Asset Management
- Pipeline Assessment
- Hydrant Assessment
- Valve Assessment
- Leak Detection
- Flushing & UDF

Advanced Solutions
- Utilis Satellite Leak Detection
- p-CAT Pipeline Condition Assessment
- ArcServer Operations Dashboard

water

Advanced Solutions
- CCTV Condition Assessment
- Manhole Inspection
- Smoke Testing

gas

sewer

- Cross Bore Elimination
- Condition Assessment
Pipeline Condition Assessment using Inverse Transient Pressure Waves

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Director
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The pipeline condition assessment challenge

Current technologies for assessing pipeline condition are often:

• Highly invasive
• Time consuming
• Disruptive
• Costly
• May not give a representative picture of pipe wall condition (average condition over long pipe lengths ≤ 300+ ft.)
Average Condition vs. Sub-Sectional Condition

The average wall thickness measurement method is simply the average wall condition between two test points.

Sub-Sectional wall thickness (p-CAT) measurement separates the pipe into multiple sections between the two test points into smaller sections (approx. 30 ft. sub-sections).

• This method provides the average for much smaller sections and finding faults that the average wall thickness technique cannot.
Average Condition vs. Sub-Sectional Condition

Often less than 2% of a pipeline is affected by serious corrosion or defects.

Example:
1,500 ft. long section where 1,470 ft. of the pipeline is 85% of its original condition
  - And, the remaining 30 ft. is severely corroded to 30% of its original condition

The acoustic method’s average wall condition would provide an average of 83.5% and report the pipeline as “good”.

Yet the pipe could still experience a catastrophic failure at any time.
Average Condition vs. Sub-Sectional Condition

The $p$-CAT method could identify this corroded section from within the 1500 ft, allowing for targeted repair or replacement and minimising risk while saving considerable cost.
Fundamental Physical Mechanisms

There is a correlation between changes in the thickness of metal and cement mortar lining forming a pipeline wall and the speed with which a wavefront from a hydraulic transient propagates along the pipeline.

Changes in this thickness give rise to reflections which can be theoretically interpreted to obtain a distribution of damage in the pipe.
Fundamental Physical Mechanisms

This theory has been developed into a non-invasive technique which can determine:

• The interior and exterior condition of pipelines including corrosion and cement mortar lining spalling
• Wall loss
• Locations of leaks, air pockets and blockages
• The sealing status of valves, closed valves and cross-connections
Fundamental Physical Mechanisms

\[ a = \sqrt{\frac{K}{\rho W}} \]
\[ e_{eq} = e_m + e_c \times \frac{E_c}{E_m} \]

a = speed of propagation of hydraulic transient pressure wave
K = bulk modulus of water
\( \rho \) = density of water
E = Young’s modulus of elasticity of the pipeline wall material
D = internal diameter of the pipeline
\( e_{eq} \) = wall thickness of a single material pipe
or
the total equivalent wall thickness of the composite material pipe
\( e_m \) = thickness of the metal wall component
\( e_c \) = thickness of the cement lining wall component
\( E_m \) = Young’s modulus of elasticity of the metal
\( E_c \) = Young’s modulus of elasticity of the cement lining
psi = pipeline restraint factor.
Fundamental Physical Mechanisms

Properties of steel, cement and water at 15°C

\[ E_s = 210 \text{ GPa} \]
\[ E_c = 25 \text{ GPa} \]
\[ K = 2.14 \text{ GPa} \]
\[ \rho_w = 999.1 \text{ kg/m}^3 \]
\[ \rho_s = 7850 \text{ kg/m}^3 \]
\[ \gamma_w = 9.8 \text{ kN/m}^3 \]
\[ \gamma_s = 77.0 \text{ kN/m}^3 \]
\[ \gamma_c = 23.0 \text{ kN/m}^3 \]
\[ \nu_s = 0.30 \]
\[ \nu_c = 0.15 \]
Morgan – Whyalla pipeline testing example
Morgan – Whyalla pipeline testing example
Ultrasonic wall thickness measurements

- Average wall thickness
- Position 1
- Position 2
- Position 3
- Position 4
- Position 5
- Position 6
- Position 7
- Position 8

Values range from 3.5 to 7.0.
Transient reflections vs. Ultrasonic
Transient reflections vs. Ultrasonic
Transient reflections vs. Ultrasonic

Sections of recovers pipe
Identification of Anomalies

Signal Analysis Overview

• The key benefit of p-CAT is the identification of pipeline anomalies (localised pipeline faults) with approx. 10 m spatial accuracy along a pipeline.

Anomalies

Significant reflection from large air pocket
Identification of Anomalies

Detailed Signal Analysis

- Anomalies A to F are described in the next table.
# Identification of Anomalies

Example summary of anomalies detected in previous plot segment

<table>
<thead>
<tr>
<th>Anomaly Identifier</th>
<th>Approx. Location</th>
<th>Interpretation</th>
<th>Priority</th>
<th>Recommended Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>340m from FP2 towards FP3</td>
<td>Unknown structural component or air pocket</td>
<td>Medium</td>
<td>Check records to determine if repair has occurred</td>
</tr>
<tr>
<td>B</td>
<td>SV4</td>
<td>Change in pipe wall thickness</td>
<td>Low</td>
<td>None, known feature.</td>
</tr>
<tr>
<td>C</td>
<td>153m from SV5 towards FH9</td>
<td>Concrete encasement</td>
<td>Low</td>
<td>None, known feature.</td>
</tr>
<tr>
<td>D</td>
<td>402m from FP10 towards SCV2</td>
<td>Unknown structural component or air pocket</td>
<td>Medium</td>
<td>Check records to determine if repair has occurred</td>
</tr>
<tr>
<td>E</td>
<td>18m from SCV2 towards SV5</td>
<td>Unknown structural component or air pocket</td>
<td>Medium</td>
<td>Check records to determine if repair has occurred</td>
</tr>
<tr>
<td>F</td>
<td>13m from FP11 towards FH12</td>
<td>Discrete large air pocket</td>
<td>HIGH</td>
<td>Check valve operation at pit and check air valves.</td>
</tr>
</tbody>
</table>
Valve Sealing

• The status of in-line isolation valves is important for operational effectiveness

• Closed valves in network systems can seriously compromise hydraulic efficiency

• Knowing if a cross-connection between potable and recycled water systems occurs is also important
**p-CAT™ - Benefits / Advantages**

- Non-Invasive
- Not disruptive
- Minimal or no civil costs required
- Generally minimal or no site preparation required
- Use existing assets to test from (hydrants, air-valves, etc.)
- Distance between fittings can be 3000 ft. or more
2006 – 2016 Field Program

For 27 different clients –

• Such as water utilities, councils, contractors and mining companies

For over 70 different pipeline systems

For over 700km / 450 miles of pipeline
**p-CAT™ - Suitability**

- Potable water
- Force Mains

**Materials:**

- CI, CICL, DI, DICL, steel, AC, concrete
- PCCP, theoretically, yes but untested to date
Thank You!

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