Flexible Pipe Integrity Assessment

An Alvheim Case Study

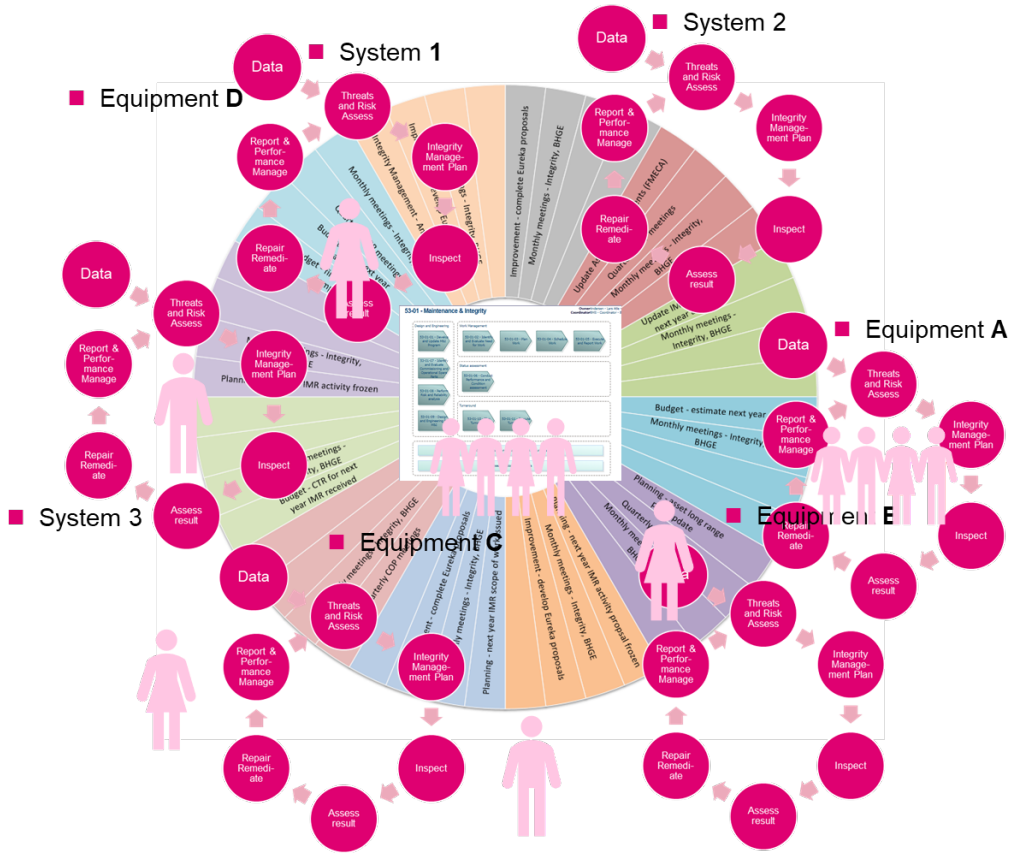
04.12.2019

Subsea Integrity Management – A Full Time Job

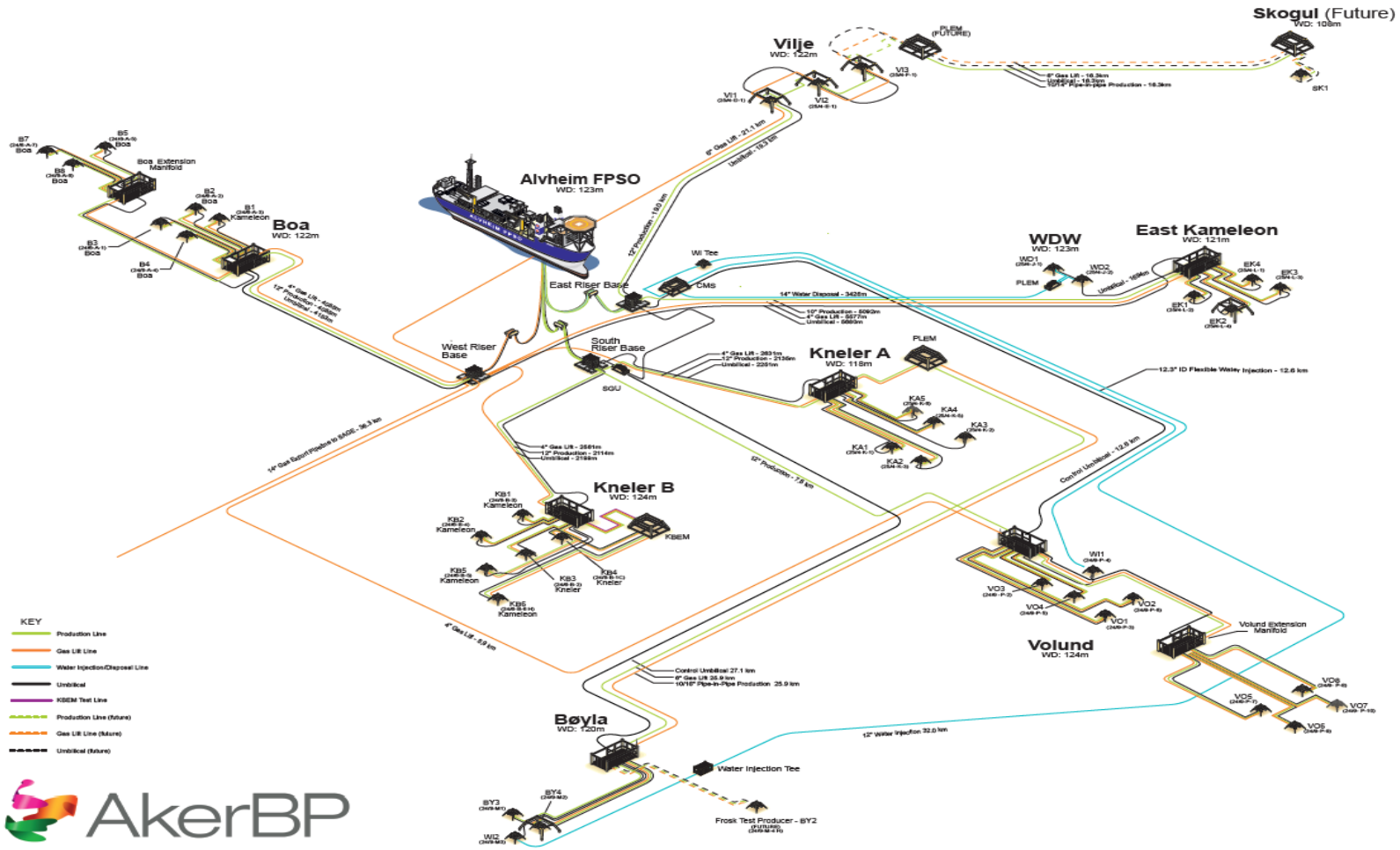
AkerBP Subsea Assets

- 582km Pipelines
- 60 XT's
- 15 Manifolds
- Umbilicals
- Power cables
- Fibre optic cables

AkerBP Subsea Engineers with Industry Support

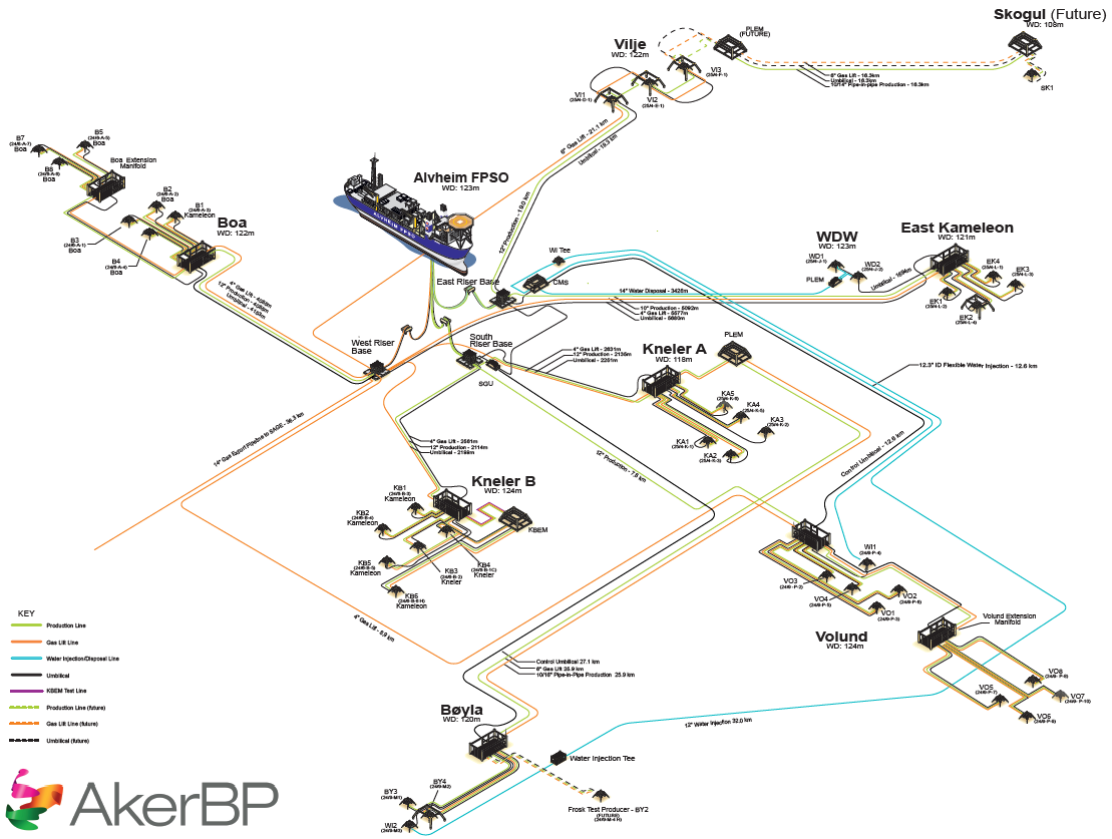


Greater Alvheim Area Field Developments



Alvheim Subsea Integrity Management

Greater Alvheim Area Field Developments



Neil Addison – Subsea Engineering Manager

Planned Subsea Integrity Management Activity – 4th June 2019

Alvheim Mid Water Arch

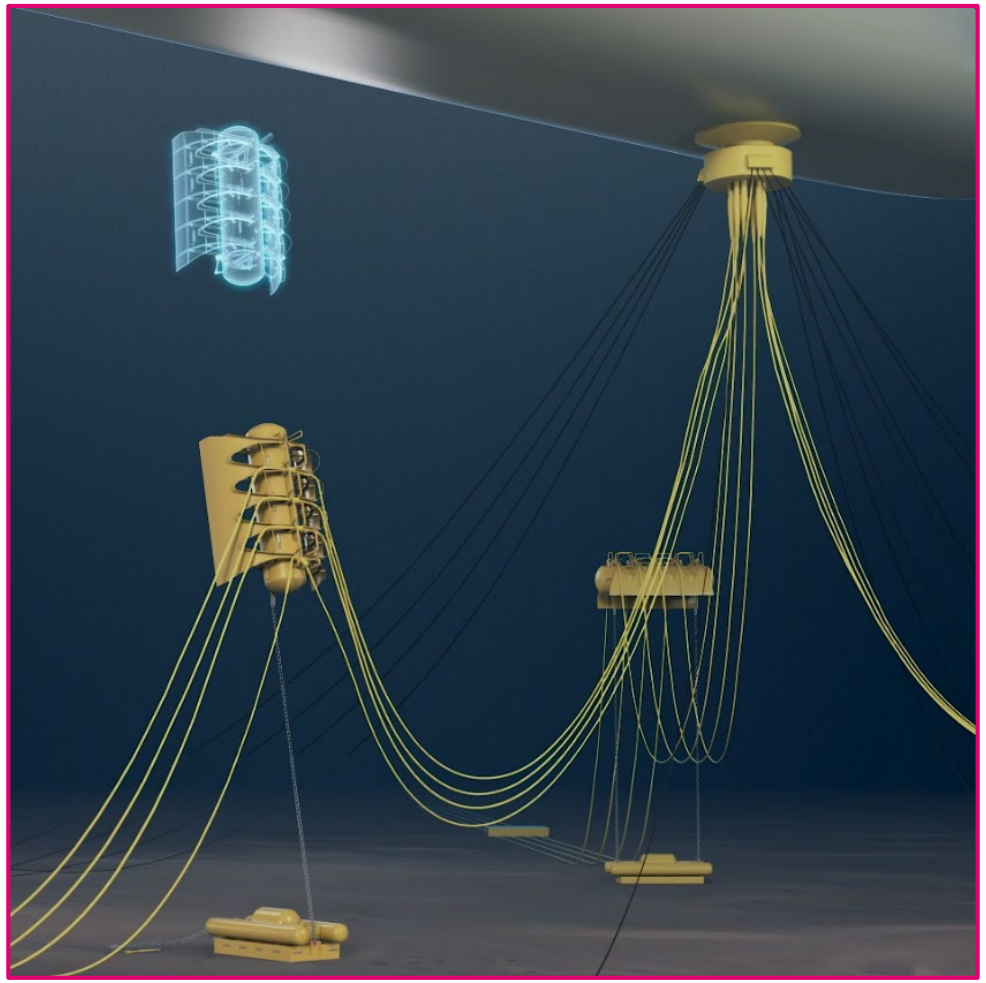
- Risk – loss of buoyancy due to flooded buoyancy tanks.
- Activity – Flooded member detection of each buoyancy tank to confirm no compromise of integrity.

Not what we expected…


4subsea

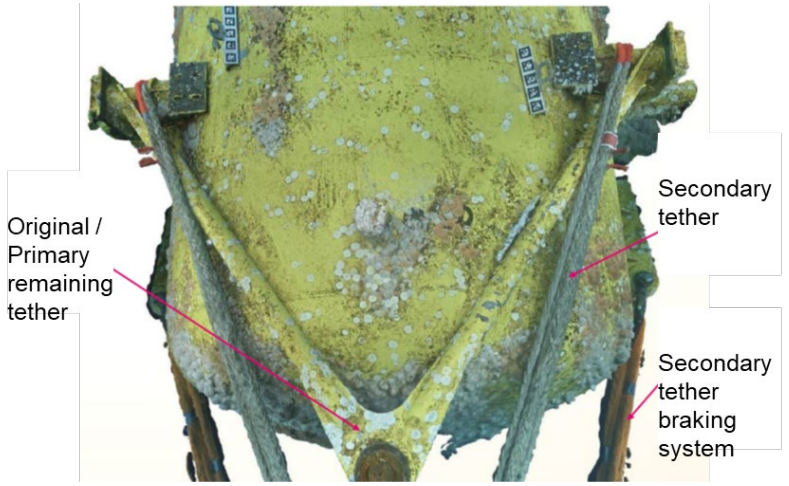
Initial Response

Complex Integrity Issue



Make Safe and Prevent Esclation

- Flexible risers shut in (well isolation and riser base valves closed) and depressurised.
- Standing instruction on FPSO to restrict headings above East Mid Water Arch
- Flexible risers secured within the riser tray guides.
- Umbilical secured to installation guide and still operational.
- Upended East Mid Water Arch secured with secondary tether.

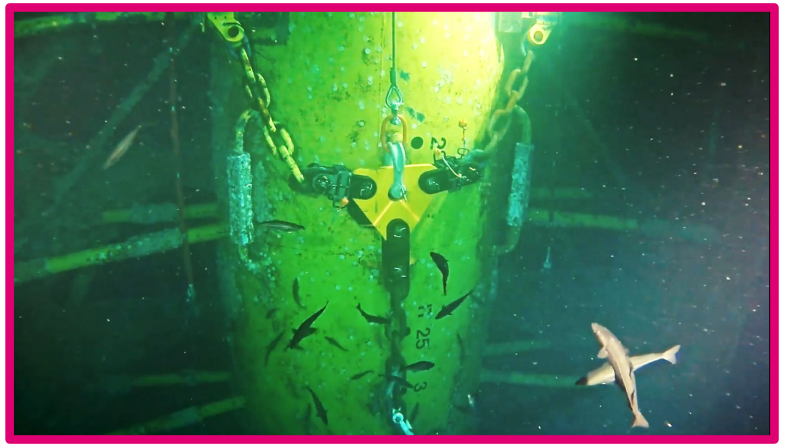


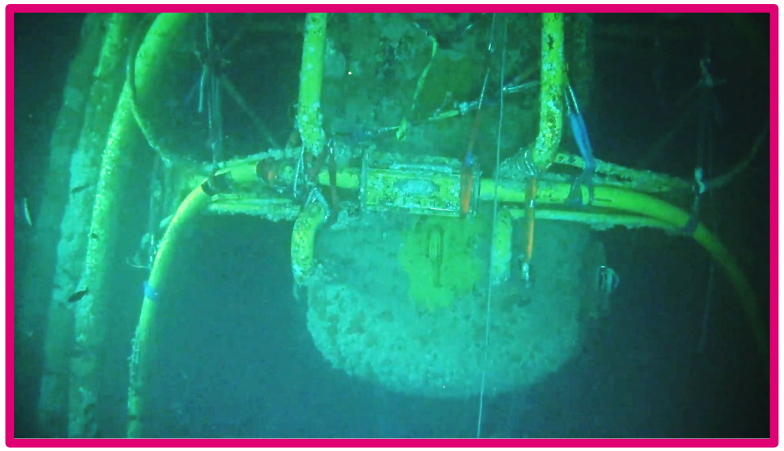
Project Reimagine

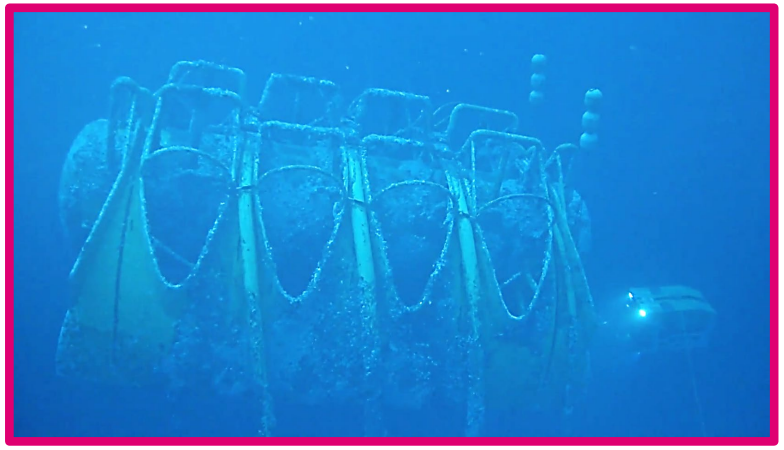
re·imag·ine (verb): rē-i-ˈma-jən
Definition: to imagine again or anew :
to form a new conception of :
RE-CREATE

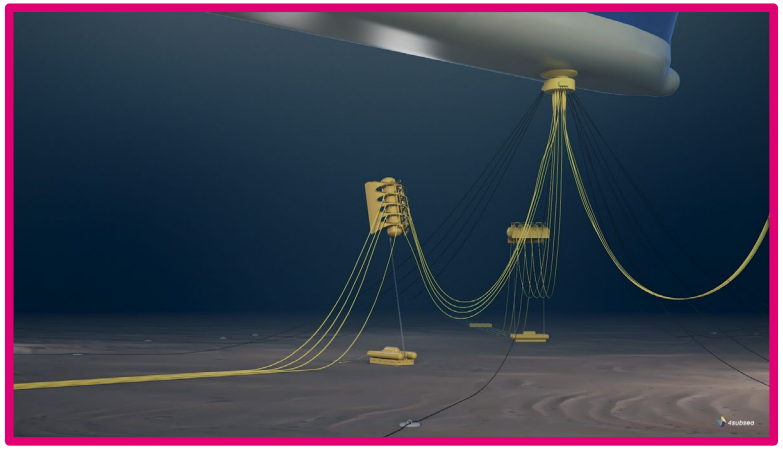
Subsea Execution

Replacing Failed Tether and Reinstating Design Configuration.





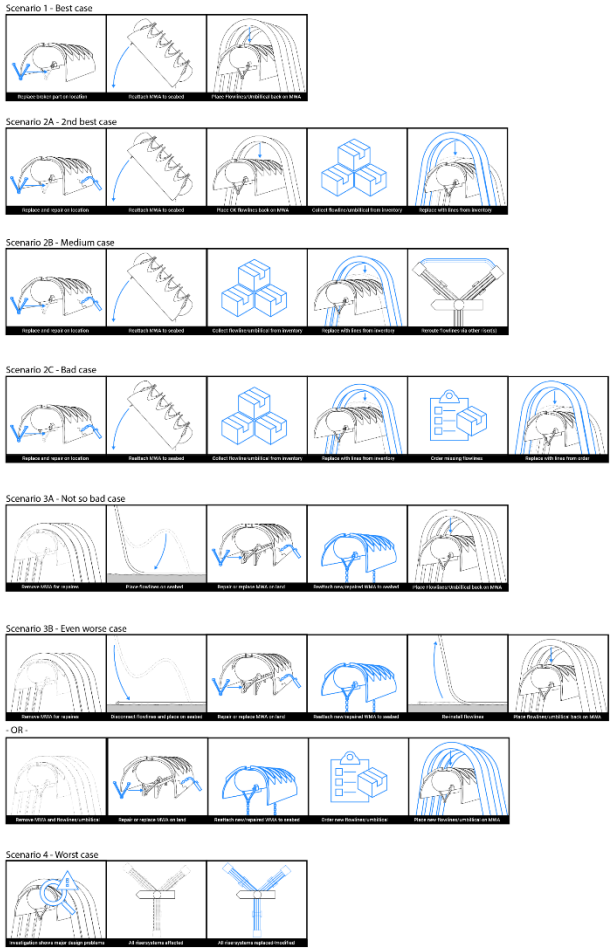




Path to Restart

Preparedness & Response Strategy

Multiple Workstreams



Governance

Risk Assessment & Basis Dossier
- Root Cause Analysis
- Anomalies
- FMECA studies
- Fitness for Service
- Verification
- Integrity Management

Operational Risk Assessment
- Asset risk assessment
- Synergi deviation
- Barrier viewpoint
- Temporary Instruction

Risk Endorsement Note
- Corporate risk
- Major Accident Risk

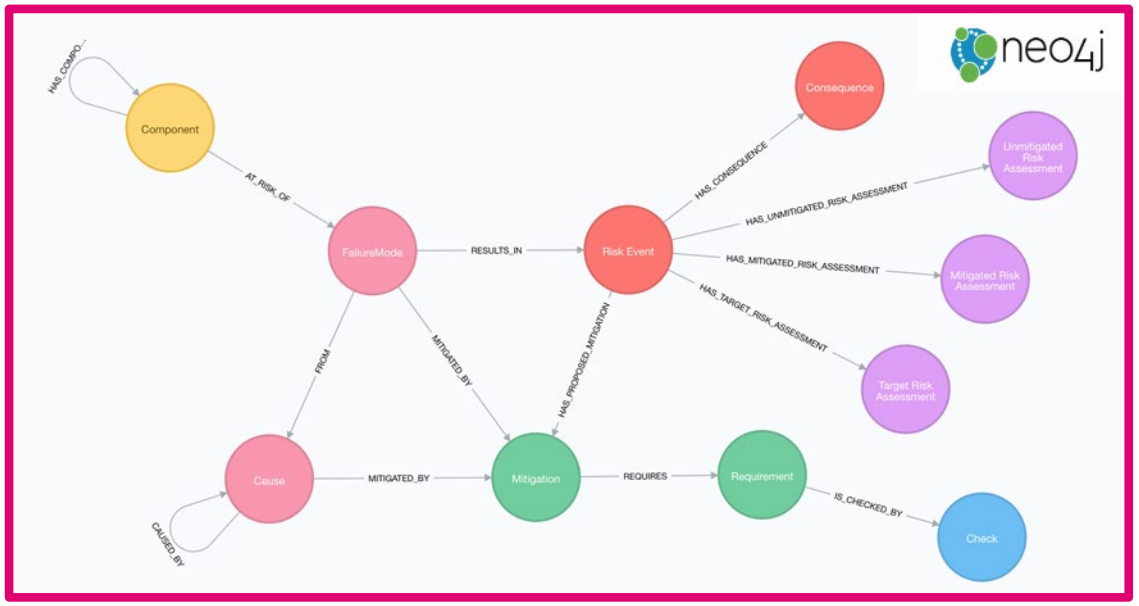
Rectification Handover Dossier
- Completed procedures
- Test records
- Management of Change

Restart

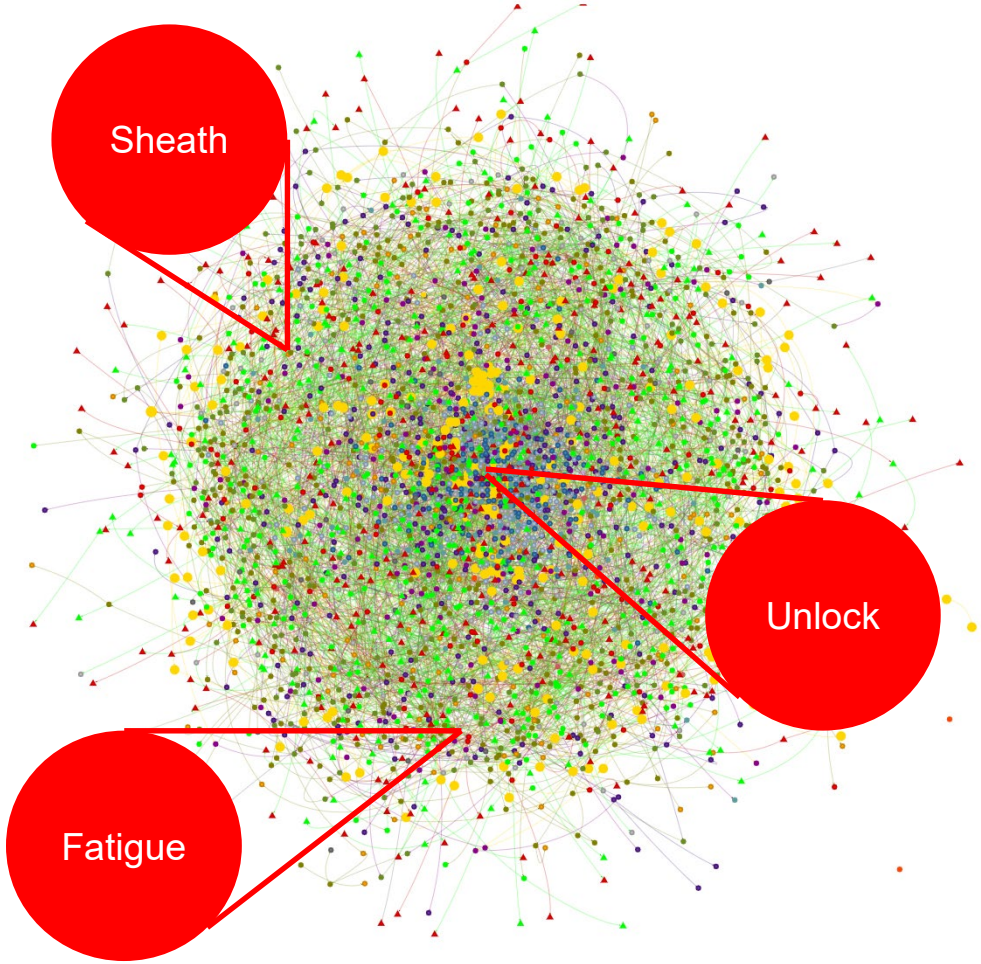
FMECA and Fitness for Service

«AkerBP Smart Subsea tool»

- Risk assessment
- FMECA
- Knowledge
- Compliance

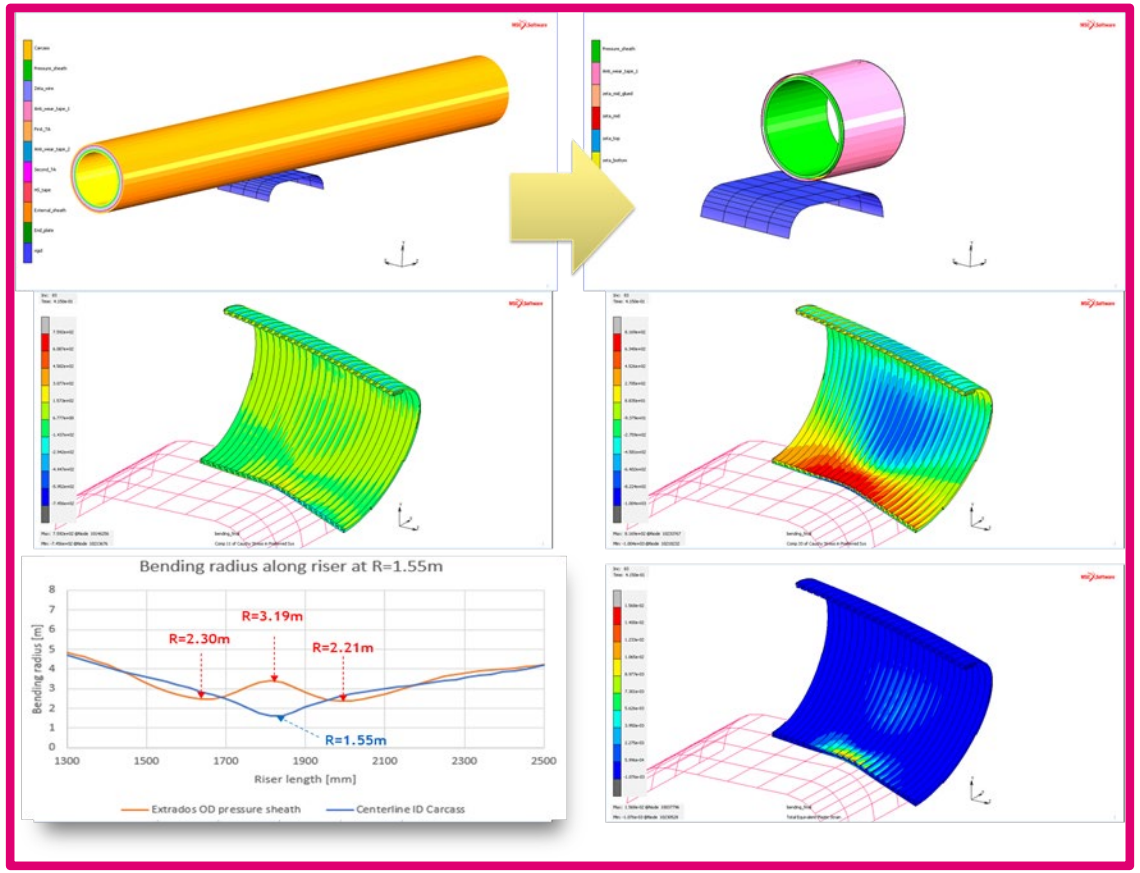


Alvheim Mid Water Arch and Flexibles «graph»



Potential for Unlocking of Pressure Layer

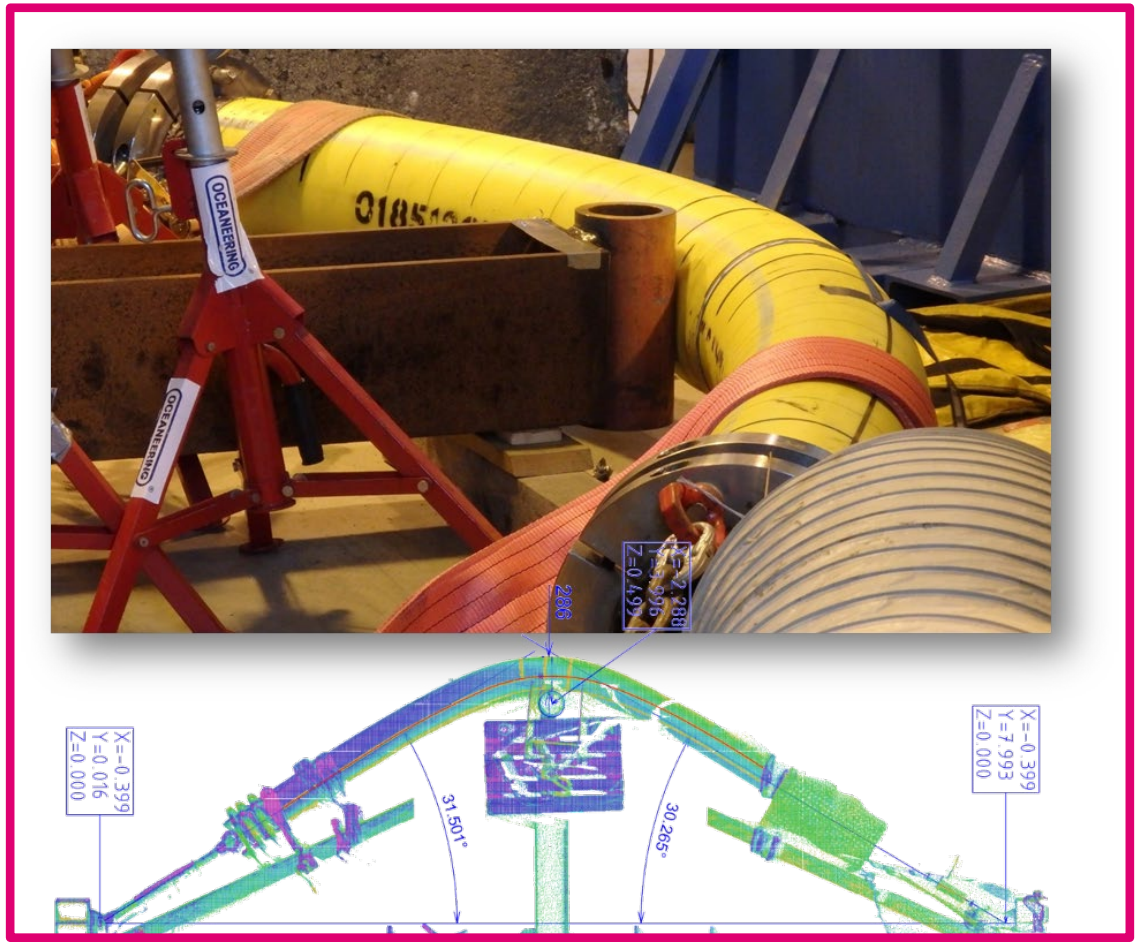
Finite Element Analysis



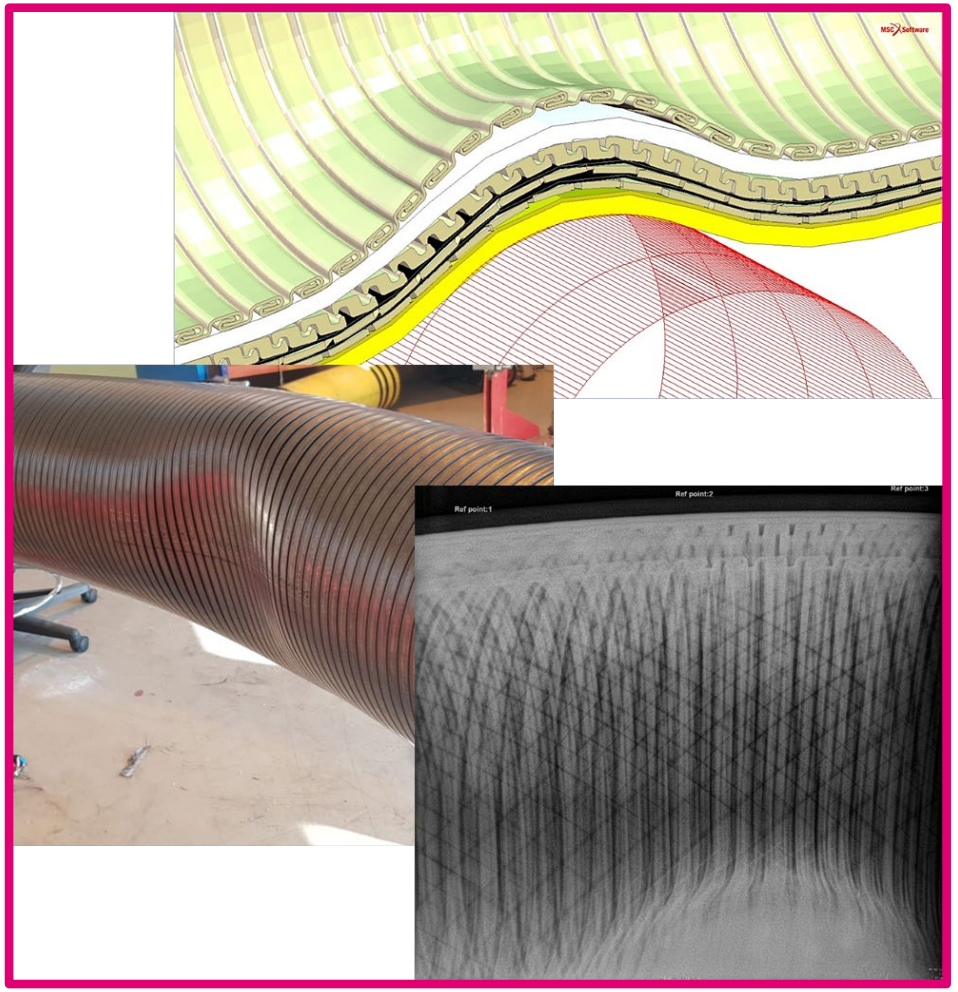
- Risers bent beyond the allowable dynamic and storage minimum bending radius.
- Risers resting and bent around installation guide tubulars.
- Risers passed leak test.
- No inspection tooling available for inspecting condition of pressure armour layer.
- Finite Element Analysis to understand expected condition of armour layer.
  - No unlocking in analysis when bending against narrow support.
  - Ovalization “saves” the pressure armour extrados
  - Pressure armour ring collapse the governing failure mode
- Finite Element Analysis supported by full scale bend tests and high accuracy offshore bending and ovality data.

Potential for Unlocking of Pressure Layer

Full Scale Bend Tests



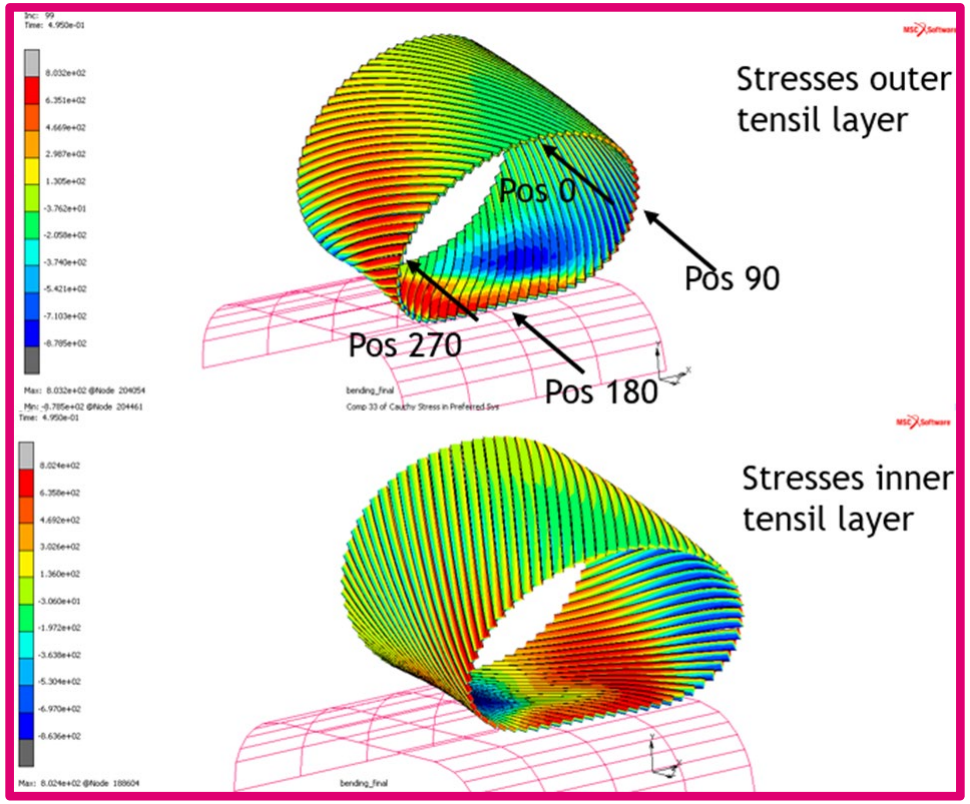
Final Destructive Test with Safety Factor 2.5



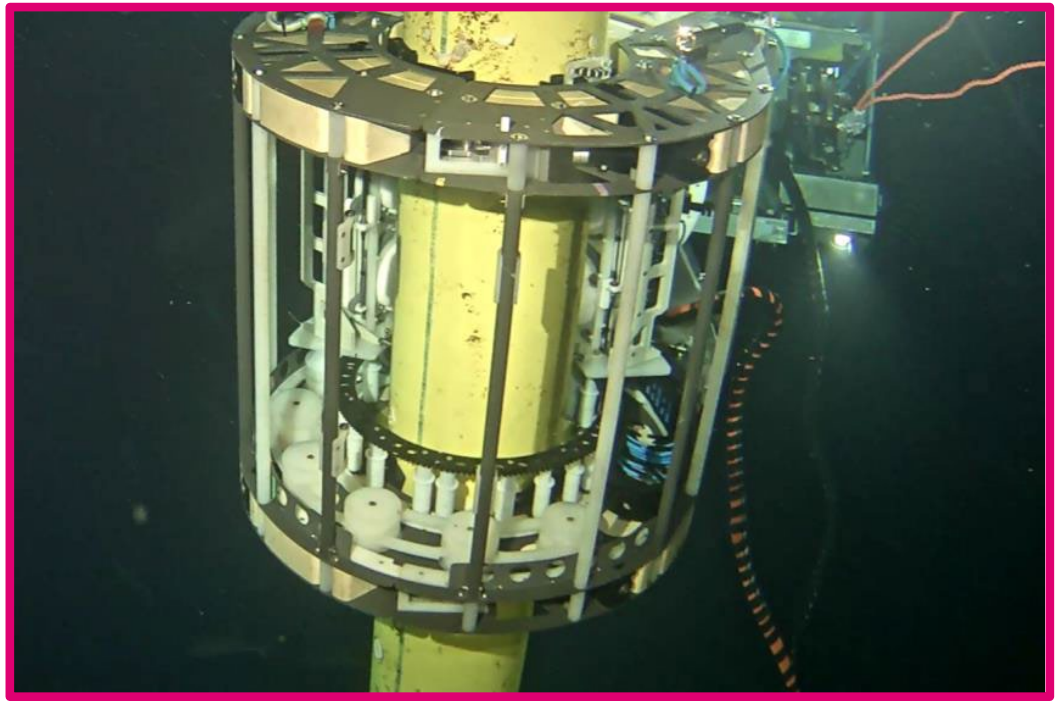
Potential Fatigue of Armour Wires

Analysis

- Original Equipment Manufacture Fatigue Analysis
- Supported by Finite Element Analysis approach

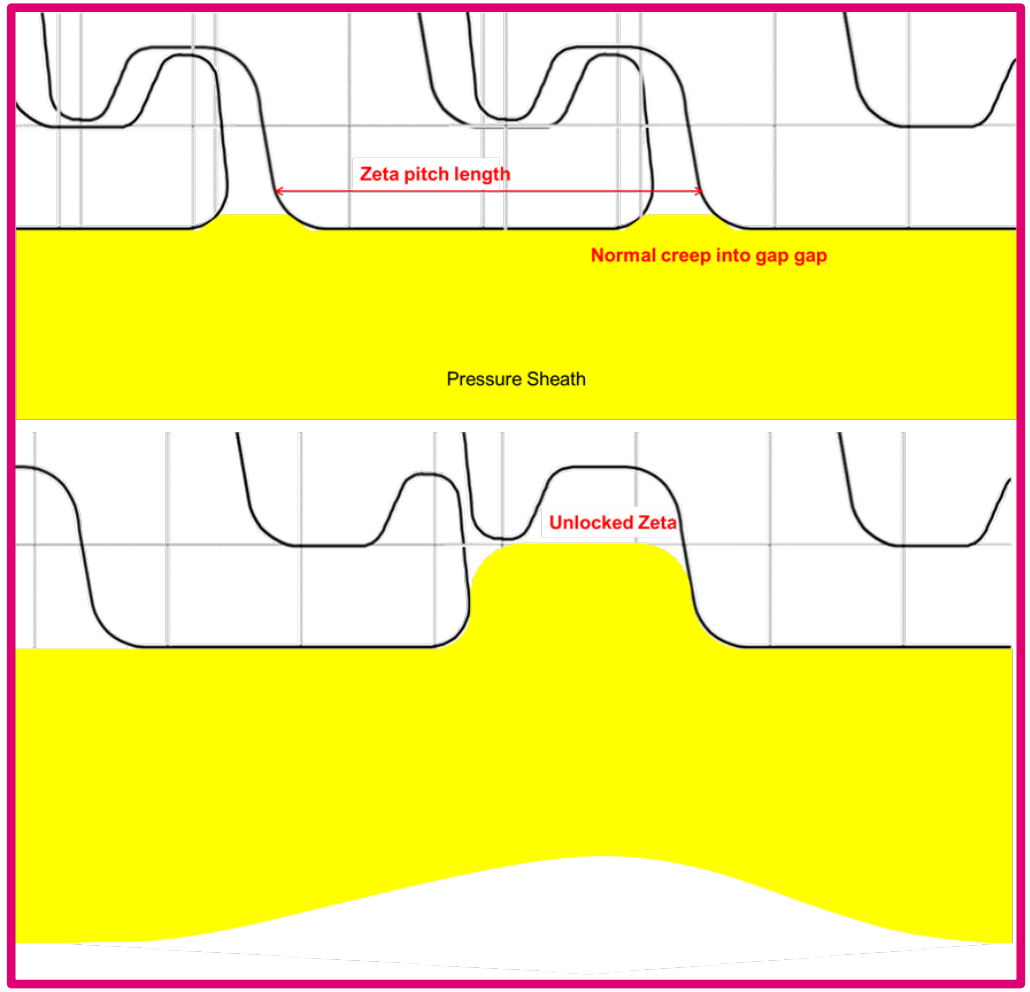


Field Inspection

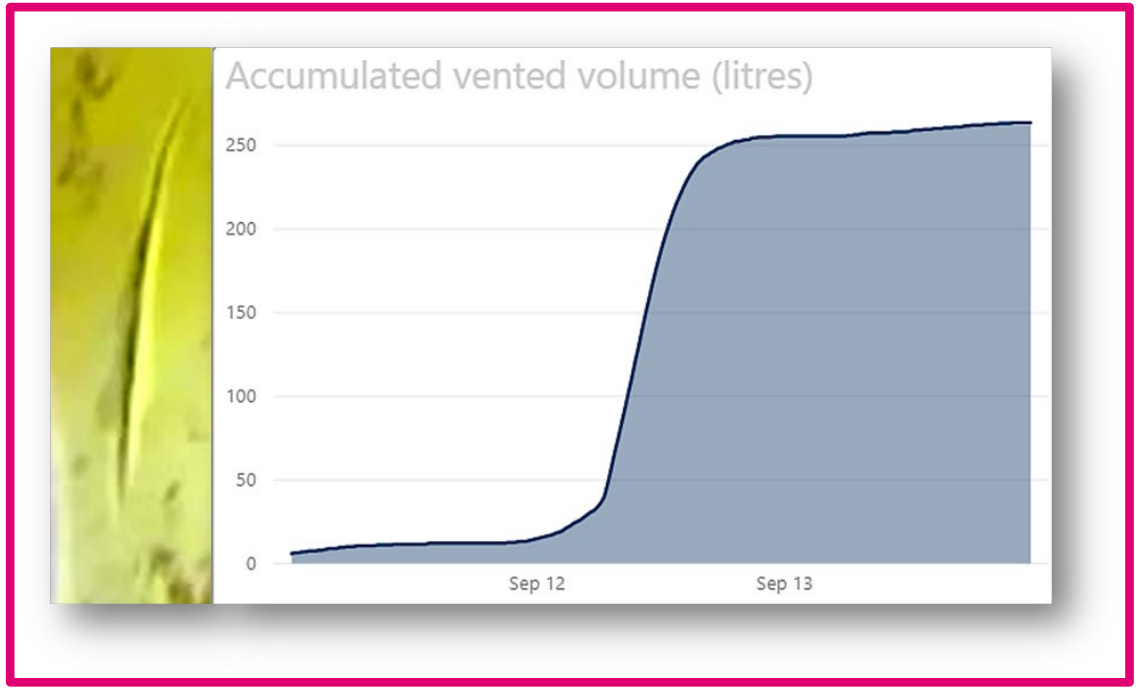


Pressure Sheath and Outer Sheath

Monitoring Annulus During Leak Test



Monitoring Annulus During Down-ending Mid Water Arch



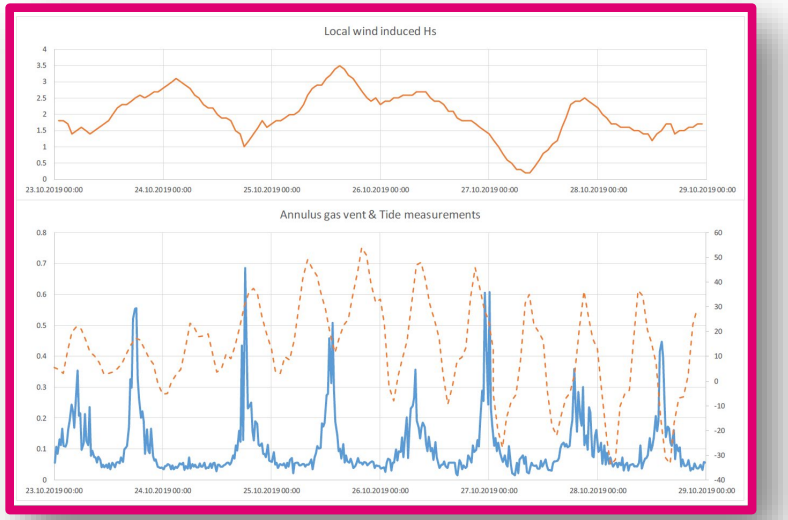
Pressure Sheath and Outer Sheath

Monitoring During Operation

- Monitoring flexible riser ‘health’ on a daily basis

Machine Learning

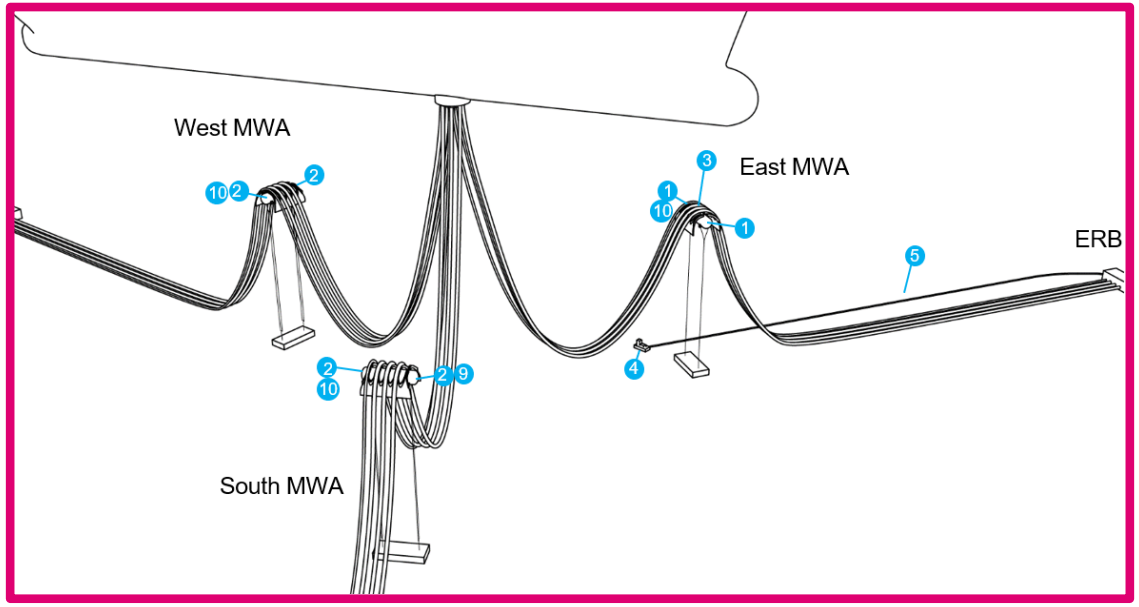
- Need to recognize deviation from «normal»
  - Input process parameters (valves, chokes, temperature, pressure)
  - Other relevant input (waves, vessel motions, air pressure….)
  - Model vent rate
  - Model vent composition



Improved Diagnostics

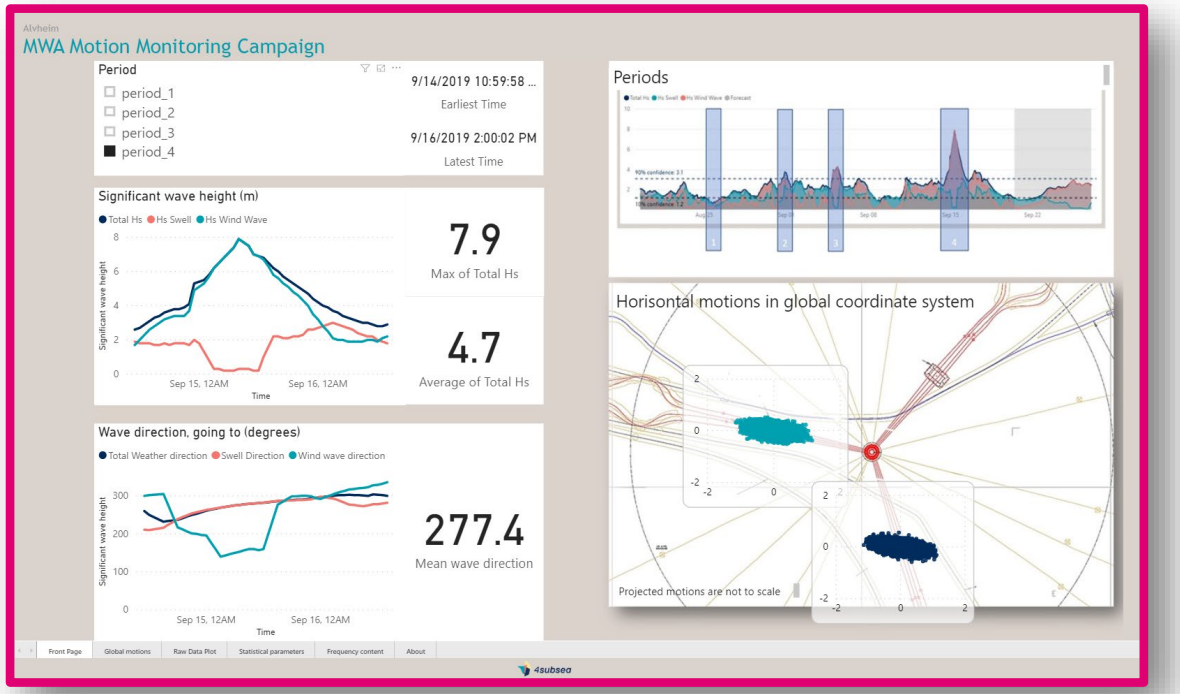
Ongoing Integrity Management

System Monitoring Hardware



Gaining Knowledge

- Acoustic depth sensors
- Sonar
- Motion Response Units on mid water arches.
- Fatigue counter



Key Learnings

- Industry collaboration – Flexshare
- Acknowledge todays “state of the art” (computational power)
- Product robustness and governing failure modes
- Updated Design Basis
- Improved hydrodynamic coefficients & models
- High value in measured responses / data
- Corporate knowledge

Thank you

Official opening at Alvheim in 2008 – **Reimagined !!**

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