Structural Health Monitoring

Utilizing Installed UT Sensor Technology to Assess Infrastructure

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Outline

- UT sensor technology meets Structural Health Monitoring (SHM)
- How is the technology being utilized TODAY
    - Applications
    - Scenarios
    - Case Studies
- Technology deep dive

What do all these have in common?

- Aging infrastructure
- Aging workforce
- More regulation
- More safety concerns

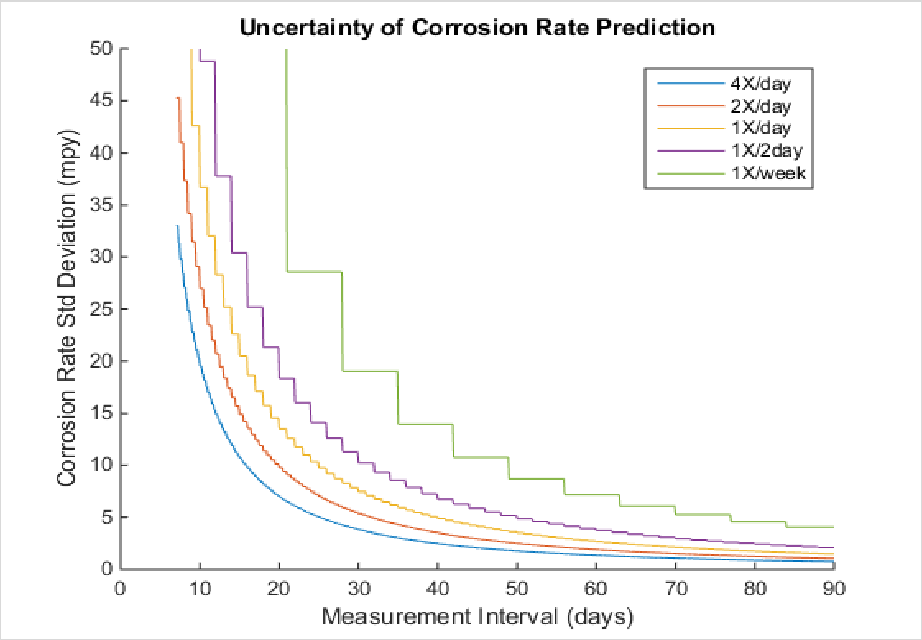
SENSOR NETWORKS, INC
Installed ultrasonic sensors for asset-integrity monitoring

Installed UT Sensors

- Conventional UT thickness gauge/flaw detector **BUT**
- Low power / power management for years of battery life
- Wired/wireless connectivity
- Permanently installed transducers
- Frequent measurements
- Data accessibility

Measurement Uncertainty

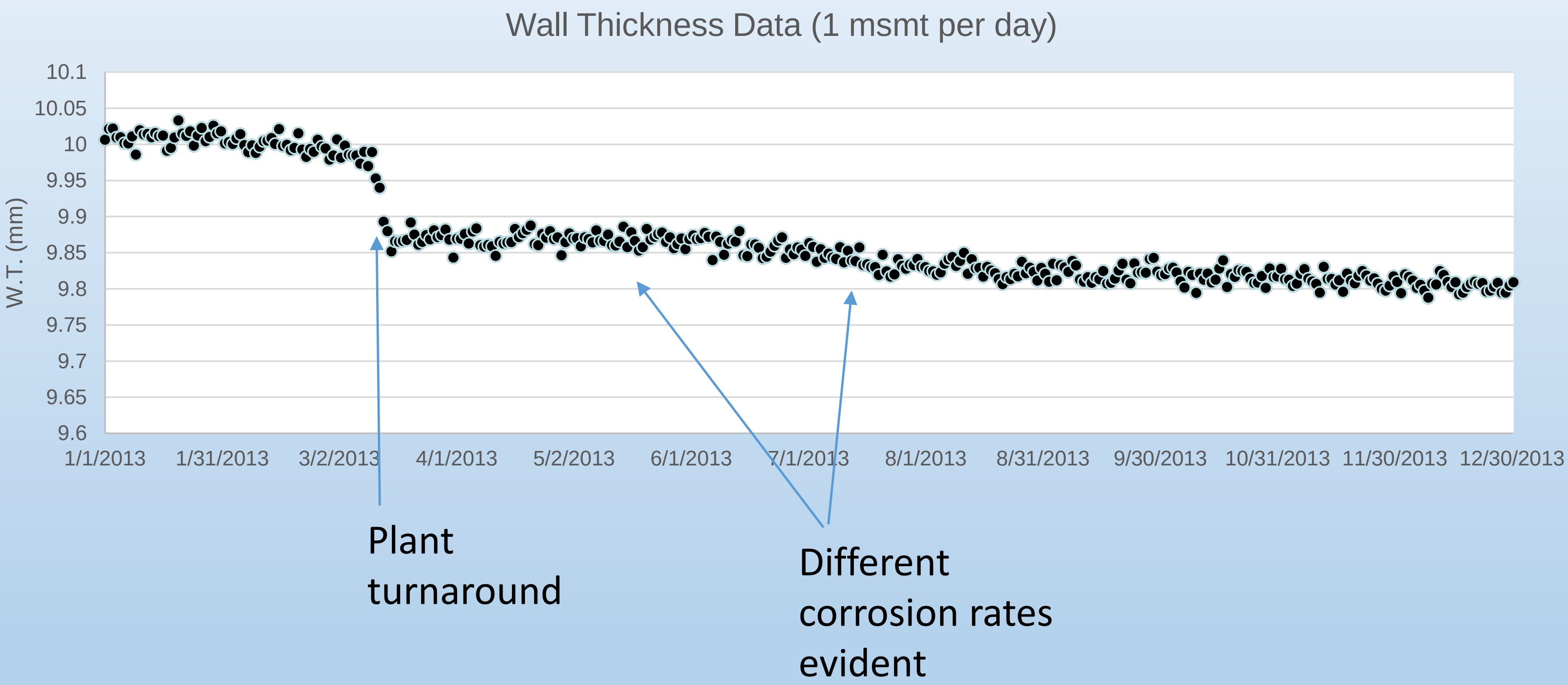
- Precision can be achieved that exceeds the precision of the base measurement.
- Uncertainty can be calculated (with assumptions)
- A more precise measurement system moves the curves to the left
- Factors:
  - Standard deviation of the measurement system
  - Measurement frequency
  - Measurement interval



$$s_m^2 = \frac{\frac{1}{n-2}\sum_{i=1}^{n}(y_i - Y(x_i))^2}{\sum_{i=1}^{n} x_i{}^2 - \frac{1}{n}\left(\sum_{i=1}^{n} x_i\right)^2}$$

$$95\%\ C.I. \cong m \pm 2s_m \ \ (n - 2 \geq 6)$$

Process feedback



- Another tool/data source for the plant engineer

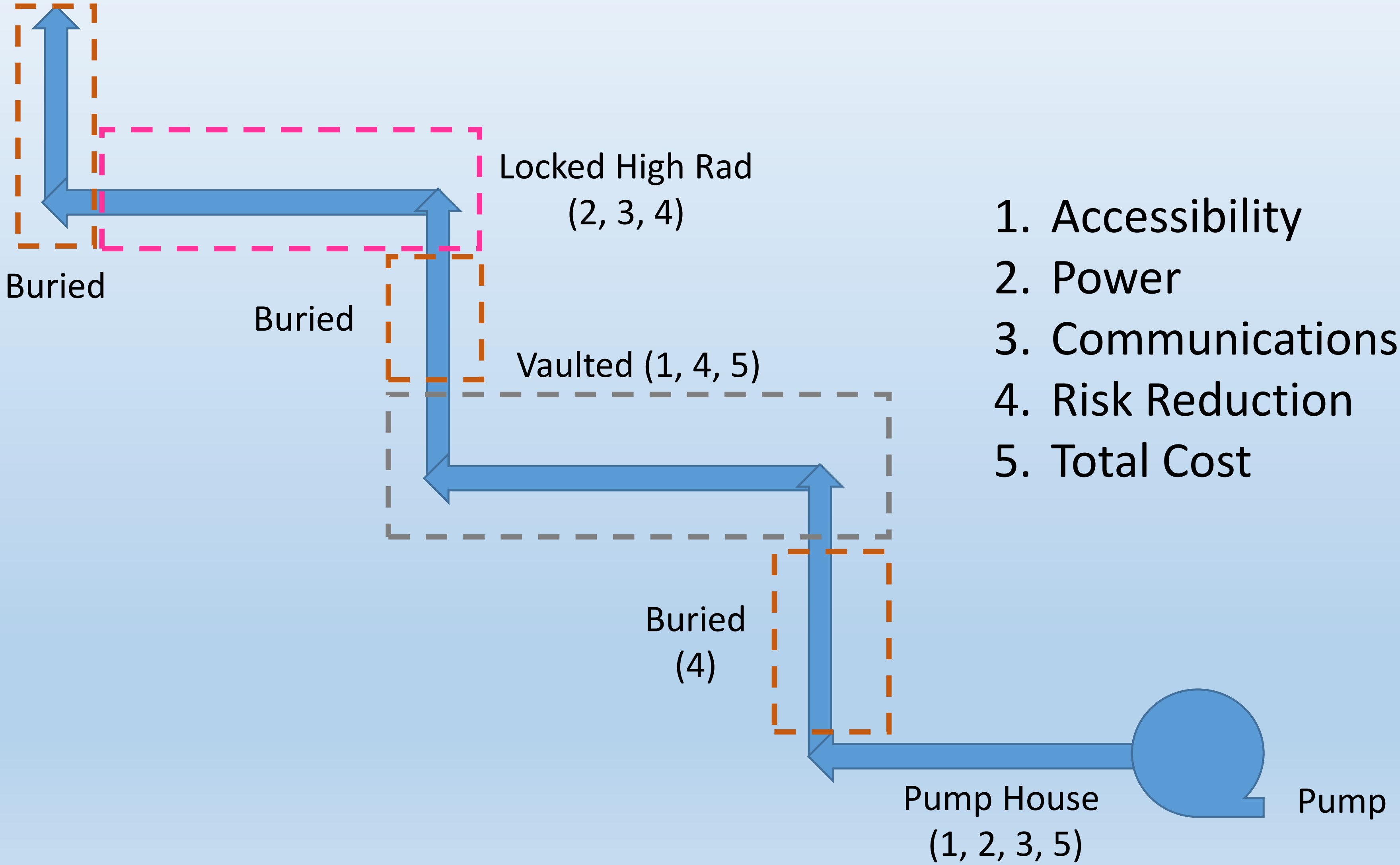
What can be monitored?

- Wall thickness: Accuracy <0.01”, Precision <0.001”
- Corrosion rate: < 5 mils/yr
- Flaws? Yes but highly application dependent (like conventional UT)

Where to apply – for PG apps …

- Anywhere that monitoring brings VALUE
  - In conjunction w/ mass screening techniques (mark & apply)
  - Known problematic (historic or 'educated') areas
  - Coverage strategies vary depending on application
- Key strategies:
  - Monitoring – value linked to process feedback. Use the data to improve process and reduce future damage. **High frequency of data … sensor lifetime reduced – 3-5 yrs / battery**
  - Inspection – value linked to savings over conventional inspections from a cost/safety perspective. i.e. reduced access cost, insulation removal / scaffolding, etc., reduced dose. **Low frequency of data … sensor lifetime maximized – 10+ yrs / tethered**
- Examples:
  - Buried piping
  - High point vent
  - Containment

Buried Pipe Monitoring Schematic



1. Accessibility
2. Power
3. Communications
4. Risk Reduction
5. Total Cost

UT Sensor Case Studies – Oil & Gas

Process Control

- Corrosion RATE monitoring
- Chemical inhibitor injection mgmt.
- Different crude TAN rates require more/less chemical to reduce exposure to wall loss
- **Temporary UT wireless sensors** placed in misc. areas **(1 reading per hour for 3 months)**
- Reduction in chemical inhibitor spend varying based on crude slate (in this instance is estimated to be **~$20K/wk.**)

Inspection

- Localized corrosion monitoring
- Gas spheres
- "underbelly" pitting/corrosion
- Inspection crews sent bi-weekly to inspect known areas on 4 spheres
- **Cost $25K** each time
- Manual UT gauges marked "low" spots, **tethered UT sensors** placed (**3 readings per wk. using tablet**)
- Saved **>$150K in first 3 months** of program

Re-Engineering

- TML reduction programs
- **Cellular UT sensors** in lieu of manual inspection (**2 readings per month**)
- <1 mil/yr. for +5 yrs.
- 27,000+ TML locations, **cost >$3M to inspect** 1/3 per year
- Were able to reduce from 27,000 TML points to 13,000 TMLs
- **Saving ~$1.7M/yr** in manual inspection cost

Q&A

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