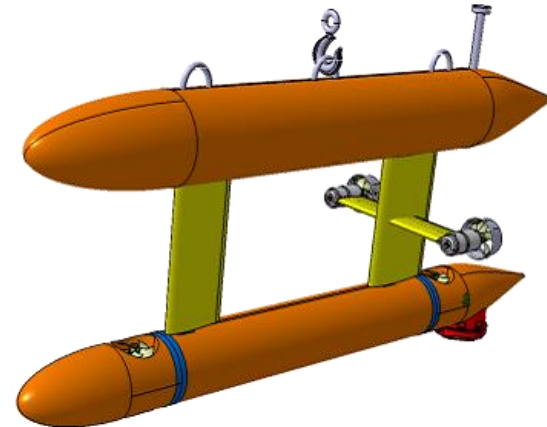


MEDUSA  
DEEP SEA



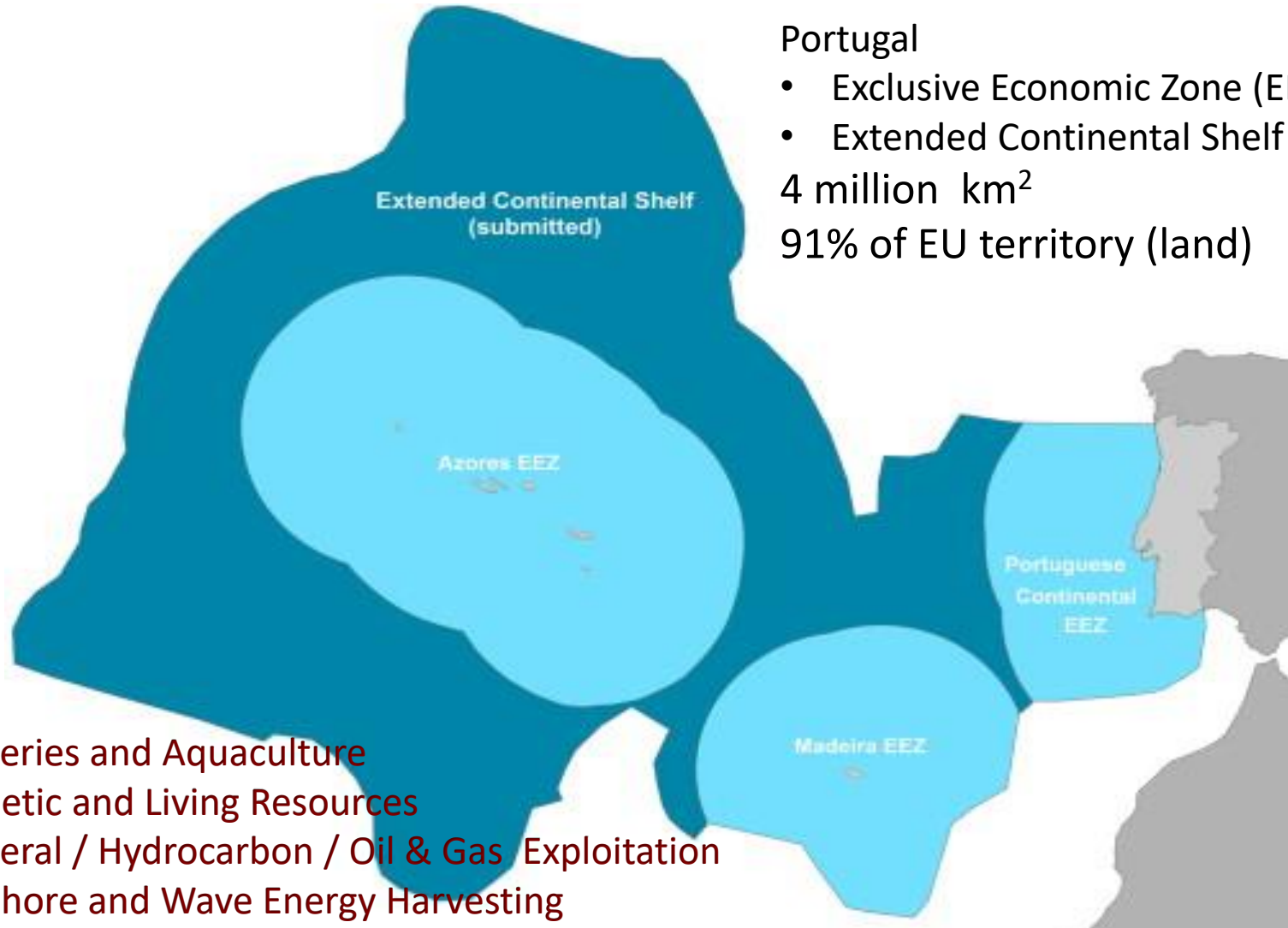
# The MEDUSA Deep Sea and FUSION AUVs: When Research and business get together



Bruno Cardeira/IST

# Deep Ocean Exploration

## -Why the effort?



Portugal

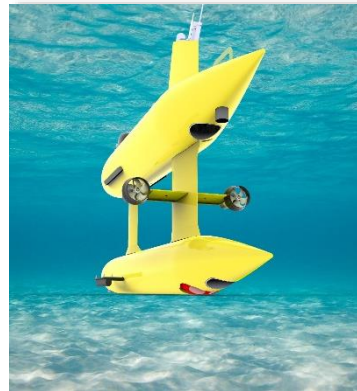
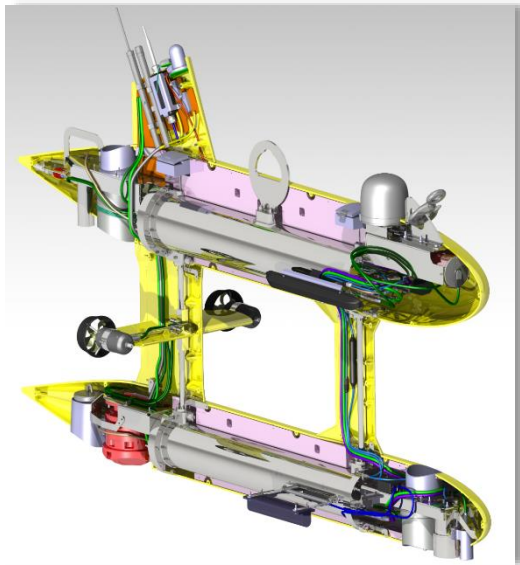
- Exclusive Economic Zone (EEZ)
  - Extended Continental Shelf
- 4 million km<sup>2</sup>  
91% of EU territory (land)

- Fisheries and Aquaculture
- Genetic and Living Resources
- Mineral / Hydrocarbon / Oil & Gas Exploitation
- Offshore and Wave Energy Harvesting
- Maritime Logistics

# Objectives

## MOTIVATION

Reinforce the national capacity for mobile autonomous and extended range deep-sea exploration and monitoring, affording scientists and commercial operators means to open and explore the deep sea frontier and contribute for the Good Environmental Status in oceanic and coastal areas.



## MISSION

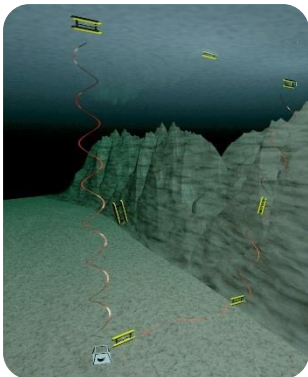
Develop a system of multiple autonomous vehicles for ocean exploration and monitoring, capable of operating at water depths of up to 3000 meters, with light logistic requirements.

"It's remarkable that so much of the deep sea has never been seen by human eyes at a time when we are viewing the far reaches of the universe using modern technology."

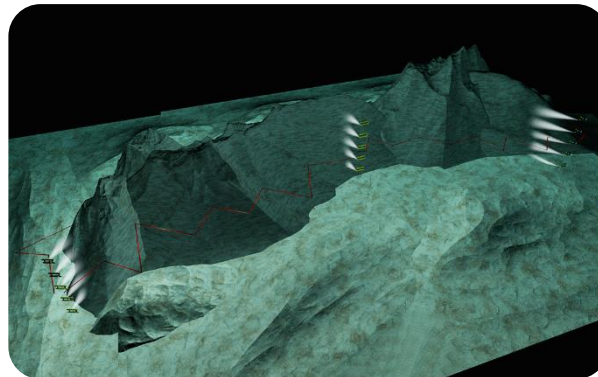
# Requirements



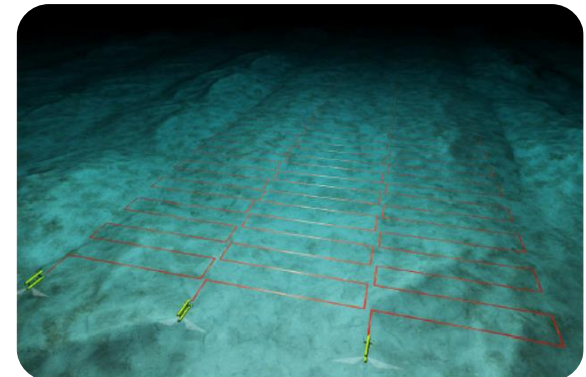
- **Develop** a **deep-sea AUV** to cover the deep-sea areas of the national remote oceanic areas, up to **3000 m depth**.
- The MEDUSA Deep Sea system should be **designed** to **comply** with the **requirements** of three **typical scenario missions** (while leaving the flexibility for other future developments):
  1. **data download and water column profiling,**
  2. **resource exploration and mapping, and**
  3. **high resolution habitat mapping.**
- The **final demonstration** will cover at least **Scenario 1** at a **deep-sea location (1000 m depth minimum)**.



Scenario 1



Scenario 2



Scenario 3

# Mission Scenario 1

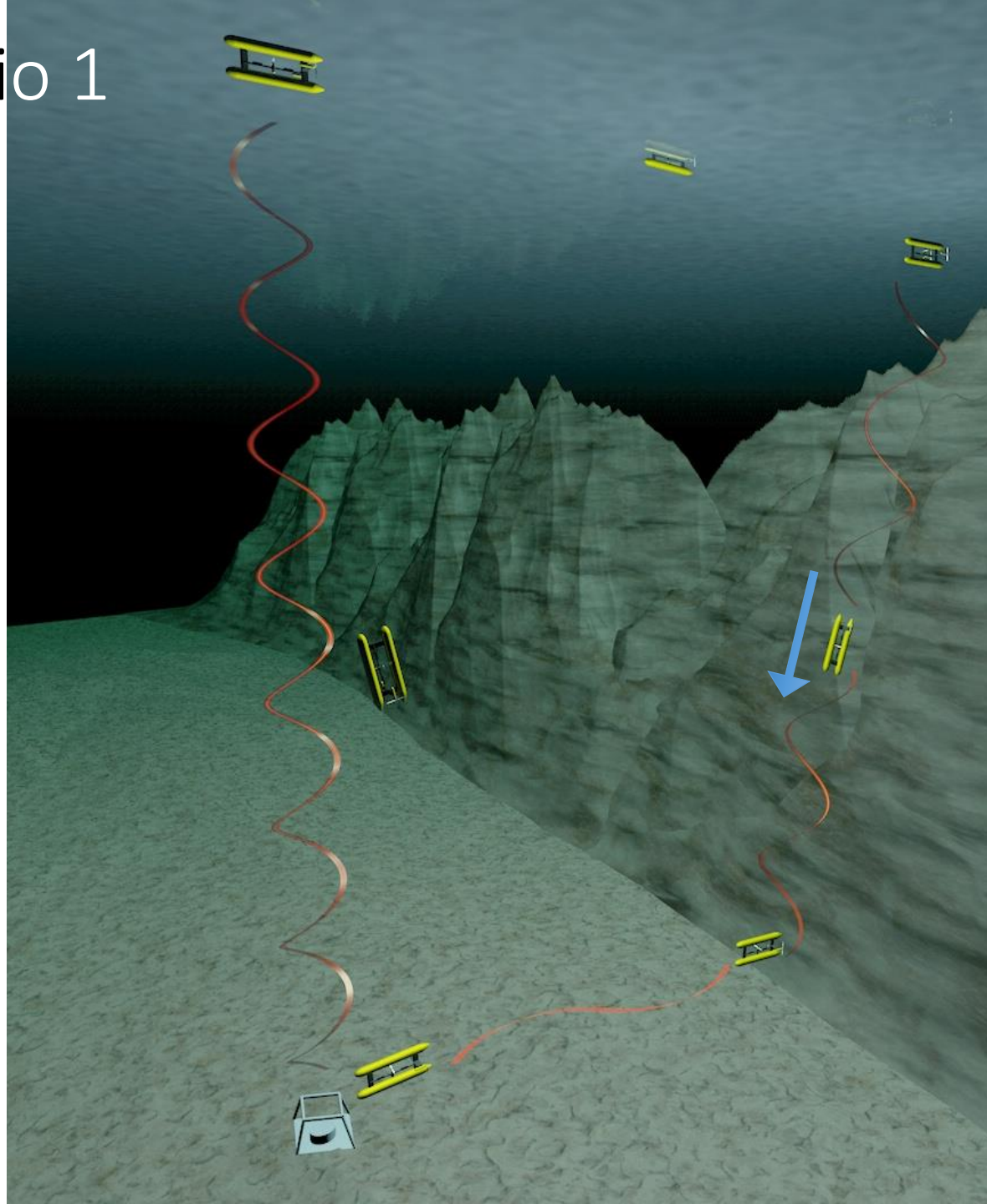
## Data download and water column profiling

Shuttle carrying data (data download or data mule) in collaboration with other platforms.

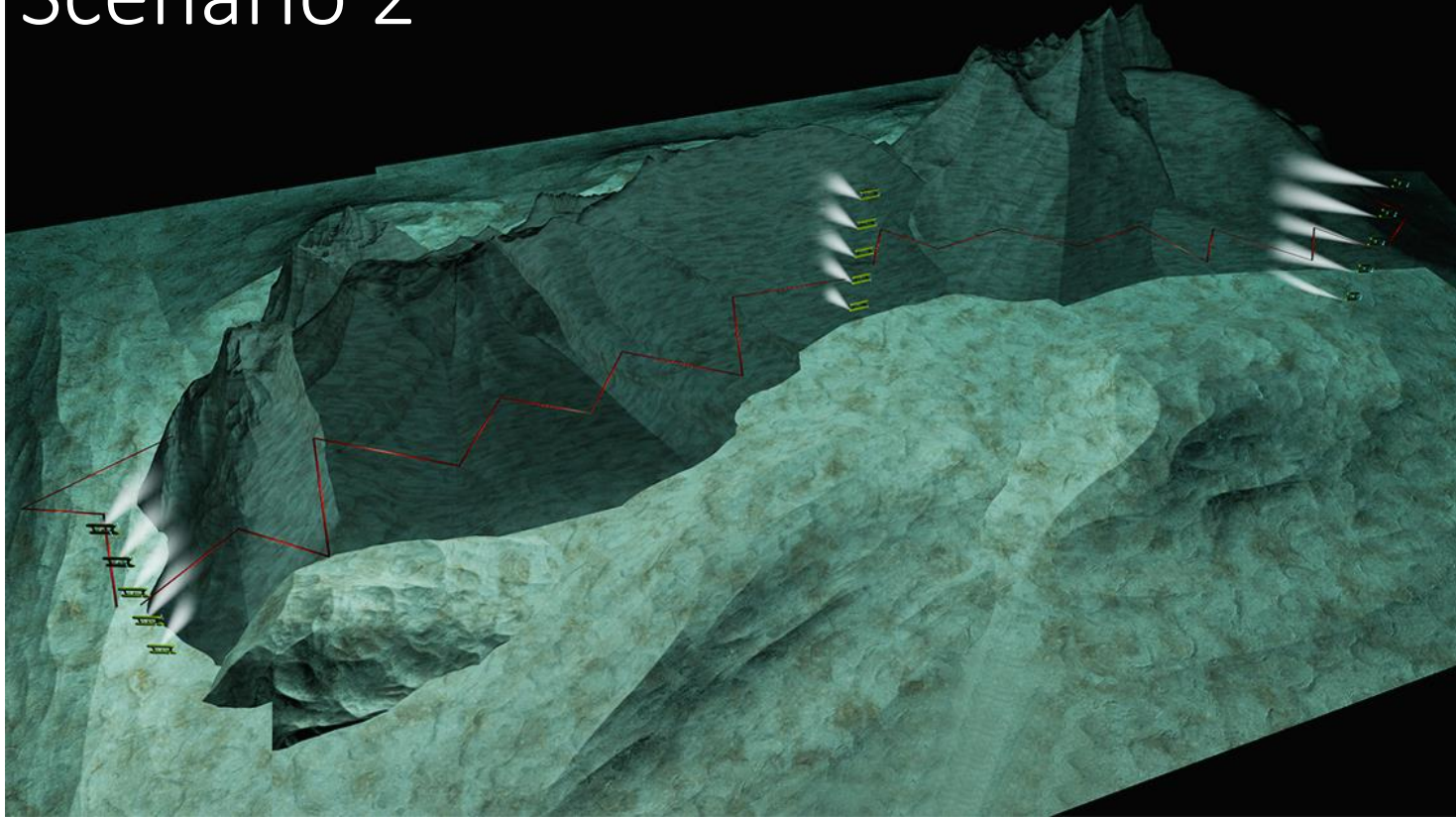
The goals are:

- To reach the seabed and homing on a fixed lander or oceanic observatory.
- In the descent the AUV will perform water column data acquisition in a well defined “spiral” with negative pitch.

Finally the AUV changes to high pitch attitude for the ascent and will spiral all the way up to the surface.



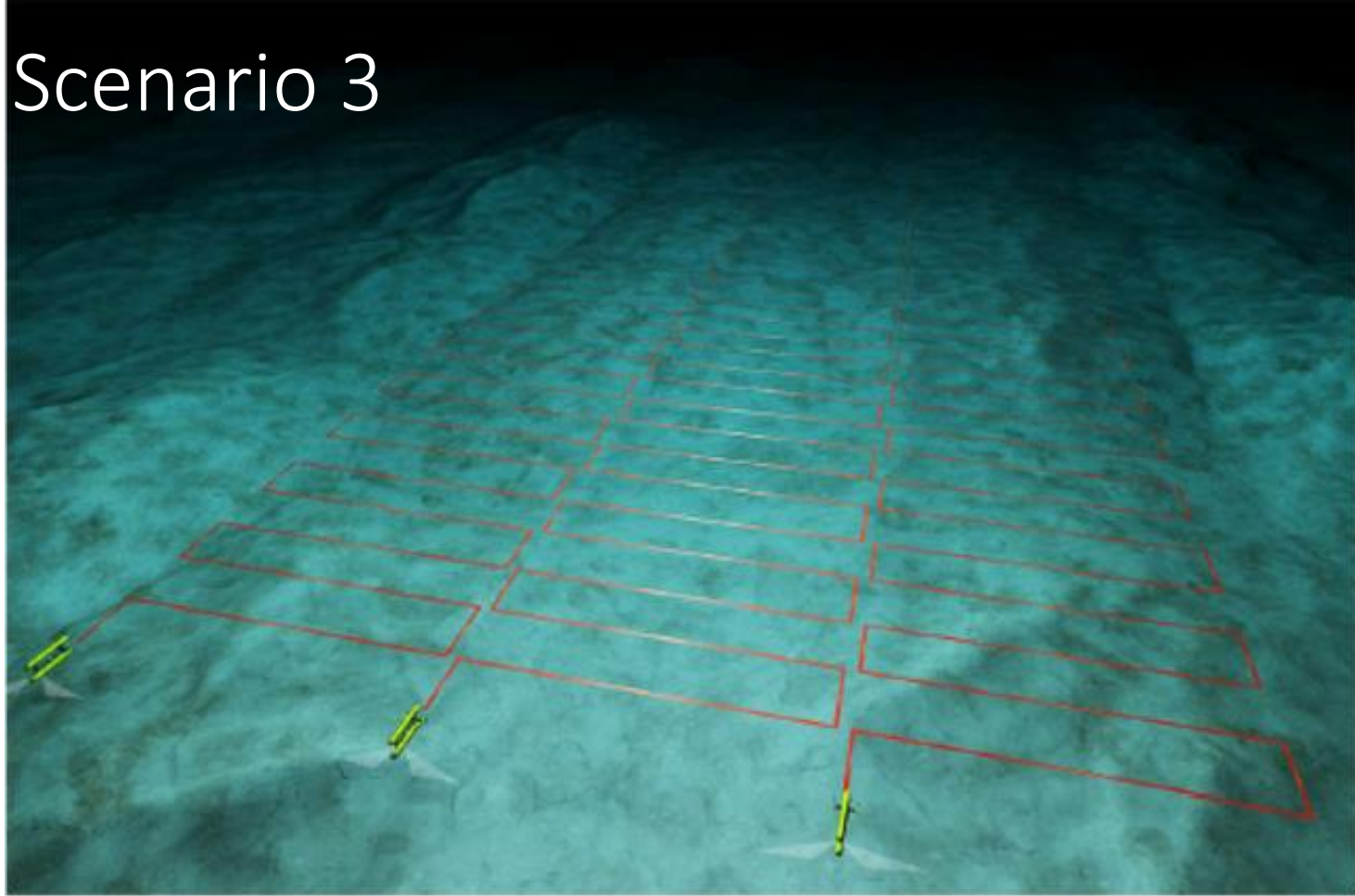
# Mission Scenario 2



## Resource exploration and mapping

- Exploring and mapping resources from the deep-sea (e.g. Mid-Atlantic Ridge).
- The AUV group will perform transects, measure water parameters near the seabed acquiring side scan sonar data.
- In this mission the MEDUSA Deep Sea system will have an ASV plus 3 to 5 collaborating AUVs.
- During transects the AUV system will search for hydrothermal sources.

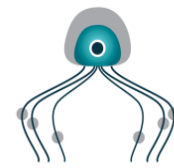
# Mission Scenario 3



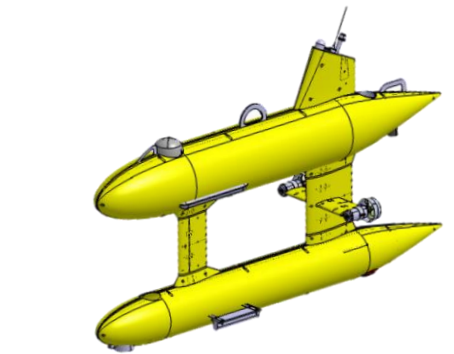
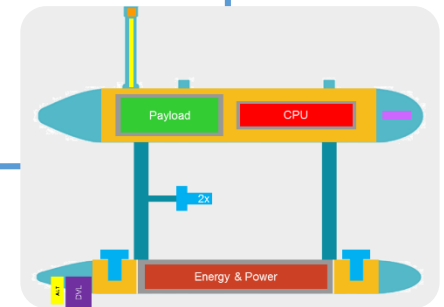
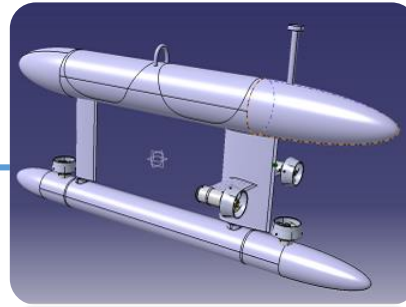
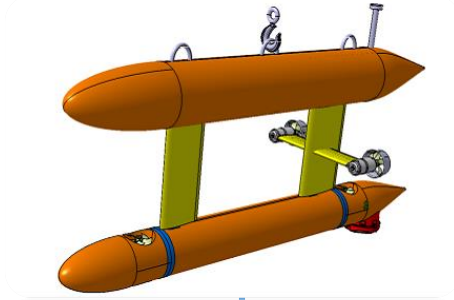
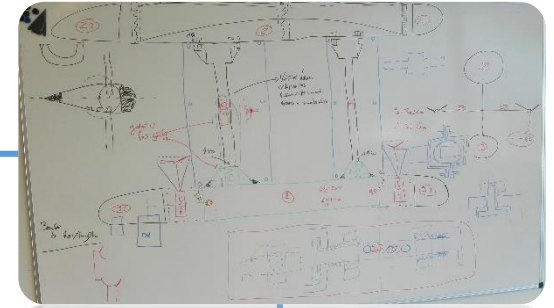
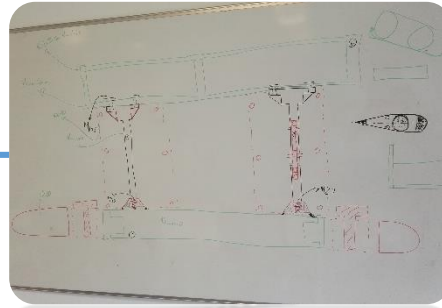
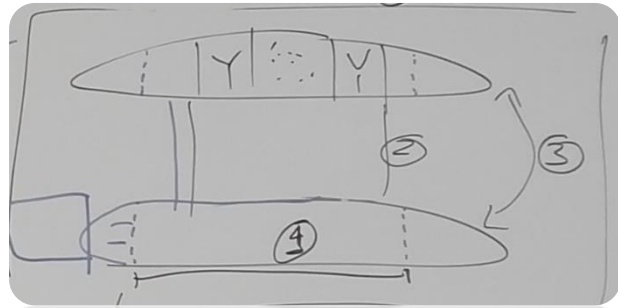
## High resolution habitat mapping

- high resolution habitat mapping with an ASV and 3 to 5 AUVs performing “lawn mower” trajectories, at 2-3 m altitude from the sea bottom
- carrying high resolution cameras and side scan sonar configured for the highest resolution
- to allow scientists to map and describe deep-sea ecosystems benthic communities and its functioning

# Development - Concept(s)



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# Spec. Summary



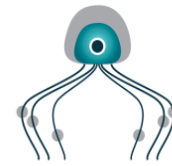
## MAIN CHARACTERISTICS

- Type: Double hull AUV
- Size: 2.8 m x 1.5 m x 0.7 m
- Weight: ~300 kg
- Endurance: ~10 hrs
- Range: ~50 km
- Maximum depth: 3000 meters
- Maximum speed: 3 m/s
- Nominal speed: 1,25 m/s
- DOF: 4
- Power system capacity: 2.4 kWh
- Launch and recovery: Crane

## MISSIONS

- Seabed Mapping
- Oil and Gas Survey
- Geophysical Survey
- Oceanographic survey
- Search and Recovery

# System Breakdown



MEDUSA  
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POSEIDON GPS  
Antenna

NOVATECH™

Iridium Beacon  
Mini Flasher Beacon



Wi-Fi 802.11 b/g

GPS Board | AHRS Vectornav |  
Gyros | EPIC Computers | Wi-Fi elect |  
Hard Disks | SSS + SBP electronics |

KELLER

KELLER PAA-33XEi Depth  
Cell



ECO FLNTU  
Fluorometer and  
Scattering Meter



4x Thrusters  
Argus ARS-800  
Mini-Thruster



Workhorse Navigator  
Doppler Velocity Log



Lithium polymer batteries



EdgeTech 2200  
Sub-Bottom Profiler

EvoLogics®

EvoLogics USBL Modem



KONGSBERG

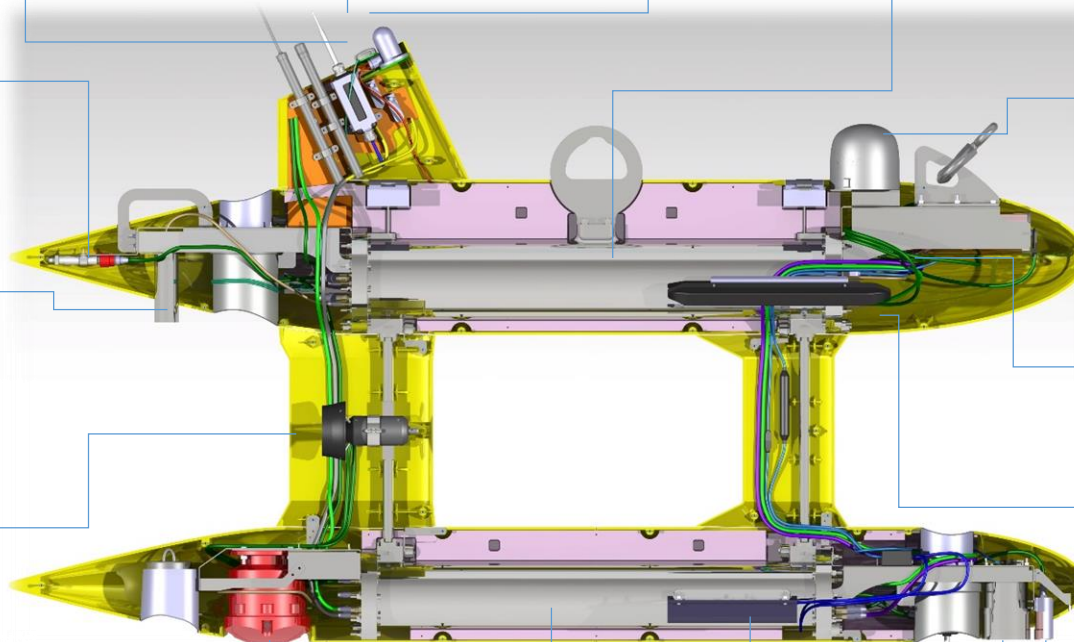
O2 Subsea Oxygen Sensor



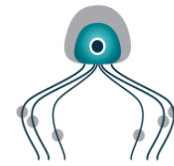
EdgeTech 2200  
Side Scan Sonar

ImpactSubsea

ISA 500 Altimeter

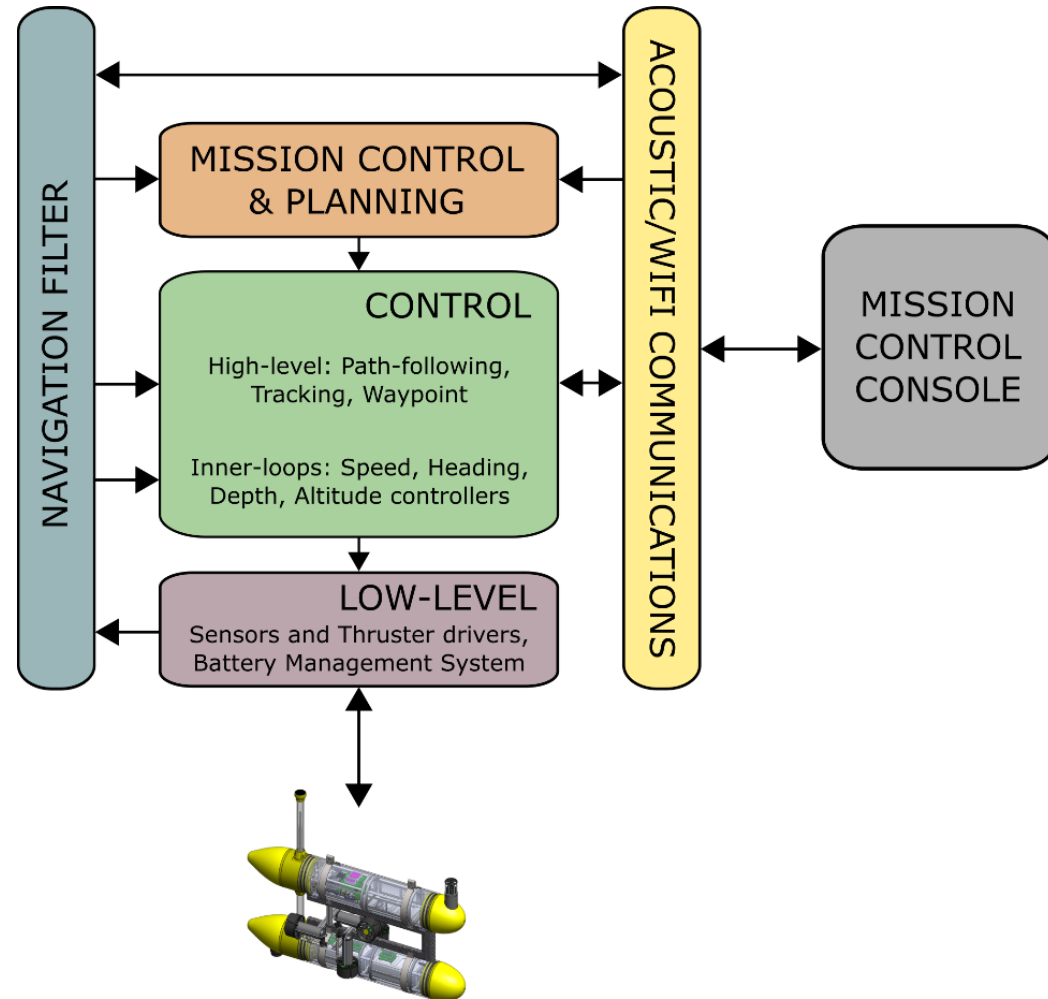


# Software Architecture



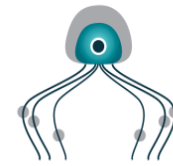
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DEEP SEA

- Built in **ROS** (Robot Operating System)
- Based on software *nodes* that communicate via *topics*; all communications handled transparently by ROS
- Very active community, large code base publicly available
- Easy to extend



# Sea trials

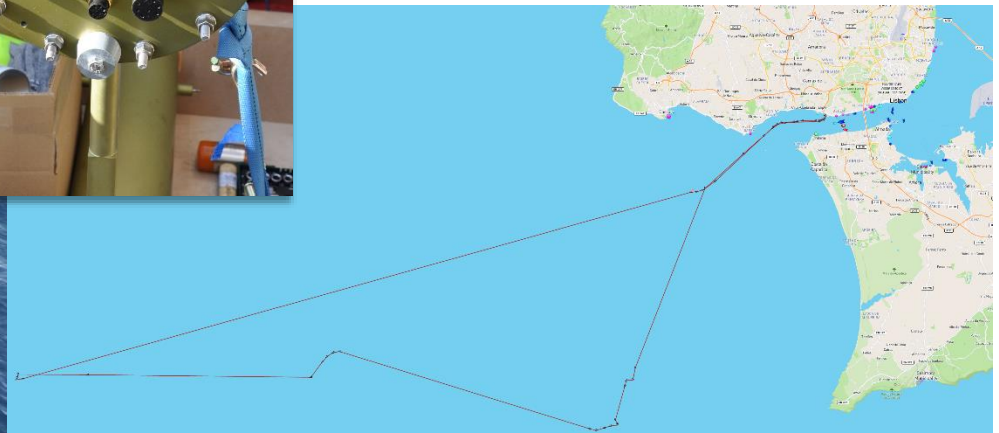
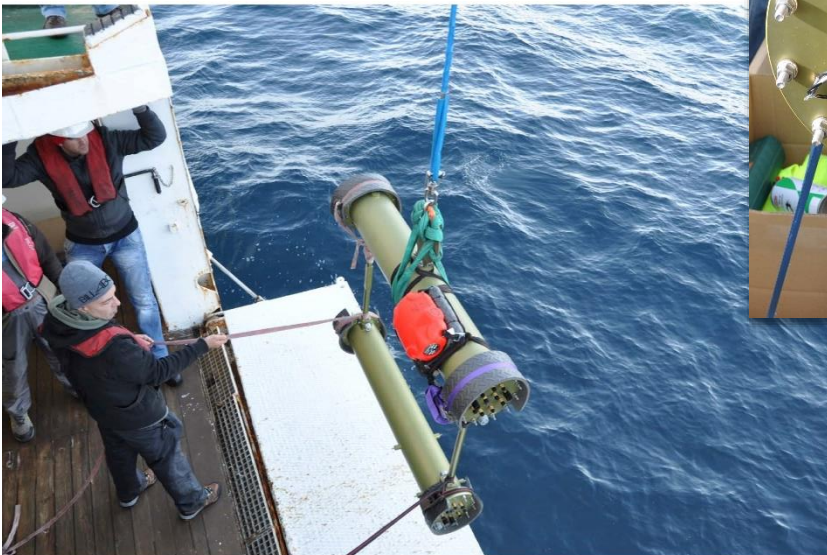
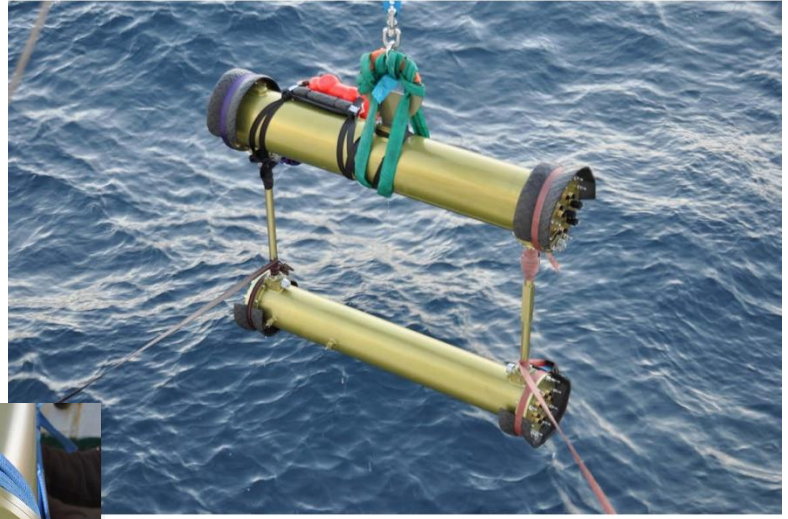
-Hull pressure testing at 1000 m (2016/:



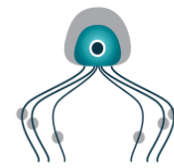
MEDUSA  
DEEP SEA



IPMA's research vessel NORUEGA



# The story of the Medusa Deep Sea...



MEDUSA  
DEEP SEA



...so far!

**...and now, for something  
slightly different...**

# Merging Industry and Academia Innovation



FUSION  
FUSION

*"SRS has teamed up with talented companies and individuals around the world that work together with bright and clever ideas. The sharing environment instills creativity, fresh outlooks and challenging conformity. The result is evident in the exceptional products that reshape the way underwater operations are conducted."*

**SRS** | STRATEGIC  
ROBOTIC  
SYSTEMS

# SRS FUSION Hybrid System - An Innovative Concept

## Hybrid System



- Comprehensive Sensor Suite
- Complex Mission Patterns
- 300m (1,000ft) Depth
- USBL Correction / Communications



- Vectored Thruster Configuration
- Small Diameter Rugged Tether
- 4+ Knot Forward Speed
- Stability and Automation Control



- Sonar and Navigation Aid for Diver
- Propulsion Device for Diver
- Virtual Anchor When Not in Use
- Fully Operational Subsea UI



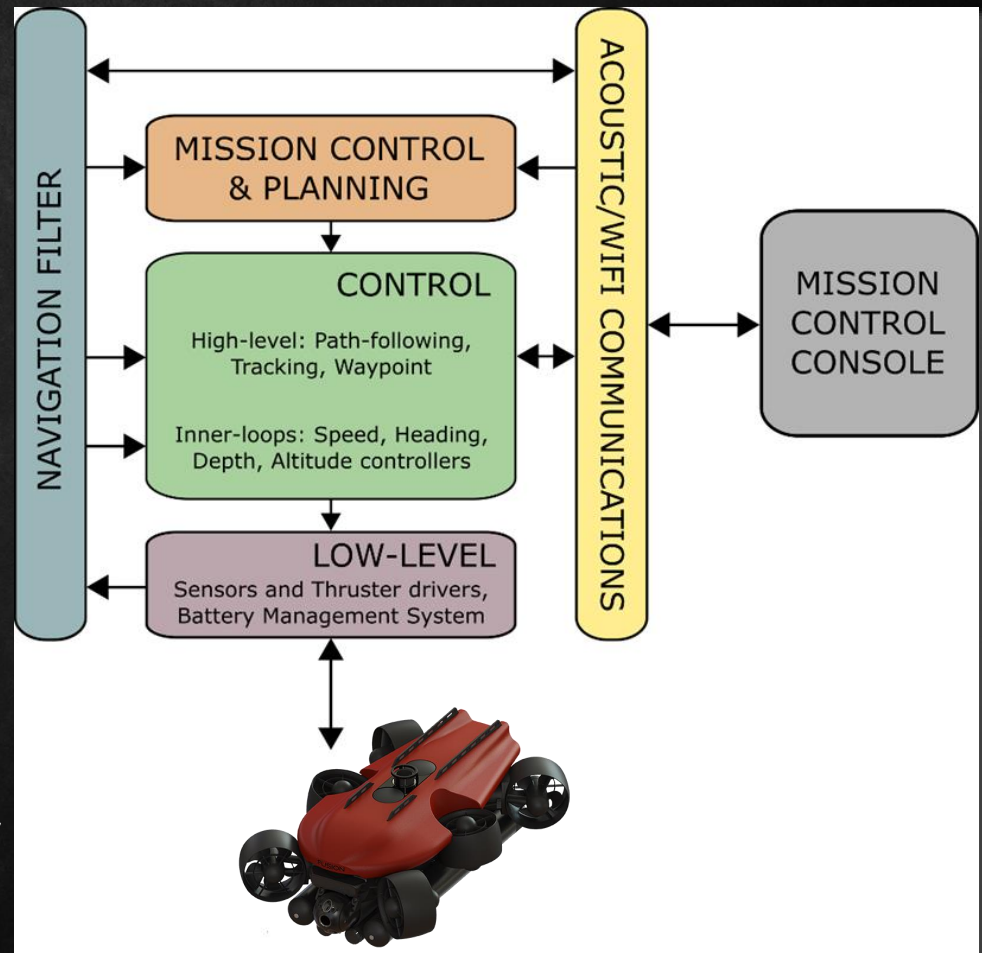
# SRS FUSION Hybrid System – Key Components

## Key Components



# IST Know-How Applied to SRS FUSION

- Capitalizing on the know-how obtained from years of developing the MEDUSA Class AUVs
- IST main contribution:
  - Navigation and Control Systems
    - Development
    - Implementation
    - Optimization
- IST also contributes on
  - Simulation Environment
  - FUSION *Field-Testing* – *want to see a demo? Come a and talk to us!*
  - The different operating modes rely on IST's Software Architecture Implementation

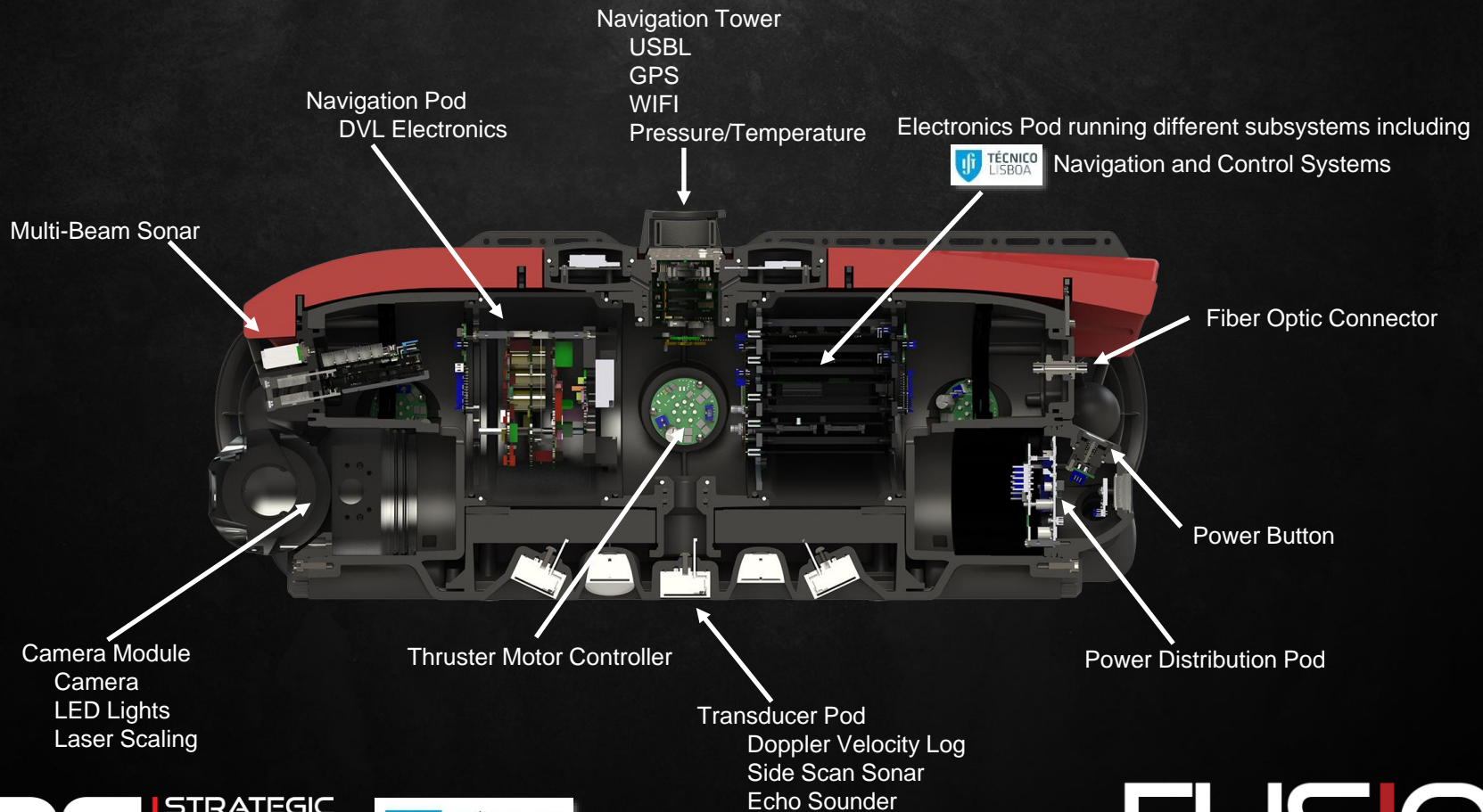


# IST Know-How Applied to SRS FUSION

## Vehicle Components

### Key Features

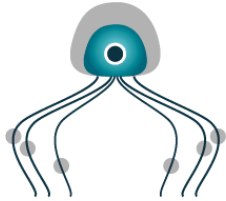
- Single Titanium Exterior Fastener
- Single Interior Fastener
- Connectorized Electronics with Wiring Loom
- Rugged Aluminum/Composite Construction
- Barometric Pressure Monitor



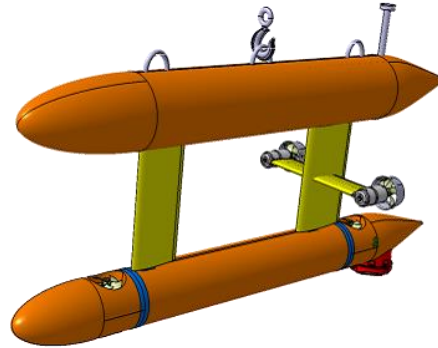
# IST Know-How Applied to SRS FUSION



# The **MEDUSA Deep Sea**



MEDUSA  
DEEP SEA



and **FUSION** AUVs



## When research and business get together

Bruno Cardeira/IST