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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

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Aboveground Metal Loss Assessment Tool

– Development Status and Remaining Gaps

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Aboveground Metal Loss Assessment Tool

- Under Sponsorship from the GTI Sustaining Membership Program, a technology to detect wall thickness loss from <u>aboveground</u> 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

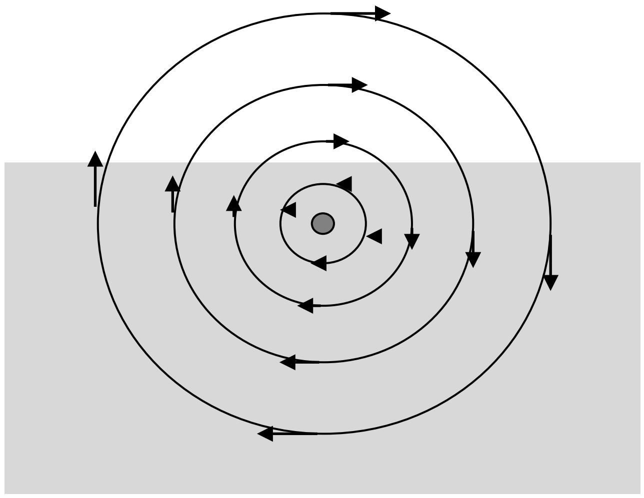
- Develop a technology that can detect surface flaws on buried metal piping from aboveground.
- Perform testing to quantify the detection limits for different sizes and types of flaw (characterization).
- Construct a hardened prototype that can deployed to utility test sites.

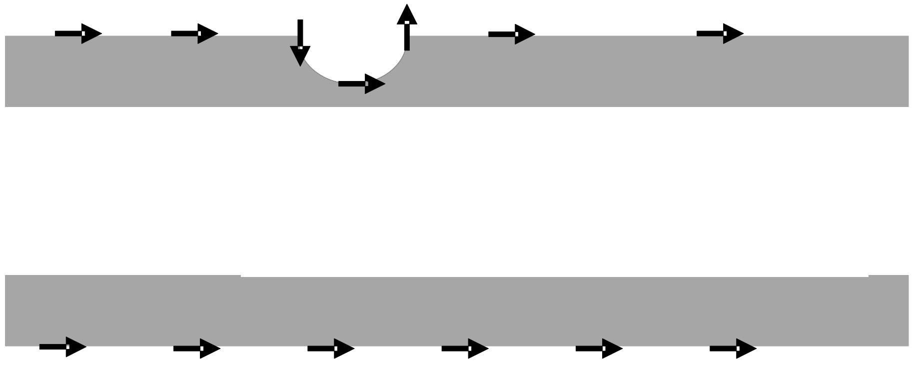
Benefits of Remote (Aboveground) Metal Loss Assessment

- 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

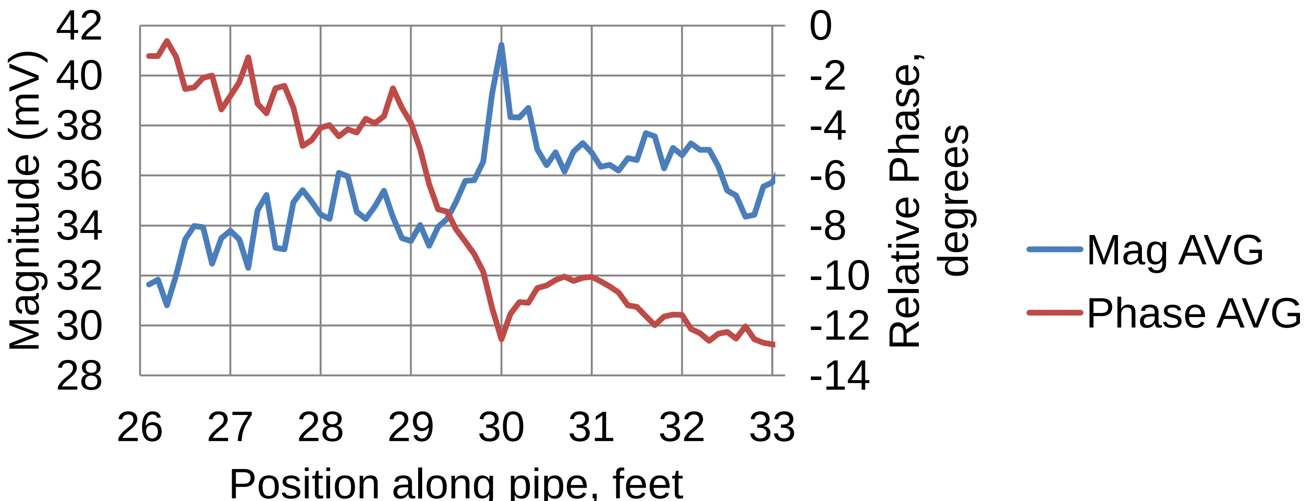
- Previous approaches to this problem have examined exotic cryogenic sensors such as SQUIDs.
- GTI approach is to use a two-coil gradiometer that travels along the pipe.
- These coils are oriented orthogonal to what is normally used for pipe location

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.

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Aboveground Coating Disbondment Detector – Development Status and Remaining Gaps

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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.

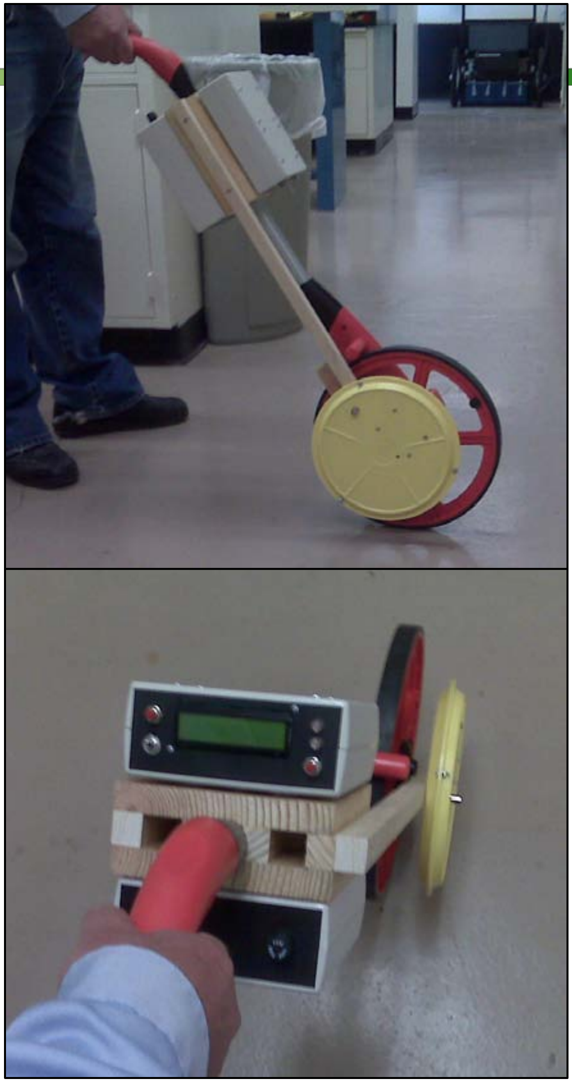
Disbondment Detector <u>Objectives</u>

- There is <u>no</u> 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.

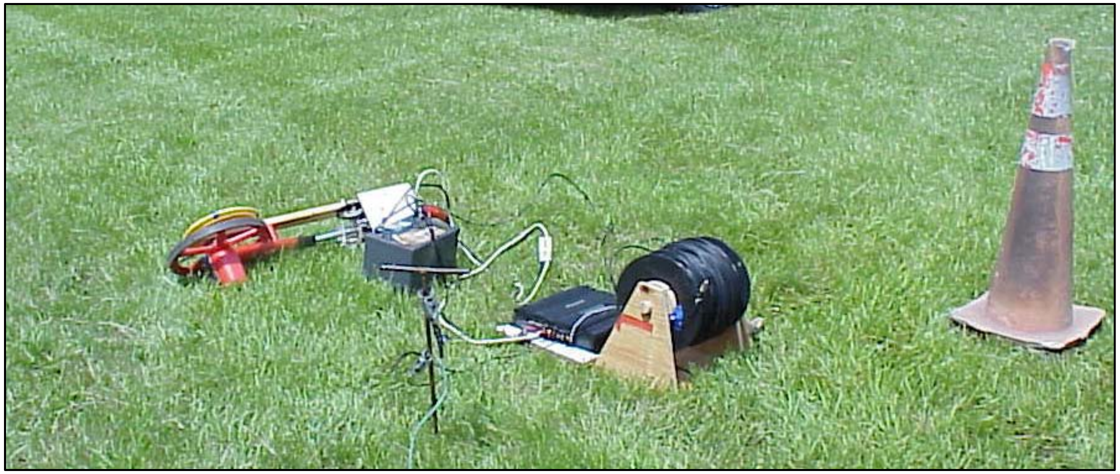
Disbondment Detector Prototype



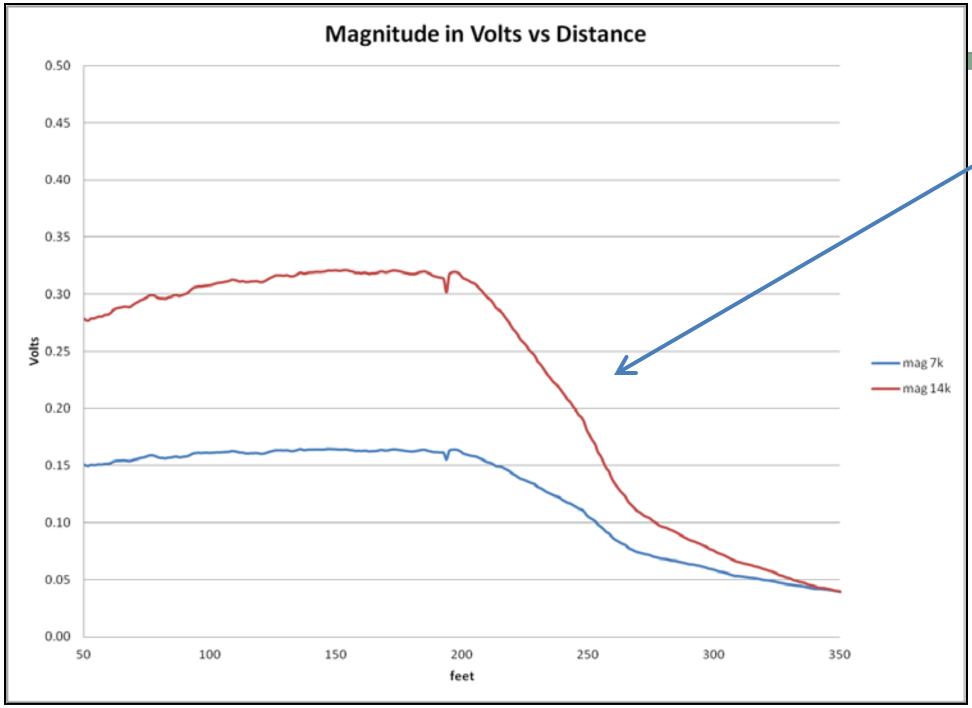
- The current prototype uses one pick-up coil mounted with an odometer wheel
- Coax cable connects the movable pick-up to the stationary signal injector to provide phase reference
- Maximum survey range is now 1000’ but can decrease if coating flaws ground signal
- Operator must know the line of the 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.

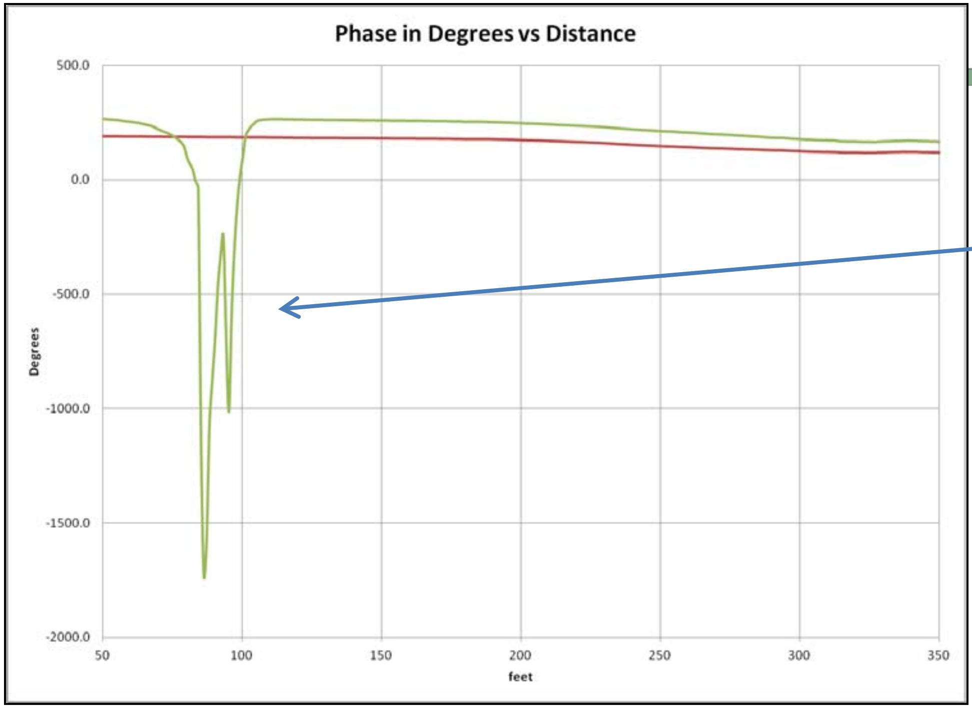


Magnitude Data for 20" main with CTE



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 odometery 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

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Project Goals

> Identify Quick "Wins" Commercial Technologies Not in Use That Could/Should Be

> Emerging Technologies That Could Be Moved to Commercial Availability Quicker

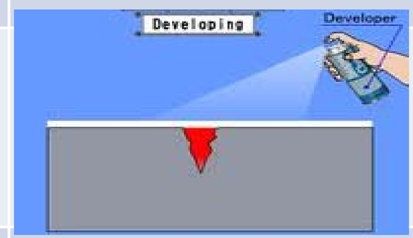
> Leverage and Optimize the Use of the Advanced Metering Infrastructure (AMI)

> Develop an Implementation Plan

Technology Categories and Examples

Category	Example(s)	
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 Chromatography	 
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

Category	Example(s)	
Detection of Pipeline Leaks and Ruptures	•Foot, Mobile and Aerial Surveys •Pressure/Flow Monitoring	
Remote Stress/Strain analysis of Pipeline	•Ring Expansion testing •Strain gauge	
Tools, techniques and data Analysis Methods in IM P's	•FRASTA •MIC Testing	
Non-destructive Examination & Testing	•External Crack detection •Metal Loss detection •X-Ray Analysis	
Automated/Semi-Automated and manual Methods of Shutdown	•Remote Controlled Valve •SCADA and RTU's •System Modeling	
Data Collection & Communications Techniques	•GIS •SCADA - Wired and Wireless •Human Machine Interface	

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

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

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Phase 1 - Objective

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

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

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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