



Research
Excellence

Research Excellence

Faculty of Engineering Science and Technology



NTNU – Trondheim
Norwegian University of
Science and Technology

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From the Dean

Faculty of Engineering Science and Technology at NTNU is the major provider of engineering education in Norway, and one of the primary research organizations in engineering science and technology. High quality and relevance research based education puts Faculty of Engineering Science and Technology at a competitive edge when young students decide to enroll for a university education in Norway.

The organization has recently completed two fundamental processes which have provided guiding documents for the management of Faculty of Engineering Science and Technology.

Firstly, a research group assessment provided important insight into the conditions for conducting high quality research faced by our scientific staff, and the state of research being conducted.



Secondly, The Faculty of Engineering Science and Technology has just resolved a research strategy for 2012-2020 where we have highlighted four main goals of our scientific activities. Subsequently 16 research areas are appointed, that will receive special attention in the coming years.

A number of researchers and research groups will contribute to the development of knowledge within these research areas, I have selected influential representatives of the academic staff to lead the work within each of them. For each of the areas a research plan is developed, aiming to bring our research, across disciplines, accompanied by industry, towards excellence.



The road towards excellence involves a clear focus on building an international academic reputation as well as a strong and resilient research environment for scientific activities and initiatives. The research group assessment showed us that some of our scientists are already in the forefront of their disciplines and thus need to focus on means to maintain their excellence status. One of their most important success criteria has become their ability to obtain long term funding by taking the lead in research centers funded by the Research Council of Norway. I am proud to present our six most outstanding research groups in this brochure!

Ingvald Strømmen
Professor Ingvald Strømmen, Dean



Marine Structures and Hydrodynamics

Norway has a long coastline along the Atlantic, the Arctic Ocean and the North Sea providing an essential part of our wealth and well-being. Safety at sea, greener maritime transport, marine monitoring, offshore renewable energy, sea food and other biological production, and exploitation of hydrocarbons and minerals in deep water and Arctic regions have become research areas of great importance.

Marine Technology for extreme environment

Structures and operations in these areas must endure harsh-est weather conditions with severe wind and waves, strong currents, ice and low temperatures, which may be even more aggravated by climate changes. The fundamental understanding and characterization of environmental loads and accidental actions and their consequences in terms of load effects, structural degradation and progressive collapse represent critical research topics, being essential inputs to the design of robust marine structures and control systems.

Research programmes

The group has been hosting the Centre of Excellence (SFF) Centre for Ships and Ocean Structures (CeSOS) since 2003, and has recently been awarded the host position of SFF Autonomous Marine Operations and Systems (AMOS). Further, the group is involved in several research programmes funded by the Research Council of Norway and EU, for example:

- Novel support structures and floaters for offshore wind power plants (In the Norwegian Research Centre for Off-shore Wind Technology - NOWITECH), *T. Moan*
- Ship collision with Icebergs (In Sustainable Arctic Marine Coastal Technology - SAMCoT), *J. Amdahl*
- Arctic DP: Safe and green dynamic positioning operations of offshore vessels in an arctic environment (In SAMCoT), *R. Skjetne*
- Marine Computational Fluid Dynamics, *B. Pettersen*
- Performance in a seaway (Rolls Royce University Technology Centre), *S. Steen*
- Construction and intervention vessels for Arctic oil and gas (CIV Arctic), *T. Moan*
- Multi-purpose platforms for marine renewable energy- MARINA platform project



International collaboration

- Members of EU-funded networks, such as MARSTRUCT, WAVETRAIN2 AND SAFEREL
- Collaboration with universities worldwide: MIT, UCAL-Berkeley, Denmark Technical University, Nat. Academy of Sciences, Ukraine, Osaka University, Pusan National University, Kyushu University, National Sun Yat-sen, Taiwan, Shanghai Jiao Tong University, National University of Singapore, Seoul National University, University of Newcastle AUS, INSEAN

Unique laboratories

Laboratory facilities are shared with MARINTEK, a SINTEF research company. With 180 employees MARINTEK is one of the world's largest marine technology research institutes.

- Towing Tank: 260 m long; two sections with a water-depth of 4 m and 10 m respectively; wave-maker.
- Ocean Simulation Basin: 80 x 60 m²; variable depth up to 10 m; wave-makers along two sides for generation of 3D sea-states; facilities for generation of current and wind.
- Marine Cybernetics Laboratory: for testing ships, rigs, underwater vehicles, and propulsion systems in a dynamic system.
- Particle Image Velocimetry System: measures hydrodynamic flow around structures.
- Cavitation Loop: for testing propellers.
- Marine Structures Laboratory with a number of dynamic test rigs; full scale dynamic testing of flexible risers and umbilicals; corrosion fatigue cells with CO₂ and H₂S environments.

Group leader: Jørgen Amdahl

E-mail: jamda@ntnu.no

Telephone: +47 73 59 55 44/957 45 663

Web: <http://folk.ntnu.no/jamda/>

contact



MARINE STRUCTURES

Full time professors: 12

Adjunct professors: 9

PhD and Post doc researchers: 75

Structural Impact Laboratory, SIMLab

“The group’s research profile is characterized by a combination of a fundamental approach to material modelling, material testing at various loading conditions and implementation of material models suited for large-scale structural analyses,” says Professor Magnus Langseth, leader of the research group.

This profile serves as a basis for research activities on the structural behaviour of components and structures, taking account of the interaction between material behaviour, structural geometry and manufacturing process. *“To support the modelling activities carried out, we have developed extensive experimental facilities for the testing of materials at elevated rates of strain and temperatures as well as facilities for impact and crashworthiness testing of components and structural subsystems”*, Langseth adds.

Research and industrial partners

The Research Council of Norway awarded Centre for Research-based Innovation status to SIMLab for the period 2007-2014. SINTEF and Department of Materials Technology at NTNU are research partners. The industrial partners are Hydro Aluminium, Statoil, Norwegian Defence Estates Agency, Benteler Aluminium Systems, Norwegian Public Roads Administration, Audi, BMW, Renault, Toyota Motor Europe and SSAB.

Research strategy and activities

Within the field of structural impact the research in the group is concentrated on areas that are of common interest to the industrial partners in the Centre. Thereby, our research creates a link between Norwegian industry and some of the major actors on a global market, e.g. the automotive industry. In order to meet the future challenges in product development foreseen by the industrial partners, a multidisciplinary approach is needed where researchers from the partners and academia contribute. This is only achievable through a Centre activity with long term objectives and funding. Thus, the research activities in the group are related to the defined objective of the SIMLab Centre, i.e.

To provide a technology platform for development of safe and cost effective structures



The technology platform is developed through advances in the research areas:

- **Materials:** Development of improved quantitative constitutive models and failure criteria for large scale analyses as well as identification methods.
- **Solution techniques:** Establishment of accurate and robust solution techniques for simulation of impact problems.
- **Structures:** Investigation of fundamental response mechanisms of generic components and structures as well as the behaviour and modelling of joints. This research area serves as a link between ‘Materials’, ‘Solution techniques’ and ‘Demonstrators’.
- **Demonstrators:** Selection of demonstrators in close cooperation with the industrial partners.

The defined Basic Research areas are linked with research programmes such as *Fracture and Crack Propagation, Connectors and Joints, Polymers, Multiscale Modelling of Metallic Materials and Optimal Energy Absorption and Protection*.

The Centre is dealing with aluminium extrusions and plates, aluminium castings, high-strength steels and polymers.

Laboratory facilities

Experimental facilities: Split-Hopkinson tension and pressure bars, sheet metal forming machine, pendulum accelerator with a capacity of 500 KJ, compressed gas gun for projectile impact up to 1000 m/s, stretch bending rig, instron droptower impact system, self-piercing riveting machine, infrared camera, high speed video cameras.

Group leader and Centre Director:
Professor Magnus Langseth

E-mail: magnus.langseth@ntnu.no

Telephone: +47 73 59 47 82 / + 47 930 37 002

Web: www.ntnu.edu/simlab

contact

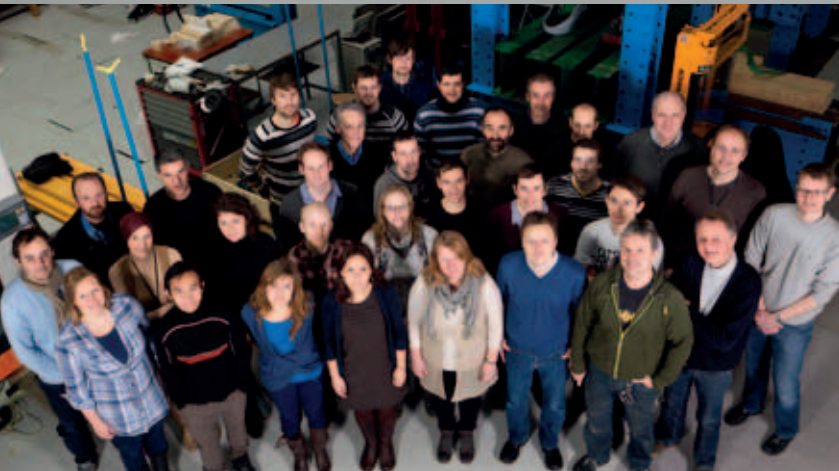


Photo: Ole Morten Melgård.

SIMLab

Professors: 6

Professor emeritus: 1

Adjunct professors: 3

PhD and Post doc researchers: 28



THERMAL ENERGY

Full time staff: 7

Adjunct professors: 1

PhD and Post doc researchers: 26

Thermal Energy

The Thermal Energy research group works to solve global challenges of energy conversion processes.

The Thermal Energy research group carries out scientific research and teaching in the intersection of various disciplines such as thermodynamics, fluid mechanics, and chemistry.

Its scientific quality and productivity are significant and places the group at a high international level. The group has achieved an international reputation due to its leadership in the field of CO₂ Capture and Storage (CCS).

The group's research areas are based on the coupling of energy and environmental issues, and are strongly relevant for society and the public at large. The group is obtaining significant external funding and shows strong industrial research relevance.

The group is working with **Combustion** of various gaseous and liquid fuels, and combustion and gasification of biomass fuels and wastes. Challenges include hydrogen-rich fuels, oxy-combustion, fires and safety, advanced laser-based measurements and CFD of combustion, involving complex heat transfer and turbulence-chemistry interactions.

The **Bioenergy** activity is about thermochemical **conversion of biomass for heat and power generation and energy conversion of fuels for transport** (road, marine and aviation). This includes biomass combustion, gasification and pyrolysis. Production and use of second and third generation biofuels are being focussed on. Biomass torrefaction and direct liquefaction are also emphasized.

Combining thermodynamic models (equations of state, fundamental thermodynamic functions) and fluid flow in CFD tools is a methodology to better understand the fundamentals of energy degradation, or exergy losses. As an example, this methodology is being applied in turbulent reacting flows, i.e. combustion and gasification processes, and a range of chemical reactors.

Turbo machinery, both components and systems, such as gas turbines, combined cycles and natural gas compressors are being focussed on. One very important activity for the oil and gas industry is the development of **wet gas compressors** and **multi-phase pumps**, enabling increased recovery rate in oil and gas reservoirs.

Another important activity is **CO₂ capture**. Novel process design and operability analysis are carried out for various gas separation methods integrated with power cycles. Reducing the energy penalty for CO₂ capture is the most important goal for this work.

Group leader: Professor Olav Bolland

E-mail: Olav.Bolland@ntnu.no

Web: ntnu.edu/ept/thermal-energy

contact

Petroleum Engineering and Applied Geophysics

Much of the Norwegian Continental Shelf is still unexplored. For the existing producing fields much of the resources will remain in the ground when the fields are closed. Research at NTNU is aimed at finding more oil and gas and at increasing recovery from existing fields.

The oil and gas upstream field

The current research strategy of the group is originally based on extensive visits and discussions with industry and official bodies in Norway during 2004–2005, and was renewed in the Research Plan process conducted by the Faculty of Engineering Science and Technology during 2011–2012. Thus, the research is addressing challenges faced by the Norwegian oil and gas activities, as well as maintaining a long term, academic perspective. The research is conducted in informal groups in the disciplines geophysics, drilling, production, reservoir and integrated operations across disciplines. Several evaluations of the research activities by international committees the past few years, organized by the Research Council of Norway and by NTNU. The group has scored very high in the evaluations, and received valuable recommendation for the way ahead. Many of the professors have been awarded prestigious research awards. This reinforces the strategy plan and ensures the quality of our program.

Master and doctor programmes

Research-based education and recruitment of the best candidates to the oil and gas field is crucial. Much of the research is conducted by graduate students in close collaboration with professors. With 80-90 Master candidates and 10 PhD candidates graduating every year in the upstream petroleum field, NTNU is among the top few universities in the upstream field for graduate petroleum engineers and geoscientists, and a major supplier of graduates to industry internationally.



Research programs and collaboration

Currently the majority of the group’s research is within geophysical exploration, seismic monitoring of reservoir under production and of CO₂ depositon, laboratory experiments and modeling for improved recovery, subsea technology, and improved drilling and safety technology. Extensive international academic collaboration is maintained with leading universities in North America, Europe and Latin America. The group has research agreements with most oil and gas companies and service companies in Norway.

The Centre for Integrated Operations in the Petroleum Industry (IO Centre)

Department of Petroleum and Applied Geophysics hosts the Integrated Operations Centre. IO is a new concept in the international oil and gas industry, for smarter deployment of human knowledge and technology, to make better and safer decisions in the operation of oil and gas fields. Decision-making is supported by global access to real time information, collaborative technology and integration of multiple expertise across disciplines, organizations and geographical locations. The Centre hosts the annual Trondheim IO conference attracting more than 300 participants, and over the first eight years of operation the centre will educate 25 PhDs.

Group leader: Professor Jon Kleppe
E-mail: jon.kleppe@ntnu.no
Telephone: +47 918 97 300
Web: www.ntnu.edu/ipt www.iocenter.no

contact



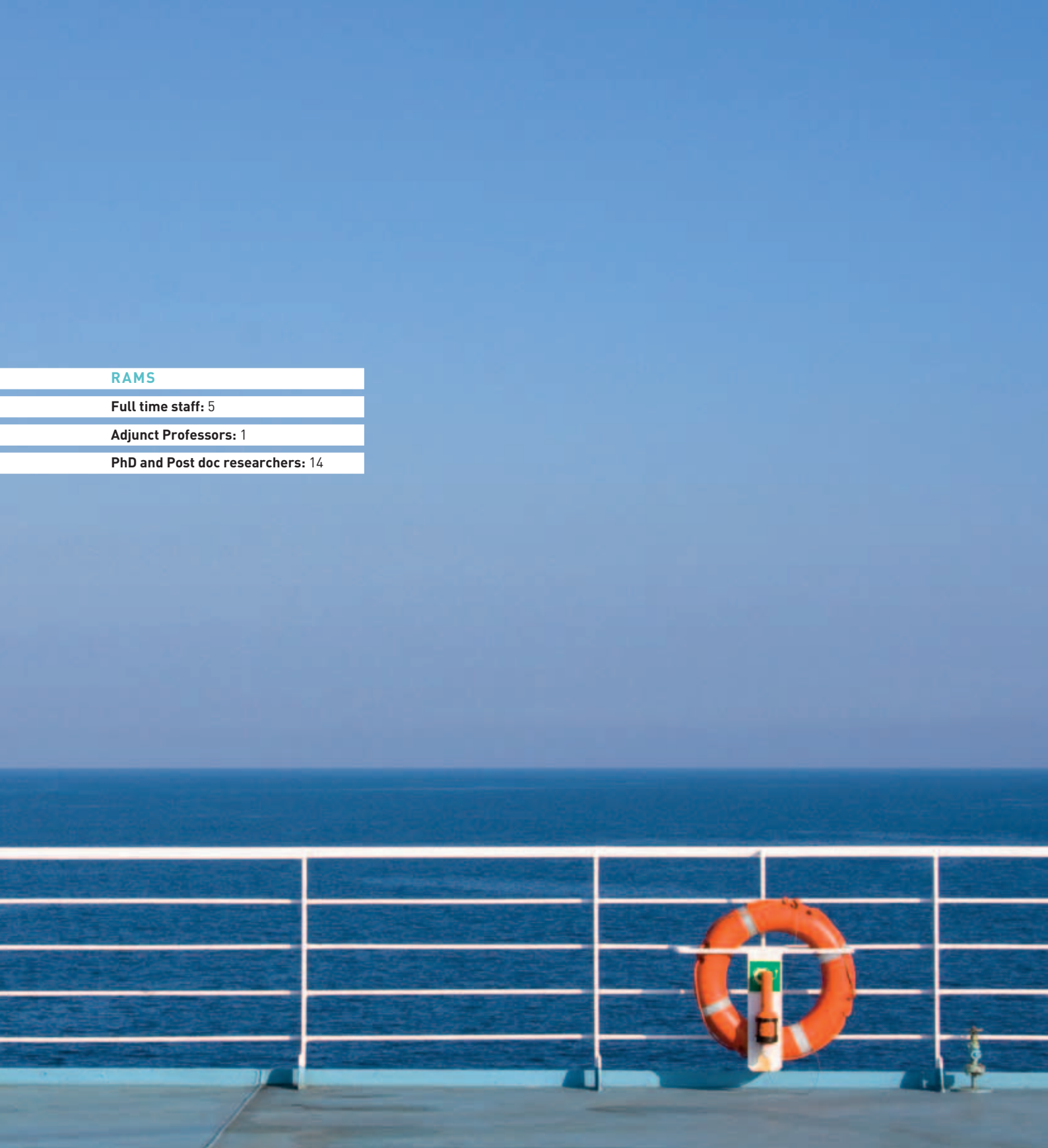
PETROLEUM ENGINEERING AND APPLIED GEOPHYSICS

Professors: 17 full-time

Adjunct professors: 15

Technical and administrative staff: 15

PhD and Post doc researchers: 65



RAMS
Full time staff: 5
Adjunct Professors: 1
PhD and Post doc researchers: 14

Saving lives, protecting the environment and avoiding unwanted stops

RAMS is an abbreviation for Reliability, Availability, Maintenance and Safety. The RAMS group develops new knowledge to help society and companies avoid accidents and failures, reduce losses and optimize production.

Strategy

The RAMS group focuses on three areas:

- Reliability assessment of safety barrier systems – especially safety-instrumented systems such as emergency shutdown systems, fire and gas systems, and automatic train control.
- New methods for risk analysis – with emphasis on modeling socio-technical systems in risk analyses in the operational phase, where results are used in operational decision-making.
- Risk-based maintenance planning – developing methods and plans to prevent accidents caused by lack of, or erroneously performed maintenance.

Research challenges

Examples of research challenges being addressed by the RAMS group are:

- We often say that “this was an accident waiting to happen” after large accidents, so why can we not learn more from accident investigations to be able to predict and avoid the next one?
- Safety relies on more and more complex systems with embedded software. How can we design to make them function when we need them, and not give false alarms or cause other negative effects?
- The competition and the demand for speed increase every day. How can we push the boundaries and still operate safely and reliably?
- Our society is increasingly relying on complex infrastructures. How can we design these systems to be reliable and less vulnerable?

Applications

The methods and knowledge are generic, but the main applications are complex systems where consequences of failures are large, in terms of loss of life, large costs or large disruptions to society. Important application areas are the oil and gas industry, transport and critical infrastructure.

Cooperation

The RAMS group cooperates closely with other research groups at NTNU and SINTEF through the ROSS Gemini Center, www.ntnu.edu/ross. ROSS has 70–80 researchers and is one of the largest research groups in this field in the world.

We have an international network and cooperate with universities in different parts of the world. Textbooks prepared by RAMS group staff are being used in many universities. The group cooperates with SINTEF and with industry on projects funded by EU or NRC, and also through e.g. the IO Centre.

Group leader: Professor Stein Haugen
E-mail: stein.haugen@ntnu.no
Web: www.ntnu.edu/ross

contact

Sustainable Arctic Marine and Coastal Technology, SAMCoT

The growing interest shown by national and international industries in the Arctic will lead to more industrial activity. In addition, an increase in transit is expected in this environmentally vulnerable area.

SAMCoT was established as a Centre for Research-based Innovation by the Research Council of Norway to meet the needs related to the increased activities in waters such as the Eurasian Arctic, East Greenland and the Chukchi Sea.

Hosted by the Norwegian University of Science and Technology (NTNU), SAMCoT has positioned itself as a leading national and international centre for the development of robust technology. Following its launch in 2011, SAMCoT is developing into a Global Arctic Technology Hub. Research Partners: Aalto University; TUDelft; HSVA; MSU; SINTEF; UNIS; VTT. Industry Partners: AKSO; DNV; GDF Suez E&P; Kongsberg Maritime; Multiconsult; Shell; SMSC; Statoil; Total E&P Norge. Public Partner: the Norwegian Coastal Administration.

Research activities and location:
SAMCoT researchers apply their fundamental knowledge in Arctic research to further develop Arctic technology. This technology will be used particularly in the energy sector and will have positive repercussions for society as a whole. The dynamic collaboration between our research and industry partners forms the foundation for our activities.

Fieldwork and lab activities are carried out in key locations such as:
Fieldwork: Barents Sea; Kara Sea; Pechora Sea; Off NE Greenland; Fjords of Spitsbergen.
Lab: HSVA (Germany); Aalto (Finland); UNIS; NTNU; Thayer School of Engineering (USA).



SAMCoT provides the scientific know-how necessary to meet the challenges caused by ice, permafrost and climate change. In addition it will set the foundation for the further development of environmentally adapted coastal infrastructure.

Six work packages (WPs) constitute the different research areas that will address these challenges.

- WP1 – Data Collection & Process Modelling;** collecting and analysing data on sea ice, icebergs, metocean and coastal permafrost, and process modelling
- WP2 – Material Modelling;** modelling of ice ridges and permafrost
- WP3 – Fixed Structures in Ice;** developing analytical and numerical models to predict the action from ice on fixed single and multi-leg structures
- WP4 – Floating Structures in Ice;** developing numerical tools that predict the behaviour and actions on floaters in ice
- WP5 – Ice Management and Design Philosophy;** establishing a design philosophy that considers the use of ice management
- WP6 – Coastal Technology;** developing technology and guidelines for the development and design of environmentally friendly and sustainable coastal structures and provide erosion protection.

Centre Director: Sveinung Løset
E-mail: sveinung.loset@ntnu.no
Telephone: +47 907 55 750
Centre Coordinator: Maria A. G. González
Telephone: +47 73 59 48 74
Web: www.ntnu.no/samcot

contact



Oden AT Research Cruise 2012 (OATRC 2012)

Research Project in collaboration between: The Norwegian University of Science and Technology (NTNU) and The Swedish Polar Research Secretariat (SPRS). Associated Project to SAMCoT; Financed by Statoil. Participants from NTNU/SAMCoT; SPRS; The Swedish Maritime Administration; UNIS; DNV; Multiconsult and Statoil.

Centre funding

The Research Council of Norway has launched three funding schemes in order to establish long term collaborative research centres within selected disciplines. These are Centres of Excellence (SFF), Centres for Research-based innovation (SFI) and Centres for Environment-friendly Energy Research (FME). Partaking in such centres is fundamental to secure long term funding of research activity and in particular, being awarded the host position of a centre posts a quality stamp on the research group in charge. Research groups at Faculty of Engineering Science and Technology host five such centres and partake in a total of 18.

Centre of Excellence

Centres of Excellence are funded by the Research Council of Norway for the purpose of bringing more Norwegian researchers and research groups up to a high international standard. SFF's are time-limited research centres characterised by focused, long-term research efforts of a high international calibre where researcher training is an important aspect. High scientific quality is the main criterion for the selection of the centres. Host institutions cooperate with one or more research institutions, organisations or enterprises to establish, operate and fund the centre as a SFF consortium. The SFF status is maintained for the duration of 10 years subject to passing a midway evaluation.



Centre for Research-based Innovation

The main objective for Centres for Research-based Innovation (SFI) is to enhance the innovation capability of the business sector by focusing on long-term research, based on forging close alliances between research-intensive enterprises and prominent research groups. The host institution has a strong reputation within the disciplines or industrial areas the centre addresses. The partners contribute to the centre in the form of funding, facilities, competence and their own efforts, pinpointing the commercial potential resulting from the centre's activities. The centre status is awarded for eight years with an initial five-year period and the possibility of a three-year extension subjected to evaluation.



Centre for Environment-friendly Energy Research

The aim of Centres for Environment-friendly Energy Research is to develop expertise and promote innovation through focus on long-term research in selected areas of environment-friendly energy, transport and CO₂ management in close cooperation between prominent research communities and users. The centres are co-financed by the host institution, partners and the research council. Similar to the SFI scheme, the centre status duration is eight years based on a five + three year model. Centre status is awarded primarily on the basis of potential to generate innovation and value creation in the scheme's thematic priority areas and on the scientific merit of their research.



The Centres

Centre	(-last funding year)	Centre full title
SFF CeSOS	(-2012)	Centre for Ships and Ocean Structures *
SFF Geohazards	(-2012)	International Centre for Geohazards
SFF CBC	(-2017)	Centre for Biomedical Computing
SFF AMOS	(-2022)	Centre for Autonomous Marine Operations and Systems *
SFI IO Centre	(-2014)	Integrated Operations in Petroleum *
SFI Norman	(-2014)	Norwegian Manufacturing Future
SFI Coin	(-2014)	Concrete Innovation Centre
SFI SIMLab	(-2014)	Structural Impact Laboratory *
SFI Create	(-2014)	Aquaculture Technology
SFI FACE	(-2014)	Multiphase Flow Assurance Innovation Centre
SFI SAMCoT	(-2019)	Sustainable Arctic and Marine Coastal Technology *
SFI SBBU	(-2019)	Drilling and Wells for Improved Recovery
FME Nowitech	(-2017)	Norwegian Research Centre for Offshore Wind Technology
FME BIGCCS	(-2017)	International Carbon Capture and Storage Research Centre
FME Cedren	(-2017)	Centre for Environmental Design of Renewable Energy
FME ZEB	(-2017)	Zero Emmission Buildings
FME Cenbio	(-2017)	Bioenergy Innovation Centre
FME CenSES	(-2017)	Centre for Sustainable Energy Studies

* Centres where Faculty of Engineering Science and Technology is host institution



Faculty of Engineering Science and Technology

DEANS OFFICE	DEPARTMENTS	RESEARCH GROUPS
	Civil and Transport Engineering	Buildings and Construction Geomatics Geotechnical Engineering Marine Civil Engineering Road and Transport
	Energy and Process Engineering	Thermal Energy Industrial Process Technology Energy and Indoor Environment Fluids Engineering Environmental Systems Analysis
	Engineering Design and Materials	Materials Design, Analysis and Manufacturing
	Geology and Mineral Resources Engineering	Geology Mineral Production and HSE Engineering Geology and Rock Mechanics
	Hydraulic and Environmental Engineering	Hydraulic Engineering Water and Wastewater Engineering
	Marine Technology	Marine Systems Marine Structures
	Petroleum Technology and Applied Geophysics	Petroleum Technology and Applied Geophysics
	Product Design	Product Design
	Production and Quality Engineering	Production Systems Project and Quality Management RAMS Production Management
	Structural Engineering	Concrete Structural Impact Laboratory Biomechanics Structural Mechanics

FACTS
Full professors: 180
Total staff: 850
Students: 4000
700 Master degrees awarded annually
PhD. Candidates: 400
11 doctoral programmes
80 doctoral degrees awarded annually
30.000 m ² of Laboratory facilities
Host for ECCSEL, an ESFRI CCS initiative
Host of three Centres for Research-based Innovation (SFI)
Host of two Norwegian Centres of Excellence (SFF)
Departments: 10
Research groups: 29



The main building NTNU, Gløshaugen.

Photo: Mentz Indergaard/NTNU Info

Postal address

The Norwegian University of Science and Tehnology, NTNU
The Faculty of Engineering Science and Technology
Høgskoleringen 6
NO-7491 Trondheim, Norway

Tel: +47 73 59 45 01

Fax: +47 73 59 37 90

E-mail: postmottak@ivt.ntnu.no

www.ntnu.edu/ivt



NTNU – Trondheim
Norwegian University of
Science and Technology