# Materials Joining:
# Building for the Manufacturing Future

# Advanced Repair and Remediation of In-Service Pipelines

## Co-Funded by DOT and PRCI

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# Presentation Outline

- Pipeline Repair Introduction
- Objectives of Project
- Prototype Design
- Weld Procedure Development
- Field Trial
- Summary

# Introduction

- In-service maintenance and repair continues to be an area in which there is much interest
- Repair of corrosion damage
  - As pipelines become older, more repairs are required
  - Currently an in-service, manual method
  - Can be repaired by building up corrosion area with welding passes or by use of full-encirclement repair sleeves
- Safety, economic, and environmental issues

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# Project Objectives

- Develop an automated welding system for use on in-service pipelines
- Incorporate real-time adaptive control system to ensure reliable welding conditions
- Evaluate system in laboratory
- Validate the system
  - Develop qualified welding procedures
  - Perform field trials

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# Prototype System Design

- **Three Welding Capabilities**
  - Longitudinal repair sleeve weld
  - Circumferential repair sleeve weld
  - Weld deposition for repair of corroded area
- **Augment Off-the-Shelf Mechanized Bug**
  - STX bug(s) and bands from Serimer-DASA
  - STX controller box for motion
- **EWI amends standard bug with software and hardware**
  - Add torch tilt capability to counteract gravity on the weld pool
  - Add torch travel angle for push/drag during corrosion fill
  - Coordinate motion for encircling corrosion patch and for weld fill
  - Increase length of cross-seam axis for filling corrosion patch
  - Integrate Laser Sensor onto STX bug system

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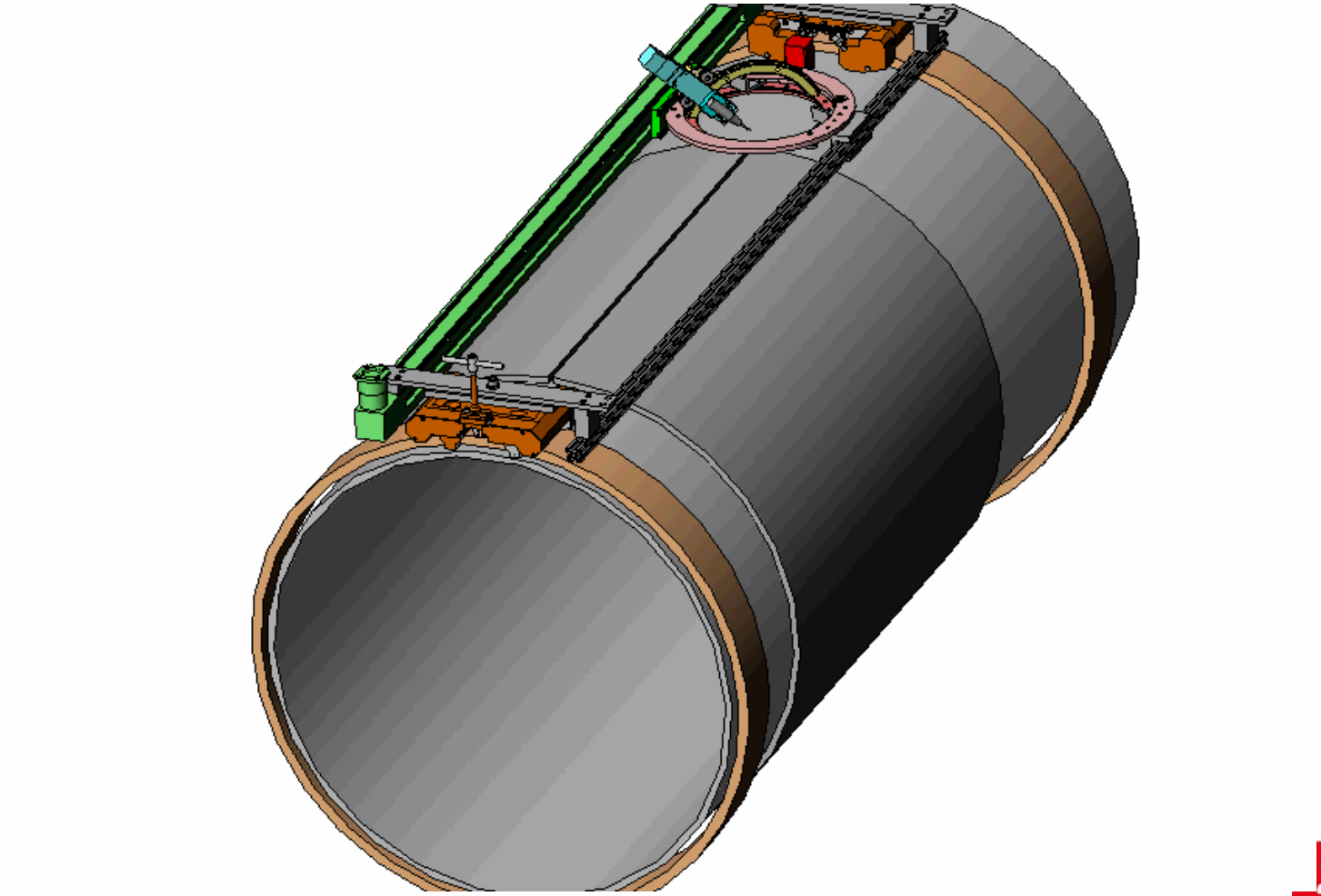
# System Hardware Design
# Repair Sleeve Welding



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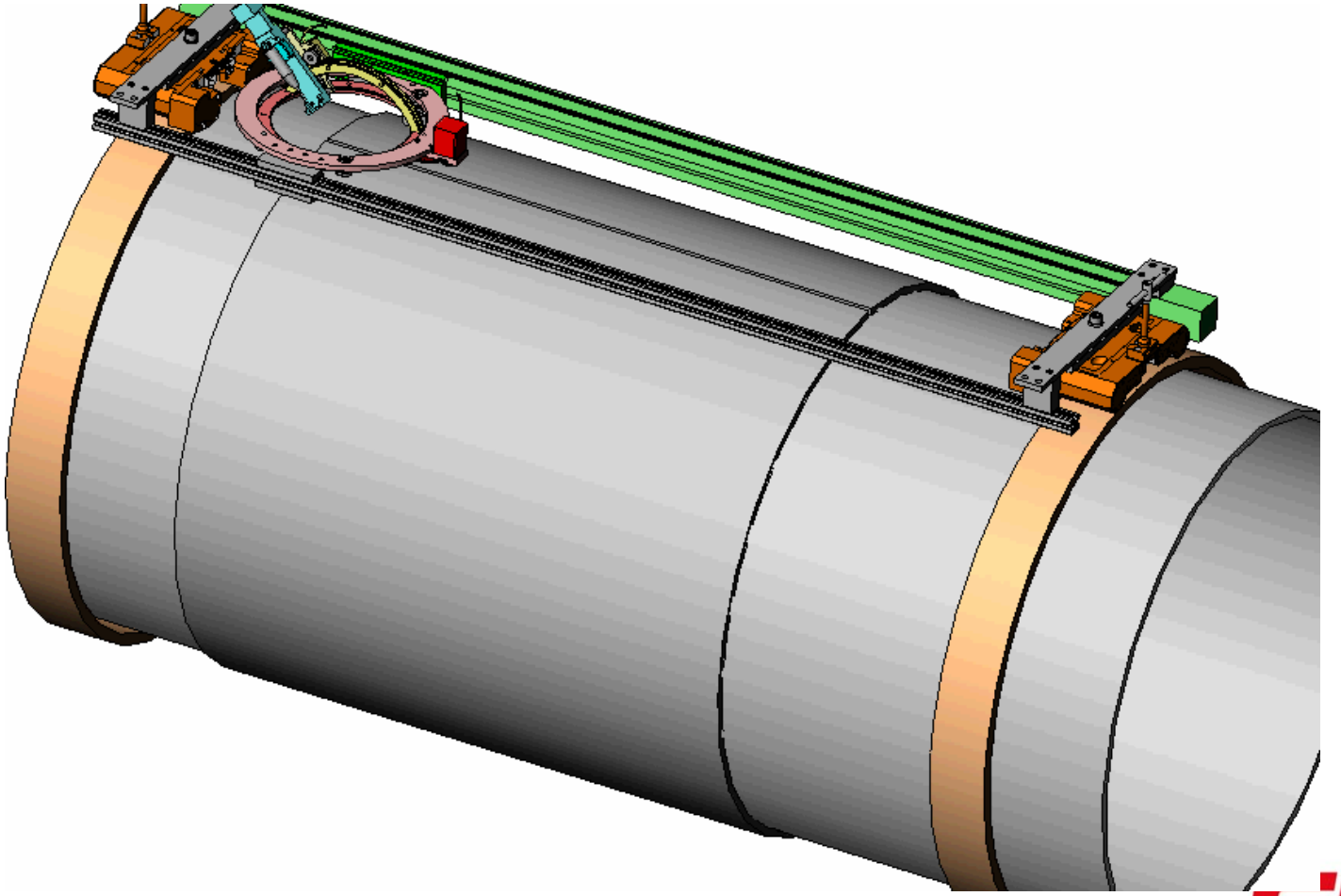
# System Hardware Design
# Corrosion Buildup



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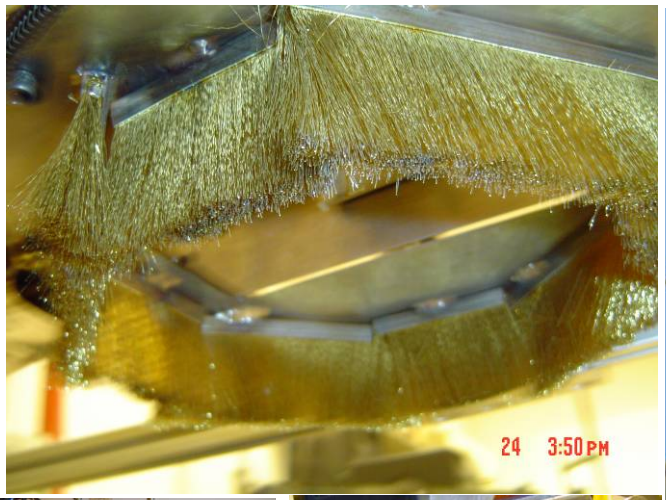
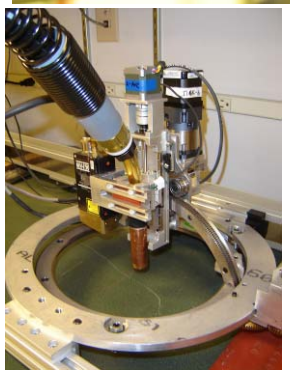
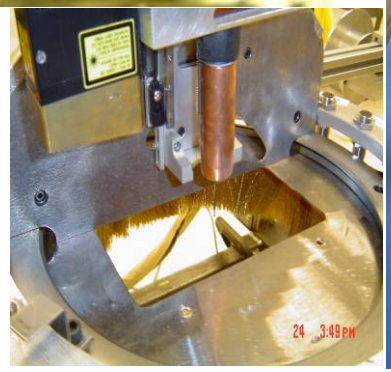
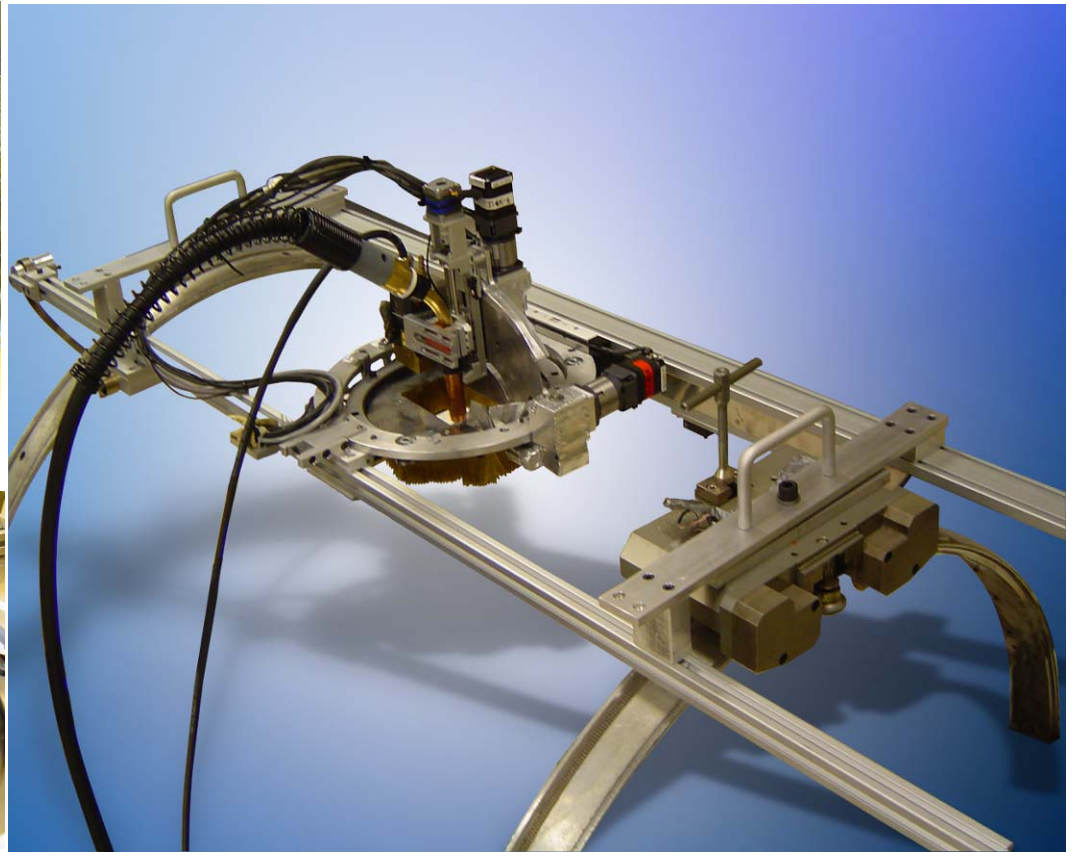
# System Hardware Development





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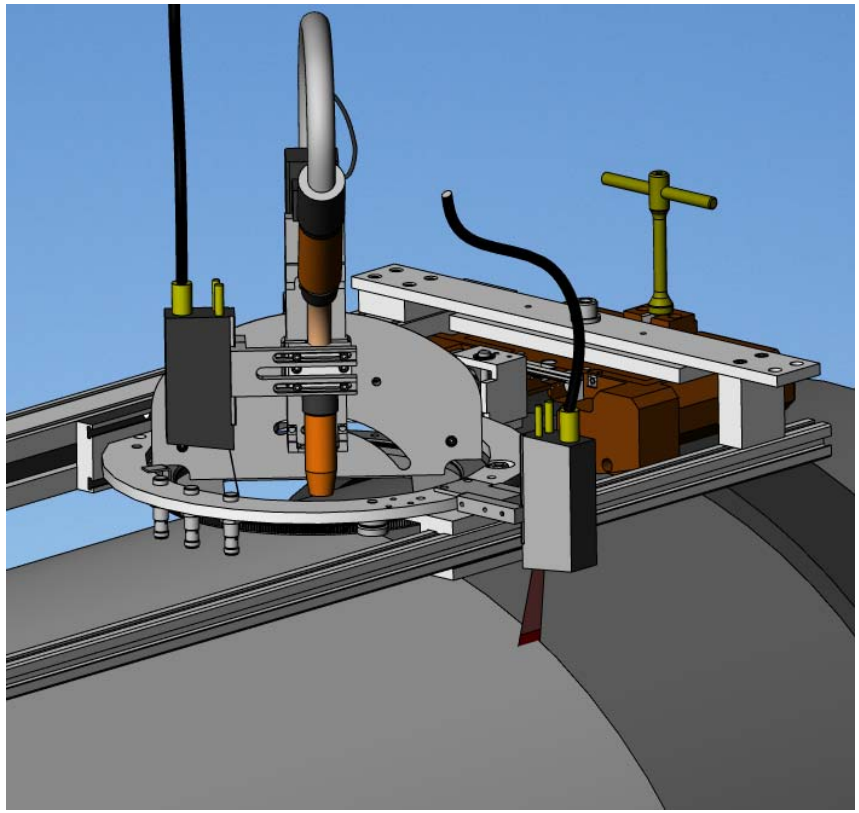
# Laser Sensor Functionality

- Seam track during sleeve welding
- Adaptive control by sensing remaining fill required and previous bead/layer position
- Map corroded area and determine corrosion fill pattern



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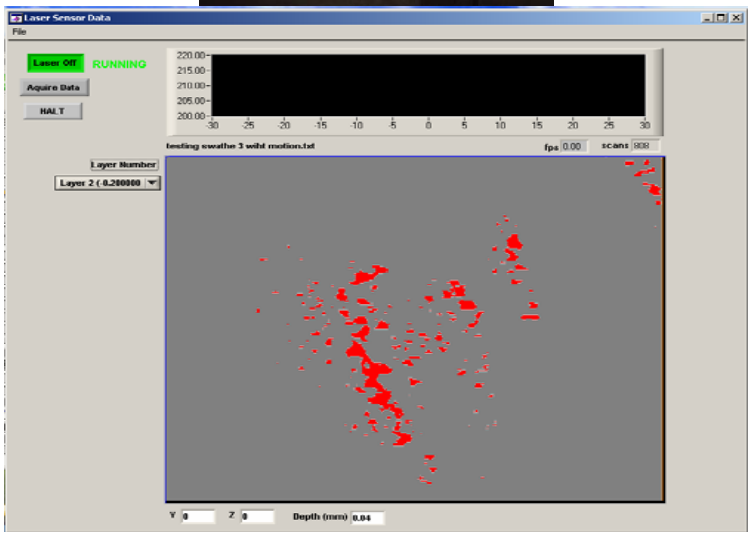
# System Hardware – Scanning Corrosion in Lab




- Laser sensor scans 3 in. swathe
- Motion and laser coordinated to patch scanned areas together
- Corrosion location and depth is mapped
- Temper bead encircles corroded patch
- Stringer beads for build up

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# Software Development

- Laser Scan of Pipe Surface
- Laser Seam Tracking during Welding
- Motion Control of Bug and Hardware
- Integrate with Operator Interface

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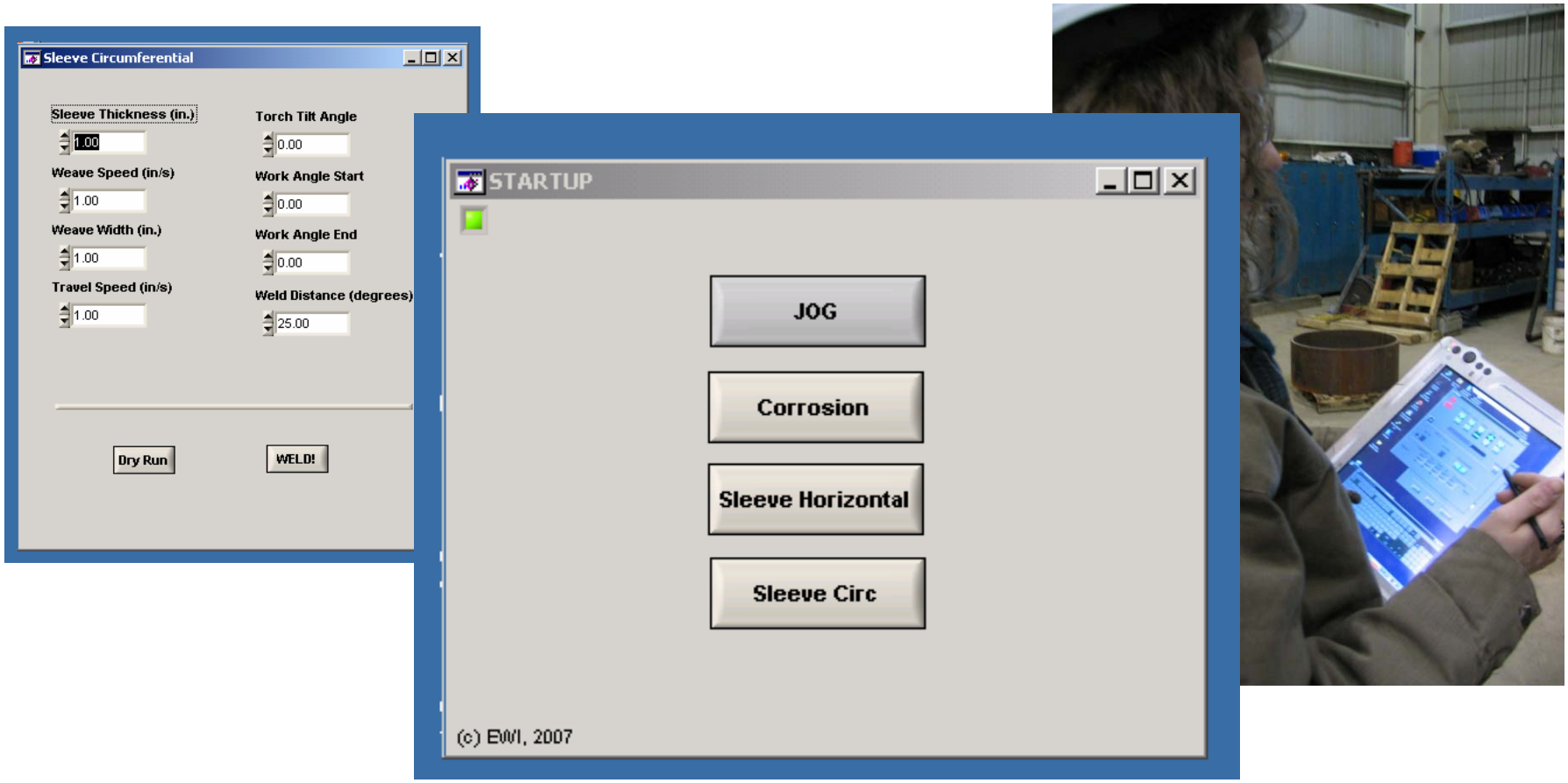
# Software User Interface

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# Weld Procedure Qualification

- EWI to qualify welding procedures for, X80 and X100 and X120
- Welds to be testing according to API 1104 Appendix B
  - Simulated in-service condition was flowing water

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# Weld Procedure Development

- Comprehensive literature review on weld deposition was completed
- Preliminary automated procedure development on simulated pipeline
  - X80, 0.75-in. WT
  - X100, 0.75-in. WT
  - X120, 0.85-in. WT

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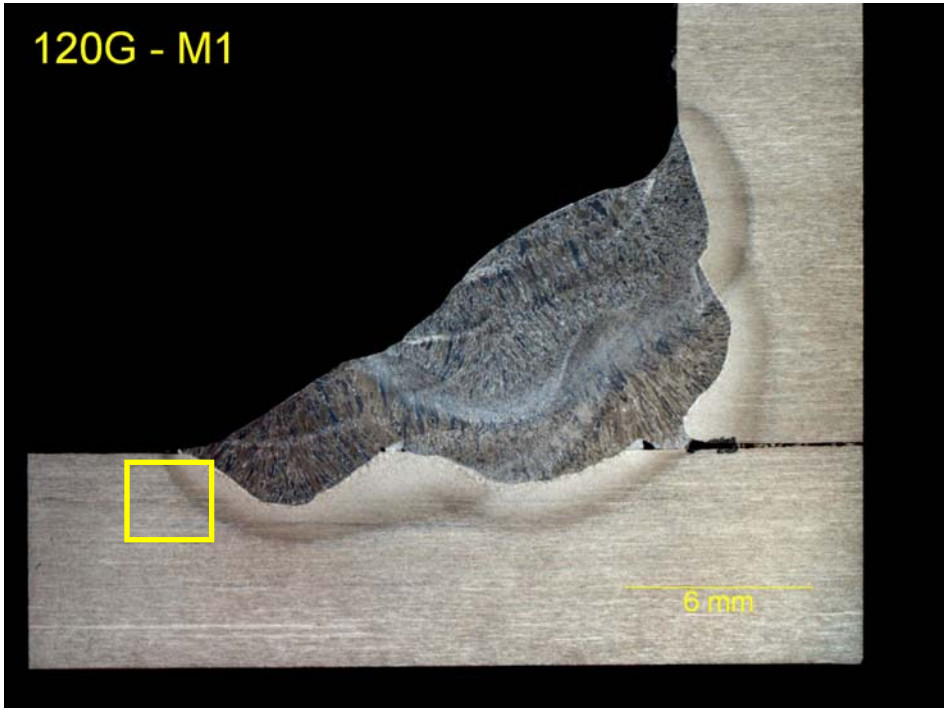
# Weld Procedure Development

- Welds have been completed
  - GMAW – ~29.5 kJ/in.
  - FCAW – ~25.0 kJ/in.
- Testing has been completed
  - Nick-breaks
  - Face bends
  - Macrographic Analysis
  - Hardness Testing
- Diffusible hydrogen measurements
  - FCAW – 1.74 ml/100g
  - GMAW – 2.37 ml/100g

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# Field Trial – North Bay

- Bug-O Carriages
  - Pipe diameter change
  - Rail availability
- Pressure-Containing Sleeve Weld
  - Weld Longitudinal Seam
  - Weld Circumferential Ends
- Reinforcement Sleeve
  - Weld Longitudinal Seam
  - No Circumferential

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# Field Trial Welding Results

- Welded from 6 o’clock to 3 o’clock position
- Doubled the speed of the manual welder
- Multi-layer linear weld over root pass
- Seam-tracking & weld parameter improvements
- System performed and demonstrated capability

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# Field Trial Welding of Longitudinal Weld on Reinforcement Sleeve

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# Summary

- Automated pipeline corrosion repair system developed
- Successfully completed field trial
- Demonstrated welding of repair sleeves
  - Reinforcement
  - Pressure Containing
- First step in automating a manual process
- EWI Pipeline Workshop May 23, 2007!
  - Demonstrate repair sleeve welding
  - Demonstrate corrosion build-up

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# Questions

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