NTNU

Kunnskap for en bedre verden

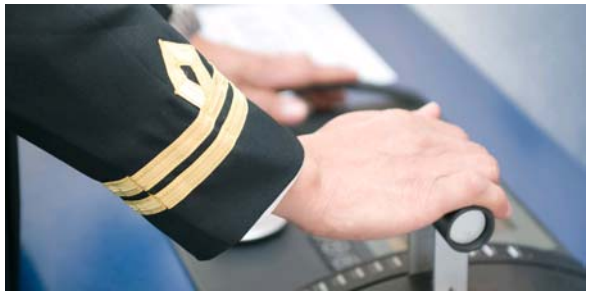
Autonome glimt fra NTNU

Morten Breivik

Instituttleder teknisk kybernetikk

Lanseringskonferansen for NFAS, Oslo, 4. oktober 2016

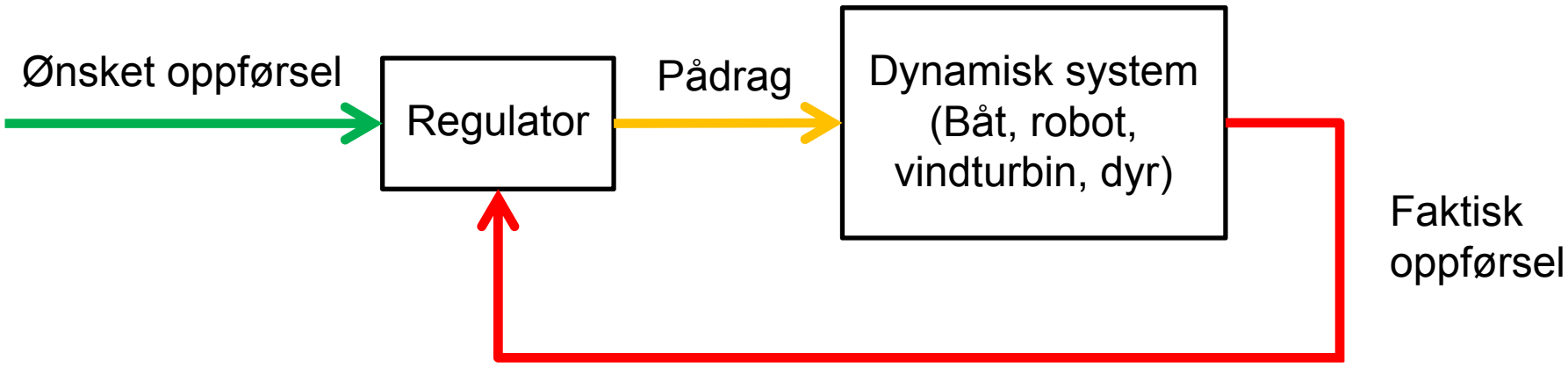
Hva er kybernetikk?



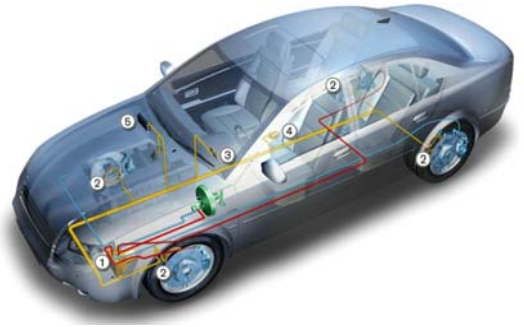
- Ordet **kybernetikk** har sin opprinnelse i det greske ordet **kybernetes**, som betyr "styrmann/rormann", dvs. "den som styrer"
- Er en tverrfaglig disiplin som ble etablert rundt 2. verdenskrig (Norbert Wiener: *Cybernetics, or Control and Communication in the Animal and the Machine*, 1948)

- Kort sagt handler kybernetikk om *hvordan kompliserte dynamiske systemer kan modelleres, styres og overvåkes ved å kombinere matematikk, naturvitenskap, målemetoder, datateknologi og pådrag + en dash reguleringsteknikk og systemteori*

- **Tilbakekobling** er et grunnleggende kybernetisk prinsipp:

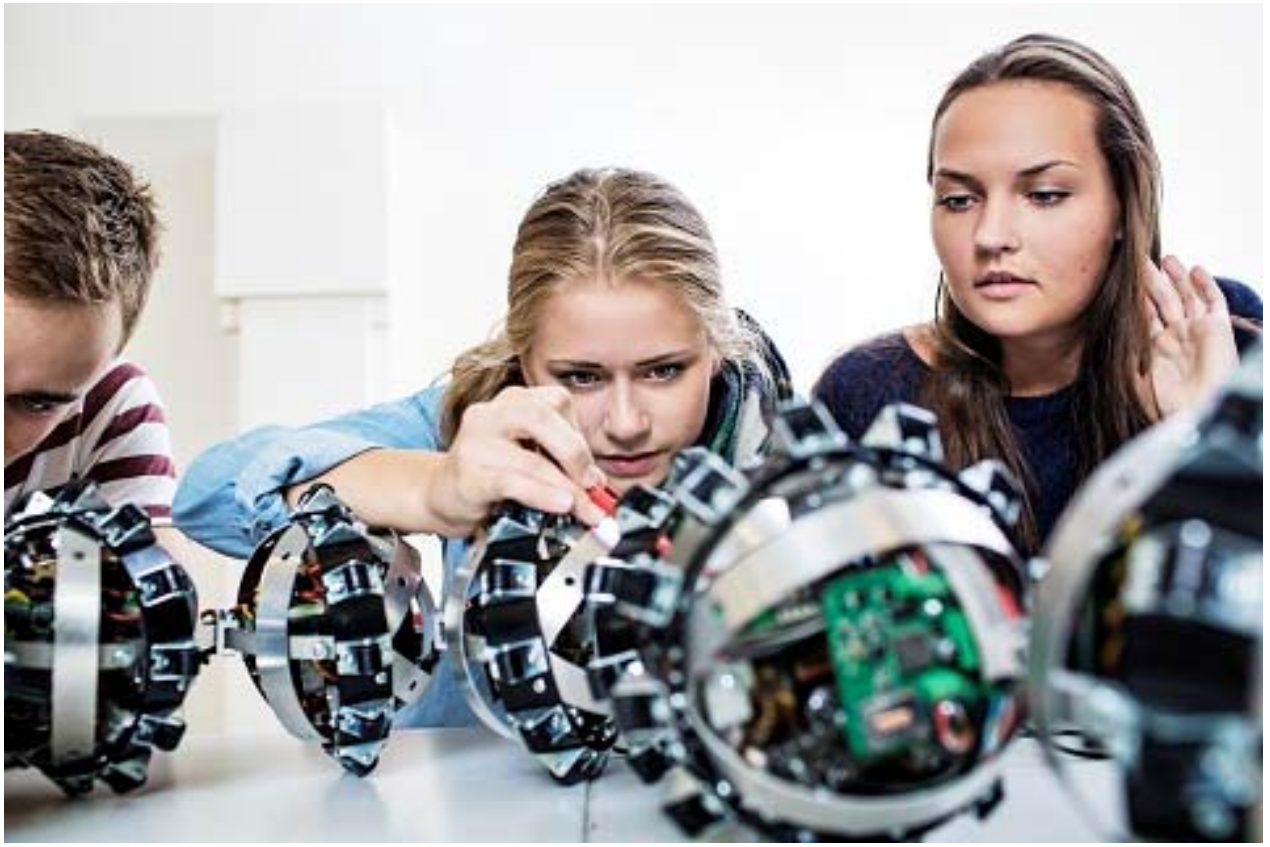


Made possible by cybernetics



cybernetics inside

Kybernetikere: «Teknologiens styrmenn»



Kybernetikk vil alltid være fremtidens fagfelt fordi...

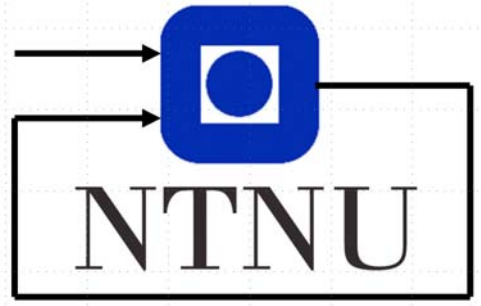
Institutt for teknisk kybernetikk (ITK)

- Hovedansvar for utdanning av master- og phd-kandidater innen teknisk kybernetikk i Norge
- Uteksaminerer 80-90 (snart 130-180) masterkandidater og 5-15 phd-kandidater hvert år

- Har per i dag inne ca. 740 masterstudenter (fordelt på 3 studieprogram) og ca. 70 phd-studenter
- Opplever rekordstor interesse for vårt 5-årig integrerte masterstudium i «Kybernetikk og robotikk» med 432 primærsøkere på 135 plasser i år (tredje mest populære sivilingeniørstudium på NTNU)

- Stab:
  - 17 professorer og førsteamanuenser → planlegger å øke til 25 innen 2020
  - 16 teknisk-administrativt ansatte (elektroverksted, mekanisk verksted, UAV-lab)

- I 2012 gjorde Forskningsrådet en internasjonal evaluering av IKT-fagmiljøene i den norske UH-sektoren, der instituttets største forskningsmiljø “Control systems group” fikk toppkarakteren 5 – “excellent from an international perspective” – som ett av tre fagmiljø blant de 53 som ble vurdert



Next step in research, education and innovation (2013-2022)

Knowledge fields & research methods

Hydrodynamics and Structural Mechanics

Guidance, Navigation and Control

Numerics

Theory

Experiments

NTNU AMOS

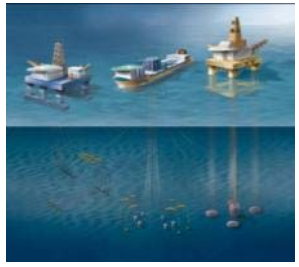
NTNU Centre for Autonomous Marine Operations and Systems

Interdisciplinary research areas & challenges

Greener operations

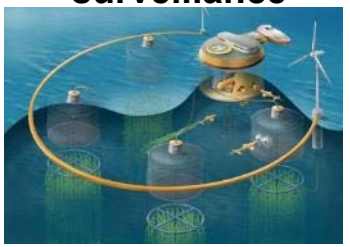
Autonomous surveillance

Offshore renewable energy



Oil & gas in deeper water…

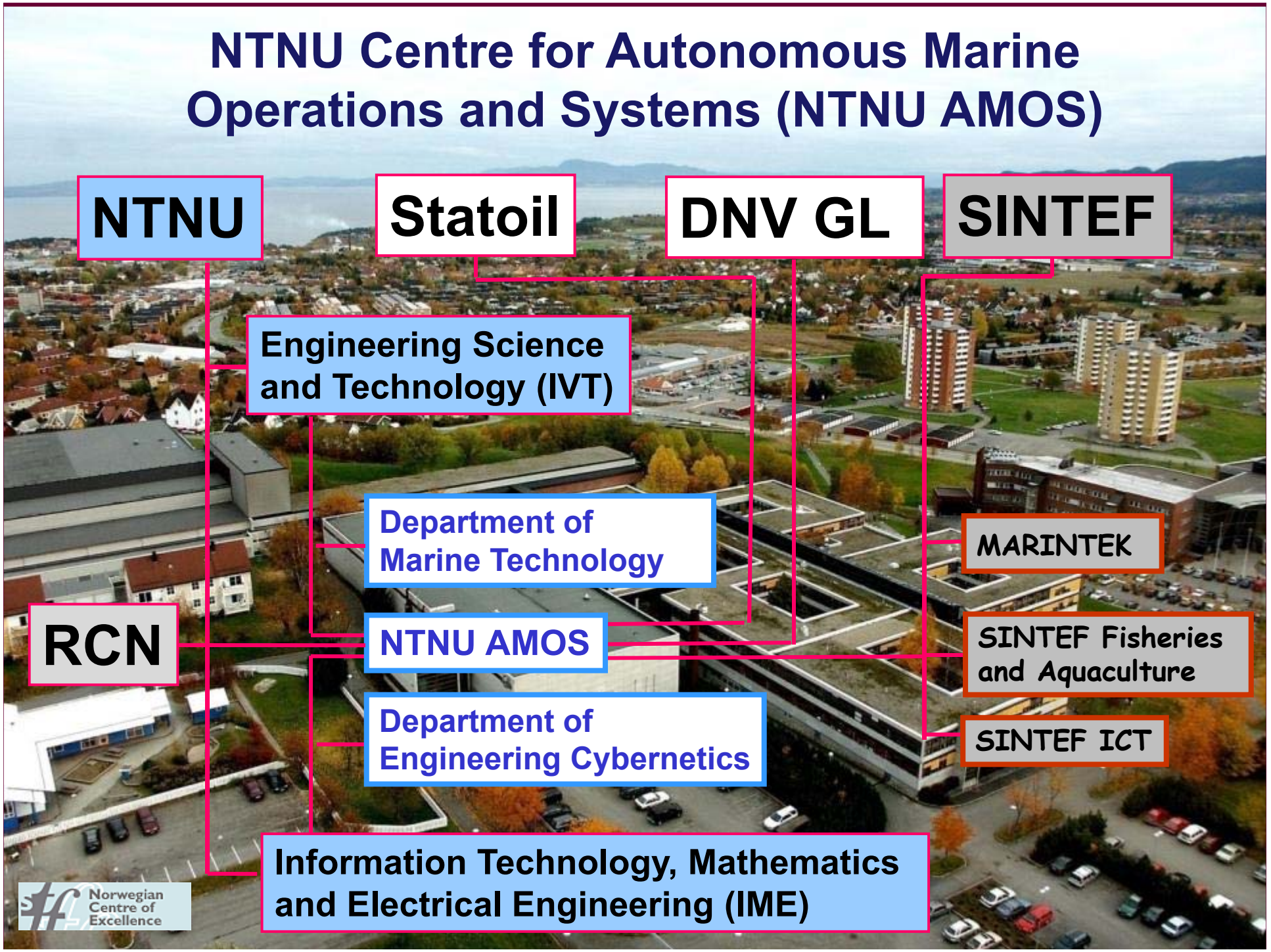
…. and in Arctic areas



Open water biological production

Norwegian Centre of Excellence

NTNU Centre for Autonomous Marine Operations and Systems (NTNU AMOS)



Theory – Simulation – Experiments – Operations

Bridging the gap from theory to practice

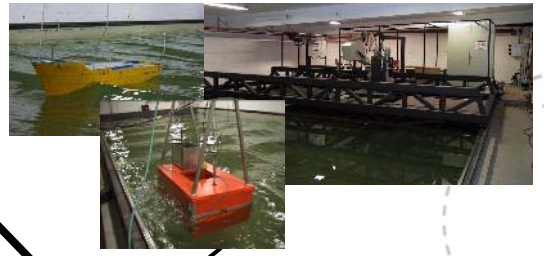
RV Gunnerus

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

NTNU AMOS
Centre for Autonomous Marine Operations and Systems

AMOS og ungdommen

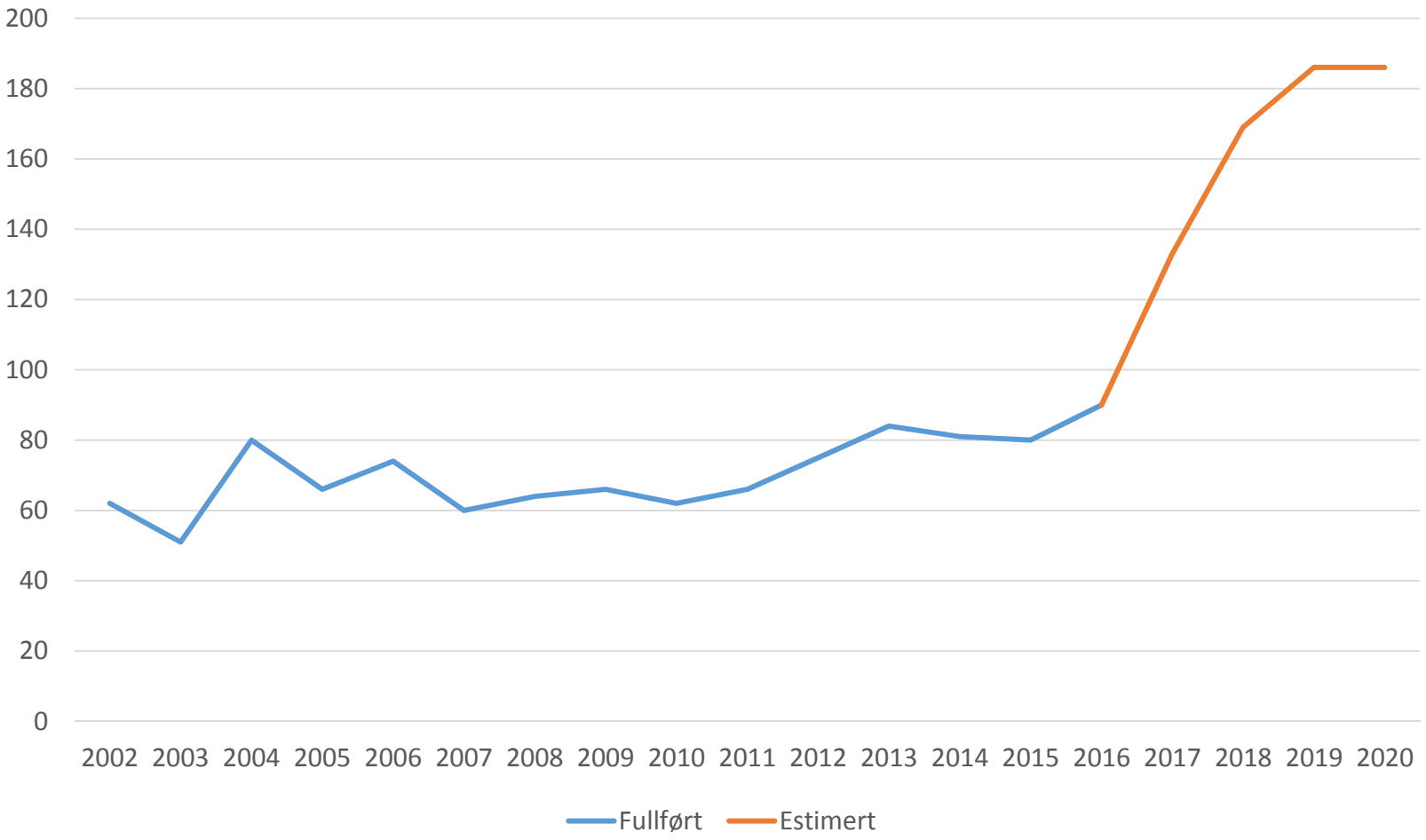
- NTNU AMOS:
  - «Senter for Fremragende Forskning» (SFF) ved NTNU med fokus på «Autonome Marine Operasjoner og Systemer» (AMOS) i perioden 2013-2022
  - 50/50-samarbeid mellom Institutt for teknisk kybernetikk og Institutt for marin teknikk
  - Basisbudsjett på 600 MNOK, mål om oppgiring med assosierte prosjekter til 1000 MNOK
  - Mål om å utdanne over 100 phd-kandidater, er godt i rute hittil med 82 aktive phd-kandidater
  - Har bidratt til rekordrask oppbygging av Norges største lab for dronefly
  - En motor i norsk forskning på droner for havrommet

- Det viser seg å være **ekstremt motiverende for norsk ungdom å søke seg til dronerelatert utdanning og forskning**:
  - AMOS-aktiviteten skaper stor entusiasme og interesse blant ungdom, studenter og folk flest
  - Senteret har klart å rekruttere en uvanlig høy andel på nesten 50% (!) norske phd-kandidater
  - Vi opplever rekordstor pågang til kybstudiene, der 50% av studentene søker seg til fordypning innen dronerelatert teknologi
  - To nye studentorganisasjoner etablert i 2015:

Dronefly (Ascend)

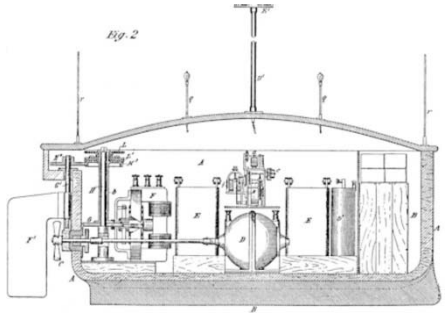
Undervannsdroner (Vortex)

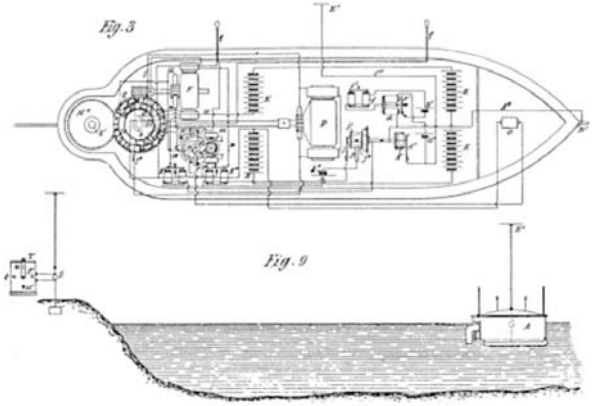
Antall masterstudenter som uteksamineres innen kybernetikk øker nå kraftig

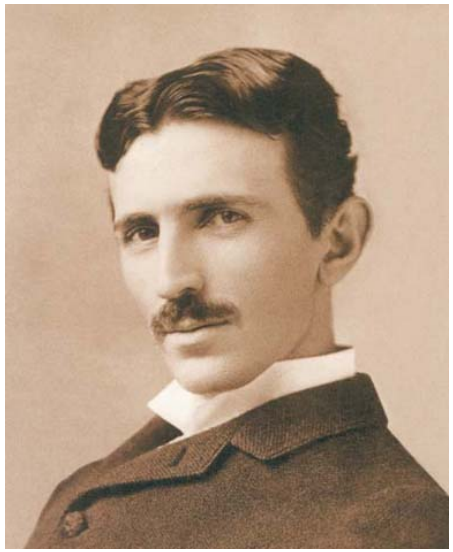


Tesla

- Already in 1898, the Serbian-American inventor and engineer Nikola Tesla obtained a patent for radio-based remote control of boats
- The same year he amazed a crowd of people who witnessed a demonstration of his system in New York's Madison Square Gardens
- In his autobiography from 1919, Tesla predicted the development of robotic vehicles "...capable of acting as if possessed of their own intelligence, and their advent will create a revolution"



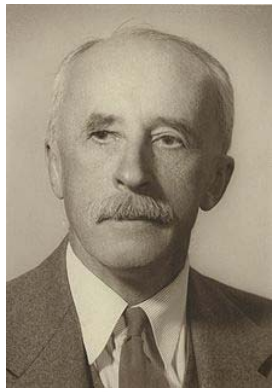




Tesla, N. (1919). ***My Inventions: The Autobiography of Nikola Tesla*****, Experimenter Publishing Company, Inc.**

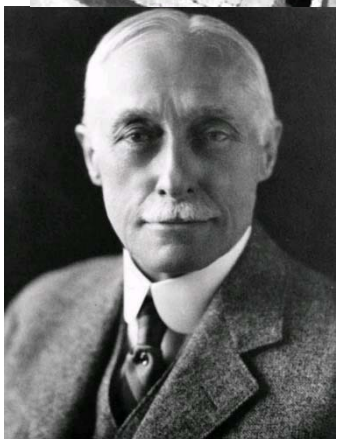
Birth of the autopilot

- Two important events occurred in 1922:
  1. The American entrepreneur Elmer Sperry commenced field trials with his gyropilot, a gyroscope-guided steering mechanism for ships
  2. The Russian-born electrical engineer Nicolas Minorsky theoretically analyzed the PID controller for ship autopilot purposes



- Sperry's «gyropilot» was soon named «Metal Mike» and characterized as a «...triumph of mind over matter»

- Together, Sperry and Minorsky laid the practical and theoretical foundations for the successful application of autopilots in the years to come
- Their contributions marked the starting point of a development which since has resulted in increasingly sophisticated maritime control systems...



Hughes, T. P. (1971). *Elmer Sperry: Inventor and Engineer*, The Johns Hopkins Press.

Minorsky, N. (1922). *Directional Stability of Automatically Steered Bodies*, Journal of the American Society for Naval Engineers, 34(2): 280-309.

Vision from Germany: Droneship convoy

- Formation of unmanned containerships following a manned leader ship (Schönknecht et al., 1973):

Schönknecht, R., J. Lüsch, M. Schelzel and H. Obenaus (1973). *Schiffe und Schiffahrt von Morgen*, VEB Verlag Technik Berlin.

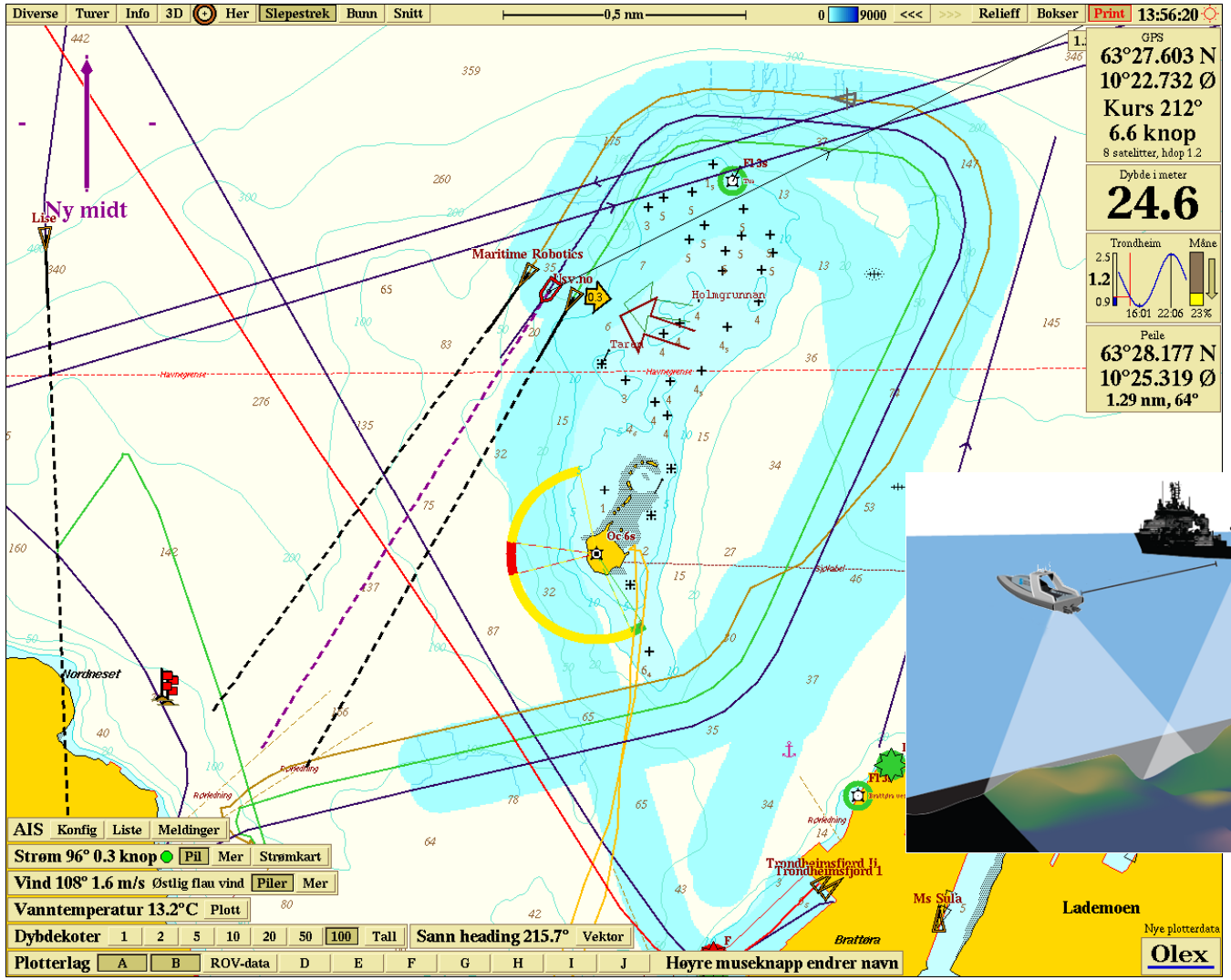
Trondheimsfjorden 2008-2009

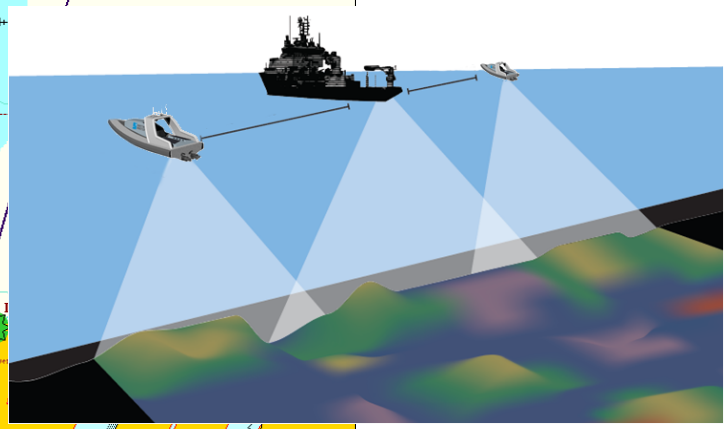
- Full-scale collision avoidance & formation control experiments:

- Collaboration between Maritime Robotics and NTNU

Trondheimsfjorden 2008-2009

- Full-scale collision avoidance & formation control experiments:

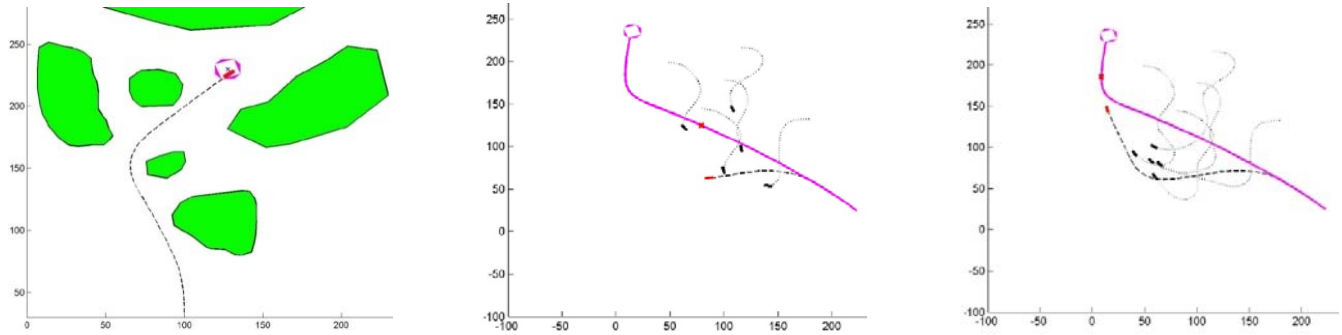




CESOS

Short-term challenges in autonomy

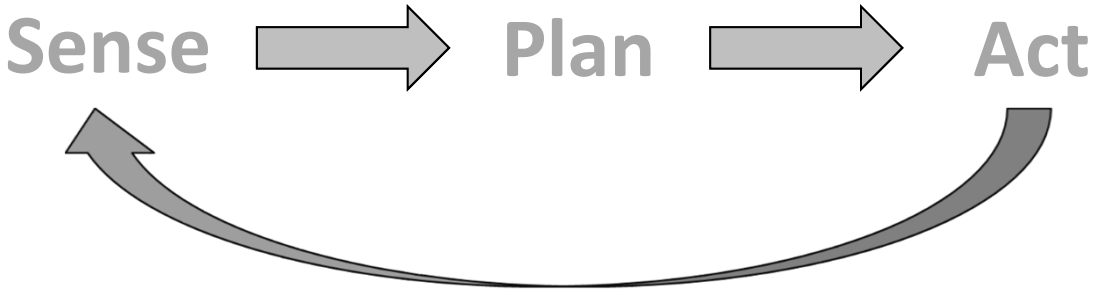
- A shift toward more autonomy will require a gradual introduction of increasingly advanced motion control functionality (“bottom-up” approach)
- In the short term, one of the most important functionalities is collision avoidance (COLAV), which requires both sense and avoid abilities:
  - **Sense**: Access to both global (ECDIS, etc.) and local (radar, AIS, lidar, vision, etc.) information about the surrounding environment
  - **Avoid**: Superior maneuverability through powerful actuators, as well as advanced motion control algorithms capable of performing both long-term (proactive) and short-term (reactive) planning to ensure avoidance

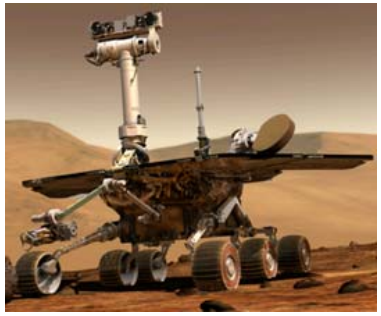


- A main challenge in making practical use of a COLAV system lies in the sensor solutions: Developing a composite sensor package (HW/SW) that can be trusted to detect both large and small objects in all types of visibility and weather conditions

What is autonomy?

- Autonomy is characterized by the ability to operate in unknown environments and to handle unexpected events in complex situations
- An autonomous robot will be able to operate independently and make its own decisions in a given situation, independent of human intervention
- In order to become autonomous, a robot needs an extra layer between its measurements and actions which enables it to plan its actions, hence making deliberate choices
- An autonomous robot will function by the principle "sense => plan => act"

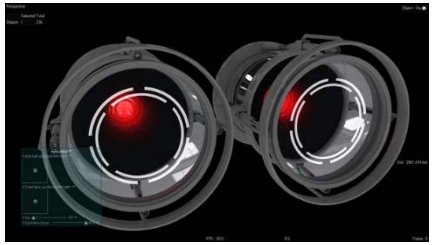




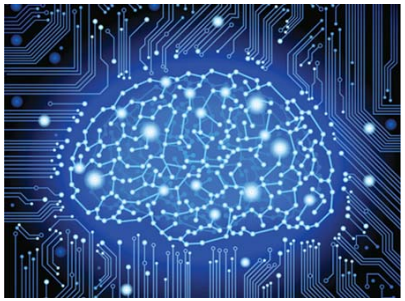
Satsingsområder ved ITK

- Den kybernetiske verktøykassa er velfylt, men trenger nå rask videreutvikling
- Derfor satser vi nå på:

Robotsyn:

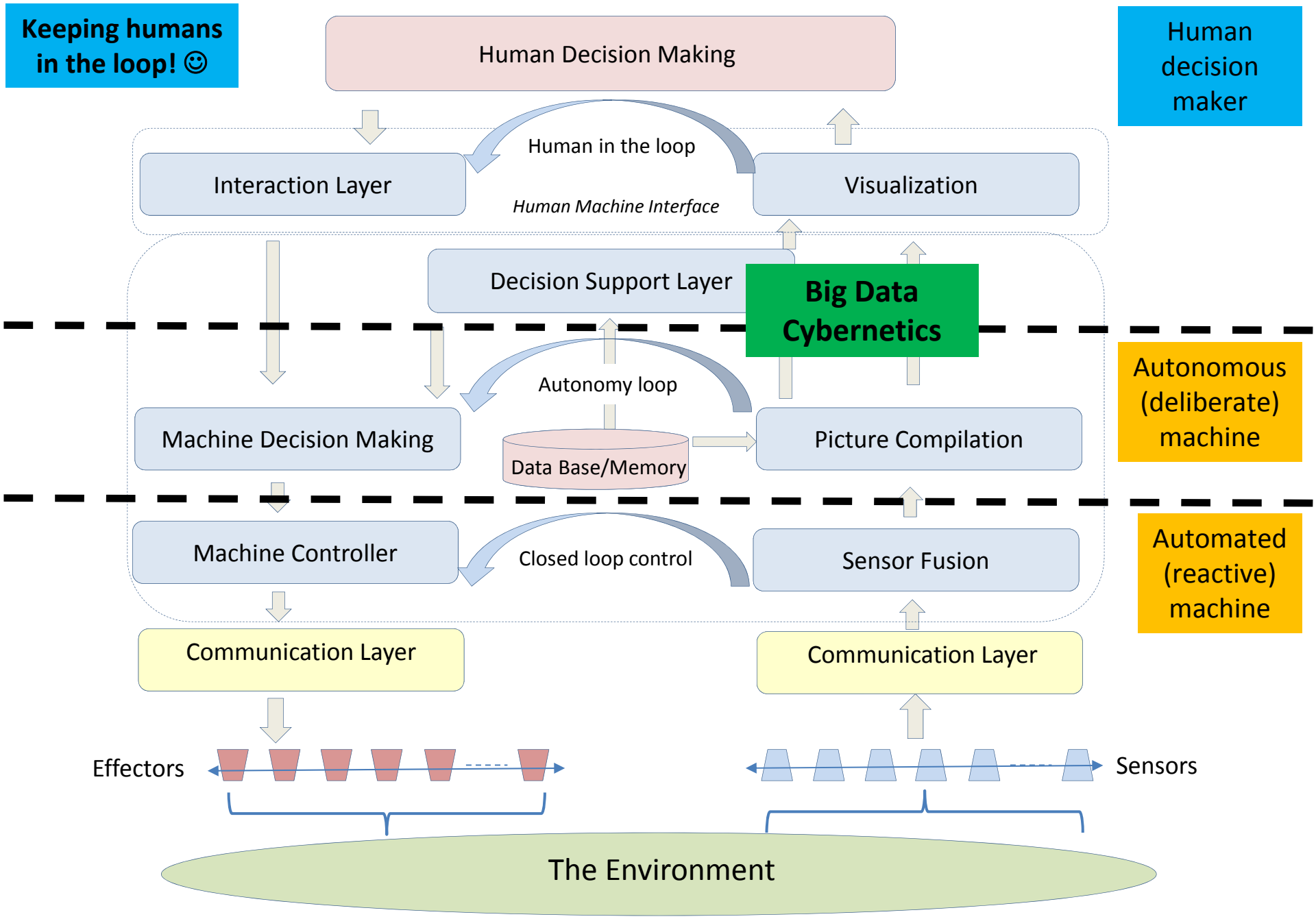


Autonomi:



Big data:

KONGSBERG



Autosea (2015-2018)

The Autosea project

- Funded by the MAROFF program of the Research Council of Norway.
- Budget 11 MNOK, with contributions from DNV GL, Kongsberg Maritime and Maritime Robotics.
- Duration: August 2015-August 2018.
- Competence building project: The aim is to educate PhDs with expertise on maritime collision avoidance.
- The project funds 2 PhD candidates and one postdoctoral fellow. In addition, 2 PhD candidates and several MSc candidates are affiliated with the project.
- The project is led by the Department of Engineering Cybernetics at NTNU.

AMOS

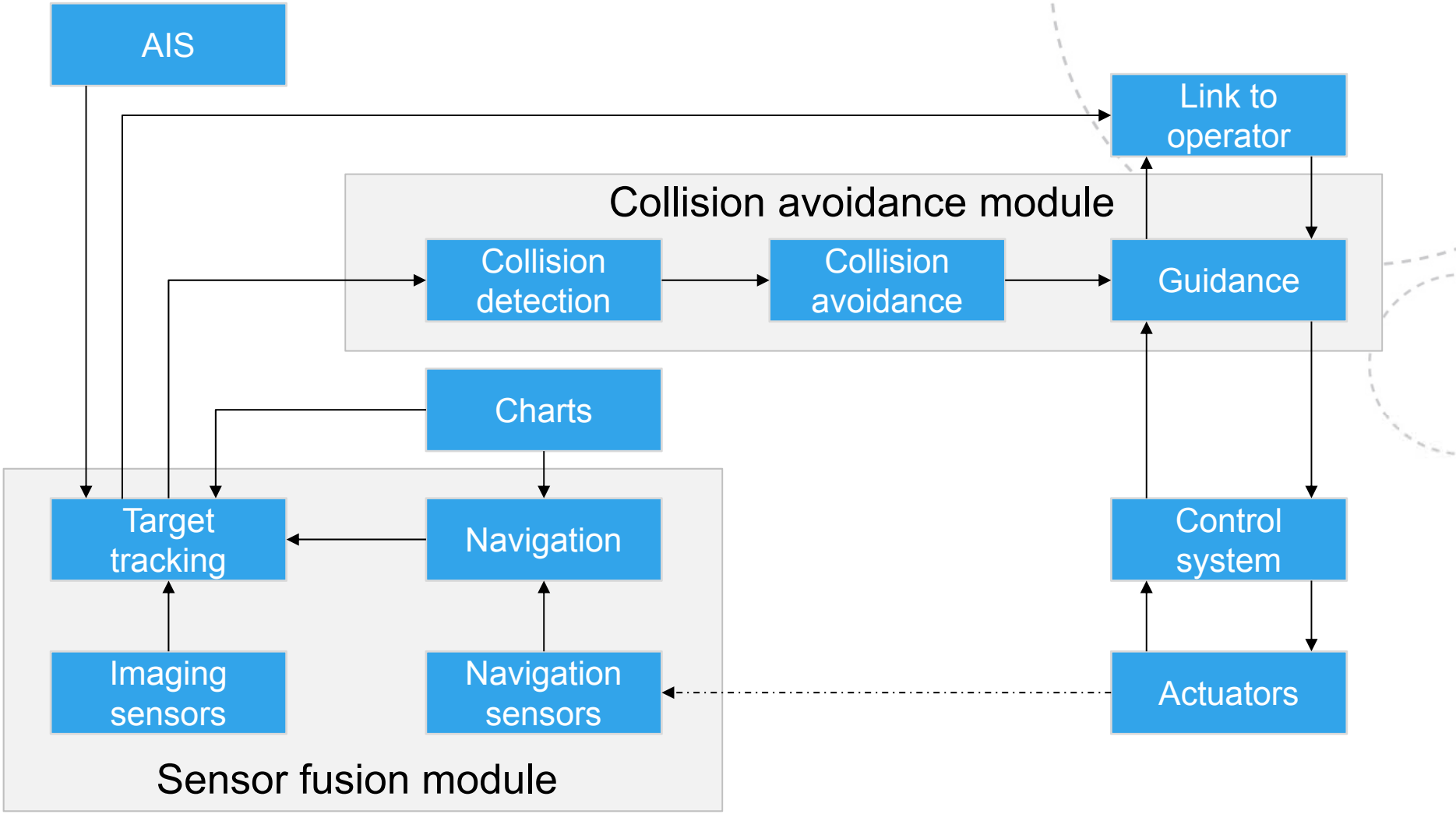
DNV·GL

KONGSBERG

MARITIME ROBOTICS

NTNU – Trondheim
Norwegian University of Science and Technology

Focus areas of the Autosea project



NTNU – Trondheim
Norwegian University of Science and Technology

Trondheim, 30. september 2016:

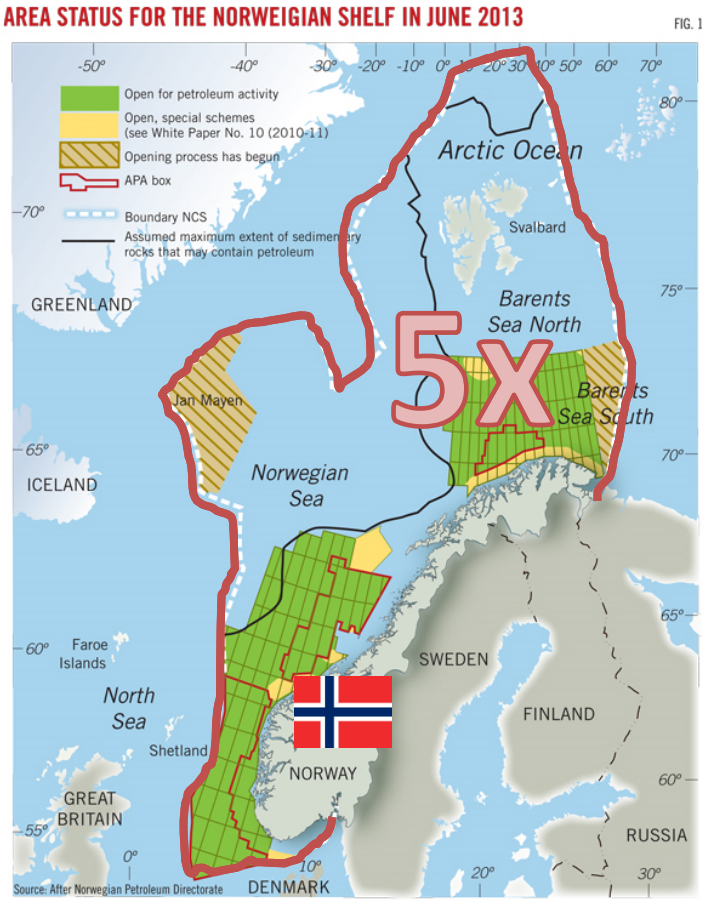
Gammel og ny tid: Maritime Robotics førerløse båt i aksjon på Trondheimsgfjorden. I fremtiden kan det bli mange skip uten fører på fjorden. Foto: ALEKSANDER MYKLEBUST

Sjøfartsmyndighetene har gitt grønt lys for at Trondheimsfjorden får status som testområde for ubemannede fartøyer.

Trondheimsfjorden testfelt for førerløse skip

Norge

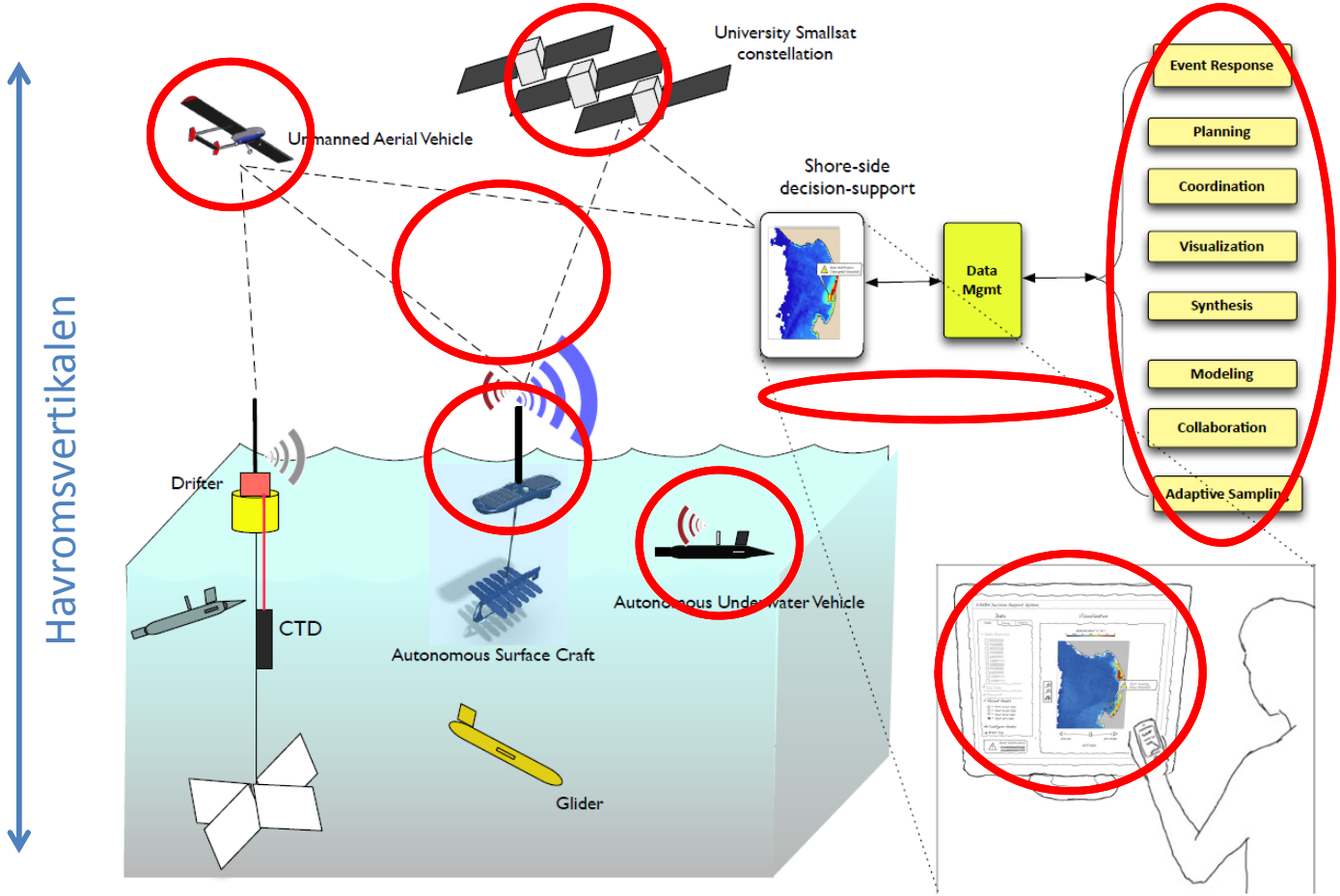
- Vårt største fysiske fortrinn og ressurs er havrommet:



- Mat
- Energi
- Mineraler
- Marine ressurser
- Transport

Norsk droneindustri

- **Norge** bør satse på **oppbygging av en droneindustri** med utgangspunkt i **havrommet**:



- Småsatellitter
- Dronefly
- Dronebåter/skip
- Undervannsdroner
- Teknologi som kobler farkostene sammen i nettverk
- Programvare som tolker de enorme mengdene data som samles inn, og gir råd og beslutnings-støtte til rette instans
- Programvare for informasjons-sikkerhet

Norsk droneindustri

Naturgitte fortrinn:	Teknologitrender:
Havrom	Digitalisering Automatisering Robotisering

Unik mulighet: **Havromsdroner**

Minimumsbehov (som også kan dekkes f.eks ved kjøp av droner fra utlandet):

- Forvalte og utnytte ressurser
- Suverenitetshevdelse

Merverdi ved satsing på utvikling og eierskap i Norge:

- Spinoff til andre anvendelser
- Løsninger skreddersydd for Norges behov
- «Dual use»
- Norsk leverandørindustri
- Bestemme retning på utviklingen ved å pushe grenser og definere standarder
- Teknologi for nettverk, infosikkerhet, tolkning av data og beslutningsstøtte

What can “small Norway” do?

- “...even a small country, when concentrating important resources in a limited field and having a high level of education, may contribute to the application of new technology worldwide. A condition for success, however, is that the fields chosen for main efforts are fields of national importance and of international recognition. Another condition is that a cooperation can be established between research institutes, users, and producers.”

Ibb Høivold (right) led the Norwegian company Norcontrol which developed a groundbreaking mix of ship automation technology since the 1960s, resulting in unmanned engine rooms and radar-based anti-collision systems (ARPA).

Høivold, I. (1984). *Norwegian Research and Development in the Field of Ship Automation*, Modeling, Identfication and Control, 5(3): 171-178.

1922: First autopilot

2022: First autoship?