Resident autonomous intervention for continuous preparedness during production

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FFU Seminar
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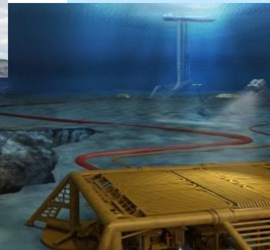
www.eninorge.no

In Norway since 1965

Heidrun

Norne

Marulk



Åsgard A

Kristin

Åsgard B

Ekofisk

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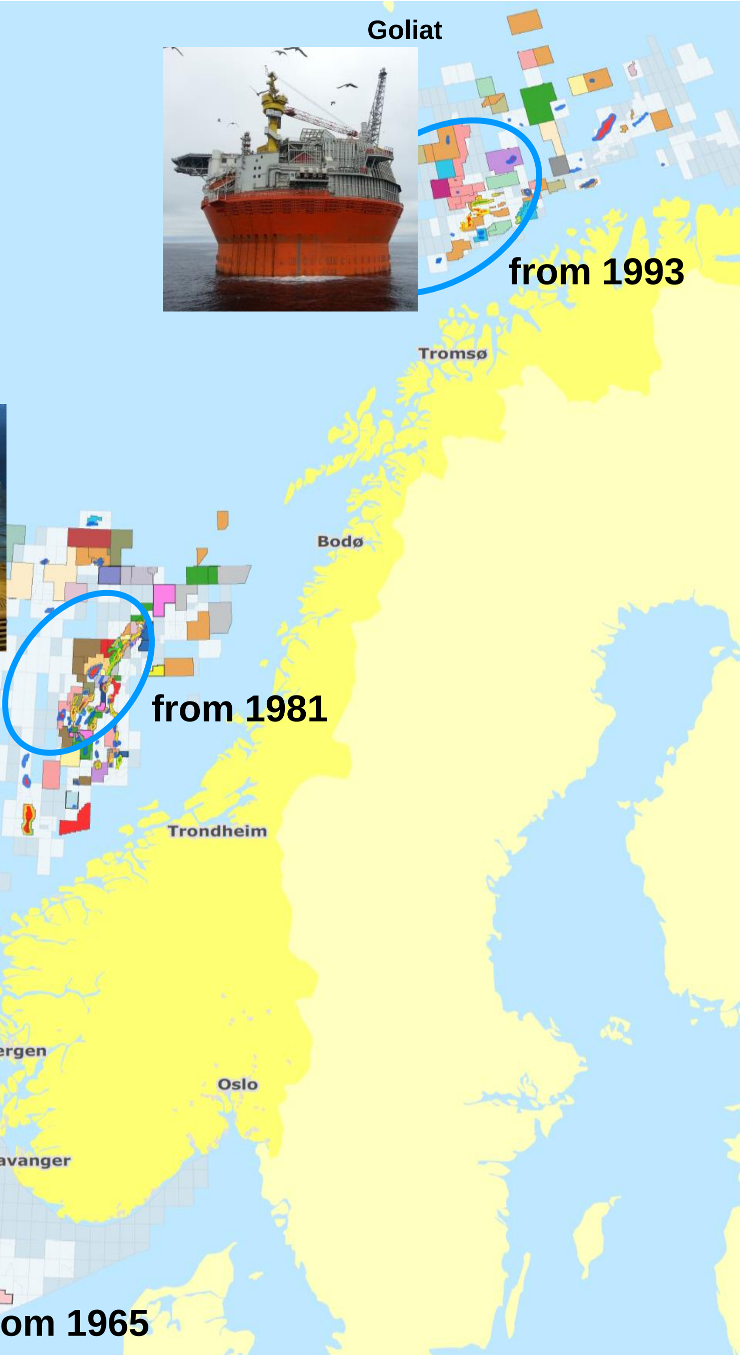


CleanSea:

Continuous environmental/asset integrity monitoring

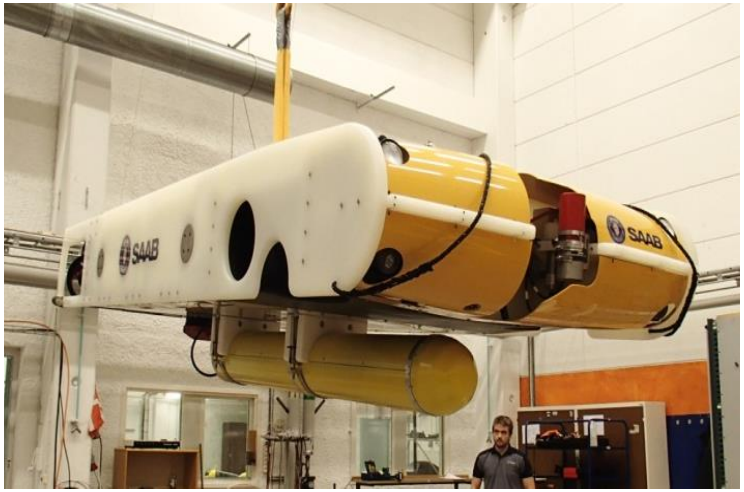
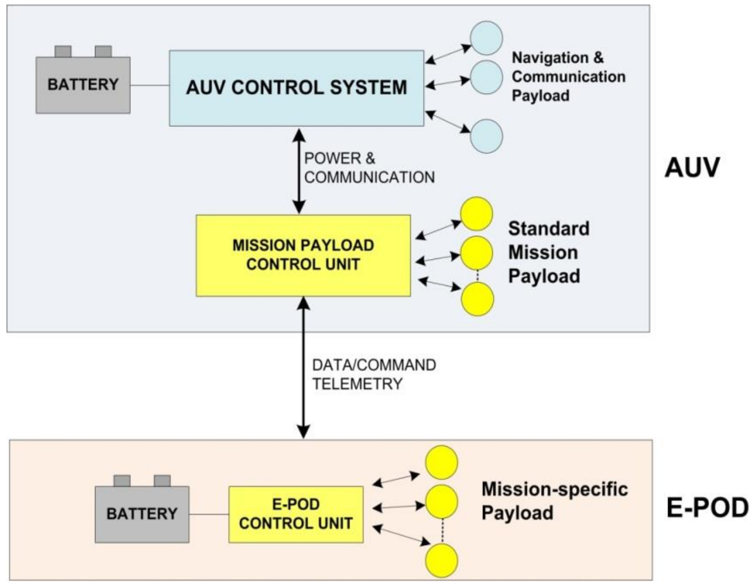


Image: Saab Seaeye

- JIP: Eni, Tecnomare and Saab Seaeye
- Environmental monitoring AUV with modular interchangeable mission payload
- Based on a commercial hybrid ROV/AUV from Saab Seaeye
- Payload controller is separate from AUV controller and capable of modifying the mission strategy in real time



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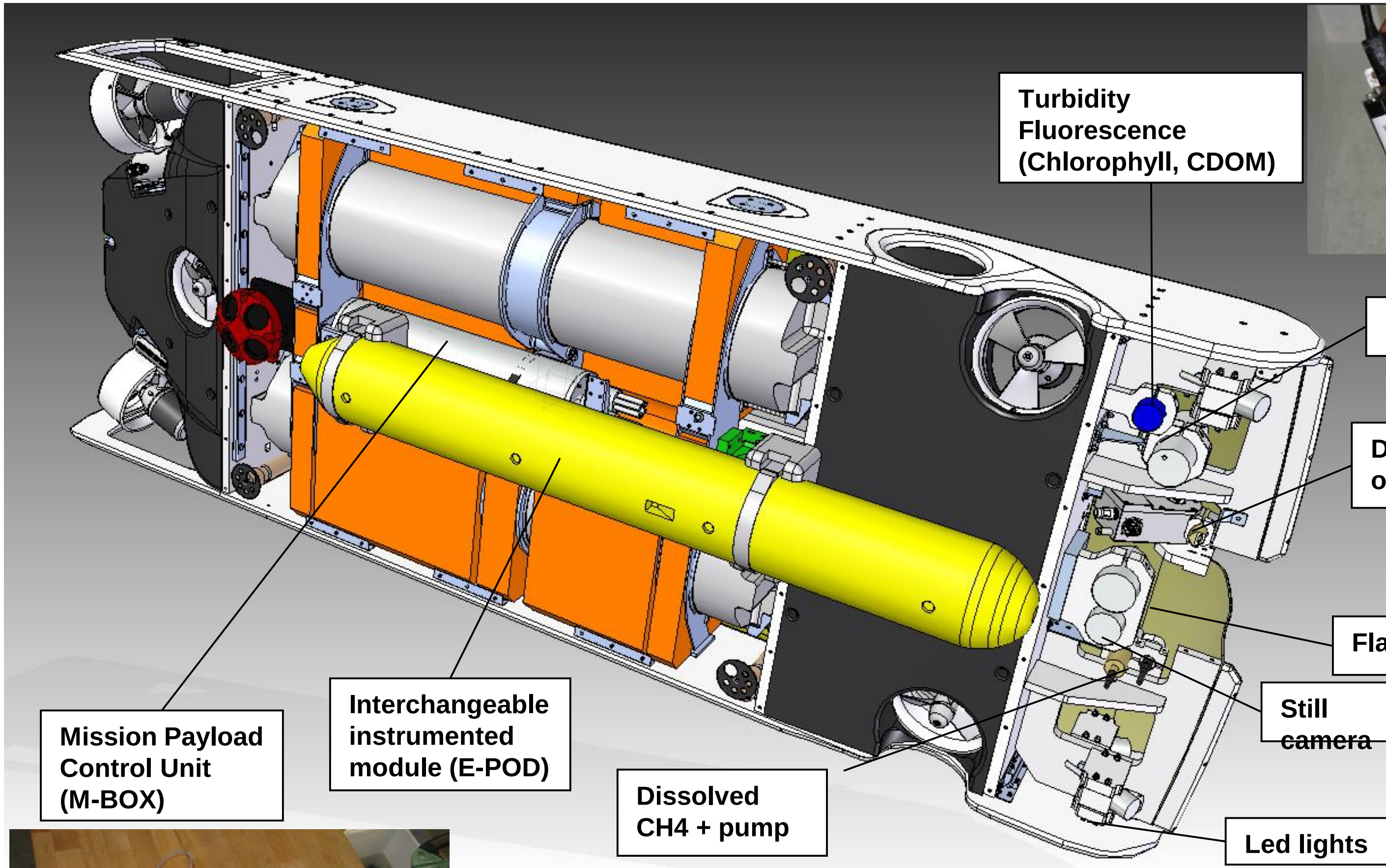
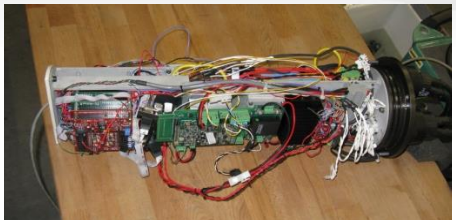
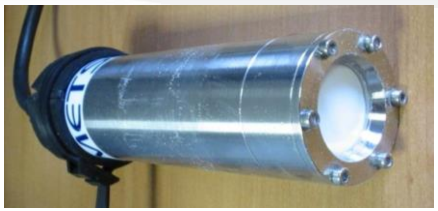
Clean Sea system configuration







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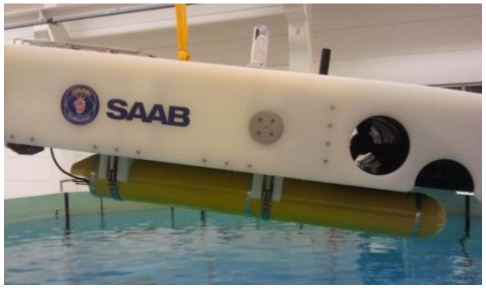
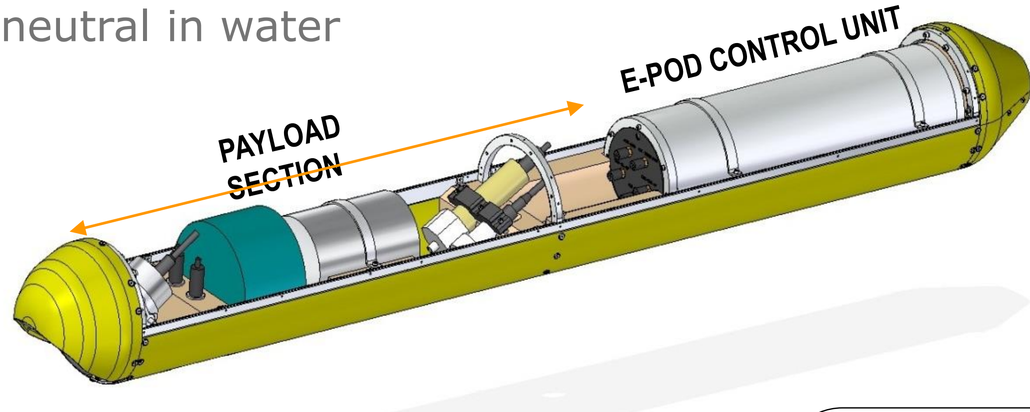
E-POD concept

- Interchangeable instrumented module, custom designed and manufactured
- Designed around common interfaces, design depth 1500 m
- Interchange time: 5 minutes
- Dimensions 250 mm diameter, 2000 mm length
- Weight 50–100 kg in air, neutral in water





E-POD 1
(*water sampling*)

- Automatic water sampler

E-POD 2
(*visual inspection and HC leakage detection*)

- 2 fluorometers (oil in water)
- 1 CH4 Methane (fast)
- Acoustic leak detector
- HRES videocamera

E-POD 3
(*trace pollutant analysis*)

- Trace metal analyser

E-POD 4
Acoustic seabed survey

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Optical communication mission

Category	Asset Integrity
Objective	Visual inspection and communication
Problem addressed	Pictures/movies shall allow the operator to evaluate • Condition of the inspected element • Presence of foreign objects • Communication with AUV
Demo test	Optical communication system

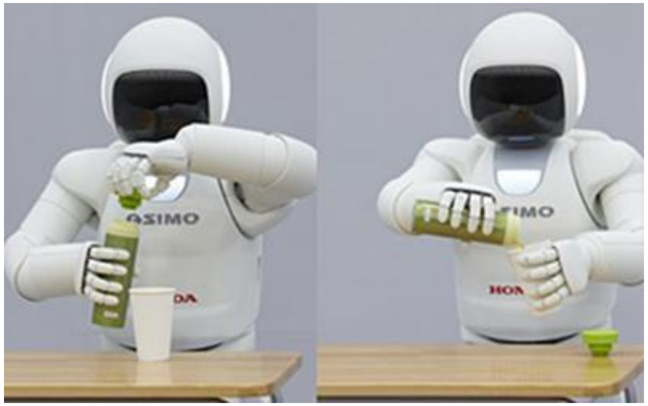
Technology development

- Autonomous navigation system
- Self-charging to the docking station
- Intelligent combination of real-time sensory feedback
- High performance lithium-ion battery

Today extreme technology advancement

- Advanced intelligence capabilities
- Advanced physical capabilities
- Improved task performing capabilities
  - tactile sensor
  - force sensor
  - object recognition technology based on visual and tactile senses

Images: HONDA



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Oil and gas industry goal

Subsea asimo?

- What does it means:
  - Able to move where and when it’s required
  - Able to recognize objects and manipulate them
  - Reliability
  - Robustness
  - Advanced sensors
  - Enough stamina to finish the job

Subsea today:
Autonomous underwater vehicles (AUV)

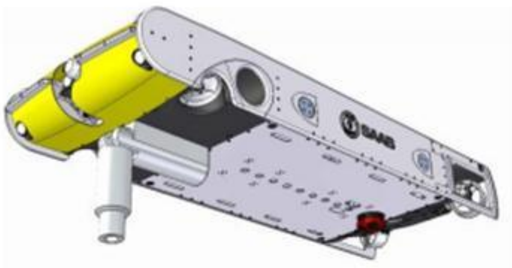
- AUV are used:
  - in subsea survey
  - as a tool for inspection tasks
- AUV requires no cables
- Can be configured with different sensors
- AUV can:
  - follow pre-programmed missions
  - transmit small amounts of data
  - obstacle avoidance systems
  - run several hours before battery recharging
  - active control
  - consider safety, energy use, and time to reach destination

Source Images published by : Lockheed Martin, Bluefin Robotics, Kongsberg

Subsea tomorrow:
Hybrid ROV/AUV or I-AUV

A subsea ASIMO will require:

- Advanced intelligence capabilities
- Advanced physical capabilities
- Improved task performing capabilities
  - Intervention Capacity
  - Electric manipulators
  - Automated component change
  - 3D monitoring systems (bad visibility navigation) merged with object recognition software
  - Wireless communication
  - Advanced Sensors Technology
  - Power autonomy



Images: Swimmer Cybernetix, Seaeye Sabertooth AUV, Subsea7 AIV

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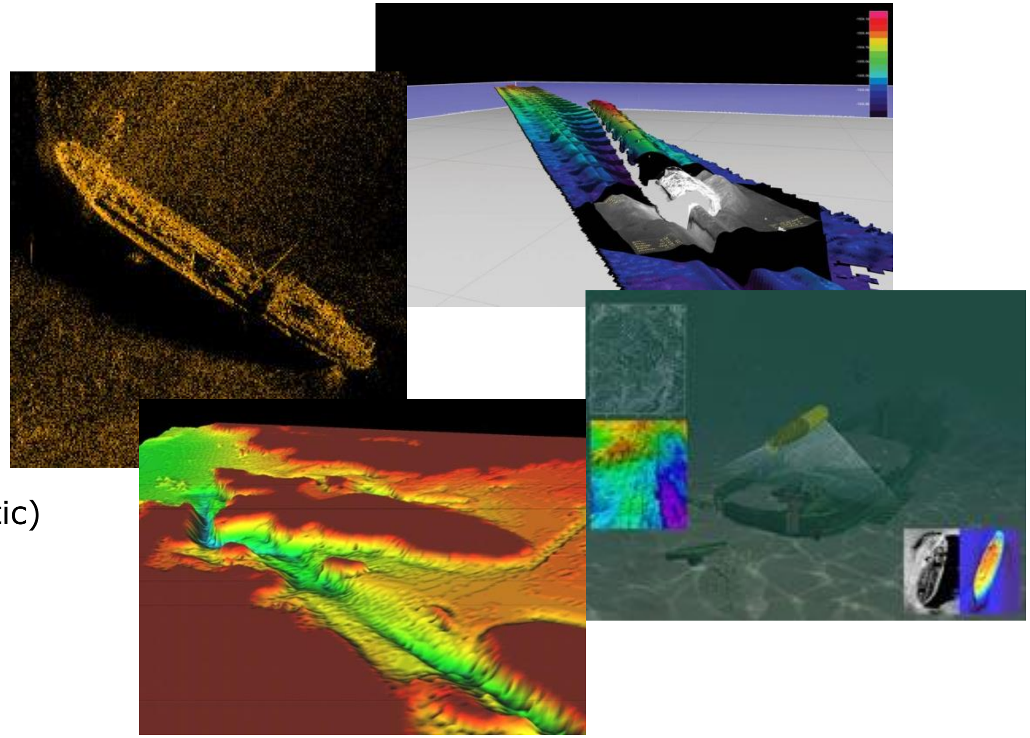
Intervention capacity

- Challenges while working with manipulators under water:
  - Motion of operating vessel
  - Motion of the ROV/AUV (currents, swell and pulling forces)
  - Human error
- Development of force-feedback manipulator to protect sensitive equipment on the seabed
- Development of electric manipulator to reduce power consumption
- Development of locking system solution to lock the AUV to the structure, and do automated manipulator and tooling tasks

Images: Alive Cybernetix, Bluefin Robotics, Kongsberg

Advanced sensor technology

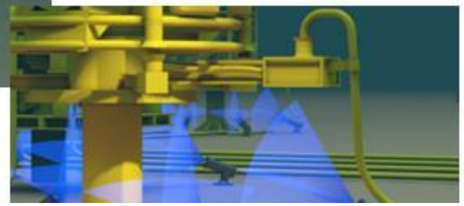
- All subsea operations are based on feedback from sensors on the vehicle
- Imagery Digital Video -HD Digital Video -4K
- New Survey and Inspection Sensors
  - Laser Profilers
  - Synthetic Aperture Sonars
  - MBE Water Column Logging
  - Optical Sensors
- Peripheral Sensors
  - Positioning (DVL, INS, gyros, sonars, acoustic)
  - Hydrocarbon Sniffers
  - Magnetometers
  - Forward Looking sonars
  - SVP/ CTD

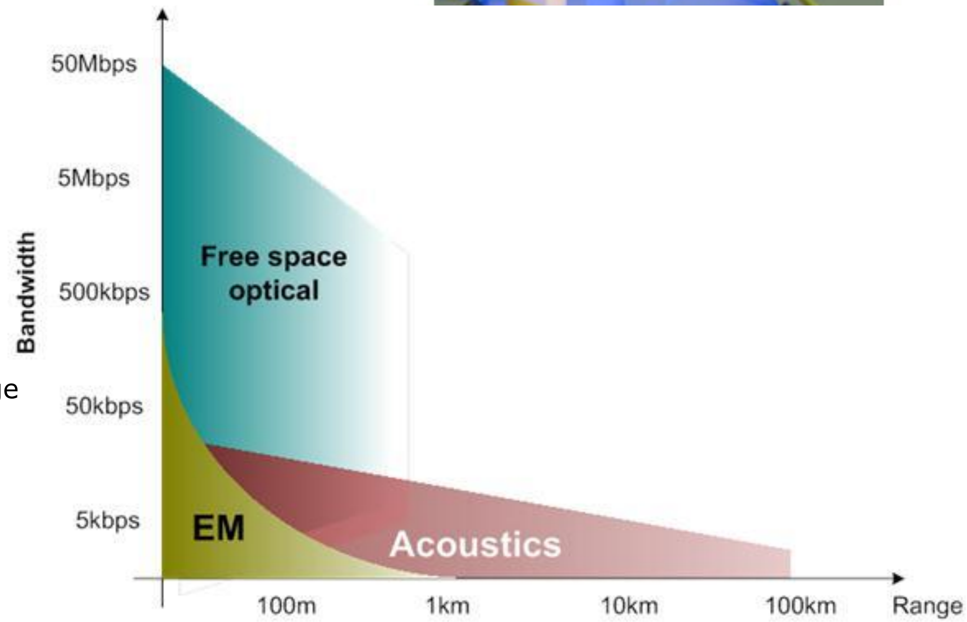


- The challenge is to implement new sensors and real time-processing to enable subsea vehicles into performing new tasks, like detection of chemicals, acoustic patterns (leaks, propeller noise, position, 3D..)

Communication

- Subsea communication is divided in
  - Cabled (FO with High bandwidth)
  - Wireless (limited due to water properties)
- Autonomous systems are dependent on a combination of the following technologies:
  - Acoustics
    - Proven Tech
    - Relatively high / flat bandwidth
    - Noise / channel dependent
  - EM / Radio
    - High bandwidth at short range, low bandwidth long range
    - Subject to interference from nearby sources of EMI (Electromagnetic Interference)
    - Large antenna & lots of power required for long range
  - Optical
    - Ultra high bandwidth at short range
    - Turbidity / water clarity/light dependent





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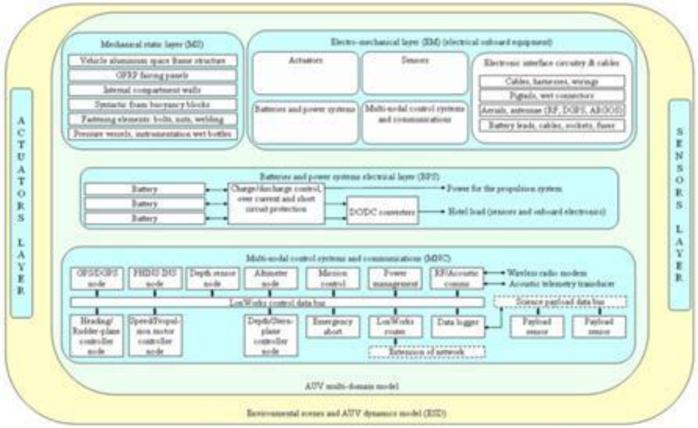
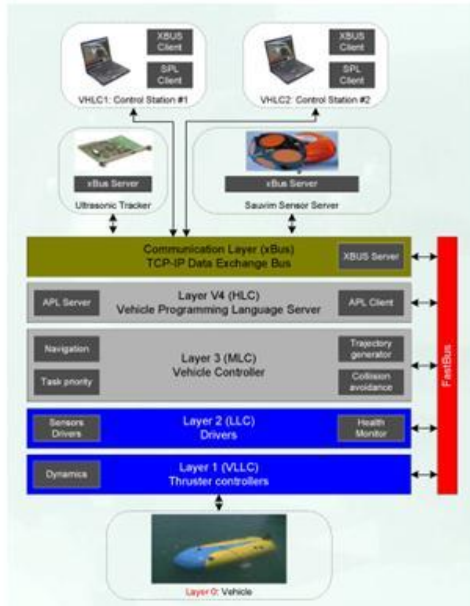
Source published by : WFS Technologies, Sonardyne

Artificial Intelligence (AI)

- Ideally, AUVs should be able to perform complex, long-duration missions without need for human intervention
- By implementing smart architectural structure, the vehicle may make its own decisions
  - Automatic navigation systems with ability to change trajectory based on mission goals
  - Manipulator control, automated intervention, based on 3D models, also based on live data processing.
  - Automated valve operations
  - Emergency detection and actions
  - Onboard adaptive control software system that integrates automated planning and probabilistic feature detection within a hybrid executive

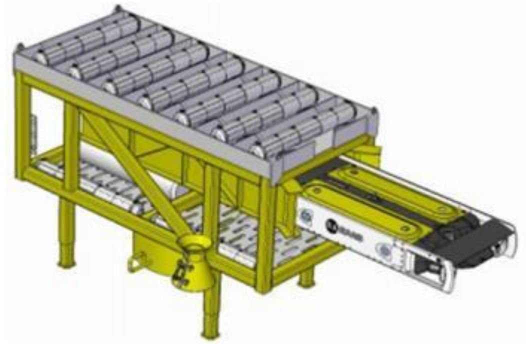


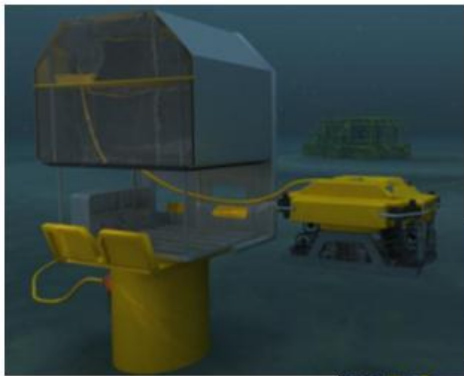


Images: Autosub AUV, Sauvim

Resident systems

- Subsea processing capabilities demands a resident ROV/AUV/AIV:
  - emergency preparedness
  - identification of problems
  - intervention on components
  - manual override of processes
  - 24/7 availability, with onshore operators
- Docking station main requirement:
  - smart design for easy parking
  - fast, reliable power charging system
  - modular system equipped with different tools
  - communication system to exchange data with surface





Images:Swimmer Cibernetix; Seaeye Sabertooth AUV, Subsea7 AIV, Oceaneering

The future:
Combination of technologies

- What will be possible in the future with new technology:
  1. A permanent underwater vehicle able to navigate and connect to a point without piloting
  2. Vehicle able to do automated intervention tasks by itself
  3. Operations are controlled from shore based on generic commands, and vehicle sends feedback trough the production systems power and communication lines
  4. **Subsea infrastructure need to be installed with power and communication nodes for subsea vehicles**

Why subsea ASIMO? Concept of Subsea Factory

- The offshore industry is moving functionality from the platform to the bottom of the sea to achieve even greater levels of productivity on smaller and less accessible oil and gas fields

- Motivation for subsea processing:
  - increased oil recovery
  - reduced cost
  - reduced topside weight
  - no weather dependency
  - optimized production
  - reduced HSE risks

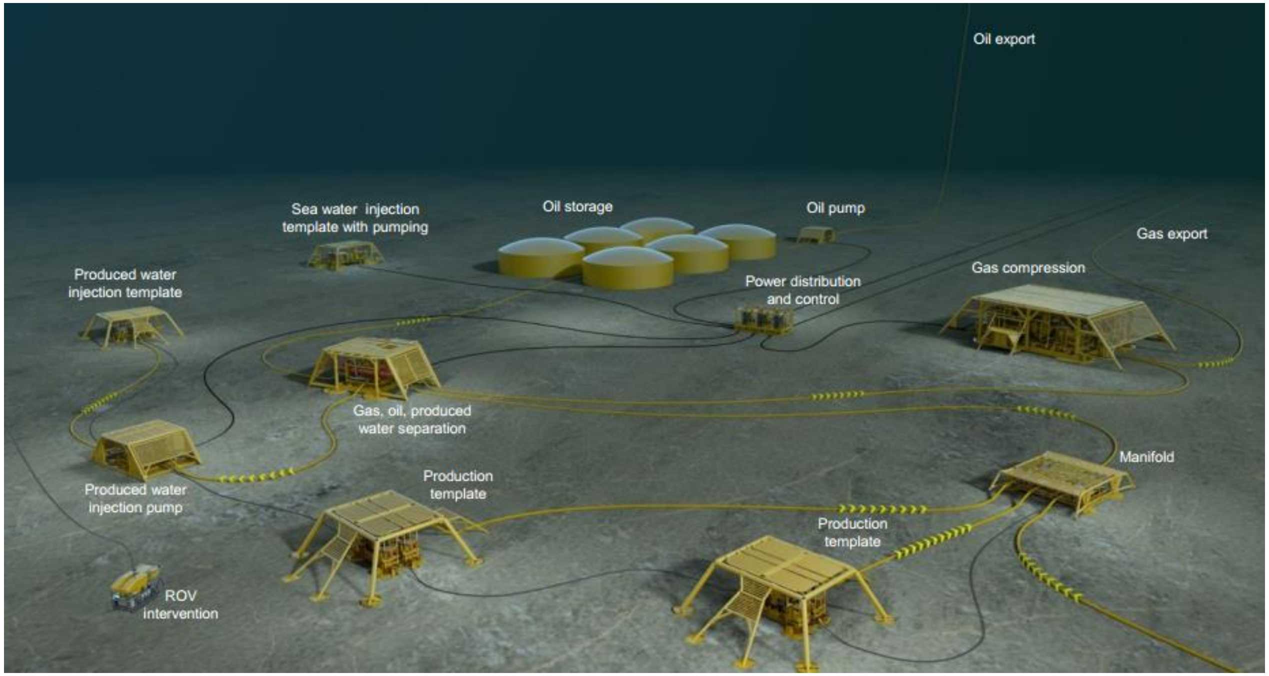


Image: Statoil

Where to use Resident Autonomous systems

1

Arctic areas. Under-ice operations with 9 months un-availability (Ref. Exxon)

2

Regions in which it is challenging to have intervention ships on standby, e.g. in various African countries (ref. Total/Statoil SWIMMER)

3

Large field layouts with many flowlines/risers which need inspection and maintenance (e.g. Goliat)

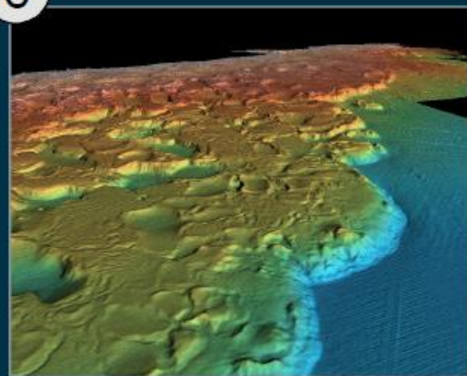
4

Fields which require environmental Monitoring (e.g. arctic areas, AKSO aldready involved through DELIOS)

5

Long Step-out/Complex SPS systems with high intervention frequency (ref. studies performed on Ormen Lange & Åsgard)

6



Ultra deep waters, e.g. GoM

Images: Aker solution

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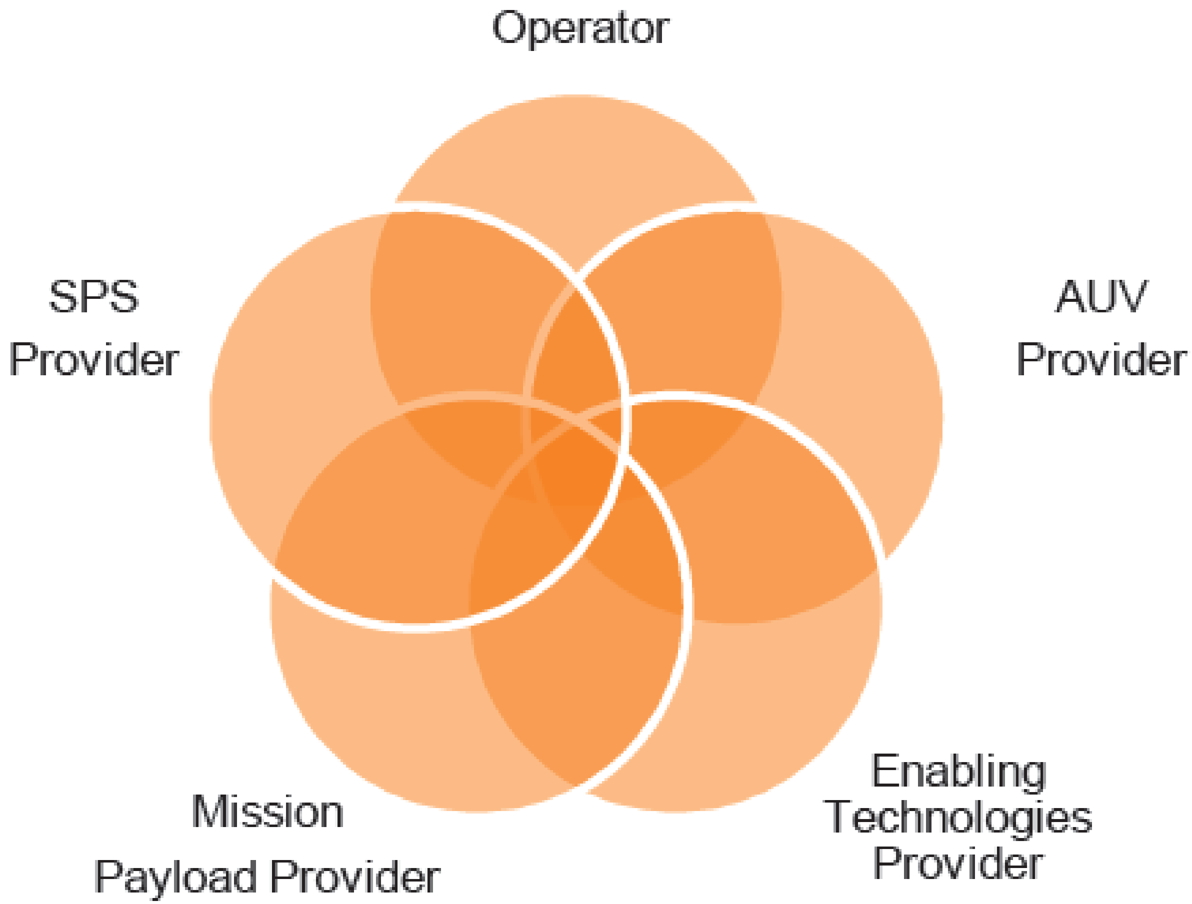
Roadmap for AUV development

- We have several parties in advanced technologigal development:



Images: AKSO

Roadmap for AUV development

- **Incremental technological qualification**:

Act
- Valve intervention
- Manipulation scope
- Connection and lift

Touch
- contact sensors
- Docking
- Light manipulation

Inspect
- Use non contact sensors
- Improved nav. data

Observe
- Structures
- Risers
- Pipelines
- Environment

Benefits with Resident Autonomous systems:

- **Instant identification of problems**
- **Identification of resources for repair**
- **Verify false alarms**
- **Perform sheduled inspections**
- **Environmental monitoring**
- **Reduce vessel days**

University of Girona demo: https://www.youtube.com/watch?v=SL-WMBdjxRg
https://www.youtube.com/watch?v=a6d7iTDhzSY

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Image: Aker Solutions


for eni
promising horizon,
long-term perspective
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