Direct Assessment Activities by GTI

> DOT R&D Forum
> Houston, TX March 2005

Daniel Ersoy
Gas Technology Institute
daniel.ersoy@gastechnology.org
847.768.0663

U.S. Department of Transportation

Gas Technology Institute

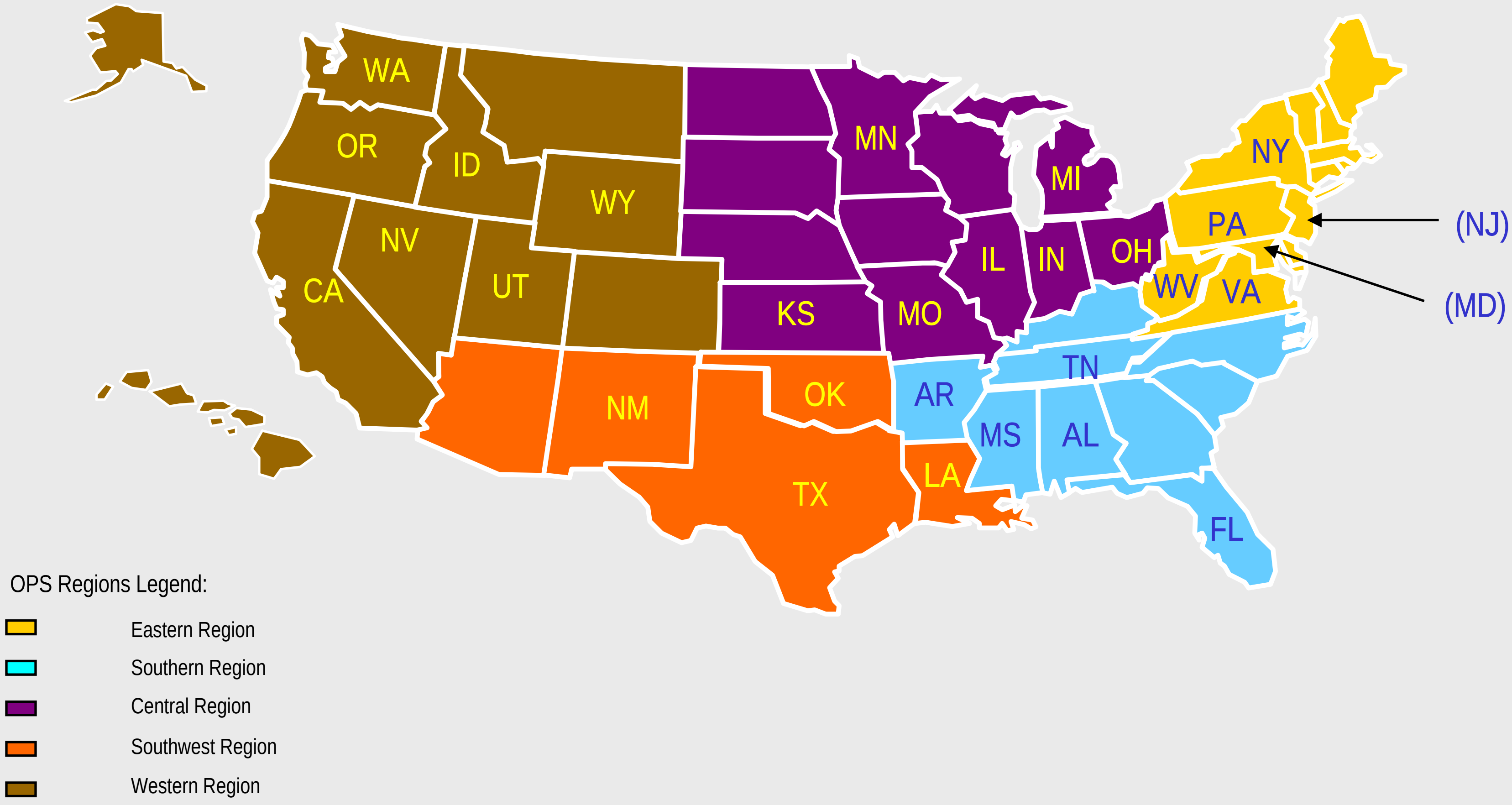
- Independent, not-for-profit research and testing organization, founded in 1941
- Testing and evaluation, technology development, education, informational services
- Natural gas, energy, and environmental research focus
- Headquarters: Des Plaines, IL (Chicago area)
  - 300,000 sq-ft facility on an 18-acre campus
  - Laboratories, test facilities, library, classrooms, offices
- Staff: Over 300: Des Plaines, other states, and DC
- GTI joined with AGA in 2002 to develop and execute an ongoing Pipeline Integrity Management Program

GTI/AGA ECDA Program (Phase One)

- Developed a Generic, Technically Justifiable, and Practical Methodology to Implement ECDA on LDC gas transmission lines
- Delivered self-contained ECDA Implementation Protocol
- Completed six case studies (cradle-to-grave) with dozens of excavations
- “Yellow Pages” of ECDA service and software providers
- Practical demonstration of inspection tools
- Detailed guide on soil chemistry analysis and affects on corrosion rates (growth rates)
- Developed Data Integration Guidelines
- Data Alignment and Analysis software “round-robin”

GTI/AGA PIM Research Participants

- Over 30 companies in All five OPS/NAPSR regions participating in the program.
- Wide breadth of operational and regulatory environments and conditions.



gti

Some Positive Outcomes of Phase 1

> Developed Comprehensive ECDA Implementation protocol refined through case studies. Tremendous feedback and help from volunteer companies.

> Greatly improved Indirect Inspection tool understanding and refined indication and severity criteria (fed back into protocol)

> Positively influenced the acceptance of DA as equivalent to Pigging (ILI) and Hydro-Testing

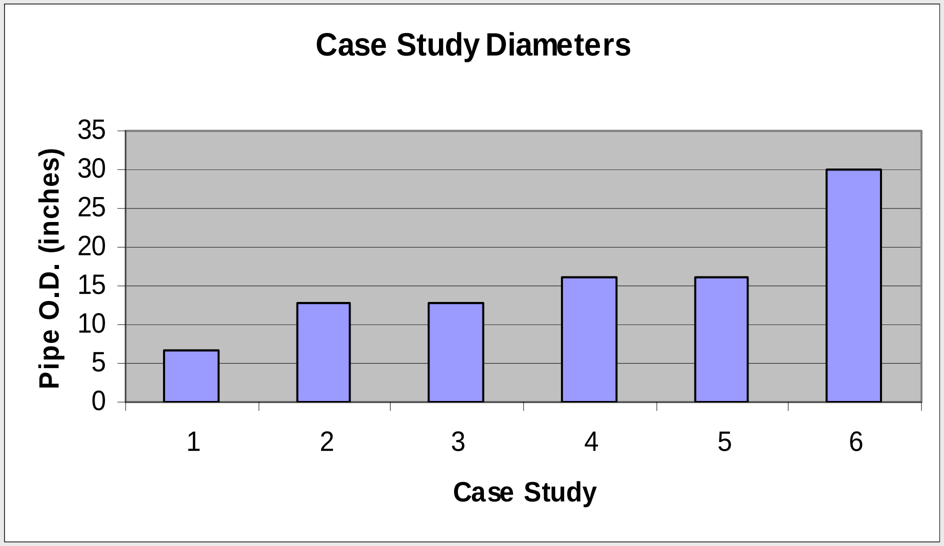
> State PSC and/or OPS at nearly every ECDA site substantially increased DA credibility with regulators

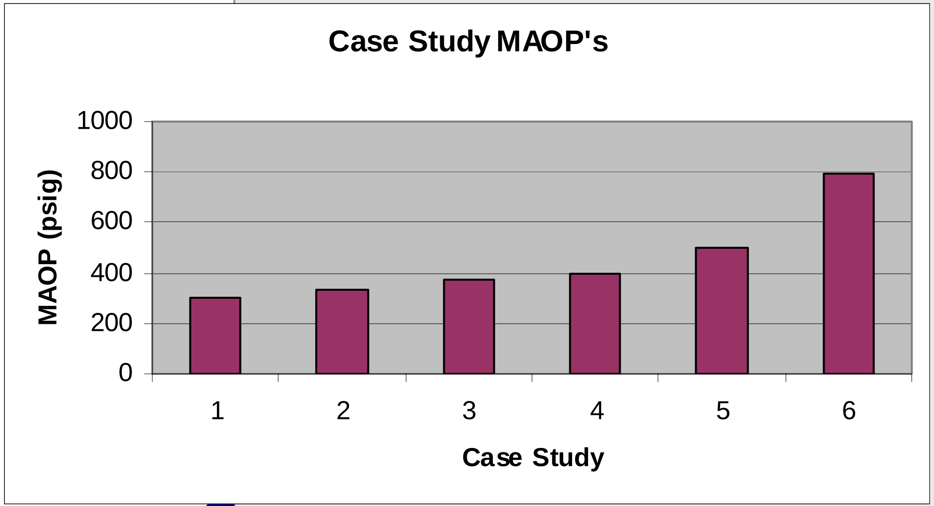
> Resulted in over 40 LDC Participants in Phases 2 and 3 for Challenging ECDA Situations and ICDA for LDC’s

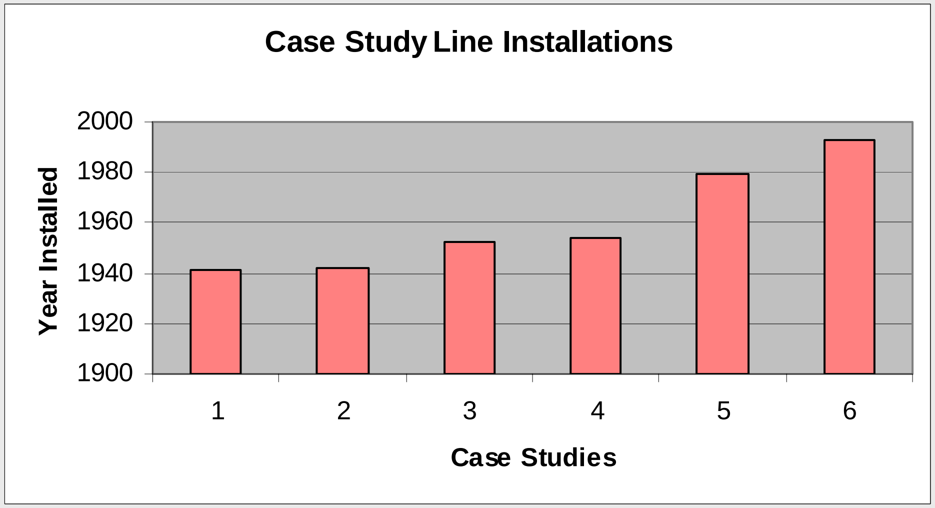
gti®

Phase One ECDA Program – Case Studies

- MAOP (range 375-790 psig)
- Diameter – Wall Thickness – Grade (range 6”-30”, 0.203”-0.375”, X-24 to X-52)
- Installation (1941 to 1993)
- Coatings (Bituminous, Wax, FBE, Bare Coatings and Mg anodes and IC (distributed and deep)







Case Study Example PCM, DCVG, CIS

Coating Defects

Salt deposit and coating defect

Large coating defect

gti

Corrosion Defects

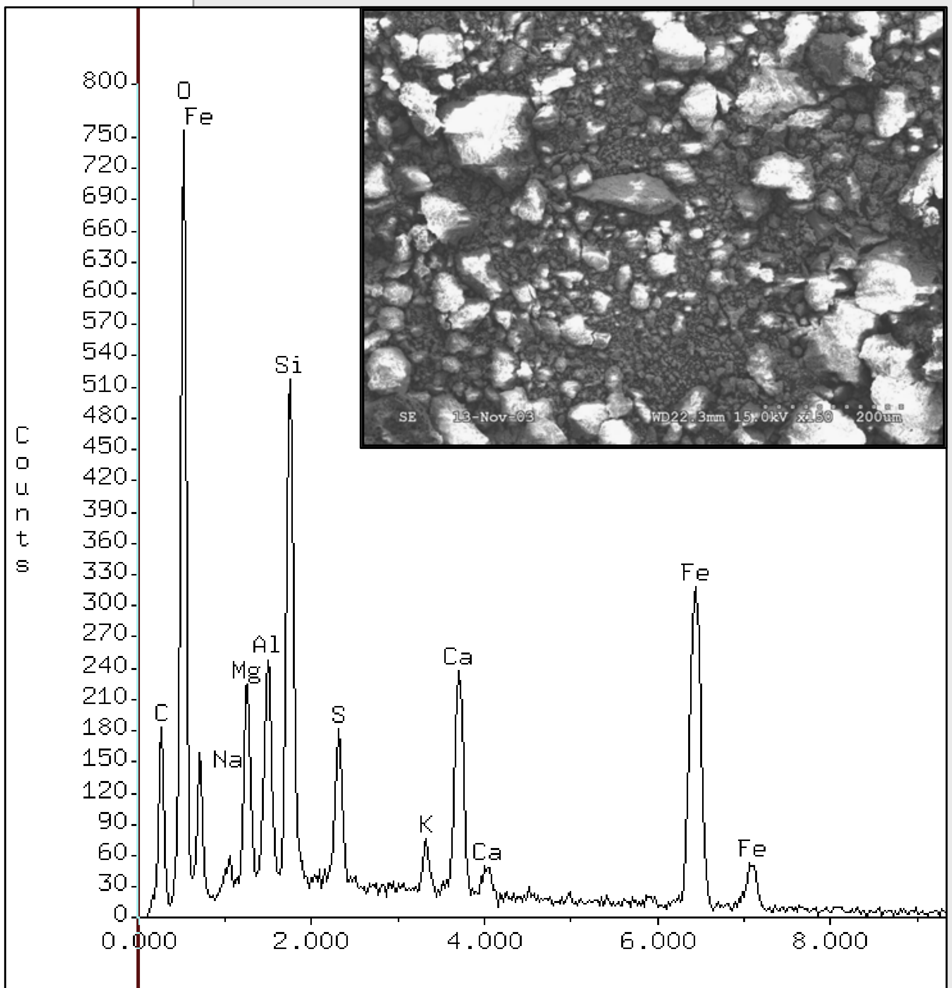
Corrosion defect 50 mils deep. Potential MIC.

Corrosion defect on bottom portion of pipe

Deepest pit. There was a smell of <u>sulfur</u> when corrosion was removed which is a good indication of MIC.

Corrosion Product & Soil Analysis

Corrosion product analysis showed very strong presence of iron oxide with moderate amounts of sand (Al, Si oxide). Minor indication of Calcium Carbonate formation.



SOIL:

pH: **7**

Carbonates (ppm): **positive**

Sulfides (ppm): **negative**

Total Iron (ppm):**0**

Chlorides (ppm): **0**

Nitrates (ppm): **5**

Sulfates (ppm): **29**

Moisture content (%): **15.3%**

Some Lessons Learned – Pre-Assessment Step

> Thorough search of records, and interviews with all departments key.

> Include Watch and Protect programs etc.

> Pre-Assessment data was critical in establishing correct tool operation and potential excavation sites, especially when a complementary set of indirect inspection data was unavailable.

gti®

Some Data Integration Lessons Learned

- By using physical markers for marking intervals and indications
- By using consistent, precise marking intervals (e.g. every 100ft)
- By referencing permanent geographical features for anchor points and indications and as often as practical elsewhere
- By taking care to do it right the first time

Lessons Learned – Indirect Inspections to Direct Exams

- For the ECDA the tools did what they were expected to do:
  - NO FALSE POSITIVES - There were always defects where two or more indications said there would be.
  - NO FALSE NEGATIVES - When two or more tools indicated no defect, the validation digs always confirmed this.
  - Tools were more sensitive than expected:
    - pinhole size defects in FBE were detected
    - tree root intrusion under field wraps and CTE was detected

gti®

Some Lessons Learned - Tool Performance

- DCVG had a finer location resolution than PCM, e.g. inches versus feet and located coating defects that were the size of a pinhole to 300 in^2 within 1-3 inches of their actual location.
- CIS located defects less precisely than DCVG, but correlated well with the excavated location; and correctly differentiated between locations with little or no cathodic protection and those that were well protected. CIS also greatly assisted in setting overall classifications and prioritizations.
- Cell-to-cell and side-drain appeared to correlate well with corrosion found on bare pipe

Some Lessons Learned - Tool Performance

- PCM worked well in indicating general regions of coating defects or large holidays (4 in^2) on well coated pipe. If the pipe had large and long holidays along the bottom, PCM did not isolate the indication.
- PCM A-Frame worked well at locating isolated, small defects and found a defect under an asphalt driveway. Comparable to DCVG in ability to locate small coating holidays if one already knows their general location.

gti

Challenging ECDA Situations (Phase 2)

- Coordinating the development of a methodology
  - Deliverables are detailed generic protocols for
    - Casing and Bare Pipe
    - Crossings such as river, road, and rail
- Detailed case studies from LDC operators
  - Verification of the methodologies and protocols
- Confirmation and validation of new and innovative use of technologies (e.g., 2nd generation commercially available GW tools vs. 3rd generation, prototype GW system)

gti

ICDA for LDCs – (Phase 3)

- Developing customized ICDA Protocol
  - Based on pending NACE RPXXXX for “Dry Gas” (based on GRI 2002-0057)
  - Will adapt for wet gas too/gravity approach
  - Develop/revise customized inspection/bell hole forms
  - Develop ICDA data element table for pre-assessment step
- Detailed Field Examples Applicable to LDCs (i.e., Validations - Which Build Confidence).
- Building a new Matrix of Service Providers for ICDA (i.e., Yellow Pages)

gti

Example Challenging ECDA Situation Case Study

Situation	Outer Diam. (in)	MAOP (psig)	Grade	Year Installed	Year CP Installed and Type of system	Coating	Length	Class	Other Info
Casing under abandoned Railroad Crossing (will remove casing)	10.75	525	X 25	1950	1953 - Impressed Current, upgraded in 1995	Wax on main and joints	97 ft	Suburban, Class 4	Casing is not filled with dielectric, Casing can be cut off after testing is complete.

gti®

Challenging ECDA Case Study – RR XING

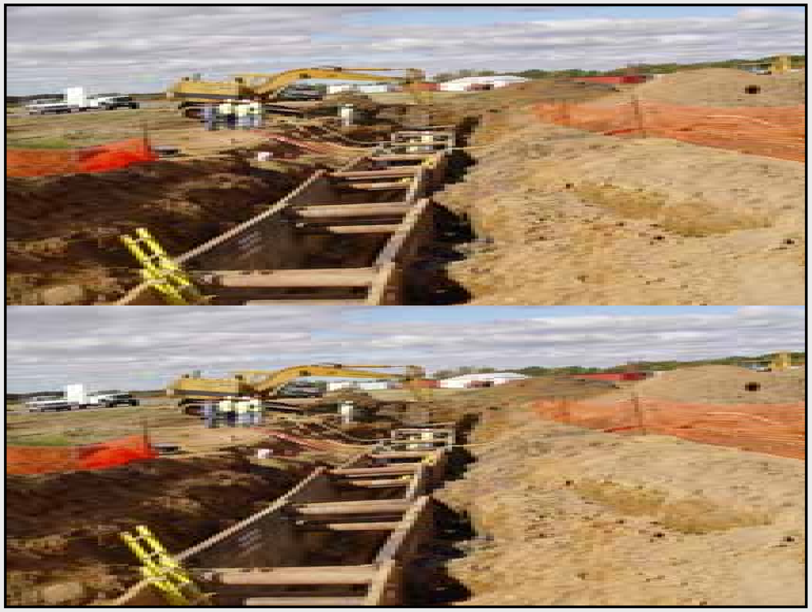
- A 97 foot casing at an abandon RR Crossing was selected on a 10" diameter line.
- This pipe was installed in 1950 and is made of Grade A (X25) seamless pipeline steel. The line has an O.D. of 10.75" and a wall of 0.279".
- The casing is buried ten feet deep in a Class 4 area, within a High Consequence Area (HCA) at the end of a closed airport runway
- The casing was installed for a now abandoned rail road line.

Background

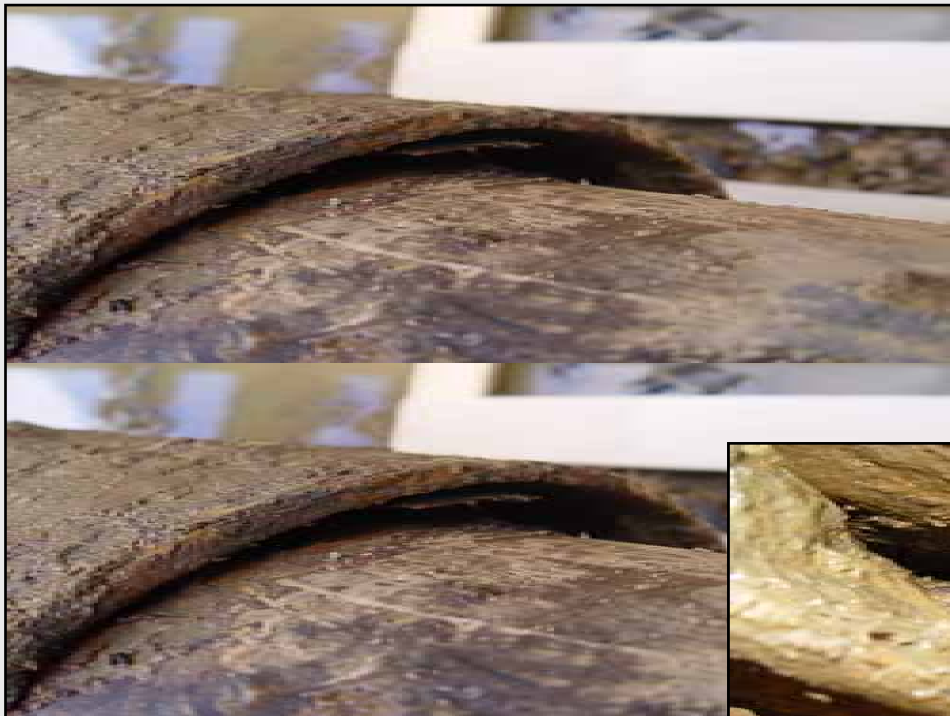
> The line is protected by an impressed current system with the casing very close to one of the rectifiers and anode beds. The soil was a clay/loam mix with a typical soil resistivity of 20,000 ohm-cm.

> Protection criteria is: -0.850 V (CSE), with actual pipe-to-soil (P/S) readings near the casing at -2.0 V with the casing at -1.2V indicating a possible short of the casing to the carrier pipe.

> Based on experience, the wax based coating was expected to be in poor condition.



Casing Seals



Top of casing, no seal

Bottom of casing, no seal. Casing filled with water and mud.

Coating Removal for GW Collar

Stripping off coating for collar placement

The condition of the exposed pipe (outside of the casing was very good to excellent. Any areas of corrosion had a depth not measurable or less than 10 mils deep

Wall Thickness Verification

The transducer collar was inflated to ensure good contact of the transducers with the pipe wall for optimal ultrasound transmission and reception.

The pipe wall thickness was measured at all clock positions along the exposed length. It varied from 0.270" to 0.300" in the radial direction but was consistent in the axial direction (artifact of forming).

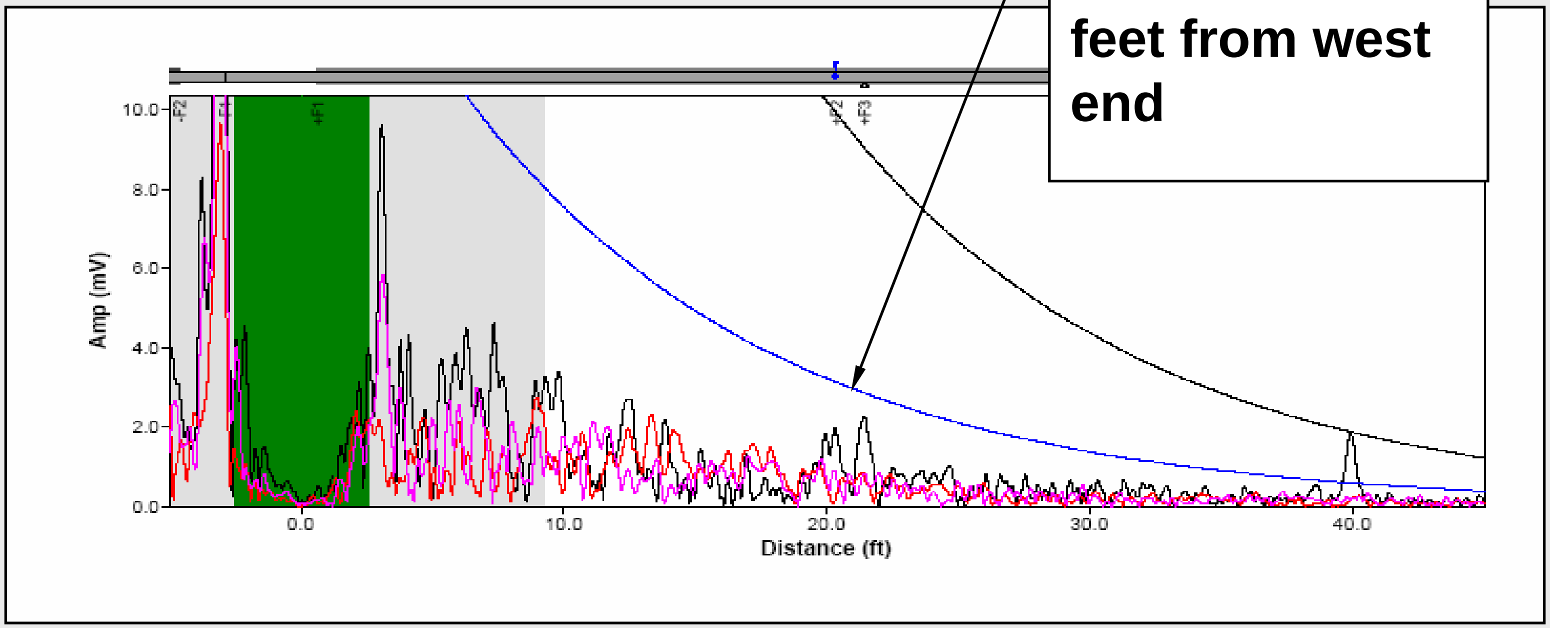
Large Variety of Test Configurations

- Large variety of scans were captured (mode, frequency, etc.) at about 10 minutes per scan
- Used both a small and large collar
- Used the existing, commercially available 2nd generation tool (GUL-16); and
- Used 3rd generation tool (Wavemaker G3) optimized for buried pipe.

gti

Challenging ECDA Case Study

Feature at 20 feet from west end



The wax wrap on the pipe attenuated the propagation of the guided waves as they traveled down the pipe axially in both directions. The attenuation rate was about -2.0 dB/meter. To obtain full coverage, the cased pipe was inspected from both ends of the casing. The two welds contained within the casing were easily identified and located. One area of suspect corrosion/wall loss was identified. A single scan is shown above. This scan shows a feature located 20 feet from the west end of the casing

gti

Challenging ECDA Case Study

- This was the only indication/feature along the casing that had a significant signal strength (approaching 10% area cross section change).
- Based on the collection of scans it was predicted that the wall loss would cover about ¼ of the pipe circumference and be between 20-40% of wall loss.
- The scans also indicated that the feature would be more *top/bottom* located versus on the sides.

gti®

Challenging ECDA Case Study

After removal of the casing, a wear patch was discovered centered at the predicted location.

Challenging ECDA Case Study

It extended about 2 inches circumferentially and 0.250 inches axially. The maximum depth was 0.043 inches (43 mils) or about 16% of wall thickness.

Challenging ECDA Case Study

The casing opposite of the defect showed signs of corrosion and wear. There was a girth weld on the casing at this location and it was misaligned, producing an offset ridge that appeared to be resting on the carrier pipe (point of wear contact).

Challenging ECDA Case Study

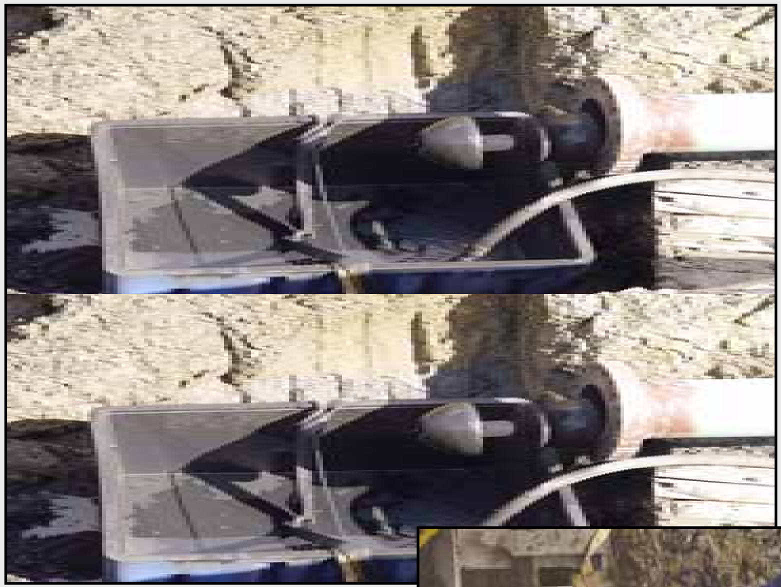
- No other areas of concern were identified and no others were actually found on the pipe through direct visual inspection.
- The results from this assessment were very encouraging, it was possible to inspect the full 97 feet from one side.
- The only defect was correctly identified and located axially.
- Its position was also correctly estimated in the radial direction.
- However, the severity of the wall loss was assigned a value higher (conservative) than actually discovered (20-40% vs. 16% actual).
- It is believed that this will improve as more case studies are completed.

ICDA Case Study Example

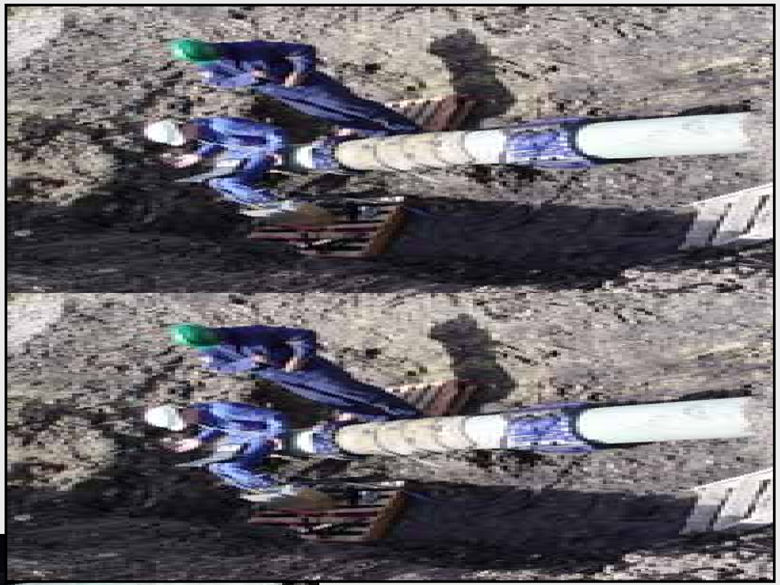
COMPANY	OUTER DIAM (in)	MAOP (psig)	Pipe Grade, Year Installed	Temperature (F)	Feature That Can Trap Water (e.g., drips, valves, etc.) Note 1	External COATING (for Guided Wave UT)	URBAN(U), SUBURBAN(S), RURAL(R)	OTHER INFO
Midwest	12.75	950	Grade varies, (early 1960's) see line chart with details	Ambient Ground	Yes	Will do test dig to verify.	Rural, Class 1	Planned maintenance in Summer 2004 and 2005, Vertiline tethered pig scheduled in 2004.

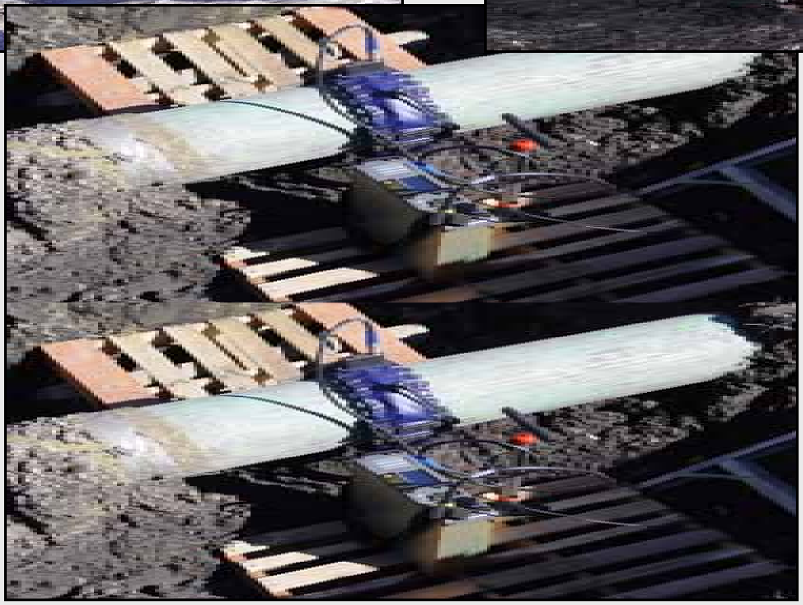
gti

ICDA Case Study– High Res. MFL

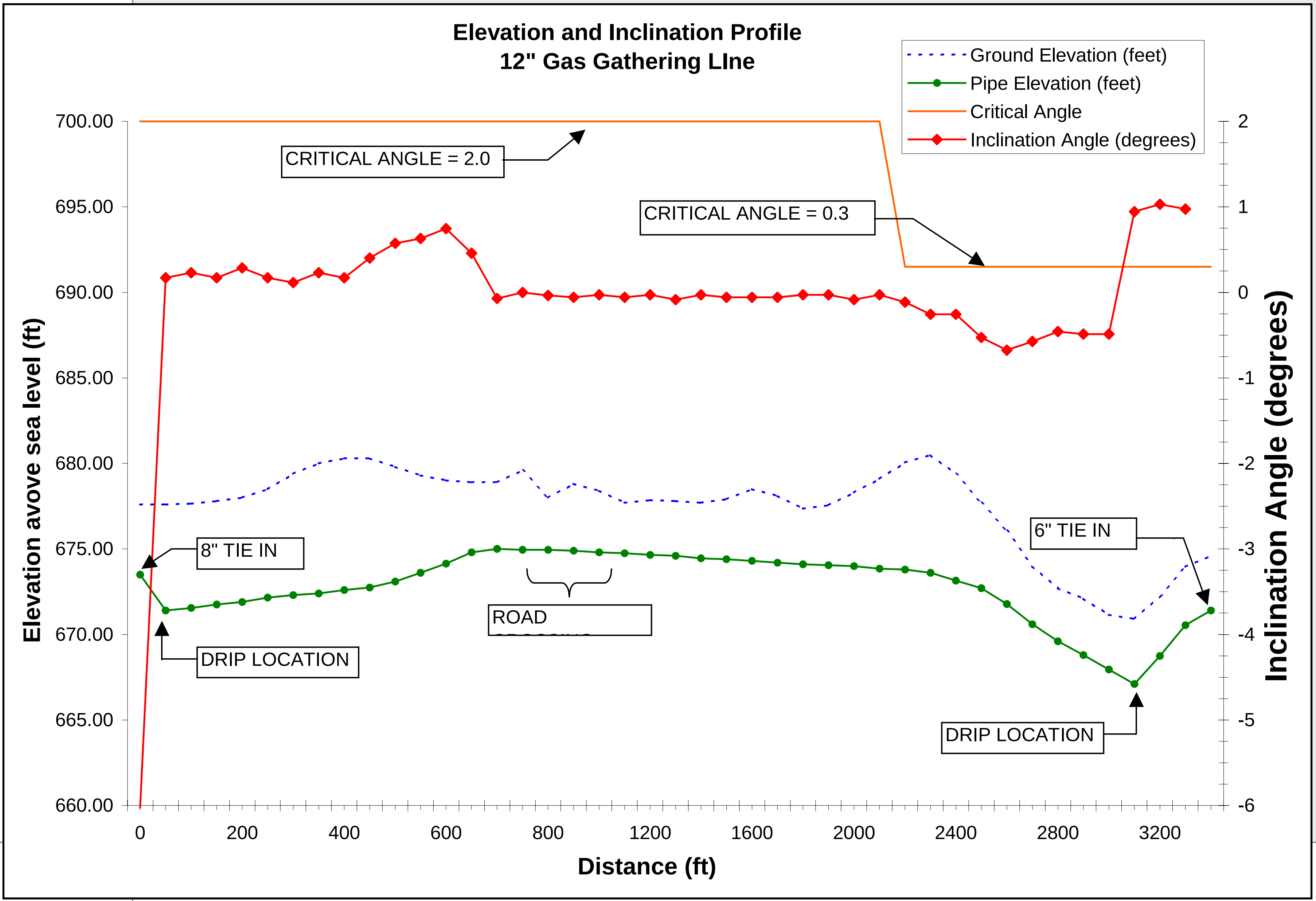


ICDA Case Study - Guided Wave



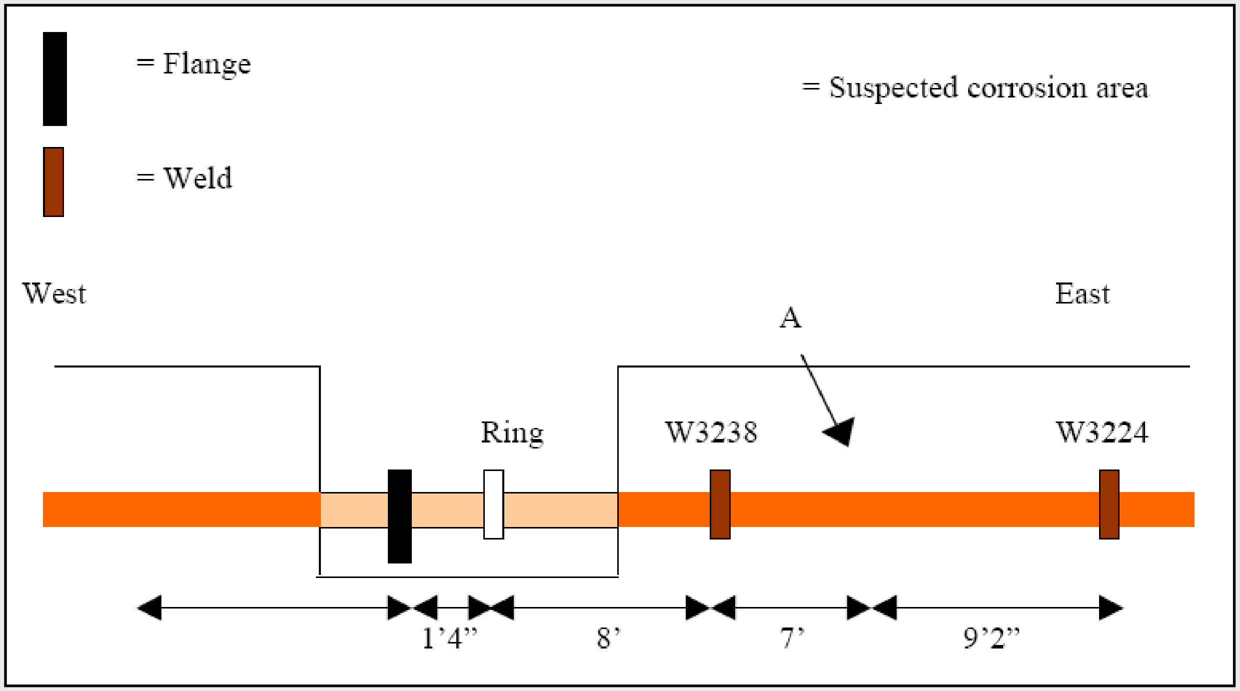


ICDA Case Study – Elev./Incl. Plot



ICDA Case Study - Dig#1

> The section of pipe shown below, between the flange and weld W3238, is a new section of FBE coated pipe. The joint to the East is the original old pipe. The only exposed pipe feature was the flange on the negative side of the ring.

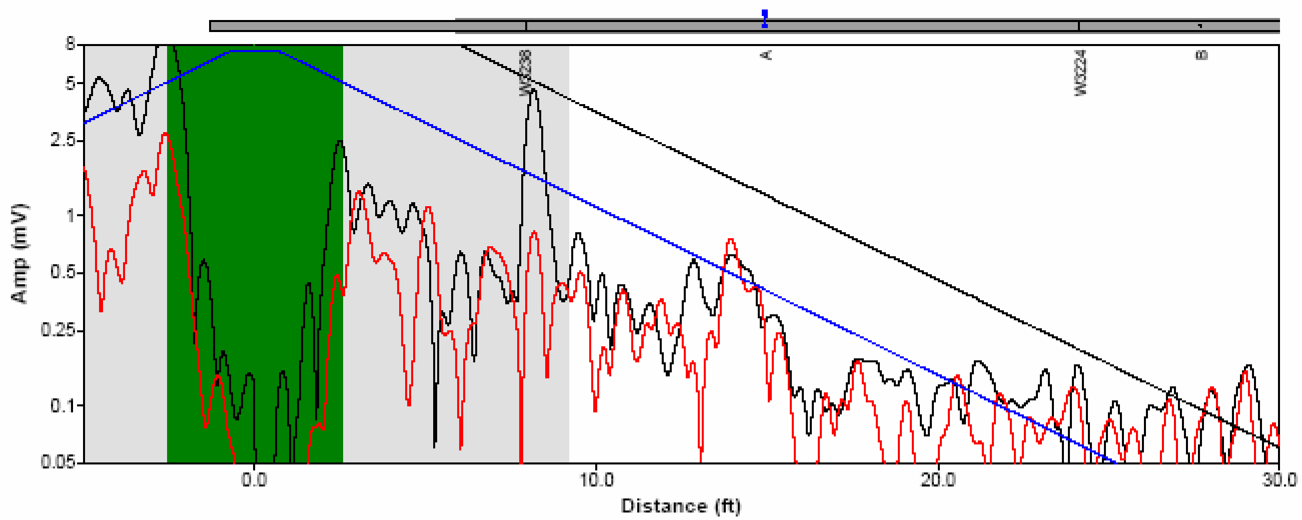


GW Results vs. MFL

- About 25’ of pipe could be tested from a single location in both directions.
- Two welds were clearly seen in the diagnostic length of the test and their position has been confirmed with the Pig results.
- An area indicated as A was identified as a possible area of concern. The length of pipe between W3238 and W3224 (including area A) was identified as Class 1 by the Pig. Class 1 is assigned by the MFL pig to areas where there could be a defect in the range of 0-25% of wall loss.

GW Results

Feature	Location	Class	Notes
W3238	8'0"	Weld	Weld between new FBE pipe and original section
A	15'0"	Medium	Suspected 10 percent cross sectional loss at the 6 o'clock position (MFL shows a bit of an increase in losses (from 10%wall to 25%wall))
W3224	24'2"	Weld	Where weld should be based on MFL data
B	27'8"	Minor	Center of an area of concern. However, the confidence is low because the amplitude of the reflections is very small. MFL scan shows about a 20 percent wall loss distiributed wall loss



2005 Schedule for DA Case Studies

> ICDA Case Studies in 2005:

- 6”, 515 psig MAOP, X42, 1976, Class 1
- 8”, 515 psig MAOP, X42, 1976, Class 1
- 30”, 899 psig MAOP, X60 1973, Class 1

> ECDA Challenging Situations Case Studies in 2005:

- 24”, Road Crossing w/casing, 485 psig, X52, has ILI and will do tethered pig, Class 1
- 30”, Road Crossing, 350 psig, X35, 1950, Class 4
- 20”, Cased Railroad Crossing, 230 psig, X30, 1944, Class 3
- 30” Cased Creek Crossing, 300 psig, X42, 1968, Class 3

2005 Schedule and What's Next

> Next Phase – Study of the Ability of Direct Assessment Methods to Locate Third Party Damage

- GTI is currently developing a fourth phase of the program to test the ability of various Direct Assessment techniques to locate/identify Third Party Damage.
- Working with LDC's and using GTI's large pipeline field facility, various types of coated pipe will be subjected to third party damage.
- The damage will be introduced from different sources and be of varying degrees of severity.
- Direct Assessment of the lines will be done before and after the introduction of Third Party damage.
- The ability of Direct Assessment to locate the damaged areas will be studied and documented.

gti

Thanks To:

>Over 40 LDC’s who have made the GTI/AGA projects possible

>LDC’s who did case studies with GTI/AGA

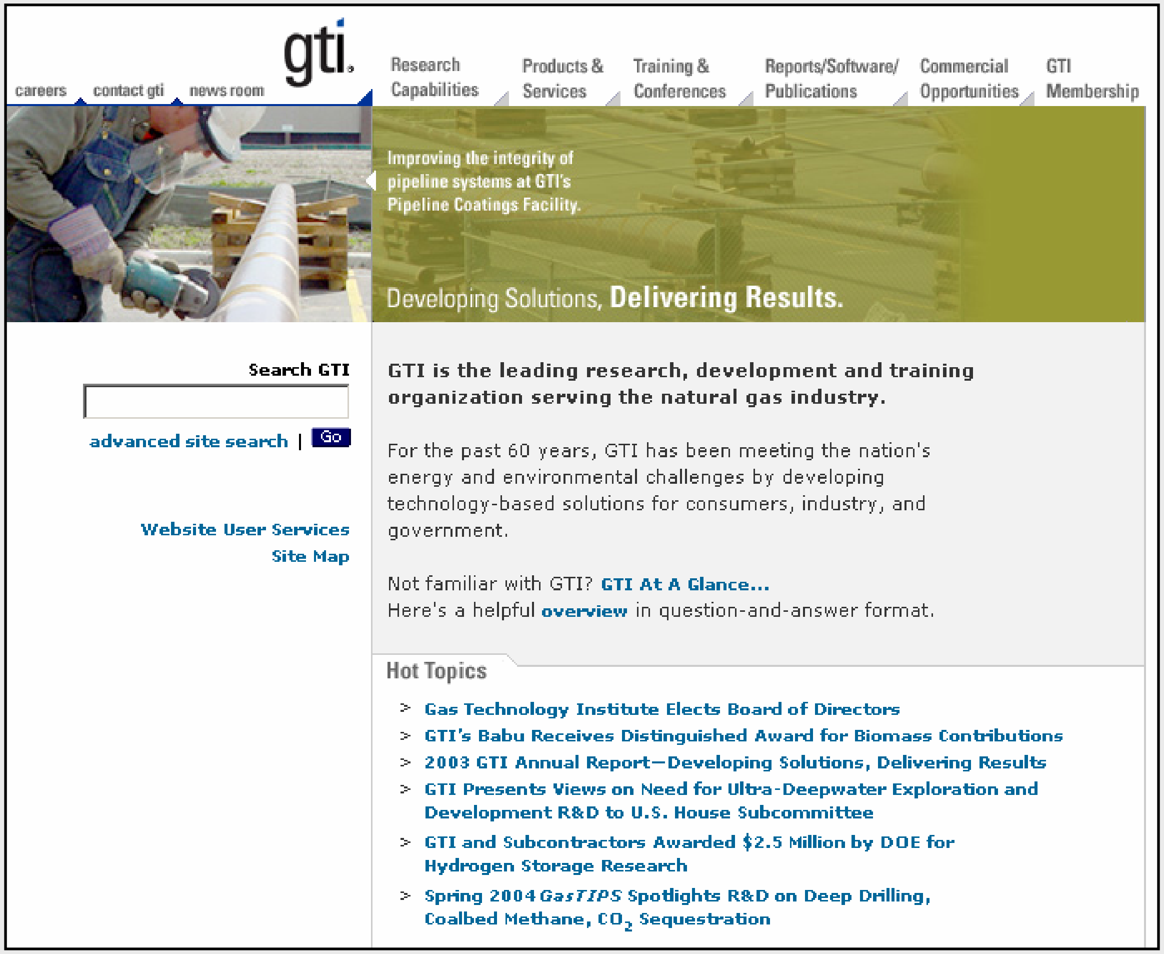
>Josie Riggio and Paul Salamondra, GTI

>Andrew Lu, AGA

>Keith Leewis, Leewis and Associates

>OPS, Cycla, and State PSC’s for valuable feedback

Visit us on the web at www.gastechnology.org



QUESTIONS ?

Direct Assessment Activities by GTI

> DOT R&D Forum
> Houston, TX March 2005

Daniel Ersoy
Gas Technology Institute
daniel.ersoy@gastechnology.org
847.768.0663