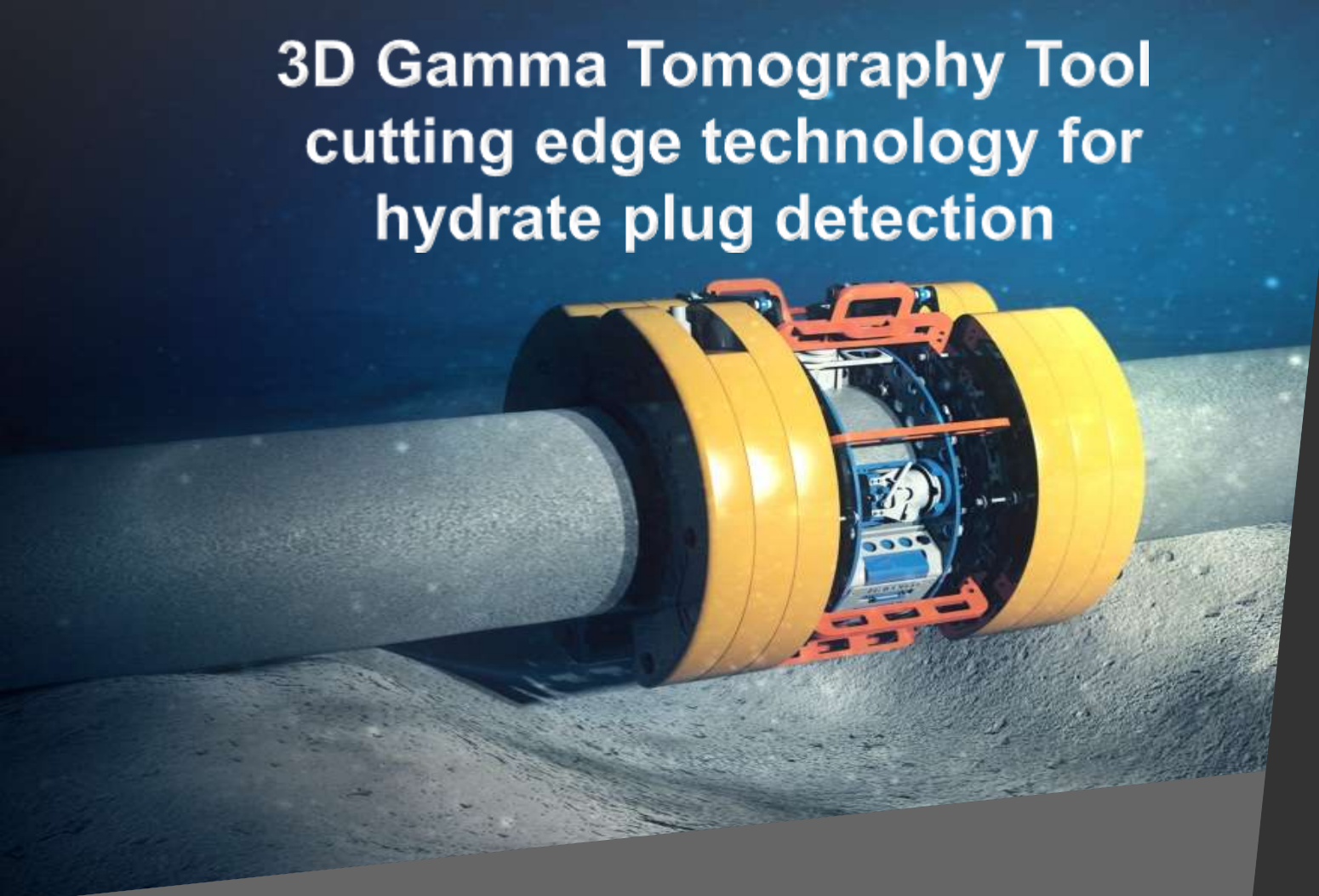
3D Gamma Tomography Tool cutting edge technology for hydrate plug detection



Statoil

3rd Trondheim Gas Technology Conference,
4th-5th June 2014

Keijo Kinnari, Senior Specialist, Technology Excellence, Statoil
Xiaoyun Li, Specialist Principal Researcher, Statoil
Lee Robins, Head of Subsea Services, Tracerco

Tracerco
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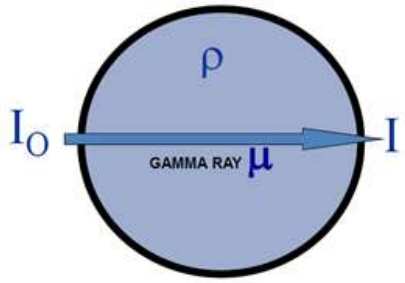
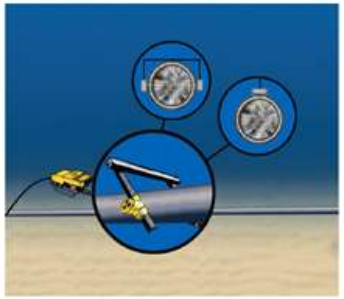
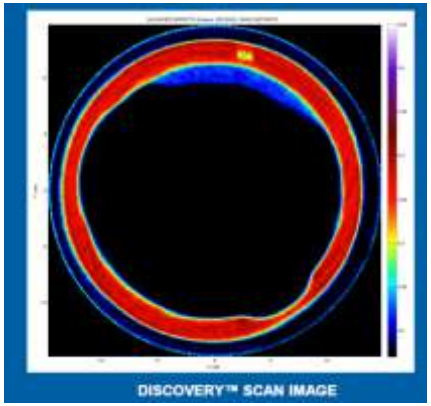
Outline

- Introduction
- Flow assurance challenges and needs
- Initial Statoil and Tracerco cooperation on developing/testing detection tools
- Examples of field tests
- DiscoveryTM - Subsea Pipeline Visualisation
- Introduction to the technology
- Trials and scan images
- Summary and Conclusion

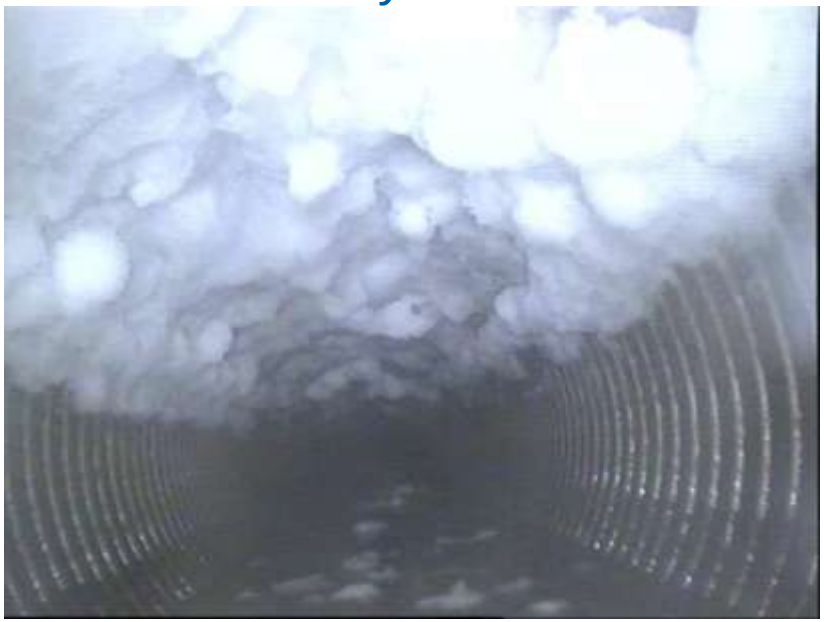






Introduction

- Hydrate restrictions in production systems
- No reliable detection tools, especially for subsea use
- Needs for high accuracy detection tools
- Cooperation between Statoil and Tracerco over last 10 years
  - To develop detection technology
  - Primary goal was FA applications
  - Application areas have expanded



Flow Assurance challenges

- Plug location
- Plug characteristics
  - Liquid pockets, wax depositions, hydrate restrictions, scale etc.?
- Information important for
  - Safety considerations
  - Evaluation of remediation solutions

Statoil's Flow Assurance Pilot

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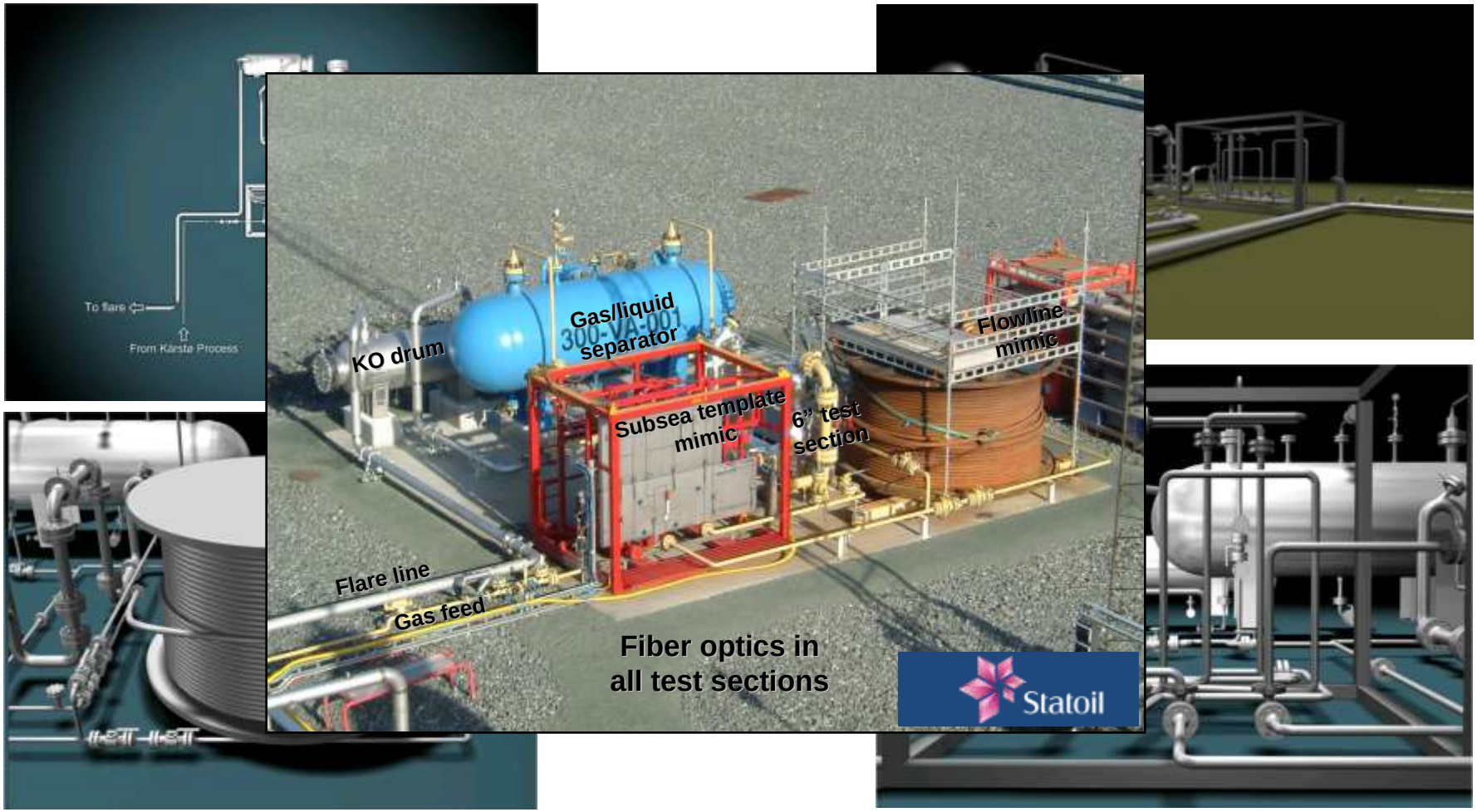

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Statoil's Flow Assurance Pilot Plant

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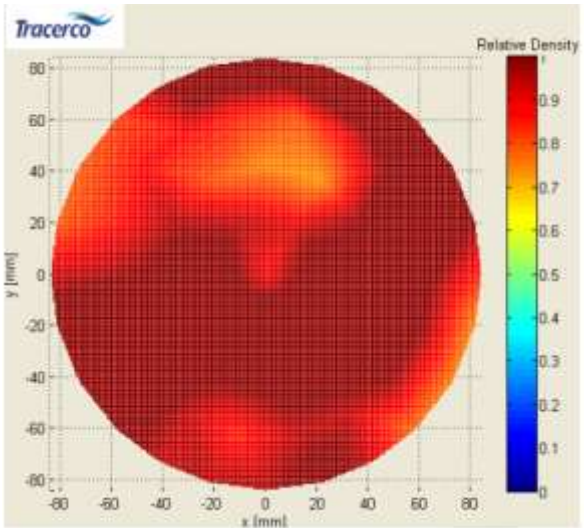
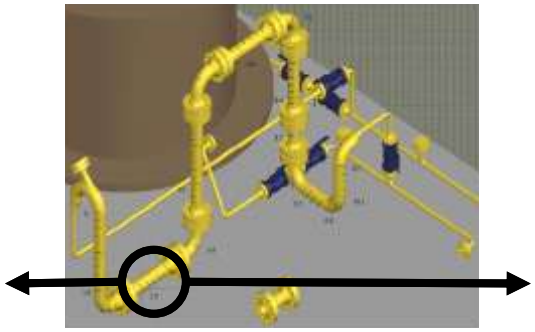
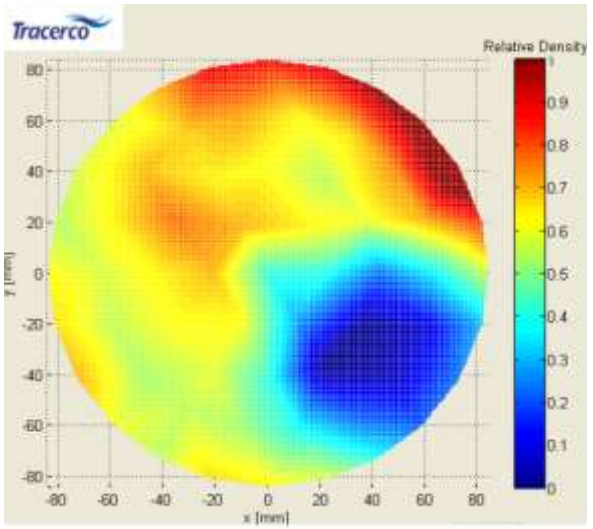
Tomography technique used during hydrate detection trials



Tomography map with liquid filled pipe section





Tomography map after draining

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Tomography applications

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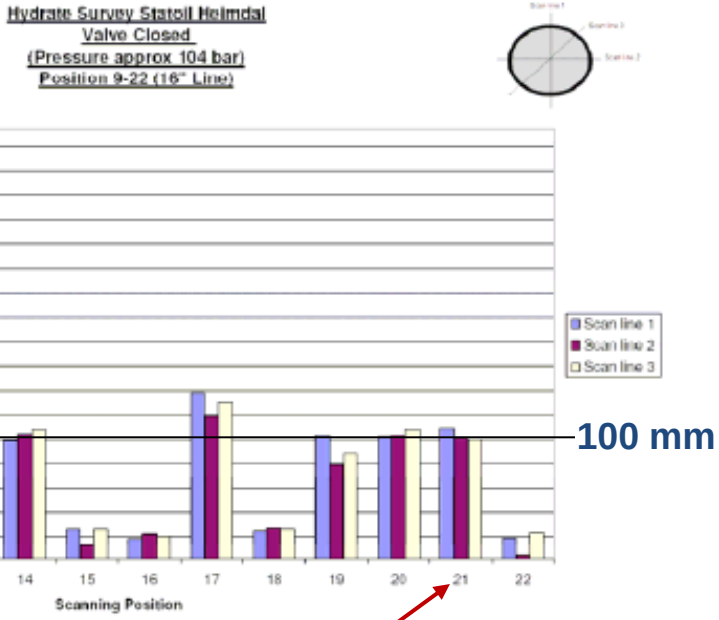
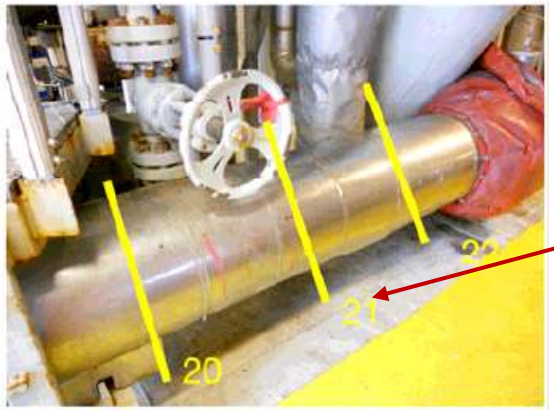
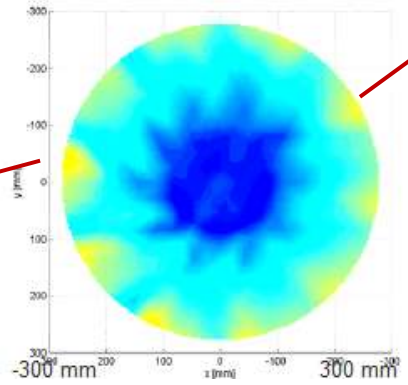
Topside field measurements







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Single gamma applications

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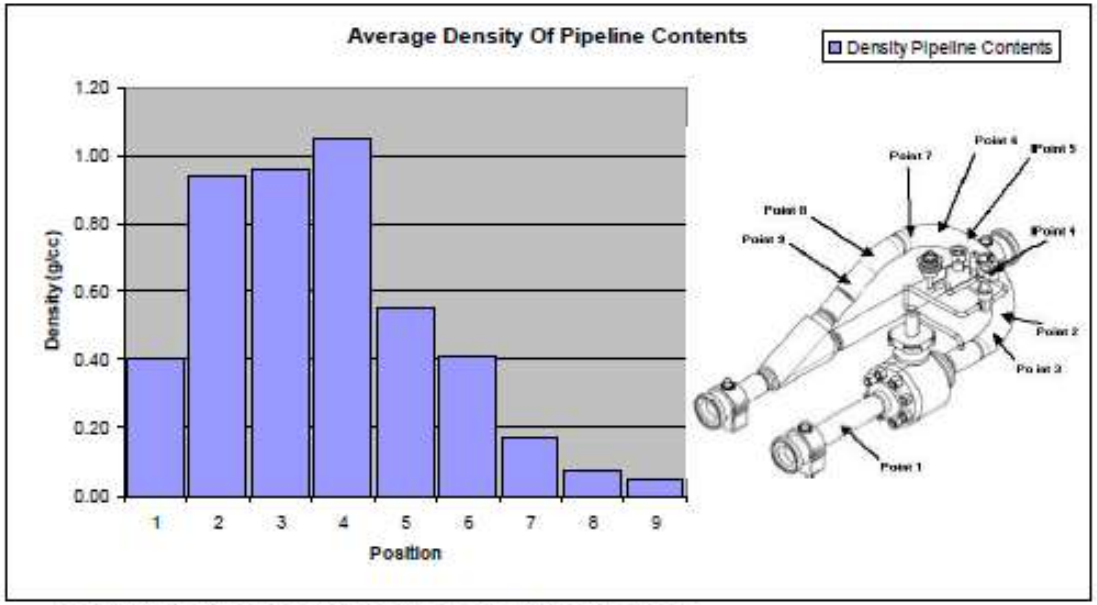
Subsea field trial



Graph 6: Density measurements on the "Wye" riserbase

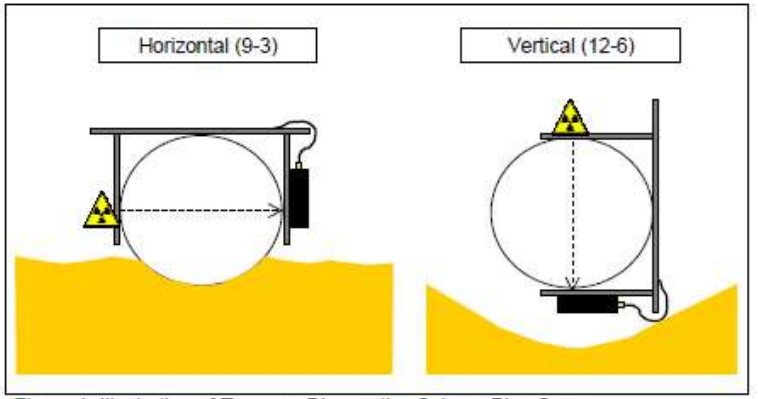


Figure 1: Illustration of Tracerco Diagnostics Subsea Pipe Scan

Picture 1: Tracerco Diagnostics Subsea Pipe Scan equipment

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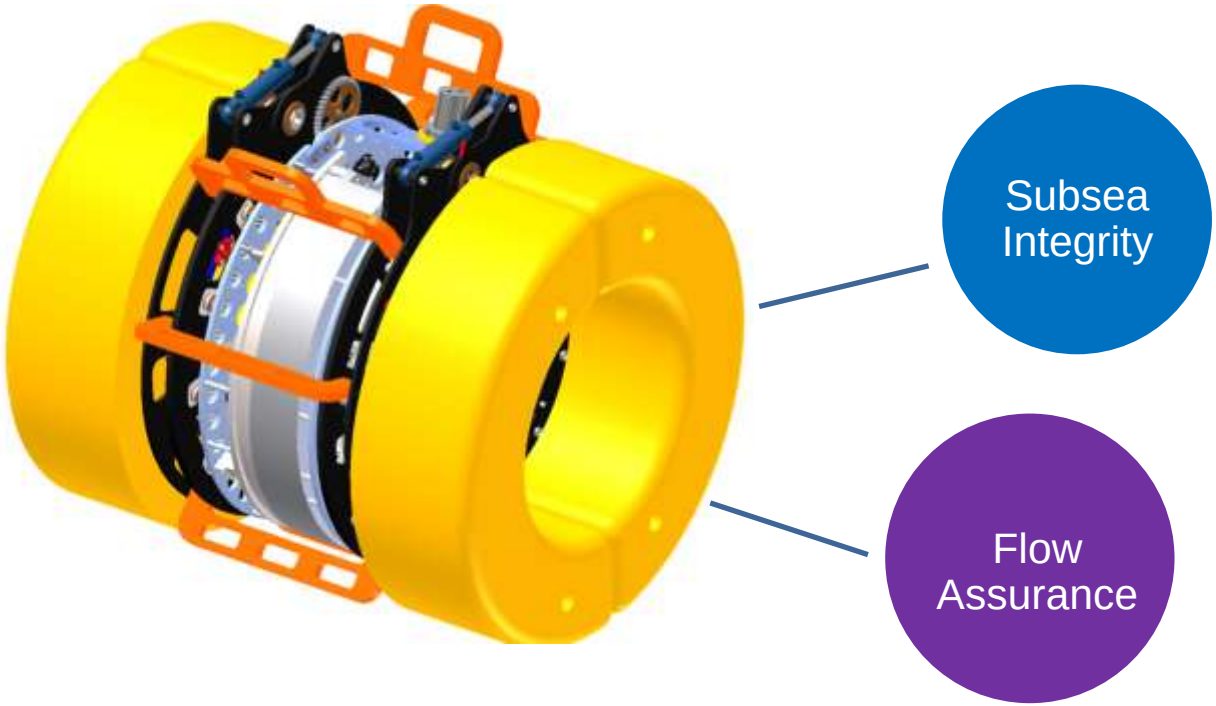
Discovery

The technology

Statoil

Discovery Pipeline Visualisation

- Tracerco Discovery™ is the world's first Subsea CT Scanner, a revolutionary non-intrusive technology for inspection of subsea pipelines.
- It is specifically targeted for the inspection of **unpiggable, coated pipelines**



Discovery Principle

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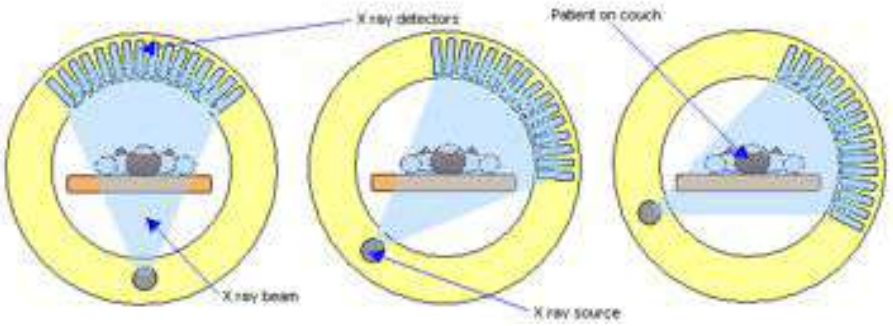
Same principle as medical CAT scanner

- Reconstructs image of a target from a series of projections
- One gamma radiation source and a large number of detectors



The same concept has been taken from the medical field to design, implement and deploy a scanner for subsea pipelines

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Discovery

Initial Prototype Results

Statoil

Initial Lab Prototype Results

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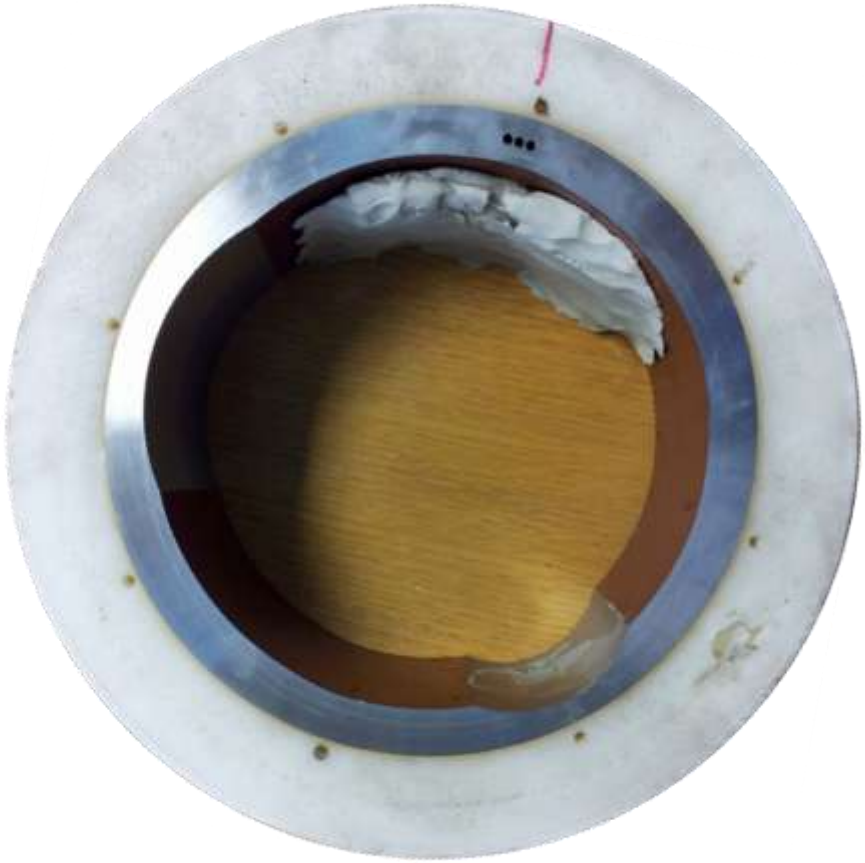
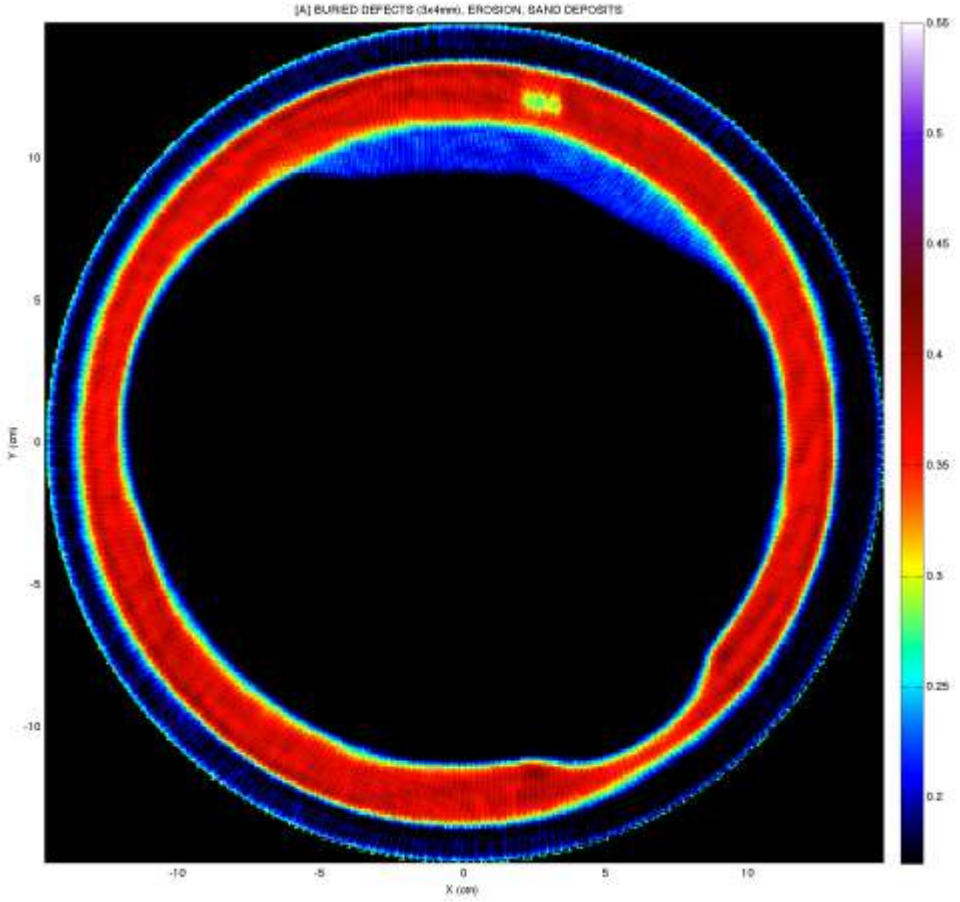
10-inch Pipe, 20mm wt, 50mm PU coating





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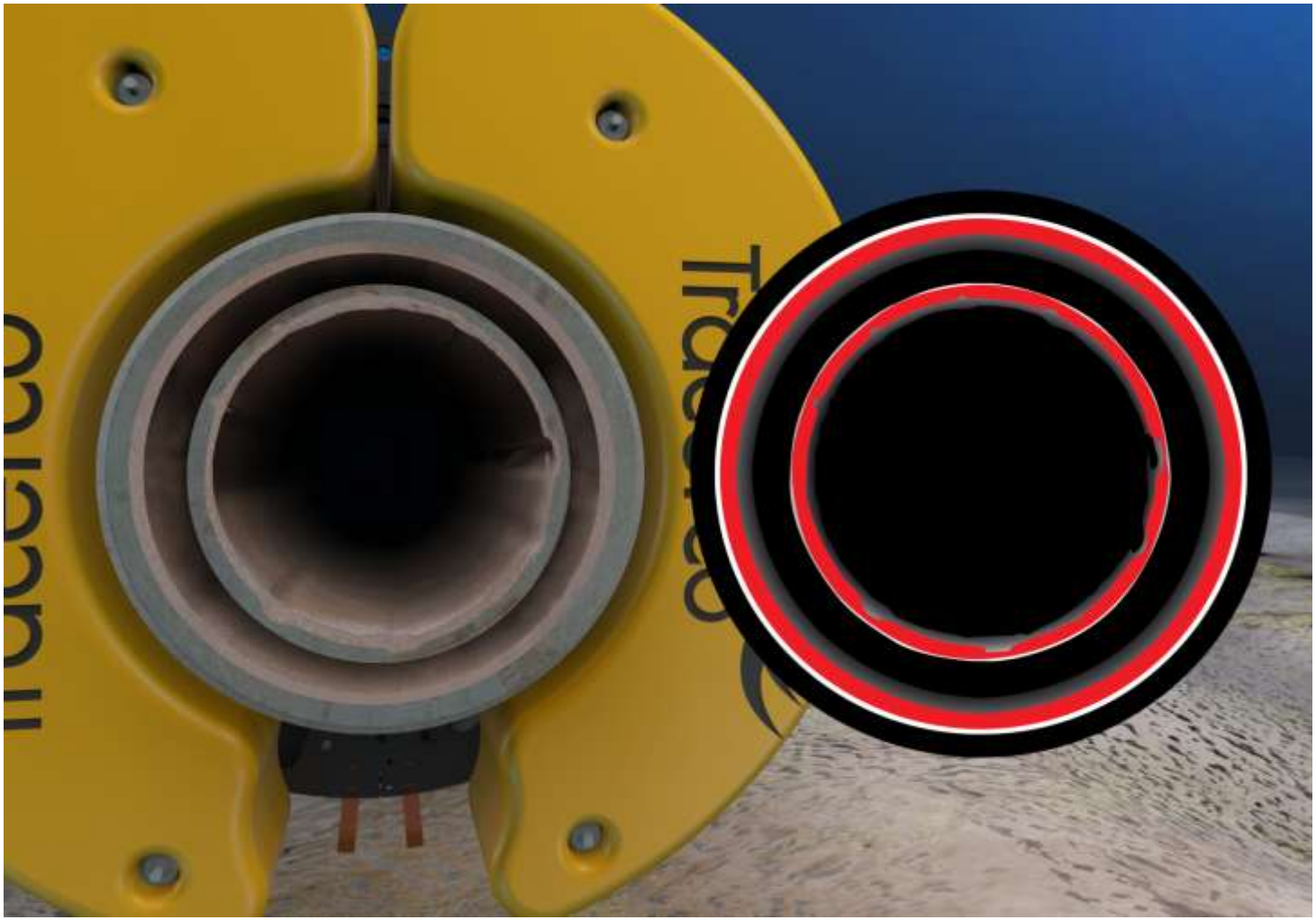
Pipe-in-pipe Systems

Tracerco
Providing Insight Onsite

Assess integrity of inner and outer pipes



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Caissons and Pipe Bundles

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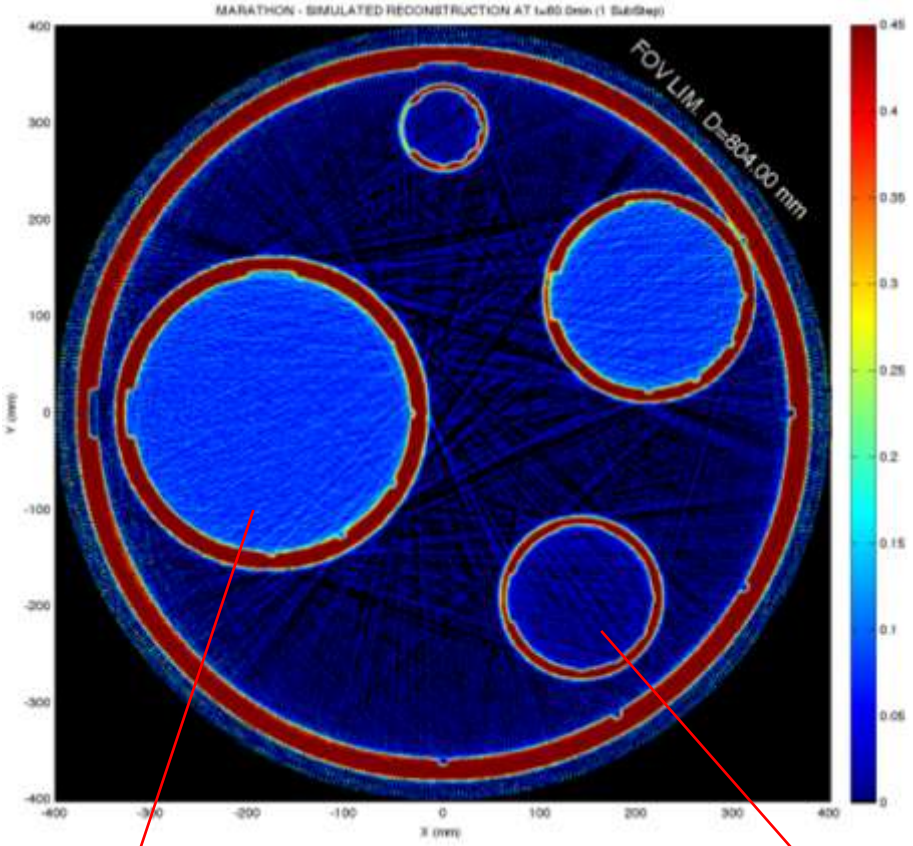
Assess integrity of internal flowlines as well as the outer pipe



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Discovery

The Instrument

Statoil

Discovery – specification overview

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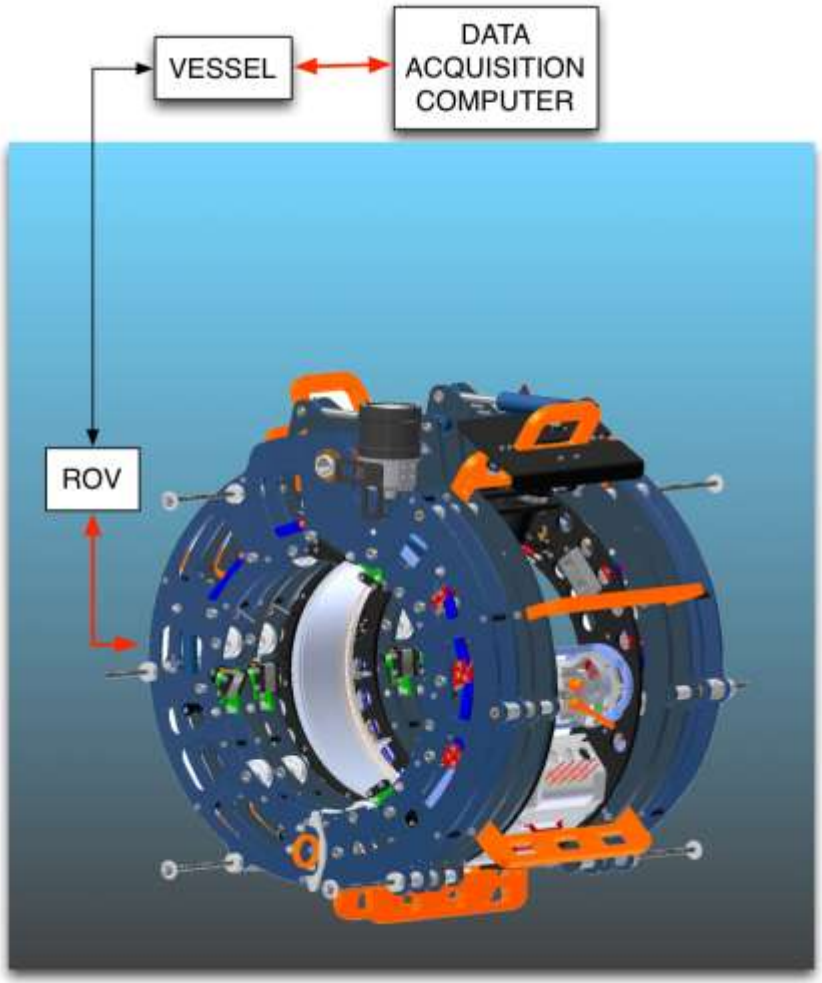
- Completely non intrusive
  - No need to remove coating
  - No need to stop production
- Wide range of pipes
  - 6 to 27 inch.
  - Integrity and Flow Assurance
  - Pipe-in-pipe and caissons
- 10000 ft / ~3000m Depth
- X/Y resolution close to 1mm
- Real-time Data Acquisition on the vessel
  - Images continuously updated **every 20-30 seconds**



Statoil

Discovery – specification overview

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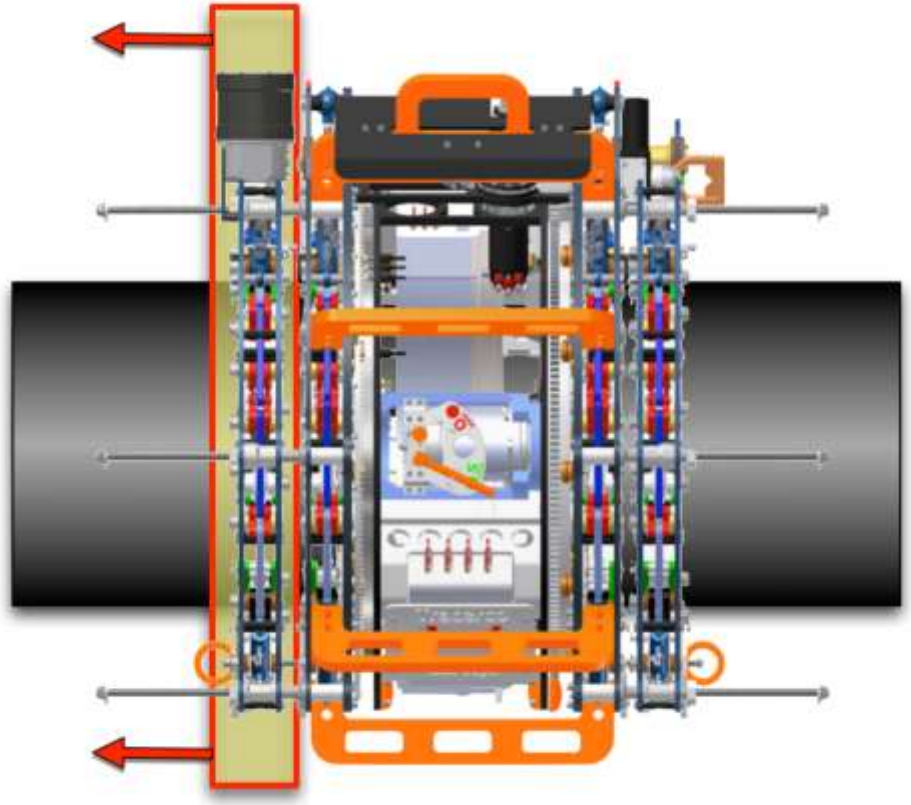
- Crawler
  - Instrument automatically advances on the pipe
- Scanning speed
  - ~2-3 ft/h for low resolution
  - ~0.5 ft/h for high resolution



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Discovery

Underwater Trials

Statoil

First Subsea Trial - Bergen, April 2013

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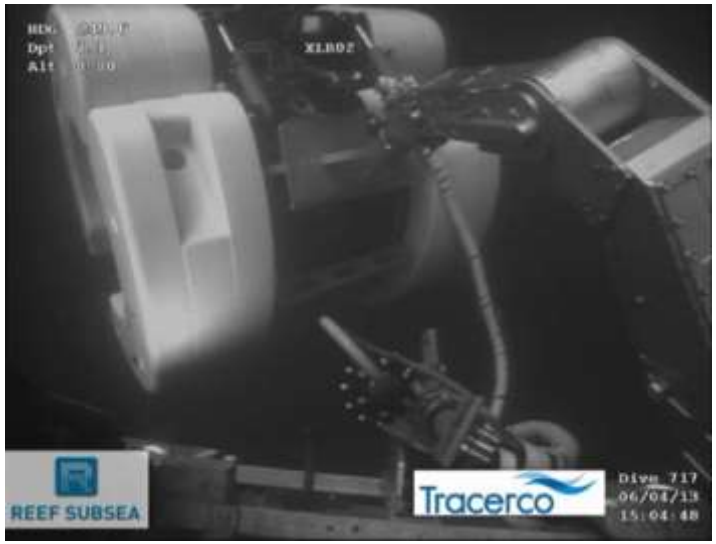

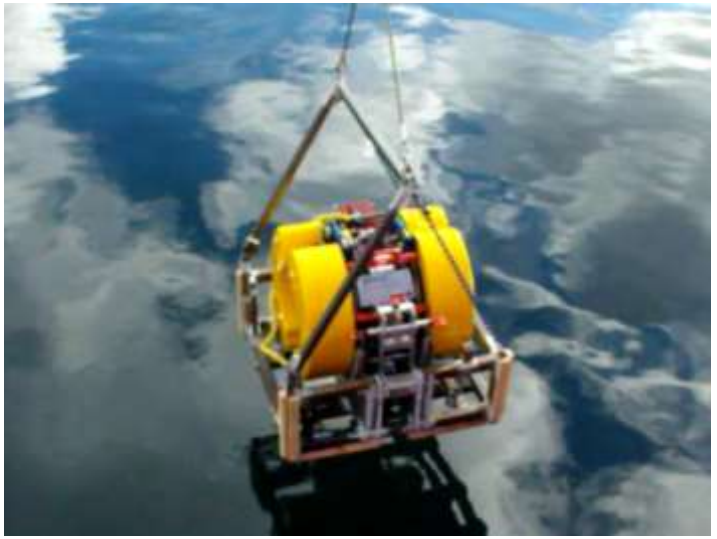

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2nd Subsea Trial – Scotland, 08/13

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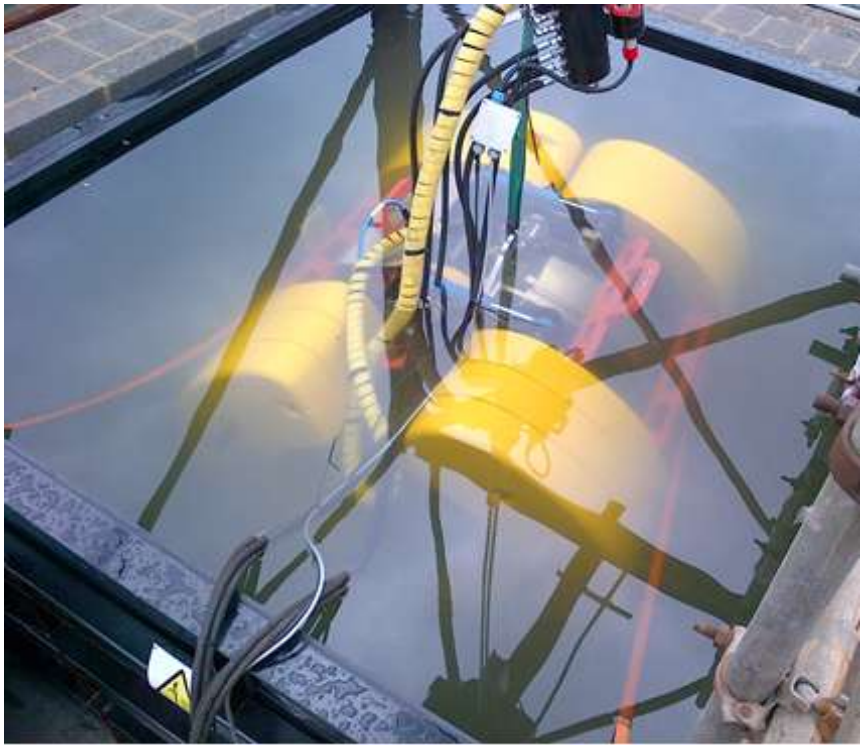
Statoil

Customer Trial Results

- Test pieces supplied by customers, for proof of capability prior to offshore inspection project



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Tracerco Discovery

Customer Trial Results – Flow Assurance

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Flow Assurance Trial 1

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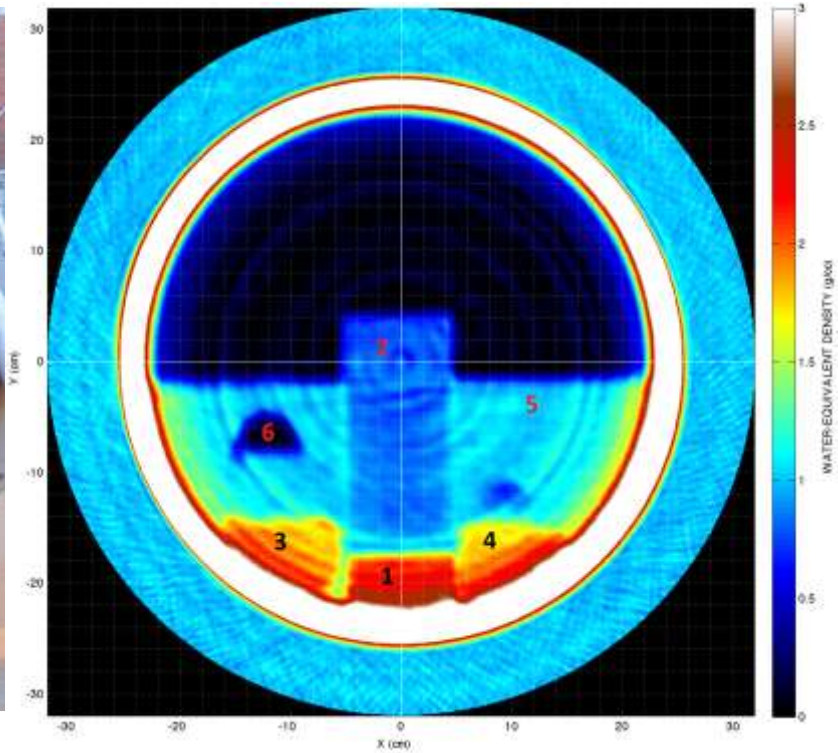
20-inch Pipe, 22mm wt, with brick, thermalite block, 2 sand bags, half filled with water



Feature	Description	Dimensional Information
1	Known feature	Object of size 100mm wide x 50mm high, density ~2.4g/cc
2	Known feature	Object of size 95mm wide x 210mm high, density ~0.9g/cc
3	Known feature	Freeform object of approx. size 100mm x 90mm high, density ~1.9g/cc
4	Known feature	Freeform object of approx. size 100mm x 90mm high, density ~1.9g/cc
5	Known feature	Fluid filled to approx. 50% of volume, density ~1g/cc
6	Unknown feature	Gas pocket of approx. size 70mm wide x 35mm high

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Flow Assurance Trial 2

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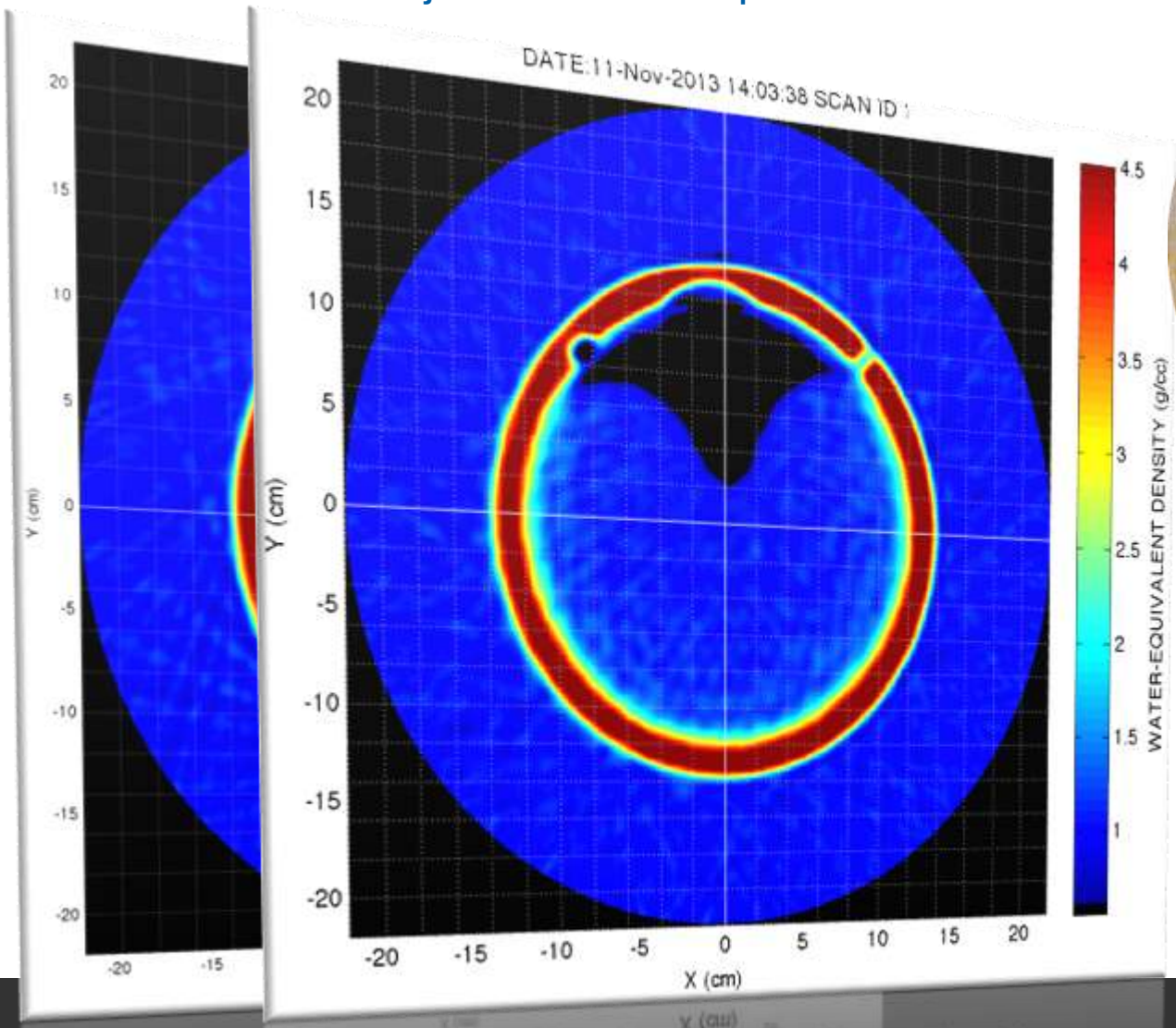
8-inch water injection line with plastic liner



- 273mm OD, 15.9mm WT
- 10mm internal plastic lining
- Manufactured blister to simulate damage

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Flow Assurance Trial 3

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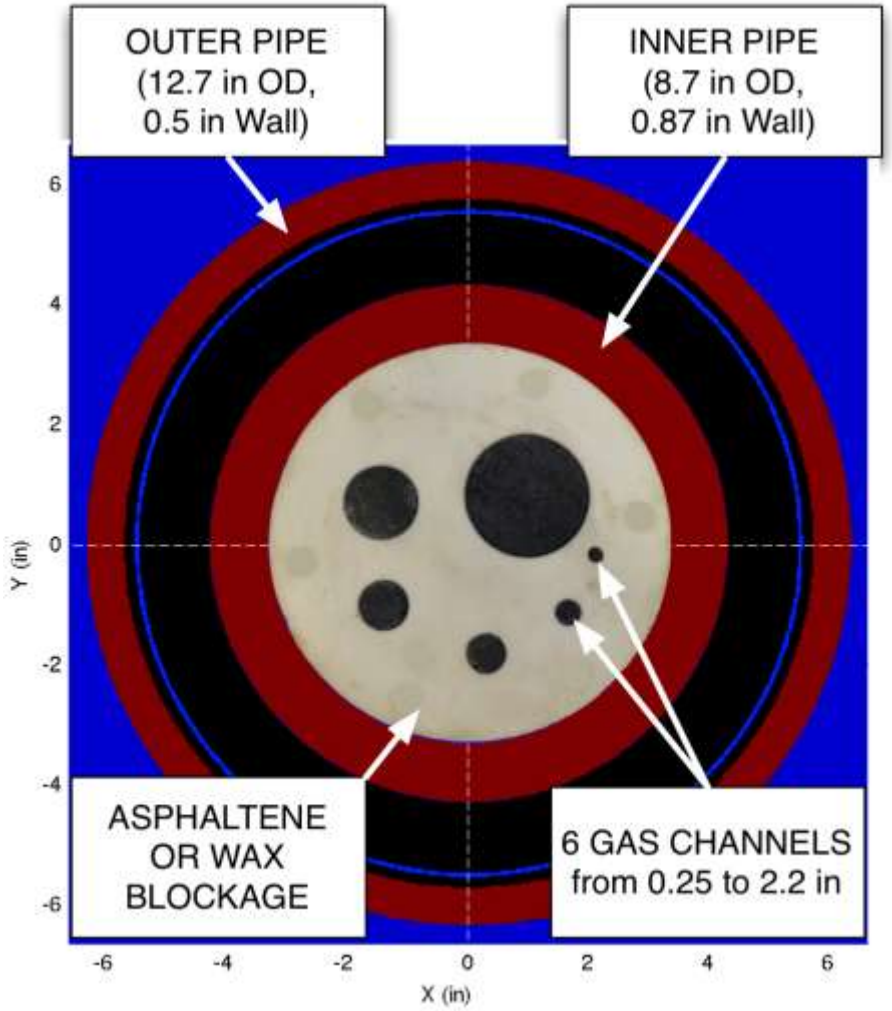
TEST	**Detect small gas channel openings in blocked pipelines**
WHY	Assess possibility of gas communication between different sections
MODEL	• 12 inch Pipe-in-Pipe • Blockage and gas as density-equivalent plastic. Then inserted in the pipe and scanned

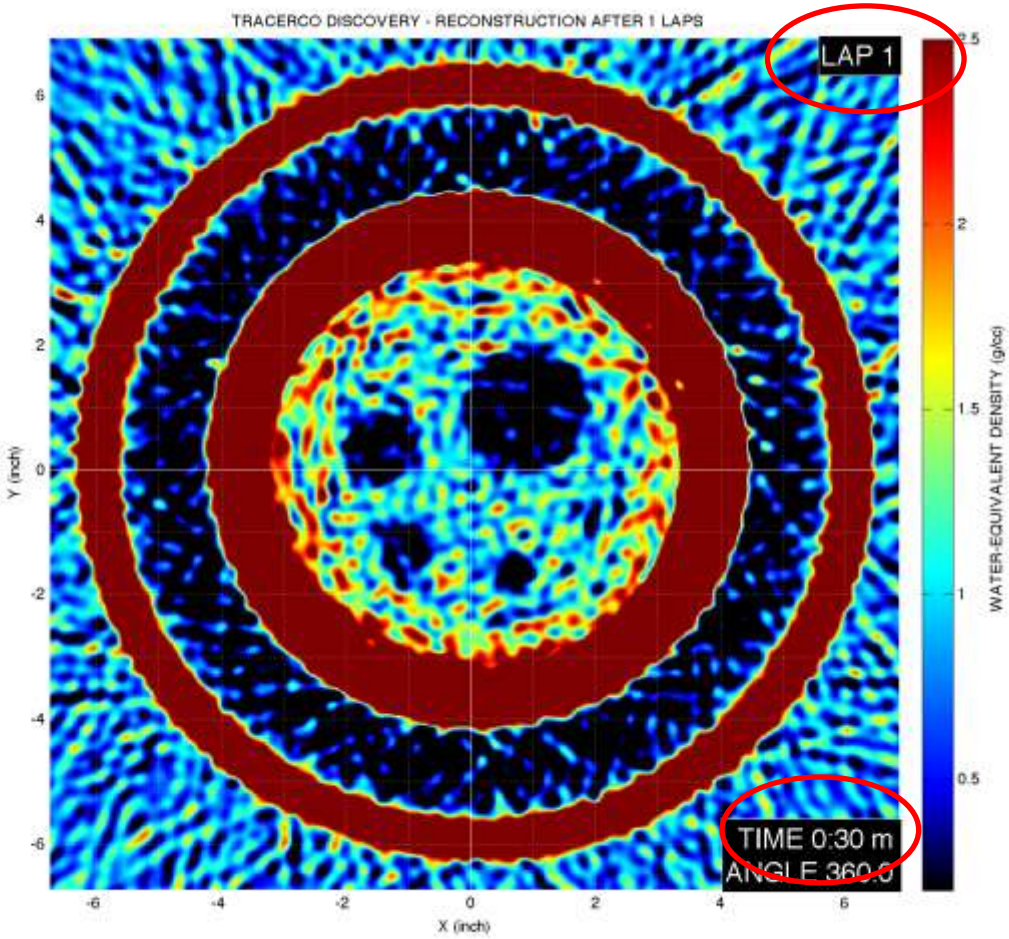


Statoil

Trial 3 – 30 seconds (1 lap)

Tracerco
Providing Insight Onsite

Most channels detected **after just 1 lap!**



MODEL

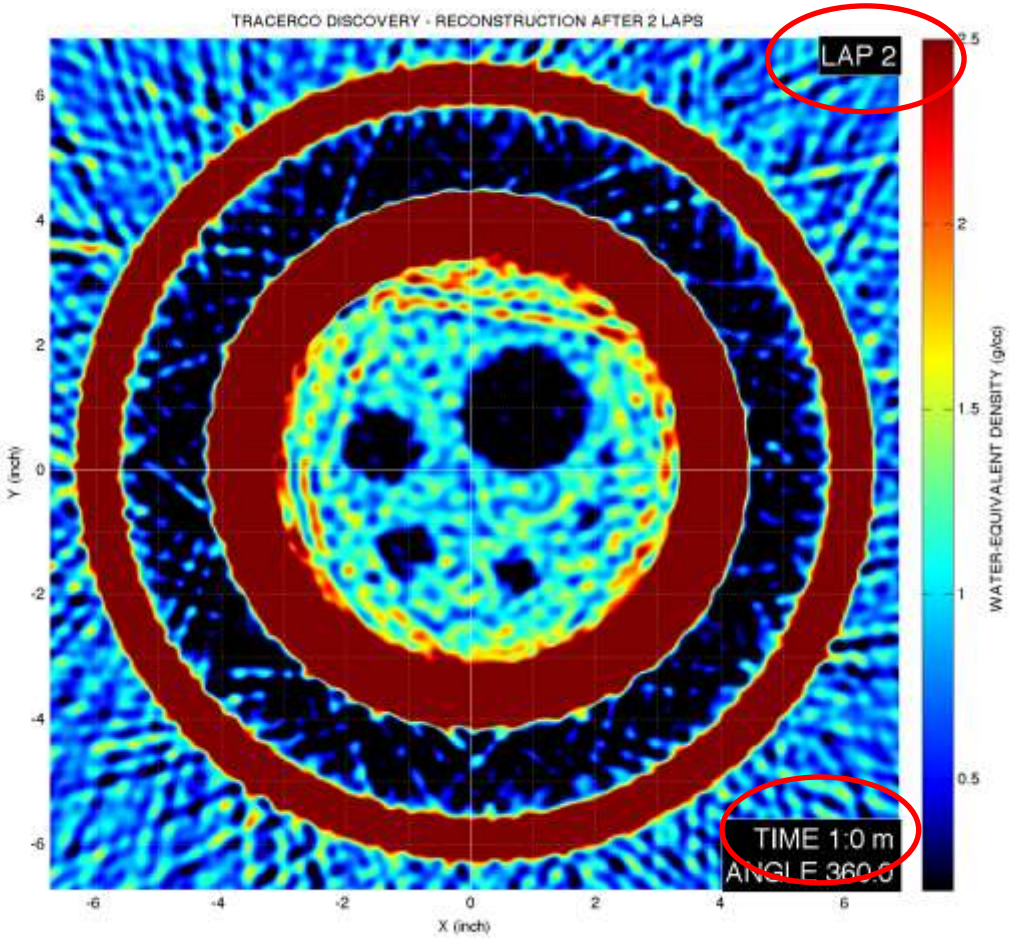
RECONSTRUCTION

Statoil

Trial 3 – 1 minute (2 laps)

Tracerco
Providing Insight Onsite

Getting Sharper. Now all channels are visible.



MODEL

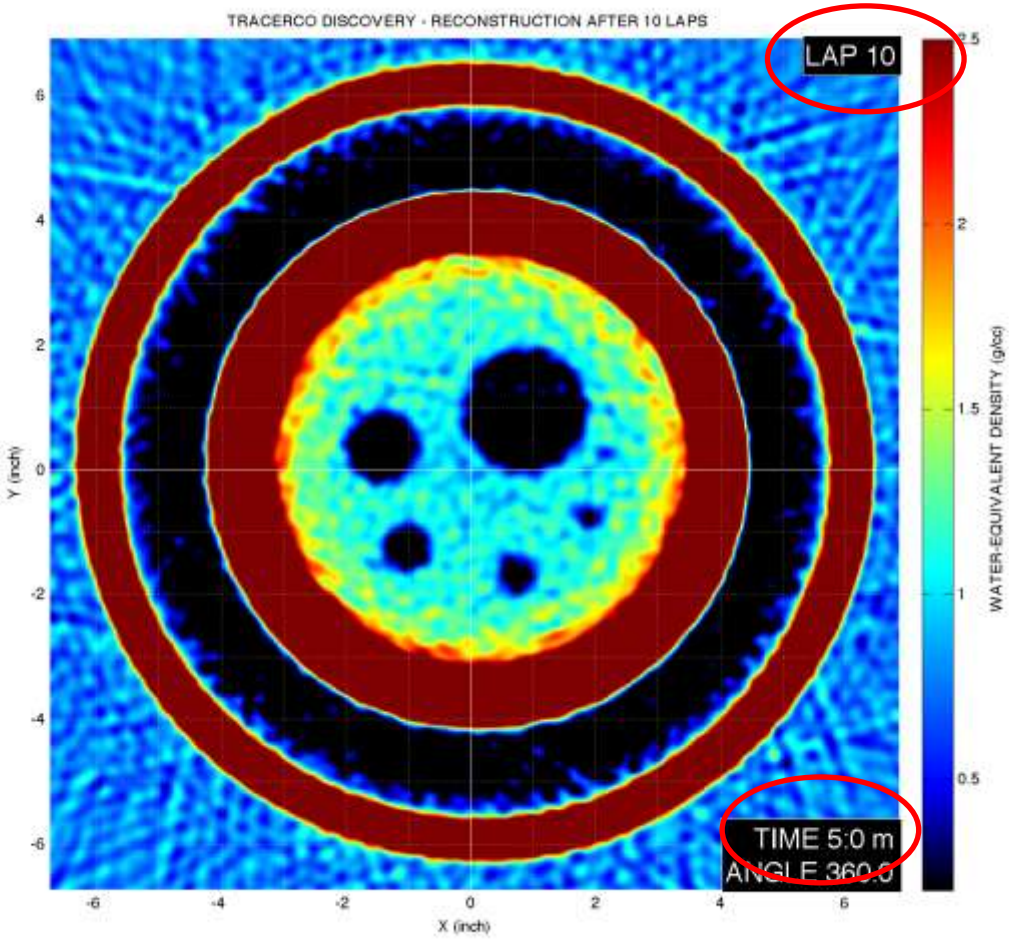
RECONSTRUCTION

Statoil

Trial 3 – 5 minutes (10 laps)

Tracerco
Providing Insight Onsite

Getting Sharper. All channels well visible.



MODEL

RECONSTRUCTION

Statoil

Trial 3 – 12.5 minutes (25 laps)

Tracerco
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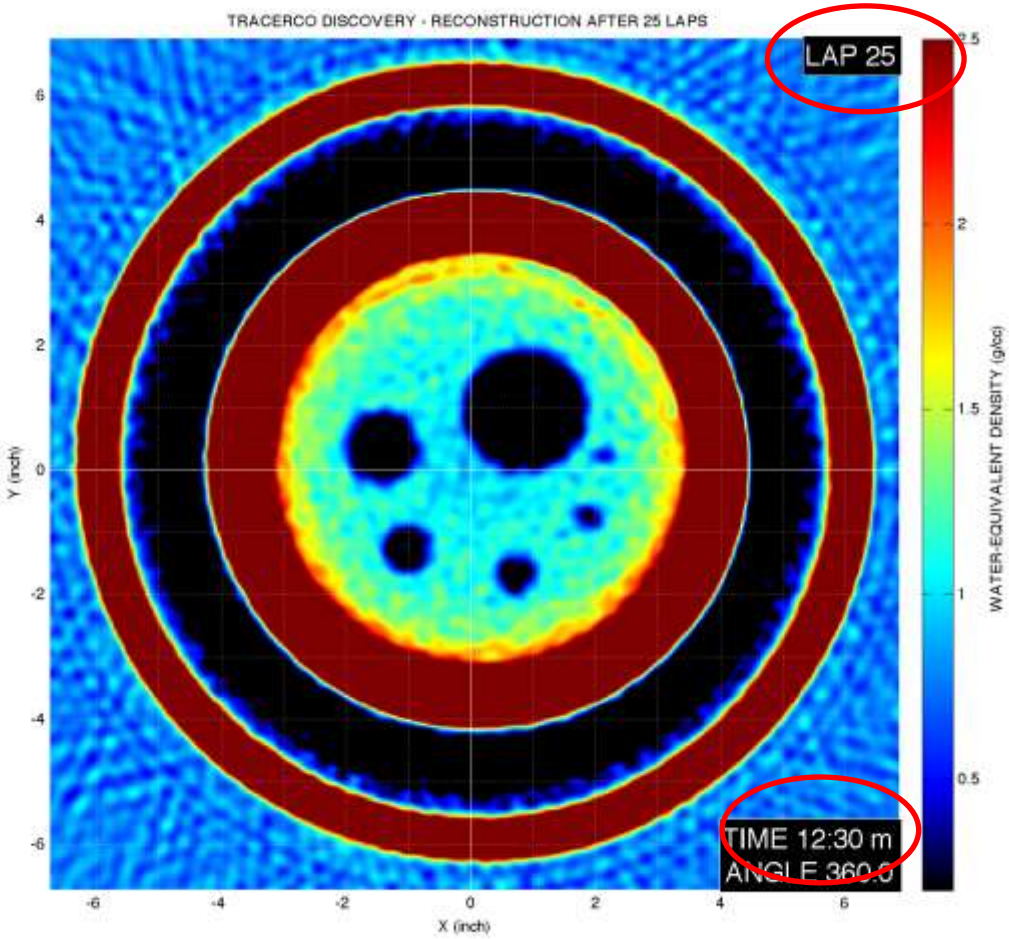
All channels completely detected.



MODEL

RECONSTRUCTION

Statoil

Flow Assurance Trial 4

Tracerco
Providing Insight Onsite

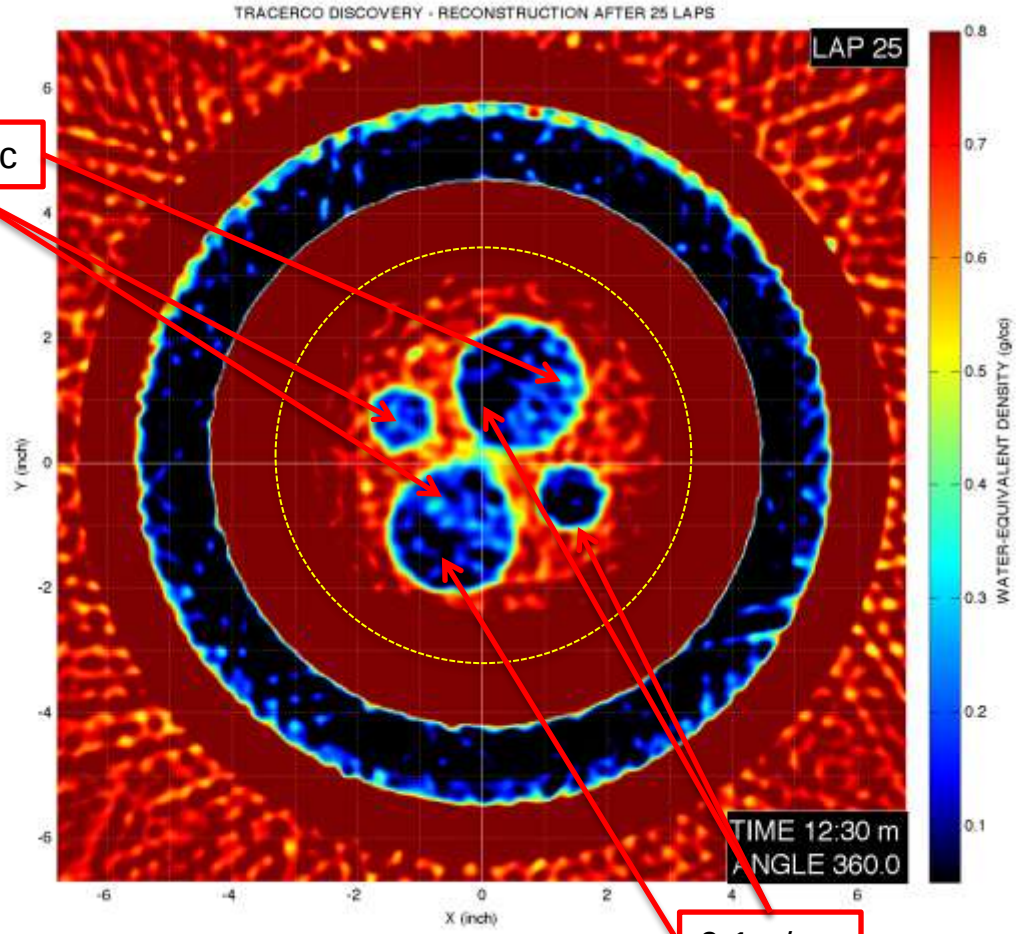
TEST	**Detecting gas pressure differences in blocked pipelines channels**
WHY	Assess gas communication (HP/LP) between sections of pipeline
MODEL	• Same Pipe-in-Pipe • Blockage and as density-equivalent plastic to asphaltene or wax. • HP/LP gas as density-equivalent foam (0.1/0.2 g/cc)

Statoil

Trial 4 – 12.5minutes (25 laps)

Tracerco
Providing Insight Onsite

Successful detection of gas density differences in channels.



MODEL

RECONSTRUCTION

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Providing Insight Onsite

Tracerco Discovery

Customer Trial Results – Pipeline Integrity

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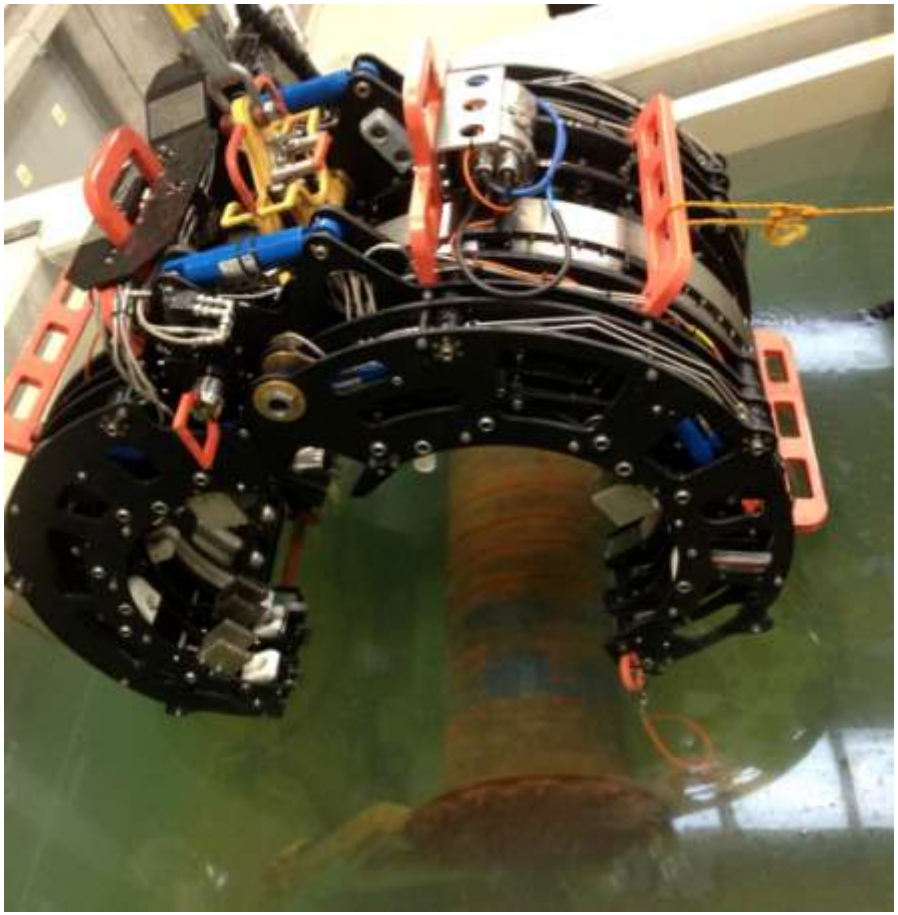
Integrity Trial 1

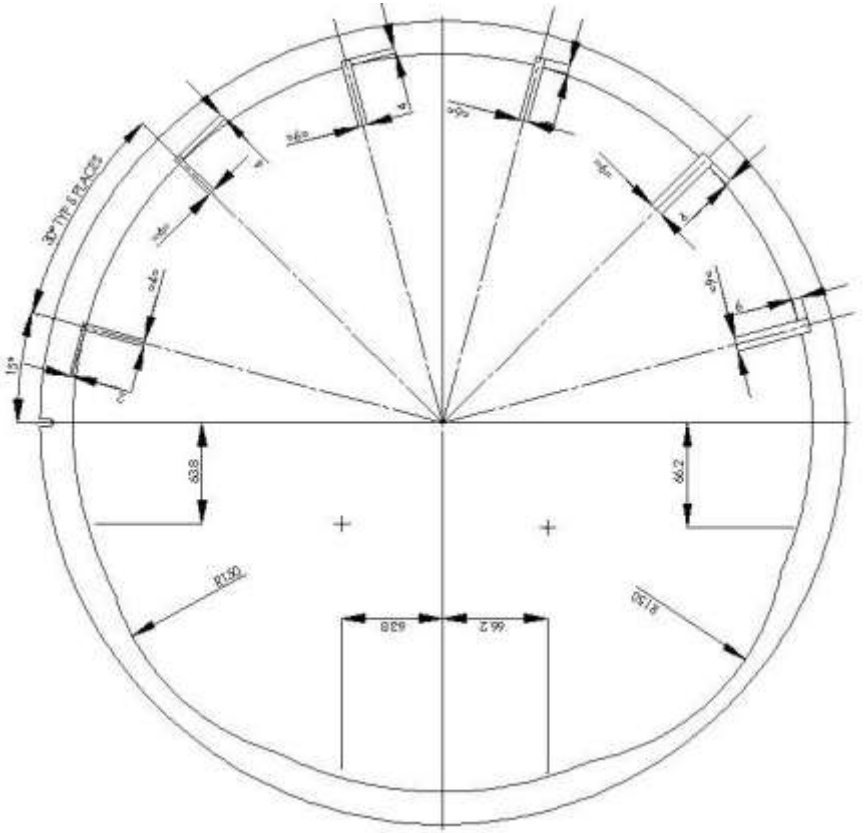
TEST	**Detect wall loss on the inner walls of pipelines**
WHY	• Assess safety margins • Extend service life
MODEL	• 20 inch pipe, ~20mm wall • Several defect profiles machined at different axial positions in the pipe

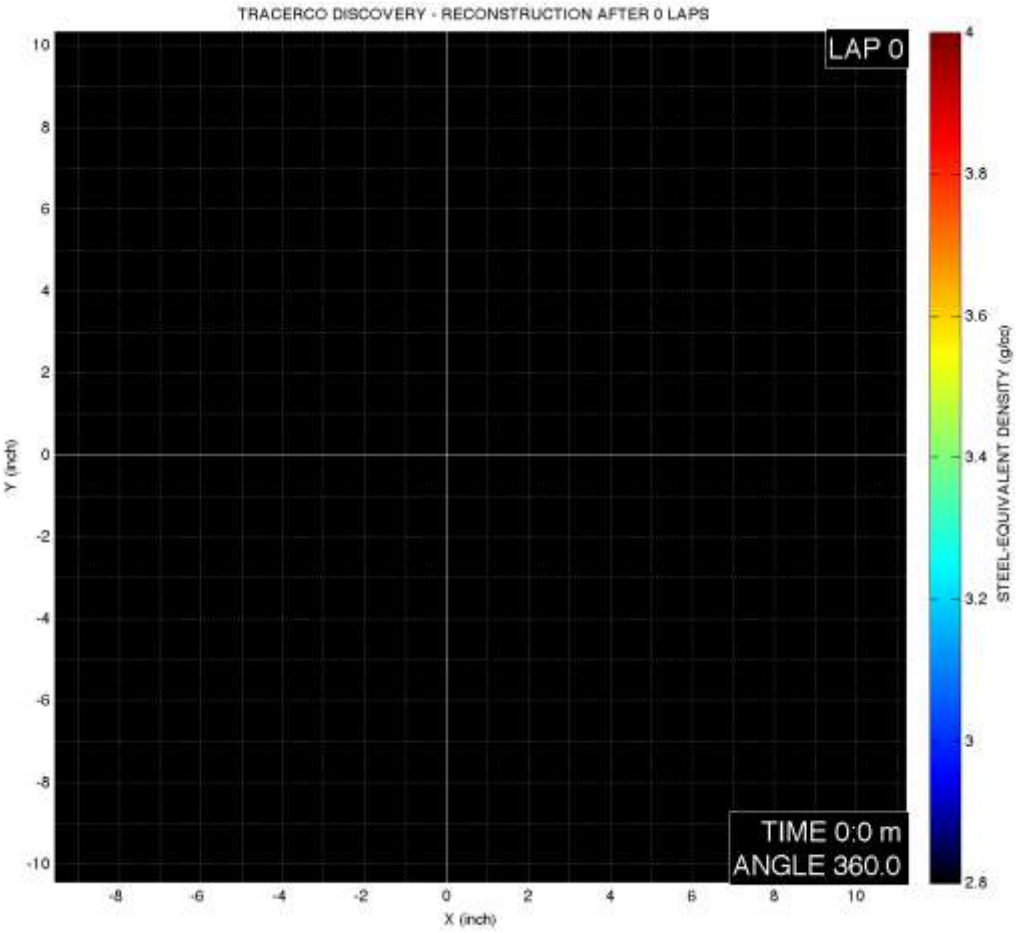


Integrity Trial 1

Tracerco
Providing Insight Onsite

6+1 localized defects and 2 scallops to model wall loss





DRAWINGS

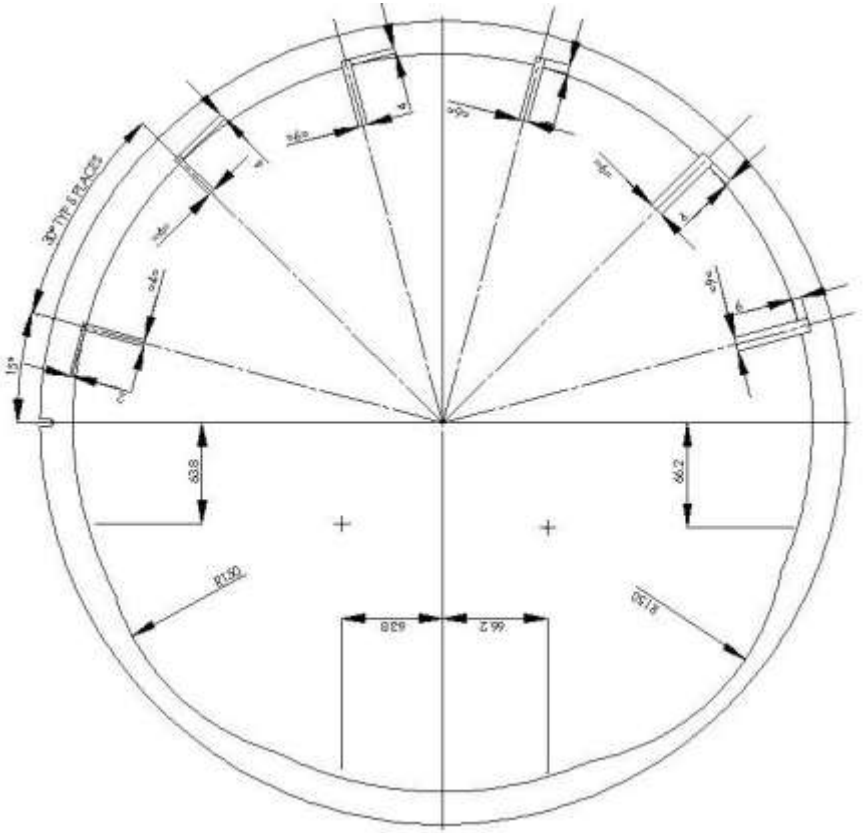
RECONSTRUCTION

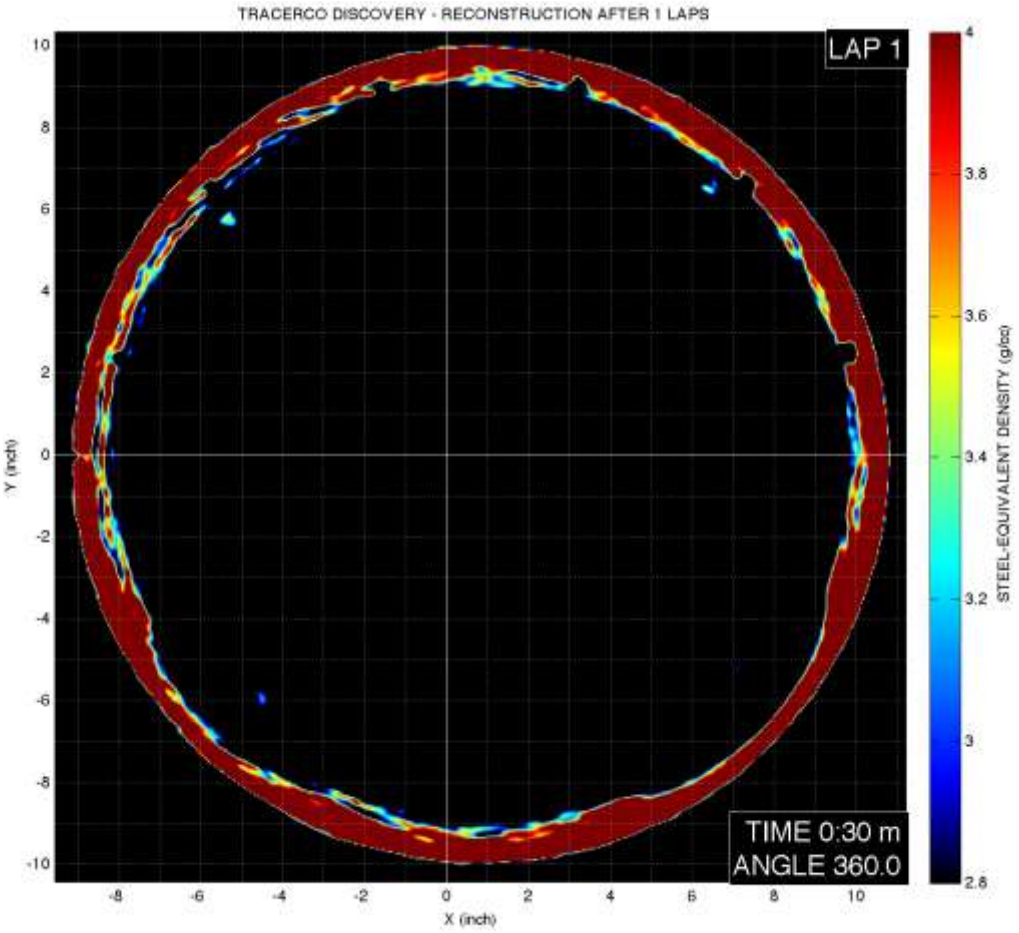
Statoil

Trial 1 – 30 seconds (1 lap)

Tracerco
Providing Insight Onsite

Early detection of most defects and scallops **in 30 seconds**.





DRAWINGS

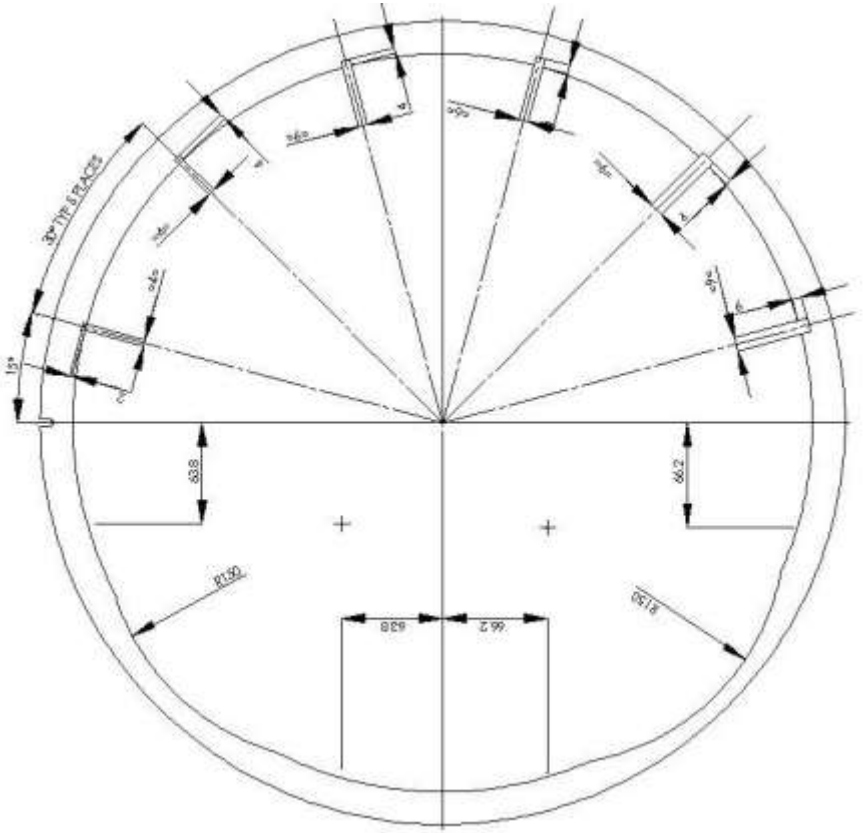
RECONSTRUCTION

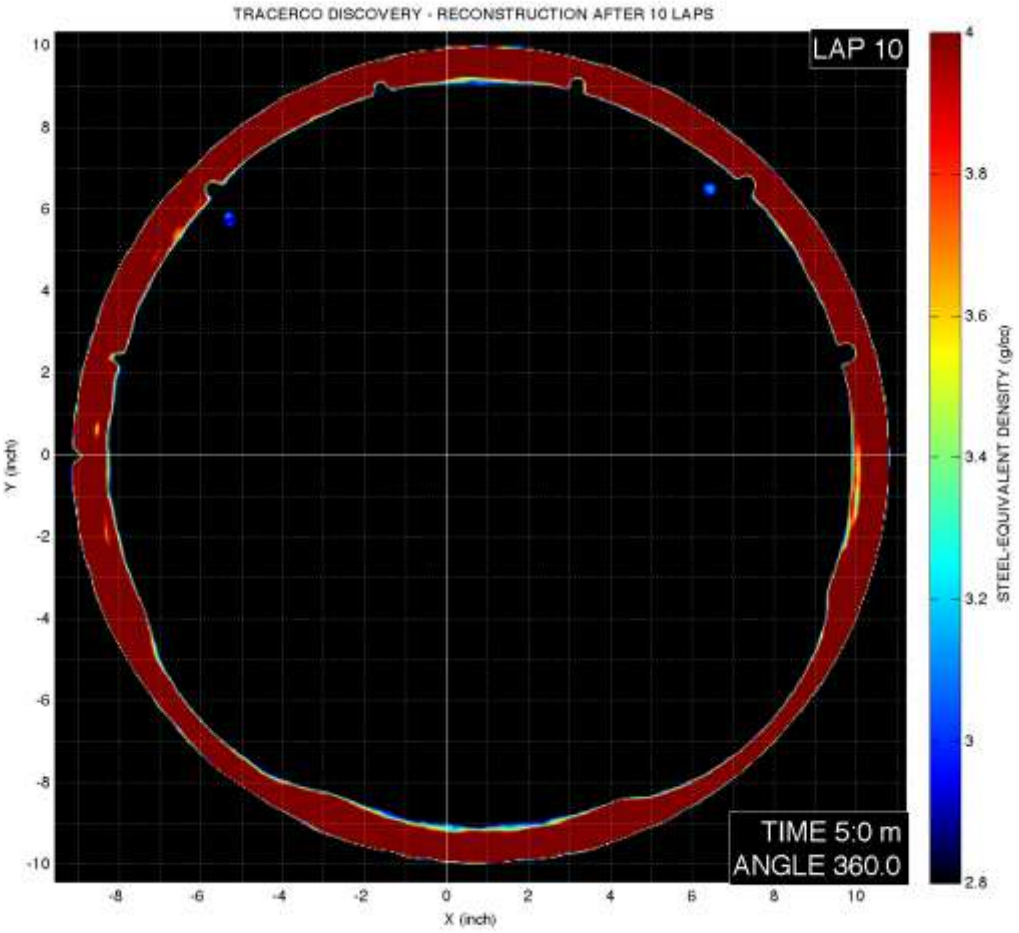
Statoil

Trial 1 – 5 minutes (10 laps)

Tracerco
Providing Insight Onsite

Image getting sharper. All defects clearly visible.





DRAWINGS

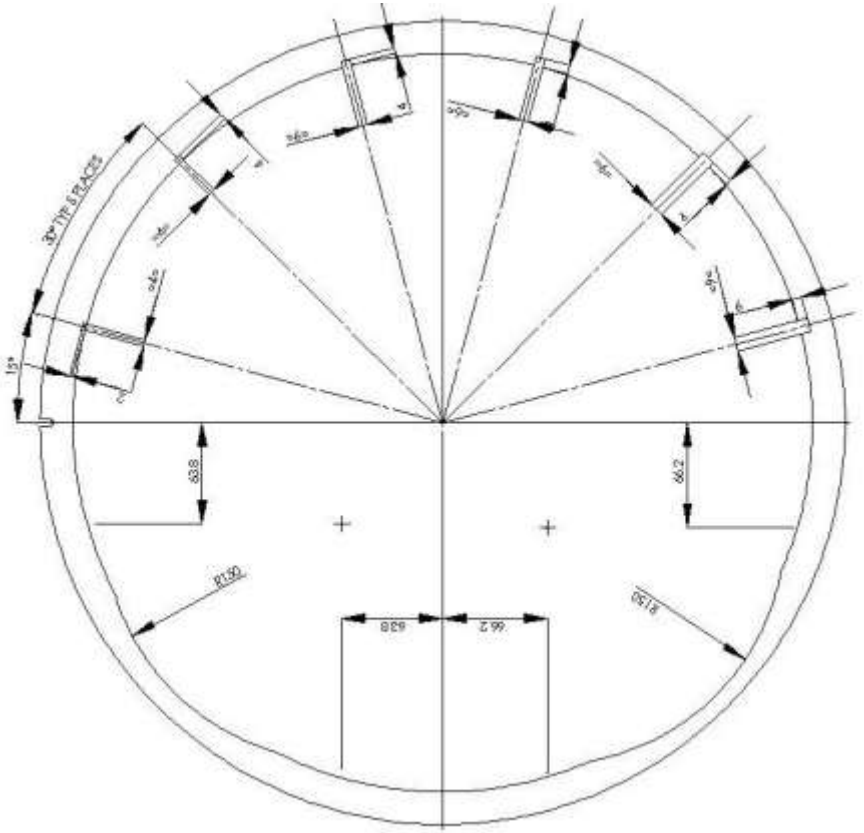
RECONSTRUCTION

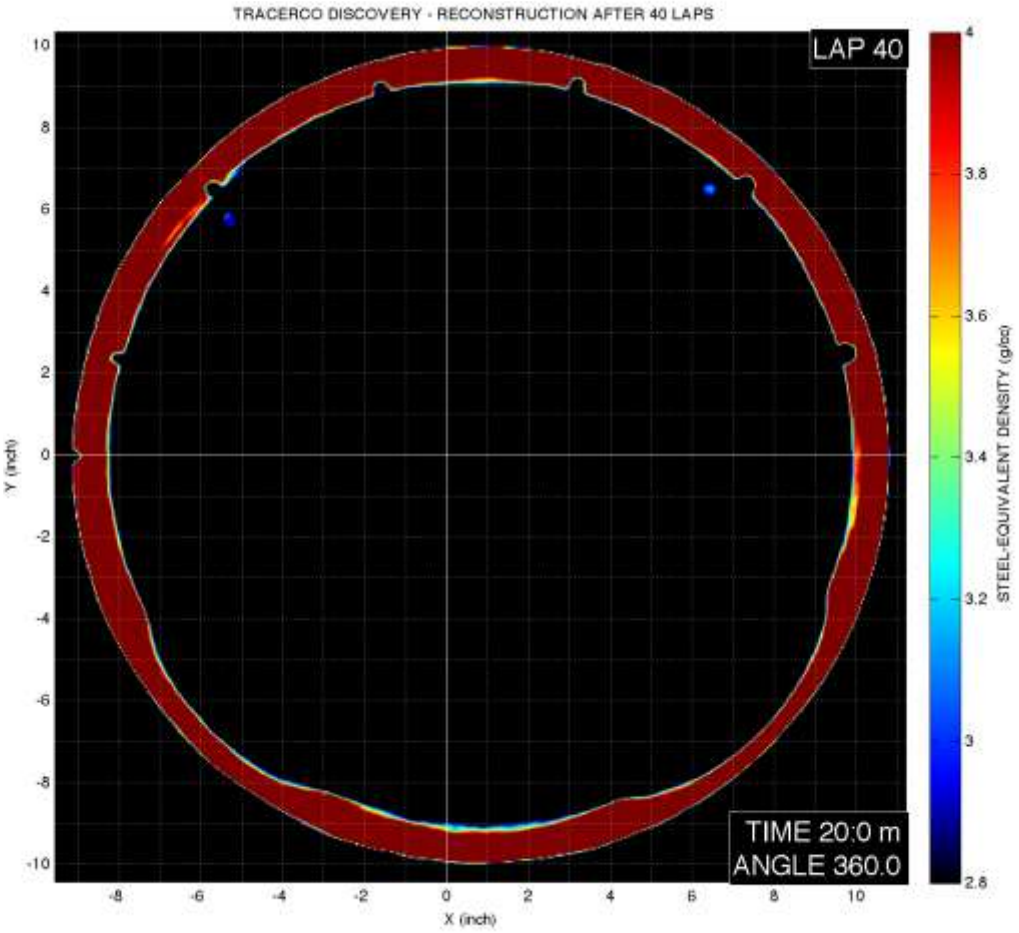
Statoil

Trial 1 – 20 minutes (40 laps)

Tracerco
Providing Insight Onsite

High resolution image. All defects visible and quantifiable.





DRAWINGS

RECONSTRUCTION

Statoil

Integrity Trial 2

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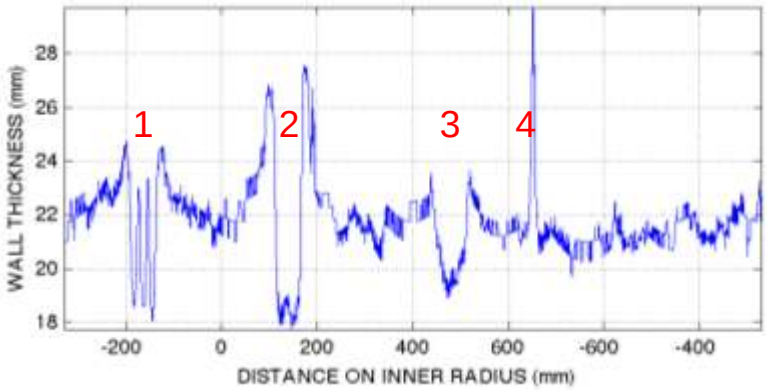
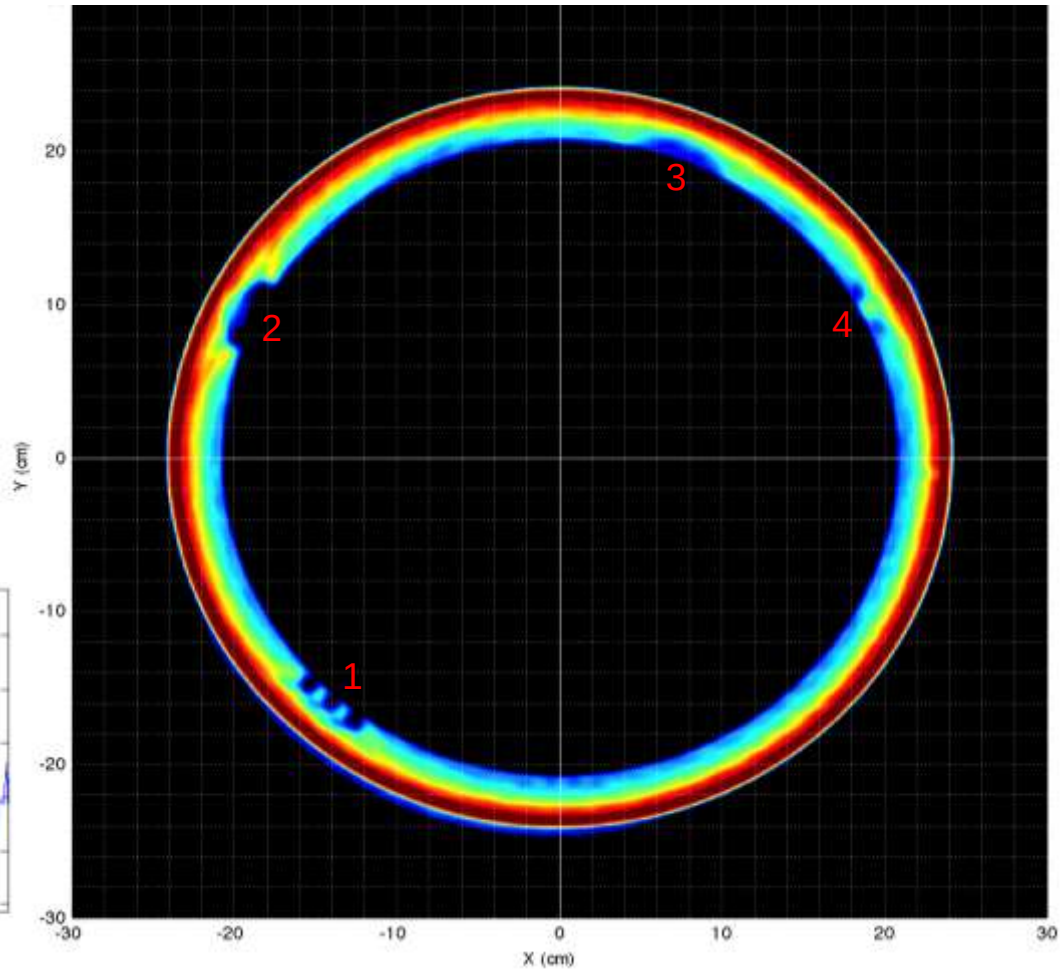
‘Blind test’ with unknown defects in a 20-inch coated pipeline





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Integrity Trial 3

TEST	**Detect voids and broken strands in flexible risers**
WHY	• Assess safety margins • Extend service life
MODEL	• 12-inch flexible riser • 1 strand segment was removed from the outer tensile armor.

Trial 3 – 30 seconds (1 lap)

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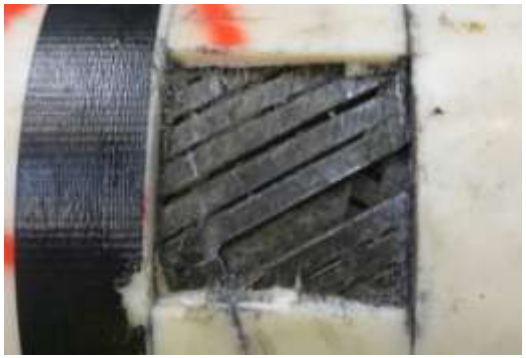
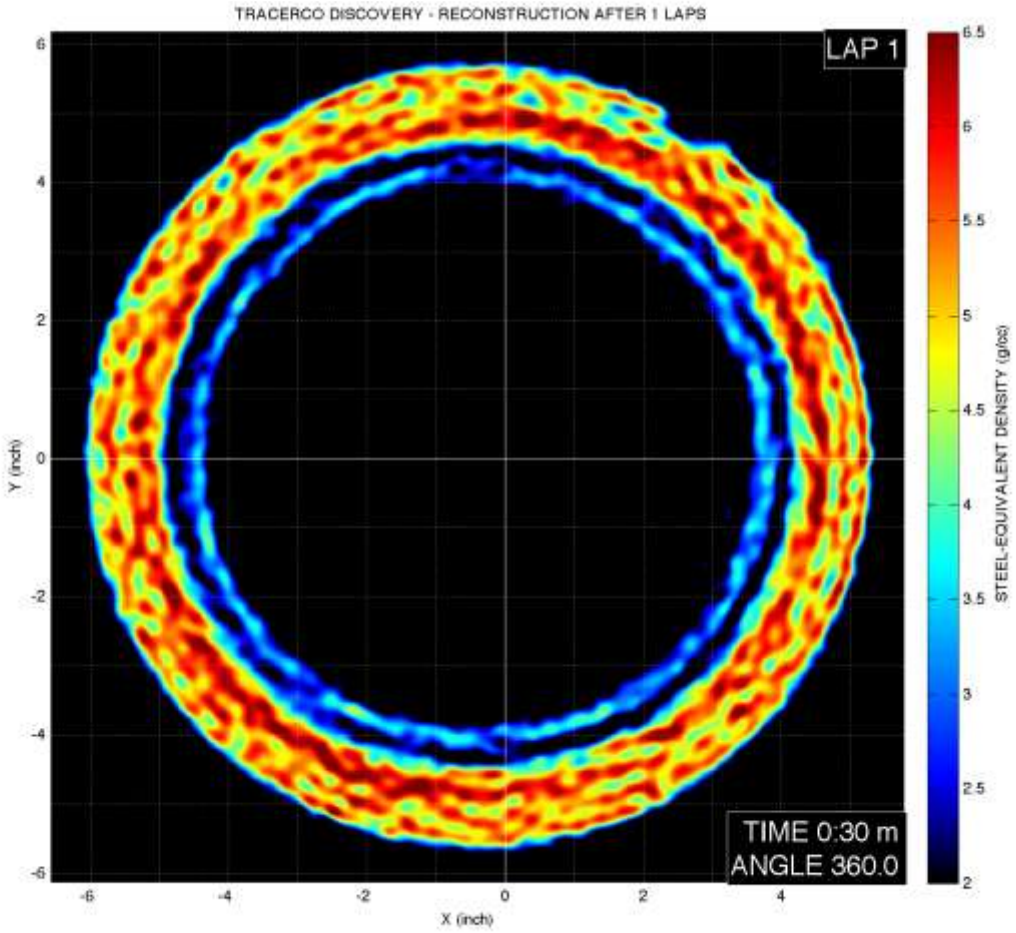
Indication of broken strand at the **first lap (30 seconds)**.





MODEL

RECONSTRUCTION

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Test 4 – 12.5 minutes (25 laps)

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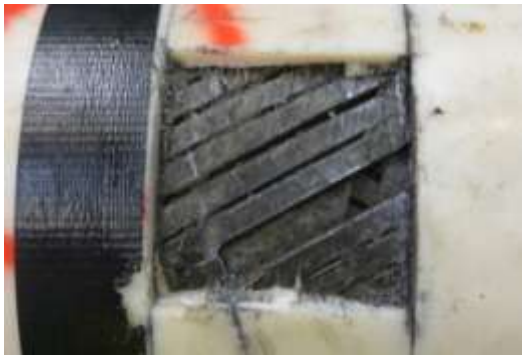
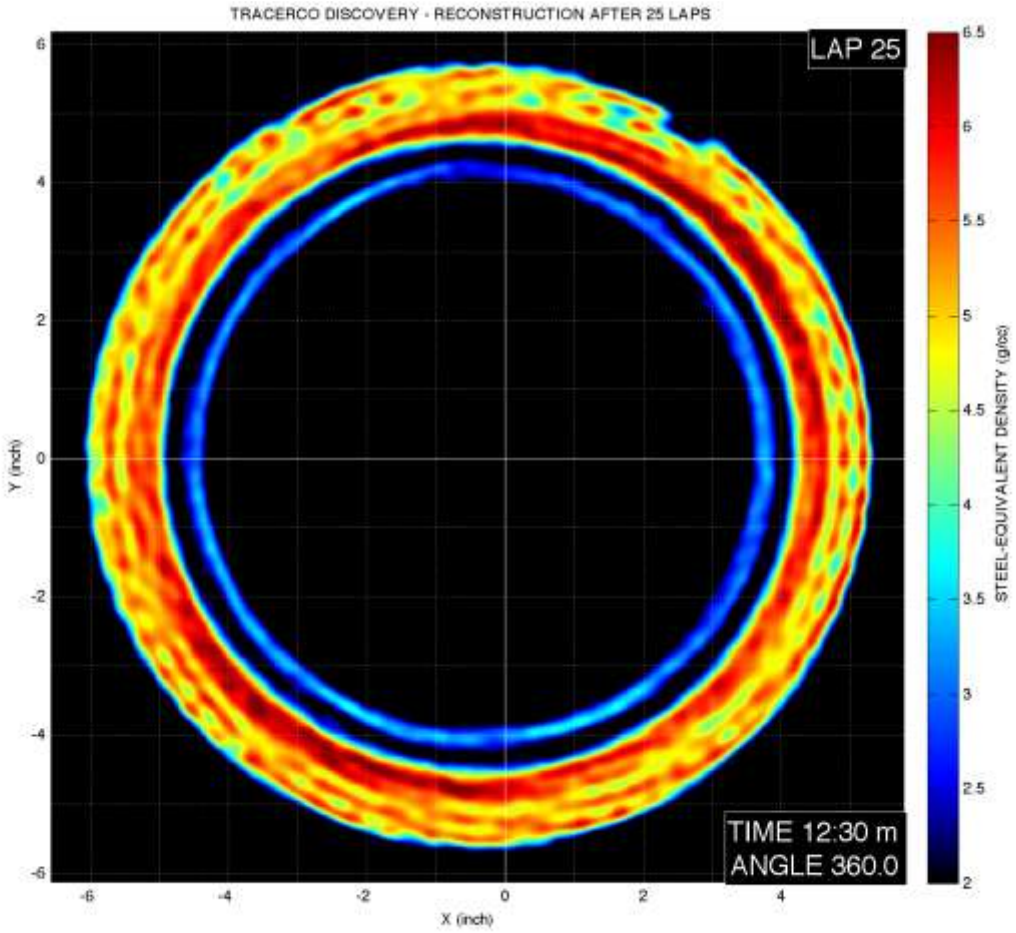
Image getting sharper. More detail on the inner carcass and all other layers.





MODEL

RECONSTRUCTION

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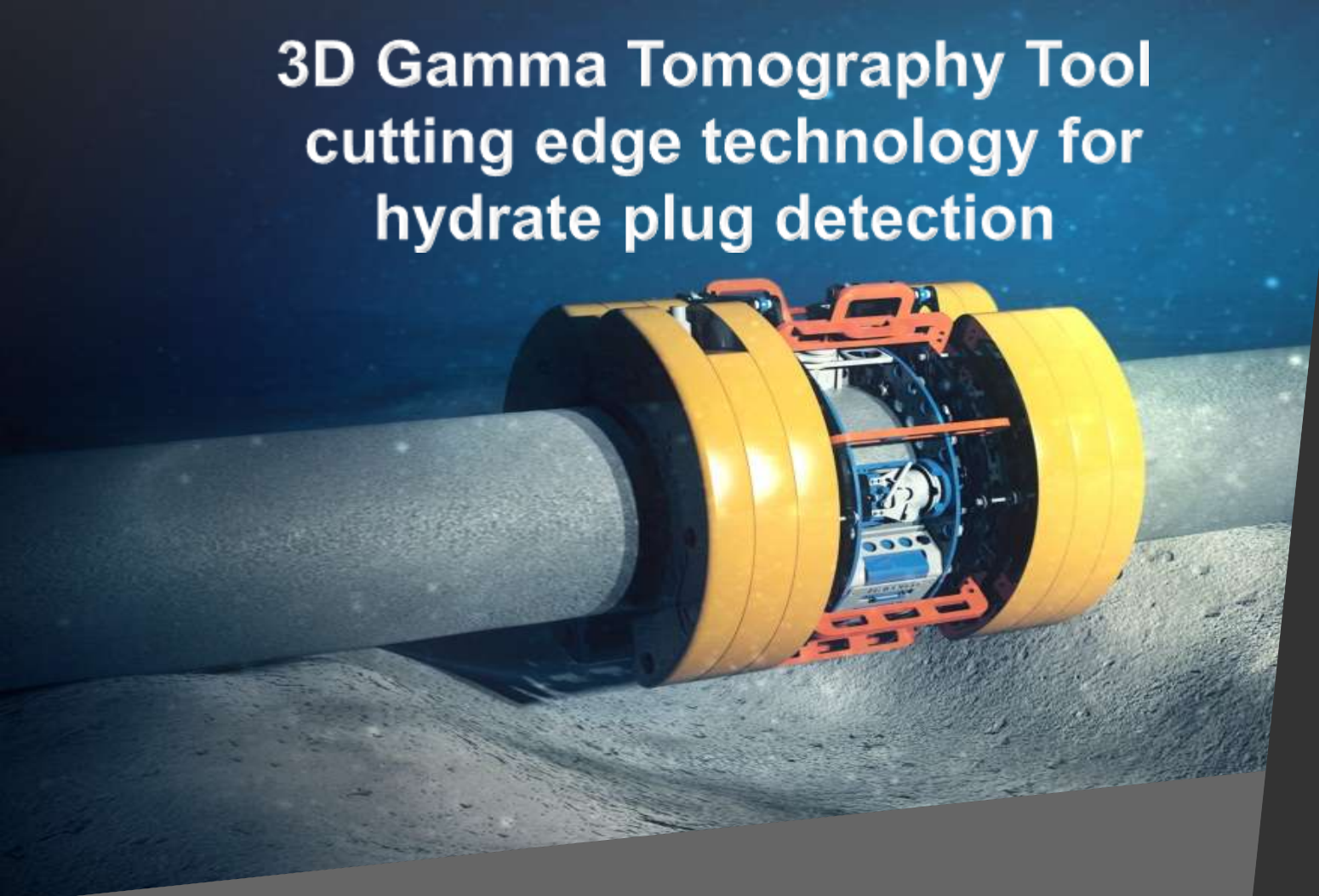
Conclusion

- Tracerco and Statoil have cooperated to produce the world's first Subsea CT Scanning device.
- Truly **non intrusive** technology
  - Through coating
  - No need to stop production
- Integrity **and** Flow Assurance
- **Real time** data
- Near **mm** accuracy

3D Gamma Tomography Tool cutting edge technology for hydrate plug detection



Statoil

3rd Trondheim Gas Technology Conference,
4th-5th June 2014

Keijo Kinnari, Senior Specialist, Technology Excellence, Statoil
Xiaoyun Li, Specialist Principal Researcher, Statoil
Lee Robins, Head of Subsea Services, Tracerco

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