Applying Advanced Assessment Methodologies and Guided Wave Testing (GWT) on Difficult to Assess Segments

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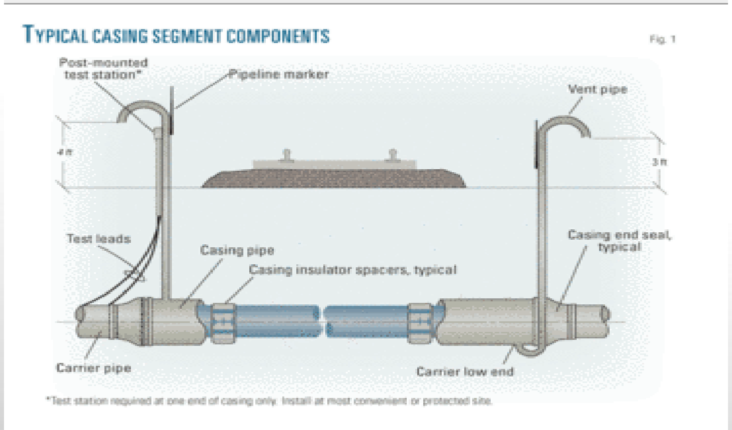
Presentation Overview

- Challenges Posed by Difficult to Assess Environments
  - Facilities (Orphan Piping)
  - Cased Segments
- Direct Assessment Review
- Application of ECDA in Difficult to Assess Environments
  - Evolving tools (3D Modeling, Indirect Tools, Guided Wave)
- GWT Overview and Advancements
- Case Study and Examples

Application of ECDA in Difficult Environments

- Short Segment - "Orphan Piping"
  - Examples: Compressors, Valve Sites, Metering Stations, and Crossover Piping
  - Challenges in facilities
    - Multiple pipelines varying in design, operations and corrosion susceptibility
    - Limited data (drawings, design specs, sources)
    - Limitations on traditional indirect tools
    - Digging more complex

- Challenges in Casings
  - Casings can shield reads of some tools making them infeasible
  - Evaluate these issues during the pre-assessment
  - Pick tools that can provide a consistent approach to testing, analyzing and prioritizing the data



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Direct Assessment (DA) Overview

- DA is one of the four methods used to verify pipeline integrity as mandated by DOT
  - Hydrostatic testing
  - In-Line Inspection (pigging)
  - Direct Assessment (DA)
  - Other Technologies (such as GWT)
    - This method requires filing a Notification with PHMSA (OTN)
- Based upon the threats of concern for a pipe segment, DA can be used to assess pipe integrity in regards to:
  - External Corrosion
  - Internal Corrosion
  - Stress Corrosion Cracking
- DA is an applied practice consisting of four well documented steps
  - Pre-Assessment
  - Indirect Inspections
  - Direct Inspections
  - Post Assessment

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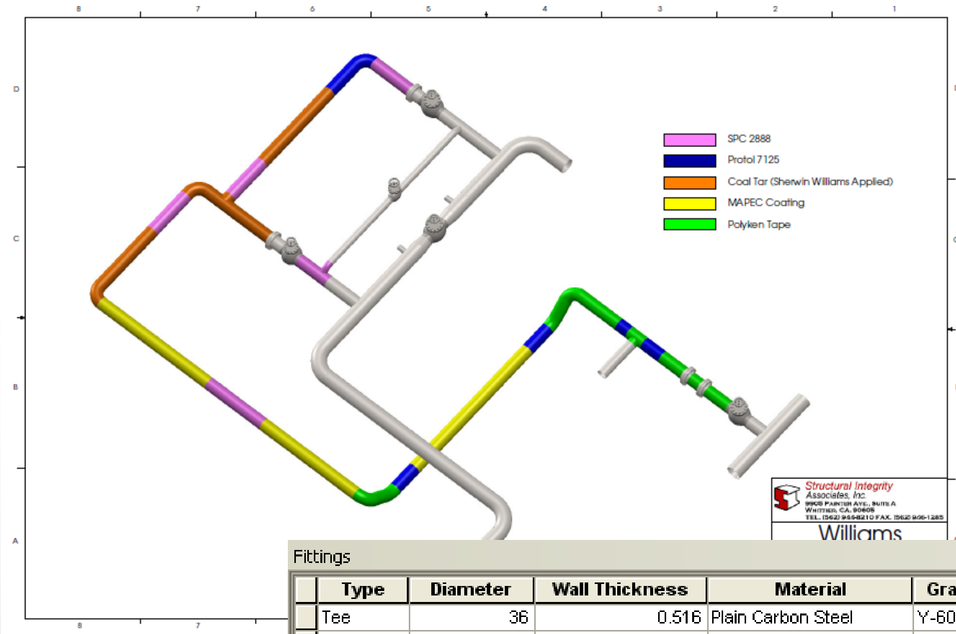
Application of ECDA on "Orphan Piping" (Facilities)

- To overcome obstacles with ECDA in facilities, it is critical to:
  - Perform a thorough collection of all available data
  - Develop a database to house available historical data
  - Implement this database to allow data integration throughout the DA process
  - Choose the appropriate indirect inspection tools for each pipe segment
  - Properly identify direct examination locations as well as difficulties that may occur during the excavation process
- Keys to success:
  - GIS and 3D Modeling
  - Careful selection and implementation of traditional inspection tools
  - Incorporation of new technologies to supplement inspections (GWT)
  - Maintaining and updating data

3-D Modeling and Geographical Information System

- Created during pre-assessment greatly assists the DA process
- Integrates existing drawings with all known data of the pipeline
- Ties key data for each component with design layout and spatial representation and pipelines for the facility

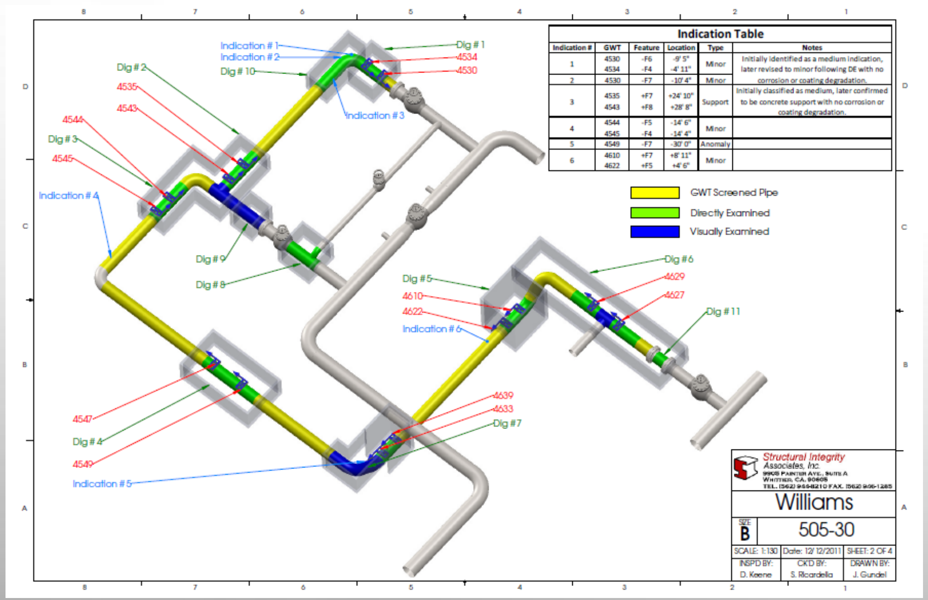


Fittings

Type	Diameter	Wall Thickness	Material	Grade	Install Date	Description
Tee	36	0.516	Plain Carbon Steel	Y-60	5/25/1997	Tee, 36"x36"x36"
Tee	30	0.5	Plain Carbon Steel	Y-52	5/25/1997	Tee, 30"x30"x30"
Tee	26	0.5	Plain Carbon Steel	Y-52	5/25/1997	Tee, 26"x26"x26"
Tee	42	0.602	Plain Carbon Steel	Y-60	5/25/1997	Tee, 42"x42"x36"
Tee	26	0.5	Plain Carbon Steel	Y-52	5/25/1997	Tee, 26"x26"x26"
Tee	36	0.516	Plain Carbon Steel	Y-60	5/25/1997	Tee, 36"x36"x26"
90 Elbow	36	0.5	Plain Carbon Steel	Y-60	5/25/1997	90 degree L.R.
90 Elbow	26	0.5	Plain Carbon Steel	Y-52	5/25/1997	90 degree L.R.
90 Elbow	30	0.5	Plain Carbon Steel	Y-52	5/25/1997	90 degree L.R.
90 Elbow	26	0.5	Plain Carbon Steel	Y-52	5/25/1997	90 degree L.R.

Key Benefits of 3-D Modeling and GIS

- Digitization of available data and drawings allows for the integration of 3-D models of the site in a database format
- Integrates data and builds through each step of the process
  - Pre-assessment data easier to organize and analyze
  - Selection of indirect inspection tools more efficient
  - Dig site selection readily available in a visual format
  - Post Assessment contains an auditable set of records in a database and visual format
- Byproduct is updated drawings reflecting the actual configuration



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Indirect Inspections on Difficult-to-Assess Piping

- Difficult-to-Assess Piping consists of locations where traditional indirect inspection tools such as CIS, DCVG and ACCA are limited in their ability to differentiate locations where corrosion control systems are functioning or inadequate:
  - Plants or stations that are tied to the common grounding system
  - Locations of congested piping
  - Multiple pipeline /HVAC corridors
  - Casings....
  - Any location where electrical continuity adversely effects indirect inspection results

Limitations of Traditional Techniques

<u>CIS</u>

- Additional structures drastically influence the potential measurements of the structure intended for assessment.
- Low potential indications may be a factor of adjacent structures, not a lack coating or cathodic protection.

<u>DCVG</u>

- Voltage gradient indications may be masked by adjacent coating holidays or structures.
- Locating coating holidays and remote earth measurements may be infeasible.

Indirect Tools

- Due to limitations, additional considerations in the selection and application of Indirect Inspection Tools
- Williams Approach
  - Met with providers and worked with ways to optimize tools for these facilities
  - Piloted tools in advance of ECDA implementation
  - Incorporated additional advanced screening tools like GWT to supplement the assessment
  - Review / integration of ILI from adjacent transmission lines as part of threat assessment indirect review

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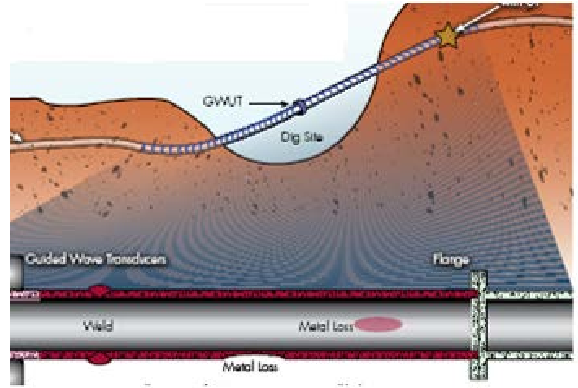
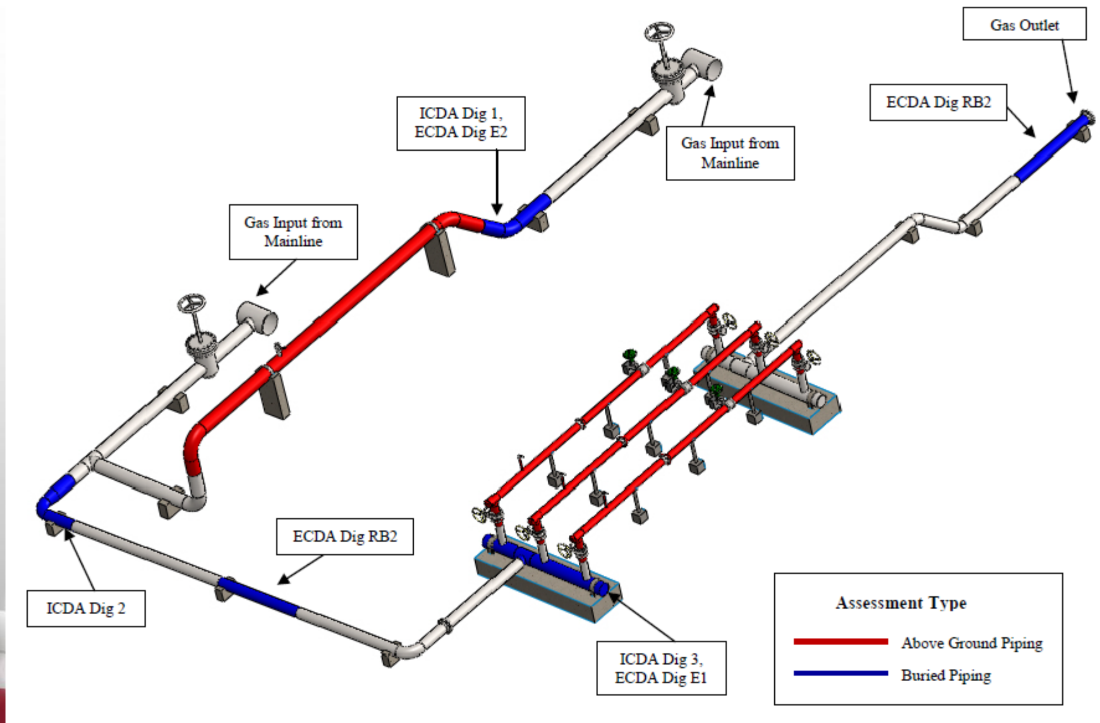
Direct Examinations

- In difficult-to-assess areas such as orphan piping, excavations can be complicated by unusual depths and multiple pipelines
- The use of GWT has proved useful in supplementing the inspection screening of difficult to access sections





- The 3-D GIS database can also be used to identify and more precisely define dig locations

GUIDED WAVE TESTING (GWT) OVERVIEW & FUNDAMENTALS

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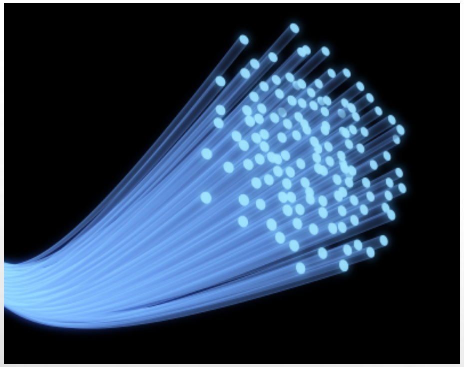
Definition

Guided Wave - a wave (acoustic, mechanical, or electromagnetic) whose propagation characteristics are dictated by the properties AND boundaries of the medium in which they travel.

Acoustic

http://www.bose.com/controller?event=VIEW_STATIC_PAGE_EVENT&url=/learning/waveguide_results.jsp

Electromagnetic



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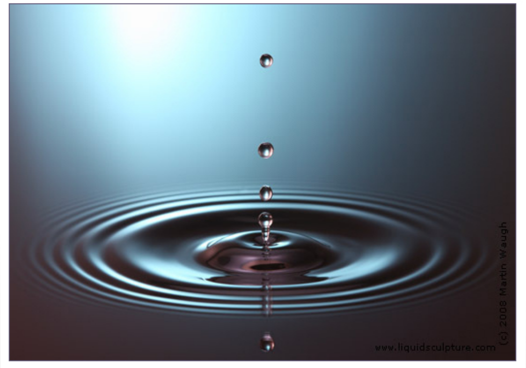
Mechanical



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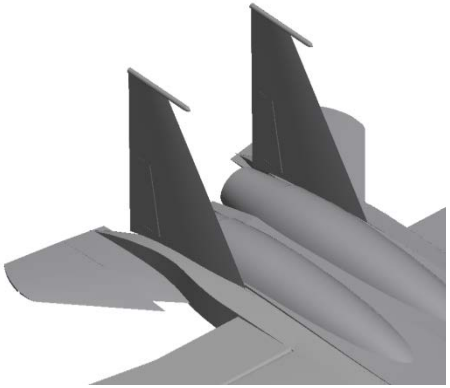
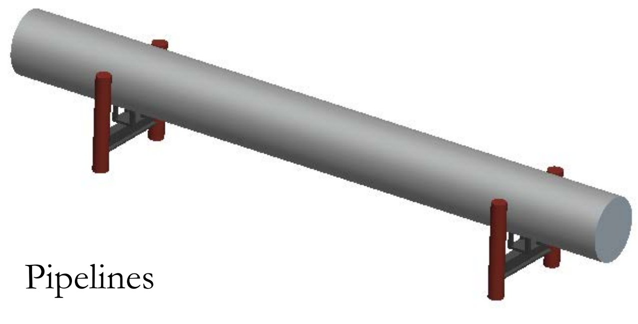
Natural Waveguide Examples

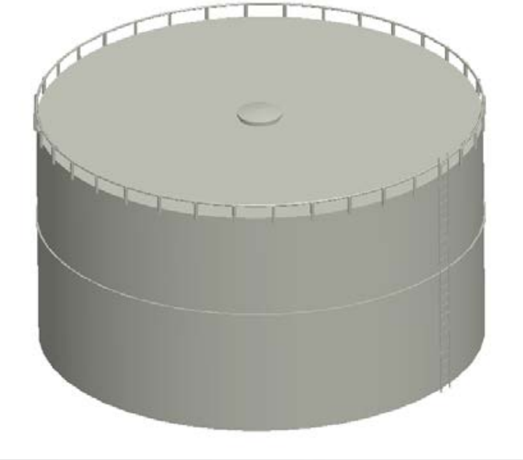
- Plates (aircraft skin)
- Rods (cylindrical, square, rail, etc.)
- Hollow cylinder (pipes, tubing)
- Multi-layer structures
- Curved or flat surfaces on a half-space



Aircraft Skins



Pipelines



Storage Tanks

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Principle Uses of GWT

- Used to detect internal or external wall loss
  - Volumetric: Change In **<u>Cross Sectional Area</u>**
- Difficult to assess areas, such as casings, CUI, station piping, ICDA
- Where large lengths and difficult to access piping need to be assessed
- Based on acoustic waves in the pipeline walls

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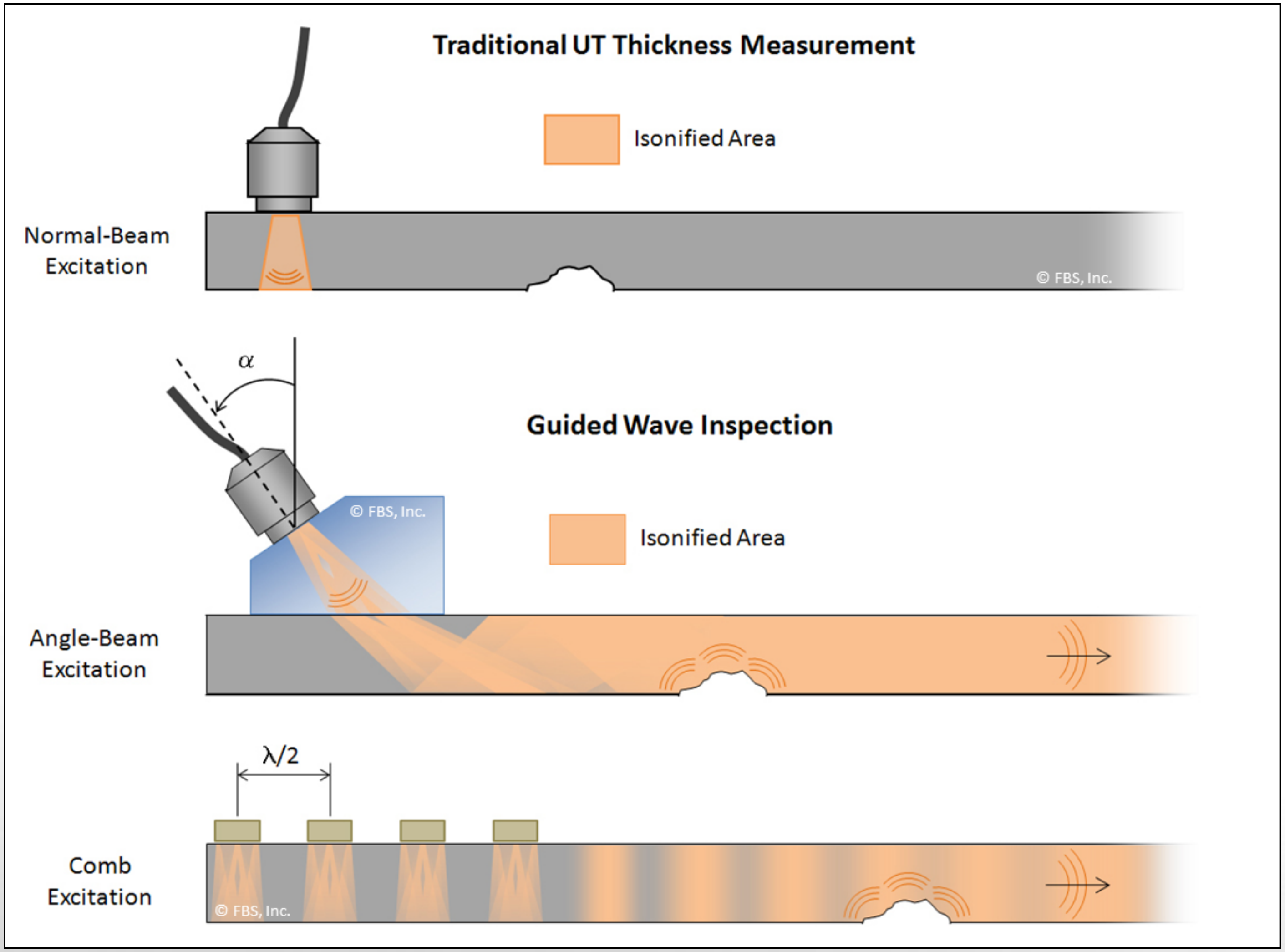
GWT Piping Assessment

- Inspection over long distances from a single probe position.
- Scans the entire volume of pipe
- Qualitative to Semi-quantitative
- Excellent as a screening tool (similar to indirect inspection)
- Ability to inspect inaccessible structures
- More difficult, pattern recognition

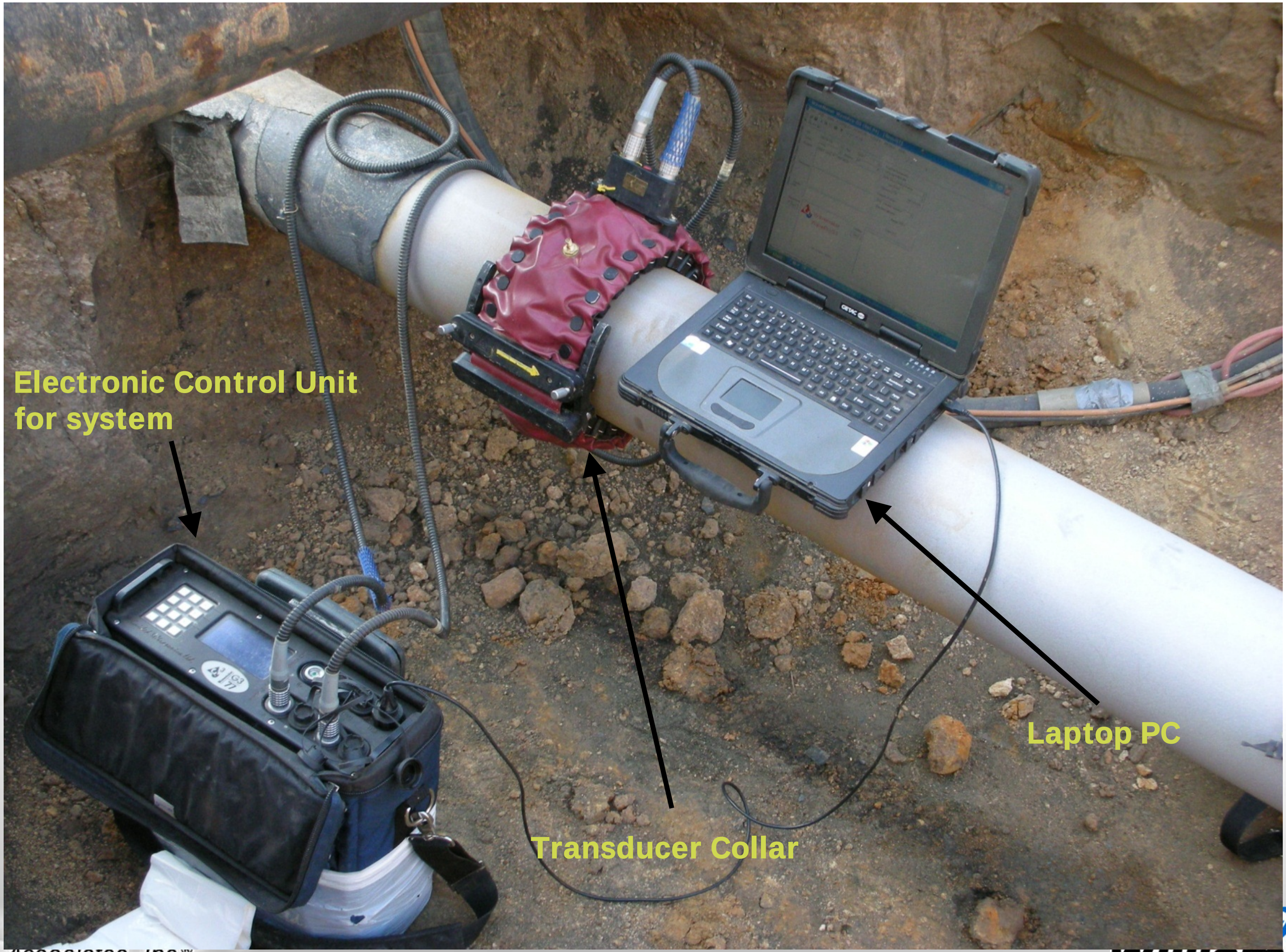
Guided Wave Concept



Propagation along, not through, a structure

The pipe walls forms a guide for ultrasonic waves, which directs them down the length of the pipe

GWT Components



Reflection of a Guided Wave from a Feature

- Guided waves are reflected from a change in cross sectional area
- The change can be either an increase or decrease in area
- If the cross sectional change is symmetric then the reflected wave is primarily symmetric (torsional or longitudinal depending on excitation)
- If the cross sectional change is not symmetric then the reflected wave will have higher a higher flexural component
- Reflections cause less energy to propagate down the pipe incrementally reducing the sensitivity

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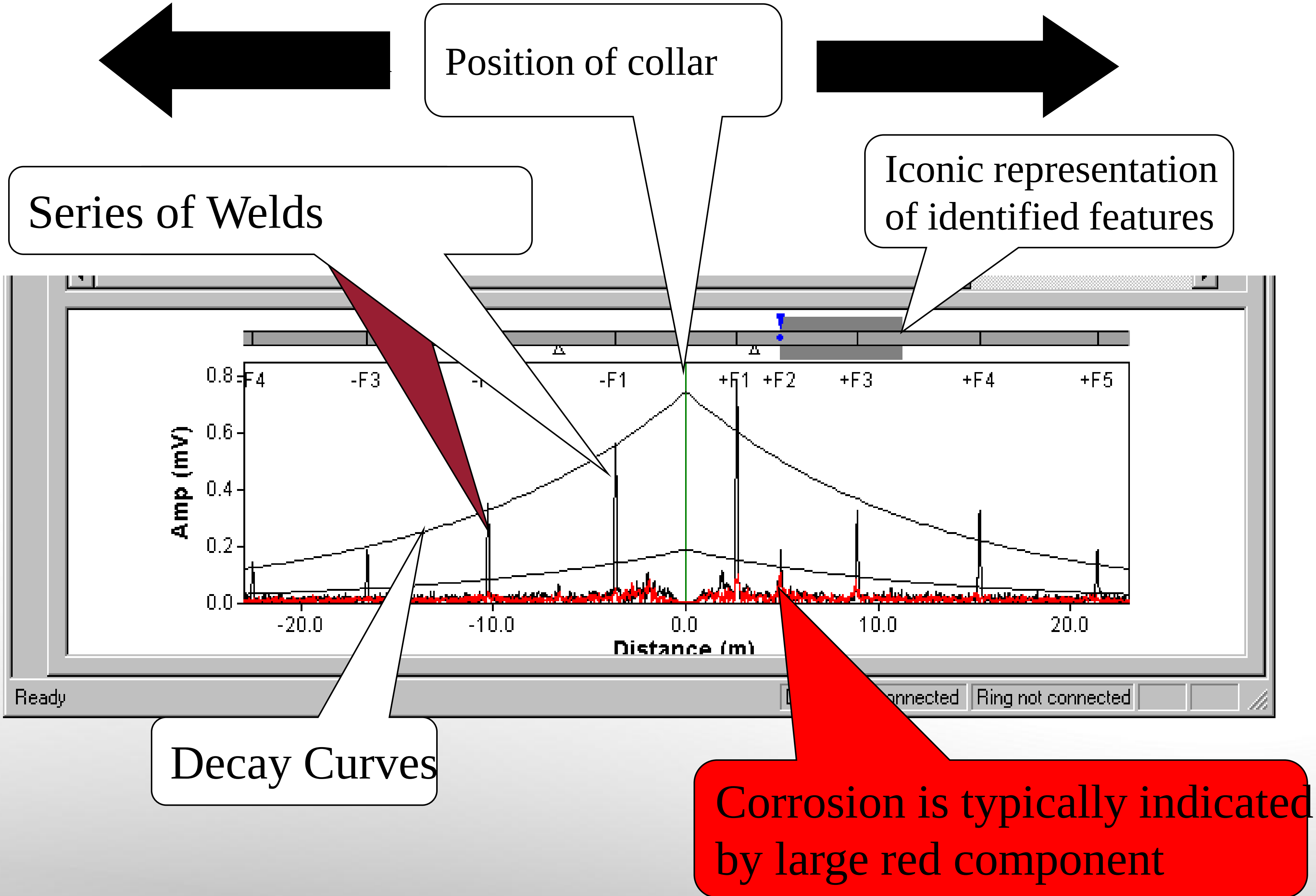

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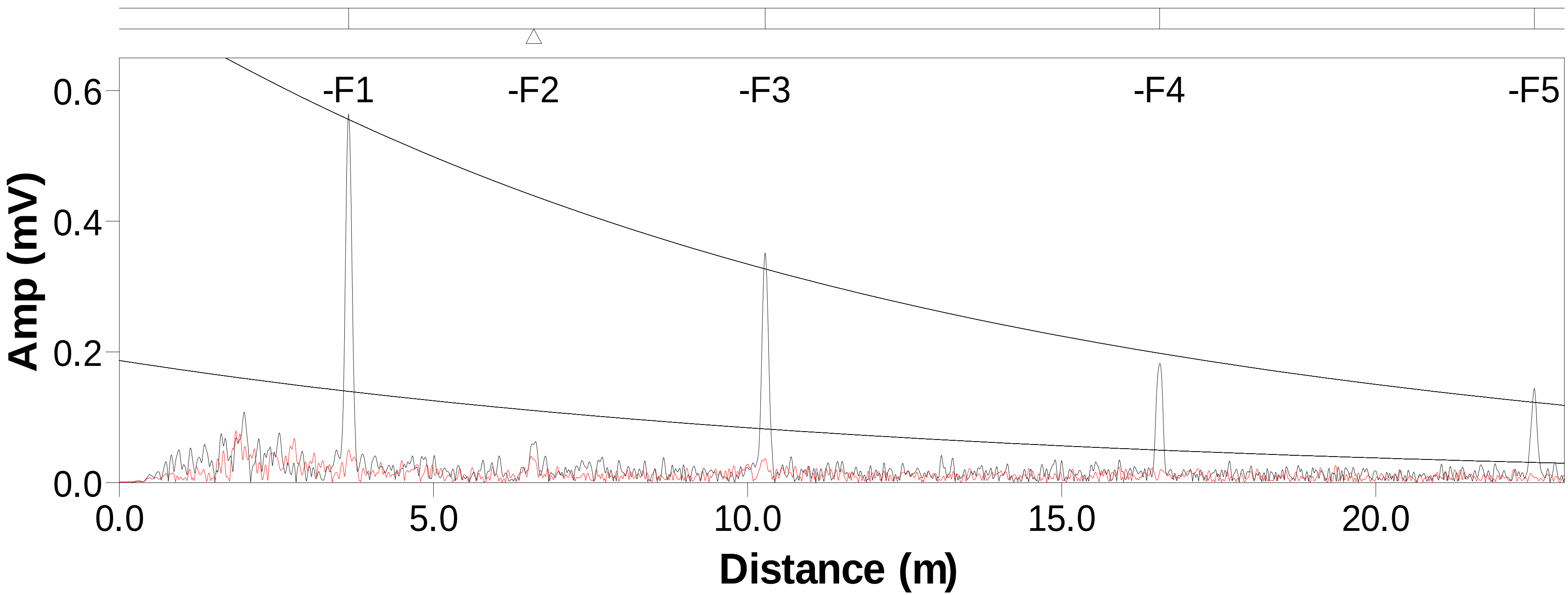
Amplitude decays over distance

- The reflected amplitude from distant features will be smaller than for close features
- The range is limited
- Two things that cause signal decay
  - Reflection from features
  - Attenuation from coating, soil, generalized corrosion, etc

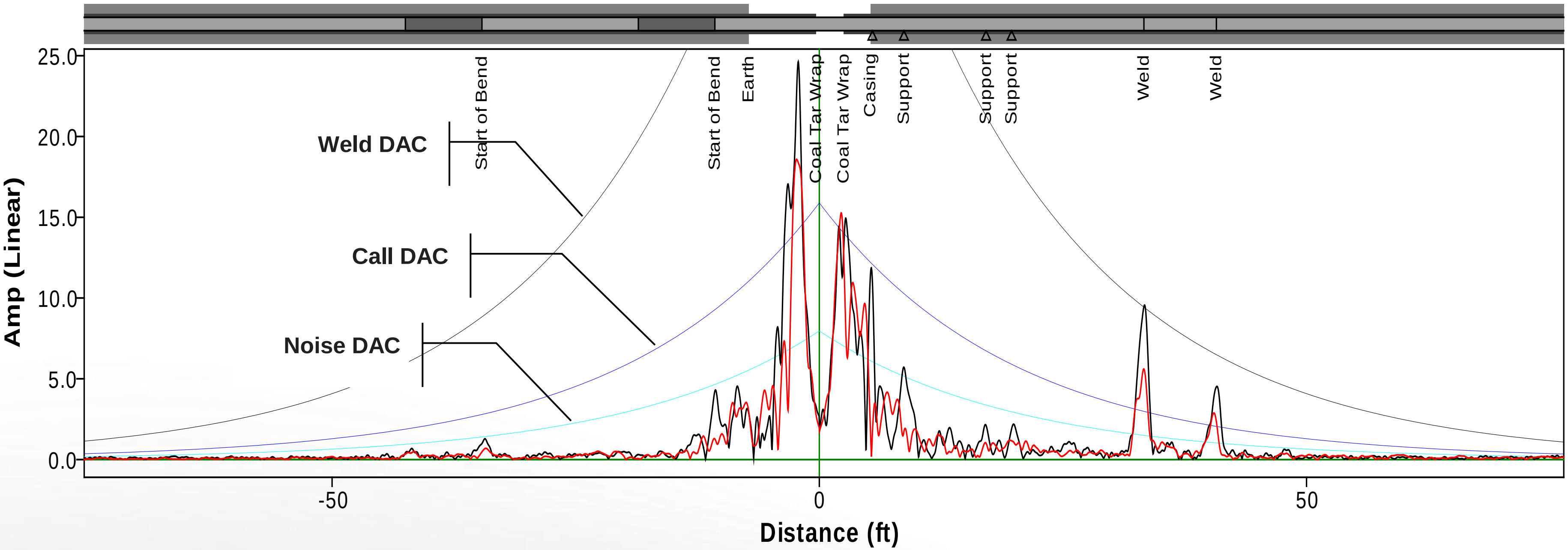


Decay of the amplitude is caused by:

- Welds
- Fittings
- Branch connections
- Corrosion damage
- Supports
- External coatings
- Internal coatings
- Soil
- Material itself

Coatings generally have the greatest attenuating affect

Four Distance Amplitude Curves (DACs)



DAC levels can be changed for different applications.

Flange DAC: 100% ECL
Weld DAC: ~23% ECL
Call DAC: 5% ECL (detectability threshold/sensitivity level)
Noise DAC: 2.5% ECL (Set to 1/2 detectable threshold)

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What is sensitivity?

- It is the percent cross sectional area that can be detected at a given signal to noise ratio (SNR)
- It is expressed as % ECL or CSC (change in cross-sectional area)
- Industry best practice and PHMSA guidance specify sensitivity at a 2:1 SNR

Things to Consider about Sensitivity

- DAC: Distance amplitude curve is expressed as percentage of cross sectional area. Weld DACs are usually 23% ECL.
- S/N Over Background: To have better confidence level a S/N ratio of 2:1 is needed. Noise DAC = ½ Call DAC
- Inspection Range: Is a function of required Sensitivity.

PHMSA (18 points require) 5% sensitivity or value corresponding to a defect that would fail a Hydrotest, whichever is less

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GWT TECHNOLOGY ADVANCEMENTS

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GWT Focusing

- GWT Focusing is a new development that has the potential to increase sensitivity, confidence, and provide approximate defect sizing information.
- There are different types of GWT focusing
    1. Frequency tuning
    2. Passive focusing / Synthetic focusing
    3. Active focusing / Phased array focusing
- The term focusing in this context is referring to methods that improve the signal to noise at a location through manipulation of sending and/or receiving the guided wave signal.

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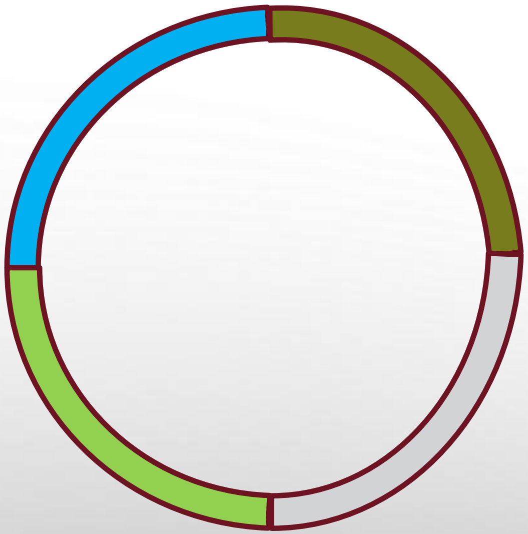
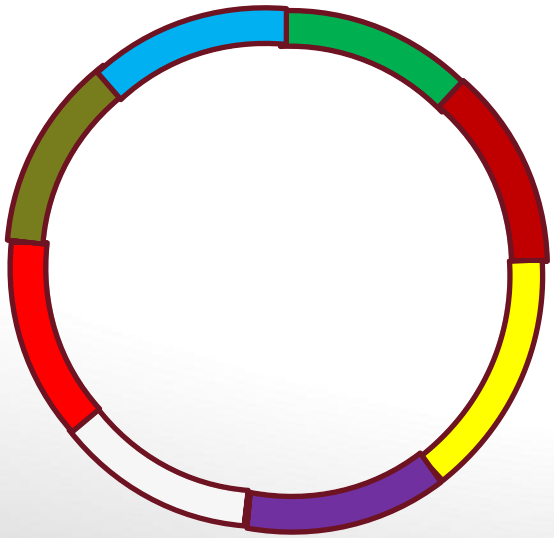
Channel Segments

- GWT transducer collars are divided in either four to eight segments around the pipe
- Loading or receiving from a given segment can provide location data and improve signal to noise ratios of a reflection



4 Segment or 8 Channel



8 Segment or 16 Channel

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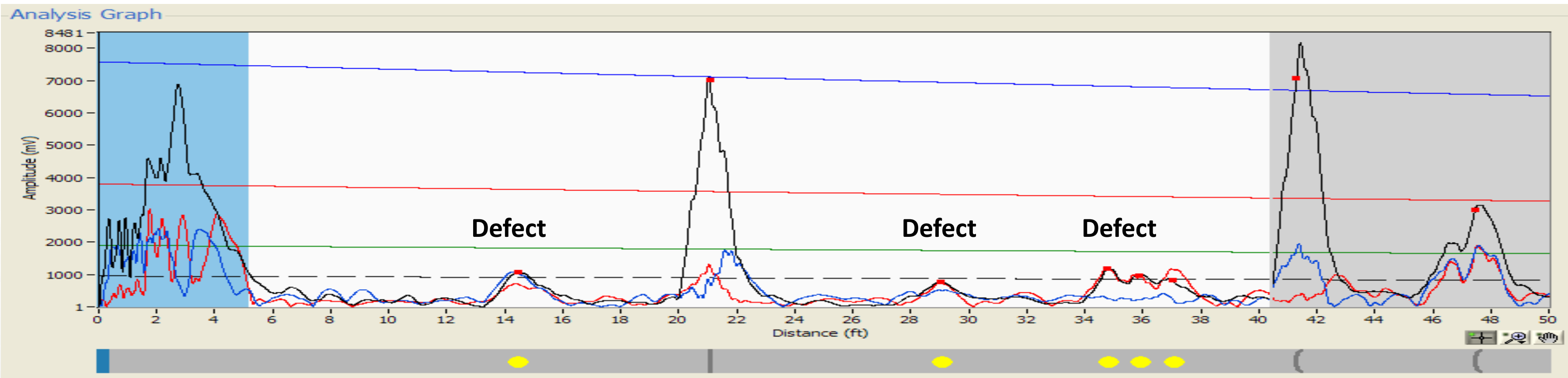
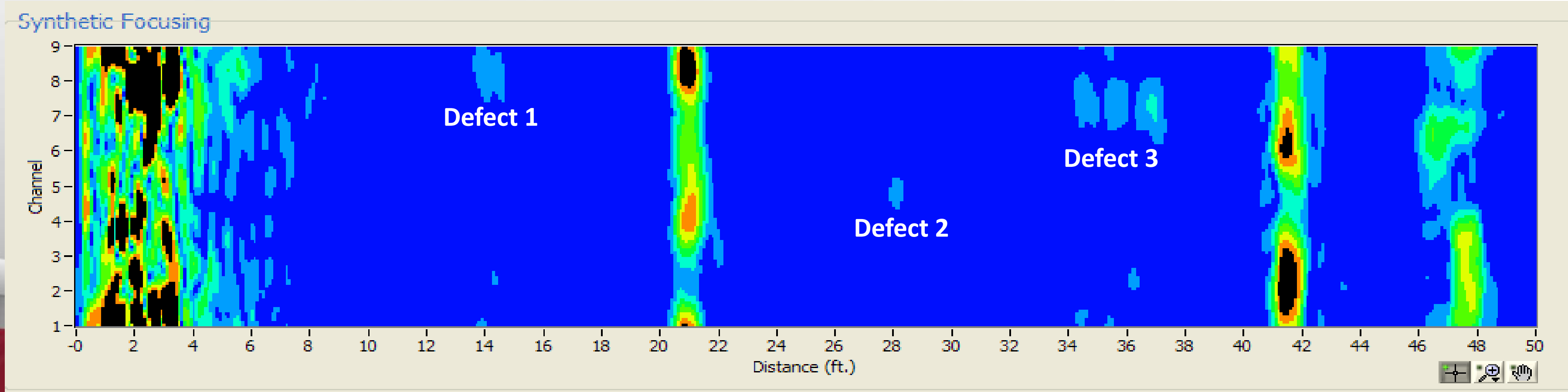
Passive/Synthetic Focusing

- Some manufacturers uses segment focusing / synthetic focusing to develop an unrolled pipe display
- The segment focusing is just on receiving the signal, not transmission.
- This focusing can provide information on the circumferential extent of a reflector

A-Scan



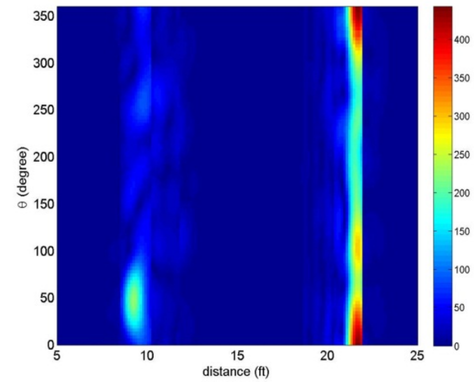
“C-Scan”



Key Advancements

- Breadth in technical capabilities offered by ***operating multiple platforms***
- **Focusing**
  - **Passive Focusing** – Unrolled Pipe Display
  - New **active focusing** can improve sensitivity
  - Three Ring torsional/longitudinal versus two Ring configurations
- Crews trained on the **fundamental operating concepts** of the methodology **in addition to operation of a particular platform**.

Synthetic / Passive:



Active:

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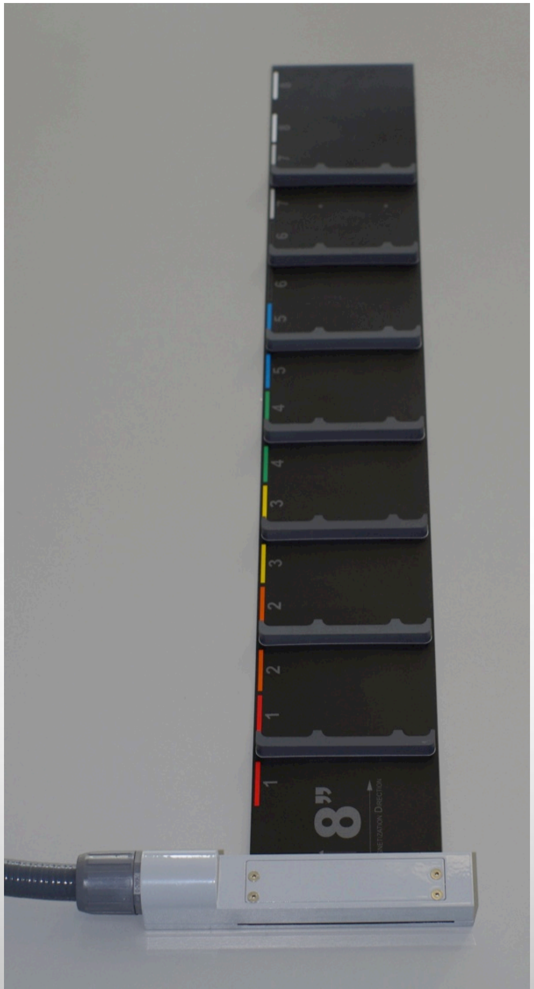
PowerFocus© MagnetoElastic Focusing Collar for SHM (Developed with FBS)



- Utilizes magnetostrictive effect to maximize loading area and transduction efficiency Potential for improved penetration power and sensitivity.
- Small Near Field (<2ft)
- Low Profile (2" axially, <1" circumferentially)
- Only requires installation of a single low-cost sensor strip (see picture below)
- Potential for monitoring for corrosion under supports, repairs, and penetration areas.
- Can be used for buried pipe monitoring (dig once inspect often).

Guided Wave Monitoring (GWM)

- A guided wave sensor is permanently mounted to the structure.
- A reference (baseline) data set is collected at the time of installation.
- Future data sets are compared to the baseline data set to monitor for changes in the component.
- Can be installed in excavations, high-rad areas, difficult-to-access locations, or on critical components.
- Facilitates “removal” of coherent noise for improved sensitivity and data trending.
- Facilitates inspection of more complex piping geometries.

FBS ME Sensor

GUL gPIMS

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EXAMPLES OF APPLYING TOOLS IN DIFFICULT TO ASSESS SCENARIOS

Case Study – Orphan Piping

- ECDA was chosen to assess the integrity of 11 "orphan" piping facilities for Williams.
- The objectives of the assessment were:
  - Assess the facilities in accordance with Integrity Management regulations
  - Identify locations of coating anomalies
  - Identify critical areas for excavation and direct examination
  - Perform direct examination supplemented by Guided Wave at feasible locations
- Project grouping
  - 5 Different projects
  - Split based on system tie-in, age, similar corrosion / CP histories

Case Study – Orphan Piping (Indirect Inspections)

- Example Project (Project 1: 505-30, 505-40, and 505-50)
  - Connected to same trunk line, similar history and age of construction
- Pre-assessment identified 2 regions based on shielding and non-shielding coatings
  - Example 505-30: Small section of tape wrap in select areas
- CIS, ACVG, and ACCA performed as primary indirect tools
  - Later during direct examination, further supplemented by GWT
  - 505-30: Only 2 minor ACVG indications
  - 505-40: Only 2 minor ACVG indications
  - 505-50: Only 6 minor ACVG indications
  - Resulting only in monitored, effectiveness, and/or contingency digs per Williams ECDA plan
  - Several additional excavations completed beyond the ECDA plan requirements based on the unique nature of the piping

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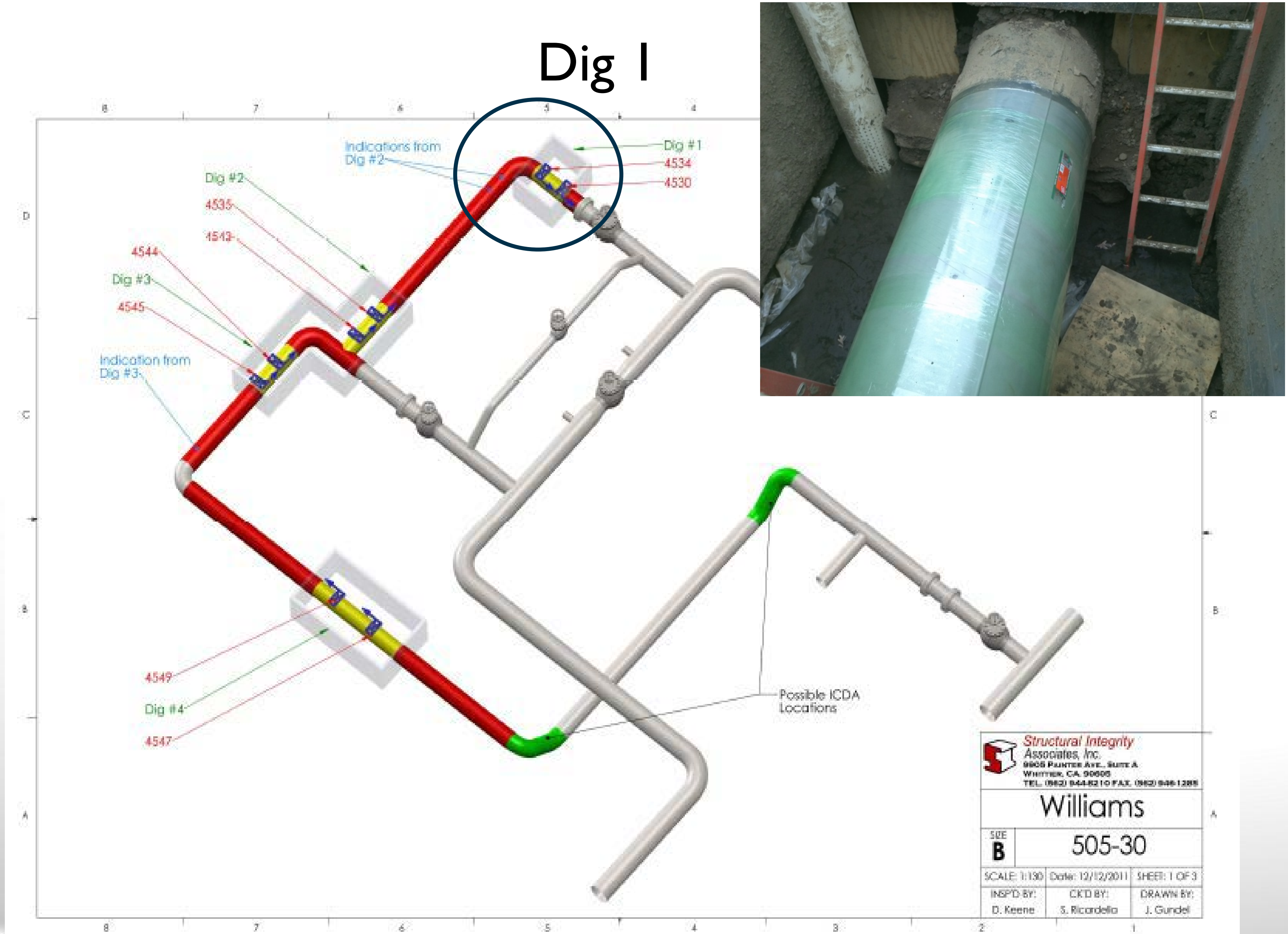
Case Study – Orphan Piping (Pre-Assessment)

- Pre-Assessment concluded that ECDA was feasible
- Regions were defined as:
  - Regions typically split based on shielding versus non-shielding coatings
- 3D Modeling / GIS created
- Indirect Inspection Tools selected
  - Close Interval Pipe-to-Soil Potential Survey (CIS) and Alternating Current Voltage Gradient Survey (ACVG) deemed most effective
  - ACCA Applied
- Preliminary trials of tools at select sites to help verify applicability within pre-assessment process

505-30 Valve Site – Direct Exam / GWT Summary

- 11 Excavations Performed, UT & Direct Examination
- GWT feasible and performed in 7 of the excavations
- Approx. 300 feet of total pipe
- Direct Exam, ~112 feet exposed (~37%)
  - No significant degradation discovered
  - New items were discovered, such as different configuration of pipeline than documented on the drawings
- GWT, ~210 feet coverage (~70%)
  - One medium indication – proven up and was an unknown support/pier
  - Only minor indications – correlated to coating holidays (example dig 2)

Dig 1



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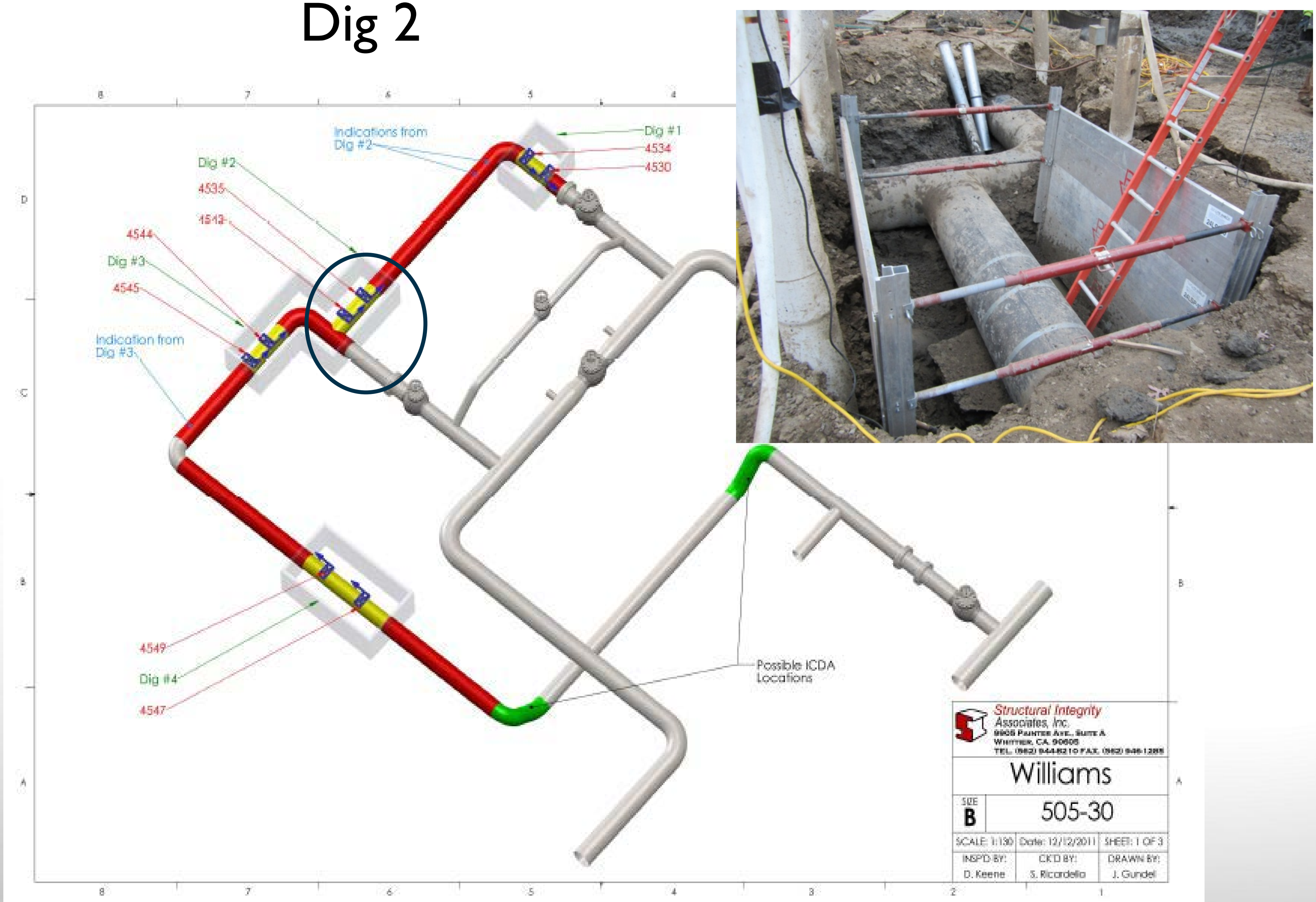
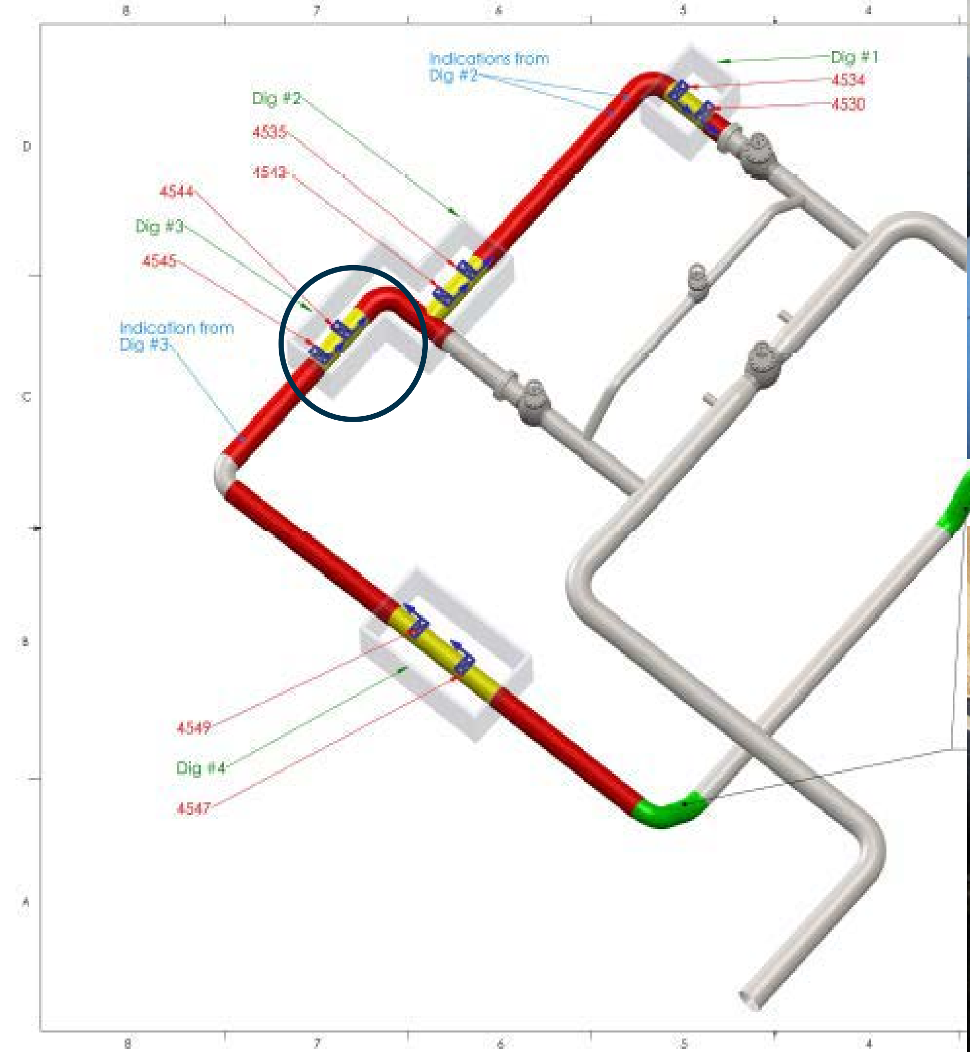
Dig 2



Indications from Dig #2
Dig #1
4534
4530
Dig #2
4535
4543
4544
Dig #3
4545
Indication from Dig #3
4549
Dig #4
4547
Possible ICDA Locations
Structural Integrity Associates, Inc.
9905 Painter Ave., Suite A
Whittier, CA 90605
TEL. (562) 944-8210 FAX. (562) 946-1285
Williams
SIZE B
505-30
SCALE: 1:130
Date: 12/12/2011
SHEET: 1 OF 3
INSP'D BY: D. Keene
CK'D BY: S. Ricardello
DRAWN BY: J. Gundel

Dig 3



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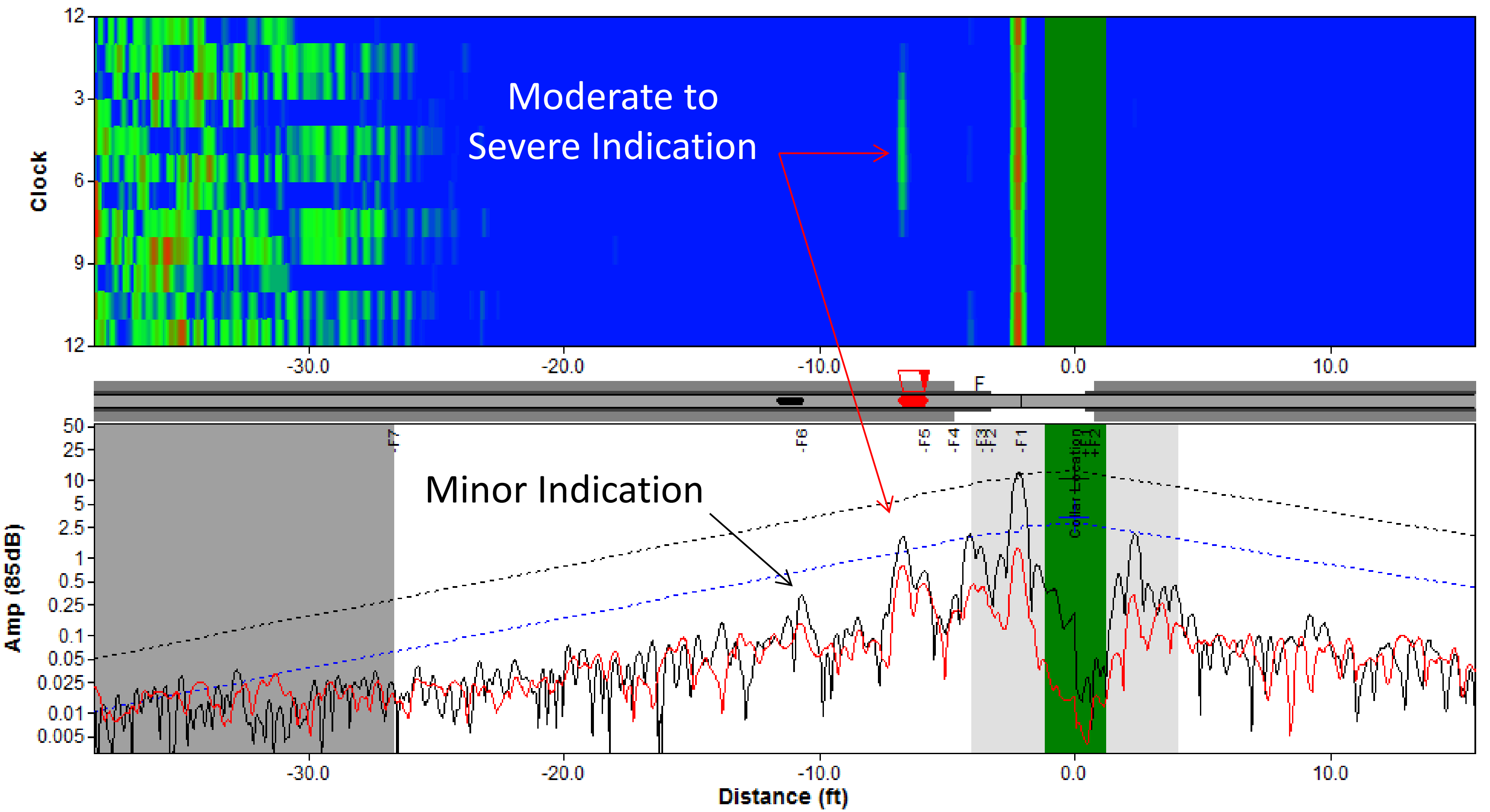
Case Example: Stanwood Lateral Casing

- Shorted casing, GWT to help verify integrity
- 6” diameter cased pipe
- Known metallic short in cased section
- Moderate to Severe indication identified



Stanwood Lateral Findings

- Two "unusual" spacers found at specified locations.
  - Unusual due to dissimilar response from other spacers on line
- Short was located at spacer which had highest amplitude response
- Over-length bolts were in contact with casing and over-tightening spacer had compromised yellow jacket coating on carrier line.
- No degradation other than damaged coating was found
- Spacers were removed, B&W-MPI and UT inspections were performed in suspect areas

Thank You

Questions?

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