

Consolidated Edison Company of New York

SMART Robot

Presented by:

Dowlatram Somrah, ME, PE

Khurram Khan, ME

Agenda

- **Presenter Introductions**
- **Con Edison Steam System Overview and Design**
- **Steam Leaks and Repairs**
- **SMART Robot Design**
- **Tether and Operator Control System**
- **Ultrasonic Measurements**
- **Laser Profilometry**
- **Benefits**

Presenter Introductions

Dowlatram Somrah, ME, PE

- Section Manager – Steam Distribution Engineering
- Education
 - Cooper Union College – Undergraduate and Graduate Engineering Programs



Khurram Khan, ME

- Engineer – Steam Distribution Engineering
- Education
 - New Jersey Institute of Technology – Undergraduate and Graduate Engineering Programs

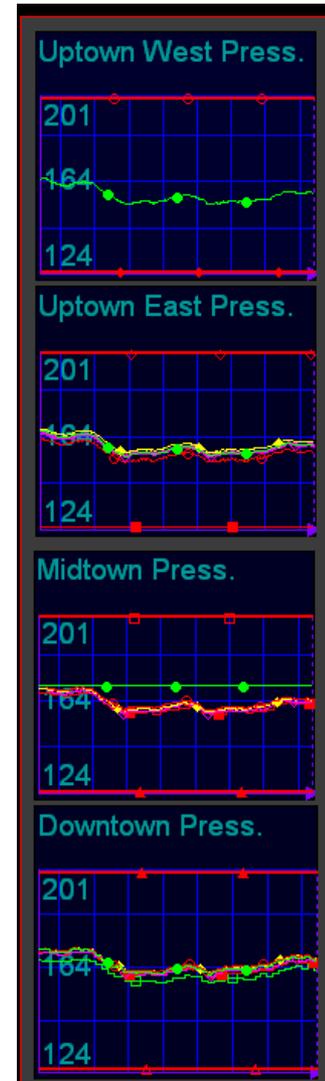


Con Edison Steam System Overview

- 23.5 billion lbs/2016
- 106 miles of pipes
- 1675 customers

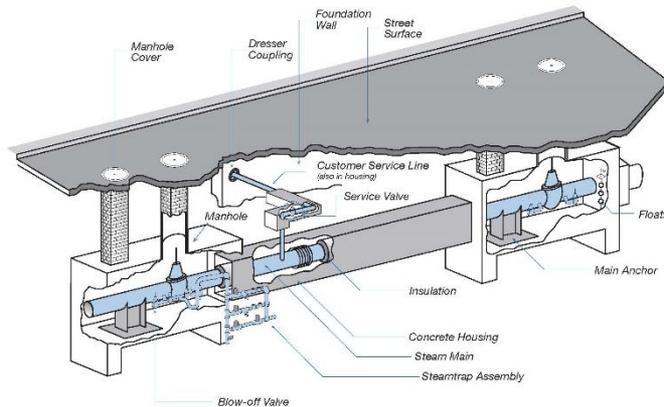
Design and Integrity of System

- Transmission and distribution mains
 - 1" – 36" diameter pipes
 - 0.179 inch to 0.675 inch wall thickness
- Design Basis
 - Distribution 200 psig
 - Transmission – 400 psig
- Operating – 140 to 180 psig
- Mains Service life > 130 years
 - No external corrosion
 - Flow accelerated corrosion
- Over 3,000 pairs of flanges
 - Gasket leaks over time
 - 2" flange leaks



Steam Leaks

- 65 leaks per year that require an excavation
 - Flange gasket leaks
 - 6 o'clock leaks
- Finding steam leaks
 - Review history/design
 - Pinpointing leaks
- Challenges of detecting leaks
 - Mains installed subsurface in conduits



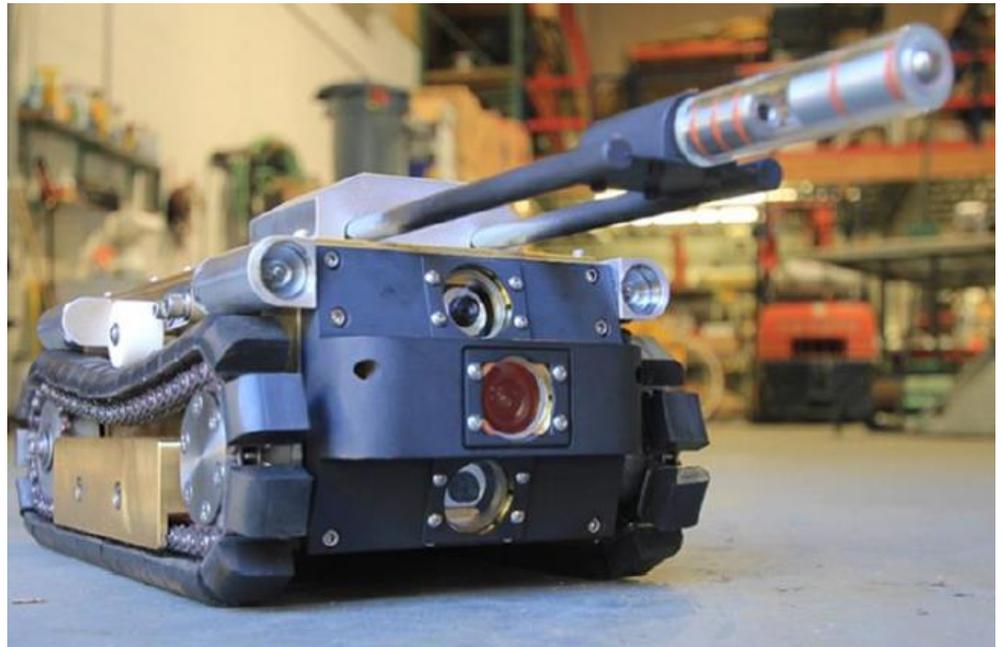
Steam Leak Repairs

- Leaks repaired within 6 months
- Main isolation is required
 - Emergency
 - Scheduled
 - Operation of valves
 - Customer interruptions
 - Multiple outages
- Concerns
 - Safety - personnel/pedestrians and vehicular traffic
 - “Stacks” and barricades
 - Loss of product/cost



Genesis of SMART Robot

- No proactive approach to finding leaks
- No available inspection technology for steam environment
- 2010 R & D project initiated

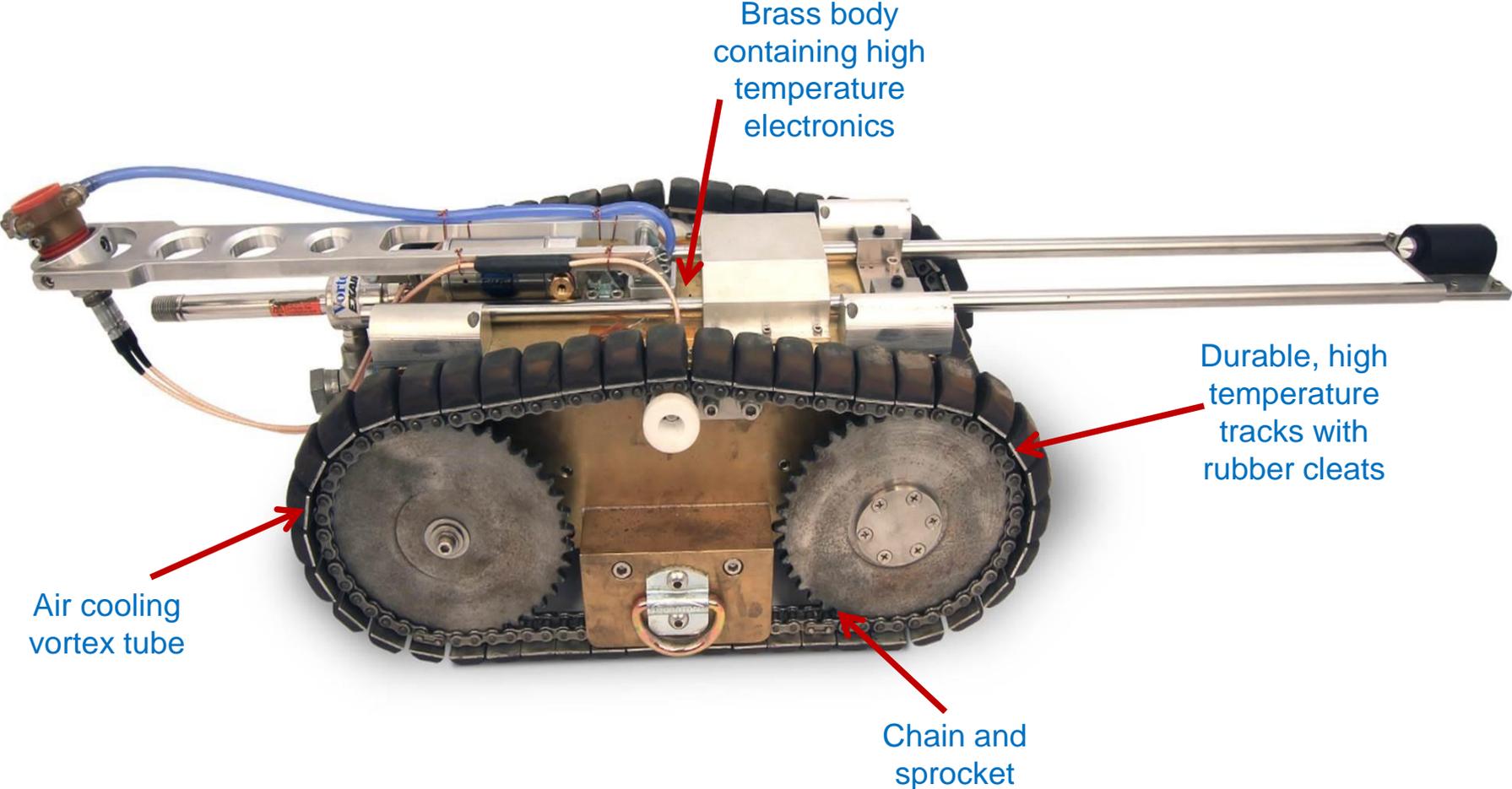


Technical Requirements

- Designed for 8"- 24" steam pipes
- Maneuver 45 degree bends
- Climb 45 degree rise
- Withstand 350 ° F
- Work at 100% humidity
- Inspect 1000 ft. in 4 hrs.
- Traverse expansion joint and valves
- Pull weight of tether
- Retrievable from POE
- Measure distance and elevation
- Record video of inspection
- Measure wall thickness
- Determine ovality
- Quantify internal corrosion

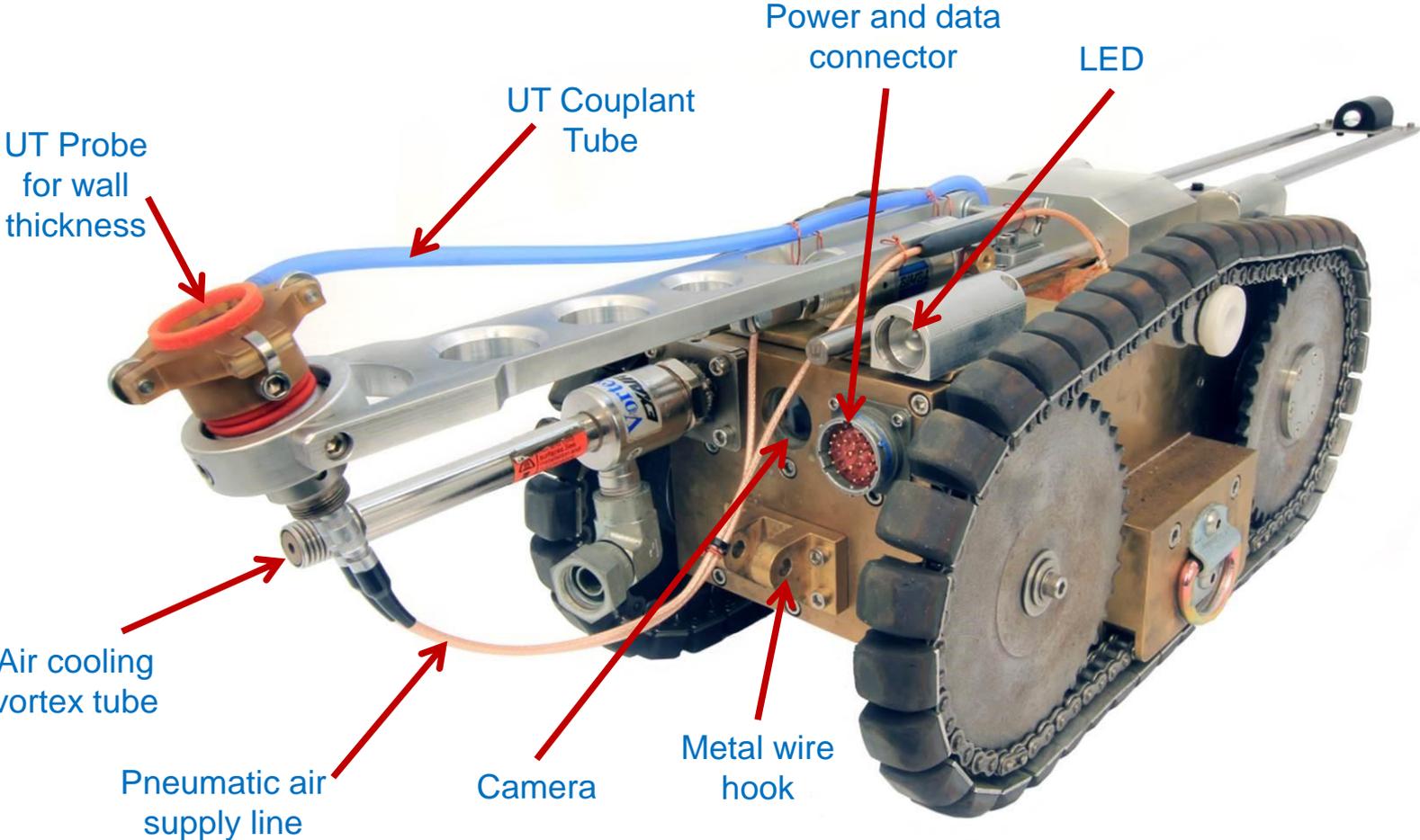
SMART Robot Design

Side View



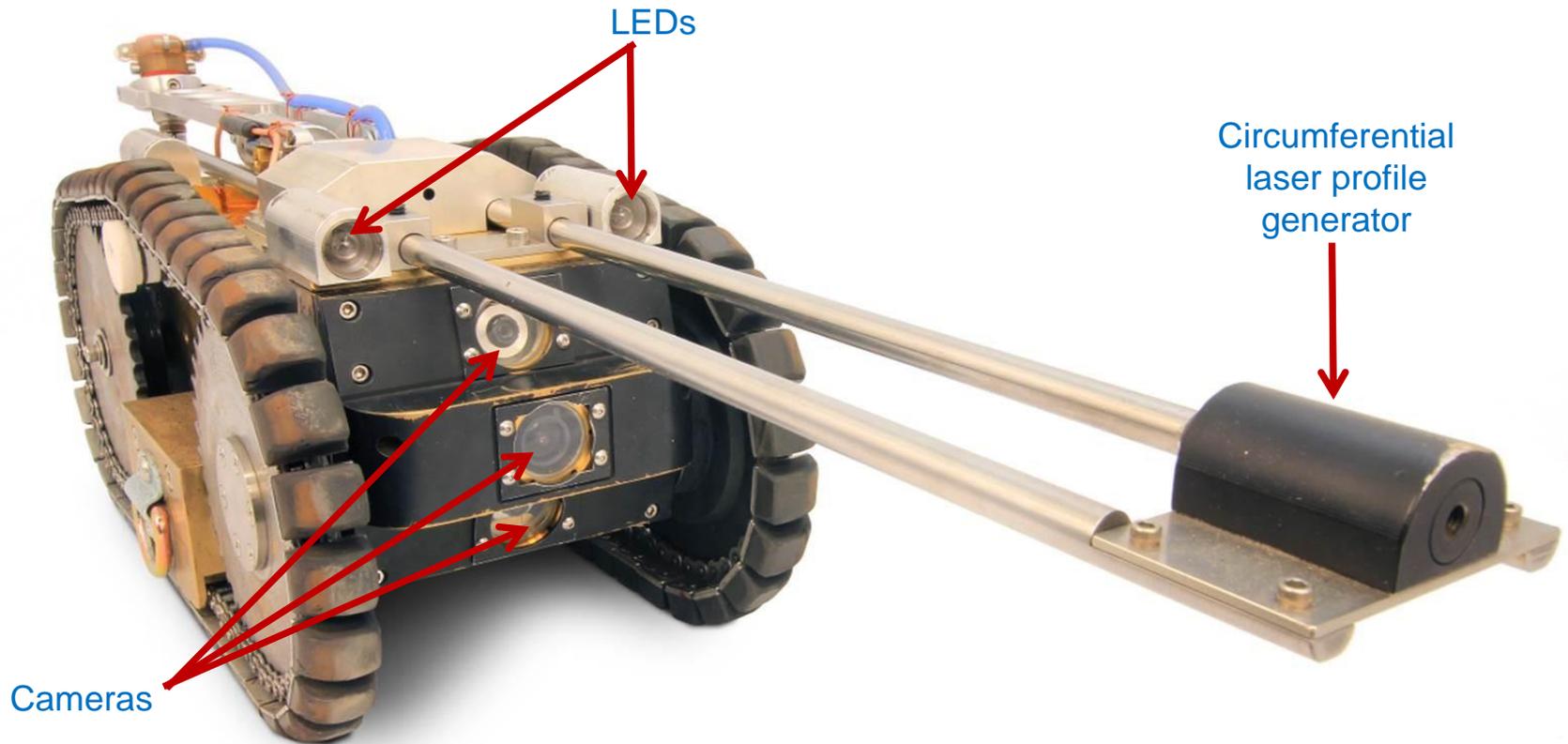
SMART Robot Design

Rear View



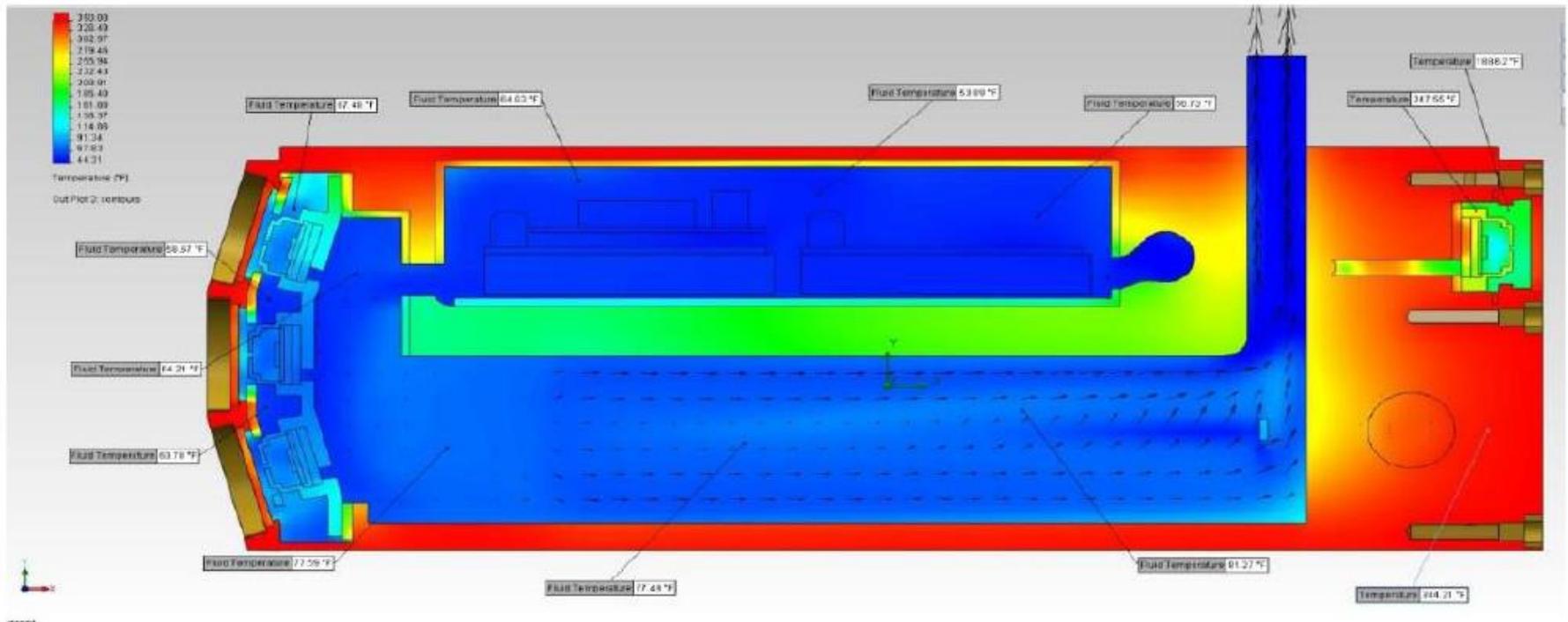
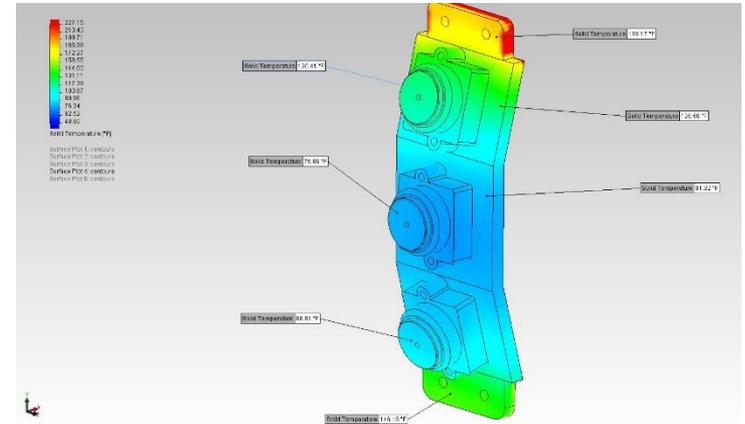
SMART Robot Design

Front View



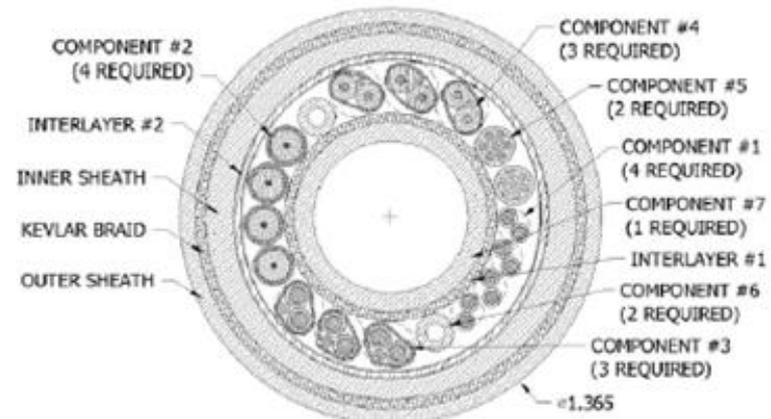
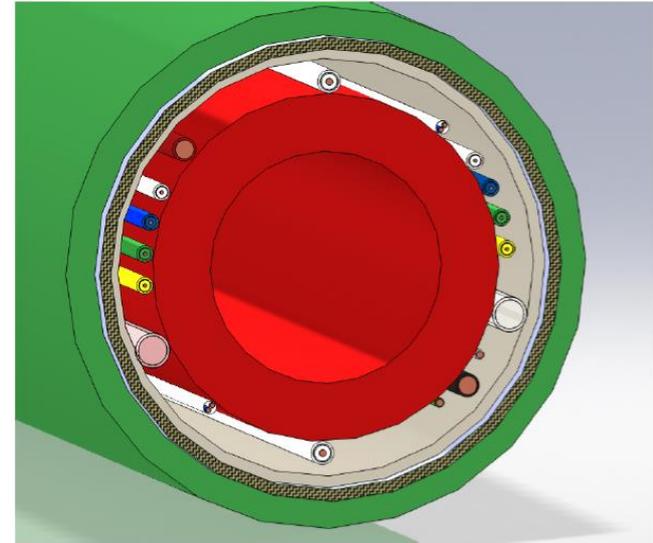
Thermal Modeling

- Maximize air flow and cooling
- Robot runs cool in steam pipe
 - Vortex Input – 70F
 - Ambient Input – 350F
 - Air Flow – 40 CFM



Custom Tether Design

- High temperature/Kevlar braid
- Data transmission
- Supplying power to robot
- Delivering cooling air
- Delivering air for pneumatic control
- Delivering couplant for UT sensing



Operator Control System

- Self-contained rugged case
- On-board computing
- Robot control
- Data logging capability
- Video displays
- Custom software
- Sensor measurement viewing tools
- Navigation and Control Couplant pump
 - Manual steering
 - Cruise control
 - Auto-balance steering
 - Prevents climbing up pipe wall and tipping over

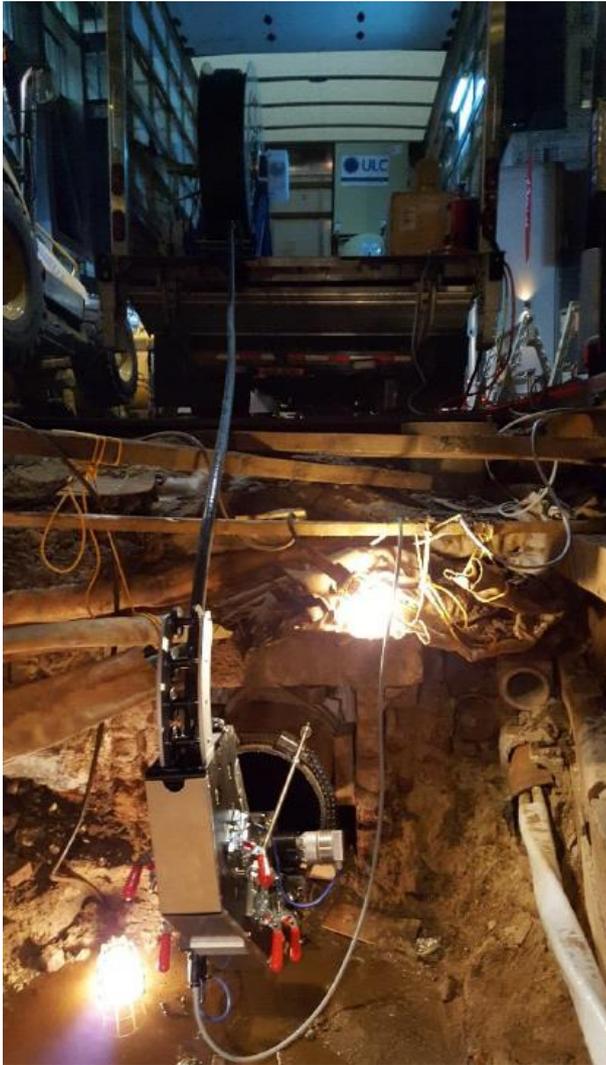


Support Equipment

- Tether management
 - Winding/Unwinding
 - Feeding forward and reverse
 - Protection
- Generator
- Compressor and chiller
- Couplant pump
- Hoisting equipment



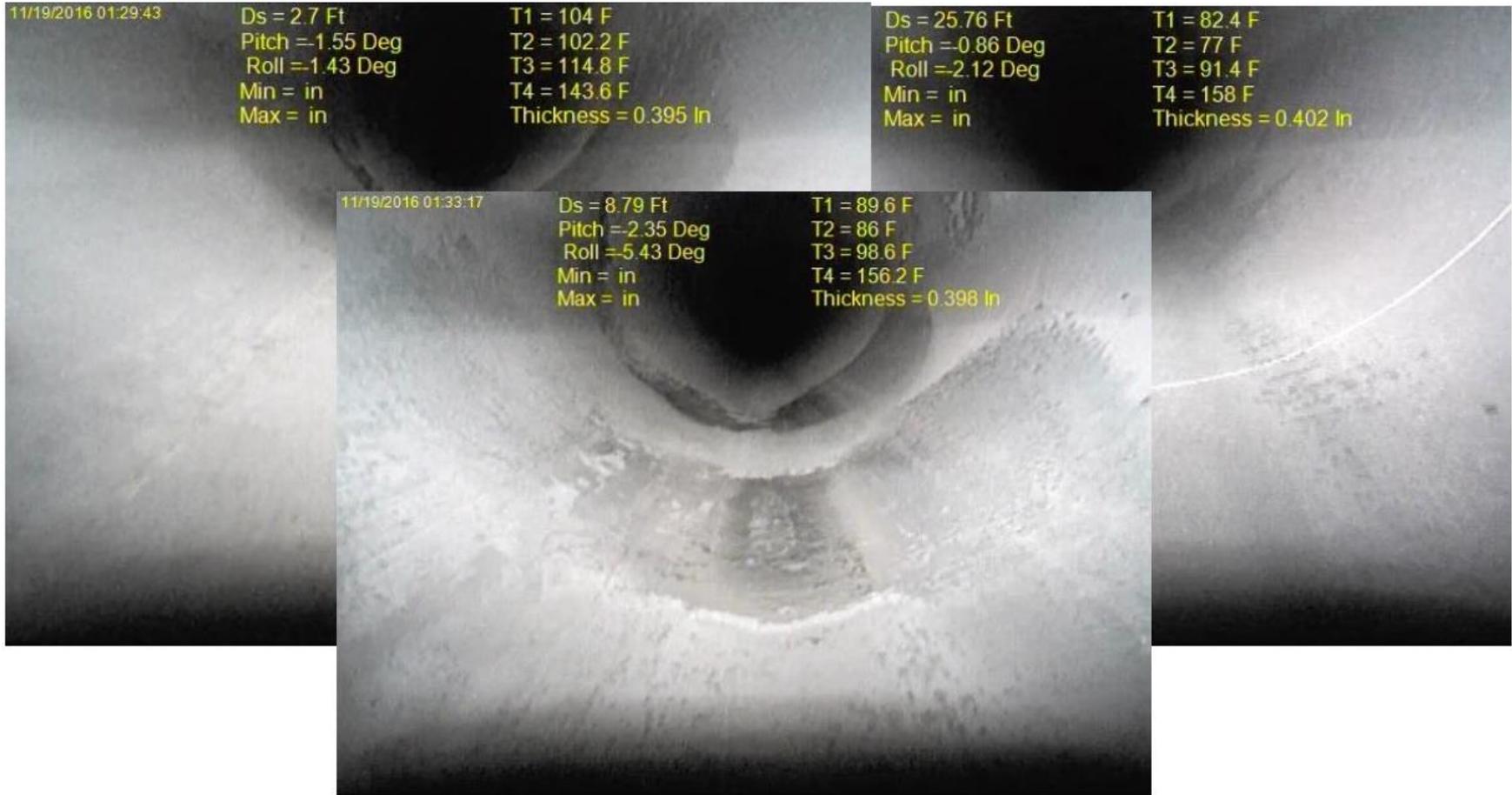
Tether Feeder



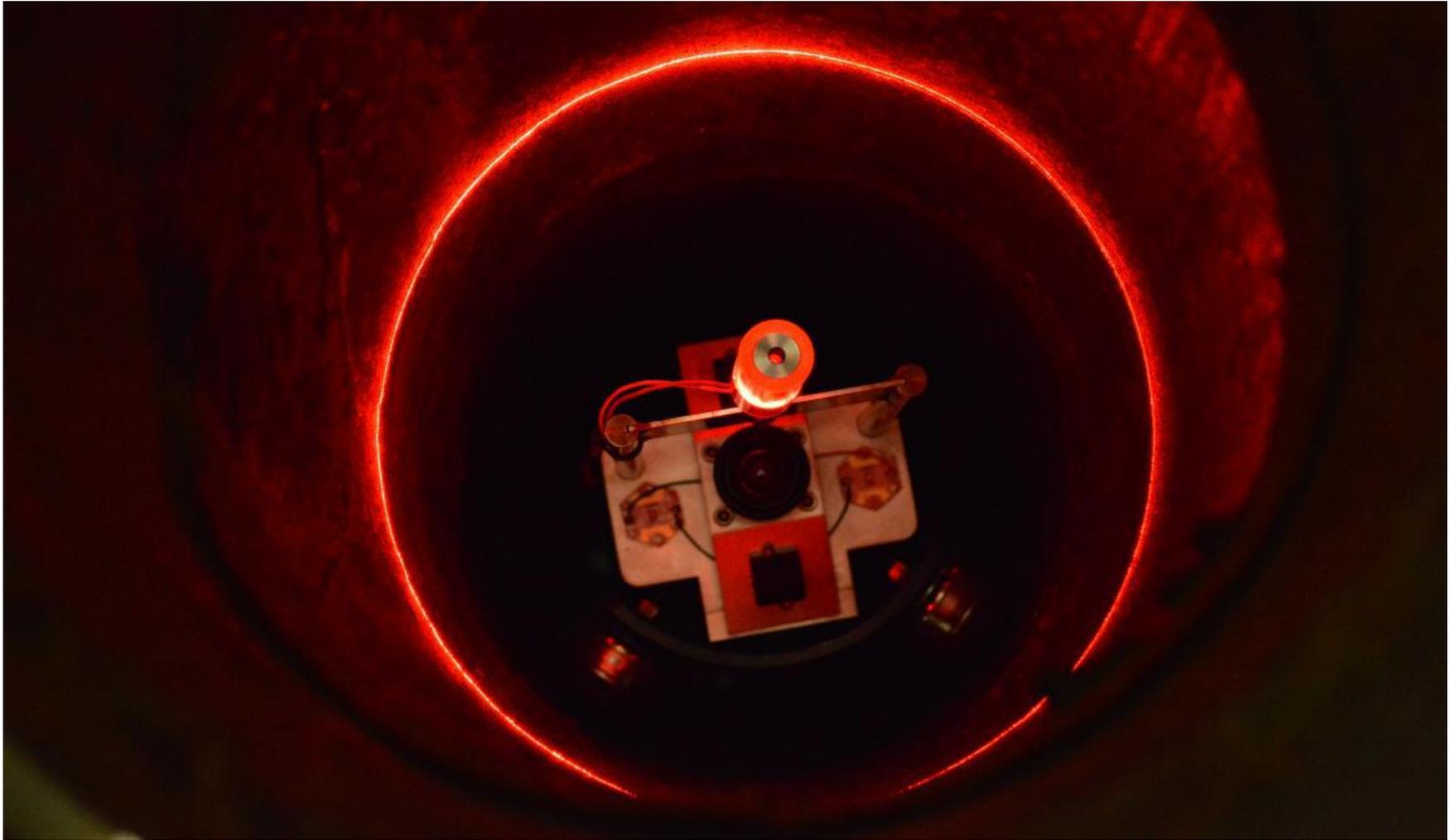
Ultrasonic Based Wall Thickness



Ultrasonic Wall Thickness Measurements



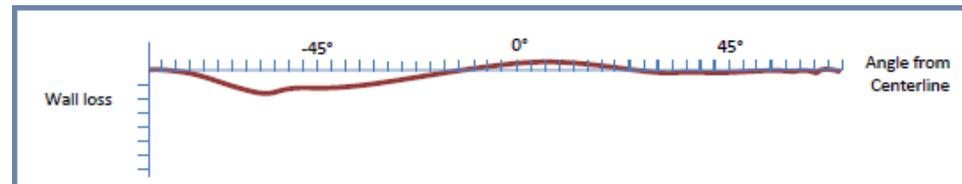
Laser Profilometry



Laser Profilometry

- Image From The Downward Facing Front Camera Is Processed To Determine The X-Y Location Of The Laser Profile
- Based On The Known Pipe Diameter, The Level Of Wall Loss Or Other Defects Can Be Measured
- Defects May Be Plotted Against Clock Position Or Circumference
- Can measure from 4 o'clock To 8 o'clock Positions

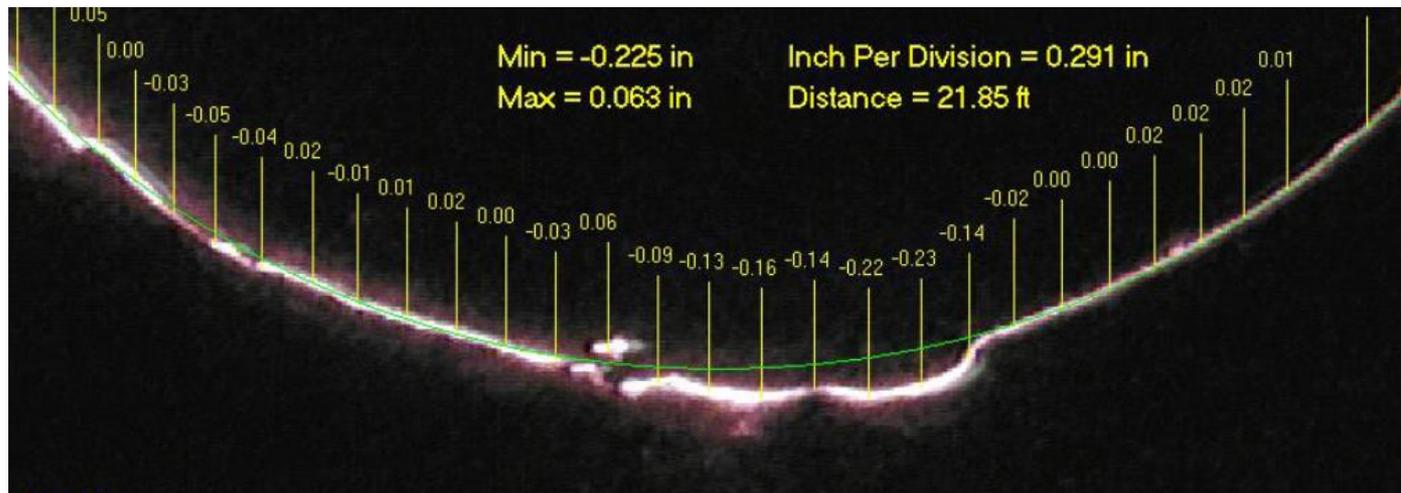
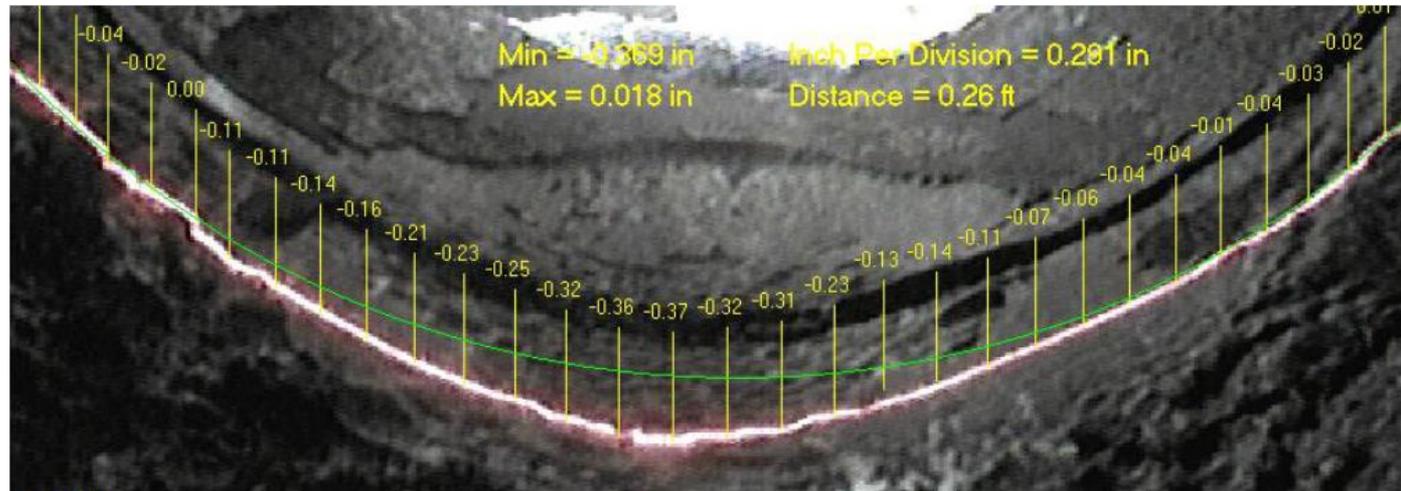
Flow
Accelerated
Corrosion



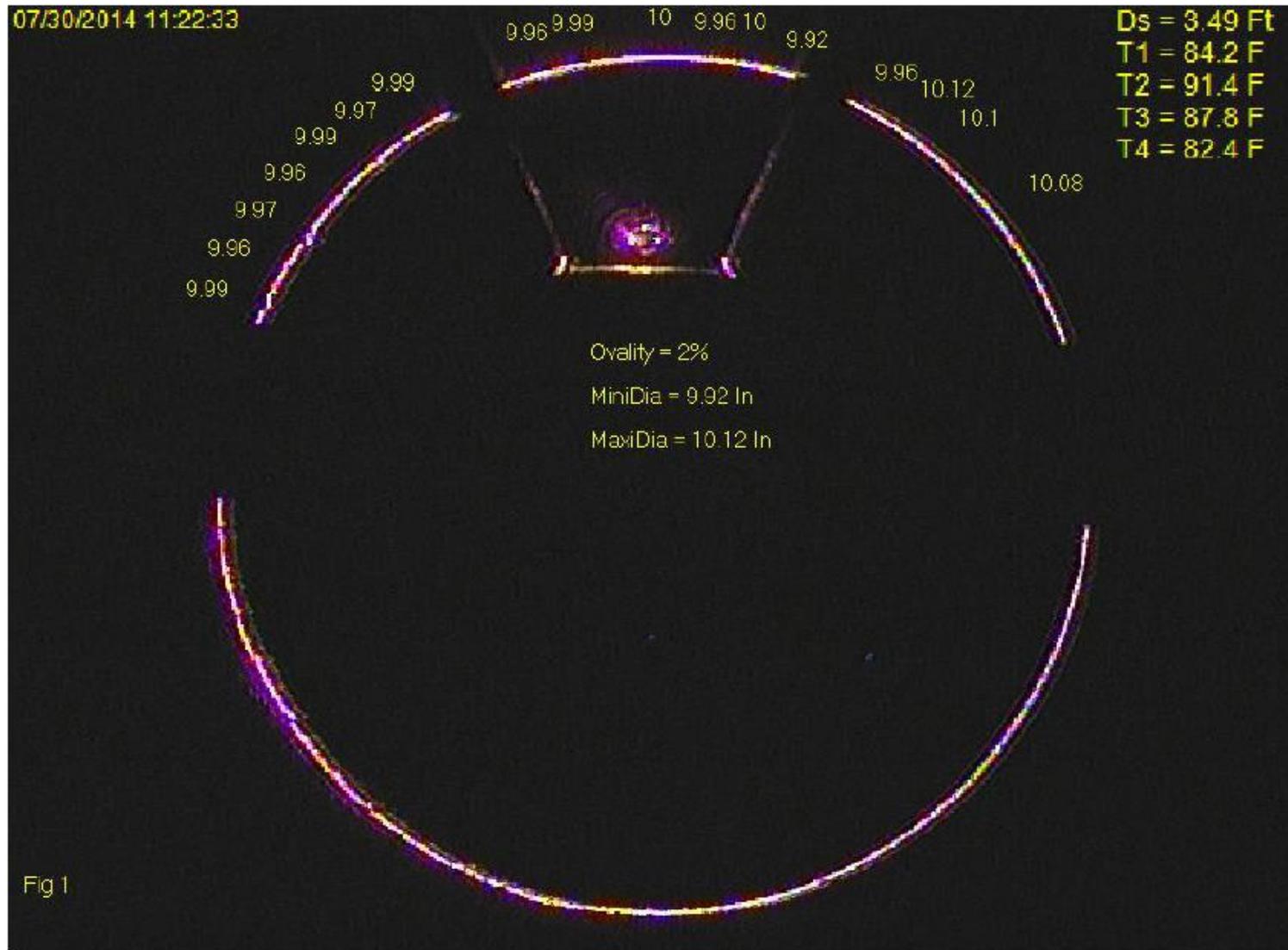
Laser Profilometry



Flow Accelerated Corrosion Measurement



Pipe Ovality Measurement

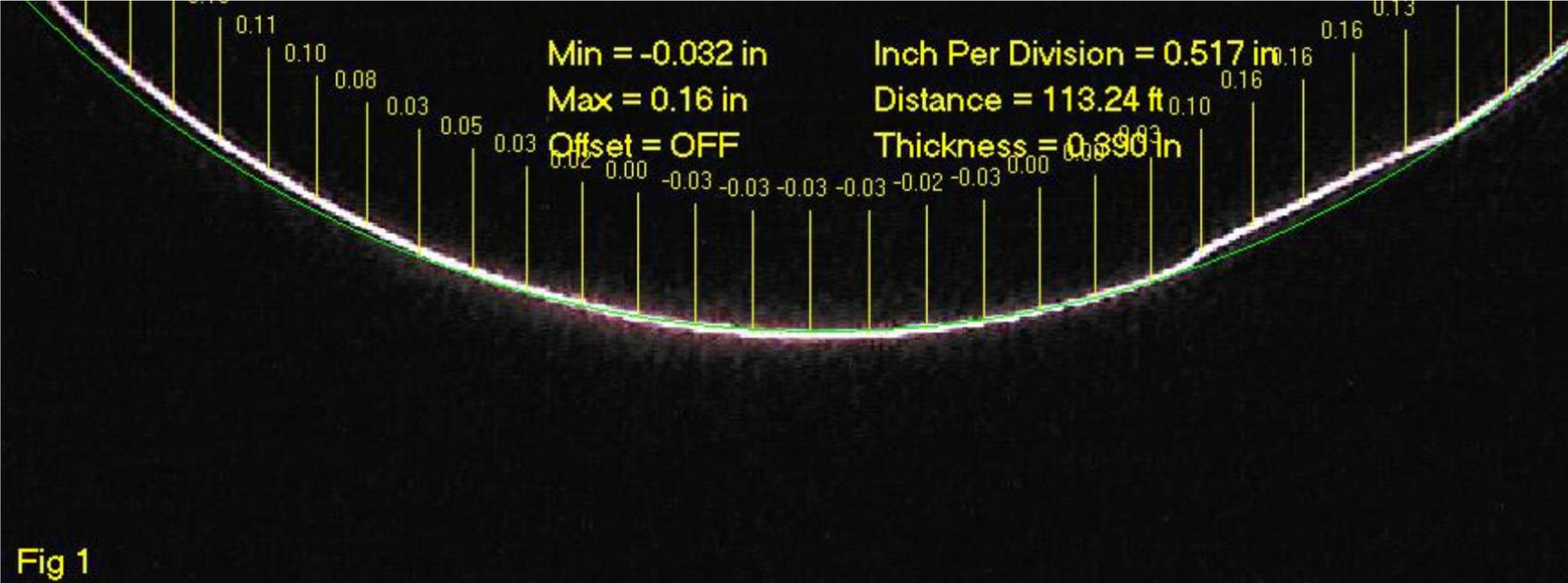


Field Test at John Street

- Robot maintained temperature of 70° F while internal pipe had a temperature of 147° F
- Inspected 110 feet of existing 8" main
- Software was able to determine ovality between 1% to 3%
- Successfully traversed expansion joint
- Quick deployment and retrieval



Laser Profilometry – Field Testing



Benefits

- Time savings
- Automated reporting
- Mapping of pipe features
- Developing pipe integrity assessments
- Real recorded pipe data for input into failure models
- Recorded pipe data for post failure analysis
- Improving safety

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