

SMaRC

SWEDISH
MARITIME
ROBOTICS
CENTRE

SMaRC

SWEDISH MARITIME ROBOTICS CENTRE

Ivan Stenius
Centre Director SMaRC
stenius@kth.se

What's SMaRC?

- National industrial research center for maritime robotics
- IRC: designated target of financiers to focus on industry needs
- Triple-Helix
- Sweden's currently largest academic initiative for maritime robotics research with a focus on underwater technology
- 2017-2024, budget over 200Msek, 15 research projects with just over 30 people involved (about 20 full-time)



Who are we?

KTH – Aeronautical & Vehicle Engineering (AVE)

KTH – Robotics Perception & Learning (RPL)

KTH – Applied Electro Chemistry (AE)

KTH – Industrial Ecology (IE)

University of Gothenburg (GU)

Stockholm University (SU)

Swedish Defence Research Agency (FOI)

Swedish Defence Material Administration (FMV)

Saab / Kockums

Saab Dynamics

Marin Mätteknik AB (MMT)

KTH-RPL



Assoc. Prof. J. Folkesson



Prof. P. Jensfelt



Prof. D. Kragic Jensfelt



Assoc. Prof. P. Ögren

University of Gothenburg



Prof. K. Abrahamsson



PhD. M. Klages



Prof. A. Wählin

KTH-AVE



Prof. J. Kutten-keuler



Ass. Prof. I. Stenius

KTH-IE



Assoc. Prof. F. Gröndahl

KTH-AE



Prof. C. Lagergren

Stockholm University



Assoc. Prof. N. Kirchner

Saab Kockums & Saab Dynamics



PhD. R. Berg



B. Rydell

MMT



O. Oskarsson



UNIVERSITY OF GOTHENBURG



FMV, Swedish Defence Material Administration



M. Andersson



FOI, Swedish Defence Research Agency



Prof. P. Sigray

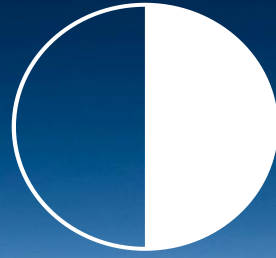
... and even more 😊



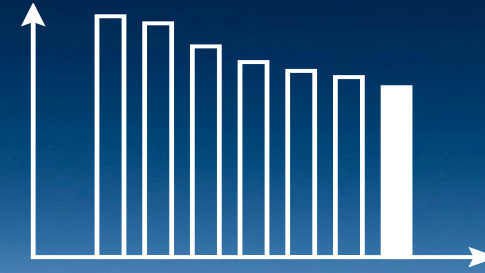
70 % of the world's surface is ocean.



It provides us 50 % of the O₂ and directly feeds over 2 Billion people.



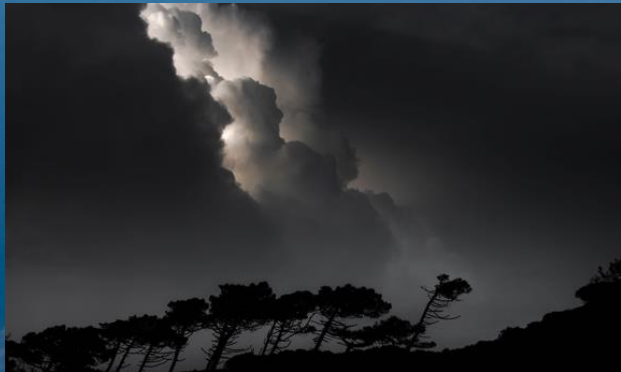
The ocean is the 7th largest economy in the world.



Yet, we have only explored 5 % of it.

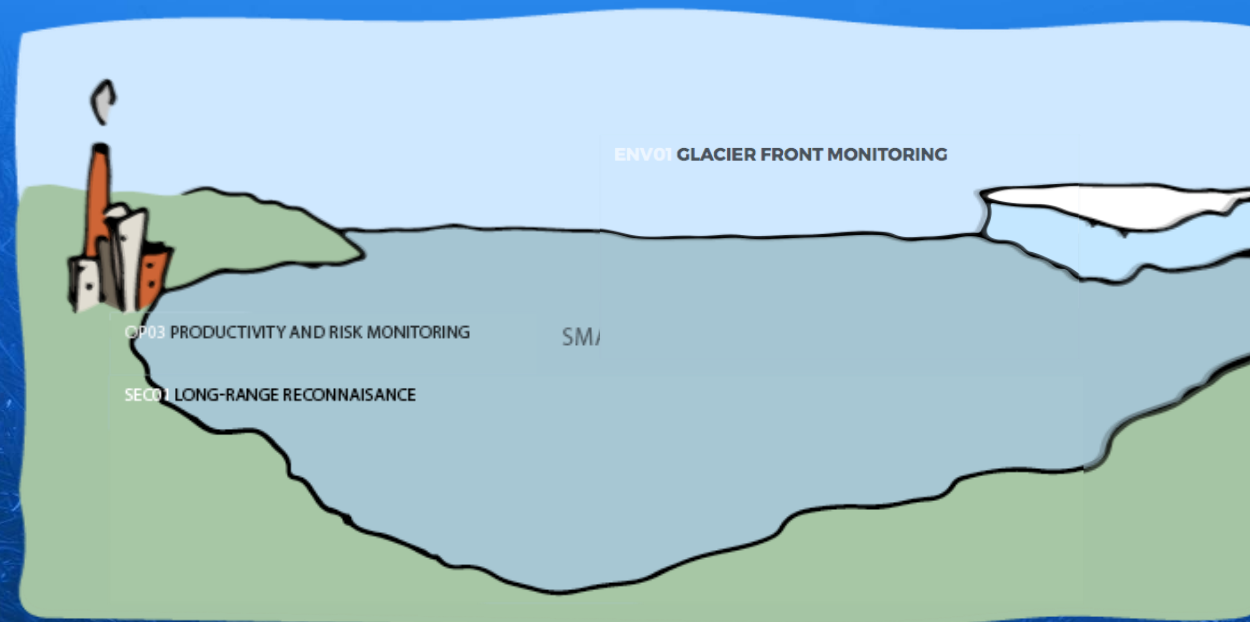


"The expert group recommends that the G7 science ministers support the development of a sustained sea and ocean observing system"
(G7 expert workshop on future of the oceans and seas, May 2016)



Scenarios

- Impact areas
- Scenarios
- Capabilities



Capabilities Perception

C39

Ability to accurately:

- localise surrounding objects for collision avoidance in murky waters at high speed (10kn).
- localise ice front in relation to vehicle position.
- operate in dynamic oceanic conditions such as: low salinity; low visibility, turbidity; shallow waters; various bottoms: sand, mud, rock, flat, corrugated; presence of ice on the surface; no GPS; depth up to 300m; sea currents up to 3kn

C38

Ability to detect pollutants on molecular level in the water column (Advanced sensor suite to detect pollutants)

C41

Autonomous in real-time accurate

- feature identification (mooring line, base fundament, algae, etc.)
- identify, classify and geo-tag (primarily) man-made objects and (secondarily) natural objects at high speed (10kn)

C42

Autonomously in real-time identify a deviation from a "normal state":
Monitor and detect variations from a "normal-state" in the underwater domain



Capabilities

Autonomy

C12

Ability to safely
without entanglement
precision manoeuvre

C2

Navigate safely in totally
unknown and dynamically
changing environments
without access to surface

C13

Ability to, beyond what
already exists today, in
real time adapt and re-
plan a mission

C10

Swarm intelligence to
Localize the source of pollutants
Map the extension of a polluted area
Autonomously handle decentralized
versus centralized control
Create perimeter (of fixed and moving
assets) around an object of interest



C8

Deploy (and preferably retrieve)
payloads to well defined positions
and in typical ambient conditions
from "Mother AUV" (e.g. acoustic
nodes for communication and
positioning).

Capabilities

Under Water Communication

C23

Ability to perform optimised underwater communication and data transfer with:

- nodes deployed at the seafloor,
- between “Mother-AUV” and micro AUV swarm,
- networks of other moving or not moving nodes/vehicles/submarines/ships,
- control central and sensors.



Capabilities

Endurance

C29

Endurance to map and monitor a glacier front (extending 20km) in one sweep as fast as possible (preferably at speeds > 5kn) without re-charging.

C30

Increased range of AUV to > 1000 km or 30 days @ optimal speed and >400km @ 5kn

C32

Ability to perform long-term continuous operations in a predefined area (perform multiple missions: dock, transfer data, recharge and repeat mission)



Scenarios

Most capabilities from the different scenarios converge into common interests!



Research Plan

Benefit areas

- B1. Ocean Production
- B2. Safeguarding Society
- B3. Environmental Monitoring

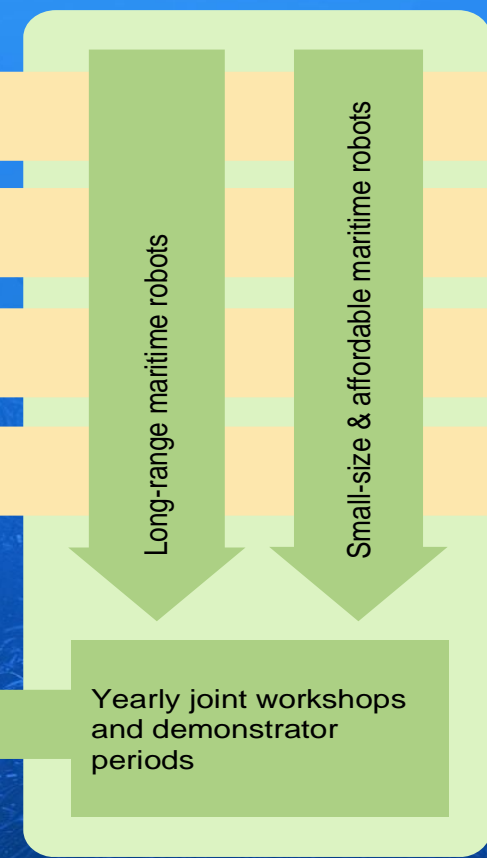
Challenges

- C1. Reducing the need for operator interaction
- C2. Enabling long-term presence
- C3. Enabling operations in unknown waters

Research areas and capabilities

- Autonomy
- Endurance
- Perception
- Communication

Demonstrator program



Main goals

Next generation of maritime robots

Research Area Perception

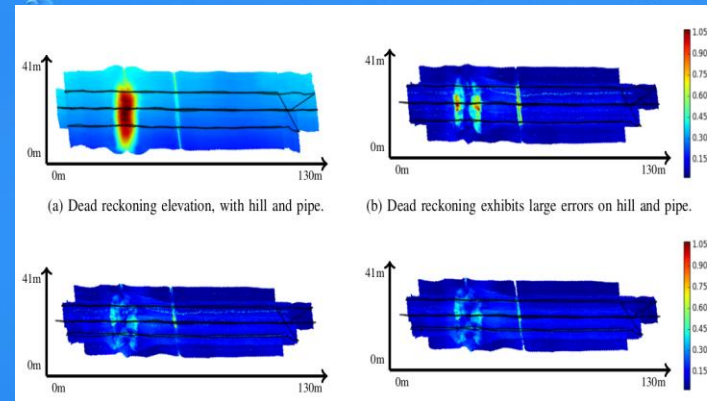
- Capabilities

- Localize and classify objects and features in dynamic oceanic conditions
- In real-time detect deviation from “normal-state”
- Detect and classify substances on molecular level in the water column

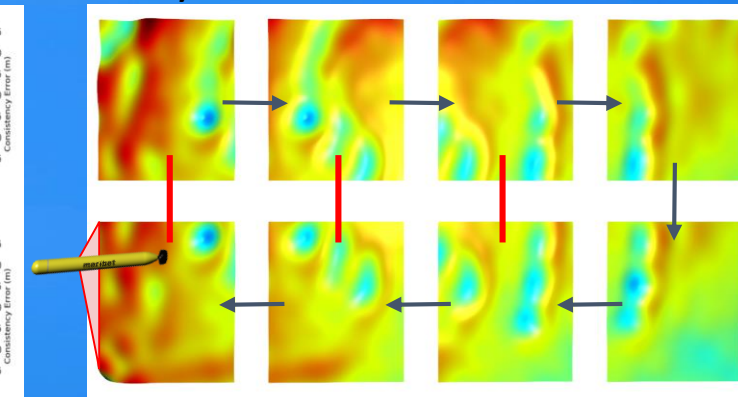
- Sub Projects

- SP02 Deep Learning
- SP05 Underwater Navigation
- SP06 Underwater Perception
- SP10 Sniffer sensor

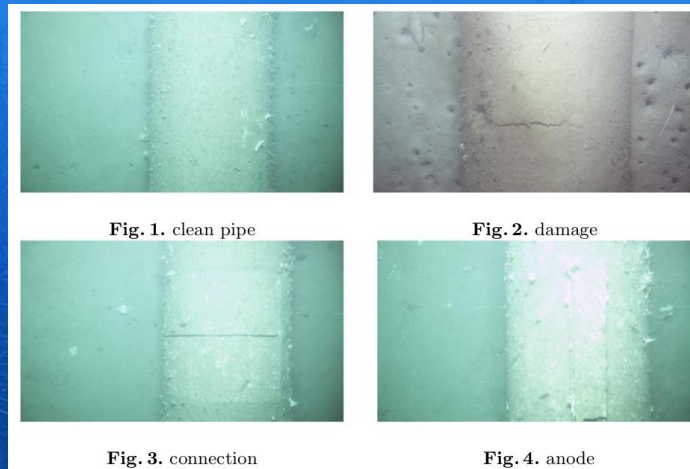
Alignment results



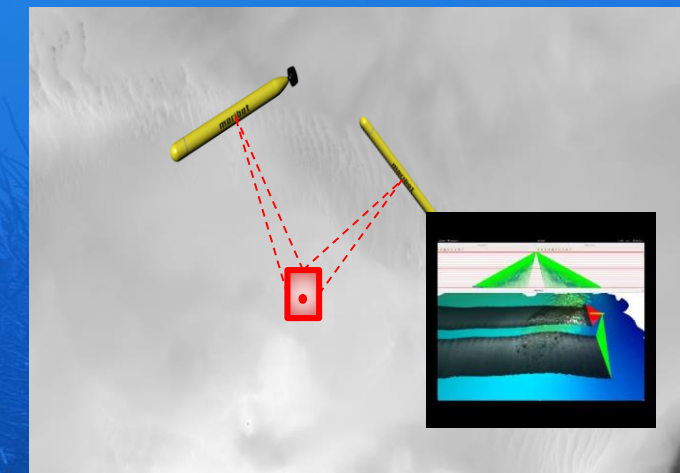
Bathymetric SLAM



Classification of Sonar Data



Place Recognition



Research Area Autonomy

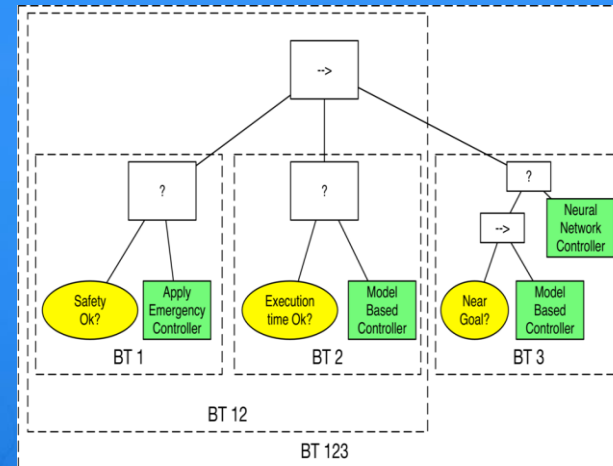
- Capabilities

- Real time decisions based on sensor data and operational constraints
- Swarm intelligence to e.g. localize and cage an intruder

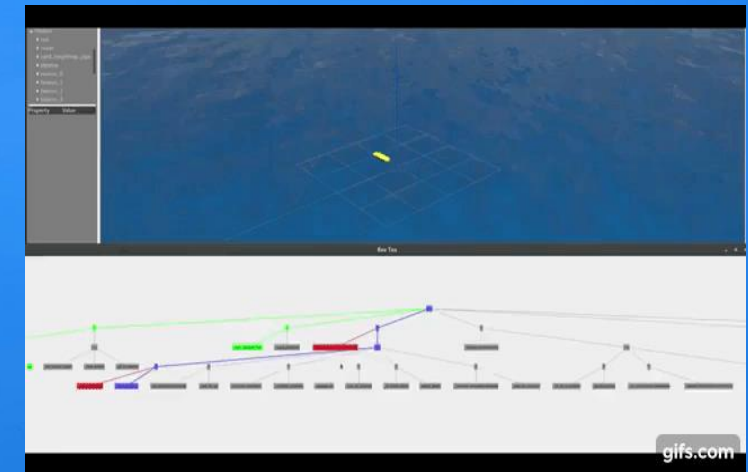
- Sub Projects

- SP7 Robust Mission Planning
- SP8 Multi-Agent Networks
- (SP01 Docking & SP04 Hydrobatics)

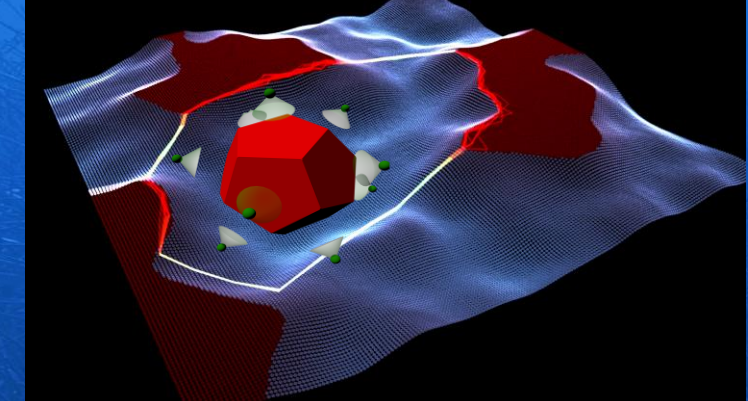
Adding Neural Network Controllers to Behaviour Trees



Improving the Modularity of AUV Control Systems using Behavior Trees



Caging: 3D Pursuit-Evasion for AUVs



Research Area Endurance

- Capabilities

- Long range in remote and unknown areas
- Long time persistence in local known waters

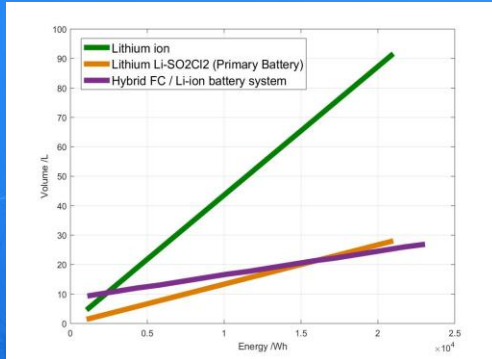
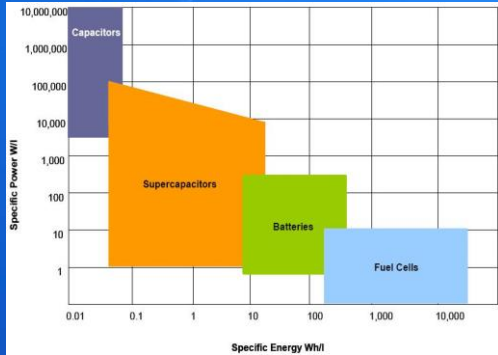
- Sub Projects

- SP01 Docking
- SP03 Performance Optimization
- SP04 Hydrobatics
- SP09 Air Independent Energy Storage

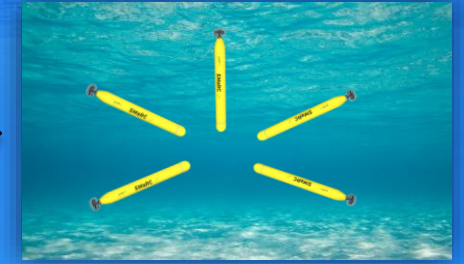
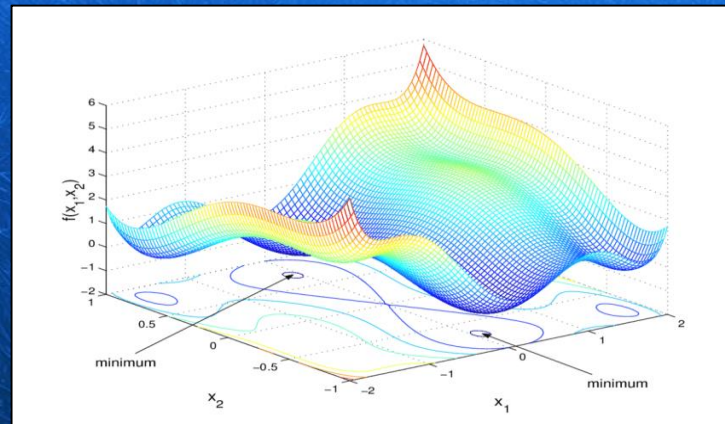
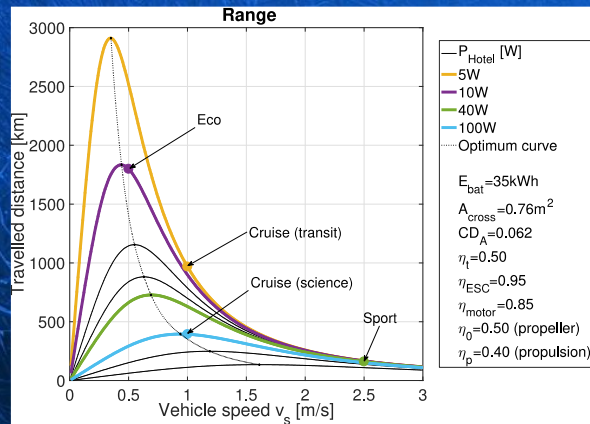


Research Area Endurance

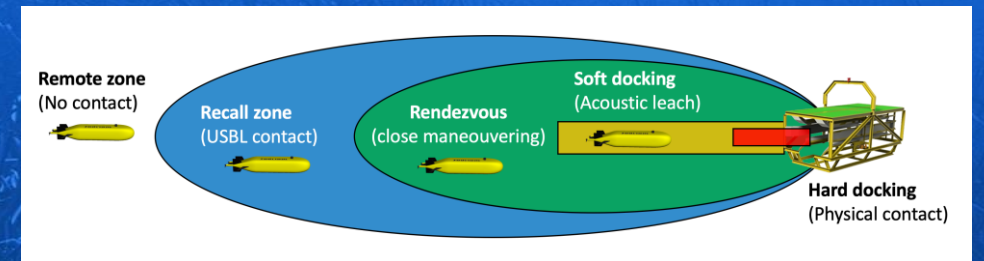
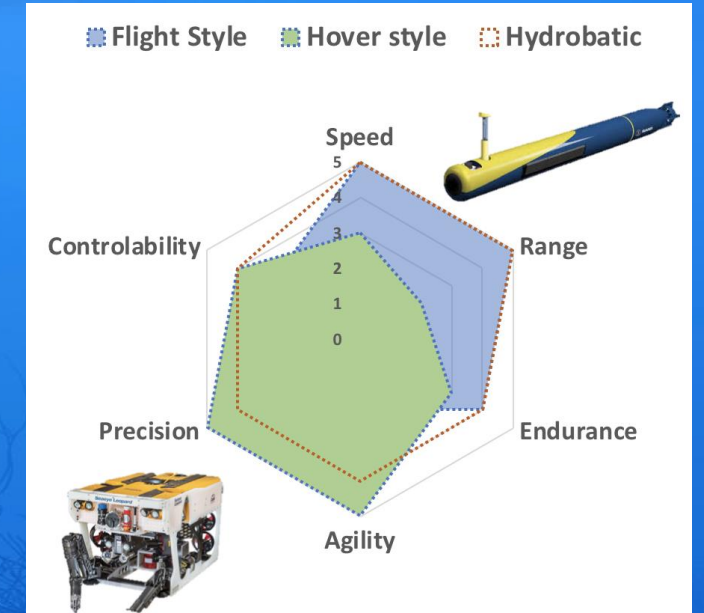
Fuel Cells in AUVs



Multivariable Performance Optimization



Hydrobatatics & Docking



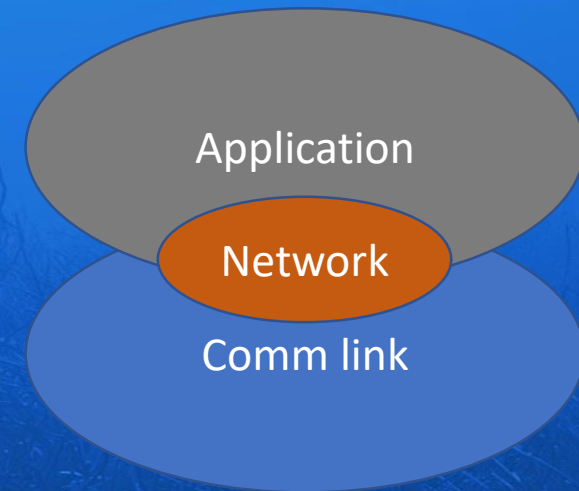
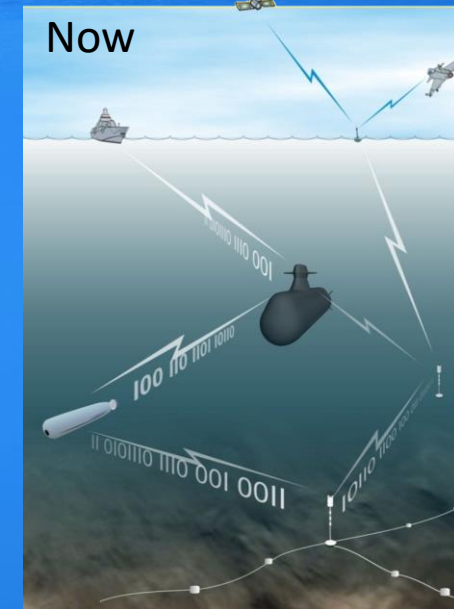
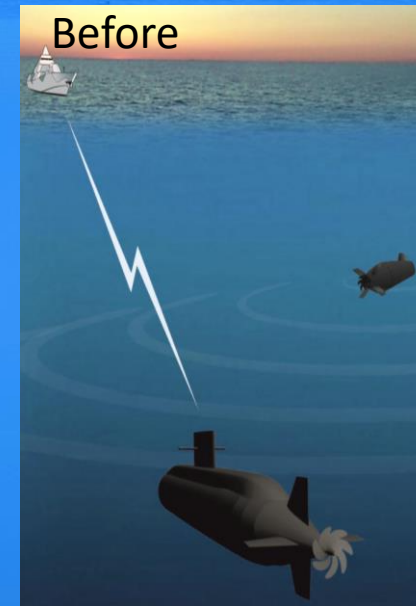
Research Area Underwater Communication

- Capabilities

- Optimized and robust underwater communication links and networks

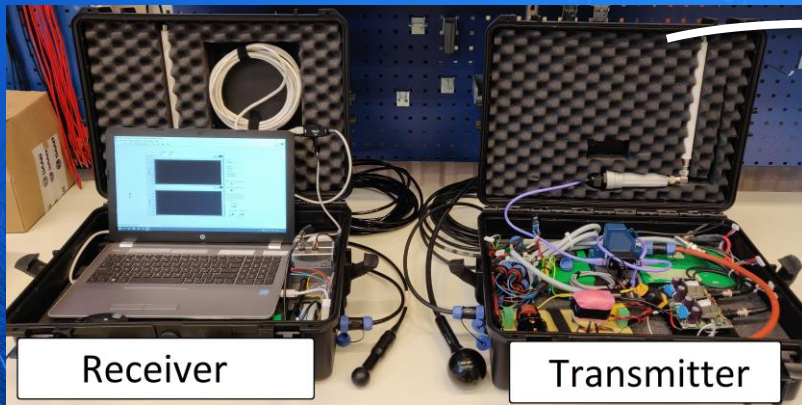
- Sub Projects

- SP11 Underwater Communication
- SP12 Underwater Networks

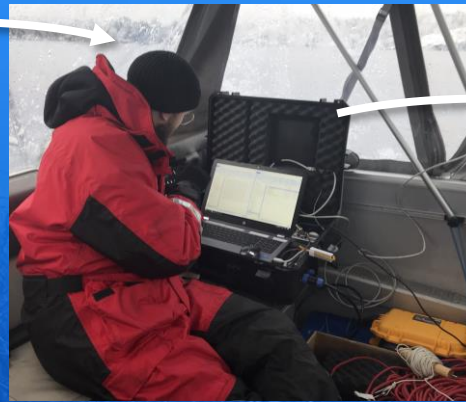


Research Area Underwater Communication

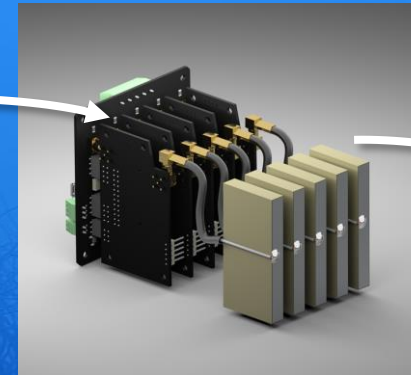
Lab Kit



Testing



"5G" Underwater com.



DEPLOYABLE UNDERWATER
COMMUNICATIONS NODES



Focus right now

AUTONOMY

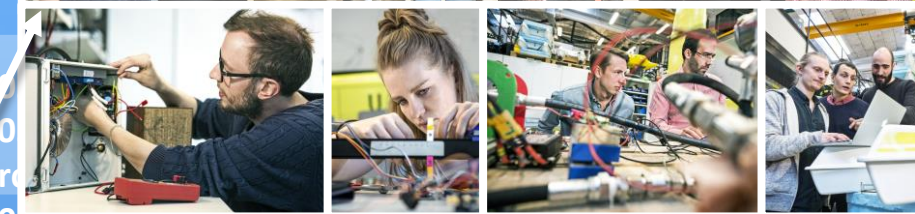
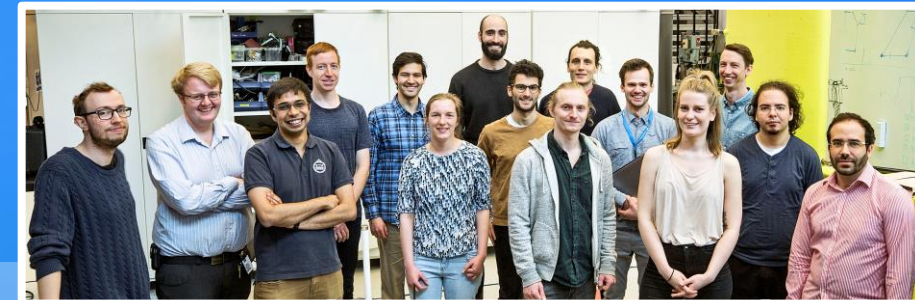
SP01 Docking
SP04 Hydrobatics
SP07 Robust Mission
Planning
SP08 Multi-Agent
Networks

COMMUNICATION

SP11 Underwater
Communication
SP12 Underwater
Networks

ENDURANCE

SP03 System Performance
SP09 Energy Storage



SP05 Underwater
Nav
SP1

Göteborgsforskare på expedition till Antark

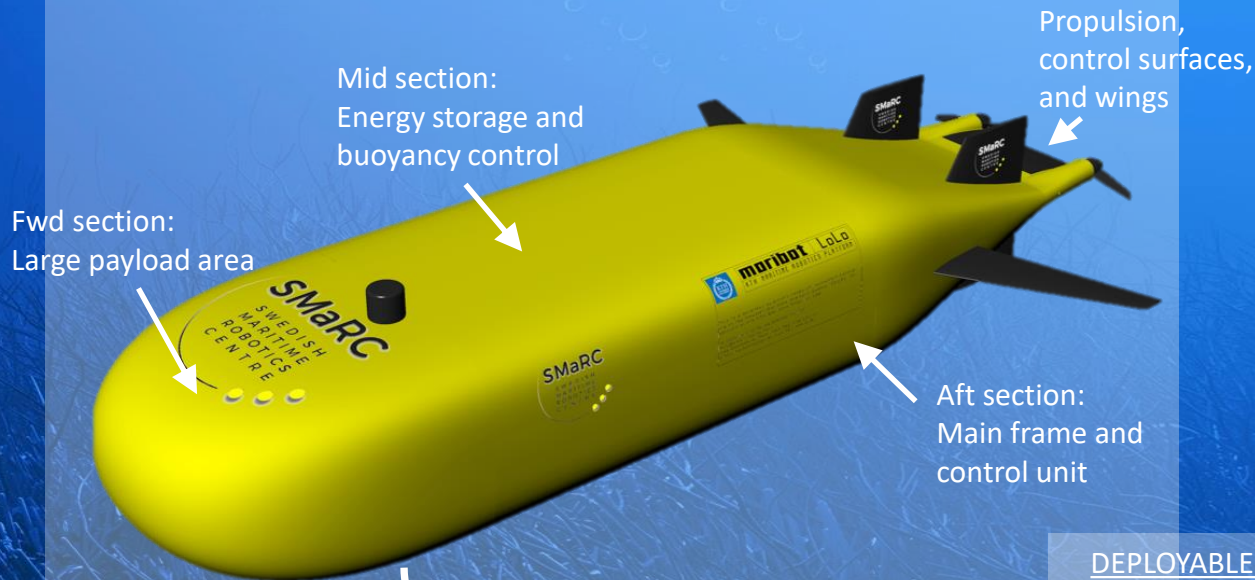
NYHET: 2018-12-20



SMaRC Demonstrator Platforms

LONG RANGE LARGE AUV (LoLo)

Dimensions:	Depth rating:	Power:	Speed:	Range:
3.8x1.05x0.6 m	1000m	2x Motors XX kWh battpack	Xkn (cruise) 7kn (max)	xx-yy km



SMALL & AFFORDABLE AUVs (SAM)

Dimensions:	Depth rating:	Power:	Speed:	Range:
L=1.3m, D=0.126m	50m	2x1kW motors 1.4kWh battpack	4kn (cruise) >10kn (max)	50-100 km



DEPLOYABLE UNWATER COMMUNICATIONS NODES



Deploy sensor nodes

Multiple vehicles for collaboration tests



Technology Demonstrator Ran

Commercial of-the-shelf state of art Maritime Robots

Dimensions:

- Length: 6,5m
- Diameter: 875 mm
- Weight: 1600 - 1800 kg

Depth Ratings:

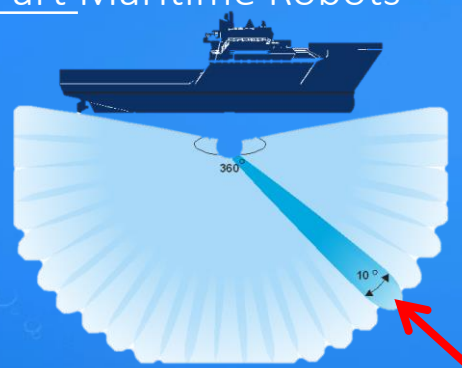
- Max depth: 3000 m

Power Supply:

- 4x (max 6) Rechargeable and swappable Lithium Polymer batteries

Endurance:

- 4 Batteries
- 26 hours at 4 knots
- 41 hours at 3 knots

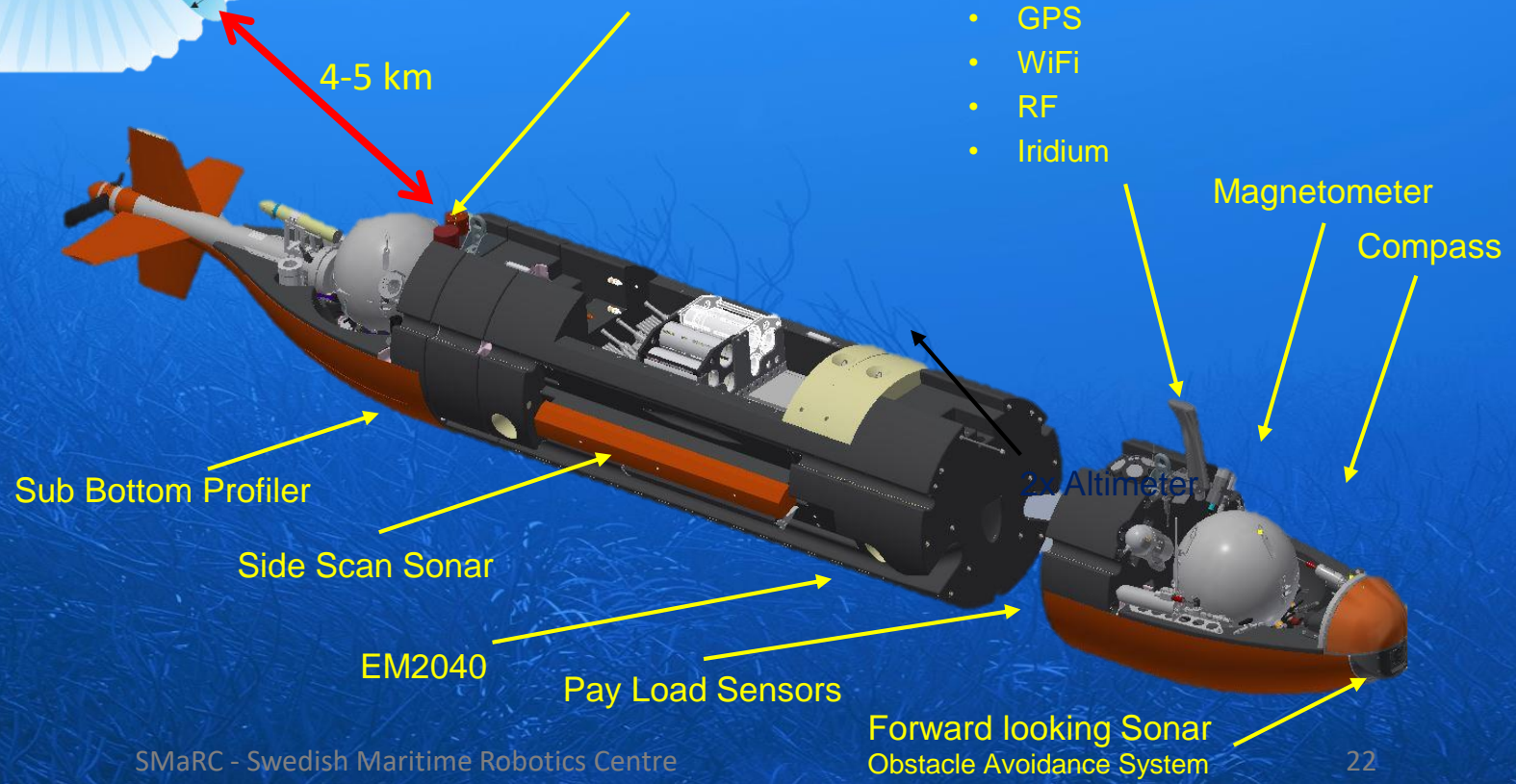


Underwater Communications:

- HiPAP USBL
- Command Link
- Data Link

Surface Communications:

- GPS
- WiFi
- RF
- Iridium



The logo for SMaRC (Swedish Maritime Robotics Centre) features the acronym 'SMaRC' in a large, white, sans-serif font. Below it, the full name 'SWEDISH MARITIME ROBOTICS CENTRE' is written in a smaller, white, all-caps, sans-serif font, arranged in four lines. To the right of the text, there are three yellow dots of increasing size, and a thin white arc curves around the bottom left of the text.

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Thanks