



**International Workshop on
Offshore Geologic CO₂ Storage**



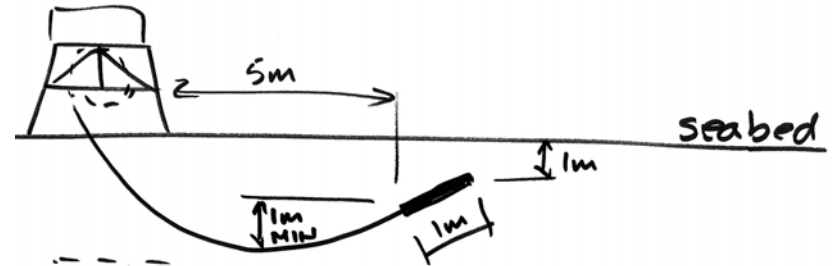
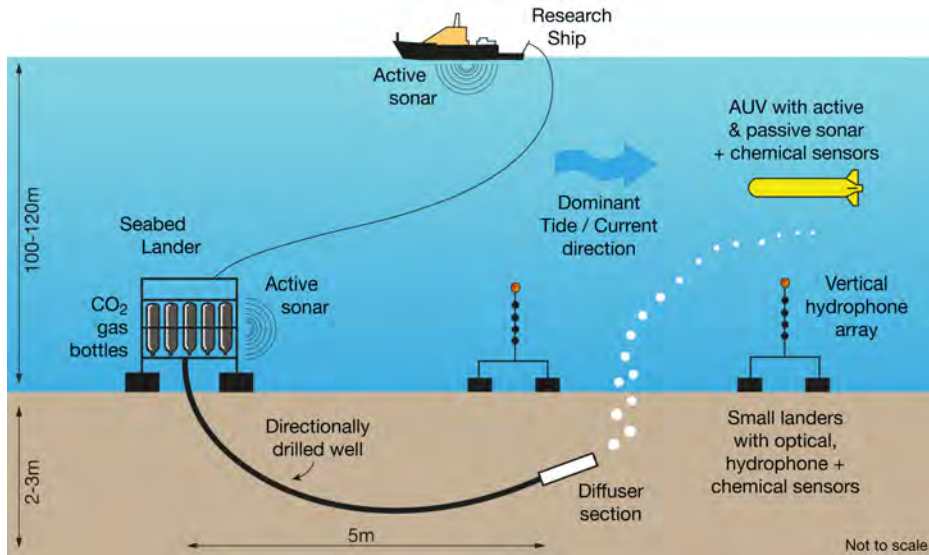
An Overview of the Design, Build and Testing
of the CO₂ Rig

Contents:

- Background
- Design Phase - Summary
- Build Phase - Summary
- Testing - Summary
- Offshore Operations Support

Background:

Where did we start....?



Design Phase

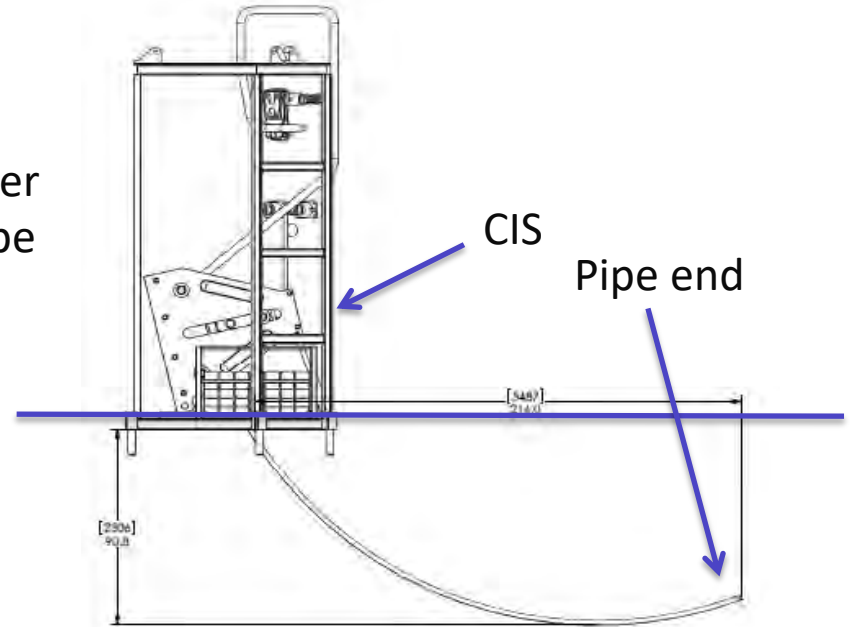
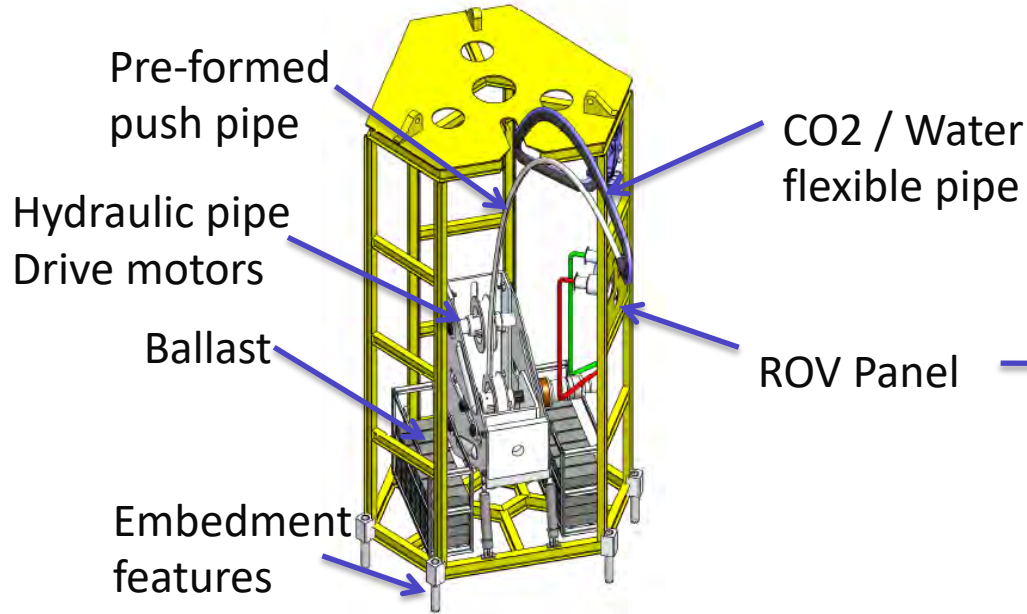
Scope:

- Design and fabrication of the subsea rig
- Design and build of top-side control system
- Design and fabrication of the CO2 injection pipe
- Factory Acceptance Testing of the fully integrated system
- Dock (submerged) Testing including injection pipe installation in seabed
- Provide Operational Spares
- Provide Operator Training
- Provide Offshore operations support

Design Phase

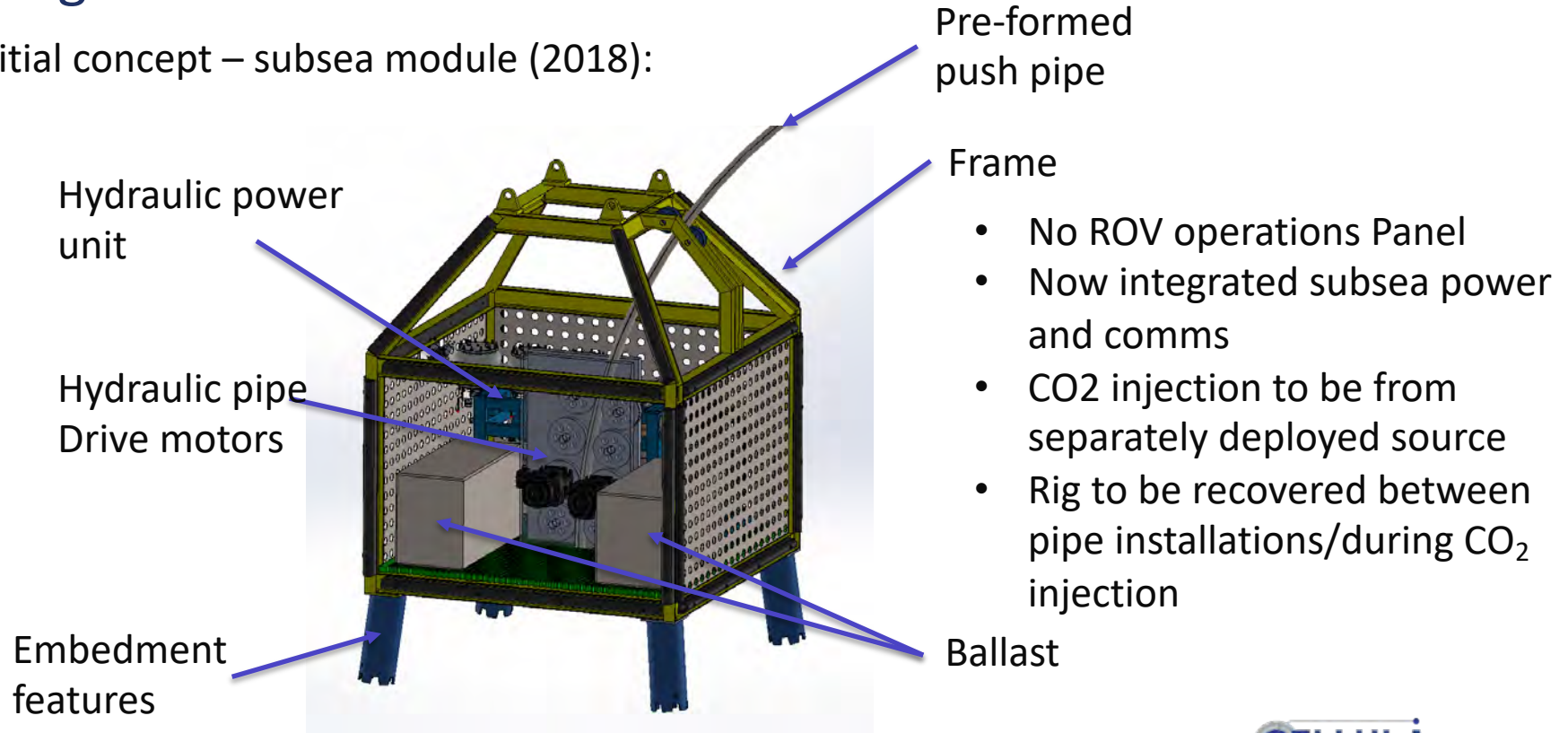
Initial concepts – subsea module (2015):

- ROV intervention to operate rig
- Rig remains on seafloor during CO₂ injection



Design Phase

Initial concept – subsea module (2018):



Pre-formed
push pipe

Frame

- No ROV operations Panel
- Now integrated subsea power and comms
- CO₂ injection to be from separately deployed source
- Rig to be recovered between pipe installations/during CO₂ injection

Hydraulic power
unit

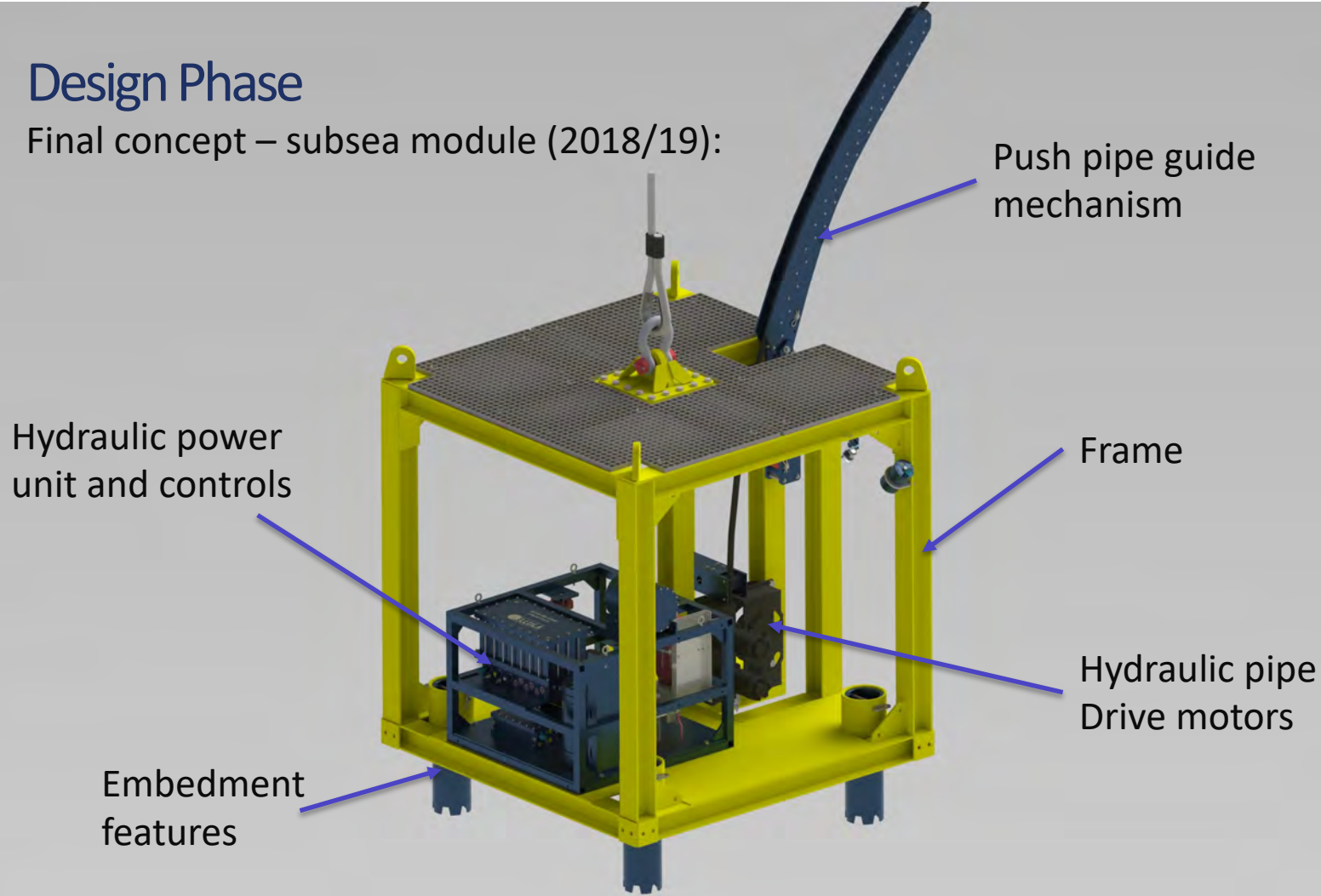
Hydraulic pipe
Drive motors

Embedment
features

Ballast

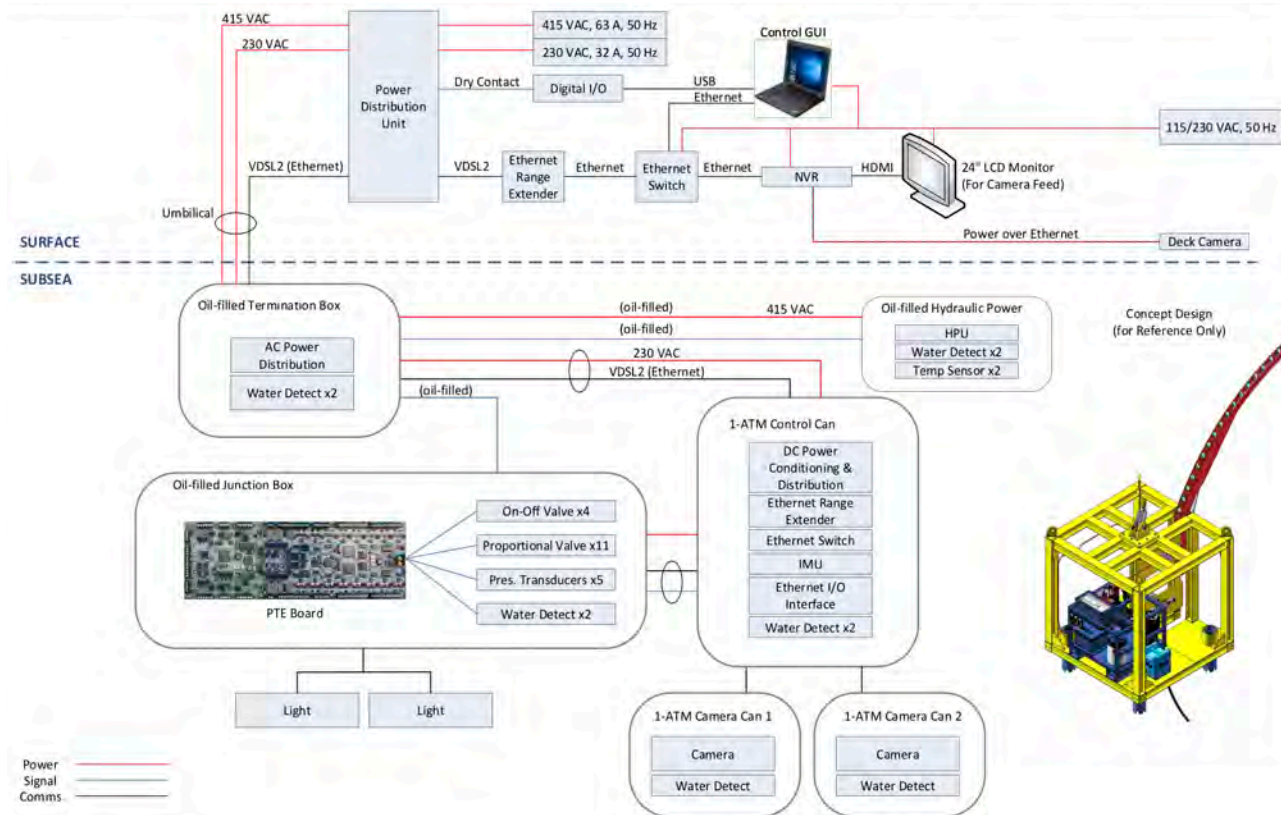
Design Phase

Final concept – subsea module (2018/19):



Design Phase

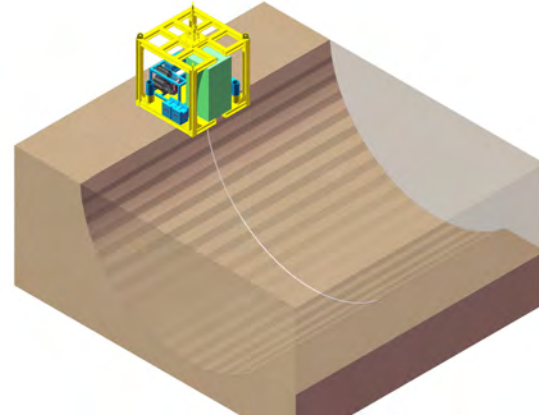
Overall System Block Diagram:



Design Phase

Challenges:

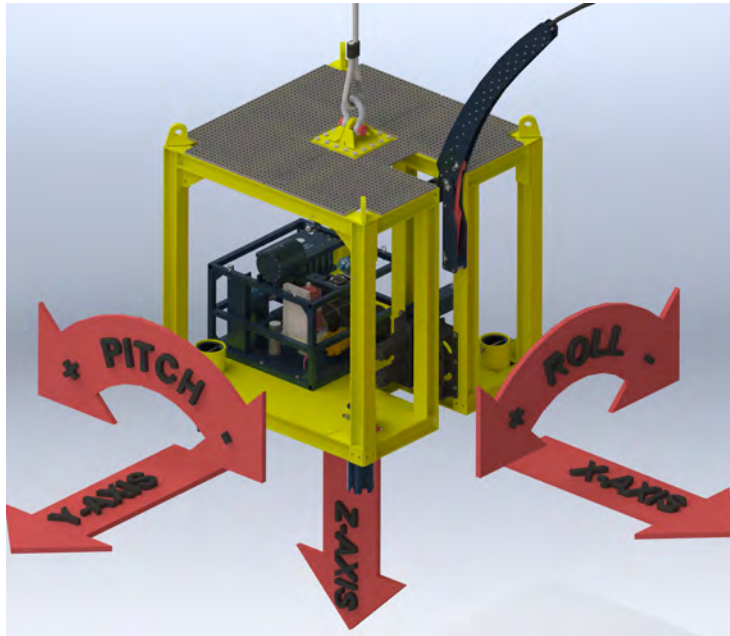
- CO₂ pipe injection method:
 - Curved pipe geometry
 - Precise positioning in seabed
 - Connection of external CO₂ supply
 - Capability to insert and retract pipe
 - Verification of pipe diffuser position following pipe insertion
- 'Stuck Pipe' Scenarios:
 - Rig breakdown/power failure with pipe partially inserted
 - Pipe refuses during insertion
 - Pipe bends/jams during pipe insertion due to ground conditions



Design Phase

Challenges:

- CO₂ pipe injection method:



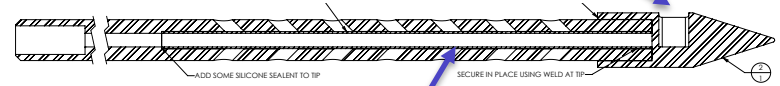
- Realtime pitch and roll monitoring during rig land out and operations (accelerometer)
- AHRS for heading reference during land out
- COTS linear engine utilized for pipe injection – bi-directional and marinized

Design Phase

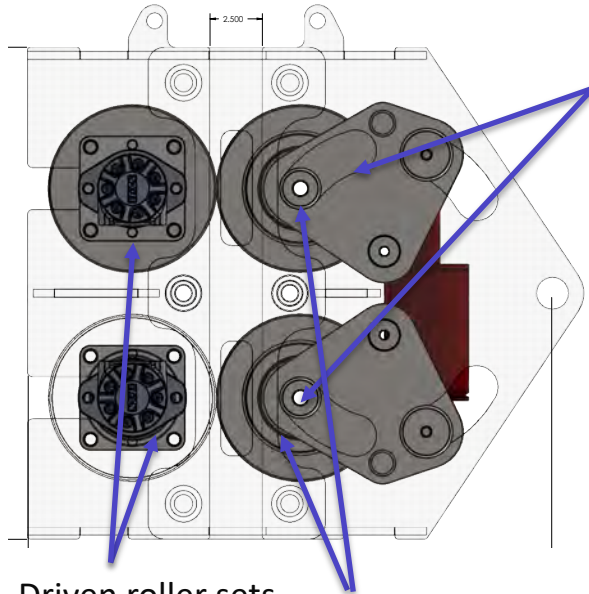
Challenges:

- 'Stuck Pipe' Scenarios/Pipe Detection:

Powerful neodymium magnet installed in pipe tip for detection by ROV magnetometer



Amesapre sintered CO₂ diffuser

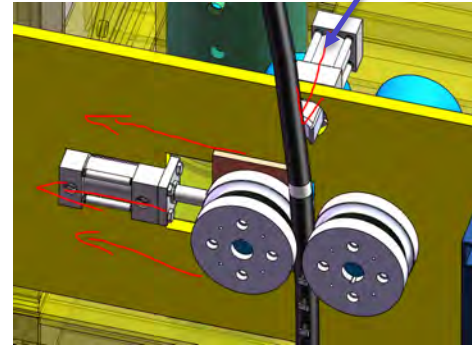


Driven roller sets

Idler roller sets

Retractable rollers on linear engine release pipe on power failure (accumulator driven)

Hydraulic push units eject pipe from linear engine on power failure (accumulator driven)



Design Phase

CONOPS Animation:



Build Phase

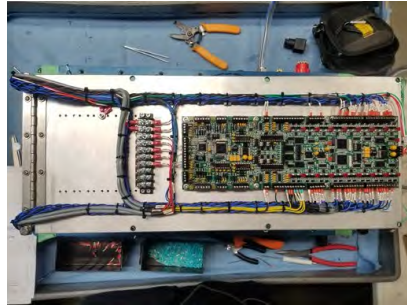
Schedule:

	<u>Planned</u>	<u>Actual</u>
• Contract Execution	16 May 2018	16 May 2018
• Kick-off meeting	07 June 2018	05 June 2018
• MS0: Preliminary Design Review (internal)	09 July 2018	24 July 2018
• MS1: Critical Design Review (Client)	09 Aug 2018	09 Aug 2018
• MS2: Completion of Build and FAT	14 Feb 2019	24 Jan 2019
• MS3: Completion of Dockside Testing	21 Feb 2019	26 Feb 2019*
• MS4: Completion of Client Training	21 Feb 2019	26 Jan 2019
• MS5: Completion of Packing for EXW Delivery	22 Feb 2019	04 Mar 2018
• MS6: Offshore Operations Support	April 2019	24 Apr – 2 May 2019

** Included factory retesting of pipe insertion mechanism – post dock trials which were completed 26 Jan 2019*

Build Phase

Main Assemblies/Systems:



Testing Phase

Factory Acceptance Testing

Location: Cellula Robotics Ltd, Burnaby, BC

Date: 24 January 2019.



- Fully function tested (dry)
- Pipe loaded and unloaded
- Pipe emergency release tested



Testing Phase

Dock Test No. 1:

Location: Allied Shipbuilders Ltd., North Vancouver, BC

Date: 26 January 2019.



- 2 Pipes pushed – 100% penetration
- Pipe emergency release tested
- No water ingress
- No IR faults
- No comms faults



Testing Phase

Dock Test No. 1:

Hmmm... but something doesn't look quite right...?

'unpushed' pipe geometry

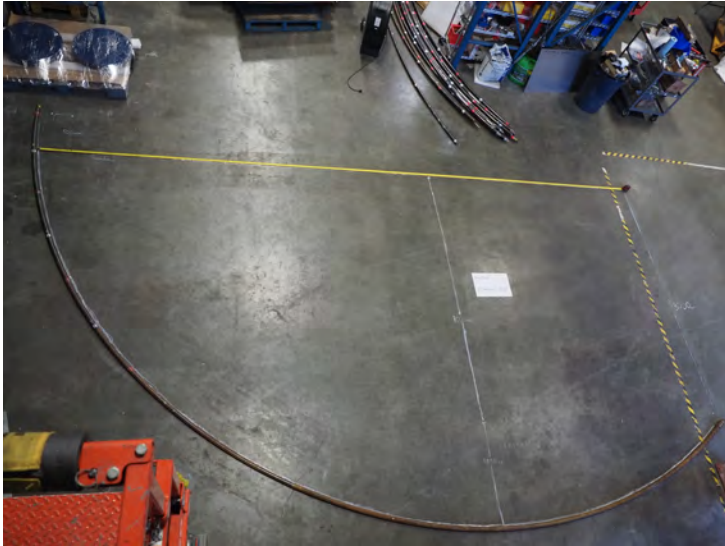


pipe geometry after push test

Testing Phase

Retest – post Linear Engine Roller adjustments:

Pre-test pipe geometry set out



Post-test pipe geometry check

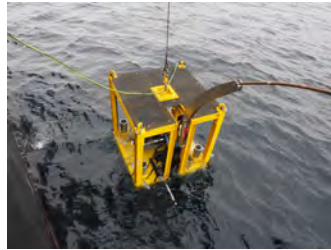
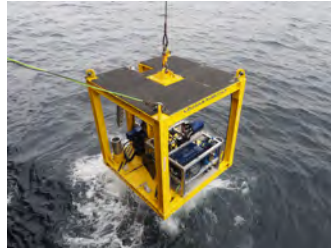


Post test pipe geometry within tolerance

Offshore Operations Support

Location: Goldeneye Gas Reservoir (depleted) UKCS.

Dates: 24 April – 2 May 2019



- 2 Pipes successfully installed and connected to CO₂ supply
- CO₂ verified as flowing through pipe
- CO₂ bubbles observed and monitored at the seafloor

Thank-you!

Allan Spencer

Managing Director (UK)

Tel +44-7961 179 973

Email allan.spencer@cellula.co.uk

Address

Cellula Robotics (UK) Ltd.

Brathens Eco-Business Park

Hill of Brathens

Banchory

Aberdeenshire AB31 4BW

Tel +44 1330 826 889

Email info@cellula.com

Web www.cellula.com



Cellula Robotics: AUV Program



12 Feb – 1130-1200

'Sea trial results from an experimental fuel cell powered, long range, autonomous underwater vehicle with anchoring capability'



WE ARE EXHIBITING AT
SUBSEA
EXPO Booth 25B
11-13 FEB 2020 | P&J LIVE, ABERDEEN