/or hydrogen gas blended with natural gas in underground storage facilities and convert existing natural gas reservoirs to hydrogen or carbon dioxide storage. Additional research within this focus area would provide knowledge on the impact of hydrogen, hydrogen-blend concentrations, and carbon dioxide on inline inspection tools to characterize the integrity of an operator's pipeline system. Further research investments will improve leak detection, make materials used in pipeline and storage infrastructure more durable and less leak-prone, and optimize operations at pipeline facilities to reduce fugitive emissions.

Potential Economic or Societal Impacts:

The pipeline infrastructure in the U.S. is the primary means of transporting natural gas and the majority of hazardous liquids from production basins and ports to areas of consumption. The importance of energy pipelines to the U.S. economy and our standard of living—as well as the risk it poses to health, safety, and the environment—requires that these assets be maintained safely and reliably and, where appropriate, transitioned or expanded to meet our energy demands while contributing to the mitigation of global climate change.

Pipelines cross through thousands of communities in every state. Congress has entrusted PHMSA to protect the safety of millions of Americans who live and work around pipelines. It is anticipated that continued R&D investments will have a positive impact on communities and improve pipeline safety, environmental protection, and equitable distribution of reliable energy transported nationwide via pipeline networks. To that end, continued investments in pipeline safety research will provide PHMSA with science-based solutions and resources to support the safe delivery of energy and other products via the more than 3.4 million miles of pipelines; protect the environment; help reduce GHG emissions; promote economic growth; and create jobs. PHMSA anticipates that the combination of improving existing infrastructure and continuing groundbreaking, evidence-based R&D will transform the pipeline industry and modernize delivery systems. The goal of this transformation is to further the pipeline industry's efforts to pursue operational excellence that enhances safety, environmental, and climate change management, and reduces harmful community impacts from pipeline accidents.

Pipeline safety R&D supports DOT's strategic goal of *Transformation* and creates innovations for national, regional, and local pipeline operational safety and reliability improvements, including identification of the best technology for commercialization. This enhances the protection of people, property, and the environment from pipeline failures, while allowing for uninterrupted operation of the U.S. energy sector. PHMSA and nonprofit institutions of higher education recognize the role research plays in innovation.

The PSRP will continue to play a significant role in finding solutions to national, regional, and local pipeline operational safety, reliability, and environmental challenges. The outcomes from pipeline safety R&D investments will assist pipeline operators with finding the most suitable technology to efficiently and effectively meet or exceed federal and state pipeline safety and integrity regulatory requirements. Knowledge-based research investments will strengthen critical industry consensus standards with the latest scientific information and data to support the safe design, construction, operation, maintenance, and repair of pipelines.

The PSRP will continue to conduct outreach that increases awareness of research funding opportunities and build research partnerships, specifically with MSIs. PHMSA reached out to more than 200 MSIs and conducted two CAAP information sessions with the invited MSIs on March 29, 2023, and April 5, 2023. These efforts will help advance the strategic goal for *Equity*, as well as diversity and inclusion, while encouraging a diverse group of young students, including those from under-represented communities, to consider careers in the pipeline workforce. In support of the strategic goals for *Safety* and *Economic Strength and Global Competitiveness*, student involvement would cultivate new talent in all aspects of the pipeline sector to continue the safe and reliable delivery of energy to support our economy while protecting the environment. Further, the PSRP will continue to focus on funding research in support of the strategic goal for *Climate and Sustainability* to advance technological solutions to rehabilitate aging cast iron pipelines, which are prone to leaks and are mostly located in disadvantaged areas of older cities and towns.

Potential Progress Made Toward Achieving Modal Strategic Goals:

PHMSA will continue to advance the safe transportation of energy and other hazardous materials essential to our daily lives by conducting research that aligns with the Department's strategic goals. Results of the research findings will continue to address both national and local challenges in urban and rural communities. The PSRP remains focused on systemic, performance-based approaches to ensure pipeline transportation safety, protect the environment, and ensure the cost effectiveness of alternative energy transportation.

PHMSA's safety mission is paramount, and its programs provide tangible safety and operational benefits to the American public. PHMSA has three primary means of improving pipeline safety: a regulatory program, which establishes minimum safety regulations while allowing for the use of new and proven technology through a special permit process; an inspection and investigation program to determine compliance with the minimum regulations; and a research program that provides financial support to advance technology and knowledge transfer. By conducting research to reduce the frequency of pipeline failures and minimize releases, the R&D program supports the safety mission and addresses climate and sustainability strategic goals. The risks from pipeline failures and releases are disproportionately among older and legacy pipeline systems. Thus, improving the performance and safety of these systems also supports equity goals in reducing risk.

Research results and outputs provide scientific and engineering support for PHMSA's safety activities and regulatory rulemaking efforts. They also increase PHMSA's knowledge on inspections and enforcement proceedings; facilitate decision-making; and support regulatory reform and policies to improve pipeline safety and reduce GHG emissions. Specifically, PHMSA's research investments provide support on developing rulemaking criteria to address anomaly detection and characterization (corrosion, seam cracking and pipe body cracking, denting, and fatigue), and integrity management on pipe assessment/reassessment inspection intervals.

The research outputs, outcomes, and impacts from PHMSA's investments are not always directly quantifiable; however, R&D plays a foundational role in addressing pipeline transportation challenges facing the U.S. by developing innovative solutions and ensuring that the best available science and technology are the basis for PHMSA's safety regulatory actions, enforcement, and programs. PHMSA's research investments have resulted in safety impacts through industry utilization and adoption of technology, and, specifically, 35 technology transfers have been commercialized. PHMSA is increasing its stakeholder engagement initiatives to increase technology transfer and commercialization. Additionally, PHMSA is making significant progress in supporting the Administration's efforts to minimize methane emissions from pipelines by upgrading and expanding federal pipeline safety regulation. Research results in the focus areas of LNG safety and pipeline leak detection will inform PHMSA in its proposed rulemaking initiatives in these areas. Specifically, PHMSA expects that the LNG Facilities Rule would strengthen standards for LNG facilities to help prevent large scale incidents and releases from storage tanks. The proposed rule would seek to prevent large-scale incidents like the 2014 LNG incident in Plymouth, Washington, which emitted 3,246 metric tons of methane, and the 2022 LNG incident in Freeport, Texas, which released 1.6 million cubic feet of methane. It also would reduce the risk of low-probability/high-consequence incidents, such as an LNG storage tank failure. Such tanks can contain as much as 69,000 metric tons of methane. PHMSA targets publication of a proposed rule in December 2023. Additionally, the Gas Pipeline Leak Detection Rule would establish standards for usage of leak detection technologies and practices, and require repair of leaks on gas pipeline facilities. PHMSA estimates that these amendments could reduce methane emissions by as much as 500,000 to

1 million metric tons of methane each year. PHMSA published the proposed rule in the *Federal Register* on May 18, 2023.

An example of PHMSA-funded research that supported the Department's strategic goal of *Safety* included five research projects, from 2005 to present and totaling \$4.8 million, in the area of anomaly characterization (dent evaluation criteria). The research projects included Mechanical Damage at Welds; Structural Significance of Mechanical Damage; Dent Fatigue Life Assessment; Full Scale Testing of Interactive Features; and Improving Models to Consider Complex Loadings, Operational Considerations, and Interactive Threats. These projects were used to help form PHMSA's technical basis for dent assessments in its pipeline safety rules, as well as for American Petroleum Institute's (API) Recommended Practice (RP) 1183–Assessment and Management of Dents in Pipelines, published in November 2020. API RP 1183 presents guidance to pipeline operators for developing a dent assessment and management program, and provides the information and methodology to make informed integrity management decisions regarding the management of dents on their systems. Several PHMSA rulemaking and advisory initiatives underway in the area of Leak Detection, Geohazards, and Class Location are supported by R&D investments in those topic areas.

Continued pipeline safety research is necessary due to the expansion and aging of existing pipelines across the U.S. PHMSA plans to continue research investments focused on corrosion, material failure, and equipment failure, which cause 59 percent of all PHMSA-jurisdictional pipeline incidents. These (as well as other) efforts to consider operational releases will also focus on containment of GHGs (such as methane), pipeline transportation of alternative fuels (including hydrogen and carbon dioxide), and improved leak detection and quantification.

Collaboration Partners

The PSRP RD&T collaboration efforts include both federal and non-federal partners. Historically, OPS has established interagency agreements with the Departments of Energy, Interior, and Commerce to conduct materials research. OPS partners with academic institutions through its CAAP. Under CAAP, PHMSA funds 80 percent of basic RD&T costs, leaving 20 percent to be funded by university partners. PHMSA may fund up to 100 percent of RD&T costs related to regulatory analysis or other purely governmental purposes. These levels are specified in and mandated by Section 12 of the Pipeline Safety Improvement Act of 2002.

Members of the PHMSA R&D team are serving on the DOT Equity Council Team. The purpose of this team is to align on the Council's purpose, desired outcomes, and intended cadence; assess the Department's progress towards the goal of institutionalizing equity across all Operation Administrations (OAs); and highlight how Equity Council members are institutionalizing equity in their OAs. The outcome of the Equity Team is to share an understanding of DOT's equity objectives for 2023; identify resources to advance equity objectives and plans; and identify action teams for 2023 chartered and activated to advance the work.

In FY 2022 and FY 2023, PHMSA participated in the following interagency hydrogen and carbon dioxide pipeline initiatives:

- U.S. Dept of Energy (DOE)
 - Hydrogen and Fuel Cell Technologies Office
 - DOE's Hydrogen Program Annual Merit Review and Peer Evaluation Meeting
 - Regional Clean Hydrogen Hubs–Technology Special Purpose Review Team
 - Fossil Energy & Carbon Management

- Workshop on Applied Research for Carbon Dioxide Transport
- CCUS Interagency Field Training
- Carbon Management Project Review Meeting
- Carbon Management Collegiate Competition Review Team
- U.S. EPA CCS Safety Summit
- Global CCS Institute D.C. Forum on Carbon Capture and Storage

External Partners

PHMSA's research program partners with a wide range of external entities who share the same objectives in developing technology, or generating and promoting new knowledge among decision makers, to advance pipeline and hazardous materials safety. Collaborative forums with academia, departmental, and federal partners help identify pertinent technology and knowledge gaps.

In March 2019, PHMSA OPS released a *Special Notice for "Identifying Pipeline Safety Research Ideas"* in the beta.SAM.gov portal. The ongoing *Special Notice* invites any interested stakeholder to submit ideas for future research. This notice is open year-round and is revised as needed to reflect initiatives coming from PHMSA or the Administration. PHMSA launched this measure to widen the participation in formulating its future research strategy. A web-based portal was created to support and manage this action, which can be found at <https://primis.phmsa.dot.gov/rd/gapsuggestions.htm>.

PHMSA is planning an R&D forum in November 2023 to continue collaboration and outreach with stakeholders and researchers, discuss current and emerging safety issues, and identify research opportunities to address safety gaps.

Partnerships with GOs and NGOs provide clear opportunities to leverage ongoing successes, cost-share on mutual safety challenges, and remove duplication. Throughout the year, PHMSA briefs the pipeline industry and public interest groups on the research program and consults with them on individual projects that are within their sphere of expertise. Research collaboration partners—both GOs and NGOs—who cost-share research with PHMSA include federal agencies, associations, regulatory entities, and industry.

Chapter 2 – FY 2025 RD&T Programs

The AMRP FY 2025 outlook year chapter in the annual plan is not developed in alignment with the President's budget request of the same year due to the AMRP development schedule per 49 U.S.C. Chapter 65 Sec. 6501 Research Planning.

Hazardous Materials Safety Research Program (\$XX)

Program Description:

In Fiscal Year 2025, HMR DATA will continue its initiatives to research ways to reduce the risks associated with the transportation of hazardous materials, and identify and evaluate new technologies to facilitate the safe, secure, and efficient transportation of hazardous materials. These goals are supported through four core areas of research in FY 2025: Risk Management and Mitigation; Package Integrity; Emerging Technologies; and Technical Analysis to Aid Risk Assessments. Each core area is described below.

Risk Management and Mitigation: Researching risk reduction strategies to lower the likelihood of transportation-related injuries and fatalities, increase packaging and operational safety, and improve system reliability.

Packaging Integrity: Researching innovative, novel packaging materials and ways to improve safety and reliability of current packaging design and integrity.

Emerging Technology: Researching and evaluating emerging materials, processes, transport operations, energy products, and packaging technologies to keep pace with an ever-evolving transportation system. This research will leverage new technology to reduce and mitigate the risks of hazmat transportation systems.

Technical Analysis to Aid Risk Assessment: Researching evaluation methods for hazardous material transportation activities, events, and incidents. This type of research will aid in understanding packaging failures and hazmat anomalies.

In FY 2025, HMR-DATA will continue to pursue its goals through its various research solicitation programs: Small Business Innovative Research (SBIR), Inter-Agency Agreements (IAAs), and Subject Matter Expert initiated projects. HMR-DATA will continue to work with academia and industry to generate self-initiated research projects from stakeholder input through our research forum as well as HMR-DATA subject matter experts. These research solicitations enable HMR-DATA to engage with a variety of stakeholders, including modal partners and small businesses. They are designed to take innovative research ideas and incorporate them into new technologies and assist with potential regulatory changes.

HMR-DATA is making strides toward research that aligns with the Department's strategic objectives, primarily focusing on Safety. The program's main objective is to reduce incidents involving fatalities and significant injuries caused by hazardous material transportation. To achieve this, the program concentrates on risk management, mitigation, technical aid, and packaging integrity. However, the program also contributes to the Department's broader goals of Equity, Climate and Sustainability, Economic Strength and Global Competitiveness, and Innovation. The program will continue to work on equity research with its federal partners to identify ways to close the equity gap in our communities and transportation systems.

To address Climate and Sustainability concerns, in FY 2025 the program will also research recycling and reusing plastics that carry hazardous materials to minimize carbon emissions and used plastic packaging. Additionally, HMR-DATA will research ways to reduce PFAS in the packaging supply chain and first-responder exposure to PFAS. PFAS are an environmental concern due to their persistence in the environment and the negative health effects they can have. Minimizing the impact of PFAS in commerce can support the agency's goal of Climate and Sustainability.

In line with the Economic Strength and Global Competitiveness department goal, HMR-DATA will continue to invest in the SBIR program to collaborate with small businesses and support the innovation to commercialization of novel technology. Within the past few years, HMR-DATA has increased the investment in SBIR by funding more Phase I projects. In this way, HMR-DATA is building the foundation for new American technology that could have a widespread impact on the safe transport of hazardous materials.

Major Program Objectives:

HMR-DATA will continue to focus on the safe transportation of energy products and other hazardous materials by identifying risk management and mitigation tools; improving packaging technologies and designs; and identifying and developing new and emerging transportation technologies through our research projects.

HME DATA's Objectives will be to:

- Continue to engage and collaborate with our modal partners on research project and review studies.
- Reduce the number of injuries and fatalities that involve hazardous materials transportation.
- Work with small businesses to promote emerging technologies and innovative risk mitigation techniques, such as leak detectors and sensors.
- Identify and address the challenges and research gaps in transporting hazardous materials and support projects that will advance the Department's strategic goals.
- Continue to develop a robust understanding of the problems sounding lithium battery technologies to help support the electric economy.

The Program hopes to develop research proposals that look to areas that help provide technology transfers or regulatory outcomes. We will use solicitations through the SBIR program and IAAs, and look into other solicitation types. We will also continue to engage with stakeholders from modal partners, other federal agencies, and industry to best direct the projects we are looking to launch.

Anticipated Program Activities:

Hazardous materials research will continue to play an important role in advancing the safe transportation of hazardous materials and energy products essential to our daily lives. The core research areas in risk assessment, management, and mitigation; packaging integrity; and emerging technology will support the Department's strategic goals on Safety, Economic Strength and Global Competitiveness, Equity, and Climate and Sustainability. PHMSA will also pursue research to help address the Department's Grand Challenges. Projects in line for FY 2025 will investigate emerging battery types; equity studies in hazardous materials transportation; safety and risk of hydrogen

integration into transportation systems; automation; and hazardous materials transportation using drones.

New packaging materials, designs, and artificial intelligence (AI) and Machine Learning (ML) advances will likely impact the hazardous material transportation system significantly. Innovative packaging materials can improve the safety and reliability of hazmat packaging, reducing the risk of incidents and accidents. Meanwhile, AI and ML can help to optimize routes, monitor and manage shipments in real-time, and identify potential hazards before they become critical. By leveraging these technologies, the transportation of hazardous materials can become safer, more efficient, and more sustainable. In FY 2025, HMR-DATA will initiate certain AI- and ML-related research projects.

Projects that will be brought online from efforts in FY 2025 will come from a variety of contracting vehicles that incorporates research needs as identified by stakeholders at meetings, conferences, and the Hazardous Materials Research, Development, and Technology annual forum. This input will be collected and vetted by a newly established internal review board that ensures projects are in proper alignment with Agency and Department goals. The same review board will also assist in vetting topics of high technology readiness levels for the next round of solicitations through the Small Business Innovative Research Program.

Pipeline Safety Research Program (\$XX)

Program Description:

In FY 2025, PHMSA will continue to seek stakeholder input, review accident trends, and evaluate the progress on its current projects and completed research. In addition, PHMSA plans to bolster its stakeholder engagement program through in-person and virtual meetings to present results from the funded projects with resulting technologies produced from the research. PHMSA will identify any additional research gaps and research topics to be funded in FY 2025 and identify any follow-up research based on the research outputs from prior years. Based upon this analysis, PHMSA will continue to support all the Department's strategic goals through research investments to develop a comprehensive research portfolio in FY 2025 while remaining focused on pipeline safety solutions.

Major Program Objectives:

The PSRP's objectives for FY 2025 will address a comprehensive review of the research portfolio that was awarded in FY 2022–2024, focused on safety, transportation of alternative fuels, and climate change solutions. PHMSA plans to host an R&D forum in FY 2023 that will build momentum from the FY 2021 R&D forum and the FY 2023 LNG R&D forum to determine strategic research needs and priorities for FY 2024 and FY 2025 through collaboration with stakeholders. These include academia, public advocacy groups, other DOT modes, federal agencies, and the pipeline industry. Research proposals would then be awarded to support addressing any safety gaps.

The PSRP will also support research that addresses PHMSA's priorities on pipeline safety; infrastructure development for transporting alternative fuels; climate change mitigation; and environmental justice and equity.

Anticipated Program Activities:

Activities from FY 2024 are anticipated to extend into FY 2025, with PHMSA continuing to pursue research investments that align with the Department's strategic goals and its safety mission. PHMSA will continue to invest in pipeline safety research in the seven program areas described above. Program activities that advance the safe transportation of clean alternative fuels, as well as solutions to mitigate the effects of geohazards (land movement, landslides, heavy rains/floods, etc.) on pipelines, may also come increasingly to the forefront as 2024 research identifies ways to connect research efforts to emerging safety risks and climate change objectives. PHMSA will publish research solicitations after the 2023 forum, review research proposals, and select prospective research projects to support the Department's and PHMSA's goals.

PHMSA will continue strengthening its research partnerships with universities, industry, and safety organizations, and continue its MSI outreach and engagement initiatives. Increased collaboration with stakeholders and interagency partners will also continue to ensure that research outcomes result in technology transfer, and adoption of innovative concepts and methods that will enhance the safety and performance for pipeline-, LNG-, and UNGS-related facilities.

As part of its research activities, PHMSA will continue to implement project evaluation methodologies, conduct project evaluations, and optimize performance management metrics. Furthermore, PHMSA will review the evaluation data to understand trends and establish new project success criteria.

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