SFI MOVE

Marine Operations in Virtual Environments

Annual Report 2016

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SINTEF MARINTEK NTNU

sfi Centre for Research-based Innovation

MOVE SFI Marine Operations

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akp

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a Fincantieri company

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Rolls-Royce

DNV·GL

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Cranemaster

HAVILA

Statkraft

FARSTAD

NTNU
Ocean Training AS

Resarch partners:

NTNU
Norwegian University of
Science and Technology

SINTEF

MARINTEK

CONTACT – SFI MOVE
Hans Petter Hildre
Centre Director
Phone: +47 70 16 12 43
Mobile: +47 959 93 659

Magnhild Kopperstad Wolff
Finance & Administrative Coordinator
Phone: +47 70 16 15 60
Mobile: +47 482 25 391

Website:
https://www.ntnu.edu/move

Postal address:
SFI MOVE
NTNU in Aalesund, Department of Ocean Operations and Civil Engineering
Postbox 1517
NO-6025 Aalesund, Norway

Office location:
NTNU in Aalesund
Larsgaardsveien 2
Aalesund, Norway

Photos:
Else-Britt Ervik
Magnhild Kopperstad Wolff
OSC (animated photos)
Thinkstock

Layout:
NTNU Grafisk Senter

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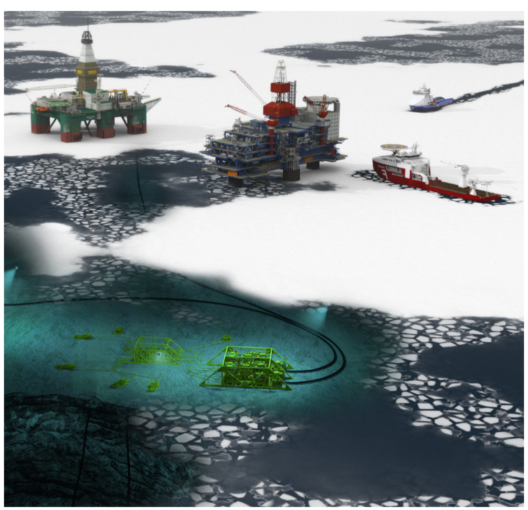
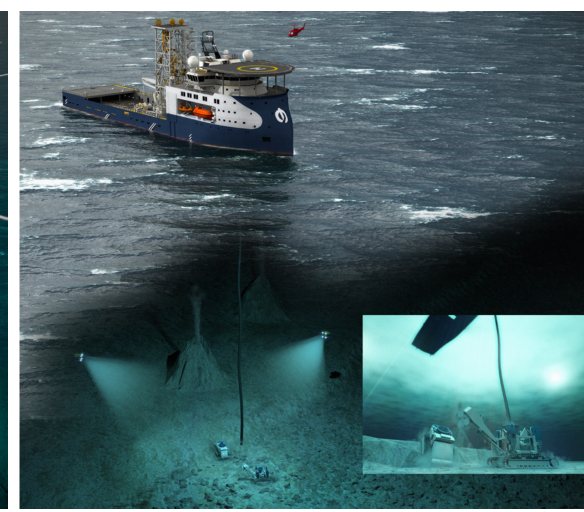
World leading position within demanding marine operations

Our vision





Our vision

To establish a world leading research and innovation centre for demanding marine operations.

Simulation has been used for decades to test the physical aspects of marine operations. Simulators are used to train crew to perform demanding operations. Next generation technology has the potential to provide Virtual Prototyping to pre-test marine operations, including the human component. Cutting-edge interdisciplinary research will provide a bridge between industrial needs, innovation and research.

Research
Our goal is to take a world leading position within demanding marine operations.

Innovation
Our goal is to put the industrial partners in front of defining needs and potential for innovation and business.

Education
The research shall lead to theory and new methods for education as well as training of professionals.

Arena
The goal is to establish an arena for research and industrial cooperation within demanding marine operations.

Objectives

The SFI centre shall support the entire marine operations value chain by developing knowledge, methods and computer tools for safe and efficient analysis of both the equipment and the operation. The developed methods shall be implemented in simulator environments to pre-test marine operations including the human component.

The SFI centre shall support the innovation process of the marine operation value chain through active involvement by industry, thus improving the competitiveness for Norwegian marine industry.

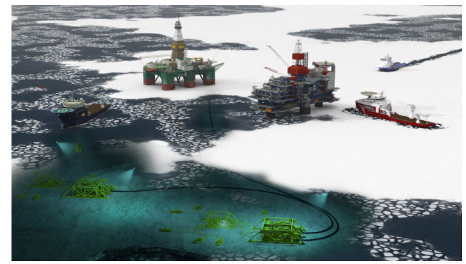
The centre shall:
- Achieve all-year subsea operations installation and service
- Perform safer and more cost-efficient operations
- Support innovation in existing and emerging ocean industries

The idea is to optimize operations, from planning to execution, by better understanding of the responses. This is a simulation-oriented approach where models are re-used throughout the value chain.

- System development and design
- System integration and configuration
- Ship and ship equipment
- Operation planning
- Crew Competence and Training concepts
- On-board systems
- Operation execution
- Learning

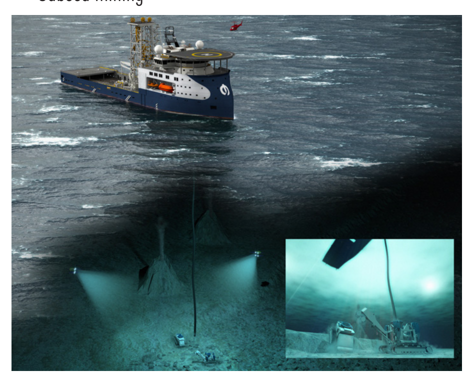
Business areas

The business areas focused on in 2016 are:
- Demanding marine offshore operations as at ultra-deep water, all-year availability, or arctic areas



- Installation and maintenance of offshore wind

- Subsea mining



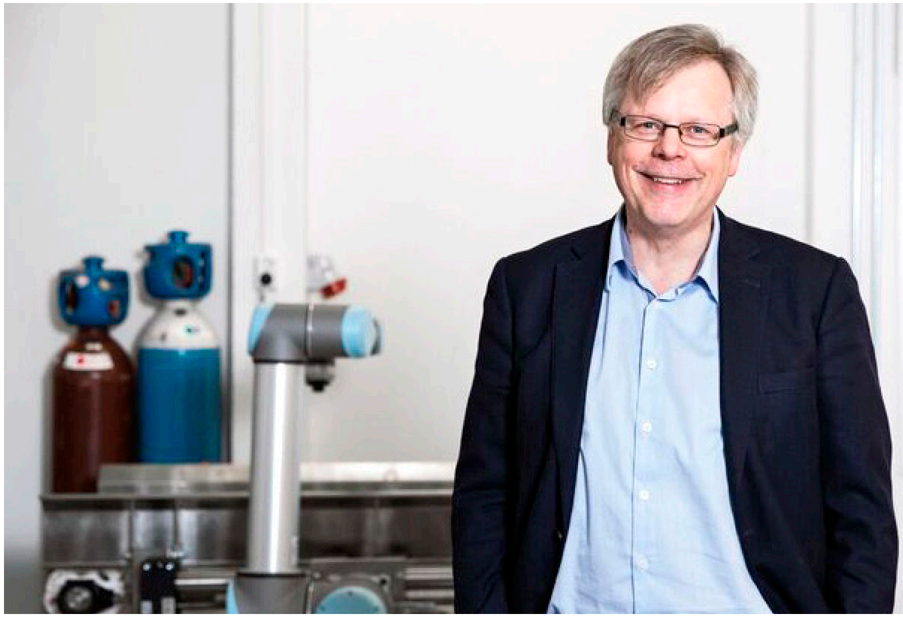
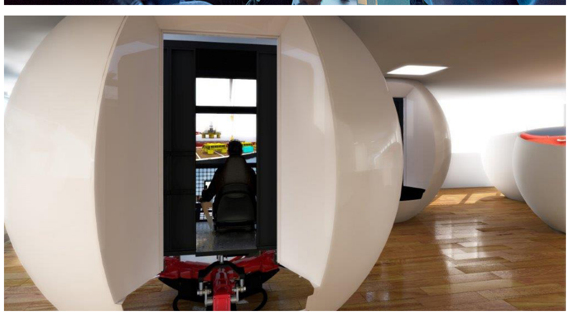


Photo: Kristin Steiten

Directors' report

Professor Hans Petter Hildre is the leader for SFI MOVE



Norway has a long coastline and a continental shelf that is six times larger than the mainland and constitutes a third of the European continental shelf. It has major oil and gas resources, rich areas for fishing, good conditions for fish farming as well as offshore wind and a leading position in the ocean industries. 70 % of Norwegian export is from ocean-based industries. Marine operation is a core of development of this industry.

SFI MOVE has completed 1.5 years of operation and has become a centrally uniting research effort among four research partners. Aalesund University College has become a part of NTNU and MARINTEK and SINTEF Fisheries and Aquaculture has become SINTEF Ocean. We are very pleased for the restructuring of the research partners in two strong organisations.

The offshore oil and gas industry have been facing huge challenges in 2016. We have seen significant restructuring of the offshore support business and efforts reducing costs have been a top priority. Research in SFI MOVE are trying to balance between activities that can enhance the competitive strength in short-term and long-term strategic research efforts.

Low-cost innovative installation of Wind Power Systems

According to Vattenfall, the development costs of offshore wind power plants were reduced by approximately 50 % in 2016. Bottom-fixed offshore wind projects have reached a cost level where they are profitable even without subsidies.

The EU is likely to reach its target that 20 % of the total energy consumption should come from renewable energy sources within 2020. Their future target is to increase the amount of renewable energy to 50 % within 2030. A report from the global wind power industry organisation GWEC estimates that the investment rate for wind power may be doubled from NOK 900 billion in 2016 to NOK 1800 billion in 2030.

Installation and service of offshore wind power plants is already a massive industry!

Installations are normally carried out with a jack-up ship and with high-lift cranes lifting the individual parts of the offshore wind turbine in place one by one. In total, this is 5 individual lifting operations. SFI MOVE is working with three innovations that can result in major cost cuts:

1. Grip and lift in the lower end of the tower, rather than using a crane which can be as high as 130–140 m.
2. Lift the whole installation onto its new foundation in one single operation.
3. Using a floating installation vessel rather than a jack-up structure. The tower handling is supposed to be taken care of by a manipulator compensating for the ship's motion.

A ship hull is developed and a crane based on robotic technology is sketched. Simulation models are made and preliminary simulations for wind power assembly on fixed structures are done and presented. Forces between the ship hull and the fixed structure are a challenge and needed damping devices are in the process of development.

Safe – All-year – Effective subsea installation and service

In the development of offshore oil and gas fields, more and more of the fields are utilising subsea technologies. An increasing number of subsea wells and trees in operation both at the Norwegian Continental Shelf as well as in other regions for offshore activities can be seen. This also leads to an increase in the volume of maintenance of subsea facilities and wells in the years to come. Today a number of fields are also being assessed for life extension, which also contributes to an increased number of systems in operation as the average years in service increases.

The objective of SFI MOVE is to facilitate marine operations taking place in a commercial and cost efficient manner and thereby contributing to positioning the Norwegian Maritime industry towards the market of such operations worldwide. As subsea field developments are getting more extensive, there is an increasing need for all-year marine operations.

All-year operation will have a significant impact on both technology, operational procedures, cost, and will require very different solutions depending on the environment in which you operate.

There is a need for new methods, systems and equipment to achieve the defined objective. Our aim is to establish a virtual prototyping (VP) approach for subsea operations. The following topics have been focused on:

- Systematic study of installation vessels leading to indicators for vessel performance. Based on this study the design parameters that contribute to increasing the operational performance for various geographical locations and type of operations will be identified. This is a multi-criteria approach making it possible to optimize the vessel design for unique operations.
- Simulation of dynamic system behaviour during deployment operations (ship, crane, winch, ballast

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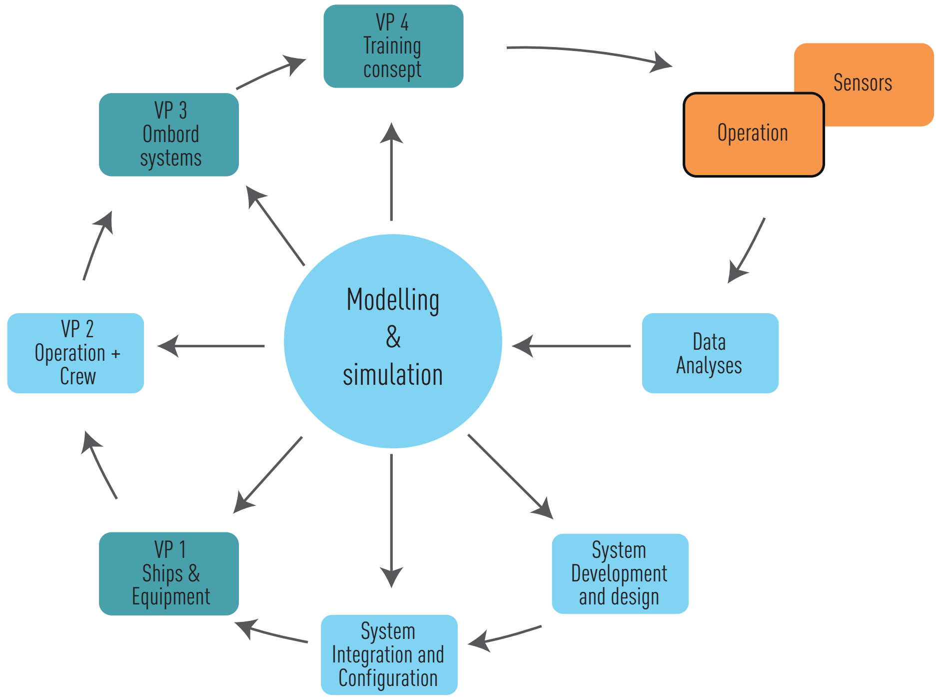
- Simulation of dynamic system behaviour during deployment operations (ship, crane, winch, ballast and damping) with systematic parameter variation. Study of system dynamics (statistical distribution of response peaks, estimation of extreme response).

Exploration of Technologies to Develop Seabed Mining as a New Business Area

The mining industry has a large growing resource potential if moving from onshore to offshore. Present challenges also creating offshore opportunity include: Future lack of onshore resources, rare earth material challenge, geopolitical positioning, conflicting societal interests (environmental damage vs business). Large volume of resources most likely available both inside/outside national waters, very high uncertainty on value of resources. In Norwegian waters alone, an NTNU study estimates low value USD 75 bn. No upper limit. SFI MOVE has focus on the design of lift systems to allow efficient lift of minerals from the seabed to the ship.

Simulation Technology and Virtual Prototyping as a Common Approach from Design to Operation

We are facing a substantial technology shift in digitalising industrial processes. We will see new methods of designing ships, equipment and operations as well as crew training. In other words, virtual ships and virtual operations. Ship designers are at present developing real time energy management systems, vessel health management systems, remote control systems and autonomous ship systems. Numerical real time behaviour models are a precondition to



an effective development of such systems. This shift will move simulation from a verification point of view to a design and operation point of view. We can see the following key benefits of this development.

- Transform the industry to a simulation and performance oriented operation approach.
- Increase innovation speed by fast prototyping of ships and operations
- Verification of operations including human factors
- Reduce cost by re-use of models during the process from preliminary investigations to execution of operations

The primary project objective for SFI MOVE is to develop an open, standardized framework and architecture for system simulation and virtual prototyping, which will be a new platform for product development, training and cooperation in the maritime industry. A key to achieving such functionality is an open framework, standardized interface and generic models to be shared in the industry.

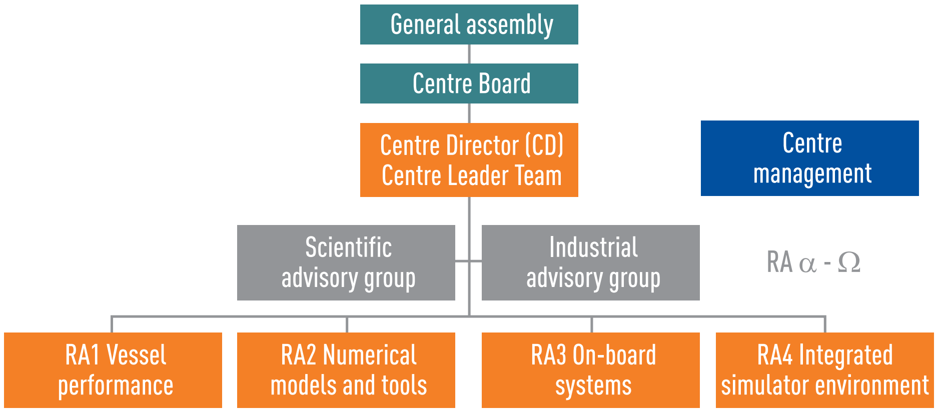
The purpose is to present methods and demonstrate the cycle from design to virtual prototyping as shown in the figure. Explore shortcomings and suggest improvements.

Research organisation

The following research partners were involved in the beginning of 2016:

- NTNU in Ålesund (former Aalesund University College)
- NTNU
- SINTEF Fisheries and Aquaculture
- Marintek

Aalesund University College has become a part of NTNU and MARINTEK and SINTEF Fisheries and Aquaculture has become SINTEF Ocean. We are very pleased for the restructuring of the research partners in few and strong organisations. *The project is organised as show in the figure.*



Organisation chart

The Board of the Centre has the following members:

- Torleif Sætrevik, Chairman, (Statkraft)
- Thore Thuestad[1] (Statoil)
- Tore Ulstein (Ulstein Group)
- Guro Løken (EMAS AMC)
- Hans Petter Hildre (NTNU in Ålesund)
- Harald Ellingsen[2] (NTNU)
- Halvor Lie (Marintek)

Centre Director:

Hans Petter Hildre, Professor, Dean of Faculty of Marine Technology and Operations, NTNU in Ålesund

Administrative key personnel:

Magnhild Kopperstad Wolff, Finance & Administrative Coordinator, SFI Move, Faculty of Marine Technology and Operations, NTNU in Ålesund

Industrial Advisory Board:

- Runar Stave, Olympic
- Harald Stenersen, Havila
- Per Ingeberg, Rolls-Royce Marine
- Bjørnar Vik, Rolls-Royce Marine
- Joel Mills, OSC
- Erling Myhre, Statoil
- Ken Nilsson, Ocean Installer
- Børge Nakken, Farstad
- Ove Bjørneseth, Vard
- Henning Borgen, Vard
- Per Erik Dalen, ÅKP/GCE Blue Maritime

The industrial partners in the project are:

- Farstad Shipping
- Olympic Shipping
- Havila Shipping
- Rolls-Royce Marine
- Ulstein International
- ÅKP/GCE Blue Maritime
- OSC
- Vard
- Cranemaster
- NTNU Ocean Training[3]
- Statoil Petroleum
- EMAS-AMC
- Ocean Installer
- Statkraft
- DNV-GL

The project leaders are:

Project	Project Leader	Deputy project leader
Offshore Wind	Karl Henning Halse, NTNU	Zhen Gao, NTNU
Subsea	Ole Økland, Marintek	Zhang Houxiang, NTNU
Virtual Prototyping	Lars Tandle Kyllingstad, SINTEF	Gaspar Henrique, NTNU
Mining	Svein Sævik, NTNU	

[1]Was replaced by Arnt Olufsen during 2016 [2]Was replaced by Sverre Steen during 2016 [3]Former Marine Operations

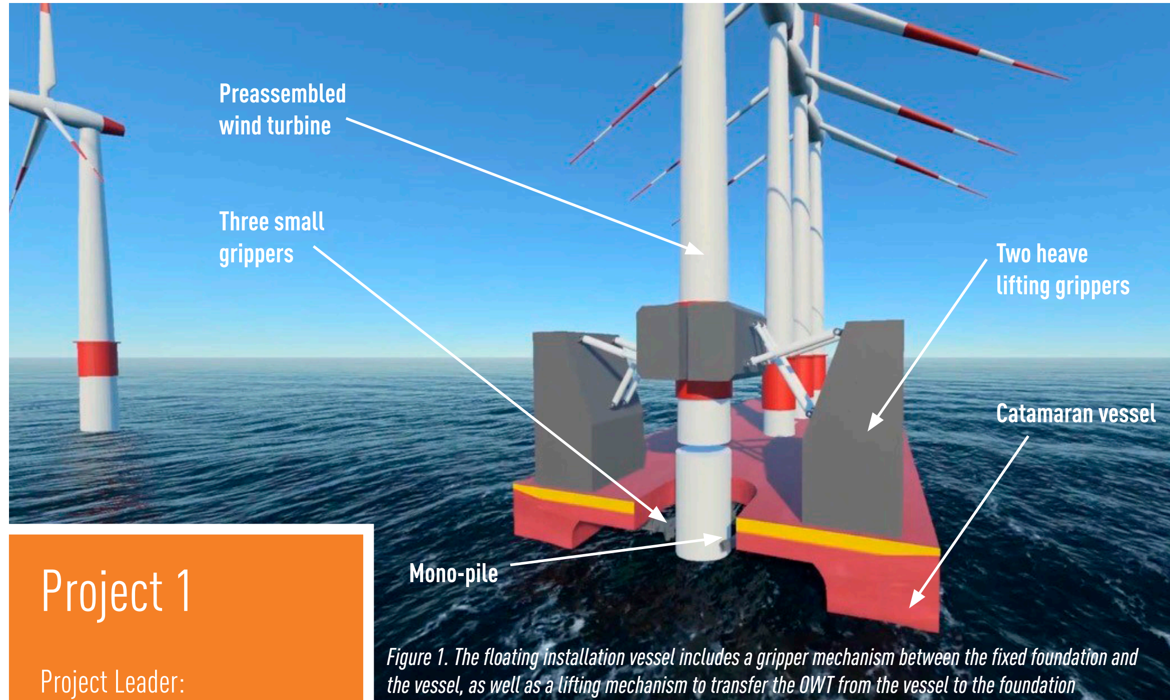


Figure 1. The floating installation vessel includes a gripper mechanism between the fixed foundation and the vessel, as well as a lifting mechanism to transfer the OWT from the vessel to the foundation

Project 1

Project Leader:
Karl H. Halse (NTNU Ålesund)

OW 2016 – Low Cost Installation and Maintenance of Fixed Offshore Wind Structures

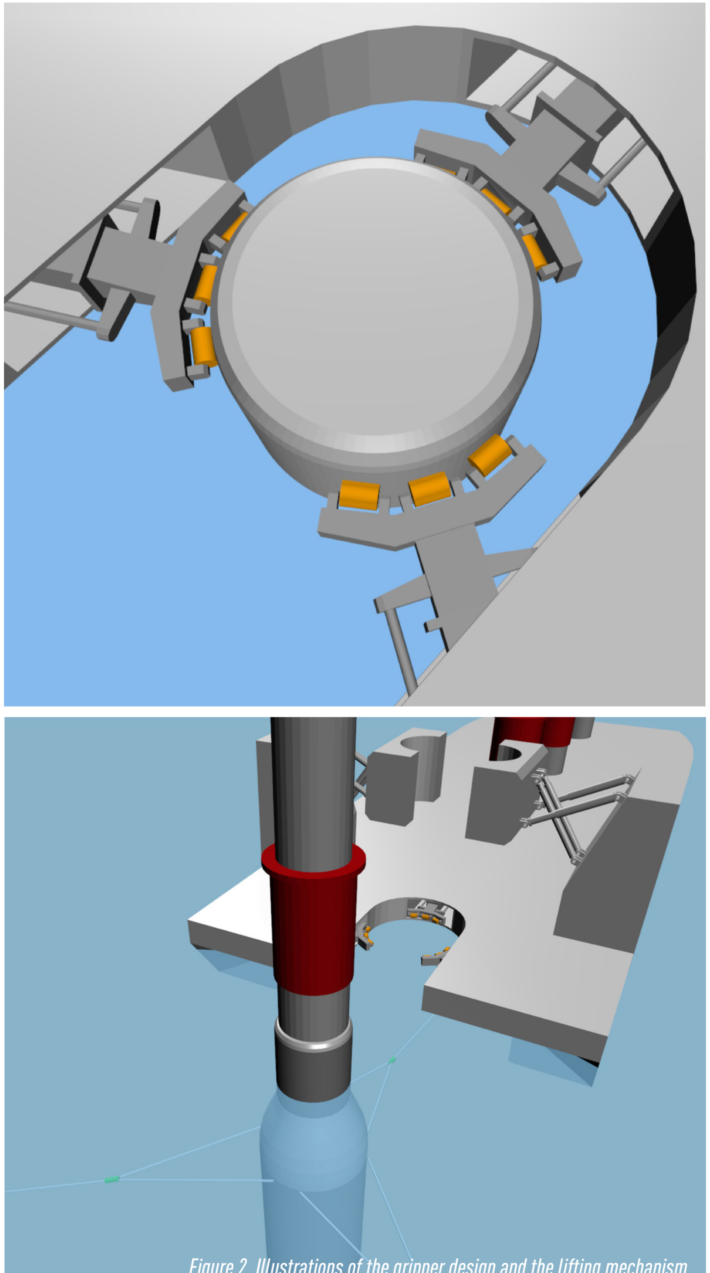


Figure 2. Illustrations of the gripper design and the lifting mechanism

The installation costs of a typical offshore wind power plant, is a substantial part of the overall costs for the project (up to approx. 30 % of the total development costs).

Today, Offshore Wind Turbines (OWT) are installed by the use of jack-up platforms (or jack-up ships). This is a costly and time-consuming way of installing the turbines. A critical phase is the positioning of jack-up legs onto the seabed. During this phase, impact forces occur, which are correlated with the barge's heave, roll, and pitch motions.

Study of the use of flopper stoppers:
One of the activities in this project has been to investigate the effect of a flopper stopper on the motion responses of a jack-up barge. The flopper stopper functions as a passive roll compensation device and is suspended from the side of the barge. A brief summary of the work carried out in this activity is given below:

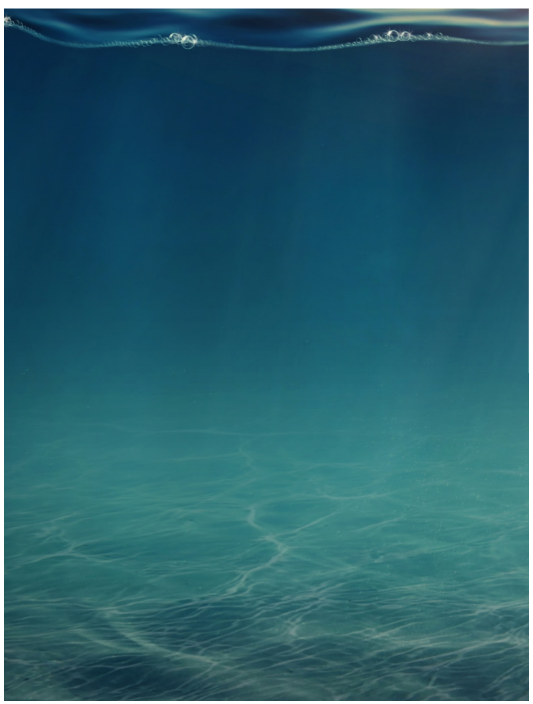
- *Performed basic design of a flopper stopper for leg positioning of a jack-up barge.*
- *Conducted global dynamic analyses for the barge system with a flopper stopper.*
- *Established the jack-up operational limits in terms of the significant wave height and peak period by use of characteristic values of leg impact velocities.*
- *Quantified the effect of the flopper stopper for different wave headings.*
- *As expected, the roll motion appears to be the response which is most affected by this device, and a 35 % increase of the operational wave height in beam sea was found.*

Study of a novel installation vessel design:
A floating installation vessel would totally eliminate the challenges involved with setting down the jack-up legs. This will save both time and money in the process of installing an offshore wind power plant. The project includes an activity to study whether it is possible to do the installation of an OWT onto a fixed installation from a floating vessel (see Fig. 1). A brief summary of the work carried out is given below.

- *Design of a catamaran vessel to be used for installation of OWTs. The concept was designed to carry 4–5 OWTs each weighing 1000–1500t.*
- *Stability calculations were carried out and compared with a monohull vessel of similar size. The catamaran proved to have increased stability compared to the monohull.*
- *Hydrodynamic response analyses were carried out using the vessel response module in SHIPX, to support the response found in the physics engine in the simulator (AGX).*
- *Design and modeling of a Tank flow control system for the catamaran, both for anti-heeling and roll-reduction purposes.*
- *Compared the response amplitudes of the Catamaran from WAMIT analysis with those from ShipX analysis, and found a general agreement despite some discrepancies*
- *Design of a possible gripper mechanism (see Fig. 2) to control the vessel motions relative to the fixed foundation.*
- *A preliminary design of a lifting mechanism (see Fig. 2) to lift the OWT and control the motions of the OWT relative to the fixed foundation.*

Normand Mermaid during a Subsea Lifting Operation at Gina Krogh in November 2015 (Photo: Kristin Steilen)

Figure 3. Installation of the Troll-Olje Satellite Protection Structure with suction anchors (Photo: Peter Chr. Sandvik)



Project 2

Project Leader:
Ole Økland, Marintek

Subsea: Safe – All-Year – Cost-efficient Subsea Operation

The scale of complex subsea field developments will probably increase. There will be a continuous need for cost improvements for field developments and the cost and ability of maintenance, repair and intervention of such fields.

Subsea *installation and services* have operational limitations due to environmental conditions such as waves, wind, currents and water depth. In areas with a harsh environment, there will be operational limitations in performing marine operations. For areas with water depth down to 3000m, there will be limitations on weight and dimensions of modules and units. In addition there are challenges with vertical span dynamics. The water depth makes the operations time consuming and puts limitations on the payload capabilities. In addition the landing sequences may be complex due to sensitivity to current.

The objective of the project is to facilitate marine operations taking place in a commercial and cost-efficient manner and thereby contribute to positioning the Norwegian Maritime industry towards the market of such operations worldwide.

- Make operations safer and with required accuracy.
- Improve HSE by making the operations more robust vs. available weather window.
- Reduce total field development costs by more cost-efficient marine operations.
- Increase operational efficiency of subsea fields by all-year vessel operation.

As tools and methods to simulate marine operations vs. weather criteria become more accurate, the Rules & Regulations should be adjusted accordingly.

The operational limitations of marine operations through a moonpool, or from the deck of an installation vessel are influenced by several factors. The specific limitations need to be assessed carefully based on vessel motion characteristics, the deck handling system (including personnel), and shape and size of the object to be installed. Accurate simulation tools are a vital key with respect to planning of operations as well as training for realistic operations with simulators and monitoring systems offering support during operations. In 2016 an important part of the work in this project has been related to assessment of hydrodynamic coefficients for various complex structures. Marintek have issued a paper and a technical report summarizing results from this study, and hydrodynamic load on complex structures is also the topic of one PhD and one postdoc in the subsea project. A 2D model test to obtain added mass and damping for complex subsea structures has been conducted in May–June, 2016.

A case study based on data from the subsea installation of an integrated template structure (ITS) with mass 285.7 t, on the Johan Sverdrup field (depth 120m) has been defined in 2016, and will be used to explore potential and limitation for different types of installation vessels and operations. These case studies will also serve as a basis for development and validation of new or enhanced simulation models, monitoring systems and implementation of enhanced functionality in simulator systems for training.

In the first part of the case study, a numerical model of lifting vessel and equipment will be defined, and initial simulations of the operation will be performed. The work will consist of the following tasks:

- Model of lifting vessel with simplified positioning system. The model will include diffracted wave points for study of shielding effects.
- Model of ITS with depth dependence coefficients and shielding effects.
- Model and analysis of lift in air.
- Model and analysis of water entry, splash zone crossing.
- Model and analysis of lowering through the wave zone.
- Model and analysis of landing on sea bed.

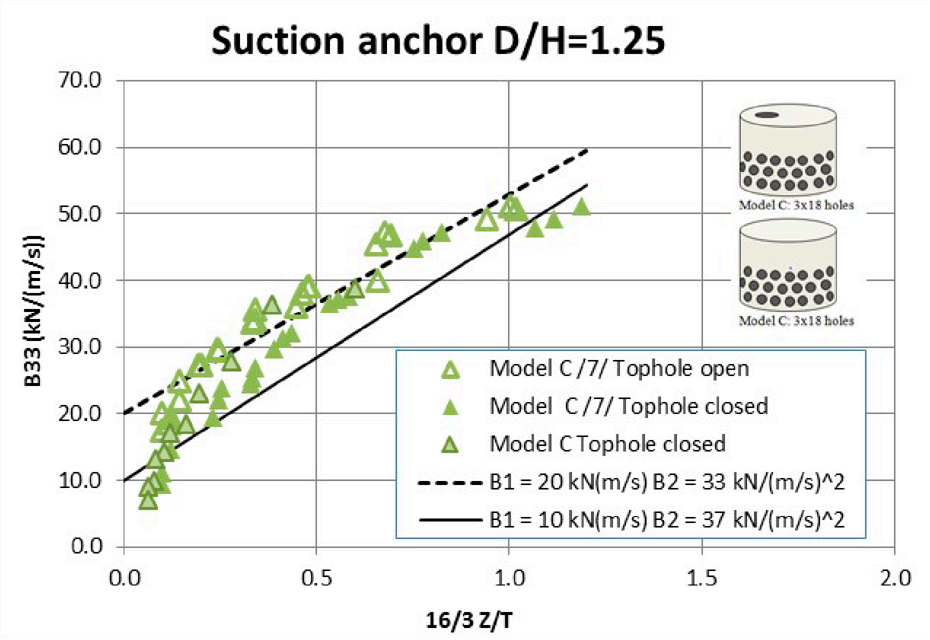
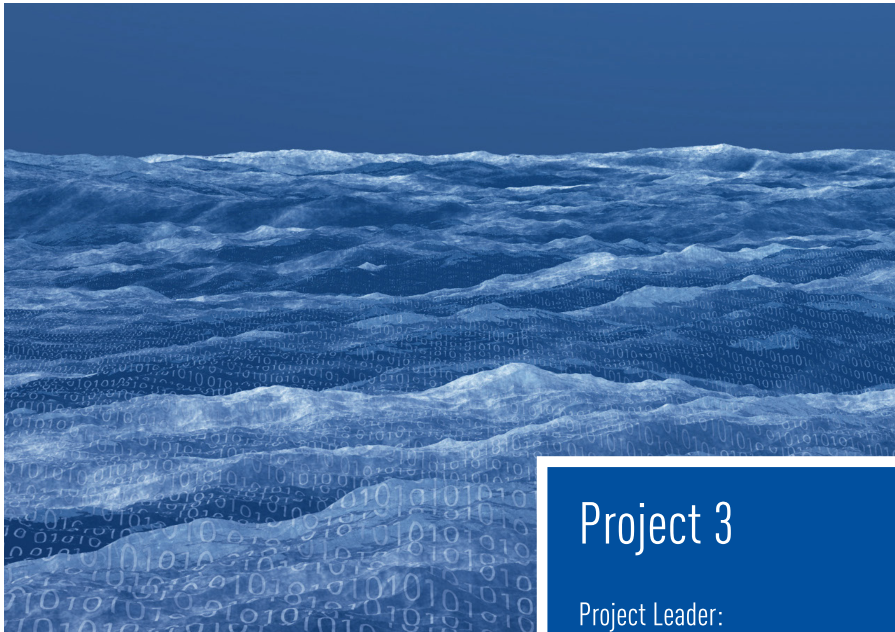
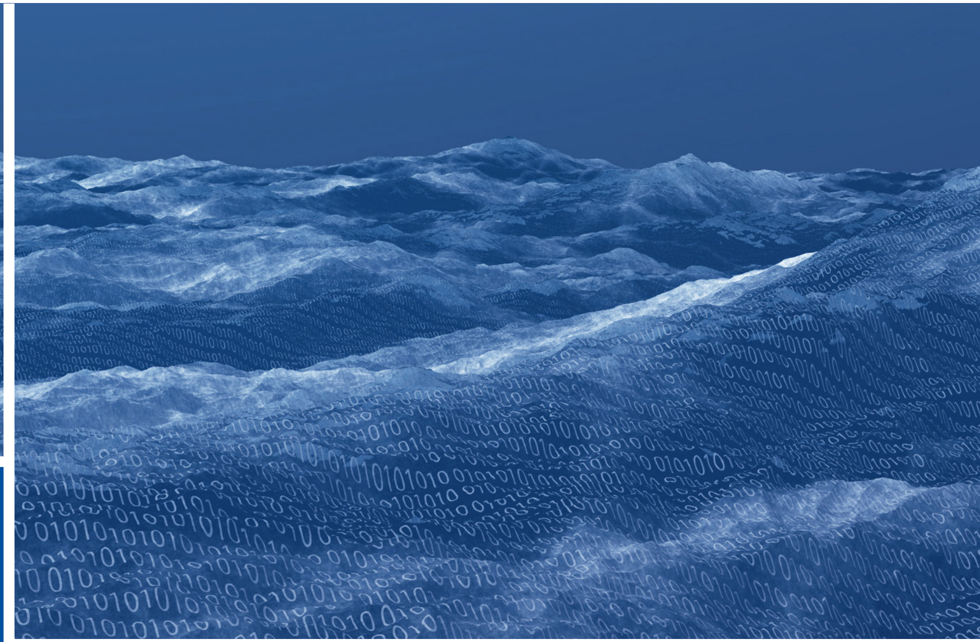


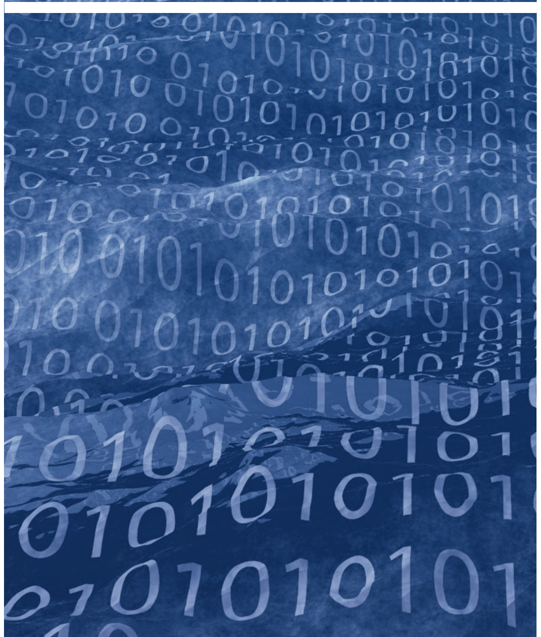
Figure 4. Illustration of manually fitted linear and quadratic damping for suction anchor with different perforation on the side walls.

The numerical modelling of the ITS will include estimation of hydrodynamic coefficients based on data for similar structures and sensitivity to choice of coefficients on the obtained limiting sea state will be assessed. Depth dependency of the coefficients will be included and effect of slamming studied. Modelling of tugger wires and winches will be studied and different set-ups will be tested.

Work on data collection systems and on-board monitoring has also been initiated in 2016 and will be followed up in 2017. Validated simplified models established in the case studies will be used in this work and also lead to improved numerical models for integrated simulator environment (e.g. for training of personnel).



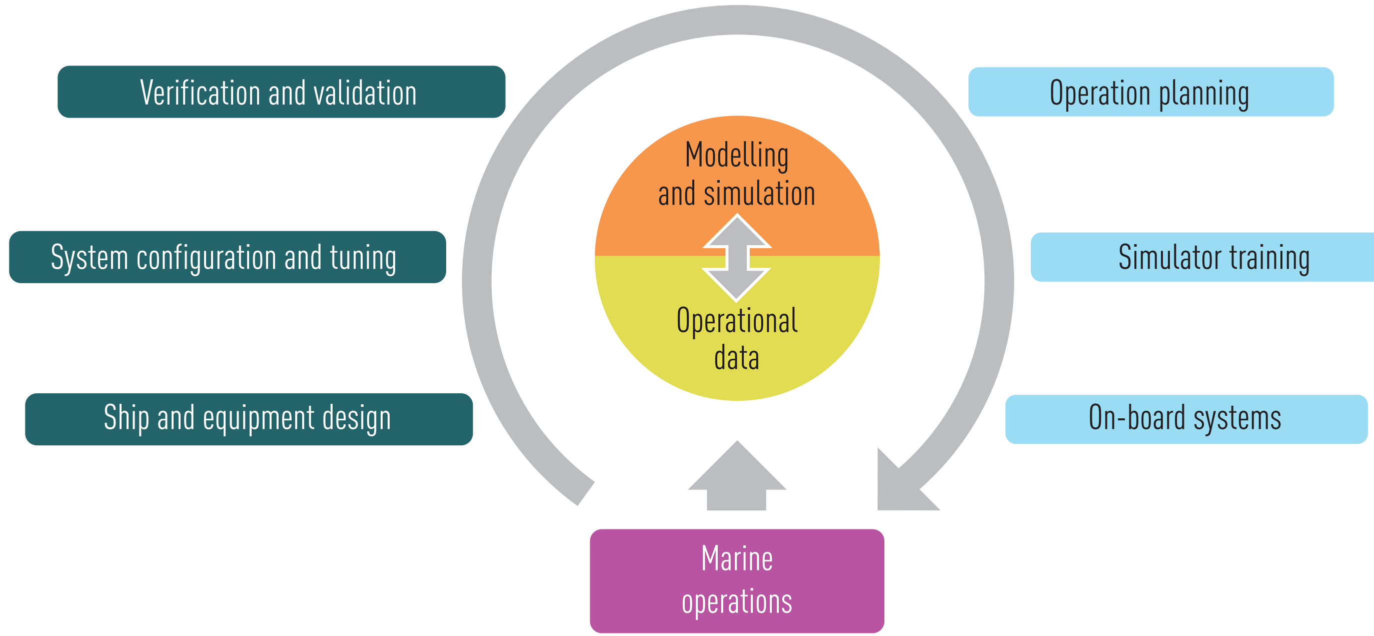




Project 3

Project Leader:
Lars T Kyllingstad, SINTEF

Demonstration of State of the Art Simulation Technologies and Virtual Prototyping as a Common Approach from Design to Operation



The idea of the "Virtual Prototyping" sub-project is to explore the opportunities offered by simulation-based workflows and tools throughout the maritime value chain, from design to operation and, closing the loop, back to design again. The maritime industry is under constant pressure to deliver better solutions and more efficient operations at a lower price and in a shorter time span, and virtual prototyping methods promise great improvements over traditional workflows when it comes to achieving this.

The project has two primary goals:

- To establish common standards and formats for exchange and re-use of digital information and models in the maritime industry.
- To present methods and demonstrate how simulation and virtual prototyping can be used throughout the whole cycle from design to operation.

These are closely linked, as the former is a prerequisite to achieving the latter. Agreed-upon data formats would allow data collected in real operations to be more easily used by different people for a variety of purposes, while common modelling and simulation interfaces would allow exchange and re-use of mathematical models between organisations and throughout the maritime value chain.

Real-world data collected from vessels during actual operations is needed for several purposes:

- As a basis for development and verification of models, methods and software
- As input to performance analyses, decision support systems and simulations.

In 2016, activities were initiated within MOVE to begin systematic collection of data from offshore construction/maintenance vessels. This included developing and preparing software and hardware to be installed on the vessels, and to identify the information needs of other MOVE sub-projects. Unfortunately, it proved difficult to begin the actual installation on the vessels, but the work will continue in 2017 with a goal to have continuous data collection up and running on several vessels by the end of the year.

With a solid data foundation and good mathematical models, it becomes possible to perform highly sophisticated simulations of the complex dynamics of maritime systems and operations. Too often, however, the potential of such simulations is never fully realised, because the models are made for a single purpose or even a specific study, and are difficult to re-use in a different context. A commonly encountered reason is that the models are constructed in a monolithic fashion where it is difficult to extract single components for later re-use. Incompatibilities between programming languages and modelling software are another. Ideally, what we want to enable is:

- The ability to construct full-system models from component models.
- Easy reuse and adaptation of models for different purposes, such as analysis, prototyping, training simulations and onboard decision support systems.
- Efficient knowledge transfer between research, development and industrial use.

There are several obstacles to achieving this, including the large number of incompatible simulation tools used in different engineering disciplines and by different companies, some of which require a high degree of specialist expertise to use.

In 2016, MOVE took the first steps in this direction by starting to adapt the research partners' in-house modelling and simulation software to support FMI, an open, standardised interface for model exchange and co-simulation. This work will continue in 2017 and will be demonstrated in a series of comprehensive case studies of simulated marine operations. The standardisation work in MOVE is being coordinated with several other R&D projects and research centres, including the other SFIs Smart Maritime and Exposed.

Project 4

Project Leader:
Svein Sævik, NTNU

Seabed Mining:
Exploration of Technologies to Develop Seabed Mining as a New Business Area

The interest for subsea mining is growing. Norway controls one of the world's largest sea areas – six times the land area of Norway, including the northern expanse of the Mid-Atlantic Ridge. In Norwegian waters alone, NTNU study estimates low value USD 75 bn No upper limit. The Marmine NFR project (https://www.forskningsradet.no/prosjektbanken/#!/project/247626/no) started with a research cruise to the Arctic Mid-Ocean Ridge (AMOR) in 2016, covering the extended Norwegian Continental Shelf. NTNU and NIVA, together with several research partners, surveyed and sampled potential mineral deposits on the ridge. AUVs and ROVs were used for surveying selected target areas. Survey data were collected using different types of imaging equipment to provide means of defining the prospective sites. The mission included water depths down to 3000 m. Selected sites were studied through sampling of rocks and drill cores from the sea floor and inside the upper part of the sea floor. This sample material will be used for characterization of the ores.

Parallel to this, NTNU Oceans, Pilot Deep Sea Mining is an ongoing project being part of NTNU Oceans, which is one out of four strategic research areas at NTNU. This program coordinates all activities related to sustainable Ocean Space utilization (https://www.ntnu.edu/oceans). With respect to Ocean Mining the current activities include a wide range of related topics: Autonomous exploration, detection of sea-floor minerals based on spectral signatures, energy supply, environmental aspects of deep sea mining, ethics and social responsibility, exploration – geophysics, history of subsea mining – legal aspects, platform development, resource assessment, resource geology and vertical transportation.

With respect to SFI MOVE, the marine operation aspects of ocean mining including the structural behaviour of the riser system needed to transport the deposit from the seabed to the vessel is focused on. The material transport may be provided by pumping water and rock particles (slurry low) possibly combined with compressed air through the riser. The structural behaviour of the riser system when exposed to both external current and internal flow at large water depths is identified as a critical topic. Therefore, two PostDocs, Niranjan Reddy Challabotla and Mats Jørgen Thorsen have been allocated in SFI MOVE to work on these issues. The objective includes development of models that enable studying coupled dynamics phenomena related to both two-phase (water and rock) and three-phase flows (water, rock and air). The overall objective of the work is to provide a fully dynamic model that can handle both steady state and transient dynamics of such systems. The concept is illustrated in Figure 5 and its performance as compared to the state of the art is illustrated in red in the Table 1 where it is noted that the state of the art of today only includes Methods 1–3.

	Flow model	Structural model
Method 1	Steady state	Static
Method 2	Steady state	Dynamic
Method 3	Transient	Static
Method 4	Transient	Dynamic

Table 1: Illustration of the research objective (red) as compared to the state of the art.

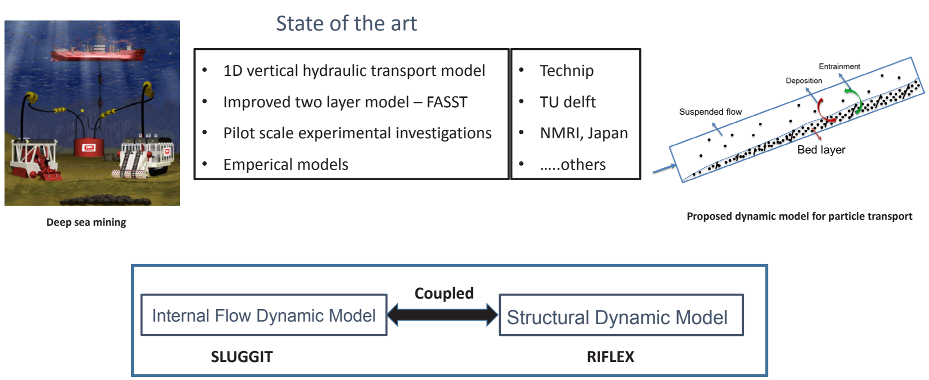


Figure 5: The coupled dynamic model concept.

Figure 6. Illustrations of simulator environment for marine operations (Both photos over.)

Project 5

Project Leader:
Karl H. Halse (NTNU Ålesund)

OW 2016 – Installation of Floating Wind Power Systems

Statoil installed a 2.3 MW floating wind turbine in 2009 (Hywind Karmøy), and with that they are one of the pioneers of floating wind turbines. During the summer of 2017, they have planned to install the world's first floating wind power park, known as Hywind Scotland. The wind park consists of five floating wind turbines of 6 MW each and is estimated to cost approx. NOK 2 billion..

Although the technology development has reduced the installation costs significantly for fixed offshore wind installations, they still have cost challenges. The technology development of floating wind parks has an even longer way to go, but Statoil has already reduced the installation costs with 60–75 % per MW, and claim that they will earn money on the HyWind Scotland project. Furthermore, the pressure on shallow water areas will force offshore wind power plants further from the shore and into deeper water. The challenge is to develop solutions which can be realized at lower costs both for installation and operation.

In 2016, this project was just initiated and should be considered in conjunction with Project 1 Installation of OWTs at fixed installations. Some of the ideas elaborated in that project may be continued for floating foundations.

The goals for a floating OWT power plant will include:

- Water depths from 40m to approx. 700m
- Heights of the OWTs between 150 and 200m
- Weights of OWTs between 500–2000t

In this project one of the ultimate goals is to develop a simulator, which can be used to test out new ideas, including both new designs and new installation methods. To achieve this, the project has to work along two axes; one is to implement existing numerical models into a real time simulator environment, while another is to continue to develop more advanced numerical models to account for new effects. One of the benefits of a real time simulator is to demonstrate new installation projects as a part of planning the real project (see Fig. 6). This also includes raining of – maritime personnel. This will increase safety and efficiency of the marine operation, thus contributing to reduce the costs involved with these installations.

Research cooperation

National cooperation

Project leaders in ocean based research projects at NTNU and SINTEF have regular meetings coordinating activities. SFF-AMOS[3], SFI-EXPOSED[4], SFI-SMART, SAMCoT[5], SFI-MOVE and NTNU strategic research area Ocean is a part of this co-ordination.

SFI MOVE has also a close cooperation with GCE Blue Maritime.

Ocean School of Innovation

This group has in cooperation with NTNU-TTO established Ocean School of Innovation. The purpose of this program is to simulate PhD students for innovation.

Main goals

1. Create a culture for innovation
2. Strengthen the awareness and competence on innovation
3. Contribute to increased commercialization of research results

Courses and training

- Entrepreneurship
- Innovation in start-ups and large companies
- IPR and Asset Management
- Design Thinking

Culture for innovation

- Innovation Lunches
- Teambuilding and Networking
- Pitching
- Tech Transfer Speed-dating
- Funding Opportunities

Members

"Centre for Autonomous Marine Operations and Systems – AMOS"
Senter for fremragende forskning (2013–2023)
Web: https://www.ntnu.edu/amos
"Sustainable Arctic Marine and Coastal Technology – SAMCoT" Centre for Research based Innovation (SFI)
Web: https://www.ntnu.edu/samcot
"Marine Operations MOVE"
Centre for Research based Innovation (SFI)
Web: https://www.ntnu.edu/web/move/sfi move
"Exposed Aquaculture"
Centre for Research based Innovation (SFI)
Web: http://exposedaquaculture.no/
"Smart Maritime"
Centre for Research based Innovation (SFI)
Web: http://www.smartmaritime.no/
"NTNU Oceans"
Strategic Reasearch Area at NTNU 2014–2023
https://www.ntnu.edu/oceans

Activities 2016

Innovation lunches

- The Story of Telcage with Oddbjørn Rødsten (08.09.16)
- Funding of start-ups with Inge Hovd Gangås, Sintef TTO and Venture (03.10.16)
- The Story of MemfoAct with Arne Lindbråthen and Gøril Forbord (postponed to 2017)

Seminars and courses

- Technoport "Crack the Code" (02.03.16)
- Entrepreneurship – Perspectives from Silicon Valley with Prof Jack Fuchs (03.03.16)
- From Idea to Market with Innovation Norway (18.10.16)
- "PUBLISH OR PERISH – DEMO OR DIE" Design Thinking with Prof Martin Steinert (postponed to 2017)

Other activities

- Kick off meeting with center leaders at TTO (09.09.16)
- Kick off meeting at AMOS with PhDs (18.08.16)
- Exposed: Seminar for Phd's in Aquaculture at SeaLab (04.11.16)
- SAMCoT: TechTrans and IP session at Valgrinda (23.11.16)

In general there has been quite a high number of attendees at the events. At the two courses there has been 27 (Jack Fuchs) and 18 (From Idea to Market) the participants. The interest for the last course was low, and this is probably because of the timing in the middle of exams. One full day seminar and one lunch postponed to 2017. Between 15–45 participants at the Innovation Lunches.

Invitations to events has been distributed via e-mail both directly and through administrative personell in the centers. The center leaders has also been incouraged to motivate the phd's to attend Ocean School of Innovation.Ocean School of Innovation is on web: https://www.ntnu.edu/oceans/osi

International cooperation

The MOVE Centre has a strategic cooperation with the University of Sao Paulo (USP) in Brazil. The key person in contact is professor Kazuo Nishimoto. USP is combining marine research and nautical operations and has a similar approach as we have defined in SFI MOVE.

A cooperation agreement is signed. Student exchange in 2015 and 2016.

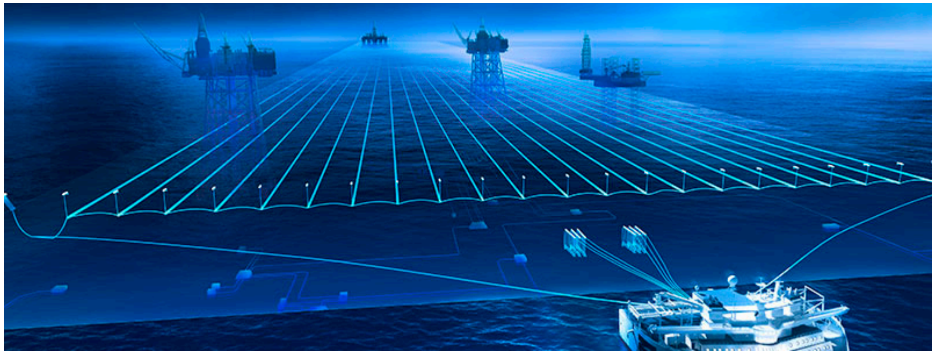
The photo shows signing of the co-operation agreement with the Dean, Gunnar Bovim, and the Minister of Education, Torbjørn Røe Isaksen.

[3]Centre for Autonomous Marine Operations and Systems [4]Exposed Aquaculture [5]Sustainable Arctic Marine and Coastal Technology

Recruitment

Due to late formal start of the SFI MOVE we had a minor delay in hiring PhD students in 2015.
We are very pleased with the number and quality of applicants.

PhD candidates and Postdocs					
PhD candidates with funding from AFI MOVE					
Name	**Start**	**Planned exam**	**Project**	**Nationality**	**Gender M/F**
Martin Friedwart Gutsch	2015	2018	Subsea Safe All Year	German	M
Fredrik Mentzoni	2015	2018	Subsea Safe All Year	Norwegian	M
Zhengru Ren	2016	2018	Offshore Wind Low Cost	Chinese	M
Amrit Shankar Verma	2016	2019	Offshore Wind Innovative Inst.	Indian	M
Robert Skulstad	2016	2019	Virtual Prototyping	Norwegian	M
Jiafeng Xu	2015	2018	Subsea Safe All Year	Chinese	M
PhD candidates with funding from other sources					
Tor Huse Knudsen	2014	2018	Mining	Norwegian	M
Svenn Are T. Værnø	2014	2017	Virtual Prototyping	Norwegian	M
Senthuran Ravinthrakumar	2016	2019	Subsea Safe All Year	Norwegian	M
Postdocs with funding from SFI MOVE					
Mia Abrahamsen Prsic	2016	2018	Subsea Safe All Year	Croatian	F
Zhiyu Jiang	2016	2018	Offshore Wind Innovative Inst.	Chinese	M
Mats Thorsen	2016	2018	Mining	Norwegian	M
Niranjan Reddy Challabatla	2016	2018	Mining	Indian	M



Department of Marine Technology • Faculty of Engineering

Photo: Thor Nielsen

Title

Performance Indicators for vessel performance for challenging marine operations

Research topics

The ongoing exploration of the maritime environment and the increasing effort to use the sea as a source of energy leads to increasing global demands for more weather independent services within marine operations. Although, ships and on-board equipment are designed to operate in harsh environmental conditions, the current practice is often to terminate operation when a rigid and often conservative weather limitation is reached, often specified in terms of the significant wave height as the exclusive criterion. Since the offshore industry is aiming for all-year-round safe operations, a strong interest among ship designers, owners and operators arises to establish and use vessel and task specific criteria.

The main objective of the PhD work is to address the question what makes an offshore working-vessel perform better, especially in harsh environmental conditions. The identification of rational performance criteria for vessels fulfilling selected operational tasks shall provide knowledge for a better understanding of factors contributing to a successfully completed offshore operation work task and shall deliver tools to estimate ship specific operational limitations.

Industrial goals

The use of rational performance criteria shall provide tools to evaluate operational performance by the use of vessel- and task specific limitations beyond a general HS-limit. This addresses a primary concern of the offshore industry to increase operability and approach the objective of safe all-year operations. The work shall provide strategies for the application of performance measures in order to support the vessel design process, the assessment of vessel performance in operations, and the selection of the suitable vessel for a specific task.

Scientific questions

- What is a good offshore vessel and why are some vessel performing better than others?
- What are the main factors contributing to operational performance?
- What are the performance indices to measure and quantify operational potential?
- How to validate newly established performance indices?

Innovations

The knowledge of operational performance criteria shall give guidance for vessel design with the goal of increased operability, cost-efficiency, and safety.

- provide knowledge for the assessment of vessel design for a specific operational task and estimated environmental condition with the aim to select the most suitable vessel for an operation
- provide tools to identify task specific weaknesses for a given ship design and/or the planning of an operation and give guidance for improvements
- provide information for further development of on-board support systems

Cooperating companies

Ocean Installer
EMAS CHIYODA
Statoil

Supervisor: Sverre Steen
Co-supervisors: Florian Sprenger, Trygve Kristiansen

Fredrik Mentzoni

Photo: Thor Nielsen

Title

Hydrodynamic loads on complex structures in the wave zone.

Research topics

The purpose of the PhD work is to provide enhanced knowledge about hydrodynamic loads on complex structures during deployment. This includes performing new benchmark experiments for hydrodynamic loads in the wave zone. The end goal is to develop rational methods for load estimates on complex structures.

Industrial goals

Rational methods to calculate hydrodynamic loads on complex structures need to be developed to ensure proper load estimates for marine operations involving, among others, the replacement of complex modules for subsea installations. Experience show that planning of marine operations is of high importance. Load predictions in terms of rational load models are necessary in this respect. Rational methods have been developed for simpler geometries, but there still exists knowledge gaps on several fundamental issues as well as large uncertainties in the hydrodynamic load estimates for more complex structures.

The present research will focus on hydrodynamic loads on 2D and 3D structures in the wave zone – as the structure goes into water – with regards to off-the-side (crane) operations. Moon pool operations and loads as the structure is further submerged and lowered to its seabed destination may also be relevant.

Scientific questions

- Is it possible to accurately estimate hydrodynamic loads on complex structures?
- Which effects dominate the load response at different stages during deployment?
- How can rational models be simple and fast to use, and at the same time take into account the complexity of subsea structures?
- How can the current recommended practices be improved to increase accuracy of load predictions for complex structures?

Innovations

Increased knowledge on hydrodynamic loads on complex structures in the wave zone can contribute to innovations and new solutions for offshore marine operations. This includes increased predictions of hydrodynamic loads that can be used for development of software, calculation methods, operational window predictions and new solutions for lowering of structures through the wave zone. In addition to potentially increasing the operability and reducing cost, research findings may also contribute to increased confidence in training and planing of marine operations.

Cooperating company

DNV GL

Supervisor: Trygve Kristiansen
Co-supervisor: Odd M. Faltinsen

Department of Marine Technology • Faculty of Engineering

Photo: Thor Nielsen

Title

Control and Online Decision Support of Crane Operations for Fixed and Floating Offshore Wind Turbines.

Research topics

- Build control plant models for marine lifting operation.
- Design controllers to precisely locate the payloads (lumped-mass, tower, and blade) and verify it through experiments.
- Consider fixed-to-floating, floating-to-fixed, and floating-to-floating installation operations, as well as an integration with DP system.

Industrial goal

- Design real-time robust controllers for the mating and positioning operations during wind turbine installation.
- Improve the weather limits during lifting and mating operations.

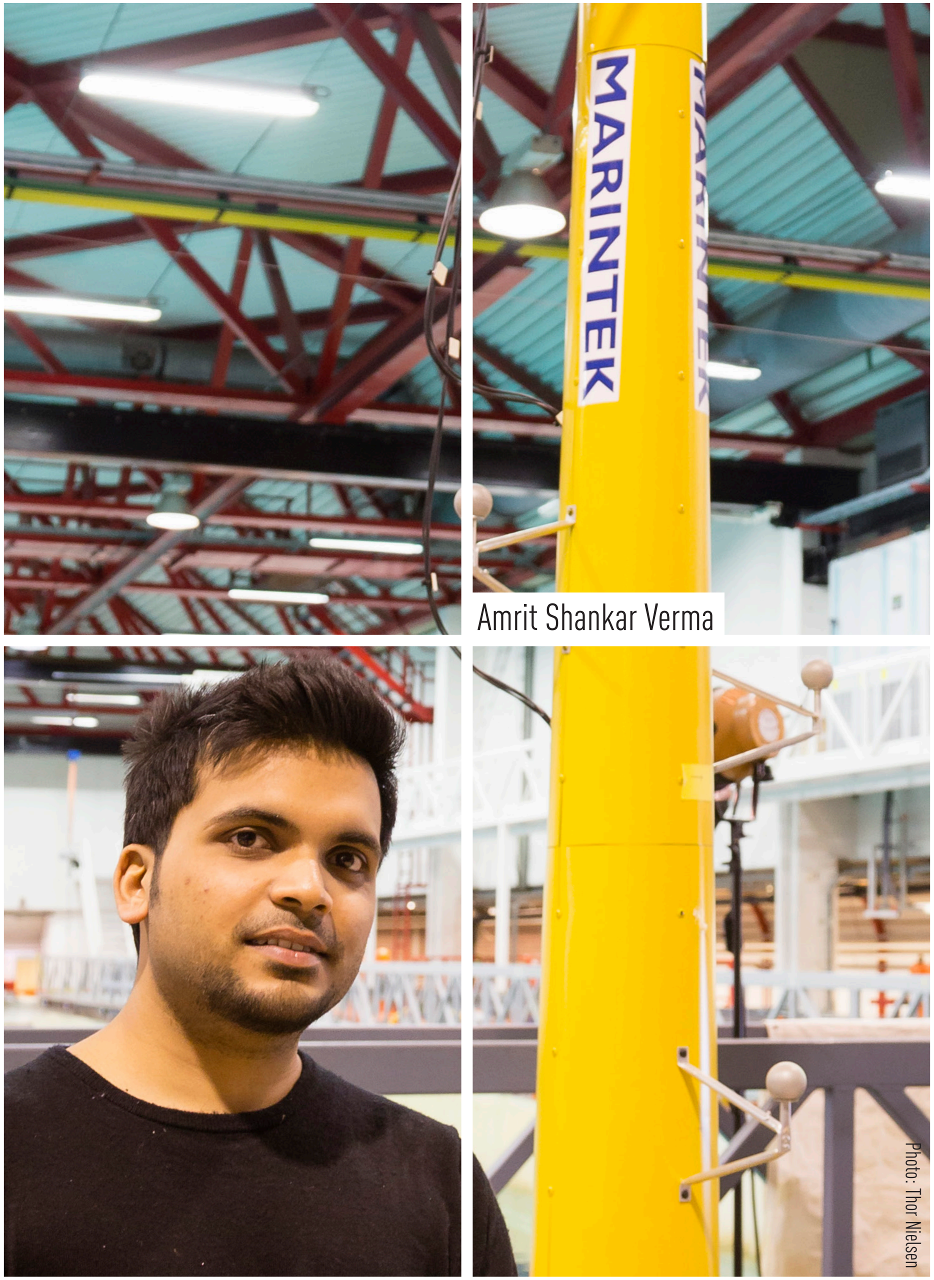
Scientific questions

- Influence of wave-induced motion to the crane operation; Underactuated system; High lifting; Robust control; Model-free control.

Innovations

- Attempt to study vessel-based installations, not commonly jackup-based.

Supervisor: Roger Skjetne (IMT, NTNU)
Co-Supervisors: Zhen Gao (IMT, NTNU)



Amrit Shankar Verma

Photo: Thor Nielsen

Title

Development of explicit response-based criteria for operability assessment for installation of offshore wind turbines using floating vessels.

Research topics

In view of the movement of offshore wind industry into deeper waters and the limitation of jack-up vessels, floating crane vessels are now being developed and used for installation of bottom-fixed wind turbines and also floating wind turbines (for example spar wind turbines). However, the big challenge is the motions of floating crane vessels, which may lead to contact/impact between the objects and therefore damages in the critical components (blades, nacelle or pre-assembled rotor-nacelle-tower) in particular in the lift-off and mating operations. In order to obtain an accurate estimate of the operability to reduce the cost for such operations, it is crucial to develop response-based criteria by explicitly assessing the damages in the wind turbine components in case of contact/impact. The purpose of this study is to develop the numerical methods for response and damage assessment of critical wind turbine components during installation and to derive the operational limits in terms of sea state parameters (Hs and Tp) for operability assessment. Case studies for installation of individual blades and integrated rotor-nacelle assembly onto bottom-fixed foundations and floating foundations using floating installation vessels will be considered. Active winch control to reduce or avoid the contact/impact during lifting operations will also be considered.

Industrial goals

- To reduce costs in the installation of OWTs by using floating installation vessels
- To develop explicit motion and structural response-based criteria for floating installation vessels

Scientific questions

- What are the criteria for operability assessment in terms of allowable vessel motions or allowable structural responses (maximum stress or allowable damage) of the critical components (blades, rotor-nacelle assembly) during installation?

Innovations

- A new way to determine the operational limits for floating installation vessels using response-based criteria

Cooperating company

Statoil
DNV-GL

Supervisor: Zhen Gao
Co-supervisors: Torgeir Moan, Karl Henning Halse, Nils Petter Vedvik

Department of Marine Technology • Faculty of Engineering

Mats Jørgen Thorsen

Title
Coupled dynamic analysis of subsea mining riser systems.

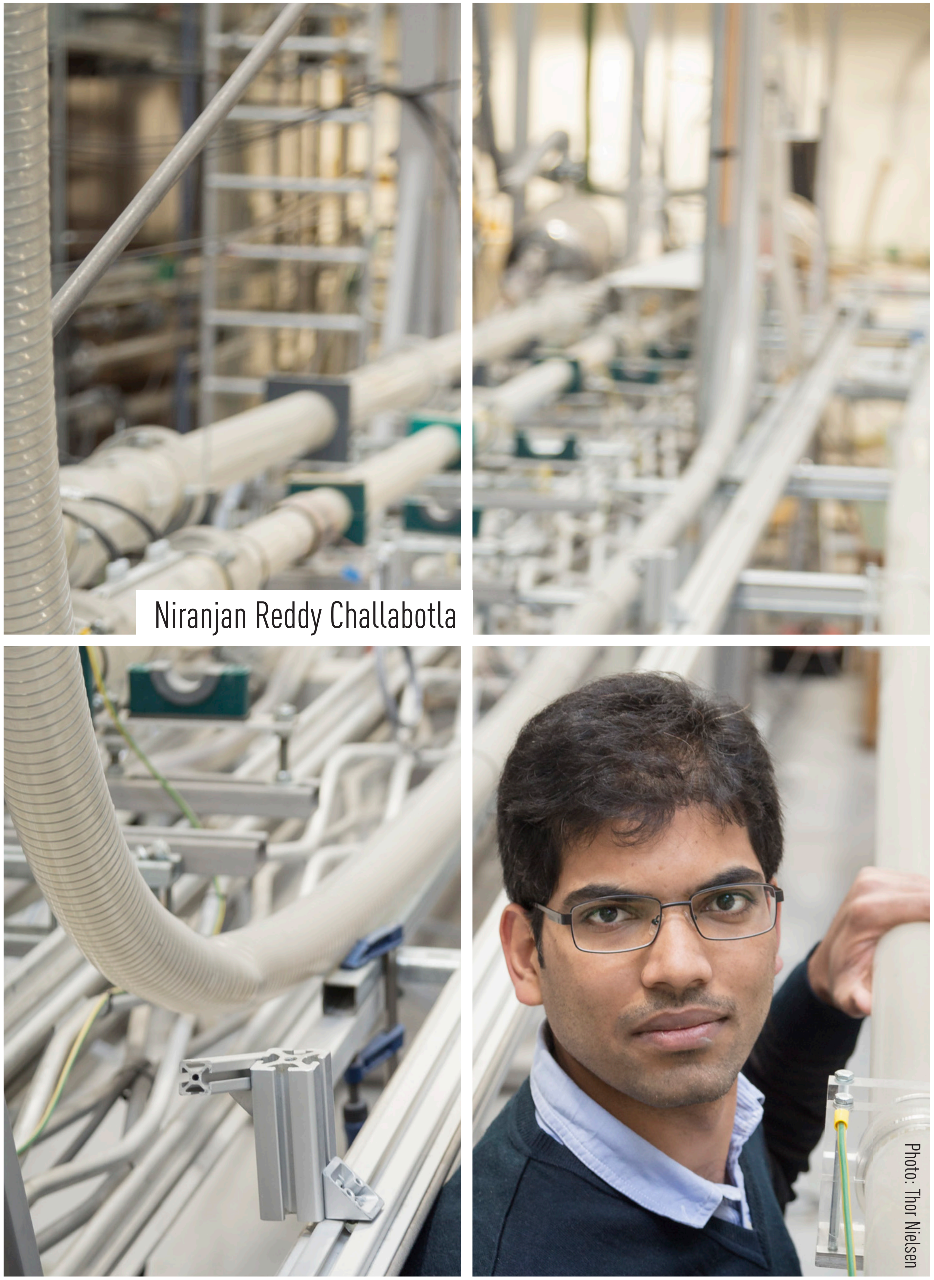
Research topics
- Build a numerical model that allows coupled dynamic analysis of long riser systems applied in subsea mining operations
- Integration of time domain VIV model in SIMA
- Integration of 1D flow model in SIMA

Industrial goal
To contribute towards positioning the Norwegian Maritime industry in the forefront wrt. commercial harvesting of subsea minerals

Scientific questions
How will transients related to start-up and operation of mining riser system contribute to riser response?

Innovations
A framework for performing dynamic response analysis of long riser systems with internal and external flow.

Supervisor: Svein Sævik (IMT, NTNU)
Co-Supervisor: Ole J. Nydal(IPT, NTNU)



Niranjan Reddy Challabotla

Photo: Thor Nielsen

Title

Coupled dynamic analysis of subsea mining riser systems.

Research topics

- Tflow model to include particles and three phase flow with compressible gas (gas-lift scenarios).
- Integration of 1D flow o extend the 1D model in SIMA

Dynamic pipe flow modelling for Ocean Mining Lift System

Lifting of particles in long pipes from the sea bed to the surface is a challenging problem in deep sea mining. Many correlations were proposed in the literature for prediction of the pressure drop in horizontal and inclined pipes. Most of these correlations were semi-empirical and valid for steady state liquid-solid two-phase flows and particular range of particle parameters. The validity of these correlations is not well established in the application of deep-sea mining, where the particle size is larger and the fluid flow in pipe is highly transient. Recently, there is an increased interest towards better understanding of the particle transport in deep-se mining application. TECHNIP has developed transient flow assurance model FASST (Flow Assurance Simulation for Slurry Transportation) for design and monitoring of large particles transportation in liquid-solid riser systems (Beauchesne et al., 2015). Different mechanisms leading to riser blockage during the transport of particles in vertical hydraulic lift were reported by experimental and 1D models (van Wijk, 2016).

Dynamic flow conditions may occur during operations, and the structural pipe dynamics may also be influenced by the internal flow dynamics. The current postdoctoral candidate is focusing on extension of a 1D dynamic flow model (Sluggit) to include particles (Kjeldby, 2013). The proposed flow model will be based on a bubble tracking method which has been developed for analysis of flow transients in multiphase pipelines (based on C++, semi-implicit, moving grid). The developed dynamic flow model will be coupled with the structural pipe model. At later stage, flow model will be extended to investigate the feasibility of the gas lift system for deep sea mining application.

References

Beauchesne, C., Parenteau, T., Septseault, C., Béal, P.-A., 2015. Development & Large Scale Validation of a Transient Flow Assurance Model for the Design & Monitoring of Large Particles Transportation in Two Phase (Liquid-Solid) Riser Systems, in: Proceedings of Offshore Technology Conference, 04-07 May, Houston, Texas, USA. doi:10.4043/25892-MS

Kjeldby, T.K., 2013. Lagrangian Three-phase Slug Tracking Methods. PhD Thesis NTNU, ISBN: 978-82-471-4744-3.

van Wijk, J., 2016. Vertical Hydraulic Transport for deep sea mining. PhD Thesis TU Delft, ISBN 978-90-9029-540-4.

Industrial goal

To contribute towards positioning the Norwegian Maritime industry in the forefront wrt. commercial harvesting of sub-sea minerals.

Scientific questions

How will transients related to start-up and operation of mining riser system contribute to riser response?

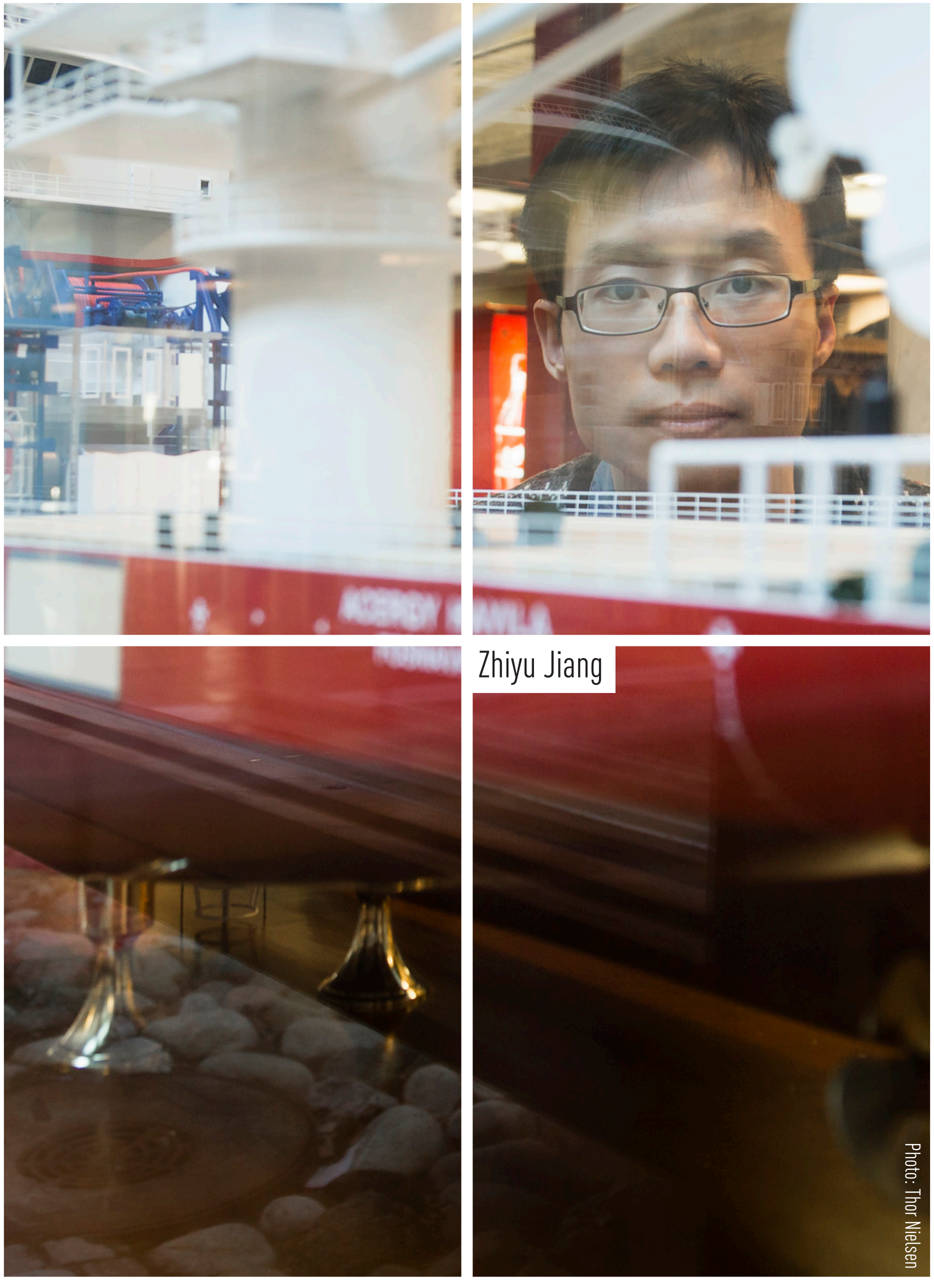
Innovations

A framework for performing dynamic response analysis of long riser systems with internal and external flow.

Supervisor: Ole J. Nydal (IPT, NTNU)
Co-Supervisor: Svein Sævik (IMT, NTNU)

POSTDOC

Department of Marine Technology • Faculty of Engineering



Zhiyu Jiang

Photo: Thor Nielsen

Title

Efficient and accurate numerical methods and models for dynamic response analysis for installation of offshore wind turbines using floating vessels.

Research topics

When using a floating vessel to install wind turbine blades or rotor-nacelle assembly, dynamic behaviour of the coupled system under simultaneous wind and wave loads are complicated. It is challenging to accurately model such floating system and predict the dynamic responses for design of the installation mechanism and system. The purpose of this study is to develop accurate numerical methods and models to analyse the actual installation procedure and to obtain the system responses for design check. The following case studies will be considered.

- Advanced modelling and analysis of the installation system for a pre-assembled rotor-nacelle-tower using the novel catamaran developed by NTNU Ålesund for design check and for validation of the numerical models used in the real-time simulation. The focus will be on modelling of the coupled system of the catamaran vessel, rotor-nacelle-tower and lifting mechanism.
- Modelling of floating installation vessels to study the effectiveness on roll motion reduction using various damping devices (such as flopper-stopper, anti-roll tank).

Industrial goals

- To assess the feasibility of novel installation methods for a pre-assembled rotor-nacelle-tower system
- To reduce the roll motions of floating vessels to increase the weather window for installation

Scientific questions

- How to accurately model the coupled system of a floating installation vessel, blades or rotor-nacelle-tower assembly and a bottom-fixed or floating foundation and predict the dynamic responses under stochastic wind and wave loads?
- How to reduce the roll motions of a floating installation vessel by passive or active damping devices?

Innovations

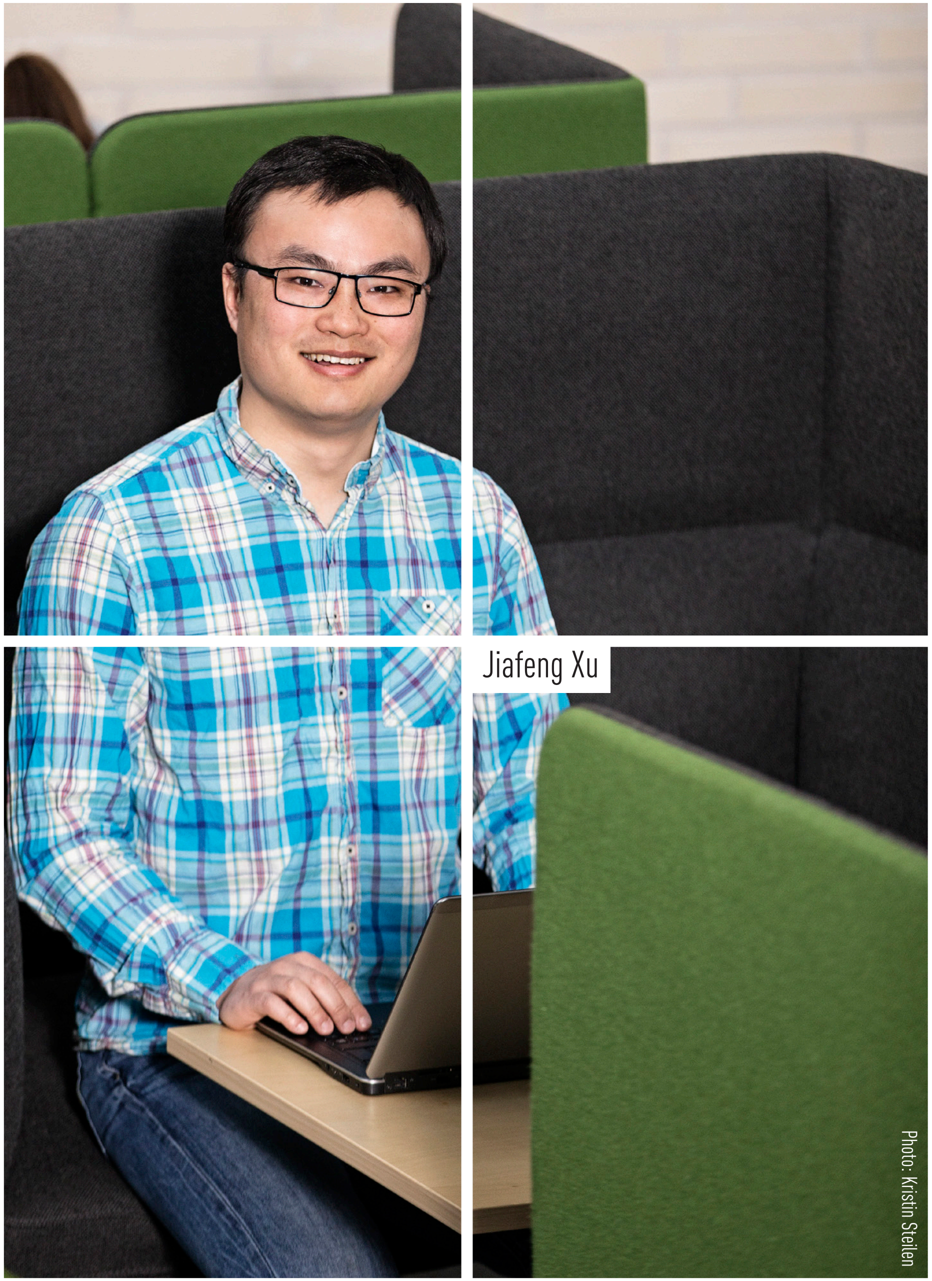
- A new numerical method for dynamic response analysis of the coupled installation system using floating vessels

Cooperating company

OSC, DNV-GL, Ocean Installer, Statoil

Supervisor: Zhen Gao

Co-supervisor: Karl Henning Halse



Jiafeng Xu

Photo: Kristin Støylen

Title

Real-time Simulation of Marine Operations.

Research topics

My research aims at developing a computer program environment and proper algorithms that can simulation marine operation in real-time with good reliability and flexibility. The focus will be on the result accuracy and calculation speed. Such simulation can serve as a powerful tool for both personnel training and product development.

Industrial goals

Ongoing projects include development of multibody dynamics simulation environment and development of real-time hydrodynamic simulation with mesh or meshless method. A more integrated simulation framework with higher interaction level between different systems can better predict different kinds of marine operation scenarios. With better knowledge from the simulation, operators can make faster and more rational decisions in real operations and engineers can adjust the products more efficiently with lower cost.

Scientific questions

- How to define a generic and robust simulation framework?
- How to implement modular concept into simulation?
- How to democratize simulation methods to the industry?

Innovations

Traditional methods need to be modified and adapted to the real-time world. Isolated simulation perspectives need to be integrated for a higher interaction level.

Cooperating company

Offshore Simulation Center (OSC)

Supervisor: Karl Henning Halse
Co-supervisor: Eilif Pederson

Communication and dissemination activities

The SFI-MOVE home page is up running, see **http://www.ntnu.edu/move**

The project has arranged following main conferences/workshops in 2016:

- **SFI-MOVE user conference, 7–8 March**
- **SFI-MOVE work shop in Seabed Mining, 10–11 May**
- **SFI-MOVE user conference, 18–19 October**

Publications

2016

Agusta, Arifian; Ji, Guomin; Sævik, Svein
Non-Linear Clay Soil Model for Lateral Pipe-Soil Interaction. I: ASME 2016 35th International Conference on Ocean, Offshore and Arctic Engineering – Volume 5: Pipelines, Risers, and Subsea Systems. ASME Press 2016 ISBN 978-0-7918-4996-5.
MARINTEK NTNU

Chu, Yingguang; Pedersen, Birger Skogeng; Zhang, Houxiang
Parameterization and Visualization of Marine Crane Concept Design. I: ASME 2016 35th International Conference on Ocean, Offshore and Arctic Engineering – Volume 7: Ocean Engineering. ASME Press 2016 ISBN 978-0-7918-4998-9. s. V007T06A095
NTNU

Gao, Zhen; Moan, Torgeir; Wan, Ling; Michailidis, Konstantinos
Comparative Numerical and Experimental Study of two Combined Wind and Wave Energy Concepts. Journal of Ocean Engineering and Science 2016 ;Volum 1. (1) s. 36–51
NTNU

Guachamin Acero, Wilson Ivan; Gao, Zhen; Moan, Torgeir
Assessment of the Dynamic Responses and Allowable Sea States for a Novel Offshore Wind Turbine Tower and Rotor **Nacelle Assembly**
Installation Concept Based on the Inverted Pendulum Principle. Energy Procedia 2016 ; Volum 94. s.61–71
NTNU

Guachamin Acero, Wilson Ivan; Li, Lin; Gao, Zhen; Moan, Torgeir
Methodology for assessment of the operational limits and operability of marine operations. Ocean Engineering 2016; Volum 125. s. 308–327
NTNU

Jin, Jingzhe; Solaas, Frøydis
Comparison of direct and stationary approach in prediction of lift wire tension in splash zone crossing operation. Marine Operations Specialty Symposium (MOSS 2016); 2016-09-20 – 2016-09-21
MARINTEK

Knudsen, Tor Huse; Sævik, Svein; Thorsen, Mats Jørgen
Numerical Analysis of Combined VIV and Slug Flow in Time Domain. OMAE 2016; 2016-06-19 – 2016-06-24
NTNU

Kyllingstad, Lars Tandle.
Simulation technology and virtual prototyping as a common approach from design to operation. MOVE Autumn Conference 2016; 2016-10-18 – 2016-10-19
FISKOGHAV

Li, Guoyuan; Pedersen, Birger Skogeng; Deng, Yuxiang; Hatledal, Lars Ivar; Zhang, Houxiang
Towards A Virtual Prototyping Framework for Ship Maneuvering in Offshore Operations. I: OCEANS 2016 Shanghai – MTS/IEEE. IEEE conference proceedings 2016 ISBN 978-1-4673-9723-0.
NTNU

Li, Guoyuan; Zhang, Houxiang; Kawan, Bikram; Wang, Hao; Osen, Ottar; Styve, Arne
Analysis and Modeling of Sensor Data for Ship Motion Predicition. I: OCEANS 2016 Shanghai – MTS/IEEE. IEEE conference proceedings 2016 ISBN 978-1-4673-9723-0.
NTNU

Li, Lin; Gao, Zhen; Moan, Torgeir
Analysis of lifting operation of a monopile considering vessel shielding effects in short-crested waves. ISOPE – International Offshore and Polar Engineering Conference. Proceedings 2016; Volum 2016 – January. s. 943–951
NTNU

Li, Lin; Gao, Zhen; Moan, Torgeir
Operability Analysis of Monopile Lowering Operation Using Different Numerical Approaches. International Journal of Offshore and Polar Engineering 2016 ; Volum 26.(2) s.88–99
NTNU

Li, Lin; Guachamin Acero, Wilson Ivan; Gao, Zhen; Moan, Torgeir
Assessment of Allowable Sea States During Installation of OWT Monopiles with Shallow Penetration in the Seabed. Journal of Offshore Mechanics and Arctic Engineering – Transactions of The Asme 2016; Volum 138. (4) Suppl. 041902.
NTNU

Longva, Vegard; Sævik, Svein
On prediction of torque in flexible pipe reeling operations using a Lagrangian-Eulerian FE framework. Marine Structures 2016; Volum 46. s. 229–254
NTNU

Ommani, Babak; Kristiansen, Trygve; Berget, Kjetil; Sandvik, Peter Christian; Faltinsen, Odd Magnus
Investigation on Moonpool Blockage by Box Shaped Object Close to Free Surface. 3rd International Conference on Violent Flows (VF-2016); 2016-03-09 – 2016-03-11
MARINTEK NTNU

Pan, Yushan
Cooperative Systems for Marine Operations Using Actor-Network Design: A Discussion. I: Proceedings of the 2016 IEEE 20th International Conference on Computer Supported Cooperative Work in Design (CSCWD). IEEE conference proceedings 2016 ISBN 978-1-5090-1914-4. s.607–612
NTNU

Pan, Yushan
Design of Digital Environments for Operations on Vessels. I: COOP 2016: Proceedings of the 12th International Conference on the Design of Cooperative Systems, 23–27 May 2016, Trento, Italy. Springer Publishing Company 2016 ISBN 978-3-319-33463-9. s.123–138
NTNU

Pan, Yushan
Improving maritime technology: A cooperation technology perspective on cooperative artifacts. I: OCEANS 2016 Shanghai – MTS/IEEE. IEEE conference proceedings 2016 ISBN 978-1-4673-9723-0.
NTNU UiO

Pan, Yushan; Finken, Sisse
Visualising Actor Network for Cooperative Systems in Marine Technology. HCC12 2016, IFIP AICT 474; 2016-09-07 – 2016-09-09
NTNU UiO

Pan, Yushan; Finken, Sisse
Visualising actor network for cooperative systems in marine technology. I: Technology and Intimacy: Choice or Coercion. Springer Publishing Company 2016 ISBN 978-3-319-44804-6. s.178–190
NTNU UiO

Pan, Yushan; Hildre, Hans-Petter
Using Actor Network to Enhance Maritime System Design. Learning and Collaboration Technologies, LTC 2016, Held as Part of HCI International 2016; 2016-07-17 – 2016-07-22
NTNU UiO

Pan, Yushan; Hildre, Hans-Petter
Using Actor Network to Enhance Maritime System Design. I: Learning and Collaboration Technologies. Springer Publishing Company 2016 s. 616–627
NTNU UiO

Ren, Zhengru; Skjetne, Roger
A Tension-based Position Estimation Solution of a Moored Structure and its Uncertain Anchor Positions. IFAC-PapersOnLine 2016 ;Volum 49. (23) s.251–257
NTNU

Ren, Zhengru; Skjetne, Roger
A Tension-based Position Estimation Solution of a Moored Structure and its Uncertain Anchor Positions. The 10th IFAC Conference on Control Applications in Marine Systems (CAMS 2016); 2016-09-13 – 2016-09-16
NTNU

Ren, Zhengru; Skjetne, Roger
An On-site Current Profile Estimation Algorithm for a Moored Floating Structure. IFAC-PapersOnLine 2016; Volum 49. (23) s.153–158
NTNU

Ren, Zhengru; Skjetne, Roger
An On-site Current Profile Estimation Algorithm for a Moored Floating Structure. The 10th IFAC Conference on Control Applications in Marine Systems (CAMS 2016); 2016-09-13 – 2016-09-16
NTNU

Sandvik, Peter Christian; Solaas, Frøydis; Firoozkoohi, Reza
Hydrodynamic forces on complex subsea structures. Marine Operations Specialty Symposium (MOSS 2016); 2016-09-20
MARINTEK

Sandvik, Peter Christian; Solaas, Frøydis; Firoozkoohi, Reza
Hydrodynamic forces on complex subsea structures. Some results from a Norwegian research based innovation program.. Marine Operations Specialty Symposium (MOSS 2016); 2016-09-20
MARINTEK

Thorsen, Mats Jørgen; Sævik, Svein; Larsen, Carl Martin
Time domain simulation of vortex-induced vibrations in stationary and oscillating flows. Journal of Fluids and Structures 2016 ; Volum 61. s. 1–19
NTNU

Værnø, Svenn Are Tutturen; Brodtkorb, Astrid H.; Skjetne, Roger; Sørensen, Asgeir Johan
An Output Feedback Controller with Improved Transient Response of Marine Vessels in Dynamic Positioning. IFAC-Papers OnLine 2016; Volum 49.(23) s.133–138
NTNU

Wang, Hao; Fossen, Sindre; Han, Fang; Hameed, Ibrahim A.; Li, Guoyuan
Towards data-driven identification and analysis of propeller ventilation. I: OCEANS 2016 Shanghai – MTS/IEEE. IEEE conference proceedings 2016 ISBN 978-1-4673-9723-0.
NTNU

Wang, Hao; Zhuge, Xu; Strazdins, Girts; Wei, Zheng; Li, Guoyuan; Zhang, Houxiang
Data integration and visualisation for demanding marine operations. I: OCEANS 2016 Shanghai – MTS/IEEE. IEEE conference proceedings 2016 ISBN 978-1-4673-9723-0.
NTNU

Xu, Jiafeng
A Marine Simulation Framework and A Dual Quaternion Variational Integrator. MOVE Autumn Conference 2016; 2016-10-18 – 2016-10-19
NTNU

Li, Yue; Halse, Karl Henning; Xu, Jiafeng
Sloshing flows in a free surface anti roll tank – Numerical simulations and experimental validation. I: Proceedings of the 13th International Symposium on PRActical Design of Ships and Other Floating Structures (PRADS' 2016). Danmarks Tekniske Universitet, DTU 2016 ISBN 978-87-7475-473-2. p. 313–320
NTNU

Master's degrees

Simon Holm Hemstad	M	Power and energy optimization for marine operations
Zafer Zortul	M	Investigation of sloshing through experiments and modeling with mechanical equivalent models
Junjie Ding	M	Parametric mechanical design for system integration and simulation of virtual crane
Dahai He	M	Virtual winch prototyping - Active/passive heave compensation system in 20 Sim
Yu Li	M	Component model development and management oriented to both system performance testing and operational behaviour simulation
Bingqiang Wang	F	Modelling and simulation of accumulator systems for heave compensated winches in cranes AGX
Zhongkai Wang	M	HIL simulation of hydraulic crane control
Kjell Lennart Nygård	M	Effect of anchor cable tension on an AHTS vessel at sea.
Petter Svardal Langeland	M	Modelling of anchor lines, resulting tension on AHTS (Aquasim)
Zhaonan Zhong	M	Smoothed particle hydrodynamics calculations
Sthefano Lande Andrade	M	Optimal Structural configuration for Ulstein PX
Greta Levisauskaite	F	Implementation of GD framework in ship design for improving exchange and minimizing 3D remodelling
Ruta Mastekaite	F	Product lifecycle management applied to offshore support vessels
Brigita Matulaityte	F	Shell product concept applied to ship design
Thiago Gabriel Monteiro	M	A knowledge-based approach for an open object-oriented toolbox in ship design
Tian Xu	M	Intelligent library in ship design
Georgiana Chelmu	F	Framework for product configurator deployment
Simen Haddal Sæther	M	Study of vibration control and analysis on ships
Arne Solevåg	M	Ship response and manoeuvrability - Main Machinery characteristics, configuration modes, and its resulting effect on thrust response
Jon Bjørnø	M	Thruster-assisted position mooring of C/S Inocean Cat I Drillship
Preben Frederich	M	Constrained Optimal Thrust Allocation for C/S Inocean Cat I Drillship
Evgenii Koloshkin	M	Torsion Buckling of Dynamic Flexible Risers
Jens Mjøen Hafstad	M	Numerical investigation of collapse and ductile fracture in X65 offshore pipelines subject to external pressure, bending and axial loads (cooperation with the Federal University of Rio de Janeiro)
Martine Gripp Bay	M	Assessment of Marine Riser Joints During Offshore Drilling Operation (cooperation with Bureu Veritas Paris)
Marius Maastad	M	Numerical and Experimental Study of the Fred Olsen Wind Turbine Concept
Fride Midtbø Birkeland	F	Numerical Simulation of Installation of XL Monopile for Offshore Wind Turbines
Shi Deng	M	Numerical Simulations for Lift-off Operation of an Offshore Wind Turbine Monopile
Dapeng Xu	M	Numerical Modelling and Simulations for Lowering of an Offshore Wind Turbine Tripod
Nishat Al Nahian	M	Structural Analysis of the Gripper Connection during Monopile Installation
Efstathios Tsigkris	M	Dynamic Response Analysis of a Spar Floating Wind Turbine in Level Ice with Varying Thickness

Accounts

The tables show the distribution of funding and costs in SFI MOVE for 2016. The funding plan shows where the funding comes from, and the cost plan shows where the research activity has been carried out.

Funding	Project 1	Project 2	Project 3	Project 4	Project 5	Lab/Dissemination	Management	Total
The Research Council	1488	4042	214	448	974	480	2013	9659
The Host Institution, NTNU in Ålesund	254	1509	134	6	107			2010
Research partners:	416	2822	413	81	142	0	0	3874
NTNU	178	1646	0	71	132			2027
MARINTEK	219	1128	0	0	0			1347
SINTEF	19	48	413	10	10			500
Enterprise partners:	852	3809	568	95	541	450	0	6315
Total	3010	12182	1329	630	1764	930	2013	21858

Costs	Project 1	Project 2	Project 3	Project 4	Project 5	Lab/Dissemination	Management	Total
The Host Institution, NTNU in Ålesund	859	2013	193	24	430	930	1916	6365
Research partners:	1899	8561	668	511	1243	0	97	12979
NTNU	1341	3183		501	913		97	6035
MARINTEK	539	4373	158		320			5390
SINTEF	19	1005	510	10	10			1554
Enterprise partners:	252	1608	468	95	91	0	0	2514
Public partners								0
Equipment								0
Total	3010	12182	1329	630	1764	930	2013	21858

Dean Hans Petter Hildre and Finn Gunnar Nilsen from Statoil

Wind power is greater than nuclear power

NTNU in Ålesund,
Else Britt Ervik

In March there was a meeting for those who wish to revolutionise offshore technology, specifically SFI Marine Operations.

- "What we are doing here is huge", said Finn Gunnar Nilsen from Statoil, referring to the ambitions regarding offshore windmills going further and further out, and into deeper water.
- "The opportunity of utilising resources is enormous, because the effect of wind power is greater than nuclear power", said Mr Nilsen categorically to an attentive audience.

All associated researchers and PhD students were invited to Ålesund, together with both relevant professors and co-operation partners from industry. The researchers received inspirational lectures including from Statoil, Vard, Ulstein, Rolls Royce and Havila.

The Pro-rector for research, Kari Melby, was also present on the first day, and pointed out that the SFI had high ambitions concerning innovation and new thinking for marine resources.

- "What will you do better and differently than other SFIs in this area", was Pro-rector Melby's question to Hans Petter Hildre, who leads the project.
  To this the Pro-rector received the reply that many meetings were planned between those working on the project and industry, to ensure good communication.
- We hold this type of meetings once or twice a year. In addition, we receive frequent visits from our industrial partners, in order to ensure progress in the SFI.
  Not surprisingly, there were several interesting discussions when people from various companies and disciplines met, such as when the crane operator from Havila described how he operated the crane in four meter high waves. The person who had developed the crane technology was also in the audience, and wondered why the driver did not follow the instruction book.
- "There's a better way of performing the operation", was the opinion of the developer.
- "The instructions are incomprehensible", replied the driver.

The developer admitted that he was in agreement with this, and said that the person who had written the book had already been dismissed - a statement that drew loud laughs from the audience.

On Day 2, the PhD students and Postdocs presented their projects. More about the research and the SFI is to be found at: www.ntnu.edu/move

SFI MOVE Workshop

Trondheim May 11th

SFI MOVE Workshop

Mining; Exploration of Technologies to Develop Mining

Workshop Agenda

- 09:00–09:10: Welcome by Prof. Svein Sævik, IMT, NTNU
- 09:10–09:30: Technip activities in Deepsea mining, with focus on flow modelling and deepsea mining architecture by Thomas Parenteau and Johann Rongau, Technip Innovation and Technology Centre
- 09:30–09:50: The Architecture of deep Sea Mining Systems by Prof. Meng Tang, Southwest JiaoTong University, China
- 09:50–10:10 Time domain hydrodynamic modeling for riser VIV by PhD student Mats J. Thorsen
- 10:10–10:30: Two and Three Phase Flow Models for mining riser applications by Prof. Ole J. Nydal, Department of Energy and Process Engineering, NTNU
- 10:30–10:50: Model testing of combined VIV and slug flows by PhD student Tor HKnudsen
- 10:50–12:00: Discussions
- 12:00–13:00: Lunch

Participants:

Borgundvåg, Stig Ole Rolls-Royce Marine AS
Brett, Per Olaf Ulstein International AS
Eknes, Arnstein DNV GL
Giertsen, Egil MARINTEK
Ingeberg, Per Rolls-Royce Marine AS
Lie, Halvor MARINTEK
Nydal, Ole Jorgen NTNU
Ren, Zhengru NTNU
Rongau, Johann Technip
Parenteau, Thomas, Technip (On Skype)
Sævik, Svein NTNU
Thorsen, Mats Jørgen NTNU
Torben, Sverre Rolls-Royce
Vartdal, Leif Rolls-Royce Marine AS
Vindstad, Jens Emil Statoil R&T
Æsøy, Vilmar NTNU Ålesund
Hildre, Hans Petter, NTNU Ålesund

In addition to this about 10 students and scientific employees at IMT were taking part of the workshop, about 30 in total.

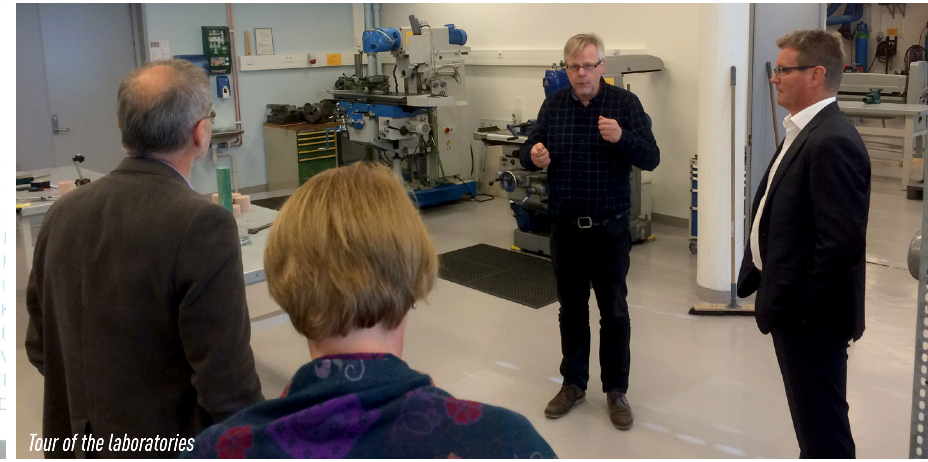
About the workshop

The workshop was arranged as a seminar including presen tations both from NTNU and invited speakers representing both industry and academia. The invited speakers were:

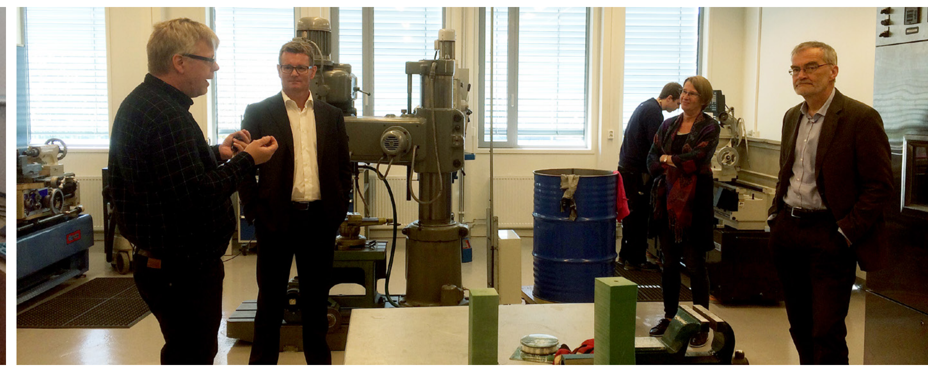
- Prof. Meng Tang: Southwest JiaoTong University, China
- Thomas Parenteau and Johann Rongau, Technip Innovation and Technology

Technip is heavily involved in the Solwara project outside New Guinea, being the first full scale mining development in deep waters, starting up in 2017. One important outcome of the seminar was related to Technip being willing to act as a partner with respect to quality assurance of research within this topic in SFI MOVE by sharing their experiences.

From the left: Hans Petter Hildre (Centre leader, SFI MOVE), and Kai Mjøsund (Department Director, NFR)



Tour of the laboratories



Visit by the Research Council of Norway

During the Autumn of 2016 and the Spring of 2017, the Research Council of Norway will be conducting site visits to the 17 SFI that started up in 2015 (SFI III). On Thursday, 6 October it was the turn of SFI MOVE. The main purpose of the visit was a review and discussion of the stage in the progress of the work of the realization of the Centre, and the challenges that were faced at the start-up of the activity.

The Research Council of Norway has not been present at any of the opening events for SFI MOVE. Department Director Kai Mjøsund therefore introduced the meeting by extending his congratulations on the establishment of SFI MOVE and presenting the Centre with the SFI Plaque as visible proof that the Centre has the status as an SFI (Centre for Research-based Innovation).

The Research Council of Norway had expressed a wish for a dialogue-based and informal setting for the visit. A program was therefore drawn up to reflect this, and the visit was carried out with presentations and dialogue in a good balance.

Halfway through the program a tour took place of the premises of NTNU, Campus Ålesund and the Norwegian Maritime Competence Centre (NMK). The tour was to laboratories, workshops and simulators, including the simulators at the Offshore Simulator Centre (OSC), which is one of SFI MOVE's corporate partners.

The feedback by the Research Council of Norway regarding the visit was that the main impression of SFI MOVE is that it is well managed, and that overall the Centre is on track both professionally and administratively. The Centre faces some challenges because of the situation the industry finds itself in, and these must be handled in good dialogue with the Research Council of Norway.

Working to revolutionise wind power

NTNU in Ålesund
Else Britt Ervik

In October there was a new meeting of SFI MOVE Marine Operations. The meeting took place at Ålesund, and on the agenda were presentations from all ongoing research projects connected to the SFI. Fellows and scientists presented their most recent work on everything from new details about cranes and offshore wind turbines, to the finances regarding the installation of equipment for wind power. In addition, representatives from industrial partners presented the experiences and challenges they face in their work.

The project is being expanded

Professor Hans Petter Hildre is the leader of SFI MOVE, and welcomed the gathering by saying that he had been requested to adjust the vision for the SFI. The wording was far too modest in relation to what was being accomplished, and the project is constantly being expanded. Five new PhD positions will be advertised next year.

Co-operation partners have high expectations

The presentations took place before an Auditorium filled to capacity, since all SFI's co-operation partners had been invited. The audience continually put questions to the scientists, and it was evident that the investors had high expectations of their investments in the project. At the meeting they were also given the chance to communicate the most important problems to which they wanted answers, and the priorities that should be made, in more explicit terms,.

All industrial partners were invited to hear the presentations from fellows and other researchers.

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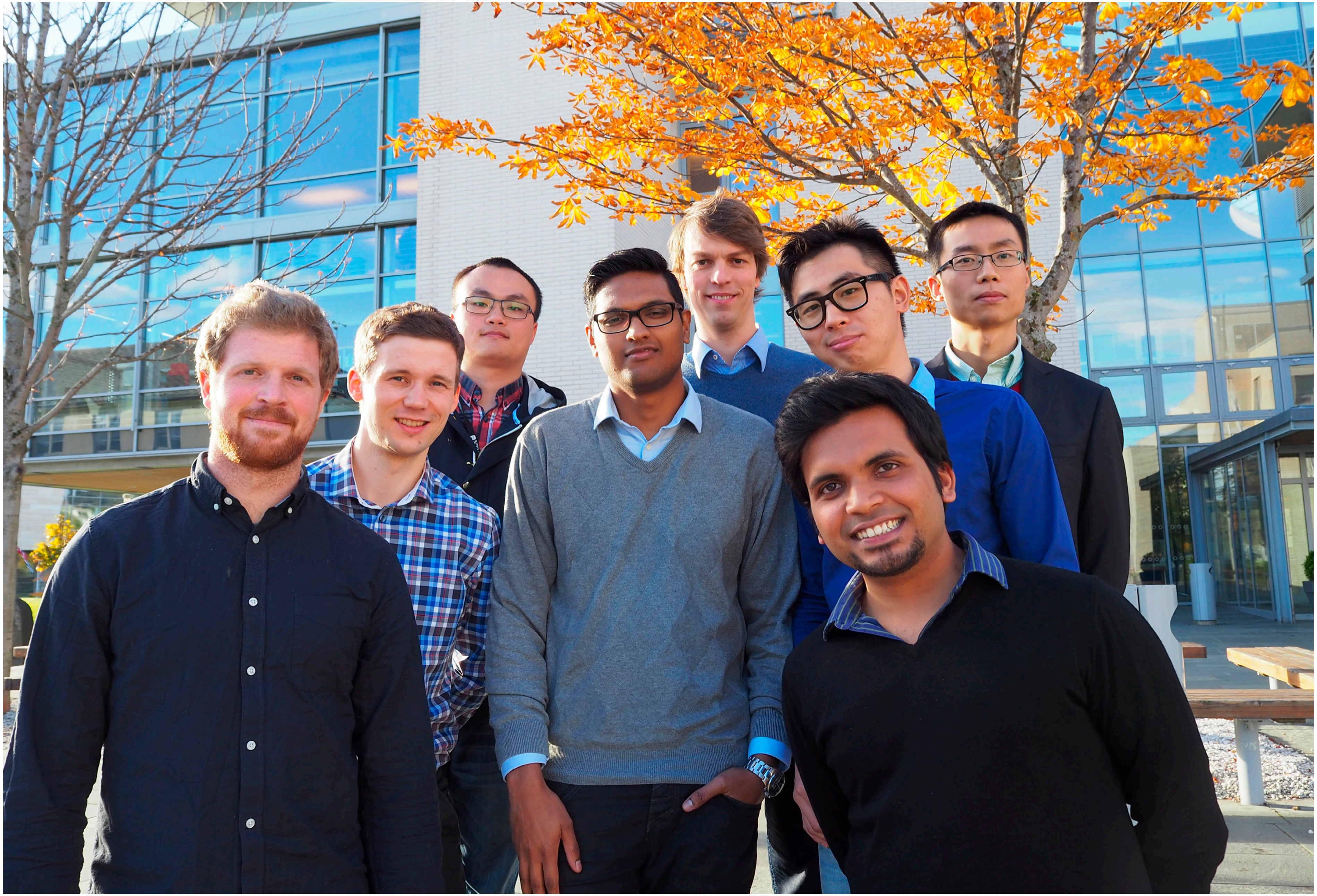

From the left: Tor Huse Knudsen (PhD), Fredrik Mentzoni (PhD), Jiafeng Xu (PhD), Senthuran Ravinthrakumar (PhD), Martin Gutsch (PhD), Zhengru Ren (PhD), Amrit Verma (PhD, in front) and Zhiyu Jiang (PD)