60 år

Kybernetikk

1954-2014

NTNU

60 år Kybernetikk 1954-2014

Fredag 7. november 2014

Kybernetisk fagdag

NTNU
Kunnskap for en bedre verden

- Arrangeres av NTNUs Institutt for teknisk kybernetikk i Glassgården, Elektrobygget på NTNU Gløshaugen. **Gratis og åpent for alle interesserte**
- Ti norske næringslivsbedrifter fra alle typer bransjer kommer for å snakke om **spennende bruk av kybernetikk i praksis**, om alt fra verdens minste helikoptre til verdens største styrte konstruksjon
- Ti av instituttets PhD-stipendiater vil også presentere postere som viser hva de forsker på. Disse posterne stilles ut i vrimleområdet i Glassgården, og kan besøkes i de to pausene og lunsjen
- Auditorium EL5 i Glassgården, Elektrobygget, NTNU Gløshaugen:
  - **Kl. 09.30-10.00**: **Institutt for teknisk kybernetikk: Velkommen og presentasjon av instituttet**
    ved Morten Breivik, Instituttleder
  - **Kl. 10.00-10.25**: **Kongsberg Seatex: eBird - Control of Marine Seismic Streamers**
    ved Ola Erik Fjellstad, IPR Manager
  - **Kl. 10.25-10.50**: **Prox Dynamics: Developing World-Leading Nano UAV Technology**
    ved Jørgen Syvertsen, R&D Engineer
  - **Kl. 10.50-11.10**: **Pause** med kybernetisk mingling og postere på vrimleområde i Glassgården
  - **Kl. 11.10-11.35**: **Prediktor: Kybernetikk i miniformat: Klokke for ikke -blodig måling av blodsukker**
    ved Steinar Sælid, Chief Technology Officer
  - **Kl. 11.35-12.00**: **Cybernetica: Kybernetikk for lønnsom prosessdrift**
    ved Peter Singstad, Managing Director

KONGSBERG

proxdynamics

Prediktor

CYBERNETICA
Provides Profitable Process Performance

60 år Kybernetikk 1954-2014

Fredag 7. november 2014

Kybernetisk fagdag

NTNU
Kunnskap for en bedre verden

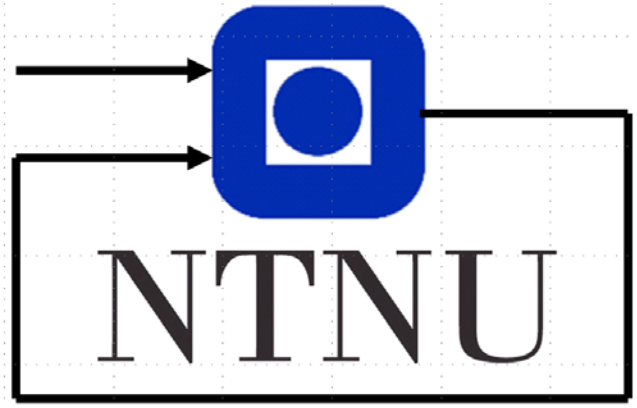
- Auditorium EL5 i Glassgården, Elektrobygget, NTNU Gløshaugen:
  - **Kl. 13.00-13.25**: **Marine Cybernetics: Fra 0-100 på 10 år**
    ved Øyvind Smogeli, Chief Operating Officer
  - **Kl. 13.25-13.50**: **Maritime Robotics: Fra D-blokka til virkeligheten**
    ved Vegard Hovstein, Managing Director
  - **Kl. 13.50-14.10**: **Pause** med kybernetisk mingling og postere på vrimleområde i Glassgården
- Auditorium EL3 i Glassgården, Elektrobygget, NTNU Gløshaugen: (**NB! Skifte av auditorium**)
  - **Kl. 14.10-14.35**: **GE Vingmed Ultrasound: On the Use of Cybernetic Methods in Diagnostic Ultrasound Imaging** ved Kjell Kristoffersen, Chief Engineer
  - **Kl. 14.35-15.00**: **ABB: From PID Control to Integrated Operations**
    ved Håvard Devold, Group Vice President
  - **Kl. 15.00-15.25**: **Statoil: Modelprediktiv regulering i Statoil** ved Stig Strand, Specialist Automation
  - **Kl. 15.25-15.50**: **nLink: Drømmen om roboter: Å bygge det neste "Kongsberg" fra t=0**
    ved Konrad Fagertun, Business Developer
  - **Kl. 15.50-16.10**: **Avslutning, kåring av beste poster og signering av rammeavtale for faglig samarbeid og forskerutdanning mellom Forsvarets Forskningsinstitutt og NTNU**

MARINE CYBERNETICS a DNV GL company
MARITIME ROBOTICS
ABB
Statoil
nLink roboter for byggeplassen

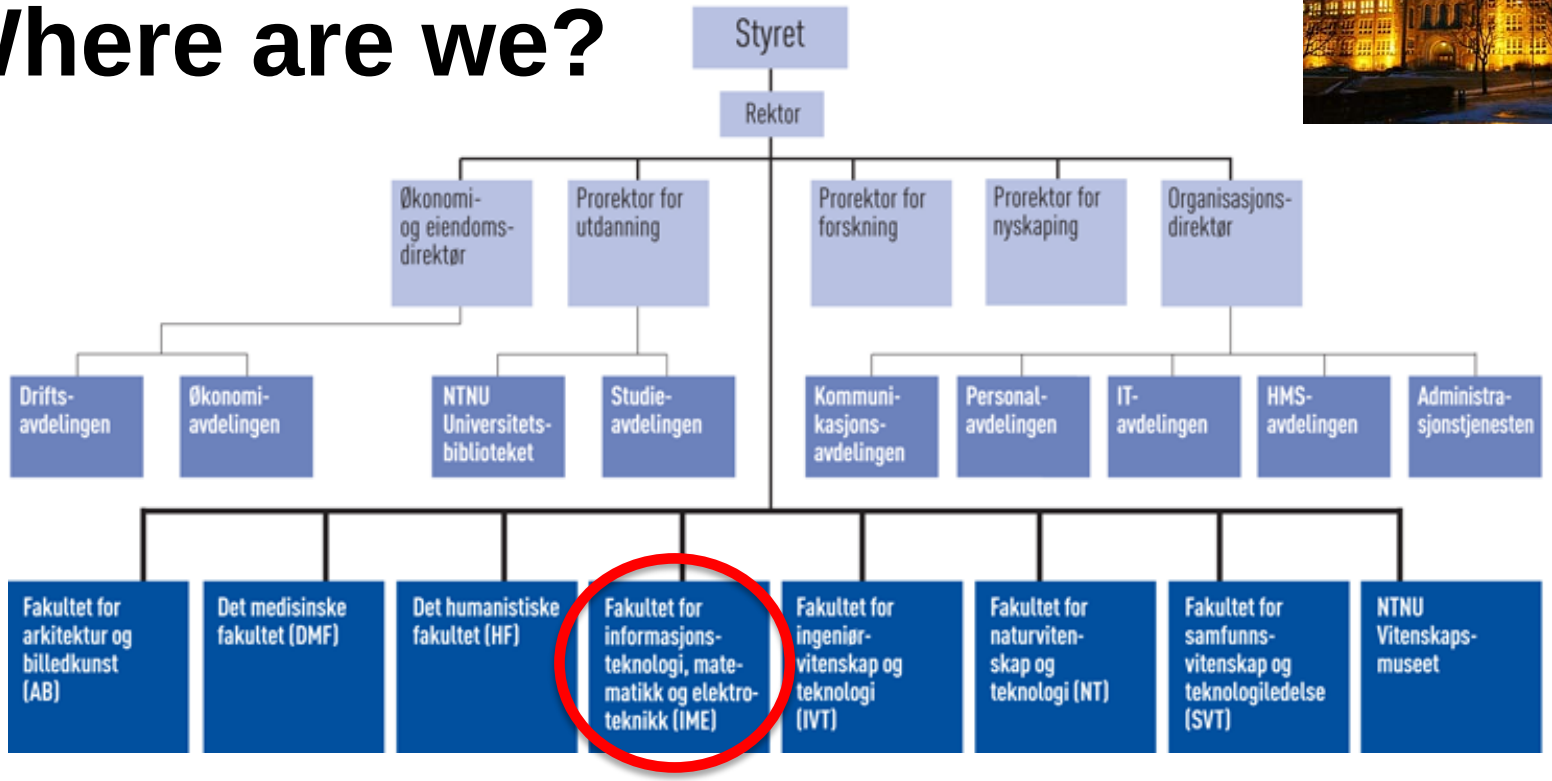
NTNU – Trondheim
Norwegian University of
Science and Technology

Department of Engineering Cybernetics

Institutt for teknisk kybernetikk (ITK)



Where are we?



NTNU:

- Main responsibillity for the higher technology education in Norway all the way back to 1910 (70% MSc, 90% PhD)
- 23 000 students in total
- 7 facultys, 48 departments

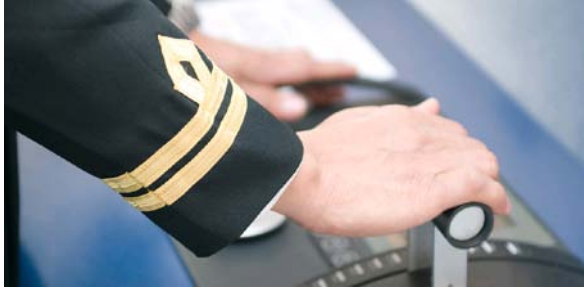
IME:

- Main responsibility for NTNU's ICT education
- 6 departments:
  - Computer science
  - Telecommunications
  - Electronics
  - Mathematics
  - Electrical Power Engineering
  - Cybernetics

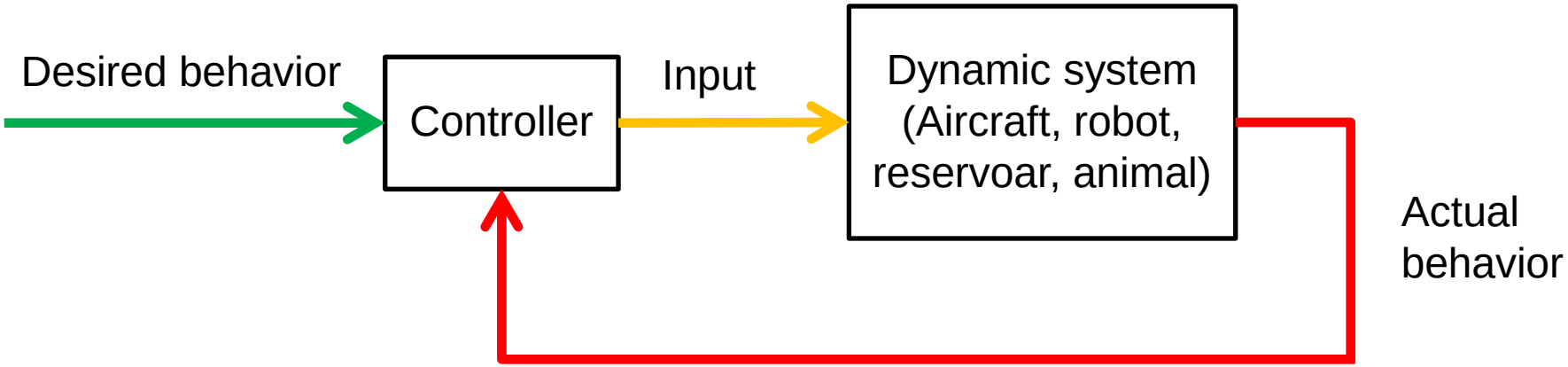
Where are we?


Trondheim sentrum
Studentersamfundet
Institutt for teknisk kybernetikk
NTNU Gløshaugen
RBK Lerkendal

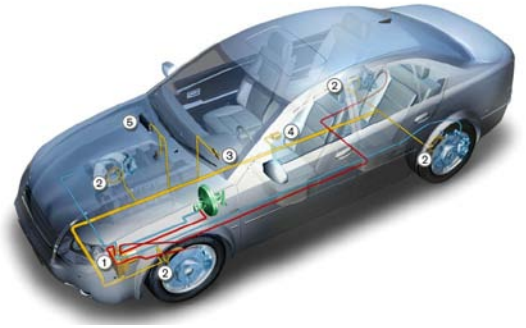
What is cybernetics?



- The word **cybernetics** originates from the Greek word **kybernetes**, which means "steersman", i.e. "the one who steers"
- An interdisciplinary field established around the Second World War (Norbert Wiener: *Cybernetics, or Control and Communication in the Animal and the Machine*, 1948)
- In short, cybernetics is about *how complicated dynamical systems can be modelled, controlled and monitored by combining mathematics, natural sciences, measurement devices, computer technology and actuators*
- **Feedback** is a fundamental cybernetic principle:



Made possible by cybernetics



Engineering cybernetics

Applications

- Marine automation and operations
- Integrated operations in oil and gas production
- Process control systems
- Robotics
- Drilling control systems
- Dynamic positioning
- Vessel maneuvering control systems
- Integrated ship bridge systems
- Automotive active safety
- Unmanned vehicles (ROV, UAV, AUV, USV, ...)
- Electric power generation
- Electric power distribution (SmartGrid)
- Electric drives and converters
- Marine power and propulsion
- Crane and lifting control
- Fish farms
- Automated medical diagnosis and healthcare
- Biomedical instrumentation
- Traffic control (air, road, rail, ...)
- Diving computers
- Environmental monitoring
- ...

Toolbox

Algorithms, design methods and software

- Dynamical systems theory
- Mathematical modelling and simulation
- Feedback control design methods and algorithms
- Stability and robustness analysis
- State and parameter estimation and monitoring
- Real-time programming
- Adaptive systems
- Optimization
- Numerical mathematics
- Signal processing
- Safety and reliability
- Remote operations
- Fault detection, diagnosis and supervisory control

Hardware and software systems

- Industrial information and communication technology
- Embedded systems
- Electronics
- Real-time operating systems
- Software engineering
- Human-machine interaction
- Sensors
- Instrumentation
- Actuators
- Mechatronics

Cybernetics in Norway

- Established at NTH in 1954 (Jens Glad Balchen)
- Changed name from Automatic Control to Engineering Cybernetics in 1972

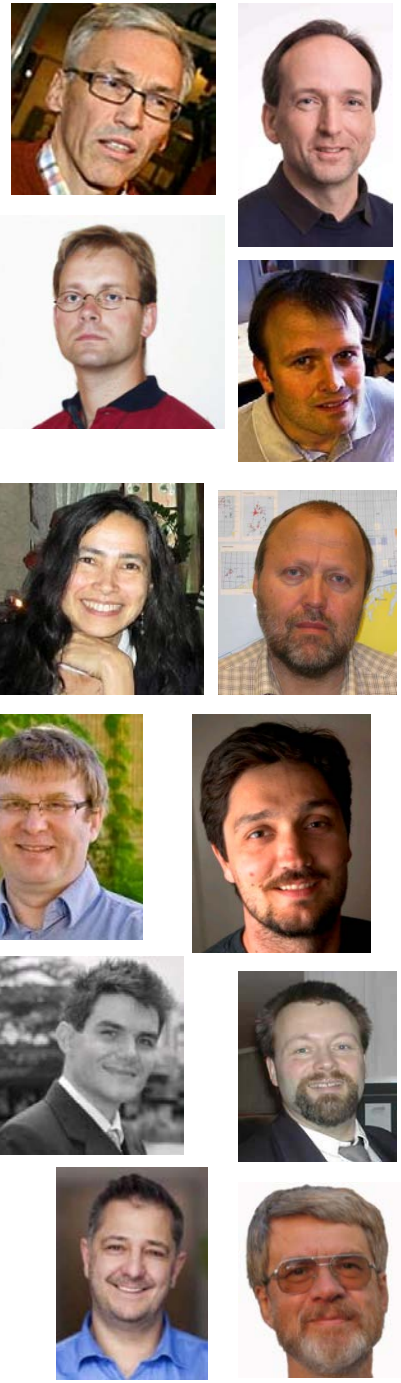
Cybernetics in Norway

Key facts

- Permanent scientific staff: 17
- Technical-administrative staff: 14
- Adjunct scientific staff: 12
- Postdocs and researchers: 10
- PhD candidates: 60
- Annual student admission for 5-year MSc program: 120
- Annual student admission for 2-year MSc-programs: 20 + 15
- Annual graduation of PhD candidates: 5-15
- Total costs in 2013: NOK 84.7 million (EUR 10.1 million)
- Close collaboration with chemical engineering, petroleum engineering, biomedical imaging and circulation, biology, marine technology and other NTNU departments
- Close contact with the industry
- The Norwegian Research Council's evaluation of the ICT communities in Norway in 2012:
  - 53 Norwegian ICT research groups within the Norwegian university and college sector evaluated
  - Three of the 53 groups received the top grade 5 – one of them at NTNU: The ITK Control systems group, rated "…excellent from an international perspective."
  - Industrial computer and instrumentation systems group: 3

Permanent scientific staff

- Professor Bjarne A. Foss (system and optimization theory)
- Professor Thor I. Fossen (guidance, navigation and control)
- Professor Jan Tommy Gravdahl (control engineering)
- Professor Morten Hovd (process control)
- Professor Lars Imsland (control engineering)
- Professor Tor Arne Johansen (nonlinear identification and control)
- Professor Marta Molinas (control of power electronics)
- Professor Tor E. Onshus (instrumentation engineering)
- Professor Kristin Ytterstad Pettersen (motion control)
- Professor Anton Shiriaev (robotics)
- Professor Ole Morten Aamo (control engineering)
- Associate Professor Jo Arve Alfredsen (aquaculture cybernetics)
- Associate Professor Edmund Brekke (sensor fusion)
- Associate Professor Sverre Hendseth (software development)
- Associate Professor Amund Skavhaug (real-time software)
- Associate Professor Øyvind Stavdahl (medical cybernetics)
- Assistant Professor Trond Andresen (control engineering)



Technical-administrative staff




- Kontorsjef Tove Johnsen (administrasjon)
- Førstekonsulent Eva Amdahl (administrasjon)
- Konsulent Unni Johansen (administrasjon)
- Konsulent Janne Karin Hagen (administrasjon)
- Konsulent Bente Lindquist (administrasjon)



- Verksmester Terje Haugen (mekanisk verksted)
- Mekaniker Glenn Angell (mekanisk verksted)



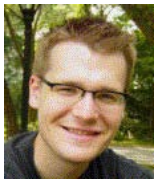
- Overingeniør Stefano Bertelli (elektronikkverksted)
- Overingeniør Knut Reklev (elektronikkverksted)
- Avdelingsingeniør Lars Semb (elektronikkverksted)
- Avdelingsingeniør John Olav Horrigmo (elektronikkverksted)
- Avdelingsingeniør Rune Mellingseter (elektronikkverksted)


- Avdelingsingeniør Jan Leistad (datalab)
- Avdelingsingeniør Torkel Hansen (datalab)


Adjunct scientific staff







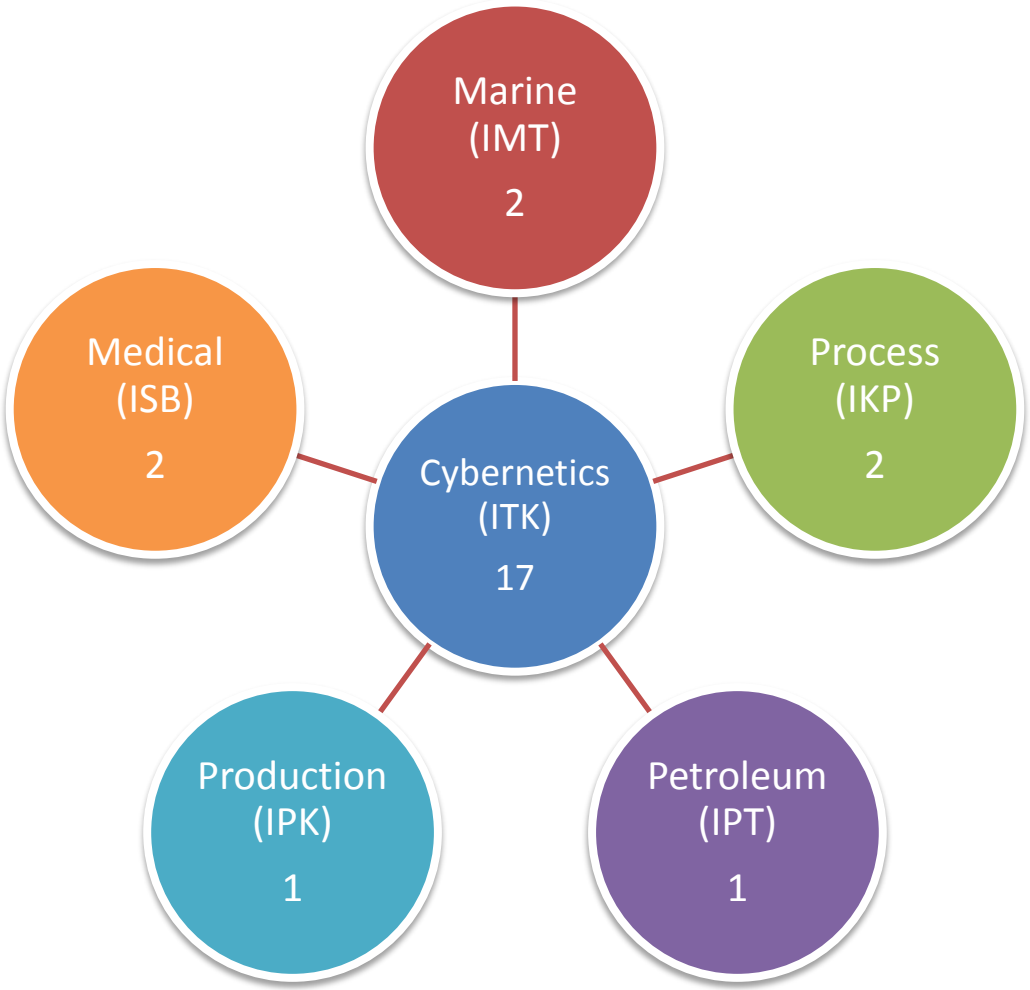





- Professor II Mogens Blanke (fault-tolerant control)
- Professor II Oddvar Hallingstad (guidance, navigation and control)
- Professor II Harald Martens (metamodelling and data analysis)
- Professor II Svein I. Sagatun (control engineering)
- Associate Professor II Morten Alver (aquaculture cybernetics)
- Associate Professor II Håvard Grip (estimation and navigation systems)
- Associate Professor II Glenn-Ole Kaasa (nonlinear and adaptive control)
- Associate Professor II Geir Mathisen (embedded computer systems)
- Associate Professor II Charlotte Skourup (human-machine interactions)
- Associate Professor II Bjørnar Vik (navigation systems)
- Associate Professor II Nadia Sokolova (integrated navigation systems)
- Associate Professor II Rune Storvold (sensors and measurements)

Note: "Professor II" = "Adjunct Professor"

Unique cybernetics ecosystem at NTNU



- Collaboration between the cybernetics researchers at ITK and at the "application departments"
- Gives excellent interdisciplinary research and education
- Results in innovations and spin-offs
- Unique model with both centralized and decentralized cybernetics competence!

Name change

- What do you associate with the word "robot"?
- This term is no longer reserved for industry robots inside a production facility, but is now used about everything from autonomous lawnmovers and donkeys (!) to unmanned cars, boats and aircraft

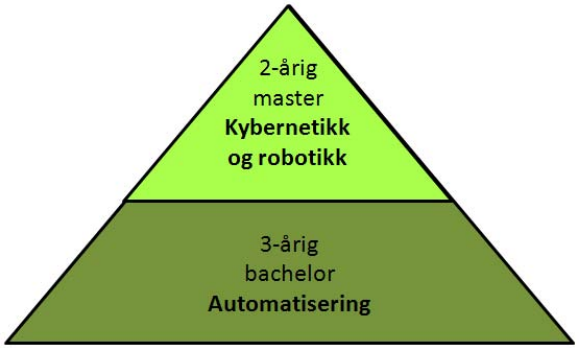
From industry robotics to field robotics

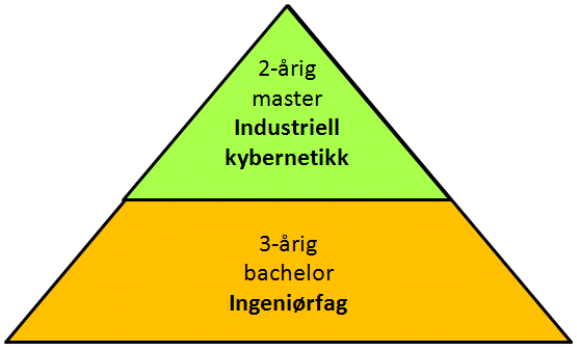
- Our existing study programs have therefore changed name from "Teknisk kybernetikk" to "**Kybernetikk og robotikk**", reflecting the increasing importance of robots in research, education and society in general

Three study programs

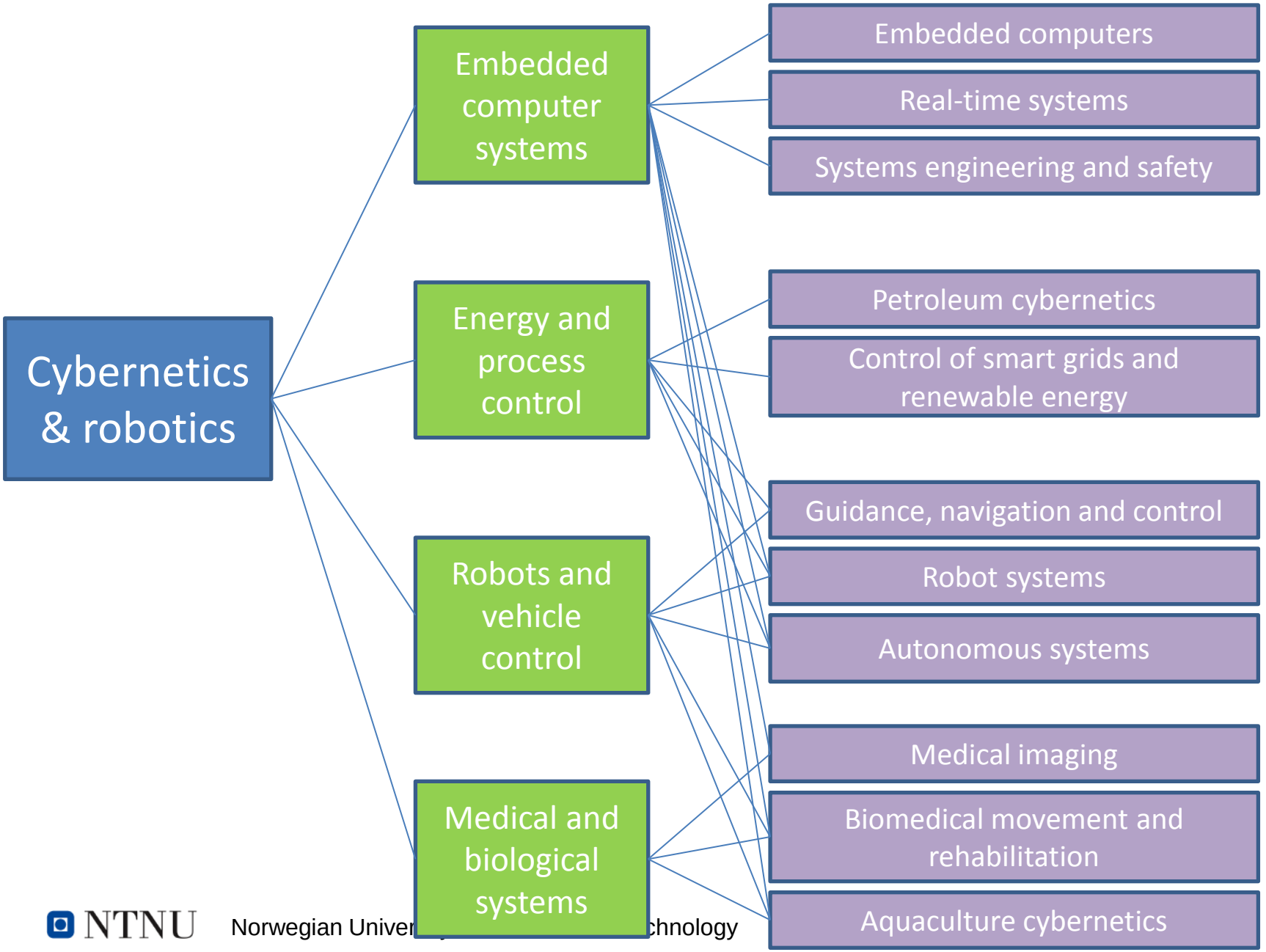
- 5-year Cybernetics and Robotics (120 places)
- 2-year Cybernetics and Robotics (20 places)
- 2-year Industrial Cybernetics (15 places)

5 vår	Masteroppgave			
5 høst	Fordypningsprosjekt		Fordypningsemne	Komplementært emne (valgbart)
4 vår	Studieretningsemne	Studieretningsemne	Studieretningsemne	Eksperter i team
4 høst	Studieretningsemne	Studieretningsemne	Studieretningsemne	Komplementært emne (valgbart)
3 vår	Modellering og simulering	Optimalisering og regulering	Sanntids-programmering	Fra annet studie-program (valgbart)
3 høst	Lineær systemteori	Fra annet studie-program (valgbart)	Teknologiledelse	Algoritmer og datastrukturer
2 vår	Reguleringsteknikk	Statistikk	Fluidmekanikk	Objektorientert programmering
2 høst	Industriell elektroteknikk	Matte 4	Fysikk	Digitalteknikk og datamaskiner
1 vår	Tilpassede datasystemer	Matte 2	Matte 3	Examen philosophicum
1 høst	Kybernetikk intro	Matte 1	IT intro	Kretsteknikk





Study program: Study specializations: Majors:



Some research activities

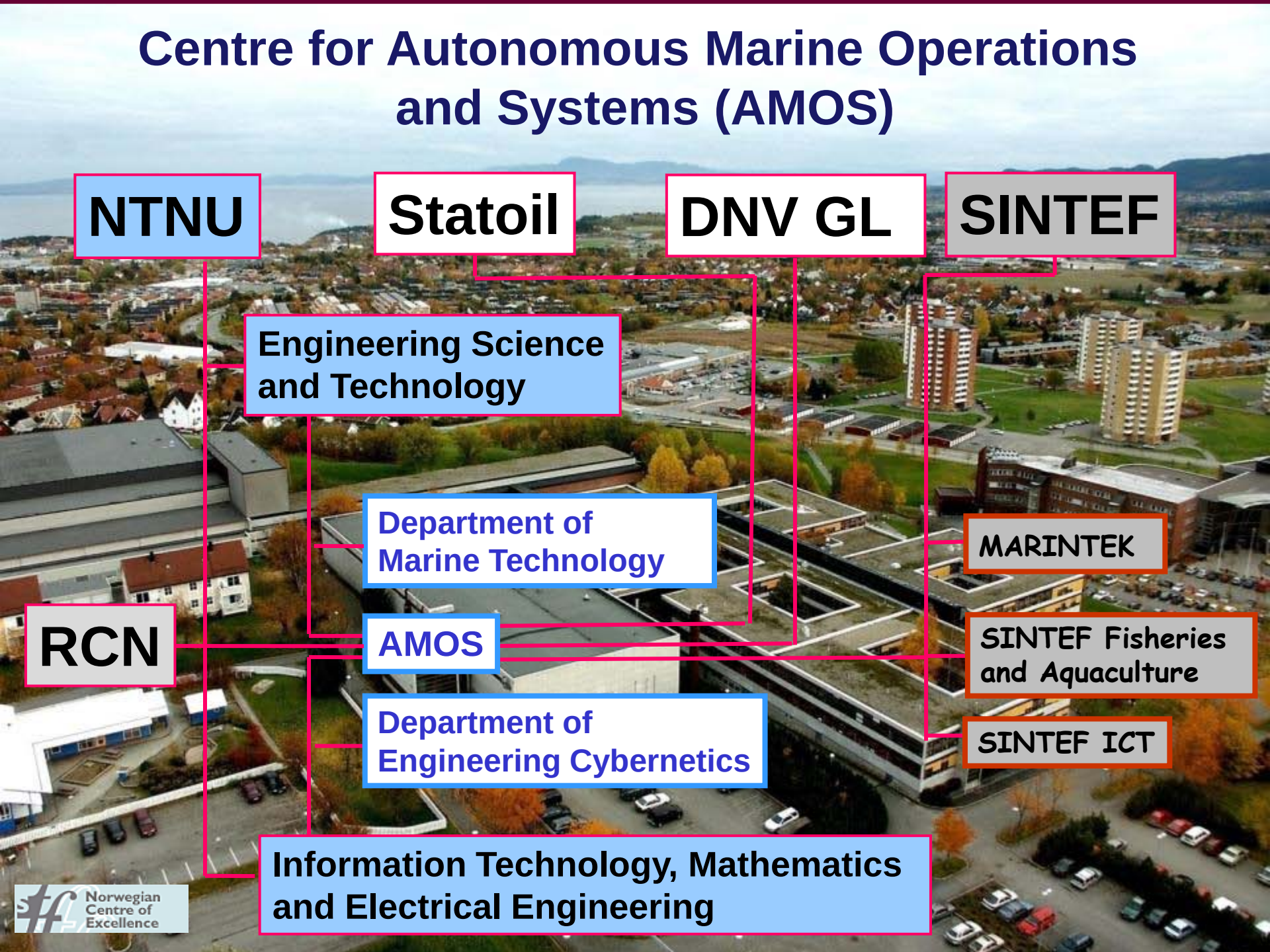
- SFF Centre for Autonomous Marine Operations and Systems (AMOS)
- SFI Centre for Integrated Operations in the petroleum industry (IO Center)
- SFI Centre for REsearch-based innovation in Aquaculture TEchnology (CREATE)

- Norwegian Smart Grid Center
- Norwegian Research Center for Offshore Wind Technology (NOWITECH)
- ROBOTNOR Centre for Advanced Robotics (SINTEF, IME, IVT): robotnor.no
- Fyrtårn CAMOS Sensor Networks - Coastal and marine operations and surveillance
- Fyrtårn Robotics

- FRINATEK project on Low-cost integrated navigation systems using nonlinear observer theory
- KMB project on Arctic dynamic positioning systems
- KMB project on Enabling high-performance safety-critical offshore and subsea automatic control systems using embedded optimization (emOpt)
- KMB project on Design and verification of control systems for safe and energy-efficient vessels with hybrid power plants (D2V)
- KMB project on Fault-tolerant inertial sensor fusion for marine vessels
- KMB project on Next generation robotics for Norwegian industry (NextGenRob)
- KMB project on Aquaculture biomass estimation (Exactus)
- KMB project on Optimal power network design and operation

- EU project on Embedded model predictive control and optimization (TEMPO)
- EU project on Sustainable smart grid open system for the aggregated control, monitoring and management of energy (e-GOTHAM)

Centre for Autonomous Marine Operations and Systems (AMOS)



AMOS Key Figures

2013-2022

Cost:	**NOK 537 million**	**AMOS**
Funding:	NOK 240 million,	**NTNU**
	NOK 175 million,	**NRC**
	NOK 122 million,	**SINTEF Fisheries and Aquaculture, MARINTEK, SINTEF ICT, DNV GL and Statoil**

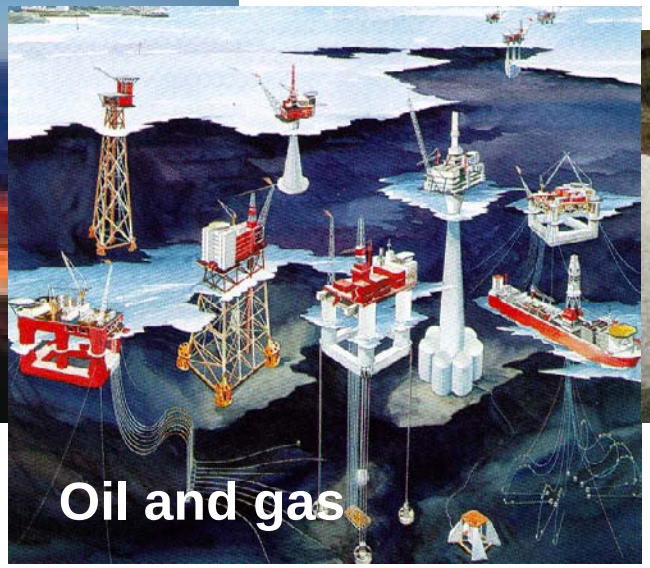
Associated projects per April 2014:

~NOK 63 million,	**NTNU, NRC MAROFF, NRC FRINATEK and industry partners**

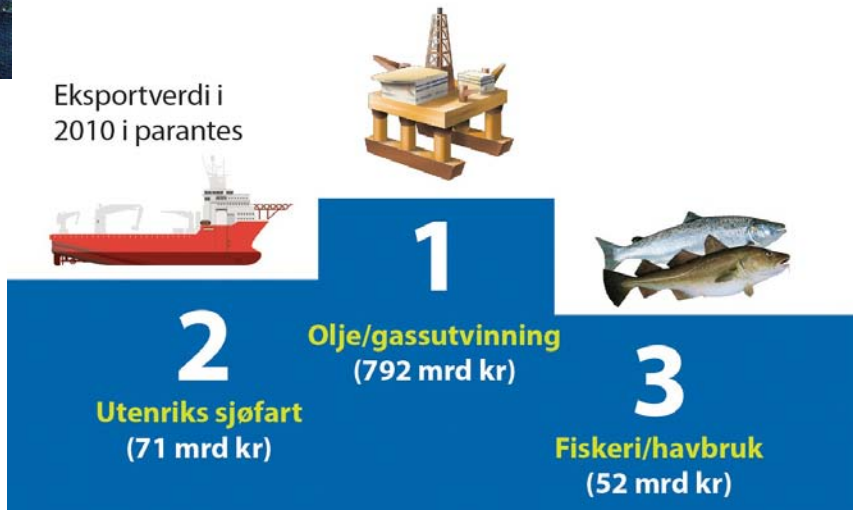
Total: **NOK 600 million**

Norwegian Centre of Excellence

The 3 major businesses in Norway…

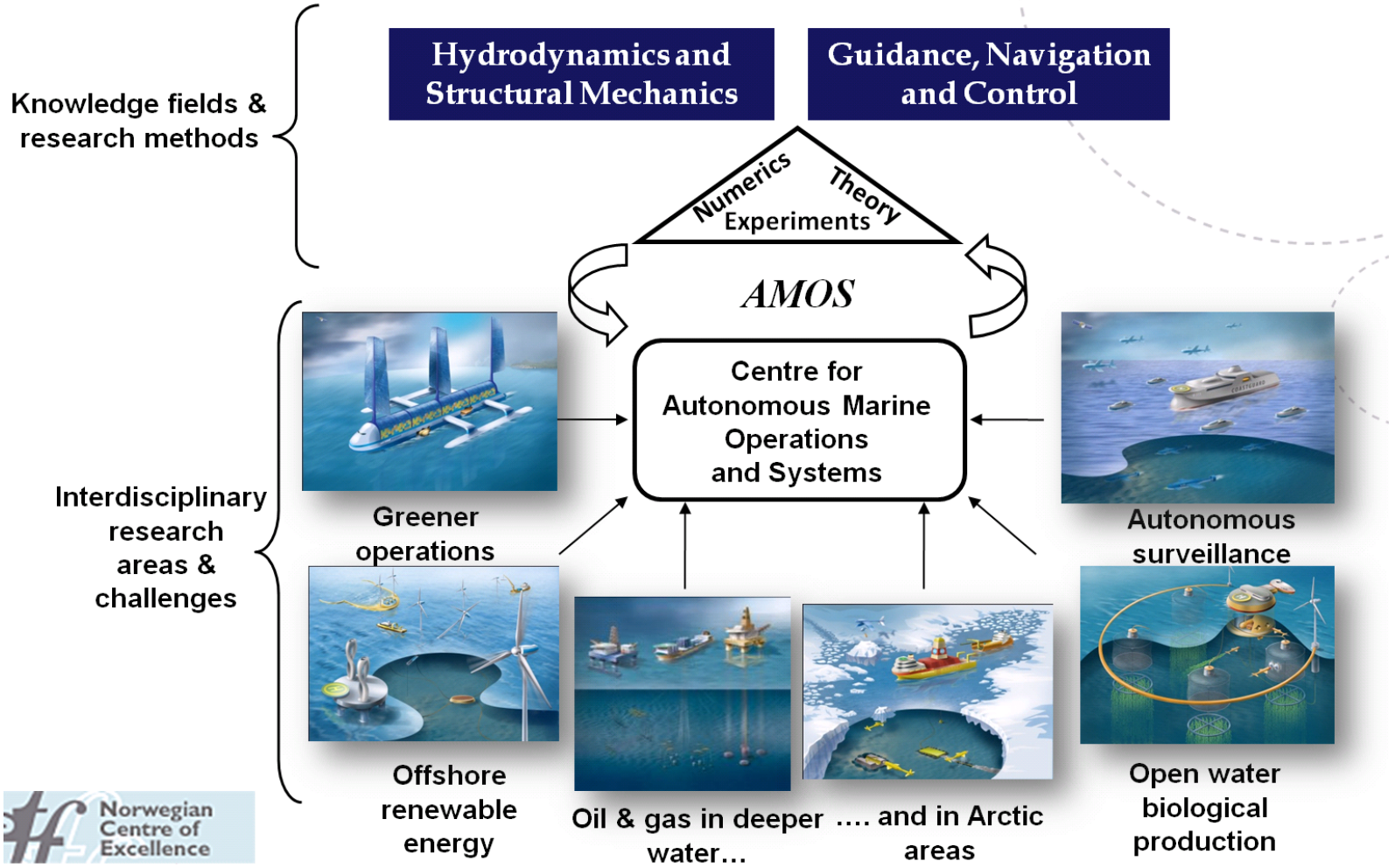


These clusters contribute with more than 70% of Norway's export revenue:



Research: Autonomous systems

Next step in research, education and innovation



Norwegian Centre of Excellence

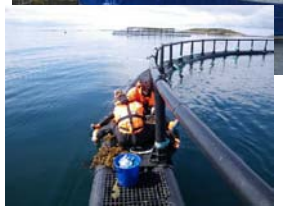
Theory – Simulation – Experiments – Operations

Bridging the gap from theory to practice

RV Gunnerus

AUR-Lab

Unmanned Vehicles Lab



ACE

Marine Cybernetics Laboratory

Simulator Environment

- Control and instrumentation
- Hydrodynamics
- Mechanics
- Machinery systems
- Databases, analysis
- Visualisation
- Run time infrastructure

Full-scale and prototype applications

Centre for Autonomous Marine Operations and Systems

Experimental techniques & prototyping

- Cavitation Tunnel
- Ocean Basin
- Structural Laboratory
- Towing Tank

- Hydrodynamics and Structural mechanics
- Guidance, Navigation and Control

AMOS

Unmanned Vehicle Laboratories

NTNU AUR-Lab and UAV-Lab: Integrated technology platform for ocean space research

Air:

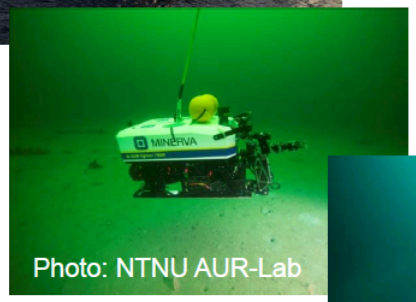
Penguin B fixed-wing UAV
X8 fixed-wing UAV
Hexa-copters

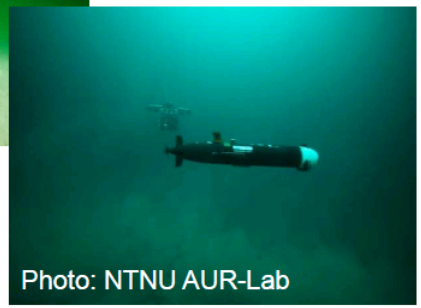
Sea surface:

Ships - Gunnerus

Water column and sea floor:

ROV Minerva
ROV 30k
ROV SEABOTIX
AUV Remus 100
HUGIN HUS

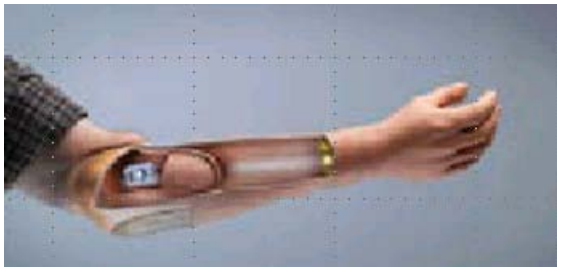


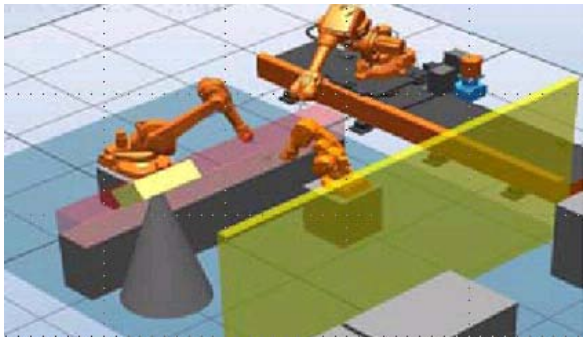


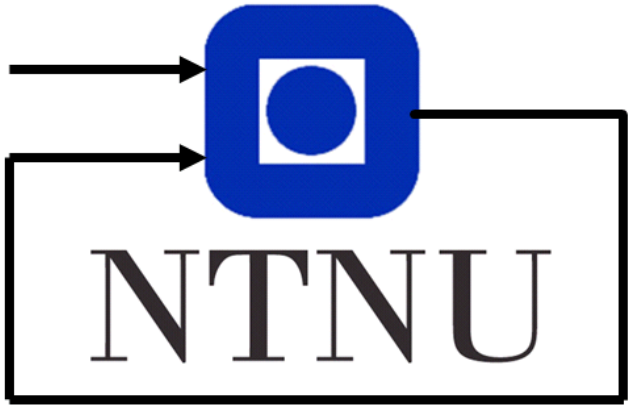
Agdenes Airfield

Laboratories

- Neuromotor lab
- Nano positioning
- Industrial robotics
- Snake robotics
- UAV lab







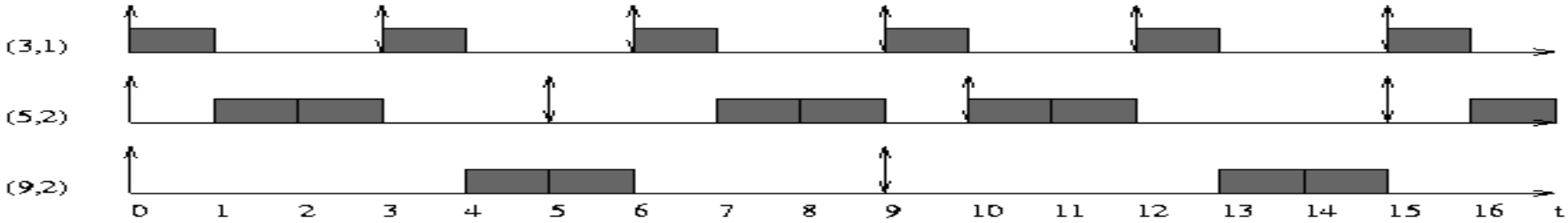
Challenge:

MAKE 1 SLIDE DESCRIBING YOUR MOST EXCITING RESEARCH ACTIVITY AT THE MOMENT

Sverre Hendseth

A new take on Real-Time systems

- **Fact:** When a task has been released, we can make a better estimate of its execution time.
- Using this information, the scheduler can make better decisions.
- …and there may be time for error handling before the deadline is missed.

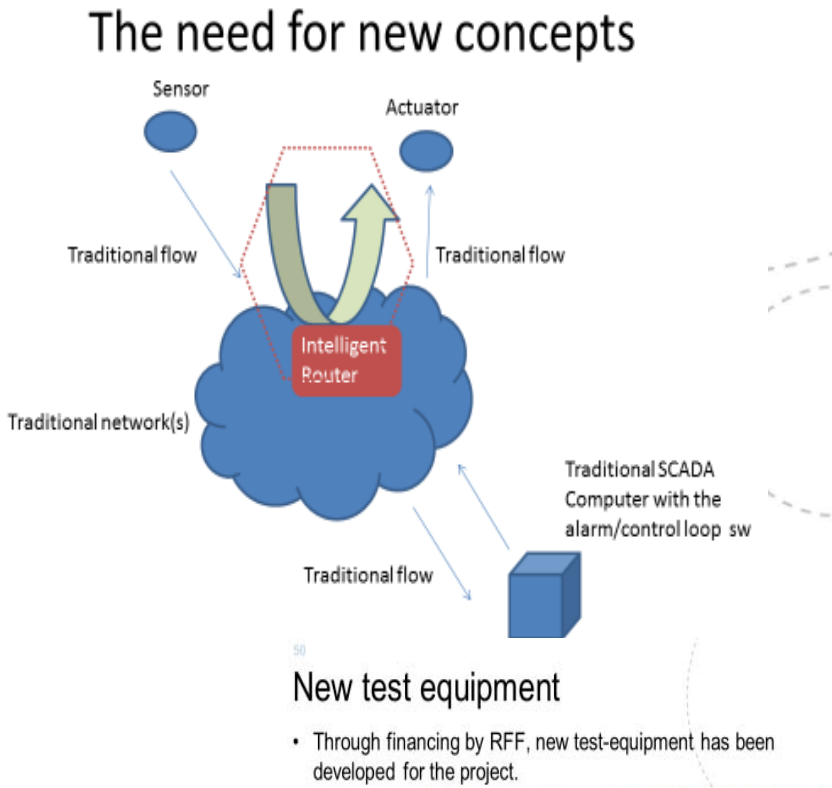


Next Generation Intelligent Sensor Networks

In order to run operations optimally, both financially and resource-wise, Oil and Gas industry uses a large number of different sensors. A production platform can have several thousands I/O points.
The increasingly important issue of environmental protection and pollution prevention adds demand for new and different types of sensors.

In order to handle these challenges, more intelligent sensors and sensor networks are needed:

- Self-Organizing
- Self-Awareness
- Standardized interfaces
- Local decisions



Amund Skavhaug

NTNU UAVlab – Unmanned Aerial Vehicles

Professors Tor Arne Johansen & Thor I. Fossen

- Driven by CoE AMOS – Center for Autonomous Marine Operations and Systems
- About 15 PhD candidates doing research on UAVs:
  - Autonomy, intelligent remote and insitu sensing, fault tolerance, navigation, robustness, marine and coastal applications.
- Test field at Breivika, Agdenes.
- About 20 UAV's owned by NTNU are in operation or under development.
- Strategic national and international collaboration established (Maritime Robotics, NORUT Tromsø, FFI, NASA Ames, NASA JPL, University of Porto).
- EU Innovative Training Network on Unmanned Aerial Systems for Marine and Coastal Monitoring coordinated by NTNU.

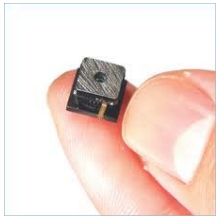
- http://www.itk.ntnu.no/english/lab/unmanned

Low-Cost Strapdown Inertial Navigation Systems aided by Camera and GNSS

Professors Thor I. Fossen & Tor Arne Johansen

- 6 PhD candidates doing research on MEMS-based strapdown INS:
  - Replace the Kalman filter with nonlinear observers with global stability properties and small computational footprints
  - Fault-tolerant inertial sensor fusion for marine vessels
  - Sea-state estimation using IMU (wave spectrum estimation)
  - UAV research problems: Autonomy, sensor fusion, camera-based navigation, optical flow for attitude, fault tolerance
- Test fields: NTNU UAVLab and full-scale ships
- IMUs from Sensonor, Analog Devices and XSENS
- Strategic collaboration established with Rolls Royce Marine, FFI, NASA JPL and Maritime Robotics.
- Funded by NFR through CoE AMOS, FRINATEK and MAROFF

Rudolf E. Kalman Aleksandr M. Lyapunov



- **Grip, Fossen, Johansen and Saberi (2012).** Attitude Estimation Using Biased Gyro and Vector Measurements with Time-Varying Reference Vector. *IEEE Transactions on Automatic Control*.
- **Grip, Fossen, Johansen and Saberi (2014).** Globally Exponentially Stable Attitude and Gyro Bias Estimation with Application to GNSS/INS Integration. *Automatica.*
- **Bryne, Fossen and Johansen (2014).** Nonlinear Observer with Time-Varying Gains for Inertial Navigation Aided by Satellite Reference Systems in DP. *IEEE MED'14*, Italy.
- **Fusini, Fossen and Johansen (2014).** A Uniformly Semiglobally Exponentially Stable Nonlinear Observer for GNSS- and Camera-Aided Inertial Navigation. *IEEE MED'14*, Italy.
- **Rogne, Johansen and Fossen (2014).** Observer and IMU-based Detection of Faults in Position Reference Systems and Gyrocompasses with Dual Redundancy in DP. *IEEE MSC'14*, France.

Professor Kristin Y. Pettersen

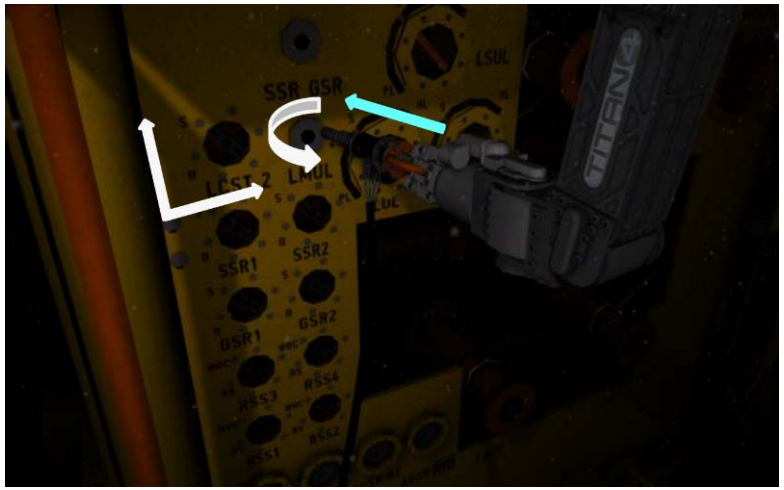
AMOS

Project manager: **Autonomous underwater robotics for mapping, monitoring and intervention**

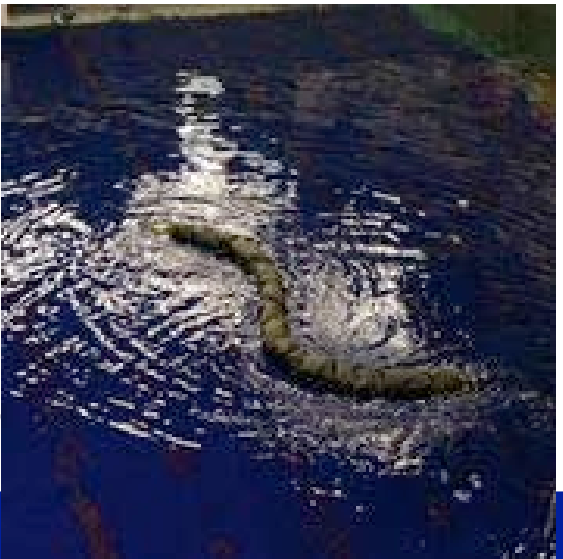
Sample research projects:

- Increased autonomy in underwater robotic manipulator operations:

  "Incorporating set-based control within the singularity-robust multiple task-priority inverse kinematics" IEEE Conference on Robotics and Control, Seattle, May 2015



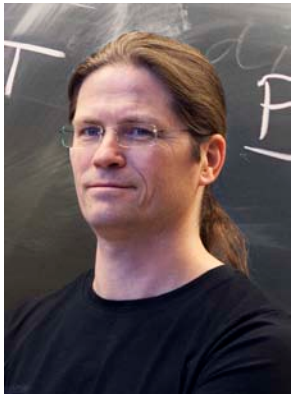
- Underwater snake robots:



Improve the efficiency and maneuverability of next generation AUVs

"Integral Line-of-Sight for path-following of underwater snake robots", 2014 IEEE Multi-Conference on Systems and Control, Nice/Antibes, France, Oct. 2014.

Professor Jan Tommy Gravdahl



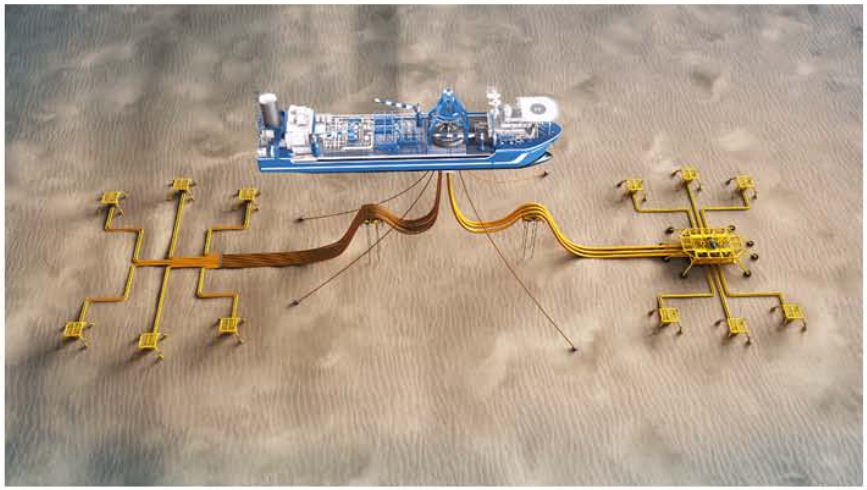
Sample research projects:

- "Automated detection and control of weeds“
  F. Urdal, T. Utstumo, S.Å. Ellingsen and J.T. Gravdahl, Design and control of precision drop on demand herbicide application in agricultural robotics, ICARCV 2014, Singapore, Dec., 2014
- ”Modeling, control and optimization of freezing of fish”
  C.J. Backi, J.D. Bendtsen, J. Leth, J.T. Gravdahl - Estimation of inner-domain temperatures for a freezing process, IEEE Multi-Conference on Systems and Control, Antibes, France, Oct., 2014
- “Surface Effect Ship Motion Control”
  Ø.F. Auestad, J.T. Gravdahl, A. Sørensen and T.H. Espeland, Motion Compensation System for a Free Floating Surface Effect Ship, 19th IFAC World Congress, Cape Town, South Africa, Aug., 2014
- “Nanoscale robotics in liquid environment”
  M.R.P. Ragazzon, J.T. Gravdahl, K.Y. Pettersen, and A.A. Eielsen, Topography Estimation in Atomic Force Microscopy by State and Parameter Estimation

Target tracking, mapping and navigation for unmanned vehicles on and below the sea surface

- Motivation: Safe and precise navigation, collision avoidance, docking.
- The estimation methods should have just the right amount of confidence in their own estimates (also known as “consistency”).
- Optimal solutions to data association and optimization-based alternatives to the Extended Kalman Filter for weakly nonlinear problems.

Daily production optimization – Pilot study



PETROBRAS

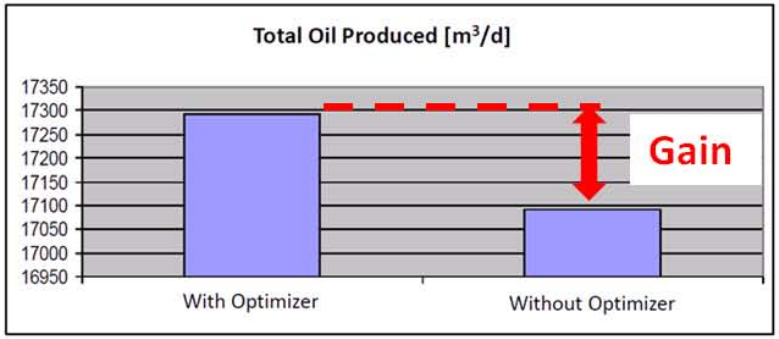
IO Center research outcome

Novel Real-time Decision Support based on mathematical optimization

Pilot test results
=> 1.2% production increase
=> $35mill/yr on *one* FPSO

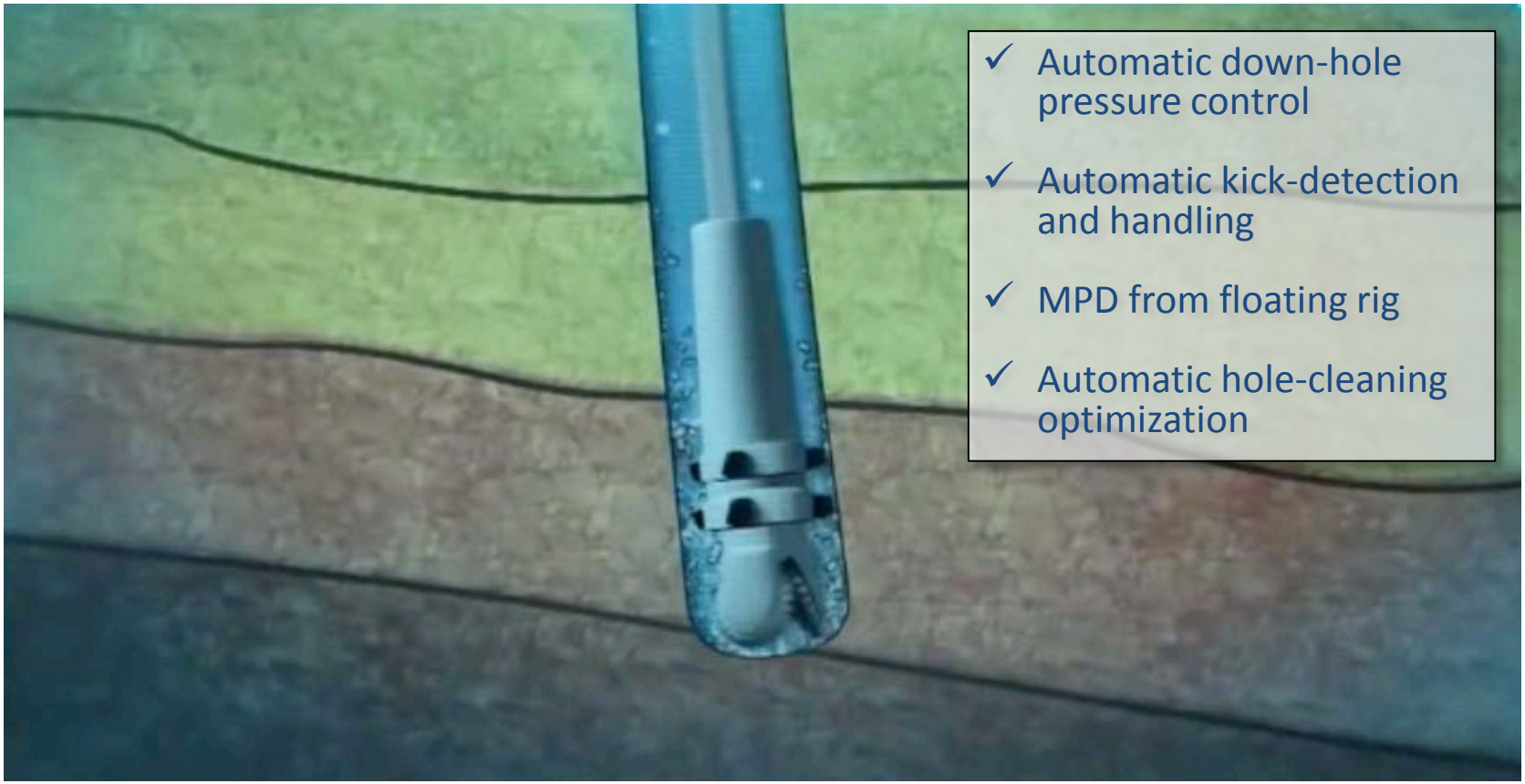
❖ **Case Study 2 – FPSO with 13 wells:**

Comparison based in a real scenario – limited compression capacity.



Contact: Professor Bjarne Foss (Bjarne.Foss@ntnu.no)

Automatic Managed Pressure Drilling



NTNU Statoil KELDA drilling controls IRIS

Fault diagnosis in drilling

Anders Willersrud, Mogens Blanke, Lars Imsland, Alexey Pavlov

IRIS

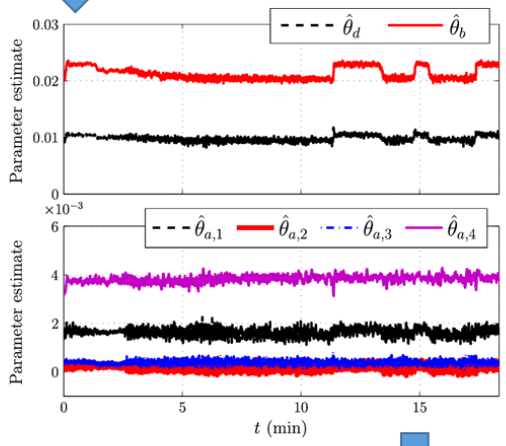
Statoil

Model-based fault diagnosis combined with **statistical change detection** thoroughly and successfully tested on test data from 1500 m medium-scale flow loop (Statoil, IRIS) with realistic equipment and wired-pipe type instrumentation.

Flow loop: gas influx and drillstring washout (left), bit plugging and fluid loss (right)

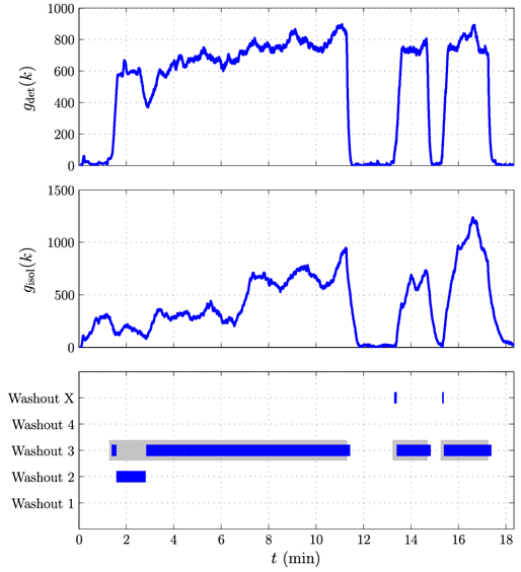
Difficult to see what happens, and especially where it happens!

Model-based estimation of friction



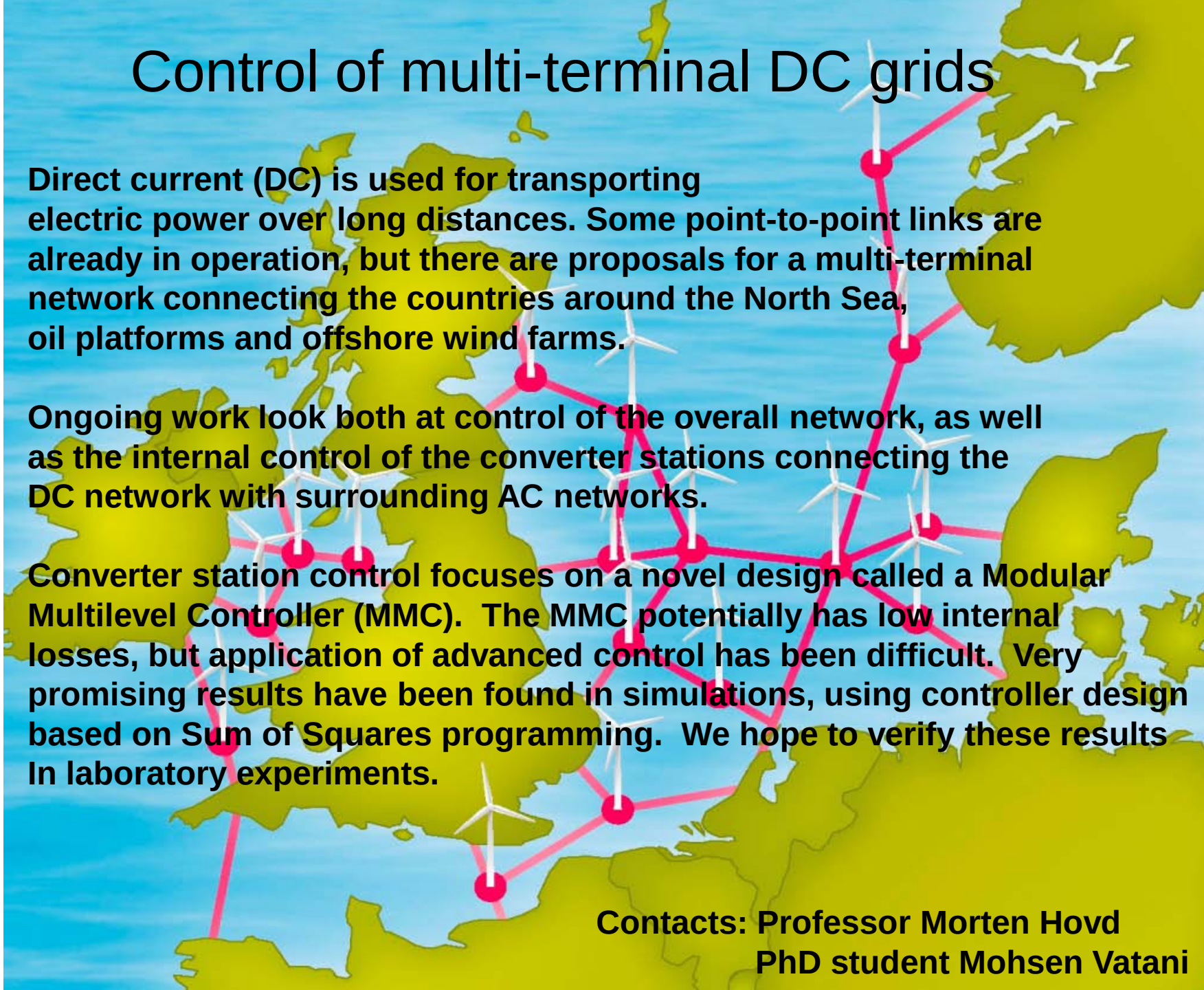
Statistical change detection and fault isolation

Fault successfully detected and isolated!



Willersrud, A., Blanke, M., Imsland, L., and Pavlov, A. (2014). **Fault diagnosis of downhole drilling incidents using adaptive observers and statistical change detection**. *Journal of Process Control* (conditionally accepted).
Willersrud, A., Blanke, M., Imsland, L., and Pavlov, A. (2014). **Drillstring Washout Diagnosis using Friction Estimation and Statistical Change Detection**. *IEEE Trans. Control Syst. Technol.* (conditionally accepted).

Control of multi-terminal DC grids

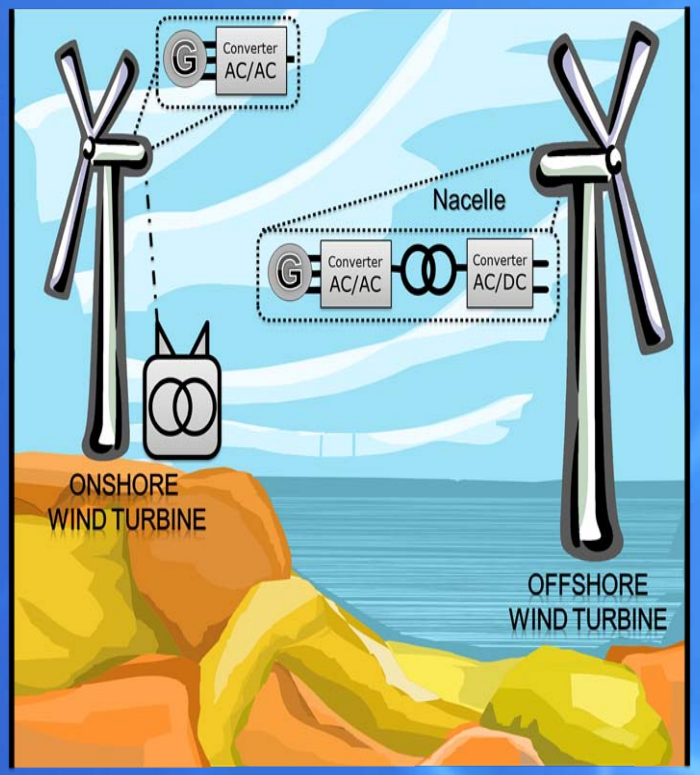


Direct current (DC) is used for transporting electric power over long distances. Some point-to-point links are already in operation, but there are proposals for a multi-terminal network connecting the countries around the North Sea, oil platforms and offshore wind farms.

Ongoing work look both at control of the overall network, as well as the internal control of the converter stations connecting the DC network with surrounding AC networks.

Converter station control focuses on a novel design called a Modular Multilevel Controller (MMC). The MMC potentially has low internal losses, but application of advanced control has been difficult. Very promising results have been found in simulations, using controller design based on Sum of Squares programming. We hope to verify these results In laboratory experiments.

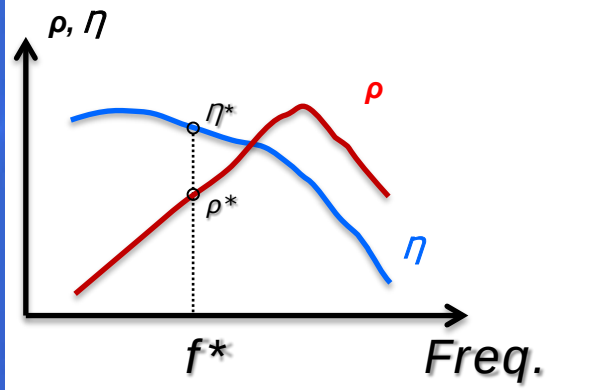
Contacts: Professor Morten Hovd
PhD student Mohsen Vatani

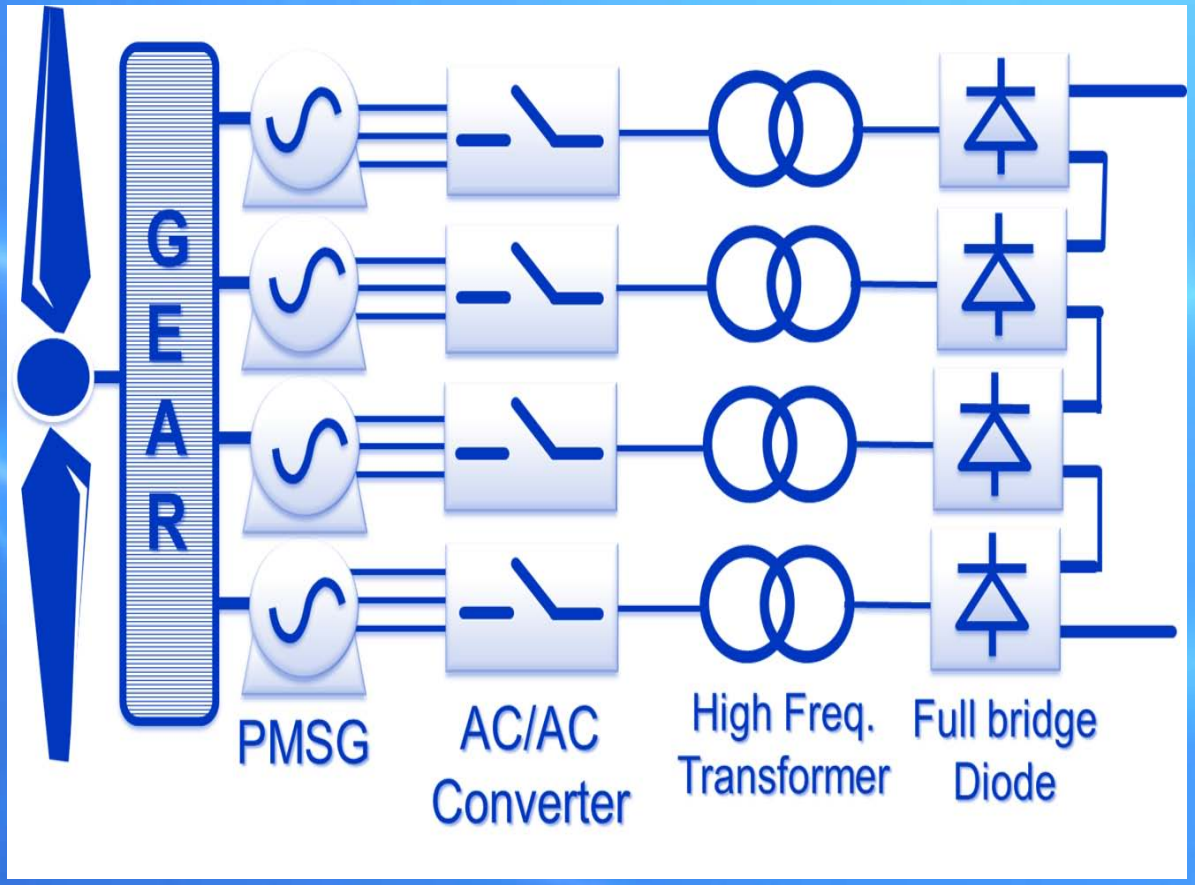


Optimal system design tool targeting conflictive objectives

O1. Maximize power density (ρ) of conversion system: Minimize weight/Size for a given power. Increase the Frequency

O2. Maximize efficiency (η): Reduce power losses. Less conversion stages

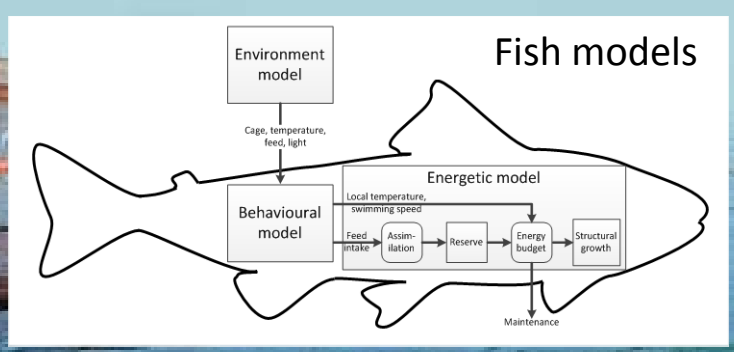


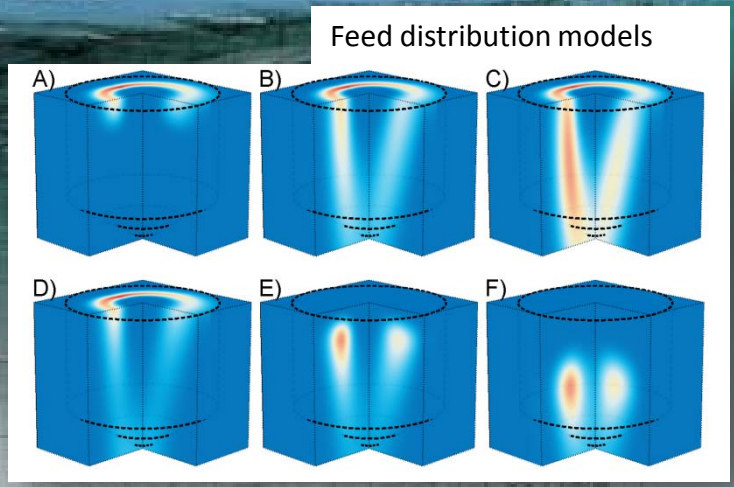


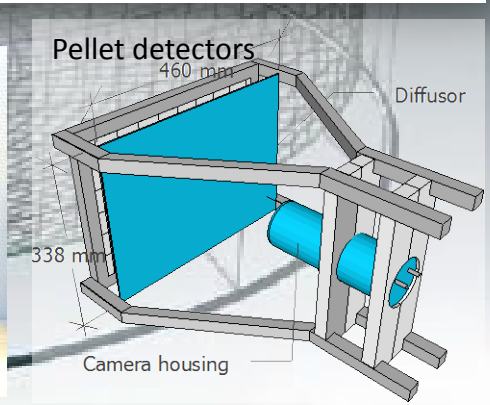
Monitoring and control of large-scale of fish farms

Closing the information gap:

- Integrated bio-physical models
  - Fish physiology
  - Fish behaviour
  - Environment
  - Feed density
- Instrumentation
  - Biotelemetry
  - Wireless sensor networks
  - Computer vision
  - ROV/AUV
- Monitoring
  - Feeding control
  - Biomass estimation
  - Disease monitoring







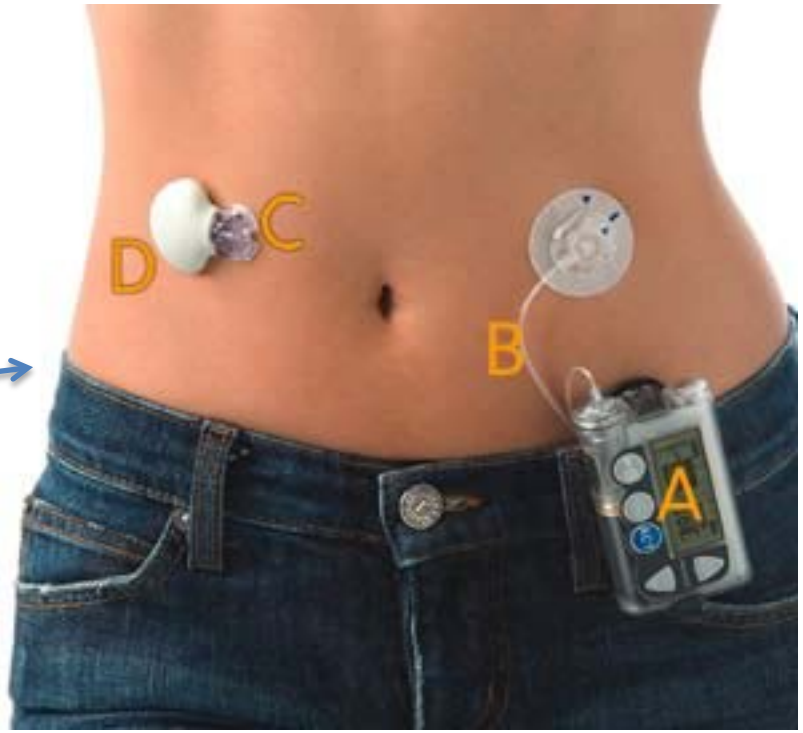
Artificial Pancreas Trondheim (APT) - Cybernetic prosthesis for diabetics!

Goal: robust closed-loop glucose control system for patients with diabetes

Great societal relevance!

Today

- Dangerously slow (really!)
- Impractical (really!)



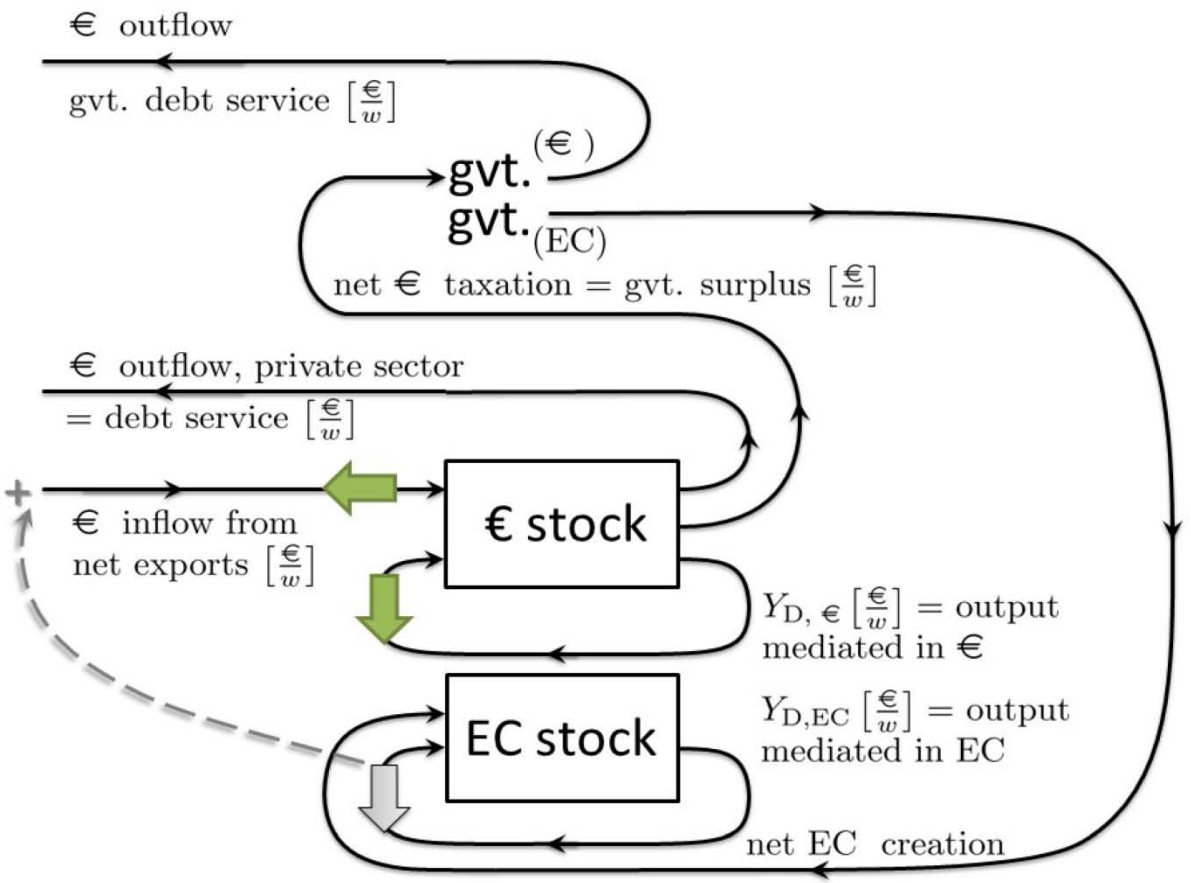
Our solution

- Optimal instrumentation =>
  - Increased bandwidth
  - More practical placement
- Redundancy =>
  - Increased reliability

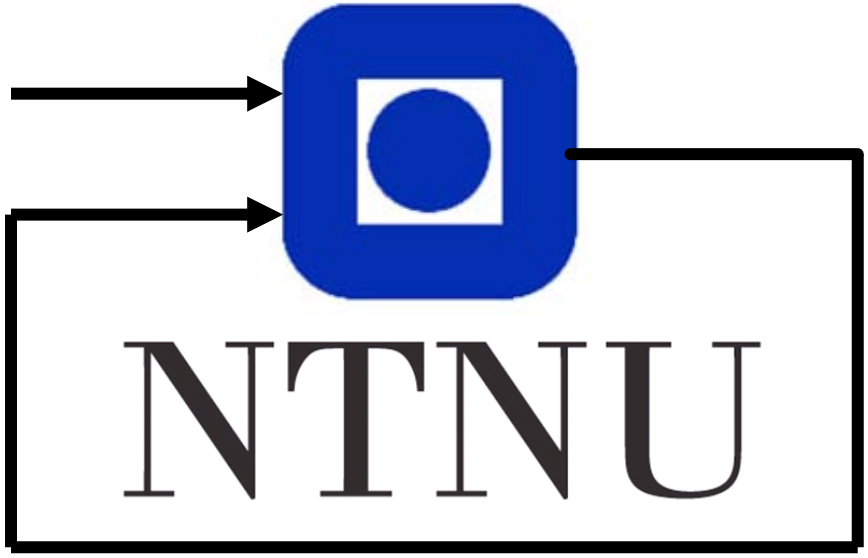
Research activity Trond Andresen

Dynamic models of money flows and credit in macroeconomic systems. Modeling debt-related crisis mechanisms. Alternative monetary systems and fiscal policies. Advantages of electronic currency systems, no bills and coins. Advising and cooperating with the government of Ecuador and academics there, on monetary systems and policies.

Parallel national currencies as a crisis remedy for eurozone countries.



"Instituttet for de moderne ting"



Velkommen til kybernetikkens vidunderlige verden!