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COLLEGE OF  
ENGINEERING AND  
PHYSICAL SCIENCES

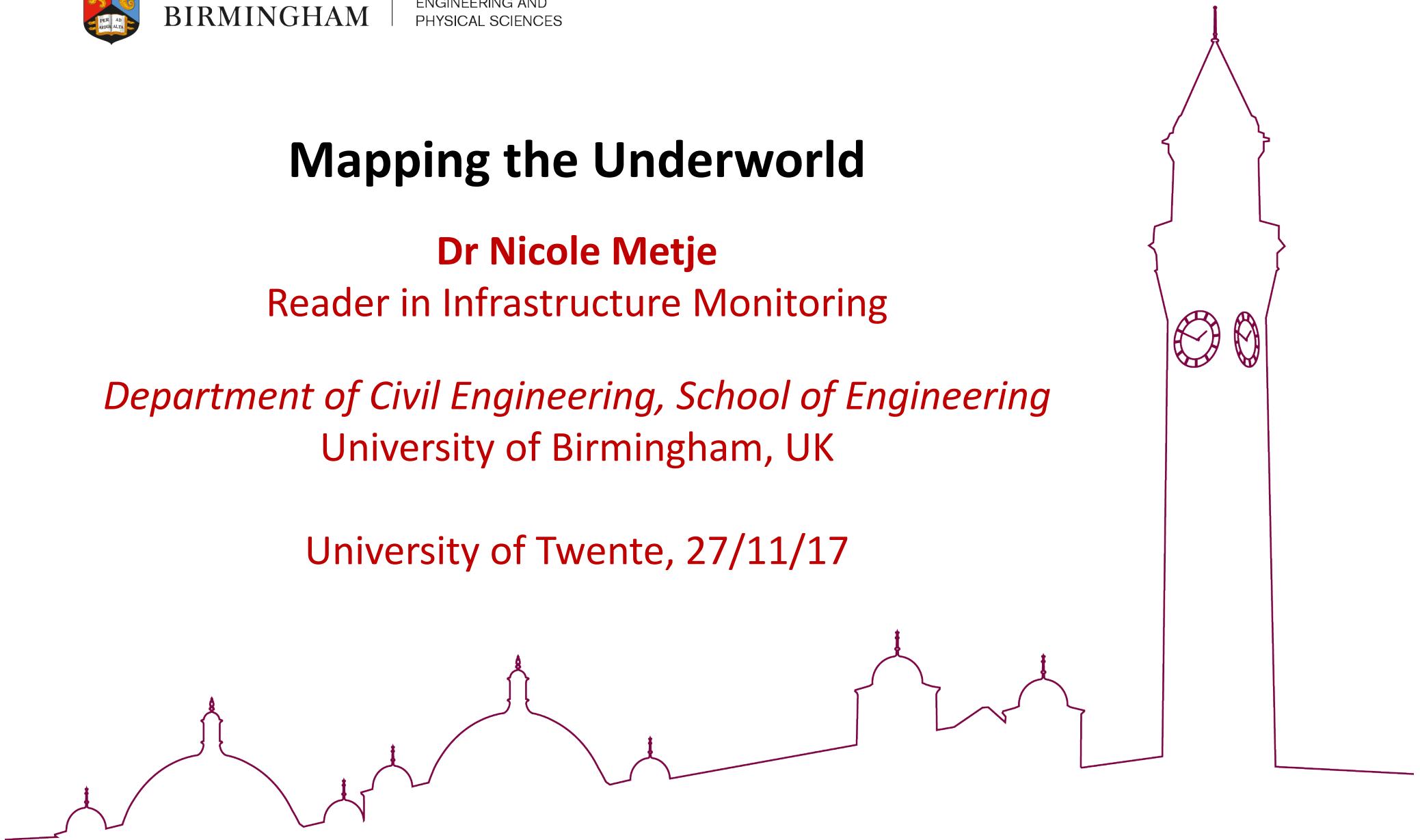
# Mapping the Underworld

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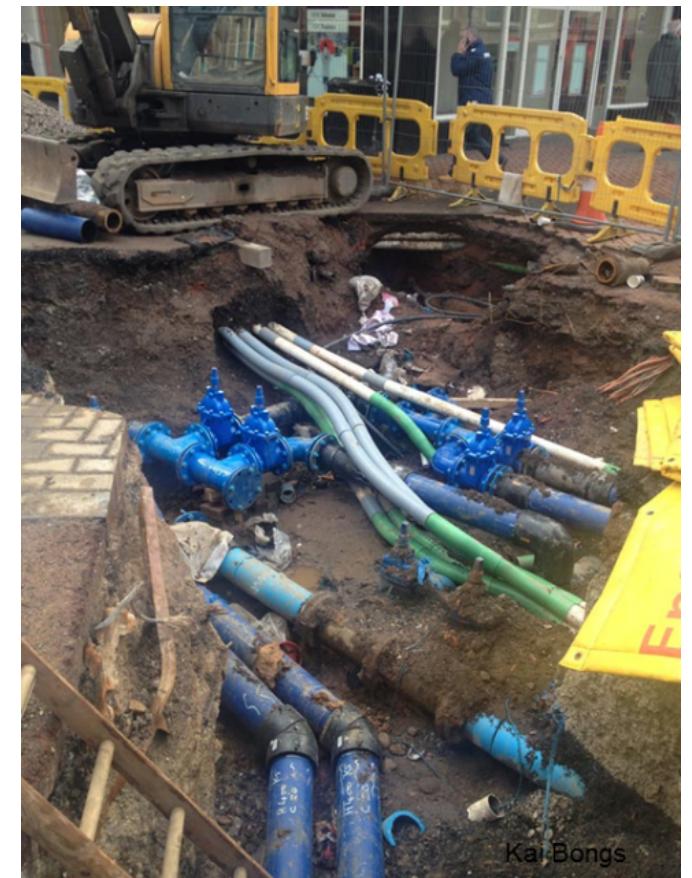
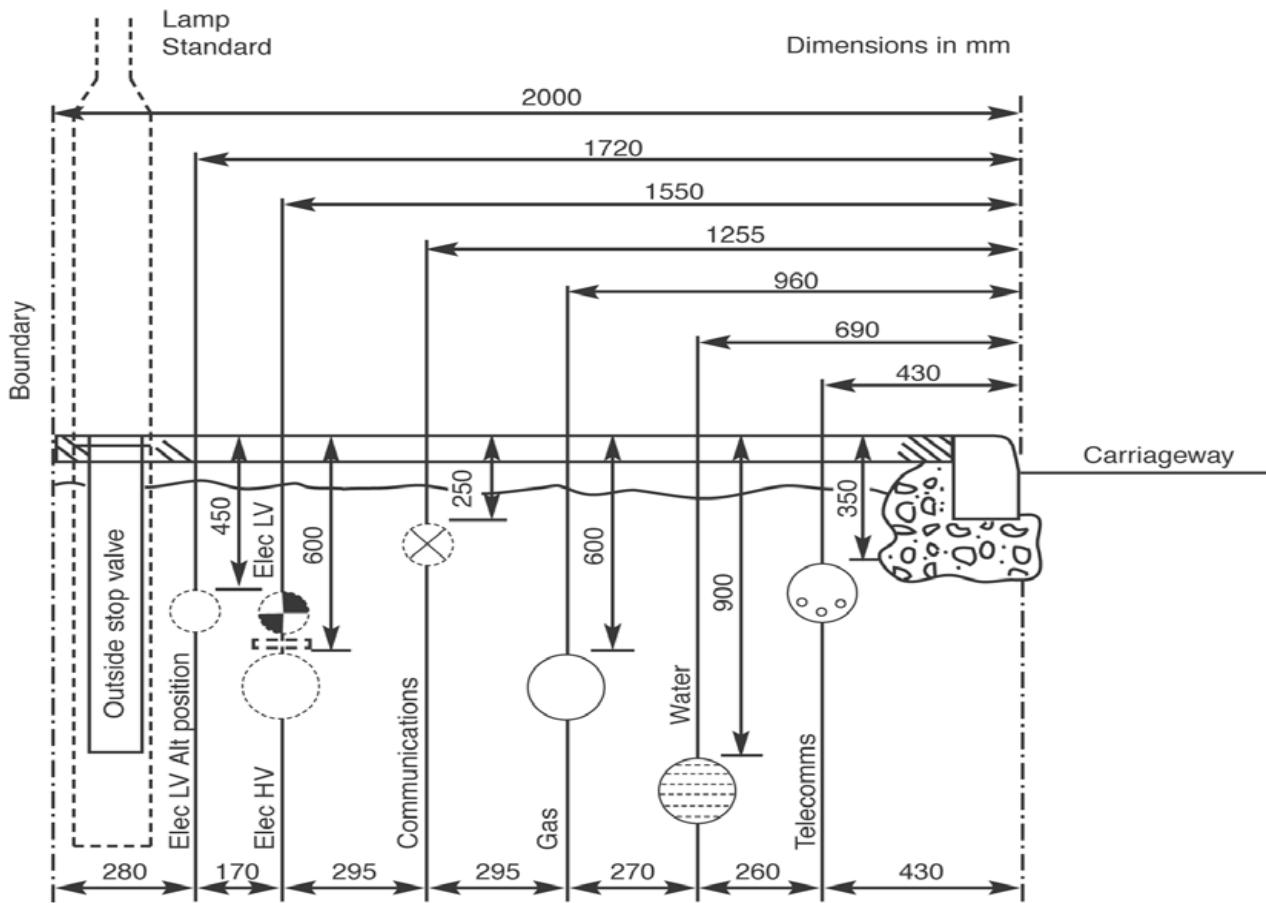
University of Twente, 27/11/17



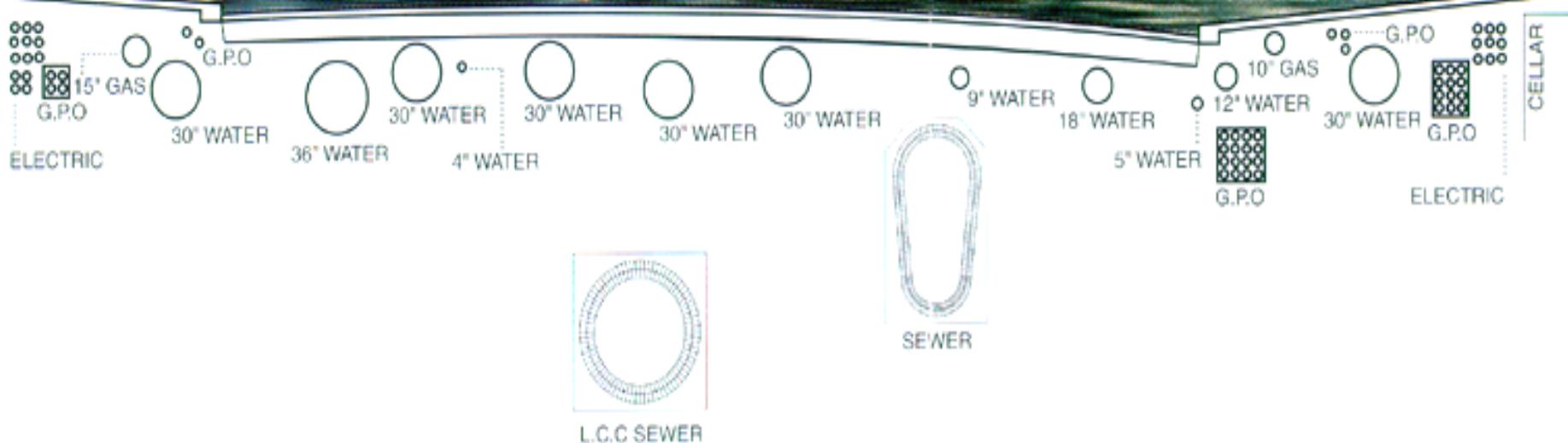
# Overview

- Background
- Mapping the Underworld
- Assessing the Underworld
- Quantum Technology
- Smart Pipes
- Return on Investment Calculation
- New Research Facility – National Buried Infrastructure Facility

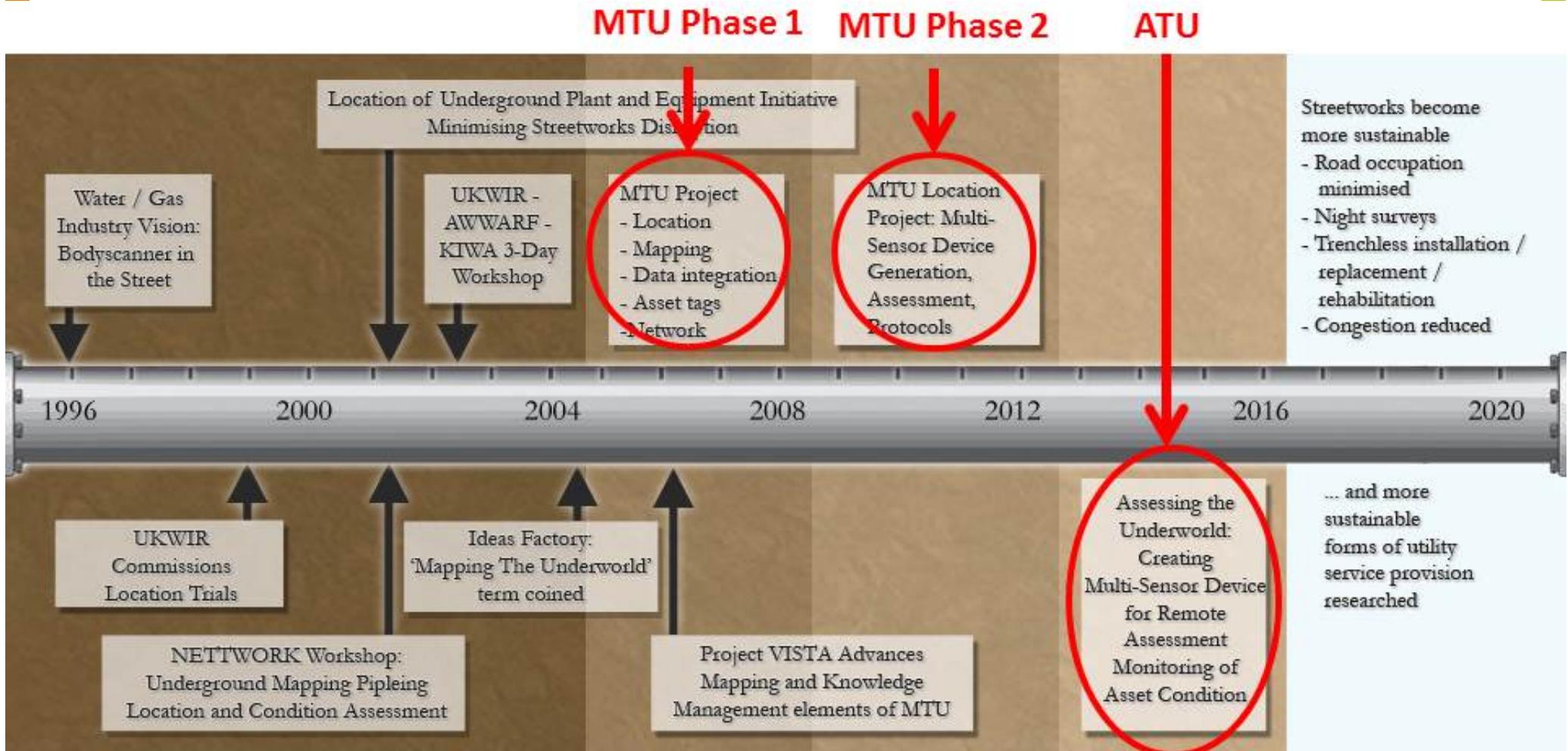
# Nominal Position of Buried Utilities



# A Street in London



# Mapping the Underworld Initiative



Utility companies conceived of a multi-sensor scanner  
... part of a 25 year initiative to remove the need  
for excavation when finding utilities

# Development of a Multi-Sensor Device

The data from the four sensors ...

- *are fused with each other, and*
- *are fused with utility and ground records*

Utility records might be inaccurate and incomplete ...

*... yet they provide data on likely targets*

Prior knowledge of the ground, updated by site testing,  
has been shown to enhance the deployment of the  
sensing technologies by

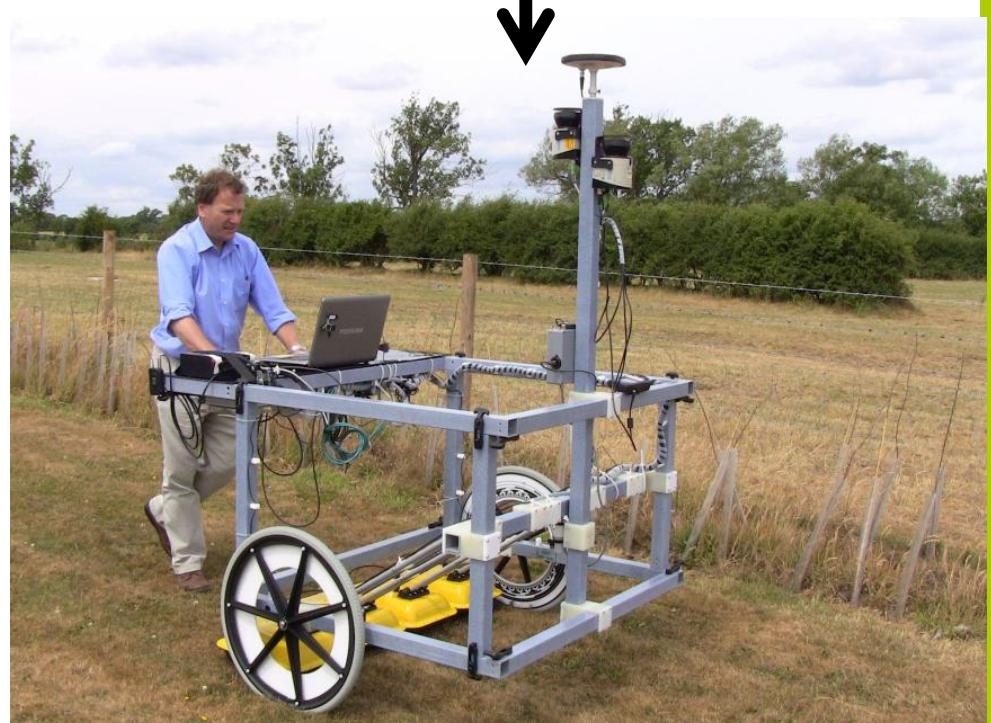
- *optimizing operational parameters*
- *further enhancing data processing*

# 'Mobile' sensor platforms were developed



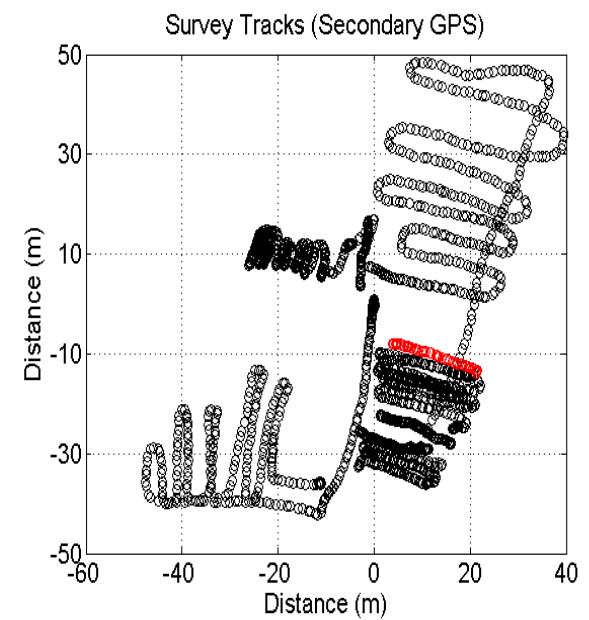
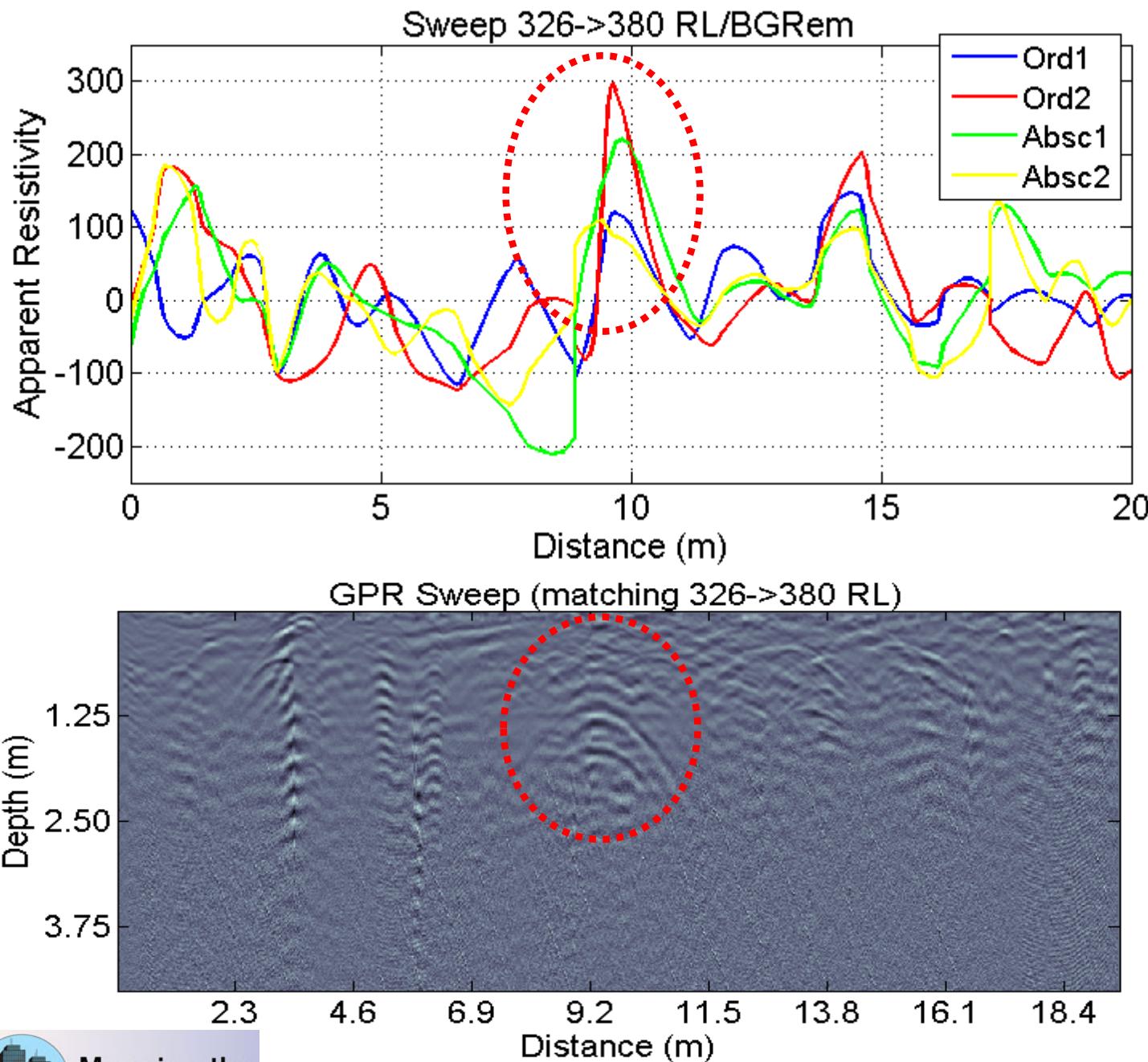
Vibro-acoustics, passive magnetic fields and ground penetrating radar

Low frequency electromagnetic fields



We are currently doing proving trials of this equipment as part of ATU...

# Combined Testing



**LFEM + GPR**

# ***Assessing the Underworld***

We contend that what is buried in, and on, the ground is to some degree controlled by the ground

*... if the ground properties change, or the ground moves, the adjacent / overlying infrastructure responds accordingly*

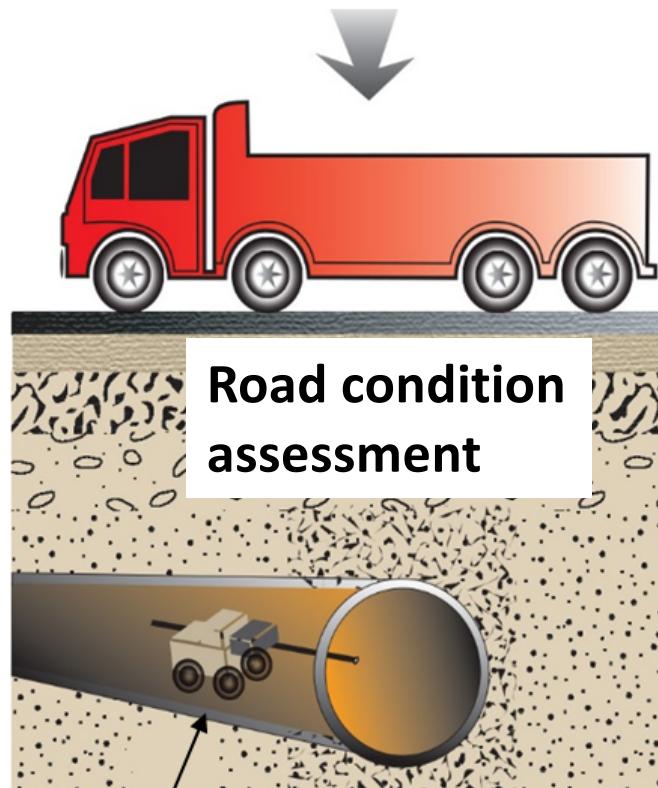
We seek to create a system able to manage, coherently, what we do to the buried infrastructure (add new services, repair or renovate existing services, leave it alone for now), and for this

*... we need to be informed by the ground conditions and how the ground might react to any new activity or intervention*

The same argument holds true for the transport infrastructure

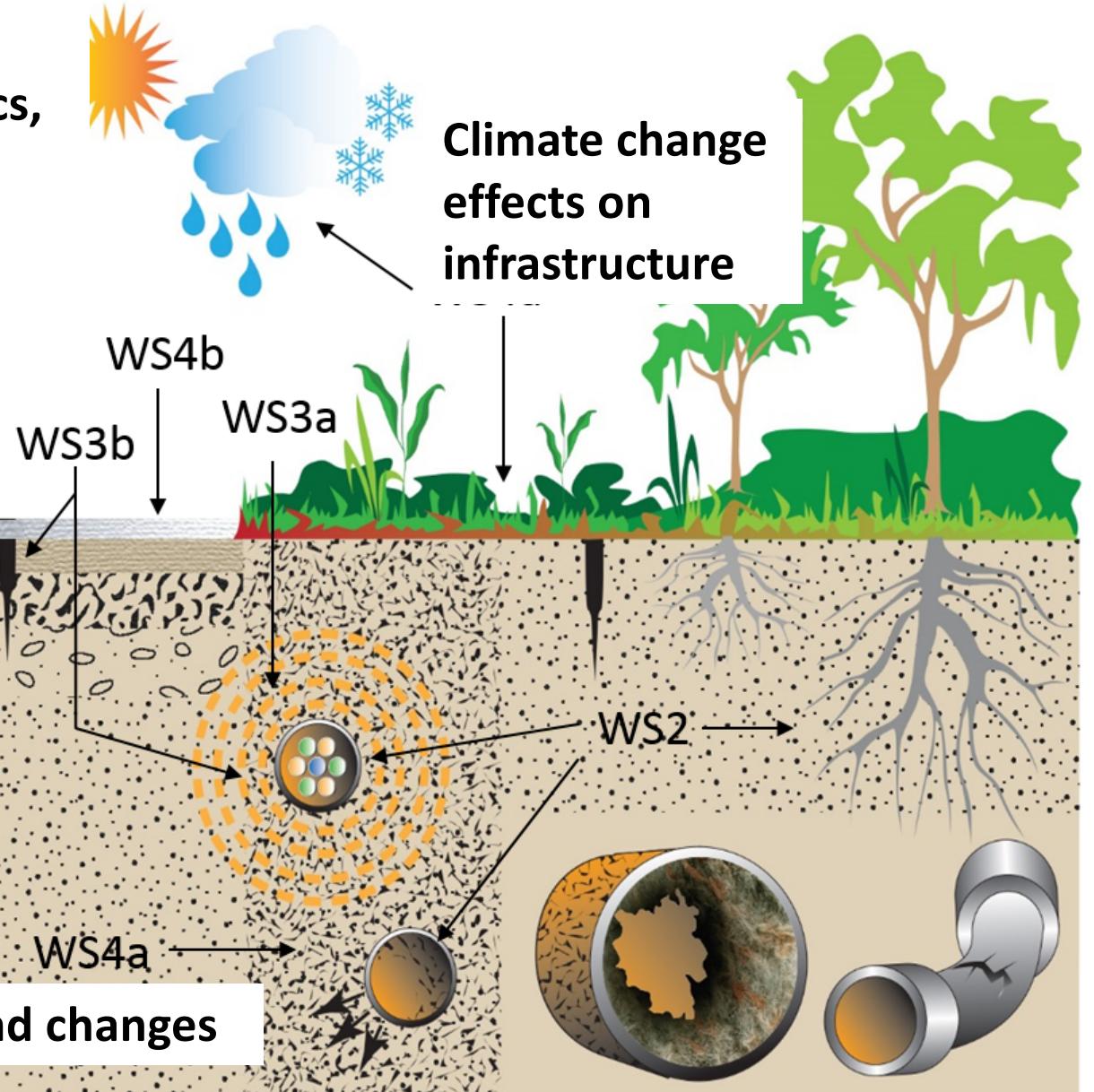
# Overview of the ATU project

Sensors to assess infrastructure condition – GPR, electromagnetics, vibro-acoustics



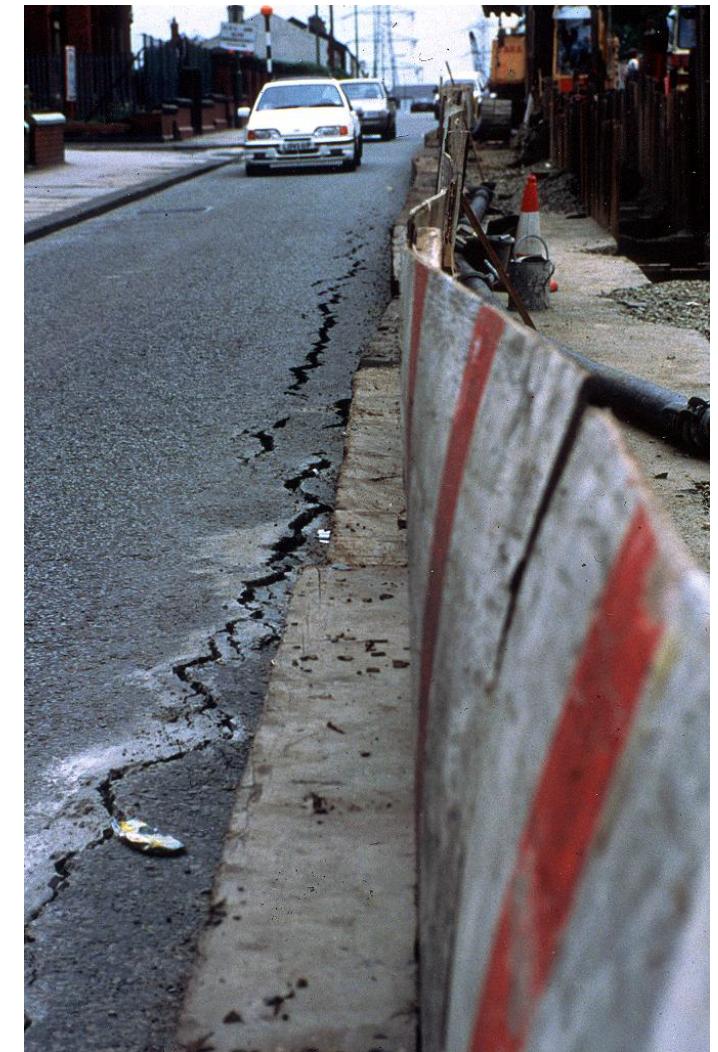
In-pipe robots for pipe assessment

Ground changes



# *Assessing the Underworld*

Street works disrupts society, damages the environment ...  
and adjacent services, and the overlying road structure

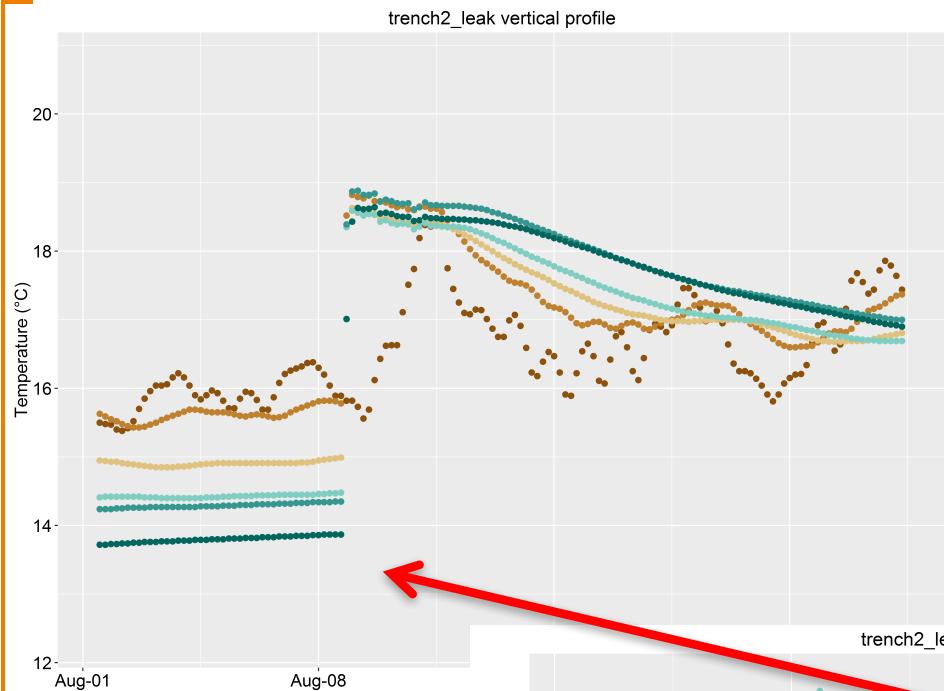


Some 4 million road structures are  
damaged each year in the UK

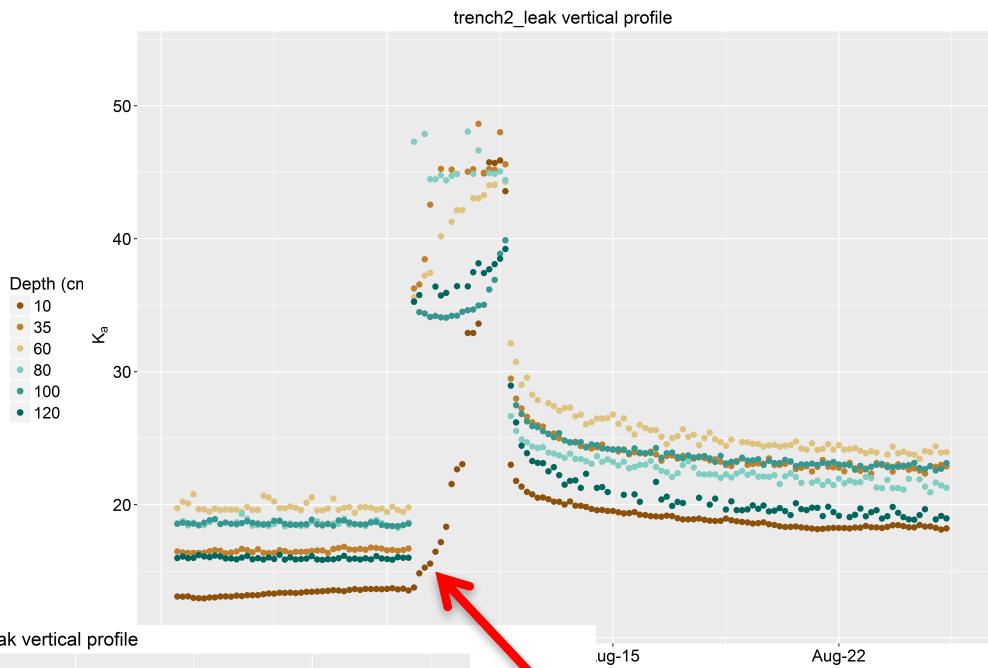
# Instrumented field trials....leaking pipe test



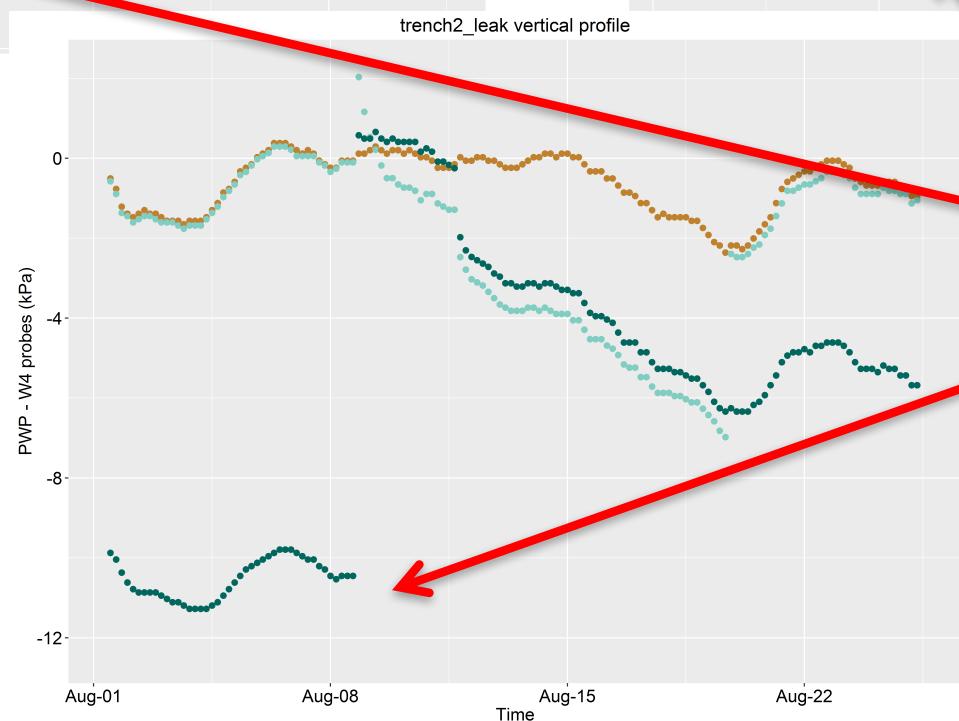
# Some results during a leak test...



Temperature



Permittivity



Pore water  
pressure

Leak  
started

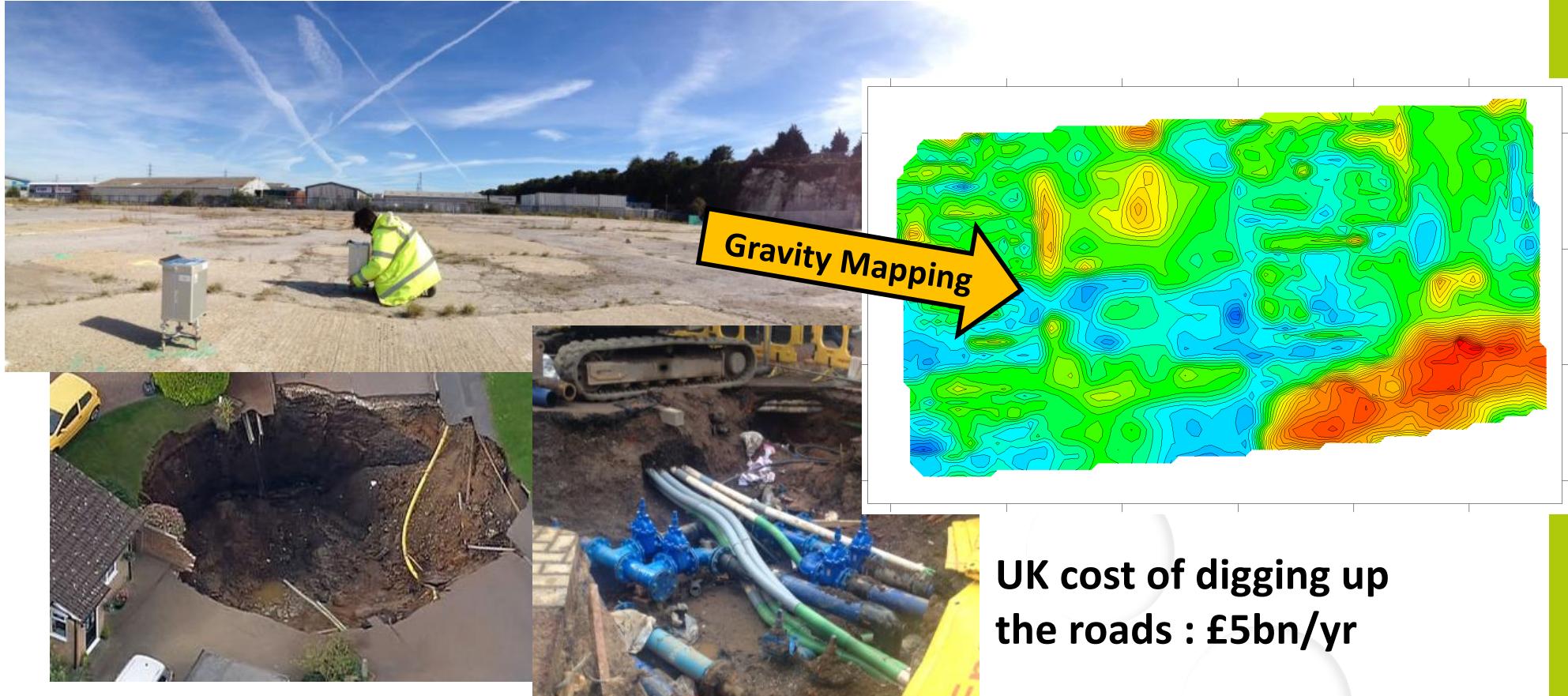
# (Quantum Technology) Gravity Gradient Sensor

- Existing sensors have their limitations
- Biggest issue is the soil (attenuation)
- Stacked pipes are also problematic
- Use a field potential in the ground? Magnetics or Gravity?

**So is a QT gradiometer the holy grail?**

# Progress in Quantum Sensing

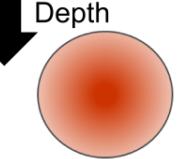
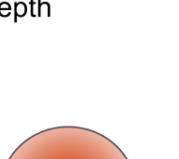
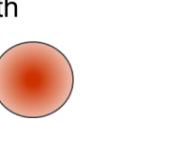
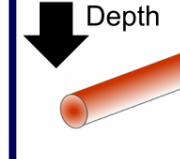
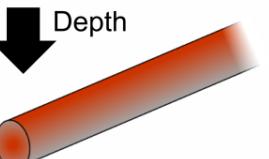
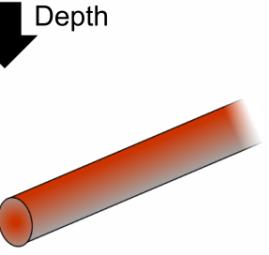
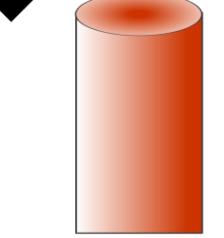
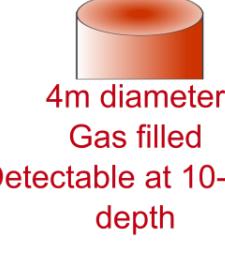
Via engineers into applications



Reaching applications through:

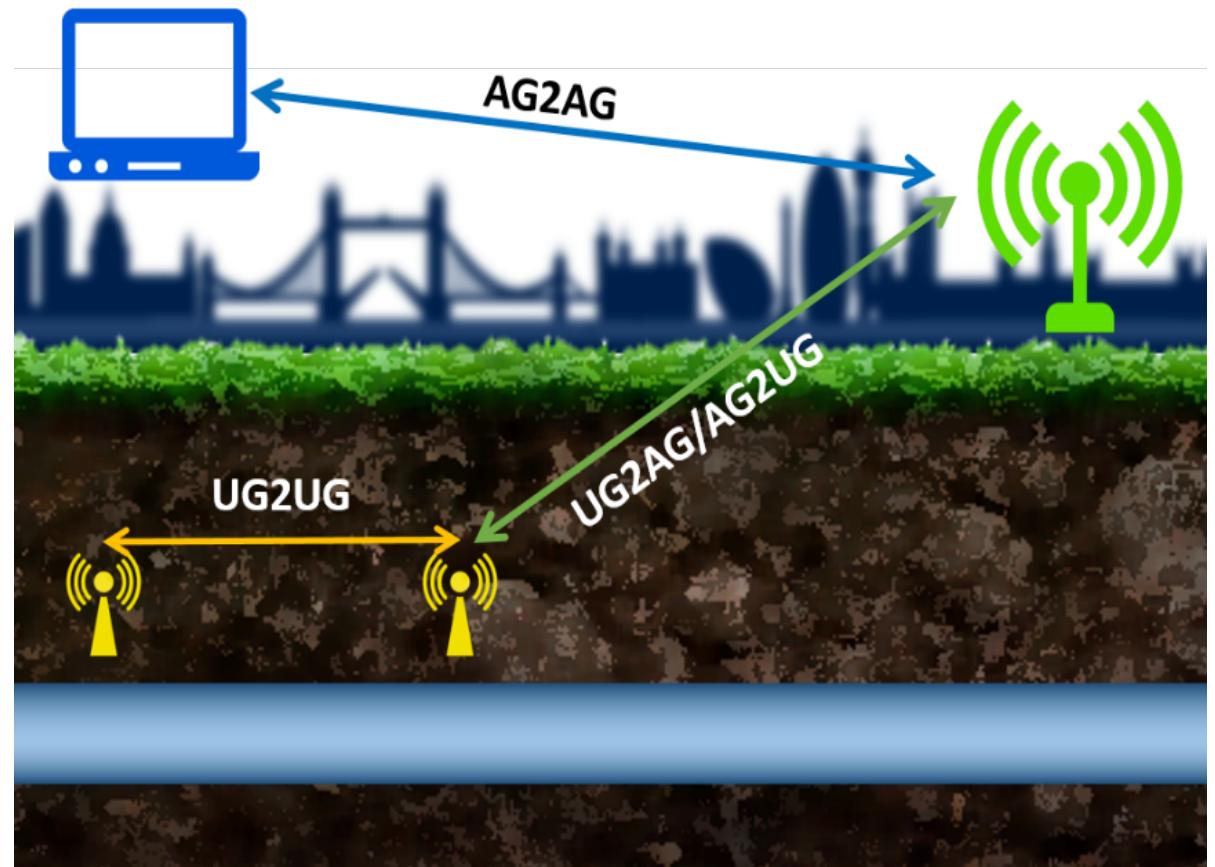
- Interacting strongly with end users to understand needs and use
- UoB civil engineers interacting strongly with industry
- Provide demonstrations to build market interest

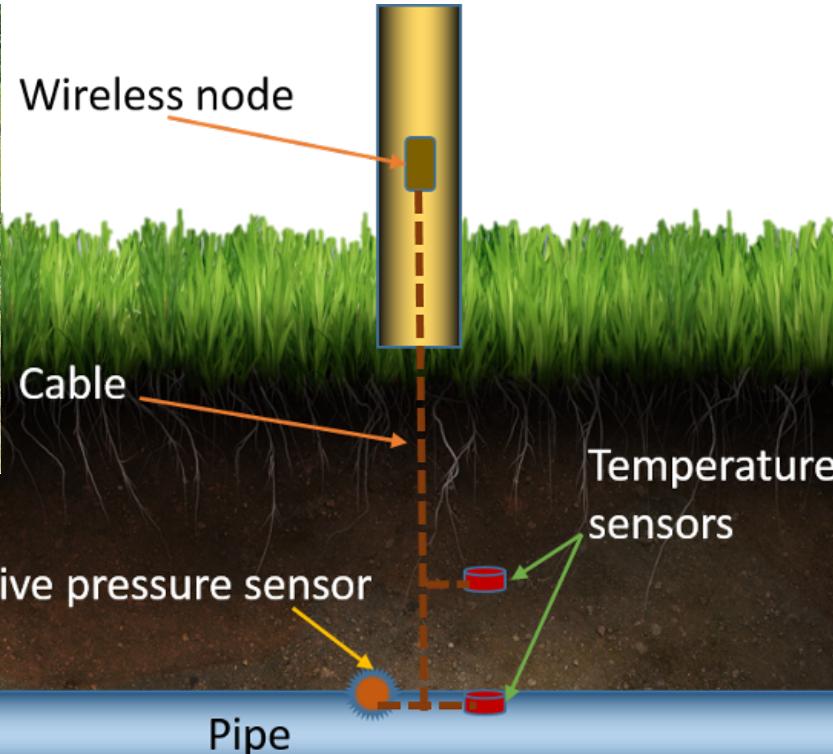
# What is now Detectable?

CURRENT TECHNOLOGY	QUANTUM TECHNOLOGY	CURRENT TECHNOLOGY	QUANTUM TECHNOLOGY
 5m diameter Gas filled Detectable at 5-7m depth	 5m diameter Gas filled Detectable at 8-10m depth	 3m diameter Gas filled Detectable at 2-4m depth	 0.6m diameter pipe Gas filled Detectable at 2-4m depth
 2m diameter pipe Gas filled Detectable at 2-4m depth	 1m diameter pipe Gas filled Detectable at 5-7m depth		
 4m diameter Gas filled Detectable at 5-7m depth	 4m diameter Gas filled Detectable at 10-12m depth	 2m diameter Gas filled Detectable at 5-7m depth	 2m diameter Gas filled Detectable at 5-7m depth

# Monitoring Pipelines – Smart Pipes

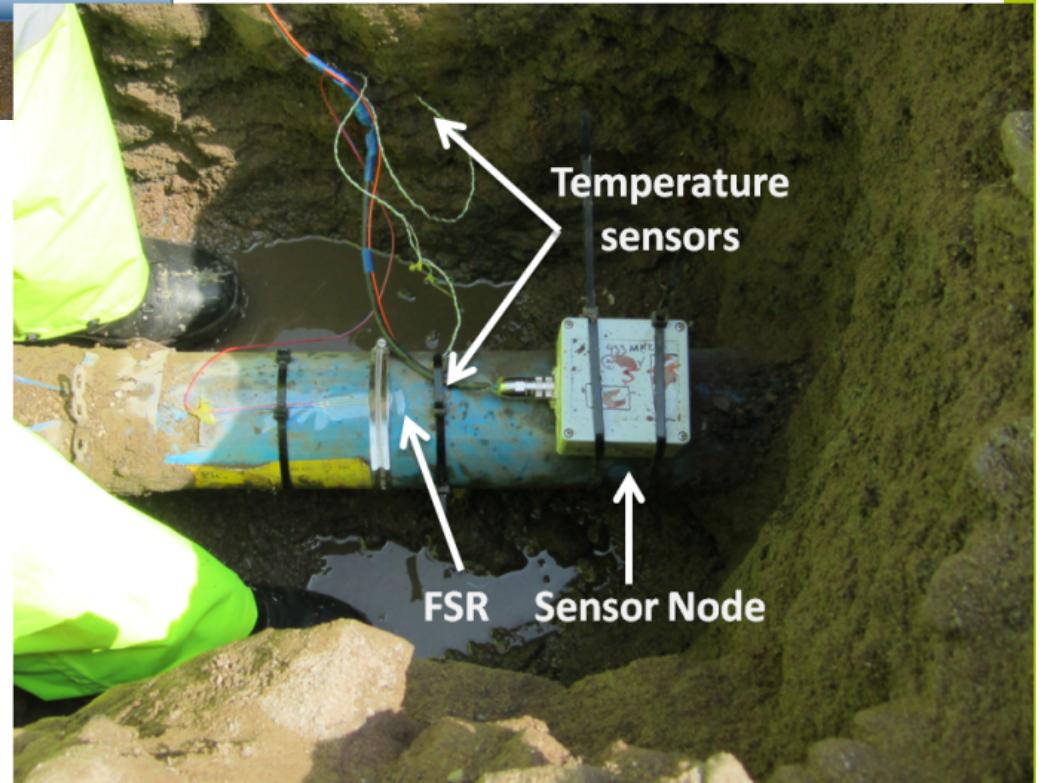
- Leak detection and asset management of buried pipelines
- Wireless sensor networks to collect data



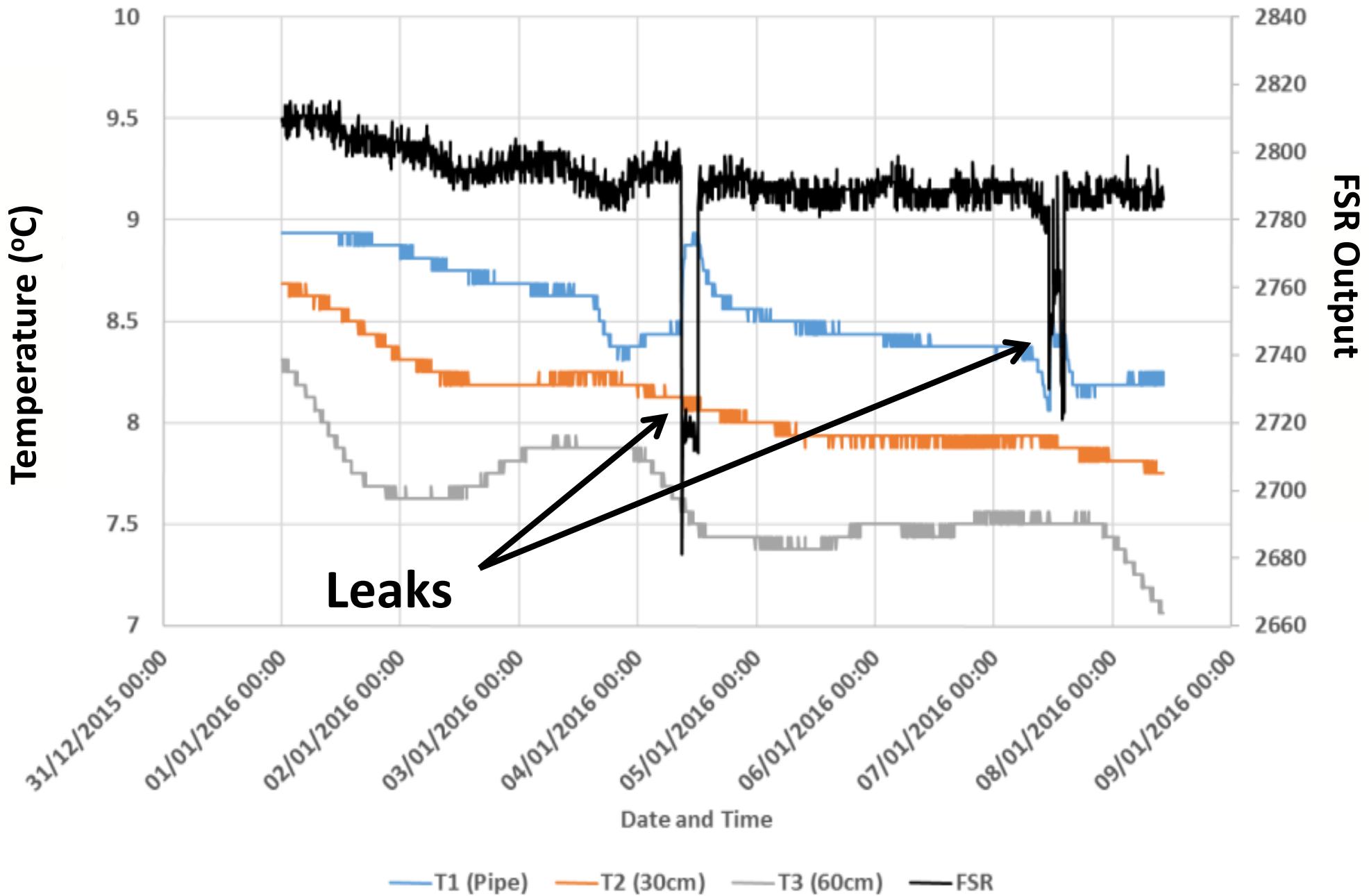


- ...and testing in the field
- ...based on wireless sensor networks

- ...continuously monitoring for two years
- Industry is currently testing system

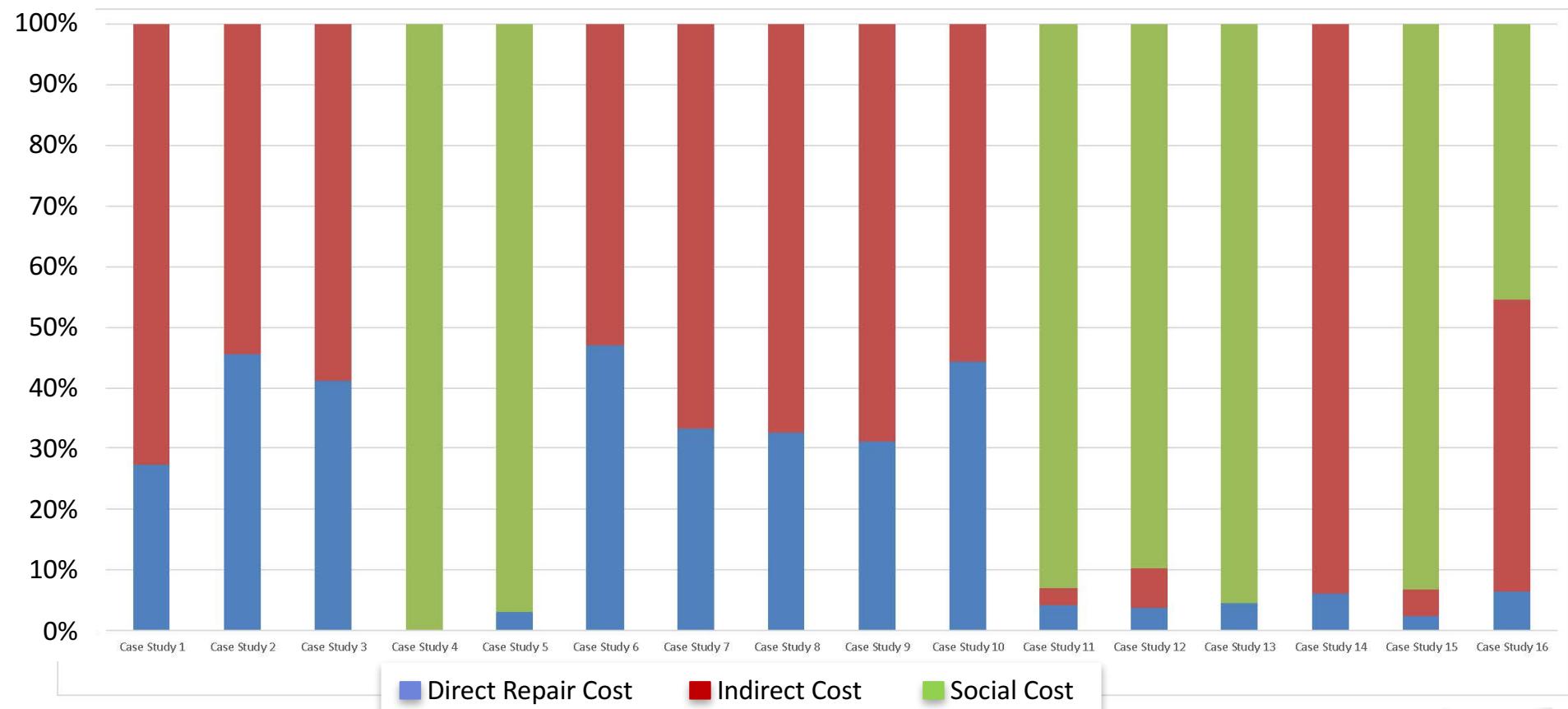


- ...some data...combined temperature and FSR (relative pressure) indicates **leaks**



# Costs of Utility Strikes – 16 Case Studies

- This is not all about Health & Safety  
....there is a real economic impact



**Utility Strike Cost Ratio = 1:29**

# A brand new facility – National Buried Infrastructure Facility

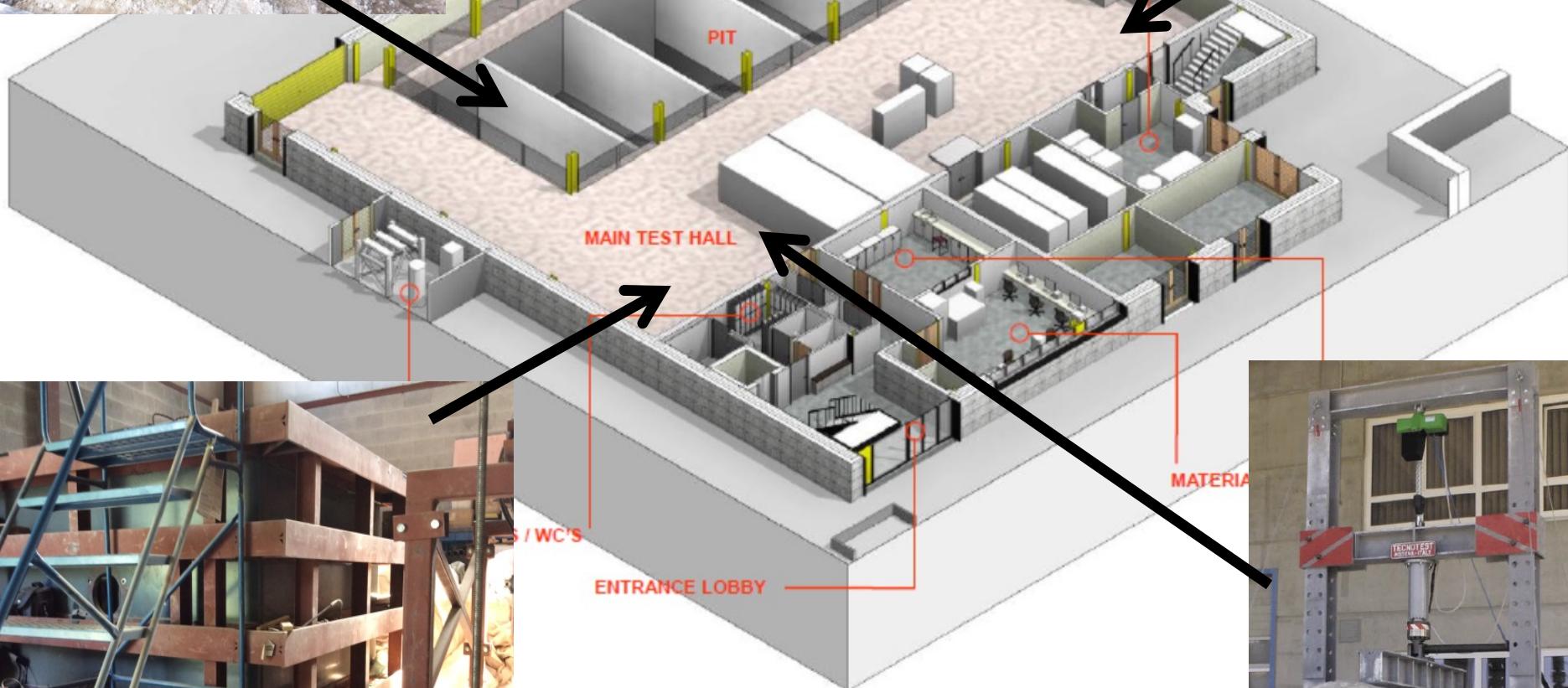
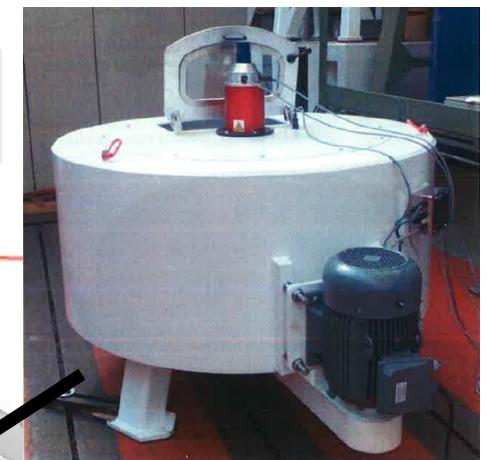


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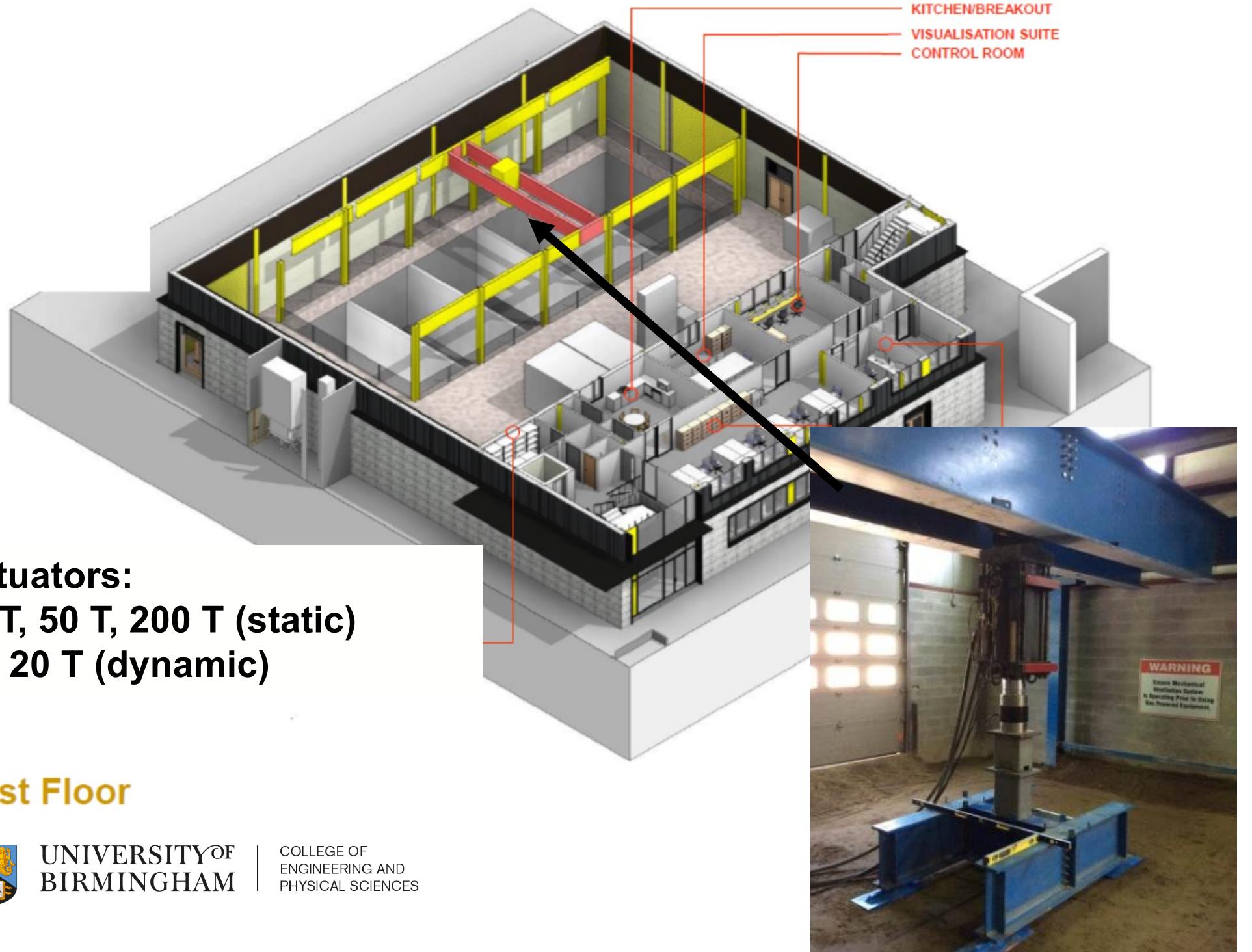


Mini-geotechnical  
centrifuge



Bi-axial test cells for  
smaller scale buried  
infrastructure testing





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# SUMMARY

- Our knowledge of what is buried in the ground and the ground conditions is at times limited  
... resulting in sometimes unacceptable risks when excavating
- Multi-sensor approach is needed...
- ... utilising the advantages of each technology
- Quantum Technology gradiometers should help  
... but are not the holy grail!
- Discrete, embedded sensors are helpful....  
....if we can solve the communication and power challenges
- Utility strikes can result in a significant cost (indirect & social)  
... and a significant H&S impact

# Thank You for Listening

## Any Questions?

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