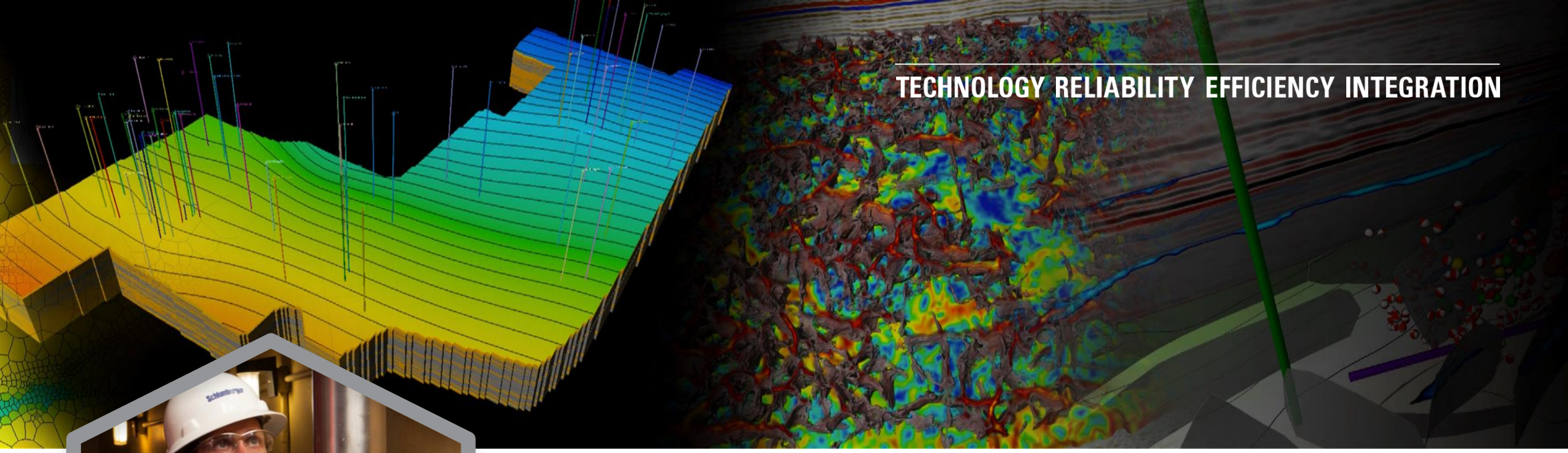

Leak detection technologies and applicability in subsea environment

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Interpretation Domain Champion
2018 11 21

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Overview

What are we trying to do?

Tests to understand and detect leaks; what is the underlying physics?

Distributed fibre optic measurements for leak detection

Subsea systems

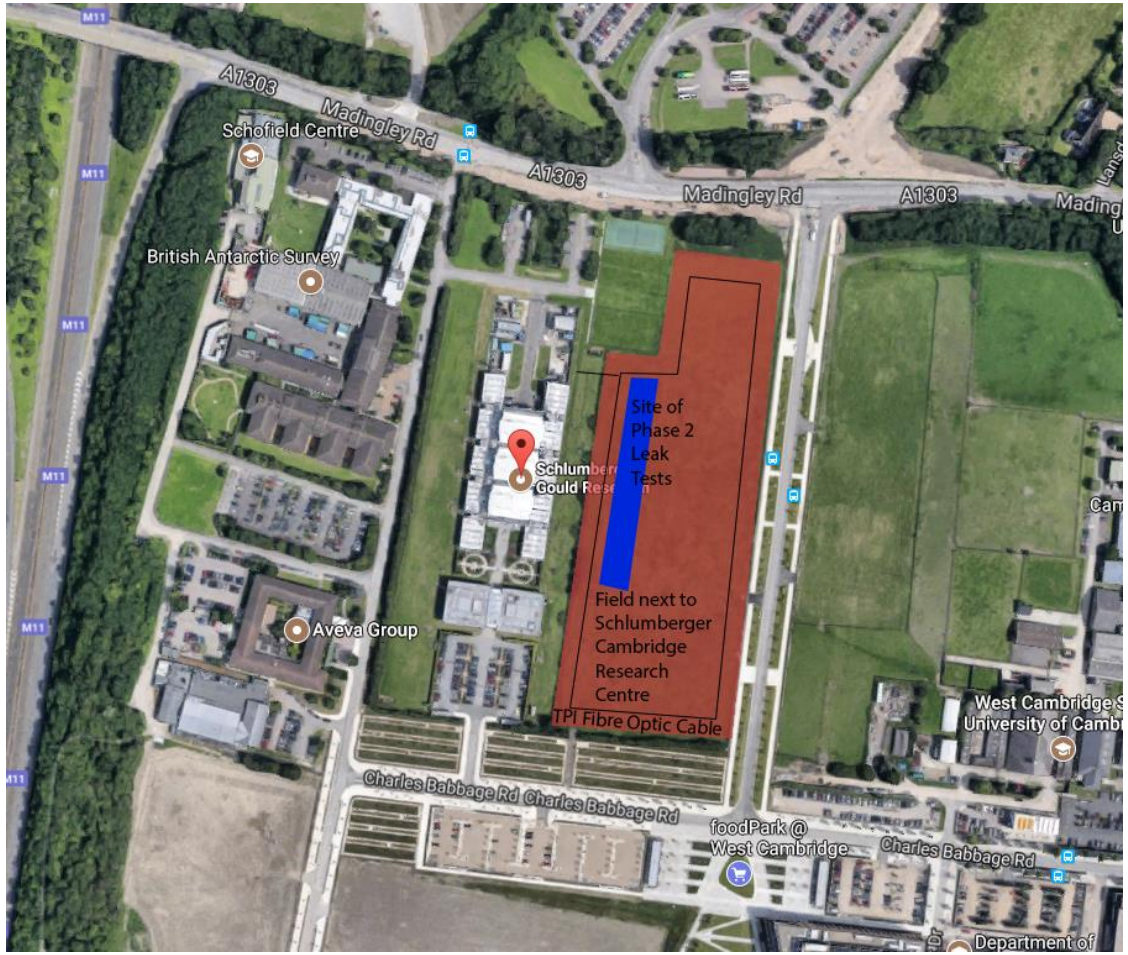
Fibre optics for subsea leak detection

Example of subsea leak detection system (not fibre)

Prevent loss of product, reputation and environmental damage, through third party intrusion detection, asset health monitoring, leak detection, and predictive data analytics.

Leak Physics

Cambridge Third Party Interaction and Leak Detection Research



- Testing conducted at the Schlumberger Cambridge Research Centre (SCRC)
- Fibre optic cable has been buried in a loop around a filed adjacent to the SCRC building
- Third party interaction detection, such as walking, driving, digging, etc
- Leak testing using 300 m long 1 inch diameter instrumented buried pipeline

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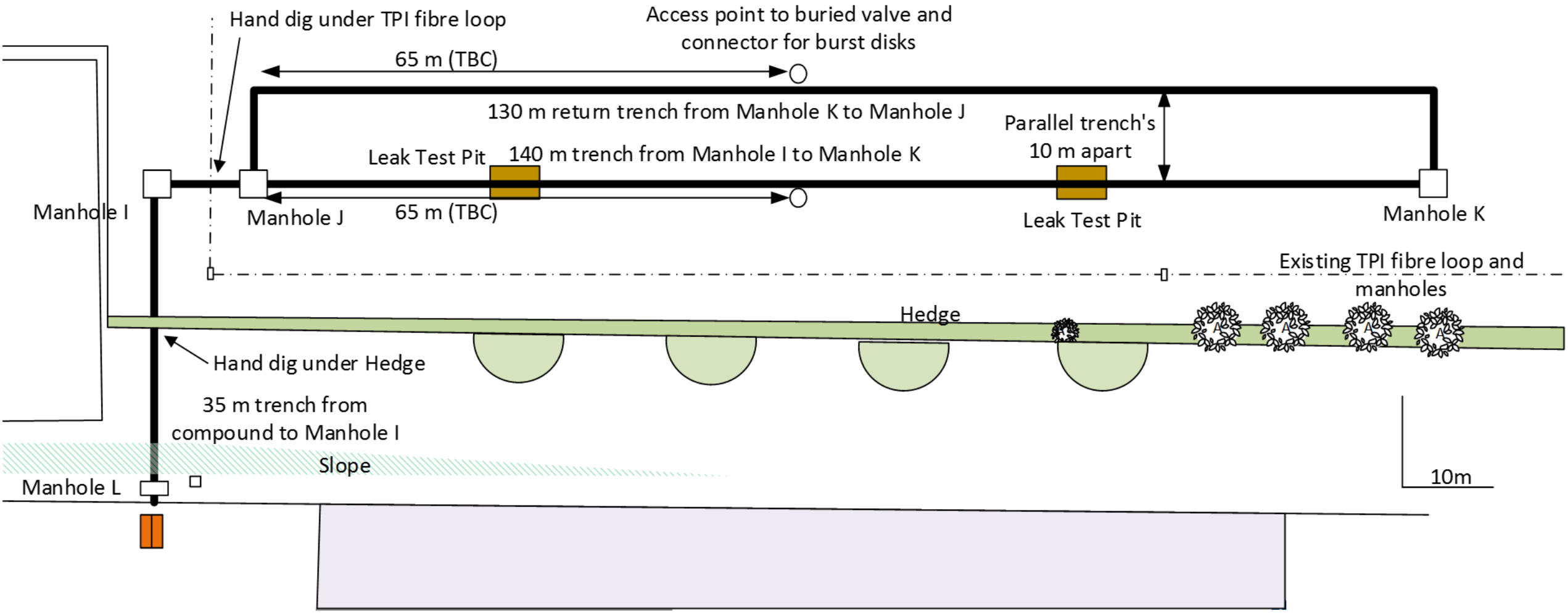
Trench Plan



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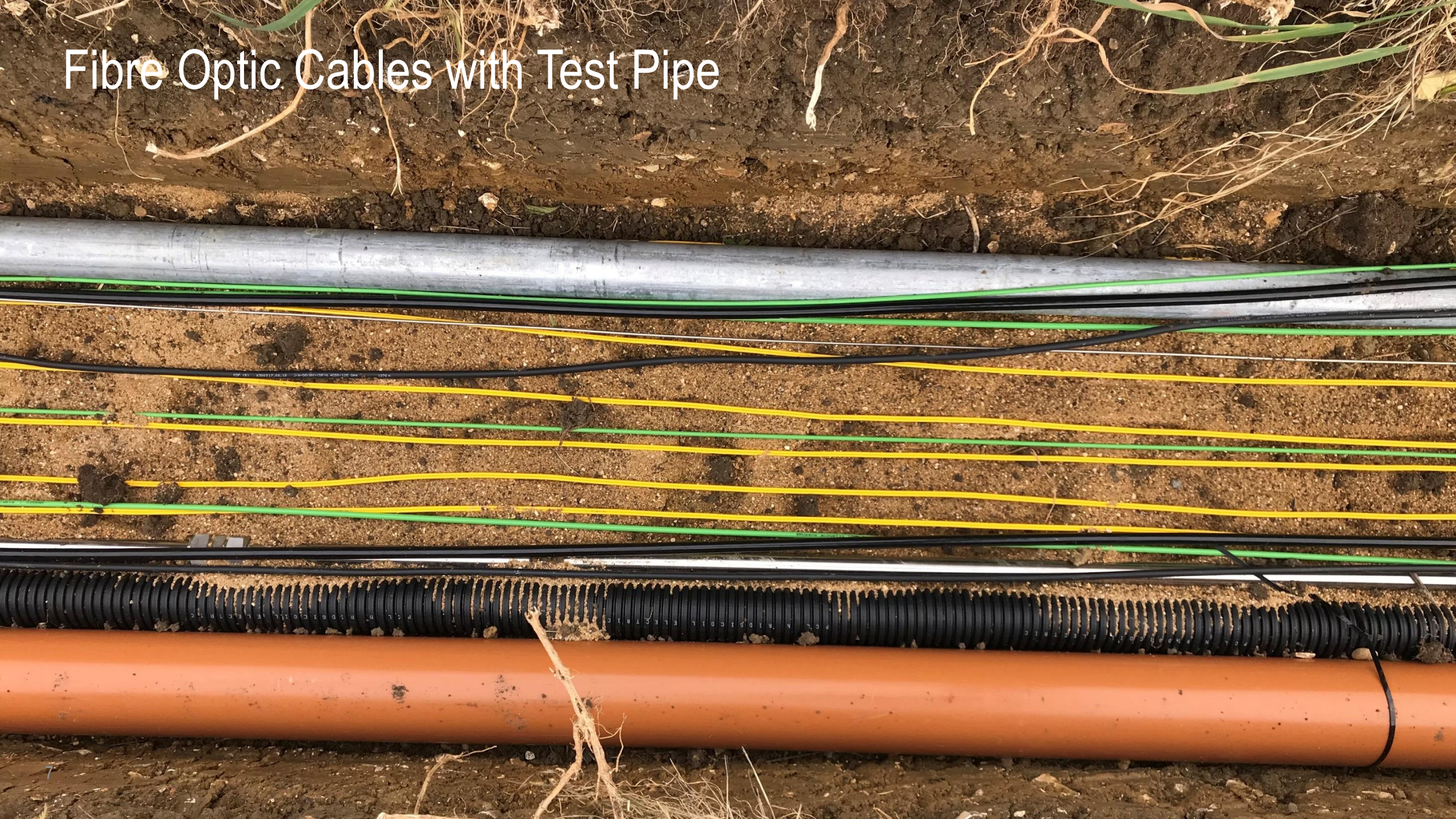
Fibre Optic Cables with Test Pipe



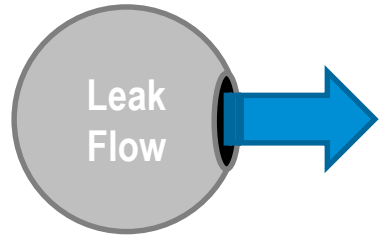
Examples of the Leak Tests Conducted

Leak Physics and Mechanisms

Normal Operating – No leak
Media flows through pipeline without interruption or incident

Leak Initiation
Something creates a hole in the pipe wall

Causes
Rupture – explosive release of energy due to reduction in pipe wall
Erosion/corrosion – gradual reduction in pipe wall causing a hole, but not rupture
Overpressure



Leak Flow
Media escapes through the hole

Leak Hole Growth
Erosion, corrosion and wear by the media of the pipe wall which increases the size of the leak hole

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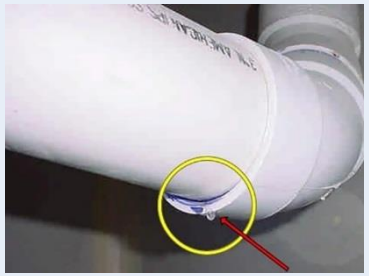
Types of Leak

Weep leak	the slow and steady escape of media through a tiny path. This typically occurs at a joint or seal.	Tiny	
Small, or simple leak	the escape of media through a small hole, typically less than 10% of the pipe diameter that does not significantly disrupt the flow through the pipe,	< 10 % diameter	
Gross leak	the escape of media through a large hole, typically greater than 10% of the pipe diameter that disrupts the flow through the pipe.	> 10 % diameter	

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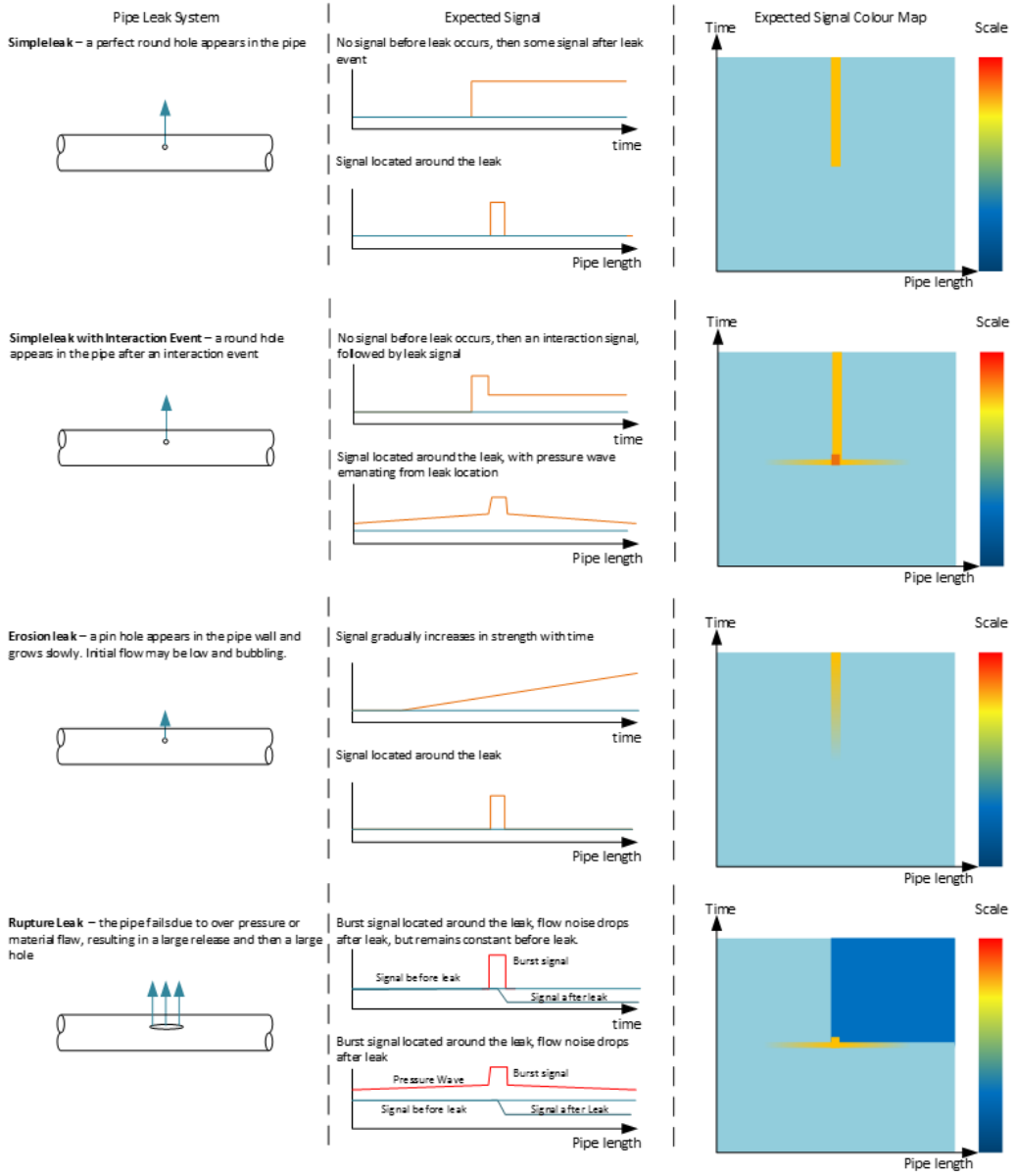
Leak detection using vibration

From the key components four leak signatures were identified which are:

- Simple Leak
- Simple leak with interaction event
- Erosion/corrosion leak
- Rupture leak



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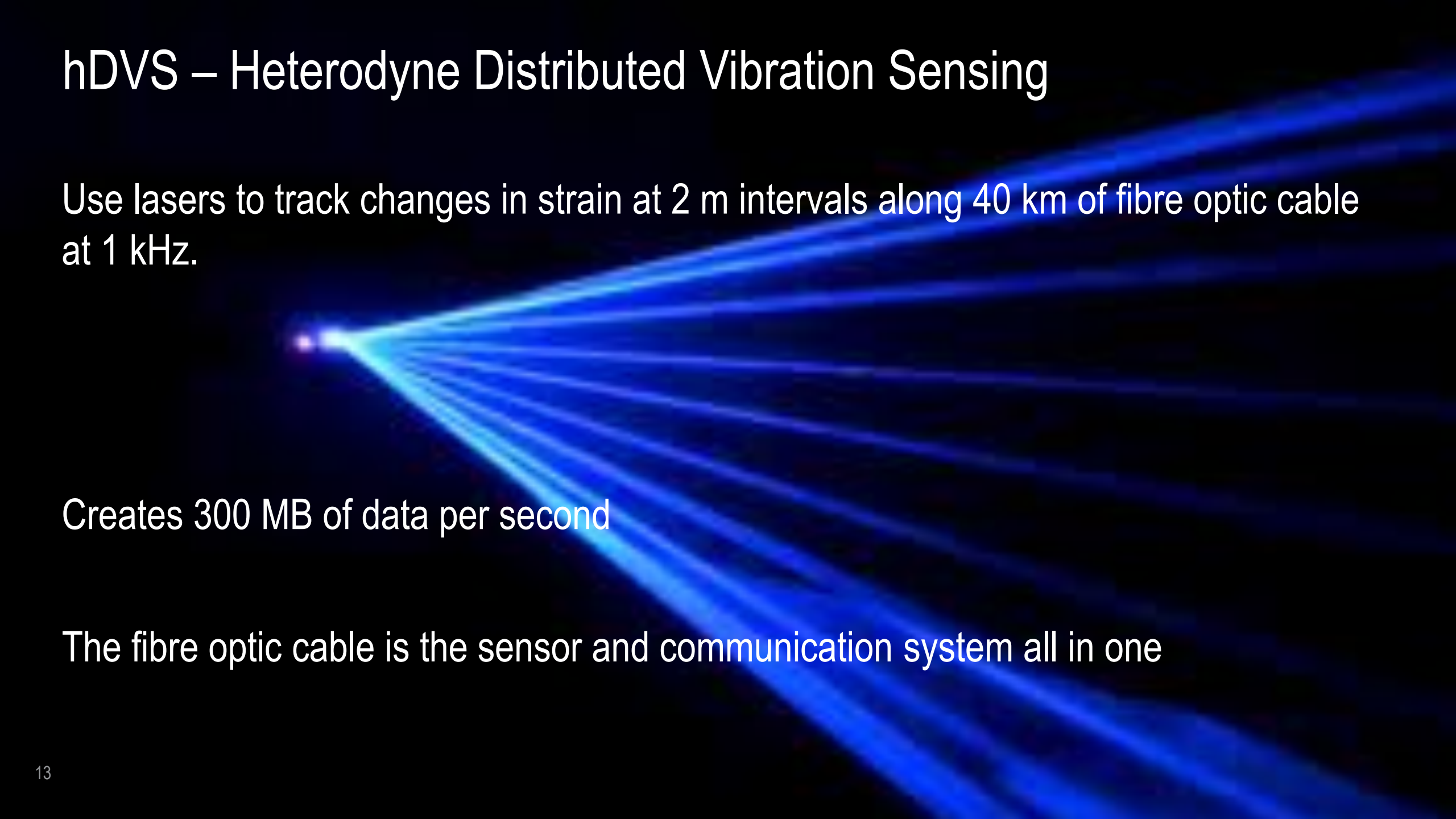
Distributed Fibre Optic Monitoring

hDVS – Heterodyne Distributed Vibration Sensing

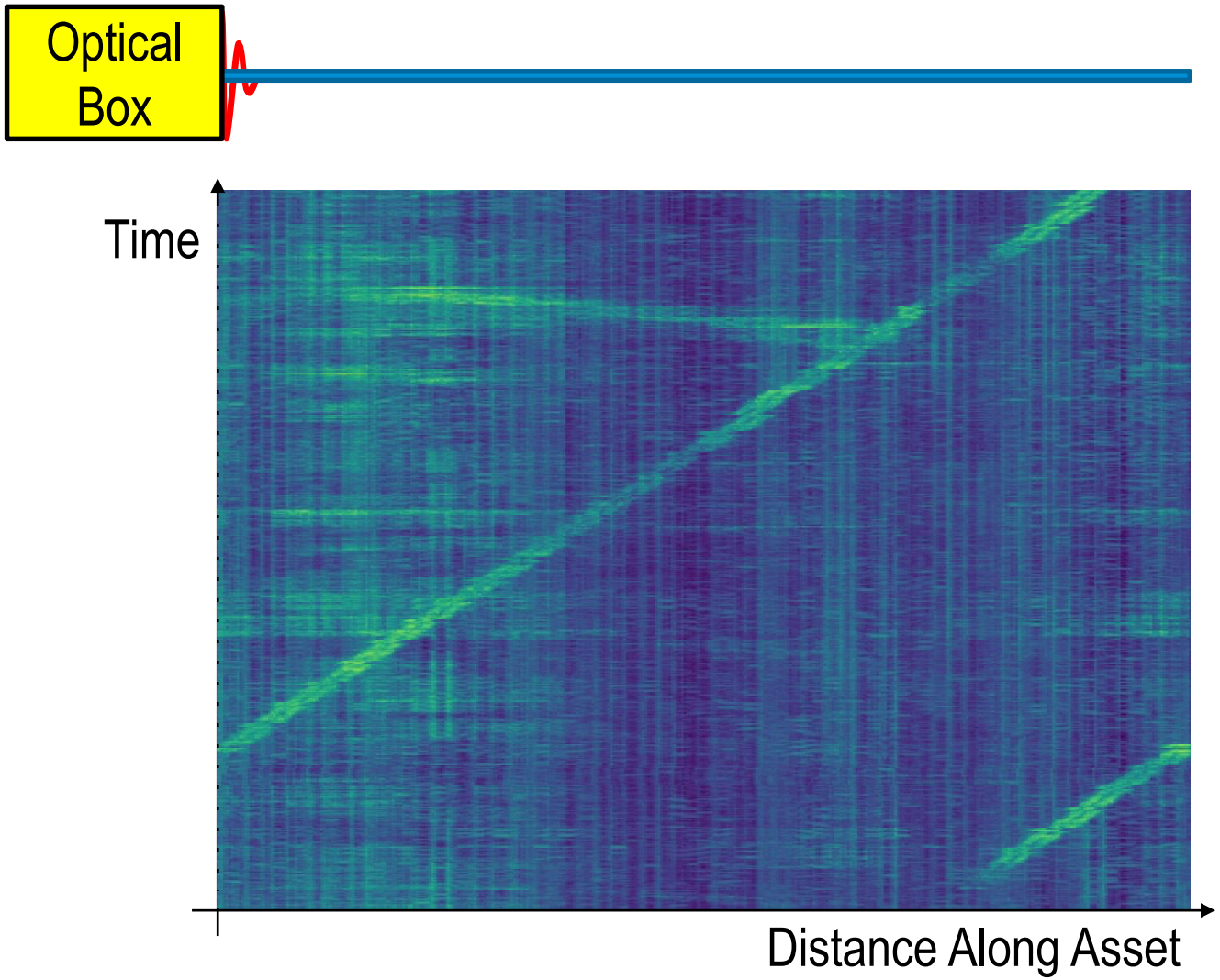
Use lasers to track changes in strain at 2 m intervals along 40 km of fibre optic cable at 1 kHz.



Creates 300 MB of data per second

The fibre optic cable is the sensor and communication system all in one

Principles of Distributed Fibre Optic Measurements



Fibre optic box sends a short pulse into the fibre optic cable

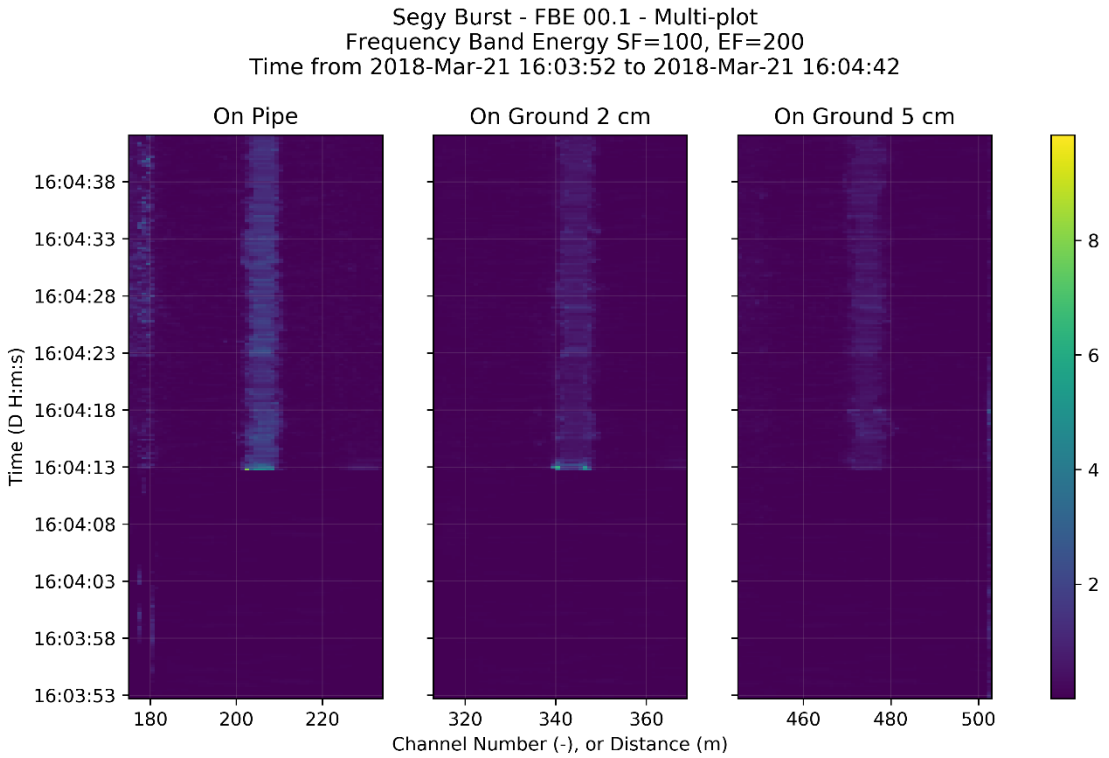
This returns light backscatter to the fibre optic box

Time Domain Reflectometry is used to determine the signals at locations along fibre

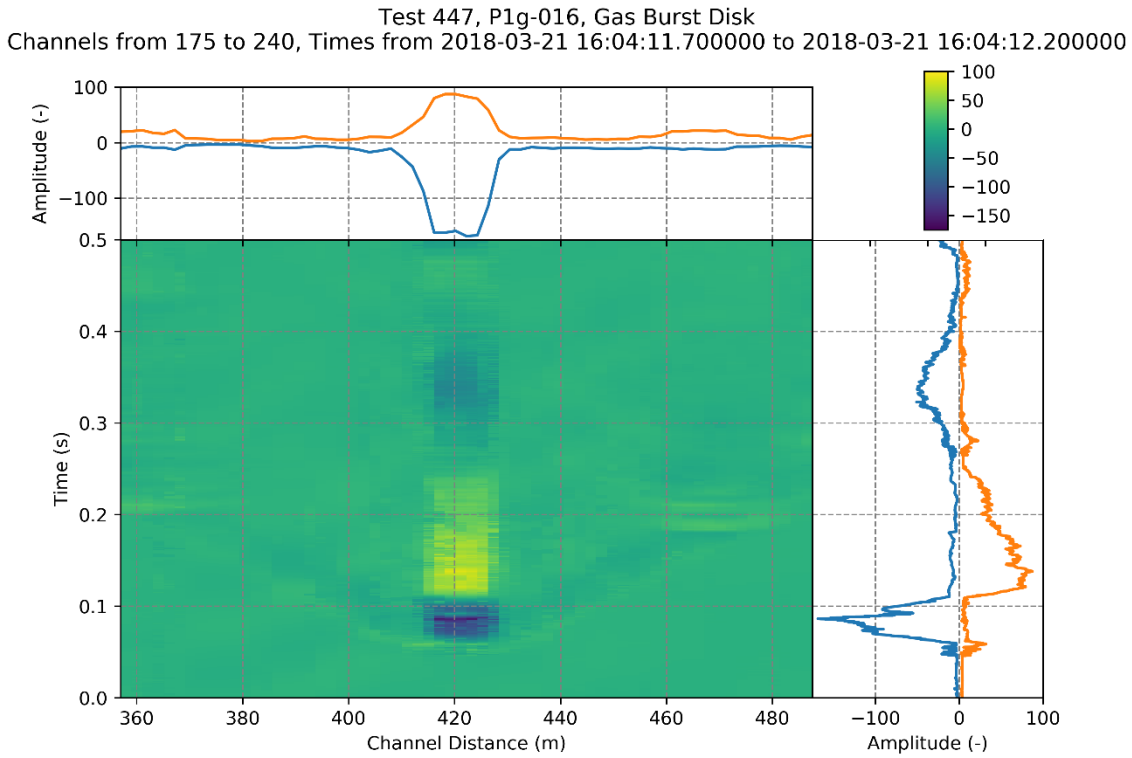
Repeating the light pulse builds up a picture with time

What does a leak look like?

Simple leak



Rupture



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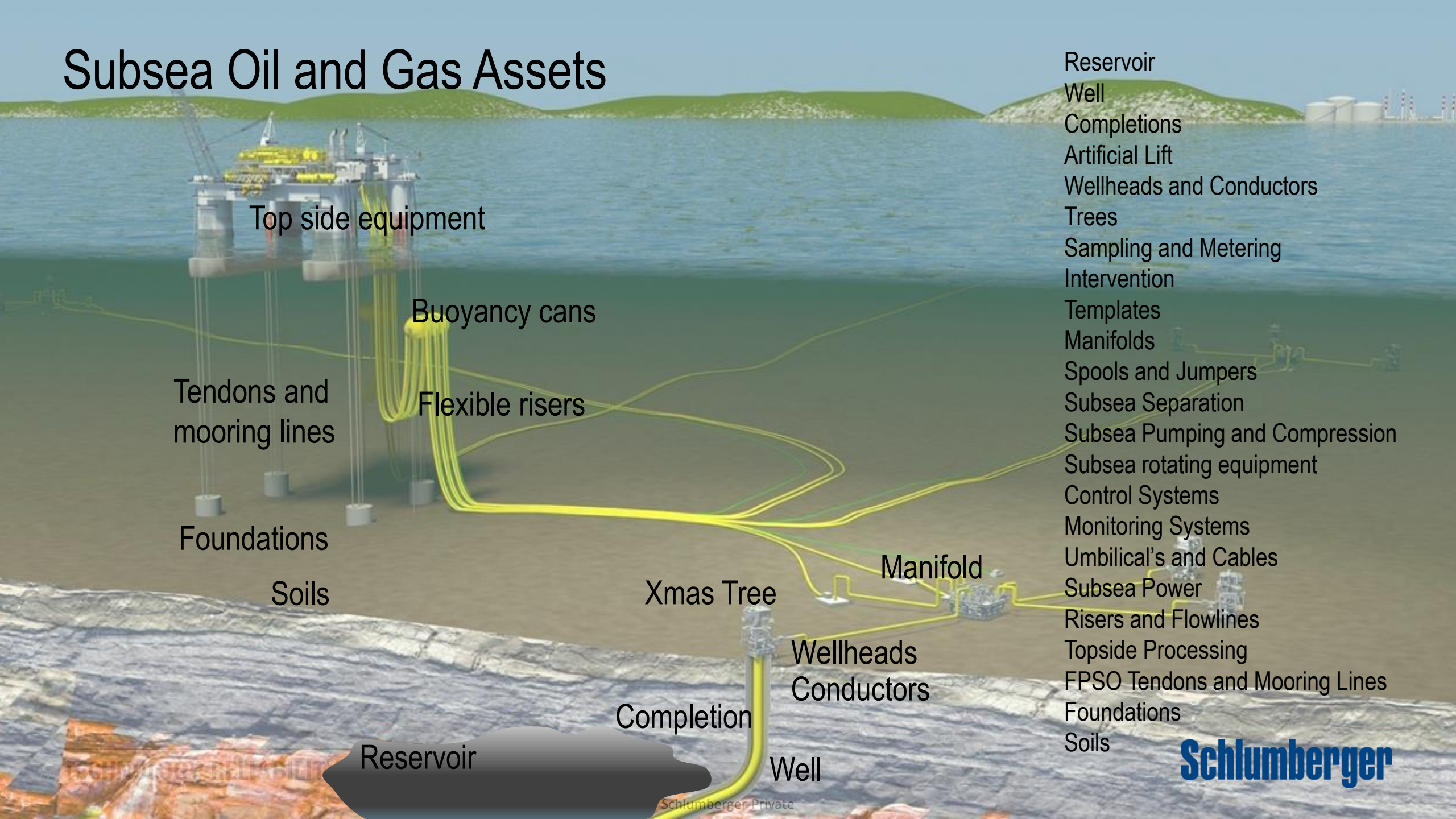
Subsea

Subsea Oil and Gas Assets



Reservoir
Well
Completions
Artificial Lift
Wellheads and Conductors
Trees
Sampling and Metering
Intervention
Templates
Manifolds
Spools and Jumpers
Subsea Separation
Subsea Pumping and Compression
Subsea rotating equipment
Control Systems
Monitoring Systems
Umbilical's and Cables
Subsea Power
Risers and Flowlines
Topside Processing
FPSO Tendons and Mooring Lines
Foundations
Soils

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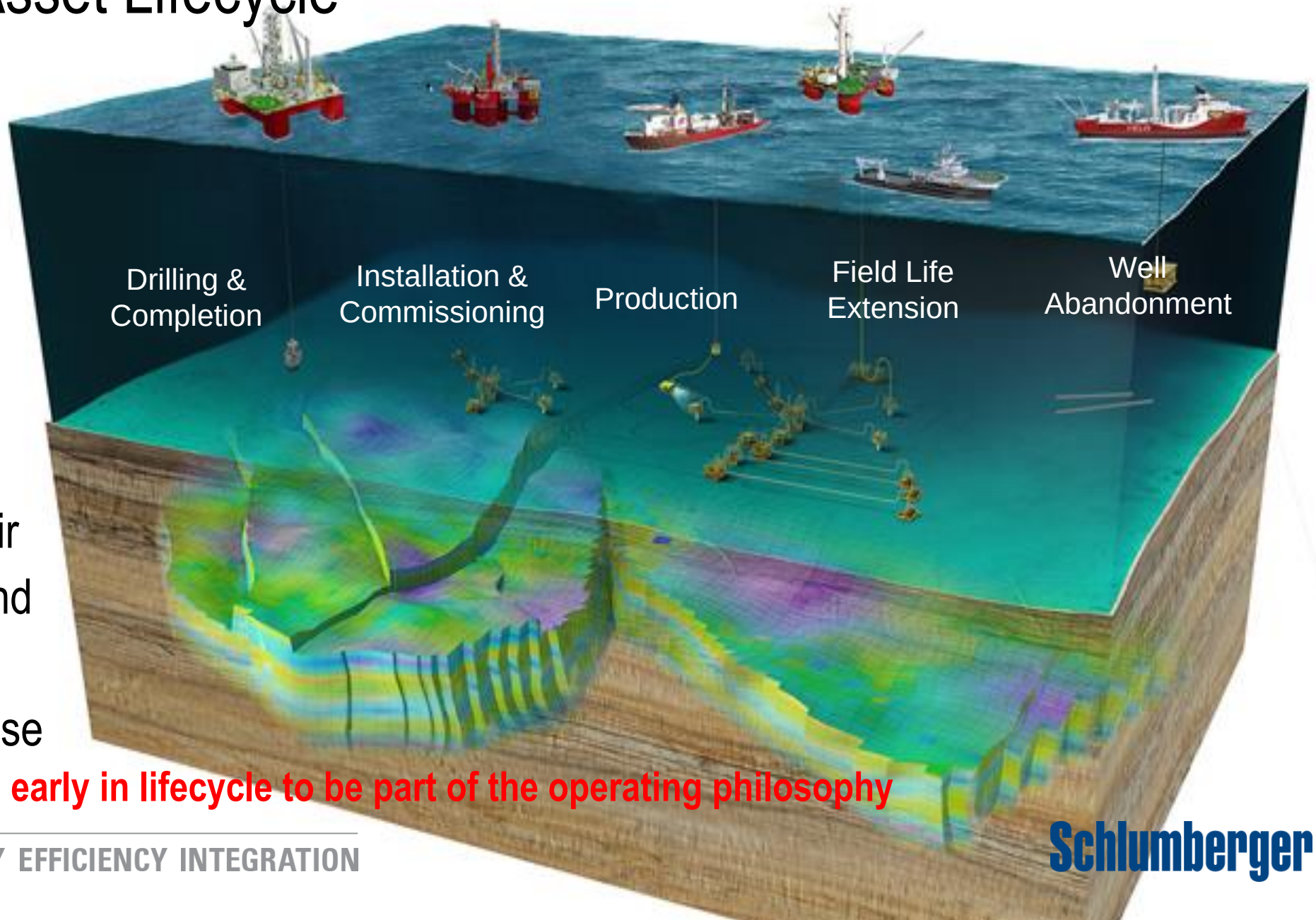
Oil and Gas Asset Lifecycle

Design
Manufacture
Transport
Deploy
Commission
Operate
Maintain and Repair
Enhance and Extend
Decommission
Retrieve and Dispose



Introduce monitoring early in lifecycle to be part of the operating philosophy

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Consider Monitoring as Part of the Asset's System

Find new value for monitoring

Operating philosophy is devised with monitoring in mind.

Early engagement of operations, engineering, data scientists, security and business to define approach

Remove conservative analysis assumptions

Report actual utilisation and condition (Digital Avatar)

Long term stable measurements with minimal drift and high accuracy improve the data and quality of the decision

Predict failure to enable remediation plan and reduce down-time

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Fibre Optics for Subsea Leak Detection

- Monitoring needs to be part of the system operating philosophy at project conception
- Fibre optic cable can be installed during manufacture
- Communications can double as sensing system
- Monitoring box connected over life of field or as a service/inspection system
- Deliver temperature, vibration and strain information and interpreted to enable leak detection and other functions
- Measurements enable greater understanding of subsea structures
- Other sensors are available, but fibre is the distributed sensing system

Example Leak Detection of Buoyancy Cans

Buoyancy Cans Leakage Detection

https://www.researchgate.net/figure/Free-Standing-Hybrid-Riser-system-FSHR_fig1_256249456

Buoyancy cans supply tension to the riser, enabling them to be free standing

If a buoyancy can leaks, the tension reduces and the riser buckle

A leak detection system ensures the continued safe operation of the riser tower

If a leak cannot be detected directly, the impact of a leak can be

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Tension Monitoring for Leaks

Not a simple task!

System Physics

During normal operation the tension remains stable (ignoring temperature and environmental loading)

Leak caused by corrosion of the buoyancy can structure,

Leaks result in a drop in tension, which we can measure

Monitoring Requirements

Monitoring system must last for the life of the field,

Measurement needs low drift and high accuracy

Communicate accurate tension at multiple locations to enable validation and cross checking

Date available in real time

High Precision Long Term Measurement System

Field proven strain measurement device

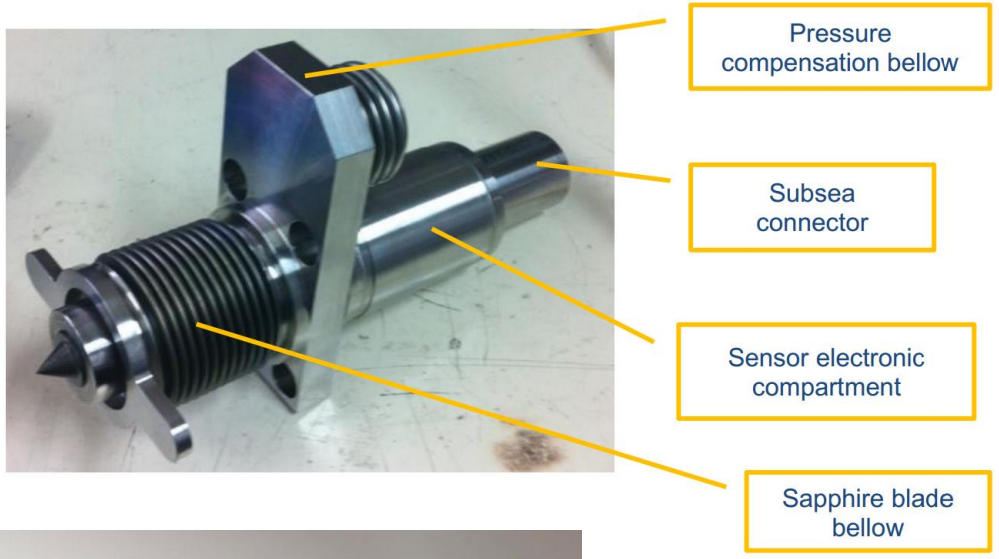
Sapphire and titanium blades with plasma deposited and laser etched strain gauges for high precision

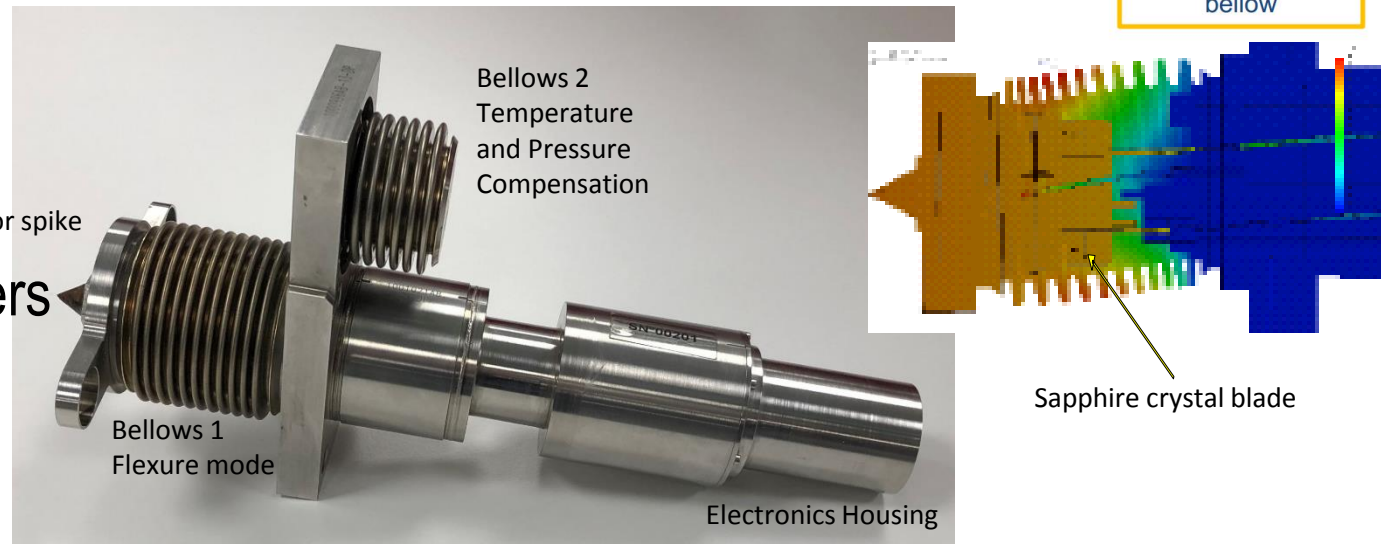
Low sensor drift

ROV deployable

Applications include:

- Structural monitoring
- Life extension
- Operational efficiency of intervention risers
- Air can leak detection
- External pressure gauge





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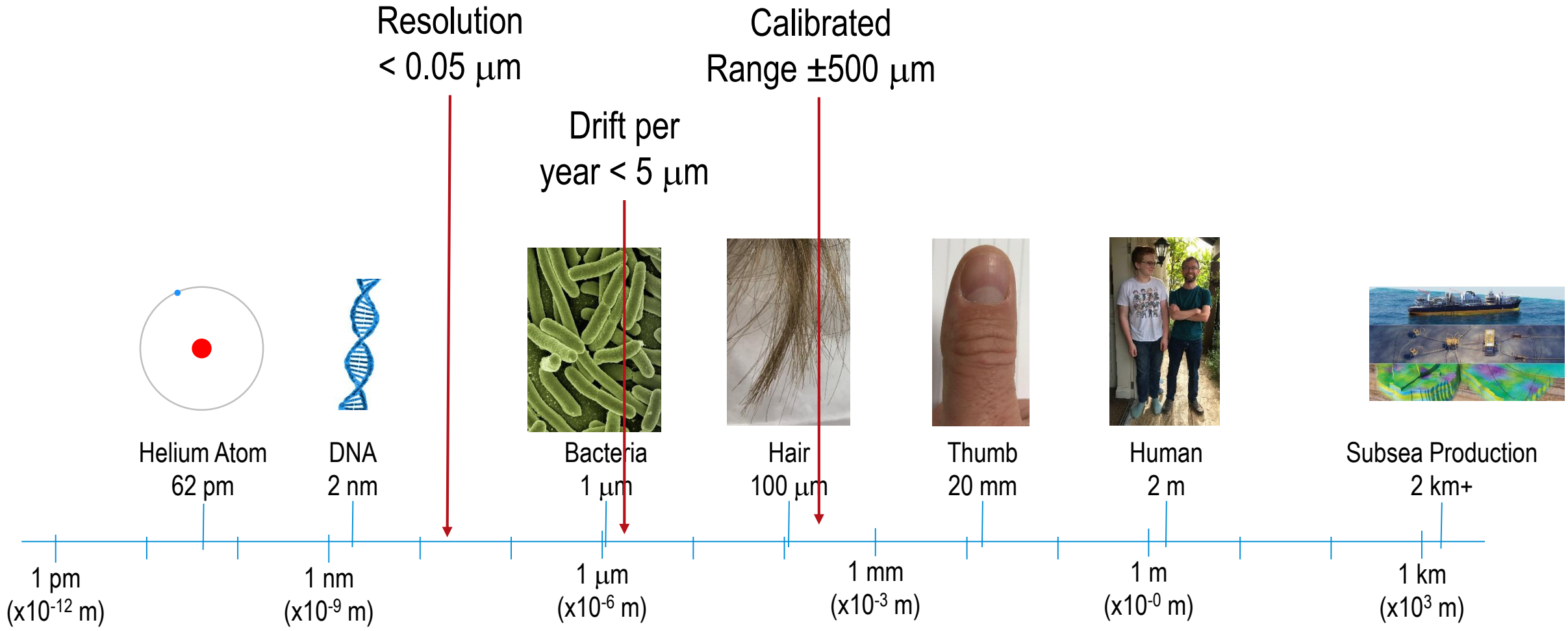
Accuracy and Resolution



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Buoyancy can leak detection system has been deployed

The monitoring system has been deployed for over two years

Tension measurements within drift and operational limits

Hoping to be able to present the results soon!

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Any Questions?