Integrated Wireless Sensing Technology for Surveillance & Monitoring of Bridge Scour

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Scour in the UK

- Scour is identified as key risk to infrastructure arising from the long term gradual climate change *(Defra, 2012)*.

- 40% chance that at least one rail structure will fail each year due to a flood event *(JBA, 2004)*.

- Main cause of more than 130 railway bridge failures in the UK with an average cost of damage over £1 million/year *(RSSB, 2005)*.
Bridge Failures

• Scour is **inspected visually** due to technical and cost issues.
• It can cause sudden loss to a structure without apparent signs of impending failure.

The collapsed Northside bridge in Workington (Cumbria, 2009) *(source: Byrne, 2009).*

The Malahide viaduct failure (Ireland, 2009) *(source: RAIU, 2011).*
To develop a Scour Monitoring System in order to provide real-time safety surveillance.
The capacitive principle is used for the first time for scour/deposition monitoring.

Scour probe is equipped with several capacitive sensors.

Between the two rings a high frequency electromagnetic field is generated penetrating the soil outside the tube.

The signal of the sensor is a function of the permittivity of the medium surrounding the shaft.
Scour Monitoring System

![Diagram of Scour Monitoring System]

- Water level
- Sensor response over time
- Original riverbed
- Riverbed after scour
- Capacitive sensor
- Anchor system
- Not To Scale

Solar Panel for power energy harvesting
RF signal
WDAS
Concrete Pier
Flow
Tube for Data transfer
Wires data conduit
Power Cable
Wind Turbine for power harvesting

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Sensor evaluation under different environmental conditions:
Sensor Evaluation

- Long term degradation test:
Sensor Evaluation

- Scour/sediment deposition test:
Sensor Evaluation

- Temperature influence:

**Fresh Water**

- Gravel
- Sand
- Fine Sand
- Silt-Clay

**Saline Water**

- Gravel
- Silt-Clay
- Fine Sand
- Sand

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## Comparison

<table>
<thead>
<tr>
<th>Method</th>
<th>Scour/Deposition monitoring</th>
<th>Accuracy</th>
<th>Durability</th>
<th>Applicability</th>
<th>Cost ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diving</td>
<td>X</td>
<td>Low</td>
<td>N/A</td>
<td>Low</td>
<td>1,000*</td>
</tr>
<tr>
<td>Sonar</td>
<td>✓</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>5,000-15,000**</td>
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<tr>
<td>Automatic Sliding Collar</td>
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<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>10,000***</td>
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<tr>
<td>Ground Penetrating Radar</td>
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<td>Medium</td>
<td>N/A</td>
<td>3,000-10,000*</td>
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<tr>
<td>Global Positioning System</td>
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<td>High</td>
<td>N/A</td>
<td>Low</td>
<td>5,000-20,000**</td>
</tr>
<tr>
<td>Float out devices</td>
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<td>Medium</td>
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<td>Low</td>
<td>3,500***</td>
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<tr>
<td>Optical sensors</td>
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<td>Time Domain Reflectometry</td>
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<td>Medium</td>
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<td>Tilt/Vibration Sensor devices</td>
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<td>High</td>
<td>High</td>
<td>500***</td>
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<tr>
<td>Sounding Rods</td>
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<td>Medium</td>
<td>Low</td>
<td>7,500***</td>
</tr>
</tbody>
</table>


| Capacitance Scour Probes       | ✓                          | High     | Work in Progress | Work in Progress | 300          |

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Conclusions & Next Steps

✓ High conductivity due to increased temperature and salinity was found to have contrasting effects on the sensor output amplitudes.

✓ Technique is capable of monitoring scour and sediment deposition processes under different environmental conditions.

➢ A new capacitive sensor with an improved geometry is currently being trialled in the laboratory.

➢ Development of monitoring system and implementation to a scour-critical bridge is planned.

➢ Application of the monitoring technique to offshore wind turbine foundations is proposed.
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Q & A

Control Coordination & Data Processing

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