Update on Selected NYSEARCH Transmission Integrity Projects including Robotics Program for Inspection of Unpiggable Pipelines

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NYSEARCH/NGA
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Topics to Discuss

• Selected Integrity Inspection/Risk Assessment Projects
  – NYSEARCH/Kiefner Interacting Threats Project
  – TransKor
  – Cased Pipe Inspection
    • Via Vents
    • Annular Space Direct Assessment

• NYSEARCH Robotics Program for Unpiggable Lines (Commercial & Pre-commercial activities)
Interacting Threats Project 

Background

• Integrity Engineers from NY familiar with NYSEARCH/NYGAS work in late 1990s with Kiefner on relative Risk Model
• NY PSC urging engineers to address interacting threats in a more thorough fashion
• Other states and members experiencing same concerns
• PHMSA also expressing need for more technical work on assessment of interacting threats
Interacting Threats Project Objective & Threats/Risks

• Identify and quantify effects of interacting threats

• Incorporate consensus-based methodology into Kiefner risk assessment model and develop stand-alone module for use in other risk modeling software programs

• Nine primary threats/risks from ASME B31.8S
  – External corrosion*
  – Internal corrosion
  – Stress corrosion cracking
  – Manufactured related defects*
  – Welding/fabrication related defect**
  – Equipment
  – Third party/mechanical damage
  – Incorrect operational procedure
  – Weather-related and outside force**
Interacting Threats Workscope

• Identify Interacting Threats
  – Kiefner Failure Database
  – SMEs from NYSEARCH funder Advisory Group
  – Industry papers, past experience
  – PHMSA ‘Reportable Incidents Database’

• Develop Rationale/Technical Support for Selected Interacting Threats

• Develop method for quantifying (scoring/weighting) risks from interacting threats

• Develop/modify software for calculating risk from interacting threats
  – Kiefner Risk model & Stand-alone software
Project Definition of Interacting Threats

• Definition based on Kiefner conf calls with SMEs and iteration after discussing basis for (22) interacting threats

• Definition
  – Two or more threats acting on a segment or pipeline that increase the probability of failure to a level greater than (the sum of) the effects
  – Notes and examples:
    • The distinction that makes threats interacting is that the resulting prob of failure from the IT is GREATER THAN the sums of the probs of failure of the individual threats
    • Example 1: Consider threats A, B, and C. The prob of failure from these threats are $P_A$, $P_B$ and $P_C$ respectively. Threats are considered interacting if $P_{(A+B+C)} > P_A + P_B + P_C$
Two Examples of Interacting Threats (with Qualifiers)

• External corrosion (EC) on low freq ERW pipe seam can cause ‘grooving’ corrosion or ‘selective seam’ corrosion that has growth rates up to 4x greater than EC outside the ERW seam
  – Thus EC and defective pipe (DP) are interacting where potential selective seam corrosion exists BUT they are not interacting when the potential does not exist

• EC and Internal Corrosion (IC) have been documented to occur at the same location on a pipeline
  – Prob of Failure is greater at this location BUT they are not considered interacting because the prob of failure is NO GREATER THAN the sum of the pros of the individual threats \( P_{\text{EC and IC}} = P_{\text{EC}} + P_{\text{IC}} \)
  – Mathematically: \( P_{(A, B \text{ and } C)} > P_A + P_B + P_C + P_{AB} + P_{BC} + P_{AC} + P_{ABC} \)
  • For non-interacting threats, these terms are 0: \( P_{AB} = P_{BC} = P_{AC} = P_{ABC} = 0 \) and \( P_{(A, B \text{ and } C)} = P_A + P_B + P_C \)
## Project Threats Matrix (Updated)

<table>
<thead>
<tr>
<th>Time-Dependent</th>
<th>Stable</th>
<th>Time-Independent</th>
</tr>
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</tr>
<tr>
<td>CW</td>
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</tr>
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</table>

### Footnotes

1. A 1 applies unless the history of the segment indicates the construction damage has not contributed significantly to corrosion.
2. A 1 applies if the segment has not been subjected to a pressure test to at least 1.25 times MAOP.
3. A 1 applies if the Dresser-coupled segment has no CP or has CP but no bonds across the Dresser couplings.
4. A 1 applies unless it can be shown either that little or no coating damage exists or that the segment is not susceptible to SCC.
5. A 1 applies if the pipe is seam-welded and was installed with wrinkle bends.
6. A 1 applies if the pipe was manufactured with a low-frequency-welded ERW seam or a flash-welded seam.
7. A 1 applies unless it is known that the pipe material exhibits ductile fracture behavior under all operating circumstances.
8. A 1 applies only if the pipe is joined by acetylene girth welds or girth welds of known poor quality.
### Simplified Matrix of Interacting Threats for Assessment of Risk Factors

<table>
<thead>
<tr>
<th>CD</th>
<th>Construction Damage</th>
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<tbody>
<tr>
<td>CW</td>
<td>Cold Weather</td>
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<tr>
<td>DFW</td>
<td>Defective Fabrication Weld</td>
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<tr>
<td>DGW</td>
<td>Defective Girth Weld</td>
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<tr>
<td>DP</td>
<td>Defective Pipe</td>
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<tr>
<td>DPS</td>
<td>Defective Pipe Seam</td>
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<td>Corrosion</td>
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<td>Earth Movement</td>
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<tr>
<td>GF</td>
<td>Gasket Failure</td>
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<tr>
<td>HRF</td>
<td>Heavy Rains/Floods</td>
</tr>
<tr>
<td>IC</td>
<td><strong>Internal</strong></td>
</tr>
<tr>
<td>IO</td>
<td>Incorrect Operation</td>
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<tr>
<td>LIGHT</td>
<td>Lightning</td>
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<tr>
<td>MCRE</td>
<td>Malfunction of Control/Relief</td>
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<tr>
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<td>Miscellaneous</td>
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<td>Previously Damaged Pipe</td>
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<tr>
<td>SCC</td>
<td>Stress Corrosion</td>
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<tr>
<td>SPPF</td>
<td>Seal/Pump Packing Failure</td>
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<td>TP</td>
<td>Third Party</td>
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<td>TSBPC</td>
<td>Threads Stripped, Broken</td>
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<td>UNK</td>
<td>Unknown</td>
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<td>V</td>
<td>Vandalism</td>
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<tr>
<td>WROF</td>
<td>Weather Related and Outside Forces Confidential and Proprietary to NYSEARCH/NGA</td>
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#### 0353-1102 Interacting Threats Table

<table>
<thead>
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<th>Stable</th>
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<tr>
<td>WROF</td>
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</tr>
</tbody>
</table>

- Yellow shaded items are those that are being considered as interacting threats significant enough to factor into risk model
Industry

- IMP rules state that all transmission line segments in HCAs must be assessed by ILI, pressure testing, direct assessment or ‘other technology’
- Corrosion engineers need to detect coating disbonds, holidays or metal loss
- NYSEARCH actively seeks remote inspection technologies which can determine metal loss

MTM Technology

- Developed by Transkor-K of the Russian Federation
- Detects stress concentrators - Unique to ILI or ECDA
- Uses passive electromagnetic technique - No electrical connections
- Requires at least 1 NDE excavation for calibration
TransKor Validation Program Summary

– Phase I start February 2008
– Phase II start March 2010

– Objectives
  • Observe Transkor’s ability to meet industry demand
  • Assess technical performance by a third party
  • Notify PHMSA of MTM as an “Other Technology” if appropriate
TransKor Program Ph I & II Results Summary

– Final Kiefner report completed in August 2012

– 15 MTM reports, 49 Dig sites
Cased Pipe Vent Inspection  
Phase I Concept

• Video Inspection
• Robot Train
• Mecanum Wheels
• Side to Side Mobility
Cased Pipe Vent Inspection
Phase I Summary

• 7 month duration (12/11 – 7/12)
  – 4 month duration originally projected
    • concept path change
    • final report revision
    • winter holidays

• Proof of Concept Robot Developed
  – Could pass through 2” pipe
  – Could pass through two 2” elbows
  – Could enter a casing through a 2” round opening
  – Could navigate within the annular space
  – Could not traverse a plastic casing spacer
  – Could not enter the casing through smaller or irregular openings
Cased Pipe Vent Inspection
Sample Phase I Results

Casing Mock-up Results

• Navigated through 2” pipe
• Navigated through two 2” elbows
• Entered a casing through a smooth 2” opening
• Navigated within the annular space
• Could not transition from pipe to casing spacer
Cased Pipe Vent Inspection
Proposed Phase II

Continued Testing & Development by Honeybee Robotics

- Task 2A – Field Testing with Proof of Concept Robot
  - Go/No-go Milestone
- Task 2B – Alpha Prototype Development
  - Go/No-go Milestone
- Task 2C – Alpha Prototype Field Testing
- 18 month duration, $350,000
Casing Camera or Annular Space Direct Assessment Tool
Overall Objective & Benefits

- Develop a tethered robotic camera to inspect cased pipe via the annular space
  - Avoid casing removals
  - Minimize excavation
  - Judge coating integrity
  - Evaluate spacers
  - Locate electrical shorts
  - Assess annular environment (min 1-1/4” clearance)
Casing Camera or Annular Space Direct Assessment Tool
Phase II Objective & Benefits

- **Increase device availability**
  - Construct additional phase I systems
  - Begin path toward commercialization

- **Increase device reliability**
  - Improve wheel & track design
  - Improve user controls & feedback

- **Provide specific information**
  - Humidity
  - Temperature
  - Inclination
  - Feature Sizing

- **Assess pipeline integrity**
  - Ultrasonic Wall Thickness Measurement
Casing Camera or Annular Space Direct Assessment Tool
Phase II Tasks

✔ Task 1:  Build (1) Complete System & (2) Spare Robots

✔ Task 1a: Self-cleaning Drive Train (for all robots)

✔ Task 1b: Dedicated Report Format via GUI

✔ Task 2:  Develop Prototype with Wall Thickness Sensor

✔ Task 3:  Develop Prototype with Temp./Humidity & Inclination Sensors

✔ Task 4:  Develop Prototype with Feature Measurement System

✔ Task 5:  Prototype Field Testing & Minor Revisions

Final Report Delivered 8/12 - being released for review 10/12
Casing Camera or Annular Space Direct Assessment Tool
Technical Status

- **Task 5: Phase II Field Testing - CHG&E**
  - May 15, 2012 - Wappinger’s Falls, NY
  - 140 foot casing - 16”/20”
  - 5 feet inspected - space limitation at 2nd casing spacer
  - Demonstrated operation and ALL enhancements successfully
NYSEARCH Robotics Program

Overview

- Initiated in 2001 in anticipation of the PHMSA 2002 Rule
- Focus on developing technologies for the inspection of unpiggable natural gas pipelines
- Funded by:
  - NYSEARCH
  - PHMSA
  - OTD
  - DoE
  - PRCI
- Over $20M over 11 years
- Technology is now commercialized via Pipetel Technologies
NYSEARCH Robotics Technologies

- **Explorer 6-8**: currently commercially available; RFEC sensor; negotiates all obstacles but plug valves

- **Explorer 10-14**: currently commercially available; MFL sensor; negotiates all obstacles but plug valves

- **Explorer 20-26**: undergoing field demonstrations; to be commercially available in Fall 2012; MFL Sensor; negotiates all obstacles including plug valves

- **Explorer 30-36**: under development; to be commercially available in Fall 2013; MFL sensor; negotiates all obstacles including plug valves
Technology Features

• Unpiggable natural gas pipelines application
• Modular, tetherless robotic platforms; wireless communication
• Launch/receive through hot tap into live pipeline
• RFEC or MFL sensing for metal loss
• High Resolution Visual Capability for Navigation
• Modular for easy add-on functionality
• Negotiates all obstacles; including plug valves for sizes >20”
Available Sensor Specifications

- **RFEC**
  - Minimum anomaly size: 20% wall loss with a diameter of 3x pipe wall thickness
  - Anomaly axial length sizing: +/- 0.5 in with 75% confidence
  - Anomaly depth sizing accuracy: +/- 20% pipe wall thickness with 75% confidence

- **MFL**
  - Minimum Anomaly Size: 10% wall loss with a diameter of 3x wall thickness
  - Anomaly axial length sizing accuracy: +/- 0.5 in with 80% confidence
  - Anomaly depth sizing accuracy: +/- 10% pipe wall thickness with 80% confidence
Field Testing Program

• All systems undergo extensive field testing prior to commercialization
  – Explorer 6-8
  – Explorer 20-26

Confidential and Proprietary to NYSEARCH/NGA
Current Development Efforts to Add Functionality

• Explorer Sensing
  – Combination transverse MFL, EMAT for crack detection
  – Optical mechanical damage and ovality

• Explorer supporting technologies
  – In-line charging
  – Rescue tools

• Overall ~$4.5 million financial commitments made thru 2013

Confidential and Proprietary to NYSEARCH/NGA
Crack Sensor

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<th>Would be nice to detect</th>
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<th>MFL</th>
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Mechanical Damage Sensor
Explorer Hot Tap Cleaning Tool
Explorer 6-8 Rescue Tool

- Tether spool
- Battery
- Control electronics
- High torque drive module
- Rescue to robot interface
- 3 Camera & light
Explorer In-line Recharging Tool

- Adds range
CHG&E Gas Transmission
Robotic Inspections
Explorer 8” – 12”
AH, MP, TP, TPM Pipelines

David W. Merte, P.E.
Section Leader Gas System Safety and PI
Central Hudson Launches

*Completed 10 launches of Explorer II (8”-12”) between May 30 and August 20, 2012.

*Pipe wall thicknesses ranged from 0.172”-0.500” and MAOP ranged from 512-750 psig.

*Total distance traveled was 9,921 feet and the average distance inspected per launch was 324 feet.

*Total of 92 welds and 11 cased carrier pipes were inspected.

*Four “dents” were detected
Explorer “Dents”
Summary

• NYSEARCH’s portfolio remains strong with several projects in the pipeline integrity area resulting in commercial products or coming to completion

• Robotics products are being used; interest/support for supporting technologies and other sizes on an accelerated schedule

• Interacting Threats Project and others are built on input by funder advisors with Integrity Management experience; field tests of inspection products are also key and we appreciate continued support