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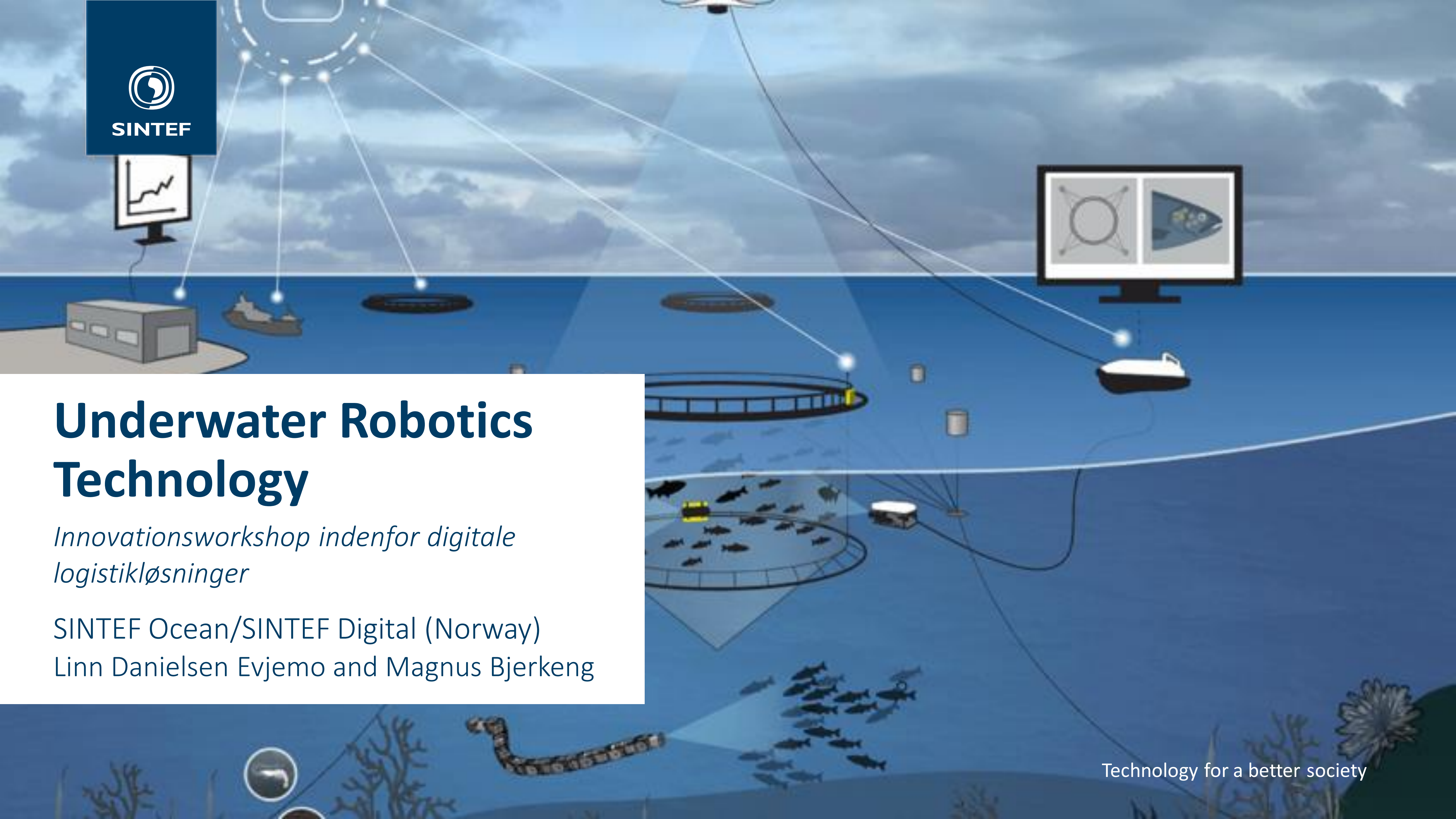


Underwater Robotics Technology

Innovationsworkshop indenfor digitale logistikløsninger

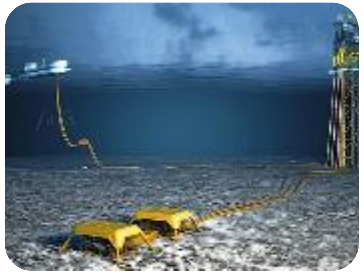
SINTEF Ocean/SINTEF Digital (Norway)

Linn Danielsen Evjemo and Magnus Bjerkeng

Outline of this presentation

- Shapes and sizes over underwater robots
- Localization under water
- Main classes of unmanned underwater vehicles (UUVs)
- Typical tasks for underwater robots
- Where is the technology headed – trends for future underwater robotics

Underwater Robotic Solutions for Subsea Applications

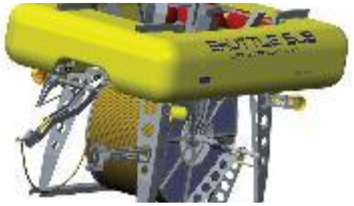


Resource Extraction

Science

National Defence

Aquaculture



Telecommunications

Construction, Inspection and Maintenance

Archeology

Search and Recovery

Dirty → Dangerous → Distant → Dull → Dear

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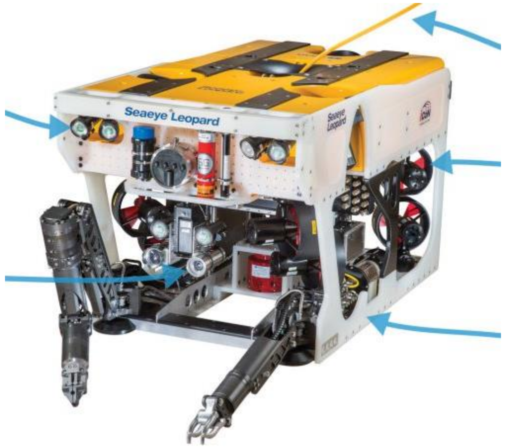
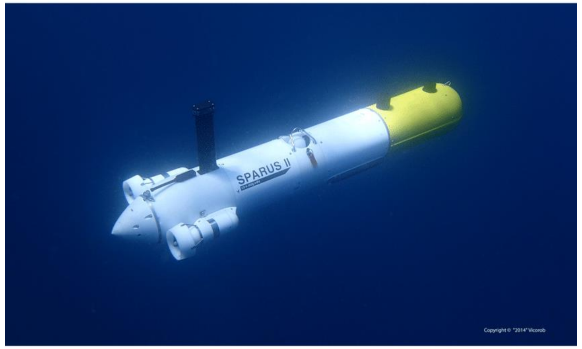
Shapes and Sizes

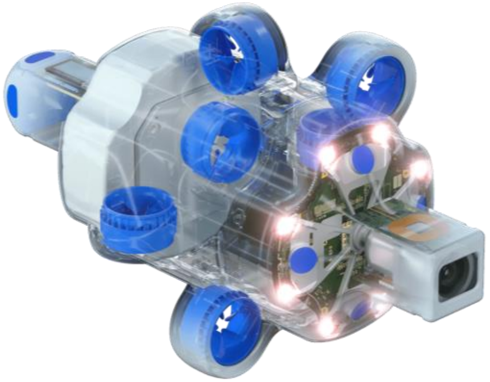
Underactuated Box, slow speed



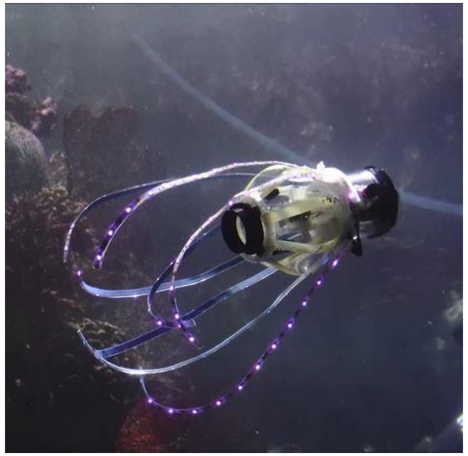
Torpedo, high-speed



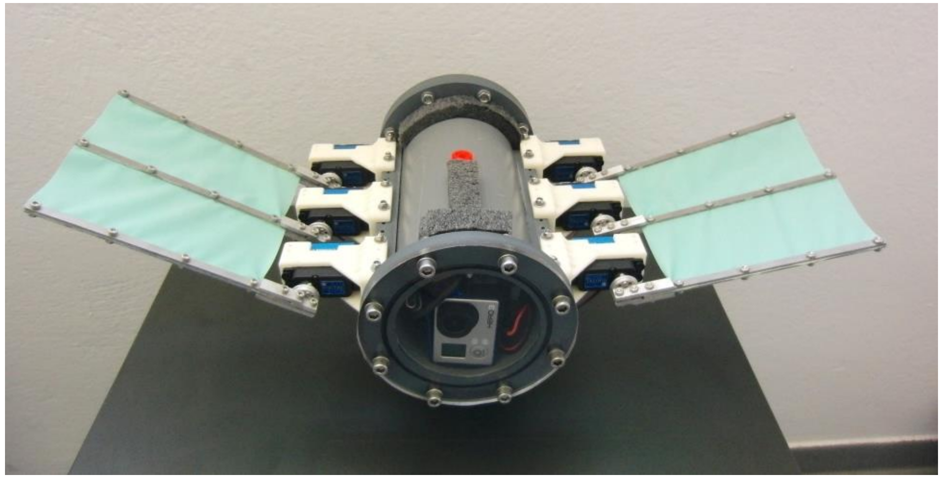
Fully actuated

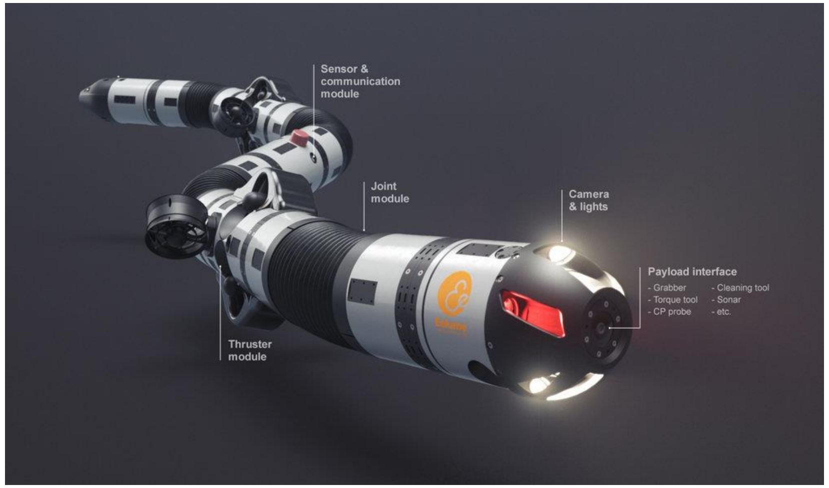


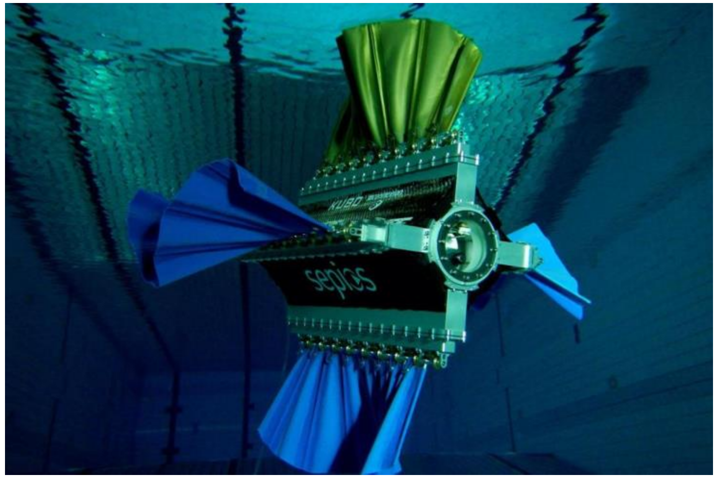
Bio-inspired



Bio inspired UUV







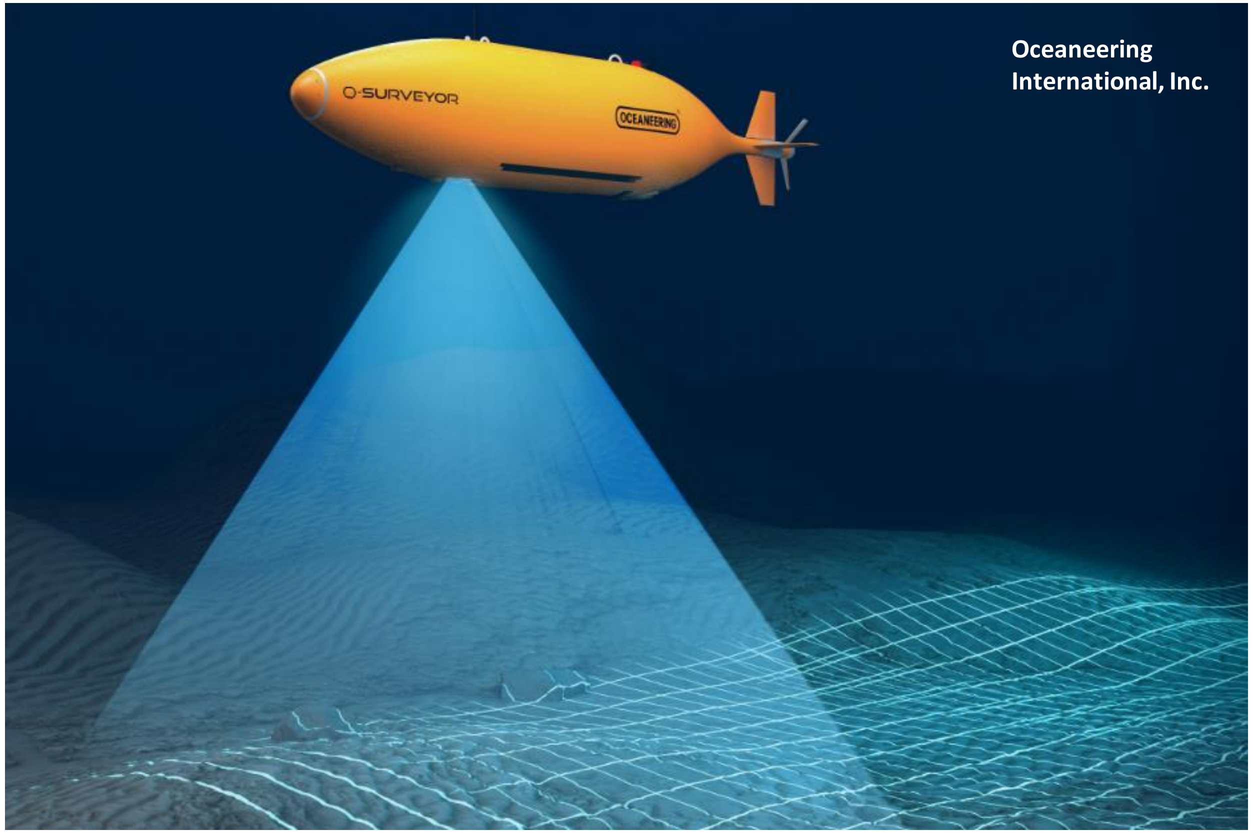
Main classes of UUVs:
ROVs – Remotely Operated Vehicles

- Underwater robot tethered to a controller on the surface
- (Usually) remotely controlled by an operator on the surface
- Attached equipment can send real-time data to the surface (e.g. video)
- Can be battery-driven, or draw power from a surface vessel
- Flexible, can work in «busy» areas

Foto: SINTEF Ocean AS - Argus Mini ROV

Main classes of UUVs: AUVs – Autonomous Underwater Vehicles

- Underwater robot without tether
- Usually pre-programmed to perform autonomous missions
- Often stores data locally until mission is complete
- Limited battery time depending on size
- Flexible, can work in environments without a tether that can get tangled



Requirements and limitations based on size

The size of the UUV will determine how it can be used and the demands on infrastructure:

- **Payload:** Larger UUVs can be equiped with more sensors or tools
- **Deployment:** Larger UUVs require a crane, smaller ones can be deployed directly
- Size and weight will affect **passive stability** of the robot

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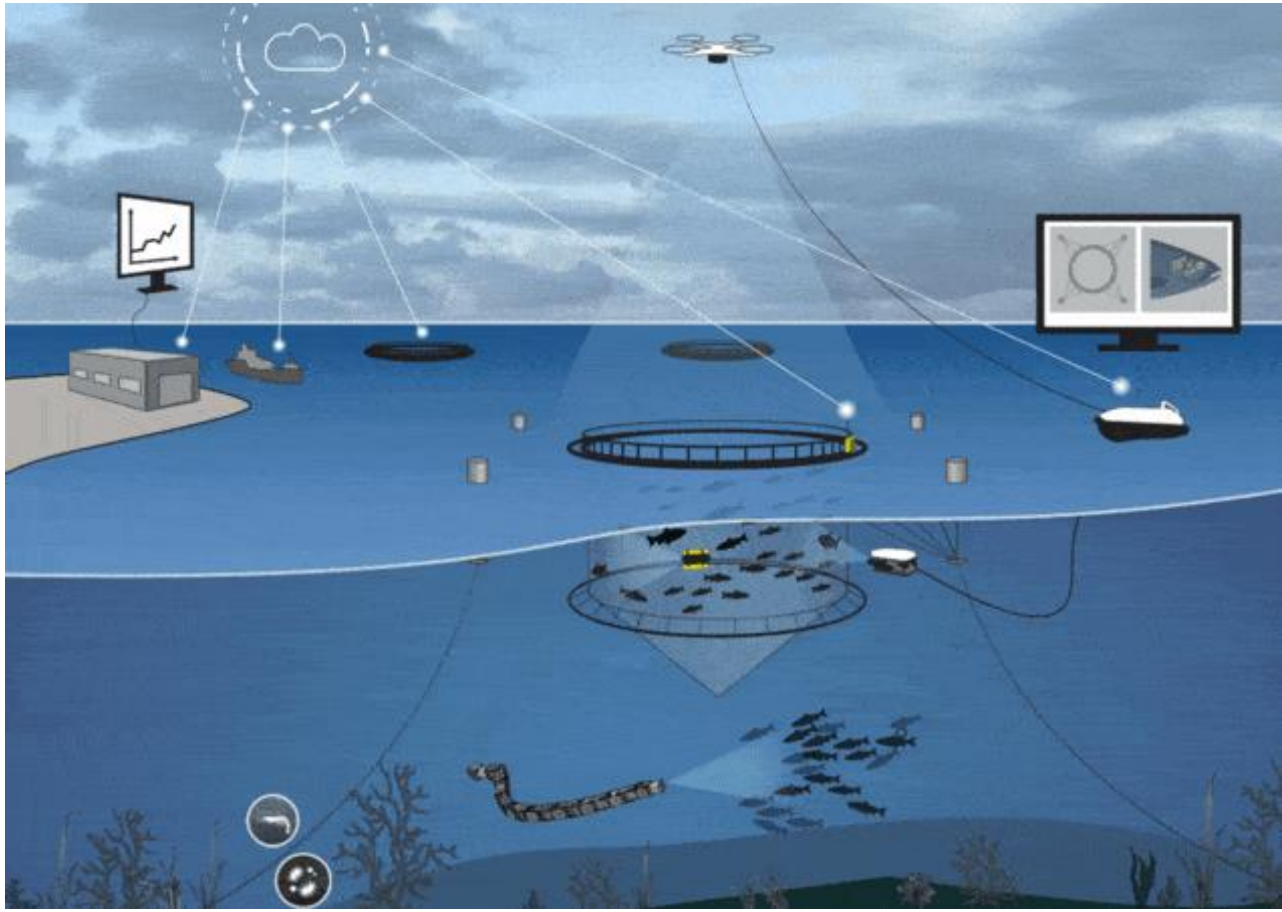
Benefits and limitations of tether

- Robots with tether:
  - Power, no limitations on battery time
  - Real time data transfer (e.g. video)
  - Allows for real-time remote control from the surface

- Unthered robots
  - More flexible in environments with many obstacles (ropes, wires etc.)
  - Generally used for autonomous, pre-programmed missions

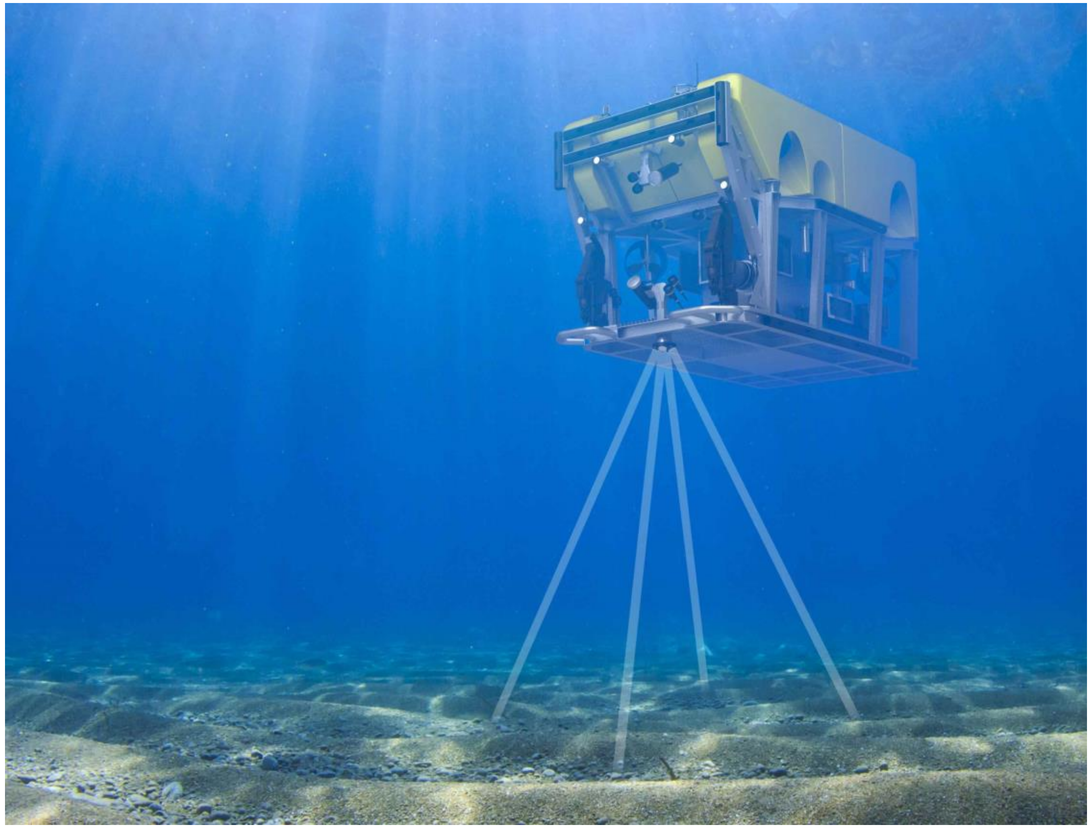
ROVs (tethered robots) considered safer to use because of hard-wired communication



Challenge: Localization under water

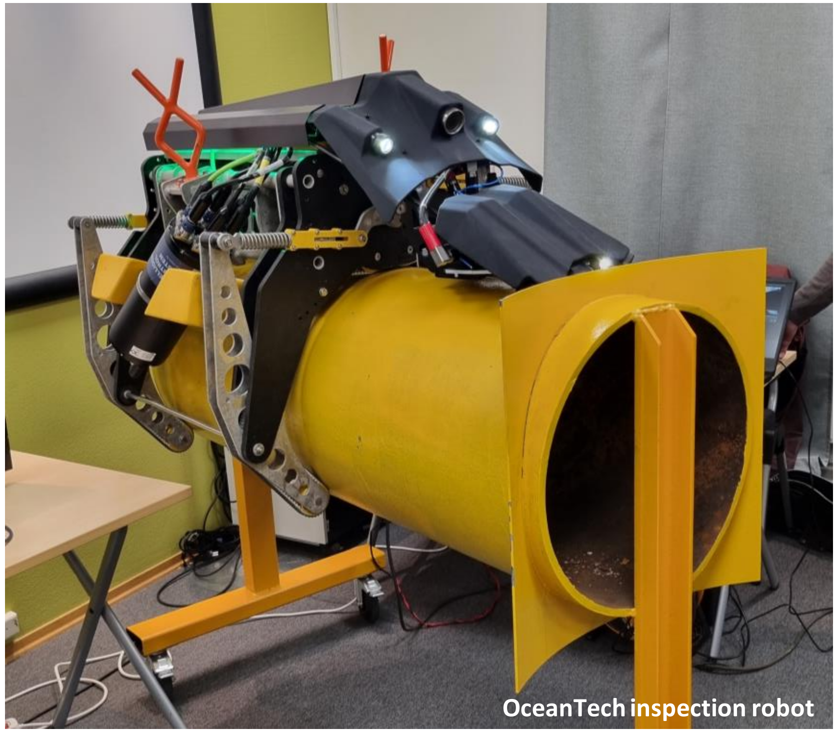
- Electromagnetic waves don't work well underwater, e.g. no GPS.
- We use sound-based sensors instead.
  - Long range
  - Works in turbid waters
  - Velocity + distance

  - Expensive
  - Not as accurate as laser (cm +)



Typical inspection tasks:

- Net inspections in aquaculture
- Ship hull inspections, pipeline inspections
- Inspection of sub-sea structures in oil and gas
- Surveying of sea bottom (biological, geological, archeological)
- Inspection of wreckage/search and rescue



OceanTech inspection robot

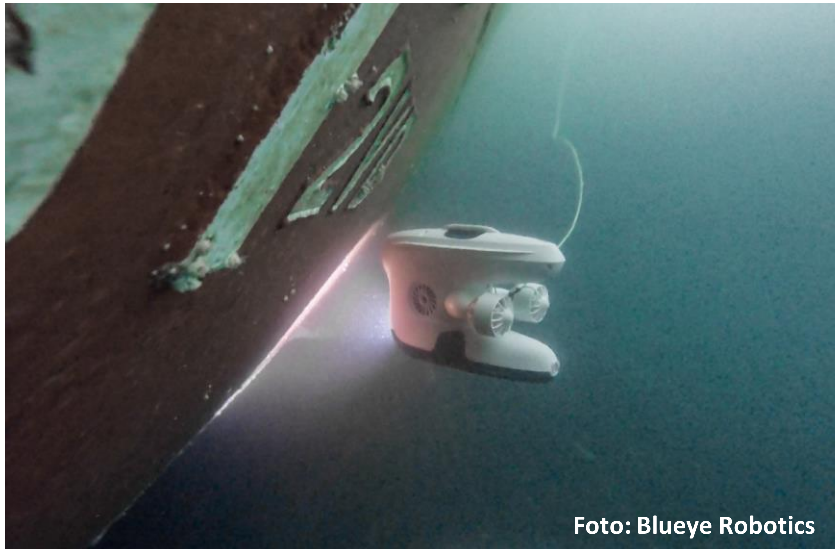
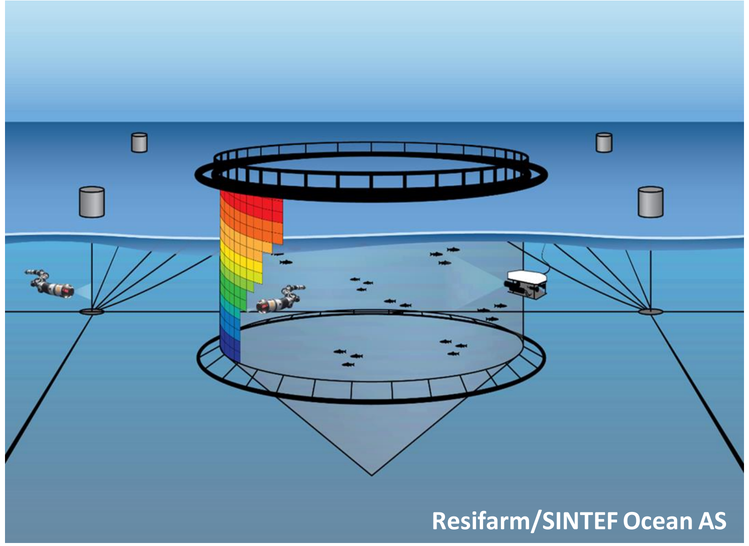
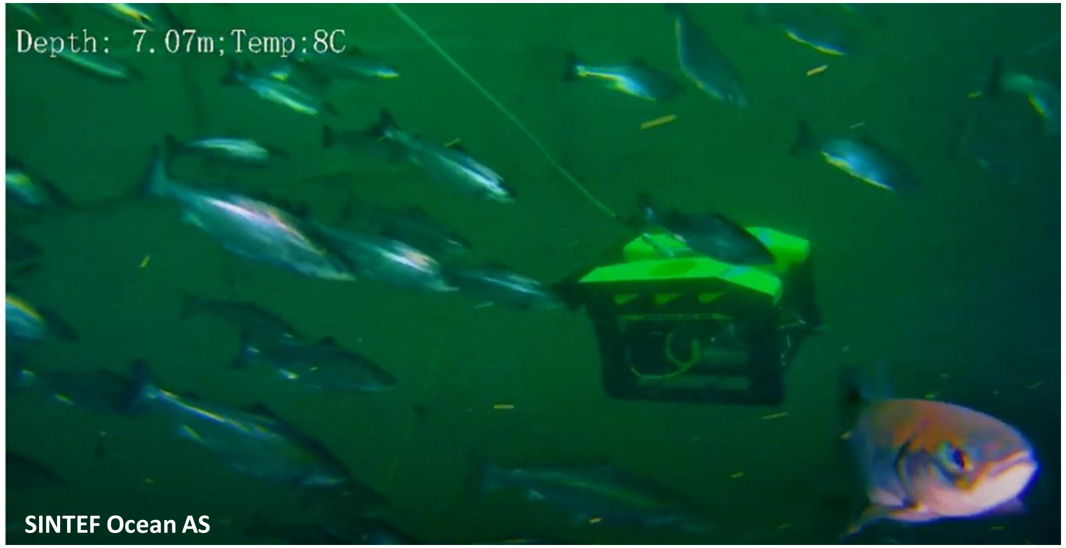


Foto: Blueye Robotics

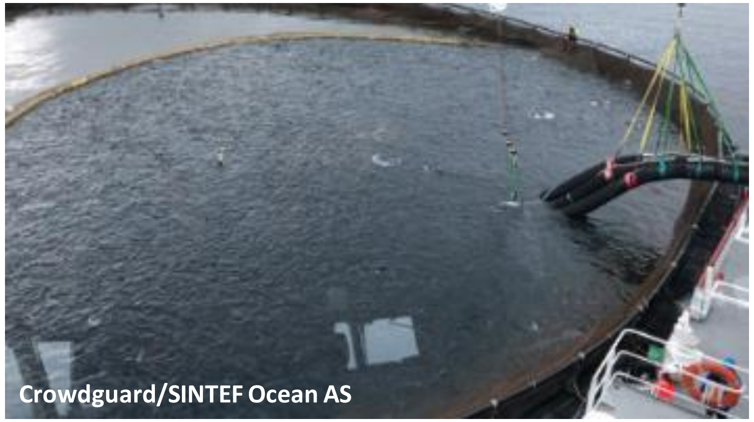
Inspection task example: Monitoring of biomass

- Monitoring of fish in aquaculture using ROVs:
  - Fish behaviour during crowding operations
  - Detecting damaged fish, winter soars
  - Monitoring amount of sea lice


Resifarm/SINTEF Ocean AS



SINTEF Ocean AS


Crowdguard/SINTEF Ocean AS

Typical intervention tasks:

- Cleaning of ship hulls, fish farms, equipment
- Net repair in aquaculture
- Repair and patching of pipes, equipment in oil and gas
- Sampling of water, biological sampling
- Transportation of equipment to/from ocean floor

Intervention task example: Cleaning

Foto: SINTEF Ocean AS

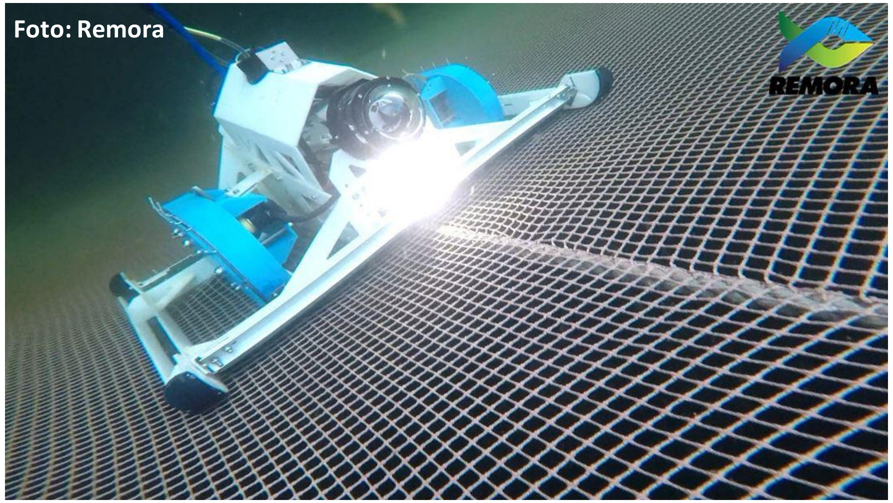


Foto: Remora

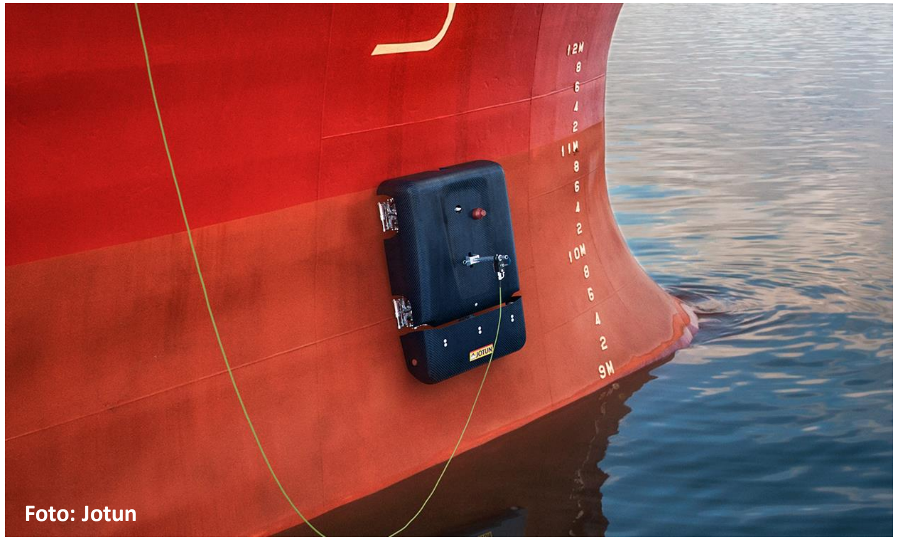


Foto: Jotun

- Relevant in several industries, such as aquaculture, oil&gas, shipping
- Can reduce risk to human operators
- Can allow for more continuous cleaning
- **Status today:** Some autonomy/remote control but mostly performed by divers/on land

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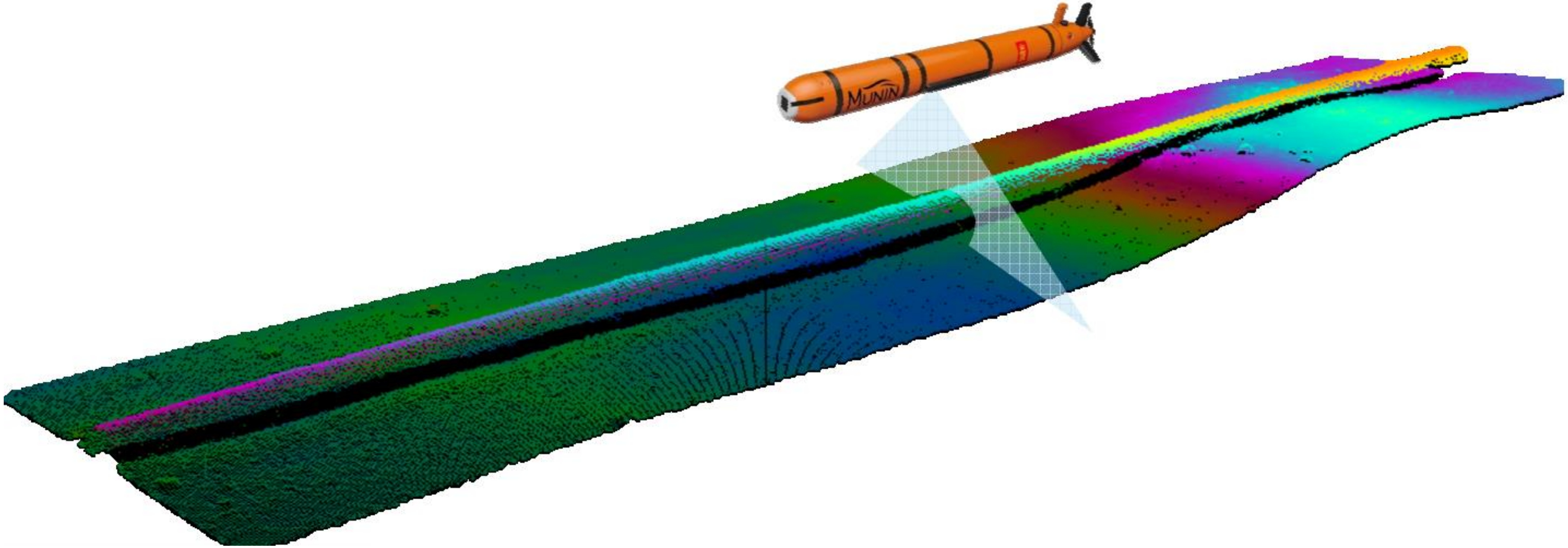
Intervention task example: Repair work

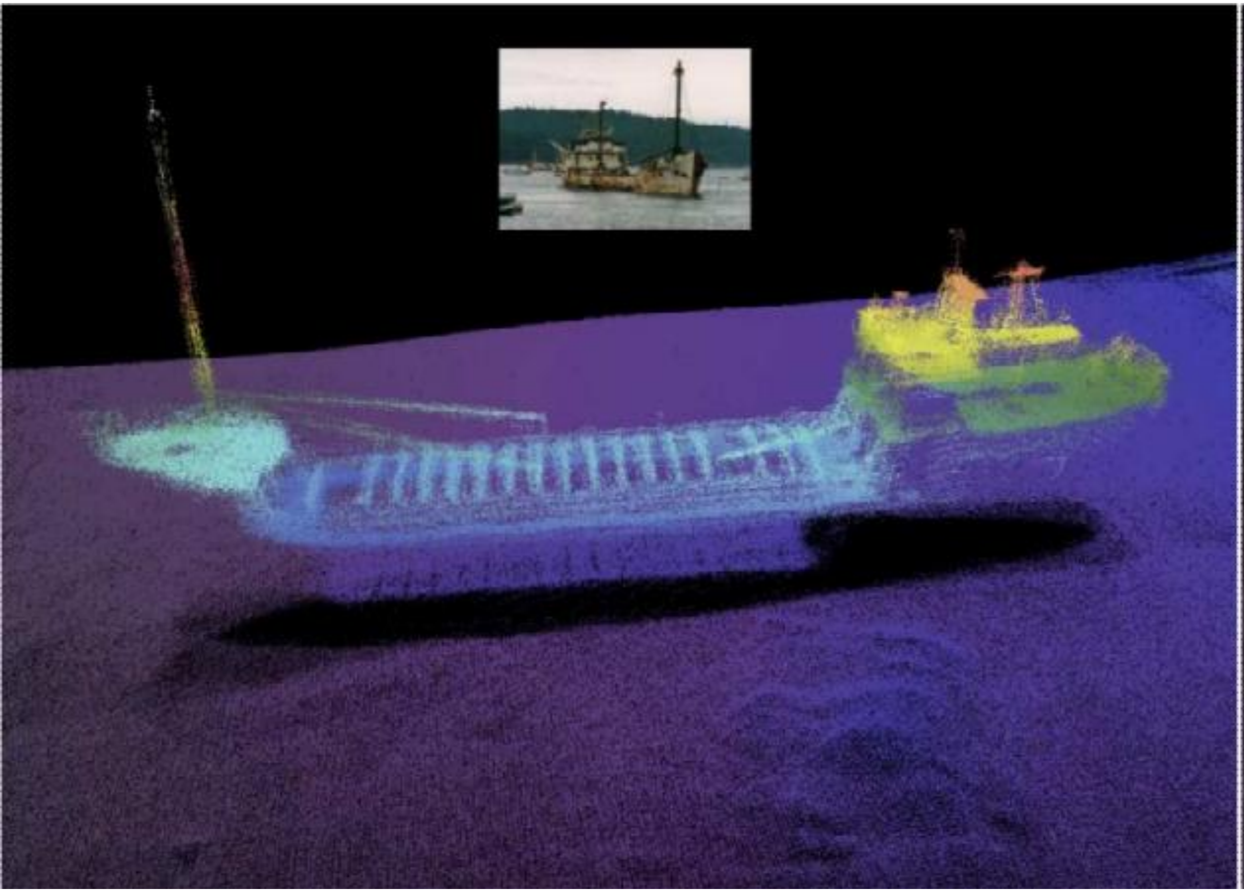
- Repairing nets in fish farms
- Repairing underwater structures in oil and gas, shipping
- **Status today:** Low degree of autonomy, mostly research stage. Performed by divers or on land

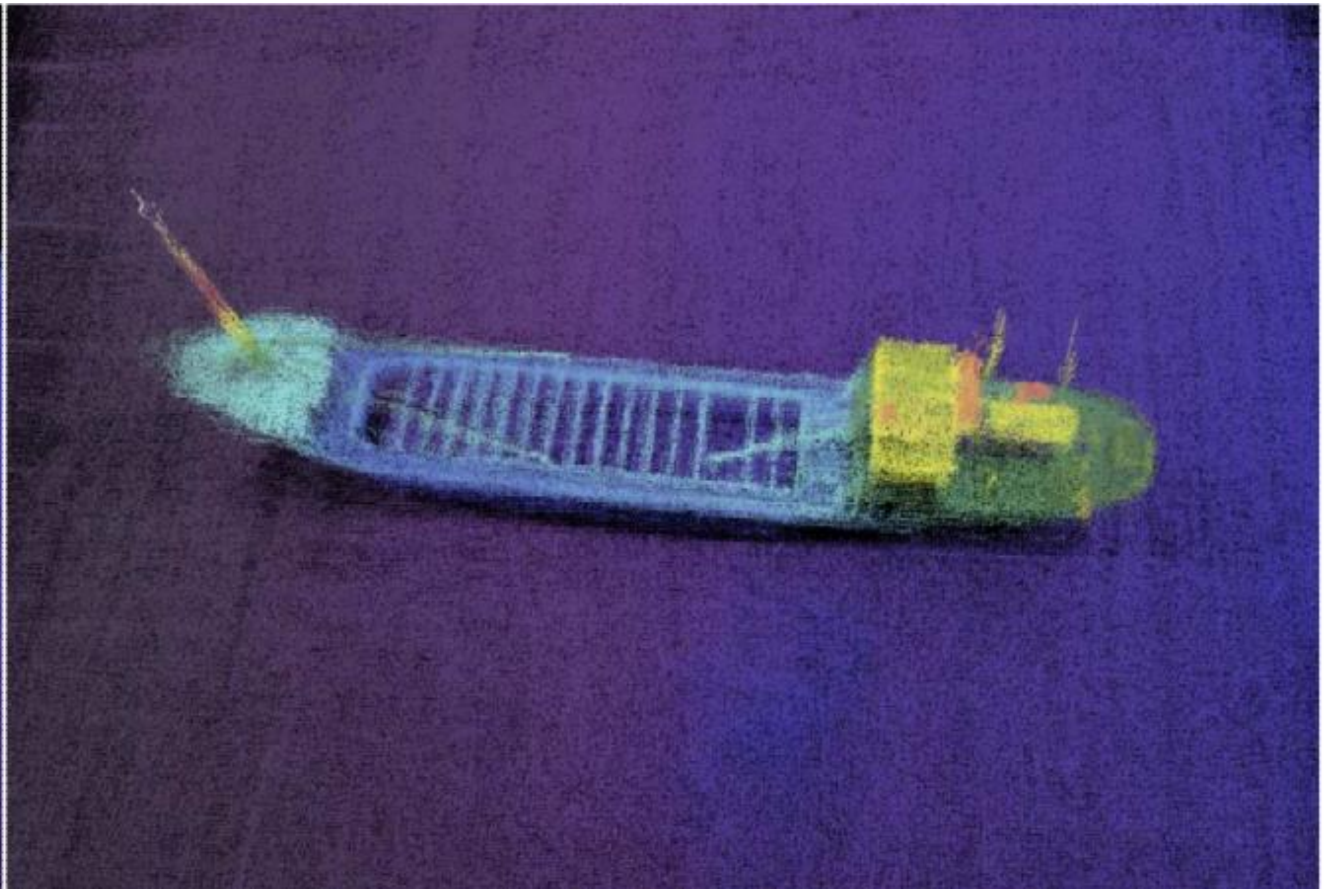
Task: Pipe following

- Vital for oil and gas industry
- Already highly autonomous



Pipe following: sidescan sonar



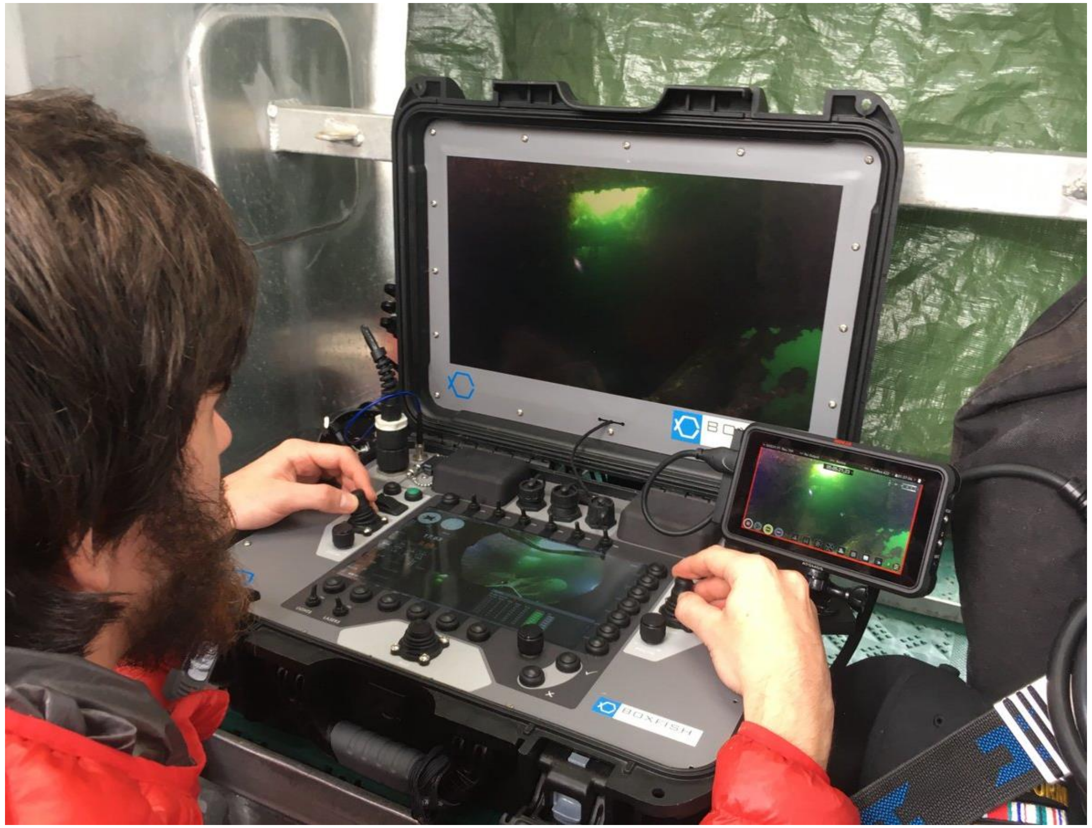


Nord stream eksplosjon

Where is the technology headed

- Today, Remotely controlled ROVs, AUVs that you launch for a specific mission.

- Limitid autonomy:
  Auto-depth
  Pipe-following



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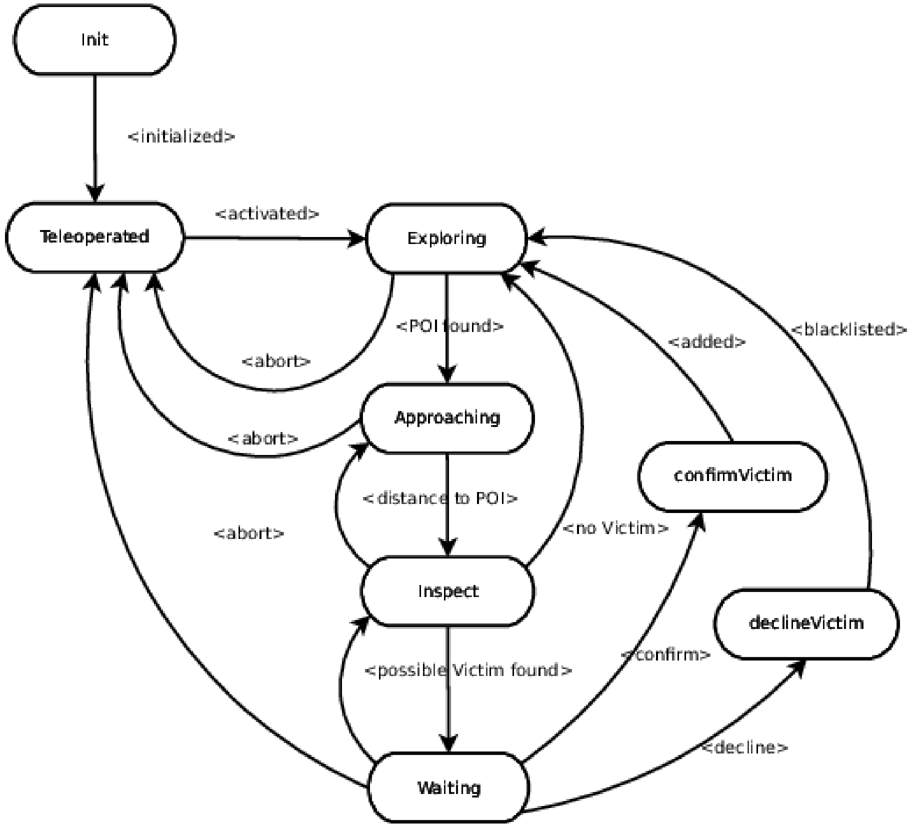
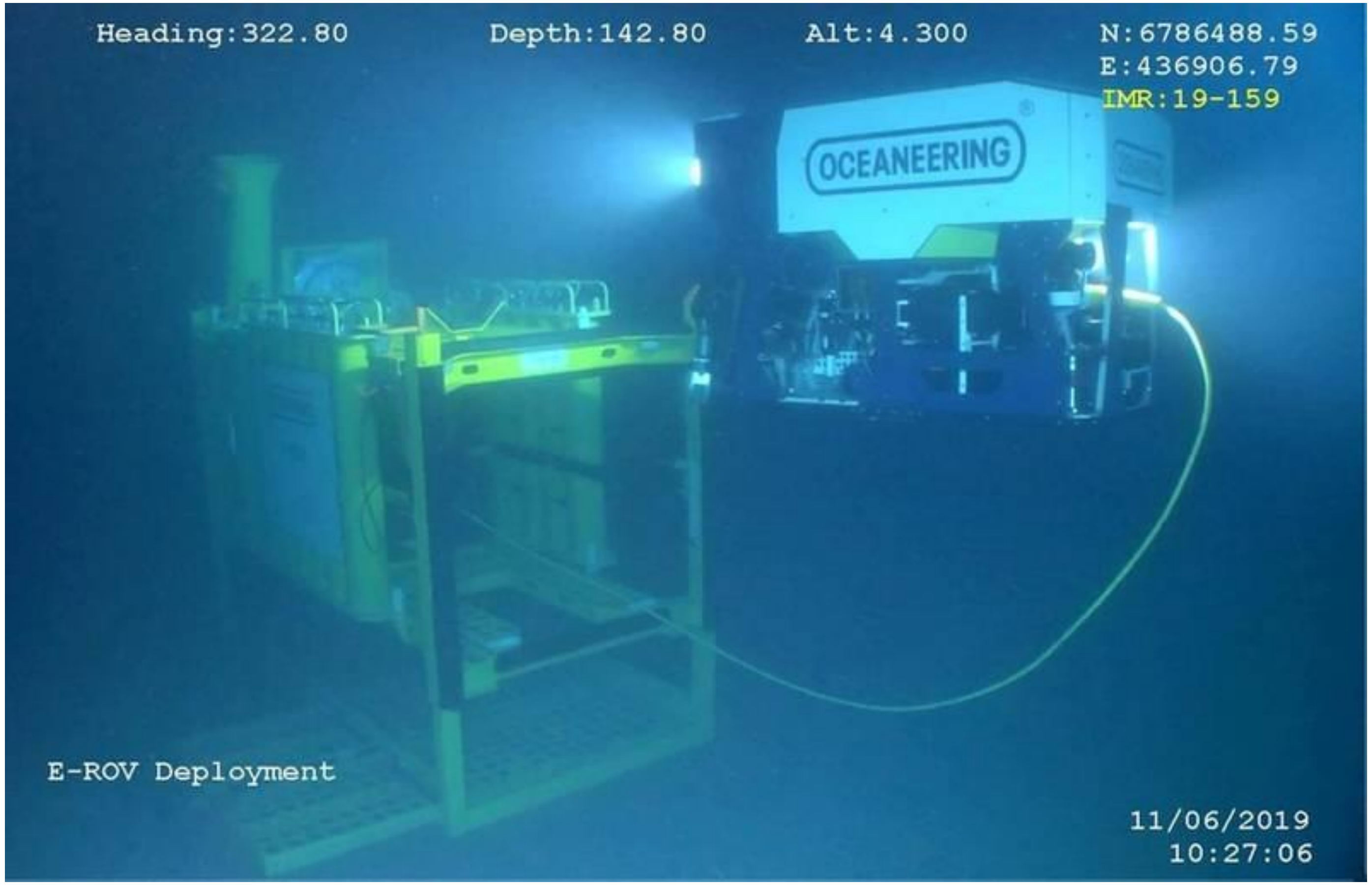
Trends: Increased Autonomy

- Developments in AI has not yet had a big impact on robotics, (Moravec's paradox).
- Researchers try to build autonomous systems that plan on their own, only require human oversight.
- Autonomy at the edge.
- Should be able to handle unexpected situations.



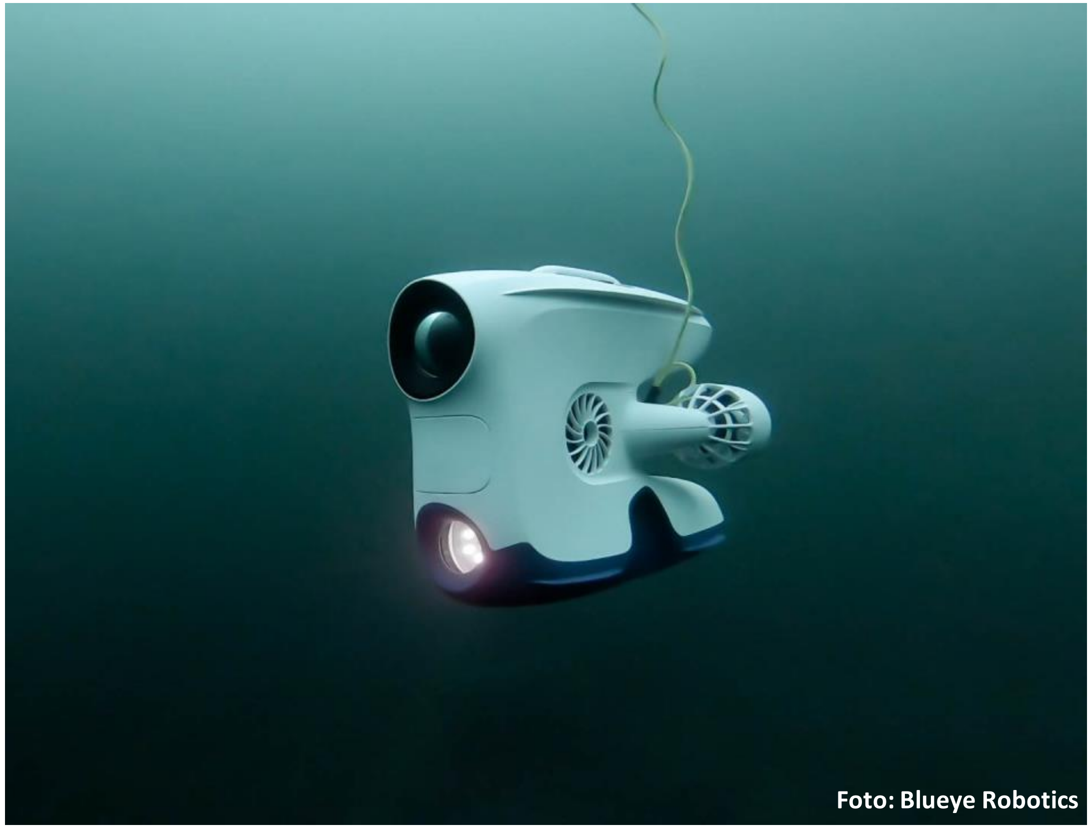
Trends: Resident vehicles

- Resident vehicles stay underwater for a long time, e.g. 1 year.
- Added complexity
- Harsh conditions



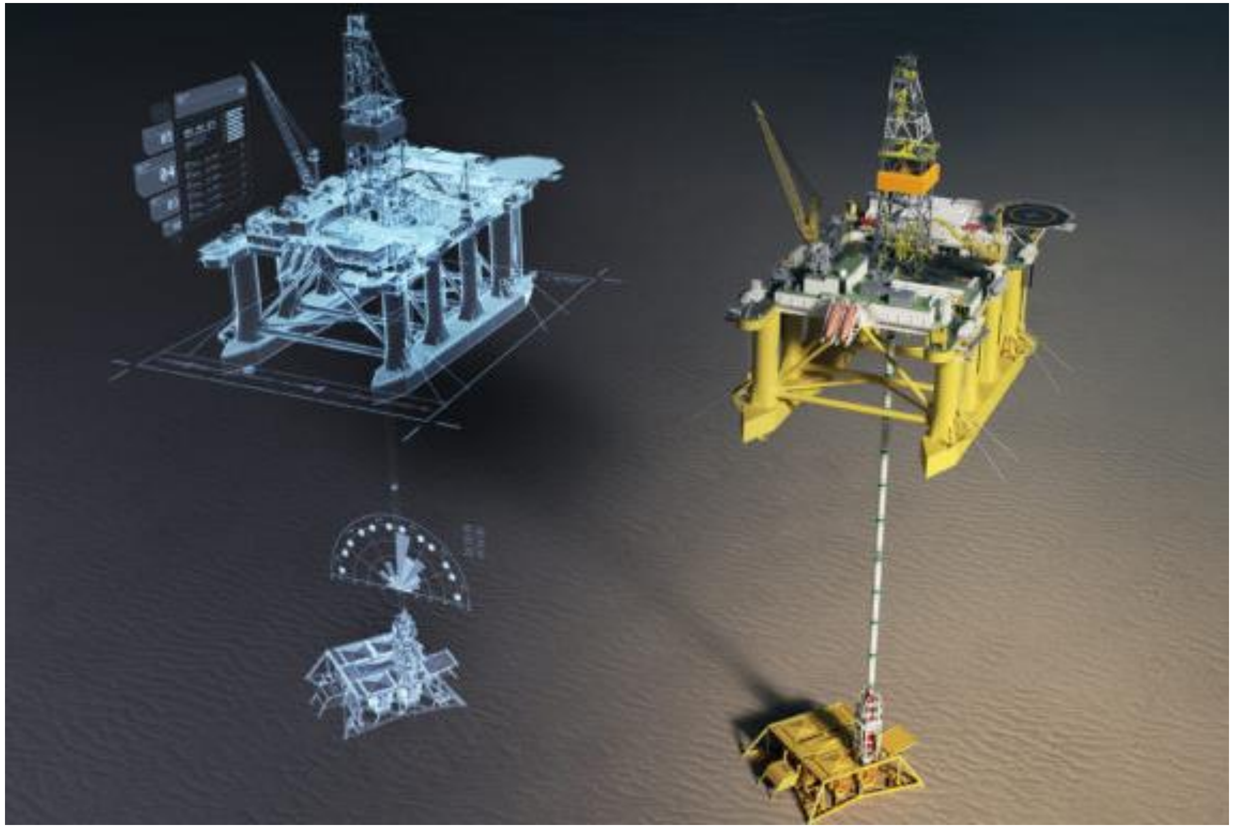
Trends: Lower price, but not like drones

- Growing UUV market leads to lower prices.
- Underwater vehicles will need to enter the consumer market to get similar prices as flying drones.
- Hydroacoustic sensors are expensive.



Trends: Digital Twin

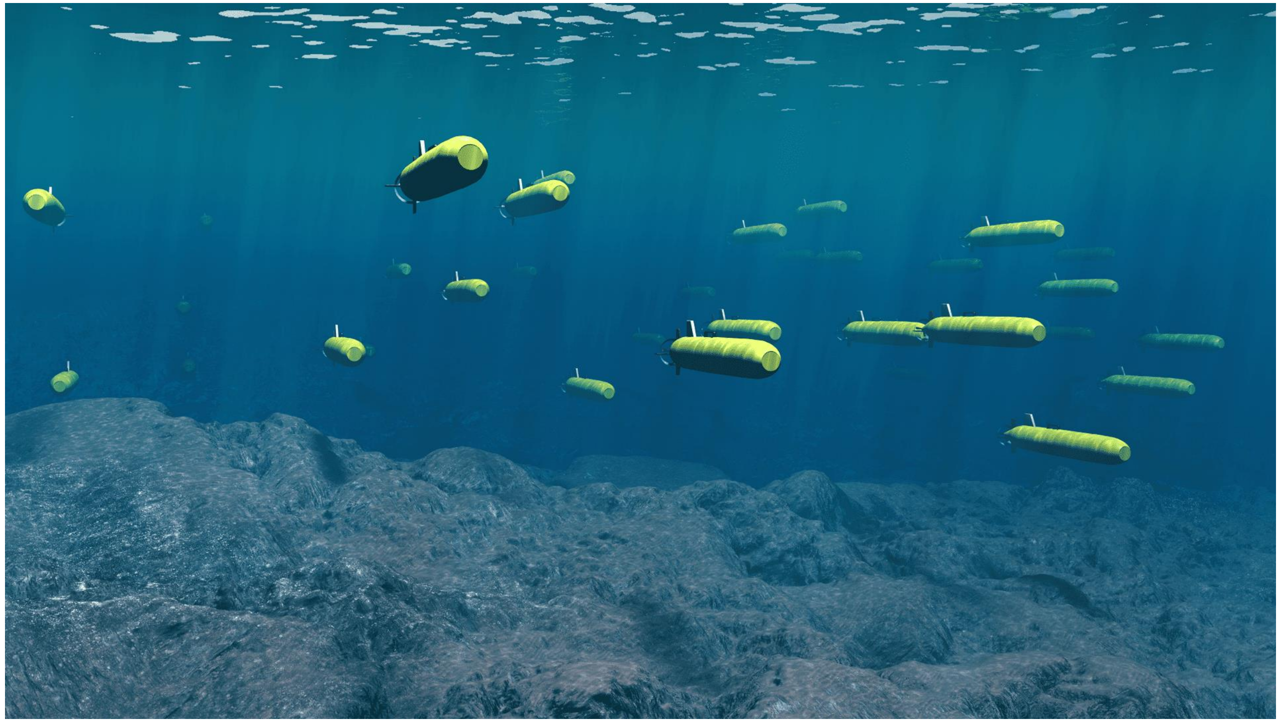
- Digital model of your infrastructure.
- planning
- Visualization
- Mapping



Trends: Swarm

- Many possibly different vehicles working together.
- Better communication.
- Expanded capabilities

- Far from reality



To summarize:

- Underwater robots are at this time used more for inspection than intervention tasks
- Large market: Similar challenges in different industries
- Can increase productivity: Robots can work 24/7 and don't need vacation
- Can increase safety of operations: Safety for human operators + avoiding human error
- As in other parts of robotics, the trend is towards more autonomy

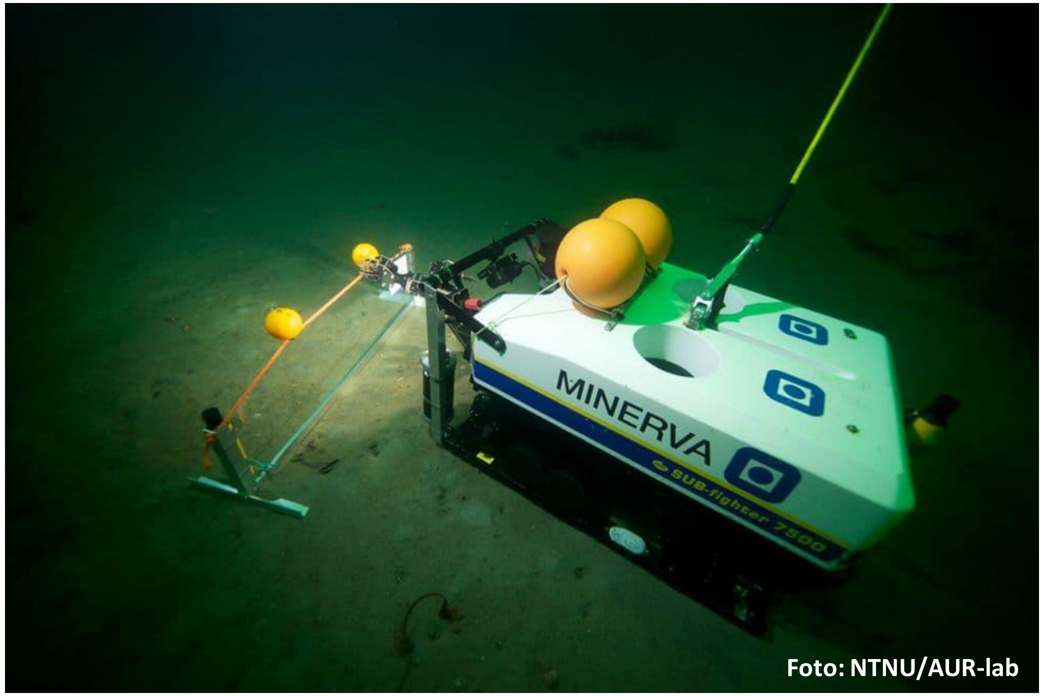


Foto: NTNU/AUR-lab

Thank you for your attention!

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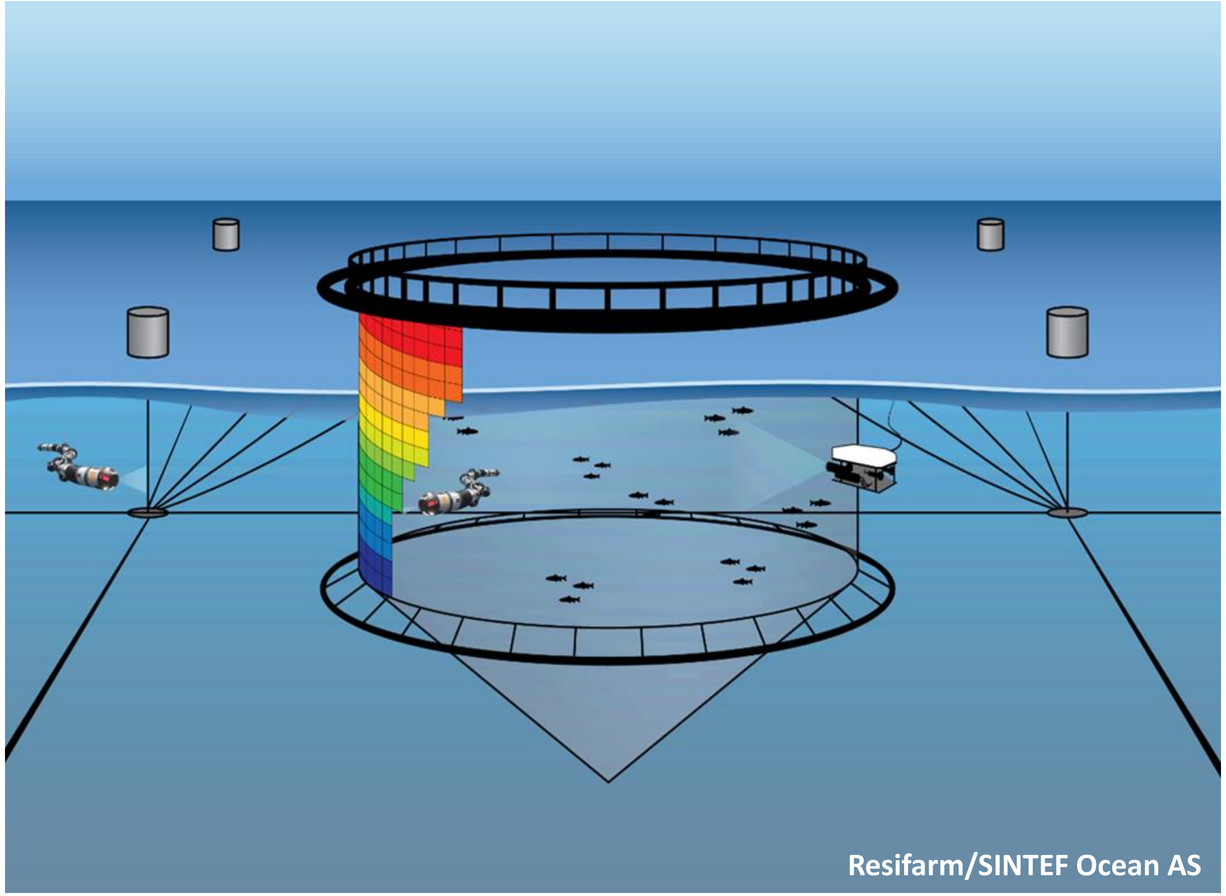


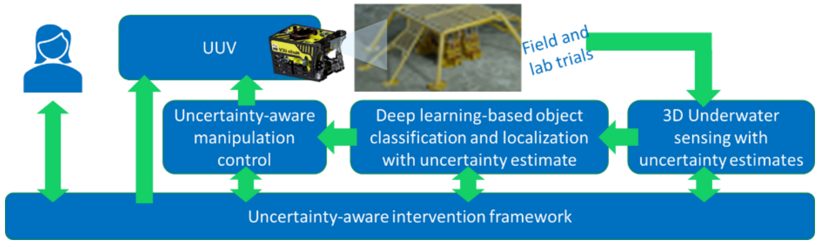
Technology for a
better society

Autoport When AI optimizes port logistics and management

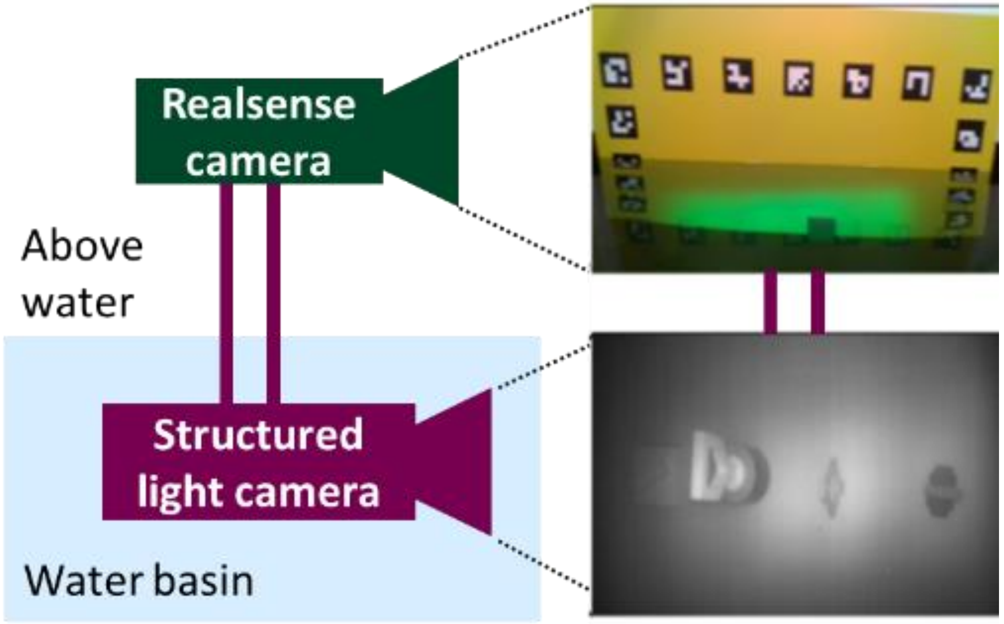
- ?

SAFESUB: Safe and Autonomous Subsea Intervention (2023-2026)

- Develop underwater 3D vision, detection and localization with associated uncertainties
- Account for uncertainties in planning and control to ensure safe and robust manipulations
- Aggregate uncertainty field to optimize manipulation and reduce operational risk
- Partners: SINTEF, NTNU, IKM Subsea, Imenco



The SAFESUB pipeline considers uncertainty estimates at all steps



Setup at SINTEF to automatically label training data for machine learning in SAFESUB

Limitation: AUV Communication