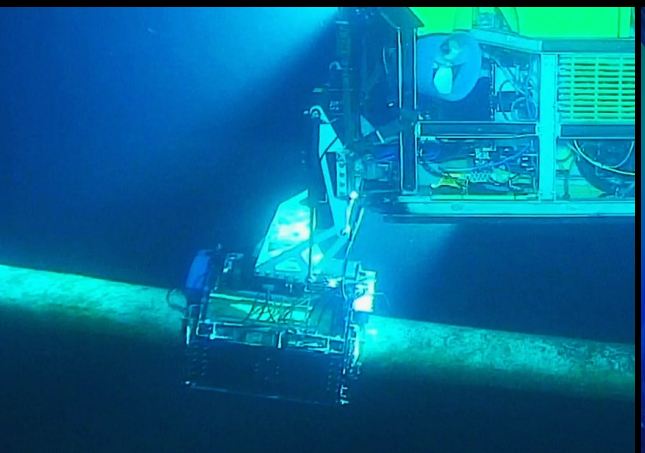
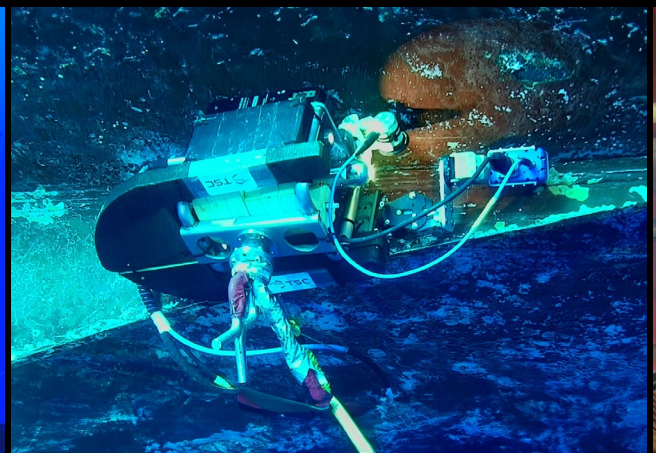
TSC SUBSEA

Solving the most challenging subsea inspections –
from the routine to the seemingly impossible.






We deliver critical inspections of subsea assets using remotely deployed robotic techniques and technologies.

We use exclusive NDT (Non-Destructive Testing) technologies to assess the integrity of offshore assets whilst minimising overall costs, environmental impacts and improving personnel safety.

Presented by:

Michel Bezemer
Subsea Technology Advisor, Europe & Africa

TSC Subsea Technologies

ACFM®

Alternating Current Field Measurement

ART

Acoustic Resonance Technology

AUT

Advanced Ultrasonic Testing

SPECTA™

Subsea Pulsed Eddy Current Array

With these 4 advanced NDT methods, there is no defect we cannot find!

Why Fixed-to-Asset Robotics

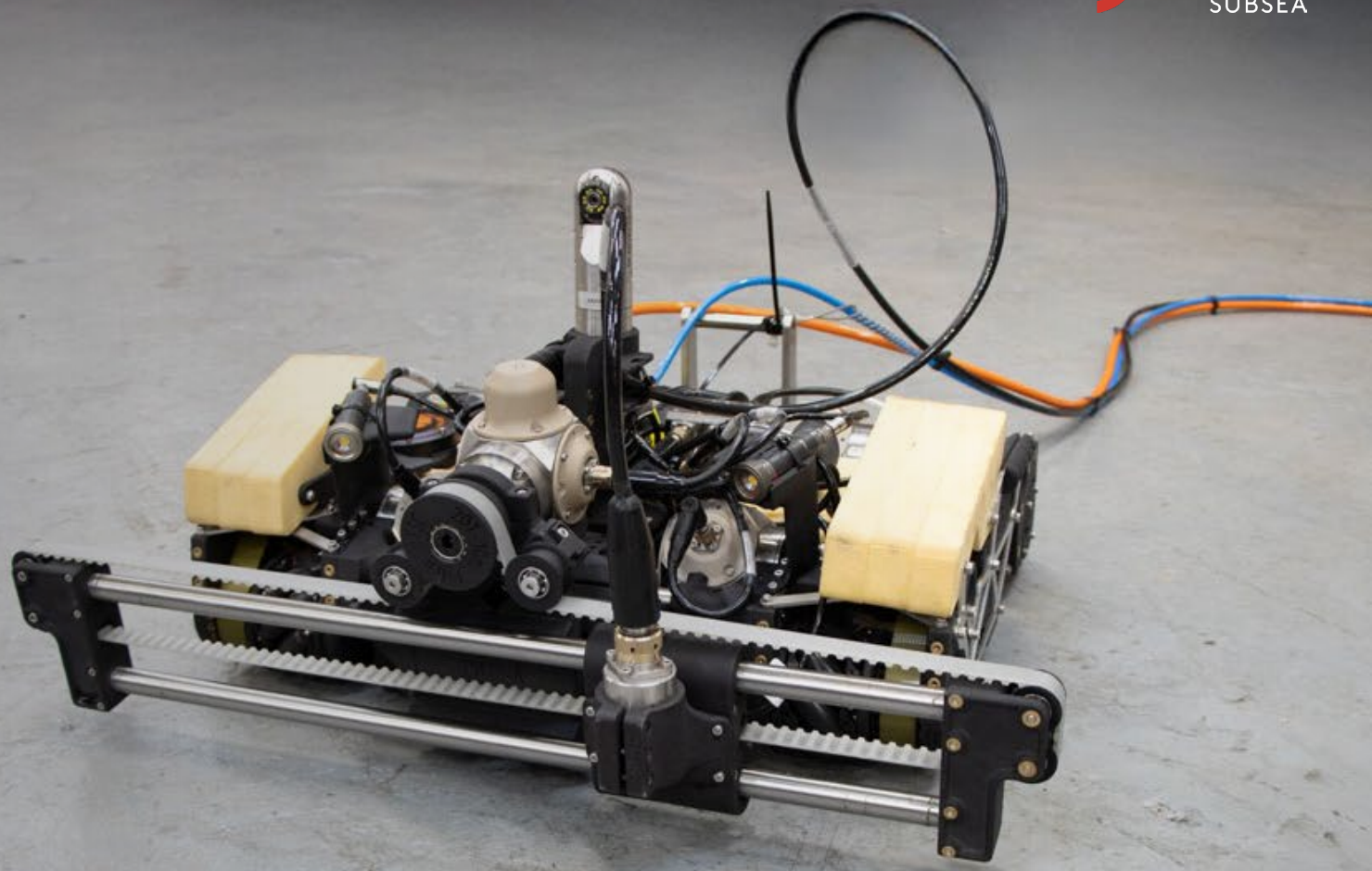
1. **Increased safety with reduced human intervention:** Robotics allow inspections to be conducted remotely, minimising the need for divers and reducing the associated risks.
2. **Fixed-to-asset**: Securing the robot to the structure enhances data quality and provides greater stability in challenging conditions, such as swells and currents.
3. **Cost efficiency:** Robotics can perform repetitive tasks accurately without breaks, reducing labour costs associated with human divers.
4. **Repeatable and accurate inspection:** Ensures consistent and reliable inspection data.
5. **Extended reach and accessibility:** Robots can access difficult-to-reach areas at any depth for as long as needed.

Eddy Current (EC) probe deployment using an ROV manipulator

TSC SUBSEA

ORCA™

Deck Launched, Robotic Crawler for In-Service Hull Inspections.



ORCA™

Delivering complete wall thickness and corrosion maps with sub-millimetre accuracy.

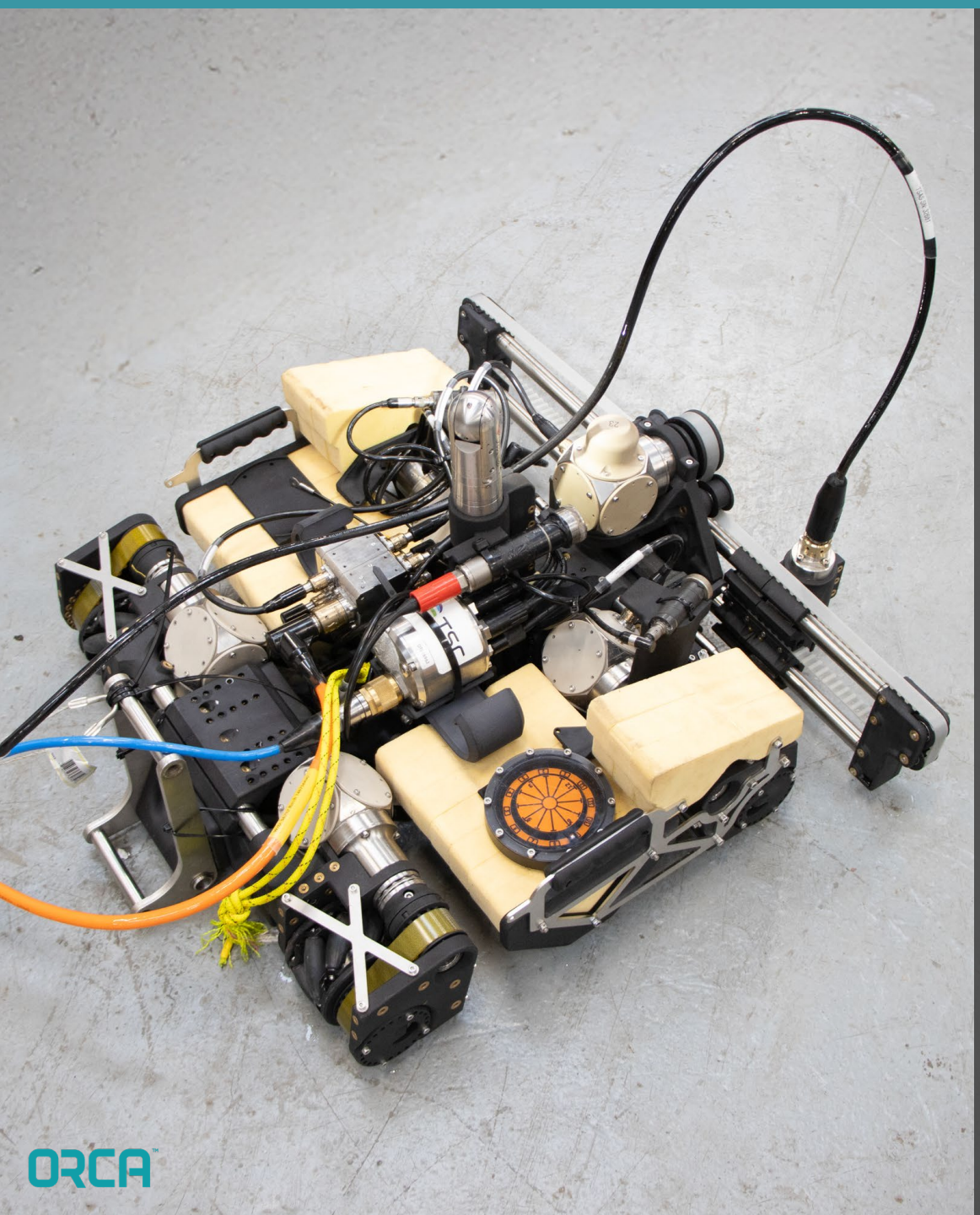

TSC
SUBSEA

Value Proposition

- **Reduce costly dry-docking times** by enabling inspections while vessels remain in service.
- **Simple deck launch** for easy deployment.
- **Lowers inspection costs** by eliminating the need for divers, ROVs, and vessel hire.
- **Increased safety** by removing the need for divers in hazardous underwater environments.

TSC SUBSEA

ORCA™

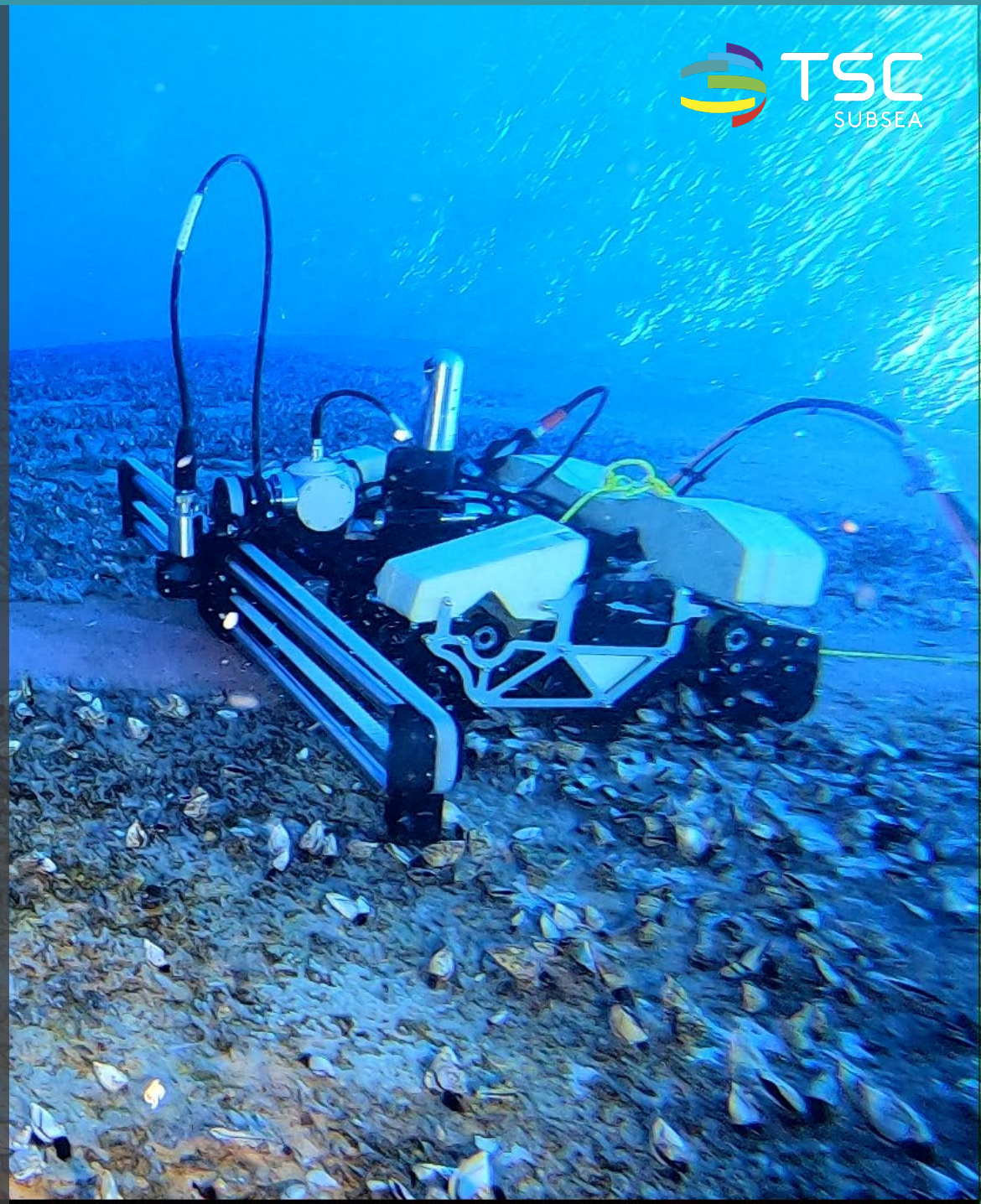


Key Benefits

- **Multi-Technology Integration**: Supports various NDT methods, including ART, ACFM®, PAUT, and ToFD.
- **Real-Time Data Analysis**: Provides immediate insights into the structural integrity, leading to informed decision-making.
- **Programmable Scan Patterns** along both X and Y axes, operating above and below the waterline.
- **Variable Resolution:** Fast screening or high-resolution data in a single deployment.
- **“Big Data”** capturing up to 1 million thickness readings per square metre.

ORCA Features

- **Semi-Autonomous Operation:** Programmable scan patterns enable efficient large-area inspections.
- **Magnetically Adheres:** Four independently driven, potted magnetic wheels for secure attachment.
- **Omnidirectional Movement:** Mecanum wheels allow seamless multi-directional navigation.
- **Coating-Friendly Wheels:** Prevent damage to the inspection surface.
- **Additional Motors:** Allow for probe head and sensor array manipulation, adapting to specific applications.



ORCA™

ORCA Features

TSC SUBSEA

- **Customisable Resolution:** Adjustable settings to meet specific client requirements.
- **High-Resolution Imaging:** Multiple cameras for navigation and close visual inspection (CVI).
- **Wide Scan Coverage:** 1200 mm (47 in) scan width, customisable upon request.
- **Modular System:** Easily expandable with additional components for varied inspection needs.

ORCA

Omnidirectional Navigation

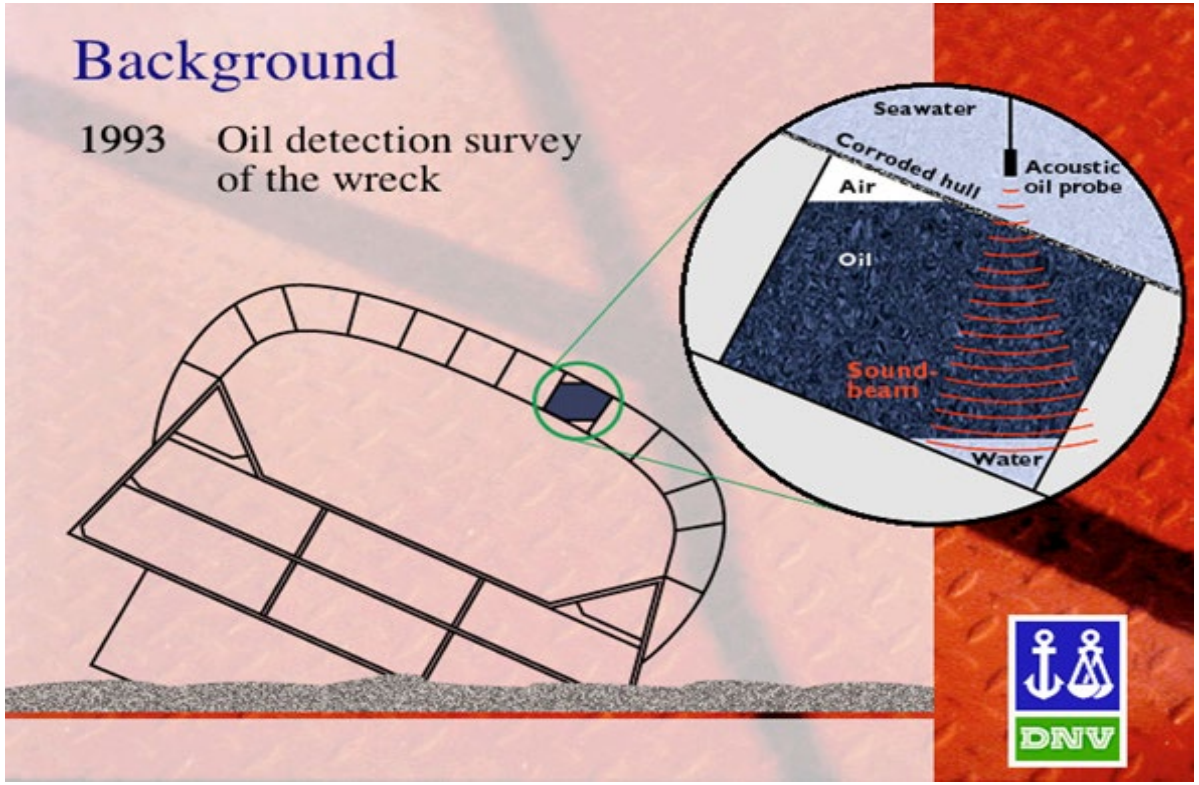
- Drive forward/backward, sideways left/right and turn on the spot.
- Efficiently navigates large and complex surfaces.
- Distance-tracking motors with encoders.
- Optimises scan patterns for maximum coverage.
- Exceptional manoeuvrability around obstacles.

History of ART

- On 9 April 1940, Blücher was sunk in the Oslofjord by Norwegian coastal defences at Oscarsborg Fortress.
- The sinking resulted in the loss of over 800 German sailors and soldiers and significantly delayed the German capture of Oslo.
- Its wreck lies at the bottom of the Oslofjord and is a protected war grave today.
- In 1993, ART was first commercially used by DNV to determine whether oil remains in its fuel tanks, posing an environmental threat.

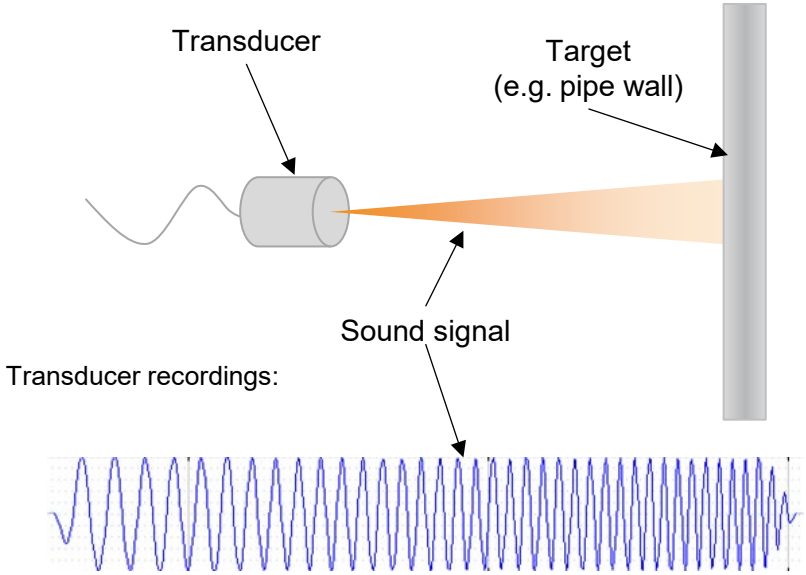
History of ART

- ART scans using ROVs revealed which of Blücher's internal tanks still contain oil.
- Findings confirmed significant oil remains onboard, raising concerns over potential leakage.
- Environmental risk is high due to the wreck's location in the sensitive Oslofjord ecosystem.
- Norwegian authorities are assessing options for oil removal or containment based on ART results.



Acoustic Resonance Technology (ART)

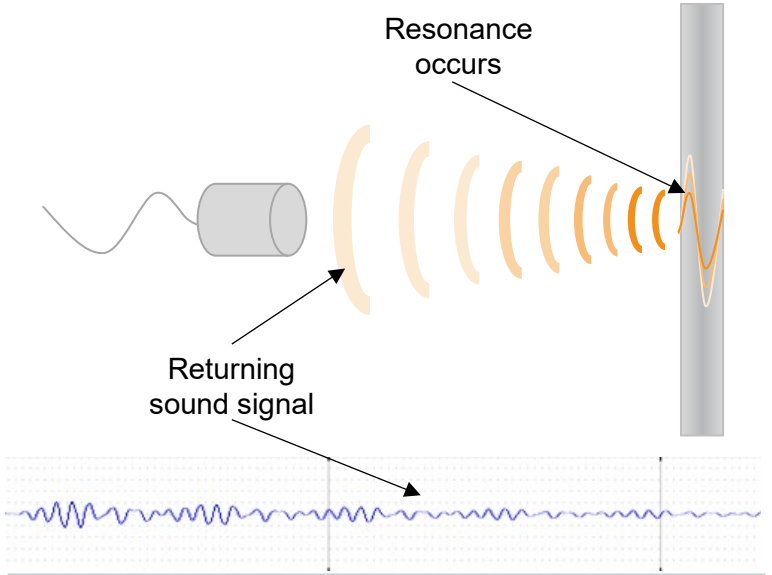
Emitting



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

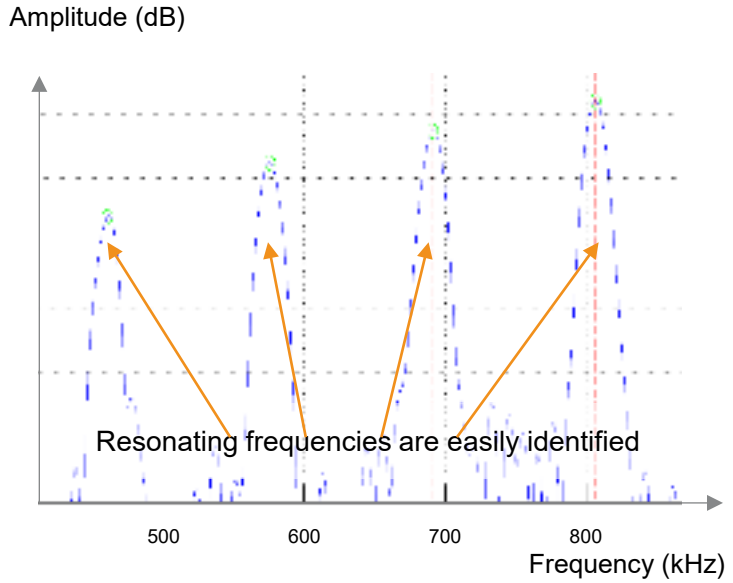
Listening



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

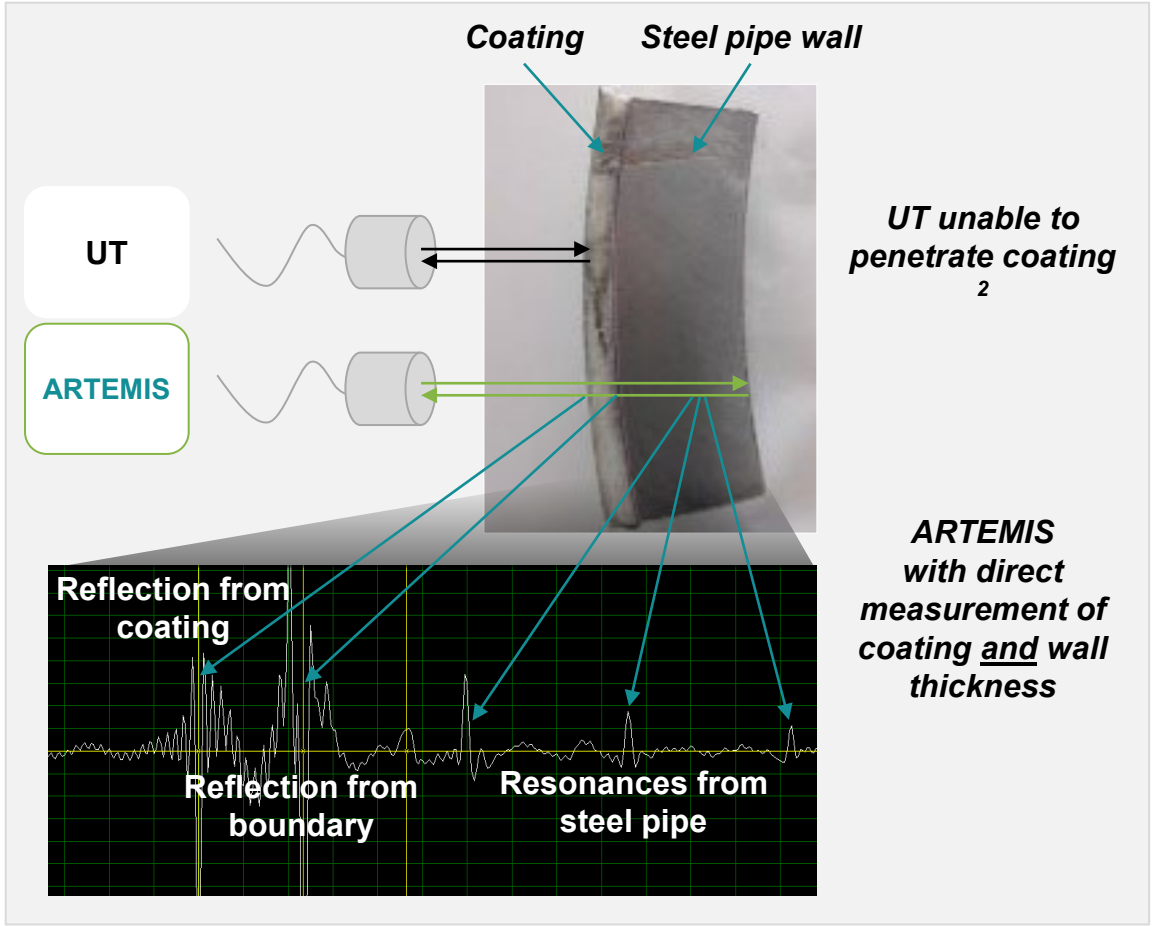


Identifying resonant frequencies allows for direct measurement of target thickness

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

ART Methodology

Coating penetration ability



UT unable to penetrate coating [2]

ARTEMIS with direct measurement of coating and wall thickness

High resolution wall thickness measurements through subsea corrosion coatings to an accuracy of +/- 0.22mm

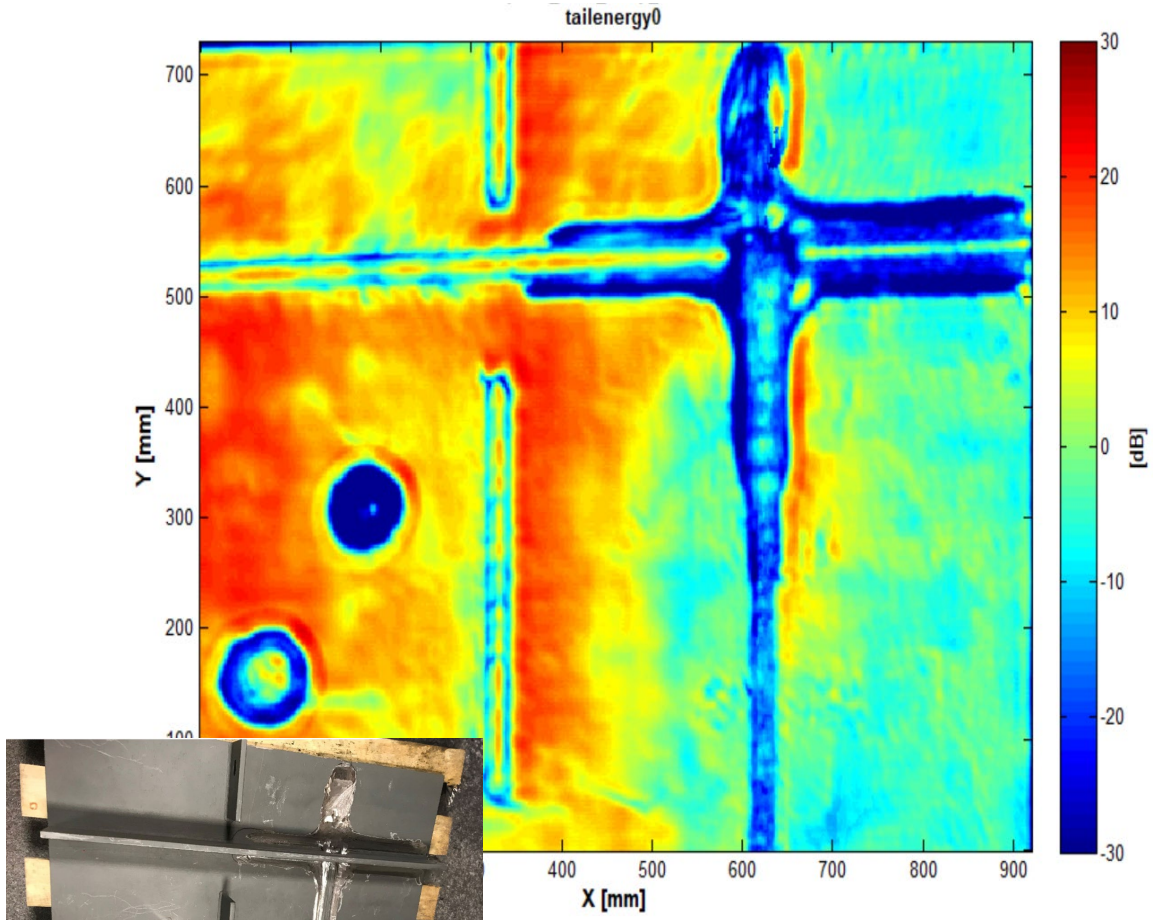
Key technical benefits & customer implications

Unmatched coating penetration	✓ Direct & accurate measurements through subsea coating *(up to 100mm polypropylene & FBE)* ✓ Coating disbondment & degradation
Inspection of flexibles	✓ Annulus status ✓ Thickness of armor wires ✓ Penetration & inspection of outer sheath
Compatible with any ROV	✓ Easy integration & operation with any ROV – inspection- or work class
Real-time communications to topside	✓ Fiber-optic data communication to topside through ROV umbilical ✓ Real-time inspection, monitoring & analysis

- **Enabling highly accurate inspection of "unpiggable" pipelines & risers**
- **Enabling inspection of flexible flowlines & risers – a key development area for integrity industry**

Acoustic Resonance Technology (ART)

- ART and Phased Array both use ultrasound technology, but ART operates at lower frequencies and offers a wider bandwidth, enabling it to penetrate coatings that Phased Array cannot.
- ART is a non-contact method that is more tolerable to surface conditions and marine growth.
- Capable of obtaining WT data through highly attenuative and antifouling coatings to an accuracy of +/- 0.22mm.
- Corrosion mapping of external and internal surfaces.
- Detect coating disbondment & degradation.
- Geometry measurements for assessing dents, gouging and other anomalies.

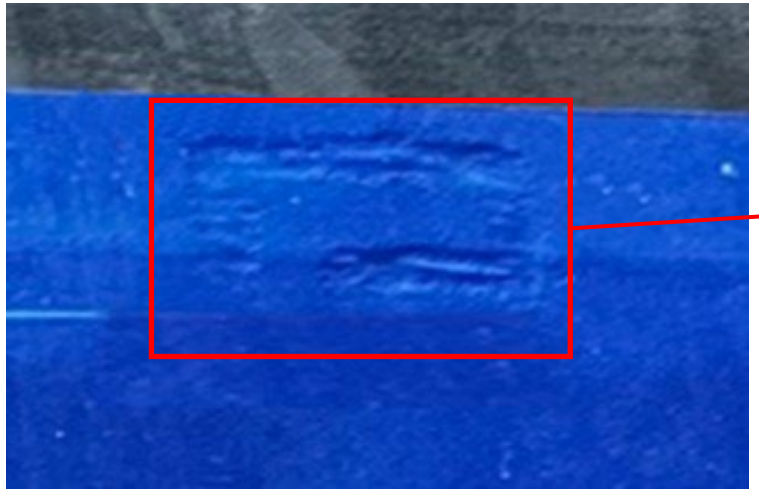


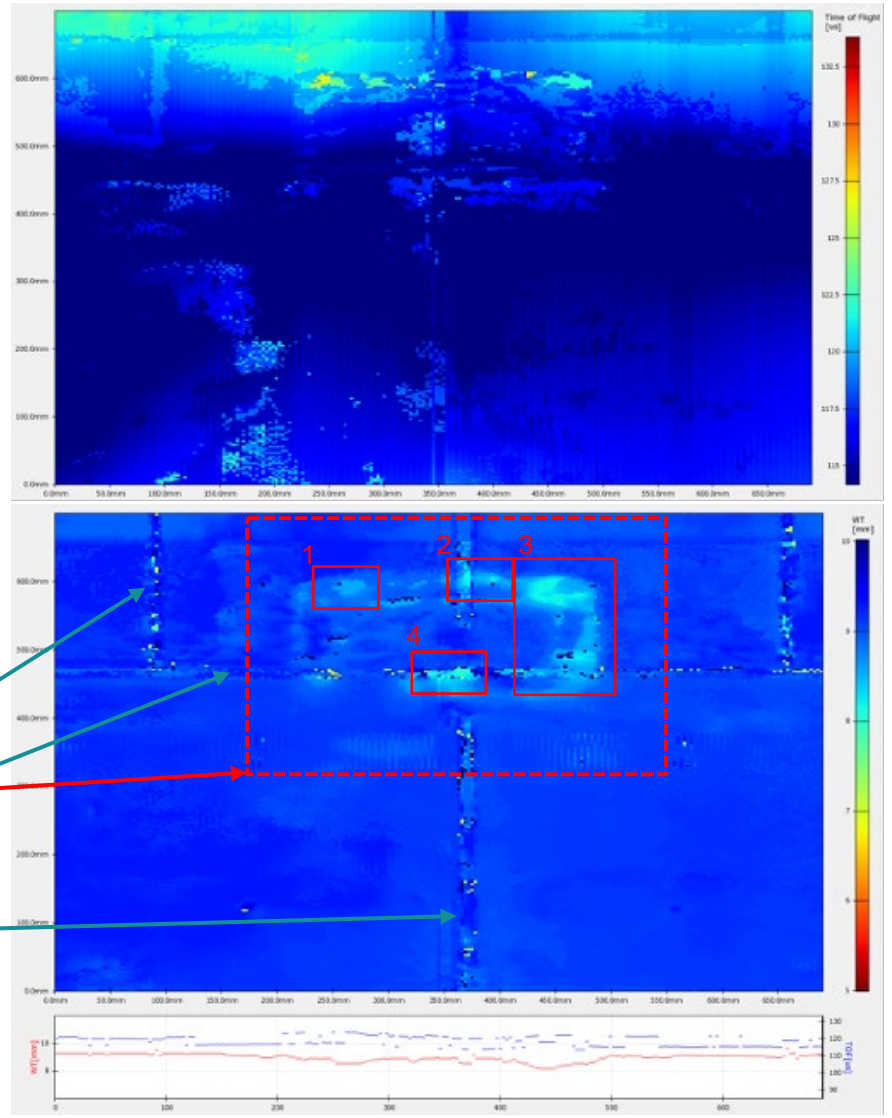
Scan conducted from the opposite side of the test plate.

ART Data from Navy Trials

Defect No	As built WT	X Pos	Y Pos	Length	Width	Remaining WT	WT Loss	% WT Loss	Location
1	9.0	252.0	575.5	26.6	25.4	8.5	0.7	7.6	External
2	9.0	363.4	593.7	40.8	22.2	8.2	1.0	10.9	External
3	9.0	419.0	428.9	67.8	183.3	8.2	1.0	10.9	External
4	9.0	315	430	61.4	44.3	7.9	1.4	15.0	External

All measurements in mm





Lloyds Validation of ART

- **Objective**: To gain validation from Lloyd's Register for Hull Plate thickness inspection.
- **Task:** Conduct an **Acoustic Resonance Technology (ART)** corrosion mapping inspection of an FPSO single skin test sample (owned by HITS JIP).
- **Why**: Requested by major FPSO operators and several naval forces.
- **Location**: Forth Engineering, Flimby, UK.
- **Benchmark:** Phased Array Ultrasonics (PAUT) for accuracy comparison. PAUT is widely recognised as one of the most reliable methods for quantitative wall thickness measurement.

Scope of Validation

Application of Acoustic Resonance Technology (ART) to perform quantitative Ultrasonic Thickness Measurement (UTM) for both internal and external corrosion defects of ship hull carbon steel plate through coating.

Big Data-Driven Integrity Insights

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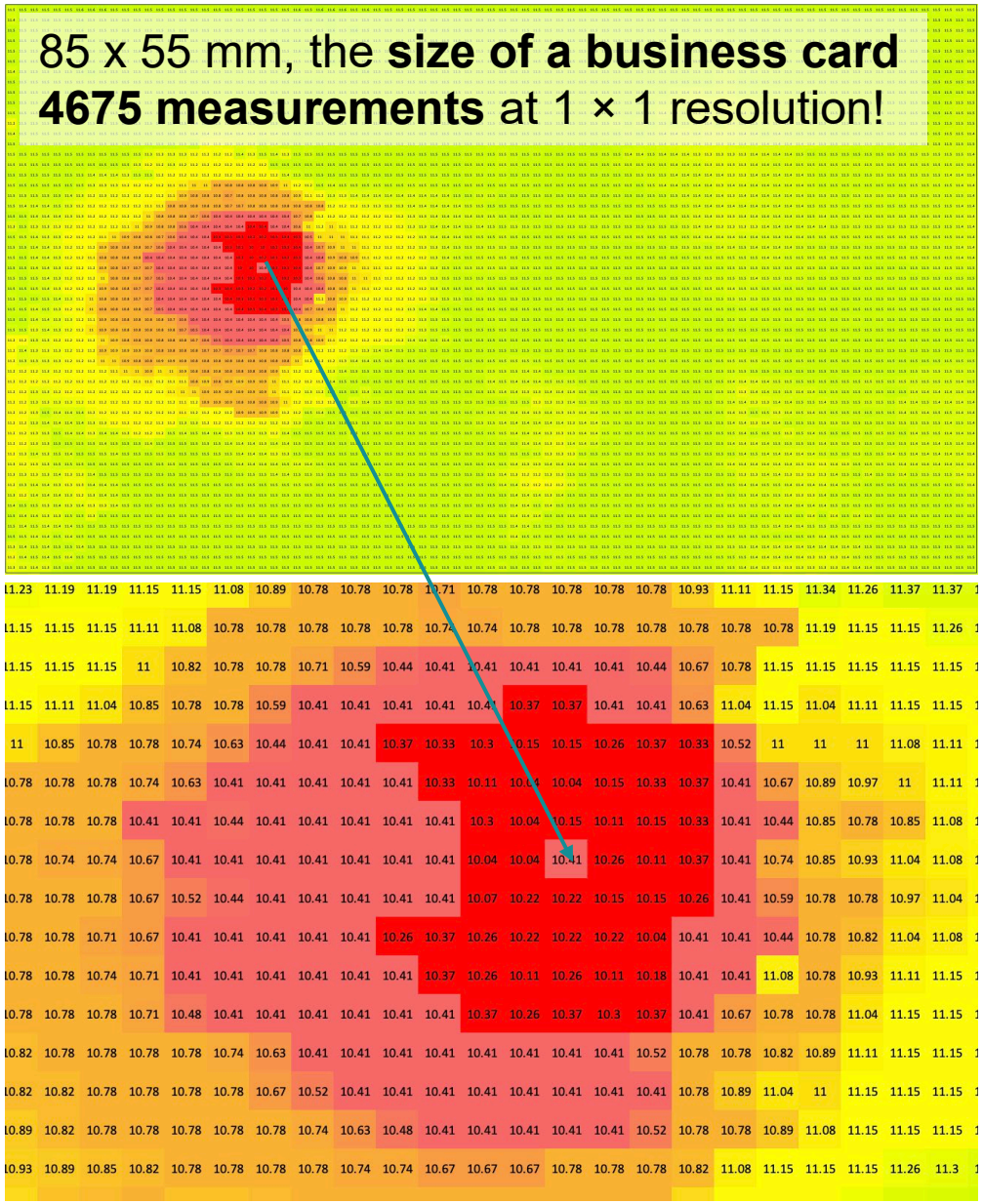
Inspection Performance Comparison per 1 sq/m.

Resolution (mm)	Total Time (min)	No of Readings
100 × 100	1.67	10,000
50 × 50	3.33	20,000
25 × 25	6.67	40,000
10 × 10	16.67	100,000
5 × 5	33.33	200,000
3 × 3	55.56	333,333
1 × 1	166.67	1,000,000

- C-Scan is made up of individual wall thickness data.
- Adjustable resolution ranging from 1×1 to 100×100mm.



ORCA

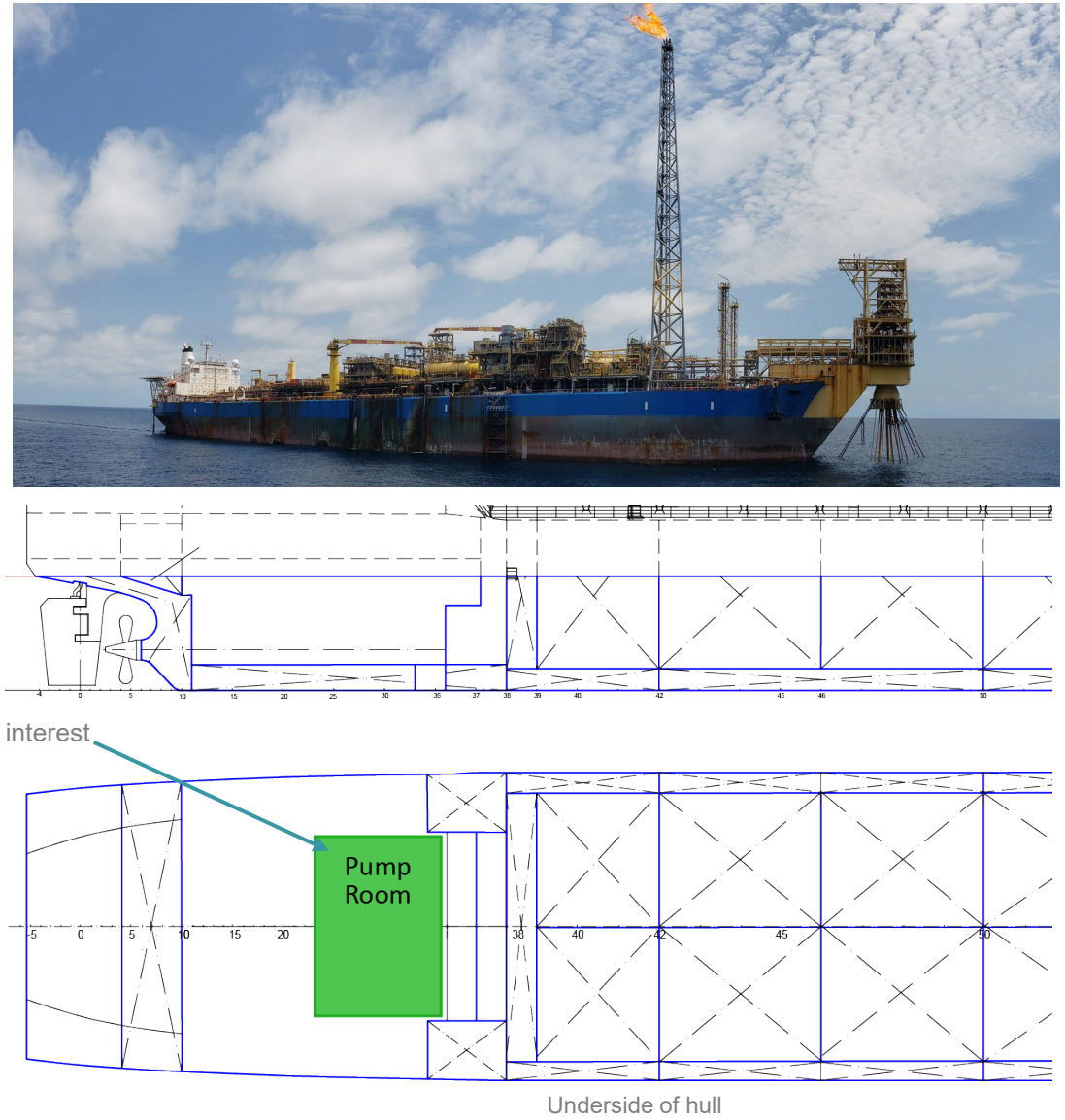
Case Study – In-service Hull Inspection

Introduction

- Built in 1981 as a single-skinned tanker, converted to FPSO in 2008.
- Operating under a Risk-Based Inspection (RBI) regime.
- Area below the engine/pump room was not accessible for internal inspection.
- Required diverless in-water inspection without stopping production operations.

Challenge

- Accurately map and size external hull defects >1 mm.
- Overcome subsea issues: currents, swell, marine growth.



Case Study – In-service Hull Inspection

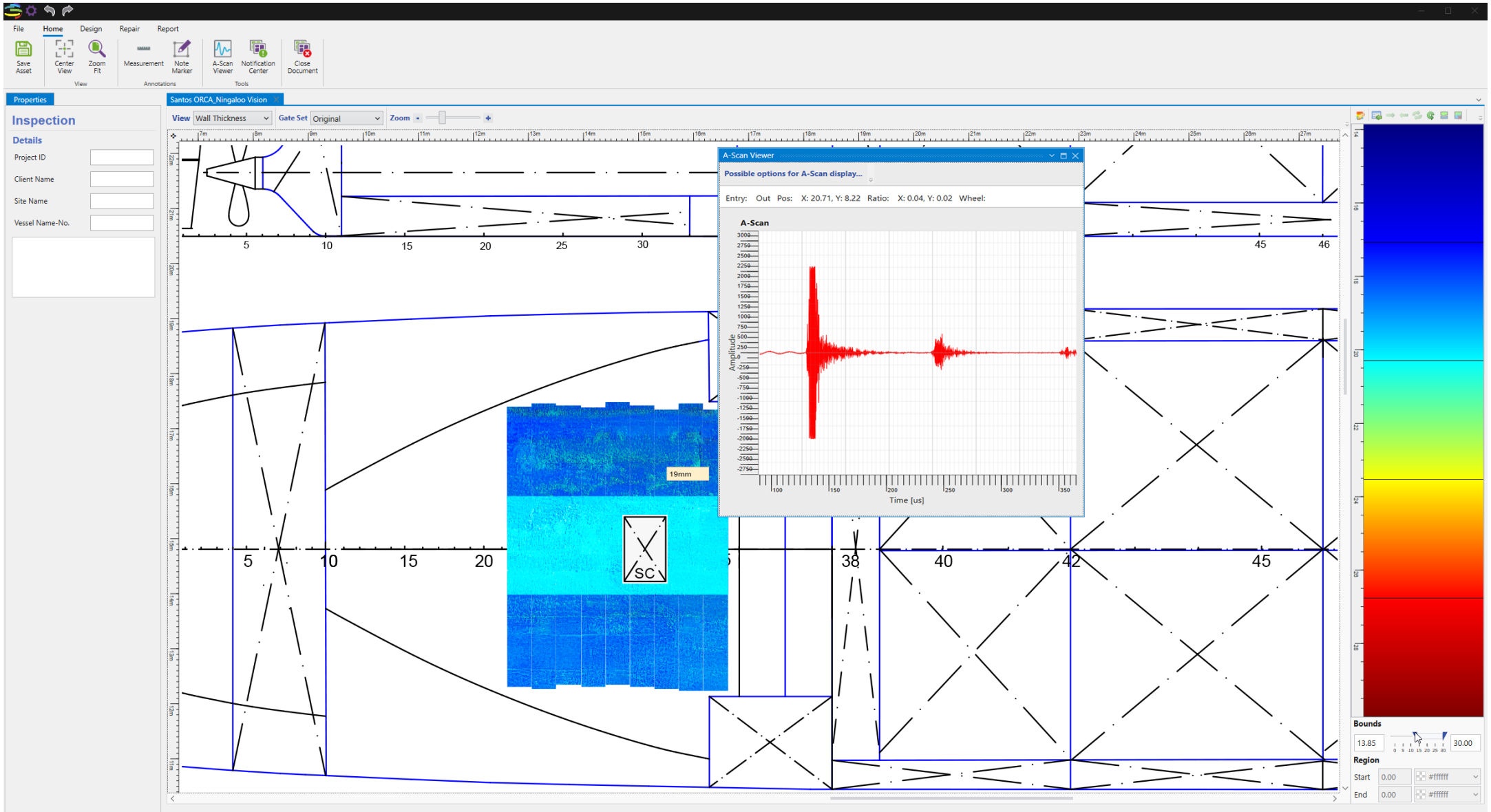
Solution

- ORCA: deck-launched, omnidirectional robotic crawler.
- Acoustic Resonance Technology (ART) delivering sub-mm thickness accuracy.
- Adjustable resolution ranging from 25 x 25 mm for high-speed scanning and 25 x 1mm for higher resolution.

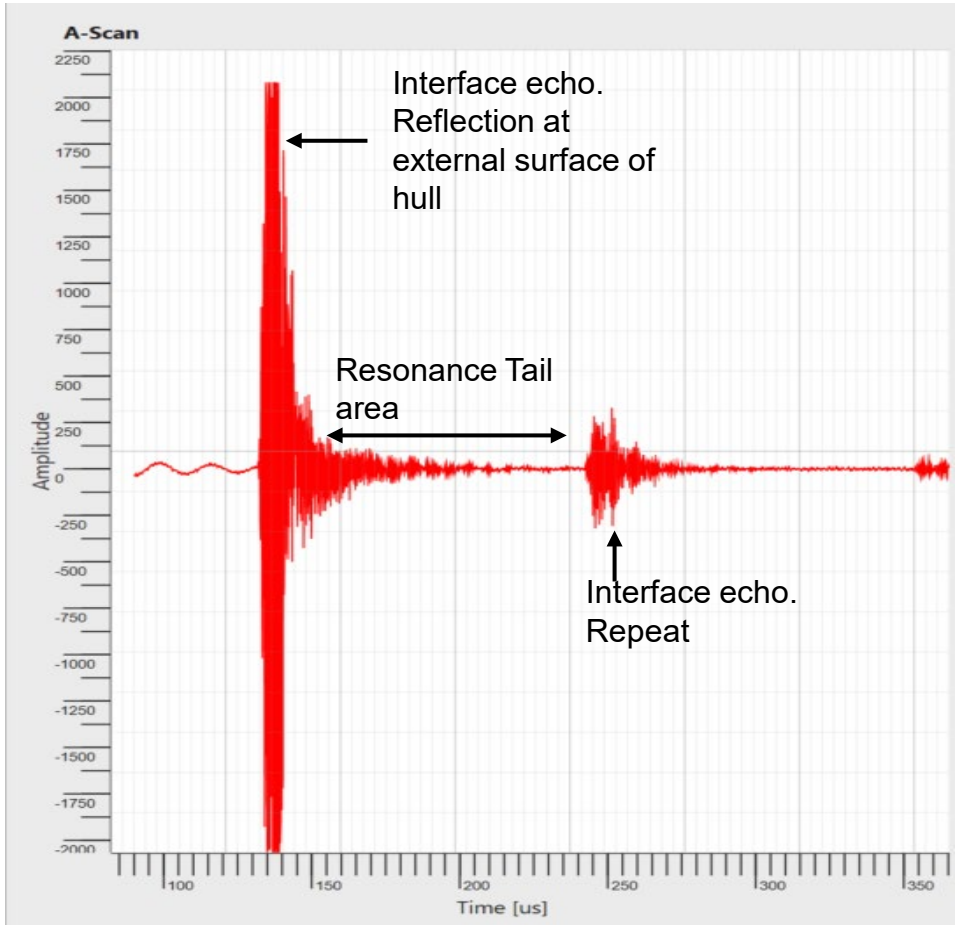
Results

- Detailed corrosion mapping generated from stitched scan data.
- Verified hull integrity with no critical wall loss.
- No production loss, no divers, no support vessels.

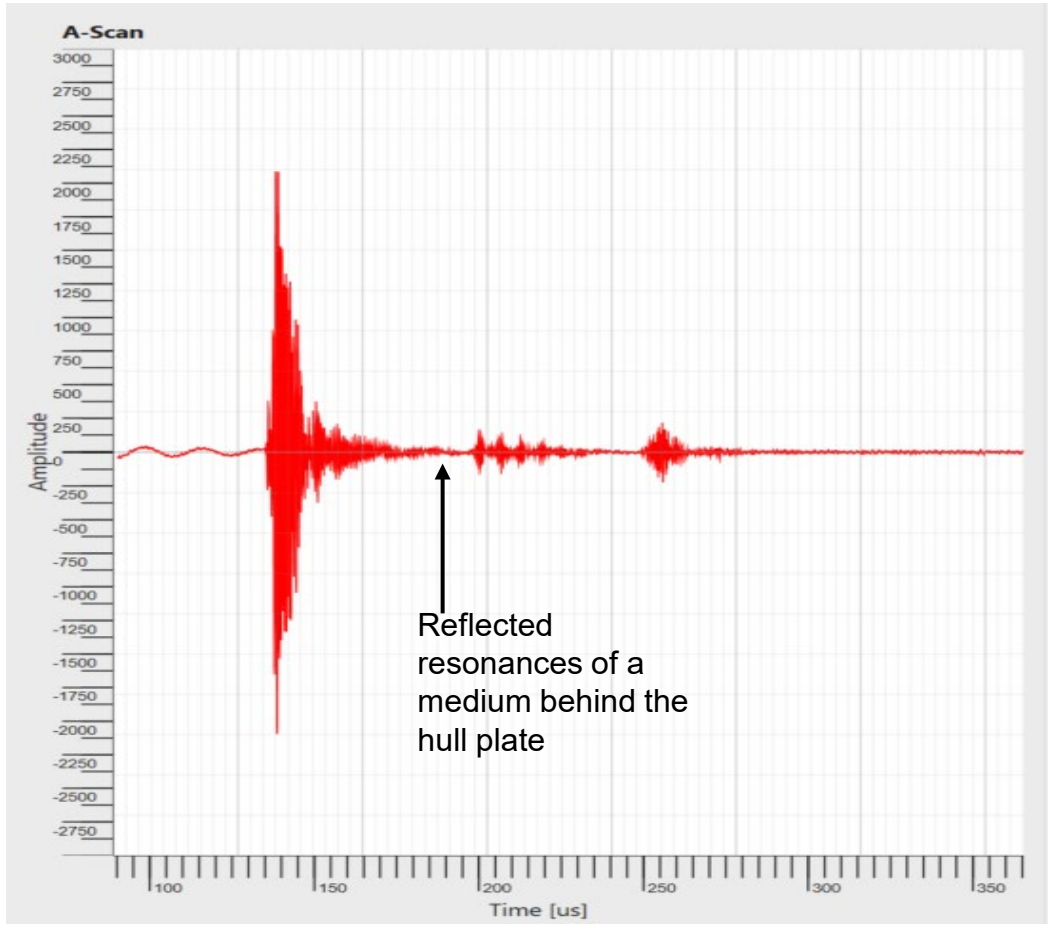
ART Stitched Data



Advanced Analysis



Raw A-scan showing nothing at the backwall



Raw A-scan showing resonances reflected at a boundary of a medium behind the hull plate

Inspection Achievements

- **Safe and Cost-Effective:** Delivered results more economically than any alternative solution, without compromising safety.
- **No Dry Docking Required:** Inspected areas previously only accessible via dry docking, now achieved in-service.
- **Diverless Deployment:** Deck-launched and remotely operated, eliminates diver-related risks.
- **Maximum Coverage & Efficient Scanning:** Omnidirectional mobility enabled optimal scan patterns and precise positioning.
- **Internal Medium Detection:** Detected the presence of medium behind the hull plates, offering additional insight.
- **Aligned with RBI Strategy:** Enables continuous monitoring, reduces downtime, and supports predictive maintenance.

Why Choose TSC Subsea with ORCA?

01

Maximum Uptime, Minimum Disruption

Inspections are performed **in-service**, no dry-docking, no divers, no shutdowns.

02

High-Resolution, Validated Technology

Lloyd's validated **Acoustic Resonance Technology (ART)** delivers sub-millimetre wall thickness and corrosion mapping through coatings and soft marine growth.

03

Proven Cost & Safety Advantages

Diverless, deck-launched crawler reduces personnel risk, cuts mobilisation costs, and eliminates the need for support vessels.

Thank You!
Questions?

Check our website for information on all our technologies and case studies.

www.tscsubsea.com