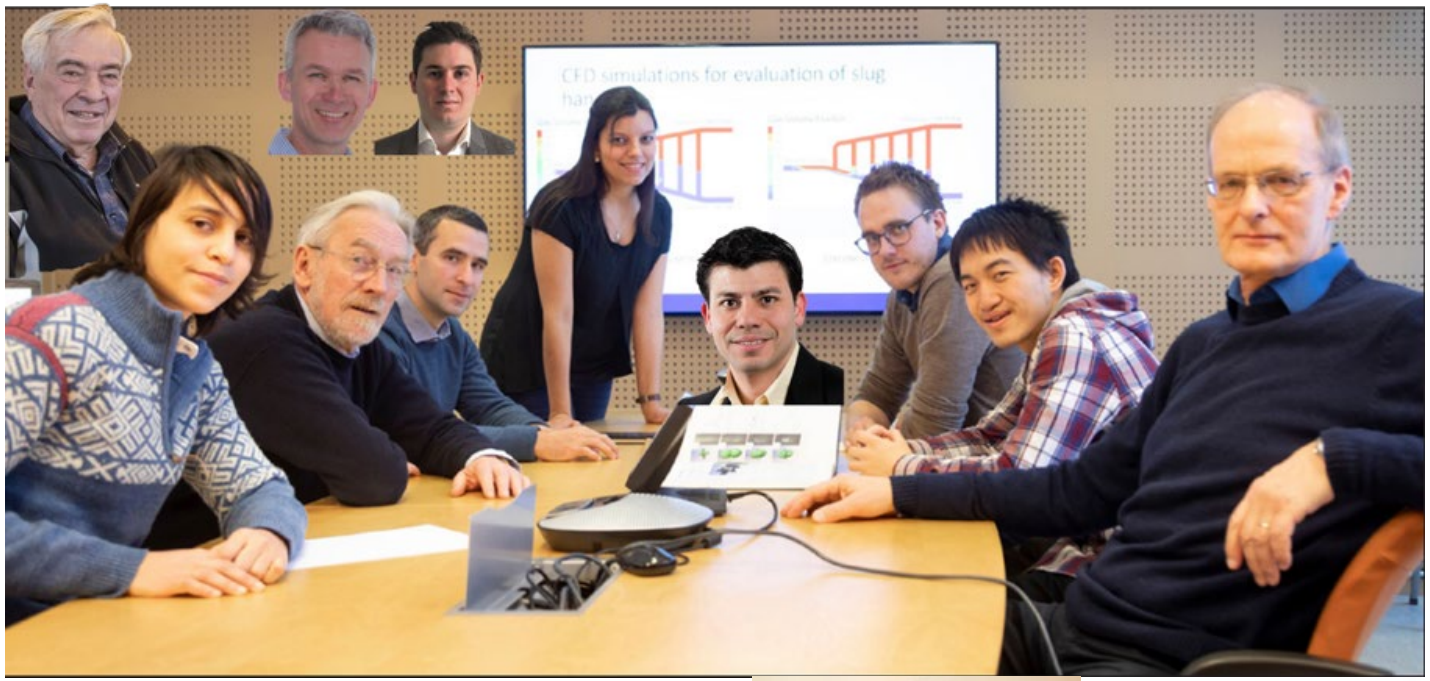
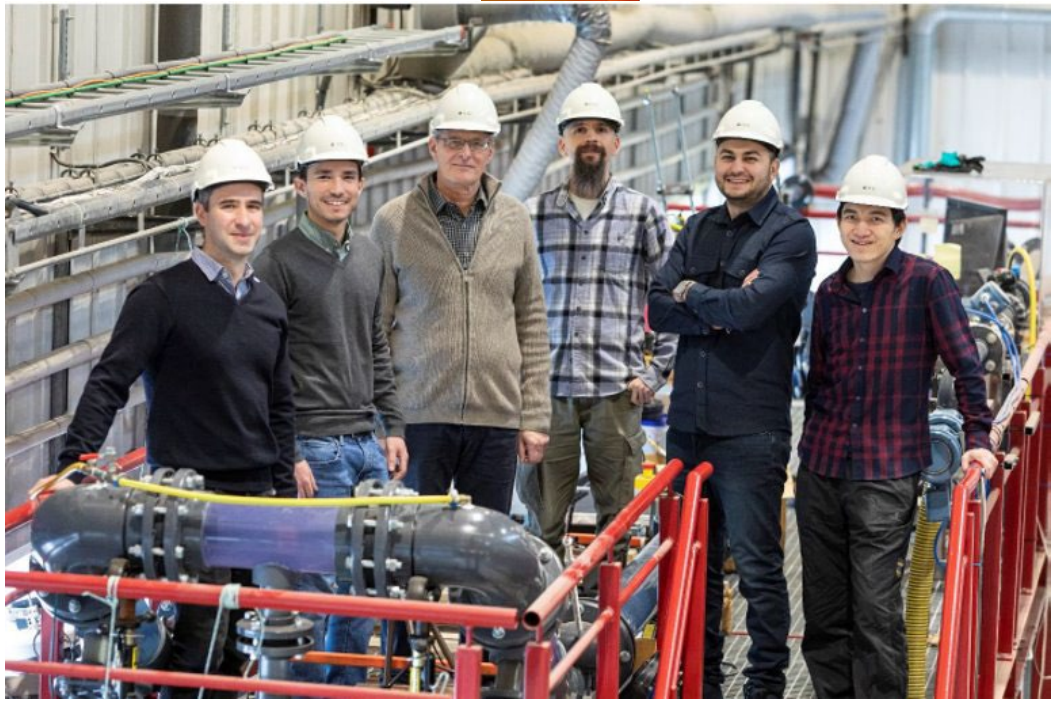
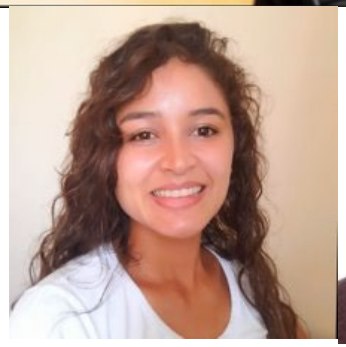


SUBPRO





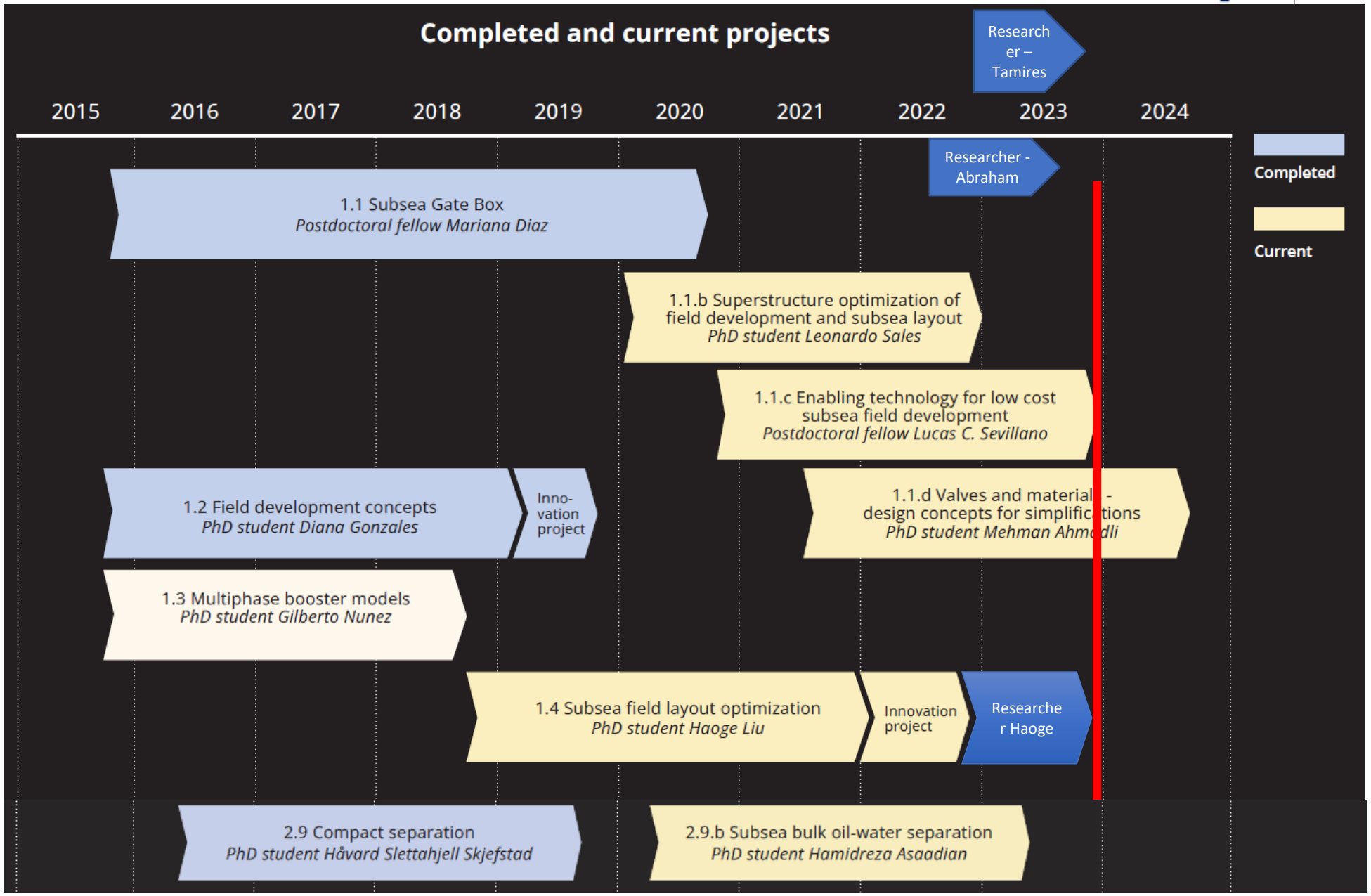
Concluding 8 years of research in Field Architecture (FA)

Sigbjørn Sangesland / Milan Stanko, Nov 27, 2023

Goals and objectives

Develop methods, models, technologies and alternative architectures to improve subsea field development

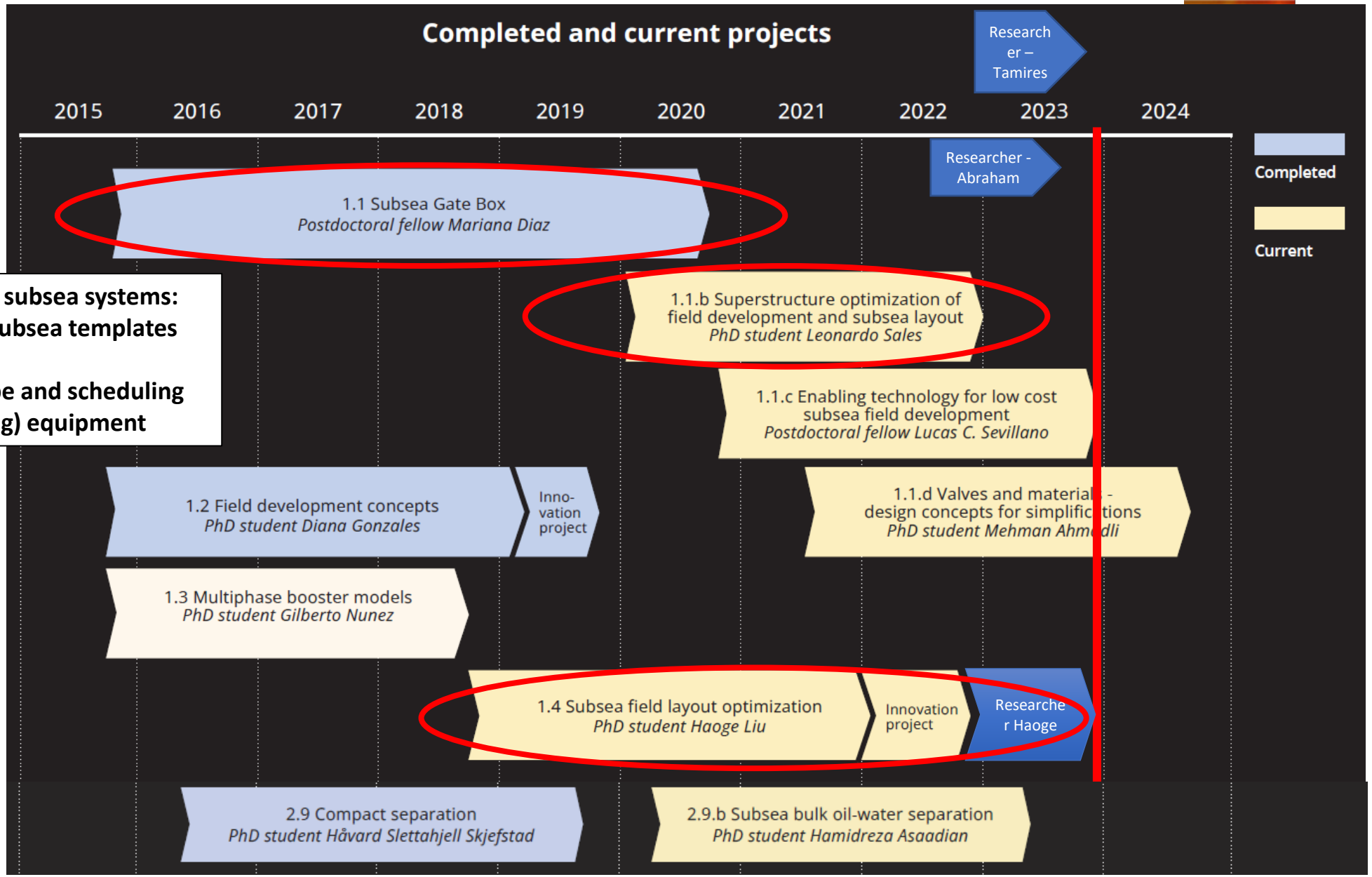
Research area chronologic overview



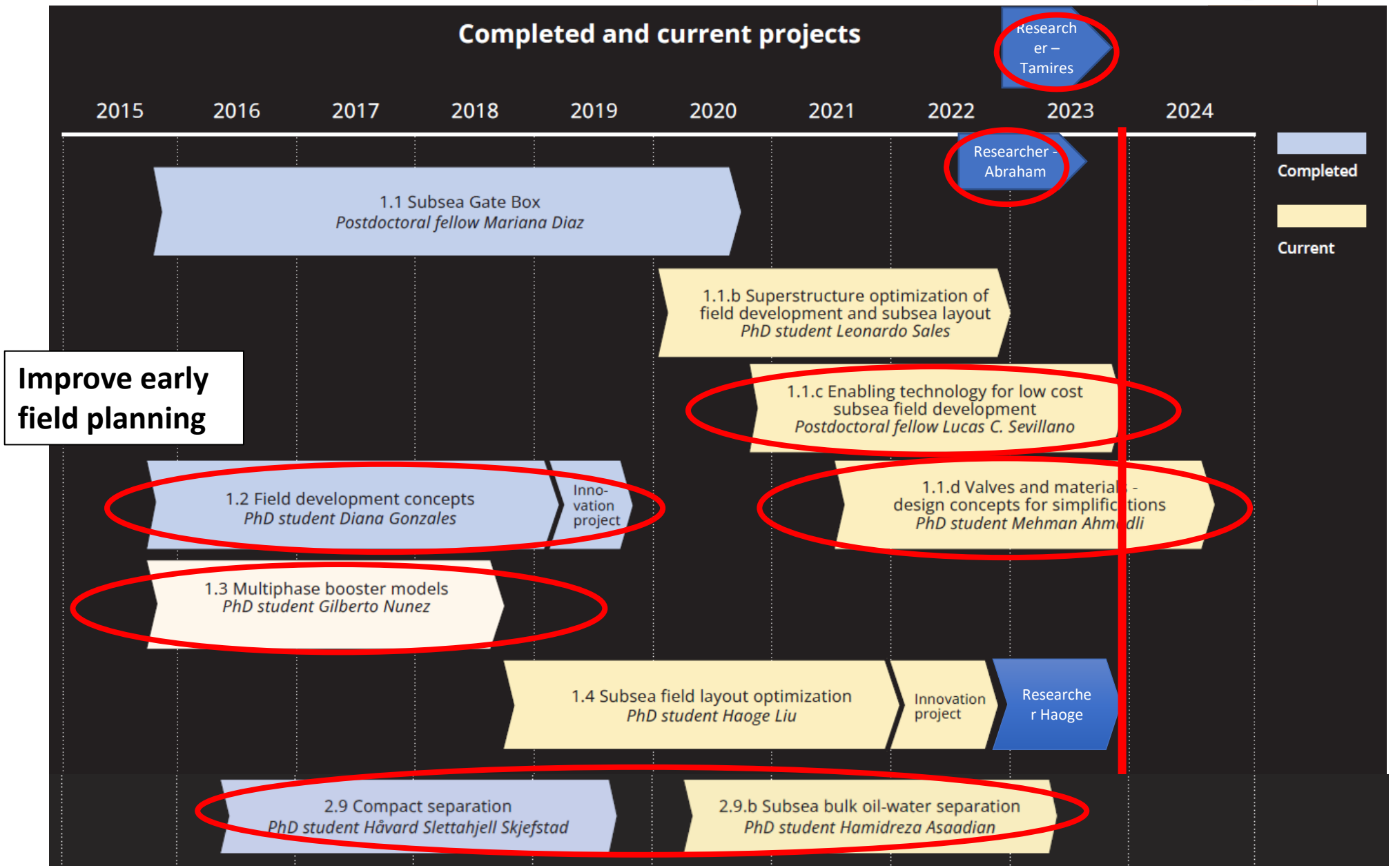
Research area chronologic overview

Designing better subsea systems:

- **Location of subsea templates and wells**
- **Location, type and scheduling of (processing) equipment**

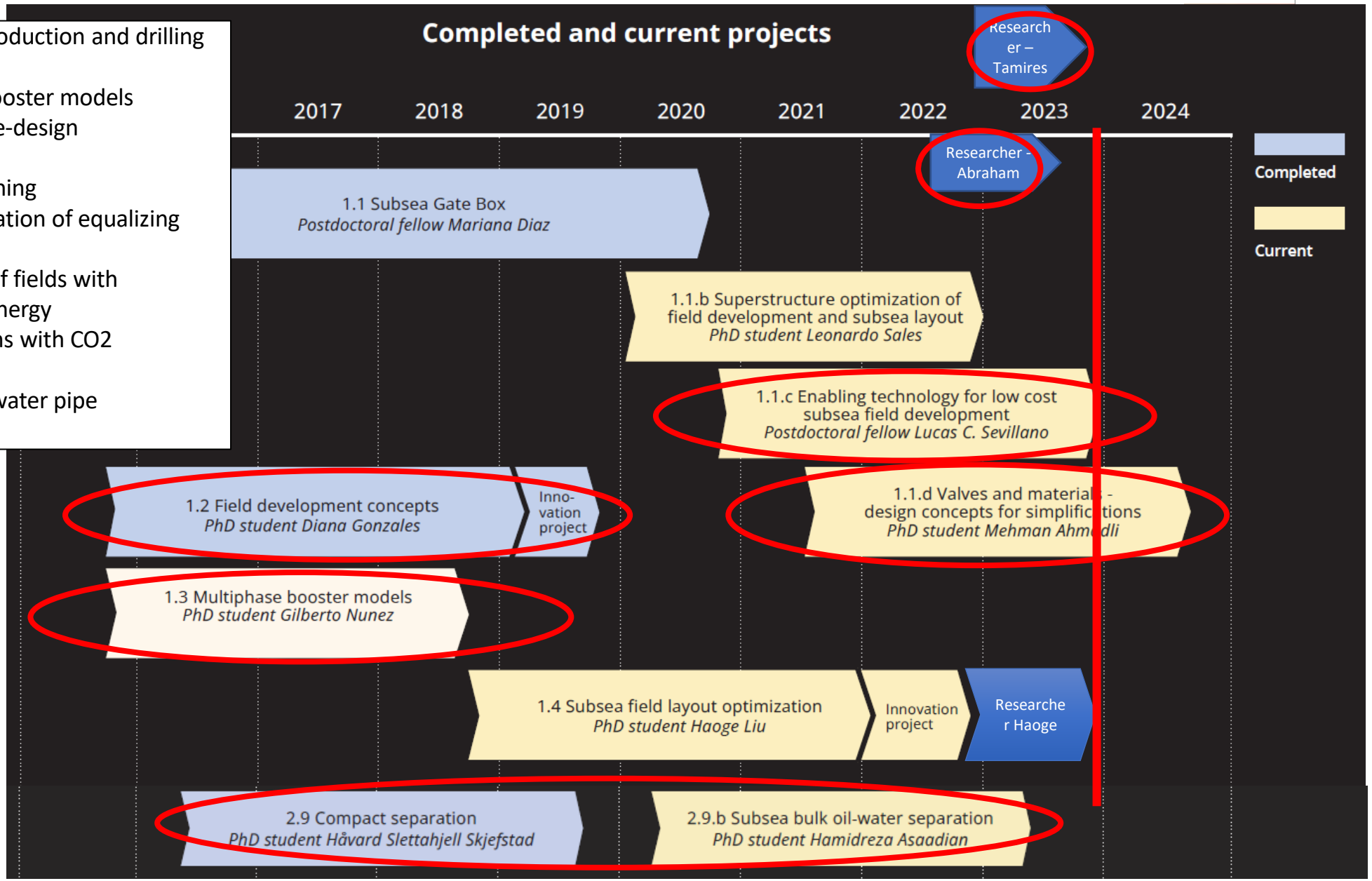


Research area chronologic overview

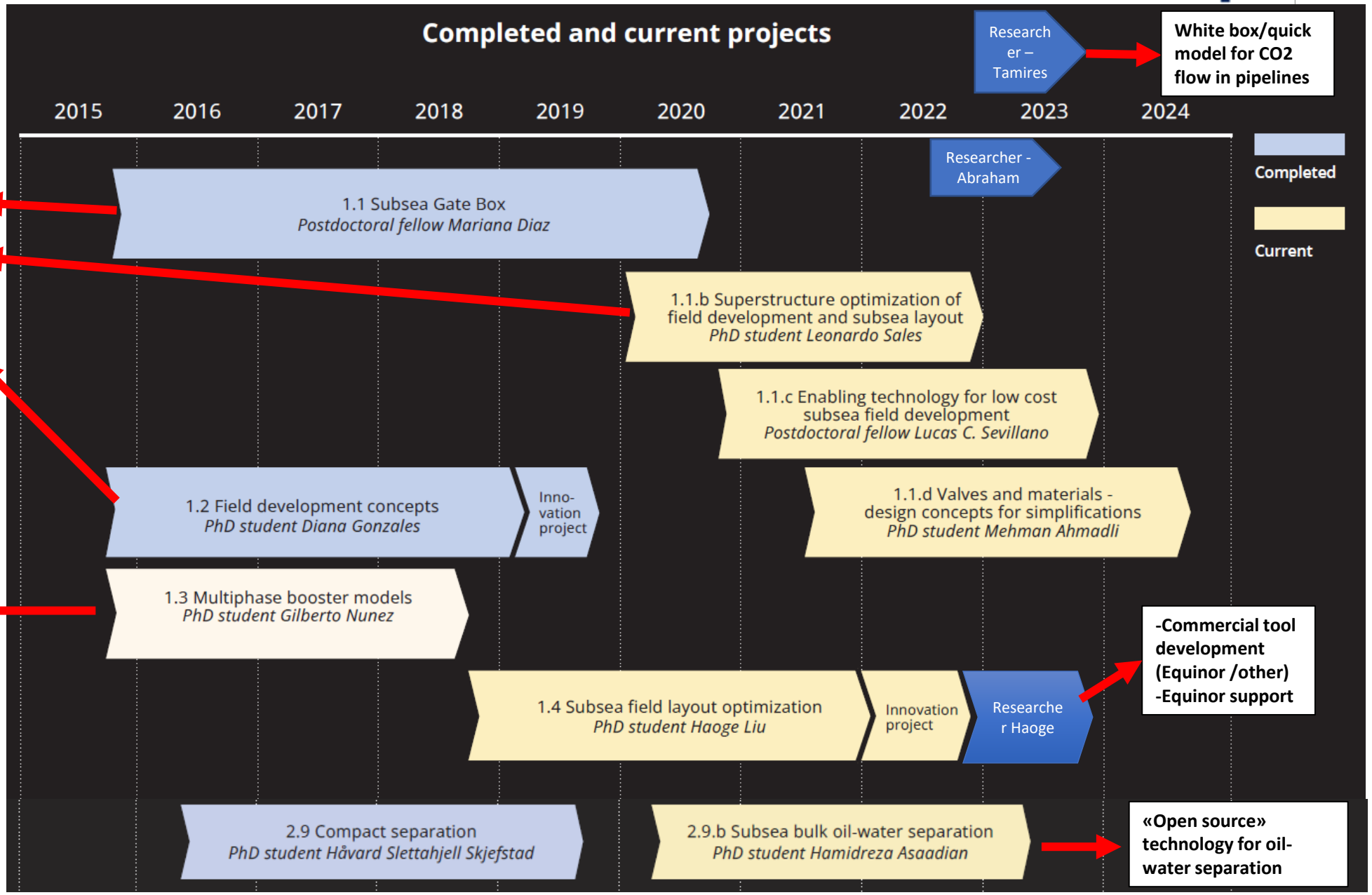


Research area chronologic overview

- Designing production and drilling schedule
- Simplified booster models
- X-mas tree re-design
- Gate valves
- Efficient flushing
- Better estimation of equalizing chemicals
- Integration of fields with renewable energy
- Better designs with CO2 injection
- Efficient oil-water pipe separation



Innovation – knowledge transfer



Tool development for in-house use (AkerBP) - OFFA

Tool development and implementation in commercial sofware (Aker Solution)

Working in AkerSolutions (pumping)

-Commercial tool development (Equinor /other)
-Equinor support

«Open source» technology for oil-water separation

PD Project: The Subsea Gate Box

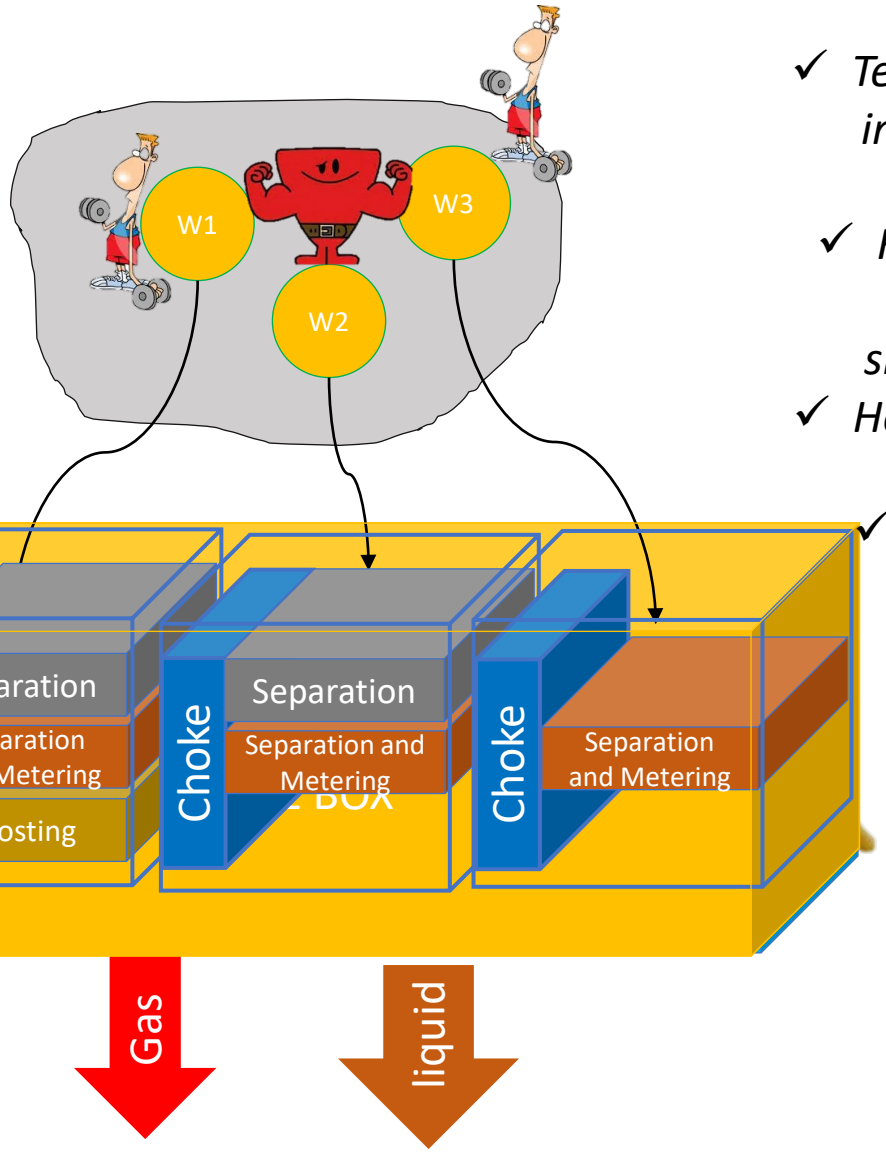
SUBPRO

Postdoc: Mariana Diaz
Supervisors: Sigbjørn Sangesland
Milan Stanko

The Subsea Gate Box is a decentralized subsea processing approach

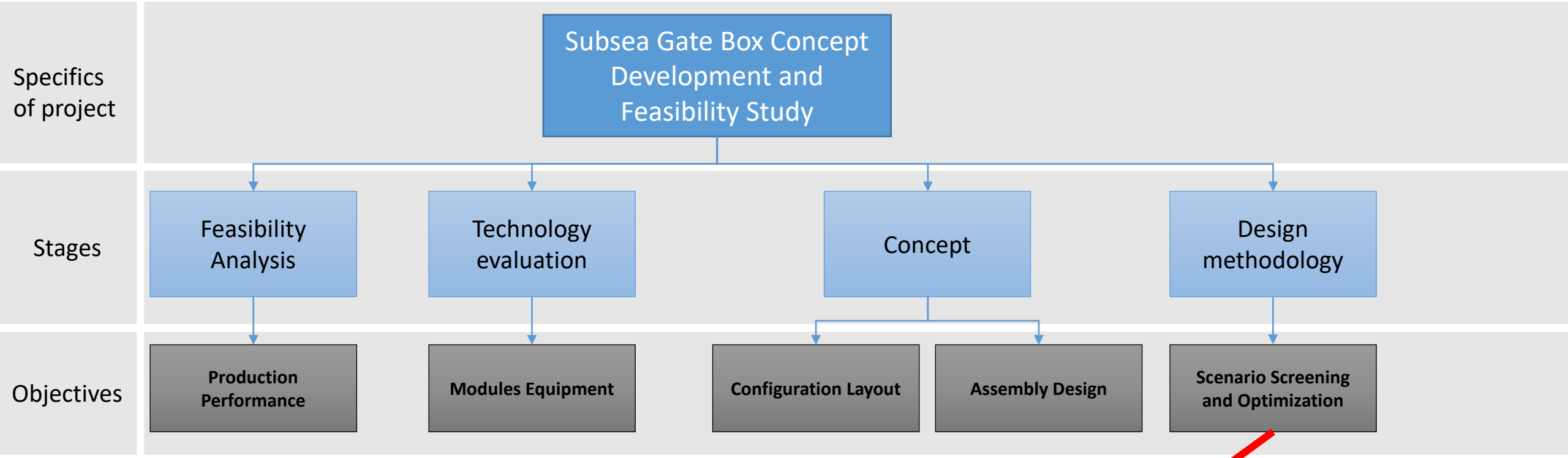
Tailored solution of separation and boosting for each well

LEGO principle



- ✓ *Template that accommodate individual well modules and compartments*
- ✓ *Retrievable individual well modules – smaller sizes, smaller intervention vessels*
- ✓ *Honor the reservoir strategy,* increasing recovery
- ✓ Increase flexibility and efficiency.

Summary of activities

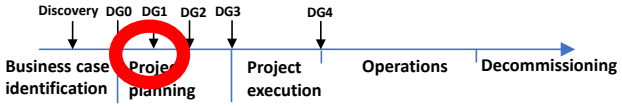


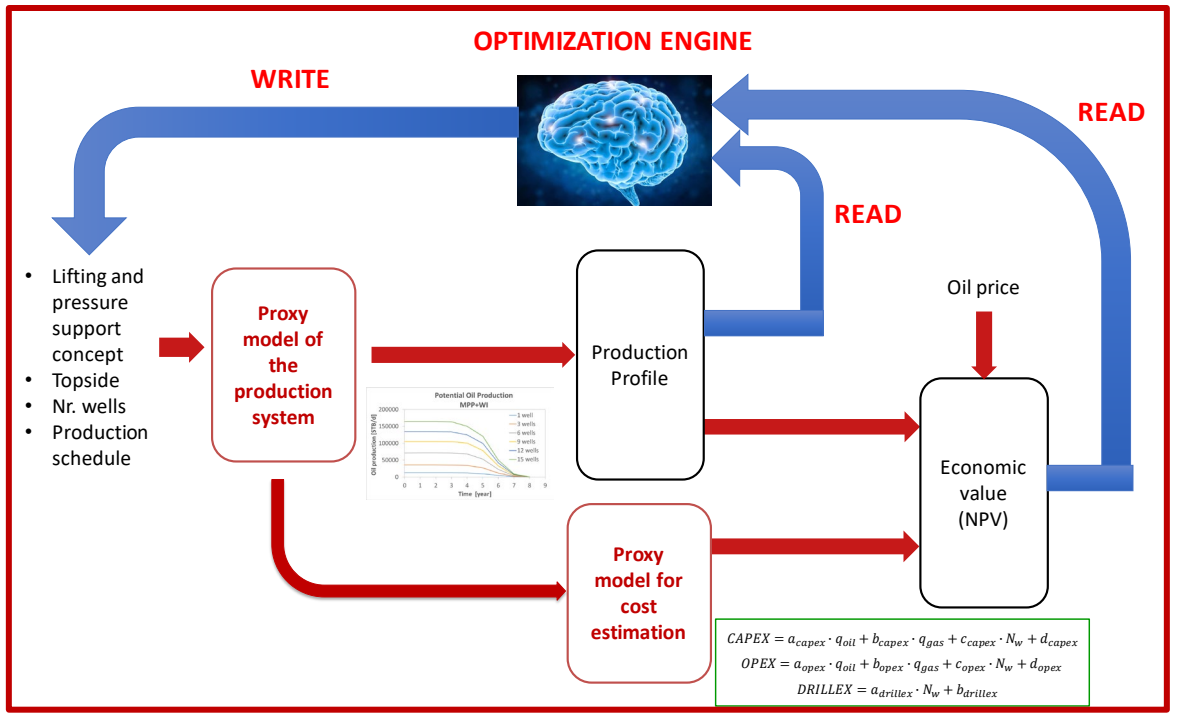
OFFA- OPTIMAL FLEXIBLE FIELD ARCHITECTURES

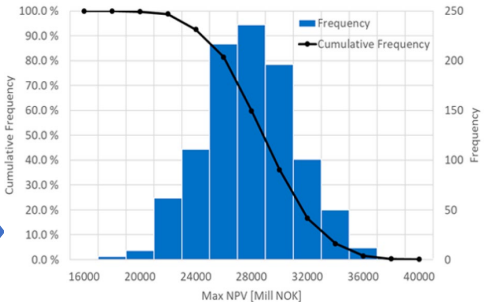
PhD project: Methods for early-phase field development

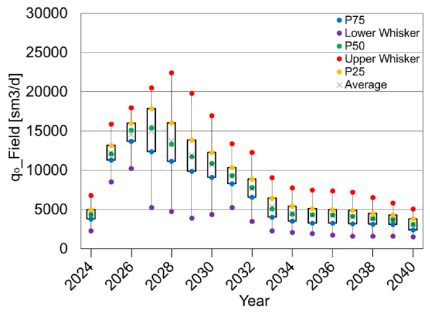
Candidate: Diana Gonzalez
Supervisor: Milan Stanko

- Develop and test a methodology to provide decision support during early field development using integrated models, optimization and quantifying uncertainty









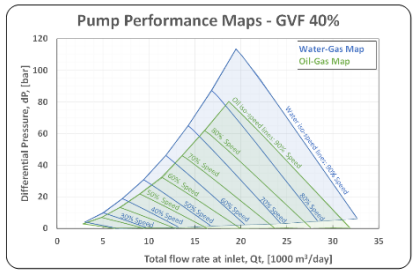
PhD project: Multiphase boosting models

SUBPRO

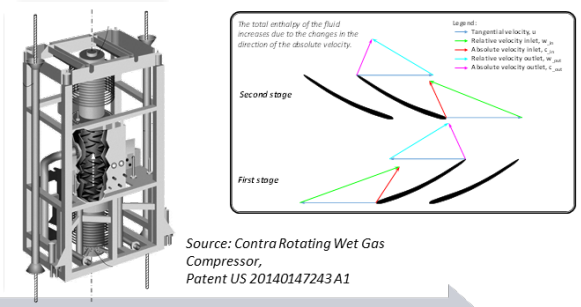
Postdoc: Gilberto Nunez
Supervisors: Sigbjørn Sangesland
Jesus de Andrade

*Simple **multiphase boosting models** to use in integrated modelling of subsea field solutions and production optimization.*

MPP Performance Maps

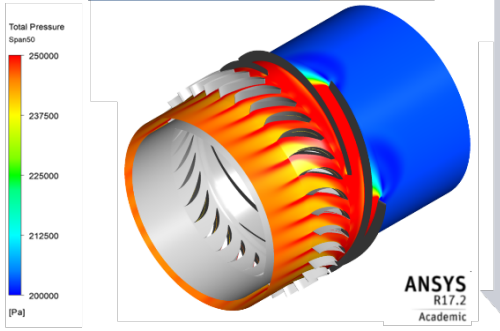


WGC Performance Model

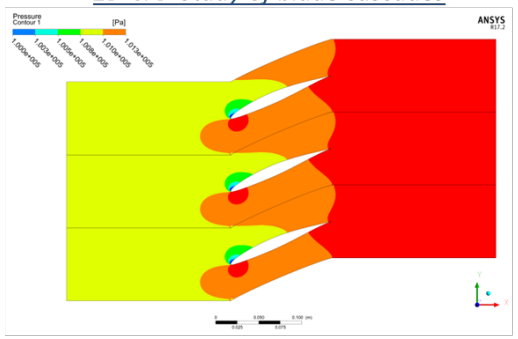


Source: Contra Rotating Wet Gas Compressor, Patent US 20140147243 A1

3D CFD Study of HAP



2D CFD Study of blade cascades



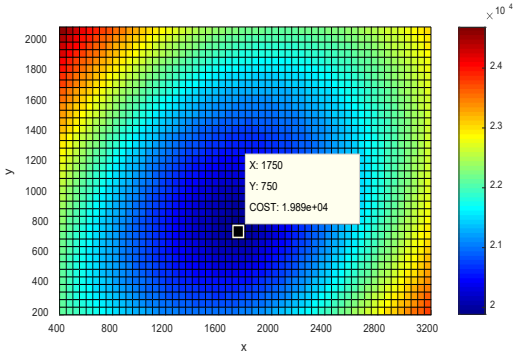
PhD project: Subsea Field Layout Optimization to Minimize Development Cost

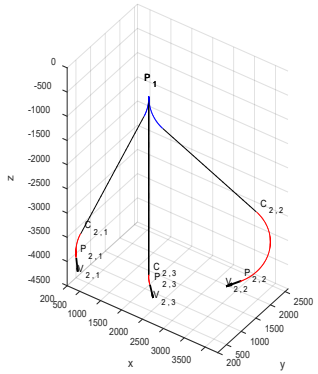
Haoge Liu

(PhD 2018-2022)

Supervisor: Tor Berge S. Gjersvik, NTNU

Co-supervisor: Audun Faanes, NTNU and Equinor

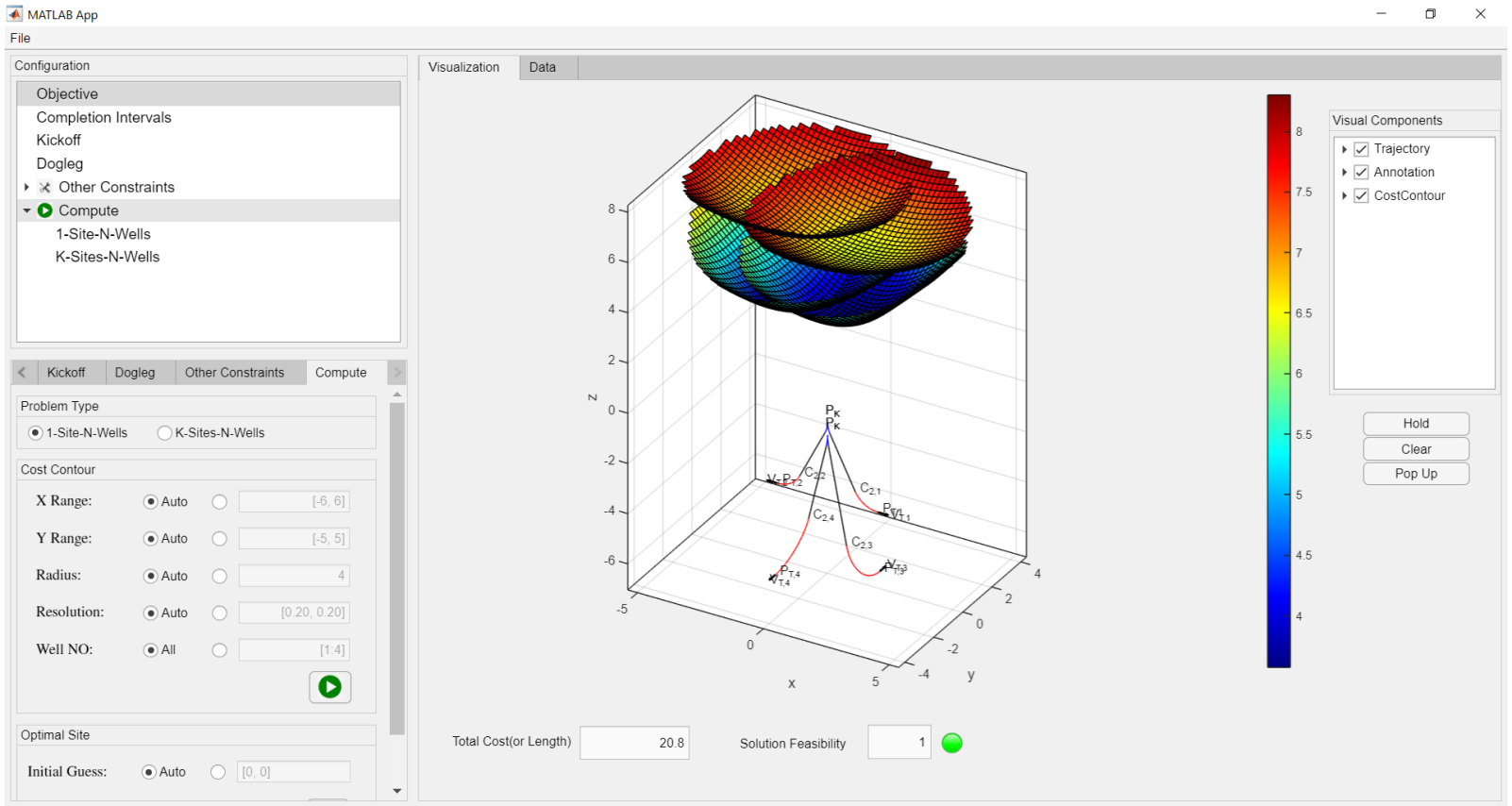




One-sentence description:

Given *subsurface completion intervals, cost items/functions and engineering constraints,* optimize the subsea field layout so that the overall development cost can be minimized.

Demo app



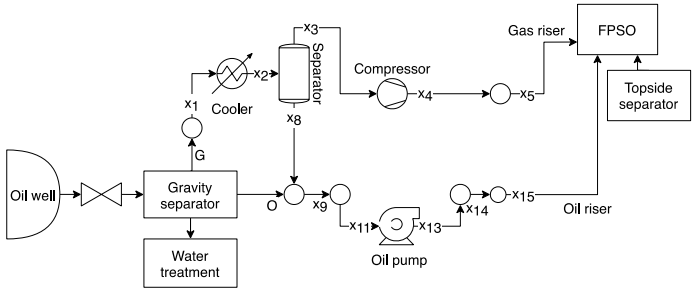
Equinor has now awarded a software development contract with a SoW to supply a demo application with specified features.

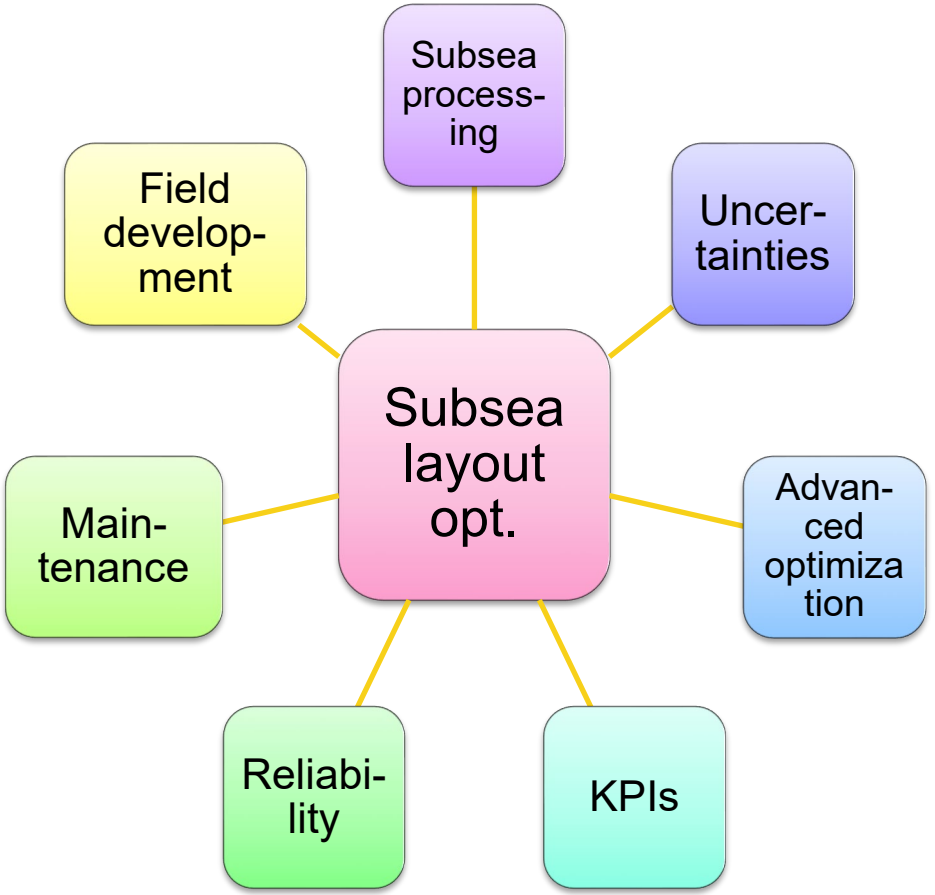
"*A first step towards commercialization*"

PhD project: Methods to design subsea systems with subsea processing

SUBPRO

Candidate: Leonardo Sales
Advisor: Milan Stanko





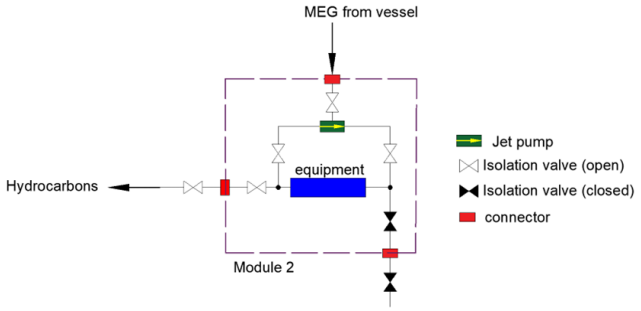
Manual design to Computer-aided design

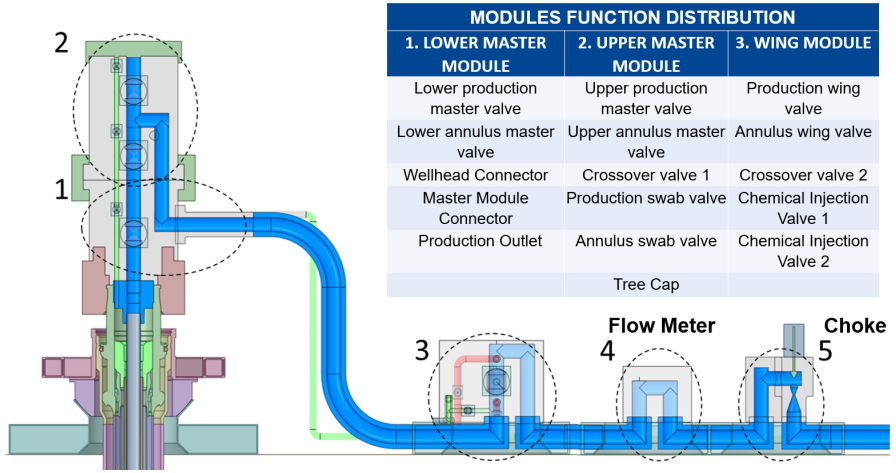
Insights about this problem

How should we select the best subsea layout, considering subsea processing, uncertainties and others?

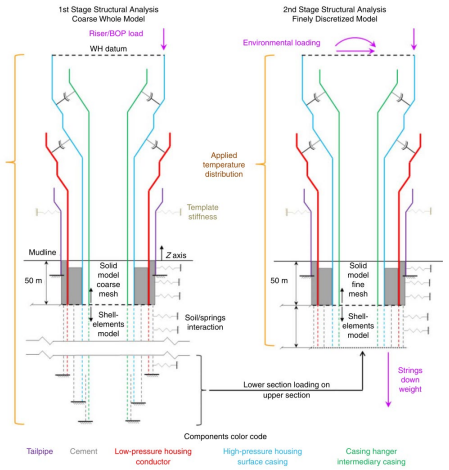
PD Project: Enabling technology for low cost subsea field development

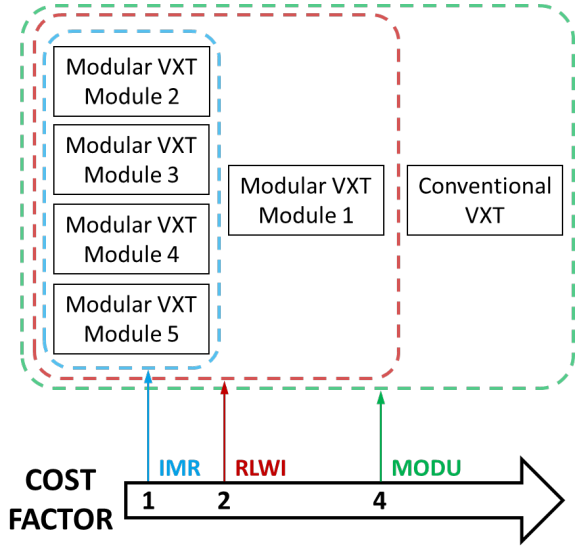
Lucas C. Sevillano





MODULES FUNCTION DISTRIBUTION		
1. LOWER MASTER MODULE	2. UPPER MASTER MODULE	3. WING MODULE
Lower production master valve	Upper production master valve	Production wing valve
Lower annulus master valve	Upper annulus master valve	Annulus wing valve
Wellhead Connector	Crossover valve 1	Crossover valve 2
Master Module Connector	Production swab valve	Chemical Injection Valve 1
Production Outlet	Annulus swab valve	Chemical Injection Valve 2
	Tree Cap	





Professors: Sigbjørn Sangesland,
Tor Berge S. Gjersvik, NTNU,
and Audun Faanes (NTNU / Equinor)

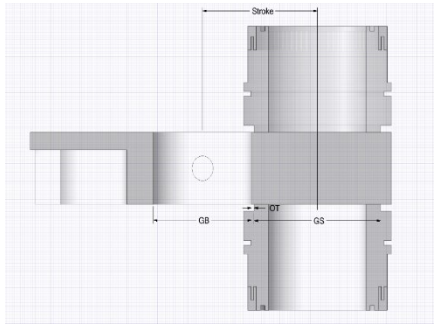
PhD project: Valves and materials – design concepts for simplifications

Mehman Ahmadli

(PhD 2021-2024)

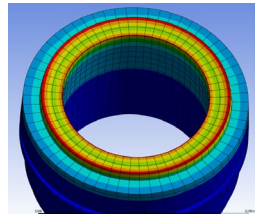
Goal:

To reduce friction force and power requirements in subsea valve operations



Activities:

- Investigate alternative coating materials
- Simulation of compatibility (Thermal expansion)
- Lab testing at Sintef, WC (Tungsten Carbide) and PDC (Poly crystaline Diamond Compact)



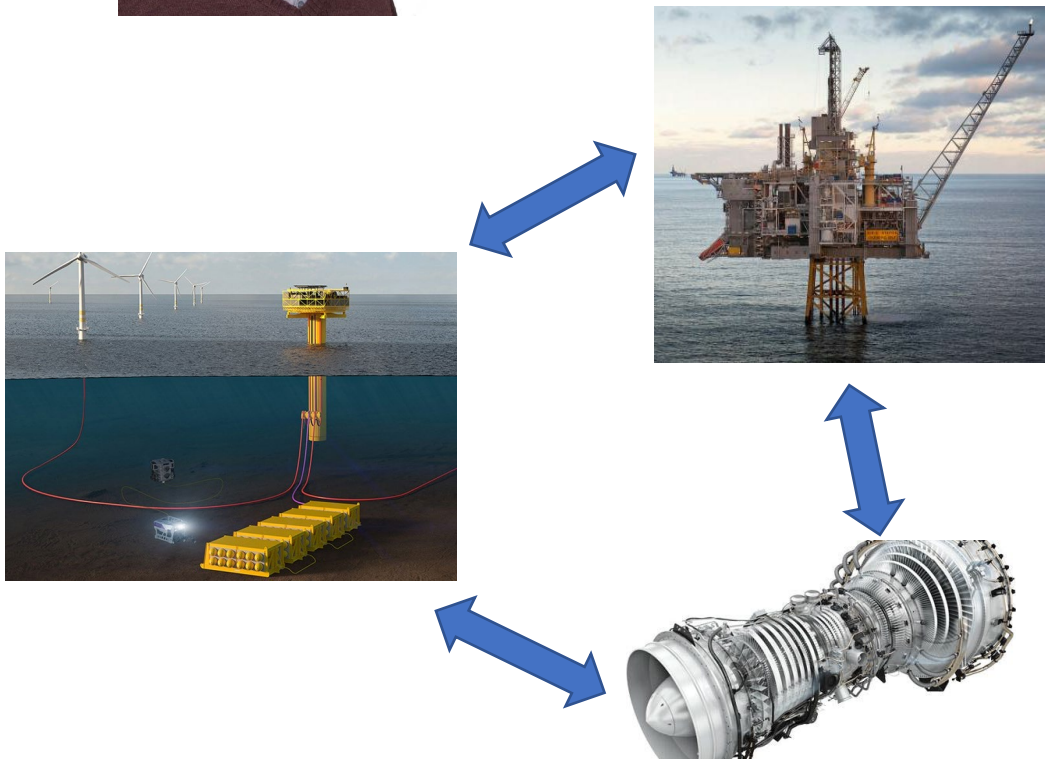
Supervisor: Tor Berge S. Gjersvik, NTNU
Co-supervisor: Sigbjørn Sangesland, NTNU
Industry supervisor: Christian Reynes, TotalEnergies

Results:

- Replacing WC with PDC material coating decreases the total friction force by approximately 15 -16%

Researcher Project: Operation and design of fields with power constraints

Researcher: Abraham Parra
Supervisor: Milan Stanko

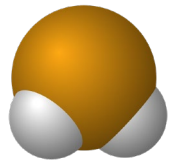


How to integrate power from renewables with oil and gas offshore fields?

- New fields → design considerations
- Existing fields → operational considerations

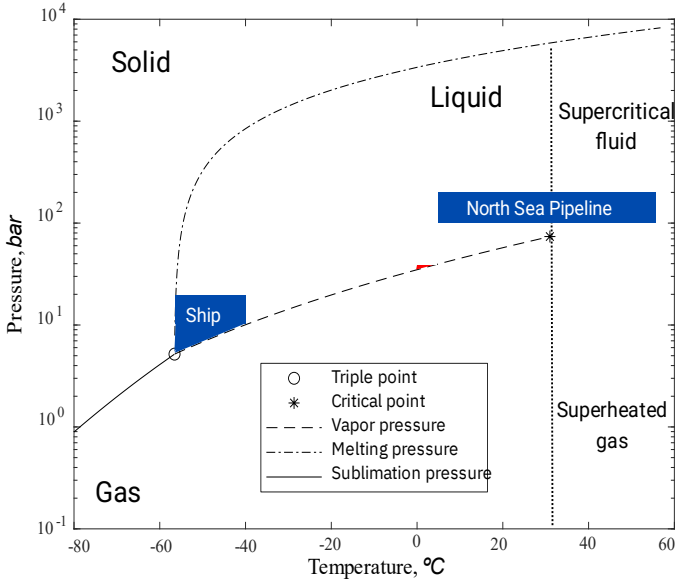
Issues:

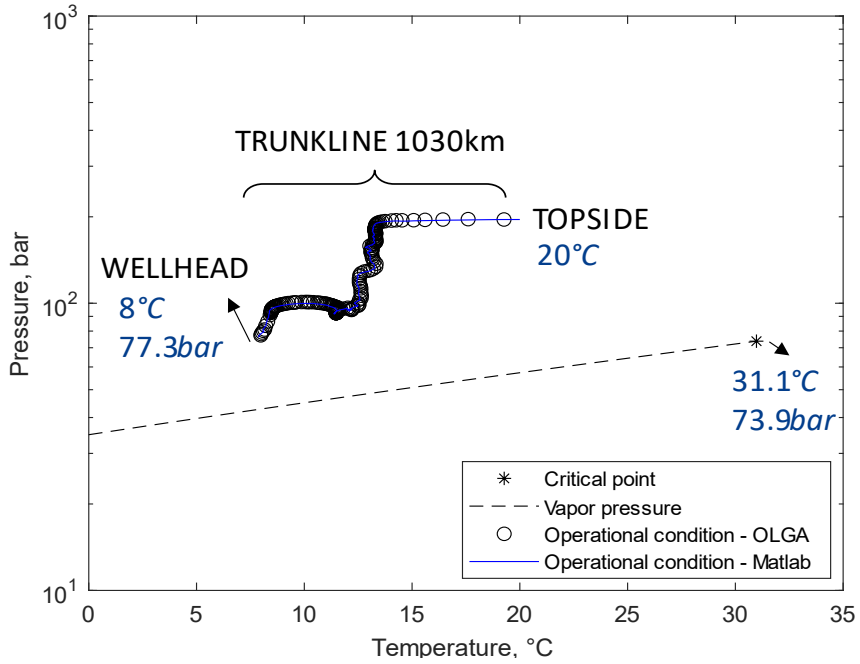
- Quantify technical, economical feasibility
- Integration of power storage (hydrogen, amonia)
- Fluctuating production
- Gas line-pack management



Researcher Project: Simplified model for subsea CO2 transport in pipelines

Tamires de Souza Alves da Silva





Supervisors:
Sigbjørn Sangesland
Audun Faanes
Milan Stanko

SUMMARY

- Easy-to-use tool for studying CO_2 transport
- Simplest model in agreement with benchmark Software (OLGA)

2 PhD projects: Bulk oil-water separation in pipes

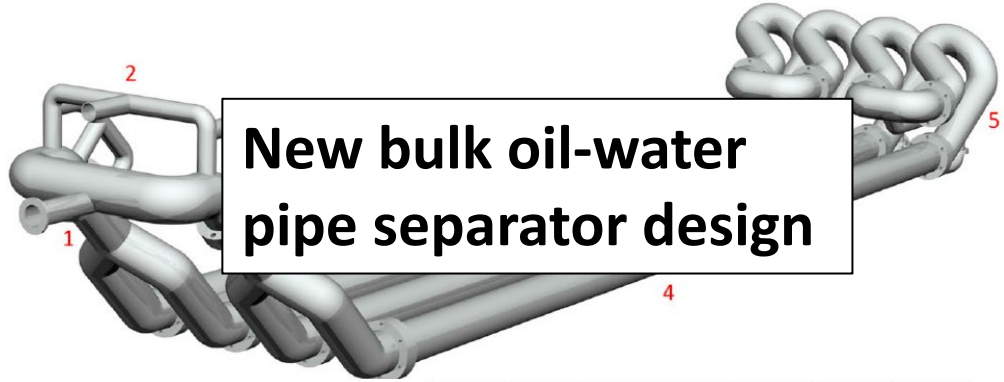
PhD candidates:
Håvard Skjefstad
Hamidreza Asaadian

1

2

Supervisors:
Milan Stanko

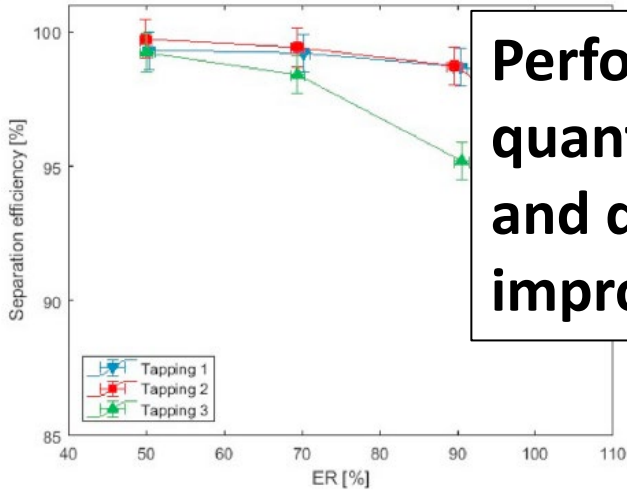
1



New bulk oil-water pipe separator design

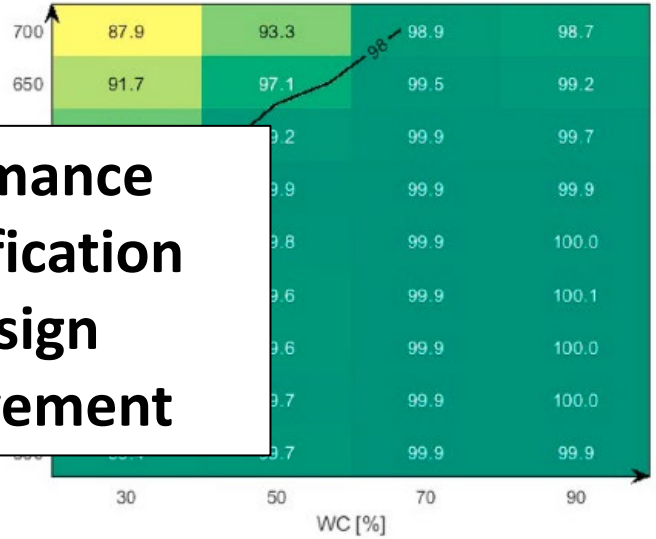
SUBPRO

Construction of experimental facilities



(c) Efficiency at $\dot{Q}_{tot} = 250\ L/min$, WC = 30%

Performance quantification and design improvement

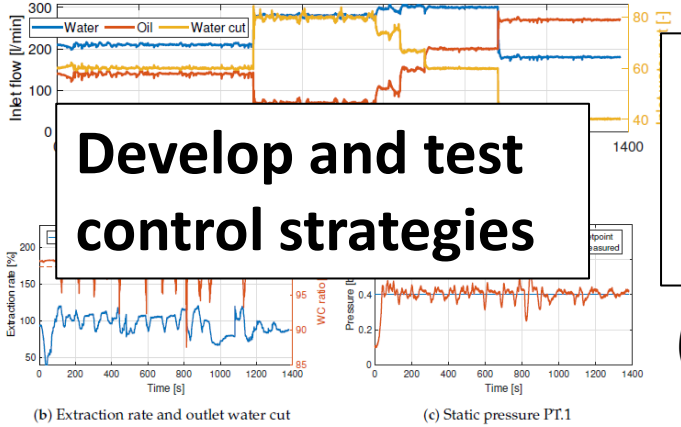


(a) Efficiency [%] at ER = 50%

(a) Left pipe, ER = 50%

(b) Right pipe, ER = 50%

Uneven splitting in branches

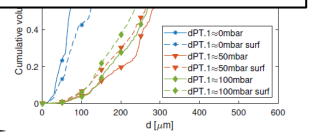


(b) Extraction rate and outlet water cut

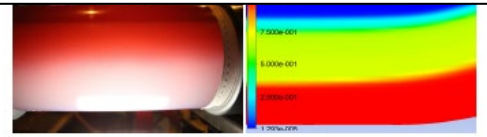
(c) Static pressure PT.1

Develop and test control strategies

What happens when you choke and add surfactant?



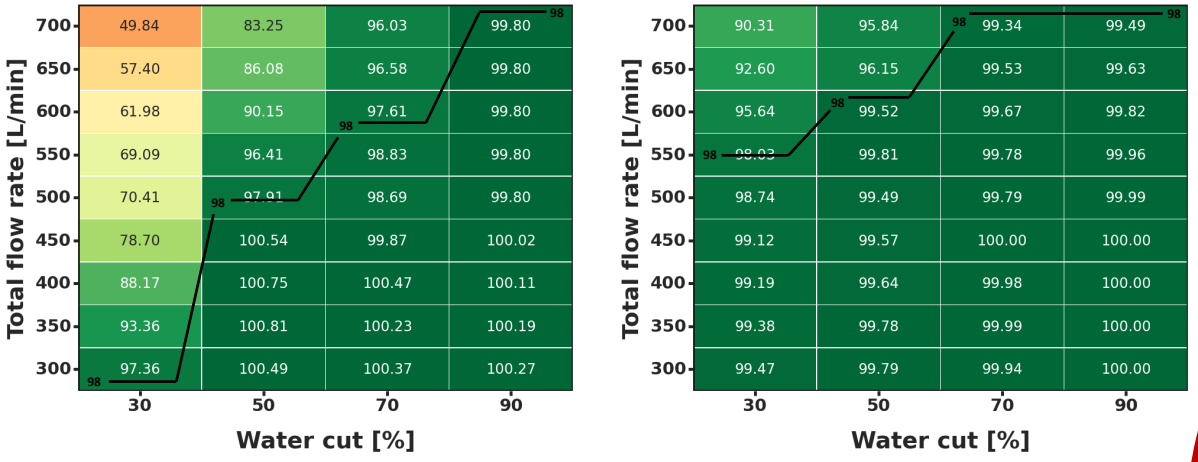
Develop models for design and prediction



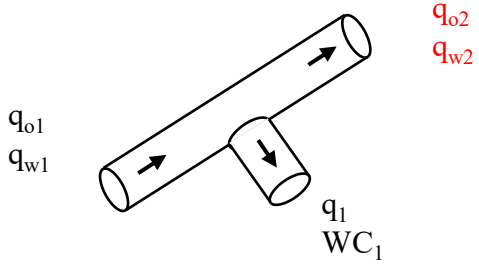
(a) Experimental (b) Simulation

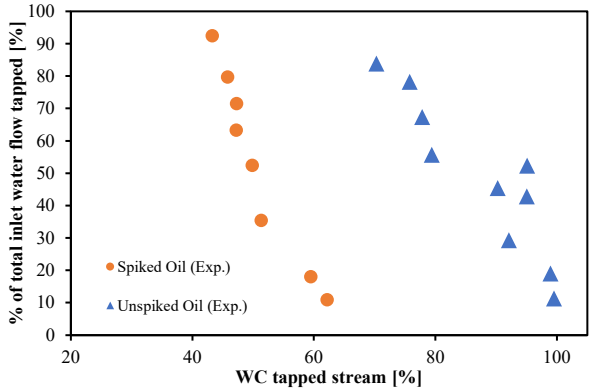
2 Effect of crude oil spiking

Separator Efficiency

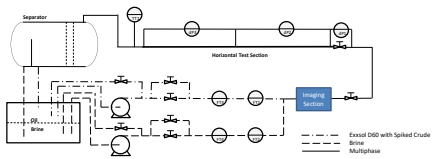


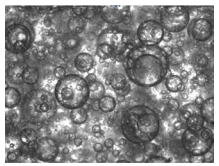
Tapping point drainage potential

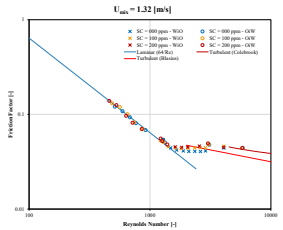


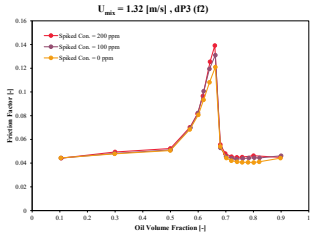


O&W mixture rheology and dispersion

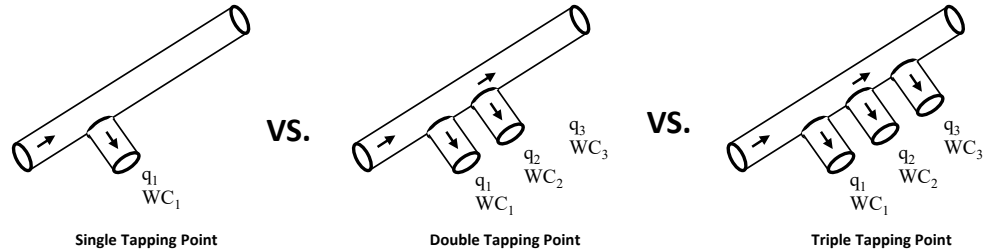


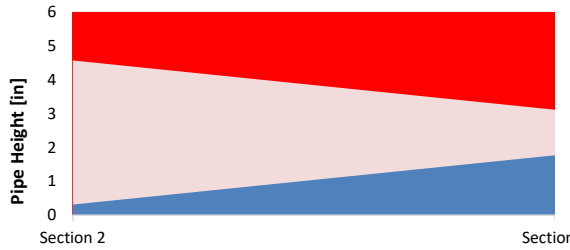


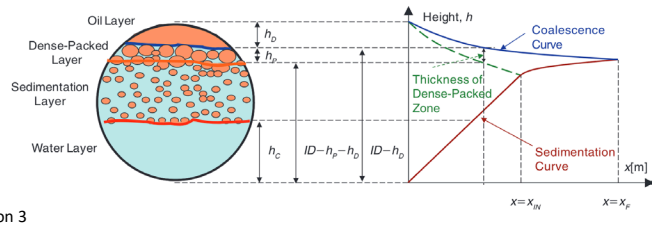


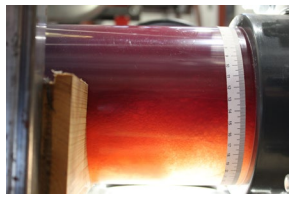


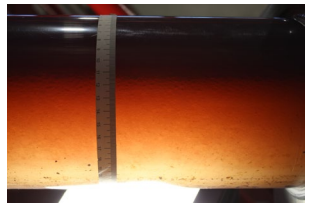
Modeling for design



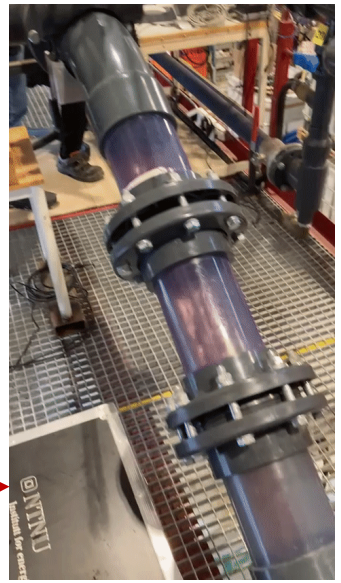






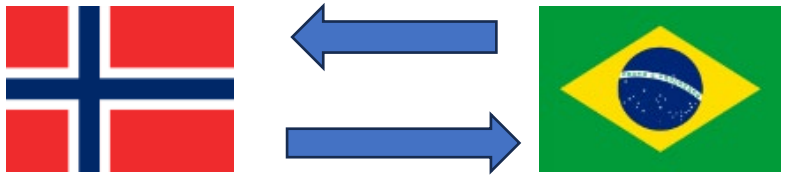


Effect of gas



SUBPRO

Seminars - Student exchange



Brazilian Norwegian Subsea Operations Cosortium (BN-SOC) Intpart Linked to SFI Subpro and MOVE

Intpart 1, 2017 - 2020

Intpart 2, 2022 - 2024

Annual funding (RCN and SIU): NOK 1,12 mill.

NTNU
Norwegian University of Science and Technology

equinor

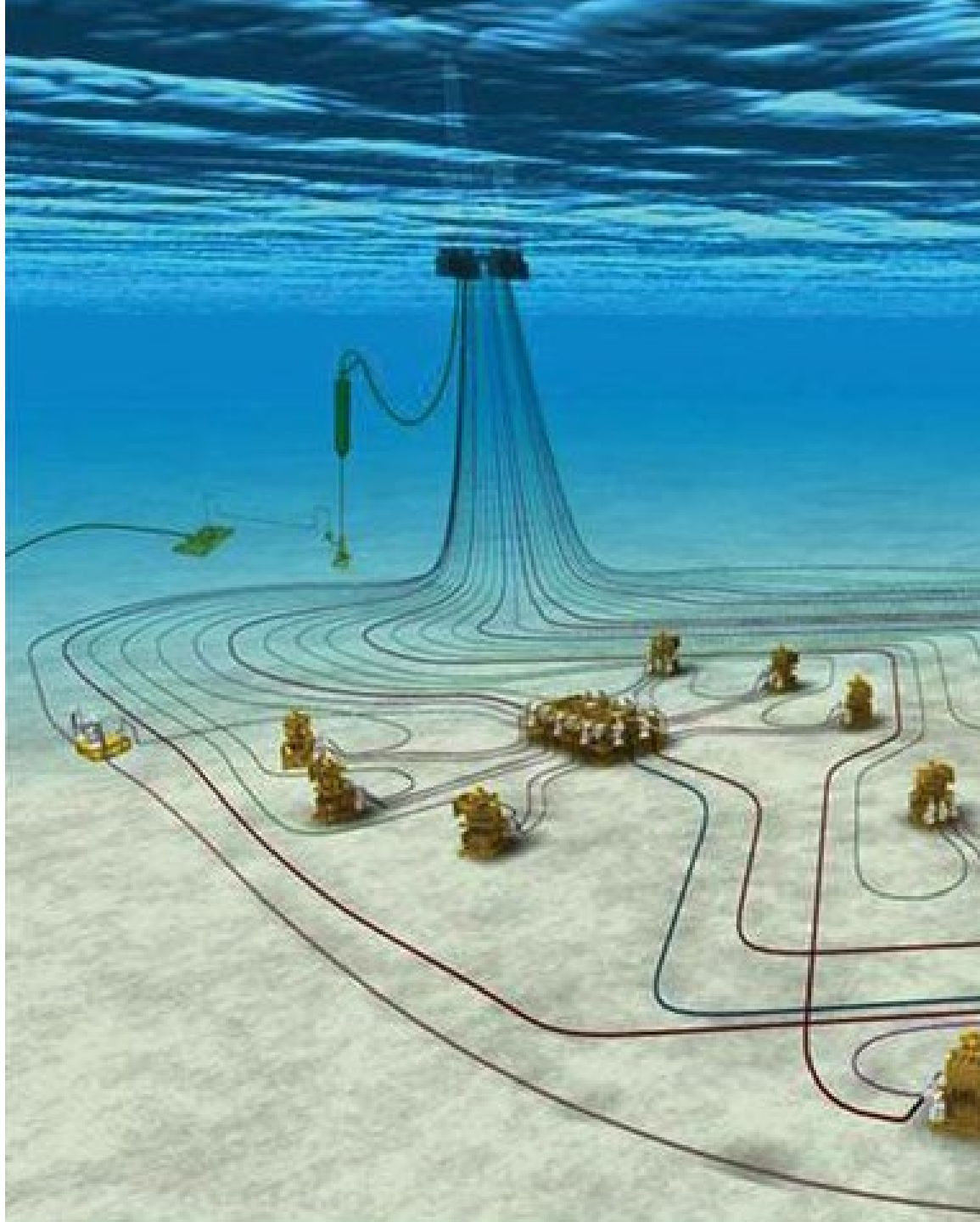
USP
Universidade de São Paulo

BR PETROBRAS

Universidade Federal do Rio de Janeiro UFRJ

GCE Ocean Technology

UNICAMP



Objective of the project partnership

- The main objective of the Brazilian-Norwegian Subsea Operations Consortium (2022-2024) is to continue / establish and develop a partnership within subsea operations, education, research and development.

Workshop in Rio de Janeiro, April 2017

- Subsea field development and architecture
- Safety, reliability and maintenance of subsea facilities and systems
- Subsea operations
- Process operations and process control

Workshop in Trondheim, May 2018

BN-SOC Intpart - Summer school 2019- UniCamp, Brazil

SUBPRO

Project task:

Deep water field development

Workshop in Rio de Janeiro, November, 2022

SUBPRO

- Subsea field development and architecture
- Safety, reliability and maintenance of subsea facilities and systems
- Subsea operations
- Process operations and process control

Workshop in Trondheim, May 2023

Way forward

SUBPRO-Zero projects (2023 – 2026)

Project Title:

- (**PD**) Lean designs for carbon dioxide subsea injection systems
- (**PD**) Design and operation of subsea oil and gas fields powered by renewable sources

THANK YOU!