SUBPRO

A new Norwegian research innovation center on subsea production and processing

Sigurd Skogestad, NTNU

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SUBPRO = SUBSEA PRODUCTION AND PROCESSING
OBJECTIVES AND GOALS

The primary objective of the SUBPRO center at NTNU is to become

• a leading international subsea research center

that provides

• top quality candidates,
• knowledge,
• basis for industrial innovations and technology

in partnership with the most important industrial players in the field.
From NTNU side: Joining forces across disciplines

Professor Hallvard Svendsen (Separation and Reactor Technology)
Professor Johan Sjøblom (Ugelstad lab)
Professor Sigbjørn Sangesland (Petroleum Technology)
Professor Sigurd Skogestad (Process Systems Engineering) Centre Director

Co-Director: Professor Mary Ann Lundteigen, Reliability, Availability, Maintenance and Safety (RAMS)
Project Coordinator: Jon Lippe
From NTNU side: Joining forces across disciplines

Professor Sigurd Skogestad
(Process Systems Engineering)
Centre Director

Professor Sigbjørn Sangesland
(Petroleum Technology)

Professor Johan Sjøblom
(Ugelstad lab)

Ass. Professor Hanna Knuutila
(Separation and Reactor Technology)

Co-Director: Professor Mary Ann Lundteigen, Reliability, Availability, Maintenance and Safety (RAMS)

Faglig koordinator: Gro Mogseth

Project Coordinator: Jon Lippe

Updated August 2015
System design
Boosting
Gas compression
Separation
Power Transmission & distribution
Control systems
Cooling
Water handling
Artificial lift
Storage
Flow Assurance
Installation, Intervention & IMR
Structures, Pipelines & Risers
Subsea Field Center Technology
Gas treatment
Oil treatment
Monitoring
Installation, Intervention & IMR
Structures, Pipelines & Risers
Subsea Field Center Technology
Gas treatment
Oil treatment
Monitoring
Main process directly covered by SUBPRO
Main process partly covered by SUBPRO
Main process not covered by SUBPRO
Supporting systems directly covered by SUBPRO
Supporting systems indirectly covered by SUBPRO
Subsea systems engineering and operation

- Modelling and simulation of subsea components and systems
- System design: Design for more available and robust subsea systems
- Safety: Barrier philosophy for subsea facilities
- Operation: Condition based maintenance and performance optimization
- Control: Development of robust and self-optimizing control strategies

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Subsea separation

- Fundamentals of heterogeneous systems
- Solid/liquid separation
- Liquid/liquid separation and water management
- Gas-liquid separation
- Gas treatment
RESOURCES

- 30 million NOK per year over 8 years (30 million USD in total)
- About 20 PhD’s and postdocs at any time
- Master students

- 18 professors at three NTNU departments – cross discipline collaboration
  - Chemical Engineering
  - Petroleum Technology and Applied Geophysics
  - Production and Quality Engineering

- In kind contributions from industry partners (personnel, knowledge, data)

Duration of project: June 2015 – 2023
BUDGET (TENTATIVE)

Total budget ca. 33 mill. NOK per year
Numbers in 1 mill. NOK

- Industry partners: 15
- NTNU: 6
- Research Council of Norway: 12
PROJECT STRUCTURE

FIELD ARCHITECTURE

CASE 1 (Gas field)  CASE 2 («Arctic»)  CASE 3 (Mature oil)

SEPARATION

WATER MANAGEMENT  OIL TREATMENT  GAS TREATMENT

REMOTE OPERATION

RAMS
(RELIABILITY, AVAILABILITY, MAINTENANCE, SAFETY)

SYSTEM CONTROL
## RESEARCH AREA 1. FIELD ARCHITECTURE

### Industrial challenges
- Standardization of subsea modules
- More effective separation and boosting systems.
- Reduce weight and size of systems / Modularization
- Cost effective strategies for development and operation of remote offshore oil reservoirs with low pressure and low temperature.
- Increase separation efficiency by avoiding choking
- Long transportation to shore or existing production facilities / flow assurance issues: high water cut, low productivity wells, harsh environment.

### Sub projects

<table>
<thead>
<tr>
<th>Sub project details</th>
<th>Sub project leader</th>
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<tbody>
<tr>
<td>1.1 Subsea gate box</td>
<td>Sigbjørn Sangesland</td>
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<td>Milan Stanko</td>
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<td>Jesus De Andrade</td>
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### Research area reference group (Companies):
Input from industry partners is welcome!

### Research area team:
- Sigbjørn Sangesland, Milan Stanko, Jesus De Andrade, Michael Golan; NTNU Department of Petroleum Engineering and Applied Geophysics
- Industry partners which are interested to contribute with in kind:
  Input from industry partners is welcome!
RESEARCH AREA 2.
SEPARATION - WATER / OIL / GAS TREATMENT

Industrial challenges
- Modularization of sea bed systems /more compact unit design/standardization
- Improved separation efficiency / New separation concepts
- Water management (injection and disposal)
- H2S and CO2 handling
- Hydrate and wax control

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<td>2.4 Membrane and membrane contactors for subsea separation</td>
<td>Liyuan Deng</td>
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<td>2.5 Combined H₂S and hydrate control</td>
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<td>2.7 Modelling and experimental investigations of fluid particle breakage</td>
<td>Hugo Jakobsen</td>
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<td>2.8 Multi-scale modelling of interfacial mass transfer and adsorption during coalescence</td>
<td>Brian A. Grimes</td>
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<td>2.9 Compact subsea separation concepts</td>
<td>Milan Stanko/Sigbjørn Sangesland</td>
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**Research area reference group (Companies):**
Input from industry partners is welcome!

**Research area team:**
- Johan Sjöblom, Gisle Øye, Kristofer Paso, Sebastian Simon, Brian Grimes, Hugo Jakobsen, Hanna Knuutila, Magne Hillestad, Liyuan Deng and Hallvard Svendsen, Department of Chemical Process Engineering
- Sigbjørn Sangesland and Milan Sanko, Department of Petroleum Engineering
- Participants from Department of Production and Quality Engineering

Industry partners which are interested to contribute with in kind:
Input from industry partners is welcome!
RESEARCH AREA 3.
REMOTE OPERATION

Industrial challenges

- Improving and complementing process models needed to support more robust and flexible dynamic control
- Design and operation with autonomous control strategy
- Achieving high reliability and availability
- Higher precision in condition based maintenance
- Safety operation with no negative impact on environment

Sub projects (PhD projects, Postdoc projects, industrial projects, lab projects etc.)

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<th>Sub project (short title)</th>
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<td>3.1 New integrated safety and control philosophy subsea (short title: Subsea control and safety philosophy)</td>
<td>Mary Ann Lundteigen</td>
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<td>3.3 Condition and prognostics based maintenance (short title: Prognostics-based maintenance)</td>
<td>Anne Barros</td>
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<td>Sigurd Skogestad</td>
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<td>3.5 Formalisms for control-oriented modelling of subsea systems (short title: Control-oriented modelling)</td>
<td>Olav Egeland</td>
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<td>3.6 Improved control of demanding subsea processes (short title: Control of demanding processes)</td>
<td>Christian Holden</td>
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<td>3.7 Estimation of un-measureable variables (short title: Process state estimation)</td>
<td>Johannes Jäschke</td>
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<td>3.8 Control degrees of freedom for extending remaining useful life (RUL) (short title: Control strategies for life extension)</td>
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**Research area reference group (Company and persons):**
To be specified

**Research area lead:** Mary Ann Lundteigen

**Research area project team:** Sigurd Skogestad, Johannes Jäschke, Anne Barros, Christian Holden, Olav Egeland

Industry partners that are interested to contribute with in kind:
Input from industry partners is welcome!
## 4.1 Overview of sub projects

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SUBPRO goals
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Our goals
- Develop new knowledge and technology to meet future challenges in subsea production and processing
- Provide technological platform for oil companies and suppliers
- Establish international excellence in academia and industry in subsea production and processing
- Educate master students and PhD candidates within subsea production and processing

About SUBPRO and the background for the centre

Visit us at www.ntnu.edu/subpro
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Project coordinator Jon Lippe
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Co-director Prof. Mary Ann Lundteigen
Email: mary.a.lundteigen@ntnu.no
Phone: 00 47 930 59 365

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