NTNU
Department of Marine Technology

Annual Report 2015

DEPARTMENT OF
MARINE
TECHNOLOGY

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THE YEAR 2015 IN SUMMARY

The year 2015 was both interesting and prosperous for the Department of Marine Technology. The Department graduated 127 master's degree students and saw a high number of newly admitted students. Approximately 120 PhD students are currently enrolled, which also indicates promising numbers for graduates in coming years. The completion of externally financed activities, including EU projects, increased in comparison to previous years. Further improvements in administrative support, including systems for project initiation and follow-up, contributed strongly to enhancements in both efficiency and the quality of our work environment.

The new Centres for Research-Based Innovation - SFI EXPOSED, SFI Smart Maritime and SFI MOVE - in which the Department is heavily involved commenced operation and made good progress in 2015. These centres represent critical areas of marine and maritime study, and in conjunction with the Centre of Excellence (CoE) NTNU AMOS will strengthen research activities within maritime, offshore and aquaculture sectors.

NTNU Oceans, one of four strategic research areas at NTNU, is located in the Department. This centre has initiated and overseen a number of activities including PhD student research, pilot projects and dedicated NTNU Ocean week.

The CoE NTNU AMOS has made impressive progress in project initiation, international co-operation and high levels of PhD engagement. It has also focused on innovation and value creation built on new and fundamental research.

The Department is also involved in the application process for two new CoEs and several FMEs that have been announced by the Research Council.

Space availability at the Marine Technology Centre is a challenge, as the number of staff is increasing and many new PhD candidates and master students are expected. During 2015 most of the office areas were rebuilt, allowing additional room for new employees and students. The Department has also spent considerable resources on upgrading its laboratories in order to offer the best possible infrastructure for students and employees.

The Ocean Space Centre (OSC) is still undergoing an evaluation process. A decision is expected to be made by the end of 2016 regarding the conceptual direction for the centre and how progress will be made towards the next steps in the realization process.

In 2014, the Research Council conducted a study titled *"Evaluation of Basic and Long-term Research within Engineering Science"*, in which the Department was examined. In this process, research groups were evaluated based on their qualifications within three areas: scientific quality and productivity, relevance and impact, and strategy, organization and research cooperation. The outcome of this evaluation was presented in early 2015, and our two research groups received very satisfactory results. The Marine Structures group was determined to be one of the two strongest engineering research groups in Norway with top score all the way. The Marine Systems group was assessed as being at a high level and considerably improved in comparison to previous evaluation results.

In-house co-operation with MARINTEK has contributed to the success of the Marine Technology Centre in the marine and maritime sectors. The Department's co-operation with other parts of the SINTEF organization has also been important, especially with SINTEF Fisheries and Aquaculture. Furthermore, laboratories such as the AUR-lab initiative are under continued development.

As in previous years, co-operation and day-to-day contact with students are inspiring and constructive. Even outside of the classroom, our active students contribute to making the Marine Technology Centre "a living centre" with activities all throughout the week. Among many other activities, this includes the annual "Bedriftsdagen," the bi-annual "Skips-fartskonferansen," and of course the bi-annual RUKA student festival.

The Department strives to steadily improve its work environment, and the social event working group has done an excellent job with many events including the summer and Christmas parties. The Department also did very well in the Trondheim Marathon in September 2015. There are, of course, high expectations for social activities in 2016.

By the end of 2015, it could not be overlooked that the marine industry, particularly within the offshore sector, is confronted by severe challenges caused by a dramatic drop in oil prices on the world market. So far this has not affected the Department to a considerable degree, as the recruitment of both new students and PhD's to our programmes has been strong, as has our ability to finance external projects. However, in the coming year the situation within the offshore industry is expected to influence our operations. In light of this, recruitment activities have been made high priorities.

Several events have been and will be organized, such as "Women's Day" (Jentedagen) to recruit more female students. Other events intended to increase the interest of young people in physics, mathematics and technology include the Ocean Space Race, the Talent Camp during Nor-Shipping in Oslo, participation in the Boat festival in Ålesund, and Researchers Night at NTNU. These activities have proven to be both necessary and highly successful and will be high priorities in 2016.

Prof. Harald Ellingsen
Head of the Department of Marine Technology

FACTS AND FIGURES

Staff
22 professors
8 professors emeriti
3 associate professors
2 assistant professors
15 adjunct professors
6 adjunct associate professors
7 researchers
15 postdoctoral fellows
103 PhD candidates*
16 graduated PhD candidates
127 graduated MSc students
97 MSc exchanges to universities abroad **
14 administrative staff
19 technical staff
2 apprentice

Revenues ***
Income: 135,1 MNOK
Costs: 147,7 MNOK

Publications
5 book chapters
128 refereed journal articles
141 refereed conference papers
9 international keynote and plenary lectures
32 media contributions
28 other presentations

*Note: This number only includes PhD candidates who are financed by the Department of Marine Technology and/or CeSOS.
**Note: Spring and autumn semester 2015 combined.
***Note: In 2015, the department had high costs mainly related to two major issues: one of them was rebuilding in order to get enough offices for a growing scientific staff; the other was important investments in laboratory equipment. We started the year 2015 with a very high level of reserve assets, actually above the tolerated limit. We managed to keep the whole reserve because of the need to rebuild and invest for the department's future activities. At the end of 2015, the department had reserve assets at an amount of 2 MNOK, the tolerated limit was 6 MNOK.
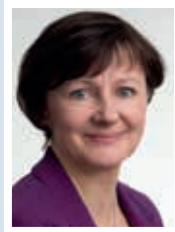
ORGANIZATION

| Head of Department Prof. Harald Ellingsen | Assistant Head of Department Prof. Svein Sævik | Head of Office Astrid E. Hansen | Head of Marine Systems Prof. Bjørn Egil Asbjørnslett | Head of Marine Structures Prof. Roger Skjetne |

The Department of Marine Technology consists of two research groups: the Marine Systems research group and the Marine Structures research group.

The Marine Systems research group teaches and conducts research on major aspects of marine systems, such as machinery, ships and maritime transport systems; offshore oil and gas infrastructure and systems; other offshore energy production systems; and fisheries and aquaculture. The research group focuses on system design and operation as well as interaction and adaptation to the surroundings in a total lifecycle perspective. The prioritized research areas are as follows:

• Risk and safety management of marine systems
• Multi-level design of complex marine systems
• Design and verification of complex energy systems
• Sustainable development of shipping in Arctic waters

The Marine Structures research group educates and conducts research in the fields of marine structures, marine hydrodynamics, underwater technology, and marine control engineering. Key research application areas are the following:

• Oceanography
• Wave-induced motions and strongly nonlinear loads
• Structural load effects
• Abnormal loads and accidental load effects
• Slender marine structures
• Ship and marine operations
• Propellers and propulsion
• Renewable energy propulsion
• Aquaculture facilities
• Very large floating structures
• Deep-sea mineral mining
• Wind, current, and wave energy production
• Structural design
• Underwater robotics
• Ocean science
• Autonomous marine systems

PRESENTATION OF NEW PROFESSORS

Zhen Gao

Professor, Department of Marine Technology, NTNU

Prof. Zhen Gao obtained his PhD degree at NTNU in 2008 and then worked as a postdoc and a researcher at CeSOS from 2008 to 2015. Currently, he is a professor of marine structures in the Department of Marine Technology, and his professorship is financed by DNV GL. His main research works are related to off-shore renewable energy, with focuses on the design, modelling and analysis of bottom-fixed and floating wind turbines, and marine operations related to installation and maintenance of offshore wind turbines. He has published more than 100 peer-reviewed journal and conference papers. He has participated in several EU projects and in one national research centre project on offshore wind. He is the chair of the Specialist Committee V.4 Offshore Renewable Energy in ISSC (2012-2018).

Trygve Kristiansen

Professor, Department of Marine Technology, NTNU

Trygve Kristiansen earned his MSc degree in Applied Mathematics from NTNU in 2002. He was employed at MARINTEK during 2002 – 2015, where he worked on different topics within offshore hydrodynamics, including wave run-up on platforms, vortex-induced vibrations, riser galloping, ship roll, moon-pool resonance, shallow water wave loads and responses of offshore wind turbines and aquaculture structures in waves and currents. He was a member of an ITTC committee on wave run-up and VIV in 2013.

Meanwhile, he earned his PhD degree in marine hydrodynamics from NTNU in 2009, and held a three-year postdoc position during 2010-2012, both at the Centre for Ships and Offshore Structures (CeSOS) at NTNU. His PhD and postdoc research topics mainly included moonpool resonance and aquaculture structures. He employed both experimental, numerical and theoretical research methods. The work on moonpools has led to new, fast and robust computational methods for marine resonance problems, such as moonpool ship-by-ship situations and ship roll. MARINTEK is presently developing a commercial code called the Potential Viscous code (PVC3D) based on this work. He developed new rational hydrodynamic load models for fish farm nets that are useful for the industry.

Since June 2015, he has held a professorship in "Marine Operations, with a focus on hydrodynamics" in the Department of Marine Technology at NTNU. Statoil is financing the first five years of the position. He will focus on developing useful knowledge and technology for different hydrodynamic aspects of marine operations, using both experimental, numerical and theoretical research methods.

Stein Haugen

Professor, Department of Marine Technology, NTNU

Stein Haugen earned his MSc in Marine Technology from NTNU (then NTH) in 1984. He completed his PhD in 1991 under the supervision of Professor Torgeir Moan. In his PhD, he worked on a model for determining the probability of collisions between ships and offshore platforms, focusing particularly on the uncertainty associated with risk analysis models. From 1985 to 2010 he worked with the safety consultancy company Safetec. He held a variety of positions, ranging from Safety Engineer and Department Manager to Managing Director of the company from 1993 to 1998. From 1998 to 2010, he worked with Research and Development, including a period as R&D Director of the company. While working with Safetec, he held a position as Adjunct Professor at the Department of Production and Quality Engineering for 10 years before being appointed as a full professor in October 2010 in the same department. His position was funded by K G Jebsen. Since 2015, he has been working in the Department of Marine Technology. In 2016, he was also appointed an Adjunct Professor at Wuhan University of Technology. His main research interests are risk analysis, the influence of human and organizational factors on safety, major accidents and operational risk.

Ingrid Schjølberg

Professor, Department of Marine Technology, NTNU

Ingrid Schjølberg received her PhD in 1996 from the Department of Engineering Cybernetics at NTNU. The topic was modelling and control of underwater robots. Currently, she is professor in underwater robotics at the Department of Marine Technology. Her research focus is autonomy, navigation, localization, modelling and control of underwater robots for inspection, maintenance and repair in oil and gas, deep sea mining and aquaculture. She has broad experience from 15 years in SINTEF and has been in charge of a large number of research projects at both the national and EU level. Earlier projects have addressed the sustainable production of hydropower, LNG and hydrogen. Moreover, automation and robotization in manufacturing and land-based and offshore industry has been a focus. She is a reviewer and evaluator for European projects, has led several projects under the IEA network and holds a number of positions in steering committees and on boards of directors. She is the Director of NTNU Oceans, one of NTNU's four strategic research areas. The overall vision of NTNU Oceans is science and technology for the sustainable use of the oceans.

EDUCATIONAL PROGRAMMES

The department is responsible for the organization and imple-mentation of the Marine Technology educational programme at the faculty. It is offered to students in three main options (number of students graduated in 2015 in parentheses):

- as a 5-year integrated Master programme (87)
- as a 2-year Master programme for students with a Norwegian Bachelor degree (9)
- as a 2-year international Master programme (14)
- other Master programmes with a specialization in Marine Technology (3)

The first 3 years of the integrated Master programme feature introductory courses in mathematics, statistics, physics, chemistry, mechanics, and thermodynamics in addition to courses that introduce the marine disciplines and their aspects, design, and operational problems to be encountered throughout the programme.

From the 6th semester onwards, students can choose among eight specializations:

- Marine structures
- Marine cybernetics
- Marine hydrodynamics
- Marine engineering
- Safety and asset management
- Marine systems design
- Marine resources and aquaculture
- Marine subsea engineering

The study specializations combine the disciplines of hydro-dynamics, structural engineering and marine systems. An emphasis is placed on the students' ability to combine practical understanding with the use of mathematical models and computer-based methods of analysis. Emphasis is also placed on the development of the students' ability to view the big picture in technical problems related to design, analysis and operation of marine systems.

The 2-year Master of Science programmes in Marine Technology is offered to students with a Bachelor degree in Naval Architecture, Ocean Engineering or an equivalent upon admission. The structure of the programmes is built on the courses offered in the last two years of the 5-year programme.

In addition to Marine Technology, the department is involved in the following programmes:

- Engineering and ICT— 5-year integrated Master programme
- Maritime Engineering— 2-year international Master programme (Nordic Five Tech programme, in coopera-tion with the Technical University of Denmark, the Royal Institute of Technology and Chalmers University of Tech-nology in Sweden, and Aalto University in Finland)
- Marine Coastal Development— 2-year international Master programme
- Subsea Technology— 2-year Master programme in coop-eration with Bergen University College
- European Wind Energy Master— 2-year international Master programme in cooperation with Delft University of Technology, Technical University of Denmark, and Carl von Ossietzky Universität Oldenburg

Figure 1: Second year master students get to operate a ship simulator.

RECRUITMENT ACTIVITIES AND EVENTS

Project managers: Assistant Prof. Kristin Lauritzsen (Kristin.lauritzsen@ntnu.no) and Associate Prof. Håvard Holm (Haavard.holm@ntnu.no)

Ocean Space Race (OSR): 5-6 March

Figure 2 (Kristin Lauritzsen, NTNU): Preparations for the Ocean Space Race at the ocean basin of the Marine Technology Centre in Trondheim.

Friday the 6th of March, the Ocean Space Race 2015 competition (OSR2015) took place at the Marine Technology Centre. A total of 511 participants (461 pupils and 50 teachers from 29 different secondary schools in Norway) attended the competition at the Ocean Basin Laboratory; the competition was to create the fastest and most operative and stable ship models. Unfortunately, 50 of the participants were not able to appear at OSR2015 due to a stoppage in air traffic caused by a strike of the Norwegian airline.

Prior to the competition, the participants had worked for approximately half a year to design and build their ship models. During OSR2015, the pupils were also able to attend exciting lectures about ongoing research projects, student life and future job opportunities in the marine industry. OSR has been conducted annually for eight years via a collaboration among the NTNU's Department of Marine Technology, MARINTEK and "Samarbeidsforum Marin". The aim is to increase the interest of pupils at the secondary school level in the study of mathematics and physics, in particular for studying ocean space technology.

A video was recorded by MARINTEK from OSR2015: http://www.oceanspacerace.no/film-bilder/video-osr2015 The competition was positively commented on by the national media Teknisk Ukeblad and also by many regional media organizations:

- Teknisk Ukeblad, Ocean Space Race – Blant de mest vellykkede prosjektene for realfagsrekruttering i Norge, 6 March 2015: http://www.tu.no/industri/2015/03/06/-blant-de-mest-vellykkede-prosjektene-for-realfags-rekruttering-i-norge
- NRK Rogaland, Flystreiken kan ødelegge drømmen om seier, 4 March 2015: http://www.nrk.no/rogaland/elever-fra-karmoy-skal-til-trondheim-med-egenprodusert-bat-1.12239373
- Sunnmørsposten, Haram-elevar vann Ocean Space Race, 9 March 2015: http://www.smp.no/nyheter/nordre/article10729417.ece
- Fjordenes Tidende, Fikk belønning etter et år med hardt arbeid, 15 March 2015: http://www.fjt.no/nyheter/article10747542.ece

Additionally, it received much attention on the web sites of regional communities and various secondary schools:

- Ulstein vgs, Elevar ved Haram vgs vann Ocean Space Race, 11 March 2015: http://www.ulstein.vgs.no/Organisasjon/Informasjonsseksjonen/Pressemeldingar/Elevar-ved-Haram-vgs-vann-Ocean-Space-Race
- Kristelig Gymnasium, Jørnship i norgestoppen!, 12 March 2015: http://www.kg.vgs.no/jornship-i-norgestoppen/
- Greåker videregående skole, Unge skipsdesignere til NTNU, 13 March 2015: http://greaker.vgs.no/ikbViewer/page/ofk/pages/nyheter/artikkel?doc_id=106286

Educational Exhibitions in January in Halden, Ålesund, Bergen and Trondheim

Students contributed at recruitment stands at educational exhibitions in Halden, Ålesund, Bergen and Trondheim. The stands at the educational exhibitions were organized by the central administration of NTNU. They offered information about the study programs of NTNU to pupils at the secondary school level in Norway.

NTNU Jentedagen ("Girls' Day"): 5-6 February

250 female pupils who scored on the highest levels in mathematics and physics at the secondary school level in

Norway participated at the NTNU's Jentedagen for two days. Presentations of the study programs, social lunches and dinner the first evening were on the agenda. The second day, the girls visited different stands showing the NTNU's broad activities related to mathematics and physics. The NTNU's Department of Marine Technology took part in organizing a stand at NTNU's Jentedagen.

Ocean Space Exploration Day: 27 April

Figure 3 (Kristin Lauritzsen, NTNU): Research Vessel Gunnerus and the Norwegian Coast Guard ship KV Njord.

Pupils and teachers at the primary school level of Norway, having "Research in practice" as an option, were invited to an inspiration day at NTNU. Five different classes from five different regions of Norway were selected. The selection was based on their reports from ongoing technological building projects. During this inspirational day, the pupils presented their projects and visited the laboratories of the Marine Technology Centre at Tyholt. Afterwards, they visited Trondhjem Biological Station, the Research Vessel Gunnerus and the Norwegian Coast Guard ship KV Njord. On shore, they could watch seafood dish preparations by a master chef and also have a taste of the delicious food. The fish and marine organisms had been caught the same morning by the RV Gunnerus. This event was arranged by the NTNU Department of Marine Technology, the NTNU Department of Biology (Trondhjem Biological Station), RV Gunnerus and "Samarbeidsforum Marin".

It was broadcasted by the following media:
• NRK Radio, Distriktsprogram Trøndelag, 27 April 2015
• NRK.no, Elever med på havforskning, 27 April 2015:
  http://www.nrk.no/video/PS*209293

Ocean Talent Camp at Rådhusplassen in Oslo: 1-4 June

The Norshipping Exposition is arranged every second year at Lillestrøm. On this occasion, a recruitment camp was arranged near the City Hall of Oslo. The camp was called Ocean Talent Camp. The NTNU's Department of Marine Technology and MARINTEK participated with a stand. Approximately 11000 pupils at the 9th and 10th levels of different primary schools in Norway visited the camp during this week. The student recruitment team did excellent work on the stand. Readymade cards with questions were given to the pupils, who were supposed to find the answers by visiting different stands. The questions were prepared by the stand members.

The winners of the Ocean Space Race 2015 demonstrated their boat models in a small basin near the camp. These schools were called Ocean Talent Camp Ambassadors, and their pupils wore special clothing labelled with their names. See one of the many videos recorded from the camp:
https://www.youtube.com/watch?v=HOPchMkjGYs

Figure 4 (Kristin Lauritzsen, NTNU): Pupils try out an underwater robot at Ocean Talent Camp.

The Tall Ships Race of Ålesund: 14-19 July

NTNU's Department of Marine Technology had a stand with recruitment activities for the general audience visiting the Tall Ships Race of Ålesund. Five students of the recruitment team organized the stand's activities, which were quite popular, especially among children. Here is a link to one of the many videos recorded during the event:
https://www.youtube.com/watch?v=-EfimDA2Xes

Tjuvstarten ("Jumping the gun event"): 10 August

The Tjuvstarten arrangement was a half-day seminar for new female students at the Marine Technology study programme, held at the Marine Technology Centre. The aim of the seminar was to let new female students meet and get to know each other prior to the start of the rest of the students. A total of 51 girls joined the seminar, which informed about student life in general and student life in particular at Tyholt. Job opportunities in the marine industry were also highlighted.

Forskningsdagene ("Research Days") 18-19 September and Researcher's Night 25 September in Trondheim

Figure 5 (Kristin Lauritzsen, NTNU): Pupils at "Forsknings-torget" trying out equipment.

A stand with recruitment activities was arranged at the city centre of Trondheim called "Forskningstorget" on the 18th-19th of September and at Researcher's Night on the 25th of September, "Realfagsbygget", at NTNU's Gløshaugen campus. The 18-19th were dedicated to pupils at the primary and secondary school levels in Norway and a general audience. Pupils at the secondary school level from central Norway were the focus on the evening of the 25th. This year, food was the focus of Forskningsdagene. Here is a link to an informational video recorded at Forskningsdagene 2015:
https://www.youtube.com/watch?v=za5gpDsFMwQ

Courses for Teachers in Secondary and Middle Schools

In cooperation with "skolelabben", NTNU now offers courses for secondary and middle school teachers in technology. In these courses, we offer projects with both a theoretical and a practical approach. All projects are targeted to be applied in school courses and address topics that are part of the curriculum. Workshops have also been arranged for the science centres. The intention of these workshops is to enable the science centres to provide courses and support for local schools. We have also had requests from institutions that educate teachers and are looking for opportunities to collaborate with them. This activity is a strategic action to set the focus on the marine sector in Norway and increase interest in working in this sector.

Visitors to NTNU's Tyholt Campus

External persons frequently visited NTNU's Tyholt campus in 2015. These visitors usually wanted to have a look at the unique laboratory facilities of the Marine Technology Centre and receive a presentation of the Marine Technology study programme of the Department. The most frequent visitors were pupils and teachers from both the primary and secondary school levels of Norway. Occasionally, the visitors were representatives from the marine industries, politicians, voluntary associations, NTNU technical personnel and international students. During 2015, a total of 16 different types of visits to the campus were organized.

Some visitors at the department of marine technology in 2015:

Visitor	Date
Norway's head of government Erna Solberg and foreign secretary Børge Brende	14 February
Delegation from the University of Tokyo, Japan	19 March
Local Chairman of Longyearbyen (Svalbard) Christin Kristoffersen	6 May
Norway's Minister of Education and Research Torbjørn Røe Isaksen	6 May
Delegation from Nelson Mandela Metropolitan University, South Africa	8 June
Delegation with Eirik Sivertsen from Bodø municipality	29 June
University of Warmia and Mazury, Poland	28 August

Visitor	Date
Delegations from the Federal University of Rio de Janeiro (UFRJ) and Federal University of Santa Catarina (UFSC), Brazil	26-28 October
The Japan Agency for Marine-Earth Science and Technology (JAMSTEC)	25 November
Norway's Minister of Fisheries Elisabeth Aspaker	1 December

NTNU Bridgehead Frøya

NTNU Bridgehead Frøya is a regional development programme that is an initiative of the Norwegian University of Science and Technology (NTNU) and the secondary school of Frøya. The main objectives are to strengthen the recruitment of highly qualified candidates to the aquaculture sector and to ensure an education and research experience that are consistent with the latest technologies and methodologies.

In 2015, NTNU Bridgehead Frøya connected and engaged with several hundred people on its own and also participated in partnering initiatives. These people include students, teachers, researchers and professors, industry professionals, politicians and policy implementation representatives.

Activities include the Bridgehead conferences, excursions, company visits, student attendance at industry arenas such as akvARENA, student day at AQUA NOR, hosting pupils visiting at NTNU, providing continuing education tailored for industry, developing aquaculture-themed «villages» in the NTNU program Experts in Teamwork (EiT), and many more.

Figure 6 (Jakob Berntsen, Bridgehead Frøya): Discussions at the Bridgehead conference.

Figure 7 (Adresseavisen): Students visiting a fish farm with the programme.

RESEARCH HIGHLIGHTS

A list of all of the department's research projects in 2015 is located in the appendices of this annual report. The following pages are selected research highlights from several of the department's projects in 2015.

Accidental Ship Collisions against Floating Bridges and Suspension Bridges with Floating Towers

Project manager: Prof. Jørgen Amdahl
(Jorgen.amdahl@ntnu.no)
Project web page: www.vegvesen.no/vegprosjekter

Statens vegvesen

The Norwegian Public Roads Administration (NPRA) is currently investigating the possibility of building a new coastal highway Route E39 along the Norwegian west coast from Kristiansand to Trondheim. The background for the project is that previous research shows that compared with ferry crossings, fixed crossings can stimulate the development of trade and industry along the E39 route. Eight fixed fjord crossings of bridges or tunnels will replace the existing ferry connections. One connection that was investigated is the floating bridge concept across Bjørnefjorden, which is approximately five kilometres wide and 600 metres deep.

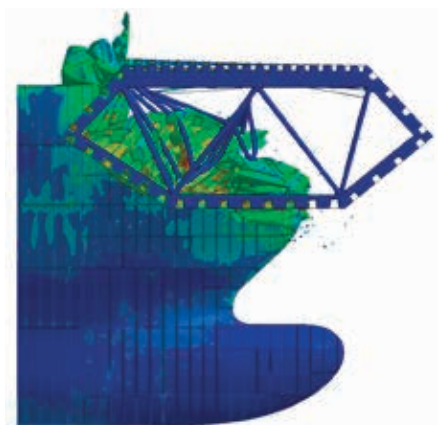The bridge shown in Figure 8 has 10 continuous side spans supported by pontoons on each side. In the middle, a cable-stayed span is supported by two floating towers resting on two main pontoons. The waterway below the 450 m long cable-stayed span is the main navigation channel for passing ships. There are routes for large container ships and cruise ships with length up to 200 metres, which operate regularly in the fjord.

The ship traffic under the bridge raises the concern of ship collisions According to a risk analysis, an impact from a container vessel weighing 32,000 tons and travelling at a speed of 5 m/s yielding a kinetic energy of 400 MJ might need to be considered. Special attention is given to the concrete pontoons, which have the highest possibility of suffering ship impacts. The pontoon wall has a thickness of 0.9 m

A collision with the bow of a container vessel of 20000 DWT was simulated using the software package LS-DYNA. The pontoon wall is not capable of resisting the force and is damaged due to punching shear failure. Next, the bulb pushes a small hole in the pontoon. The deformation of the pontoon wall and the bulbous bow of the container vessel are shown. The reinforced concrete wall dissipates a small part of the energy, but it is not strong enough to force the bulb to collapse. Thus, the considered pontoon wall needs to be strengthened.

Figure 8:a) Floating cable-stayed bridge in Bjørnefjorden.   *b) Simulated collisions damage*

A collision between the bow of a passenger vessel and a bridge girder outside the ordinary waterway was also analysed. Figure 8b shows a snapshot of the damage created in the bow and the bridge girder

Blue Mining

Project manager: Adjunct Prof. Fredrik Søreide (Fredrik.soreide@ntnu.no)
Project web page: **www.bluemining.eu**

The overall objective of Blue Mining is to provide break-through solutions for a sustainable deep sea mining value chain. This means developing the technical capabilities to adequately and cost-effectively discover, assess and extract deep sea mineral deposits at up to 6,000 m water depths, as this is the range in which valuable seafloor mineral resources are generally found.

The Department of Marine Technology is involved in Work Package 1 and Work Package 5. Work Package 1 aims to deliver new tools for the exploration for inactive seafloor massive sulphide and Mn-nodule deposits, providing a new measure of the true metal potential of these deposits. The application of new sensors such as hyperspectral imagers to identify marine minerals on the seabed are investigated in our work. Work Package 5 investigates new alternatives for the vertical transport of minerals in a marine mining setting. NTNU will perform a demonstration of the experimental equipment developed by the project in 2016. To do so, a prototype pump will be deployed on the seabed , showing its performance in deep water.

The Blue Mining project is financed by the EU through the Seventh Framework Programme.
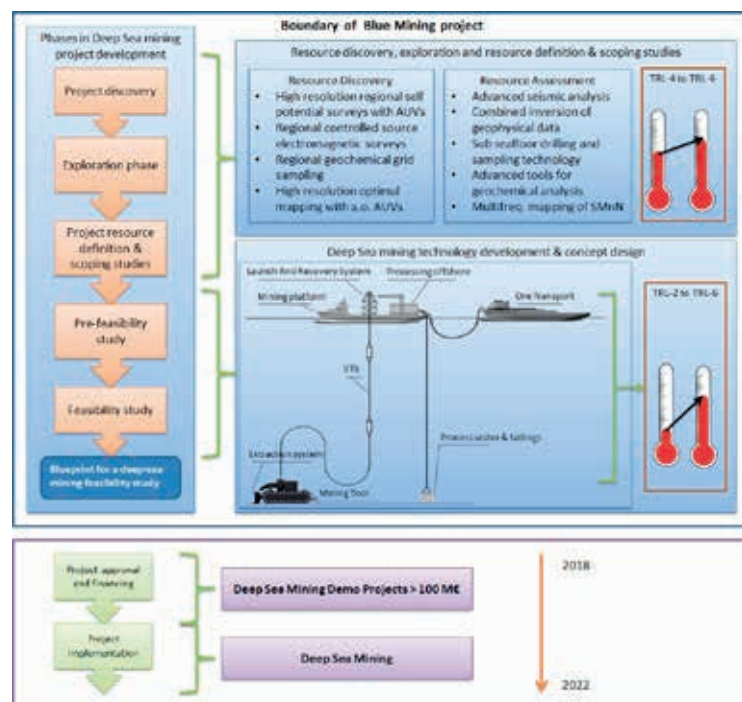
Figure 9: Concept of deep sea mining and the approach used in the Blue Mining project.

Design and Verification of Control System for Safe and Energy-efficient Vessels with Hybrid Power Plants (D2V)

Project manager: Prof. Asgeir J. Sørensen (asgeir.sorensen@ntnu.no)

Dynamically positioned (DP) vessels with electric power plants in the range of 10 -–80 MW are used in the offshore industry in several safety-critical operations, including drilling, supply, offloading, construction, anchor handling, and production. DP vessels are increasingly used, and they constitute a major part of the national and international maritime activities related to the exploration and exploitation of hydrocarbons and other advanced offshore operations. The development of knowledge and competence in the design and qualification of safe and environmentally robust power and energy management systems for safer and greener offshore vessels is critical for the Norwegian industry.

In 2015, we worked further on the development of the marine hybrid power plant simulator and performed simulations of user cases for the design of control systems. In addition, the Hybrid Power Laboratory was set up, partly funded by the project, to measure the system performance of the power plant including diesel engines, DC/AC electrical systems and energy storage devices (Figure 10). In recent laboratory measurements, we have identified the effect of transient load on fuel consumption and gas emission of the diesel engines. In the test, we applied a sinusoidal load with different frequencies and a fixed amplitude.

Figure 10: Hybrid Power Laboratory.

Through these activities, the project addresses the following:
• Design and verification of complex systems by system simulations
• Analysis of transient and stationary dynamics on fuel consumption and gas emissions
• Optimal and fault-tolerant control of hybrid power systems on ships and rigs
  - Diesel- and LNG-driven gensets
  - Energy storage using battery banks, capacitor banks, etc.
  - AC and DC systems

Holistic Risk-based Design for Sustainable Arctic Sea Transport (RISKAT)

Project manager: Prof. Sören Ehlers (Soren.ehlers@ntnu.no)
Project web page: www.ntnu.edu/sast/projects

The motivation for this project arises from the fast exploration of the arctic sea and the fact that Norwegian waters are the primary entrance to high north transport. Thus, the key decision and innovation must be made with the Norwegian maritime industry.

Consequently, this project develops the cutting-edge arctic ship design knowledge considering: Consistent identification of design relevant sea ice conditions and resulting loads; Concise identification of the effect of these loads on the structural design of arctic ships; and Identification of goal- and risk-based design in the context of arctic sea transport systems.

Highlights:

Bergström, Martin Vilhelm; Erikstad, Stein Ove; Ehlers, Sören. Applying risk-based design to arctic ships. I: Proceedings ASME 2015 34th International Conference on Ocean, Offshore and Arctic Engineering Volume 8: Ian Jordaan Honoring Symposium on Ice Engineering. ASME Press 2015 ISBN 978-0-7918-5656-7.

Bergström, Martin Vilhelm; Erikstad, Stein Ove; Ehlers, Sören. Assessment of the effect of uncertainties in design parameters on the design of arctic ships. I: Proceedings of the 12th International Marine Design Conference (IMDC 2015) - Volume 2. Tokyo, Japan: The Japan Society of Naval Architects and Ocean Engineers 2015 ISBN 978-4-930966-04-9. p. 309-323

Erceg, Boris; Ralph, Freeman; Ehlers, Sören; Jordaan, Ian. Structural response of ice-going ships using a probabilistic design load method. I: Proceedings ASME 2015 34th International Conference on Ocean, Offshore and Arctic Engineering Volume 8: Ian Jordaan Honoring Symposium on Ice Engineering. ASME Press 2015 ISBN 978-0-7918-5656-7.

Erceg, Boris; Taylor, Rocky; Ehlers, Sören. Structural response comparison using different approaches to account for ice loading. Proceedings - International Conference on Port and Ocean Engineering under Arctic Conditions 2015

Piehl, Henry Peter; von Bock und Polach, Rüdiger Ulrich Franz; Erceg, Sandro; Polic, Drazen; Bambulyak,

Figure 11 (illustration: Bjarne Stenberg, copyright: NTNU): Illustration of the Arctic region.

Alexei; Das, Jitapriya; Erceg, Boris; Tõns, Tõnis; Bergström, Martin Vilhelm; Myland, Daniela; Milakovic, Aleksandar-Sasa; Ehlers, Sören. A framework for a design and optimization platform for ships in arctic conditions. Proceedings - International Conference on Port and Ocean Engineering under Arctic Conditions 2015

Tõns, Tõnis; Freeman, Ralph; Ehlers, Sören; Jordaan, Ian. Probabilistic Design Load Method for the Northern Sea Route. I: Proceedings ASME 2015 34th International Conference on Ocean, Offshore and Arctic Engineering Volume 8: Ian Jordaan Honoring Symposium on Ice Engineering. ASME Press 2015 ISBN 978-0-7918-5656-7.

Hydrodynamic Aspects of Sail-Supported Merchant Vessels

Project manager: Prof. Bjørn Egil Asbjørnslett (Bjorn.e.asbjornslett@ntnu.no)

High-tech sails are suggested as a solution to reduce fuel consumption in shipping. Many different design solutions exist. Some examples are wing-sails, Flettner rotors and kites, all with different strengths and weaknesses.

The purpose of this PhD project is to explore the hydrodynamic challenges connected with different sail technologies. The main challenge is that sails produce a very large side force in addition to thrust. If we consider a specific route across the North Atlantic as an example, a typical wing-sail will produce a side force that is larger than the thrust more than 50% of the time. This side force must be balanced by the ship hull, causing travel with a drift angle.

The hulls of modern cargo ships are not designed for this, and the question becomes: Do we need to change the design of the cargo ship hull to use modern sail technologies? To answer this, CFD studies of hull geometries and sail solutions, coupled with historical wind data on typical shipping routes, are used. As a ship hull moving with a drift angle is a complex phenomenon, experimental validation experiments on a ship-like foil have been performed (see Figure 12a).

This study is carried out as part of the Low Energy and Emission Design of Ships (LEEDS) project, supported by the Norwegian Research Council.

Figure 12a (Jarle Andre Kramer, NTNU): Validation experiment for drift-induced forces.

Figure 12b (Jarle Andre Kramer, NTNU): Artistic illustration of a sailing cargo ship.

Next Generation Subsea Inspection, Maintenance and Repair Operations (NextGenIMR)

Project manager: Prof. Ingrid Schjølberg (Ingrid.schjolberg@ntnu.no)

Maintaining high regularity with subsea facilities requires reliable installed equipment, but also *efficient ways for inspection, condition monitoring and early detection of equipment fault.* NextGenIMR develops robust perception methods for localization and positioning of underwater vehicles carrying intervention tools. This is the first step towards autonomy in IMR operations. Moreover, the project focuses on development of methods for collision-free motion planning for autonomous subsea inspection and light intervention operations. This is important in the pre-phase when the underwater vehicles is moving towards a facility and in the operational phase when the tool is positioned before the intervention. The project also has a strong focus on subsea factory design for autonomous intervention as well as development of tools and methods on-line risk management during IMR operations. The project especially addresses autonomous platforms but results are applicable to cable connected ROVs that will shift from manual to automatic control with autonomous functions. A dynamic simulator is under development using the MORSE and MOOS framework. NextGenIMR results will be tested, verified and demonstrated in full scale test beds available at NTNU and among industry partners. The technology will be highly relevant for IMR operations in fish farms and in deep sea mining. The project has published five articles in international peer-reviewed conferences.
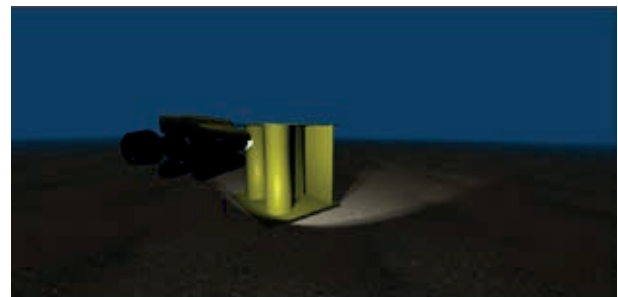

Figure 13: Dynamic ROV simulator.

Sea Trials and Model Tests for the Validation of Shiphandling Simulation Models (SimVal)

Project manager: Prof. Sverre Steen (Sverre.steen@ntnu.no)
Project web page: www.sintef.no/simval

The objective of the project is to develop and apply a method for the validation of ship manoeuvring simulation models, typically used in engineering tools for studies of ships' manoeuvring performance in deep and restricted waters and ship handling training simulators. Manoeuvring trials at full scale have been performed with the NTNU research vessel "Gunnerus", the ferry "Landegode" and the offshore vessel "Island Condor". Model tests have been performed with the same vessels, and manoeuvring simulation models have been developed. The project is managed by MARINTEK. At NTNU, Sergey Gavrilin is performing PhD work on the uncertainty analysis of manoeuvring trials and simulation models, and Afshin Abbasi-Hoseini is performing post-doctoral work on the use of ship monitoring data for the validation of manoeuvring simulation models.
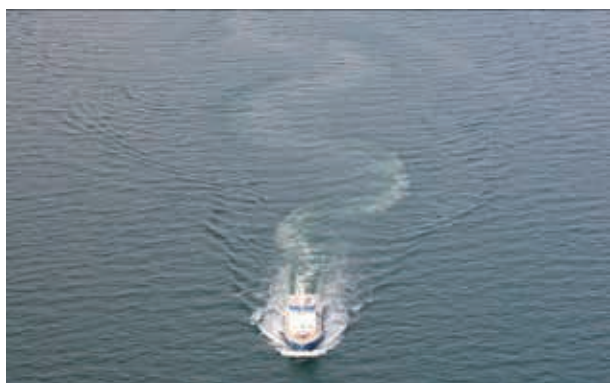

Figure 14: Research vessel Gunnerus during a zig-zag manoeuvring trial.

SFI Sustainable Marine and Coastal Technology (SAMCoT)

Researchers from IMT:
Professors Roger Skjetne (Roger.skjetne@ntnu.no),
Ingrid B. Utne (Ingrid.b.utne@ntnu.no)
and Jørgen Amdahl (Jorgen.amdahl@ntnu.no)
Project web page: www.ntnu.edu/samcot

The research centre CRI SAMCoT was awarded to NTNU and started in 2011, with a duration of 4+4 years, and it success-fully passed the midterm evaluation in 2015. The vision is to become a *"Leading international centre for the development of robust technology needed by the industry operating in the Arctic region."* The centre has achieved a high external impact, with a consortium of 13 industrial partners, 8 research partners, and 2 public partners. It is organized into 6 work packages (WPs). Prof. Amdahl is involved in WP4 *Floating structures*, whereas WP5 on *Ice Management and Design Philosophy* is managed by Prof. Skjetne, and Prof. Utne is a key researcher.

An example of a focus of research has been on developing smarter Dynamic Positioning (DP) and Position Mooring (PM) control systems that better understand ice loads and how to mitigate them. An important study was the phenome-nological investigation of ice loads from sea-ice broken by icebreakers conducted by Kjerstad et al. (2015). The study shows that ice loads have very different characteristics than open water loads from wind, waves, and currents. Learnings from this has then shown how intelligent feedforward of IMU measurements can further improve the responsiveness of the DP and PM control systems to rapidly handling changing external loads (see the PhD thesis of Ø. K. Kjerstad, 2016, for more details).

Figure 15 (Per Frejvall): Oden Arctic Technology Research Cruise 2015. Scientific crew on icebreaker Oden.

In September-October 2015, SAMCoT researchers organized the Oden Arctic Technology and Research Cruise (OATRC'15) expedition, an NTNU field campaign sponsored by Exxon-Mobil. Two Swedish icebreakers, Oden and Frej, set out from Longyearbyen on Sept. 18th to an ice field at 82.5°N, 16°E. The objective of this cruise was to test ice management tactics with two icebreakers to test the technology and methods for measuring and monitoring ice parameters and to collect data. The highly valuable data are now being analysed to generate new knowledge of marine technology and operations in the Arctic.

Smart and Networking Underwater Robots in Cooperation Meshes (SWARMs)

Project manager: Prof. Ingrid Schjølberg (Ingrid.schjolberg@ntnu.no)
Project web page: www.swarms.eu

The overall goal of the SWARMs project is to expand the use of AUVs/ROVs and facilitate the creation, planning and execution of maritime and offshore operations. The SWARMs project aims to make AUVs/ROVs accessible to more users by

• Enabling AUVs/ROVs to work in a cooperative mesh, thus opening up new applications and ensuring re-usability, as no specialized vehicles are needed, but heterogeneous standard vehicles can combine their capabilities and
• Increasing the autonomy of AUVs and improving the usability of ROVs.

The approach is to design and develop an integrated platform (a set of software/hardware components) incorporated into the current generation of underwater vehicles to improve the autonomy, cooperation, robustness, cost-effectiveness, and reliability of the offshore operations. SWARMs' achievements will be demonstrated in two field tests in the following different scenarios:

• Inspection, maintenance and repair of offshore infrastructure
• Pollution monitoring
• Offshore construction operations

The final demonstration will be in the fjord of Trondheim using vessels and underwater vehicles from NTNU. SWARMs is an industry-dominated project where large technology

Figure 16: Kick-off meeting in Madrid in July 2015.

companies will collaborate with SMEs specialized in the sub-sea, robotics and communication sectors, universities and research institutions to ensure that the newest innovations in subsea robotics will arrive quickly to market. As the voice of the customer, two end-users are also part of the consortium.

WaveSpring

Project manager: Dr Jørgen Hals Todalshaug (Jorgen.hals@ntnu.no)

As part of its efforts to support renewable ocean energy, the Department of Marine Technology has maintained activity in the field of wave energy research. One research result that was picked up by NTNU's Technology Transfer organization and later supported by the NTNU Discovery fund is the concept of a mechanical component that improves the dynamic properties of wave energy buoys.

Starting with sketches and simulation models in 2012 and followed by small lab experiments at NTNU in 2013, the activity has developed into the current collaboration with several academic and commercial partners across Europe.

The concept is simple: An arrangement of pneumatic or hydraulic cylinders installed in parallel with the wave-energy buoy's machinery provides a "negative spring" force that serves to make the buoy more responsive to incoming waves. The name WaveSpring was coined for the concept – could it contribute to an awaited "spring" for wave energy conversion?

One version of the mechanical device has been engineered and manufactured by the Swedish wave-energy company CorPower Ocean, who is preparing a prototype system to be deployed at EMEC/Orkney during the winter of 2016/2017.

Alternative configurations are being investigated in a collaboration project between NTNU, Aalborg University and the company Wavestar.

More information:
www.corpowerocean.com
http://energiforskning.dk/en/node/7965
http://www.marinet.eu/access_user_project_PhaseX.html

Figure 17: CorPower Ocean's wave energy buoy, with three WaveSpring cylinders connected between the buoy hull and the centre rod.

RESEARCH CENTRES

Centre for Autonomous Marine Operations and Systems (NTNU AMOS)

Director: Prof. Asgeir J. Sørensen (Asgeir.sorensen@ntnu.no)
Web page: www.ntnu.edu/amos

NTNU AMOS

The NTNU Departments of Marine Technology and Engineering Cybernetics, together with MARINTEK, SINTEF Fisheries and Aquaculture, SINTEF ICT, DNV GL and Statoil and leading international and national collaborators, were awarded a Centre of Excellence (CoE) by the Research Council of Norway in 2013.

NTNU AMOS creates fundamental knowledge and innovates through multidisciplinary theoretical, numerical, and experimental research within the knowledge fields of hydrodynamics, structural mechanics, guidance, navigation, and control. Cutting-edge inter-disciplinary research will provide the necessary bridge to realize high levels of autonomy for ships and ocean structures, unmanned vehicles, and marine operations and to address the challenges associated with greener and safer maritime transport, monitoring and surveillance of the coast and oceans, offshore renewable energy, and oil and gas exploration and production in deep and Arctic waters.

Centre for Ships and Ocean Structures (CeSOS)

Director: Prof. Torgeir Moan (Torgeir.moan@ntnu.no)
Web page: www.cesos.ntnu.no

The Centre for Ships and Ocean Structures (CeSOS) was established as a Centre of Excellence by the Research Council of Norway (RCN) in 2002 with support from RCN as well as NTNU, MARINTEK, DNV and Statoil. Key researchers involve professors from the Departments of Marine Technology, Engineering Cybernetics and Mathematics at NTNU.

The centre has been operating in close cooperation with sponsors and scientists from the Technical University of Denmark (DTU), Massachusetts Institute of Technology (MIT), INSEAN and other universities and research institutes. CeSOS focuses on the development of fundamental knowledge concerning the design and operation of future ships and ocean structures by integrating theoretical and experimental research in marine hydrodynamics, structural mechanics and automatic control.

The support from RCN formally ended after 10 years, as scheduled; however, CeSOS personnel still conduct high-quality research activities as key personnel in NTNU AMOS. Furthermore, several PhD candidates are affiliated with NTNU AMOS. An overview of key personnel, scientific publications and PhD theses during the period of 2002-2012 are available on the CeSOS website (see link above). Since 2013, research activities have primarily been reported through the Department of Marine Technology and NTNU AMOS.

Rolls-Royce University Technology Centre (UTC) "Performance in a Seaway"

Director: Prof. Sverre Steen (Sverre.steen@ntnu.no)
Web page: www.ntnu.edu/imt/rolls_royce

Rolls-Royce

The University Technology Centre is a research collaboration with Rolls-Royce Marine and MARINTEK. The research is organized into four focus areas:
1. Greening shipping in waves
2. Dynamic loads on propulsors
3. Marine operations
4. "Big data" analysis of ships in operation

The main research activities at NTNU IMT in 2015 were:
- Renewable energy propulsion using wave foils; a practically realizable concept for using foils to utilize waves as extra propulsion on merchant ships was developed in cooperation with Rolls-Royce in the UK. This project was run by post doc research fellow Eirik Bøckmann.
- Anirban Bhattacharyya completed his PhD by developing a practical method for quantifying the scale effect of ducted propellers. His study was based on RANS CFD and model testing.
- Propulsion in waves; the effect of waves on the cavitation characteristics and propeller-engine interaction when a ship is travelling in waves were examined by Bhushan Taskar in his PhD. A simulation model for the propeller-engine coupled performance was developed together with Kevin Koosup Yum. Guidance on how to account for waves in the propeller design is given.
- Hydrodynamics of merchant vessels with sails; PhD-student Jarle A Kramer performed CFD calculations and model tests to quantify the lift and drag of ship hulls travelling with a yaw angle, and he compared the performance of wing sails and Flettner rotors, taking the hull hydrodynamics into account.

- Validation of ship manoeuvring simulation models using both dedicated full-scale trials and data from ships in normal operation was conducted in the PhD work of Sergey Gavrilin and the post-doc studies of Afshin Abbasi-Hoseini.
- Øyvind Dalheim and Anna Swider are doing their PhDs on using "Big data" to analyse ship performance data collected on permanently installed instrumentation when the ships are in normal operation. Dalheim focuses on hydrodynamics, while Swider focuses on machinery systems. The objectives are to provide knowledge for better ship designs and to optimize the operation of the ships.
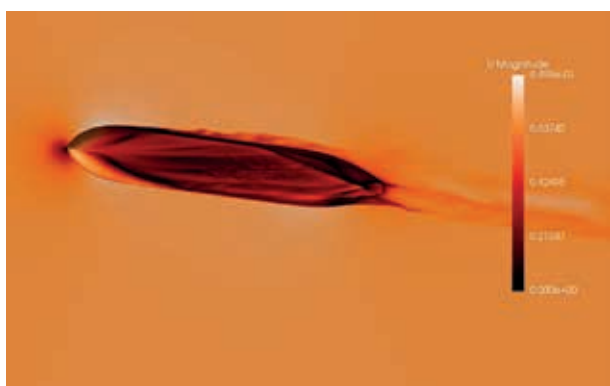

Figure 18: Velocity field around a ship hull moving with a drift angle, computed with CFD by PhD candidate Jarle A. Kramer using OpenFoam.

SFI Smart Maritime

Norwegian Centre for Improved Energy Efficiency and Reduced Emissions from the Maritime Sector (MARINTEK AS)

NTNU responsible: Prof. Bjørn Egil Asbjørnslett
(Bjorn.e.asbjornslett@ntnu.no)
Web page: www.smartmaritime.no

The purpose of Smart Maritime is to establish a Norwegian Centre for improved energy efficiency and reduced harmful emissions within the maritime sector. The ultimate vision is one of greening maritime transport, and enabling the Norwegian maritime industry to be a world leader in environmentally friendly shipping. This position will be gained through innovative improvements, and a combination of technologies that are cost, energy and emission efficient and could also increase revenues in the maritime industry.

After the eight-year SFI period, the Centre will become a permanent part of the planned Ocean Space Centre in Trondheim.

The Centre formally opened on July 1, 2015, but the main activity on work packages (WPs) began in September with three PhD candidates. All WPs are progressing well, with journal papers published. A kick-off and networking meeting was arranged in November, at which partners discussed the proposed work and two sub-projects (fuel and hybrid). Relevant industrial partners have been actively involved in these sub-projects. One result of the fuel project is a promising solution to meet existing IMO emission limits for vessels running on Heavy Fuel Oil (HFO) in a cost efficient manner using Scrubbing and Exhaust Gas Recirculation (EGR).

Smart Maritime has developed an active website at www.smartmaritime.no, which is updated at least monthly with information and news. The site has content that is publicly accessible, as well as a section for closed member access. The Centre uses this platform to disseminate public information and for internal member communication.

SFI EXPOSED

**Exposed Aquaculture Operations
(SINTEF Fisheries and Aquaculture AS)**

NTNU responsible: Prof. Ingrid Schjølberg
(Ingrid.schjolberg@ntnu.no)
Web page: http://exposedaquaculture.no/en

The main objective of SFI EXPOSED is to develop knowledge and technologies for EXPOSED aquaculture operations, enabling the sustainable expansion of the fish farming industry. EXPOSED will develop knowledge and technology for robust, safe and efficient fish farming at exposed locations.

The EXPOSED Centre brings together global leaders among salmon farmers, key service and technology providers, SINTEF Fisheries and Aquaculture representatives, and other robust research groups, including NTNU AMOS (the Norwegian Centre of Excellence for Autonomous Marine

Operations and Systems). Eight initial projects have been selected for 2015-2016 and beyond. In 2015, an initial project (P1) documented the existing knowledge base and opportunities for innovation. Other projects have focused on developing methodology (P5), establishing research infrastructure (P8), carrying out preliminary studies (P4) and initiating research with PhD candidates (P6 and P7). Full project activity will commence in 2016.

To support cross-disciplinary innovation and good communication within the centre, the centre has arranged two days of "EXPOSED Days" in the spring, and a similar one-day event in the autumn. Such events will be arranged yearly, in addition to PhD/postdoc workshops and more targeted project-related meetings. The "EXPOSED Days" will serve as a meeting place for discussing innovation, presenting results, exchanging ideas, and creating new projects. There has been significant industrial and political interest in EXPOSED and its objectives in 2015.

Also internationally, the topic of exposed farming raises significant interest. The research areas of the centre have been presented in various national and international forums to support future collaboration with other stakeholders.

SFI MOVE

Marine Operations (Ålesund University College)
NTNU IMT responsible: Prof. Svein Sævik
(Svein.savik@ntnu.no)
Web page: https://www.ntnu.edu/move

SFI MOVE aims to support the entire marine operations value chain by developing knowledge, methods and computer tools for safe and efficient analysis of both equipment and installation processes. The developed methods will be tested in simulated environments to both train individual users as well as improve team performance.

The business focus areas are as follows:
• Demanding marine offshore operations, such as operations in ultra-deep water or arctic regions, or those requiring year-round availability
• Installation and maintenance of offshore wind
• Subsea mining

Active involvement from the industry is key to supporting the marine operation innovation process. An Industrial Advisor Group has been established to achieve needed industrial involvement and commitment and is composed of participants from companies in the consortium. This group will develop an annual innovation plan, the first of which was established in the fall of 2015 and will be implemented in 2016.

The Industrial Advisor Group outlined major challenges and sub-projects to be executed by SFI MOVE. The following 5 innovation projects have been defined:
• Sub-pr. 1: OW1; Low-Cost Installation and Maintenance of Fixed Offshore Wind Structures
• Sub-pr. 2: Subsea; Safe, Year-Round, Cost Efficient Subsea Operations
• Sub-pr. 3: VP2; Simulation Technology and Virtual Proto-typing as a Common Approach from Design to Operation
• Sub-pr. 4: Mining; Exploration of Technologies to Develop Seabed Mining as a New Business Sector
• Sub-pr. 5: OW; Installation of Floating Wind Power Systems

The Industrial Advisory Group initiates projects through business cases and follows up on the results on an annual basis.

Other National Expertise Centres with the Involvement of the Department of Marine Technology

Sustainable Arctic Marine and Coastal Technology (SAMCoT): A Centre for Research-based Innovation for the development of robust technology necessary for sustainable exploration and exploitation of the valuable and vulnerable Arctic region. Lead partner: NTNU Department of Civil and Transport Engineering.

Web page: www.ntnu.edu/samcot

Norwegian Research Centre for Offshore Wind Technology (NOWITECH): A Centre for Environment-friendly Energy Research established to conduct concentrated, focused and long-term research to solve specific challenges in the field of energy and the environment. Lead partner: SINTEF Energy Research.

Web page: www.sintef.no/Projectweb/Nowitech

OCEAN SPACE CENTRE

Web page: www.oceanspacecentre.no/english
NTNU contact: Prof. Sverre Steen (Sverre.steen@ntnu.no)

Efforts to establish an understanding for the need of the Ocean Space Centre continued. However, the government has decided that parts of the first quality assurance point (KS1) needed to be redone since partners MARINTEK and NTNU disagreed with the previous concept for a combined seakeeping tank and ocean basin, which was included in the project by the assessors in the first quality assurance point (KS1). Therefore, DNV GL and Menon were hired to complete a concept selection study, comparing the concept that was recommended in the first quality assurance point (KS1) with the modified concept preferred by NTNU and MARINTEK, as well as a reference alternative based on a continuation of the Centre as is.

As part of the modified concept, the Department of Marine Technology proposed making a flexible area consisting of a collection of smaller, specialized laboratories for education and research, and a relatively large seakeeping and wave basin (see Figure 19). The flexible space will allow for the easy re-configuration of laboratories; the collection of labs shown in the illustration should be considered an example rather than a fixed plan for the laboratories. Additionally, we want

this lab area to bolster the use of laboratories in research and education by making these spaces more accessible and improving the quality of the facilities.
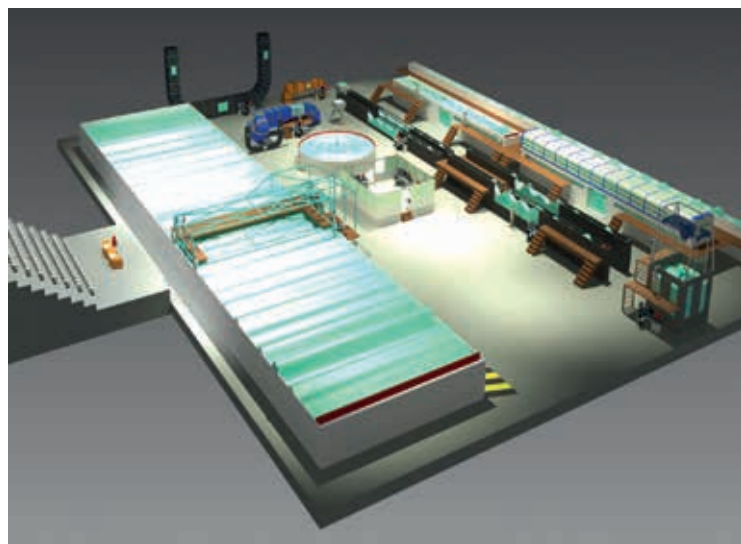
Figure 19: Flexible lab area for research and education proposed for the Ocean Space Centre.

STRATEGIC RESEARCH AREA NTNU OCEANS

Director: Prof. Ingrid Schjølberg (Ingrid.schjolberg@ntnu.no)
Coordinator: Alexandra Neyts (Alexandra.neyts@ntnu.no)
Web page: www.ntnu.edu/oceans

NTNU Oceans is one of four strategic research areas at NTNU. The faculty of Engineering Science and Technology and the Department of Marine Technology host NTNU Oceans.

The overall vision of NTNU Ocean is knowledge for the sustainable use of oceans. The focus is on science and technology for polar regions, deep ocean operations and exploration, marine minerals, aquaculture and maritime transport. NTNU Oceans builds multidisciplinary research

across knowledge fields. The fields of ICT, biotechnology, advanced materials, safety and risk management provide essential knowledge and tools. The ocean environment, policy, governance and society are key factors to ensure sustainable knowledge development.

In 2015, two major pilot projects were initiated.
- **Deep Sea Mining**, including more than 10 PhD positions addressing ethics, geophysics, environmental issues, geological processes, history of sea laws and concept development for retrieving marine minerals.
- **Eco-intensive Aquaculture**, more than 8 PhD positions addressing biological aspects such as lice and algae development, waste management, water column and seafloor effects, life cycle aspects and technology development for sustainable aquaculture.

INNOVATION

Spin-off companies founded in 2015

BluEye Robotics AS

The company is developing a remote controlled subsea drone aimed at the semi-professional and consumer market. BluEye Robotics AS aims to develop underwater drones that will revolutionize the experience of exploring the ocean and that takes the user down to the seabed. In 2015, BluEye finalized their first two prototypes, which were used in expeditions across both the Atlantic and Pacific Oceans. The planned product launch is in the autumn of 2016.

Figure 20 (BluEye): CEO Erik Dyrkoren, Borja Serra and Christine Spiten testing the PX underwater robot in the towing tank at MARINTEK.

Eelume AS

Eelume AS is a new spin-off company from the Department of Engineering Cybernetics and the Department of Marine Technology at NTNU and NTNU AMOS, and its technology is based on exte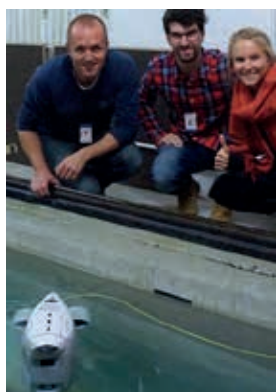nsive research on snake robotics and marine control systems. Eelume AS is developing a disruptive solution for underwater inspection and intervention in the form of a swimming robot.

The idea is to let these robots perform inspections and light intervention jobs on the seabed, thus reducing the use of large and expensive surface vessels. With its snake-like form, the slender and flexible body of the Eelume robot provides access to confined areas that are difficult to access with existing technology.

Eelume robots will be permanently installed on the seabed and will perform planned and on-demand inspections and interventions. The robot can be installed on both existing and new fields where typical jobs include visual inspection, cleaning, and adjusting valves and chokes. These jobs account for a large portion of the total spending on subsea inspection and intervention.

Wavespring technology licensed to CorPower Ocean AB

In 2015, NTNU made a license agreement based on research from the Department of Marine Technology, the former Centre of Excellence CeSOS and NTNU AMOS. The Swedish technology start-up CorPower Ocean AB was founded in 2009 to develop Wave Energy Converters (WEC). A highly efficient phase control technology, Wavespring, invented by PhD Jørgen Hals Todalshaug at the Department of Marine Technology, was a perfect match to CorPowers wave energy converter technology. The WaveSpring technology has demonstrated a game-changing performance that is set to revolutionize wave power. It is a result of research on phase-controlled point absorbers that has been conducted in Trondheim since the 1970s.

Commercialization project VeriArc

VeriArc stands for "Verifying Arctic offshore field activities" and is a commercialization project at NTNU that has received significant funding from the NTNU Discovery fund. The objective is to commercialize a product around a dynamic simulator on ice-structure interaction (loads and responses), and find out how to utilize this in a commercial setting. The development of the numerical simulator is based on research and competence built up from numerous research projects on Arctic topics at NTNU. The SFI SAMCoT is the latest and largest effort in this direction, also including close collaboration with the Department of Marine Technology and NTNU AMOS. The vision of VeriArc is to become "pioneers in verification of Arctic offshore activities", and the business idea is "safer and publically accepted Arctic offshore activities through verification of structure designs, operational procedures, and decision support tools using superior sea-ice simulation technology". The principal researchers initiating the VeriArc commercialization project are Professor Sveinung Løset, Assistant Professor Raed Lubbad, and Professor Roger Skjetne.

More details are presented in:
Lubbad, Raed; Løset, Sveinung; Skjetne, Roger. Numerical Simulations Verifying Arctic Offshore Field Activities. Proceedings - International Conference on Port and Ocean Engineering under Arctic Conditions 2015 ;Volume 2015-January.

RESEARCH FACILITIES

	Facility	Description	Operational institution	Website
1	Ocean basin	LxWxD = 70m x 50m x 10m; waves from two directions, variable water depth, winds and currents	MARINTEK	https://www.ntnu.edu/imt/lab/ocean
2	Large towing tank (tank I+III)	LxWxD = 260m x 10m x 5m - 10m; waves in the direction of the tank, two carriages, max 10m/s	NTNU and MARINTEK	https://www.ntnu.edu/imt/lab/towing
3	Cavitation laboratory	Circulating water tunnel with controlled pressure; measurement section of 1.2m in diameter, velocity up to 12m/s	NTNU and MARINTEK	https://www.ntnu.edu/imt/lab/cavitation
4	Circulating water tunnel	Used for flow visualization, PIV and LDV measurements in connection with student exercises and PhD research projects	NTNU	https://www.ntnu.edu/imt/lab/cwt
5	Small towing tank	LxWxD = 25m x 2m x 1m; towing tank for educational purposes	NTNU and MARINTEK	https://www.ntnu.edu/imt/lab/towing
6	Marine cybernetics laboratory (MC-lab)	LxWxD = 35m x 3.5m x 1.6m; waves from one direction, advanced towing carriage and instrumentation for control system experiments	NTNU	https://www.ntnu.edu/imt/lab/cybernetics
7	Marine HIL simulation laboratory	Hardware-In-The-Loop (HIL) simulation lab for students and researchers to verify their HW/SW setups, signal communication, user interfaces, and test scenarios in real time for bugs and weaknesses prior to conducting actual time-limited experiments	NTNU	https://www.ntnu.edu/imt/lab/hil
8	Wave tank	LxWxD = 13m x 0.6m x 1m; for 2-D studies of wave kinematics	NTNU	-
9	Marine structures laboratory	Static and dynamic testing of structures and structural components	NTNU and MARINTEK	https://www.ntnu.edu/imt/lab/structures
10	Machinery laboratory	Equipment for testing of marine engines, fuel, and new concepts	NTNU and MARINTEK	https://www.ntnu.edu/imt/lab/machinery
11	Hybrid power laboratory	Combined power and simulation lab for testing novel marine power plants	NTNU and MARINTEK	https://www.ntnu.edu/imt/lab/hybrid
12	Applied underwater robotics labora-tory (AUR-lab)	Two remotely operated underwater vehicles (ROV), one autonomous underwater vehicle (AUV), research vessel Gunnerus and associated instrumentation systems	NTNU	https://www.ntnu.edu/aur-lab
13	Unmanned aerial vehicles laboratory (UAV-lab)	Unmanned aerial vehicles and open-source guidance, navigation, control, and communication systems, payload sensors, simulators, test fields, crew, and support systems	NTNU	http://www.itk.ntnu.no/english/lab/unmanned
14	Aquaculture engineering laboratory (ACE)	Large-scale laboratory facility designed to develop and test new aquaculture technologies	SINTEF Fisheries & Aquaculture, NTNU and more	http://aceaqua.no/en/
15	Flume tank	LxWxD = 2.5m x 0.61m x 0.61m; flume with a test section, velocity of 0.03-1.0m/s, laminar flow	SINTEF Fisheries & Aquaculture	www.sintef.no/en/fisheries-and-aqua-culture/about-us2/laboratories/sin-tef-fisheries-and-aqua-culture-flume-tank/

Applied Underwater Vehicle Laboratory (AUR-lab)

The lab's web page: www.ntnu.edu/aur-lab

The AUR-Lab is an interdisciplinary lab where engineering science, natural science and archaeology join forces to explore the ocean space. Technology providers and users work together with underwater vehicles and sensors to improve our understanding of the ocean and to further develop the necessary robotic tools. The lab is a common effort between the IVT, IME, SVT faculties and the University Museum to serve all of NTNU. The lab runs several ROVs and one REMUS 100 AUV equipped with advanced scientific and navigation instruments. The Department of Marine Techno-logy hosts the lab, along with the facilities at the Trondheim Biological station, provided by the Department of Biology. Arctic research, autonomy development and marine mineral investigation are some of the areas of research of the AUR-Lab in 2015.

2015 began with course work and research on zooplank-ton migration and robotics in the polar night at 79° North in Ny-Ålesund in a joint operation with UNIS and UiT. AUV REMUS was sent into the polar night searching for acoustical signatures of marine life. In August, we headed for Jan Mayen to map Lake Nord-Lagunen for geological features in collab-oration with NGU. A surprising discovery of the remains of a modern settlement was made. Read the full story at the links below. Only a few weeks later, a new adventure was underway in Svalbard. Together with UNIS, the AUV REMUS was deployed in Trygghamna and located the wreck of the whaling ship Figaro, which sank in 1905. It is known as the northernmost shipwreck identified.

Back in Trondheim, engineering research included collaborative vehicles, such as having an unmanned surface vessel from Maritime Robotics AS autonomously track and tender our AUV during the mission. To open for more advanced operations in the future, AUV docking was investigated, and the USBL system was adapted to the AUV to allow the vehi-cle to track docking stations and navigate its way home for battery charging and data retrieval.

The AUR-Lab has implemented a method for developing underwater photogrammetry models using a stereo camera rig that has been configured and installed on our ROVs. The wreck of the tug Herkules, located at approximately sixty meters depth, close to Munkholmen, was used as a test site to refine the method to increase the accuracy of the photo-grammetric models.

For ROV control, an integration of the Oculus Rift system was demonstrated, both for vehicle control and for 3D tele-presence.

In 2015, we mapped the wreck of a British Halifax bomber aircraft using photogrammetry, hyperspectral imaging and video. The plane was shot down during an Allied bombing raid of the German cruiser Tirpitz in April 1942. A detailed photogrammetry model was established to document the current state of the wreck site and provide central informa-tion about the crash.

The Discovery Channel visited NTNU and the AUR-Lab during one of our campaigns to map the plane. Working on the ship-wreck requires special attention with respect the two British plane crew members who perished during the crash in 1942.

During 2015, the AUR-Lab also set a new internal depth record, running a hyperspectral imager to 4200 meters depth on a European JPIO cruise onboard the German research vessel RV Sonne in the Pacific. The target for the investigation was seabed nodules containing high mineral concentrations.

Figure 21 (Stein M. Nornes, NTNU): Photogrammetry model of the wreck of the Halifax bomber aircraft.

AWARDS AND HONOURS

PhD graduate Arnt G. Fredriksen was awarded the prize "Årets Unge Rådgiver"

PhD graduate Arnt G. Fredriksen was awarded the prize «Årets Unge Rådgiver» («This year's young consultant») by the Norwegian Association of Consulting Engineers (RIF). An excerpt from the statement of the jury (translated by the editor): "Fredriksen develops things that haven't been there before. He is innovative and has contributed to the development of new tools and standards, among others, within current and wave loads".

Find more information on RIF's websites, Arnt Gunvald Fredriksen er årets unge rådgiver, 10 November 2015: **http://www.rif.no/nytt-fra-rif/2015/arnt-gunvald-fredriksen-er-aarets-unge-raadgiver/**

Best Student Paper Award

Auestad, Øyvind Fidje; Perez, Tristan; Gravdahl, Jan Tommy; Sørensen, Asgeir Johan; Espeland, Trygve H. Boarding Control System - for Improved Accessibility to Offshore Wind Turbines. 10th IFAC Conference on Manoeuvring and Control of Marine Craft; 2015-06-24 - 2015-06-26

The Moan-Faltinsen Best Paper Awards 2015

Figure 22 (Xiaopeng Wu, NTNU): Zhijun Wei (left) and Vegard Longva (right) with their certificates.

For the first time, the Moan-Faltinsen Best Paper Awards were handed out during MARINTEK's and NTNU's annual Christmas lunch on December 18, 2015, at the Marine Technology Centre. The recipients were Zhijun Wei within marine hydrodynamics for her paper "Sloshing-induced Slamming in Screen-equipped Rectangular Tanks in Shallow-water Conditions", and Vegard Longva within marine structures for his paper "A Lagrangian–Eulerian Formulation for Reeling Analysis of History-dependent Multilayered Beams".

New honorary positions in societies

Professor Asgeir J. Sørensen has been awarded membership in the Norwegian Academy of Technological Sciences (NTVA) in 2015.

Professor Oleksandr Tymokha has become a Corresponding Member in the National Academy of Sciences of Ukraine in 2015.

The marine structures group score international top grade

Three international panels have evaluated 64 Norwegian technology clusters. Two of them receive the label "world leading": SIMLab and the marine structures research group at the Department of Marine Technology.

Read more on gemini.no, To NTNU-miljøer får internasjonal toppkarakter, 7 May 2015: **http://gemini.no/notiser/to-ntnu-miljoer-far-internasjonal-toppkarakter/**

Find more information on the website of the Research Council of Norway, Rom for forbetring for teknologi-faga, 6 May 2015: **http://www.forskningsradet.no/no/Nyheter/Rom_for_forbetring_for_teknologifa-ga/1254008659740/p1174467583739?WT.ac=for-side_nyhet**

70-Year Anniversary Seminar and Celebration for Professor Larsen

On the occasion of Prof. Carl Martin Larsen turning 70 years old, the Department of Marine Technology arranged a seminar on 21 August 2015 in auditorium T2 at the Marine Technology Centre in Trondheim, followed by dinner at the Britannia Hotel.

At the seminar, there were presentations by Prof. Larsen and some of his PhD candidates, as well as by professors Kim Vandiver and Mike Triantafyllou from MIT.

The presentations were:
Prof. Kim Vandiver (MIT): **Undergraduate research at MIT**
Prof. Michael Triantafyllou (MIT): **Tuna fish hydrodynamics**
Dr Elizabeth Passano (Marintek): **Extreme response statistics**
Dr Are Berstad (AquaStructures): **Fish farm structures**
Arturo Ortega (Aker Solutions): **Flexible risers with slug flow**
Dr Kristoffer Aronsen (Statoil): VIV of SCRs on Aasta Hansteen Spar
Dr Jie Wu (Marintek): **Inverse analysis of VIV experiments**
Mads J. Thorsen (NTNU): **Time domain analysis of VIV**

Figure 23 (Asgeir J. Sørensen, NTNU): Prof. Larsen with some of his PhD candidates.

For more news from the department, visit: **www.ntnu.edu/imt/newsandevents**

APPENDICES

Staff

Academic staff

Name	Position
Aanondsen, Svein Aanond	Assistant Professor
Amdahl, Jørgen	Professor
Asbjørnslett, Bjørn Egil	Professor
Digernes, Torbjørn	Professor
Erikstad, Stein Ove	Professor
Gao, Zhen	Professor
Greco, Marilena	Professor
Haugen, Stein	Professor
Holm, Håvard	Associate Professor
Holmedal, Lars Erik	Researcher
Karlsen, Ludvig	Associate Professor
Kristiansen, Trygve	Professor
Larsen, Carl Martin	Professor
Lauritzsen, Kristin	Assistant Professor
Leira, Bernt Johan	Professor
Ludvigsen, Martin	Professor
Myrhaug, Dag	Professor
Pedersen, Eilif	Associate Professor
Pettersen, Bjørnar	Professor
Schjølberg, Ingrid	Professor
Skjetne, Roger	Professor
Steen, Sverre	Professor
Sævik, Svein	Professor
Sørensen, Asgeir Johan	Professor
Utne, Ingrid Bouwer	Professor
Vinnem, Jan Erik	Professor
White, Maurice Furneaux	Professor
Ås, Sigmund Kyrre	Professor

Administrative staff

Name	Position
Bremvåg, Annika	Higher Executive Officer
Dahl, Ingelin	Higher Executive Officer
Ellingsen, Harald	Professor & Head of Dept.
Gripp, Jannike	Executive Officer
Hansen, Astrid Elisabeth	Head of Office
Karoliussen, Renate	Senior Executive Officer
Kristiansen, Lasse	Project Manager

Name	Position
Mahic, Sanda	Higher Executive Officer
Mørkve, Kristin Johansen	Senior Executive Officer
Neyts, Alexandra	Project Manager
Nordtiller, Marit	Higher Executive Officer
Wesoly, Dorota	Higher Executive Officer
Wold, Sigrid Bakken	Senior Executive Officer
Østhus, Oddny Kristine	Senior Executive Officer

Technical staff

Name	Position
Bach, Bjørn Tore	Head Engineer
Bakken, Cato	Apprentice
Bratlie, Emil	Head Engineer
Bremset, Gunnar	Engineer
Dahl, Magnus	Apprentice
De la Torre O., Pedro R.	Head Engineer
Fleischer, Eirik	Head Engineer
Gran, Frode	Head Engineer
Innset, Trond	Staff Engineer
Jalali, Mostafa	Staff Engineer
Kristiansen, Øystein	Staff Engineer
Lines, Johan Terje	Engineer
Minde, Kristian	Staff Engineer
Paulsen, Oddvar	Staff Engineer
Rosten, Terje	Head Engineer
Schjetne, Roar	Head Engineer
Selven, Mats Johan S.	Engineer
Vinje, Ole Erik	Engineer
Volden, Frode	Head Engineer
Wahl, Torgeir	Head Engineer
Aasen, Einar Magnus	Head Engineer

Scientific staff, temporary

Name	Position
Abbasi-Hoseini, Afshin	Postdoctoral Fellow
Bachynski, Erin E.	Adjunct Associate Professor
Balland, Océane	Adjunct Associate Professor
Berg, Tor Einar	Adjunct Professor
Bindingsbø, Arne Ulrik	Adjunct Professor
Brett, Per Olav	Adjunct Professor

Name	Position
Bø, Torstein I.	Postdoctoral Fellow
Bøckmann, Eirik	Postdoctoral Fellow
Dumke, Ines	Postdoctoral Fellow
Ehlers, Sören	Adjunct Professor
Eliassen, Lene	Postdoctoral Fellow
Fagerholt, Kjetil	Adjunct Professor
Faltinsen, Odd Magnus	Professor
Fredheim, Arne	Adjunct Professor
Hagen, Arnulf	Adjunct Professor
Hansen, Martin O.L.	Adjunct Associate Professor
Hassani, Vahid	Adjunct Associate Professor
Haver, Sverre	Adjunct Professor
Jensen, Jørgen Juncher	Adjunct Professor
Jiang, Fengjian	Postdoctoral Fellow
Kim, Ekaterina	Postdoctoral Fellow
Koushan, Kourosh	Adjunct Professor
Krokstad, Jørgen	Adjunct Professor
Larsen, Kjell	Adjunct Professor
Lefebvre, Nicolas	Researcher
Lekkas, Anastasios	Researcher
Lugni, Claudio	Adjunct Professor
Malmquist, Christian	Researcher
Michailidis, Konstantinos	Researcher
Moan, Torgeir	Professor
Nematbakhsh, Ali	Postdoctoral Fellow
Nielsen, Ulrik Dam	Adjunct Associate Professor
Pettersen, Sigurd S.	Researcher
Piehl, Henry Peter	Postdoctoral Fellow
Ren, Nianxin	Postdoctoral Fellow
Riska, Kaj A.	Adjunct Professor
Rustad, Anne Marthine	Adjunct Associate Professor
Sadjina, Severin Simon	Postdoctoral Fellow
Sha, Yanyan	Postdoctoral Fellow
Shi, Wei	Postdoctoral Fellow
Su, Biao	Postdoctoral Fellow
Søreide, Fredrik	Adjunct Professor
Todalshaug, Jørgen Hals	Researcher
Tymokha, Oleksandr	Researcher
Wang, Hong	Postdoctoral Fellow
Wang, Jingbo	Researcher

PhD candidates*

Name	Country
Abrahamsen-Prsic, Mia	Croatia
Afzal, Mohammad Saud	India
Alwan, Sabah Nouri Jasem	Australia
Bakkehaug, Rikard	Norway
Bardestani, Mohsen	Iran
Bergström, Martin	Finland
Bhattacharyya, Anirban	India
Bore, Pål Takle	Norway
Borri, Daniele	Italy
Brandtsegg, Andreas Saur	Norway
Brodtkorb, Astrid H.	Norway
Canabes, José Particio G.	Chile
Candeloro, Mauro	Italy
Chabaud, Valentin Bruno	France
Cheng, Zhengshun	China
Cho, Seongpil	South Korea
Choi, Minjoo	South Korea
Dahl, Andreas Reason	Norway
Dalheim, Øyvind Ø.	Norway
Das, Jitapriya	India
De Almeida Fernandes, Daniel	Brazil
De Vaal, Jacobus Bernardus	South Africa
Eidsvik, Ole A.	Norway
Erceg, Boris	Croatia
Erceg, Sandro	Croatia
Fossum, Trygve Olav	Norway
Fredriksen, Arnt G.	Norway
Fu, Ping	China
Gavrilin, Sergey	Russia
Ghamari, Isar	Iran
Ghane, Mahdi	Iran
Giske, Finn-Idar G.	Norway
Godø, John Martin K.	Norway
Guachamin Acero, Wilson I.	Ecuador
Gunnu, Giriraja Sekhar	India
Gutsch, Martin	Norway
Hanssen, Finn-Christian W.	Norway
Hassel, Martin	Norway
Hatefi, Seyed Behzad	Iran

Name	Country
He, Zhao	China
Horn, Jan-Tore Haugan	Norway
Hegde, Jeevith	India
Henry, Pierre-Yves	France
Heyn, Hans-Martin	Germany
Holen, Siri Marianne	Norway
Hoseini Dadmarzi, Fatemeh	Iran
Jafarzadeh, Sepideh	Iran
Jørgensen, Erlend K.	Norway
Jørgensen, Ulrik	Norway
Karpa, Oleh	Ukraine
Kjerstad, Øivind Kåre	Norway
Knudsen, Tore H.	Norway
Kramer, Jarle Andre	Norway
Krivopolianskii, Vladimir	Russia
Li, Lin	China
Li, Quinyuan	China
Longva, Vegard	Norway
Luan, Chenyu	China
Ma, Shaojun	China
Malin, Maximilian	Austria
McGuinness, Edgar John	Ireland
Mentzoni, Fredrik	Norway
Milakovic, Aleksandar-Sasa	Croatia
Miyazaki, Michel Rejani	Brazil
Nam, Woongshik	South Korea
Natskår, Asle	Norway
Nielsen, Jørgen B.	Norway
Norgren, Petter	Norway
Nornes, Stein M.	Norway
Ortega Malca, Arturo J.	Peru
Patricksson, Øyvind S.	Norway
Pedersen, Morten Dinhoff	Norway
Polic, Drazen	Croatia
Rasekhi Nejad, Amir	Iran
Rehn, Carl Fredrik	Norway
Rivera Medina, Ausberto	Peru
Rokseth, Børge	Norway
Shen, Yugao	China
Siddiqui, Mohd A.	India

Name	Country
Singh, Dig Vijay	India
Skjong, Stian	Norway
Smilden, Emil	Norway
Storheim, Martin	Norway
Stovner, Bård B.	Norway
Strand, Ida M.	Norway
Strandenes, Håkon	Norway
Taskar, Bhushan	India
Thieme, Christoph A.	Germany
Thorat, Laxminarayan	India
Thorsen, Mats Jørgen	Norway
Tõns, Tõnis	Estonia
Ulveseter, Jan Vidar	Norway
Viuff, Thomas	Denmark
Værnø, Svenn Are Tutturen	Norway
Wan, Ling	China
Wang, Kai	China
Wu, Xiaopeng	China
Yu, Zhaolong	China
Yum, Kevin Kosup	South Korea
Zhang, Qin	China
Zhao, Bo	China
Zhao, Yuna	China
Ødegård, Øyvind	Norway

Note: This list only includes PhD candidates who are financed by the Department of Marine Technology and/or CeSOS.

Nationality and gender distribution of PhD candidates

In 2015, the Department of Marine Technology had 103 PhD candidates, of whom 9 were female. The geographical distribution of the origin of PhD candidates was as follows:

- Norway: 41 %
- other European countries: 15,5 %
- China: 14,5 %
- Other Asian countries: 19 %
- Other regions: 10 %

Professor emeritus

Berge, Stig	Rasmussen, Magnus
Endal, Anders	Sillerud, Bjørn Oskar
Kristiansen, Svein	Valland, Harald
Minsaas, Knut Johan	Westby, Ola

The Department's Economy

Distribution of financial contribution

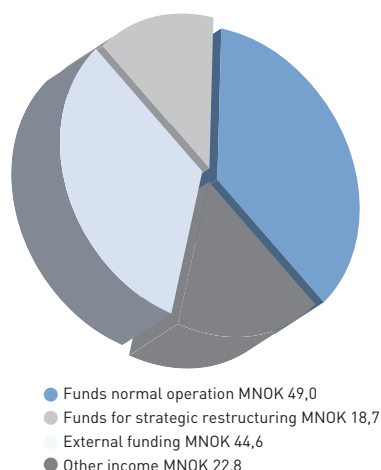The income of the department of marine technology is generated from two primary sources:

- funding from the government for normal operations and strategic restructuring
- external funding from private and public contributors for both commissioned and sponsored projects

The governmental funding is relatively stable. However, as it depends on both the quality and the quantity of research results, there are some variations in time. Income from commissioned and sponsored projects varies with the economic situation in the industry.

Distribution of cost categories

Zero-based budgeting is used, having the costs adjusted to the income level. Salary and social costs make up over 65% of the total costs.

Income 2015

- Funds normal operation MNOK 49,0
- Funds for strategic restructuring MNOK 18,7
- External funding MNOK 44,6
- Other income MNOK 22,8

Cost allocation 2015

- Investments MNOK 7,0
- Salary and social costs MNOK 95,9
- Other operating costs MNOK 44,8
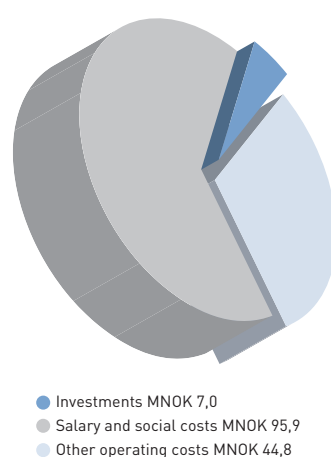
Research Projects

European projects

Project	Programme
AQUAEXCEL 2020: AQUAculture Infrastructures for EXCELlence in European Fish Research towards 2020	Horisont 2020
Blue Mining: Breakthrough Solutions for the Sustainable Expliration and Extraction of Deep Sea Mineral Resources	7th Framework Programme (European Union)
COLUMBUS: Monitoring, Managing and Transferring Marine and Maritime Knowledge for Sustainable Blue Growth	Horisont 2020
Hydralab IV: A Network Dealing with the Complex Interaction of Water with Environmental Elements, Sediment, Structures and Ice	7th Framework Programme (European Union)
HyDynPro: Hydroelastic Effects and Dynamic Response of Propellers and Thrusters	Era-Net MARTEC Project HyDynPro
MARE-WINT: New Materials and REliability in Offshore WINd Turbines Technology	7th Framework Programme (European Union: Marie Curie)
MARINA: A Platform Project to Establish a Set of Equitable and Transparent Criteria for the Evaluation of Multi-purpose Platforms for Marine Renewable Energy	7th Framework Programme (European Union: ENERGY)
SWARMs: Smart and Networking Underwater Robots in Cooperation Meshes	ECSEL (European Union)

National projects

Project	Programme
Air-sea Interaction and Transport Mechanisms in the Ocean	NRC (FRINATEK)
Arctic Field Logistic and Transarctic Shipping	Ministry of Foreign Affairs (MFA B2020)
Arctic DP: Safe and Green Dynamic Positioning Operations of Offshore Vessels in an Arctic Environment	NRC (KMB)
Brohode Frøya	Innovation Norway & Sør-Trøndelag County Authority
Corrosion Fatigue of Armor Wire	Statoil ASA
Damage Assessment of Kristin FPU	Statoil
Design and Verification of Control Systems for Safe and Energy-efficient Vessels with Hybrid Power Plants (D2V)	NRC (KMB)
Development of a Significantly More Efficient and Eco-friendly Fishing Vessel (ECOFIVE)	NRC
Dimensioning Sea Loads on Offshore Wind Turbines in Shallow to Intermediate Waters (DIMSELO)	NRC
Et Fullskalalaboratorium eller Testing av Fremtidens Marine Teknologi i Tett Samarbeid Mellom Næring og Akademia (F/F Gunnerus)	NRC (BIP)
Exploitation Technologies for Marine Minerals on the Extended Norwegian Continental Shelf (MarMine)	NRC (BIA)
Fergefri E39 - Forskning Knyttet til Flytebruer og Flytende Nedsenkede Tunneler fra 2014	Norwegian Public Roads Administration
FIV & VIV in Ultra-deep Waters	UIT Solutions
Follow-up JIP on Nonlinear FE-methods for Determination of Structural Capacity	DNV GL
Forprosjekt Risiko Norske Skip	Norwegian Maritime Authority
Full Scale Performance Prediction for Energy Efficient Ship Design (PropScale)	NRC (KPN)
Handling Uncertainty in the Design of Ocean Engineering Systems (SIMOSYS)	NRC (KPN)
Holistic Risk-based Design for Sustainable Artic Sea Transport (RISKAT)	NRC (KPN)
Joint Centre of Excellence for Arctic Shipping and Operations	Lloyd Register Foundation
Kjedet Flytebru	NRC (BIA)
Low Energy and Emission Design of Ships (LEEDS)	NRC (KMB)
Maritime Logistics Fleet Size and Mix (MARFLIX)	NRC (KMB)
National Ship Risk Model	NRC (SMARTRANS)
Next Generation Subsea Inspection, Maintenance and Repair (NextGenIMR)	NRC (KPN)
Qualitative Assessment North Rankin Alpha	Alliance Engineering Consultant Pty. Ltd
Reducing Risk in Aquaculture - Improving Operational Efficiency, Safety and Sustainability	NRC
Safe, Environmental Friendly, and Cost Effective Operation of Vessels and Installations in the Arctic	NRC (BIA)
Centre of Sustainable Arctic Marine and Coastal Technology (SAMCoT)	NRC
Sea Trials and Model Test for Validation of Shiphandling Simulation Models (SimVal)	NRC (KPN)
SFI Exposed Aquaculture Operations	NRC (SFI)

Project	Programme
SFI Marine Operations (MOVE)	NRC (SFI)
SFI Smart Maritime - Norwegian Centre for Improved Energy-efficiency and Reduced Emissions from the Maritime Sector	NRC (SFI)
Ship Concepts for Harvesting Recovery and Storage of Energy (HRS-Ship)	NRC (BIP)
Sustainable Design of Ships for the Future (SHIP-4C)	NRC (KMB)
SUSTAINFARMEX - Towards Sustainable Fish Farming at Exposed Marine Sites	NRC (KMB)
University Technology Centre (UTC): Providing an Integrated and Validated Approach to "Performance in a Seaway"	Rolls-Royce Marine AS
Virtual Prototyping of Marine Systems and Operations (ViProMa)	NRC (KPN)
WaveSpring - Discovery Verification	Aalborg University

NRC: Research Council of Norway
KPN/KMB: Knowledge building project for the industry (Kompetanseprosjekter for næringslivet)
BIP: User-driven innovation project (Brukerstyrt innovasjonsprosjekt)
BIA: User-driven innovation platform (Brukerstyrt innovasjonsarena)
FRINATEK: Independent projects in mathematics, natural sciences and technology under the FRIPRO funding scheme
SFI: Centre for Research-based Innovation
SMARTRANS: Næringslivets transporter og ITS

NTNU Students Abroad

Spring semester 2015

Number of students	University	Country
8	University of California, San Diego	USA
7	University of New South Wales	Australia
5	University of California, Santa Barbara	USA
3	National University of Singapore	Singapore
3	San Diego State University	USA
3	Universidade Federale do Rio de Janeiro	Brazil
3	University of Strathclyde, Glasgow	UK
2	Pontificia Universidade Catolica do Rio de Janeiro	Brazil
2	University of Michigan	USA
1	Technische Universität Berlin	Germany
1	Universidade de Lisboa Instituto Superior Tecnico	Portugal
1	University of California, Berkeley	USA
1	University of Texas at Austin	USA

Autumn semester 2015

Number of students	University	Country
11	University of California, Santa Barbara	USA
9	University of California, San Diego	USA
6	National University of Singapore	Singapore
5	Universidade Federale do Rio de Janeiro	Brazil
3	Universidad Politecnica de Madrid	Spain
3	University of California, Berkeley	USA
3	University of New South Wales	Australia
2	Curtin University of Technology	Australia
2	Pontificia Universidade Catolica do Rio de Janeiro	Brazil
2	Technische Universität Hamburg	Germany
2	Universidade de Lisboa Instituto Superior Tecnico	Portugal
1	Massachusetts Institute of Technology	USA
1	Pusan National University	South Korea
1	San Diego State University	USA
1	Shanghai Jiao Tong University	China
1	Technische Universität Berlin	Germany
1	University of New Orleans	USA
1	University of Strathclyde	UK
1	University of Tasmania	Australia
1	University of Western Australia	Australia

Master Degrees

Candidate	Supervisor	Title
Aamot, Sigrid Knutsdatter Gaup	Ehlers, Sören	A Sensitivity Study of Ice Resistance Prediction Methods Using a Developed Bow Shape Modelling Tool
Aarsnes, Lars Holterud	Haver, Sverre Kristian	Estimation of Extreme Response
Alm, Thomas Gløersen	Pedersen, Eilif	Integrated Engine Torsional Vibration Simulations
Andersen, Andreas	Amdahl, Jørgen	Simulering av Marine Løfteoperasjoner med Fokus på Kontroll av Konstruksjonsrespons
Andresen, Mari Løvald	Asbjørnslett, Bjørn Egil	Formal Safety Assessment of an Open Loop System
Beckenkamp, Alexandra	Pedersen, Eilif	Modeling and Simulation of a Flexible Damper during Ice in Propeller Impacts
Berntsen, Martine	Leira, Bernt Johan	Comparative Analysis of Umbilical Pull-in through J-tubes by Detailed Models and Simplified Methods
Billington, Thor Helge	Skjetne, Roger	Online Shape Estimation of Icebergs at Sea
Bjørnsen, Gaute Sjeggestad	Leira, Bernt Johan	A Comparison of Methods for Estimation of Fatigue and Extreme Mooring Response for a Floating Spar Wind Turbine
Bjørvik, Henning	Pettersen, Bjørnar	Simulation of Flow Around an Oil Boom

Candidate	Supervisor	Title
Bore, Pål Takle	Amdahl, Jørgen	Ultimate- and Fatigue Limit State Analysis of a Rigid Offshore Aquaculture Structure
Borenius, Rasmus	Myrhaug, Dag	Kombinert Wind- og Bølgekraft
Bottolvs, Per Arild	Ehlers, Sören	Stability Monitoring during Ice Accretion
Brask, Annette Kristin	Skjetne, Roger	Control and Estimation of Wave Energy Converters
Bratlie, Patrick	Leira, Bernt Johan	Analysis of the Hull Structure of Sevan Arctic Mobile Offshore Drilling Unit Subjected to Accidental Ice Loads
Centen, Irma Hetty	Myrhaug, Dag	Predicting Scour around Offshore Wind Turbines Using Soft Computing Techniques
Dalheim, Øyvind Øksnes	Steen, Sverre	Development of a Simulation Model for Propeller Performance
Djupvik, Ole Martin	Aanondsen, Svein Aanond	Probabilistic Damage Stability
Dyrseth, Silje	Myrhaug, Dag	Time Scales for Scour Below Pipelines and Around Vertical Piles in Nonlinear Random Waves and Current
Eide, Egill	Steen, Sverre	Calculation of Service and Sea Margins
Eidsvik, Ole Alexander	Schjølberg, Ingrid	Identification of Hydrodynamic Parameters for Remotely Operated Vehicles
Engh, Hanne Dreyer	Erikstad, Stein Ove	Optimization of an Upstream Supply Chain
Fehn, Manuel Andre	Utne, Ingrid Bouwer	Spare Parts Evaluation in the Oil and Gas Industry
Fernandez Cordova, Gonzalo Alfonso	Moan, Torgeir	Ice Loads and Induced Dynamic Responses of a Monopile Wind Turbine
Follestad, Jostein	Erikstad, Stein Ove	Design av en ROV for Forbrukermarkedet
Fossan, Pål Alexander	Amdahl, Jørgen	Ultimate- and Fatigue Limit State Analysis of a Rigid Offshore Aquaculture Structure
Friedberg, Vegard	Myrhaug, Dag	Numerical Simulation of Flow around Two Side-by-side Rectangular Cylinders with Vertical and Horizontal Offsets
Frimann-Dahl, Joakim Fürst	Krokstad, Jørgen Ranum	Experimental Validation and Design Review of Wave Loads on Large-Diameter Monopiles
Godø, John Martin Kleven	Steen, Sverre	Biomimetic Ship Propulsion through Oscillating Hydrofoils
Gregersen, Kathrine	Sævik, Svein	Evaluation of Wellhead Fatigue for Drilling Risers
Grevstad, Simon	Larsen, Carl Martin	Vortex Induced Vibrations on an ''Artificial Seabed'' for Support of a Floating Bridge
Grønningsæter, Einar Kristiansen	Myrhaug, Dag	Tidal Boundary Layer Flow in Coastal Zones
Grøtting, Heine	Krokstad, Jørgen Ranum	Small Water Plane Area Solutions for Access of Offshore Wind Turbines
Haavik, Andreas Stangeland	Steen, Sverre	Design and Testing of Non-Axisymmetric Propeller Ducts
Handeland, Michael Piccard	Steen, Sverre	Importance of Fluid-Structure Interaction on Dropped Lifeboats
Hansen, Jørgen Lima	Amdahl, Jørgen	Analysis and Design of Ship Collision Barriers on a Submerged Floating Tunnel Subjected to Large Ship Collisions
Hanstveit, Britta	Pettersen, Bjørnar	Numerical Investigation of Flow Around Rectangular Cylinders at Low Reynolds Numbers

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Hasvåg, Thomas	Leira, Bernt Johan	Evaluation and Design of Large Precast Concrete Panels as Modules of Tanks for Smolt Breeding
Heggem, Thomas	Holm, Håvard	Simulation of Flow around a Viking Ship Rudder
Hellum, Håkon Arne Torp	Asbjørnslett, Bjørn Egil	Optimization of Resource Allocation Using Queueing Theory
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Holmemo, Marius	Myrhaug, Dag	Flow over Marine Vegetation
Holsen, Sigurd Andreas	Sørensen, Asgeir Johan	DUNE: Unified Navigation Environment for the REMUS 100 AUV
Horn, Jan-Tore Haugan	Amdahl, Jørgen	Stochastic Dynamic Analysis of Offshore Bottom-fixed Structures
Høvik, Ragnhild Farstad	Asbjørnslett, Bjørn Egil	Application of Probabilistic Damage Stability for Risk Reduction Related to Cruise Ship Operation in Arctic
Idland, Tor Kvestad	Skjetne, Roger	Marine Cybernetics Vessel CS Saucer
Irman, Arifian Agusta	Sævik, Svein	Non-linear Soil Models for Pipeline and Riser Analysis
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Jahangiry, Tara	Asbjørnslett, Bjørn Egil	Valuing Flexibility in Ship Design
Jahn, Andreas Anthonsen	Pedersen, Eilif	Design Calculations for a Selective Catalytic Reduction Unit
Jakobsen, Marion F.	Ehlers, Sören	Assessment of Helicopter Emergency Response Capacity in the Barents Sea
Jenssen, Fredrik Rødne	Sævik, Svein	Dynamic Analysis of ROV Operation
Jespersen, Karoline	Asbjørnslett, Bjørn Egil	Optimizing the Machinery System Selection in a Ship Design Process, Taking Environmental Regulations and Uncertainty into Consideration
Kalvig, Ragnhild Birgitte Hidle	Pettersen, Bjørnar	Numerical Investigation of 3D Flow Around Two Tandem Cylinders
Kang, Gahyeong	Utne, Ingrid Bouwer	Risk Assessment of Ship's Fuel Change-over Process
Kim, Suyeon	Vinnem, Jan Erik	Risk Model Applied to Non-operational Hydrocarbon Leaks on Offshore Installations
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Kålås, Stephen	Hagen, Arnulf	Small-Scale Automation in Shipbuilding
Landhaug, Daniel L.	Larsen, Carl Martin	Dynamic Simulation Of Dart Anchor Installation
Larssen, Guro	Skjetne, Roger	Ice Detection and Tracking Based on Satellite and Radar Images
Larsson, David	Leira, Bernt Johan	Methods of Reliability Analysis for Marine Structures
Laverton, Edward	Haver, Sverre Kristian	Modelling of Metocean Conditions for the Purpose of Planning Marine Operations
Li, Chunyu	Sævik, Svein	Dynamic Stress Behaviour of Bonded Pipes and Umbilicals
Li, Miao	Sævik, Svein	Dynamic Stress Due to End Effects in of Non-bonded Flexible Pipes
Liu, Meitong	Leira, Bernt Johan	Transient Dynamic Response of Ship Hull
Lylund, André	Leira, Bernt Johan	Analysis of Riser-induced Loading on Wellhead
Marquesin De Oliveira, Nathalie	Bindingsbø, Arne Ulrik	Risk Based Maintenance for Compressor Systems
Milak, Dino	Pedersen, Eilif	Numerical Simulation of Twin Nozzle Injectors
Mo, Sigrid Marie	Schjølberg, Ingrid	Development of a Simulation Platform for ROV Systems

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Moldenhagen, Sindre Jin S.	Larsen, Carl Martin	Design av Flytende Vindturbin
Myklebost, Oda	Steen, Sverre	Comparative Evaluation of the Performance of a Trimaran Seismic Vessel
Møgster, Christian	Sørensen, Asgeir Johan	Bayesian Estimation of Non-stationary Ship Response Spectra
Nesjø, Eirik Nubdal	Steen, Sverre	Resistance Due to Open Moonpools on Offshore Ships
Nguyen, Kim	Pedersen, Eilif	Design Optimization of a Low Pressure LNG Fuel Supply System
Nous, Roel Johannes Maria	Moan, Torgeir	A Dynamic Approach to Evaluating the Effect of Slamming on a Jacket Foundation Template Lowered through the Wave Zone
Nymo, Dennis Alexander	Myrhaug, Dag	Numerical Simulation of Boundary Layer Flow around Simplified Subsea Structures
Olsen, Camilla Waldum	Steen, Sverre	Including the Effect of Shielding in Prediction of Weather Window for Offshore Lifting Operations
Ommundsen, Andreas	Holm, Håvard	Unconventional Propeller Tip Design
Opsahl, Jostein	Erikstad, Stein Ove	Conceptual Design of a Closing Device for the Moonpool on Construction Support Vessels
Palm, Astrid Maria	Amdahl, Jørgen	Knekking og Omfordeling av Laster i Redundante Platekonstruksjoner
Paulsen, Ole Brynjar Helland	Asbjørnslett, Bjørn Egil	A Discrete-event Simulation Model for Estimating Steel Weight of OSV Superstructure
Paust, Henrik Sogn	Sørensen, Asgeir Johan	Finite Element Modeling and Structural State Estimation of a Bottom Fixed Offshore Wind Turbine
Pedersen, Joar	Larsen, Carl Martin	Dynamic Simulation of Module Installation on Deep Water
Pettersen, Sigurd Solheim	Erikstad, Stein Ove	Designing Flexible Offshore Construction Vessels to Handle Future Uncertainty
Rehn, Carl Fredrik	Erikstad, Stein Ove	Identification and Valuation of Flexibility in Marine Systems Design
Ren, Zhengru	Skjetne, Roger	Fault Tolerant Control of Thruster-assisted Position Mooring System
Riley, Eivind Finne	Steen, Sverre	The Potential Energy Savings by Application of a Wave Foil on the Autonomous Container Vessel ReVolt
Riple, Marina Myhrvold	Erikstad, Stein Ove	Allocation of Emergency Response Assets in the Barents Sea
Rygh, Bjørn Mikkel	Pedersen, Eilif	An Experimental Study on the Application of Fish Oil as Fuel
Saccoman, Marine Yvette Josette	Moan, Torgeir	Coupled Analysis of a Spar Floating Wind Turbine Considering both Ice and Aerodynamic Loads
Saidee, Mohammad Hasan	Larsen, Kjell	Fatigue Analysis and Design of Mooring Systems. Assessment and comparison of Different Methods
Sandved, Fredrik	Skjetne, Roger	Remote Control and Automatic Path-following for C/S Enterprise I and ROV Neptunus
Schultz, Eirik	Sørensen, Asgeir Johan	Modelling and Control of a Two-Body Offshore Wave Energy Converter
Skjetne, Erlend Hopsdal	Leira, Bernt Johan	Local Structural Analysis of a Semi-submersible Exposed to Ice Loads
Smestad, Bjørnar Brende	Asbjørnslett, Bjørn Egil	A Study of Satellite AIS Data and the Global Ship Traffic through the Singapore Strait
Smilden, Emil	Sørensen, Asgeir Johan	Preventing Tower Resonance Induced by Thrust Variations on a Large 10MW Wind Turbine
Sodeland, Per Sondre	Sørensen, Asgeir Johan	Combined Dynamic Positioning and Optimal Wave Frequency Motion Damping of Surface Effect Ship
Stang, Tore	Erikstad, Stein Ove	Optimal Hub-Solution for Remote Field Development in Arctic

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Steffensen, Mads Vambheim	Leira, Bernt Johan	Fatigue Lifetime Assessment of Typical Longitudinal/End Connections for Large Offshore Service Construction Vessels (OSCVs)
Stendal, Lars Christian	Larsen, Kjell	Analysis Methods for Mooring Systems with Focus on Accidental Limit State
Strand, Anders Salberg	Amdahl, Jørgen	Fire Resistance of Unmanned Wellhead Jackets
Strømberg, Hanne-Sofie S.	Asbjørnslett, Bjørn Egil	Strategic Fleet Renewal for Offshore Support Vessels
Strømsøyen, Simen	Sørensen, Asgeir Johan	Propulsion Methods for Under Water Snake Robots
Støwer, Knut Skaseth	Erikstad, Stein Ove	Optimal Positioning of Emergency Preparedness Assets Based on Dynamic Traffic Situation
Sundstrøm, Tonje Seglem	Larsen, Kjell	Installation of Subsea Equipment with Focus on Slender Objects
Svoren, Nikolas Øksdal	Steen, Sverre	Investigation of Hydrodynamic Performance of a Twin-Screw Trawler Using CFD
Søgnesand, Sigmund Anders Isaac	Leira, Bernt Johan	Analysis of Riser Loads during BOP sailing
Søndenaa, Sjur David	Hagen, Arnulf	Decision Support Model for Evaluating the Use of Small Scale Automation in Shipbuilding
Trygsland, Eirik	Myrhaug, Dag	Numerical Study of Seabed Boundary Layer Flow around Monopile and Gravity-based Wind Turbine Foundations
Tvedt, Peter Kristian Hindar	Utne, Ingrid Bouwer	Human and Organizational Factors in Vessel-Platform Collision Risk on the Norwegian Continental Shelf
Uddin, Mohammad Irfan	Larsen, Kjell	Analysis Methods for Mooring Systems with Focus on Viscous Drift Force Modelling
Ulveseter, Jan Vidar	Larsen, Carl Martin	Non-linear Time Domain Analysis of Vortex Induced Vibrations
Valle, Eirik	Skjetne, Roger	Marine Telepresence System
Vestum, Emil	Sørensen, Asgeir Johan	Wind Powered Marine Vehicle
Visser, Niels	Moan, Torgeir	Experimental Set-up of the Double Slip Joint
Vittori, Felipe Eduardo	Moan, Torgeir	Design and Analysis of Semi-submersible Floating Wind Turbines with Focus on Structural Response Reduction
Voortman, Ralph Lucas Bernard	Moan, Torgeir	State-of-the-art Design Methods for Wind Turbine Towers
Wabakken, Iselin	Utne, Ingrid Bouwer	Application of RCM to Construct a Maintenance Program for a Maritime Vessel
Wei, Ying	Sævik, Svein	Anchor Loads on Pipelines
Wergeland, Therese Veland	Larsen, Carl Martin	Vortex Induced Vibrations in Fish Farm Structural Elements
Wist, Andrea Sørdal	Erikstad, Stein Ove	Simulation Model for Hub
Xu, Kun	Moan, Torgeir	Design and Analysis of Mooring System for Semi-submersible Floating Wind Turbines in Shallow Water
Zhang, Wenzhe	Pedersen, Eilif	Dynamic Modelling, Simulation and Visualization of Marine Crane Operations on DP Vessels
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Øien, Pauline Kværnes	Greco, Marilena	Physical Investigation of Slamming Loads on a 2D Body
Øverleir, Magnus Anders	Erikstad, Stein Ove	Hybridization of General Cargo Ships to Meet the Required Energy Efficiency Design Index

All Master theses can be found at **http://brage.bibsys.no/xmlui/handle/11250/227458**

PhD Degrees

Date	Name	Sex	Title of the thesis	Country	Main supervisor
03/02/2015	Eirik Bøckmann	Male	Wave Propulsion of Ships	Norway	Sverre Steen
14/04/2015	Kai Wang	Male	Modelling and Dynamic Analysis of a Semi-submersible Floating Vertical Axis Wind Turbine	China	Torgeir Moan
07/05/2015	Arnt G. Fredriksen	Male	A Numerical and Experimental Study of a Two-dimensional Body with Moonpool in Waves and Current	Norway	Odd M. Faltinsen
08/05/2015	Jose Gallardo Canabes	Male	Numerical Studies of Viscous Flow around Bluff Bodies	Chile	Bjørnar Pettersen
12/05/2015	Vegard Longva	Male	Formulation and Application of Finite Element Techniques for Slender Marine Structures Subjected to Contact Interactions	Norway	Svein Sævik
09/06/2015	Jacobus de Vaal	Male	Aerodynamic Modelling of Floating Wind Turbines	South Africa	Torgeir Moan
10/06/2015	Fachri Nasution	Male	Fatigue Performance of Copper Power Conductors	Indonesia	Svein Sævik
23/06/2015	Oleh I. Karpa	Male	Development of Bivariate Extreme Value Distributions for Applications in Marine Technology	Ukraine	Arvid Næss
29/06/2015	Daniel de Almeida Fernandes	Male	An Output Feedback Motion Control System for ROVs	Brazil	Asgeir Sørensen
30/06/2015	Bo Zhao	Male	Particle Filter for Fault Diagnosis: Application to Dynamic Positioning Vessel and Underwater Robotics	China	Asgeir Sørensen
26/08/2015	Wenting Zhu	Male	Impact of Emission Allocation in Maritime Transportation	China	Stein Ove Erikstad
27/08/2015	Amir Rasekhi Nejad	Male	Dynamic Analysis and Design of Gearboxes in Offshore Wind Turbines in a Structural Reliability Perspective	Iran	Torgeir Moan
14/09/2015	Arturo J. Ortega Malca	Male	Dynamic Response of Flexibles Risers due to Unsteady Slug Flow	Peru	Carl Martin Larsen
01/12/2015	Dagfinn Husjord	Male	Guidance and Decision-support System for Safe Navigation of Ships Operating in Close Proximity	Norway	Tor Einar Berg
02/12/2015	Anirban Bhattacharyya	Male	Duced Propellers: Behaviour in Waves and Scale Effects	India	Sverre Steen
17/12/2015	Qin Zhang	Female	Image Processing for Ice Parameter Identification in Ice Management	China	Roger Skjetne

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The Norwegian University of Science and Technology (NTNU)

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Department of Marine Technology

Marine Technology Centre
NO- 7491 Trondheim
Tel.: (+47) 73 59 55 01
Fax: (+47) 73 59 56 97
E-Mail: imt-info@ivt.ntnu.no