The Value of Condition-Driven Asset Management for Buried Infrastructure Assets

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Optimizing Asset Management

1. What is the current state of my assets?
   - Develop Asset Registry
   - Assess Performance, Failure Modes
   - Determine Business Risk ("Criticality")

2. What is my required level of service?
   - Determine Residual Life
   - Determine Life Cycle & Replacement Costs

3. Which assets are critical to sustained performance?
   - Optimize O&M Investment
   - Optimize Capital Investment

4. What are my best O&M and CIP investment strategies?
   - Optimize O&M Investment
   - Optimize Capital Investment

5. What is my best long-term funding strategy?
   - Determine Funding Strategy
   - Build AM Plan

- Condition Assessment Protocol; Rating Methodologies
- Set Target Levels of Service (LOS)
Planning of Buried Asset Renewal

*Maximizing Value of Replacement & Rehabilitation Programs*

Focus Capital on Bad Pipe First

- Customer Service
  - Reliability: *Breaks per 100 miles of pipe*
  - Availability: *Water main break repair time*
- Non-Revenue Water - Real Losses
  - Real Losses: Leakage (MGY)
  - Energy Costs, e.g. Pumping ($)
- Sustainability
  - Map *Probability of Failure vs Consequence*
### Optimizing Pipeline Asset Management

**How to Prioritize Based on Condition?**

<table>
<thead>
<tr>
<th>Pipeline 1</th>
<th>Pipeline 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installed 1860</td>
<td>Installed 1860</td>
</tr>
<tr>
<td>Brown clay soil</td>
<td>Brown clay soil</td>
</tr>
<tr>
<td>Corrosive soil</td>
<td>Moderately corrosive soil</td>
</tr>
<tr>
<td>6” Cast Iron Pipe</td>
<td>6” Cast Iron Pipe</td>
</tr>
</tbody>
</table>

- **Pipeline 1**
  - Installed in 1860
  - Brown clay soil
  - Corrosive soil
  - 6” Cast Iron Pipe
  - 47.3% Measured Loss

- **Pipeline 2**
  - Installed in 1860
  - Brown clay soil
  - Moderately corrosive soil
  - 6” Cast Iron Pipe
  - 0.5% Measured Loss
Condition Assessment Pyramid
Tiered approach, each level inspects a smaller % of network

Desktop study

Survey level inspection: **Echologics Acoustic Testing**

Detailed NDT inspection

Destructive testing

- Total Replacement
- Selective Replacement
- Selective Refurbishment
- No Action

- Lowering of Risk
- Deferral of Capital
Assessing Pipe Condition

- Installed defect failure period
- Random failure period
- Degradation related failure period

Bursts per km per yr

Maximum economical failure rate

Age
Acoustic Wall Thickness Testing

- First identifies if leaks are present
- Determines the *Minimum Average Wall Thickness* between two points of the pipeline
  - Typically about 300-500 feet sections of pipe
- Works on any diameter, most materials
- Completely non-destructive, non-invasive technique
- Direct indication of
  - The current structural strength of the pipe
  - The state of degradation of the pipe
- Can be used to evaluate
  - The fitness for service of the line
  - The remaining useful life
Acoustic Condition Assessment:

*Field Testing*

Diagram showing field testing setup with noise source, RF transmitter, sensor, receiver, and PC-based correlator.
Acoustic Pipe Integrity Testing

- A low frequency acoustic pressure wave is induced in the pipe
- Dominated by a non-dispersive axi-symmetric mode ($S1,n=0$)
- This pressure wave causes pipe wall to “flex” on a microscopic level
- Thicker (and therefore stiffer) pipe walls are more resistant to this “breathing,” causing the wave to travel faster
- Measuring this phenomenon allows calculation of remaining wall thickness
Structural Wall Thickness: A Direct Measurement of Structural Strength

- Average structural wall thickness
  - Band of continuous material

Graphitized material: Not structural, not measured

Tuberculation: Not structural, not measured

Longitudinal Crack: Reduces structural thickness over its full length

Structural Wall Thickness: Maximum continuous band of metal
Summary - Creating New Options

**Condition-Driven Asset Management**

- Capital Improvement Programs lack **Direct** condition data
  - Joint leaks often false indicator of pipe condition
  - Relining programs ineffective on pipes lacking structural integrity
  - Estimate 70% of replaced pipes have remaining life

- Leakage
  - Pipe Replacement Programs do not typically address service leaks, estimated to be 2/3 of the leaks in distribution networks
  - Conventional leak detection fails on Plastic, Asbestos Cement, Subsonic Leaks

### No Condition Assessment (Historic Practice)
- **REPLACE:** $150-400/ft
- **REHAB:** $50-200/ft
- **GOOD PIPE:** $0

### Condition Assessment
- **REPLACE:** $150-400/ft
- **REHAB:** $50-200/ft
- **GOOD PIPE:** $0
Case Study: City of Newark

This is the remaining structural thickness!
Monetizing Assets Based on Condition

**Prioritization Tools**

1. Inventory buried assets
2. Determine asset criticality
3. Assess condition, e.g. Pipes
   - Determine wall thickness
   - Condition Score
4. Determine asset value and monetization plan
5. Build Investment Plan for Rehabilitation and/or Replacement
Case Study

• Need to Create a System Map of Pipeline Condition

Focus Capital on Bad Pipe First

- Customer Service
  - Reliability: *Breaks per 100 miles of pipe*
  - Availability: *Water main break repair time*

- Non-Revenue Water - Real Losses
  - Real Losses: Leakage (MGY)
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- Sustainability
  - Map *Probability of Failure vs Consequence*
WSSC AM Program Overview

- Over $1.0B is projected over the next decade to address water pipe infrastructure needs
- Increased condition assessment accuracy will result in better use of infrastructure renewal funds
- A pilot project was initiated in 2012 to inspect the pipes already scheduled for replacement to calibrate and verify the desktop model
  - Ultrasonic sensor remaining wall thickness measurements
  - Destructive testing and micrometer measurements for corrosion, graphitization, tuberculation, cracks, and degradation of internal lining
Example Measurement Comparisons

<table>
<thead>
<tr>
<th>Cooper 1.3, Ladd 2.13</th>
<th>Echologics</th>
<th>Echologics</th>
<th>Corana</th>
<th>Corana</th>
<th>Sherry</th>
<th>Dacco</th>
</tr>
</thead>
<tbody>
<tr>
<td>% loss</td>
<td>% loss 8.1</td>
<td>53.6</td>
<td>Notes 14</td>
<td>5.1</td>
<td>0.27</td>
<td>0.35</td>
</tr>
<tr>
<td>Average wall thickness (INCH)</td>
<td>0.23</td>
<td>0.35</td>
<td>0.32</td>
<td>0.37</td>
<td>0.31</td>
<td>0.36</td>
</tr>
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Determining Condition / Probability of Failure

Condition Rating Applied to Calculate the Probability of Failure

• Used 1-5 score for all assets for convenience –
  o 1 = New; 5 = Failed
  
  ![Condition Rating Scale]

  • Chose PACP/MACP since Collection System already had PACP scores from CCTV.
  • Simple and Easy to Use Scale
Prioritizing and Packing Projects
Developing Condition Scores

• Level 1: Desktop Modeling
  • Develop condition scores based on decay curves by asset type and maintenance history.

• Level 2: Inspection
  • Assess the condition of pipes targeted for rehabilitation to make rehab/replacement decisions and update Level 1 condition scores. Examples: acoustic-based testing, electromagnetic assessment, visual inspection, etc.

• Level 3: Monitoring
  • Do selective monitoring of critical (high risk) pipelines.
The Business Case for Testing Programs

• Testing is warranted for all high cost assets in order to:
  • Avoid premature replacement
  • Determine if potential rehabilitation options can be applied
  • Improve knowledge of decay mechanisms used in AM model.

• From the perspective of the utility’s balance sheet, the residual value for any asset that is replaced before it is consumed should be added to the cost of the asset replacing it.
WSSC Example: Level of Service

Bad Pipe Drives the Number of Main Breaks

[Graph showing the number of main breaks per 100 miles of pipe from 2010 to 2049 for different replacement scenarios: Do Nothing, Replace at 35 MPY, Replace at 55 MPY, Replace at 70 MPY, Replace at 85 MPY.]
Extension of Asset Life: Monitoring

• There may be some transmission mains that evidence shows are in good condition, but are critical
• Distribution Pipes will have a natural rate of rise of failure
• What is the vision
What is the vision? Integrated Technology

- Integrated Logger, network hardware, and battery
- High Sensitivity Sensor
- Hydrant Cap
Customers Looking for Enterprise Quality Solutions, Lots of data:

- Potential for very rich data
- What data do we need?
- What will we do with the data? Most utilities not good with lots of data
Continuous Monitoring
What is the potential?

Ability to track the progression of a leak from...

+4 weeks
(prior to excavation)

“It was a time bomb diffused”
Full Time Transmission Main Monitoring
Product Description: Node

Start with a sampling node:

- Cover-mounted antenna (optional)
- Power Source
- Data Logger
- Comm. hardware
- Hydrophone

EchoShore node installed in an access chamber
Nodes form continuous network

Product Description: Network

System comprised of a series of nodes:

Network of interconnected nodes monitors a service area
Customer Interface

EchoShore system easily integrates with customer infrastructure:
• Web-based application
• ESRI map display
• SCADA integration
• Full communication with nodes

The EchoShore system delivers SCADA “outside of the fence”
Continuous Monitoring
Opportunity to Expandable Functionality

<table>
<thead>
<tr>
<th>Turbidity</th>
<th>Additional input ports reserved for sensor signals</th>
</tr>
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<tbody>
<tr>
<td>Pressure/Flow</td>
<td></td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
</tr>
<tr>
<td>Chlorine</td>
<td></td>
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Opportunity to expand from advanced leak detection to customized pipeline monitoring.