Remote Sensing and Reliability of Gas and Electrical Infrastructure Systems

Research and Regulatory Perspectives

Robert Smith

THANKS!

- **Thanks to GTI and U-CONN for the invite!**
- **We agree technology solutions in remote sensing will play huge future role; and**
- **Looking forward to the discussions since we strive to expand our research enterprise to any interested stakeholder**

Large/Diverse Infrastructure

PHMSA Regulated

Pipeline Facilities by System Type data as-of 3-28-2018			
System Type	**Miles**	**% Miles**	**# Operators**
Hazardous Liquid	**212,189 7,920 Tanks**	**8%**	**517**
Gas Transmission	**300,390**	**11%**	**1,032**
Gas Gathering	**18,186**	**1%**	**351**
Gas Distribution (Mains & Services)	**2,230,727**	**80%**	**1,295**
Liquefied Natural Gas	**151 Plants, 226 Tanks, 83 Operators**		
Underground Natural Gas Storage	**397 Facilities, 444 Reservoirs 17,458 Wells, 124 Operators**		
Total Miles 2,761,492		**Unique OpID 2,644**	

Robotic/Remote Sensing:
Where Do We See Utilization?

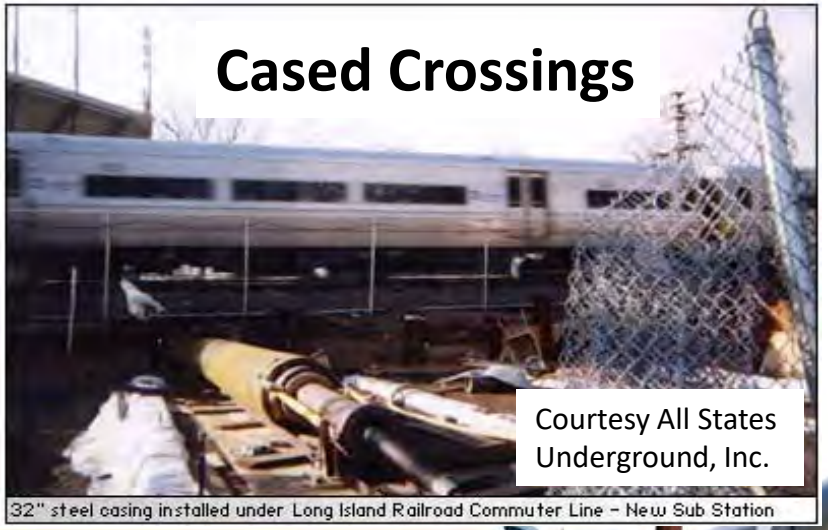
- Right of Way Monitoring
- Leak Detection
- Anomaly Detection – Hard to inspect areas


Courtesy Tech Briefs June 2017

- Facility Inspection – Various Types
  - Tanks
  - LNG
  - Underground Natural Gas Storage

Hard to Inspect Areas

- Unpiggable systems in general
- Environmentally Sensitive
- Native/Private Lands



Robotic/Remote Sensing:
What Do We See As Benefits?

- Improved Pipeline Safety – Sensors – Ability to deploy…"where no tool has gone before!"
- Efficiency – Less time and $$
- Less disruption to the public
- Less impact to the environment
- Improved worker safety - OSHA

New Technology & Compliance

- New Technology can find acceptance through four different paths:
  - Special Permits
  - State Waivers

  } Public review via the Federal Register

  - Other Technology Notifications
  - Revised Regulation under Title 49 Sub. B Chap. I Parts 190-199

New Technology & Compliance
"Ultimate Goal"

- When can new technology have compliance outside of any permit or notification process?
  - Rulemaking is required
    - Numerous Other Technology Notifications on given tech

PHMSA Inspections & Drones/UAS

- **Policy Vision:** To enhance pipeline safety inspections and investigations by giving inspectors the ability to safely gain visual access to areas that would otherwise be inaccessible.
- **Primary benefits:**
  1. Identifying potential risks; and
  2. Determining regulatory compliance

PHMSA Inspections & Drones/UAS

- **Rights-of-way/clearings**
  - General condition
  - Land movement
  - Flooding impact
  - 3rd party excavation
- **River Crossings**
- **Class location verification**
- **Accident Response Assessments**
  - Spill size
  - Spill trajectory
- **Tank inspections**
- **National Pipeline Mapping System accuracy verification**
- **Development of Inspector Training Materials**

Drone/UAS Compliance

- **Drone usage growing with Pipeline Operators**
  - PHMSA generally fine with usage for general or visual inspections
  - Integrity Inspections govern more dialog with PHMSA on compliance
- **Sensor research still needed**
- **Demonstrations and validation needed to improve regulator confidence**

Pipeline Safety RD&T

Pipeline Safety RD&T Program Mission:

To sponsor research and development projects focused on providing near-term solutions that will improve the safety, reduce environmental impact, and enhance the reliability of the Nation's pipeline transportation system.

Key Points

- We employ a collaborative approach to address mutual challenges
- We help remove technical barriers on a given challenge
- We measure our research results/outputs/outcomes
- We are transparent – Interactive program website

Pipeline Safety Improvement Act of 2002 established our modern program

RD&T Program Objectives

Developing Technology	Strengthening Consensus Standards	Promoting Knowledge
Fostering the development of new technologies so that pipeline operators can improve safety performance and more effectively address regulatory requirements.	Targeting and feeding new knowledge into the process of keeping standards relevant to their purpose.	Generating and promoting general knowledge to decision makers.

Overall Program Performance

Since 2002, awarded 270 Projects $109.7 million PHMSA + $101.3 million Resource Sharing

Program Status: Technology Impacts

Technology Impact Metric	Metric
Technology Projects	93
Technology Demonstrations	54
Patent Applications (U.S. + Other)	31
Commercialized Technologies[A]	28
Commercialization Success Rate[A]	35%

Program Status: Promoting Knowledge

Knowledge Promotion Metric	Count
Final Reports Publicly Available	223
Conference or Journal Papers	166
Public Events	37
Patent Applications (U.S. + Other)	34
Annual Peer Reviews Held	12

Communicating Knowledge to Stakeholders

Event Type	Events Held	Stakeholders Reached
Blue Ribbon Panel	2	39
Gov/Industry R&D Forums	7	1555
Interagency Coordination Meetings	13	101
R&D Workshops/Conferences	14	2135
Safety Advisory Committees	1	30
Grand Totals:	**37**	**3860**

Programmatic Element & Technology Research Impact

Category	Technology Projects	Technology Demonstrations	Patent Applications (U.S. + Other)	Commercialized Technologies[A]	PHMSA ($M)
Threat Prevention	16	10	3	4	$ 5.92M
Leak Detection	13	6	2	4	$ 7.97M
Anomaly Detection	37	25	22	14	$23.29M
Anomaly Characterization	9	3		1	$ 4.32M
Materials	5	1	2	1	$ 7.36M
Welding	7	5		2	$ 4.92M
Joining	3	2	1		$ 1.35M
Alternative Fuels	3	2	1	2	$ 1.09M
Footnotes: A. Note: The measurement of "Commercialized Technologies" only occurs on non-active or completed projects.					
Grand Totals:	**93**	**54**	**31**	**28**	**$56.26M**

Website Usage

Website Usage Metric	Measure
Total Number of Hits	21,073,752
Average Number of Hits/Month	118,391
Files Downloaded (since 1/01/2008)	1,530,704

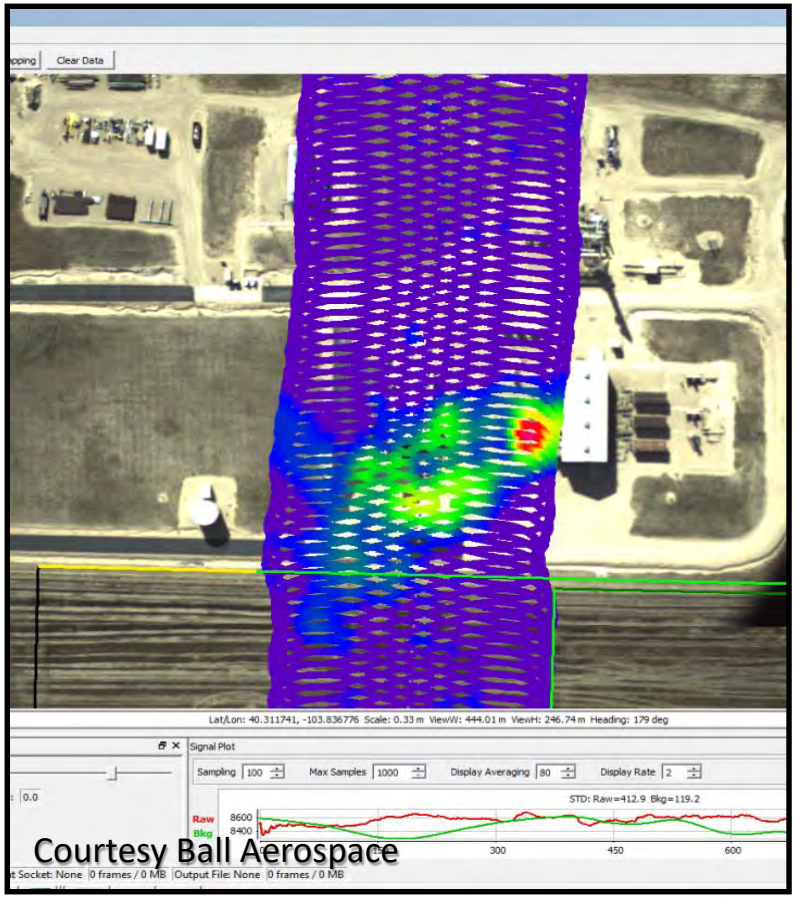
Areas of PHMSA Research

- **Laser Based Leak Detection**
  - Handheld
  - Vehicle or ROW/facility fixed
  - Airborne – helicopter/fixed wing
- **Sonic & Strain sensors**
- **Robotic Platforms – Untethered/Tethered**
  - Various sensors – MFL/EMAT/GWUT/EC

Laser Based Leak Detection

Vehicle Based

Hand Held



Aerial Based

Sonic & Strain Sensors

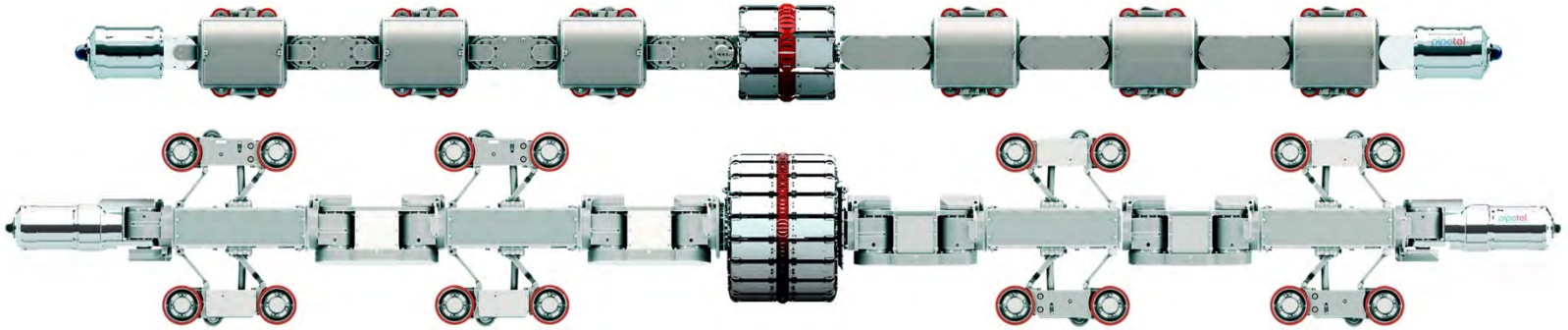
Deployable/Retrievable sensors for detecting sound/water

Sensors: soil vibration, pipe strain, soil moisture & temperature

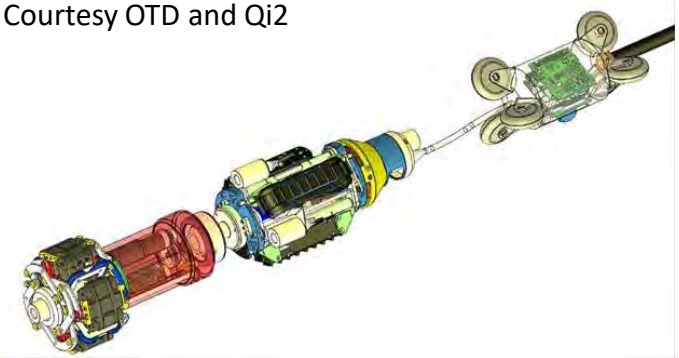
Multiple Sensor Nodes communicate through a single Access Point

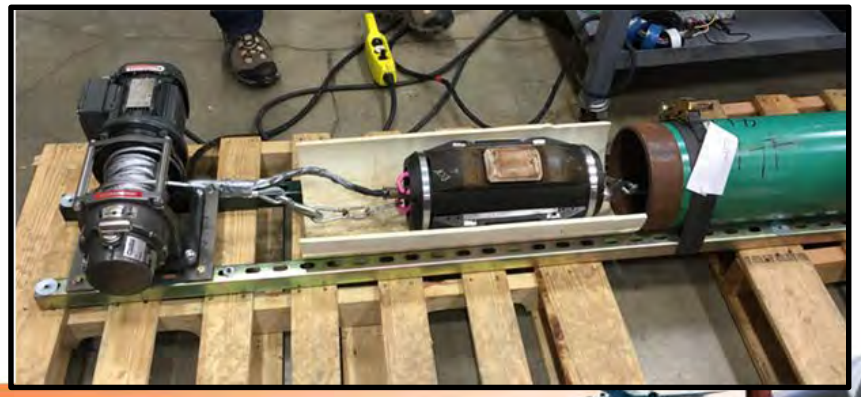
Robotic Platforms

Courtesy Pipetel



Courtesy OTD and Qi2





Robotic Platforms (cont.)

- **First of several projects funded in 2004**
- **Over $18M invested**
- **High commercial success**
- **Focus on both robotic platform and sensors development**
- **Sensors**
  - Initially MFL for corrosion, then focus on cracking and mechanical damage with EMAT and other UT
- **Challenges**
  - Weight/drag, battery life, communications, valves, back to back turns, diameter changes, retrievability, pipe cleanliness, etc…

Transparent Project Pages

Completion of Development of Robotics Systems for Inspecting Unpiggable Transmission Pipelines

Main Objective

The main objective is to complete the development of the Explorer II and TIGRE robotics systems for inspecting unpiggable transmission pipelines. In response to the field demonstration program that industry and DOT/PHMSA have with the commercial partner, design enhancements and additional demonstrations have been identified as needing R & D funding support by industry and government to ensure timely introduction of a reliable and economically-viable and unique product for addressing unpiggable pipelines. The work will complete the development and field demonstrations of these two systems and allow for successful commercialization.

Public Abstract

The completion of a research, development and demonstration effort that was initiated in 2001 for the development of two robotic systems for the in-line, live inspection of unpiggable transmission natural gas pipelines, supported by PHMSA/DoT since 2004. Two robotic platforms have been developed: (a) Explorer II, which carries a remote field eddy current (RFEC) sensor for the inspection of 6" and 8" unpiggable pipelines, and (b) TIGRE, which carries a magnetic flux leakage (MFL) sensor for the inspection of 20" to 26" unpiggable pipelines. The work will allow certain design enhancements for Explorer II, identified through the field demonstrations that the systems underwent, as well as the development of commercial grade defect sizing algorithms for the RFEC sensor. The work will also complete the development of the TIGRE system and will carry out a series of field demonstrations in dead and live pipelines that will bring it to the point of commercial deployment. This work will be conducted by a team consisting of NYSEARCH/NGA and Invodane Engineering (IE), the commercializer of this technology.

FINAL REPORT

NYSEARCH-DoT- robotics-final-report -PUBLIC-022013

NYSEARCH-DOT- ROBOTICS-FINAL-REPORT -PUBLIC-022013.PDF (2,986,969 bytes) [VIEW] [DOWNLOAD/SAVE...]

TECHNOLOGY DEMONSTRATION REPORTS

Article on Recent Technology Demonstration

ARTICLE_-_SOLUTIONS_NEAR_FOR_INSPECTING_UNPIGGABLE_NATURAL_GAS_PIPELINES_.PDF (532,260 bytes) [VIEW] [DOWNLOAD/SAVE...]

Fast Facts	
Research Award Recipient:	Northeast Gas Association 20 Waterview Boulevard, 4th Floor Parsippany, NJ 07054
AOR:	Robert Burrough, robert.burrough @ dot.gov, 609-989-2171
Contract #:	DTPH56-10-T-000008
Project #:	353
Researcher Contact Info:	Daphne D'Zurko, 973.265.1900x200/973.263.0919/ddzurko @ northeastgas.org George Vradis, 516.298.8427/973.263.0919/gvradis @ northeastgas.org
Peer Review	Very Effective (PHP-6-2011, Apr 20-27, 2011)
Peer Review	Very Effective (PHP-7-2012, Apr 11-24, 2012)
Downloads of Project Reporting	
Since Jan 1, 2017	393
Technology and Commercialization	
Technology Demonstrated?	Yes
Commercialized (in whole/part)?	Yes
Commercial Partner	Pipetel Technologies 1 (855) PIPETEL (747-3835) http://www.pipetelone.com/
Net Improvement	This work led to the commercial deployment and deployment of the first ever robotic inspection platform (Explorer) and integrated Magnetic Flux Leakage sensor capable of internal unpiggable gas pipeline inspection through many internal obstructions including plug valves. Explorer is an untethered, modular, remotely controllable, self-powered inspection robot for the visual and nondestructive inspection of 20" and 26" natural gas transmission and distribution system pipelines.
Financial and Status Data	
Project Status:	Closed
Start Fiscal Year:	2010 (09/30/2010)
End Fiscal Year:	2013 (12/31/2012)
PHMSA $$ Budgeted:	$1,708,831.00

Competitive Academic Agreement Program (CAAP) Objectives

1. Spur innovation, high risk/high reward research
   – Feed hand-offs into PHMSA's core research program
2. Involve students with technical/engineering pipeline challenges

CAAP: Historical Summary

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	$719K	$391K		4	14	10	28	1	3
CAAP-3-15	11	$2,960K	$888K		16	22	19	57	2	
CAAP-4-16	3	$899K	$368K		2	7	1	10		
Grand Totals:	**29**	**$5,394K**	**$2,002K**	**1**	**45**	**62**	**46**	**154**	**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.

NOTE: CAAP initially awarded projects at up to 24 month duration with $100 K PHMSA + 30% academic resource sharing. CAAP now awarded at up to 36 month duration using $300 K PHMSA + 20% academic resource sharing.

2018 Pipeline R&D Forum

- September 11-12, 2018
  Baltimore, MD
- Working Groups:
  - Improving Assessment Methods for Dents & Cracks
  - Remote Sensing/Leak Detection-Mitigation
  - Locating & Preventing Damage to Distribution Pipelines
  - Expanding In-Line Inspection Capabilities & Application
  - *Liquefied Natural Gas*
- 9 Student Poster Papers
- Research Gaps Identified
- Event Page

https://primis.phmsa.dot.gov/meetings/

Web-Based Debriefs

The Department of Transportation
Pipeline and Hazardous Materials Safety Administration
Pipeline Safety Research Program

Risk Tolerance, Predicting Catastrophic Events & Quantitative Risk Models

Overview: Please join us to learn the results of three key risk model projects that are informing PHMSA's Risk Model Working Group about recommendations to improve risk models in the future. The three projects are listed below with the URL to the project pages with more information.

Meeting Information:

Thursday, November 10, 2016, 1PM to 4PM ET

Project #1 Starts at 1PM ET
White Paper on Risk Tolerance
https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=639

Project #2 Starts at 2PM ET
Approaches for Preventing Catastrophic Events
https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=638

Project #3 Starts at 3PM ET
Critical Review of Candidate Pipeline Risk Models
https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=656

Conference Call Line: 877-336-1839 Access Code 2781644

LiveMeeting URL:
https://connectdot.connectsolutions.com/riskmodels/

Please contact Robert Smith (919-238-4759 or robert.w.smith@dot.gov) with any questions.

The Department of Transportation
Pipeline and Hazardous Materials Safety Administration
Pipeline Safety Research Program

Slow Crack Growth Evaluation of Vintage Polyethylene Pipes

Project Objective: Was to develop an integrated set of quantitative tools that provides a structured approach to reducing operational risk in vintage plastic distribution systems susceptible to Slow Crack Growth failures. The tools will provide a probabilistic estimate of the remaining effective lifetime of individual segments of vintage plastic pipe and a yes/no determination of whether a short-term pressure test is capable of validating the maximum defect size in the system. For more project information and final reporting, please visit https://primis.phmsa.dot.gov/matrix/PrjHome.rdm?prj=643 .

Meeting Information:

Wednesday, November 1, 2017, 2PM to 3PM Eastern

Conference Call Line: 1-877-336-1839 Access Code 9849115

Adobe Connect URL:

https://connectdot.connectsolutions.com/r60mfee42nb/

Agenda:

Welcome and PHMSA Introductions

Summary Slideshow of Project Results

Open Q&A and Discussion

Adjourn

Please Contact Robert Smith (919-238-4759 or robert.w.smith@dot.gov) with any questions.

Summary

- **Research will continue on robotic solutions**
  - Primarily on sensors vs robotic platforms
  - Goal to have same inspectability or better than traditional ILI
- **Remote sensing in general will become more common as the need for real-time data increases**
- **Final DOT/FAA movement on drone policy and regulations will open up wider usage**
- **PHMSA stands ready to have a technology dialog with the regulated**

Thank You!/Program Contacts

Kenneth Lee
Director – Engineering & Research
Department of Transportation
Pipeline & Hazardous Materials Safety Administration
Office of Pipeline Safety
P(202) 366-2694
Email kenneth.lee@dot.gov

Robert Smith
Department of Transportation
Pipeline & Hazardous Materials Safety Administration
Office of Pipeline Safety
P(919) 238-4759
Email robert.w.smith@dot.gov
LinkedIn https://www.linkedin.com/in/robert-smith-935aa033

Joshua Arnold
Department of Transportation
Pipeline & Hazardous Materials Safety Administration
Office of Pipeline Safety
P(202) 366-6085
Email joshua.arnold@dot.gov

PHMSA RD&T Providing/Supporting: