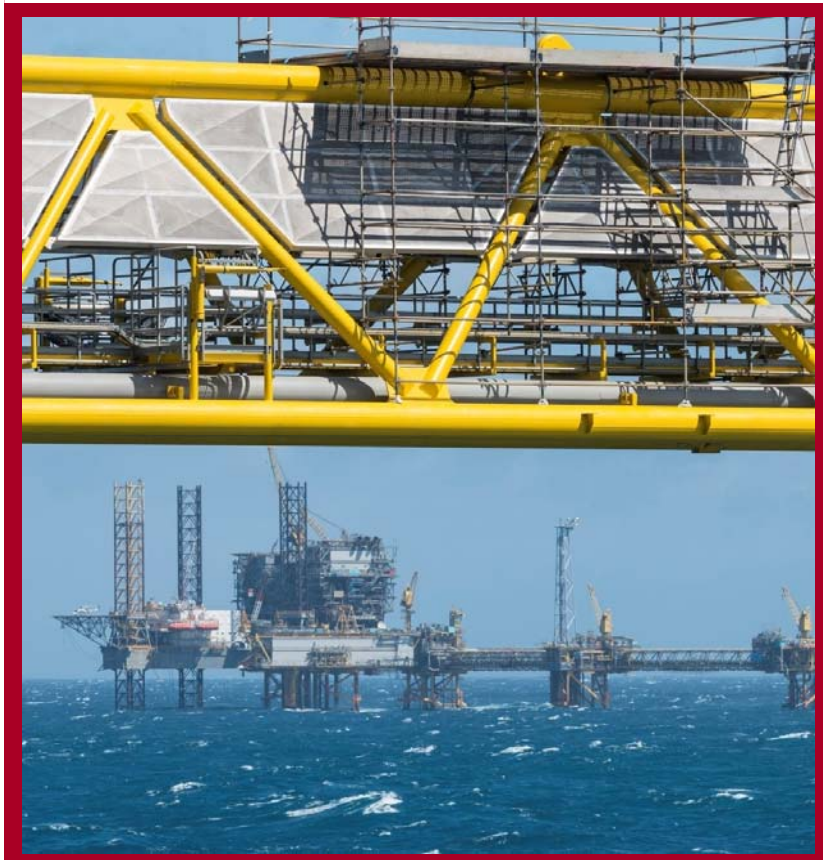


DELIVERING HIGH PERFORMANCE IN A MAJOR NORTH SEA BROWNFIELD PROJECT: THE TYRA FUTURE PROJECT, DENMARK

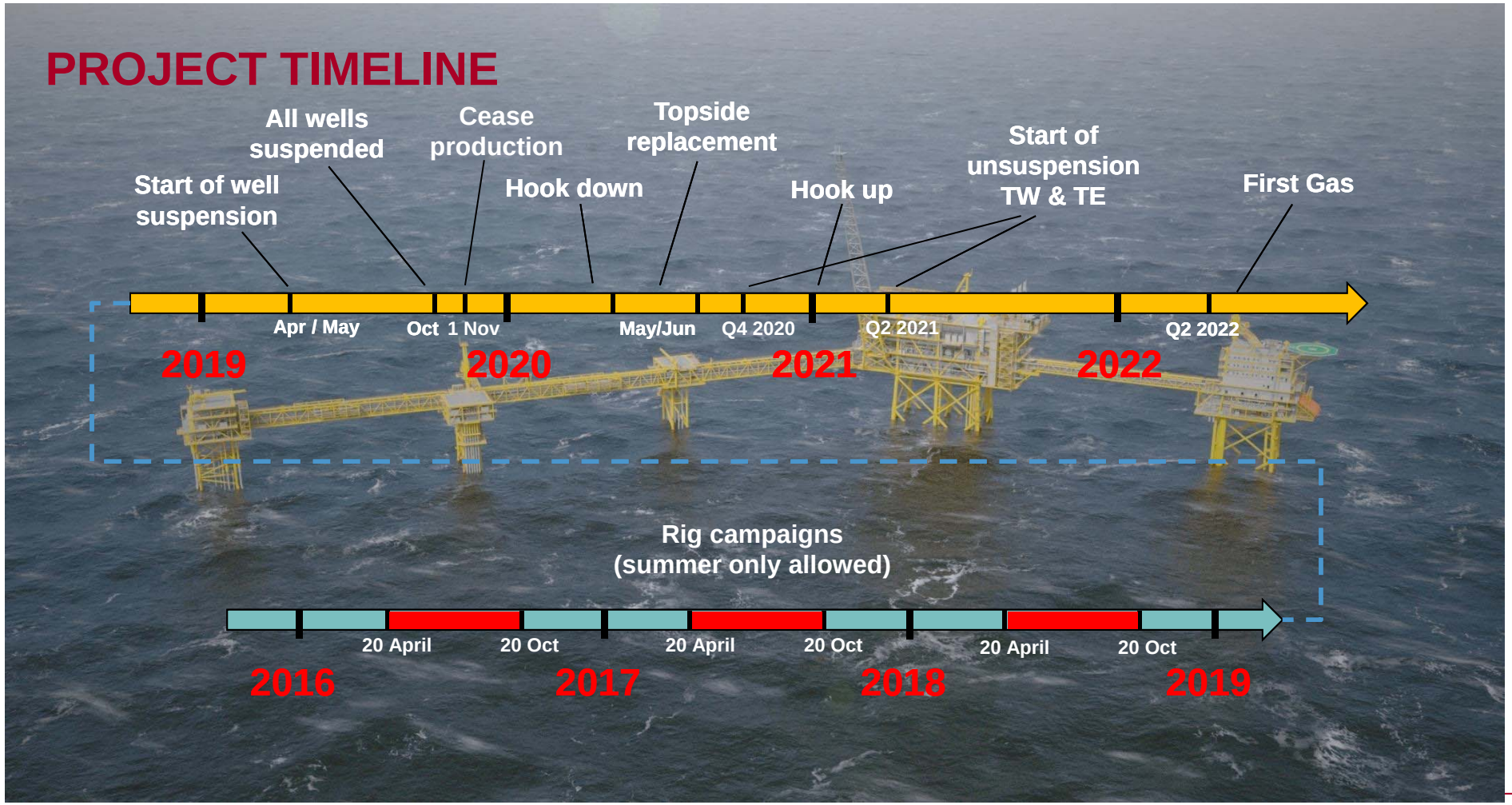
Nick Jensen-Visser

Alex Lucas (presenter)

Total E&P Danmark A/S

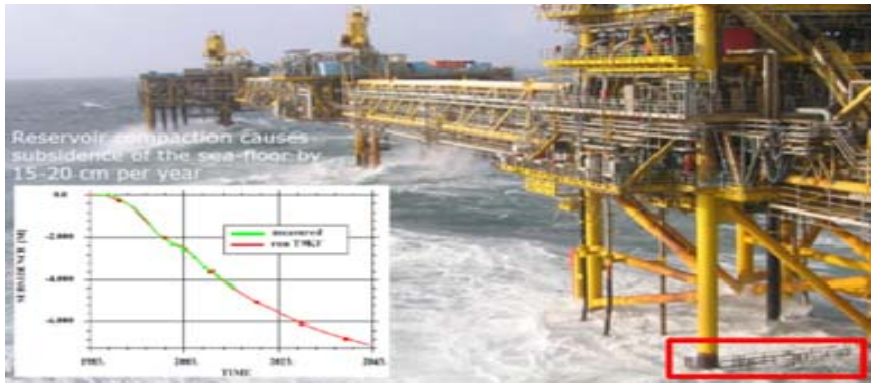
https://www.youtube.com/watch?v=eUivMcvbmbc

PROJECT TIMELINE



REQUIREMENTS – MUST DO FOR WELLS

- All wells suspended safely for topsides replacement (on time)
- Ability for Xmas Trees to be installed in elevated position (interface with current Wellhead – spool design)



WELL CLASSIFICATION

- The 72 wells were divided up into 3 different groups based on their remaining production life and integrity status:
  - Resource wells (45)
    - wells with production potential after 2020
    - wells with production potential with integrity issues that are economic to remedy

    = ***16 workovers required***
  - Non resource wells (25)
    - wells that have no production potential after 2020 or have integrity issues that are uneconomic to remedy

    = ***25 abandonments required***
  - Wells already abandoned (2)

Solution:

Only workover or abandon wells if considered unsafe to suspend:

- Packer leak (loss of primary barrier for inner annulus)
- Not able to set deepset plug (loss of primary barrier in tubing)
- DHSV issue
- Intermediate (B) & outer (C) annuli SCP reaching trigger pressure in 30 days (secondary barrier envelope lost and considered unmanageable)

Q2 2015 Panic moment!
~1250 days (3.4 years) of rig work!

- Earliest start 20th April 2016/latest finish 20th October 2018
- Only allowed to work summer months
- Only 540 days available and lack or rig availability

Scope reduced to:

- 2 workovers
- 12 abandonments
- 58 offline well suspensions

Rig scope reduced to **395 days**

ASSESSMENT OF WELL STOCK

Age-related integrity

A number of studies were performed to validate the remaining life time of the well stock:

- Current well status
- Intervention history
- Corrosion study
- Completion Equipment reliability

Geomechanical

Comprehensive study of reservoir compaction induced well failure has been performed by a combined Maersk, Shell and Rockfield team, using the latest geomechanics technology

Reservoir

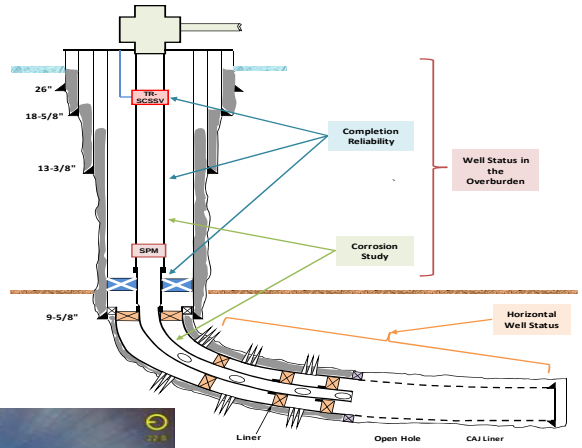
- The risk of compaction-induced well failure in the Tyra reservoir is low

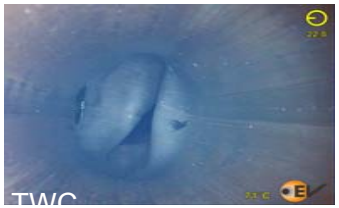
Overburden

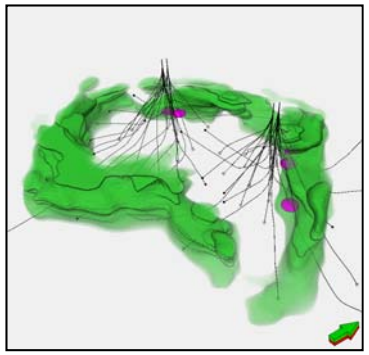
- The risk of further compaction-induced well failure in the Tyra overburden is low
  - Most of the depletion-induced compaction has already taken place
  - The compaction-induced changes in total stress are very small (typically < 5% of the absolute value)

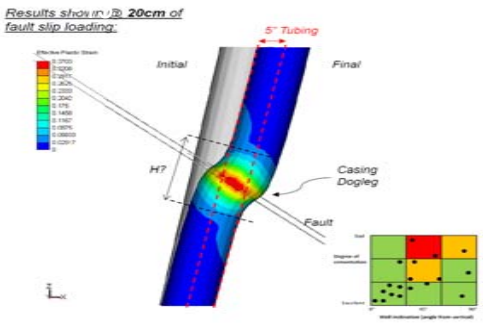
Recovery

- Low impact on ultimate recovery



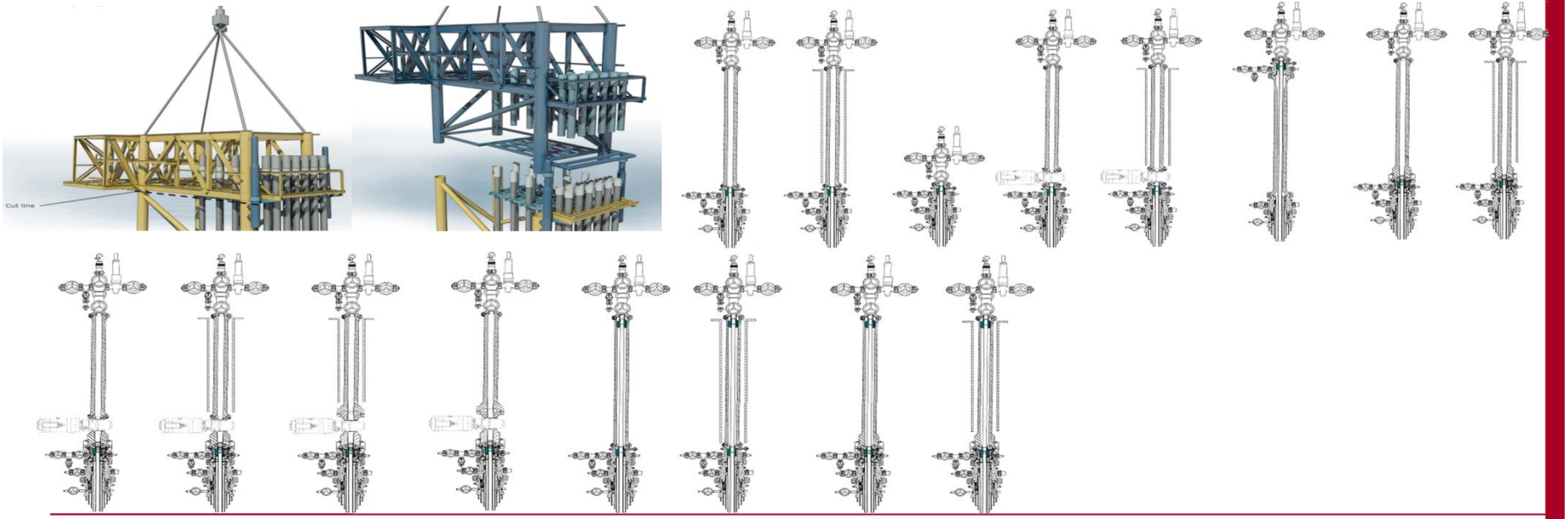






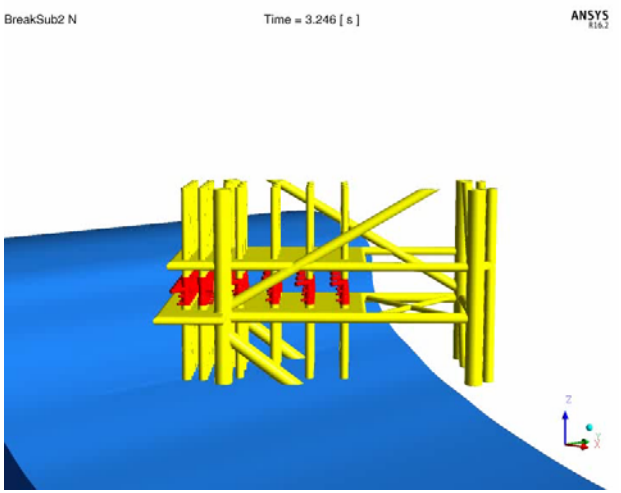
ELEVATION OF XMAS TREES

- As part of the redevelopment Strategy the top sides will be lifted ~13m to mitigate the rogue wave impact loads.
- Stress analyses has been conducted on 57 different configurations of the X-mas trees and Wellheads.



WAVE LOAD ANALYSIS

- Analysis performed with different wave heights and directions have validated wellhead integrity under worst case conditions (10,000 year wave impact)
- Shielding/blocking from wave protection caissons have been included in the evaluations
- Connection strengths evaluated by the vendor & compared against loads subjected to by a 10,000 year wave impact



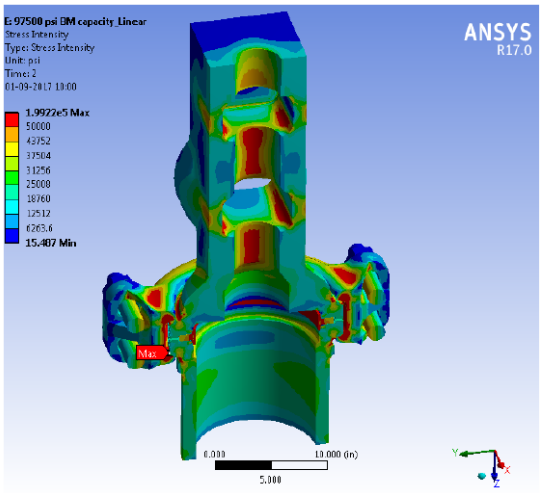
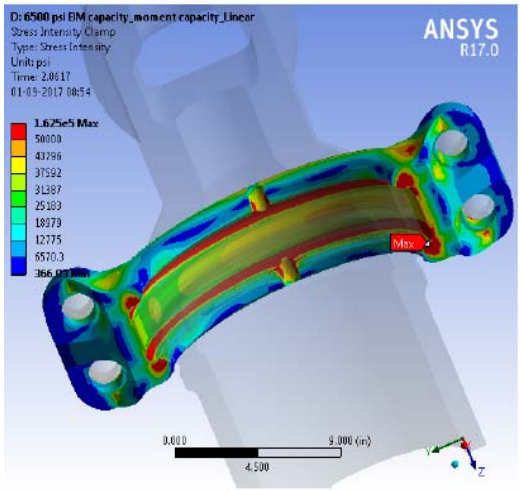
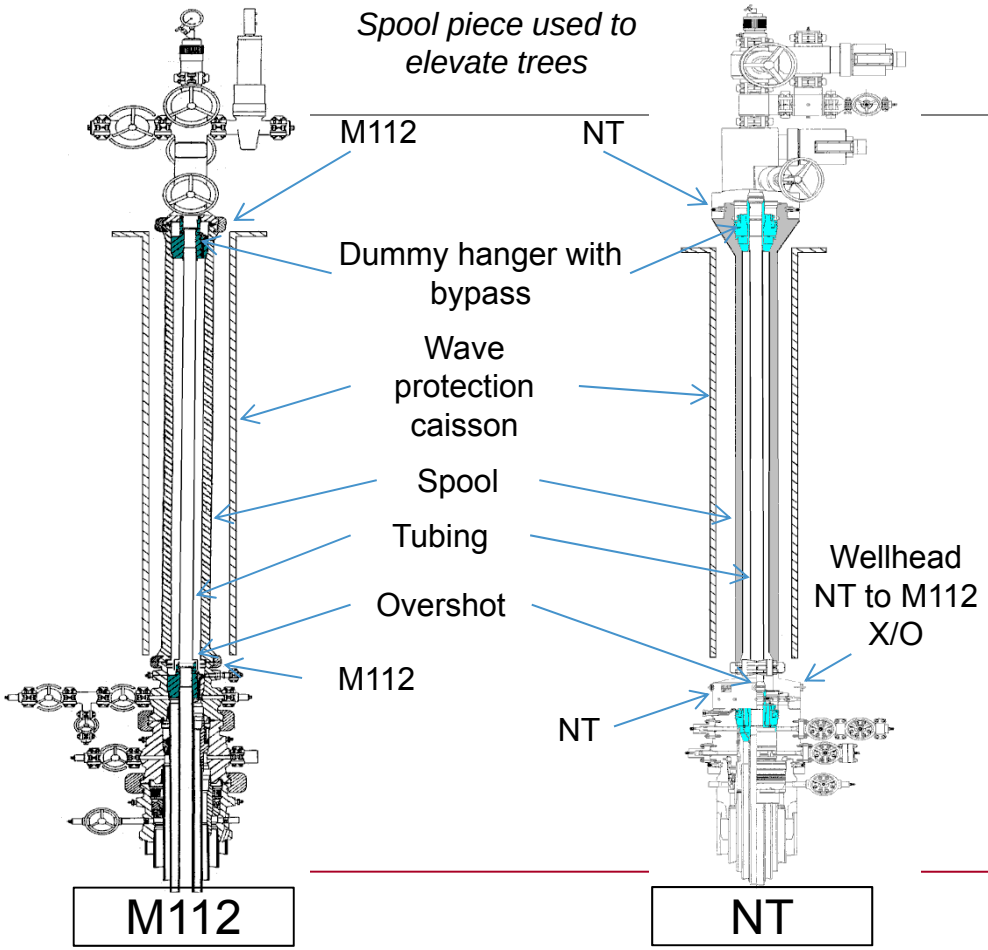


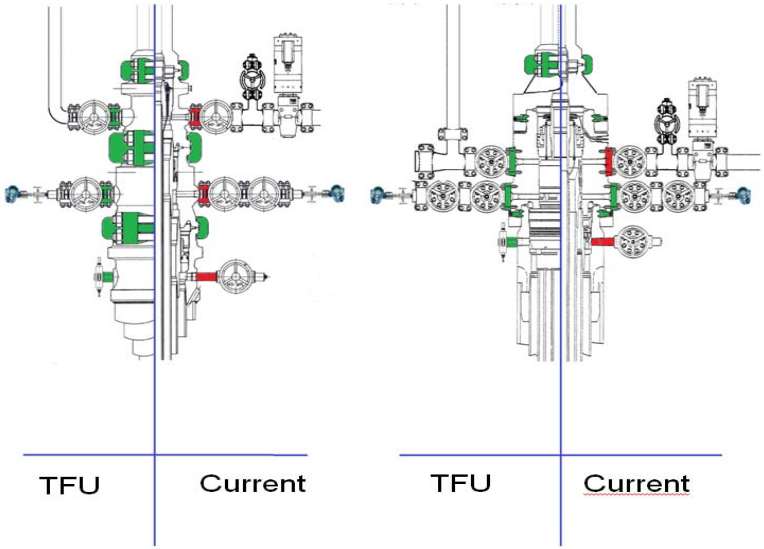
Figure 30: Stress intensity in the connection, LC 3



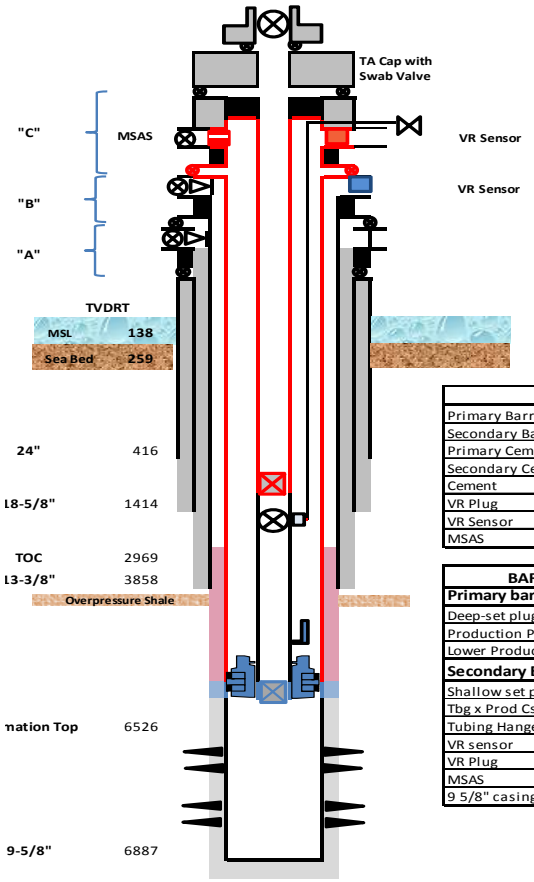
ACCEPTED / FINAL DESIGN



Slimline gas lift line designed to minimise wave loading



TYRA Main Producer SUSPENDED with SCP Anomalies



Legend	
Primary Barrier	
Secondary Barrier	
Primary Cement Barrier	
Secondary Cement Barrier	
Cement	
VR Plug	
VR Sensor	
MSAS	

BARRIERS ON PRODUCER w/ SCP anomalies		
Primary barrier	**Test**	**Monitori**
Deep-set plug	Pressure test	VR sensor
Production Packer	Pressure test	VR sensor
Lower Production casing & cement	Original Inst.	
Secondary Barrier	**Test**	**Monitori**
Shallow set plug	Pressure test	Gauge at TA
Tbg x Prod Csg above shallow set plug	Pressure test	
Tubing Hanger Body Seals	Pressure test	
VR sensor	Pressure test	
VR Plug	Pressure test	
MSAS	Pressure test	
9 5/8" casing & cement	Original Inst.	

WELL SUSPENSION - BARRIERS

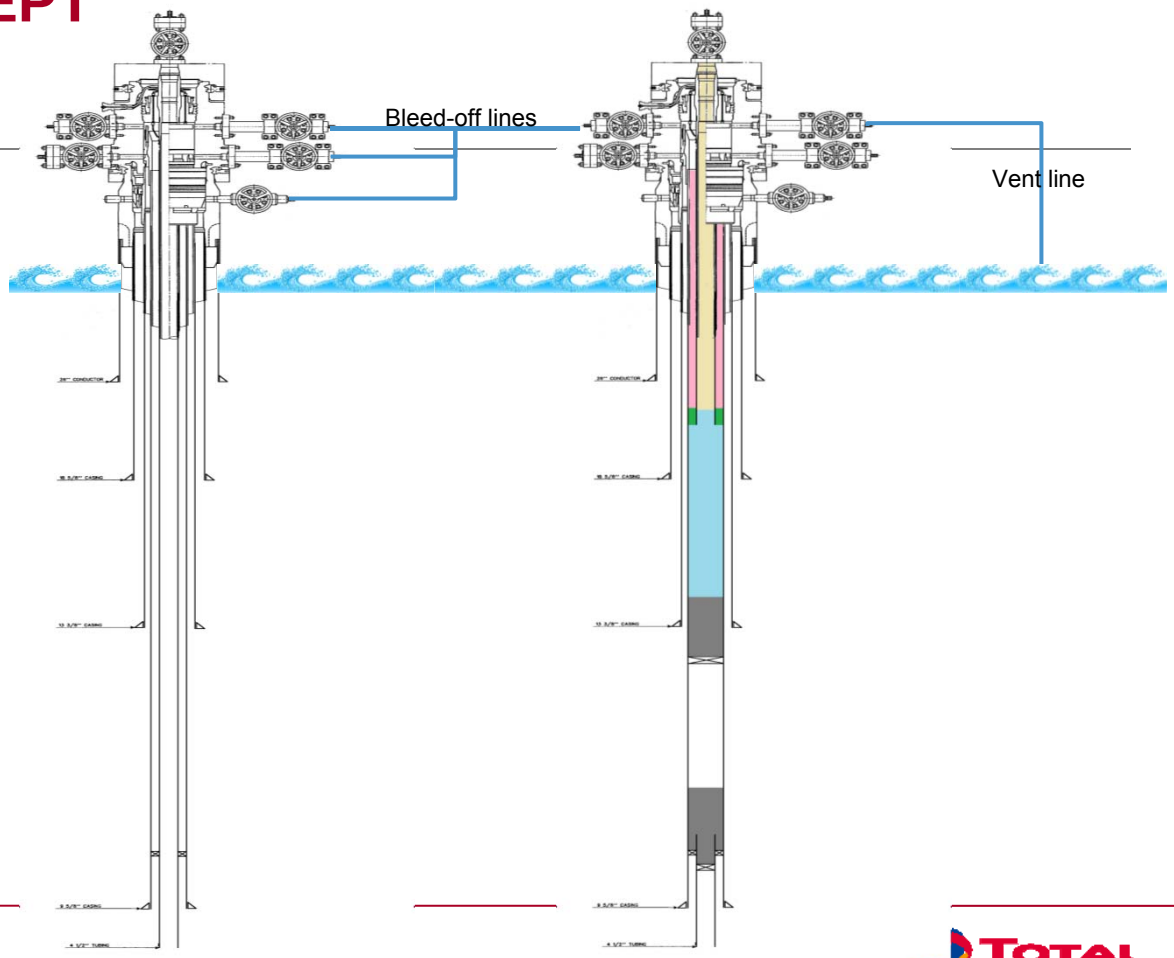
Minimum requirements for the temporary suspension of wells:

- 2 x plugs to isolate the reservoir
  - One deep set plug below the packer
  - One shallow set plug approximately at the depth of the conductor shoe (shallowest)
- Inhibited seawater suspension fluid
- SSSV C/L de-pressured / closed.
- Downhole gauge lines terminated and capped
- Xmas Tree removed for refurbishment and a temporary abandonment cap installed
- Temporary wireless gauges will be installed on all casing annuli currently monitored
- Wells with SCP monitored and bled off as required to drain well (brownfield group)

In full compliance with Company Well Barrier Standards

DRAIN WELL CONCEPT

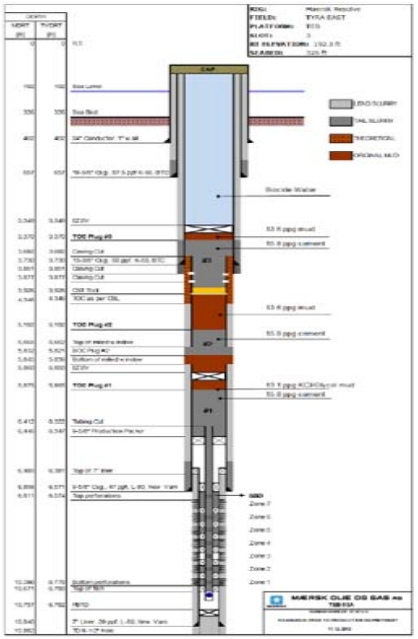
- Monitoring of all annuli
- Drain well used as separator vessel to prevent discharge of liquid to sea
- “Kill string” length of 1,000 ft to ensure enough volume for expected bled-off volumes
- Collapse load on 9-5/8” verified



MINIMUM SCOPE DEFINED FOR EACH WELL TYPE

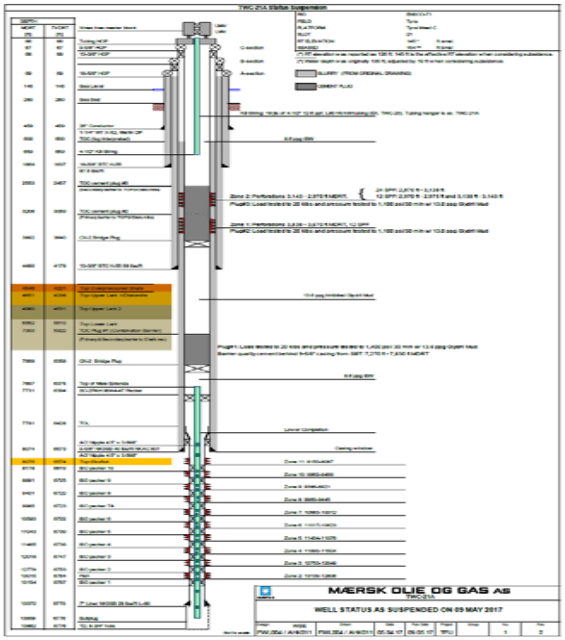
Pre-WBS 2016 days. 'Gold plated' P&A

TEB-03A (2010): 44.7 days



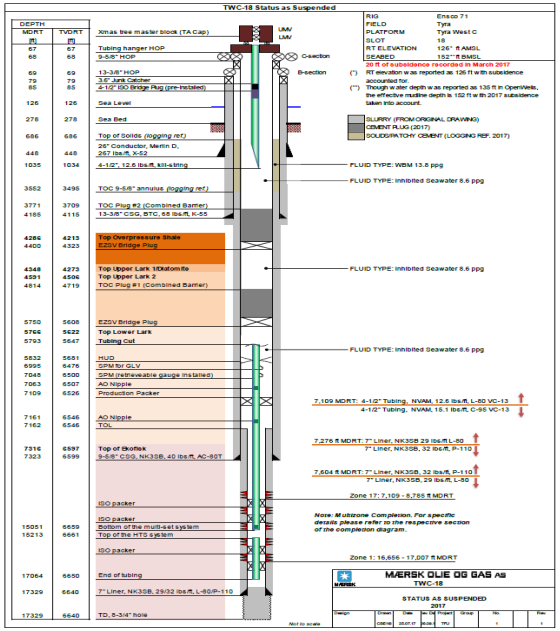
WBS 2016: Engineered to meet minimum requirements: remediation required

TWC-21A (2017): **20.1 days**



WBS 2016: Engineered to meet minimum requirements: no remediation required

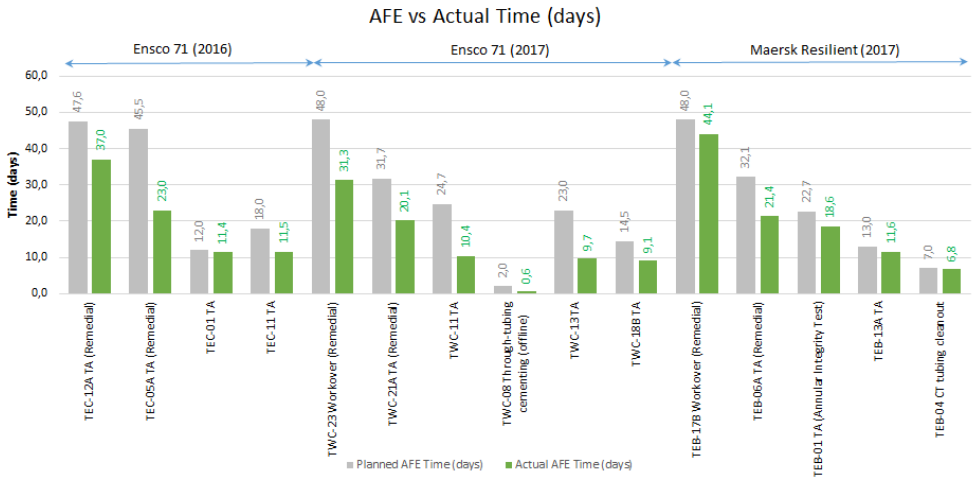
TWC-18B (2017): 9.1 days



Enabling technologies

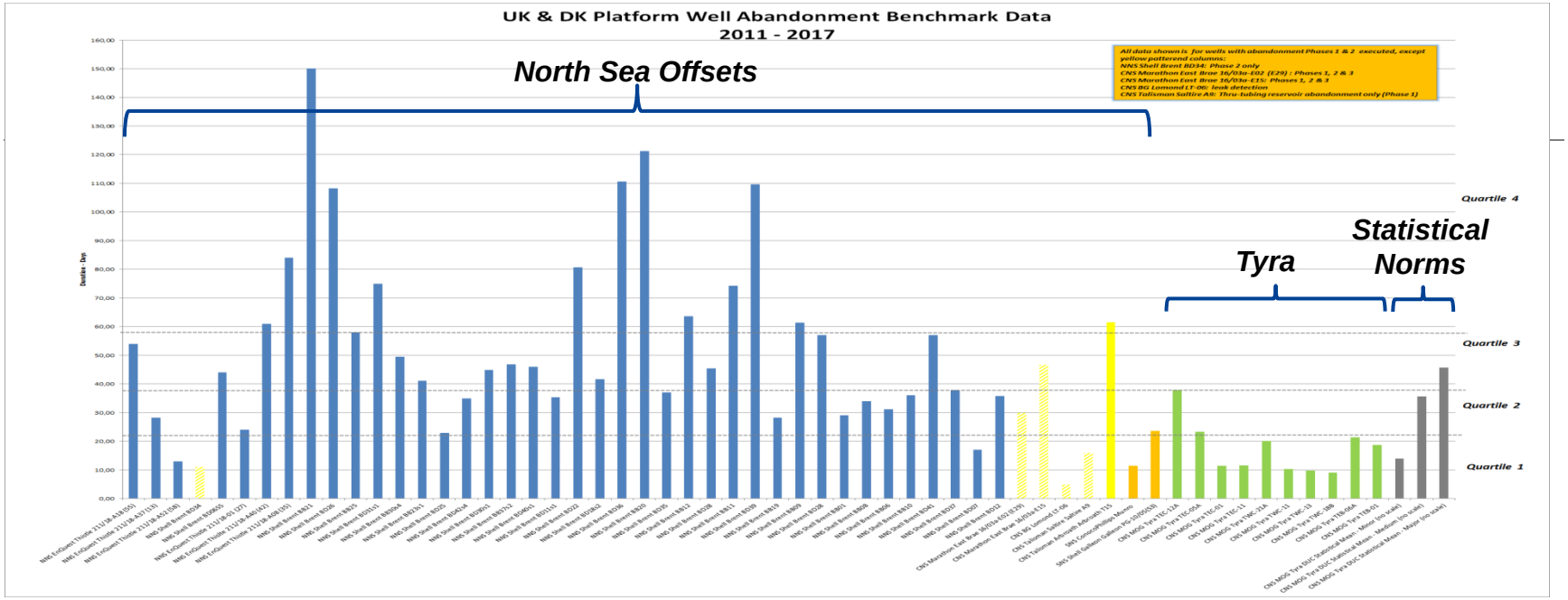
- Perf & Wash
- Selective perforating TCP
- Improved CBL interpretation
- Formation testing to verify annular bond
- Remote long-term SCP monitoring via SCADA system
- Sintered tungsten carbide buttons for section milling knives

2016-17 TYRA FUTURE ABANDONMENT CAMPAIGN RIG PERFORMANCE



- Pmean AFEs prepared based on comprehensive Monte Carlo analysis of 114 Danish North Sea offset wells (88,253 hours of QC'd offset data)
- AFEs benchmarked against Partner data and Rushmore
- Statistical approach gave better understanding of risks and potential spread of outcomes than more deterministic methods
- More complex activities involving remediation executed first to enable learnings transfer and return to fix if required
- No dispensations from corporate standards required during execution
- **Result: all activities delivered ahead of Pmean AFE. Delivered 129.2 days early & 294 MMDKK below budget**
  - Performance benefited from good tubing integrity and better than expected production casing cement integrity, requiring less remediation.

PERFORMANCE VS NORTH SEA BENCHMARKS



TFU Abandonment performance (shown in green) was high for the following reasons:

- Strong *integrated & stable* team from Assess to Execute with sufficient project time & resource dedicated to project, facilitating sound engineering & execution
- Thorough well-by-well analysis and de-risking
- Efficient concept engineered based on ESS(A) principles (Eliminate, Simplify, Standardise, (Automate))
- Learnings implemented from recent campaign (Svend) and other operators/SPE Abandonment forums and built into concept from beginning
- Application of fit-for purpose new technologies
- Campaign approach

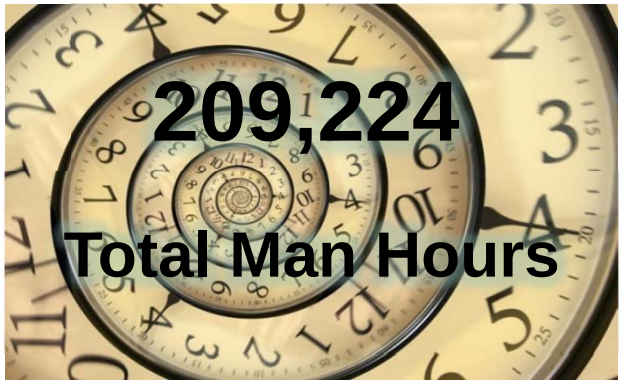
1 TRIF

- Cook sliced finger

HSE – RIG RELATED

- Contributing factors
  - Detailed planning by Wells Team
  - Early engagement of Vendors and Onshore Rig Teams
  - Appropicate level of meetings (WOP, risk and LL sessions)
  - LL quickly implemented after each operation
  - Open communications with all ensuring ‘Incident Free’ mind-set imbedded across all parties involved
  - DBU onshore Rig Teams ensuring clear expectations communicated and understood
  - Excellent buy-in from Rig Owners to ‘Incident Free’ mind-set
  - Continuous proactive involvement from TFU Wells Team throughout the execution phase

FUN FACTS



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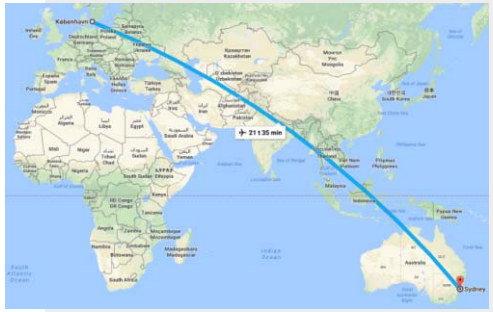

Copenhagen – Sydney

9,625 times

139,483

Football Matches

100.6 Office Work **Years**

(121.3)

Assumption 1 office work year = 2,080 hrs

27,000 meters of pipe pulled from wells

508 MT of metal removed

An Airbus A380 weights 560 MT

Thank You & Questions

The authors would like to thank:
The Tyra Future Wells & Subsurface team, TEP DK, Esbjerg, Denmark

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