Pipeline Research and Development (R&D) Forum

Event Summary Report

Cleveland Marriott Downtown at Key Center
Cleveland, OH

November 16-17, 2016

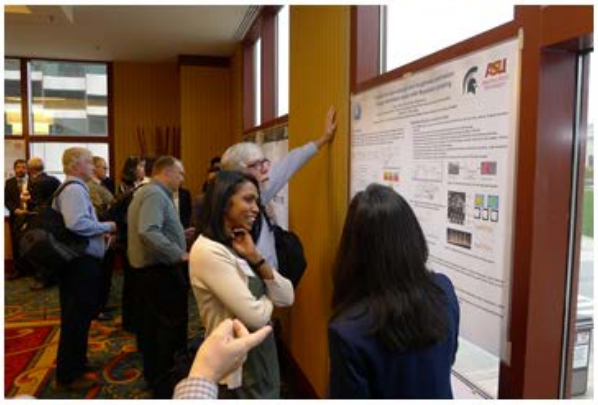
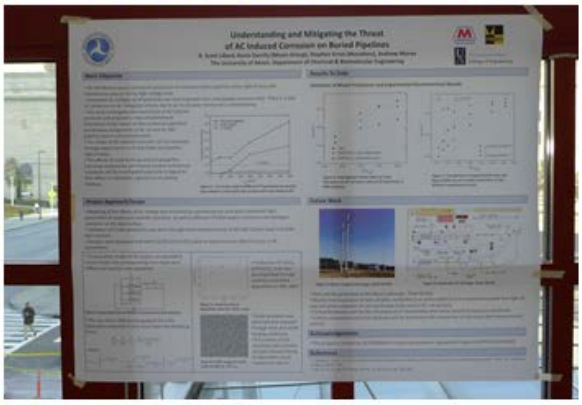
Table of Contents

Event Forward

The Pipeline Research and Development (R&D) Forum was held in Cleveland, Ohio on November 16-17, 2016. The 2 day event is held periodically to generate a National research agenda that fosters solutions for the many challenges with pipeline safety and with protecting the environment. The forum allows public, government and industry pipeline stakeholders to develop a consensus on the technical gaps and challenges for future research. It also reduces duplication of programs, factors ongoing research efforts, leverages resources and broadens synergies. The national research agenda coming out of these events is aligned with the needs of the pipeline safety mission, makes use of the best available knowledge and expertise, and considers stakeholder perspectives. Specifically the forum:

1. Identifies key pipeline technical challenges facing industry and government;
2. Disseminates information on current research efforts; and
3. Identifies new research that can help to meet known challenges.



Key Challenges Executive Summary

The Department of Transportation (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA) led a steering committee of ten government and industry organizations that organized, planned and executed this forum. The forum brought together approximately 330 representatives from Federal, State and foreign government offices along with domestic and foreign natural gas and hazardous liquid pipeline operators. The forum's goals included identifying key challenges facing industry and government, sharing information on current research efforts, and identifying research that can help meet known challenges. This was the largest attendance of any of the 6 prior forums held.

Within Panel 1 addressing national perspectives on key pipeline challenges, we first heard a perspective from PHMSA that the research program has remained very competitive and able to narrow down multiple dozens of research submissions to credible investments made. We also heard the progress is being made with active work and solutions of various types have made it to the market. However, many challenges remain as reported from various incidents corresponding to the subjects of the working groups managed at the 2016 forum. This means in many cases that

PHMSA will continue to invest in our core areas and in new ones such as for underground natural gas storage and LNG.

The perspective from the National Association of Pipeline Safety Representatives (NAPSR) reminded the audience about the importance of their mission which is to strengthen State pipeline safety programs through the promotion of improved pipeline safety standards, education, training, and technology. Several recent intrastate incidents point to remaining challenges in excavation damage for distribution piping, time dependent threats (material, weld or joint failure, corrosion) for Transmission lines. It was noted that damage prevention programs appear to be improving and that the states agree that a Safety Management Systems approach may be helpful.

Next up was the hazardous liquid pipeline perspective which well highlighted challenges in In-Line Inspection (ILI) detection capabilities, anomaly detection/characterization, the complexity of detecting interacting threats and a remaining challenge with small leak detection and damage prevention programs. That said, the liquid industry's current research focus is strong within areas of advancing ILI technologies, improving threat assessment & identification, leak detection technology advancement and with hydrostatic pressure testing.

The perspective from the natural gas transmission pipelines noted the challenges with adapting to an evolving market. This puts significant focus into maintaining and demanding more from legacy assets, developing new infrastructure in increasingly challenging environment and modernizing the regulatory framework. This creates many technical challenges within pipeline integrity management & integrity verification within areas of Maximum Allowable Operating Pressures re-confirmation, anomaly detection & characterization in complex operating environments, determining pipe material properties, new integrity programs for underground gas storage and the continuing efforts for methane emissions detection - quantification – reduction. It was also pointed out that the value of academic engagement is high and will directly pay dividends if we can further integrate academia into our programs.

The perspective from the natural gas distribution pipelines noted some similarities to the transmission pipelines such as with hydrotesting of single feed pipelines. These systems are the sole source feeding for example, water treatment plants and if shut down will cause much

disruption to communities. Also in common with gas transmission was verifying the material characteristics of existing pipelines without removing coupons or taking a line out of service. Urban pipelines contend with congestion of various types so placement and design of launching and receiving stations and extending the inspection range for robots used in non-ILI able pipelines was noted as a key challenge. The leading cause of distribution pipeline failures comes from excavation damage so the ability to locate these systems with alternatives to tracer wire and use of GPS is sought. Reducing methane emissions was also mentioned seeking cost effective methods for avoiding or reducing blow-downs and more accurate and cost efficient field measurement for emission rates were stated as focus areas. Finally, underground gas storage challenges were mentioned with new tools needed for leak detection, logging, integrity management and improved data analytics for risk assessment and risk management.

It should be noted that all presenters shared the goal of zero incidents and moving to safety management systems as the next safety frontier.

All presentation material from the forum is available for download from the following webpage: https://primis.phmsa.dot.gov/rd/mtg_111616.htm .

Introduction

Approximately 330 people attended the Pipeline R&D Forum held in Cleveland, Ohio on November 16-17, 2016. The 2 day event is held periodically to generate a National research agenda that fosters solutions for the many challenges with pipeline safety and with protecting the environment. The forum allows public, government and industry pipeline stakeholders to develop a consensus on the technical gaps and challenges for future research. It also reduces duplication of programs, factors ongoing research efforts, leverages resources and broadens synergies. The national research agenda coming out of these events is aligned with the needs of the pipeline safety mission, makes use of the best available knowledge and expertise, and considers stakeholder perspectives.

The forum was structured so attendees would hear national perspectives on key challenges from federal and state regulators and the entire pipeline industry. The forum factored other panel discussions about current industry research roadmaps and the challenges with transferring solutions into the marketplace. Finally the forum provided public roadmapping sessions in the following five subject working groups:

1. Threat/Damage Prevention
2. Leak Detection/Mitigation
3. Anomaly Detection/Characterization

4. Natural Gas Underground Storage
5. Liquefied Natural Gas

These five groups were charged with identifying technical gaps and challenges for future research that does not duplicate existing efforts. The output must identify both short and long term research objectives for hazardous liquid/natural gas and transmission and distribution pipelines as well as for gas storage and LNG. Basic roadmapping was conducted on identified technical gaps so identified research is addressing the need effectively. Details were then provided of the ultimate research goals so appropriate end users are factored into project scopes.

The forum was successful in identifying key pipeline technical challenges facing industry and government and disseminating information on current research efforts. It also did well in identifying new research that can help meet known challenges. See the working groups 1-5 report out file posted on the below webpage for much more information.

All presentation material from the forum is available for download from the following webpage: https://primis.phmsa.dot.gov/rd/mtg_111616.htm .

Competitive Academic Agreement Program

After Panel 1 on National Perspectives on Key Challenges, PHMSA presented an overview of its research program with universities entitled the "Competitive Academic Agreement Program" (CAAP) launched in CY 2013. The CAAP is intended to spur innovation through enabling an academic research focus on high risk and high pay-off solutions for wide ranging pipeline safety challenges. The CAAP is different in focus, execution and reporting than PHMSA's core program on Pipeline Safety Research. It is intended to potentially deliver desired solutions that can be "handed-off" to further investigations in CAAP or in PHMSA's core research program that employs partnerships with a variety of public/private organizations. One goal in this strategy would be to validate proof of concept of a thesis or theory potentially all the way to commercial penetration into the market.

Another goal for CAAP is to expose undergraduate, graduate and PhD research students to subject matter common to pipeline safety challenges for illustrating how their engineering or technical discipline is highly desired and needed in the pipeline field. The pipeline industry and federal/state regulators are all experiencing low numbers of entry level applications to positions that are engineering or technically focused. Public conferences, meetings and journals have identified similar shortfalls.

PHMSA presented that this fairly new program is achieving its goals by involving 138 students total into the execution of the CAAP award work scopes from the 29 awards made since FY 2013. These projects are addressing a wide variety of pipeline challenges including those for corrosion or preventing damage to pipelines.

CAAP Summary Totals

Annual Announcement	# Awards	PHMSA	Resource Sharing	# HS Students	# U-Grad Students	# Grad Students	# PhD Students	Total # Students	# Interns (a)	# Career Employed (b)
CAAP-1-13	8	$814K	$353K	1	23	19	16	59	3	4
CAAP-2-14	7	$704K	$391K		4	14	10	28	1	3
CAAP-3-15	11	$2,829K	$888K		15	17	19	51	2	
CAAP-4-16	3	$899K	$368K	*	*	*	*	*		
GRAND TOTALS:	**29**	**$5,247K**	**$2,002K**	**1**	**42**	**50**	**45**	**138**	**6**	**7**

Footnotes:
(a) Denotes the number of internships offered by engineering firms, research organizations, government agencies or pipeline operators to students involved with CAAP research projects.
(b) Denotes the number of full time career employment/jobs offered by engineering firms, research organizations, government agencies or pipeline operators to students involved with CAAP research projects.

* Student info was not available yet

Twelve schools participated with each given an opportunity for the principle investigator to summarize the work scope and objects and more importantly, introduce the student brought to the forum.

The forum then had a student poster paper session with 13 posters where the entire forum audience could meet the students and hear about the various technical aspects with their research project. Much more information on this program is available from the below website: https://primis.phmsa.dot.gov/rd/universitypartners.htm .

Five Focused Working Groups

The working groups each addressed focused areas for research roadmapping. Some subject overlap is possible but was kept to a minimum. These groups were charged with three phases of operation in order to generate the desired output.

Phase 1 sets the stage and identifies the challenges for the working group subject matter via an appropriate number of short presentations and group discussion. This period of time is also used to identify the top priorities for new research and begins to review if any ongoing work will address the specifics of each challenge.

Phase 2 can continue Phase 1 activities but quickly transitions to road mapping the identified priorities. As part of the charge for this phase the specifics to the desired output from the research priorities will be determined including the output type. For instance, is the gap best addressed by a technology, an improvement to a consensus standard or a paper study to gather more information or create a new process with some goal? The suggested timeline to develop a solution as added to each gap is subjective and just a guide to assist researchers on the amount of effort that should be applied for proposed scopes to meet a desired delivery. Gathered details are critical here for soliciting for good research projects.

Phase 3 can continue Phase 2 activities but quickly transitions to populating a provided template output presentation using audience participation. The template categories coincide with the data that the working group is gathering.

A PHMSA facilitator was assigned to each group to assist the working group leaders in executing these three phases and in capturing the necessary details that were reported out. The scope of and top gaps defined by each working group are provided below.

WG#1 – Threat/Damage Prevention

Leaders: François Rongere, R&D and Innovation Manager - Gas Operations, PG&E
Jemmie Wang, Partner, BizMetrix

PHMSA Rep: Joshua Arnold, R&D Manager
Annmarie Robertson, Senior Program Manager Program Development

Audience participants in this group discussed the following areas: excavation damage/pipeline locating/Right of Way monitoring and other threats.

The group identified four gaps for future research depicted below. More details on the presentations given within the group and the identified gaps are available for download in the working group report-out file on the PHMSA research program webpage for this forum.

Gap #1 – (Technology) **Capture of accurate location of legacy existing assets**
Gap #2 – (Technology and General Knowledge) **Predictive analytics to sort the major risks using multiple data sources**
Gap #3 – (General Knowledge) **Adoption of best practices and education of public**
Gap #4 – (Technology and General Knowledge) **Broad use of GPS with accuracy standards**

WG#2 – Leak Detection/Mitigation

Leaders: Ray Philipenko, Sr. Manager, Leak Detection, Enbridge Pipelines Inc.
Douglas Robertson, Leak Detection Technology Initiatives & BD Support Team Lead, TransCanada Pipelines

PHMSA Rep: Robert Smith, R&D Manager

Audience participants in this group discussed the following areas: line break sensors and their components and leak detection technology development from any deployment platform/ understanding capabilities and limitations. Discussions around pipeline sensing/line break detection systems to minimize unintended valve closures are also anticipated. It is also anticipated that a heavy focus will be placed on solutions for hazardous liquid pipelines.

The group identified nine gaps for future research depicted below. More details on the presentations given within the group and the identified gaps are available for download in the working group report-out file on the PHMSA research program webpage for this forum.

Hazardous Liquid Pipelines
Gap #1 – (Technology) **Increasing Computational Pipeline Monitoring Performance with Leaks: How to optimize/balance reliability with sensitivity**
Gap #2 – (Technology) **Testing External Sensors**
Gap #3 – (General Knowledge) **Cost Benefit Deploying/Retrofitting External Based Sensors**

Natural Gas Transmission Pipelines
Gap #1 – (Standards) **Development of External Leak Detection Recommended Practice**
GAP #2 – (Standards) **External Leak Detection Cable Based Leak Detection Research Study**
GAP #3 – (General Knowledge) **Consolidation of LDS Sensor Research Information**

Natural Gas Distribution Pipelines
GAP #1 – (Technology) **Improved Plume Modeling**
GAP #2 – (Standards/Technology) **Residential deployment of Methane Detectors**
GAP #3 – (Standards/Technology) **Develop Recommended Practice for Predictive Analytics Related to Damage Prevention and Safety**

WG#3 – Anomaly Detection/Characterization

Leaders: Mark Piazza, Manager, Integrity Programs, Colonial Pipeline
David Chittick, Director of Pipeline Integrity, TransCanada Pipelines

PHMSA Rep: James Merritt, R&D Program Manager

Audience participants in this group discussed the following areas: solutions for inside or outside (through coating) the pipe technology to better detect, size and shape anomalies/burst testing to improve remaining strength calculations/hard to inspect pipelines (i.e. unpiggable)/technology development in support of the implementation of ongoing PHMSA rulemakings. Detection and characterization of defects on or near girth welds will be another focus. This group will also provide a focus to non-line pipe facilities for pump/compressor stations and tank farms.

The group identified nine gaps for future research depicted below. More details on the presentations given within the group and the identified gaps are available for download in the working group report-out file on the PHMSA research program webpage for this forum.

Gap #1 – (Technology) **Validation of current methods for destructive and non-destructive methods for determining material properties (Yield Strength, hardness, toughness, etc.) – in-ditch and In-Line Inspection (ILI) and development of new methods as needed**
Gap #2* – (General Knowledge) **Advanced data management and analytics for Asset Integrity data**
Gap #3 – (Technology) **Improving the performance and efficiencies of in-line and in-ditch tools for difficult to inspect conditions**
Gap #4 – (General Knowledge/Standards) **Improvements to pipeline assessment methods and models to reduce conservatism**
Gap #5 – (Technology) **Improved Probability Of Identification for long seam anomalies**
Gap #6 – (Technology/Standards) **Development of industry calibrations and reference standards for anomaly detection and characterization**
Gap #7 – (Technology) **Develop and validate ILI technologies for: circumferential anomalies – includes circumferential cracks in dents and bending stresses**
Gap #8 – (General Knowledge) **Establish and maintain industry databases, materials properties, ILI vs in ditch, repairs/remediation (mitigation of anomalies inspected), analysis of past incidents**
Gap #9* – (General Knowledge) **Root Cause Failure Analysis of Past Pipeline Incidents**

NOTE: Gaps with* may be addressed with University Partnerships

WG#4 – Natural Gas Underground Storage

Leaders: Ray Harris, Assistant Vice President, National Fuel Gas Supply Co.
C.J. Osman, Director of Operations, Safety, and Integrity, Interstate Natural Gas Association of America

PHMSA Rep: Steve Nanney, Senior Engineer
Kenneth Lee, Director, Engineering and Research Division

Audience participants in this group discussed the following areas: a wide range of challenges for gas underground storage facilities. They include anything from well design – casing, tubing, wellheads, and safety valves to well integrity and inspection to assessing operations and maintenance programs to safety device testing – flow through tubing, casing or both – threat identification, risk assessment, preventative & mitigative measures, and remediation measures - location/frequency/valve life expectancy and mechanical integrity testing – type (pressure test, logging, or other), frequency, and remediation measures to odorant programs and down hole and facility leak detection to security – well, facility, and other and issues for emergency response and preparedness.

The group identified six gaps as depicted below. More details on the presentations given within the group and the identified gaps are available for download in the working group report-out file on the PHMSA research program webpage for this forum.

Gap #1 – (General Knowledge/Standards) **Risk Assessment and Treatment of Wells**
Gap #2 – (General Knowledge/Technology) **Evaluation of Well Casing Strength**
Gap #3 – (Standards /Technology) **Cement as a Barrier**
Gap #4 – (Standards /Technology) **Well Construction Barriers**
Gap #5 – (General Knowledge/Standards/Technology) **Subsurface Safety Valves**
Gap #6 – (Standards /Technology) **Monitoring Equipment**

WG#5 – Liquefied Natural Gas

Leaders: Ted Williams, Director, Codes & Standards, American Gas Association
Walter Doucette, Director – LNG Operations Massachusetts North, National Grid

PHMSA Rep: Julie Halliday, Senior Engineer

Audience participants in this group discussed the following areas: failure of and accounting for LNG components, including life expectancy, over pressuring, explosions, cascading effects, and intentional acts - Fires and explosions, including flash fires, fireballs, pool fires, jet fires, deflagrations, and detonations - Vapor dispersions of propane, ethylene, ethane, nitrogen, carbon dioxide, and ammonia - Accounting for natural hazards, including seismic, wind, storm surge, and snow, with design requirements - Identifying knowledge gaps in 49 CFR Part 193/National Fire Protection Association (NFPA) 59A for process safety program elements - Determining risk profiles at large marine export facilities due to vapor fences.

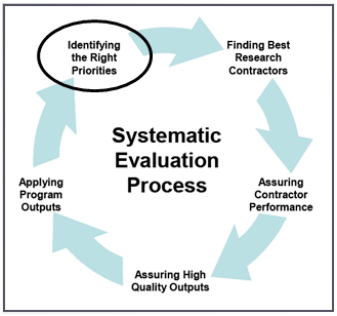
The group identified five gaps for future research depicted below. More details on the presentations given within the group and the identified gaps are available for download in the working group report-out file on the PHMSA research program webpage for this forum.

Gap #1 – (Standards/General knowledge) **Control System Testing Frequency**
Gap #2 – (General knowledge) **Comparison of Process Safety Management, American Petroleum Institute Consensus Standard, NFPA Standards, and Prescriptive Regulatory Requirements.**
Gap #3 – (General Knowledge) **Consistent Methodologies for Quantitative Risk Assessment**
Gap #4 – (General Knowledge) **Model Evaluation Protocols for LNG Hazard Models**
Gap #5 – (General Knowledge) **Efficacy and Treatment of Hazard Mitigation Measures**

Please see the report out file for each working group for much more details on these topics. Please also see the asterisk (*) that may be tagged to some of the main gaps and to some additional gaps if noted. These are suggested for university investigation and will be used by PHMSA as possible topics for the annual CAAP solicitations.

Next Steps

The forum is Step 1 in PHMSA's process for successful research outcomes. It should be noted that identifying the right priorities in this manner is a form of peer review prior to soliciting for new research. Stakeholder driven consensus on what topics to solicit is key in leveraging resources, existing efforts and for removing duplication. PHMSA will now review the findings from the forum in preparation of its next research solicitation. The details illustrated in the working group report out files will drive the development of synergies necessary for comprehensive proposals and ultimately good research projects that align with the current needs for pipeline safety. When ready the solicitation will be posted at https://www.fbo.gov/ or http://www.grants.gov/ with additional requirements posted therein.



Acknowledgments

The forum would not be possible without the volunteered time and efforts coming from the steering committee. The representation coming from these organizations were instrumental in advertising the forum, searching and securing speakers and working group leaders. PHMSA is grateful for this effort and comprehensive recommendations for the forum.

1. American Gas Association
2. American Petroleum Institute
3. California Energy Commission
4. Department of Energy

5. Interstate Natural Gas Association of America
6. National Association of Pipeline Safety Representatives
7. National Institute of Standards and Technology
8. Northeast Gas Association/NYSEARCH
9. Operations Technology Development
10. Pipeline Research Council International

Thank You to all who attended and participated!