Pipeline Research Council International, Inc.

Anomaly Detection and Characterization R&D for In-Line Inspection

Successes, Challenges, & Opportunities

PHMSA 2009 R&D Forum

Washington, DC

June 24, 2009

Mark Piazza, Program Manager

LEADING PIPELINE RESEARCH

Presentation Topics

- Summary of PRCI Programs and Approaches Related to In-Line Inspection – Drivers and Challenges

- Building on the Successes and Addressing the Next Series of Challenges for the R&D Community

PRCI Membership Drives Research

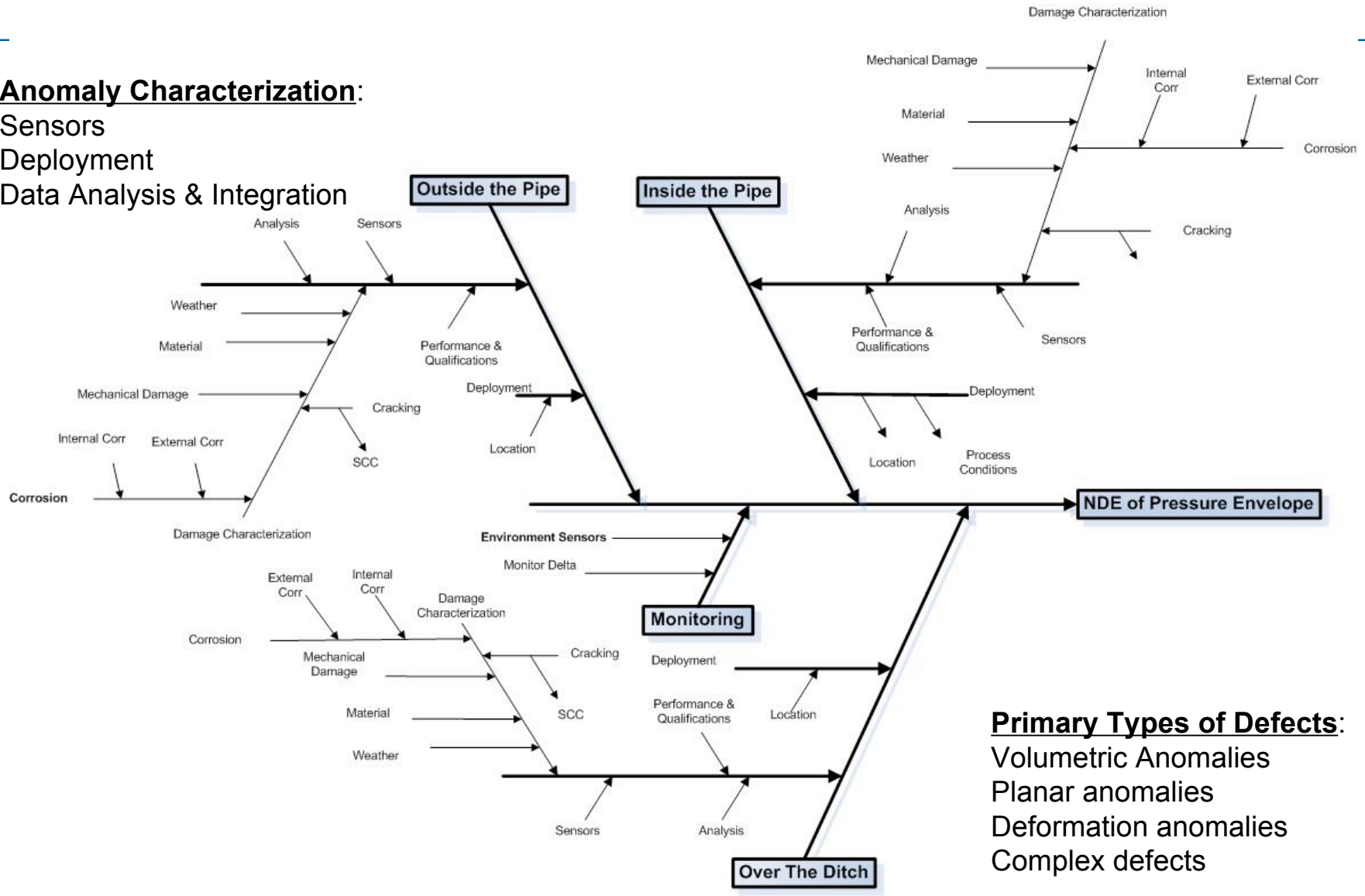
- **38 Energy Pipeline Operating Companies**
  - 25 Natural Gas Transmission; 11 Liquid
  - 2 Operators - both Liquid and Natural Gas Transmission
- **World-wide Research Organization**
  - 26 U.S. Companies
  - 12 Non-U.S. (Brazil, Canada, Europe, Saudi Arabia)
- **14 Associate Members**
  - U.S.; Canada; Mexico; Japan
- **Total mileage represented ~355,000 miles**

PRCI™

LEADING PIPELINE RESEARCH WORLDWIDE

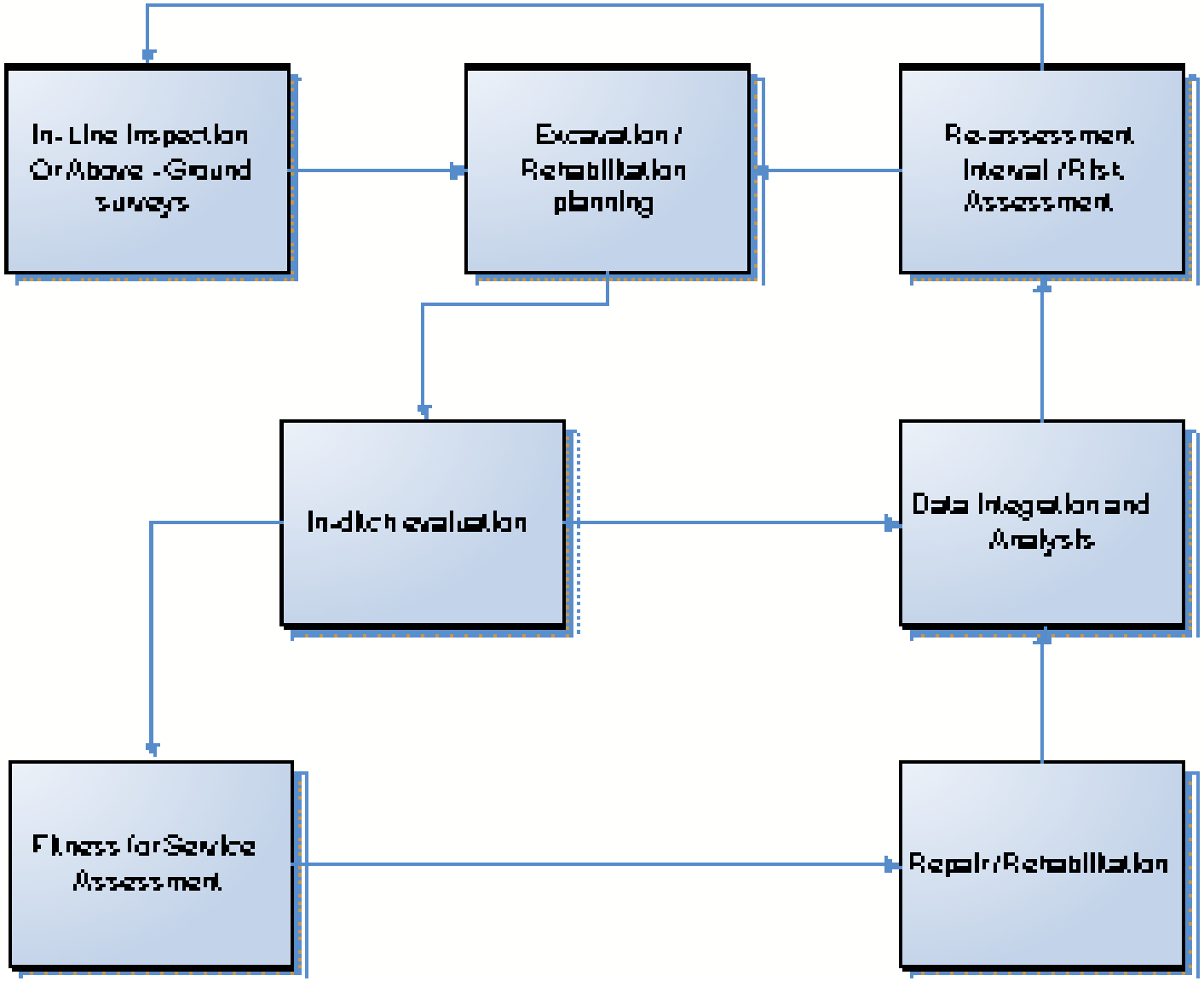
NDE Roadmap

Anomaly Characterization:
Sensors
Deployment
Data Analysis & Integration



Primary Types of Defects:
Volumetric Anomalies
Planar anomalies
Deformation anomalies
Complex defects

NDE Roadmap – Program Structure



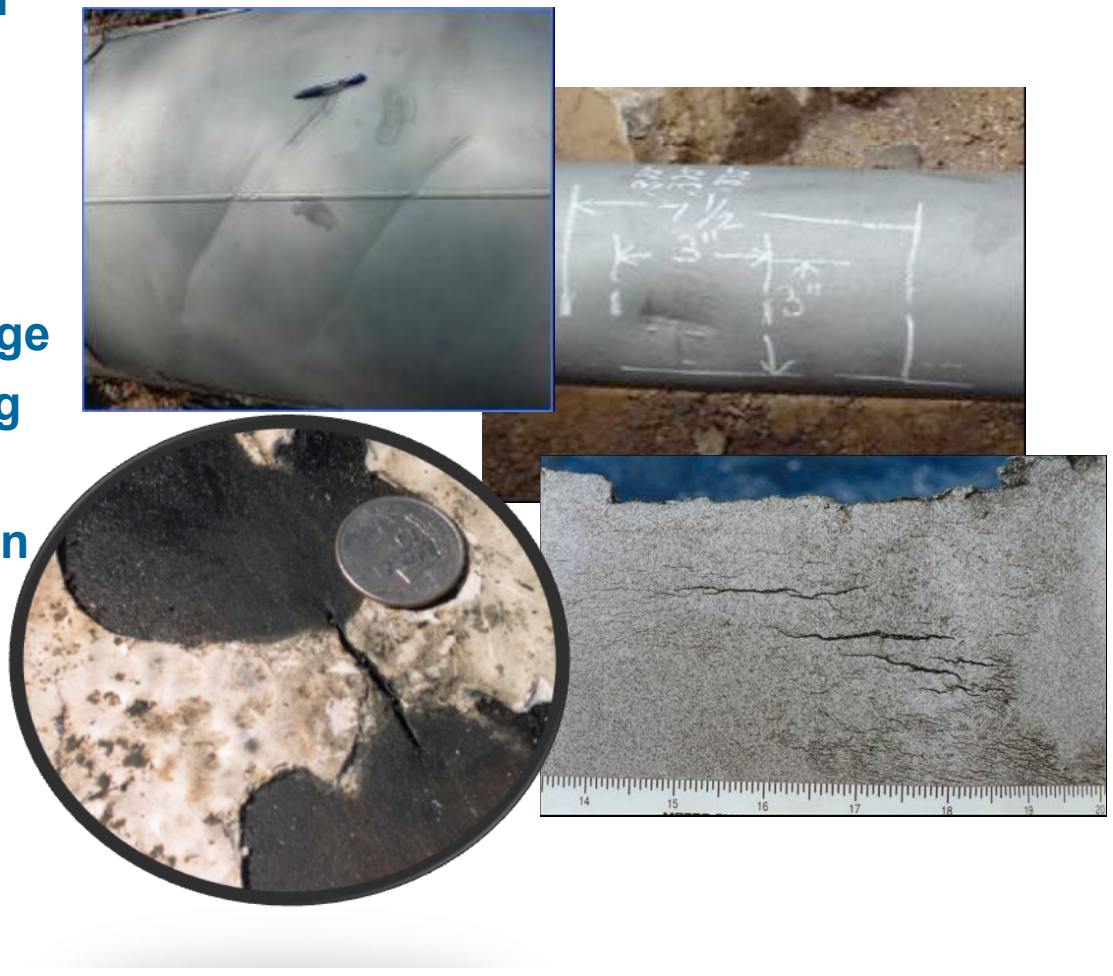
Overall Objectives of Roadmap

To develop and validate improved tools and inspection procedures for locating, sizing and characterizing:

- Corrosion and metal/wall loss
- Stress corrosion cracking
- Non-penetrating mechanical damage defects due to impact
- Other features/defects (e.g., Vintage girth welds)

Defect Populations – NDE Program

- Corrosion – Internal & External
- Coating damage, removal
- Dent (re-rounded), pipe ovalization
- Stress, strain concentration
- Metal removal, ploughing, gouge
- Surface & sub-surface cracking
- Time-dependent cracking
- MD with Nearby weld, corrosion
- Leak vs. Rupture
  - Tracks 2, 3 & 4



NDE Roadmap – Current ILI Programs in NDE

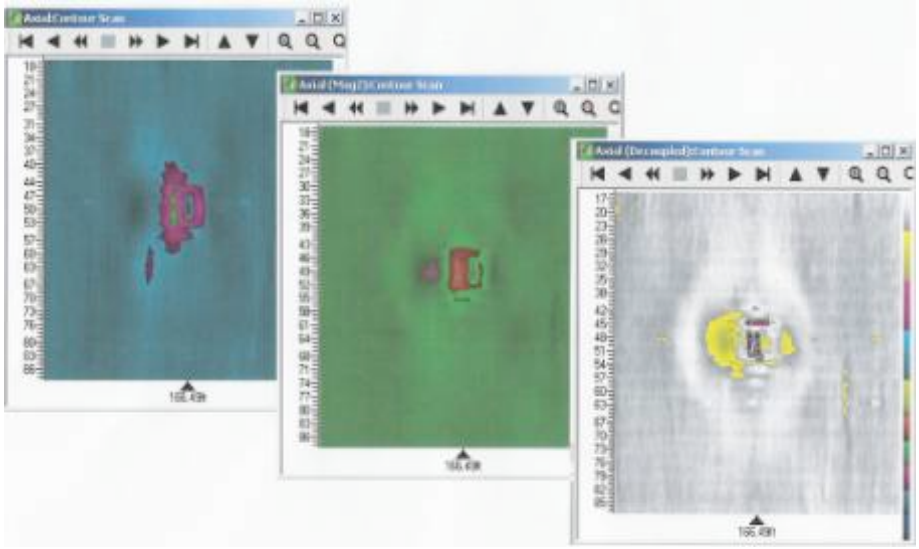
Focus on managing threats and integrity management

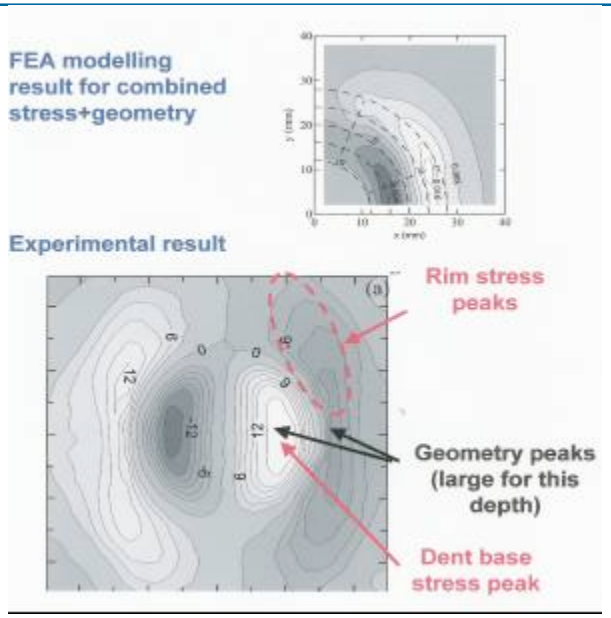
- MD-1; Tools to Detect and Discriminate Mechanical Damage
- NDE 1; NDE Inside the Pipe
- SCC-3; Sensor Technology for Sizing and Characterizing SCC Cracks
- EC-4; Accuracy of tools for corrosion mapping
- EC-5; Location and Characterization of Corrosion in Difficult to Inspect Areas
- SPIM -1; Subsea Pipeline Integrity Management and inspection

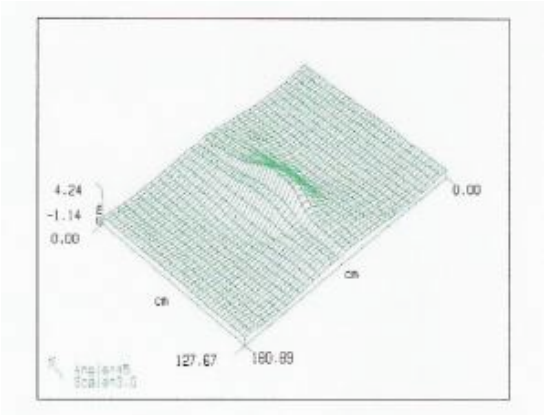
Technical Approach – Current Projects

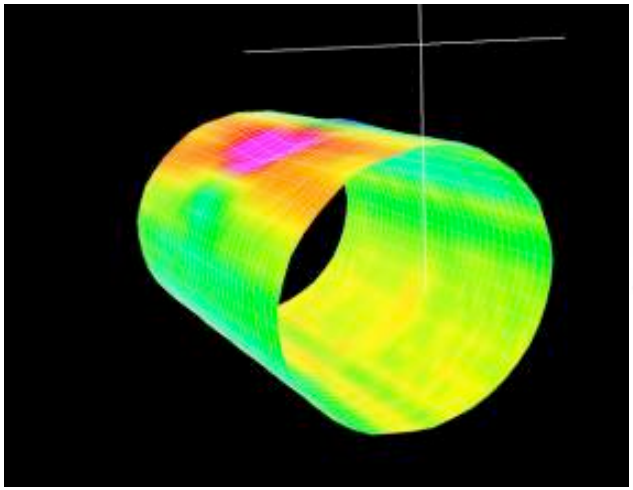
- **Benchmarking and Applying Existing Technology**
  - Performance of existing technologies – MD-1-2
  - Vintage Girth Weld Defect Detection and Characterization Using ILI Technology – NDE 1-1
  - ILI Performance Characteristics (corrosion based) – EC 4-1
  - Related in-the-ditch projects – MD 1-4, MD 1-5, NDE 2-2
  - Understanding signals from MD – MD-1-3
- **Next-generation Technology**
  - Dual-field MFL – MD 1-1
  - Ultrasonic measurement of strain – MD-1-6
  - Detection, Sizing and Characterization of SCC and Other Cracks in Dents – SCC 3-4
  - SCC crack mapping using a Flexible Eddy Current Array Probe (SCC 3-5)
  - Monitoring advances/developments for EMAT tools – SCC 3-7
- **PRCI 2010 Ballot**

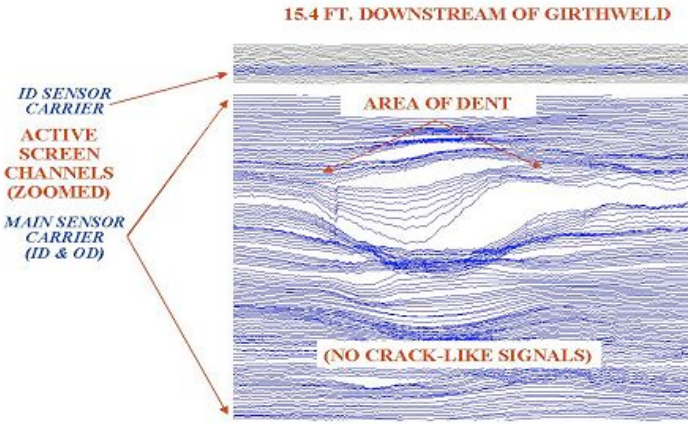
Detecting and Characterizing Damage



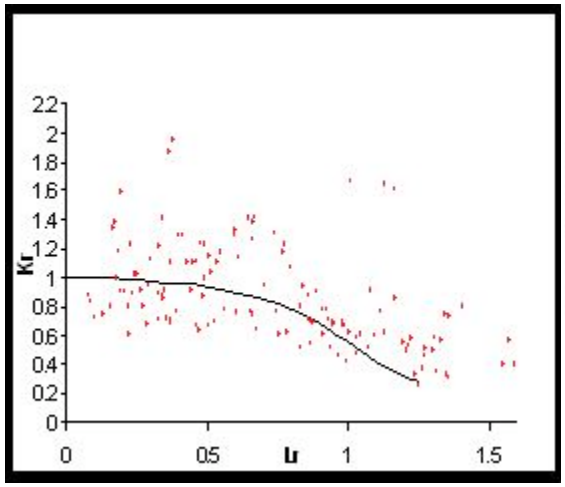


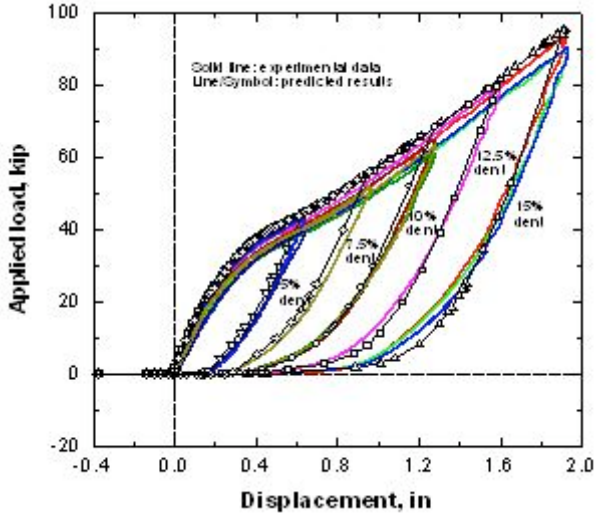


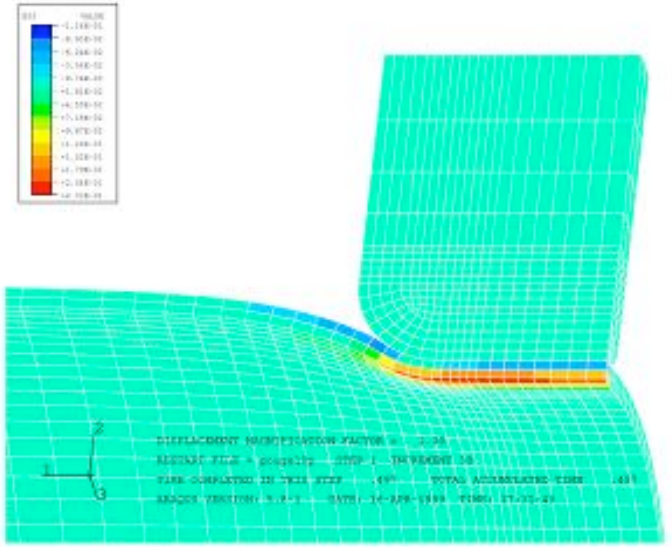


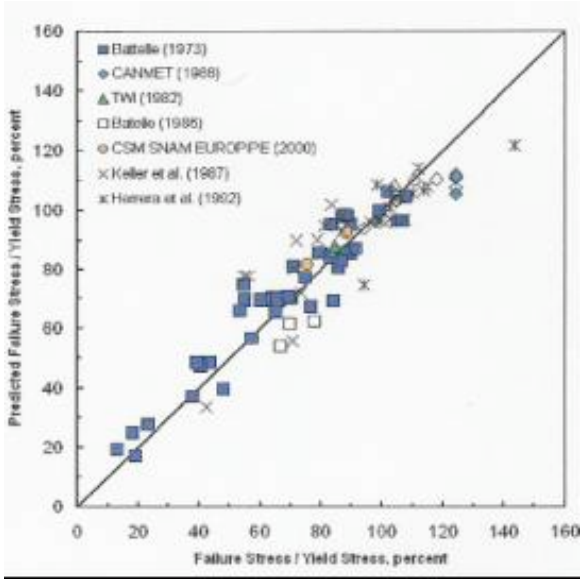


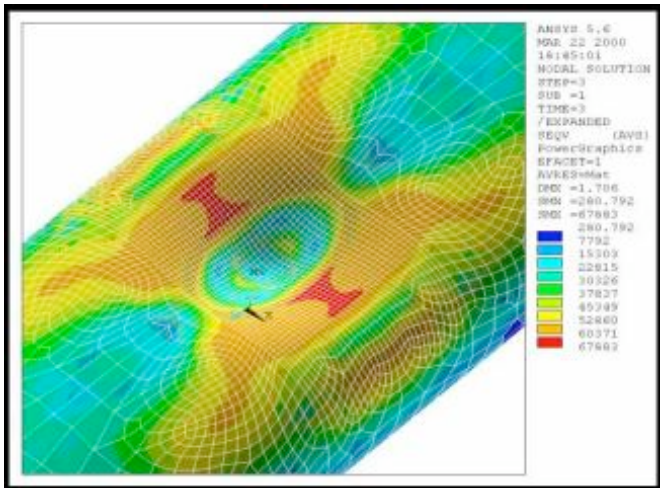
Assessing Damage Severity

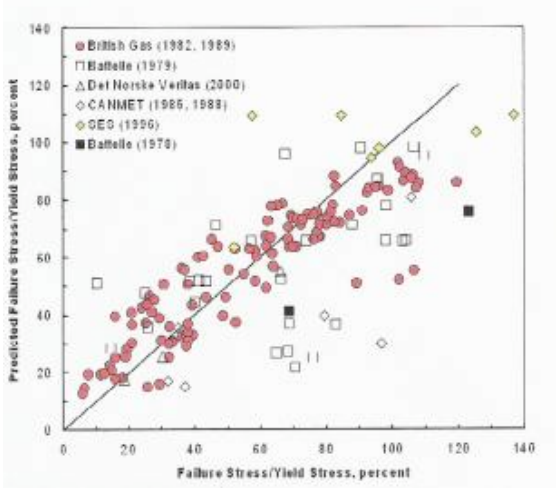












NDE Focus Areas for ILI

- Improved quantitative understanding of the ability of ILI technologies to detect and discriminate features
- Determination of the performance characteristics of existing ILI techniques
- Exploration and validation of new ILI tools/technologies
- Establishment of techniques and protocols for in-the-ditch measurements to improve understanding of ILI capabilities
- Improve (or develop new) industry guidance and best practice for characterization and measurement of anomalies

Gaps in Understanding & Capability

- Quantitative understanding of the performance of existing ILI for discriminating between significant and benign anomalies
- Ability to interpret MFL signals for accurate characterization of defect features
- Additional field experience to validate dual-field MFL and other emerging ILI technologies
- Industry guidance on feature characterization and measurement for damage severity assessment (linked to “Outside the Pipe”)
- Severity-ranking and decision-making algorithms enabling timely and proportionate responses when damage is discovered
  - *Link to Track 4*

Future Directions & Developments

- **Reliability Based Integrity Management**
  - Key Elements of the approach are directly linked to improvements in ILI technology or development of standards and/or knowledge documents; establishing reliability targets linked to ILI/ECDA
    - *ILI tool tolerances and uncertainty - Effect of ILI POD and sizing uncertainties on these predictions*
    - *Corrosion growth rates and variability*
    - *Re-inspection intervals – will rely substantially on understanding and degree of confidence in ILI readings; improved accuracy improves RB IMP*
  - Defect population and growth rates: generally comes from NDE and comparison with similar lines (databases)
    - *Several PRCI projects in this area*
  - Impact of ILI data on computational models – e.g., accuracy of prediction of limit state models (RSTRENG, ASME B31.8G)
    - *The capabilities and limitations of models used needs to be carefully assessed and understood*
    - *Recent work in this area by both PRCI and DOT*
- **Advance combo tools/technologies – "Super Pig"**

Roadmap Outcomes & Industry Benefits

- Improved tools for locating, characterizing and sizing the features that discriminate damage severity, forming the basis for reliable, quantitative assessment of structural significance (immediate/delayed failure)
- An effective suite of assessment methods to quantify damage severity, enabling sound decision-making and safe, timely repairs (screening, case-by-case, ECA)
- New recommendations for determining safe pressure reductions and working practices during repair
- Recommended practices for using composite materials to repair mechanical damage
- An Industry Guidance document to aid decisions on the characterization, severity assessment and safe excavation/repair of damaged pipe

Key Industry Challenges and R&D Needs

- **New/emerging technologies - sensors, platforms, data mgmt**
- **Better accuracy and certainty for the sizing of corrosion and estimating corrosion growth rates**
  - *Improve understanding of the effects of 'very deep defects' and the statistical distribution assumptions on their occurrence and the predicted risk*
  - *Study time-dependent effects - better assess corrosion rates/variability*
  - *Location dependence of corrosion and statistical dependence of corrosion rates on 'neighboring' defects*
- **Improved tools for crack/cracking detection**
- **A different approach to MFL - supplements to MFL technology or step changes in tool application or advancement**
- **EMAT – monitoring performance and modeling to advance understanding of EMAT signals**
- **Eddy current – A combination of MFL and Eddy Current could improve identification capabilities, e.g., deep defects**

Key Industry Challenges and R&D Needs

- **Developing databases of defects for testing and validation with real features/defects**
- **Effective and routine communication between ILI vendors and operators**
- **Reducing 'Historical' Population of Defects**
  - assessment → monitoring
  - repeat inspections – technology capabilities will need to improve on the ±10% or 15% tolerance with an 80% certainty
- **Improving Methods for Correlating ILI Signals to In-the-Ditch Assessment**
  - Algorithms and protocols
- **Continued validation of Reliability-Based approaches**