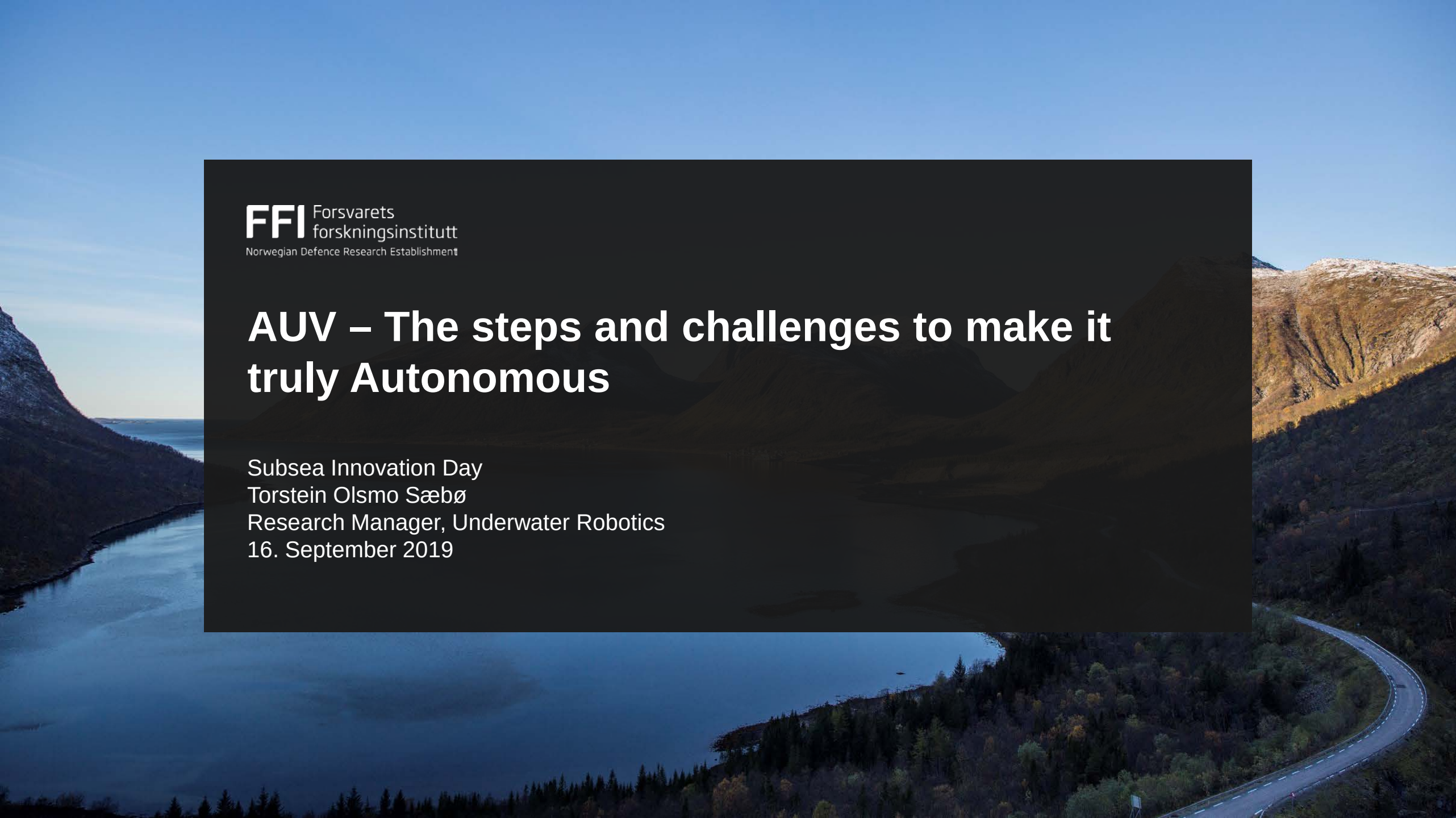


FFI Forsvarets forskningsinstitutt
Norwegian Defence Research Establishment

AUV – The steps and challenges to make it truly Autonomous

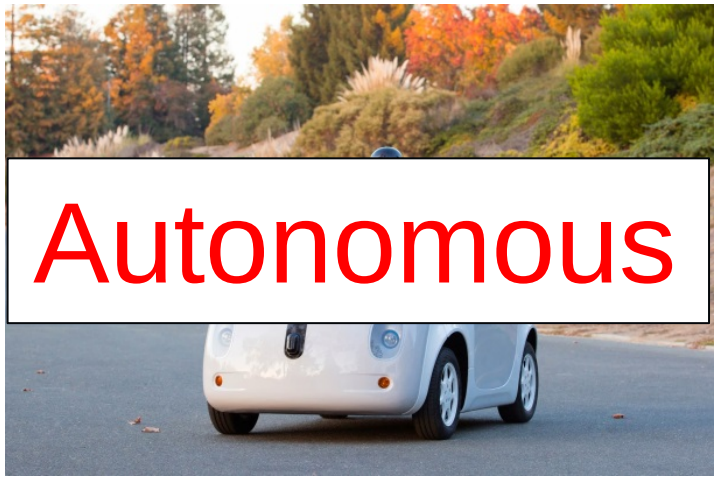
Subsea Innovation Day
Torstein Olsmo Sæbø
Research Manager, Underwater Robotics
16. September 2019

What is an Autonomous System?

Automatic

Pre-programmed

Remotely operated



Autonomous

HUGIN Autonomous Underwater Vehicle (AUV)

Tidligere leverte Hugin-systemer (prototyper) i bruk på KNM Karmøy. (Bilde: Sjøforsvaret)

HUGIN AUV

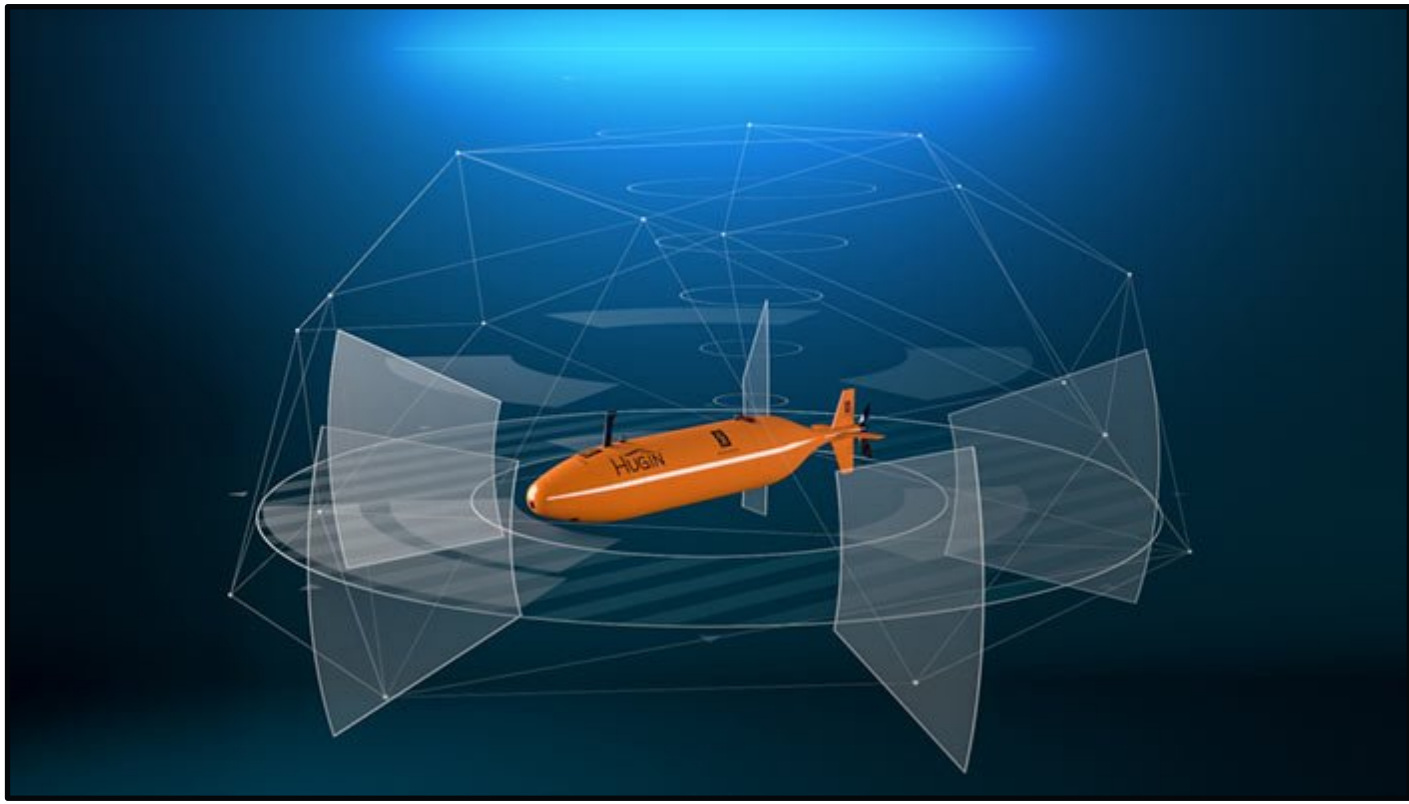
Forsvarets siste bestilling er en milepæl i overgangen til mer autonom krigføring

Why do we want Autonomous Systems?

- Cost efficient
- Scalable
- Reduced personnel risk

- Less routine tasks
- Increased security
- «Fancy» improves sales

- **Improved performance**



Increased autonomy

Supervised

Accompanying surface vessel

Acoustical updates of status, commands and position

Automated

Prior, fixed plan

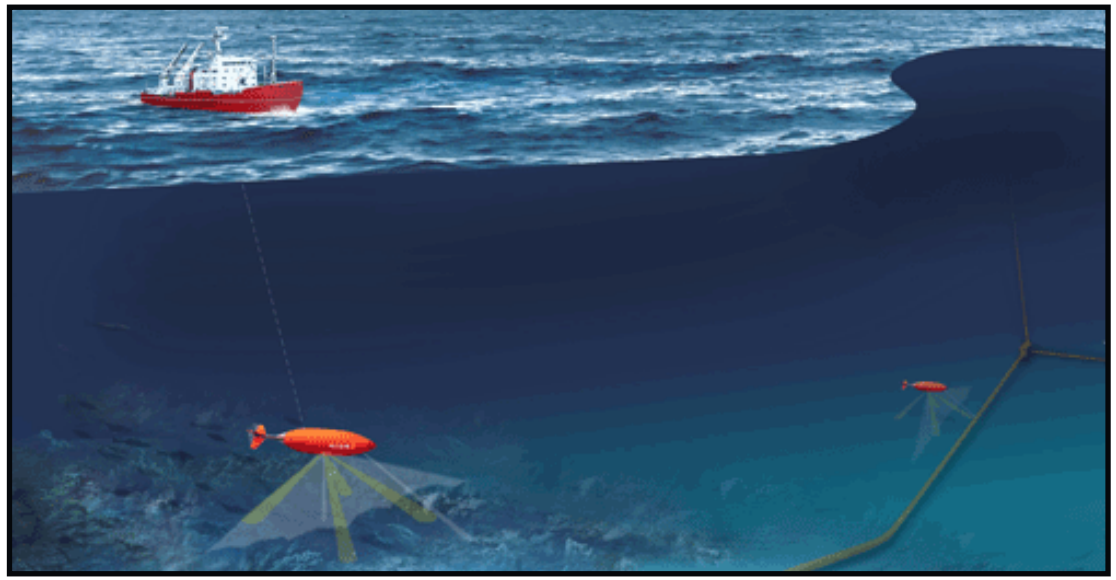
Autonomous navigation

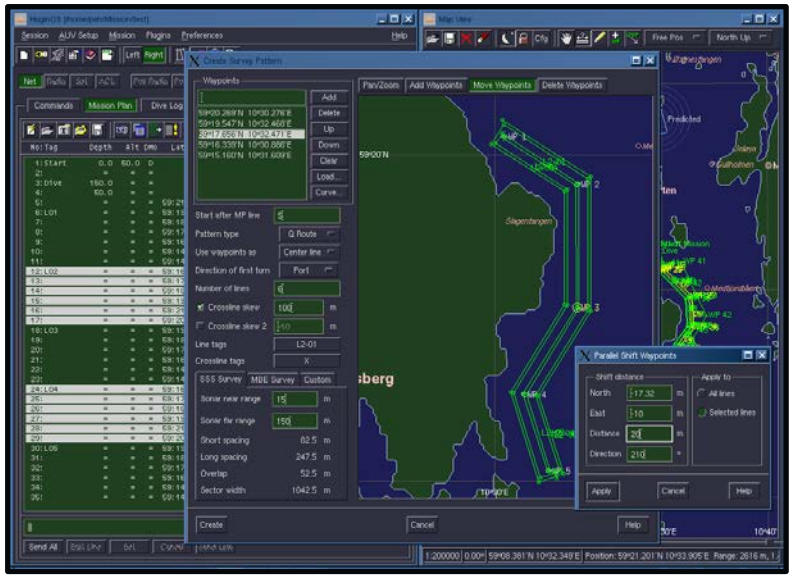
Emergency actions

Truly autonomous

Adaptive plan

Adapt to environment, status and sensor data to reach mission goals



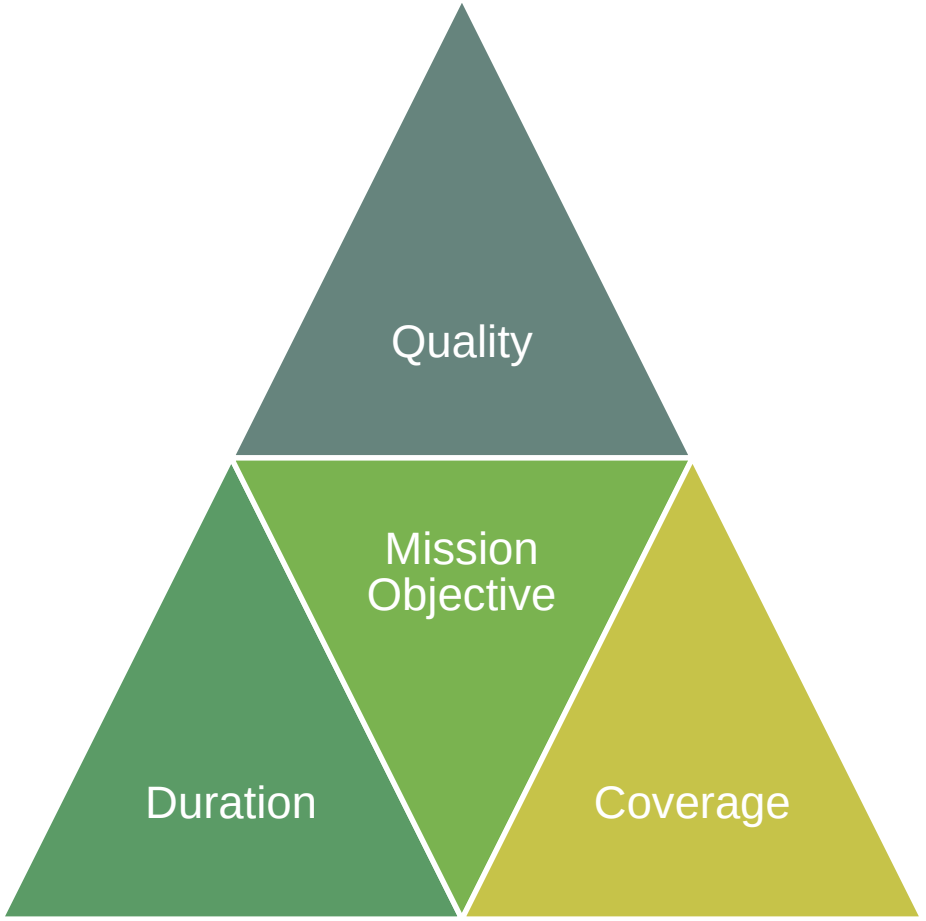


Autonomy vs predictability

- In a pre-planned, non-autonomous AUV operation mission duration and coverage are fixed, while quality is unknown

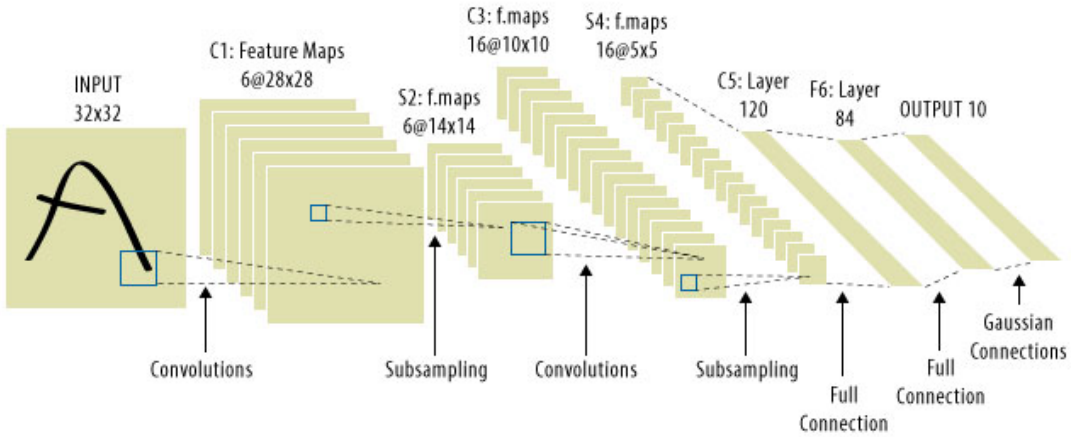
- With adaptive behavior you **have** to choose between:
  - Unknown coverage
  - Unknown duration

- We have to change how we design AUV operations with respect to
  - Ship and crew time
  - Weather situation
  - Coordination with other systems

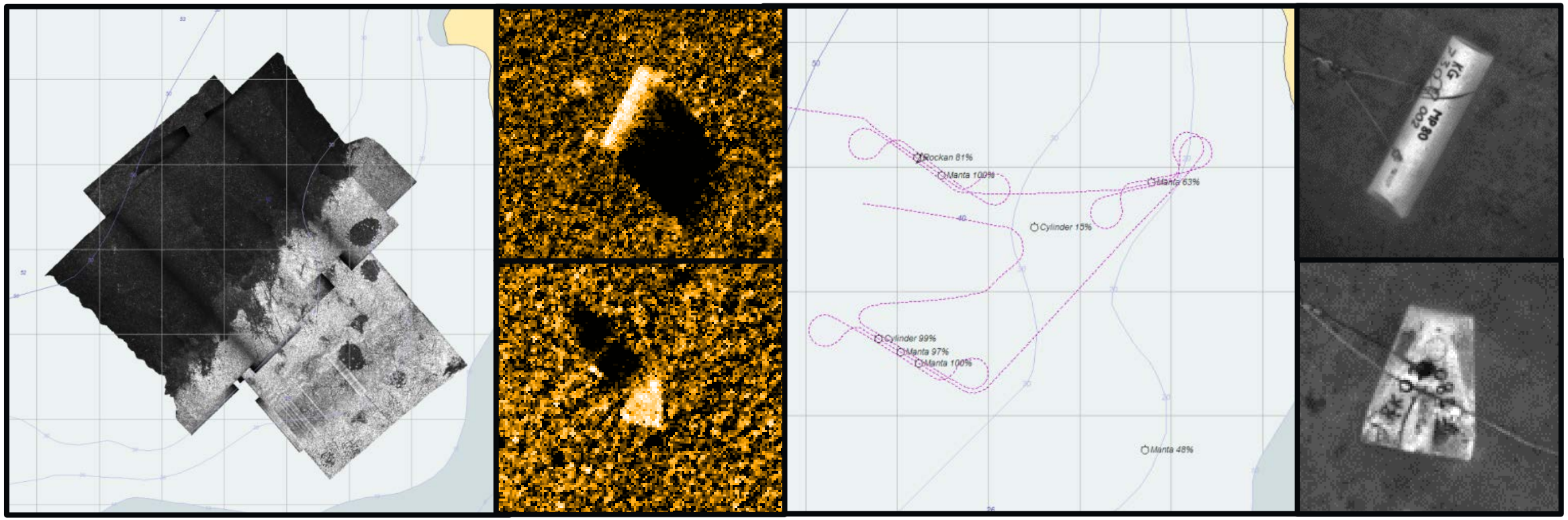


Typical misunderstandings

- Machine learning / deep learning / AI is the answer (even tough we don't know the question)
- Many small systems are cheaper and better than one big system (swarms are the future)
- Regulations and certifications have to be completely rewritten to fit new technology



Single-mission concept demonstrated during MANEX’13



Area search
In-mission SAS processing

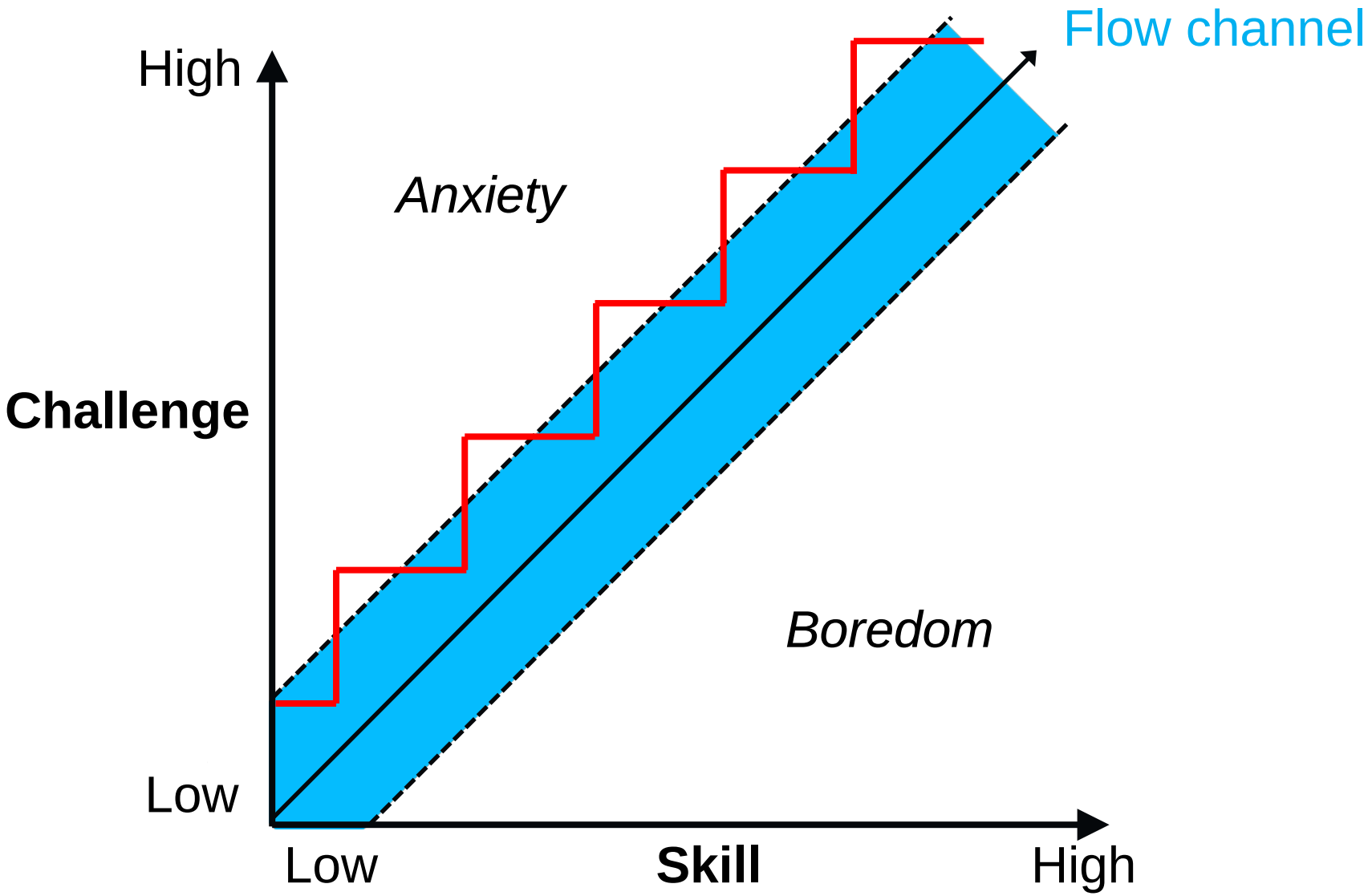
In-mission ATR

In-mission replanning

In-mission EOID

The next year…

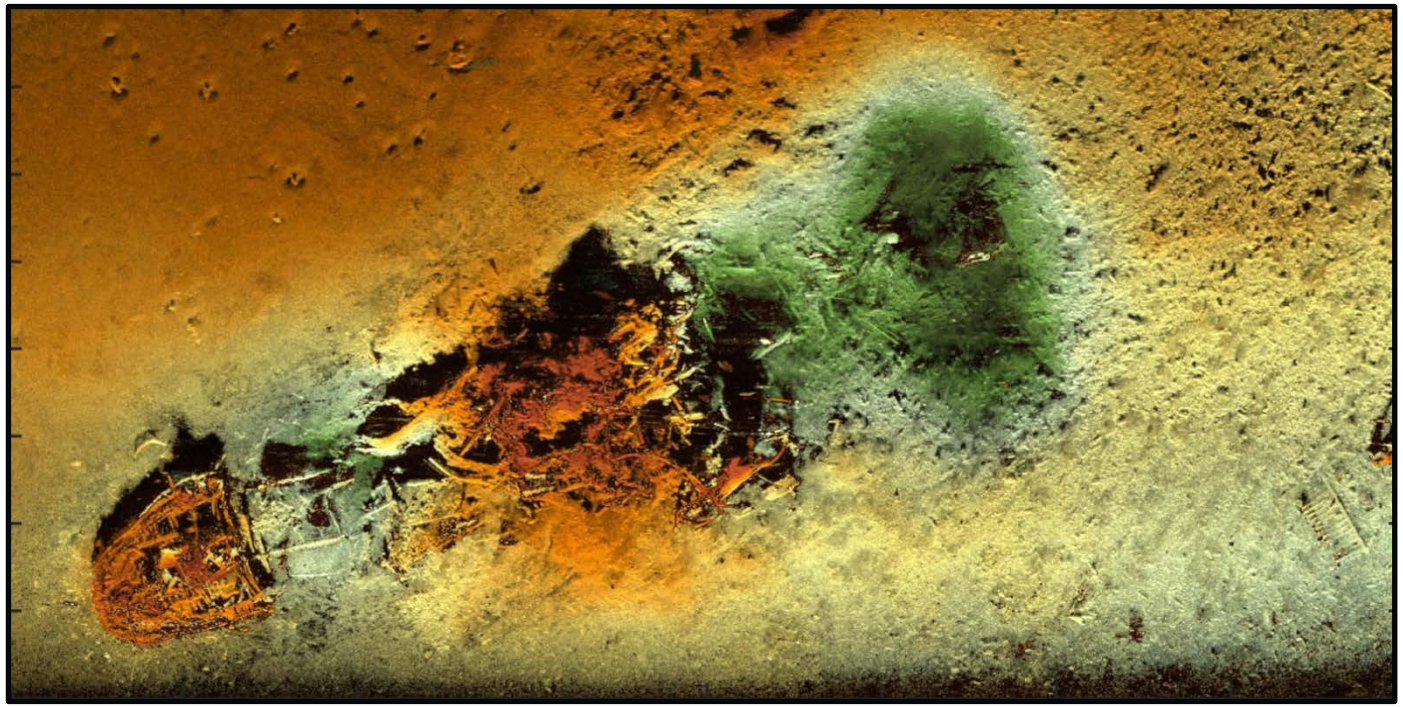
Science and experimentation are non-linear

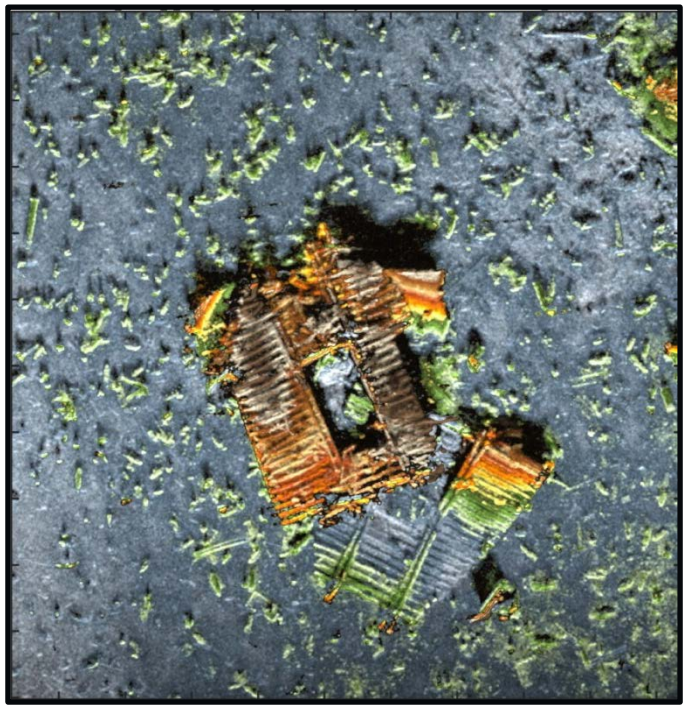


Critical technology components

- Communication
- Navigation
- Energy supply
- Sensors and sensor processing

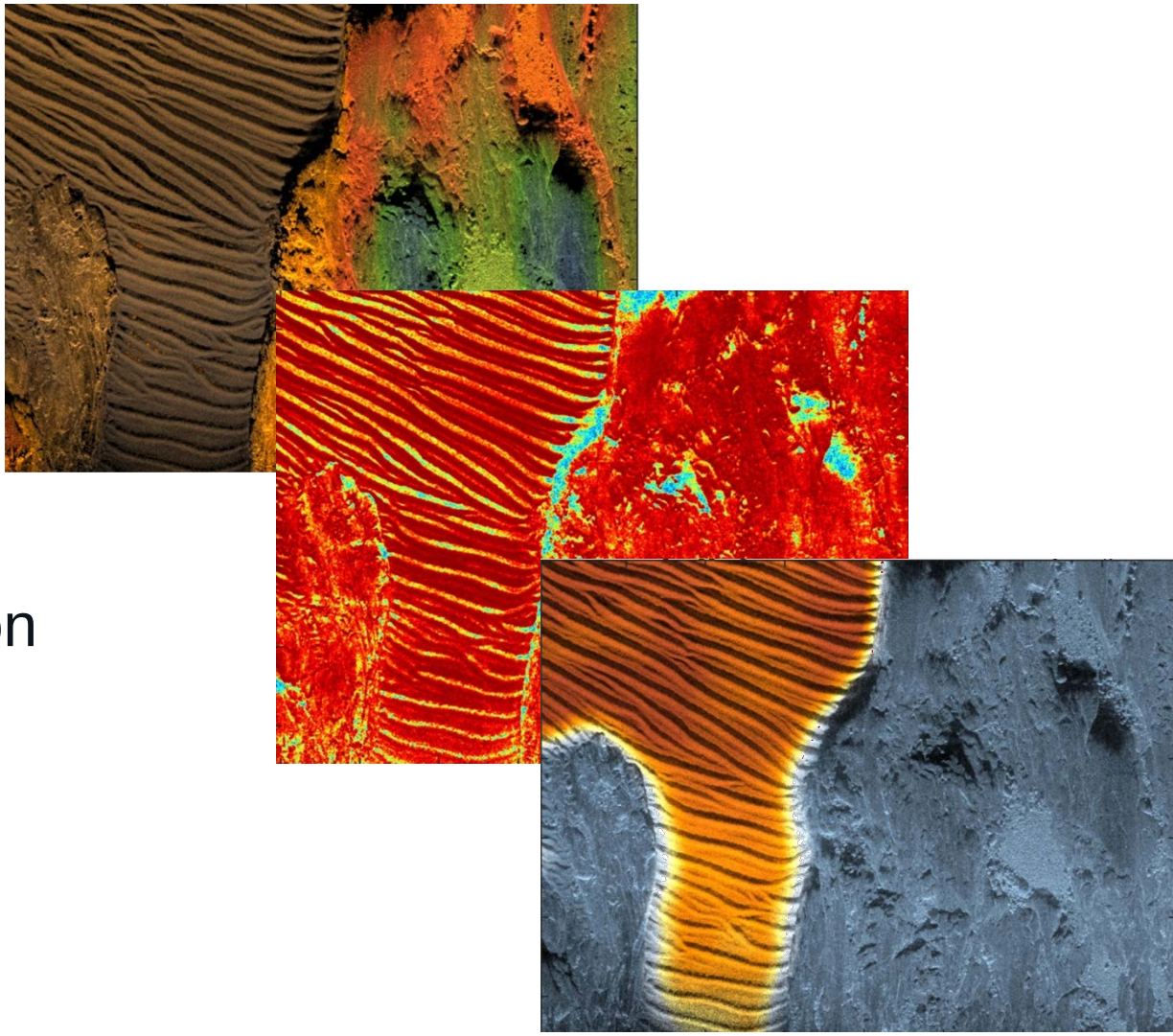
- Validation / Perfomance estimation
- Automatic datainterpretation
- Replanning and autonomy
- Error handling





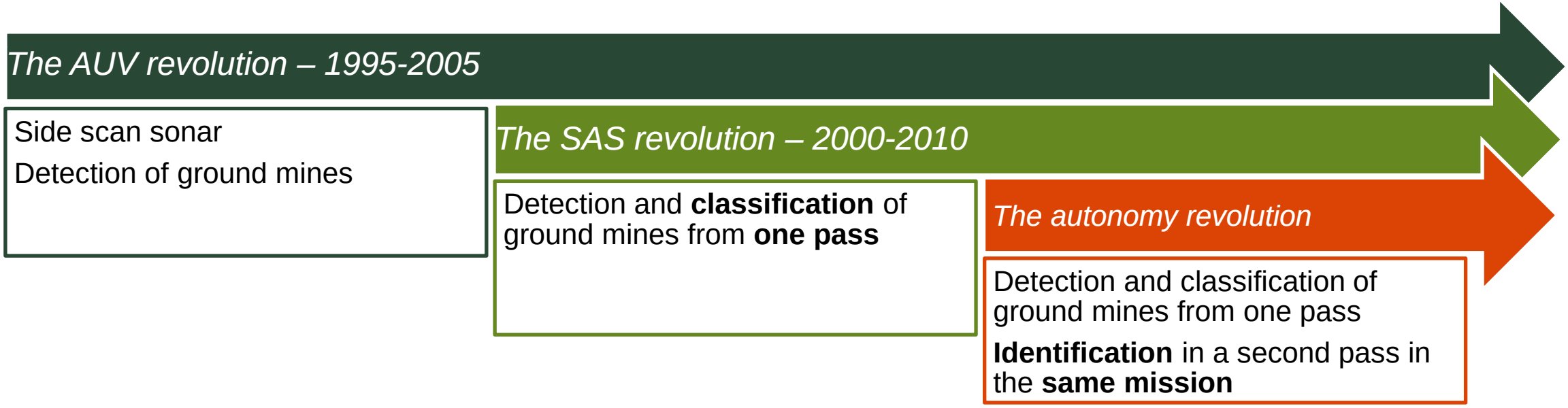
The next steps to make AUVs truly Autonomous

- More on-board processing -> provide information instead of data
- More autonomy, meaning reactive behavior
- More intelligent sensors
- More intelligent sub-systems
- Collaborative systems -> needs common standards
- «Internet of things»
- Cloud storage and processing



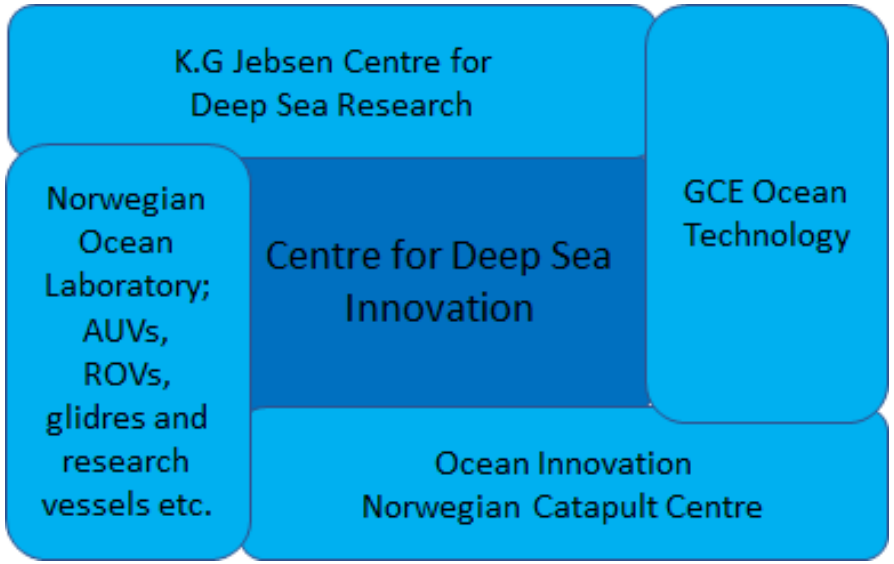
The challenges in making AUVs truly Autonomous

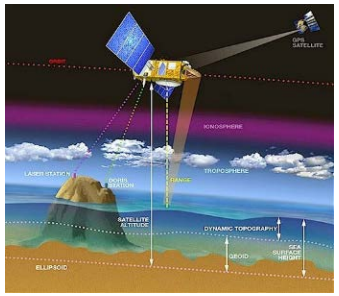
- Identifying areas and defining concepts where the utility value is clear
- Sufficiently focused development
- Industry takes responsibility for creating new markets
- Sensible ambition level for technological milestones
- Access to enough and representative training data

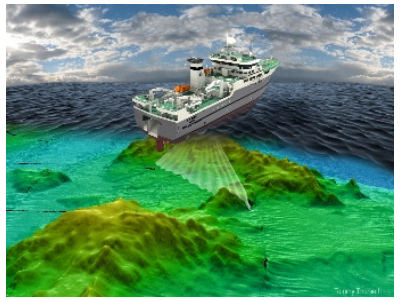


Deep Sea innovation Centre (SFI)

- Increase competence of marine minerals
  - > 30 PhD students
  - > 60 MSc students
  - Co-supervision from industry
- Partners: UiB, NORCE, FFI, HVL



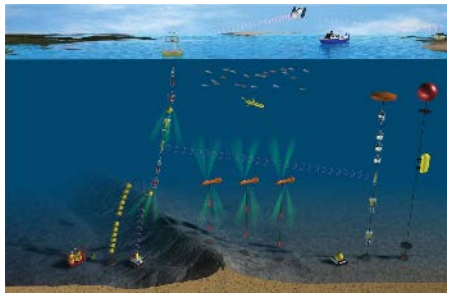

Remote Sensing

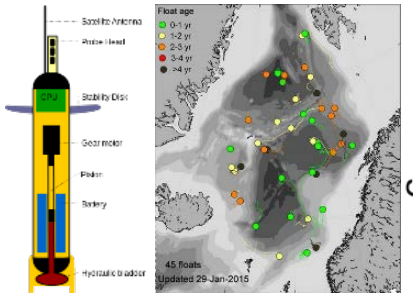

Research Vessels

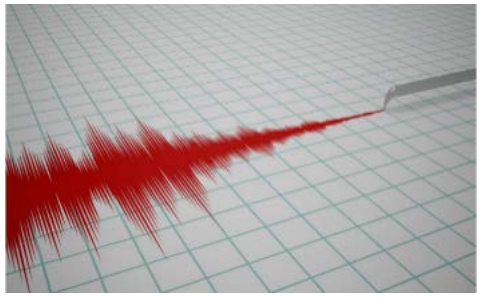

NORMAR


NORMAR II


Sailbouy


NACO


NorArgo


EPOS

LoVe

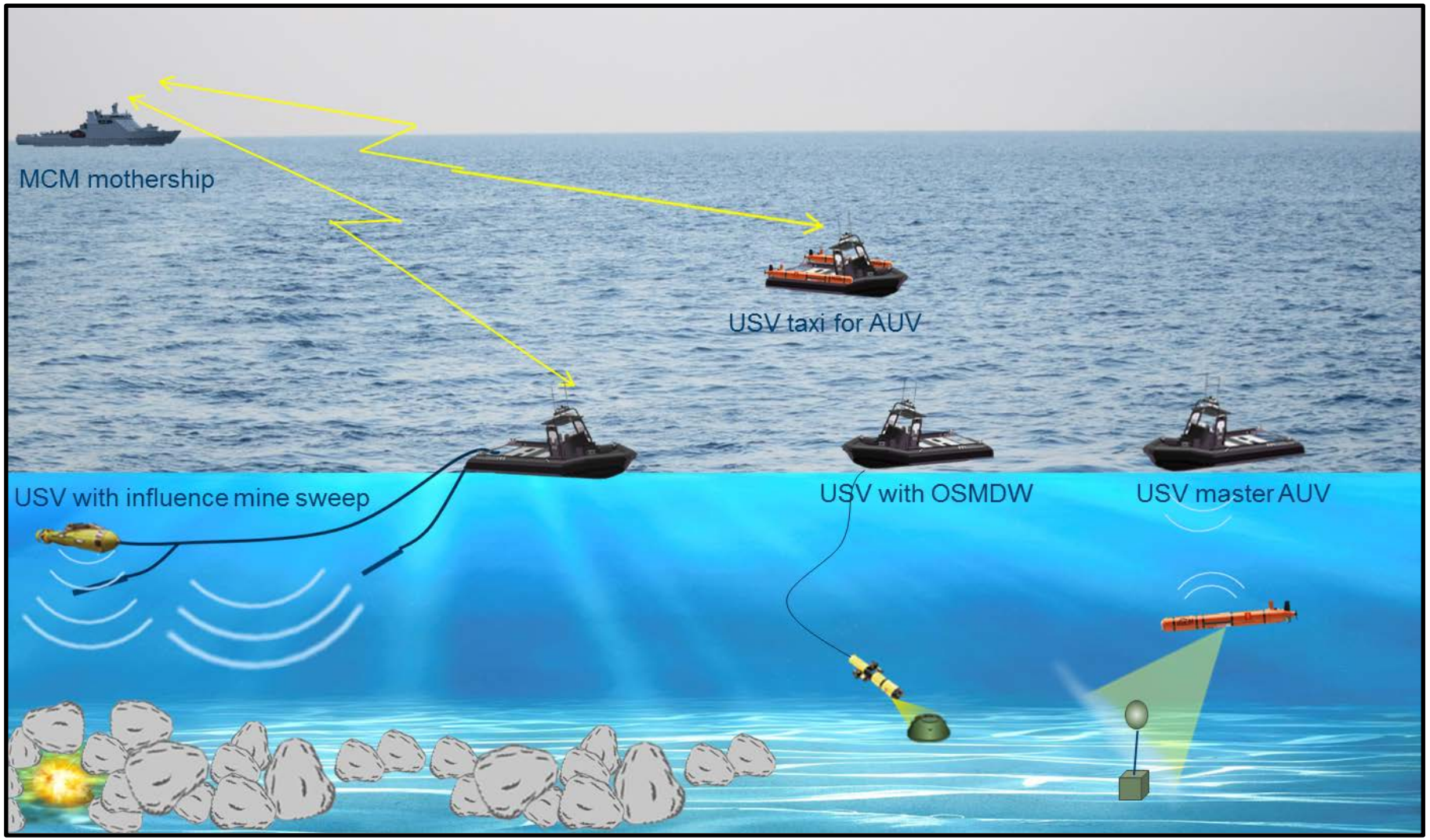
Deep Sea innovation Centre (SFI)

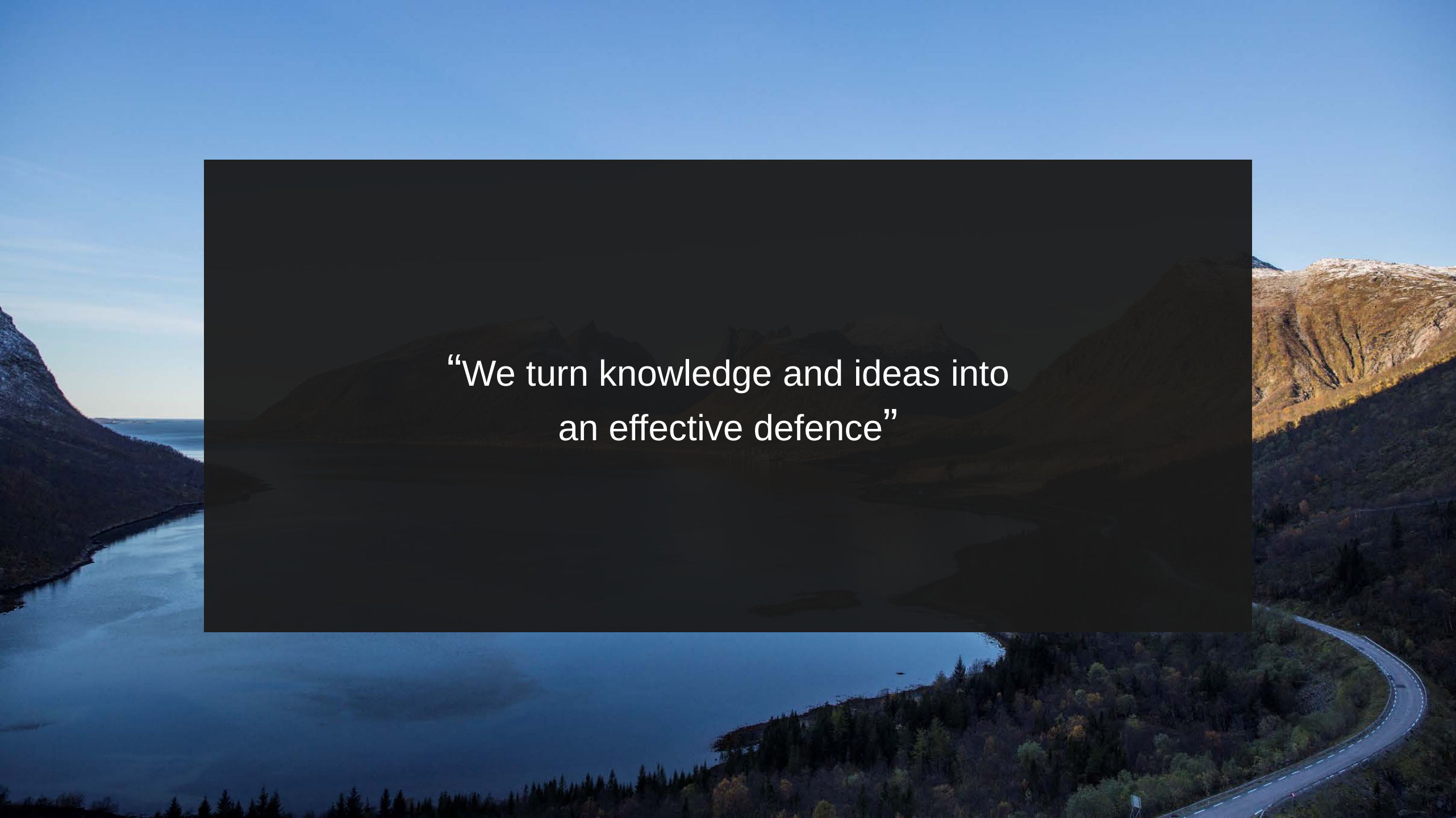
- Build competence within:
  - Exploration for Marine Mineral Resources
  - Inspection of ocean infrastructure
  - Environmental monitoring
- Establish foundation for new technologies and solutions
  - “Real” autonomy
  - Deep sea operations in very rough terrain
  - Collaborative systems
  - New and improved sensors
  - Real-time, on-board data analysis

Envision multiple AUVs launched from shore collaborative exploring the seabed and jointly adapting their mission. Using bottom penetrating echosounders; geophysical sensors; sonars, laser systems and photo cameras. Deploying and establishing their own sensor- and communication-network.

By combining such data sets we can unravel seafloor minerals; monitor environmental parameters, identify seafloor habitats and biodiversity; and inspect seafloor installations. By periodically repeating operations, changes can be detected, and the temporal effects of natural processes and anthropogenic activities can be documented.

Future NOR MMCM Concept




“We turn knowledge and ideas into
an effective defence”