Aboveground Anomaly Detection and Characterization
- Needs, Tools, and Gaps

US DOT/PHMSA Pipeline R&D Forum
- Working Group: Anomaly Detection/Characterization

July 18, 2012
Gas Technology Institute
Daniel Ersoy, R&D Director
Topics to Cover

> Aboveground Metal Loss Assessment Tool
  ─ Development Status and Remaining Gaps

> Aboveground Coating Disbondment Detector Tool
  ─ Development Status and Remaining Gaps

> California Natural Gas Pipeline Assessment
  ─ Project Status and Review of Some Key Gaps

> Internal Inspection Optimization Program
  ─ Status and How Information and Gaps Will Be Presented

> Summary of Aboveground Assessment Technology Gaps
Aboveground Metal Loss Assessment Tool
– Development Status and Remaining Gaps

US DOT/PHMSA Pipeline R&D Forum
- Working Group: Anomaly Detection/Characterization

July 18, 2012
Gas Technology Institute
Daniel Ersoy, R&D Director
Aboveground Metal Loss Assessment Tool

> Under Sponsorship from the GTI Sustaining Membership Program, a technology to detect wall thickness loss from aboveground is being investigated.

> Initial prototypes have been constructed that detect small variations in the EM field radiated by a pipe caused by flaws and thickness variations.
Remote Condition Assessment Objectives

> Develop a technology that can detect surface flaws on buried metal piping from aboveground.

> Perform testing to quantify the detection limits for different sizes and types of flaw (characterization).

> Construct a hardened prototype that can be deployed to utility test sites.
Benefits of Remote (Aboveground) Metal Loss Assessment

> Detect corrosion as early as possible, before hazardous situations develop

> Speed up the process of surveying the pipeline, reducing traffic control issues

> Cross-validate other inspection tool findings prior to excavations

> Minimize the number of excavations required to locate and remedy problems, reducing hazards to crews and to the public

> Provide an inspection method for dead legs, non-piggable sections, drips, meter-regulator station piping, etc.
Remote Assessment Principles

- A current signal on a smooth pipe generates an electromagnetic field orthogonal to the direction of the pipe.
- This field is detectable aboveground.
- Variations in the pipe surface caused by flaws or corrosion change the EM signal path.
- The signal path variations cause variations in the external field.
Remote Assessment Implementation

> Previous approaches to this problem have examined exotic cryogenic sensors such as SQUIDs.

> GTI approach is to use a two-coil gradiometer that travels along the pipe.

> These coils are oriented orthogonal to what is normally used for pipe location.
Remote Assessment Issues

> The field deviation caused by surface flaws is small compared to the “locating” field.

> Alignment of the current prototype with the pipe is critical.

> A mechanical system to align and move the gradiometer has been constructed to capture research data.
Remote Assessment Results

> GTI is currently collecting data on buried pipes with known, fabricated flaws.

> The data below was captured from a corrosion patch on a 4” steel pipe with FBE coating.

> Tests are ongoing to verify the repeatability of the results.
Remote Condition Assessment Gaps

> The mechanical method to compensate for misalignment is a good research tool but cumbersome for field deployment.

> Signal processing with additional sensors could be used to correct for misalignment instead.

> The prototype needs to be hardened for deployment to utility sites.

> Examine the possibility that this technology and the cathodic disbondment detector (next presentation in this slide deck) should be merged into a single platform.
Aboveground Coating Disbondment Detector – Development Status and Remaining Gaps

US DOT/PHMSA Pipeline R&D Forum
- Working Group: Anomaly Detection/Characterization

July 18, 2012

Gas Technology Institute
Daniel Ersoy, R&D Director
Above Ground Detection of Disbonded Coatings on Metal Pipe

> This technology development effort has been funded by the GTI Sustaining Membership Program and by US DOT/PHMSA.

> Several prototypes have been developed and tested.

> Tests have been carried on buried, fabricated flaws and on utility pipes.
Disbondment Detector Objectives

> There is **no** current technology that can detect disbonded coatings without excavation.

> Current Electromagnetic (EM) Locators can detect holidays through changes in *magnitude*

> The GTI approach is to also examine the EM *phase* data in conjunction with the magnitude

> As with standard EM locators, a known signal is injected into the metallic pipe.
Benefits of a Coating Disbondment Detection

- Detect the presence of disbonded coating during the earliest stages, before substantial corrosion has occurred.
- Speed up the process of surveying the pipeline, reducing traffic control issues.
- Could allow screening of problematic field applied coating systems with known disbondment problems which lead to corrosion.
- Minimize the number of excavations required to locate and remedy problems, reducing hazards to crews and the public.
Disbondment Detector Prototype

> The current prototype uses one pick-up coil mounted with an odometer wheel
> Coax cable connects the movable pick-up to the stationary signal injector to provide phase reference
> Maximum survey range is now 1000’ but can decrease if coating flaws ground signal
> Operator must know the line of the pipe and walk it
> Works on pavement or grass
Some Disbondment Detector Results

> The Detector has been run through initial tests on utility steel lines with both FBE and CTE coatings.

> The magnitude data can locate holidays and other breaks in the coating.

> The phase data can detect other features that magnitude would miss.
Magnitude **Data** for 20” main with CTE

Multiple holidays and missing coating were found in the area where the magnitude drops off.
Phase **Data for 20” main with CTE**

At the location with the greatest phase change several disbondments and some small holidays were found.

Also found were a set of test station wires still attached to the pipe.
Disbondment Detector Gaps

> Eliminate the tether between the antenna and signal injection point

> Improve odometry using range finder and/or GPS

> Implement two-coil antenna to provide centering feedback for operator

> Additional sensors, such as tilt, would also improve data quality

> Once these changes are made, more testing opportunities will be needed for validation
CALIFORNIA NATURAL GAS PIPELINE ASSESSMENT
- CEC #500-10-050

US DOT/PHMSA Pipeline R&D Forum
- Working Group: Anomaly Detection/Characterization

July 18, 2012
Gas Technology Institute
Daniel Ersoy, R&D Director
Project Goals

> Identify Quick “Wins” Commercial Technologies Not in Use That Could/Should Be
>
> Emerging Technologies That Could Be Moved to Commercial Availability Quicker
>
> Leverage and Optimize the Use of the Advanced Metering Infrastructure (AMI)
>
> Develop an Implementation Plan
<table>
<thead>
<tr>
<th>Category</th>
<th>Example(s)</th>
</tr>
</thead>
</table>
| Internal & External Assessment and Inspection Methods | • Alternating Current Voltage Gradient  
• Guided Wave                                                                 |
| Internal Inspection Methods                  | • Magnetic Flux Leakage  
• EMAT  
• Explorer II                                                                 |
| Long Term Condition Monitoring               | • Steel Coupons  
• Cathodic Protection Monitoring  
• Gas Chromotography                                                              |
| Risk Modeling and Incident Prediction Tools  | • Real Time Transient Model  
• Digital Signal Analysis                                                        |
| ROW Encroachment and Excavation Damage Prevention | • Pipe Locating – GPR, Acoustics, Magnetic, Current Mapping  
• Video Detection                                                                 |
# Technology Categories and Examples

<table>
<thead>
<tr>
<th>Category</th>
<th>Example(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detection of Pipeline Leaks and Ruptures</td>
<td>• Foot, Mobile and Aerial Surveys</td>
</tr>
<tr>
<td></td>
<td>• Pressure/Flow Monitoring</td>
</tr>
<tr>
<td>Remote Stress/Strain analysis of Pipeline</td>
<td>• Ring Expansion testing</td>
</tr>
<tr>
<td></td>
<td>• Strain gauge</td>
</tr>
<tr>
<td>Tools, techniques and data Analysis Methods in IM P’s</td>
<td>• FRASTA</td>
</tr>
<tr>
<td></td>
<td>• MIC Testing</td>
</tr>
<tr>
<td>Non-destructive Examination &amp; Testing</td>
<td>• External Crack detection</td>
</tr>
<tr>
<td></td>
<td>• Metal Loss detection</td>
</tr>
<tr>
<td></td>
<td>• X-Ray Analysis</td>
</tr>
<tr>
<td>Automated/Semi-Automated and manual Methods of Shutdown</td>
<td>• Remote Controlled Valve</td>
</tr>
<tr>
<td></td>
<td>• SCADA and RTU’s</td>
</tr>
<tr>
<td></td>
<td>• System Modeling</td>
</tr>
<tr>
<td>Data Collection &amp; Communications Techniques</td>
<td>• GIS</td>
</tr>
<tr>
<td></td>
<td>• SCADA - Wired and Wireless</td>
</tr>
<tr>
<td></td>
<td>• Human Machine Interface</td>
</tr>
</tbody>
</table>
Partial “Wish List” - Technologies Needing Creation or Enhancement (1)

> Improve the Value of EMAT Technology - Use a Needs Assessment

> Automated Girth Weld Inspection Tool on a Tether

> Robotic ILI Tools for Medium and Large Diameter Pipelines that are Un-Piggable with Conventional Tools

> Alternative Acoustic Pipeline/ROW Intrusion Monitoring Technologies
“Wish List” - Technologies Needing Creation or Enhancement (2)

> Tool to Accurately Measure Crack Length and Depth in the Ditch
> Assessment of Long Seams and Girth Welds
> Industry Database Available to Others for Trend Analysis and Threat Identification
Internal Inspection Optimization Program
– Status and How Information and Gaps Will Be Presented

US DOT/PHMSA Pipeline R&D Forum
- Working Group: Anomaly Detection/Characterization

July 18, 2012

Gas Technology Institute
Daniel Ersoy, R&D Director
## Phase 1 - Objective

> Develop an R&D roadmap for internal inspection tools to guide technology development

<table>
<thead>
<tr>
<th>Threats</th>
<th>Parameters of Interest</th>
<th>Sensor Technology</th>
<th>Platforms</th>
<th>Overarching Influencers / Other Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>External Corrosion</td>
<td>Wall Thickness and Loss</td>
<td>Ultrasonic/microwave</td>
<td>Tethered (e.g., mechanical cable or coiled tube pulled)</td>
<td>Existing and Impending Regulations (i.e., Post San Bruno)</td>
</tr>
<tr>
<td>Internal Corrosion</td>
<td>Cracking</td>
<td>Eddy Current/RFEC</td>
<td>Push Rod (e.g., coiled tube pushed)</td>
<td>Market Size (diameters, distances, obstructions)</td>
</tr>
<tr>
<td>Stress Corrosion Cracking (surface and subsurface)</td>
<td>Residual Stress Levels</td>
<td>Guided Wave UT</td>
<td>Robotic Tethered (e.g., self-driven brush drive but with trailing power cord)</td>
<td>Cost (development and per inspection unit)</td>
</tr>
<tr>
<td>3rd Party Damage</td>
<td>Hardness and Ultimate Strength</td>
<td>X-Rays</td>
<td>Robotic Autonomous (no tether for power, etc.)</td>
<td>Time to market</td>
</tr>
<tr>
<td>Fabrication / Weld Quality</td>
<td>Yield Strength</td>
<td>Magnetic Flux Leakage</td>
<td>Flowable Sensors (e.g., Fluidized Sensors, Smart Balls, etc.)</td>
<td>Sponsors</td>
</tr>
<tr>
<td>Wrinkle Bends / Miter Bend</td>
<td>Toughness</td>
<td>Magnetic Field Strength</td>
<td></td>
<td>Repeatability of Inspections</td>
</tr>
<tr>
<td>Residual Stresses</td>
<td>Physical Dimensions (ID)</td>
<td>Electromagnetic</td>
<td></td>
<td>Commercializers</td>
</tr>
<tr>
<td>Soil and Other Superimposed Stresses</td>
<td>Internal Defects (Porosity, Laminations, etc.)</td>
<td>Optical/IR/UV</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Phase 1 - Status

The Phase 1 R&D Roadmap will include:

- Identification of threats to be addressed
- Identification of parameters to be measured
- Analysis of currently available technologies
- Gap analysis to identify areas for further development
- Development plan for new technologies

> Collecting data from technology providers and published literature

> Roadmap to be delivered later this summer
Phase 2 - Objective

> Develop an *Inspection Technology Selection Tool* that assists operators in selecting the most appropriate inspection technology for a *specific* pipe segment to address the unique threats based on:

- pipeline vintage
- known material properties
- known construction techniques
Phase 2 – **Benefits of the New Inspection Technology Strategy Tool**

> **New Technology Development:** Assist operators, vendors, and integrity management service providers and consultants in formulating a strategy for developing new inspection technologies that can be used as an alternative to hydrotesting where appropriate.

> **Business Case Input:** Prioritize and provide the business case for new inspection technologies based on the mileage and characteristics of pipe without hydrotest records.

> **Public Communication:** Satisfy the need for a communication piece for the public that is based on sound engineering and scientific principles.
Aboveground Assessment Technology Gaps
Aboveground Assessment Technology Gaps – Metal Loss and Coating Disbondment Assessment Tools

> Compensate for misalignment between above- and belowground positions via additional sensors and centering feedback

> **Harden** prototypes for field use

> **Combine** two technologies into one multipurpose aboveground tool (e.g., measures wall loss and coating disbondment)

> Eliminate tethers between the antenna and signal injection point

> Improve **odometer** using range finder and/or GPS

> Additional **validation** testing