Next generation of autonomous systems

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GCE Ocean Technology, Bergen, Norway

Norwegian Centre of Excellence

NTNU AMOS: 2013-2022

Key figures per January 2019:
7 Key scientists/professors
2 Scientific advisors/professors
41 Adjunct and affiliated professors
29 Post Docs/researchers
121 PhD candidates (accumulated)
77 Graduated PhDs (50+ in progress)
450+ Graduated MSc
5 Spin off companies
485 Journal papers
651 Conference papers

Partners:

The Research Council of Norway · NTNU · equinor · DNV·GL · SINTEF

Budget (10 years): 1000+ MNOK (~110+ MEUR)

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AMOS Targets
New industrial era by Autonomous Unmanned Vehicle Systems

How to develop autonomous sensors and sensors platforms – small satellites, unmanned aerial vehicles, unmanned ships and underwater vehicles, buoys - in air, sea surface and underwater for ocean mapping and monitoring?

How to reduce use of surface vessels with 80% in several offshore oil and gas operations?

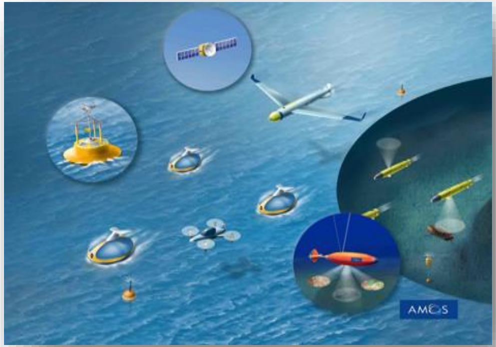
How to ramp up mapping and monitoring coverage 10 times with a cost of 1/10?

How to enable public management agencies and industry to pilot and invest in new sensor and technology platforms

Research Areas and Projects

Norwegian Centre of Excellence

- Autonomous vehicles and robotic systems
- Safer, smarter and greener ships, structures and operations

Technology for mapping and monitoring of the oceans	Marine robotic platforms	Risk management and maximized operability of ships and ocean structures
		

NTNU AMOS will contribute to improved international competitiveness of Norwegian industries as well as to safety and protection of the marine environment

Partners: NTNU, The Research Council of Norway, equinor, DNV·GL, SINTEF

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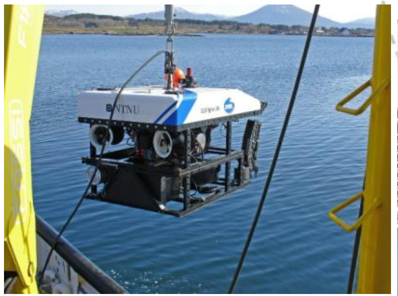
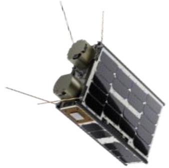
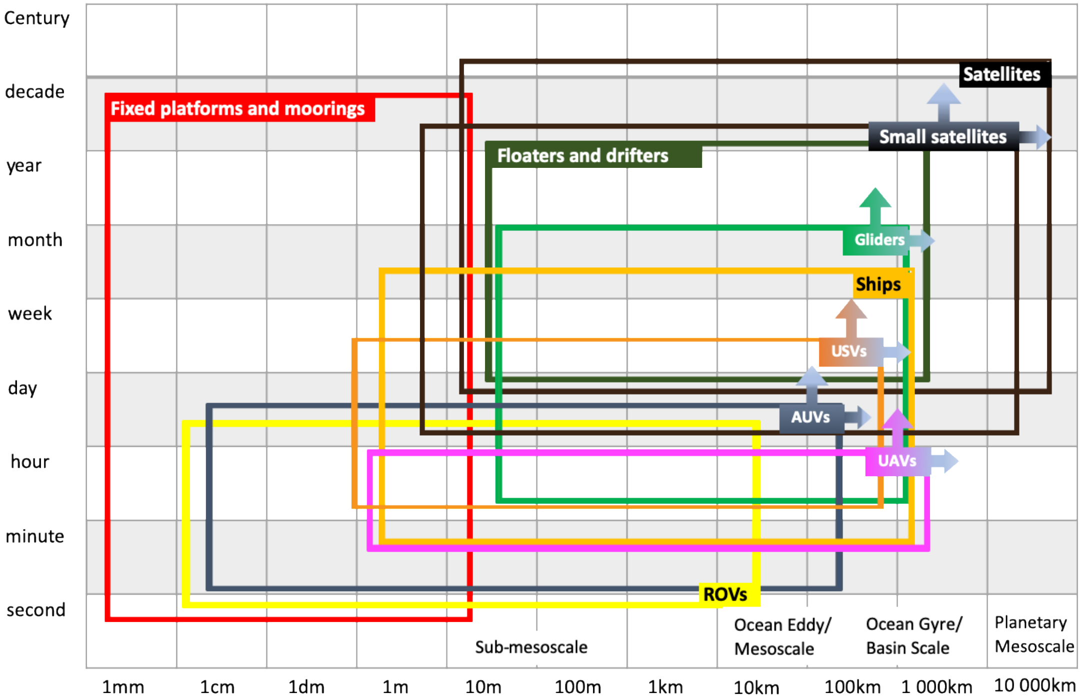
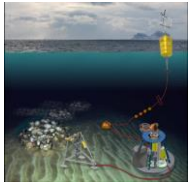
NTNU Applied Underwater Robotics Laboratory
AUR-Lab



Mapping and monitoring of the oceans in spatial and temporal domains using heterogenous sensor carrying platforms







ROVs: Remotely Operated Vehicles; AUVs: Autonomous Underwater Vehicles; USVs: Unmanned Surface Vehicles; UAVs: Unmanned Aerial Vehicles

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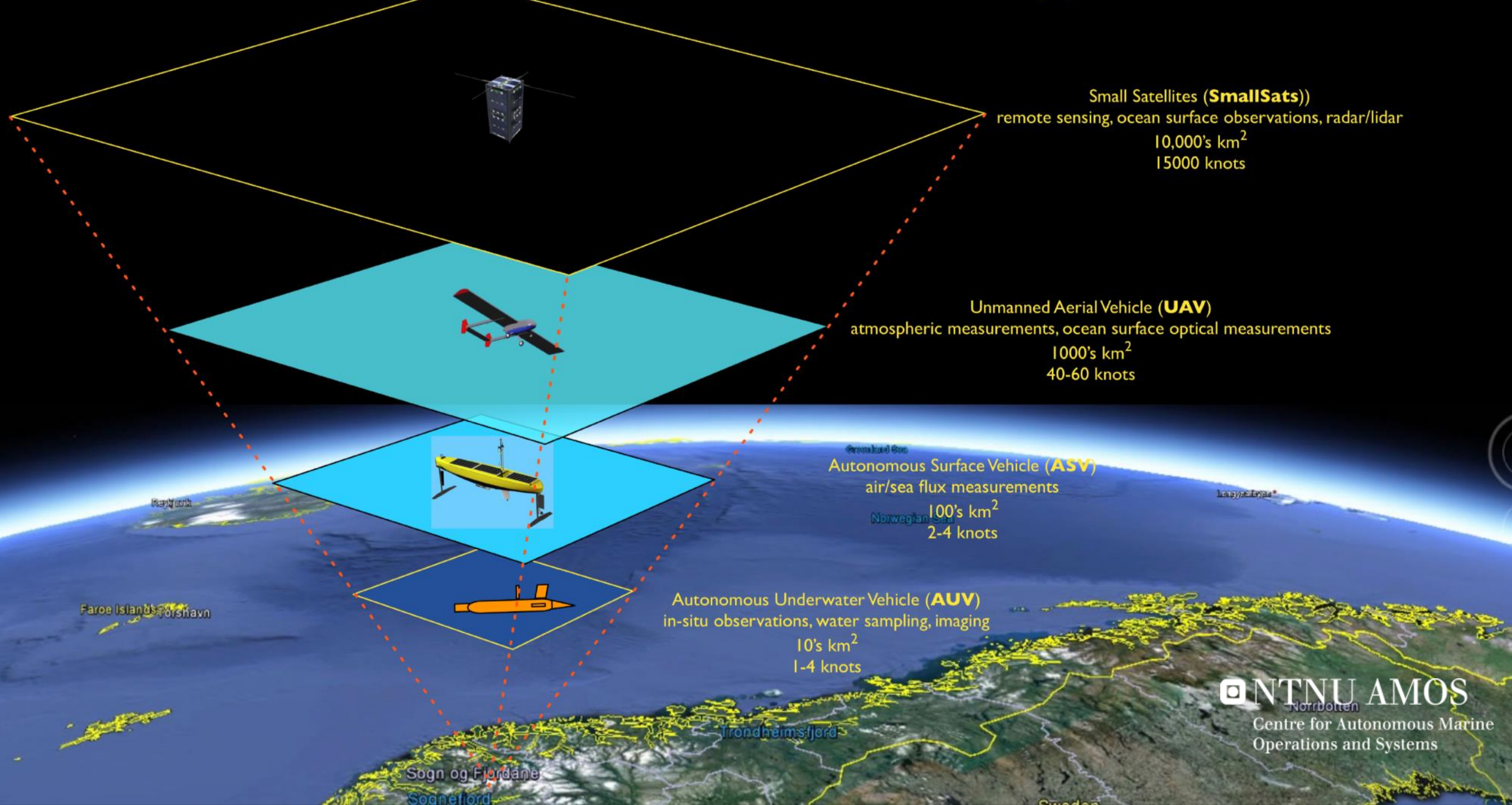
the observational pyramid



Technology for mapping and monitoring of the oceans

Example: Control objective for autonomous vehicles

- Payload sensors are carried by a technology platform for collecting data
- The objective of the platform is to position the payload sensor in space and time

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Automatic versus Autonomous

Automatic systems

- Can perform well-defined tasks without human intervention

Autonomous systems

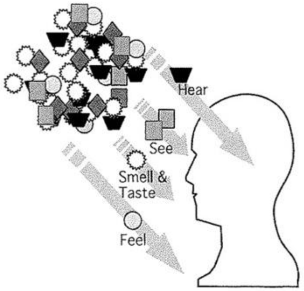
- Designed to perform complex tasks under significant uncertainties in the system and when operating in an unstructured environment
- Are highly dependable and must be able to handle external events and internal faults including reconfiguration, planning and re-planning
- Should be able to learn, adapt and improve
- Add extra layer between their measurements and actions which enable them to model and plan their actions, hence <u>making deliberate choices</u>

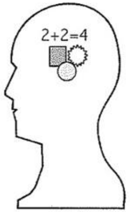
Simply speaking:
Autonomous systems have more intelligent and adaptive functionality that allows them to perform when automatic systems might fail due to more or less unexpected internal or external events

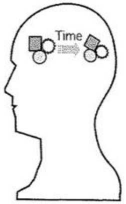
Situation awareness is crucial in autonomous systems

- Being aware of what is happening around you and understanding what this information means to you now and in the future
- The formal definition breaks down into three separate levels:
  - Level 1: **Perception** of the elements in the environment
  - Level 2: **Comprehension** of the current situation
  - Level 3: **Projection** of the future situation
- To be implemented in appropriate system models

Designing for Situation Awareness. An Approach to User-Centered Design. Endsley, Bolte, Jones







Courtesy Kongsberg Maritime

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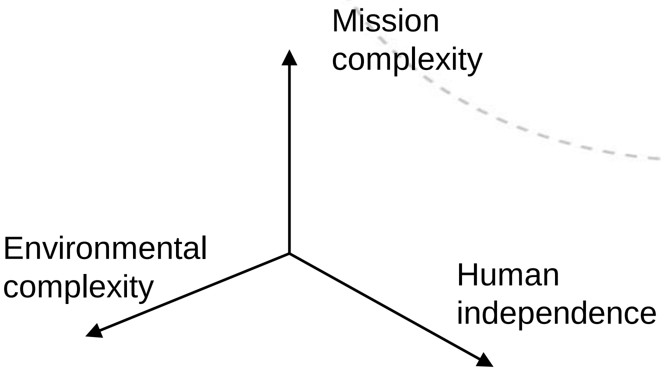
Framework for classification of candidates for autonomy based on complexity

1. **Mission complexity**
   - Subtasks, decision
   - Organization, collaboration
   - Performance
   - Situation awareness, knowledge requirements

2. **Environmental complexity**
   - Variability
   - Terrain variation
   - Object frequency, density, intent
   - Climate
   - Mobility constraints
   - Communication dependencies

3. **Human independence / Level of autonomy**
   - Frequency, duration, robot initiated interactions
   - Bandwidth of communication
   - Workload, skill levels



What about risk?

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Payload sensors and tools

- Optical sensors
  - Video
  - Pin hole camera
  - Ecopuck (cDOM)
  - 0_2 sensor
  - **Underwater Hyperspectral Imaging**

- Acoustic sensors
  - Side scan sonar
  - Multi beam echo sounder
  - Sub bottom profiler
  - Acoustic Doppler Current Profiler (ADCP)

- Other sensors
  - Gas detectors
  - Magnetometers
  - Conductivity, temp, depth (CTD)
  - ….

- Light intervention
  - Manipulators
  - Grips
  - …

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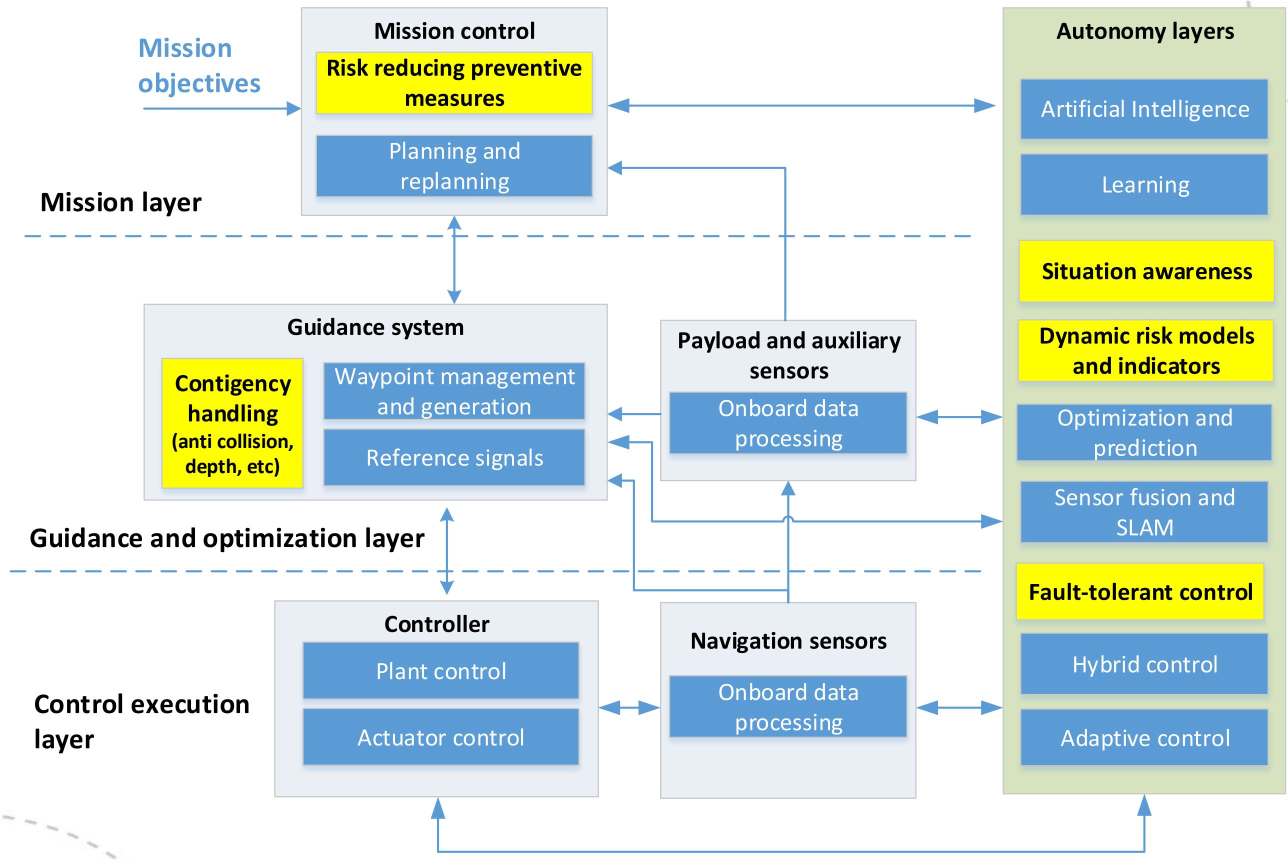
Control architecture for autonomous underwater vehicles



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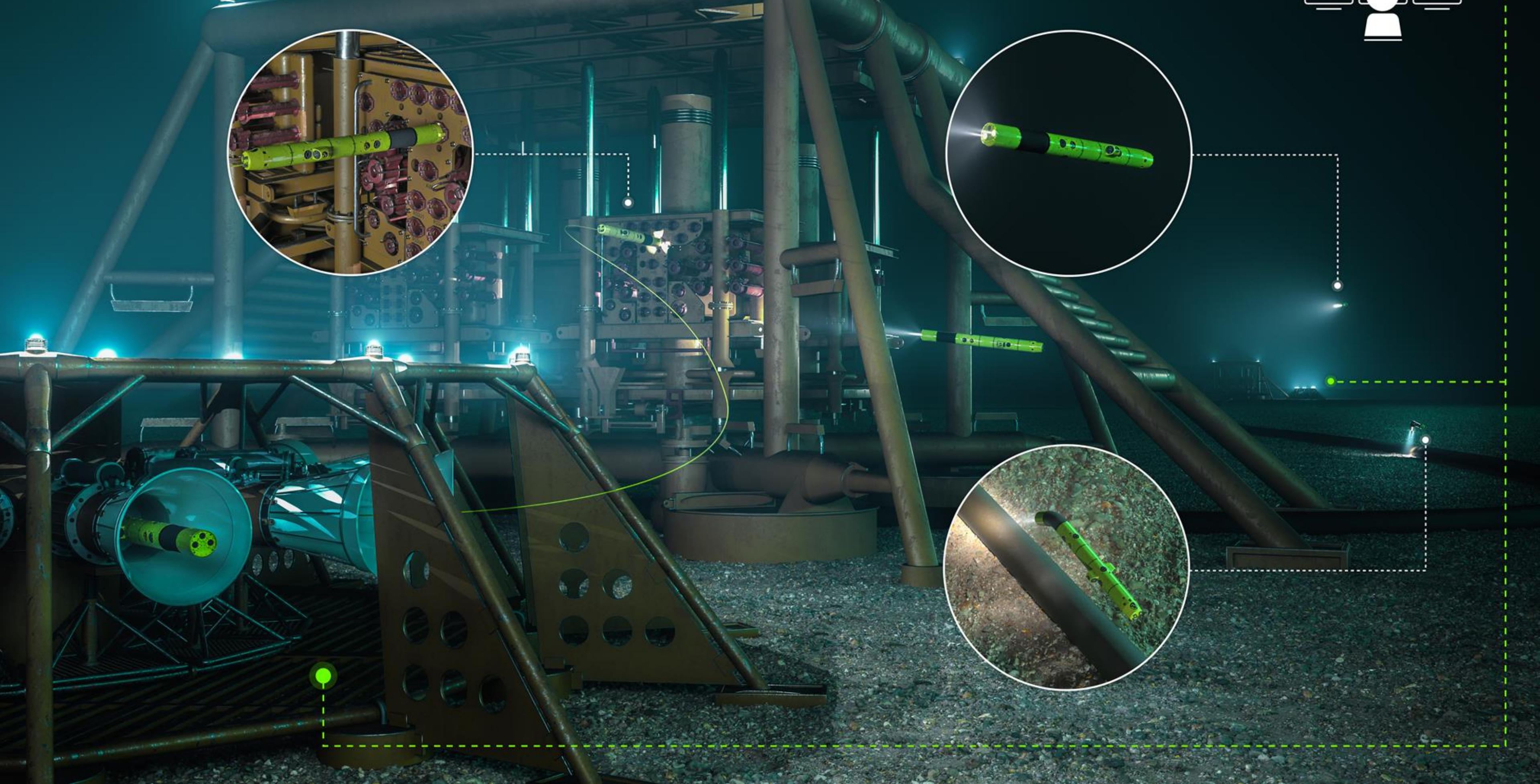
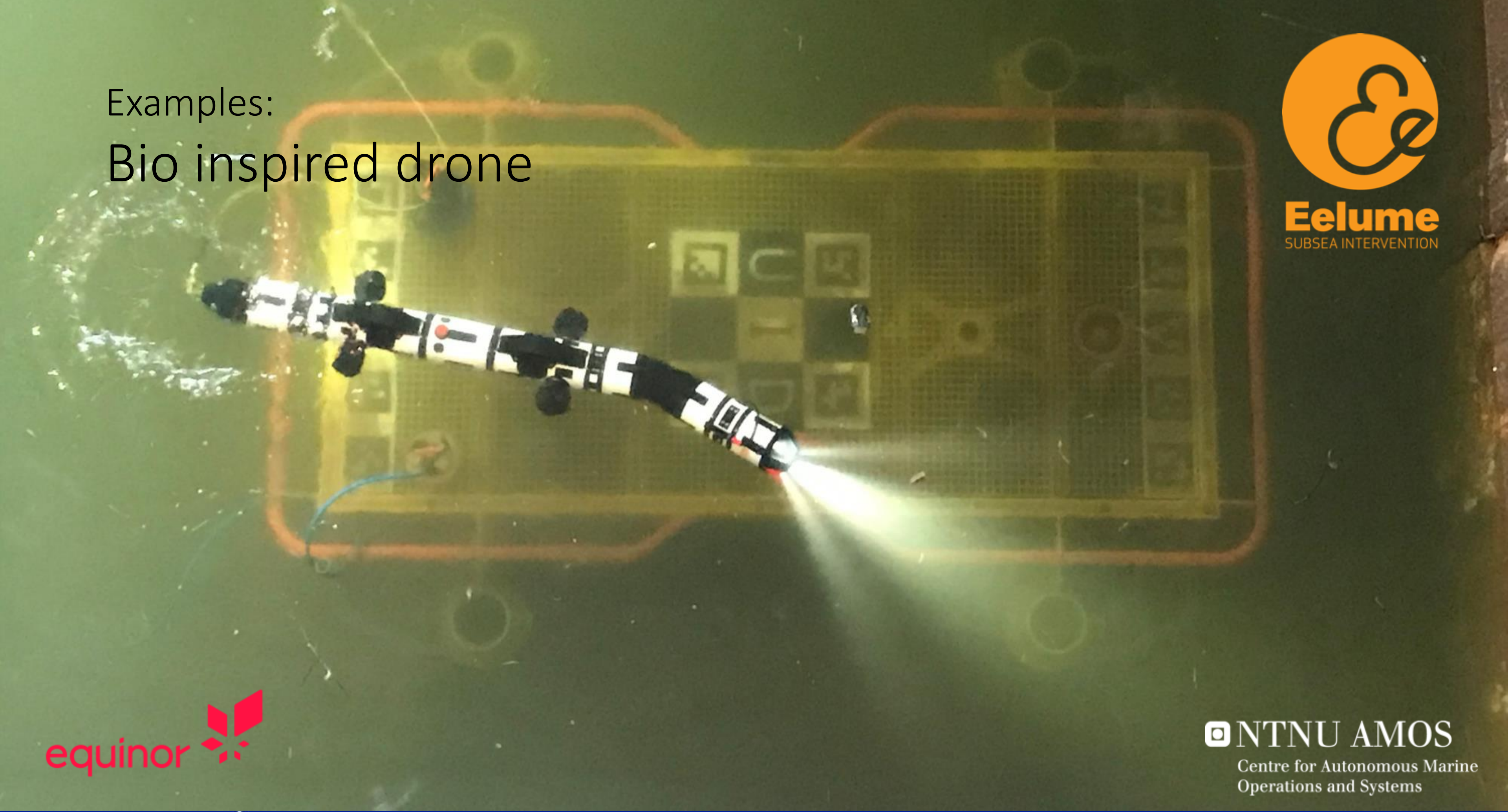
APPLICATION: SUBSEA RESIDENT IMR VEHICLES



Examples:

Bio inspired drone



Eelume
SUBSEA INTERVENTION

equinor

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Subsea docking station
Key infrastructure - Trondheimsfjord

Collaboration NTNU – Equinor - SINTEF

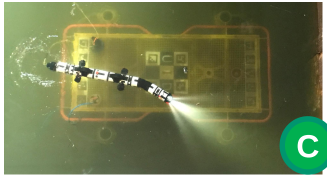
- Equipment donated by Equinor
- NTNU operated:

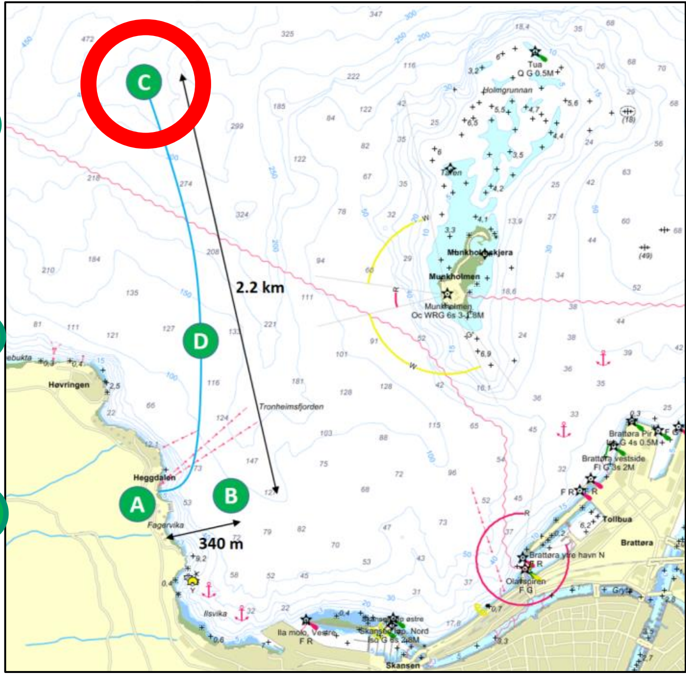
  installed May 2019

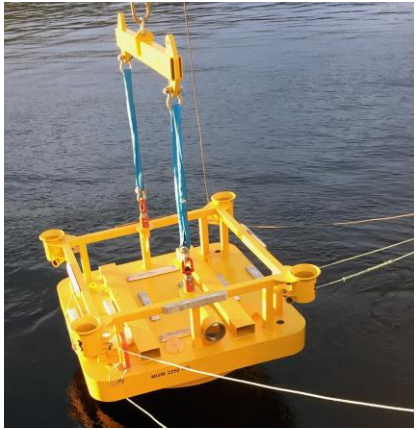
  ~ 370 meters water depth


A


B


C





A – NTNU Trondheim Biological Station

B – Subsea equipment installed in 2016

C – Docking station w/resident drones

D – Seabed cable to docking station

equinor

SINTEF

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OLYMPIC TAURUS

Project and Master thesis

- NTNU highly welcomes project and master thesis work with industry, research institutes and public sector
- Department of Marine Technology announces topics during April and early May
- Students do their final choice in August

The winning combo is summer job that evolves into project and master thesis and possible employment

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