



Statoil

# Troll C Subsea

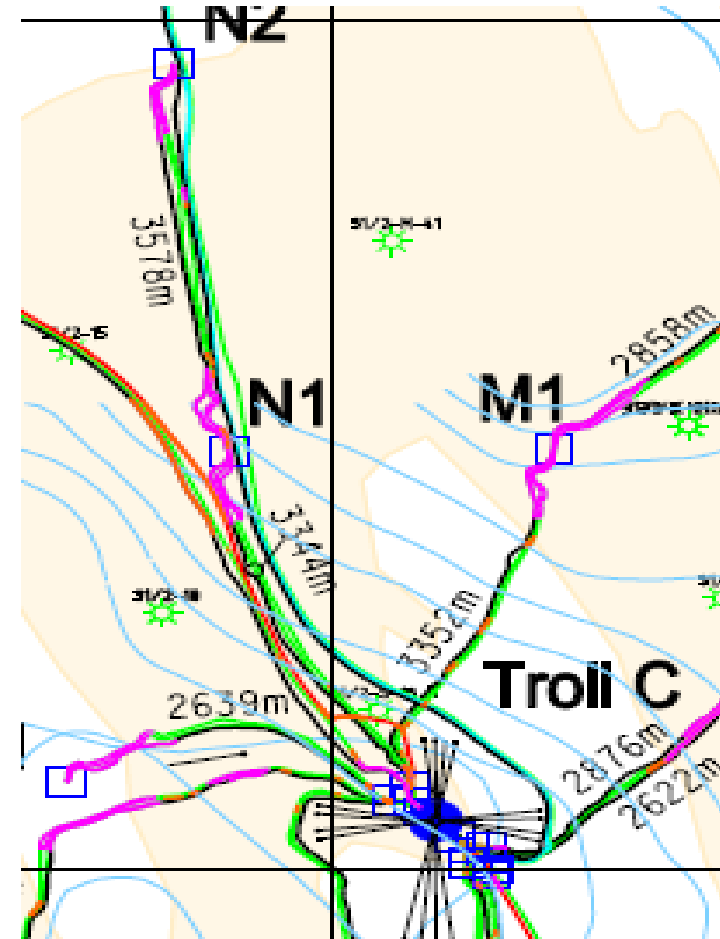
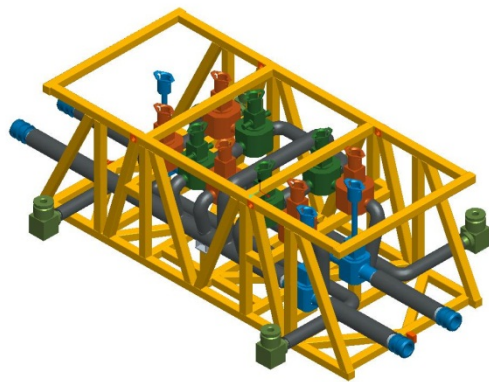
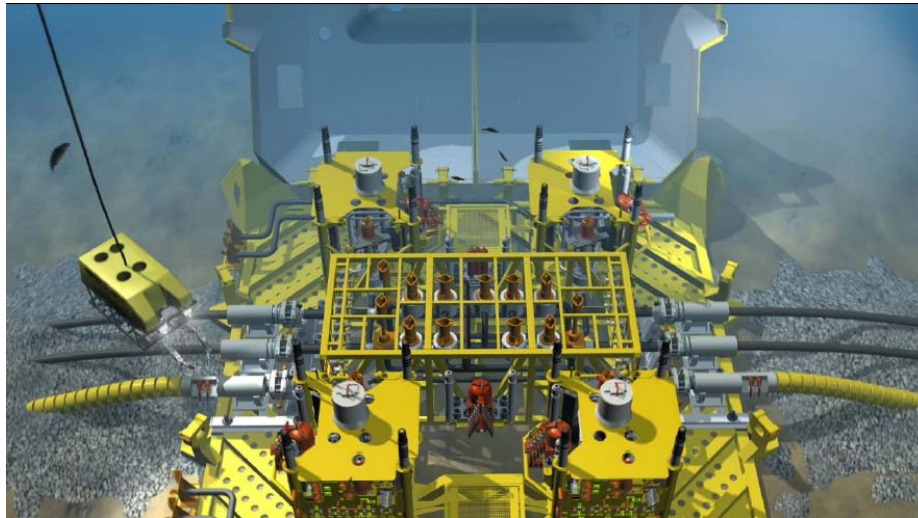
Complex Subsea Repair of Manifold N1

# Content

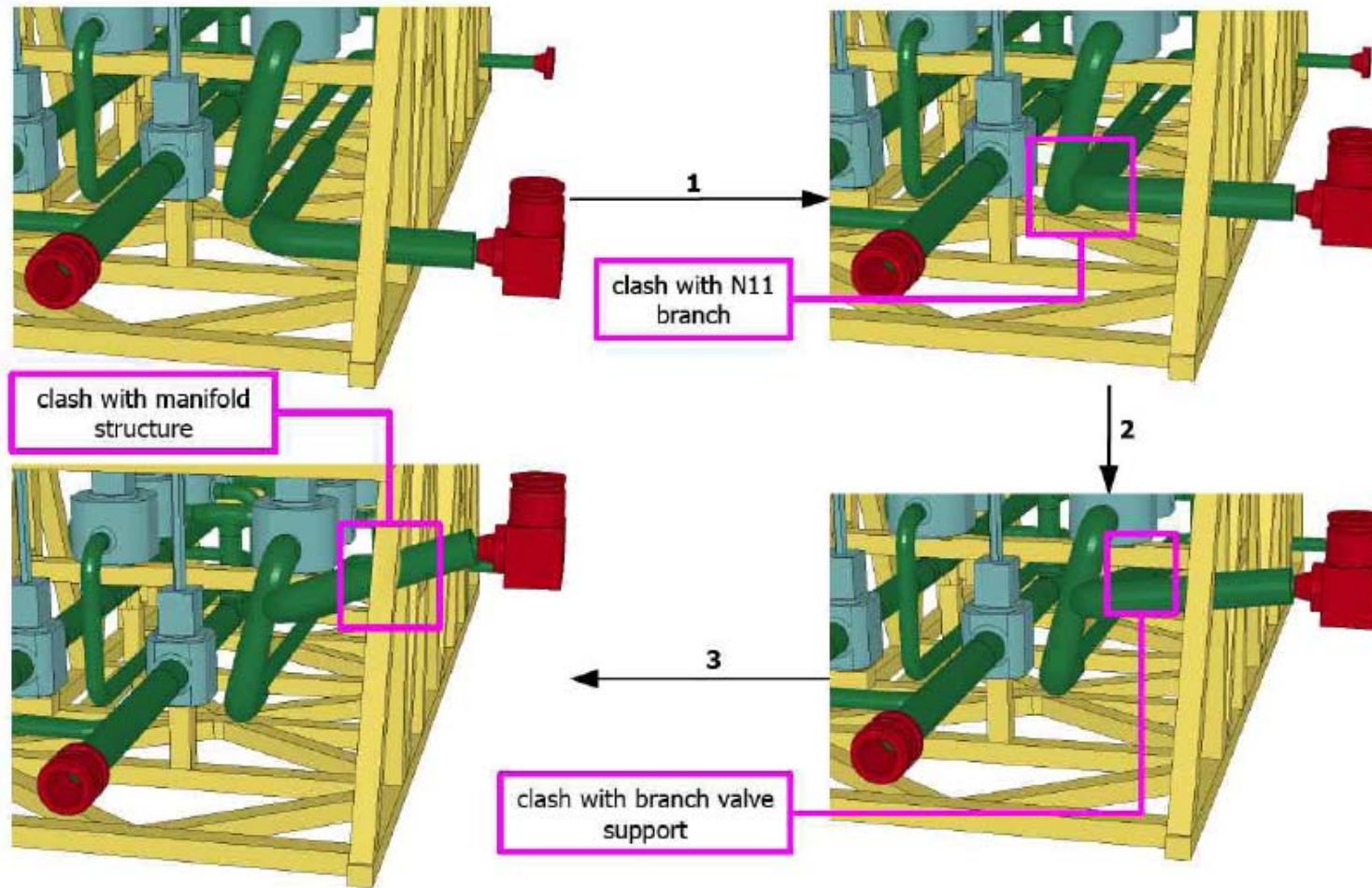
- Background
- Evaluation Phase
- Design & Verification Phase
- Execution Phase
- New Technology
- Final Status

# Background

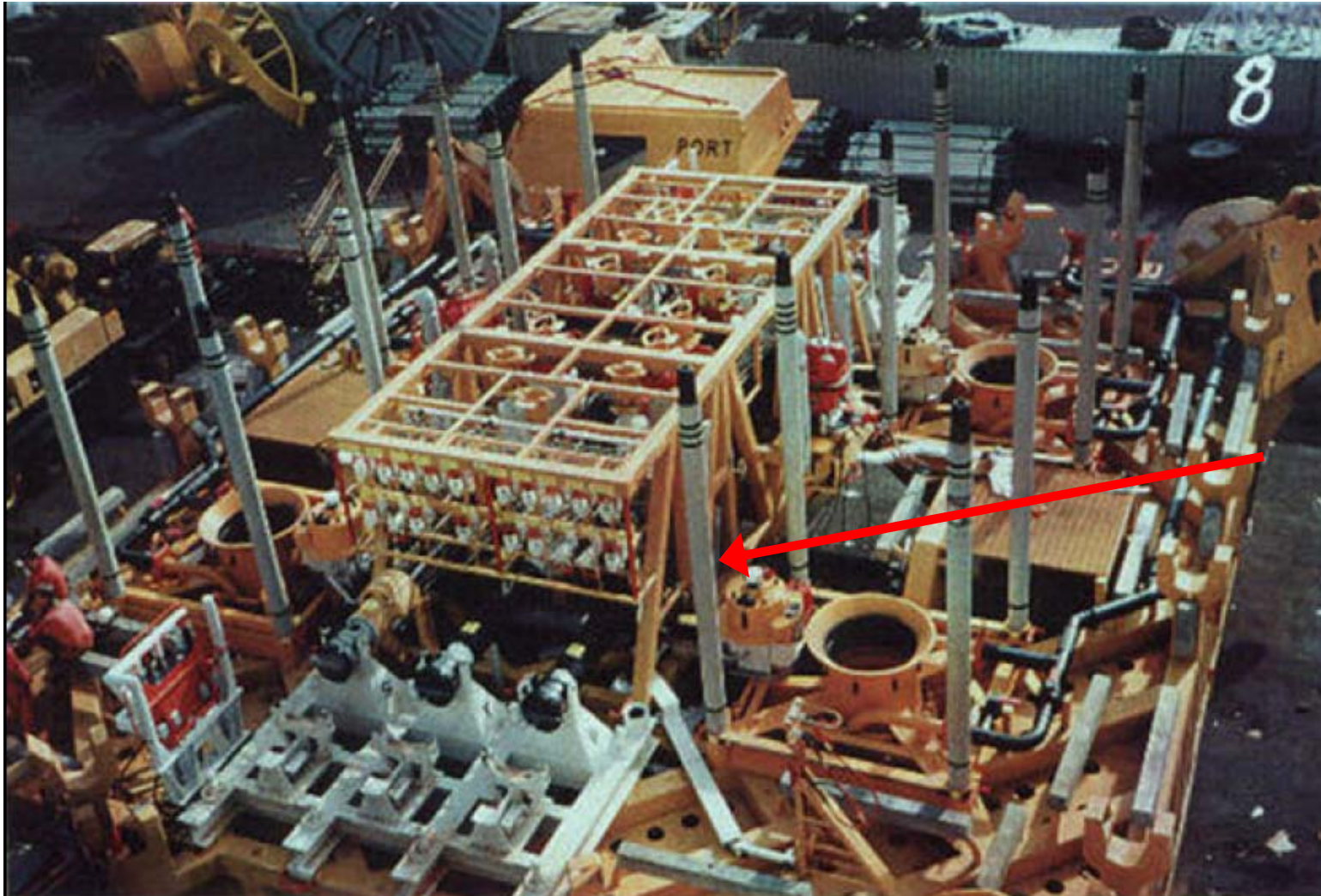
# Manifold N1 location at Troll C Subsea



# Incident Summary



# Template N1 Damage Location



# Crack in 6" Production Pipe



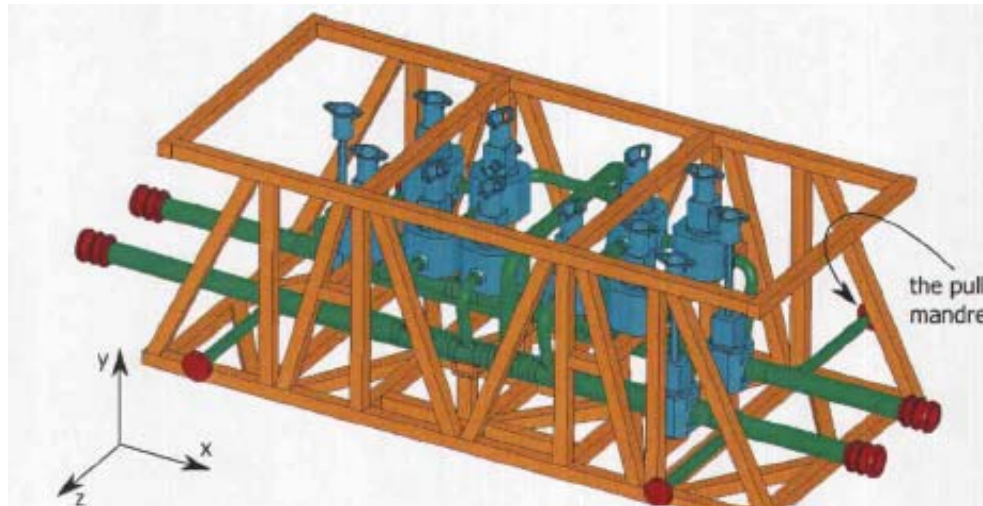
- Crack in pipe allowing pipeline content leaking to sea.
- One valve as barrier between open sea and 10" Test Header pipeline.
- Barriers not in accordance with requirements, Test Header pipeline shut down.

# Evaluation Phase

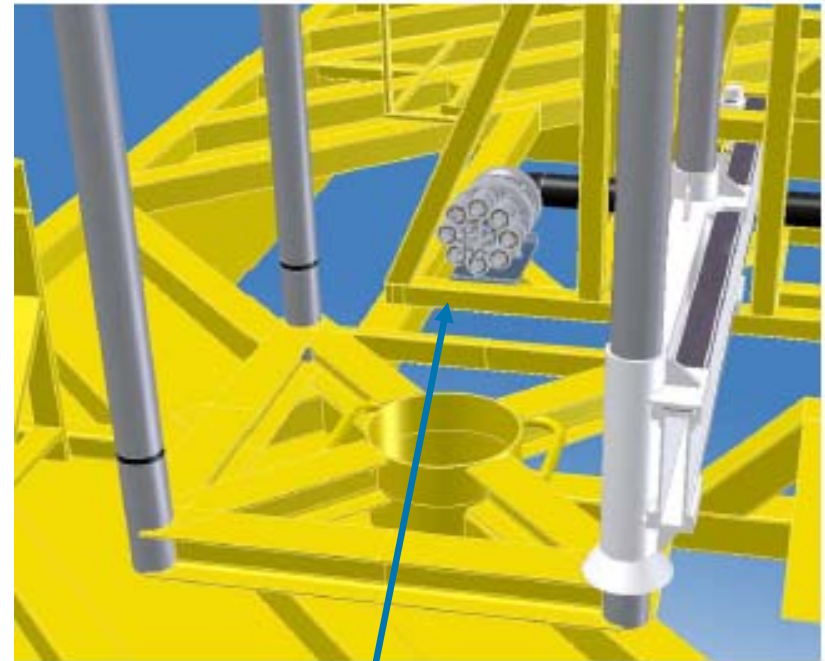


# Concept Evaluation

- New Manifold

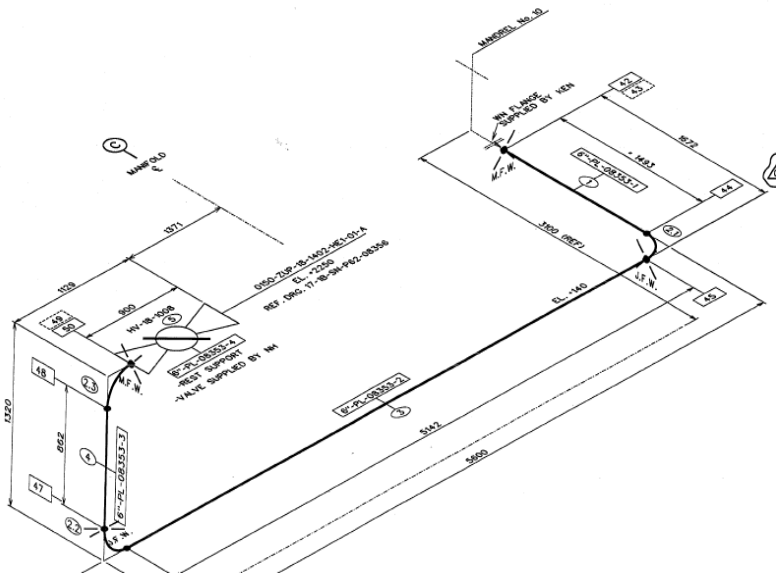


- Repair of 6" Pipe

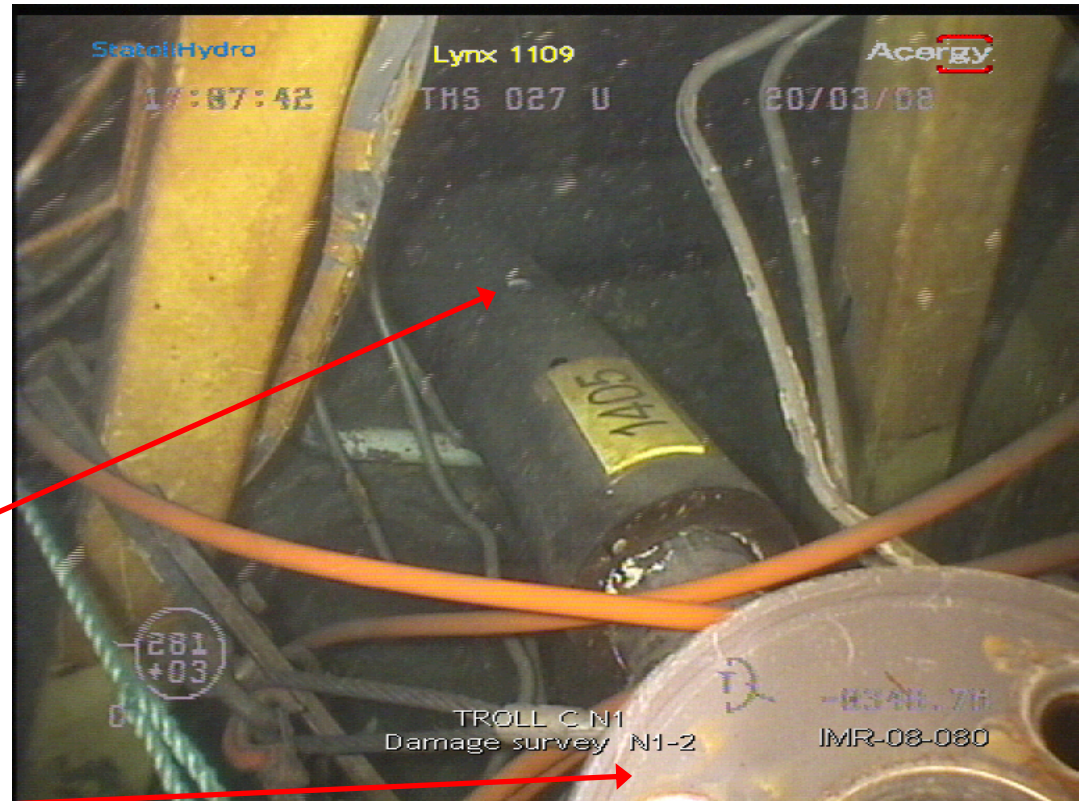


Morgrip End Connector

# Manifold Repair Location



- 6" Pipeline running from Well Mandrel to 6" Ball Valve to be cut and plugged (permanent passive barrier to be installed).
- Wellhead Mandrel



# Concept Evaluation towards DG2

- New Manifold

- Budget DG2            1530 MNOK
  - Ex. production loss
- Project Schedule 28 Months
- Overall low risk level
  - Disconnection of all flowlines and umbilicals
  - Long shut down period for Manifold N1 and N2 (7 wells for min. 4 months)

- Subsea repair of 6” Pipe

- Budget DG2            214 MNOK
  - Ex. Production loss
- Project Schedule 15 months
- Overall medium risk level
  - Small bore pipe plugging
  - Document remaining design life
  - Access to repair



Recommended Solution

# Design & Verification Phase

# Manifold Stress Assessment

- The following stress assessment were performed to document further service life for the piping system in the manifold;
  - Simulation of the accident
  - Stress level assessment in pipe after incident
  - Estimate of allowable production stresses
  - Valve strength assessment

- [Animation: movie troll-c](#)

# Material Evaluation

- HISC Evaluation:

- *HISC evaluation for N12.* An assessment of the risk for hydrogen induced stress cracking

- Conclusion:

- There are no new open sharp cracks in the welds caused by the accident.
- Restriction Introduced
  - No significant loading on the 6” pipe from the repair.
  - Shielded from seawater at Morgrip location (pipe exposed for permanent stress from Morgrip).

# Material Evaluation

- *SENT Testing, ECA and FE simulation.*
  - An assessment of the risk for fracture during the accidental lifting operation
- Conclusion
  - SENT testing for both H-charged and uncharged specimens give ductive tearing and high toughness values
  - ECA analysis of the accidental lifting operation clearly indicates that the critical flaw size is way beyond the maximum workmanship criterion
  - ECA analysis of the accidental lifting operation shows significant robustness against ductile crack extension from a 1.5mm deep around the pipe circumferential crack.

# Project Execution Phase



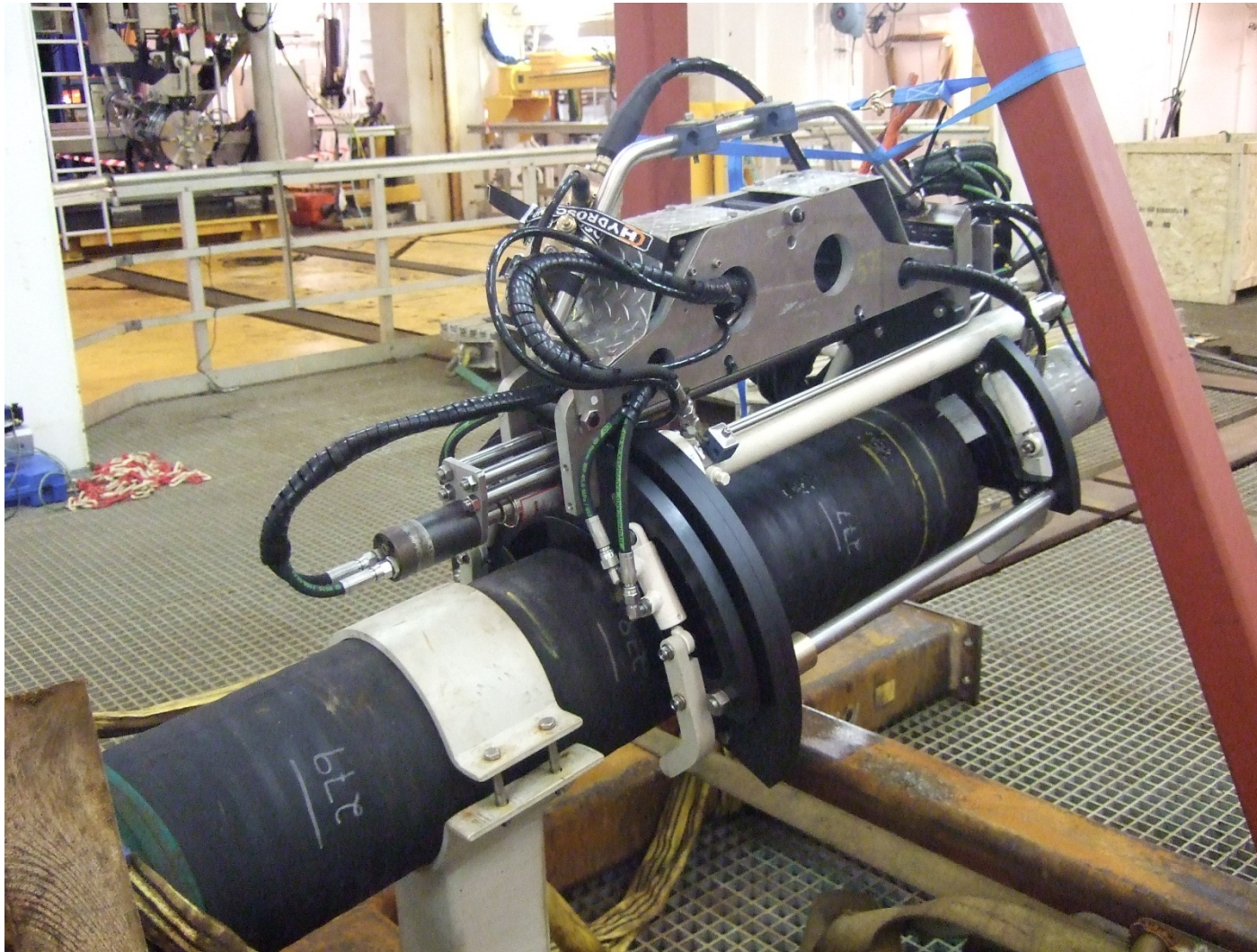
# Focus Areas

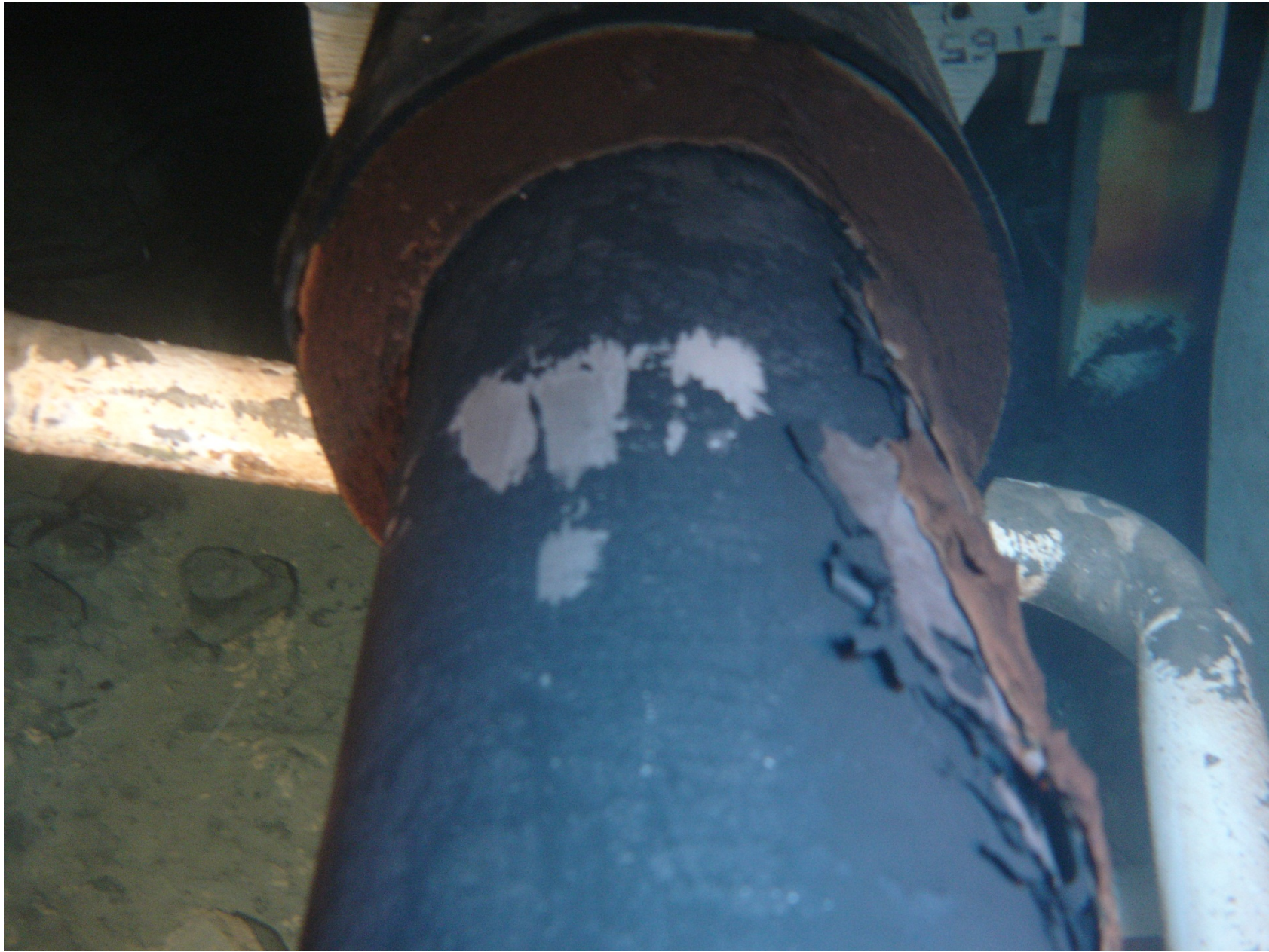
- Access for Repair
- Performed photogrammetry survey and created a 3D model early in the project. 3D model used for all tools and equipment development.
- Dummy manifold and well base fabricated based on 3D model and extensively used during testing and site integration.

# Use of Dummy Models

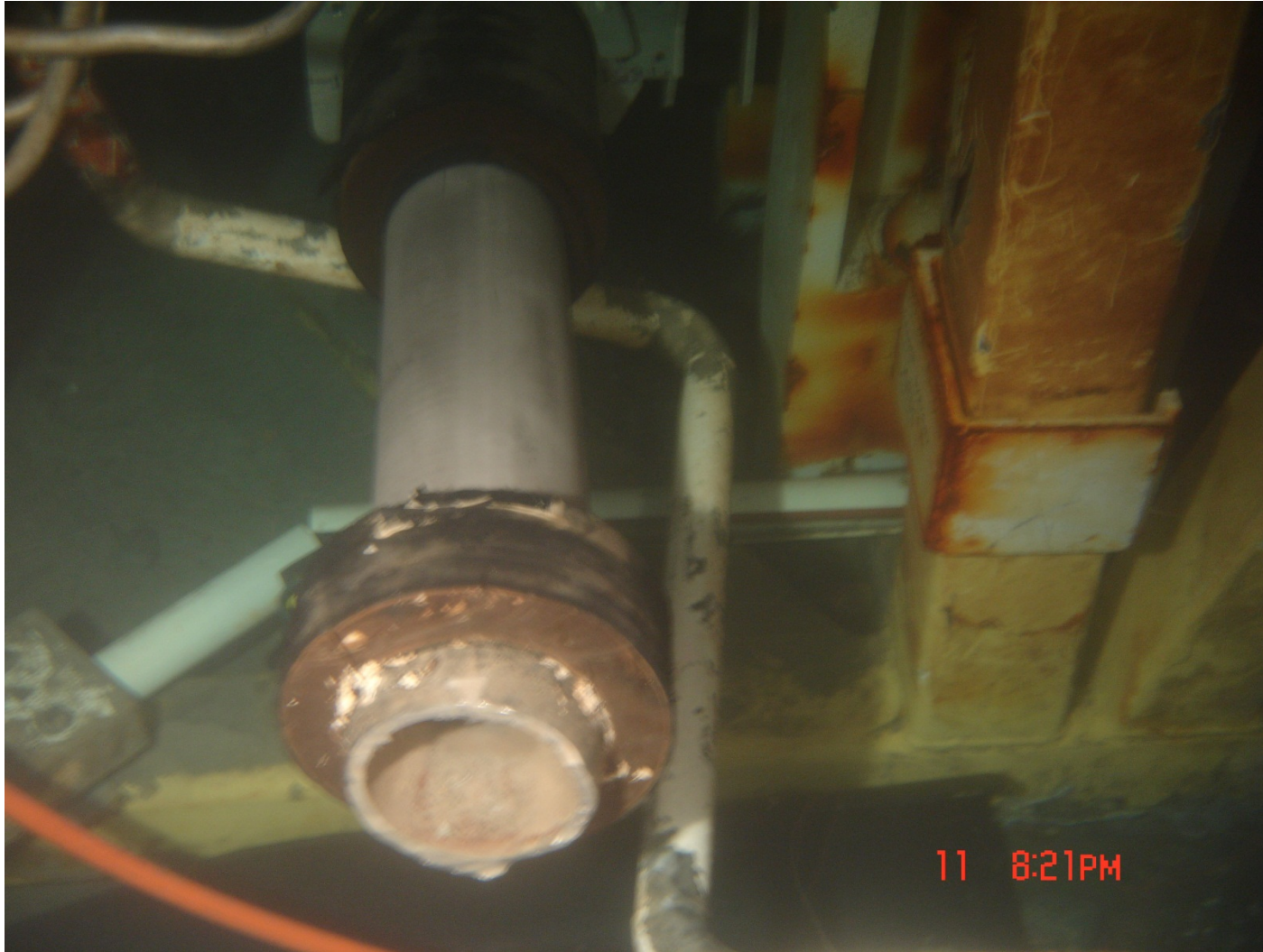


# Coating Removal Tool - Development

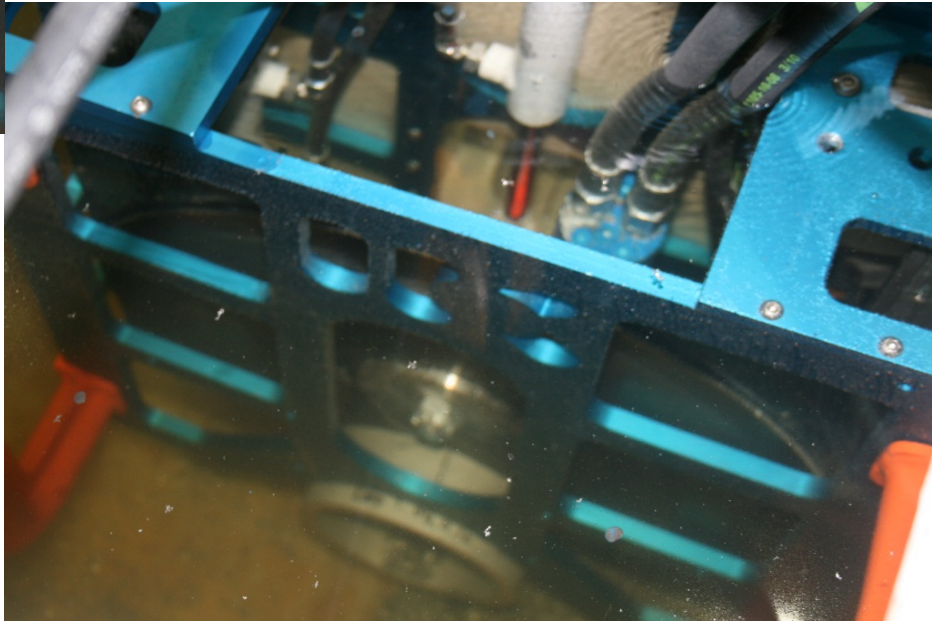
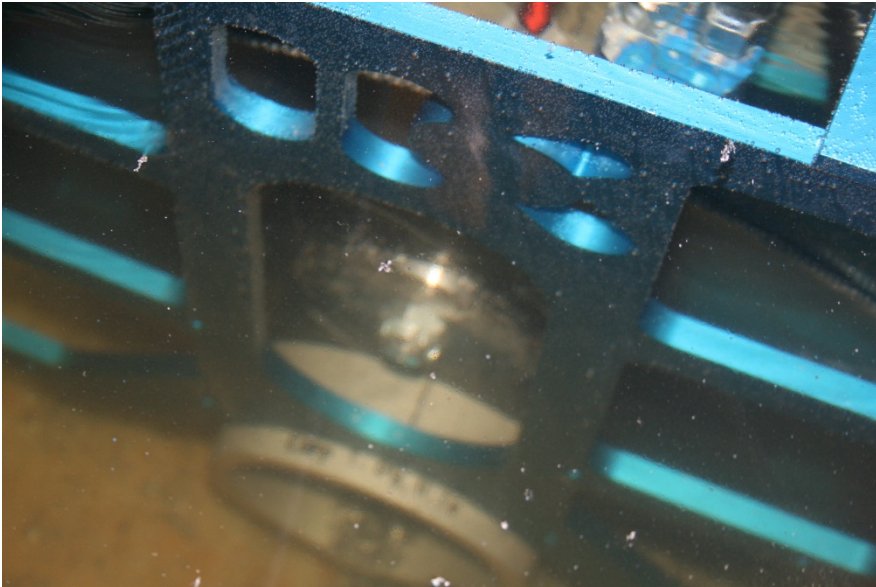




# Coating Removal Tool – Offshore



# Pipe Cutting



# Running Tool - Development



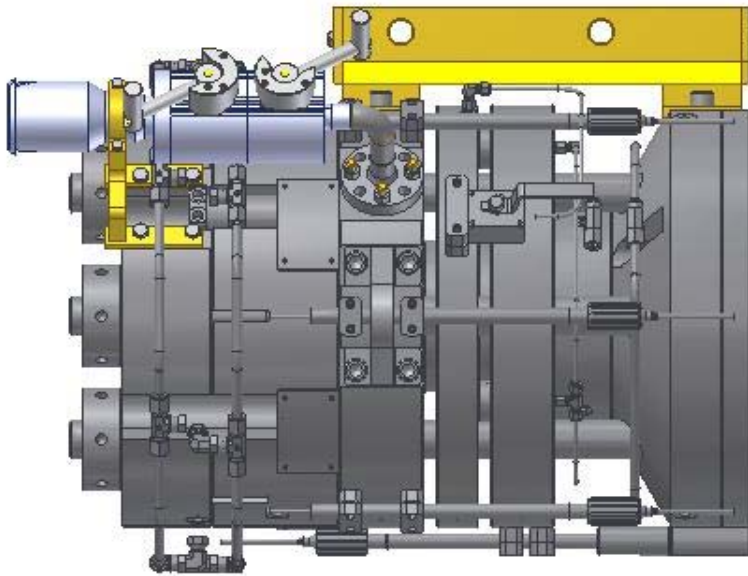
# Running Tool – Ready for Deployment



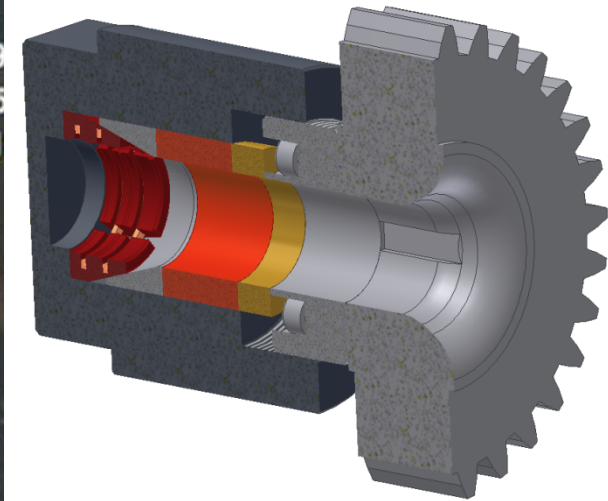


# New Technology

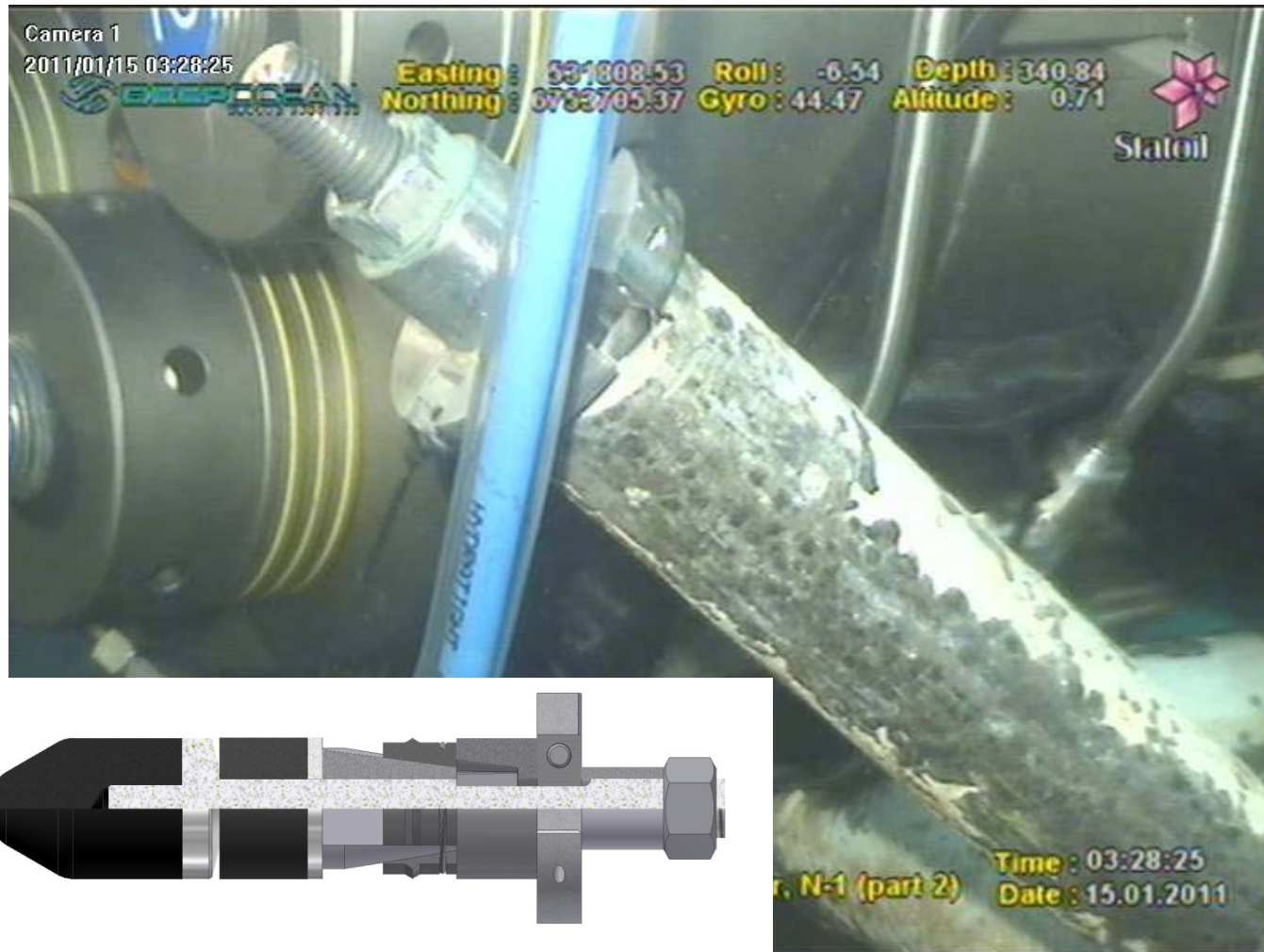
# Morgrip with Stab Receptacle



# Caps for permanent plugging of 1/2" hydraulic small bore pipes.



# Permanent Plugging of 2" Methanol line.



# Final Status

## Status Manifold N1 After Repair

- 6” pipe integrity retained with no de-rating of the pipe or deviations from original design.
- 6” pipe plugged in accordance with Statoil’s requirements to provide a permanent passive barrier.
- 2” and 1/2” pipes successfully plugged subsea.

# Acknowledge



**hydratight**

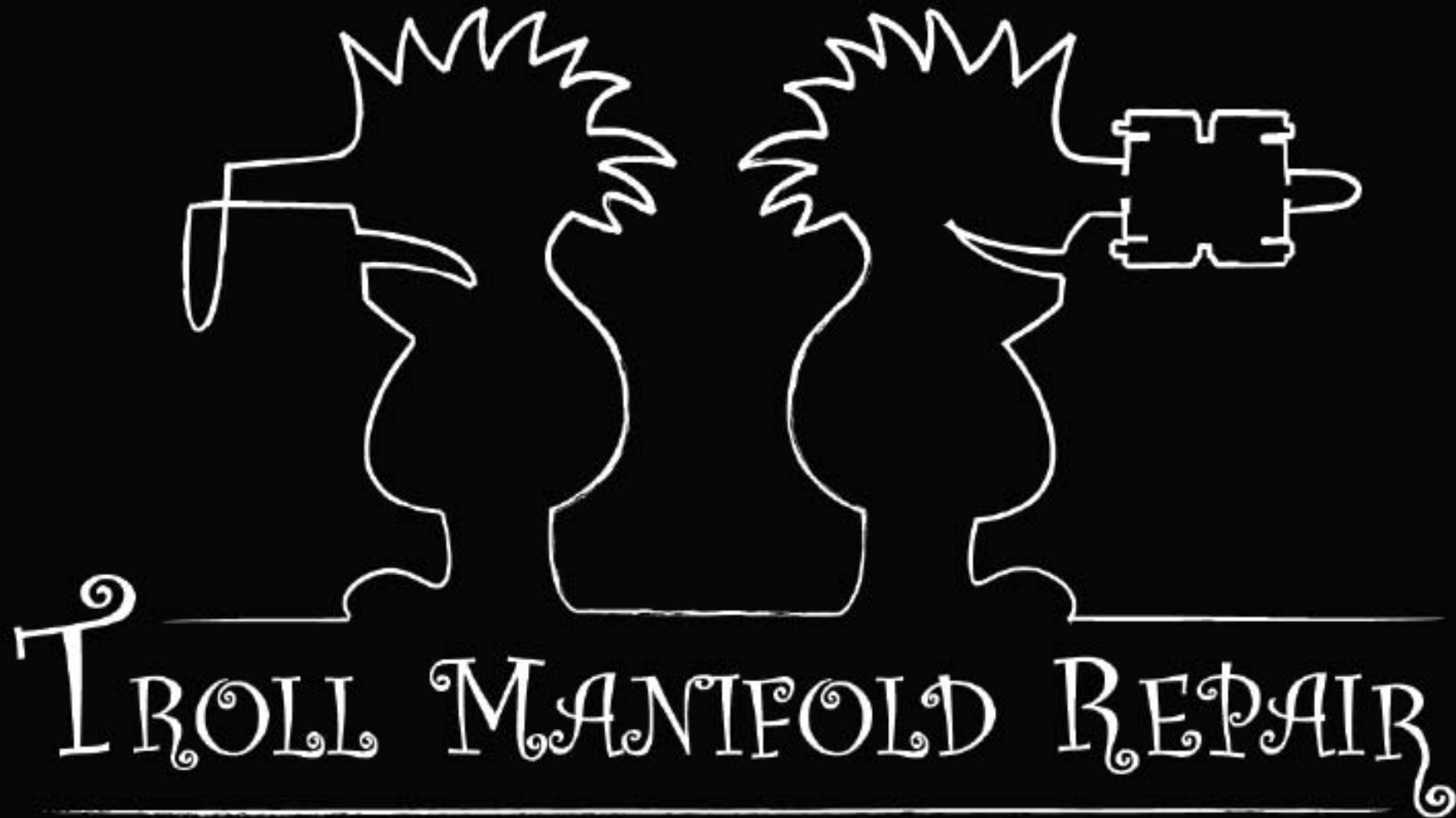


PROVIDING SAFE RELIABLE CONNECTIONS





Thank you



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