Deepwater hydrate detection and characterization with Acoustic Resonance Technology (ART)

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Issues Caused by Hydrates

- Efficiency Loss: Depressurization or chemical inhibitors may be needed to prevent hydrates.
- Flow Blockage: Hydrate plugs can block fluid flow, reducing production or causing shutdowns.
- Pressure Buildup: Hydrates increase pipeline pressure, risking damage, leaks, or ruptures.
- Corrosion: Hydrates accelerate corrosion, shortening pipeline lifespan and raising maintenance costs.

Alternative Flow Assurance Practices

In a recent client survey, it was found that long production shutdowns in deepwater operations are uncommon. As a result, operators are now more willing to reduce CAPEX by shifting from expensive prevention to efficient, rapid-response technologies. This change focuses on mitigation, addressing issues as they arise rather than relying on heavy upfront investments

Traditional Solutions:

- Expensive production loops, insulation, and chemical inhibitors.

New Approach :

- New replacement technology and remediation techniques
- Develop inspection tool technologies for rapid hydrate detection.

The Mission & Challenges

- Technique must be able to distinguish hydrate from gas or liquid
- Technique must penetrate 3-Layer Polyethylene (3LPE) 3.1 mm coating of the 8” OD Pipe
- Minimal seabed intervention, specified Line submerged under seabed up to 1-2m depth
- High-speed cost-effective ROV deployed method required with full line coverage
- Identify the exact location, size and distribution of suspected hydrate plug within 12km stretch of a water injection line off W. Africa

Pipeline Details	
Pipeline Identification	WI-8
Pipeline OD w/out Coating (mm)	235.0 / 244.5 (Variable)
Wall Thickness (mm)	15.9
Coating Thickness (mm)	3.1
Coating Type	3LPP
Pipeline OD with Coating (mm)	241.5 / 250.7
Length of Section for Inspection (km)	12 km
Water Depth (m)	1,300

Challenge 1

Technique must be able to distinguish hydrate from gas or liquid

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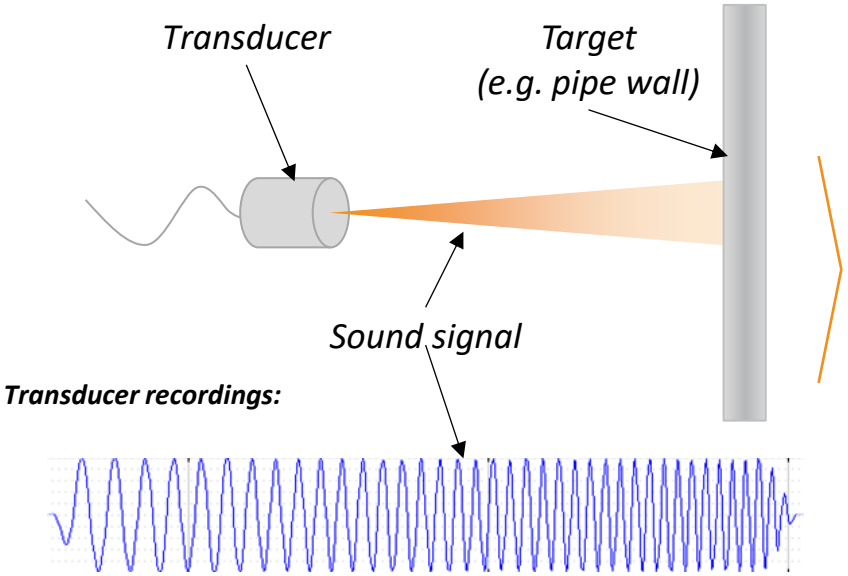
Overview ART® Methodology

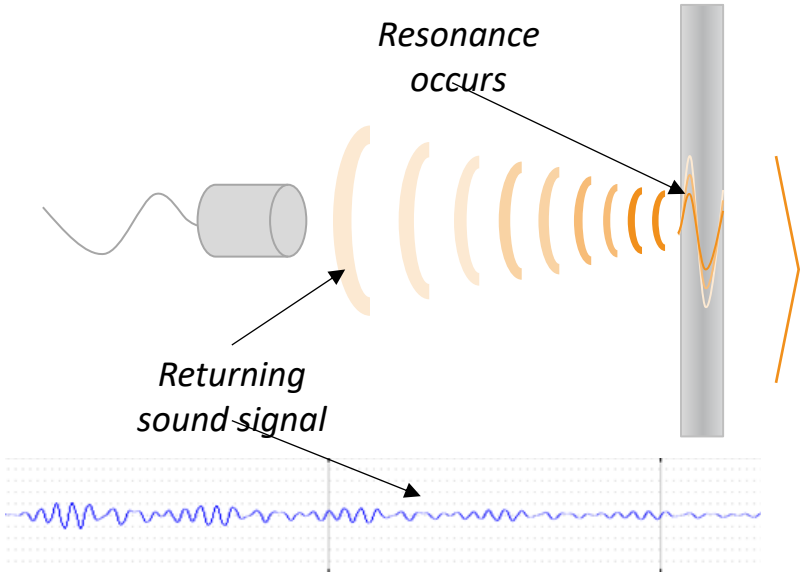
Emitting



Emitting sound signal towards a target (e.g. pipeline wall)

- Transducer shooting a broadband (multiple frequency) sound signal towards a target
- Signal duration is sufficiently long to generate oscillations in target

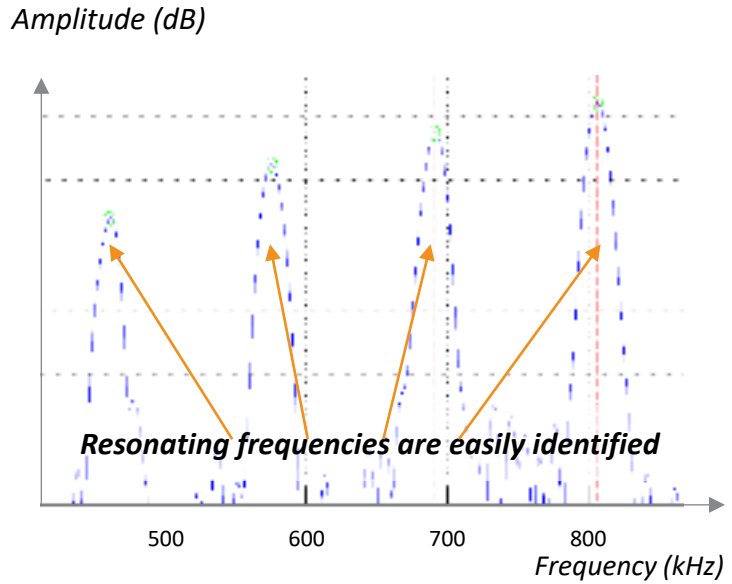
Listening



Resonance occurs in target – returning sound signal recorded

- As the oscillating target continues to be struck by the sound signal, resonance occurs in the target i.e. oscillations are greatly amplified
- These resonating frequencies are characteristic of the thickness and material of the target
- The tool records the returning sound signal

Interpreting



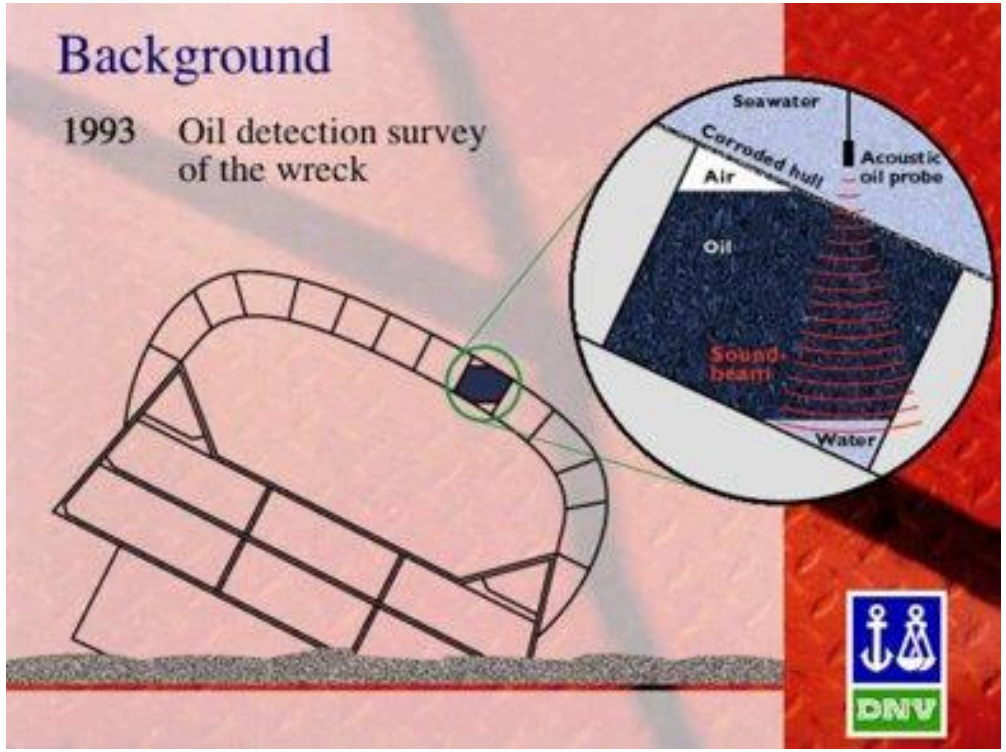
Identifying resonant frequencies allows for direct measurement of target thickness

- Direct measurement of thickness is revealed in the returning sound signal
- The frequencies that resonate are used to calculate the thickness of the steel
- time-of-flight (TOF) measurement allows for accurate caliper/geometry measurement

ART – Original Development

First industrial subsea application of the ART technology was to map air/oil/water levels in a sunken battleship from WW2.

The inspection was carried out to prepare a plan for replacing oil with water in the ballast tanks



Observations from Previous Testing

- Water and Ice (Hydrate) have very similar density
- Hydrates will typically absorb more acoustic energy than water
- ART is highly sensitive to changes in attenuation and therefore changes in medium

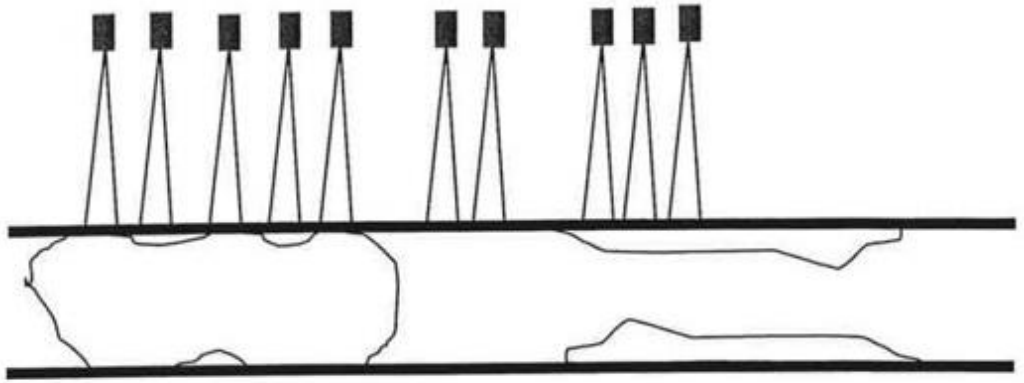
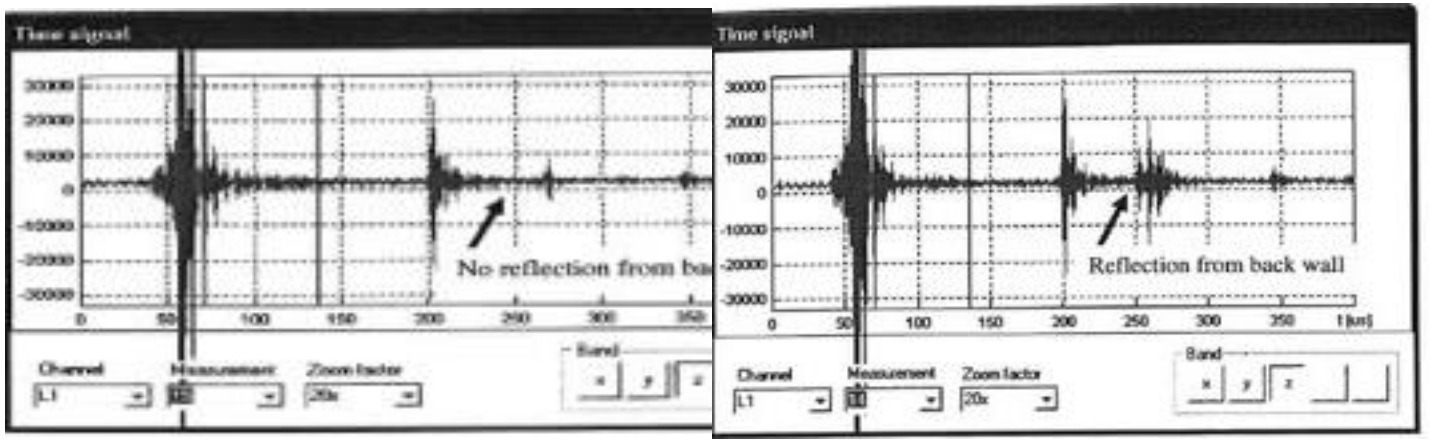


Figure 2. Example of how an ART detector would work.

Hydrate Detection Testing

Algorithms developed to differentiate water – gas – hydrate presence

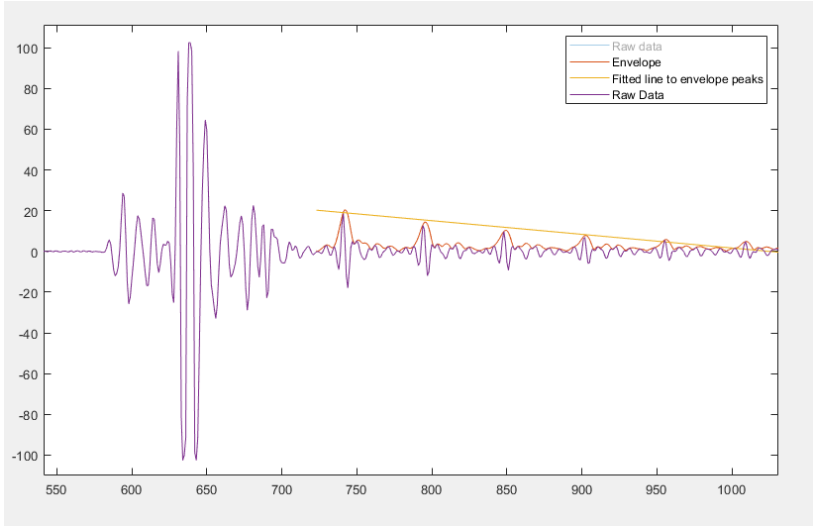


Backwall Echo

•Reflection of an acoustic signal from the far side of the pipeline.

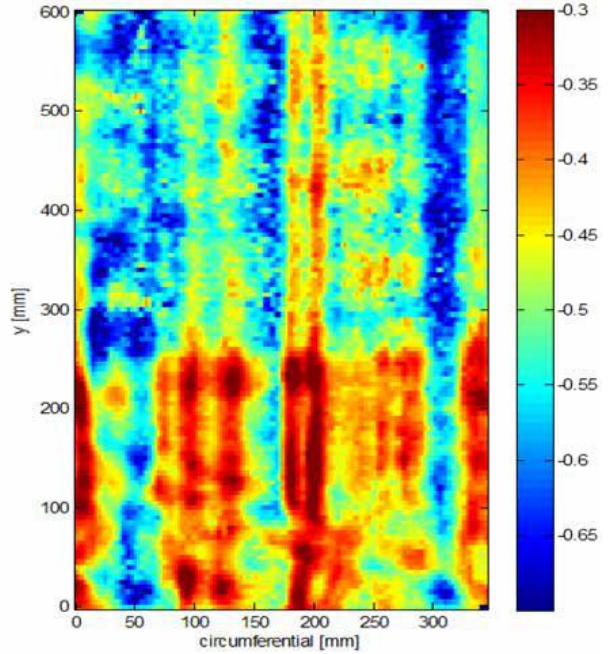
Decay Rate

•Refers to how quickly the acoustic signal diminishes after entering the pipe bore and is influenced by the medium (e.g., water, gas/air, hydrate/ice).



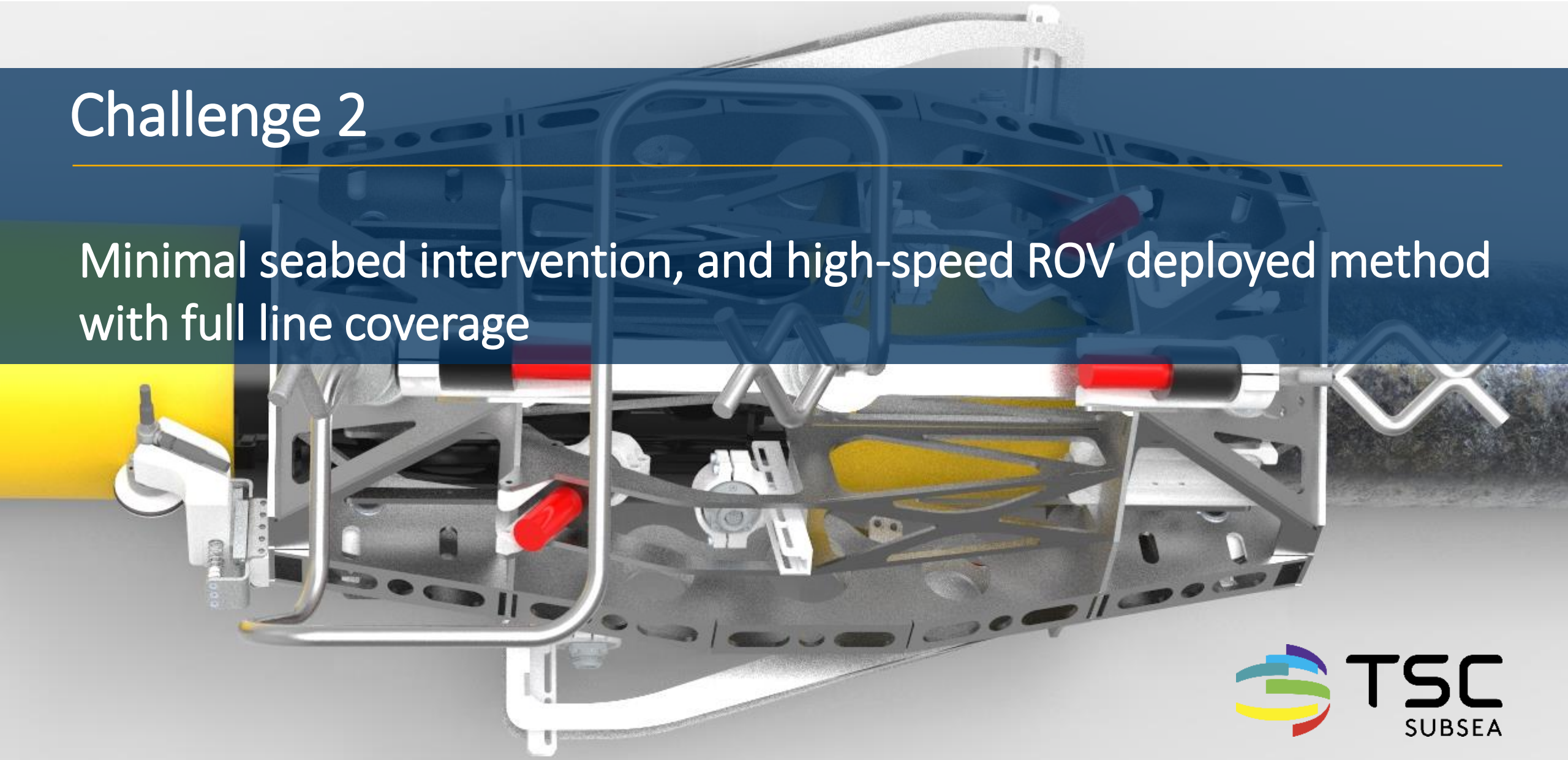
Lab Testing in Norway

- Lab testing proved that the current configuration offered robust and repeatable results
- However, a new system system needed match the ROV speed and maintain the robustness and repeatability



Challenge 2

Minimal seabed intervention, and high-speed ROV deployed method with full line coverage



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ART vPush Development

Pipeline Condition:

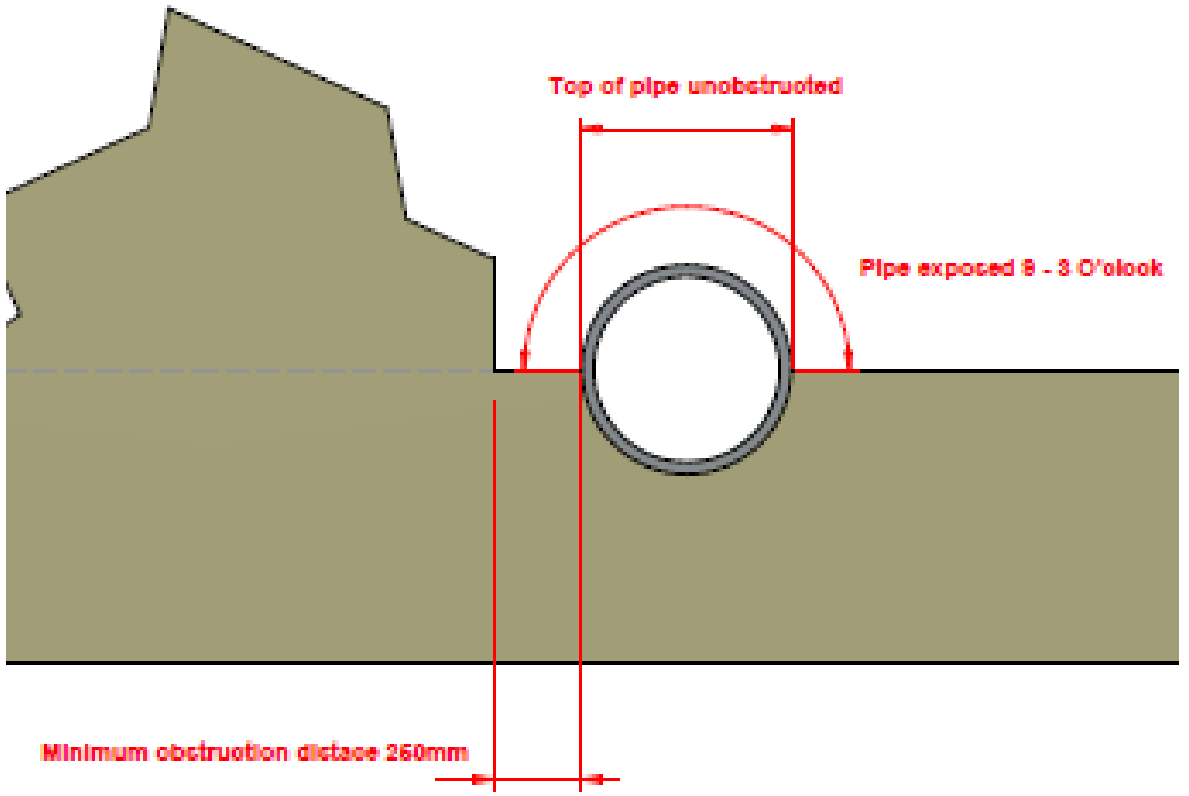
- Semi-buried pipeline.
- Client cleaned only the top 9-3 o'clock area.

Tool Adaptation:

- Tool and sensors designed to account for limited access.

Cost Savings:

- Reduced dredging time.
- Maintained tool robustness and reliability



ART vPush Development

Fast Deployment:

- Easy to integrate, ROV-operated solution.
- Designed and built in just 12 weeks.

Transducer Design:

- Circumferentially and axially offset transducers. Full coverage and minimizes signal interference.

Monitoring System:

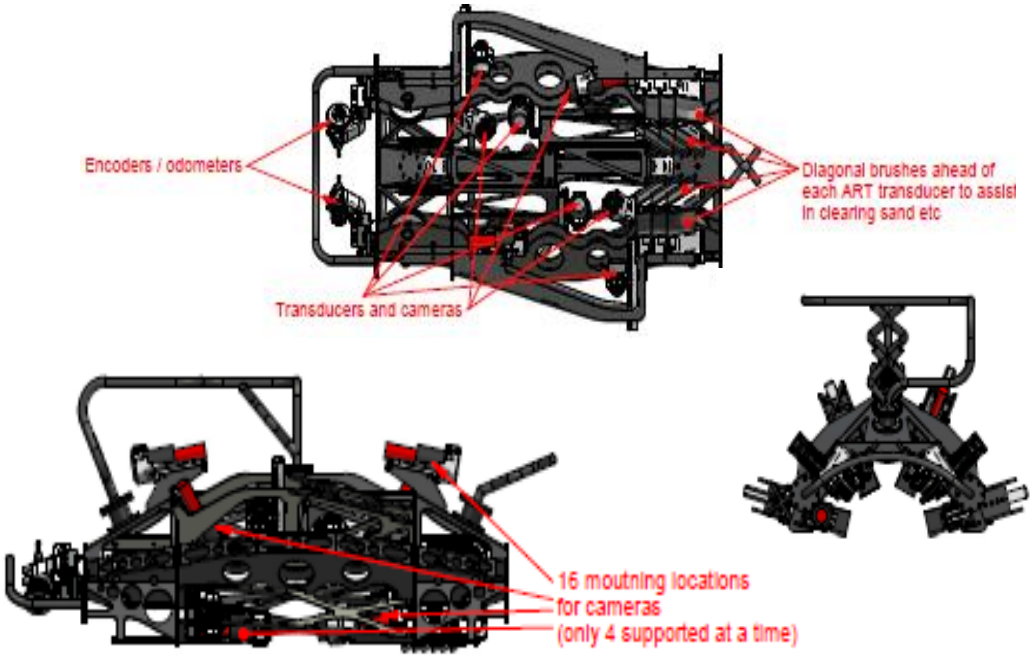
- 4 cameras to monitor each transducer's path.

Tracking

- Odometer for accurate location-encoding of data.

Robust & Stable Design:

- Stiff frame and a compliant handle maintains transducer alignment and eliminates ROV-induced 'wobble.'



Lab Testing in Norway

vPush incorporated four sensors running on three trigger points;

- First, back wall echo monitoring
- Second, echo threshold
- Third, echo decay

Challenge 3

Identify the exact location, size and distribution of suspected hydrate plug

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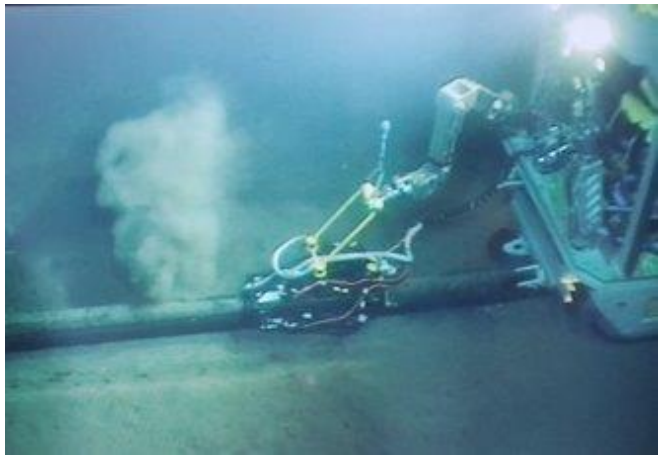
High-Speed Hydrate Detection

- 12 km continuous scanning in 33 hrs
- Hydrate plug located and sized
- High-speed data collection minimising ROV & Vessel time
- Through-coating inspection, eliminates coating removal/reinstatment
- Minimal dredging requirements



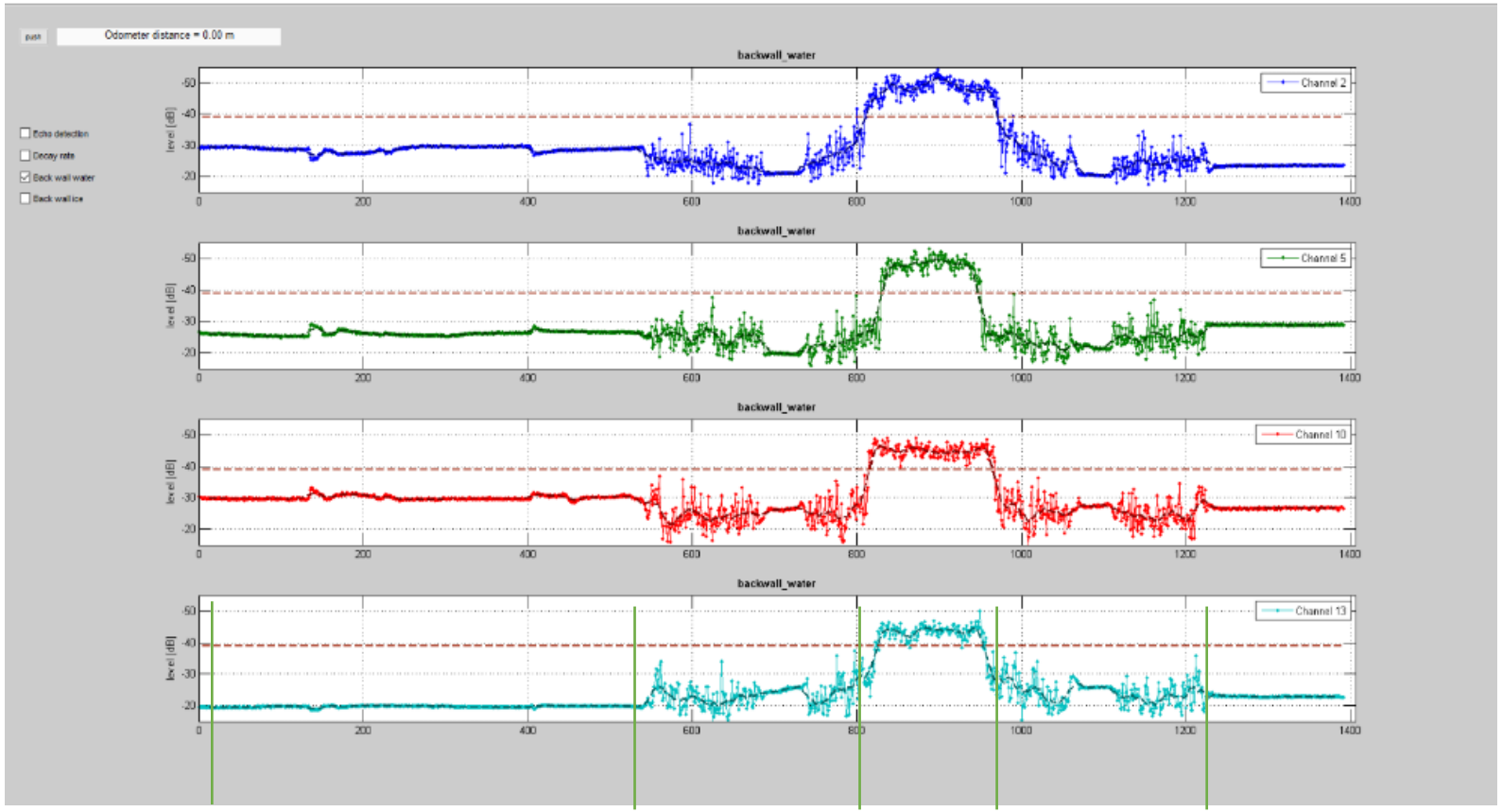
Results: High-Speed Hydrate Detection

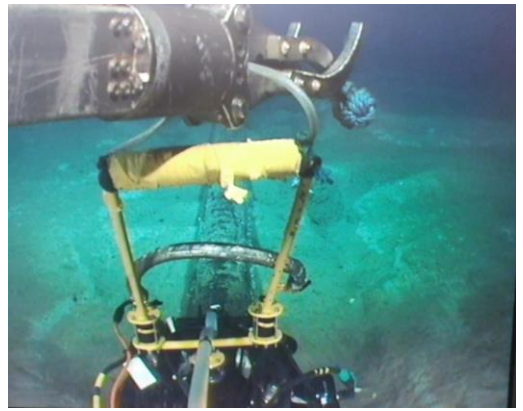
Sensor 1

Sensor 2

Sensor 3

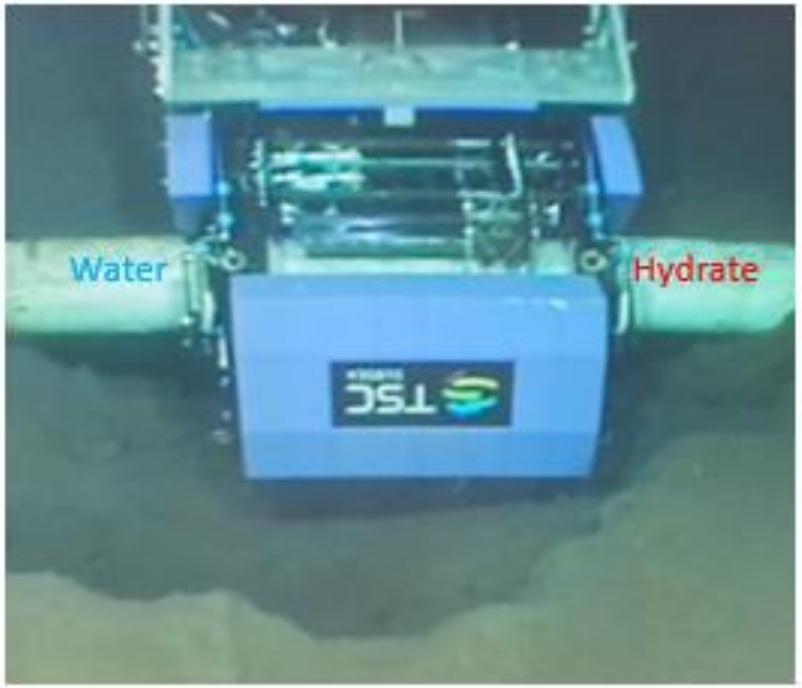
Sensor 4

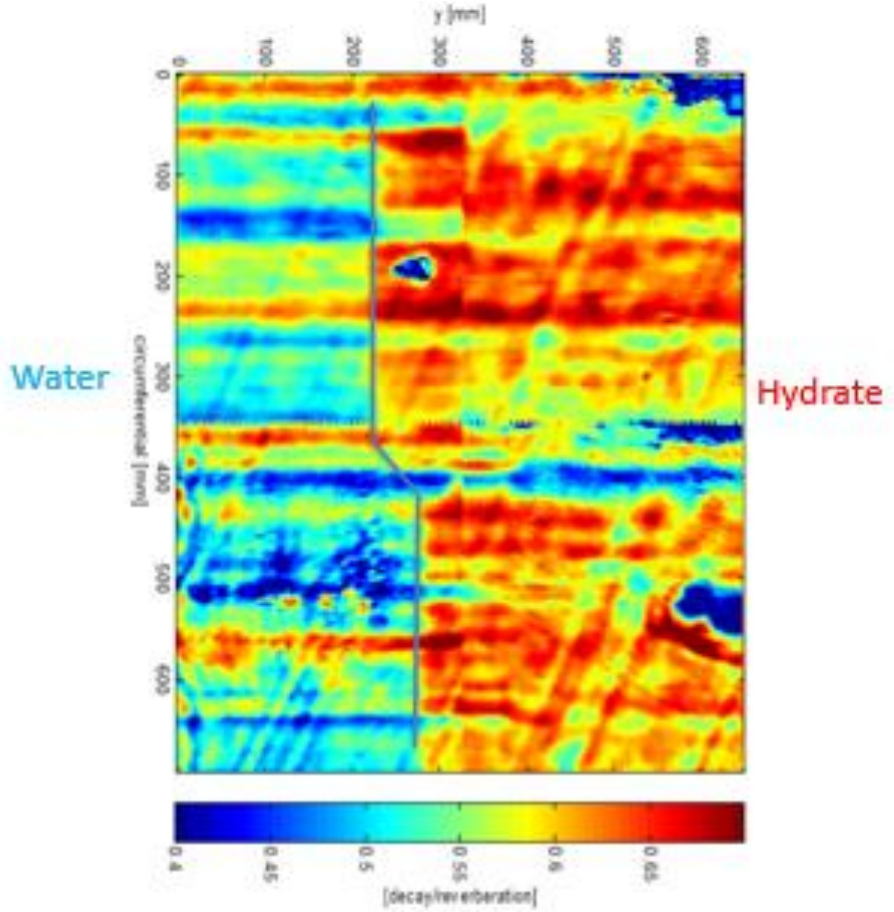




Offshore Validation Results

360 high resolution Scanning





Thank You!
Questions?