

**United States Department of Transportation
Annual Modal Research Plans FY2021
Program Outlook FY2022**

Pipeline and Hazardous Materials Safety Administration (PHMSA)

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Note: The FY 2021-2022 AMRPs will be certified using the President's budget numbers and revised with enacted budget numbers after the budget passes.

Chapter 1 – Executive Summary

The Pipeline and Hazardous Materials Safety Administration’s (PHMSA) mission is to protect people and the environment by advancing the safe transportation of energy products and other hazardous materials that are essential to our daily lives. PHMSA oversees the transportation of hazardous materials, including energy products, through all modes of the transportation industry. PHMSA operates in a dynamic and challenging environment in which changes in technology, manufacturing, and energy production affect transportation safety. We anticipate that the scope and complexity of our safety mission will continue to grow, requiring us to continuously evaluate how we use information and technology to achieve the Department of Transportation’s (DOT) safety goals. PHMSA partners with those who share the goal of developing new technology, products, and knowledge aimed at improving safety in all of its research. The research agenda adapts to address existing and future safety threats.

PHMSA’s role in the safe transportation of hazardous materials (hazmat) and energy products is essential to improved safety and security in the daily lives of Americans. PHMSA funds research that improves safety, supports supply reliability, and improves business and government productivity. To advance hazmat transportation safety, improve pipeline safety, and foster innovation, PHMSA will pursue its Research, Development, and Technology (RD&T) goals in Fiscal Year (FY) 2021 through a variety of projects carried out by its two main units: the 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 2021.

PHMSA remains focused on collaboration with all stakeholders to leverage investment and successes to date. PHMSA makes continual efforts to remove duplication, while engaging academia and a wide range of stakeholders to fund and co-fund critical research to develop new technology, products, and knowledge. PHMSA’s RD&T activities are non-duplicative with known prior or current projects within the agency.

Program Descriptions

OPS RD&T staff will continue to identify research topics on pipeline damage/threat prevention, pipeline leak detection system improvements, anomaly detection and characterization, underground gas storage (UGS) and liquefied natural gas (LNG) facilities improvements. OPS will fund research in these topics through its existing five programs in collaboration with its various stakeholders having common goals in enhancing pipeline safety and reliability. In general, the pipeline safety research objectives and goals remain

the same. However, the specific research projects and scope of activities may change each year to accommodate the development of new technologies in response to Congressional mandates, specific pipeline incidents, PHMSA's data analysis, and industry needs. Before funding projects, PHMSA evaluates each project with respect to research needs, considering key aspects such as timeframes for when results are needed, alignment with DOT strategic goals, likelihood of achieving expected benefits, criticality, risk, interdependencies, and available funding. OPS research will focus on 5 topic areas, as well conducting a cost-benefit analysis of the development and utilization of an independent pipeline safety testing facility as directed by the PIPES Act of 2020. In 2021, OPS will focus on research to prevent pipeline threats and damage, including 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.

Further supporting the OPS safety mission, research will be conducted to improve pipeline leak detection systems and anomaly detection and characterization in pipeline systems.

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.

In addition to pipeline systems, OPS provides safety oversight for many facilities. Research to improve safety systems for underground gas storage and safety systems for liquefied natural gas facilities will also be a focal point for OPS. 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.

Pipeline Safety Research, Development & Testing Facility

In FY 2021, PHMSA plans to continue to conduct pipeline safety research at the existing Federal Railroad Administration (FRA) Transportation Technology Center (TTC) in Pueblo, Colorado. Over the past several months, OPS engaged with stakeholders in a comprehensive project that determined the need for this new testing program at TTC. OPS will reflect this work in its report to congress as directed by Section 105 of the Protecting our Infrastructure of Pipeline and Enhancing Safety Act of 2020 (PIPES Act of 2020). In the meantime, PHMSA continues its work on two stand-alone, shorter-term projects (Pipe by Rail and Pipe under Rail) begun in FY 2020, leveraging existing rail research and equipment.

OPS determined that while there are several testing facilities available in the US, none can provide testbeds where a new technology can be tested in full-scale, real-world conditions (accelerated or normal time). In coordination with the FRA, OPS intends to utilize a portion

TTC to accelerate and enhance advancements in both pipeline and hazardous materials transportation safety. Initial projects at the facility will augment the current program research areas in pipeline damage/threat prevention, leak detection, and anomaly detection and characterization. Long-range planning is underway to prepare a roadmap for developing a world-class pipeline technology and innovation center of excellence at TTC.

R&D plays a vital role in helping OHMS 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 FY2021, OHMS intends to 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 the Hazardous Materials Safety Research Program (HMSRP) is packaging integrity. Risk can be reduced if hazmat remains contained within its packaging during transport. Accordingly, R&D 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 US 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 end of the contract, 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 NTL Digital Library, and PHMSA's website.¹

Anticipated Outcomes

Anticipated OPS 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 and 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

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

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*.

Agency Involvement in the Topical Research Working Groups expected in FY2021.

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. PHMSA participates in a number of the topical research working groups, including those for Systemic Safety, State of Good Repair, Environmental Stewardship, and Safety Data. PHMSA chairs the research group on environmental stewardship and hazardous materials transportation.

DOT Strategic Goal	Research Topic Areas
<p style="text-align: center;">Safety Infrastructure</p>	<p style="text-align: center;">Systemic Safety Approach State of Good Repair Environmental Stewardship Safety Data</p>

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 the DOT, and a leadership role in the Environmental Stewardship TRWG. Through this participation, the PHMSA continues to collaborate with other transportation modes in an effort to eliminate duplicative research and ensure the sharing of data where possible. Based both upon PHMSA individual partnerships and participation in the TRWG the agency certifies that the research in this plan is not duplicative of other research being conducted within DOT.

FY2021 RD&T Program Funding Details

RD&T Program Name	FY2021 Enacted (\$000)	SAFETY (\$000)	INFRA- STRUCTURE (\$000)	INNOVATION (\$000)	ACCOUNT- ABILITY (\$000)
Pipeline Safety Research (total)	\$13,363	\$12,118	\$1,245		
Threat Prevention	\$1,300	\$1,100	\$200		
Leak Detection	\$1,255	\$710	\$545		
Anomaly Detection/ Characterization	\$1,545	\$1,345	\$200		
Underground Gas Storage	\$900	\$900			
Liquefied Natural Gas	\$1,000	\$1,000			
Transportation Technology Center	\$4,000	\$4,000			
Competitive Academic Agreement Program	\$2,000	\$2,000			
Pipeline Safety Research Administrative Expenses	\$1,363	\$1,063	\$300		
Hazardous Materials Safety Research (total)	\$5,616	\$4,316		\$1,300	
Risk Management and Mitigation	\$1,000	\$1,000			
Emerging Technology	\$1,100			\$1,100	
Packaging Integrity	\$1,670	\$1,670			
Technical Analysis to Aid Risk Assessments	\$1,300	\$1,300			
Hazardous Materials Safety Research Administrative	\$546	\$346		\$200	
PHMSA Totals	\$18,979	\$16,434	\$1,245	\$1,300	

FY2021 RD&T Program Funding Details 2

RD&T Program Name	FY2021 Enacted (\$000)	FY2021 Basic (\$000)	FY2021 Applied (\$000)	FY2021 Development (\$000)	FY2021 Technology (\$000)
Pipeline Safety Research (total)	\$13,363			\$13,363	
Threat Prevention	\$1,300			\$1,300	
Leak Detection	\$1,255			\$1,255	
Anomaly Detection/ Characterization	\$1,545			\$1,545	
Underground Gas Storage	\$900			\$900	
Liquefied Natural Gas	\$1,000			\$1,000	
Transportation Technology Center	*\$4,000			\$4,000	
Competitive Academic Agreement Program	\$2,000			\$2,000	
Administrative Expenses	\$1,363			\$1,363	
Hazardous Materials Safety (total)	\$5,616		\$5,616		
Risk Management and Mitigation	\$1,000		\$1,000		
Emerging Technology	\$1,100		\$1,100		
Packaging Integrity	\$1,670		\$1,670		
Technical Analysis to Aid Risk Assessments	\$1,300		\$1,300		
Administrative Expenses	\$546		\$546		
Totals	\$18,979		\$5,616	\$13,363	

² PHMSA's research activities fall under a small number of programs. To provide a better understanding of the research, the details in this plan have been reported at the project level.

Chapter 2 – FY2021 RD&T Programs

Pipeline Safety (\$13,363)

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, PHMSA creates public-private partnerships with stakeholders who share PHMSA's safety objectives, 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 problems based on data analysis and industry needs, and in response to Congressional mandates and specific pipeline incidents. OPS-funded projects over the last several years include projects such as ground penetrating radar (GPR) for preventing damage to pipelines, aerial platform system design and reliability improvements for detecting pipeline leaks, and computer tomography validation for measuring defects including cracks and other seam anomalies in pipelines.

Program Objectives:

The primary objectives of the program are to develop new technologies or products and to generate and promote the use of new knowledge by pipeline decision-makers at all levels. America's 2.8-million-mile pipeline network has a very good safety record, serving as the safest option for transporting large volumes of oil and gas to fuel our economy. 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 financial support to advance technology and knowledge transfer.

The PSRP directly aligns with the DOT's strategic goals of Safety and Infrastructure that include the following research topic areas in Automation, Systemic Safety Approach,

Human Factors, State of Good Repair, Environmental Stewardship, and Safety Data. The PSRP is focused on systemic, performance-based approaches to ensure pipeline transportation safety and cost-effectiveness of transportation of energy by pipelines. It will also investigate pipeline assets to optimize material cost and durability.

Anticipated Program Activities (PSRP)

In FY2021, OPS will be awarding 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 is different than the Pipeline Core Research Program as it is intended to deliver solutions that can be "handed-off" for further investigations. The goal is to establish a proof of concept and ultimately demonstrate and deploy new technologies leading to commercialization in the market.

Core Research Program

Under the Pipeline Core Research Program, the main activities focus on developing new technologies or products, demonstrating them, and transferring them for 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.

Interagency Agreements

PHMSA 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 FY2021, specific program activities will fund projects in the areas of *Preventing Pipeline Threats/Damage, Improving Pipeline Leak Detection Systems, Improving Anomaly Detection and Characterization, Improving Underground Gas Storage, and Improving Liquefied Natural Gas Facilities.*

Preventing Pipeline Threats/Damage

Activities in this topic area 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. Additional opportunities in this topic area include advancements in high-altitude imaging, machine learning, and predictive analytics to mitigate external threats to pipeline infrastructure.

Improving Pipeline Leak Detection Systems

Activities in this topic area include new or improved tools and technology solutions for locating, quantifying, and reducing the volume of pipeline leaks and ruptures into the environment. Additional opportunities in this subprogram area include using machine learning to identify small leaks before they lead to catastrophic ruptures.

Improving Anomaly Detection and Characterization

Activities in this topic area are designed to support the pipeline industry in making integrity management decisions and finding and removing critical defects in the pipeline system. This area of research will support efforts to identify threats within pipelines and will provide operators with effective instrumentation allowing for accurate remediation measures.

Improving Safety Systems for Underground Gas Storage

Activities in this topic area include research to improve safety in the full life cycle of underground gas storage (UGS) facilities. Research activities will focus on reducing risks to public and UGS worker safety. Specific research areas include design and reliability improvements to UGS equipment, such as tubing, packers, and subsurface safety valves, as well as knowledge enhancement on associated maintenance practices for UGS wells.

Improving Safety Systems for Liquefied Natural Gas Facilities

Activities in this topic area 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. Additional opportunities in this research topic will address performance-based risk reduction for design, construction, operations, maintenance, and fire protection of LNG facilities.

Pipeline Safety Research, Development & Testing Facility

In FY2021, PHMSA plans to continue to conduct pipeline safety research located at the existing Federal Railroad Administration (FRA) Transportation Technology Center (TTC) in Pueblo, Colorado. Over the past several months, OPS engaged with stakeholders in a comprehensive project that determined the need for a new independent testing facility. OPS determined that while there are several testing facilities available in the US, none can provide testbeds where a new technology can be tested in full-scale real-world conditions (accelerated or normal time).

Privately managed pipeline research facilities in the U.S. have primarily focused on extending the service life of existing infrastructure and reducing costs associated with the physical “dig and inspect” requirements for certain pipeline anomalies.

Even when new and worthy technologies are developed, technology transfer is a difficult hurdle. The technology must be developed, demonstrated and commercialized and then government must provide a regulatory framework that permits its use. PHMSA’s special permits require credible data on the performance of new technologies to ensure pipeline safety is maintained. This can be a long and arduous process.

One comprehensive solution to address the gap is to create a robust pipeline research and testing facility that catalyzes innovation from the private sector, universities or other research organizations. In coordination with the FRA, OPS will utilize a portion of FRA’s TTC in Pueblo, Colorado to accelerate and enhance advancements in both pipeline and hazardous materials transportation safety. Initial projects at the facility will augment the current program research areas in pipeline damage/threat prevention, leak detection, and anomaly detection and characterization. Long range planning is underway to prepare a roadmap for developing a world class pipeline technology and innovation center of excellence at TTC.

OPS, as directed by Section 105 of the Protecting our Infrastructure of Pipelines and Enhancing Safety Act of 2020 (PIPES Act of 2020), plans to conduct an assessment and cost-benefit analysis of the need to develop an independent pipeline safety testing facility in its reporting requirements.

Expected Program Outcomes (PSRP)

PHMSA’s pipeline research program is dedicated to informing and producing new products that will improve pipeline safety and protection of the environment. PHMSA anticipates that research will result in the commercialization and transfer of cutting edge pipeline safety technologies, the issuance of new U.S. patents, and answer research questions that inform safety regulation and standards. In addition, through the CAAP, PHMSA looks forward to advancing the pipeline safety profession through both student internships and

career employment. Expected outcomes in the five research topic areas include the following:

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

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 2002.³

This collaboration and interaction with the above industry partners and stakeholders is done through various consultative processes, including Pipeline RD&T Forums every two years. The purpose of these processes is to analyze and identify research gaps with the goal of minimizing duplication of efforts. This process creates stakeholder-based justifications for federal investment in nationally recognized pipeline safety challenges. Other ideas can be submitted via PHMSA’s website.

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

³ Public Law 107–355

program implementation and the reported 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 in the pre-award merit review of submitted research proposals. Finally, academia assists the PSRP in a post-award peer review of progress made, collaboration, content, and quality of research projects. The post-award peer review results in recommendations to raise the likelihood of success.

Government and non-government research partnerships provide clear opportunities to leverage ongoing successes, co-fund research on mutual safety challenges, and remove duplication. PHMSA briefs trade associations and the pipeline industry throughout the year on the research programs and consults with them on individual projects when such projects are in their sphere of expertise. Research collaboration partners—both government organizations (GO) and non-government organizations (NGO)—who 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 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)

Hazardous Materials Safety

(\$5,616)

Program Description: Hazardous Materials Safety Research Program (HMSRP)

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 RD&T objectives are to improve transport 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.

In executing our program strategy, PHMSA collaborates with our modal partners and contracts with private organizations and universities who share our safety objectives; employs a coordinated and collaborative approach to hazardous materials transport; focuses on removing technical and regulatory barriers for given challenges; measures research results, outputs, and outcomes; and posts all program processes, actions, and data on our department website.

PHMSA's HMSRP seeks to achieve our program objectives by awarding new research in the following subprogram areas.

Program Objectives (HMSRP)

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 hazmat transport research; supporting the development of national and international transport and packaging standards; and identifying industry best practices and publicizing lessons learned.

Emerging Technology

Both 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 hazmat 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 hazmat transport best practices, and the documentation of lessons learned in safety operations.

Packaging Integrity

Because the best way to protect people and the environment from hazardous materials is to keep the materials contained within their packages, 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 accidents and incidents by improving packaging integrity, thereby enhancing a package's ability to contain its contents during hazmat-transportation incidents and accidents. This program supports the Department's safety goal, as improved packagings will decrease deaths and serious injuries resulting from package failure or improper use of packages and human error can be reduced by improved and simplified operating and handling instructions

Anticipated Program Activities (HMSRP)

Risk Management and Mitigation

Research planned for FY2021 includes identification and development of: risk management methods to assess hazmat transport; improved communication tools and best practices; and methods to utilize information technology to speed exchange of data during transport accidents involving hazardous materials. Project proposals will be evaluated and prioritized based on: the feasibility of incorporating technology; the usefulness of the product to emergency responders and local officials; and the ability to maintain and grow communication systems.

Emerging Technology

Research planned for FY2021 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. 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 hazmat transport.

Packaging Integrity

Research planned for FY2021 includes: testing and evaluation of existing packaging materials and packaging technologies; finite element modeling and physical performance testing of bulk packages; and evaluation of component materials of combination packaging. 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 FY2021 includes development of hazardous materials commodity flow analysis; review of incidents and packaging failures for patterns and similarities; and development of inspection and test methods for classification of hazardous materials and for packagings containing 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 that improve transport safety; and increase effectiveness and efficiency of hazmat transportation by identifying processes and methods that support continuous improvement in transportation industry safety management and regulatory development.

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. 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 research program and receive specific briefings on projects involving their specific mode. This coordination allows HMSRP to eliminate 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. PHMSA also solicits research needs statements and enters into agreements with federal entities, including Volpe National Transportation Systems Center, Argonne National Laboratory, Sandia National Laboratory, National Institute of Standards and Technology, 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 FY2021:

- 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 3 – FY2022 RD&T Programs

Pipeline Safety

Program Description/Activities/Objectives:

The PSRP mission and strategy for program execution will remain unchanged in FY2022. PHMSA uses research to inform safety standards on complex issues such as improving the stability of Underground Natural Gas Storage (UNGS), locating otherwise unlocatable plastic pipes, the safe movement and storage of liquefied natural gas, and the impacts of corrosion and earth movements. PHMSA 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. PHMSA is currently funding a research project on UNGS with Battelle Memorial Institute to assess the role that Subsurface Safety Valves (SSSVs) can have in improving underground gas storage safety. This research will improve the safe operation of UNGS facilities and reduce risks to UNGS maintenance personnel and the surrounding communities.

Public-private partnerships will remain a priority in technology development, and the active engagement of all stakeholders will help shape the specific FY2022 agenda. The makeup of subprogram areas may change due to several influences, including input from industry incident rates, stakeholder and research program partner participation at future research forums, and new research ideas submitted in response to the annual Special Notice to identify pipeline safety research ideas. PHMSA will continue in FY2022 its analysis pursuant to Section 105 of the Pipes Act of 2020 to develop an independent pipeline safety testing facility to accelerate and enhance advancements in pipeline safety. Development of research test sites at the TTC will continue into FY2022 through collaboration between PHMSA, the Federal Railroad Administration (FRA), private industry, and academia. Additionally, PHMSA will provide, as directed in the FY2021 appropriations bill and report language, a detailed research plan to the House and Senate Committees on Appropriations regarding its plans for pipeline safety research at the TTC. PHMSA will not utilize FY21 allocations to engineer, erect, alter, and repair buildings or make any other public improvements for research facilities at the TTC until the research plan mentioned above is approved by the House and Senate Committees on Appropriations.

Description: Research in this area leads to the development of new or improved tools and technology to aid in the prevention and reduction of damage to pipelines, thereby preventing/lessening releases of hazardous materials into the environment. This supports the Department of Transportation's (DOT) Strategic Goal of Safety. Within this research, program projects are awarded in any of the following areas:

- Pipeline Anomaly Detection/Characterization
- Pipeline Leak Detection

- Liquefied Natural (LNG) Gas Safety
- Pipeline Threat Prevention
- Pipeline Transportation Technology Center (TTC) Research
- Underground Natural Gas Storage (UGS) Facilities Safety

Investments in Pipeline Safety Research will lead to the development of new or improved tools/technology with solutions to reduce the release of dangerous chemicals into the environment and the identification of leaks before they lead to catastrophic ruptures. This supports the DOT's Strategic Goals of Safety programs and initiatives.

The Pipeline Safety Research division is collaborative by design. Research funding is derived from the operators themselves through user fee assessments and from an Oil Spill Liability Trust Fund contribution. Research projects originate from collaboration with pipeline stakeholders, including from public forums and workshops of pipeline experts and operators that pose research questions, propose research areas. PHMSA's most recent Pipeline R&D Forum was held in Arlington, Virginia, on February 19-20, 2020, with approximately 240 attendees. It resulted in the identification of pipeline technical challenges and upcoming research needs. One example of these proposed research projects is the development of portable sensors to detect mercaptans, which are the odorants that smell of rotten cabbage and are added to natural gas since it is odorless. Adding mercaptan to natural gas allows gas in the event of a leak to be more easily detected by a person with a normal sense of smell. These sensors measure the amount of mercaptans and alert inspectors to a leak if there is one. Research partners include Universities, industry, and safety organizations that specialize in bringing safety technology to production. One important component of this program is that it develops partnerships with colleges and universities through the Competitive Academic Agreement Program (CAAP), which works with colleges and universities to establish proof of concept designs for safety technology that leads to commercialization and technology transfer. This program also exposes students to both the pipeline industry and common pipeline safety challenges to illustrate how their engineering and technical disciplines are highly desired and needed in the pipeline field.

Expected Outputs/Products: PHMSA's pipeline-related research is dedicated to informing and producing new products that will improve pipeline safety and performance. 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. PHMSA is currently funding a research project with University of Tulsa to develop and validate two approaches for producing pipe technology that is locatable using electromagnetic sensing. Unlocatable utilities are a significant source of accidents throughout the U.S. and add significant costs to construction from repair of accidental damage to locating the utilities. One of the largest issues is the widespread use of plastic pipe for gas transmission. These materials are difficult to detect with traditional utility locating systems even when their location is approximately known.

Program Alignment with Strategic Goals:

The PSRP will continue to 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. The PSRP remains focused on systemic, performance-based approaches to ensure pipeline transportation safety, preserve the environment, and ensure the cost-effectiveness of alternative transportation energy. The FY2022 Annual Modal Research Plan will provide further specificity on problems addressed and expected outcomes.

DOT Strategic Goal	Research Topic Areas
<p style="text-align: center;">Safety Infrastructure</p>	<p style="text-align: center;">Systemic Safety Approach State of Good Repair Environmental Stewardship Safety Data</p>

Hazardous Materials Safety

Program Description/Activities/Objectives:

Hazardous Materials research informs 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:

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. The Office of Hazardous Materials Safety 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 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 evaluation of existing packaging materials and packaging technologies; analysis, and 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. The Office of Hazardous Materials Safety 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. In this research area, the Office of Hazardous Materials Safety is researching new materials which, when applied to rail cars, will increase thermal performance in accidents 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 and accidents involving hazardous materials to determine root cause; determine patterns or anomalies within packaging or systems; and the development of new inspection and test

methods to classify materials and certify packaging. The Office of Hazardous Materials Safety 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 accidents involving hazardous materials.

Expected Outputs/Products: PHMSA’s Hazardous Materials research informs improvements in packaging and transport of dangerous products. Some important outcomes include safety standards in transport such as rail cars, autonomous vehicle application, and lithium battery state of charge and containment in aircraft shipments. Areas such as these results in safety guidance like the Emergency Response Guidebook for hazardous materials remediation and cleanup. This publication requires research to inform cleanup and remediation of highly combustible and toxic materials often released in accident scenes.

Program Alignment with Strategic Goals:

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 research remains focused on systemic, performance-based approaches to ensure transportation safety, preserve the environment, and ensure the cost effectiveness of transport systems. The FY2022 Annual Modal Research Plan will provide further specificity on problems addressed and expected outcomes.

DOT Strategic Goal	Research Topic Areas
Safety Innovation	Package Integrity, Emerging Technology, Risk Management and Environment Stewardship

[END]