Faculty of Information Technology and Electrical Engineering (IE)

We support a smart, safe and sustainable future

https://www.youtube.com/watch?v=WWHqR5i1FHE

NTNU

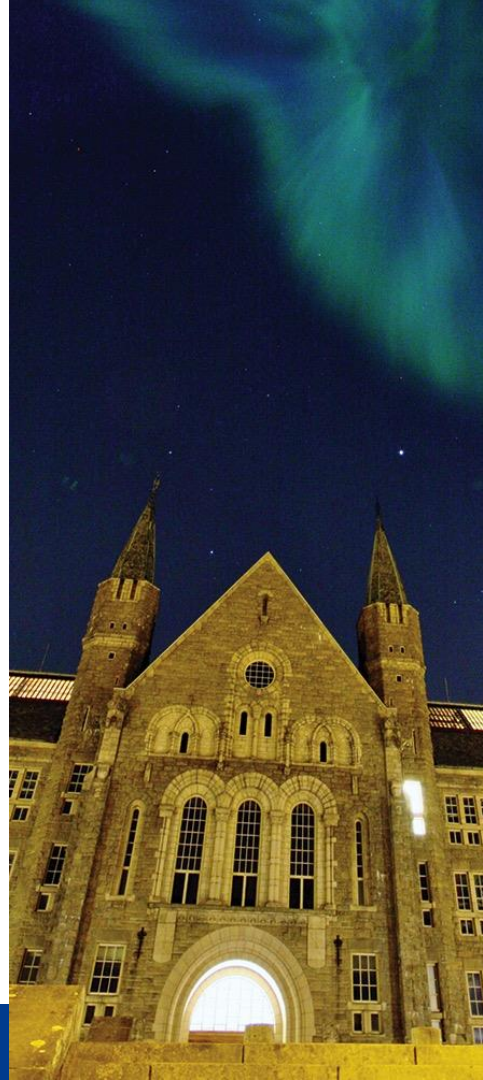
Technical and natural science profile

«Knowledge for a better world»

Main campus in Trondheim and campuses in Gjøvik and Ålesund

NTNU key figures

- 8 faculties, 55 departments and NTNU Museum of science
- 9000 employees
- 42 000 registrered students (3000 in Ålesund)
- 7889 examined bachelor- and masters degrees (2020)
- 406 PhDs (2020)
- Budget approx 1 Billion EURO, 1/3 from external sources



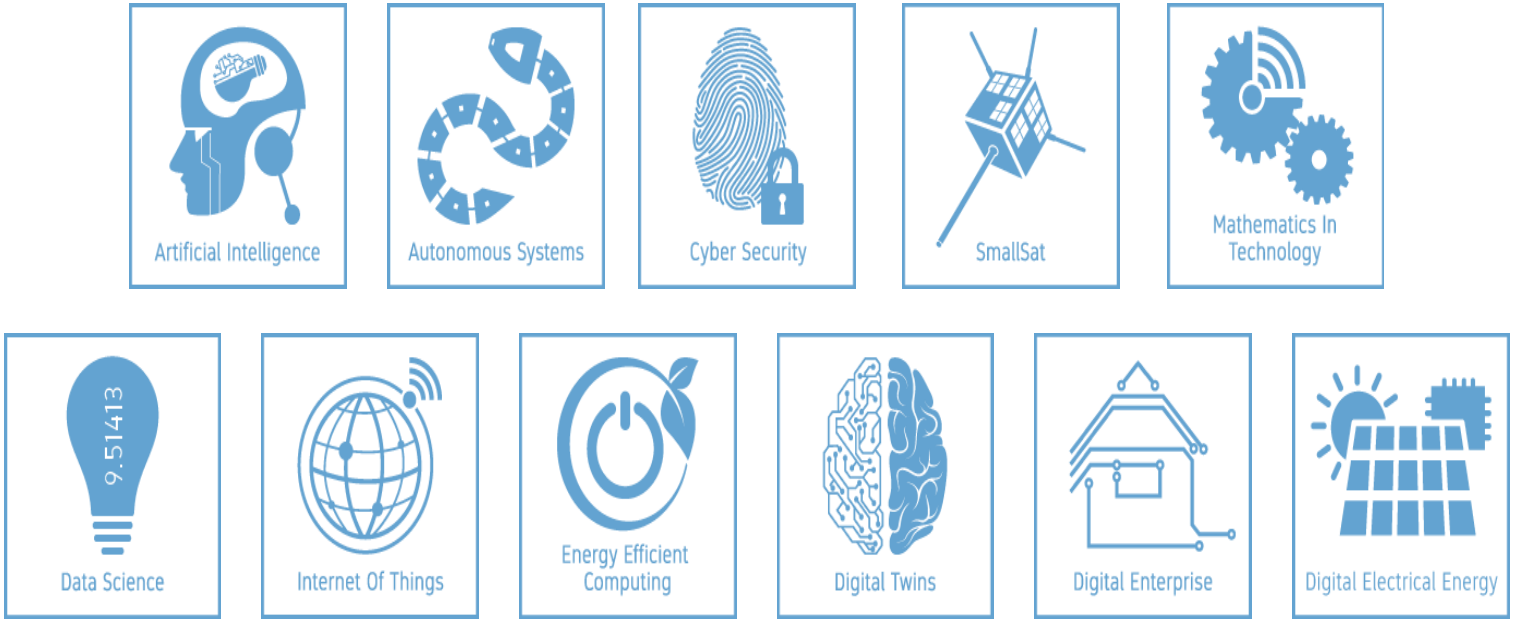
IE Key figures

1000 employees

8000 students

38 studies

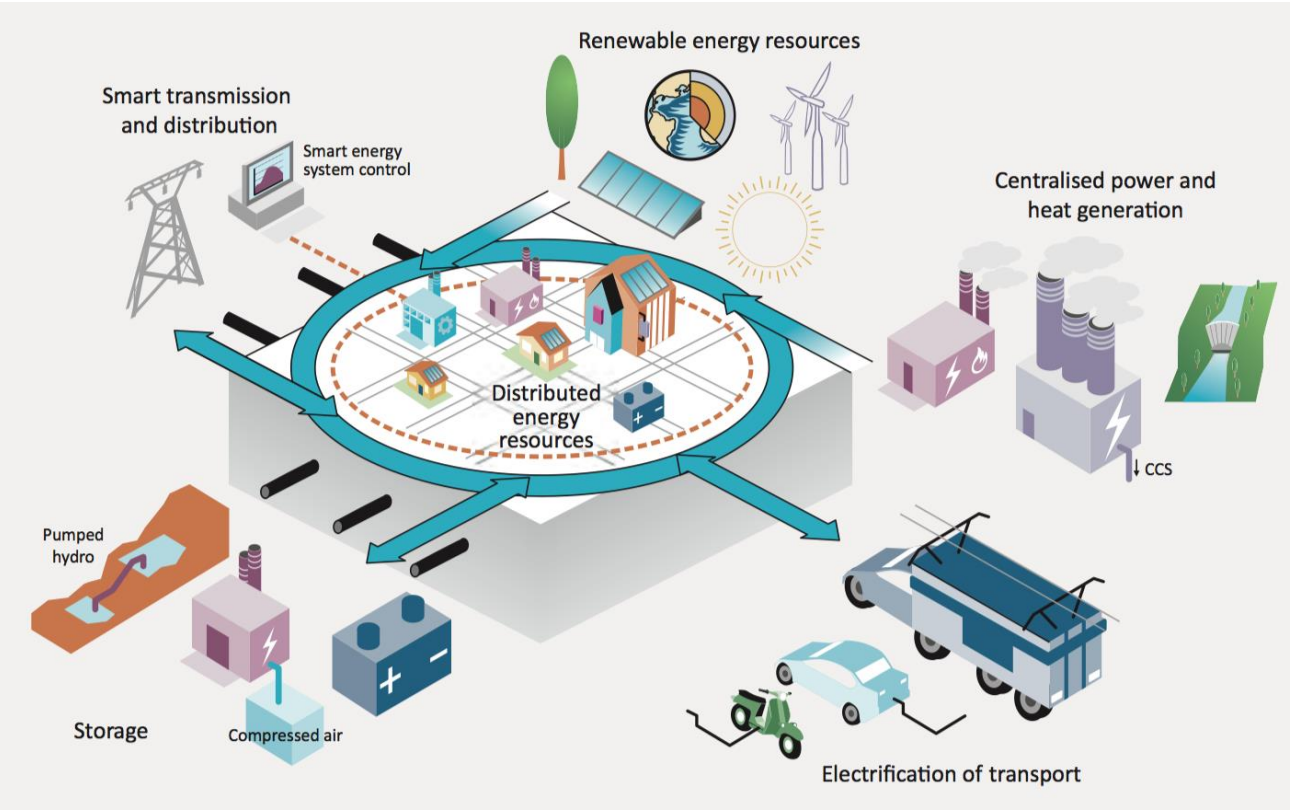
1.2 Billion revenue



11 strategy areas

IoT and sensors

The digital energy landscape



NTNU


Cyber security
NTNU CCIS
SFI Norcics

IE Organisation




Faculty of Information Technology and Electrical Engineering

Faculty administration

Department of Computer Science

Department of Electronic Systems

Department of Electric Power Engineering

Department of ICT and Natural Sciences

Department of Information Security and Communication Technology

Department of Mathematical Sciences

Department of Engineering Cybernetics

IDI

IES

IEL

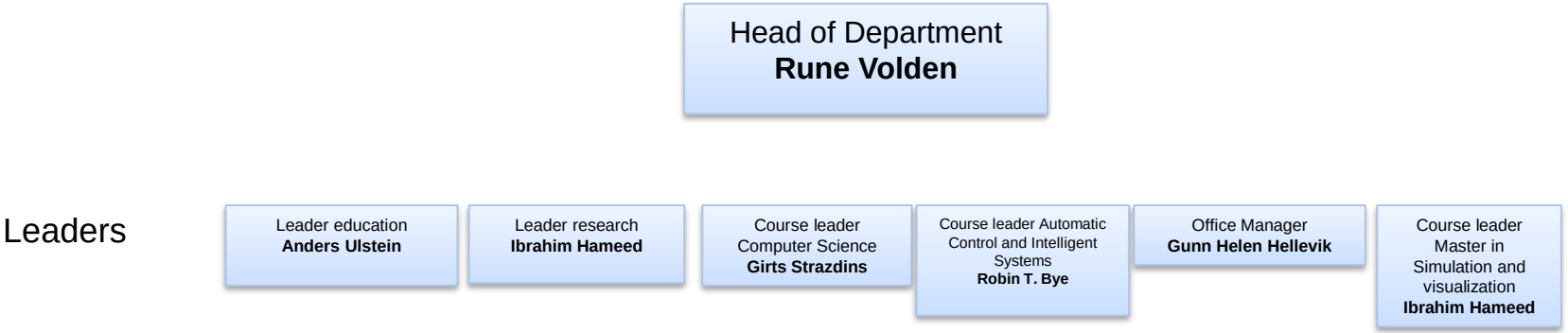
IIR

IIK

IMF

ITK

Department of ICT and Natural science (60 employees)



Department has following studies

- 1-year qualification course (63)
- 3-year Bachelor in Automatic Control and intelligent Systems (153)
- 3-year Bachelor in Computer Science (153)
- 2-year Master in Simulation and visualization (40)
- PhD program (14)

Where do they go?

- Lab intensive work
- Do the mistakes at university
- 95% Bachelor/Masters theses are industrial/public services
  - Ship systems (Kongsberg, Ulstein, Brunvoll +++)
  - Shipyards (Vard (Fincantieri), Ulstein)
  - Fish handling & processing (Optimar, MMC, Cflow, FiiZK ☺)
  - Furniture (Ekornes, Stokke)

Research topics

- Autonomous ships
- Robotics
- Cybernetics
- Medical technologies and health informatics
- Artificial Intelligence

Resarch groups

The Cyber-Physical Systems Lab

Focuses on autonomous ships and the practical needs of Ålesund's world-leading maritime industrial cluster, as well as biomechanical robotics and medical technology.

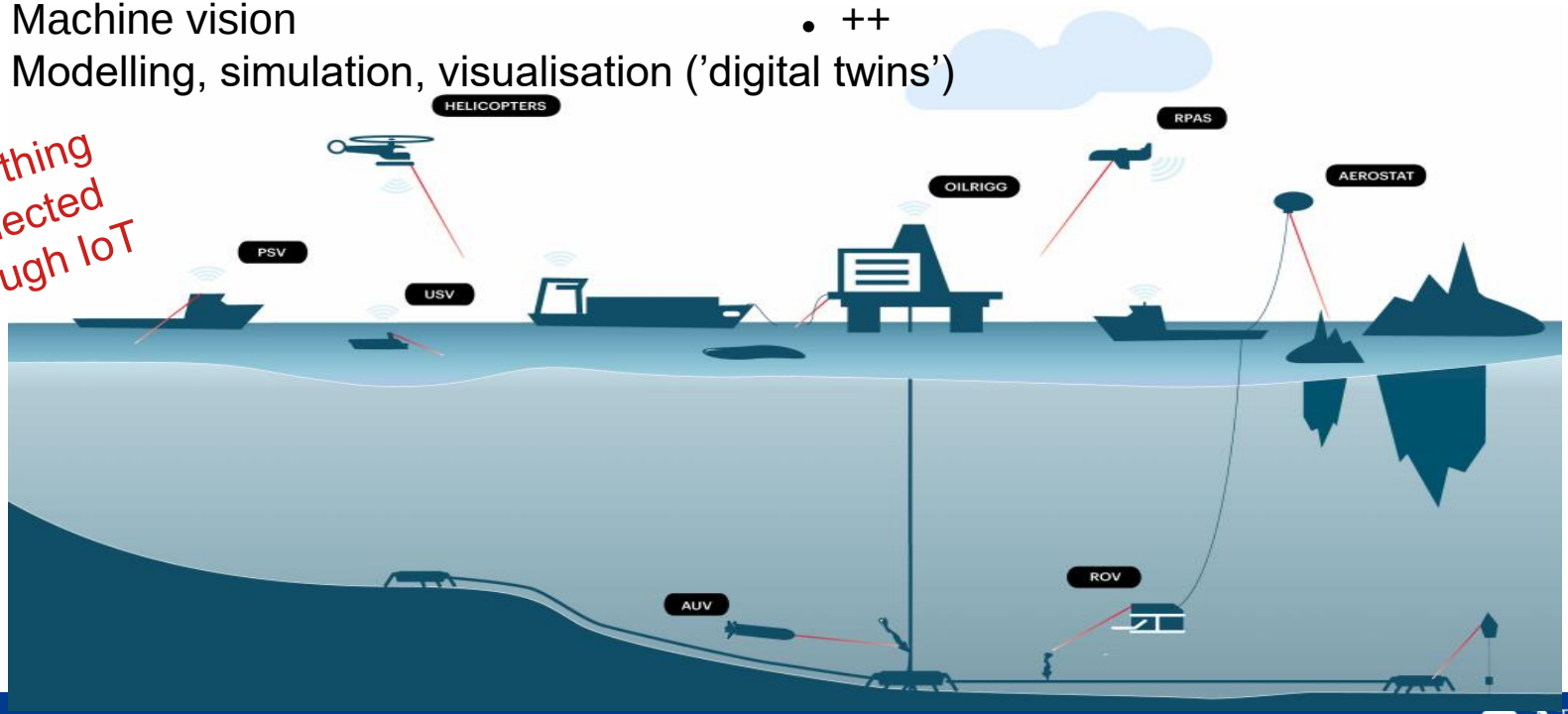
The Sustainable Digital Transformation Group

Focuses on service innovation, entrepreneurship and technology in various enterprises both within the private and public sector. We also do research on simulation and visualization for applied use and the use of social robots in education, caretaking and other settings.

What are cyber-physical systems?

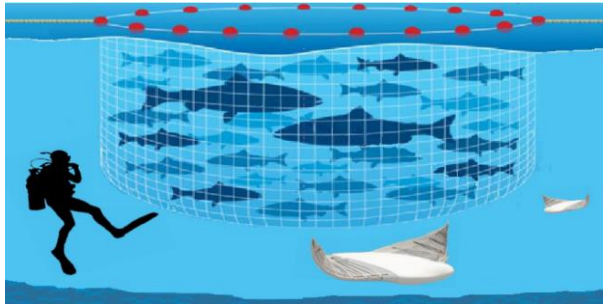
- Cybernetics and control
- AI and machine learning
- Sensor fusion and data analysis
- Machine vision
- Modelling, simulation, visualisation (’digital twins’)
- Communication and security
- Safety and assurance
- Operations planning and training
- ++

Everything connected through IoT

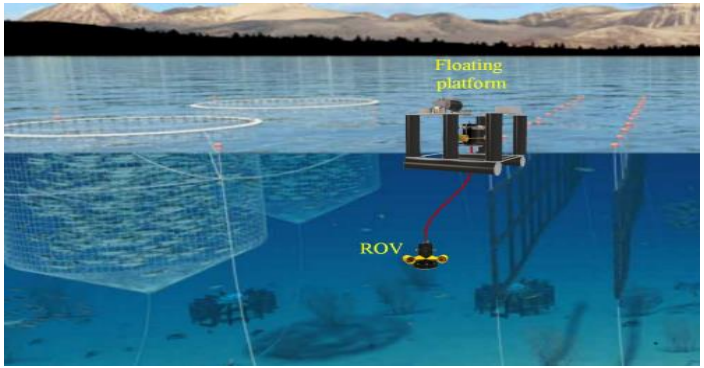


Examples

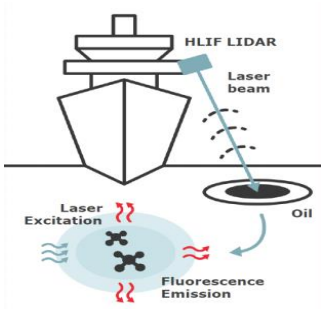
Robotic fish for aquaculture applications



Aqua farm inspection

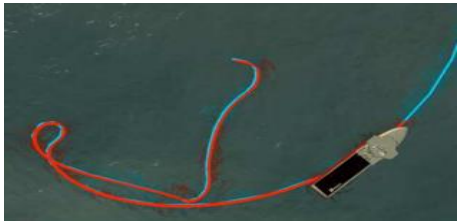


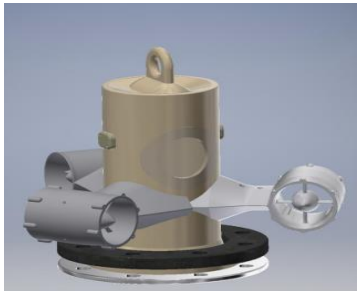
Oil spill detection

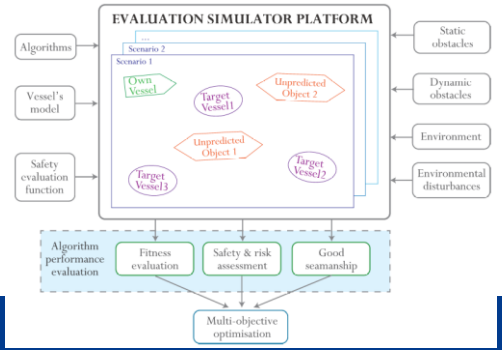


Autonomous seabed mapping

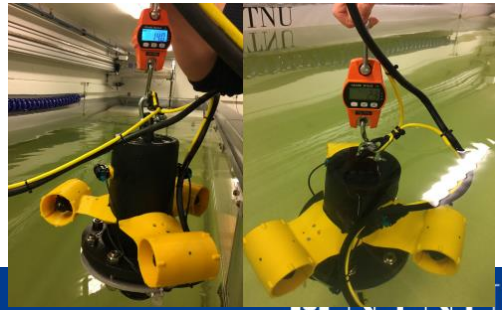
Ship motion prediction







ROV CAD design and prototype



SFI Autoship *in short*

SFI: Research-based innovation center – 8 years

Objective:
Develop and manage technologies, systems, and operations for safe, sustainable, secure and cost-effective autonomous sea transport and operations.

Partners, funding, and scope

- Partner list →
- Host: Department of Engineering Cybernetics, NTNU
- Budget of approx. 240 mill NOK over 8 years (with 33 million cash from Industry and 96 million in cash from research council.
- In-kind contribution secures an active involvement of partners
- Education: 20 PhD, 5 Postdoc, 150 master students + PhD/PDs in associated projects.

Timeline:

- Start-up of Centre: Within December 1st 2020 (requirement from research council
- Consortium agreement will be agreed signed within October 2020
- First Centre Board meeting within mid. Nov 2020

Research partners:

NTNU · SINTEF · UiO · IFE

Industry partners:

KONGSBERG (Kongsberg Maritime) · equinor · TORGHATTEN · MARITIME ROBOTICS · DNV·GL · gard · ncl · GRIEG STAR · G2 OCEAN · MACGREGOR · massterly · Telia · EMBRON · idletechs

Public and governmental partners:

Trondheim Havn · TRONDHEIM KOMMUNE · KYSTVERKET · Sjøfartsdirektoratet Norwegian Maritime Authority

Autonomous ships

PhD projects

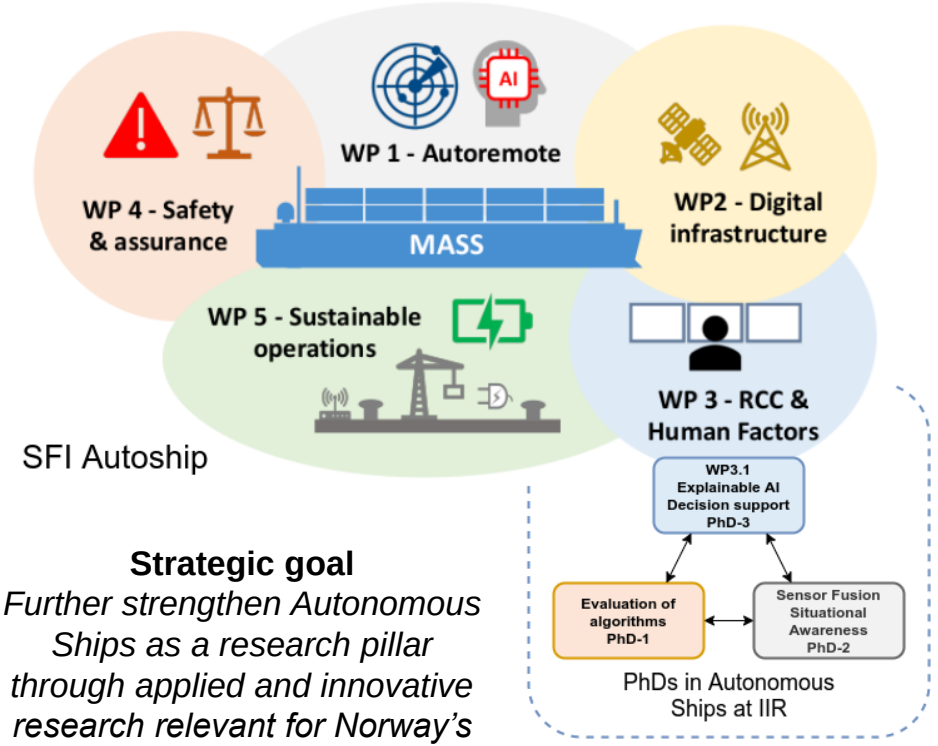
- PhD-1 (Vagale): *Evaluation of safety and risk handling in algorithms for autonomous path planning and collision avoidance in congested waters*
- PhD-3 (Fagerhaug): SFI WP3.1 *Explainable AI (XAI) for reliable decision-support systems in remote control centres for autonomous ships*
- PhD-2 (N.N.): Topic TBD (*sensor fusion and situational awareness* was the original topic)

Affiliation, cooperation, participation

- Participation in ***SFI Autoship*** (WP3)
- Affiliated with ***SFI NTNU AMOS*** (Bye & Vagale)
- Affiliated with **Autoferry** (Digital Transformation)
- Cooperation with ***Utne group*** (IMT)

Some relevant external partners

- Academia: Riga Technical University, UiT, USN, HVL
- Others: Norwegian Coastal Administration, Kongsberg Maritime, DNV-GL, Maritime Robotics, Seaonics, ICD



Strategic goal

Further strengthen Autonomous Ships as a research pillar through applied and innovative research relevant for Norway's maritime cluster, using the SFI as a driving force.

Computer Haptic Assisted Orthopaedic Surgery (CHAOS)

PhD projects

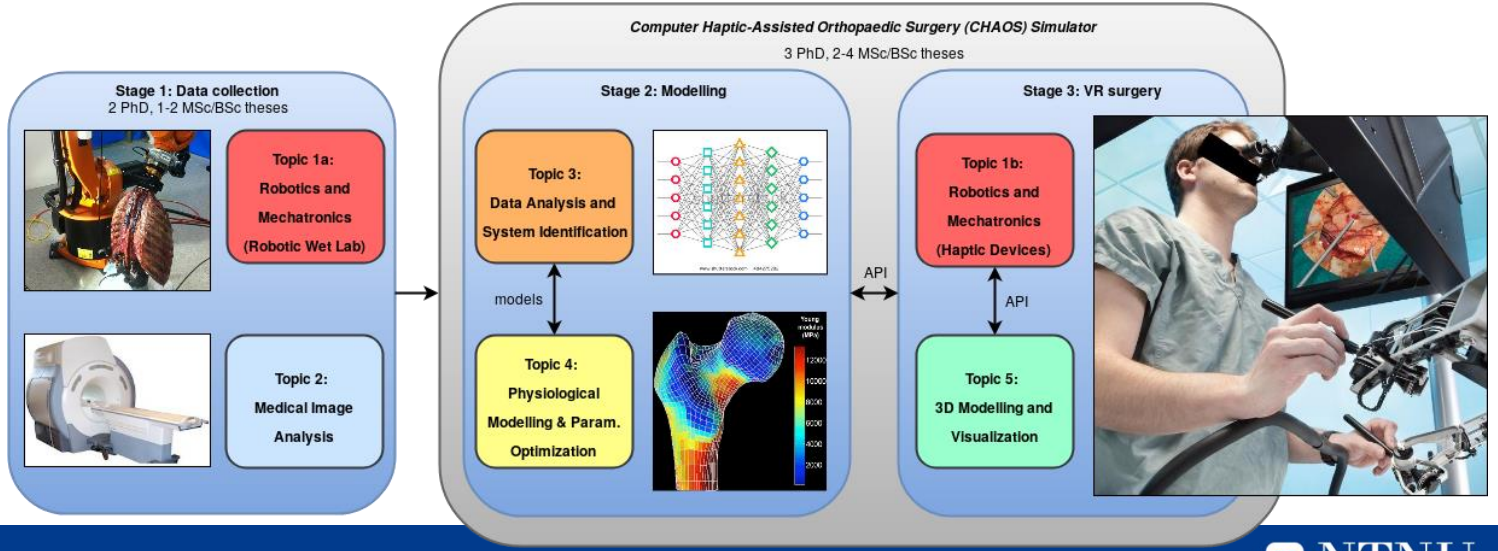
- PhD-1 (Skrede): Force feedback robot control for biomechanical examination of human joints
- PhD-2 (Bjelland): Rapid prototyping of biomechatronic devices for CHAOS simulation
- PhD-3 (Rasheed): Mathematical modelling and simulation of human joints

Collaborators

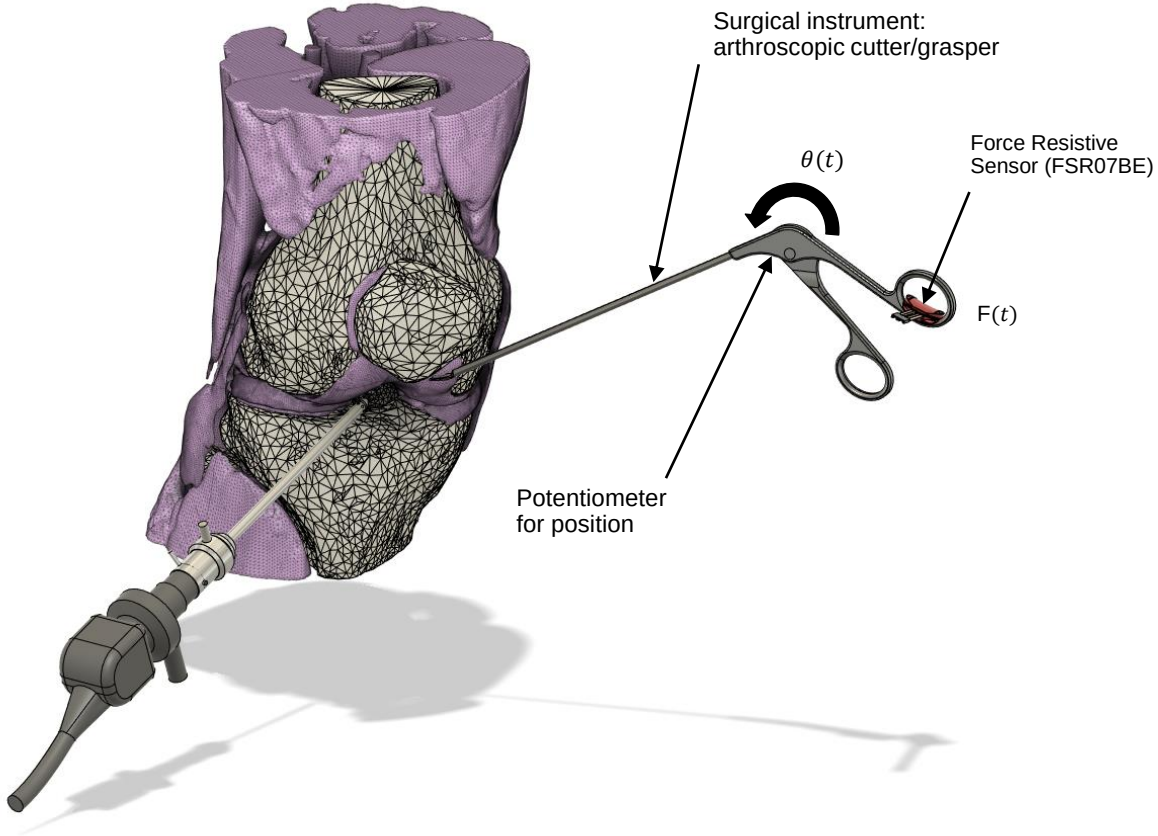
- ITK and MTP, NTNU
- Ålesund Biomechanics Lab (ÅBL), Helse M&R
- Sunnmøre MR-klinikk
- Hannover Medical School, Germany
- Steadman Clinic, Vail, Colorado, USA

Strategic goals

Develop working prototype of CHAOS simulator.
Establish ÅBL as a self-sufficient Norwegian Competence Centre for orthopaedic surgery training and research.
Apply for SFI.



Experimental setup for characterization of **finger forces** during arthroscopic surgery

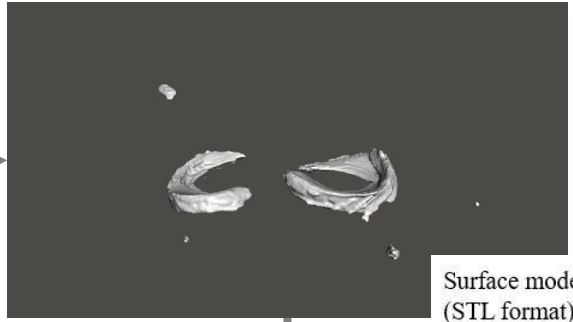


NTNU

Simulation of Tool-Tissue Interaction

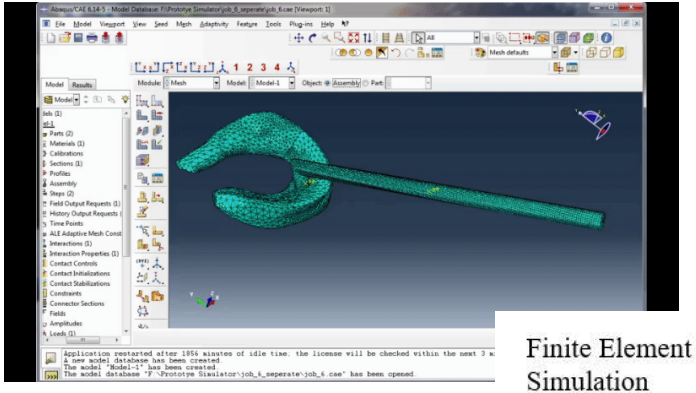
Towards the realization of CHAOS(Computer Haptic-Assisted Orthopaedic Surgery) Simulator

MR imaging
(DICOM format)



Surface models
(STL format)

AUTODESK MESHMIXER

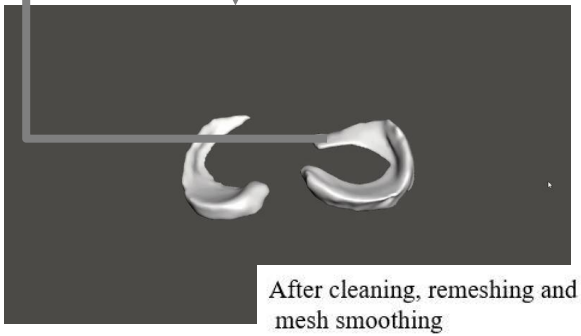


Finite Element Simulation

Medial Meniscus

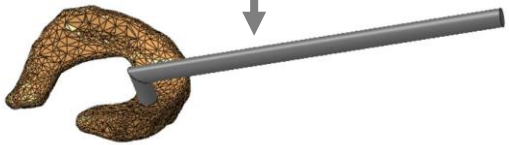
FUSION 360

Volumetric model
(SAT format)



After cleaning, remeshing and mesh smoothing

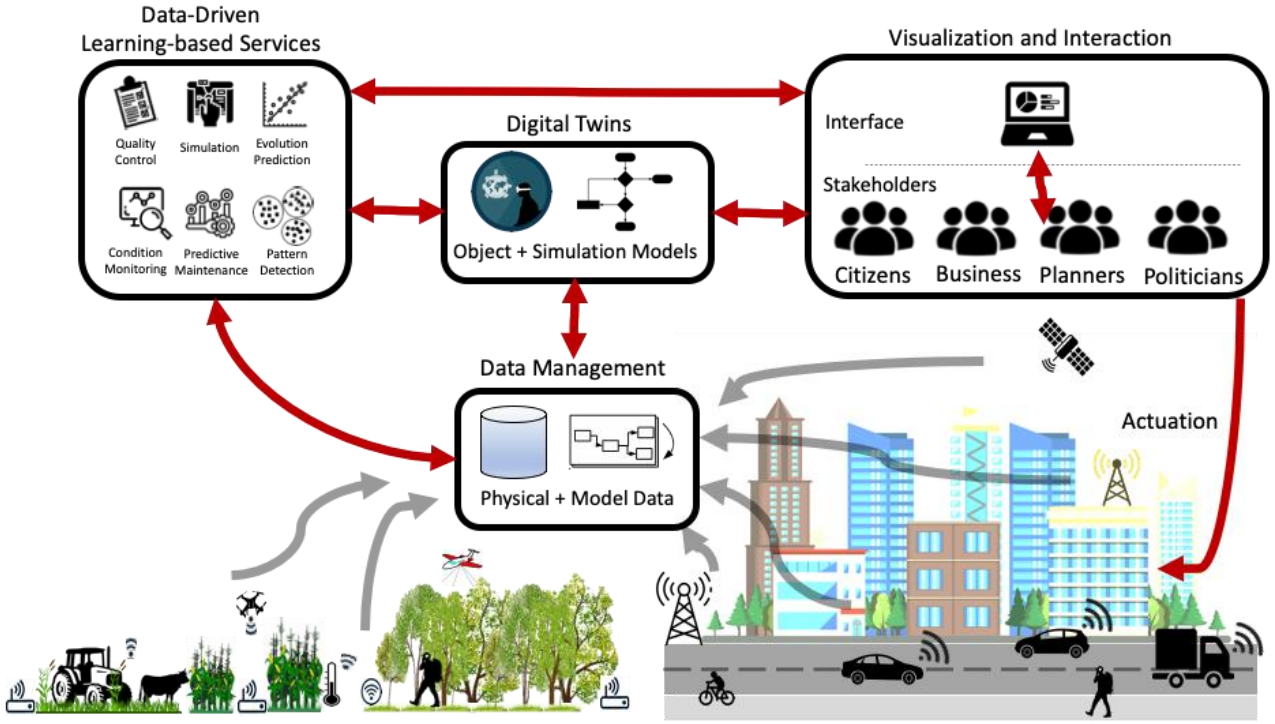
SIMULIA ABAQUS



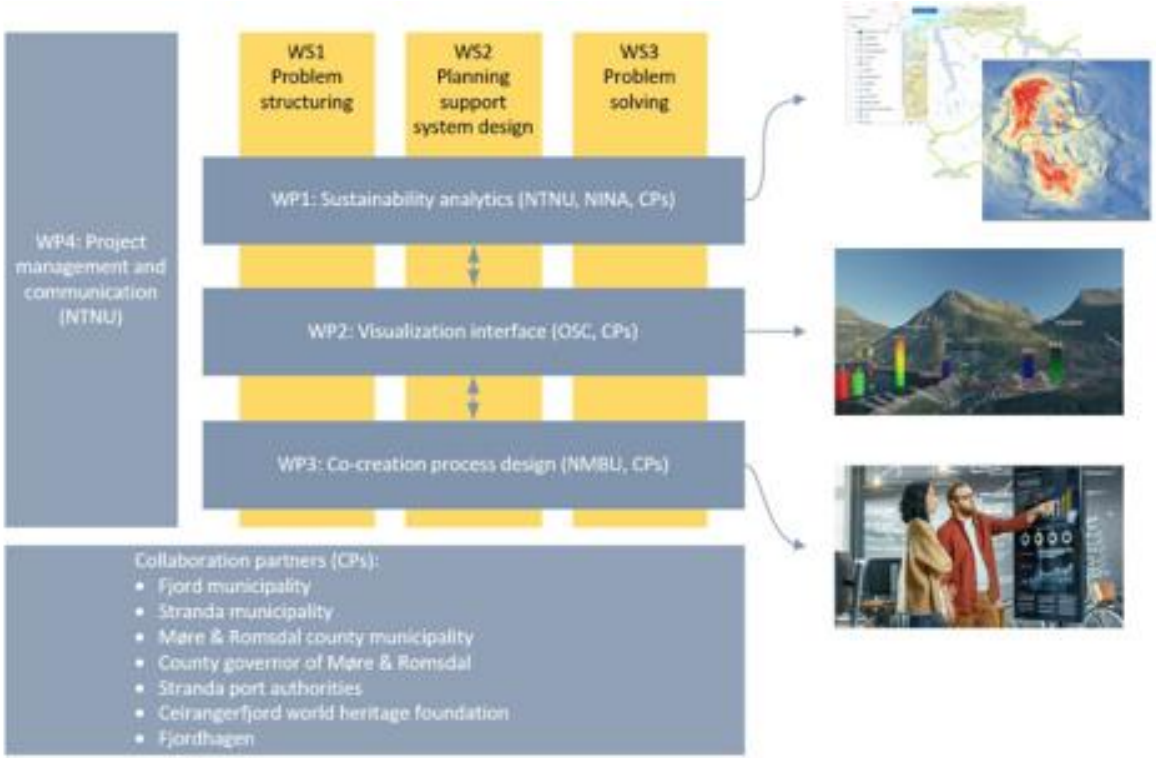
Sustainable Digital Transformation

Head: **Ricardo Torres**
Smart Society coordinator: **Anniken Karlsen**
Artificial Intelligence coordinator: **Ibrahim Hameed**

Sustainable Digital Transformation

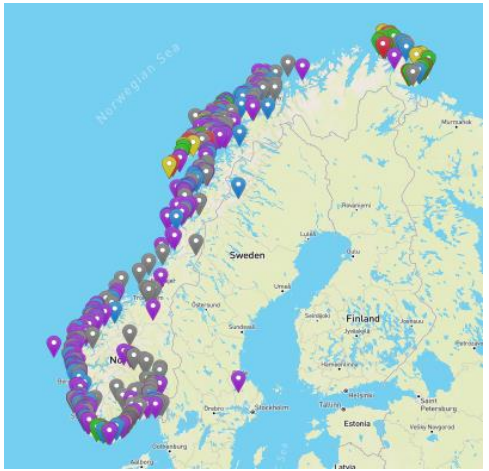


TwinFjord Project



PlastOPol Project

- Prediction Model for Ocean Plastic



NTNU

NORDARK Project

- Unconventional methods to inform sustainable design: Mediating the needs of people and nature in Nordic after-dark environments

Proposed Uppsala, Sweden site: Area with existing plans to expand residential and mixed-use development into existing forest, adjacent to a nature preserve. See short film about the project (in Swedish) https://bygg.uppsala.se/planerade-omraden/sydostra-stadsdelarna/film-som-beskriver-forslaget/

Proposed Ålesund, Norway site: Area of transition between residential development and urban park land that has rich bird and animal life with existing concerns about commuter and recreational walkways being too dark (and scary) for human after-dark navigation.

NTNU Interface

By Peder Blomvik, Muhammad Saad Jahangir, Amirabbas Hojjati, Zhicheng Hu, Ravitej Bhagavathi, Amirashkan Haghshenas, Léo Leplat, Mahdis Saharkhizan, and Andreas Flem Norman.

DDS usage

- Digital Twin windfarm project: Equinor
- Autonomous shipping
- Maritime ship systems (already in use)
- Medical systems (CHAOS)
- City infrastructure – situation awareness

Reflections on system architectures

- OPC UA de facto standard in the PLC world
  - Bachmann has DDS
- Most control architectures are based on SCADA / PLC
- Number of PLC programmers > Number of C++ programmers
- Modbus TCP → OPC UA, reduces interface job
- Complicated realtime performance where many control systems interact → DDS
- Simulation environment is based on FMI/FMU

Where to connect DDS ?

- Automatic Control and Intelligent Systems
  - ROS2
  - Industrial control systems course
- Bachelor / Master theses in relation to industry
  - Equinor, Kongsberg, BlueControl, Brunvoll?

University advantage

- Open source code and flexible non-proprietary partner
- **Educate** industrial engineer candidates with practical experience
- Can provide knowledge into **research** projects

- Thank you for listening !

- Rune Volden (rune.volden@ntnu.no)