

**United States Department of Transportation
Annual Modal Research Plans FY2022
Program Outlook FY2023**

*Pipeline and Hazardous Materials Safety Administration (PHMSA)
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Executive Summary

The Pipeline and Hazardous Materials Safety Administration's (PHMSA) 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 in which 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 the environment, serve environmental justice, and support the country's economic recovery from the COVID-19 pandemic.

America's pipeline infrastructure spans more than 2.8 million miles and is used to transport nearly all the natural gas and about two-thirds of the liquid petroleum energy products consumed domestically. According to the U.S. Energy Information Administration, oil furnishes 40 percent of our energy, natural gas 25 percent, coal 22 percent, nuclear 8 percent, and renewables make up 4 percent. Adaptation of the existing pipeline structure to support alternative energy sources and the need to serve underserved communities will drive the need 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. 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 such as with COVID-19. Research provides 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 environmental impacts, research projects promoting 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) 2022 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).

The impacts of COVID-19 have been limited to schedule changes for some of the research programs that were awarded at the beginning of FY 2020. Those impacts were managed through no-cost extensions allowing researchers more time to complete their programs. PHMSA does not plan any COVID-19 specific research in FY 2022; however, PHMSA's research program does generally support the country's recovery efforts by encouraging innovation and promoting the safe transportation of energy products and hazardous materials, which advances efforts that help ensure the efficient and effective delivery of products that contribute to the country's economic growth.

PHMSA remains focused on collaboration with all stakeholders to leverage investment and successes to date. PHMSA makes continual efforts to avoid duplication, while engaging academia and a wide range of stakeholders to fund and co-fund critical research to develop new technology, products, and knowledge.

Program Description:

Pipeline Safety Research Program

PHMSA's Pipeline Safety Research Program (PSRP) funds innovative research that helps improve safety and supports reliable supplies of energy products and hazardous materials. The PSRP utilizes public-private partnerships with stakeholders, academic institutions, small businesses and intergovernmental agreements to implement research projects. These four programs are the Competitive Academic Agreement Program (CAAP), the Pipeline Core Research Program (CORE), Small Business Innovative Research (SBIR) and Inter-Agency Agreements (IAA). The PSRP is executed through competitive awards, cost-sharing agreements, grants and inter-agency agreements (IAA). These four approaches address different research requirements and are designed to develop concepts from their initial stages to industry or government adoption.

PSRP research will focus on seven topic areas, in addition to conducting a cost-benefit analysis of the development and utilization of an independent pipeline safety testing facility as directed by Section 105 of the Protecting Our Infrastructure of Pipelines and Enhancing Safety (PIPES) Act of 2020. In 2022 the PSRP will address important new research in alternative fuels to address climate change solutions, liquefied natural gas and underground natural gas storage facility safety.

PHMSA provides safety oversight for many types of facilities. Research to improve safety systems for underground gas storage and safety systems for liquefied natural gas (LNG) facilities will be a focal point for the PSRP. This research will improve safety in the full life cycle of underground gas storage (UGS) facilities including worker safety. LNG research will address various LNG industry challenges related to LNG hazards, as well as foster development of new technologies and alternative designs for LNG storage and piping systems.

FY2022 will also include ongoing research in pipeline damage/threat prevention, pipeline leak detection system improvements, and anomaly detection and characterization. Research under this element strongly supports efforts to abate methane releases and are in line with the goals of Sections 113 and 114 of the PIPES Act of 2020. This research will include examining tools to alert operators of possible intrusions to pipelines (e.g., excavation damage), helping operators map existing pipelines, making new plastic pipes locatable without the need for a separate tracer wire, or making existing unlocatable plastic pipes locatable in advance of planned excavations. This research will include new or improved tools and technology solutions for locating, quantifying, and reducing the volume of pipeline leaks and ruptures into the environment and finding and removing critical defects in the pipeline system.

Pipeline Safety Research, Development & Testing Facility

Section 105 of the PIPES Act of 2020 requires PHMSA to conduct a pipeline safety testing enhancement study analyzing the potential value to safety of an independent testing facility for pipeline safety research and development. This study will determine whether an independent pipeline safety testing facility would be critical to the work of PHMSA.

Hazardous Materials Safety Research Program

R&D plays a vital role in helping PHMSA achieve its goal of enhancing the safe transport of hazardous materials. While hazardous materials are transported daily by licensed and trained

professionals operating in well-defined systems, accidents resulting in loss of life and environmental damage still occur. In FY2022, the Hazardous Materials Safety Research Program (HMSRP) will continue its focus on research efforts within the core areas of risk management and mitigation, package integrity, emerging technologies, and technical analysis to aid risk assessments.

A major focus for HMSRP is packaging integrity. Risk can be reduced if hazardous materials remain contained within its packaging during transport. Accordingly, HMSRP efforts in this strategic area are designed to evaluate and verify the suitability and effectiveness of packaging standards and practices, and improve transport safety by developing, evaluating, and testing new packaging technologies and materials.

The HMSRP also focuses on understanding and promoting emerging technologies. As the U.S. economy expands and diversifies, new energy sources, transport systems, and packaging technologies emerge. HMSRP research is designed to identify and analyze emerging materials, processes, packaging technologies, and transport operations, as well as to assess their potential risks or benefits to the existing hazmat transport network.

Lastly, HMSRP focuses on risk management and mitigation research which aims to minimize the probability of hazmat transport incidents and associated consequences.

Technology Transfer (T2) Deployment Activities

PHMSA seeks to promote the use of technology from its R&D programs in commercial applications and therefore tracks a variety of research performance measures. PHMSA's policy is to plan for and continually track T2 activities, when possible following up even in cases where activities occur beyond the contractual timeline of research projects. Final-end users and technology service providers cannot be fully identified until after projects are awarded and T2 occurs. For this reason, PHMSA includes several contractual stipulations in its agreements with research partners to promote and track the transfer of technology to the market. PHMSA uses the best practices such as the following to increase the likelihood of transfer of research results to the market:

- Plan for technology transfer while identifying research priorities.
- Involve end users (i.e., regulators, pipeline operators, and service providers) in the research gap analysis and road mapping activities; and
- Demonstrate technology readiness with potential service providers and other end-users.

In each contract or agreement, PHMSA mandates several actions that the researcher must take to promote project results, such as commercialization of the product at the end of the contract. In some cases, this commercialization happens long after the contract ends, limiting PHMSA's ability to observe and track it. PHMSA ensures that awarded research promotes the use of gained knowledge by decision-makers by requiring awardees to:

- Submit results at public conferences, forums, symposiums, workshops, or trade journals.
- Report any application for a U.S patent.
- Conduct an output-focused final meeting with invited decision makers and stakeholders.

- Collaborate at public events, such as RD&T forums and workshops, where ongoing work or results are discussed; and
- Participate in PHMSA’s annual RD&T Peer Reviews, where knowledge from research is reviewed and shared.

Information about research projects awarded by PHMSA is made publicly available on the U.S. DOT Research Hub, the National Transportation Library (NTL) Digital Library, and PHMSA’s website.¹

Expected Program Outcomes:

Anticipated PSPRP outcomes will include prevention of excavation damage to pipelines, reductions of pipeline facility accidents/incidents, improvements in safety systems for pipelines, underground gas storage, liquefied natural gas facilities, and technology commercialization.

Anticipated HMSRP outcomes will help to decrease transportation accidents, incidents, and hazardous materials-related consequences by improving packaging integrity and providing the transport community with affordable and sustainable technology solutions that improve transport safety.

Evaluation and Performance Measurement

PHMSA manages the planning, implementation, and reporting of the RD&T projects through internal systems implemented by its designated staff. PHMSA maintains close relationships with research partners throughout a project to ensure that it remains on track and is achieving its intended results. PHMSA uses project management best practices to track and evaluate project progress in meeting defined objectives, ensure milestones and commitments are on track, monitor and control project risks, and monitor funds to ensure they are expended properly and in a timely manner. OPS tracks projects through performance metrics such as technology demonstrations, patent applications, commercialized technologies, and commercialization success rate (frequency of each completed research project resulting in commercialization). PHMSA’s research program closely aligns with DOT’s strategic goals, which are described in the DOT Strategic Plan and Annual Performance Plan.

An example of PHMSA funded research that resulted in relevant outputs and safety benefits was from five research projects totaling \$4.5 million in the area of anomaly characterization²³⁴⁵⁶. American Petroleum Institute (API) was able to utilize the research results of these five projects to help inform the industry Recommended Practice (RP) 1183 – Assessment and Management of Dents in Pipelines that was published in November 2020. The API RP 1183 presents guidance to pipeline operators for developing a dent assessment and management program and provides the

¹ Information for both programs is available at <https://www.phmsa.dot.gov/research-and-development/phmsa-research-and-development>.

² <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=146>

³ <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=238>

⁴ <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=358>

⁵ <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=555>

⁶ <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=557>

information and knowledge necessary to make informed integrity management decisions regarding the management of dents on their systems. The results from the five projects have also provided PHMSA with engineering assessment criteria to be used by operators for dent evaluations on natural gas pipeline special permits, as well as the technical basis on dent assessments for future regulatory actions.

Support of DOT Strategic Goals

PHMSA’s research and development program will play an important role in advancing the safe transportation of energy and other hazardous materials essential to our daily lives by conducting research supporting Safety and Infrastructure strategic goals. Results of this work will continue to address both national and local challenges in urban and rural communities.

TABLE ES-1 PHMSA Research Supporting DOT Strategic Goals

DOT Goal	OST-R Linkages: TRWG Center for Climate Change Equity Task Force	Alternative Fuels	LNG Safety	Underground Natural Gas Storage	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	
	Systemic Safety Approach	x	x	x	x	x	x	x	x	x
Economic Strength and Modernization	State of Good Repair	x	x	x	x	x	x	x		
	Technology Transfer/Deployment	x	x	x			x	x	x	x
	Economic Competitiveness	x	x						x	
Equity	Equity Task Force	x	x					x	x	x
Climate and Sustainability	Environmental Stewardship (chair)	x	x	x	x			x	x	x
	Center for Climate Change	x					x	x	x	
Transformation	Emerging/Enabling Technologies	x	x	x	x	x	x	x	x	x
Organizational Excellence	Evaluation/Performance Measurement									x

Table ES-1 illustrates the contribution of PHMSA’s research activities in support of the DOT strategic goals. PHMSA’s R&D programs make organizational contributions throughout DOT. Representatives from PHMSA participate in the Center for Climate Change and several OST-R Topical Research Working Groups (TRWGs) including those for Systemic Safety, State of Good

Repair, Environmental Stewardship, and Safety. PHMSA chairs the TRWG on Environmental Stewardship and Hazardous Materials Transportation.

The topic areas addressed by the research make direct contributions to the President’s goals in climate and sustainability and will touch nearly every DOT goal.

In keeping with the priority of maximizing interagency collaboration, PHMSA research relies upon cooperation and partnerships with other DOT agencies. Further partnership opportunities include active participation in each of the twelve Topical Research Working Groups (TRWG) established by DOT, and a leadership role in the Environmental Stewardship TRWG. Through this participation, PHMSA continues to collaborate with other transportation modes to avoid duplicative research and ensure the sharing of data where possible.

CROSS-MODAL RESEARCH

In Fiscal Year 2020, PHMSA initiated two R&D projects with the Transportation Technology Center, Inc., to explore the multi-modal safety relationship between pipelines and railroads. The two projects were advised by public and private sector safety professionals from the railroad and pipeline industry. Both projects successfully culminated with the development of full-scale testing plans to determine potential safety impacts to railroads and pipelines. PHMSA intends on conducting the full-scale testing in future fiscal years contingent on funding availability.

Table 1- FY2022 RD&T Program Funding Details

RD&T Program Name	FY2022 President’s Budget (\$000)	Applied (\$000)	Technology Transfer (\$000)	Facilities (\$000)	Experimental Development (\$000)	Major Equipment, R&D Equipment (\$000)
Pipeline Safety Research (total)*	\$16,363	2,000			13,000	
Alternative Fuels Research	2,000				2,000	
Liquefied Natural Gas	2,500				2,500	
Underground Natural Gas Storage	3,000				3,000	
Pipeline Anomaly Detection/ Characterization	1,700				1,700	
Leak Detection	500				500	
Threat Prevention	1,500				1,500	
Repair / Rehabilitation	1,800				1,800	
Competitive Academic Agreement Program	2,000	2,000				
Administrative Expenses	1,363					
Hazardous Materials Safety (total)	\$8,116				7,570	
Risk Management and Mitigation	1,500				1,500	
Emerging Technology	2,570				2,570	
Packaging Integrity	2,500				2,500	

Technical Analysis to Aid Risk Assessments	1,000				1,000	
Administrative Expenses*	546					
PHMSA Totals	\$24,479	\$2,000			\$20,570	

*Administrative costs are reflected in the budget totals

Table 2- FY2022 RD&T Program Budget Request by DOT Strategic Goals

RD&T Program Name	FY2022 President's Budget (\$000)	SAFETY (\$000)	Economic Strength and Modernization (\$000)	Equity (\$000)	Climate and Sustainability (\$000)	Transformation (\$000)	Organizational Excellence (\$000)
Pipeline Safety Research (total)*	\$16,363	\$11,000		\$2,000	\$2,000		
Alternative Fuels Research to Address Climate Change	2,000				2,000		
Liquefied Natural Gas Safety	2,500	2,500					
Underground Natural Gas Storage Safety Research	3,000	3,000					
Pipeline Anomaly Detection /Characterization	1,700	1,700					
Pipeline Leak Detection	500	500					
Pipeline Threat Prevention	1,500	1,500					
Repair Rehabilitation	1,800	1,800					
Competitive Academic Agreement Program	2,000			2,000			
Administrative Expenses*	1,363						
Hazardous Materials Safety Research (total)*	\$8,116*	\$7,570					
Risk Management and Mitigation	1,500	1,500					
Emerging Technologies	2,570	2,570					
Packaging	2,500	2,500					
Technical Analysis to Aid Risk	1,000	1,000					
Administrative Expenses	546						
PHMSA Totals	\$24,479	18,570		\$2,000	\$2,000		

*Administrative costs are reflected in the budget totals

Chapter 1 – FY 2022 RD&T Programs

Pipeline Safety

(\$15,000,000)

Program Description: Pipeline Safety Research Program

PHMSA's Pipeline Safety Research Program (PSRP) carries out its mission through awards for research to improve the safety of the Nation's pipeline transportation system and to protect people and the environment.

In executing the program strategy, public-private partnerships are formed with stakeholders, as well as interagency partnerships with federal agencies, who share PHMSA's safety objectives. The PSRP employs a coordinated and collaborative approach to address pipeline safety challenges, focuses on removing technical and regulatory barriers for given challenges, and measures research results, outputs, and outcomes.

The actual research projects and scope of activities may change from year to year to address emerging issues based on data analysis and industry needs, and in response to Congressional mandates and specific pipeline incidents. The PSRP over the last several years has included projects such as ground penetrating radar (GPR) for preventing excavation damage to pipelines, aerial platform systems and sensor designs to detect leaks, and Machine Learning (ML) applications to improve pipeline monitoring and integrity management.

Program Objectives:

The key objectives of the PSRP are to advance innovation and new technology development throughout the industry and to provide scientific research and data to inform pipeline decision-makers that result in safety improvements for transportation of energy products by pipelines.

America's 2.8-million-mile pipeline network has a very good safety record,⁷ serving as the safest mode for transporting energy products. Nevertheless, the pipeline industry still experiences low-probability/high-consequence pipeline failures causing harm to people, property, and the environment. These incidents negatively impact public confidence in pipeline safety. PHMSA has three primary means of improving pipeline safety: a regulatory program, which establishes a set of minimum safety standards 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 standards; and a research program that provides government funding of R&D to advance technology, innovative solutions, and knowledge transfer based upon stakeholder input and PHMSA's pipeline data.⁸

While DOT's strategic goal of safety is the principal driver of PHMSA's PSRP, its program also contributes to other DOT Strategic Goals because safety-focused projects typically yield solutions affecting economic recovery and rebuilding, climate change, and transportation as an engine for

⁷ <https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-incident-20-year-trends>

⁸ <https://www.phmsa.dot.gov/data-and-statistics/pipeline/pipeline-incident-20-year-trends>

equity. Operating pipeline systems safely and reliably are critical to supporting climate solutions and to building a stronger economy. Safe and reliable pipeline systems will support the transportation of renewable energy, such as hydrogen. Advancing research in climate solutions and technologies will result in job promotion and economic growth.

Furthermore, funding research focused on advancing technologies and new knowledge may facilitate improvements to aging pipeline system infrastructure. PHMSA may pursue research topics to investigate the risk profiles and locations of aging cast iron pipeline systems throughout the country and will explore R&D that would advance technological solutions to rehabilitate aging cast iron pipelines in urban areas such as New York City where a major local distribution company has cast iron mains accounting for over 20% of their mains. Additional urban areas such as Boston, Detroit, and Philadelphia with higher instances of cast iron main lines may also benefit from advanced rehabilitation technology solutions. The PSRP is focused on systemic, performance-based approaches to ensure pipeline transportation safety and ultimately reduce incidents resulting in fewer methane emissions and potential harm to the public and the environment.

Anticipated Program Activities (PSRP):

The PSRP utilizes public-private partnerships with stakeholders, academic institutions, small businesses and intergovernmental agreements to implement research projects. The PSRP is executed through competitive awards, cost-sharing agreements, grants and inter-agency agreements (IAA). These four approaches address different research requirements and are designed to develop research concepts from their initial conceptual stages to industry or government adoption. In FY 2022, the PSRP will award new RD&T projects in the following four (4) subprograms:

Competitive Academic Agreement Program

Under the Competitive Academic Agreement Program (CAAP), awards will be made through competitive bidding to colleges and universities to conduct innovative research. The CAAP is intended to spur innovation by enabling academic research to focus on high-risk, high-reward solutions to a wide range of pipeline safety challenges. The program's focus, execution, and reporting are different than the Pipeline Core Research Program as it is intended to deliver solutions that can be "handed-off" for further investigations. The goal of CAAP is to establish a proof of concept and ultimately demonstrate and deploy new technologies into the Core Research Program that may lead to commercialization. The PSRP will continue to make its CAAP program more inclusive by expanding its outreach communication of its funding opportunities and by ensuring all higher education institutions—including Minority Serving Institutions, such as Historical Black Colleges and Universities, Hispanic-serving Institutions, and Asian American and Pacific Island Serving Institutions—are notified of opportunities.

Core Research Program

Under the Pipeline Core Research Program, the main activities focus on technology or product development, demonstration, and commercialization. In addition, the Pipeline Core Research Program will promote the use of new knowledge by pipeline decision makers.

Small Business Innovative Research

Under the Small Business Innovative Research (SBIR) Program, awards will support the nation's small businesses. SBIR activities will begin with technical merits and feasibilities for potential commercial use by the pipeline industry. Subsequent activities will ultimately develop and deploy the proven technology to the market.

Federal Partnerships

The PSRP partners with government research organizations through Inter-Agency Agreements (IAA) to conduct technical research. PHMSA currently has IAAs with the U.S. DOT Volpe National Transportation Systems Center, Oak Ridge National Laboratory, Sandia National Laboratories, The National Institute of Standards and Technology, and other Federal entities.

In FY 2022, PSRP will be awarding new RD&T projects in the following seven (7) subprograms:

1. Alternative Fuels Research to Address Climate Change Solutions – The 2019 U.S. Environmental Protection Agency (EPA) Draft Inventory of U.S. Greenhouse Gas Emissions and Sinks data report that natural gas transmission and distribution pipelines accounted for 24% and 9% of total methane emissions, respectively.⁹ To address climate change solutions, PHMSA will work towards methane emission reductions from its regulated infrastructure, by coordinating with its stakeholders and interagency partners to develop strategies to fund research projects in this topic area. PHMSA plans to identify research gaps for hydrogen gas and/or for various hydrogen blends in natural gas pipeline facilities, including gas transmission, gas distribution, compressor stations, and gas storage that reflect current projections for industry utilization of pipeline systems and storage. Furthermore, the PSRP plans to include a recommended prioritization of R&D topic areas based on current industry usage projections.

Much Federal and international research has been conducted on alternative renewable fuels in hydrogen and/or hydrogen blends. In order to minimize any duplication, PHMSA plans to conduct a study/literature search to identify research topic areas that are already well supported by existing research. The study/literature search will also include areas where additional R&D investments would contribute towards improving pipeline safety and climate change solutions.

Based on the results of this preliminary study, PHMSA will identify focused working groups to address technical gaps on hydrogen/energy renewables. PHMSA plans to host its FY 2022 R&D Forum in the Fall of 2021 that will include working groups on hydrogen/energy renewables and other pipeline safety initiatives. This Forum will provide an interactive venue for governmental, international, and non-governmental organizations to collaborate about ongoing work and research results on pipeline safety, including renewable fuels, such as hydrogen, and the safe transportation of such fuels by the pipeline system. PHMSA will use the results from the gap analyses and Forum to establish its specific research strategy to help reduce pipeline leaks and address climate change for FY 2022.

2. Liquefied Natural (LNG) Gas Safety – The recent growth in the production and export of LNG has required PHMSA to clarify regulatory guidance within the changing energy

⁹ 2018 EPA data.

landscape and update its regulations for LNG facilities to address the mandates in the PIPES Acts of 2016 and 2020. LNG research activities will address various regulatory and industry challenges related to LNG hazards, as well as foster development of new technologies and alternative designs for LNG storage and piping systems. Additional opportunities in this research topic will address performance-based risk reduction for design, construction, operations, maintenance, and fire protection of LNG facilities. Research outputs can optimize LNG as a transportation fuel for multiple modes of transportation and enable the transition from conventional oil-based fuels to LNG for marine vessels resulting in significant air pollution reductions in coastal and sensitive ecosystems.

3. Underground Natural Gas Storage (UGS) Facilities Safety – After the 2015 Aliso Canyon Gas Storage Field leak, Congress directed PHMSA to regulate underground natural gas storage in consistent with mandates in the PIPES Act of 2016. In 2018, the PSRP began funding research and building a portfolio of solutions to support the development of integrity management programs applicable to the more than 17,000 wells associated with underground natural gas storage facilities in the United States. Additional UGS research gaps will be pursued in FY 2022 with studying surface wellhead seal design and monitoring, use of fiber optics to monitor wellbores and methods to improve cathodic protection of storage wells to improve the integrity of UGS facilities, and thereby reduce natural gas releases into the environment.
4. Pipeline Anomaly Detection/Characterization – The detection and characterization of anomalies in the pipeline systems require solutions that integrate people, processes, and technology into a comprehensive program. Detection capability must progress past simple corrosion to complex anomalies involving a mixture of dents, gouges, and corrosion. Research activities will develop new or improved tools, technology, and assessment processes to identify and locate critical pipeline defects and to improve characterization of their severity. Corrosion continues to be a major contributor of reportable incidents, accounting for 24% of serious incidents¹⁰. This will drive further the study of detection and characterization solutions and develop technology and models that can improve the management of integrity threats.
5. Pipeline Leak Detection – Leak detection continues to present a challenge. Based on 2019 data from the Environmental Protection Agency (EPA), methane emissions from PHMSA-jurisdictional pipelines account for approximately 33% (2,038 kilotons of CH₄) of the total emissions (6,258 kilotons of CH₄) from the oil and gas industry. Of this amount, 9% (560 kilotons of CH₄) of methane emissions are from the gas distribution system. The majority of methane emissions from gas distribution systems are from pipeline mains and service lines, followed by residential and commercial meters and from excavation damage. In May of 2021, PHMSA hosted a public meeting, which focused on leak detection and leak repair. Several technology vendors participated and presented on advanced leak detection

¹⁰ <https://www.phmsa.dot.gov/data-and-statistics/pipeline/national-pipeline-performance-measures>

technologies. Input received from the public meeting will help drive the specific research strategy funded in FY 2022. Research under this element strongly supports efforts to abate methane releases and are in line with the goals of Sections 113 and 114 of the PIPES Act of 2020.

6. Pipeline Threat Prevention – Several threats to the safe operation of pipelines will be addressed in the coming year, including excavation related damage and corrosion. Damage to pipelines by excavation and outside force continues to be a leading cause of pipeline failures based on 2021 pipeline incident data.¹¹ Preventing or reducing excavation damage would dramatically improve pipeline safety and reduce methane emission. The PSRP’s research investments will develop new or improved tools and technology to aid in the prevention and reduction of damage to pipelines, thereby enhancing safety and preventing or diminishing methane releases into the environment. Internal pipeline corrosion remains a major contributor to reportable incidents. To prevent this threat, further research will be conducted into technology solutions and methodologies. The PSRP will continue to foster partnerships with stakeholders to test new approaches and validate these in the field.
7. Repair/Rehabilitation – Damaged coatings and corrosion damage are major problems for pipelines; reliable methods for repairing these issues are of paramount importance for the safe and reliable operation of pipelines. This program will focus on the development of enhanced repair materials, techniques, processes, tools, and/or technology designed to directly support this objective.

Congressional Mandates:

PHMSA will conduct congressionally mandated research and develop corresponding reports to address the PIPES Act of 2020 and the Consolidated Appropriations Act, 2021. The specific requirements are outlined below.

Section 105 of the Pipes Act of 2020 requires PHMSA to conduct a pipeline safety testing enhancement study analyzing the potential value to safety of an independent testing facility for pipeline safety research and development. This study will determine whether an independent pipeline safety testing facility would be critical to the work of PHMSA.

Section 114(d) of the Pipes Act of 2020 mandates that PHMSA develop a report on best available technologies or practices to prevent or minimize the release of natural gas. The report will address potential new pipeline facility designs that could mitigate the need to intentionally vent natural gas. Furthermore, the report will include a timeline for updating pipeline safety regulations to minimize the release of natural gas. The report will assist PHMSA with identifying potential R&D gaps in preventing or minimizing the release of natural gas without compromising pipeline safety when making planned repairs, replacements, or maintenance, or when the operator intentionally vents or releases natural gas. This would ultimately assist in tackling climate change by reducing methane emissions.

¹¹ <https://www.phmsa.dot.gov/data-and-statistics/pipeline/national-pipeline-performance-measures>

PHMSA's FY 2021 appropriation¹² mandates that PHMSA must submit an updated research plan to the House and Senate Committees on Appropriation and receive an approval prior to utilizing FY 2021 funding for construction activities at the Transportation Technology Center. The updated research plan will include a robust assessment of the causes of pipeline failure and pipeline safety risks. PHMSA will define its short-term and long-term research and development objectives that address pipeline safety risks identified in the assessment of incident and accident data. The roles and responsibilities of PHMSA and its stakeholders in advancing technological solutions that will improve pipeline safety will be described in the updated research plan.

The joint explanatory statement accompanying the Consolidated Appropriations Act, 2021 calls for a review of current and new corrosion control techniques that may be utilized to reduce leaks from regulated aboveground storage tanks. The review will include an analysis of supplementary or alternative techniques of cathodic protection systems for aboveground storage tanks.

Expected Program Outcomes:

PHMSA's PSRP activities result in the development of new technology, innovative solutions, and new knowledge intended to improve pipeline safety and reliability. PHMSA anticipates that research in this sector will result in the commercialization of cutting-edge pipeline safety technologies, the issuance of new U.S. patents, and the solutions to complex research questions that inform safety standards. The PSRP frames research questions around safety standards and measures the success of research on how well it answers the question, informs safety standards, and improves overall safety outcomes. Expected outcomes in the seven research topic areas include the following:

- Providing new knowledge in support of managing risk and removing of barriers to transportation of hydrogen and other renewables by pipelines.
- Developing new technologies and alternative designs for LNG storage and piping systems;
- Providing performance-based risk reduction for design, construction, operations, maintenance, and fire protection of LNG facilities;
- Improving safety systems for underground natural gas storage facilities;
- Locating, quantifying, and reducing the volume of pipeline leaks and ruptures;
- Identifying small leaks before they lead to catastrophic ruptures;
- Preventing pipeline threats and damage;
- Decreasing pipeline accidents and incidents;
- Alerting pipeline operators to possible excavation damage;
- Helping operators map existing pipelines;
- Providing effective instrumentation allowing for accurate remediation measures; and
- Finding and removing critical defects in pipeline systems.

The following are some examples of prior outputs and products:

¹² Consolidated Appropriations Act, 2021, (Pub. L. 116-260 – Division L, Title I)
<https://www.congress.gov/bill/116th-congress/house-bill/133/text>

Pipeline Threat Prevention – In FY 2019, the PSRP registered technology transfer after confirmation from the researcher Gas Technology Institute on the project entitled “GPS-Based Excavation Encroachment Notification”¹³. The project demonstrations validated that data collection during active construction activities could be used to reduce or eliminate damage from excavation activities. The commercialized solution was licensed to HydromaxUSA under the product name UtilAlert™. This data collection provides benefits that minimize the cost of damages, avoids delays to completion schedules, enhances safety for workers and the general public; and allows all stakeholders to benefit from enhancing situational awareness and reducing risk.

Pipeline Leak Detection – In FY 2019, the PSRP registered a technology transfer after confirmation from the researcher Physical Sciences, Inc. on the project entitled “Natural Gas Pipeline Leak Rate Measurement System”¹⁴. The project supported development of the Heath MobileGuard™ gas leak detection system, which consists of a methane/ethane analyzer, global positioning system (GPS), sonic anemometer, and proprietary leak detection software that presents real-time geospatial maps of multiple gas concentrations. The software's sophisticated leak detection algorithm combines the system's measurements of gas concentrations (CH₄, C₂H₆), GPS coordinates, and local wind velocity (sonic anemometer) to estimate the leak location. Readings are stored in the device and can be transmitted in real-time to the Cloud for centralized monitoring. The MobileGuard™ laser-based sensor's sensitivity and precision is more than 3,000 times greater than legacy methods, enabling identification of leaks several hundred feet away from the source. The system's improvement in identifying leaks and their location will enable entities to more expeditiously repair the source of the leak limiting the duration of methane emissions. Limiting the duration of unintentional methane releases will help advance the Administration's executive action to tackle climate change by ultimately lowering the U.S.'s cumulative methane emissions.

Pipeline Anomaly Detection/Characterization – In FY 2020, the PSRP registered a technology transfer after confirmation from the researcher APPLUS RTD USA, Inc on the project entitled “In-Ditch Validation Methodology for Determination of Defect Sizing”¹⁵. The research development and validation success supported incorporating Inverse Wave Field Extrapolation (IWEX) technology onto calibration tools, seam weld inspections, and magnetic crawlers for Stress Corrosion Cracking inspections at Applus. IWEX is a next-generation ultrasonic inspection technique with the ability to display flaws as a 2-dimensional cross-section or as a 3-dimensional image, allowing users to get a better look at flaws to determine if they are true defects or benign.

Pipeline Anomaly Detection/Characterization – In FY 2021, the PSRP registered technology transfer after the confirmation from the researcher Northwest Gas Association on the project entitled “Development, Field Testing and Commercialization of a Crack and Mechanical Damage Sensor for Unpiggable Natural Gas Transmission Pipelines”¹⁶. The research supported the launch of the Laser Deformation Sensor (LDS) on the Explorer line of robotic inspection tools. The LDS is a laser-based sensor that allows the identification of any mechanical damage or ovality issues in a hard to inspect or unpiggable natural gas transmission pipeline. Unlike its traditional caliper-based mechanical damage sensors found on smart pigs, this sensor has no moving parts, requires minimal power to operate; is very light and occupies very little space. These are all important attributes for

¹³ <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=249>

¹⁴ <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=650>

¹⁵ <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=503>

¹⁶ <https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=496>

effectively operating in traditionally unpiggable systems. The technology identifies mechanical damage or ovality issues at an accuracy level comparable to or better than traditional calipers.

Collaboration Partners (PSRP):

Congress directed PHMSA to “consult with or seek the advice of appropriate representatives of the natural gas, crude oil, and petroleum product pipeline industries, utilities, manufacturers, institutions of higher learning, Federal agencies, pipeline research institutions, national laboratories, State pipeline safety officials, labor organizations, environmental organizations, pipeline safety advocates, and professional and technical societies” in Section 12(d)(2) of the Pipeline Safety Improvement Act of 2002.¹⁷

This collaboration and interaction with the above stakeholders is performed through various consultative processes, including periodic Pipeline RD&T Forums. The purpose of these collaborative processes is to analyze and identify research gaps with the goal of avoiding duplication of efforts. This process creates stakeholder-based justifications for federal investment in nationally recognized pipeline safety challenges. In FY 2022, PHMSA anticipates holding a R&D Forum in the fall of calendar year 2022 to address pipeline safety initiatives, including hydrogen/climate change solutions. The Forum will identify pipeline safety gaps in the R&D areas, including those related to alternative power generation fuels and greenhouse gas emission reductions. The outputs from the Forum will further develop the FY 2022 research agenda.

The benefits of research collaboration and stakeholder engagement are many. PHMSA understands that engagement enriches the program so that it remains focused on addressing the highest priorities, leverages successes by others, and supports meeting PHMSA mandates. Robust engagement also ensures that all stakeholders are aware of program implementation and research results. To ensure that the most capable researchers are selected for award and to minimize duplication, other federal and state agencies, as well as representatives from the natural gas transmission and distribution and hazardous liquid pipeline industries, assist PHMSA in the pre-award merit review of research proposals. Stakeholder collaboration continues into the post-award where Technical Advisory Panels as part of awarded research projects allow operators, technology service providers, other government agencies and subject matter experts to assist PHMSA with ensuring project results will be germane to the solicited need. Post-award projects are managed by the PSRP’s project managers who receive and review quarterly progress reporting for technical completeness and quality. Project managers also review draft final reports to ensure technical completeness and high-quality deliverable on the final report before publicly posting any reports on the project page website. The PSRP tracks the project page visits and document downloads as one metric of the project results. Finally, academia assists PHMSA with the post-award peer review to evaluate progress, collaboration, content, and quality of the research projects. The post-award peer reviews result in project-specific recommendations to improve the likely success in achieving the research goals.

PHMSA values equal opportunity and diversity of opinion when establishing the research strategy. In March 2019, PHMSA released a Special Notice for “Identifying Pipeline Safety Research Ideas” in the Federal Business Opportunities portal. The Special Notice invites any interested stakeholder to submit ideas for future research. This notice is open year-round and revised periodically to reflect focused topic areas of PHMSA and interested stakeholders. PHMSA initiated this to widen stakeholder participation in formulating its future research strategy beyond its forums.

¹⁷ Public Law 107–355

Government and non-government research partnerships provide clear opportunities to leverage ongoing successes, co-fund research on mutual safety challenges, and avoid duplication. PHMSA shares information with trade associations, the pipeline industry, and pipeline industry service providers throughout the year on its research programs and consults with subject matter experts from these organizations on focused projects and topics. Research partners—both government organizations (GO) and non-government organizations (NGO)—that coordinate and co-fund research with PHMSA include:

- American Gas Association (NGO)
- American Petroleum Institute (NGO)
- American Public Gas Association (NGO)
- American Society of Mechanical Engineers (NGO)
- Association of Oil Pipe Lines (NGO)
- California Energy Commission (GO)
- Canada Energy Regulator (GO)
- Department of Agriculture (GO)
- Department of Commerce: National Institute of Standards and Technology (GO)
- Department of Energy (GO)
- Department of the Interior: Bureau of Safety and Environmental Enforcement (GO)
- Environmental Defense Fund (NGO)
- Environmental Protection Agency (GO)
- Interstate Natural Gas Association of America (NGO)
- NACE International (NGO)
- National Association of Pipeline Safety Representatives (GO)
- Northeast Gas Association/NYSEARCH (NGO)
- Operations Technology Development (NGO)
- Pipeline Research Council International (NGO)
- Pipeline Safety Trust (NGO)

Hazardous Materials Safety Research Program

(\$7,570,000)

Program Description

PHMSA's Office of Hazardous Materials Safety Research Program (HMSRP) supports the PHMSA mission by sponsoring research that will improve safety, protect the environment, and enhance the reliability from the risks associated with the transport of hazardous materials, including the transport of energy products. The primary Research, Development, & Technology Branch objectives are to improve transportation safety by identifying risk management and mitigation programs and tools; improving packaging technologies and designs; and identifying, developing, and fielding new packaging materials and transportation technologies.

The HMSRP recognizes the importance of addressing the President's Executive Orders on Climate Change (Exec. Order No. 14008), Environmental Justice (Exec. Order No. 13895), and the COVID-19 Crisis (Exec. Order No. 13998). Many of the HMSRP research outcomes already support these initiatives by enhancing safety for the American people. By improving hazmat transportation safety, the HMSRP initiatives also help to improve environmental conditions and benefit underserved communities because safety is positively correlated to both. Projects planned for FY2022 will focus on tank car safety standards, charged storage devices, aerogels and metal foams as novel packaging materials, and aluminum alloys in the growing hydrogen fuel industry.

The HMSRP employs a coordinated and collaborative approach to hazardous materials transport to effectively collaborate with our modal partners, private organizations, and universities that share the same safety objectives. Each year the HMSRP hosts a forum where research partners and interested parties come to hear the latest department's efforts, share scientific findings with each other, and identify research needs to further enhance the safe transportation of hazardous materials. This forum provides the vital information that drives the HMSR's success. The department communicates program activities, like the forum, actions, and data through announcements and updates on the HMSRP website. From there, the research partners and interested parties can access the HMSRP research findings and important information including upcoming conferences, presentations, and points of contact.

Program Objectives

Risk Management and Mitigation

The goal of the risk management program is to improve public safety and protect the environment by identifying transport risks and developing mitigation strategies. In support of the Department's safety goal, research will focus on risk reduction strategies designed to lower transport-related injuries and fatalities, increase packaging and operational safety, or improve system reliability. Risk strategies which may be researched include improving transport safety through application of new risk models and methodologies, use of data analytics in hazardous materials transport research, supporting the development of national and international transport and packaging standards, and identifying industry best practices and publicizing lessons learned. Research outputs include Composite Metal Foams for Impact Protection of Hazardous Material Transportation, Fine Grain

Metal Powder Standards for Consumer Pyrotechnics, and Thermo-Mechanical Responses of Fiber Reinforced Plastic (FRP) Composite Jacketing for Tank Cars under Impact and Fire.

Emerging Technology

Advancements in technology and the increased volume of energy products transported present challenges. HMSRP helps PHMSA to keep pace with the need for packaging designs and regulations to evolve. Research under this strategic element is designed to identify and analyze emerging materials, energy products, processes, packaging technologies, and transport operations and to assess their potential risks or benefits to the existing hazardous materials transport network. The goal of the emerging technology program is to improve public safety and protect the environment by developing new packaging materials and new transport systems. This research supports the improvement of packaging safety standards, the development of hazardous materials transport best practices, and the documentation of lessons learned in safety operations. Through our Small Business Innovation Research Phase I Program and Broad Agency Announcements, HMSRP has been able to promote new emerging technology such as Honeycomb-Encapsulated Phase Change Materials Composites for Battery Transportation Safety and Active Termination of Lithium-Ion Battery Fires and Thermal Runaway.

Packaging Integrity

The best way to protect people and the environment from hazardous materials during transportation is to keep the materials contained within their package. HMSRP research focuses on improving packaging design and integrity. Research efforts in this strategic area are designed to evaluate and verify the suitability and effectiveness of packaging standards and practices and improve transport safety by developing, evaluating, and testing new packaging technologies and materials. Outcomes for projects funded under the initiative will decrease transportation incidents by improving packaging integrity, thereby enhancing a package's ability to contain its contents during hazardous materials transportation incidents. This program supports the Department's safety goal and the DOT Strategic Plan, as improved packaging will decrease deaths and serious injuries resulting from package failure or improper use of packages, reducing human error by improved and simplified operating and handling instructions, and further prevent environmental disasters by increasing reliability in the transportation system. With the collaboration with the Volpe Center, we have been able to conduct several projects relating to novel packaging for highway cargo tanks and rail tank cars. Other packaging research includes, High Strain Rate Rupture and Fragmentation of Aluminum Cylinders, and Packaging Technique to Defeat Fires and Explosions due to Lithium-Ion and Related High-Energy-Density Batteries.

Anticipated Program Activities:

Risk Management and Mitigation

Research planned for FY 2022 includes identification and development of risk management methods to assess hazardous materials transport, improved communication tools and best practices, and methods to utilize information technology to speed exchange of data during transport incidents involving hazardous materials. Specific projects in this strategic area include the development of risk management methods and tools to improve the understanding of key risks by the hazardous materials packaging and transport industry. A hazardous materials commodity flow survey is currently being developed by HMSRP with the U.S. Census Bureau that will define the quantity and number of shipments of hazardous materials transported annually.

Emerging Technology

Research planned for FY 2022 includes: analysis of physical characteristics of emerging energy products, packaging requirements for new energy products, identification of new packaging materials and technologies, and analysis of transportation systems and operations. Research in this sector often looks at enhancing the safety of energy commodities, including various grades of crude oil, LNG, and charged energy storage devices (i.e., batteries). Research also includes analysis of new packaging materials and technologies, transportation systems and operations, and international collaborative research to support the export of U.S. energy products. Examples of emerging technology HMSRP research proposals include novel rail car shell materials, such as composite metal foams and aerogels, and forward-looking research in sodium ion batteries. Project proposals will be evaluated and prioritized based on their ability to identify feasible and innovative packaging materials and technologies that will improve the safety of hazardous materials transport.

Packaging Integrity

Research planned for FY 2022 includes testing and evaluation of existing packaging materials and technologies, which consists of finite element modeling and physical performance testing of bulk packages, as well as evaluation of component materials of combination packaging. Package integrity research evaluates and verifies the suitability and effectiveness of packaging standards and practices. On the emerging materials front, one of HMSRP's academic partners is currently developing the use of novel materials, primarily aerogels, as a safety enhancement to packaging systems. Aerogels have been shown to be very effective as insulation, it is also non-toxic to humans and their surroundings. Project proposals will be evaluated and prioritized based on their ability to improve public safety and protect the environment by improving package performance, improve packaging standards, and enhance packaging performance test requirements.

Technical Analysis to Aid Risk Assessment

Research planned for FY 2022 includes development of hazardous materials commodity flow analysis. This analysis will provide estimates on the types of packaging used in shipping hazardous materials as well as produce estimates by hazmat type and packaging type at a national level and possibly a subnational level. Review of incidents and packaging failures for patterns and similarities, and development of inspection and test methods for classification of hazardous materials and for packaging containing hazardous materials. Planned research activities include the analysis of individual incidents involving hazardous materials to determine root cause, patterns, or anomalies within packaging, and the development of new inspection and test methods to classify materials and certify packaging. HMSRP is currently working with the National Academy

of Sciences to identify and address transportation risks associated with the rail transport of LNG as well as researching the costs associated with rail delays due to incidents involving hazardous materials. Project proposals will be evaluated and prioritized based on their ability to improve safety by applying preventative and corrective measures, provide the transport community with the means to take advantage of technology and integrate affordable and sustainable technology solutions, and increase effectiveness and efficiency of hazardous materials transportation by identifying processes and methods that support continuous improvement in transportation industry safety management and regulatory development.

Expected Program Outcomes

HMSRP research improves packaging and transport of dangerous goods. HMSRP supports work in the safety standards on transport by rail and tank cars, autonomous vehicle applications, and the protection of passengers and environments potentially affected by the transport of charged storage devices by air. Through the analysis of commercial and novel materials, HMSRP will show whether aluminum alloys commonly used for hydrogen transportation are unduly brittle, how composite metal foams and fiber reinforced plastics can enhance the puncture and heat resistance of tank cars, and how aerogels can better contain the self-immolation or thermal runaway of lithium batteries.

The commodity flow survey aims to define the quantity and volume of shipments of hazardous materials transported annually. The data, which will be subdivided by hazard class, will improve our transportation risk modeling and analysis capability which in turn will lower the risk in hazardous materials transportation. Additionally, PHMSA will be better positioned to adapt and pivot, meeting the needs to appropriately fund work in the areas that bring challenges presented as the markets of hazardous materials continue to grow. These projects and related research areas aim to enhance safety guidance for the Emergency Response Guidebook for hazardous materials remediation, cleanup, identify and answers research related questions.

Collaboration Partners:

HMSRP's collaboration and interaction with research partners and stakeholders is consistent across all identified subprogram areas. PHMSA periodically sponsors HMSRP Research Forums and Roundtables, announced in the Federal Register and on social media, to conduct technical gap analyses and generate research topics in cooperation with hundreds of public and private stakeholders. These stakeholders identify technology and knowledge gaps within our strategic areas, which are then incorporated into PHMSA's HMSRP research solicitations and announcements. This process allows PHMSA to focus on these identified gaps and avoid duplicating efforts from other modal organizations or private funding entities. This process creates stakeholder-based justifications for federal investment in nationally recognized hazardous materials safety issues.

The HMSRP also coordinates on research priorities and initiatives with other DOT Operating Administrations to identify mutually beneficial partnerships. Collaborative and coordinated projects include research with FRA on tank car safety standards that NTSB identified as safety gaps in incidents, a portfolio with VOLPE that covers novel packaging materials for highway tank and rail cars, and a project with the Census Bureau aims to enhance the hazmat packaging and commodity flow data. Such partnerships identify clear opportunities to leverage prior or ongoing successes and to co-fund research on mutual challenges. Modal authorities (e.g., Federal Railroad Administration, Federal Aviation Administration, Federal Motor Carrier Safety Administration, and the U.S. Coast Guard) are consulted and briefed on the overall HMSRP and receive specific briefings

on projects involving their specific mode. This coordination allows HMSRP to avoid duplication and to leverage their limited research resources.

PHMSA receives support in conducting and verifying safety gap analyses and developing programs to address gaps. PHMSA also provides and receives feedback on research and program plans through the Transportation Research Board's Hazardous Materials Cooperative Research Program. HMSRP also solicits research needs statements and enters into agreements with federal entities, including Volpe National Transportation Systems Center, Argonne National Laboratory, Naval Research Lab, and the Transportation Research Board. The list below provides additional external entities with which PHMSA has partnered, and which are options for future projects in FY 2021:

- Association of American Railroads
- American Chemistry Council
- American Fuel and Petrochemical Manufacturers
- American Pyrotechnic Association
- American Petroleum Institute
- American Short Line and Regional Railroad Association
- American Trucking Associations
- Compressed Gas Association
- Chlorine Institute, Inc.
- Council on Safe Transportation of Hazardous Articles
- Commercial Vehicle Safety Alliance
- Dangerous Goods Advisory Council
- Institute of Makers of Explosives
- Industrial Packaging Alliance of North America
- National Association of Chemical Distributors
- National Industrial Transportation League
- National Propane Gas Association
- National Tank Truck Carriers
- Rechargeable Battery Association
- Reusable Industrial Packaging Association
- Railway Supply Institute
- Fertilizer Institute
- Sulphur Institute

Chapter 2 – FY2023 RD&T Programs

Pipeline Safety

Program Description/Activities/Objectives:

The PSRP mission and strategy for program execution will remain unchanged in FY 2023. The PSRP frames research questions around safety standards and measures the success of research on how well it answers the question, informs safety standards, and improves overall safety outcomes. In FY 2023, the PSRP will expand upon the FY 2022 initial efforts to address the Administration's strategic priorities of safety, economic recovery and rebuilding, climate change, and transportation as an engine for equity.

Public-private partnerships will remain a priority in technology development, and PHMSA will continue to actively engage with stakeholders to inform its specific FY 2023 agenda. In general, the makeup of subprogram areas may change due to several factors, including a review of industry incident rates, stakeholder participation at future research forums and workshops, and new research ideas submitted in response to the annual Special Notice. Development of the Research, Development, and Testing Program at the Federal Railroad Administration's (FRA) Transportation Technology Center will remain on hold pending the development of a Pipeline Safety Testing Enhancement Study, as required by Section 105 of the PIPES Act of 2020, as well as an Updated Research Plan as required by PHMSA's FY 2021 appropriation.

PHMSA anticipates funding projects in support of DOT's strategic priorities of safety, economic recovery and rebuilding, climate change, and transportation as an engine for equity. PHMSA plans to award projects in any of the following areas:

- Alternative Fuels Research to Address Climate Change
- Liquefied Natural Gas Facility Safety
- Underground Natural Gas Storage Safety
- Preventing Pipeline Threats/Damage
- Pipeline Leak Detection Systems
- Anomaly Detection and Characterization
- Repair and Rehabilitation Methodologies

The PSRP is collaborative by design. Research projects originate from input and collaboration with inter-agency partners, public interest groups, and pipeline stakeholders. Public forums and workshops provide the opportunity for pipeline experts and operators to pose research questions, propose research areas. The research agenda for the FY 2023 PSRP will be informed by PHMSA's FY 2022 R&D Forum planned in Fall of 2021; this Forum will provide an interactive venue for governmental and non-governmental organizations to collaborate about ongoing work and research results on pipeline safety initiatives, including renewable fuels, such as Hydrogen and their safe transportation by pipeline. PHMSA will continue to fund research in FY 2023 that result from the gap analyses identified from the Forum in 2021.

PHMSA will continue to develop partnerships with colleges and universities through the Competitive Academic Agreement Program (CAAP), which provides funding to colleges and universities to establish proof of concept designs on pipeline safety technologies that may lead to technology deployment/commercialization. As in 2022, PHMSA will continue to make its CAAP program more inclusive by expanding its outreach communication of its funding opportunities, by ensuring all higher education institutions, including Historically Black Colleges and Universities (HSBCU), Women's Colleges, and Tribal Colleges and Universities (TCU) are notified of opportunities.

Expected Outputs/Products: PHMSA's PSRP is dedicated to informing and producing new products that will improve pipeline safety and reduce potential harm to the environment and public. PHMSA anticipates that research in this sector will result in the commercialization and transfer of cutting-edge pipeline safety technologies, the issuance of new U.S. patents, and the solutions to complex research questions that inform safety standards.

Program Alignment with Strategic Goals:

The PSRP will continue to play an important role in advancing the safe transportation of energy products by pipeline. The PSRP remains focused on data-driven, systemic, performance-based approaches to ensure pipeline transportation safety. Research projects funded in FY 2023 will continue to support DOT's strategic priorities of safety, economic recovery and rebuilding, climate change, and transportation as an engine for equity. The FY 2023 Annual Modal Research Plan will provide further specificity on issues addressed and expected outcomes.

Hazardous Materials Safety Research Program

Program Description:

Hazardous Materials research improves the safe transport of hazardous materials across all modes. PHMSA executes research within the core areas of risk management and mitigation, package integrity, emerging technologies, and technical analysis to aid risk assessments, as discussed below:

Program Objectives:

Risk management and mitigation research considers the probability of hazardous materials transport incidents and associated consequences. Specific projects in this strategic area include the development of risk management methods and tools to improve the understanding of key risks by the hazardous materials packaging and transport industry. HMSRP is currently working with the U.S. Census Bureau to develop a hazardous materials commodity flow survey that will define the quantity and number of shipments of hazardous materials transported annually. The data, which will be subdivided by hazard class, will improve our transportation risk modeling and analysis capability that in turn will lower the risk of transport.

Package integrity research and studies help form standards that ensure hazardous materials remain contained within original packaging during the entire transportation cycle. Package integrity research evaluates and verifies the suitability and effectiveness of packaging standards and practices. Specific research areas include testing and evaluating existing packaging materials,

packaging technologies analysis, performance evaluation of emerging packaging materials and methods, and evaluation of component materials of combination packaging. One example of a package integrity project involves developing a model of a nurse tank that will predict failure. HMSRP is currently working to define material properties of fiber-reinforced plastics used to manufacture cargo tanks and will follow this work with development of a finite element model of the tank to improve design safety.

Emerging technologies research identifies and analyzes emerging materials, packaging technologies, and transport operations. Research in this sector often looks at emerging energy products, including various grades of crude oil and liquefied natural gas, analysis of new packaging materials and technologies, analysis of transportation systems and operations, and international collaborative research to support the export of U.S. energy products. HMSRP research will focus on emerging technologies such as novel rail car shell materials made of composite metal foams, aerogels, and forward-looking research in sodium ion batteries. HMSRP is researching new materials which, when applied to rail cars, will increase thermal performance in incidents and metal foams to improve mechanical performance of packages containing hazardous materials.

Technical Analysis to Aid Risk Assessments research evaluates activities, events, and incidents. Planned research activities include the analysis of individual incidents involving hazardous materials to determine root cause determine patterns or anomalies, and the development of new inspection and test methods to classify materials and certify packaging. HMSRP is currently working with the National Academy of Sciences to identify and address transportation risks associated with the rail transport of liquefied natural gas, as well as researching the costs associated with rail delays due to incidents involving hazardous materials.

Anticipated Program Activities:

HMSRP research will continue to play an important role in advancing the safe transportation of hazardous materials and energy products essential to our daily lives by conducting research supporting the Department's safety and innovation strategic goals. Results of this work will continue to address safety and availability challenges faced in urban and rural communities across the nation. HMSRP's research remains focused on systemic, performance-based approaches to ensure transportation safety, preserve the environment, and ensure cost effective transport systems.