the Energy to Lead

R&D Related to Anomaly Characterization and Assessment at GTI

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Acknowledgements

- The work described in this presentation was sponsored by a number of agencies:
  - DOT Pipeline and Hazardous Material and Safety Administration (PHMSA)
  - Operations Technology Development (OTD) LLC
  - GTI Sustaining Membership Program (SMP)
  - Additional thanks to utilities providing test sites

Above Ground Detection of Flaws

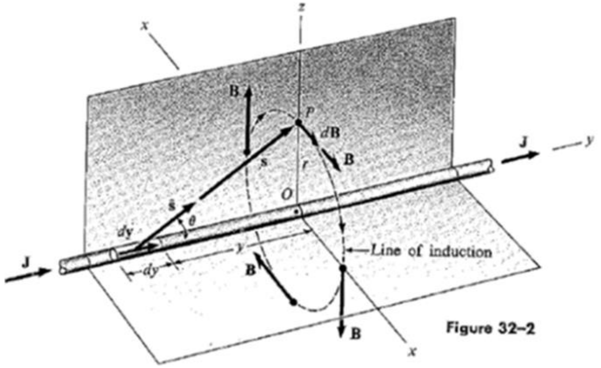
> Assess the state of metallic pipe/coating system without excavation.

> Locating, assessment, and mapping are now separate activities.

> Simplify the work flow by doing all in a single pass.

Above Ground Detection Prior Work

- Previous devices each looked at a single component of the EM field.
- Each component of the EM field provides data on location and/or condition of the pipe
- All prior work had a common problem: require precise knowledge of the pipe location
- The smaller the feature sought the more critical the location becomes



Above Ground Detection Recent Work

- The Spar-300 sensor system provides GNSS location and 3-axes of EM field data
- Captures the EM field in 3 dimensions to triangulate pipe location

Above Ground Detection Recent Work

- >Knowing pipe location allows changes in position or depth to be distinguished from real pipe/coating flaws
- >Need to tie into the pipe in order to inject a known signal

Above Ground Detection Recent Work

- Two Spar systems are used in tandem to capture phase shift.
- Both are moved along the pipe; the distance between them is automatically captured.

Operator Display

- > Live survey data is viewed on tablet/laptop
- > The operator can see estimated pipe location and other parameters with error bounds

Stored Data for Post Processing

> In the background raw data is stored for further analysis when the survey is done

@FSS!59960,$IINAV,3533,1370,162848,0*6b
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@FSS!59960,$IIENU,0,0,0,51,0,305*6c
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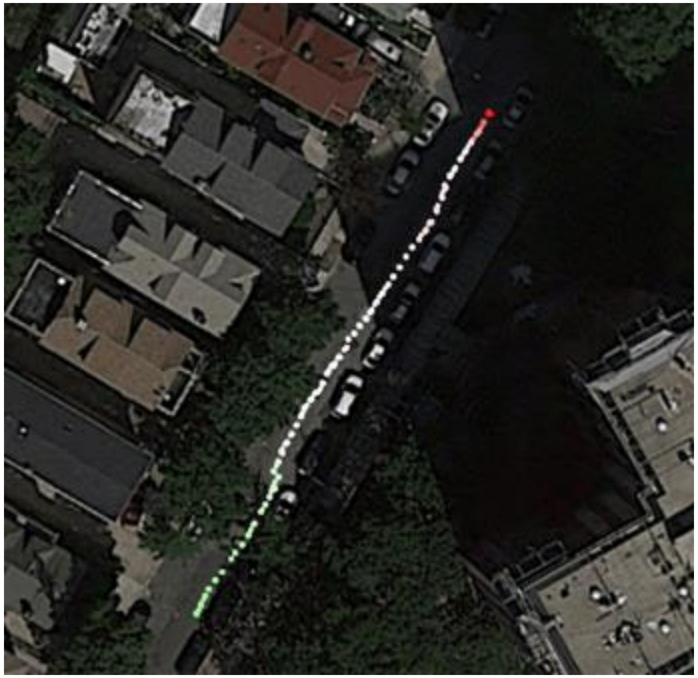
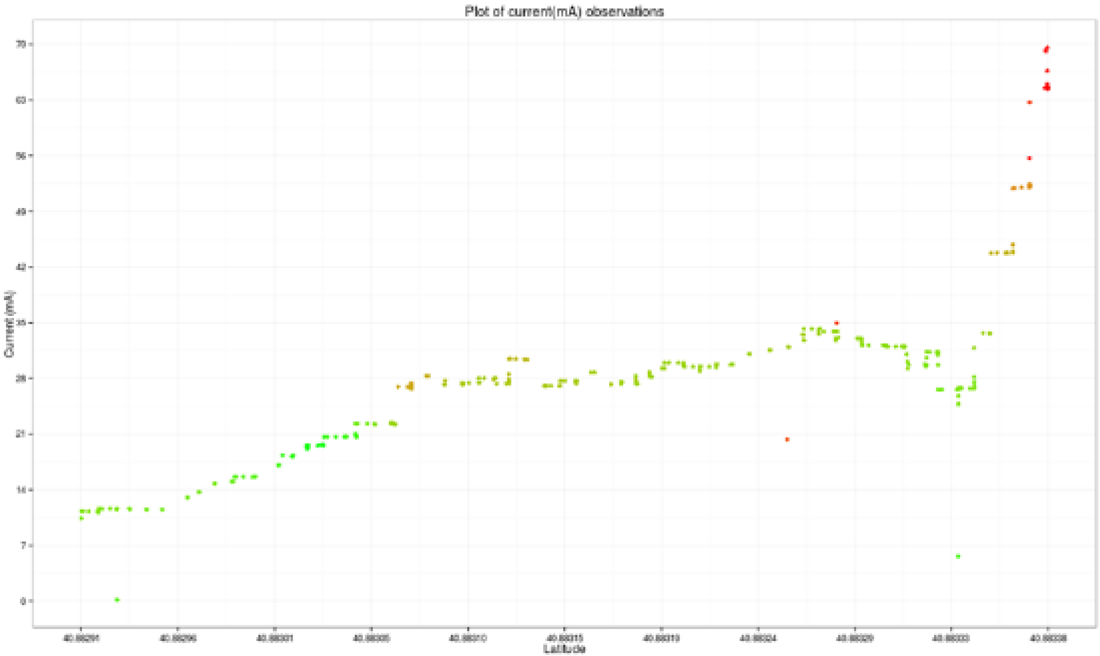
Above Ground Detection Test Results

- GTI performed surveys at several sites provided by utility companies.
- These sites had been surveyed with AC or DC voltage gradient methods and were scheduled for excavation.
- Dig decisions were made by the utility based their data.
- Some of the features located were:
  - Loose coating
  - Holidays in the coating
  - Metallic appurtenances

Example Current Data #1

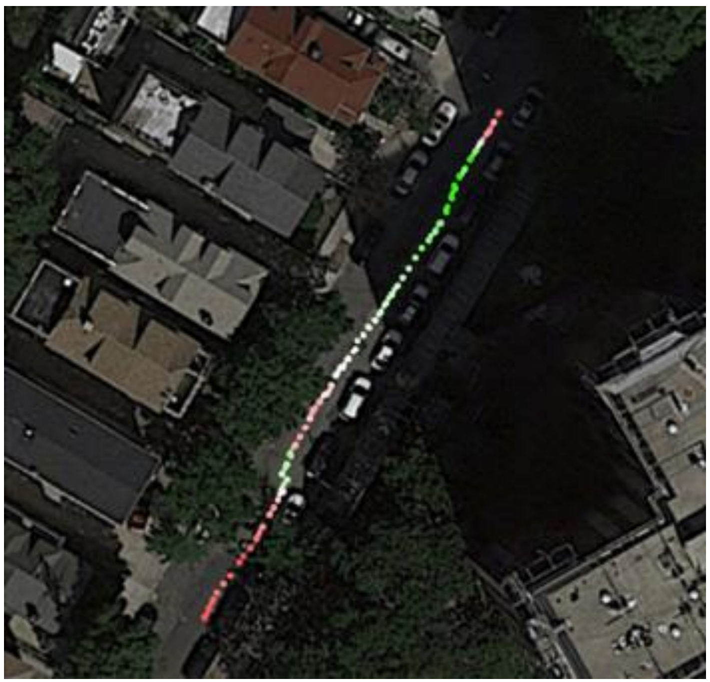
> The current data in mA shown both in map and plot

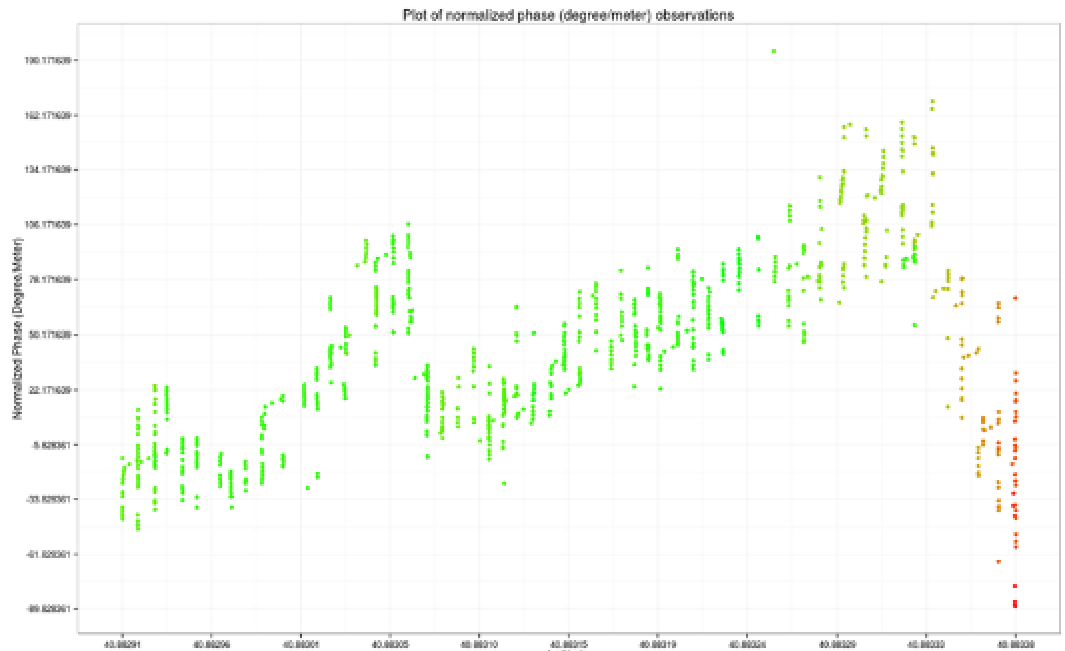




Example Phase Data #1

> The phase data shows an interesting feature both in map and plot



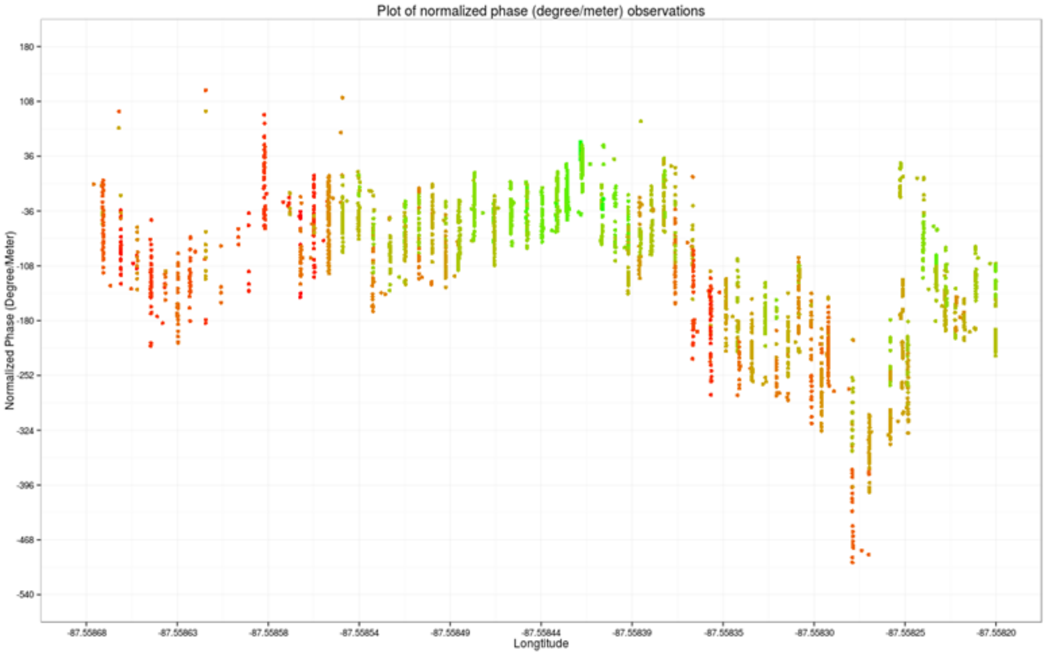


Example Excavation Data #1

> At this site there was an area of loose coating located at the point indicated by the phase data, and to a lesser extent by the current data.

Example Phase Data #2

> The phase data shows a feature in the SE area of the map

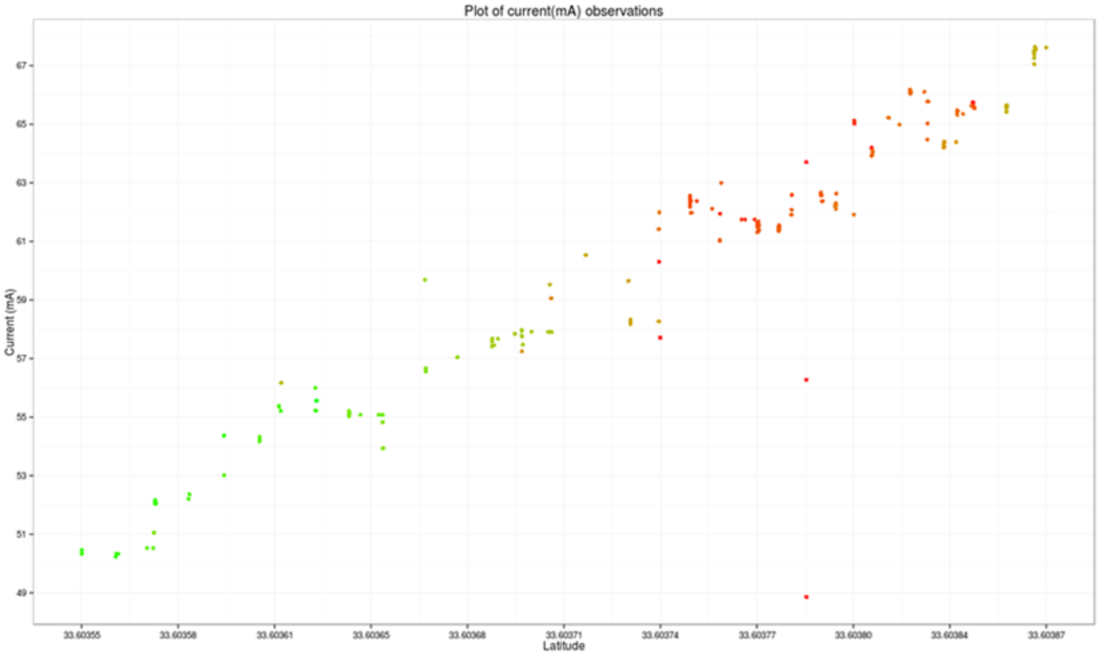


Example Excavation Data #2

- At this site there were culvert sections over a shallow portion of the pipe for protection
- These changed the “shape” of the system and caused the phase shift

Example Current Data #3

> The current data shows a small change in slope partway through the survey

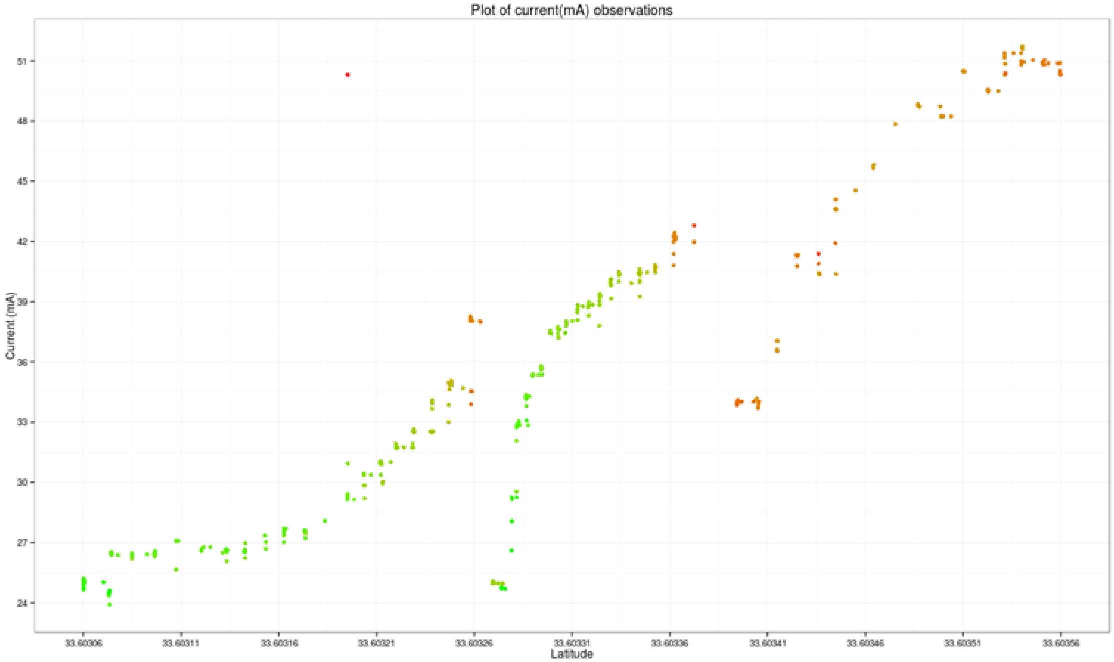


Example Excavation Data #3

- Two extremely small coating holidays were found in the designated area and repaired
- Dig was primarily based on the ACVG indicators

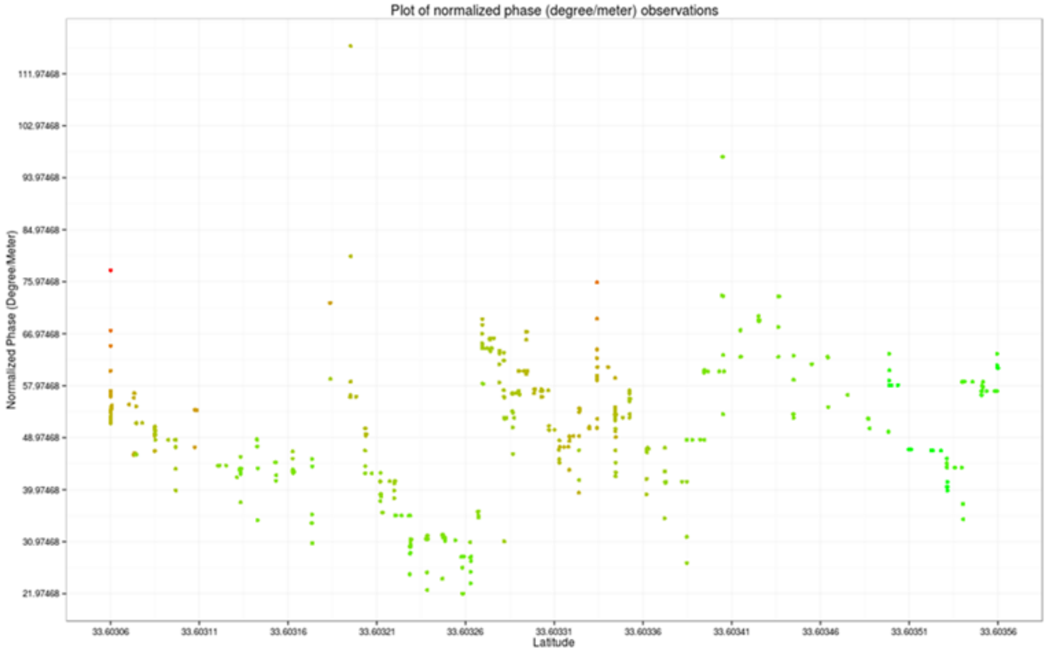
Example Current Data #4

> The current data shows several interesting transitions



Example Phase Data #4

> The phase data also shows transitions that align geographically with those in the current



Example Excavation Data #4

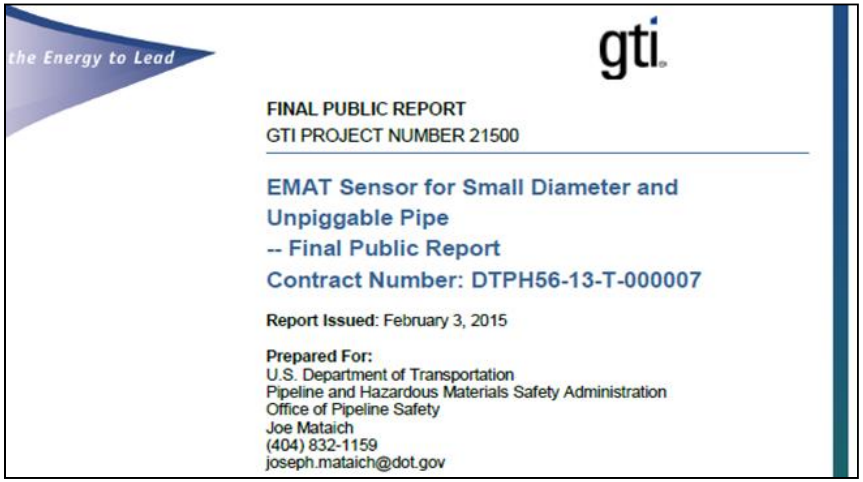
- Nothing was found when this site was excavated!
- Both the ACVG and Spar surveys gave indications.
- Did both techniques produce a false positive?
- Is there some underlying structure producing these signals?

Above Ground Detection Conclusions

- The hardware has been robust and reliable under field conditions.
- Need to establish metallic contact with the survey pipe and inject current to obtain a quality survey.
- The post processed data does find various features on the pipe/coating system.
- The intrinsic mapping and depth data that come with the survey adds value.
- More test sites are needed to develop a deeper catalog of features and signals.

EMAT for Unpiggable Pipelines

This project builds on Phase-1 of the development of the Electro-Magnetic Acoustic Transducer (EMAT) technology by GTI and Quest Integrated (Qi2).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FINAL PUBLIC REPORT
GTI PROJECT NUMBER 21500

EMAT Sensor for Small Diameter and Unpiggable Pipe
-- Final Public Report
Contract Number: DTPH56-13-T-000007

Report Issued: February 3, 2015

Prepared For:
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Pipeline and Hazardous Materials Safety Administration
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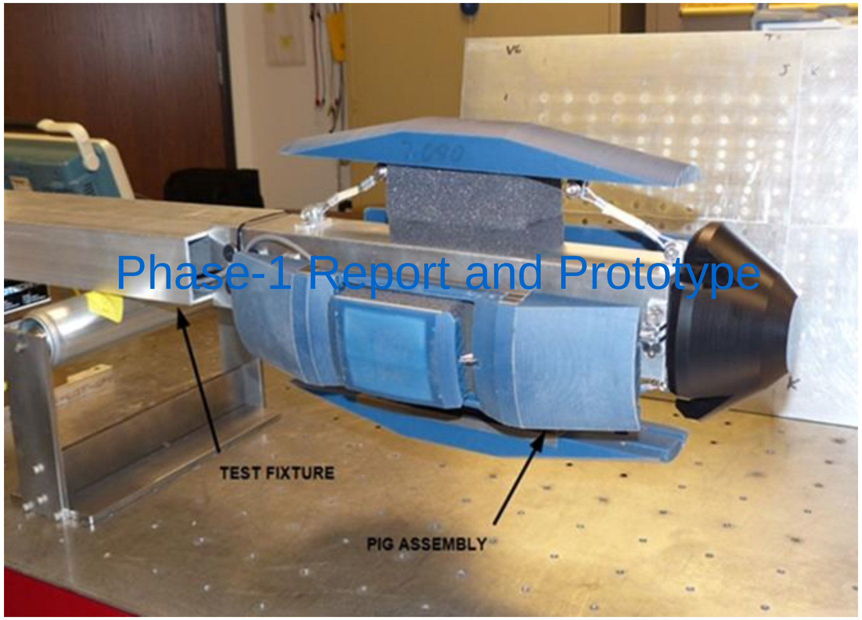


Phase-1 Report and Prototype

EMAT for Unpiggable Pipelines

- The objective of the project is to build and test an EMAT sensor prototype to detect flaws and quantify longitudinal cracks in metallic pipes.
- The sensor will be used to assess small-diameter and unpiggable pipes. The initial target is a prototype for 8-inch pipe diameters.
- Enable natural gas pipeline operators of smaller diameter pipe to identify and size crack defects, which are traditionally difficult to find and assess; and therefore improve system integrity and public safety

EMAT for Unpiggable Pipelines

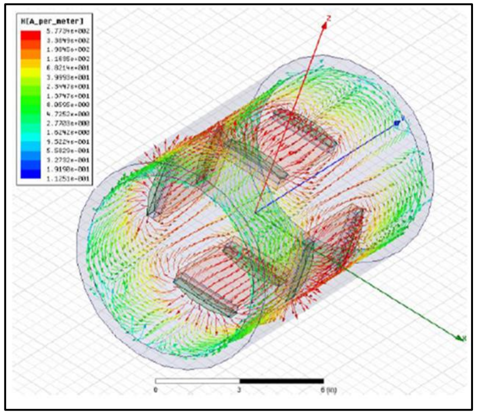
- Upon the success of the prototype, Quest Integrated (Qi2) will develop a commercialization plan. Qi2 spin-off company (Quest Integrity) produces transducers and electronics for inspection of small diameter, unpiggable pipelines.
- Pre-commercial units will be built first for field testing at operators' sites.
- The initial plan is to commercialize the EMAT sensor within 24 months of the completion of this project and to make the sensor available to other vendors for traditional ILI applications.

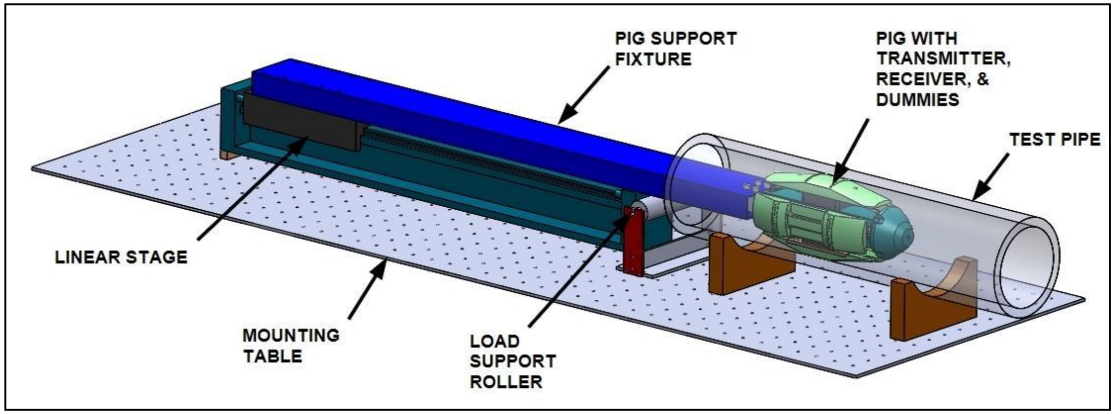
EMAT for Unpiggable Pipelines

- Work by other professional organizations: NYSEARCH and Pipeline Research Council (PRCI) on ILI inspection technologies,
- PHMSA previous funded work on guided wave and acoustic inspection technologies.
- OTD and GTI research work on acoustics.
- Quest Integrated (Qi2) is also working on AN EMAT-based wall loss tool for drilling risers. There is synergy in electronics development portion in both products.

EMAT for Unpiggable Pipelines

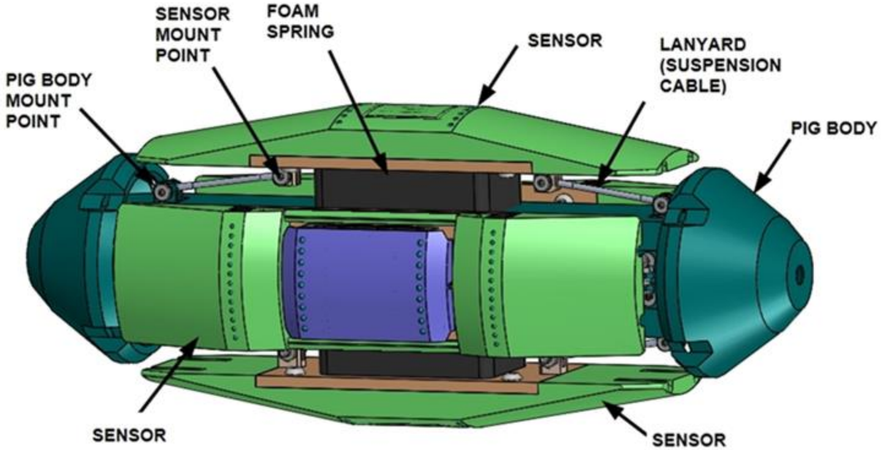
- Finite element analysis and laboratory tests in Phase-1 showed the applicability of the magnetic flux to detect surface flaws (0.5 mm deep EDM notches in a geometry that meets unpiggable pipe constraints). The testing of the sensor design optimized its geometry and configuration.





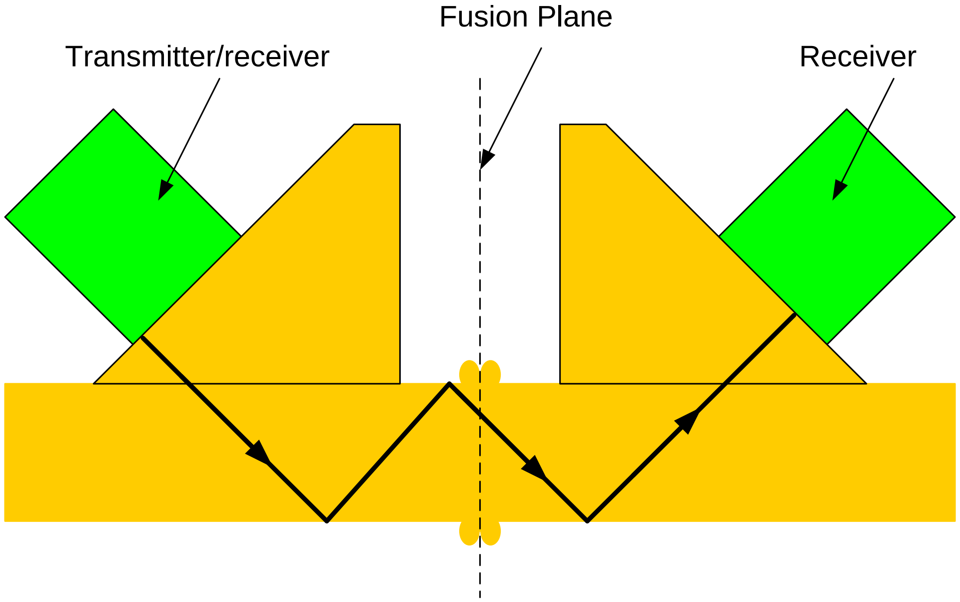
EMAT for Unpiggable Pipelines

- Phase-1 of the project was 'Step-1' to provide the technology and build a bench-type prototype for the validation.
- This project (Phase-2) provides a working prototype ready for testing 8-inch steel pipes with flaws.
- The next step is a commercial unit based on the successful prototype. This step includes integrating the sensor into existing ILI inspection platforms.



Ultrasonic NDE Butt Fusion Inspector

- Goals
  - Require no or minimal UT expertise by operator
  - Low cost to add new pipe sizes and materials
  - Low cost of hardware



UT Fusion Inspection Prior Work

- ASTM F600 78 UT technique for inspecting joints; Withdrawn in 1991
- Polyscann®: TDW/GTI built a few prototypes
- UltraMc®: Developed by GTI; ~70 units sold by McElroy; Product withdrawn in part because of too much operator expertise required
- Phased Array: Currently under development. Expensive and significant operator expertise required

UT Fusion Inspection Approach

> Built on issues and experience generated by several organizations including McElroy, GTI and others

> Added pitch/catch sensor to pulse/echo to obtain more information on joint quality

> Parametric model based on propagation paths rather than neural networks

> Took advantage of advances in ultrasonic and signal processing

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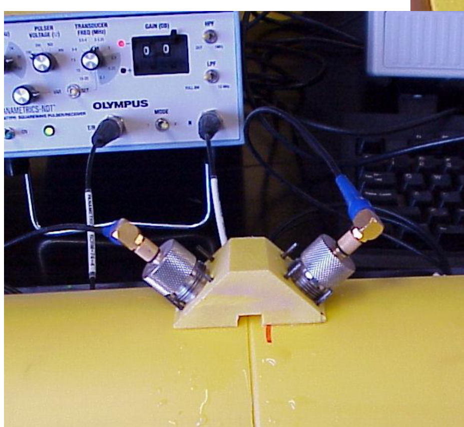
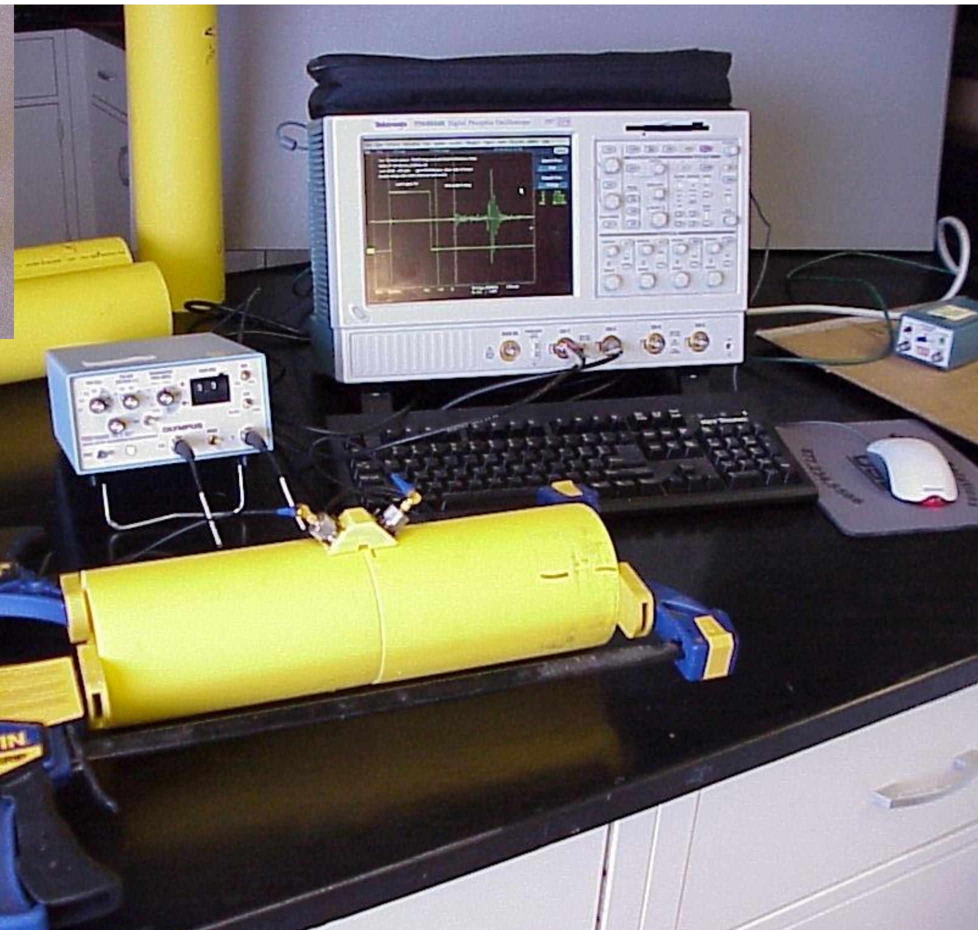
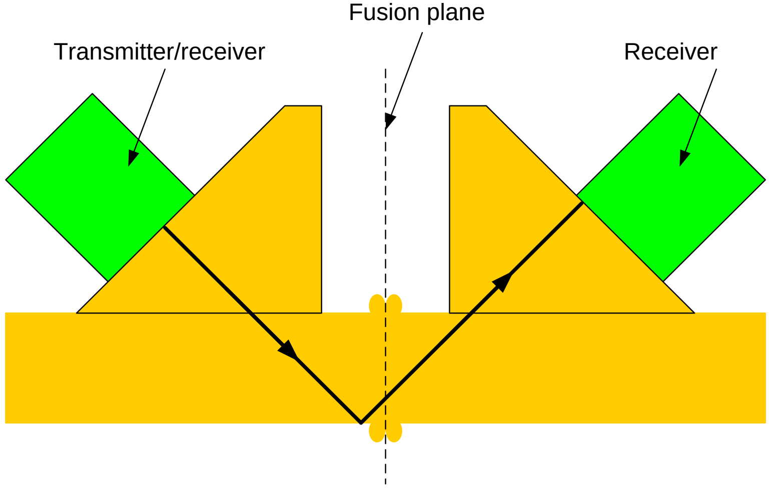
UT Fusion Inspection Development

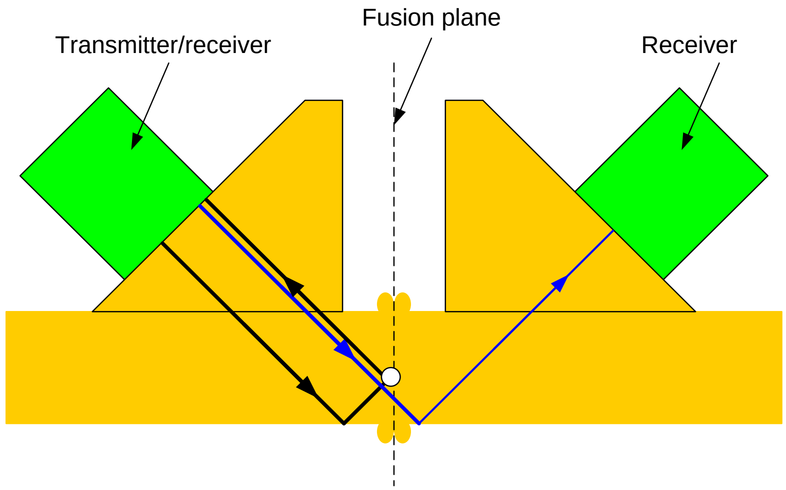




UT Fusion Inspection Concepts

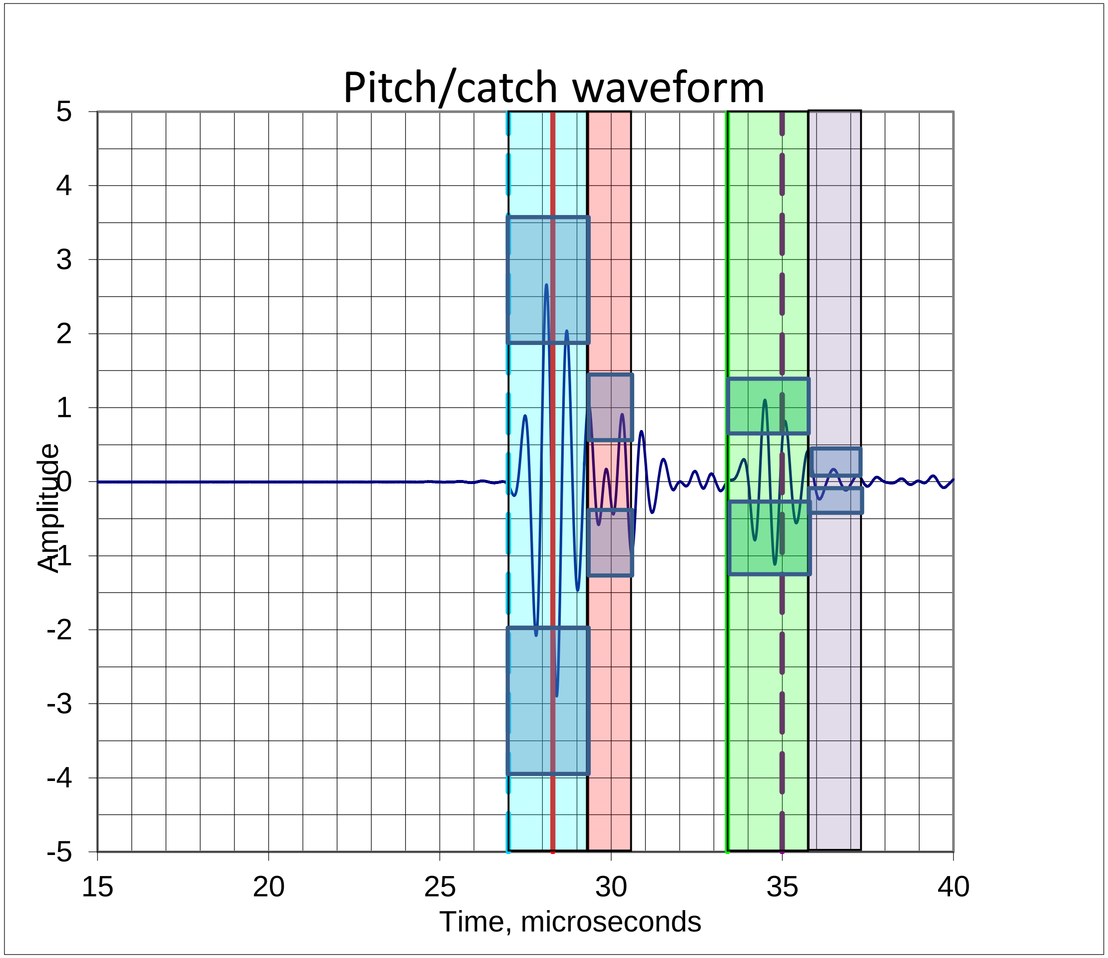


Reflections from the inner wall are affected by fusion quality and bead size.



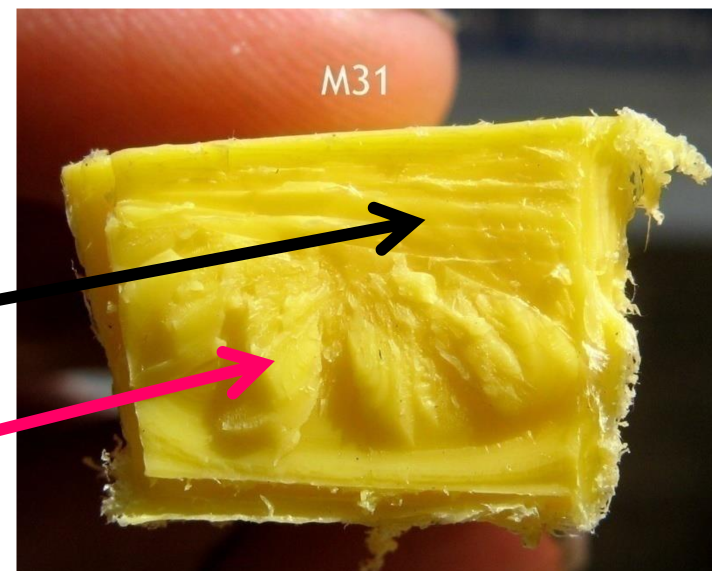
A void affects both pulse/echo and pitch/catch signal amplitude.

UT Fusion Inspection Classifier



UT Fusion Inspection Classifier

Prepared and heated properly, waited 15 seconds before squeezing



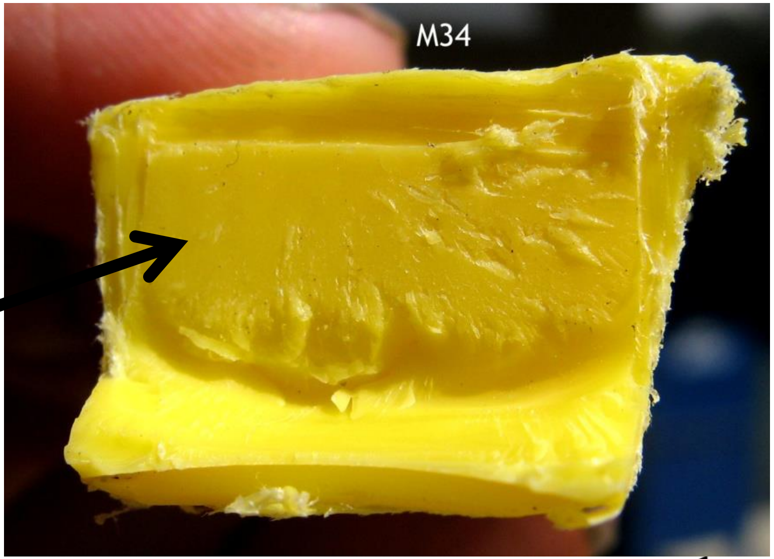
Part of joint failed

Part of joint didn't fail

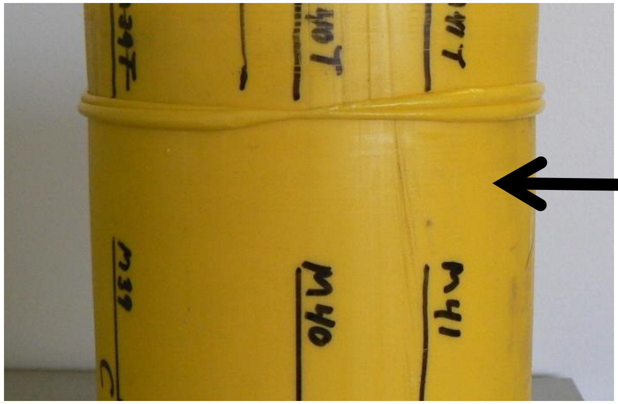
UT Fusion Inspection Classifier

Shortened heating cycle to 45 seconds and didn't press hard enough

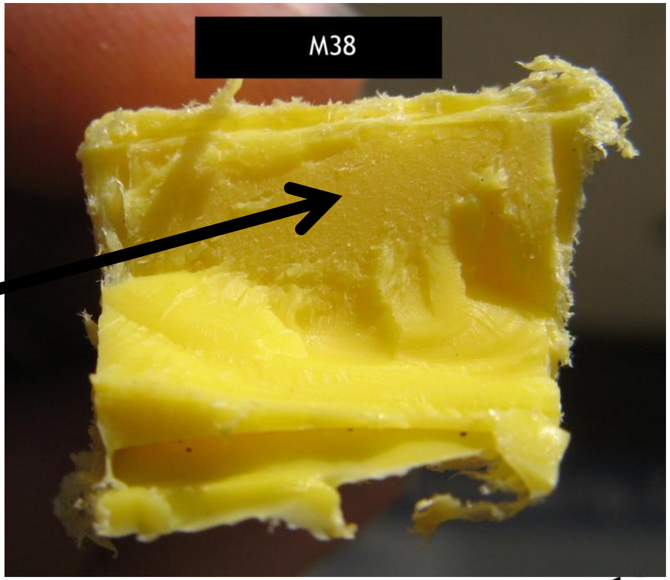
Failed at fusion plane



UT Fusion Inspection Classifier



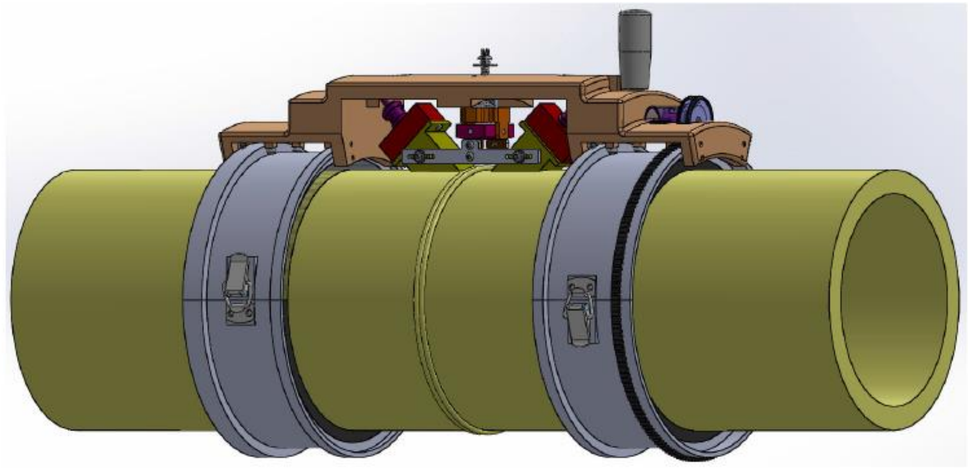
Proper procedure except one side not faced



Partial failure at fusion plane

UT Fusion Inspection Phase 2

- Current Plan (Phase 2)
  - Project funded by Operations Technology Development (OTD)
  - Working with Quest Integrated, LLC (Qi2)
- Future Plan
  - Evaluate alpha prototype with several utilities
  - Incorporate changes, if required, and manufacture device, and commercialize the butt-fusion inspector



Questions?

- Thank you for your attention