BP GoM Multi-Field Riserless Intervention Campaign – Mechanical and Hydraulic

OWI MED

September 20, 2022

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Agenda

1. Field Overviews
2. Intervention SoW
3. Intervention Equipment Philosophy
4. Planning and Assurance
5. Execution
6. Intervention Performance
7. Lessons Learnt and Best Practices
8. Q&A

Field Overviews

Field A

- 28 wells (producers and injectors)
- First oil 2008
- Water depths 5,600 to 6,300 ft
- 5” 15k Subsea VXTs
- Completions – cased and perforated, frac pack, DHFC
- Intervention scopes
  - Stimulation
  - Xylene soak
  - Sand consolidation
  - Scale squeeze
  - Production logging
  - Water shutoff
  - Slot cutting

Field B

- 30 wells (producers and injectors)
- First oil 2007
- Water depths 4,700 to 7000 ft
- 5” 10k Subsea HXTs
- Completions – frac pack, DHFC
- Intervention scopes
  - Crown plugs
  - Tubing Drift
  - Xylene soak
  - Stimulation
  - Scale squeeze
  - Sand consolidation

Field C

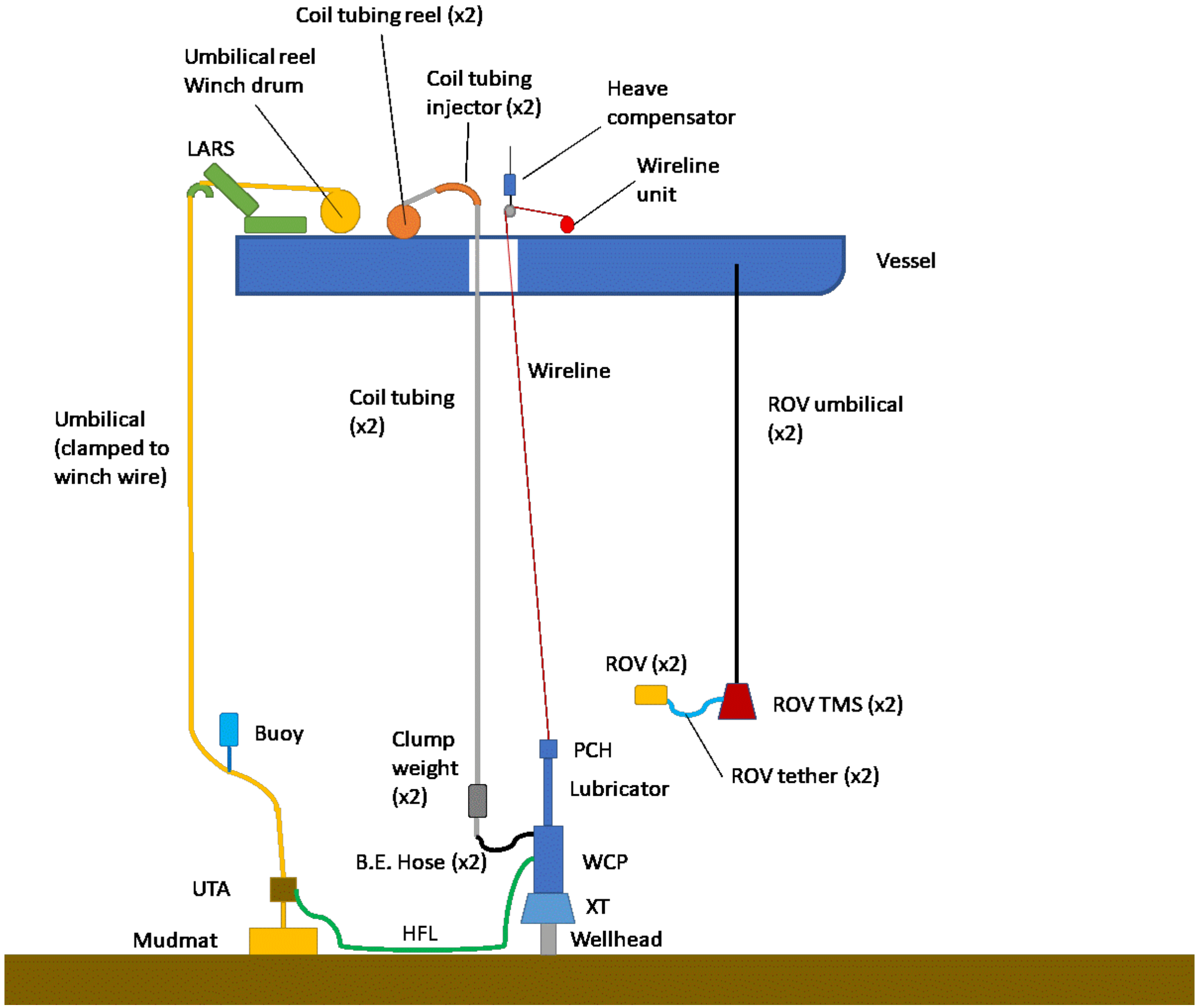
- 27 wells (producers)
- First oil 2003
- Water depths 5,400 to 6,900 ft
- 4” 10k Subsea VXTs
- 5” 10k Subsea HXTs
- 5” 15k Subsea HXTs
- Completions – frac pack, open hole gravel pack, DHFC
- Intervention scopes
  - Crown plugs
  - Well integrity repair
  - Xylene soak
  - Stimulation
  - SCSSV lockout

Intervention Equipment Philosophy

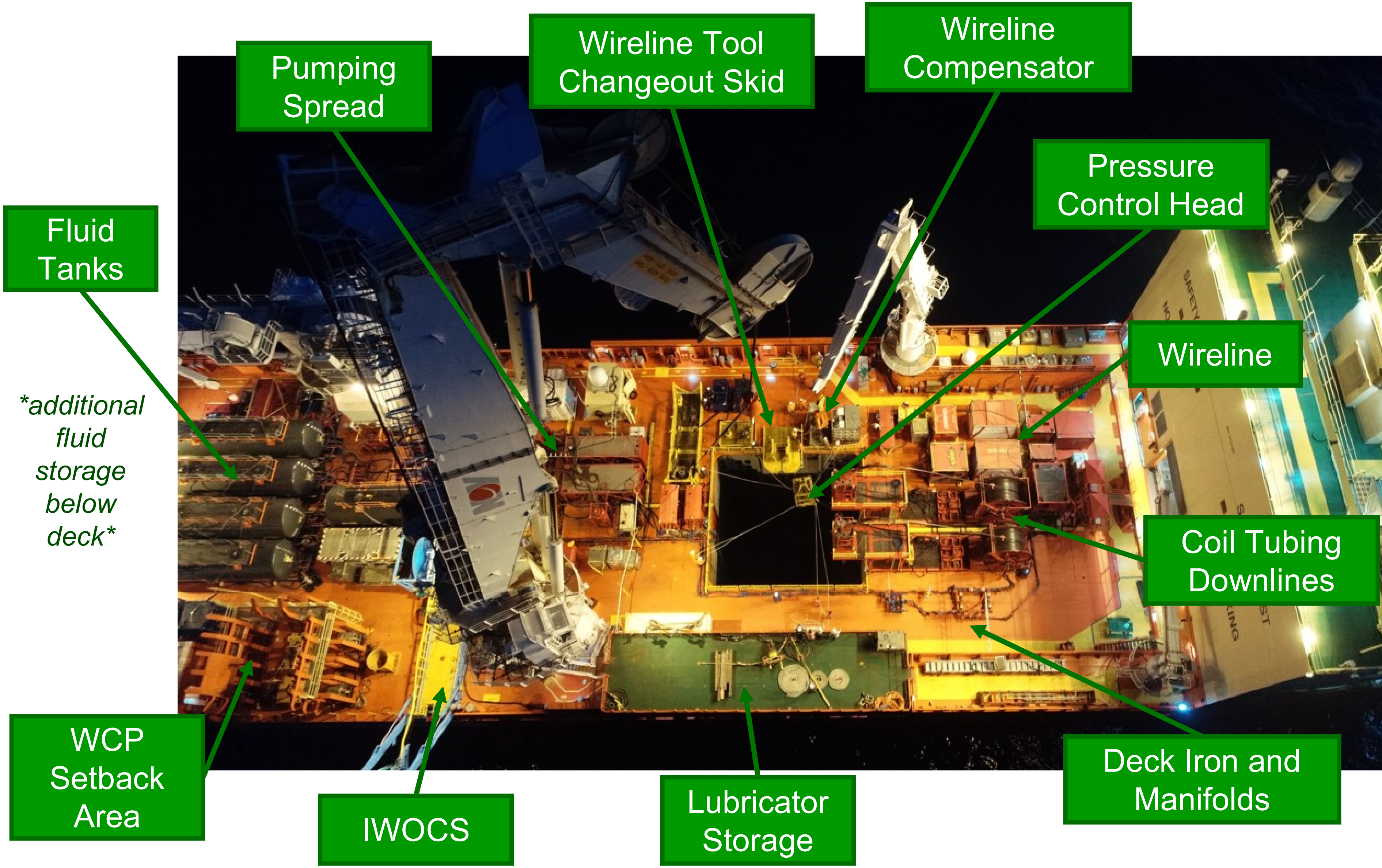
- Single supplier contracted to provide vessel, intervention systems, fluid handling equipment, and wireline equipment as a vendor-led solution, with <u>four different intervention technologies</u> used in single campaign

1. Mechanical wireline intervention system (also capable of hydraulic stimulation)
2. Hydraulic intervention via TRT
3. Hydraulic intervention via MARS choke insert
4. Well service jumper (offset well access)

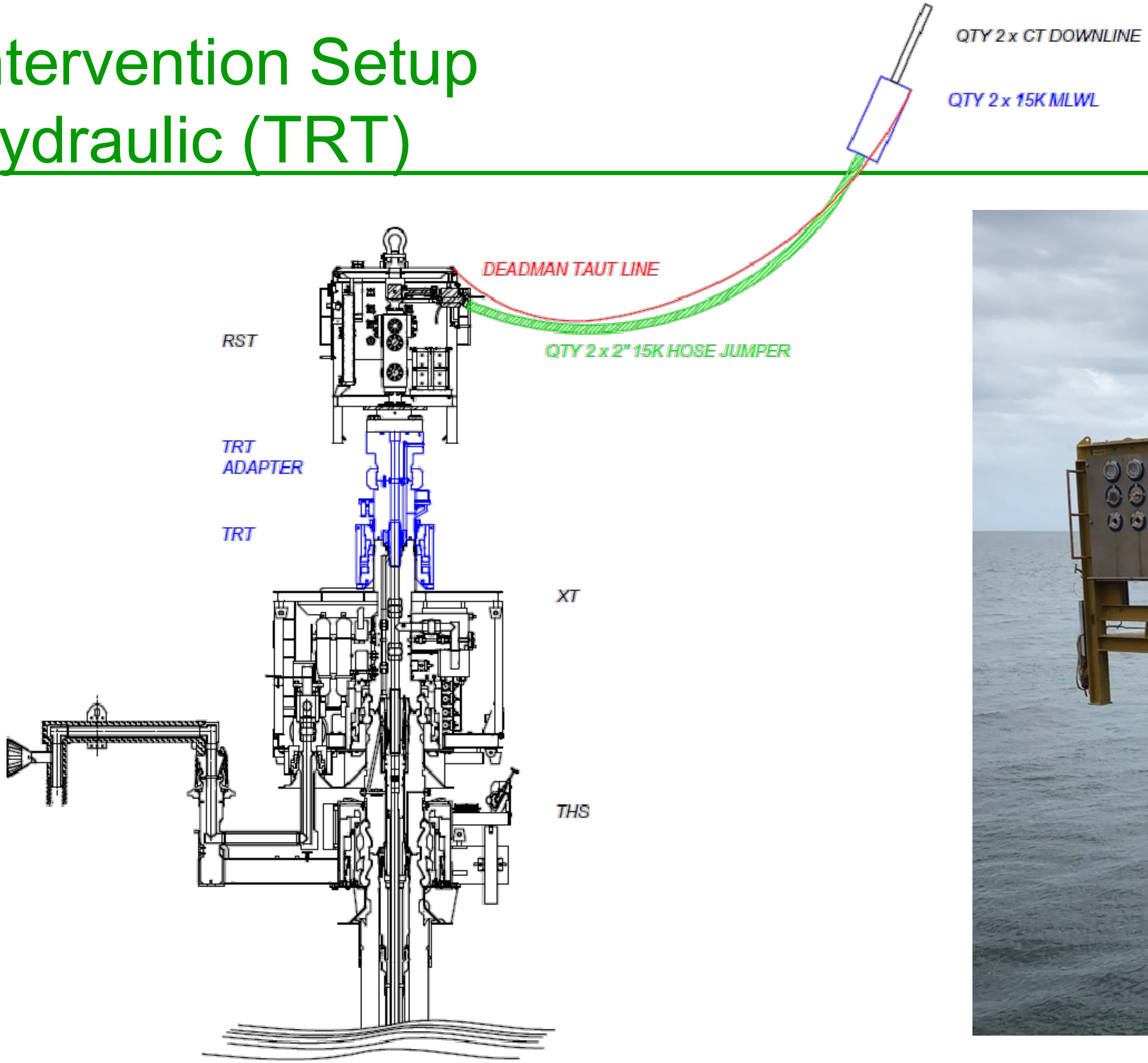
Intervention Setup - Mechanical



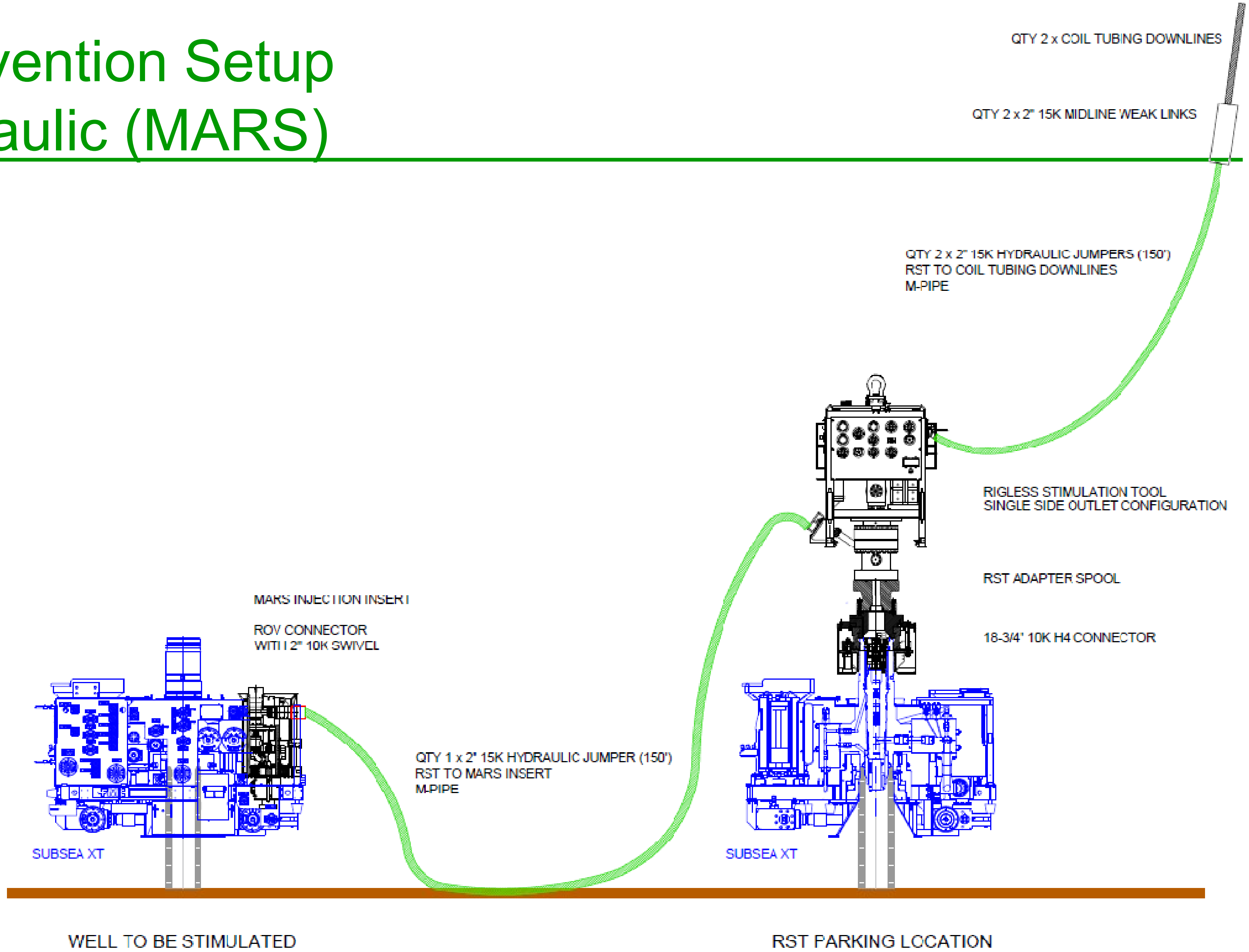
Deck Layout - Mechanical



Intervention Setup Hydraulic (TRT)



Intervention Setup
Hydraulic (MARS)



Intervention Setup – Well Service Jumper

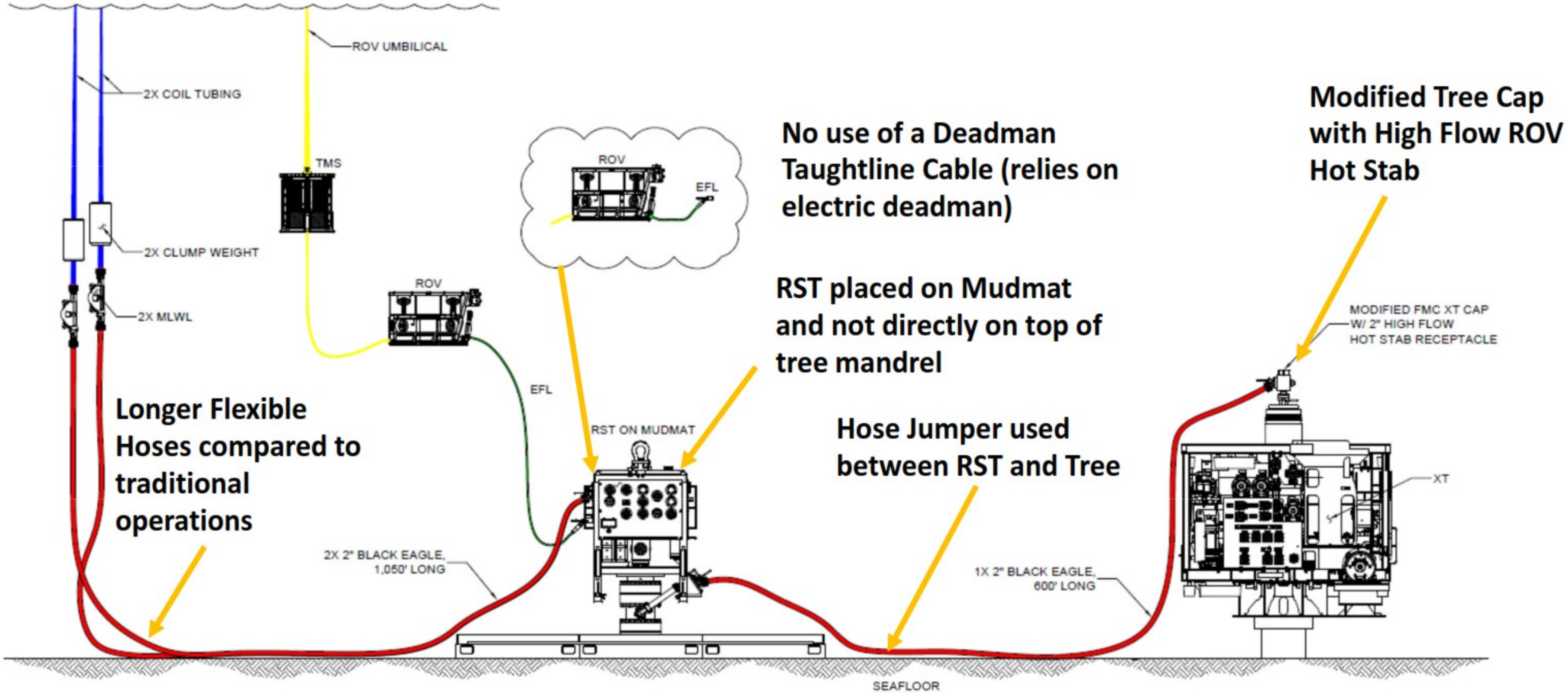


Image courtesy of Caltex

Seafloor Layout – Well Service Jumper

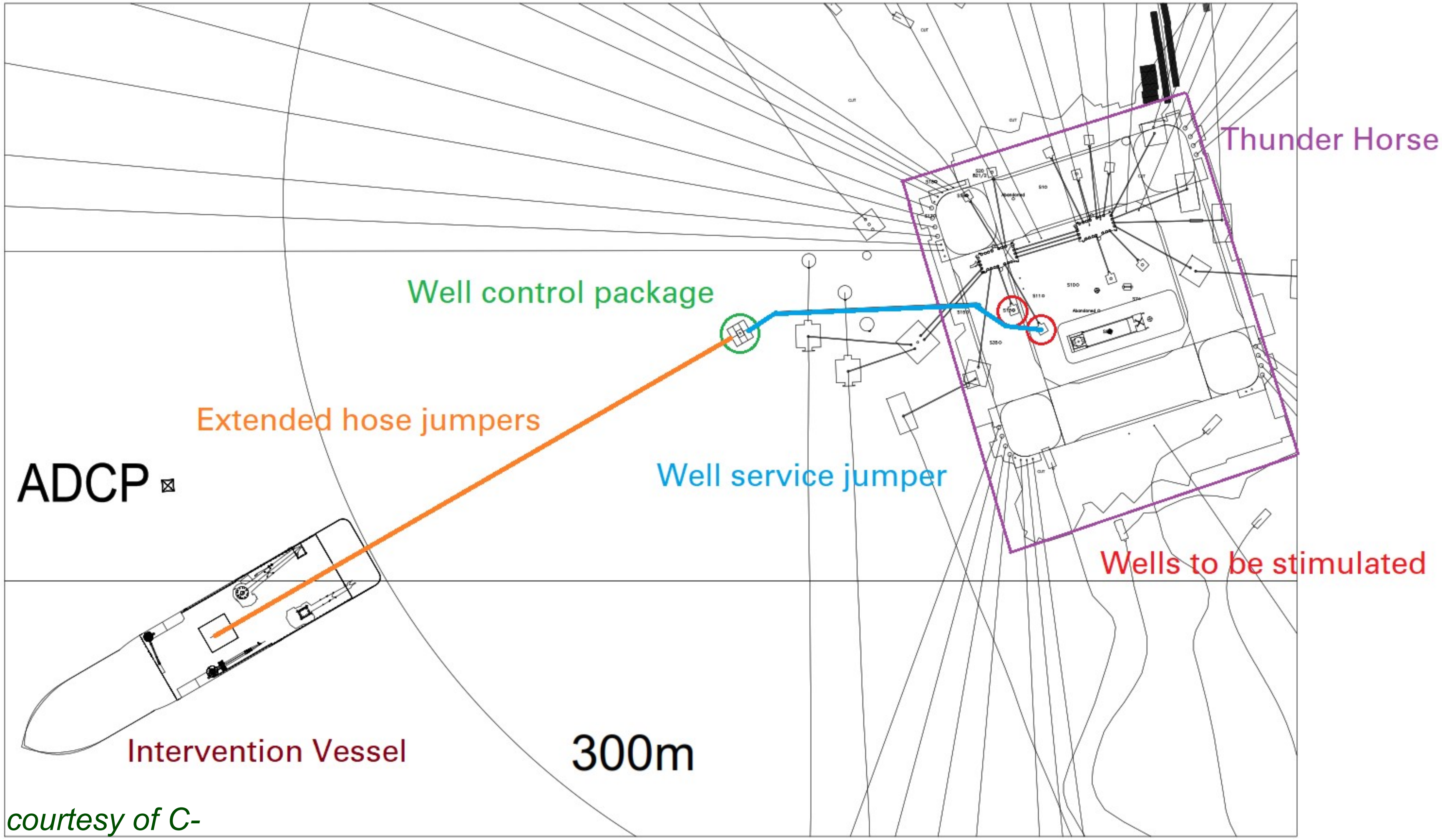


Image courtesy of C-Innovation

Planning and Assurance

Deploying mechanical well control package

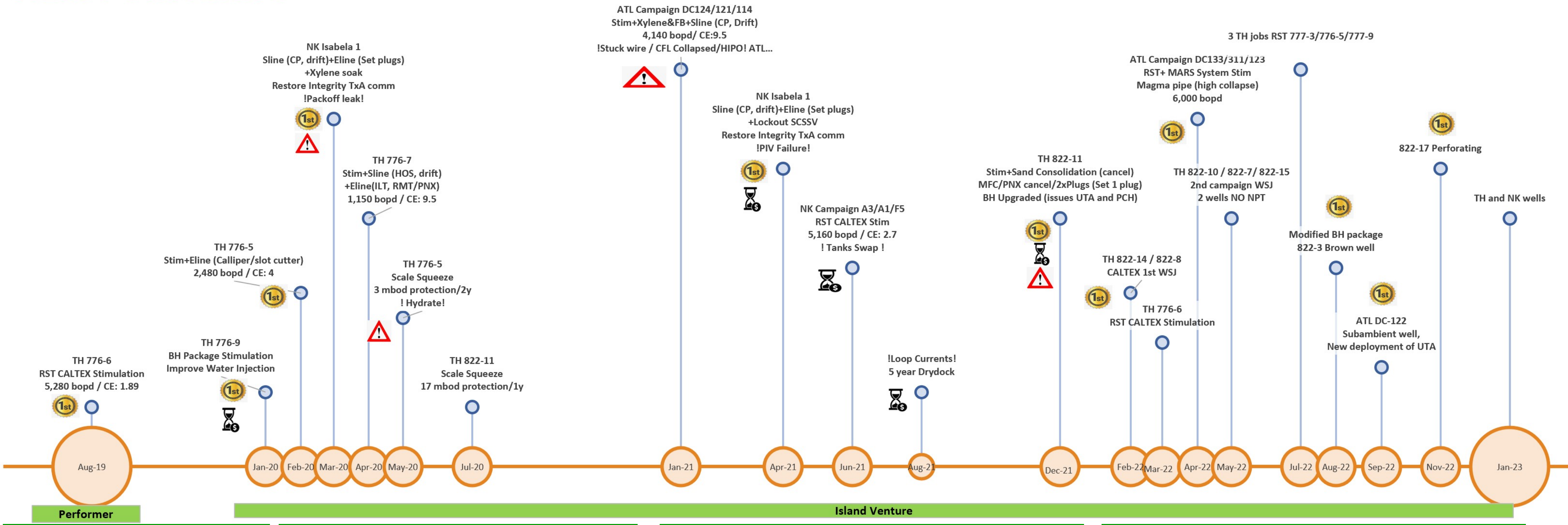
- Integrated project team with expertise in wells operations, interventions, subsea, BOPs, rig systems, marine/vessel, production operations and reservoir engineering
- Strong collaboration between suppliers to deliver integrated intervention systems
- Leveraged lessons learned from previous GoM, North Sea, and West Africa LWIV campaigns

Planning and Assurance

- Developed bespoke intake process for LWIV vessels and well control equipment
  - Existing MODU intake process not fit for purpose
- Risk assessment and management
  - HAZID, HAZOP, FMECA and operational risk assessments completed with full supplier involvement
  - Formal tracking and closeout of all risk actions prior to execution
- Intervention equipment assurance
  - ESD/EQD philosophy and equipment testing
  - Third party verification and regulatory engagement
  - Full scale SIT of well control equipment
- BP rig verification process
  - Marine systems
  - Well control equipment
- Operability analysis, weak point assessment and fatigue management to develop weather windows and watch circles

Onshore SIT of mechanical well control package

RLWI Timeline



2019
1 x Hydraulic TRT

2020
6 x Mechanical

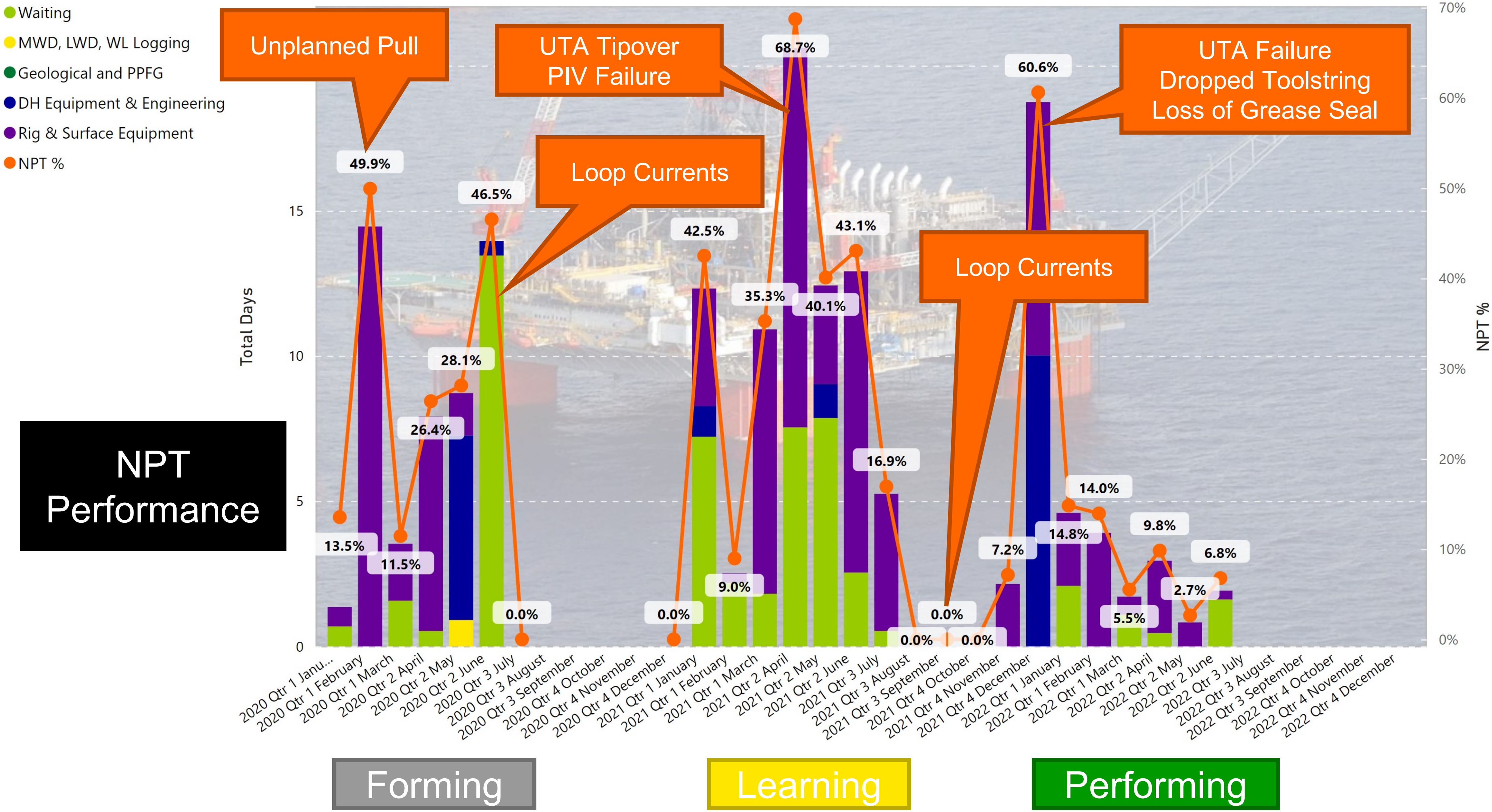
2021
5 x Mechanical
3 x Hydraulic TRT

2022 (to date)
5 x Well Service Jumper
2 x Hydraulic MARS
4 x Hydraulic TRT

2022-2023 (upcoming)
12+ Mechanical
6+ Hydraulic MARS
1+ Well service Jumper
2+ Hydraulic TRT

On towards the future

- Dedicated mechanical intervention vessel
- Dedicated hydraulic intervention vessel



Waiting
MWD, LWD, WL Logging
Geological and PPFG
DH Equipment & Engineering
Rig & Surface Equipment
NPT %
Unplanned Pull
UTA Tipover
PIV Failure
Loop Currents
UTA Failure
Dropped Toolstring
Loss of Grease Seal
Loop Currents
NPT
Performance
Total Days
NPT %
13.5%
49.9%
11.5%
26.4%
28.1%
46.5%
0.0%
0.0%
42.5%
9.0%
35.3%
68.7%
40.1%
43.1%
16.9%
0.0%
0.0%
0.0%
7.2%
60.6%
14.8%
14.0%
5.5%
9.8%
2.7%
6.8%
2020 Qtr 1 Janu...
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2022 Qtr 3 August
2022 Qtr 3 September
2022 Qtr 4 October
2022 Qtr 4 November
2022 Qtr 4 December
Forming
Learning
Performing

Lesson Learned – Stuck Wire (Asphaltenes)

- Slickline became stuck in the pressure control head due to asphaltene build up on the wire during a deep drift run
- Circulated xylene into lubricator below pressure control head to help dissolve asphaltene blockage
  - Successfully remediated and POOH
  - Required full redress of well control package rubbers (ram and PCH) after well due to material compatibility issues
  - Collapsed circulation hose due to subambient conditions
- **Lengthened xylene soaks and flowback to start interventions on at-risk wells**

Asphaltenes deposited on slickline

Lessons Learnt – Hose Collapse

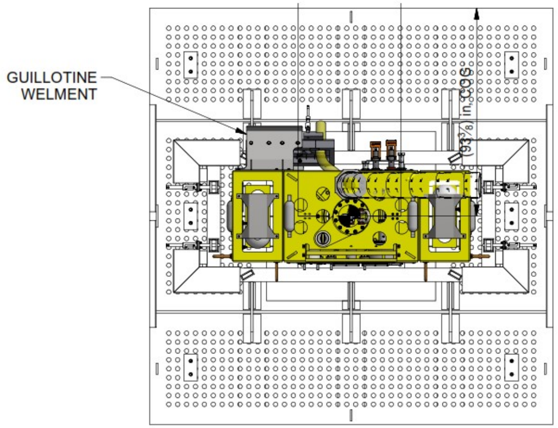
Collapsed circulation flying lead

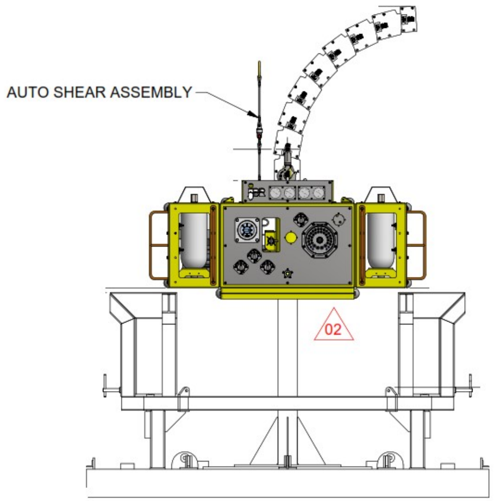
High collapse flexible pipe connected to stim tool

- Collapsed coil tubing hose jumpers (two wells) due to low wellbore pressure while bullheading stimulations
  - No leaks or loss of containment during operations
- Collapsed circulation flying lead (one well) when circulating xylene to remediate stuck wire
  - Multiple pinhole leaks found subsea when pressuring up after xylene soak
- **High collapse flexible pipe successfully implemented as hose jumpers for stimulations on lower pressure wells**
  - **Alternative HCR hose jumpers also being developed**

Lessons Learned – Operability Windows

- Inadvertent EQD when UTA fell off mudmat due to high subsea currents (>0.5 knots at seafloor), resulting in WCP emergency shut-in
  - No wire in hole
  - UTA impacted PLET (no damage)
- **Revisited operability analysis to refine safe operating windows**
- **Redesigned UTA and mudmat**
  - **Larger footprint to reduce tipping risk**
  - **Developed autoshear functionality (shear pin and guillotine) to leave UTA on mudmat and sever umbilical in event of loss of vessel position**





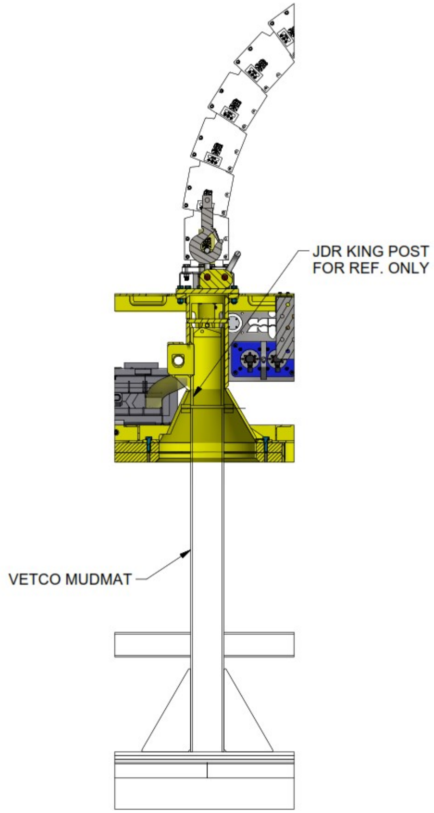
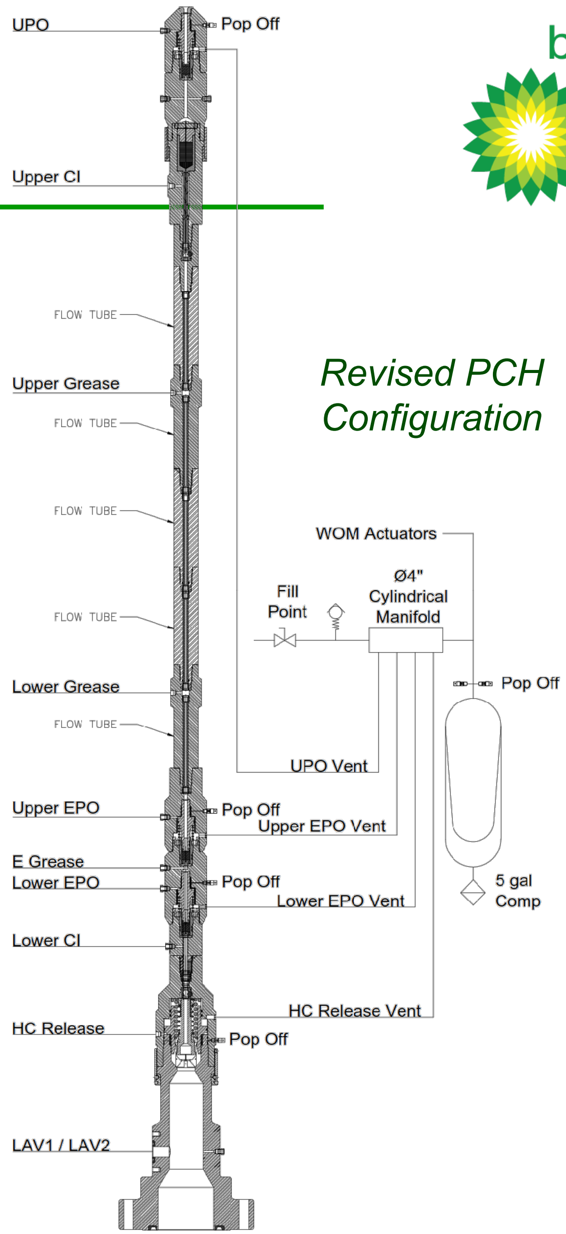


Image courtesy of JDR

Lesson Learned – Stuck Wire (Hydrate)

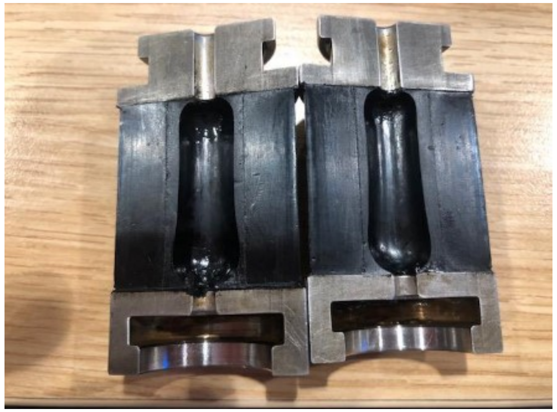
- While RIH with slickline, loss of grease occurred with visible discharge of hydrate → grease seal reestablished
- Wire became stuck after RIH additional ~500'
- Wire stuck for ~6 days before hydrate could be disassociated by combination of pulling vacuum and spotting MeOH with ROV → POOH with wire
- Lessons learned:
  - PCH chem injection lines were not flushed prior to RIH (seawater trapped) → **well entry procedures revised to flush chemical lines with control fluid on every wireline run**
  - Seawater slug left in PCH due to flushing method → **flushing sequence revised to push seawater out top of PCH before effecting wireline seal**
  - ROV unable to pull vacuum on upper chem line → **PCH replumbed to allow ROV access to both chem lines**



Revised PCH Configuration

Lesson Learned – Packoff Failure

- While RIH with R-Lock on slickline, diesel was observed leaking past the upper packoff on PCH.
- Unable to regain seal on upper packoff, emergency packoffs engaged to stop leak and POOH
- Packoffs inspected on deck with visual wear/damage, replaced
- Re-ran R-lock, no leaks, packoffs inspected after run also showed damage/wear
- Finished well utilizing grease/flowtubes to provide seal on slickline as well as packoffs, no further packoff damage seen
- Findings:
  - **Grease appeared to lubricate packoff rubbers reducing wear due to diesel**
  - **Excessive packoff pressure being applied**

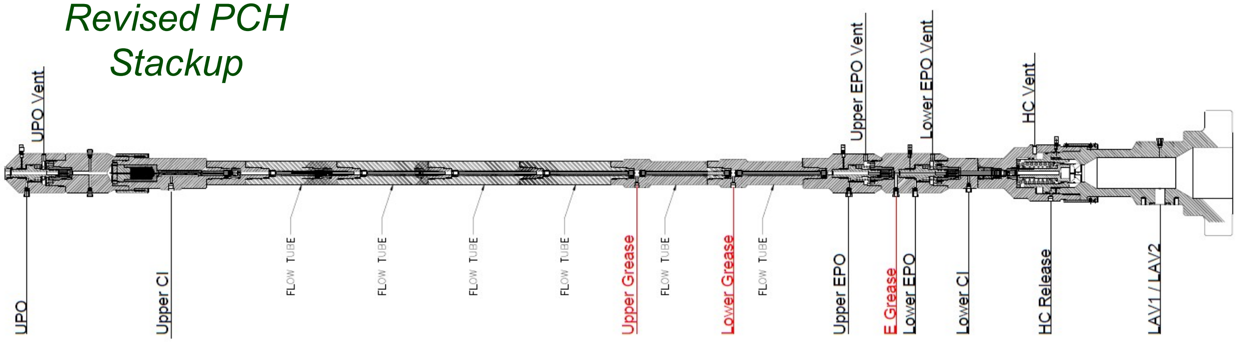
Packoff damage when RIH with diesel in bore

No packoff damage seen when also using grease with diesel in bore

Lesson Learned – Loss of Grease Seal

Dynamic testing of PCH with wireline

Revised PCH Stackup

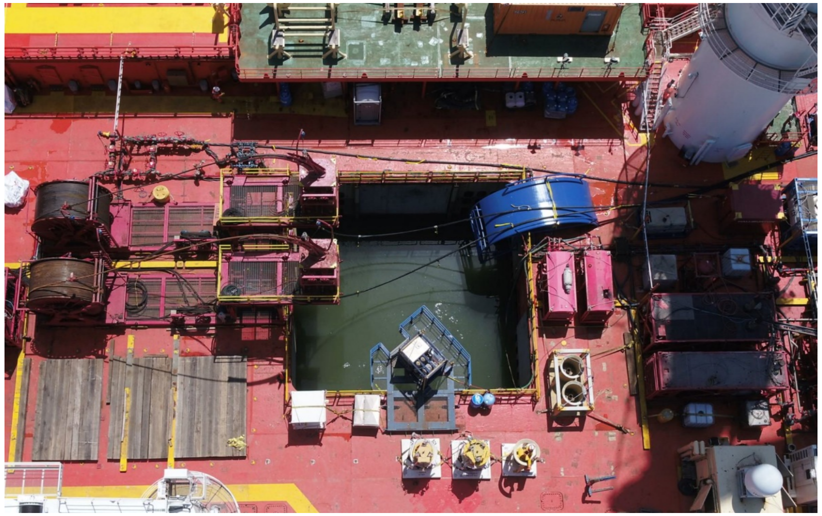


- While RIH and POOH during production logging operations on high pressure well (~9,000 psi SITP), experienced multiple losses of grease seal
- Performed investigation with contributing causes determined:
  - Insufficient grease supply
  - Grease contamination
  - Unreliable grease regulators
- Revised PCH and surface grease supply system between wells:
  - New grease regulators
  - Revised flowtube/injection stackup
  - Additional check valves, gauges, flow meters
  - Performed full scale dynamic testing to qualify new grease control system

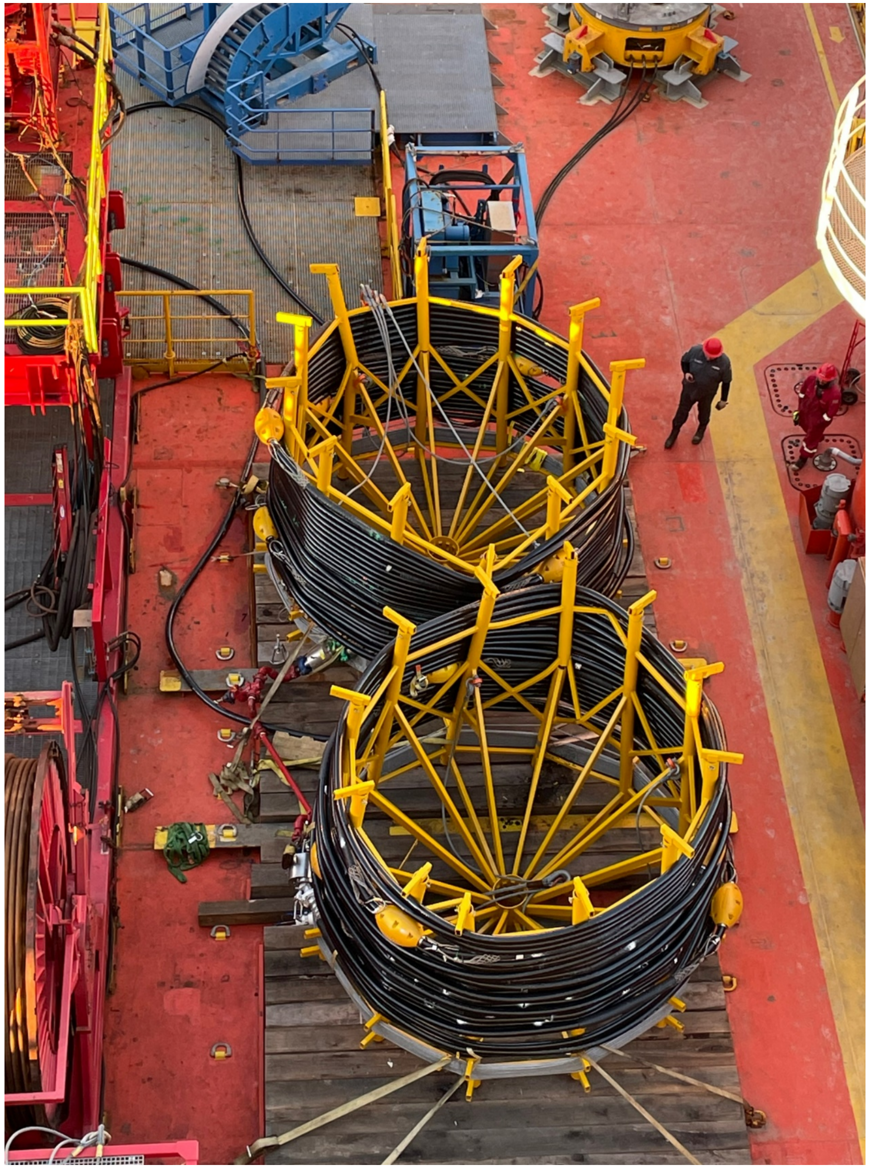
Additional Lessons Learned / Improvements

- Delivery of 740 bbls tanks for increased fluid loadout
- Pull wire out of cable head and drop toolstring
- Improvements running/retrieving chokes for MARS interventions
- Stim tool compensation during running to prevent seawater ingress
- Collapsed hose carousels due to hose shrinkage under pressure
- **Vessel to vessel fluid transfers**
- **Transformation of a construction vessel into an intervention vessel**

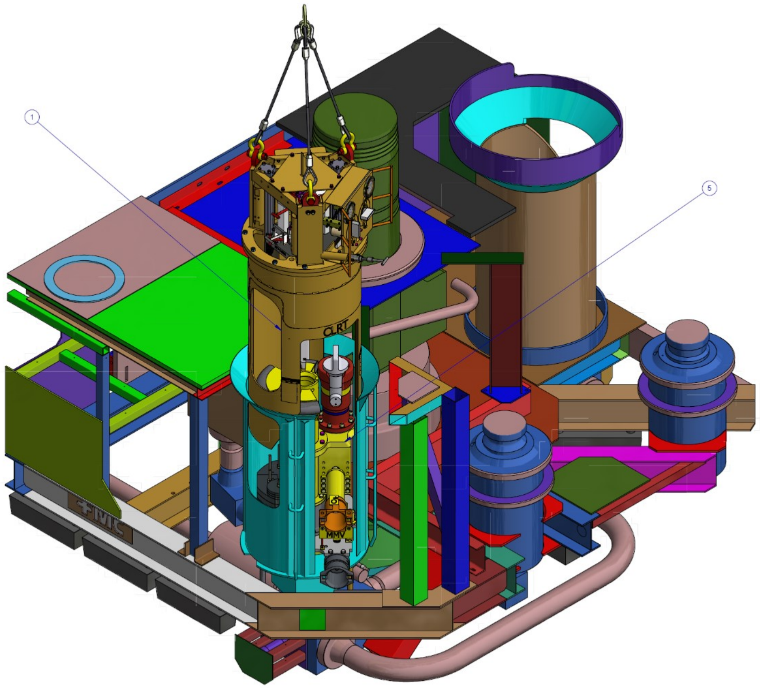
740 bbls tanks being installed



High collapse flexible pipe deployment



Collapsed carousels



MARS insert and running tool in XT

ROV handling of high collapse flexible pipe

Q&A