

Integration of science and technology enables new possibilities for NTNU in exploring the ocean space



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<http://www.ntnu.no/aur-lab>

Photo: NTNU AUR-Lab



NTNU

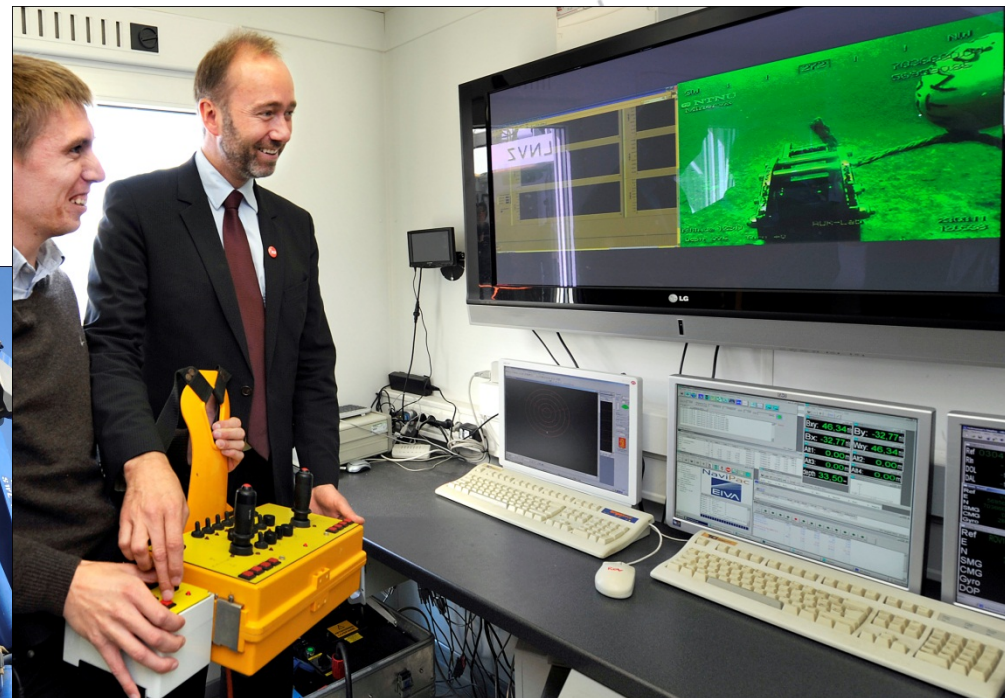
Applied Underwater
Robotics Laboratory
AUR-lab

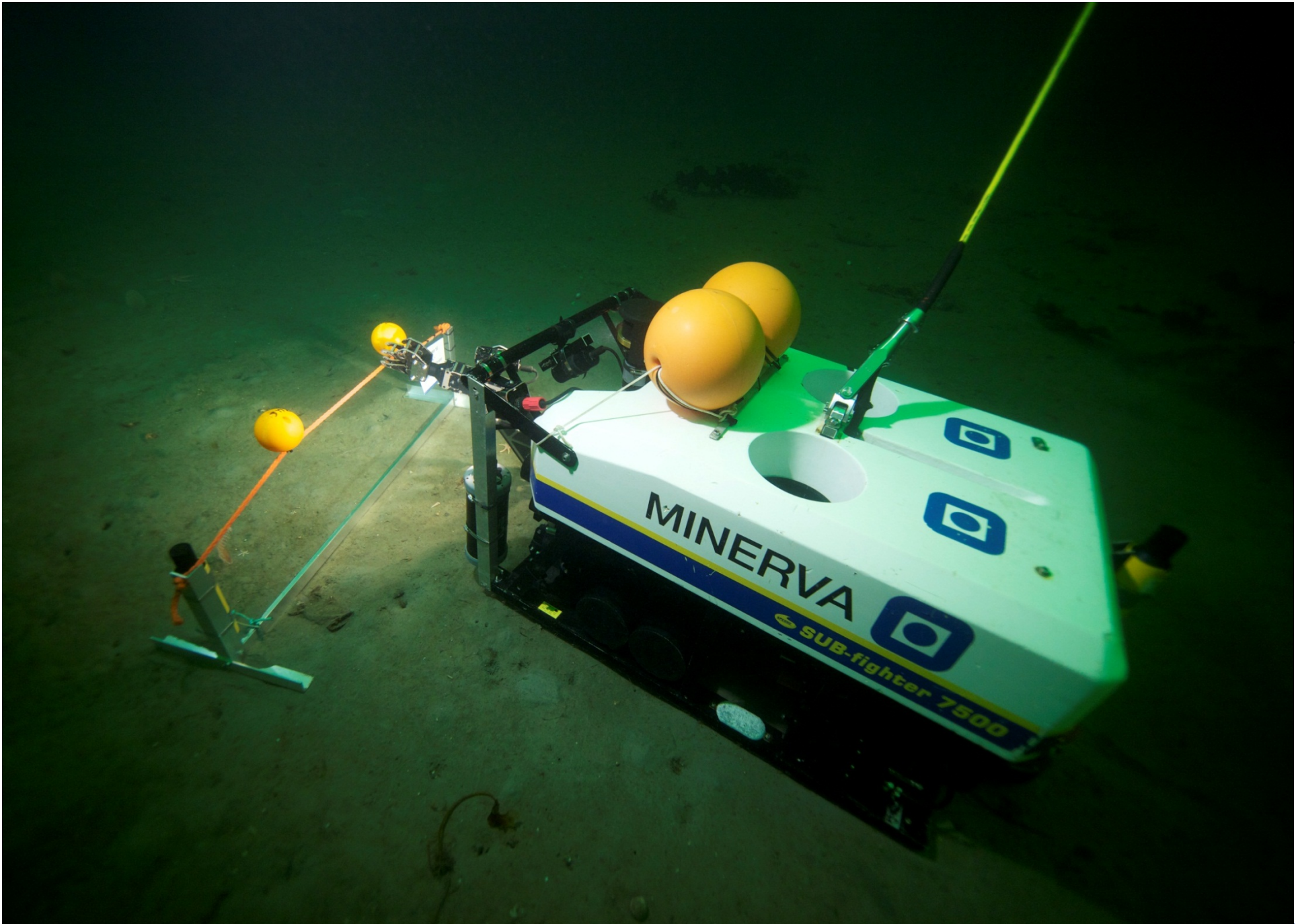
Content

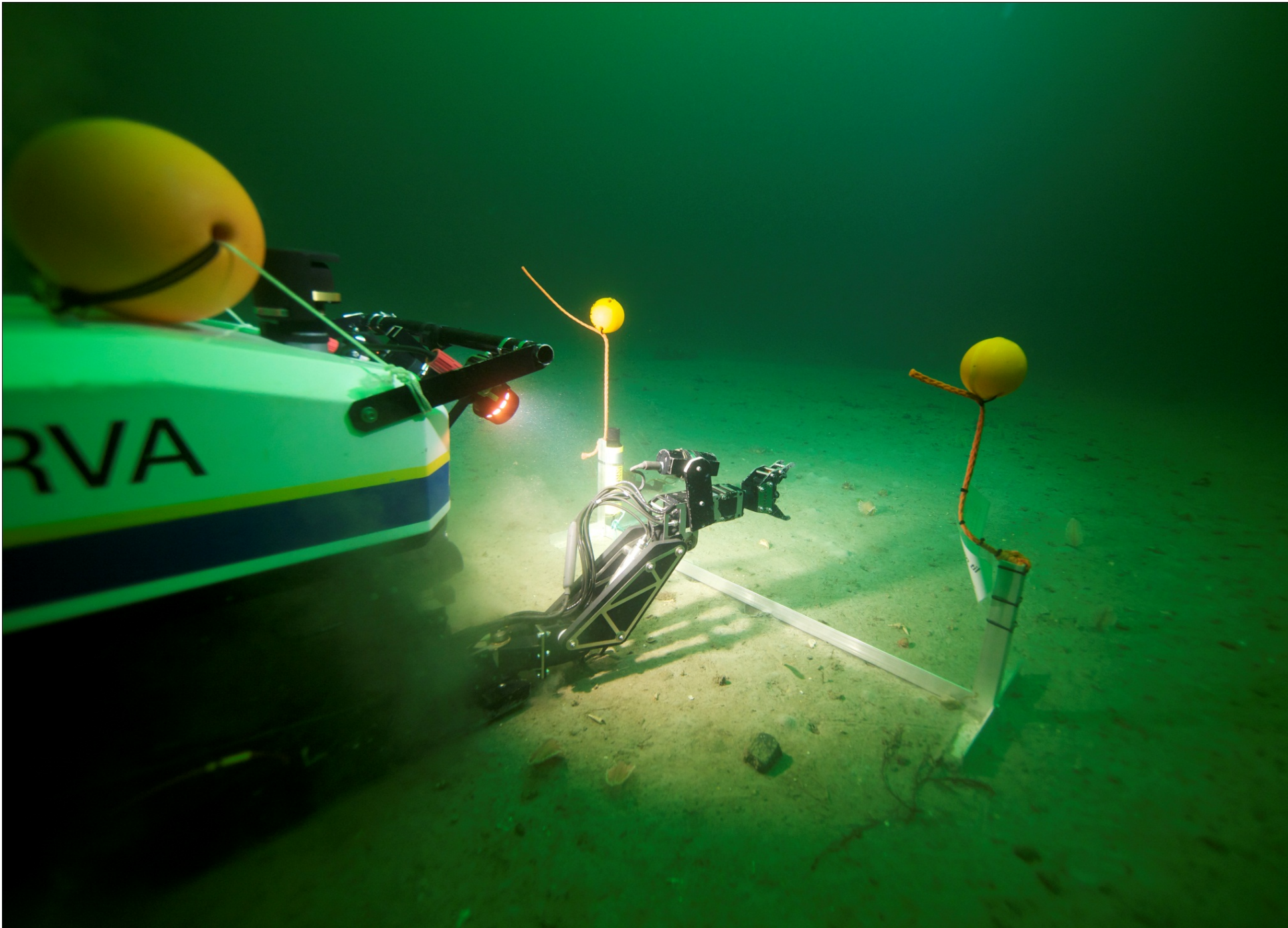
- Background and overview
- Research fields
- Dynamic Positioning of ROV
- AUR-Lab Roadmap



AUR-Lab Officially Opened 23 August 2011 by Trond Giske, Minister of Trade and Industry







Applied Underwater Robotics Laboratory

AUR-Lab

NTNU Research Groups:

- Department of Marine Technology
- Department of Biology incl. UNIS and CalPoly/Delaware
- Department for Archaeology and Religious Studies
- Department of Engineering Cybernetics
- Department of Electronics and Telecommunications
- Museum of Natural History and Archeology
- Centre for Ships and Ocean Structures (CeSOS)

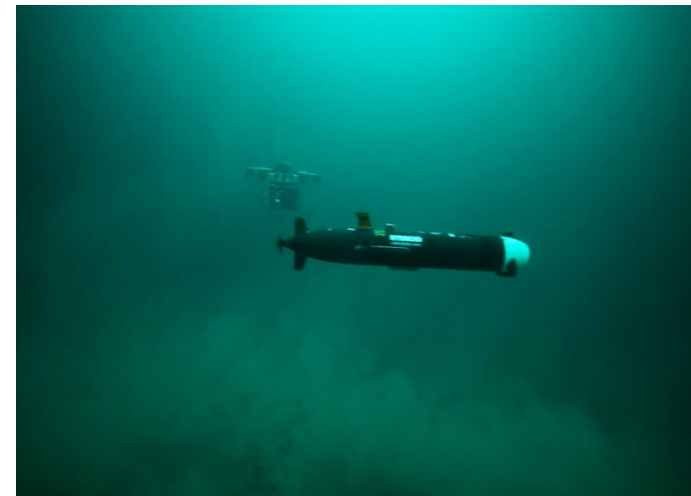
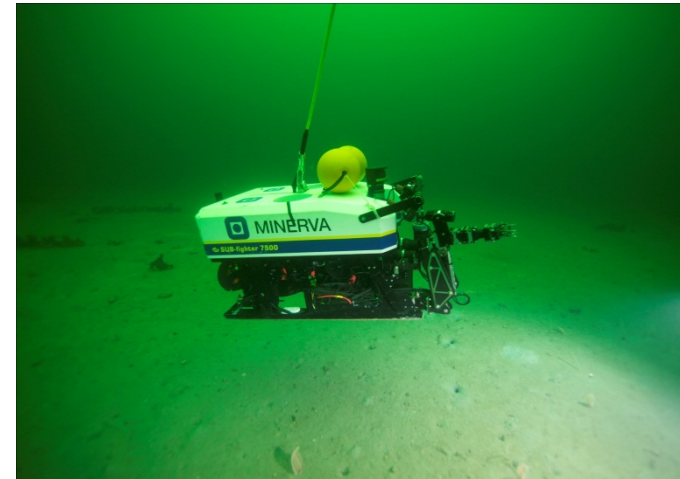


Applied Underwater Robotics Laboratory

AUR-Lab

Scientific focus areas:

- Development of technology for guidance, navigation and control of underwater vehicles (ROVs and AUVs)
- Environmental monitoring and mapping at sea surface, water column, and sea bed
- Operations under ice in the arctic
- Study of any object of interest (bio-geo-chemical objects)
- Inspection/surveillance for environmental agencies, oil industry, ecotoxicology
- Evaluation of seabed properties and habitat
- Underwater acoustic communication
- Complex deepwater underwater operations including inspection and intervention
- Deep water archeology



NTNU Research Vessel Gunnerus



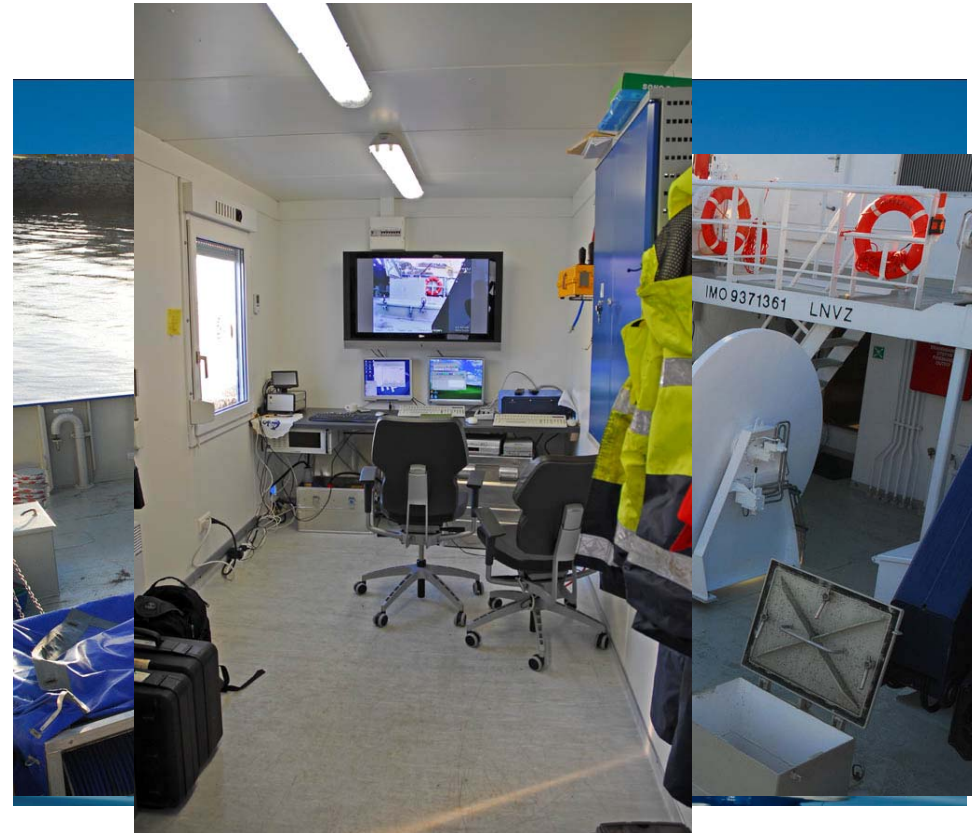
NTNU's research vessel, R/V Gunnerus, was put into operation in spring 2006. The ship is fitted with a dynamic positioning system and a HiPap 500 unit, optimal for ROV operations and the positioning of any deployed equipment.

The vessel is arranged with wet lab, dry lab and a computer lab in addition to a large aft deck.

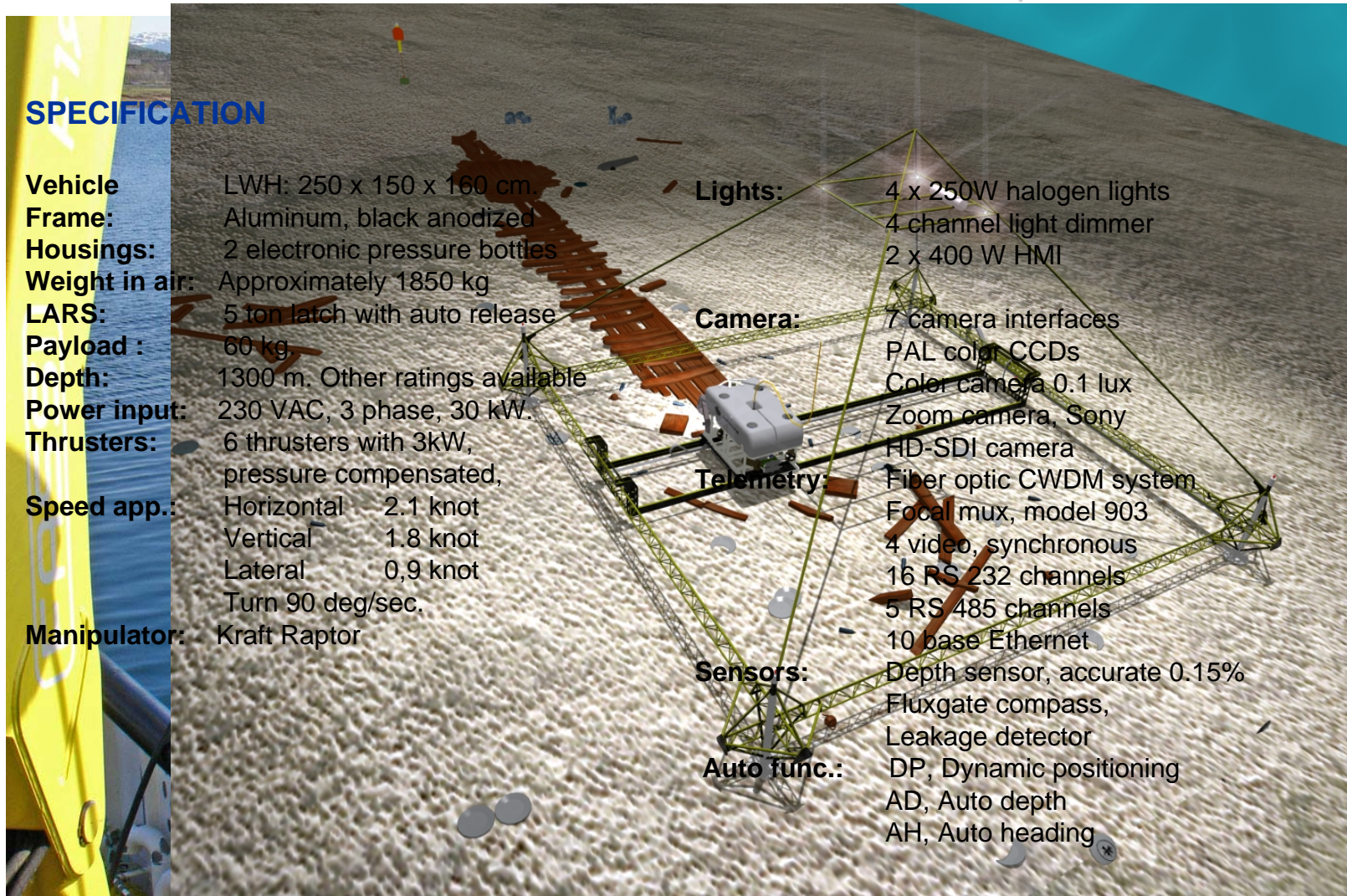
Accommodation comprise three double berth scientific personnel cabins and three single berth crew cabins. The large mess hall functions as a lecture room for 25 people.

ROV Minerva

- Observation class
 - ~400 kg
 - 3CCD camera
 - 3 "regular" ROV-camera
 - 5-function manipulator
 - 1-functions manipulator
 - Scanning sonar
 - Altimeter
 - ~600 meter cabel on winch (fiber)
 - HiPAP and DVL for positioning
 - Control container



ROV SUB-Fighter 30k



SPECIFICATION

Vehicle	LWH: 250 x 150 x 160 cm.	Lights:	4 x 250W halogen lights 4 channel light dimmer 2 x 400 W HMI
Frame:	Aluminum, black anodized	Camera:	7 camera interfaces PAL color CCDs Color camera 0.1 lux Zoom camera, Sony HD-SDI camera
Housings:	2 electronic pressure bottles	Telemetry:	Fiber optic CWDM system Focal mux, model 903 4 video, synchronous 16 RS 232 channels 5 RS 485 channels 10 base Ethernet
Weight in air:	Approximately 1850 kg	Sensors:	Depth sensor, accurate 0.15% Fluxgate compass, Leakage detector
LARS:	5 ton latch with auto release	Auto func.:	DP, Dynamic positioning AD, Auto depth AH, Auto heading
Payload :	60 kg		
Depth:	1300 m. Other ratings available		
Power input:	230 VAC, 3 phase, 30 kW.		
Thrusters:	6 thrusters with 3kW, pressure compensated,		
Speed app.:	Horizontal 2.1 knot Vertical 1.8 knot Lateral 0,9 knot Turn 90 deg/sec.		
Manipulator:	Kraft Raptor		

Innovation and Creativity

AUV REMUS 100

- Marine Sonics 900 kHz Side Scan sonar
- Teledyne RDI 1.2 MHz up/down DVL/ADCP
- Wet Labs ECO Triplet puck
- Aanderra Dissolved Oxygen Optode
- Neil Brown CT sensor
- LBL navigation system
- Imagenex Delta T multibeam

Navigation:

Inertial Navigation
GPS/HiPAP (tracking,
aiding)

Communications:

Acoustic modem, Wi-Fi,
Iridium

REMUS support from Horten

REMUS training in Horten



REMUS 100 with HUGIN Technology

- HUGIN navigation system (NavP) with HG1700 IMU
- HUGIN Payload system for initialization and supervision of payload sensors
- Accurate time synchronization and time stamping
- Sophisticated acoustic trigger synchronization hardware
- HiPAP tracking and position aiding
- SW developer kit (SDP) for free programming of customer developed GNC and sensor packages

Available options:

- UTP navigation (single transponder navigation technique)
- NavLab Navigation post-processing toolbox
- Post Mission Analysis tools



NTNU Sletvik Field Station Demonstrator

In area of Tronheimsfjorden

Typical projects:

- Photomosaics at sea-floor
- Underwater hyperspectral imaging
- PAM fluorometers
- CO₂ seepage detection
- Detection of gases and trace metals
- Testing of AUV



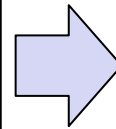
TBS and Hopavågen -
underwater robotics test site

Background for AUR-Lab

Established 2009 to create a new multi- and inter-disciplinary research arena at NTNU

Knowledge base

- Depts. of Marine Technology, Engineering Cybernetics and Electronics and Telecommunications
 - Guidance, navigation and control of ships, ocean structures and underwater vehicles
 - Robotics
 - Operational experience with ROV
 - System design and configuration
 - Instrumentation and methods for processing data
- Department of Biology
 - Operational experience with ROV and AUV including arctic
 - Instrumentation (optics)
 - Mission planning
- Dept. of Archaeology and Religious Studies
 - Operational experience with ROV



Technology needs

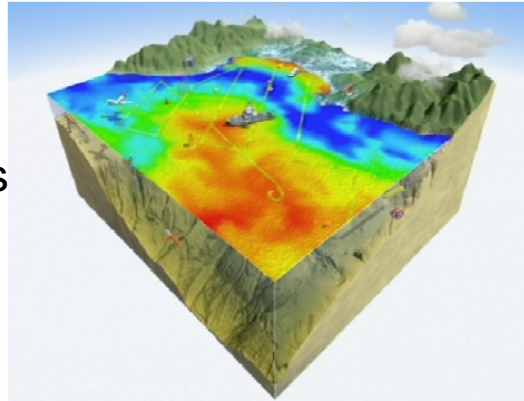
- Depts. of Marine Technology, Engineering Cybernetics and Electronics and Telecommunications
 - Test platform
 - Prototyping
 - Advanced methods for processing data
- Department of Biology
 - Instrument carriers
 - Increased vehicle capabilities
 - Increased quality of services
 - Interpretation of data
- Dept. of Archaeology and Religious Studies
 - New sampling methods
 - Increased quality of service

Integrated platform

Air:

Satellites & airplanes

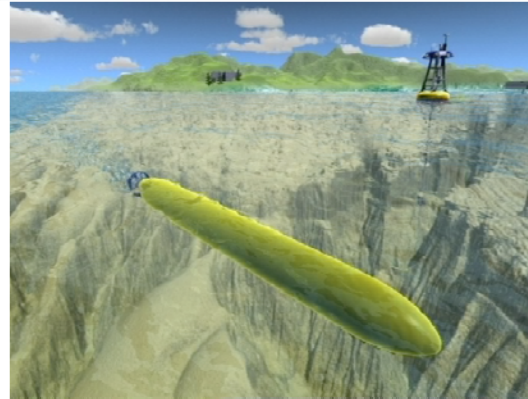
Multi- & hyperspectral imagers



Sea surface:

Ships

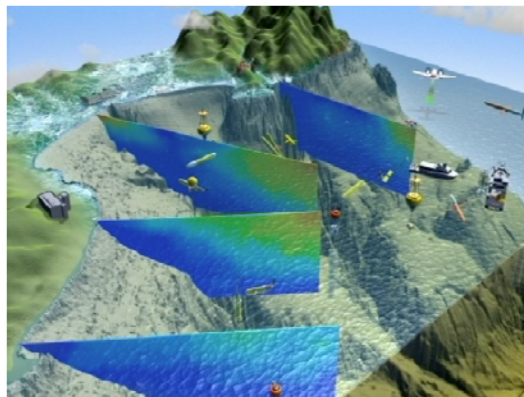
Acoustic, chemical & optical sensors



Water column:

AUV and gliders

Acoustic, chemical & optical sensors



Sea floor:

ROV, AUV, crawler & lander

Acoustic & optical sensors

3 D coverage:

Bio-geo-chemical OOI:

Physics (eg. T, S, D, E)

Chemistry (O₂, CO₂)

Biology (plankton & benthos)

Geology (habitat, substrate & minerals)

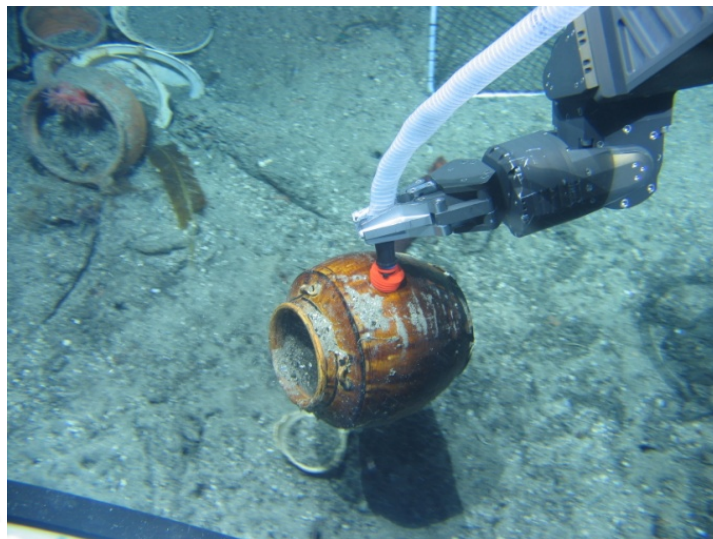
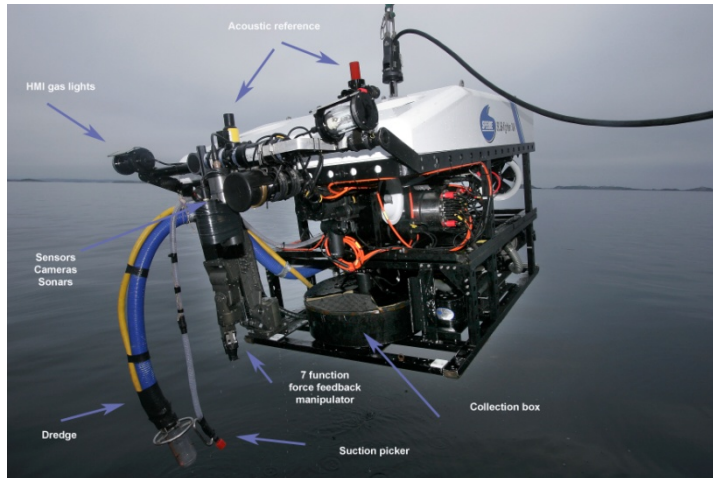
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- Research fields
- Dynamic Positioning of ROV
- AUR-Lab Roadmap

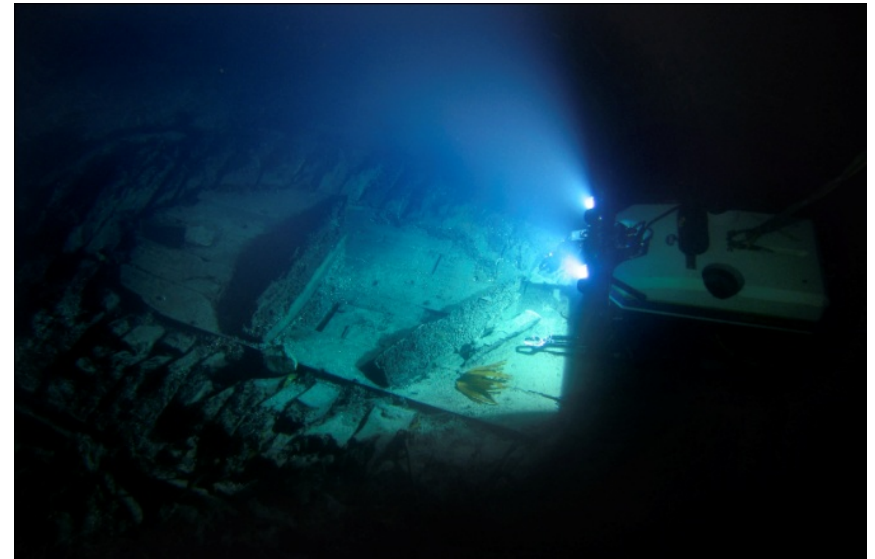


Deep water archaeology



NTNU is a leading institution within deep water archaeology; discovery and investigation of cultural heritage in the deep sea.

NTNU operates a special-purpose work-class ROV that was developed for the Ormen Lange project, world's first excavation of a shipwreck in deep water using only ROV.



Marine biology research

Ocean Space Research

- Marine surveillance systems
- Energy from the ocean
- Marine ecosystems
- Eco-toxicology
- Marine archaeology and cultural history
- Coastal zone development and infrastructure

Infrastructure

- RV Gunnerus
- Trondhjem Biological Station
- Marine Technical Laboratory
- ACE
- NTNU and SINTEF Sealab



ROV- sampling deep water corals

Glider - northernmost deployment



AUV -Remus across Isfjorden



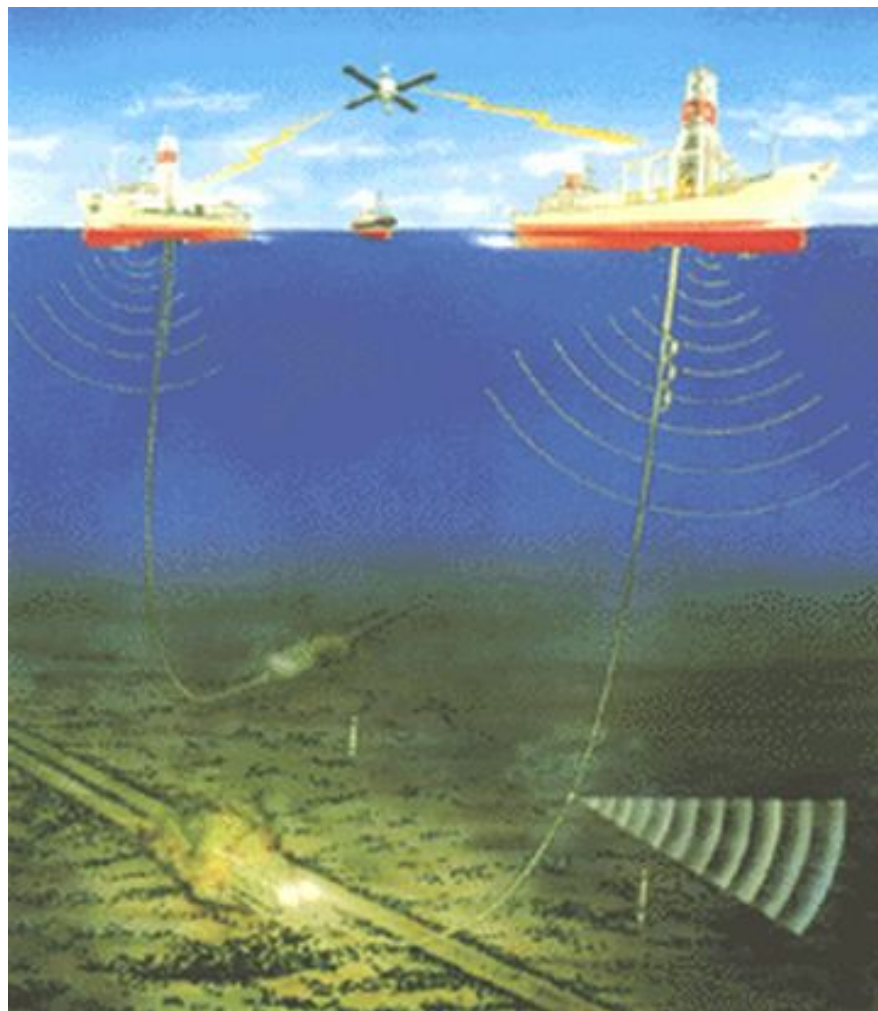
Offshore Inspection Maintenance Repair (IMR) operations including arctic



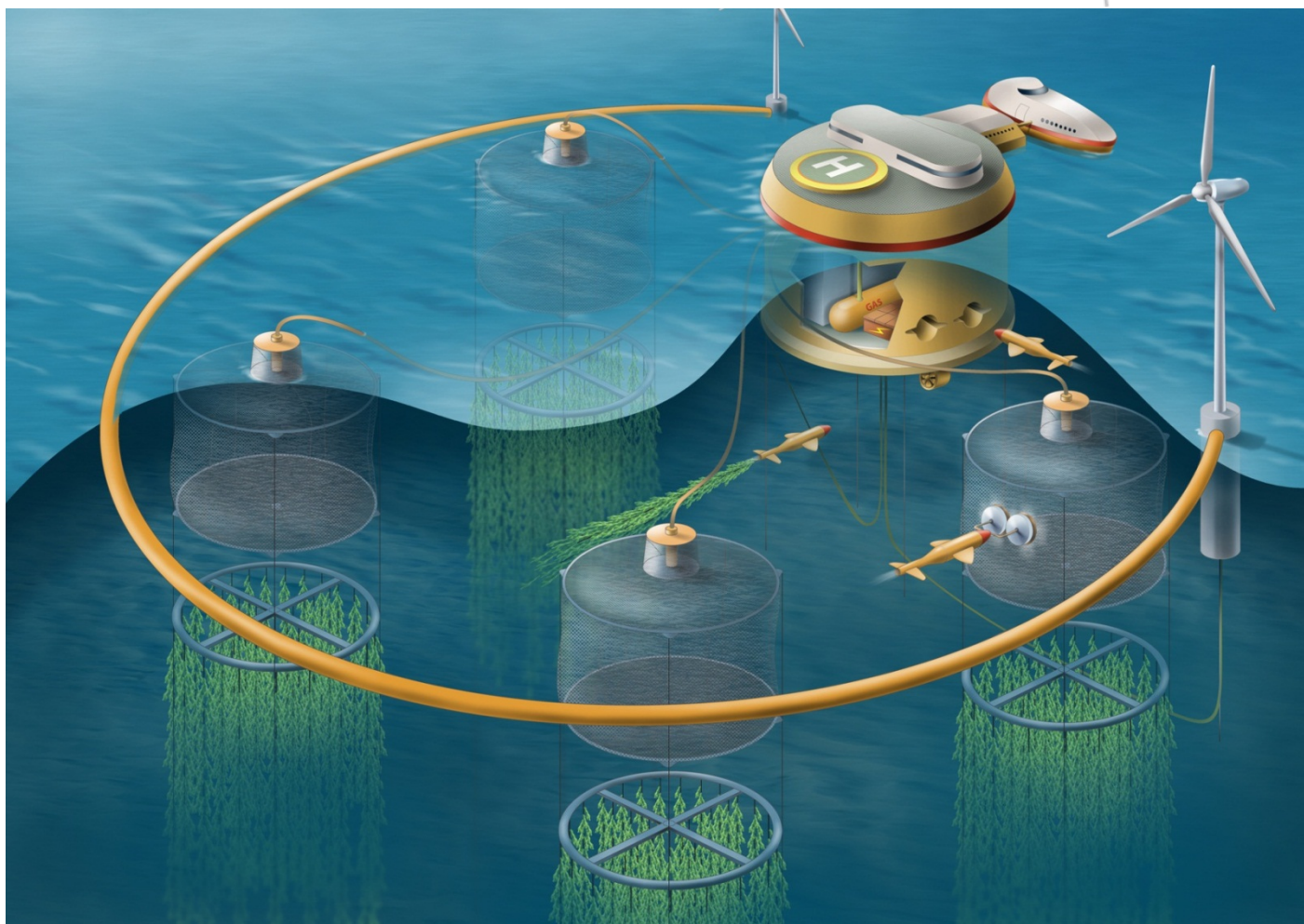
Marine monitoring and surveillance



Deep water mining



Offshore aquaculture



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Dynamic Positioning System for ROV Minerva

Goal: Make control system with user interface for dynamic positioning (DP) and tracking for use in real ROV missions.

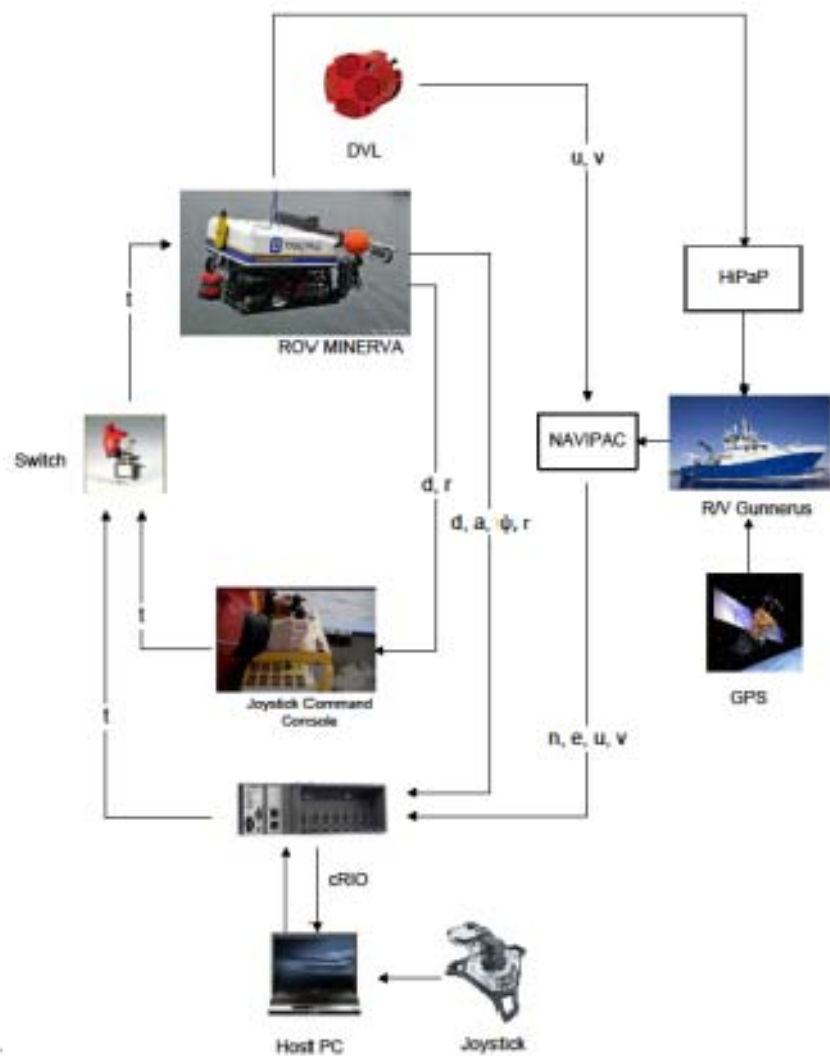
Process: A team of MSc students, PhD candidates and Post Docs has been working on this since 2010 with monthly cruises.

The control system is tested on a simulation model before deployment on ROV Minerva.

The control system is deployed and tested on the ROV Minerva during monthly cruises with R/V Gunnerus in the development stages.

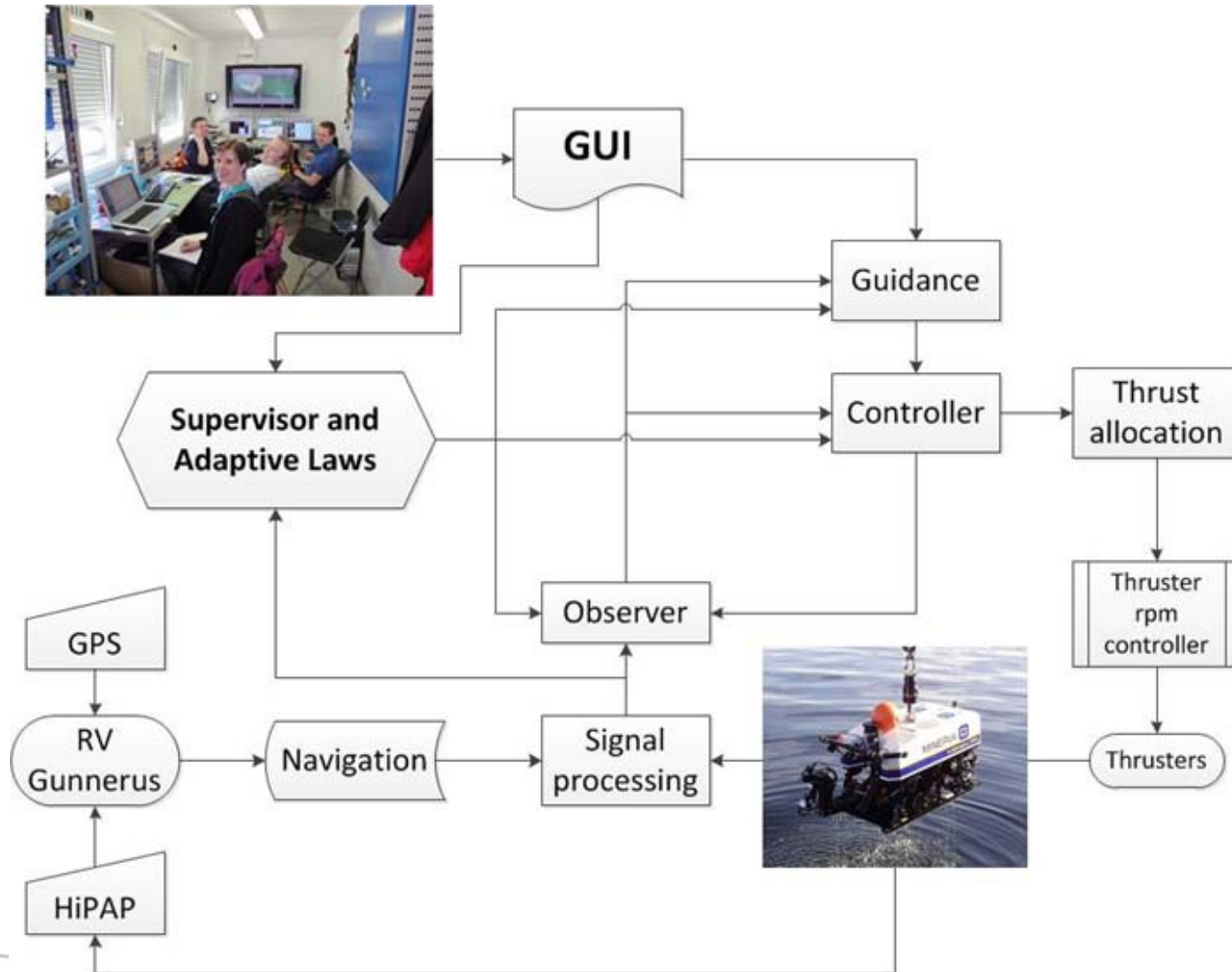


DP Control Platform

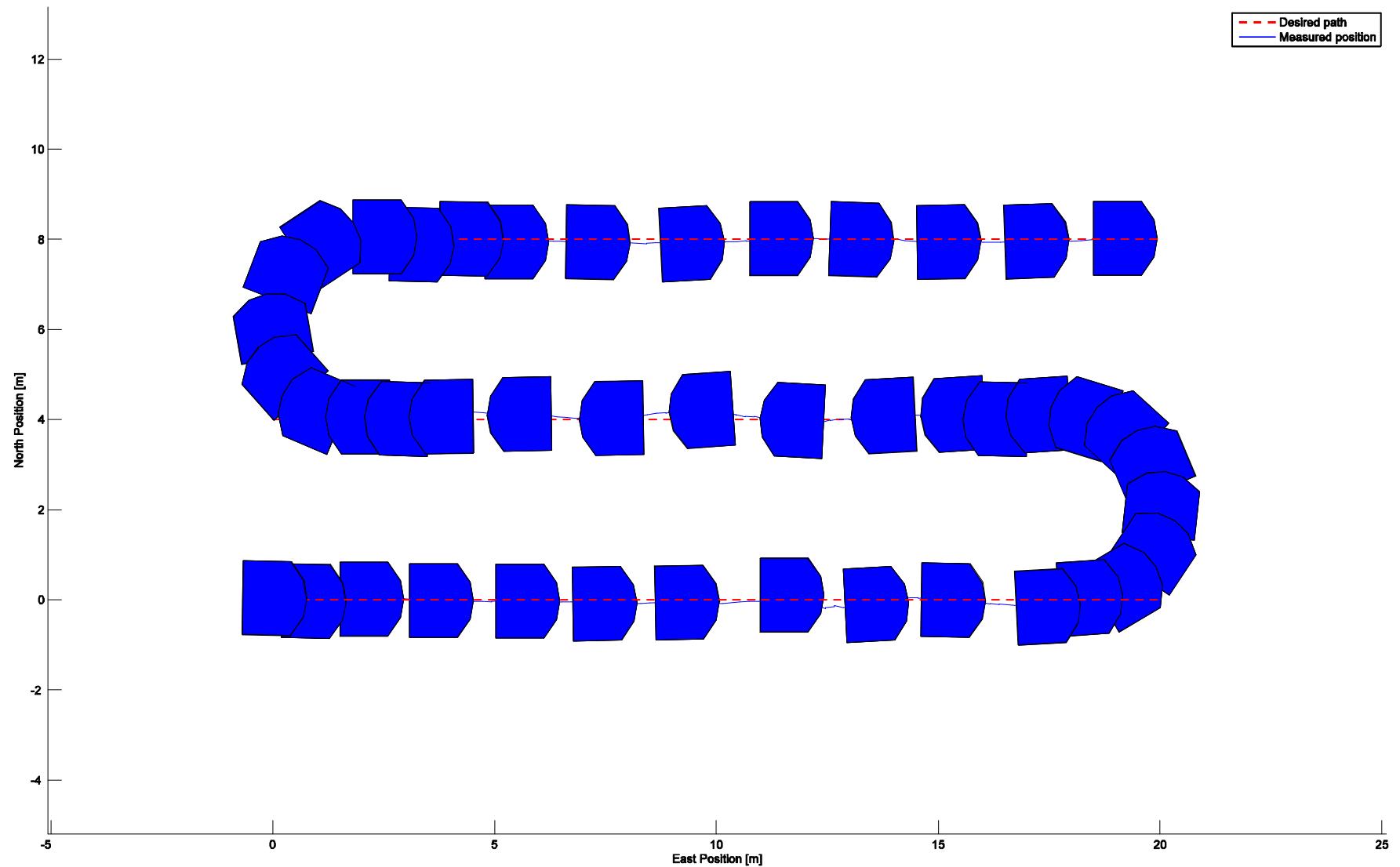


- Compact RIO (cRIO) from National Instruments is the controller platform
- Measurement signals are fed to the cRIO via serial ports.
- The control software is deployed on the cRIO but a host PC provides the user interface.

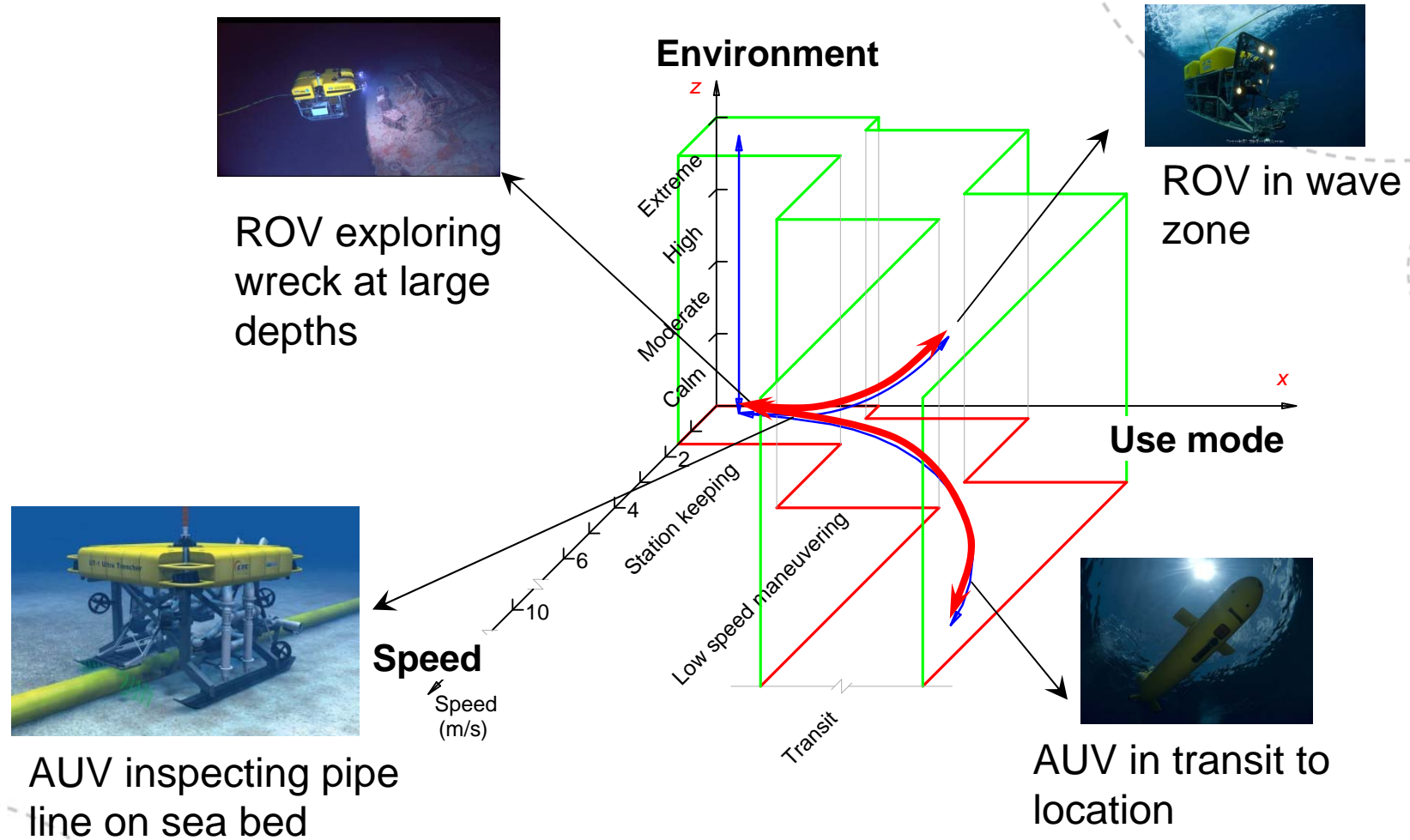
DP Control Architecture



ROV path following Demo cruise 16th February 2011



Hybrid control enables multi-objective operations

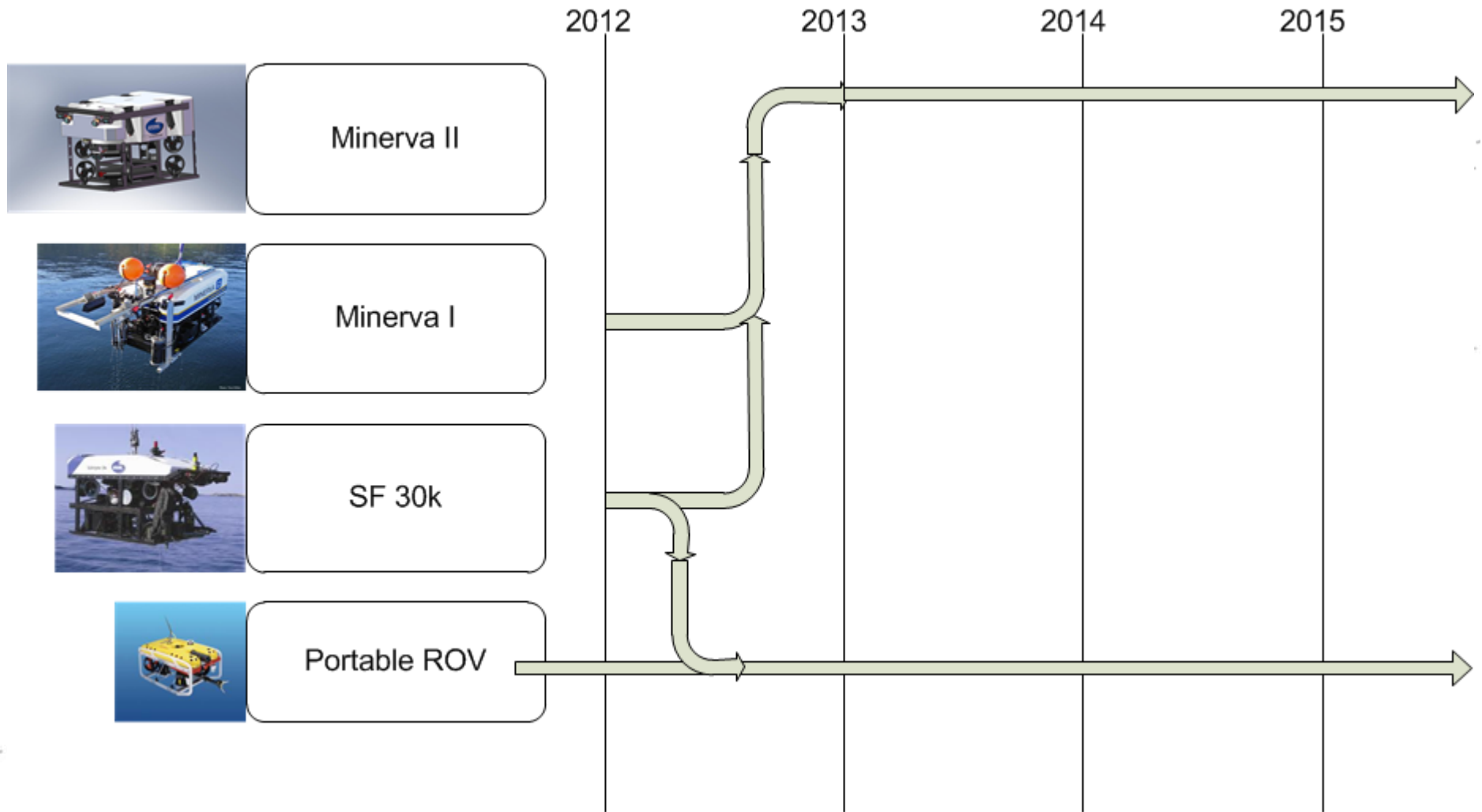


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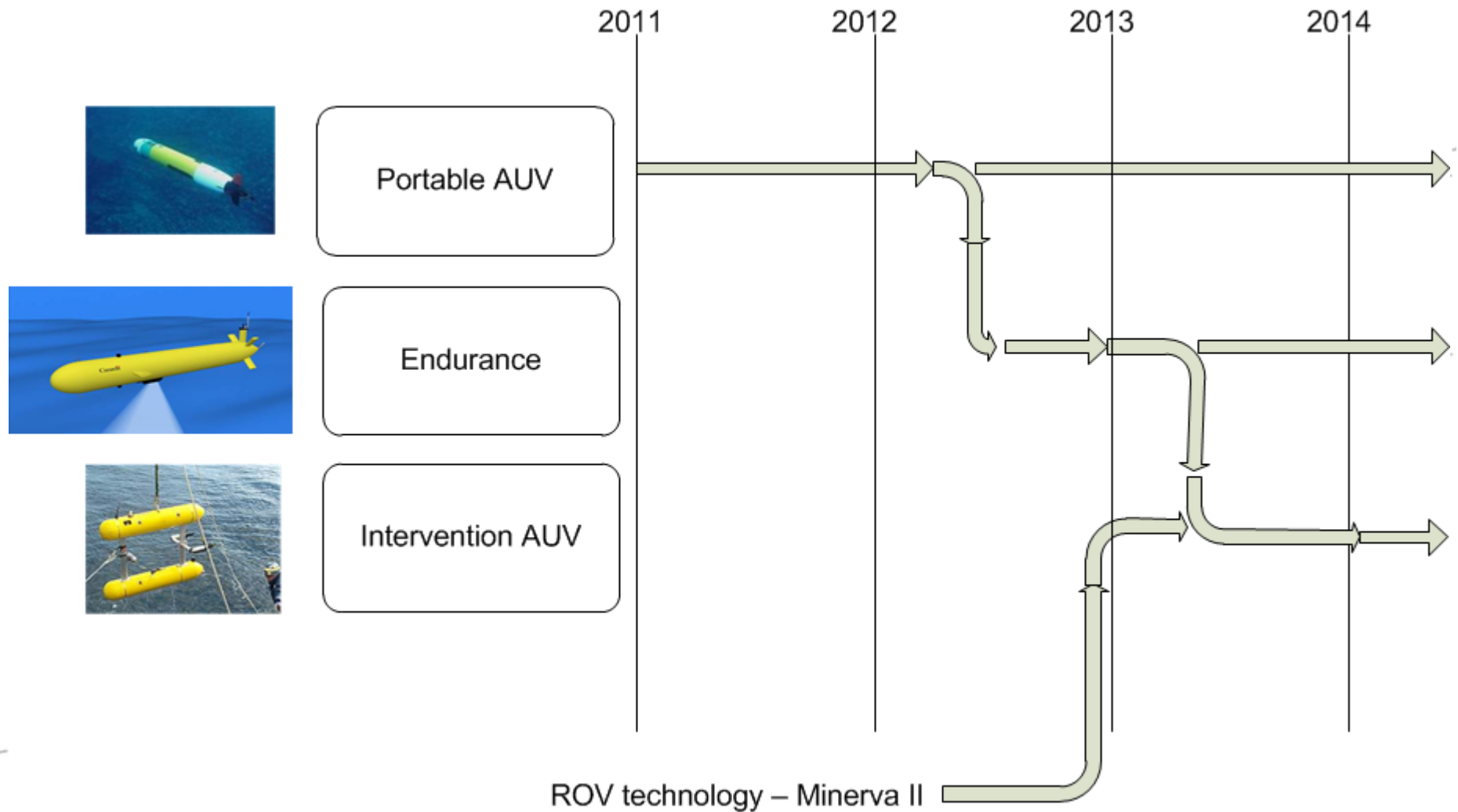
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ROV Roadmap

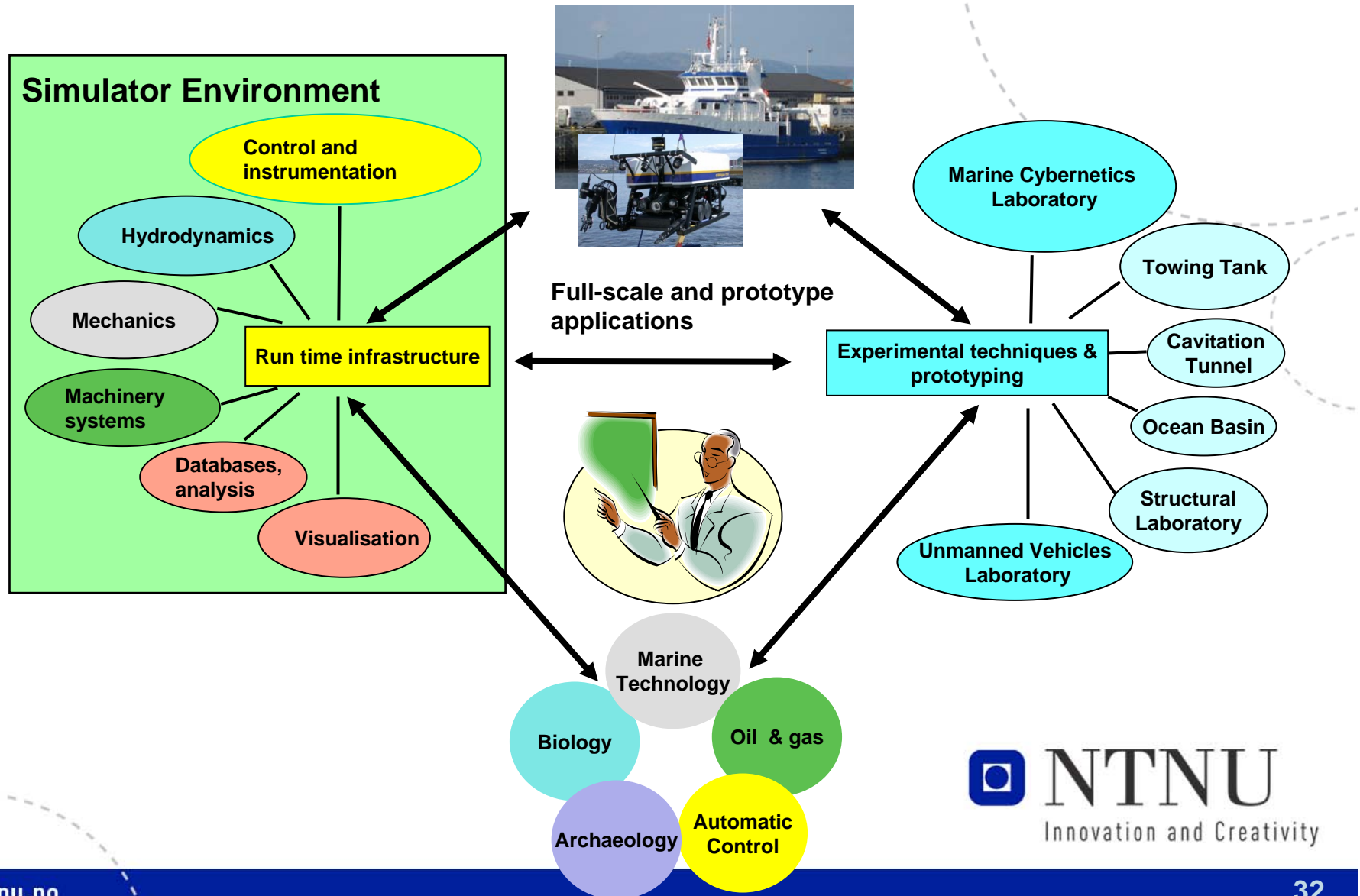


AUV Roadmap



AUR-Lab bridges the gap from theory to practice

Theory – Simulation – Model and full scale experiments – Missions



Conclusion

- AUR-Lab will:
 - Develop new knowledge by multi and interdisciplinary research groups at NTNU
 - Provide operational infrastructure for underwater operations for NTNU and externals
 - Educate MSc and PhD
- We have plans for further investments in sensors, AUVs, ROVs and research infrastructure
- We welcome cooperation with industry and research partners nationally and internationally