Jérôme Blandin Ifremer

EMSO strategic workshop
Rome, 12th March 2025

MOBILE EXTENSIONS OF FIXED-POINT OBSERVATORIES

emso ERIC
EUROPEAN RESEARCH INFRASTRUCTURE CONSORTIUM

INTRODUCTION

Framework

Work presented below mainly funded by Ifremer through its ScInObs project

ScInObs is Ifremer's contribution to One Deep Ocean, a programme 2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Additional funding from France 2030

Underlying principles

↘ cost of ocean observation data

↘ environmental footprint of ocean observation data

↗ spatial range of observation

1. DEVELOPMENT OF A RESIDENT AUV FOR SCIENTIFIC OBSERVATION

Residency

The ability of staying operational at sea,

on the seabed or in the water column,

for a long duration without recourse to a ship

RESIDENT DRONES

Hydrone-R, SAIPEM

Why?

- Defence
- Industry: Inspection, Maintenance & Repair
- Science: long-term *in situ* observation

Common motivation:

Shipless operation

Who?

- Defence: …
- Industry (oil&gas, MRE, aquaculture): historical investment in Norway, USA, UK, Italy (Aker Solutions, Equinor, Saipem/Sonsub, Oceaneering, Saab, Subsea 7, …)
- Research:

  WHOI, USA

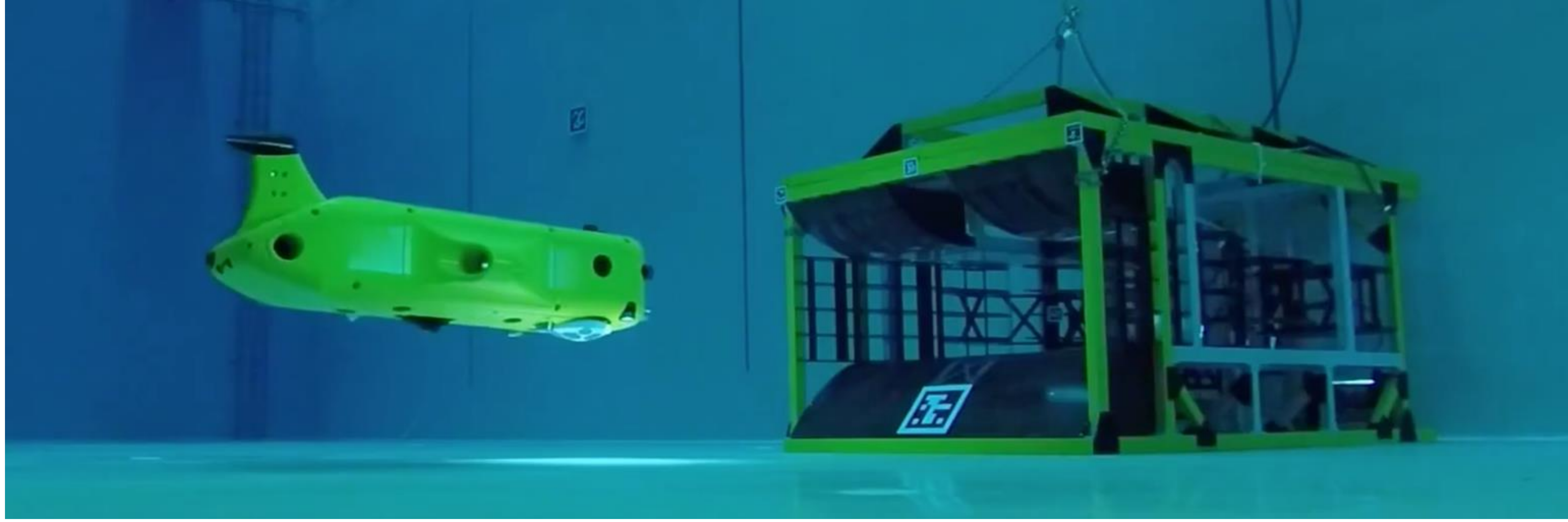
  NTNU, Norway

  IFREMER, France

  DFKI, Germany

  non exhaustive list

RESIDENT AUVs



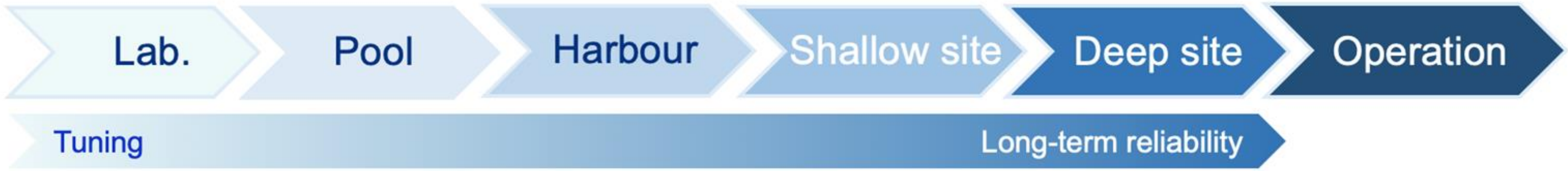
FlatFish, Deutsches Forschungszentrum für Künstliche Intelligenz

Technological challenges

Long-term reliability without human intervention

- Reliability +++
- Secured positioning/navigation
- Reliable docking manoeuvre, 100% success rate

Long & costly test sequence



RESIDENT AUV FOR SCIENCE

Why?

Permanent undersea presence of a mobile observation platform for
- acquiring spatially extended time series
- being there at the right moment

	Static observation platforms	Non-resident AUVs
Strength	Long time series	High spatial measurement range
Weakness	Space under-sampled	Short time series
		Mother-ship time: cost and carbon footprint

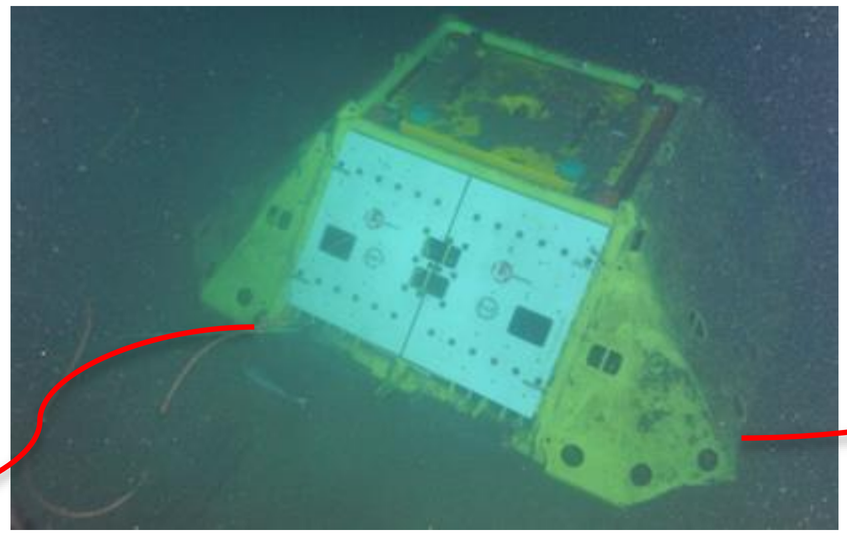
Challenge:

Shipless long-term operation

How?

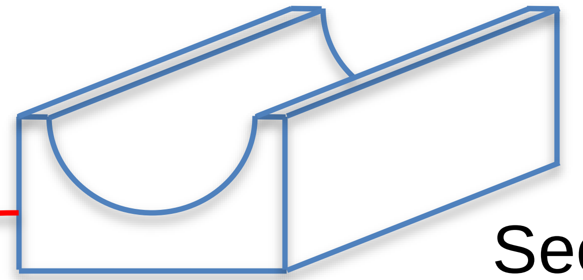
Existing cabled seabed infrastructure

High-density subsea power source



System under development

Docking station

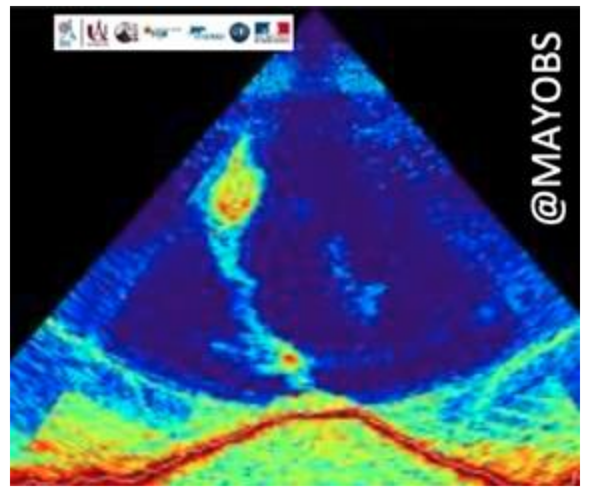


Secure place,
Battery charge,
Data link to shore.

AUV

1 year without maintenance
Daily missions returning on the docking station

RESIDENT AUV FOR SCIENCE



4 initial use cases

1. Monitoring of biodiversity and sponge abundance in coastal ecosystems
2. Study of mesophotic coral ecosytems of La Réunion
3. Monitoring of benthic ecosystems
4. Observation of fluid emissions and eruptive events

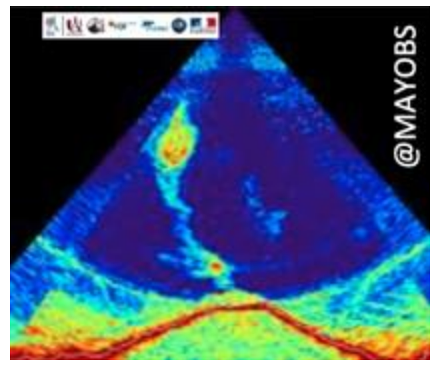
3 operation sites:

- Bay of Brest (1), average depth 8 m
- La Réunion Natural Marine Reserve (2), depth [20 - 100] m
- Mayotte (3, 4), depth 1500 m

Operational requirements

- Depth ≤ 2500 m
- Current ≤ 1 knot
- Deployment
  - in shallow water with divers
  - ROV-assisted in deep waters, ROV-less recovery desirable
- Maintenance period = 1 year

RESIDENT AUV FOR SCIENCE



4 initial use cases

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Functional requirements

- **Primary function** = acquiring observation data and delivering them to shore via a docking station
- **Mission geometry and kinematics:**
  - Mission radius = 3500 m (derived from USBL specs)
  - Mission path length = 10000 m
  - Δ depth ≤ 1000 m
  - Altitude : [1 - 1000] m
  - Max speed over ground = 1 knot
  - Min speed over ground = 0 knot (hovering)
- **On docking station:**
  - Charging power ≥ 150 W, contactlesss
  - Battery charge time ≤ 15 h
  - Contactless data rate : 100 Mbps (for uploading large video footages)

- **Payload**
  - HD stereo camera + lights
  - CTD
  - Dissolved O_2
  - Turbidity
  - ADCP 1 MHz
  - *Possibly CO_2 and CH_4*

RESIDENT AUV FOR SCIENCE

Project started in May 2023

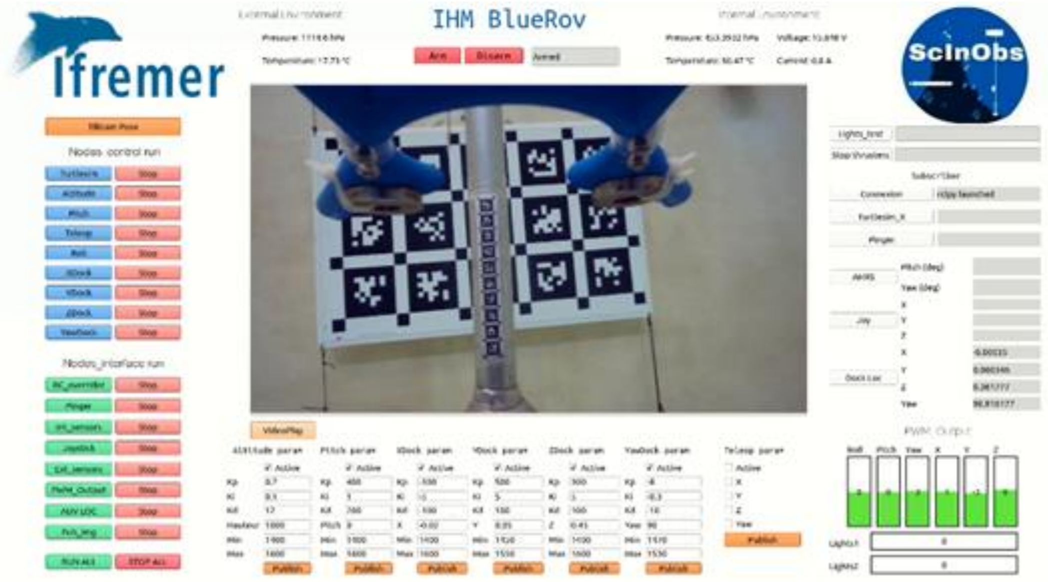
First stage = fine-tuning/qualifying enabling building blocks

Contactless power/data transmission

BlueLogic BB8112 and BB8113

550 bars qualification in hyperbaric tank

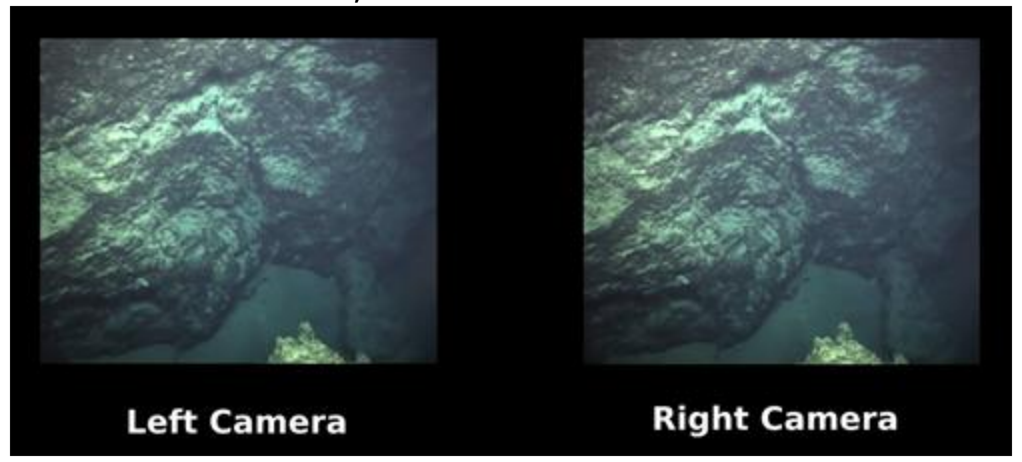
Docking maneuver



Tests vector = BlueRov (Blue Robotics)

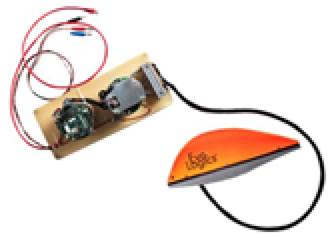
Optical positioning

Stereo camera, SLAM



Acoustic communication & positioning

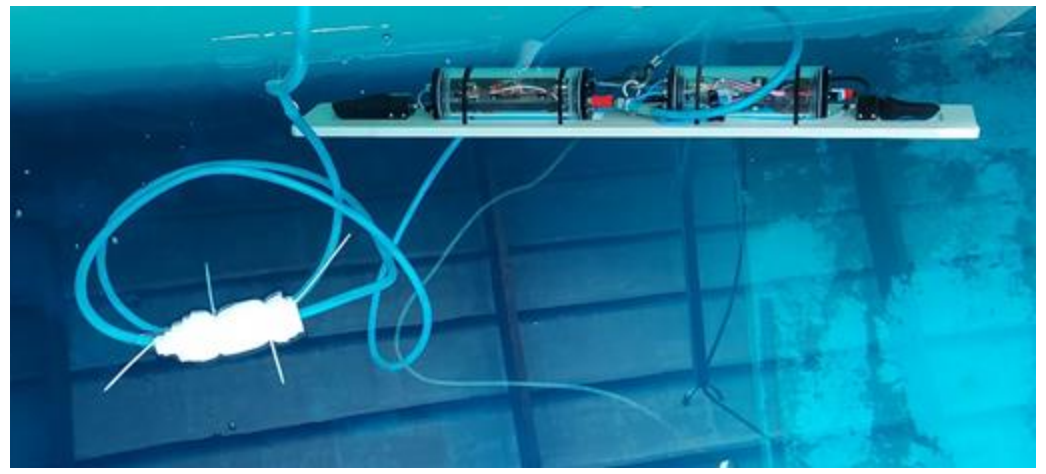
Three USBL models under tests



Tests at sea

Navigation, sensor fusion

Reversible ballast with pitch control



Home-built mock-up

Design activities

Docking station

Bi-power design

RESIDENT AUV FOR SCIENCE

Next steps

Integration of critical building blocks on
Forssea Robotics Argos-X

funded

Graaltech X-300 Explorer

funded

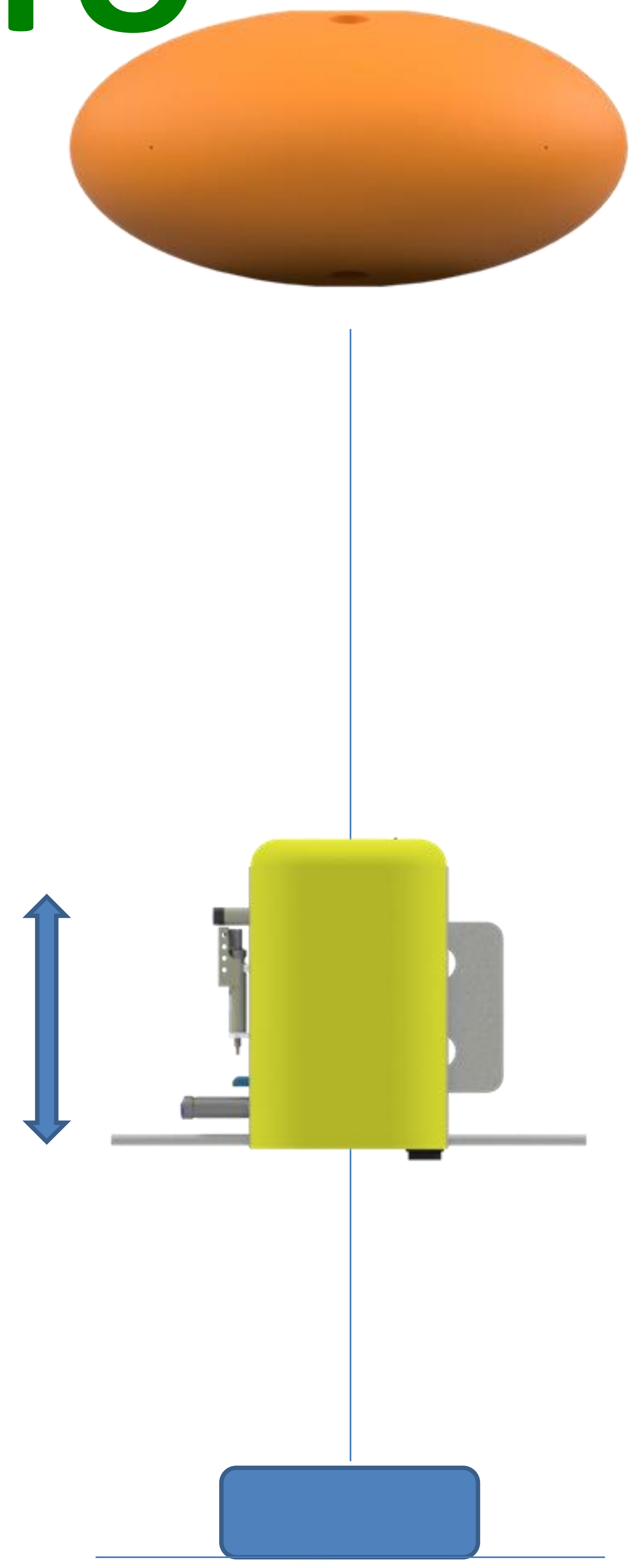
Tests in shallow water (Bay of Brest and Toulon) *funded*

Public tender for designing / building / testing operational vehicle
(300 m then 2500 m) *to be funded*

Jean-Romain Lagadec

2. DEVELOPMENT OF A MOORED PROFILER

A MOORED PROFILER, THE ALTERNATIVE TO OCEANOGRAPHIC MOORINGS



Main characteristics:

- Single set of sensors on a vector
- Vector goes up and down the water column several times a day
- Vector moves along a moored cable
- Surface or subsurface tensioning buoy

Moored profilers vs oceanographic moorings:

Advantages:
Quicker to deploy
Higher / versatile sampling resolution
One single set of sensors :
cheaper, easier sensor maintenance

Drawbacks:
Lower measurement frequency
Limited autonomy
Limited operating depth (for some of them)

SCIENTIFIC REQUIREMENTS

Profiling constraints

- Up to 24 profiles (seafloor / subsurface) each day at 2000 m depth (0,56 m/s)
- Capacity to stop and change direction during a profile
- Capacity of relative positioning underwater (depth, long., lat., azimuth, inclination)
- Water current speed up to 0,7 m/s while profiling

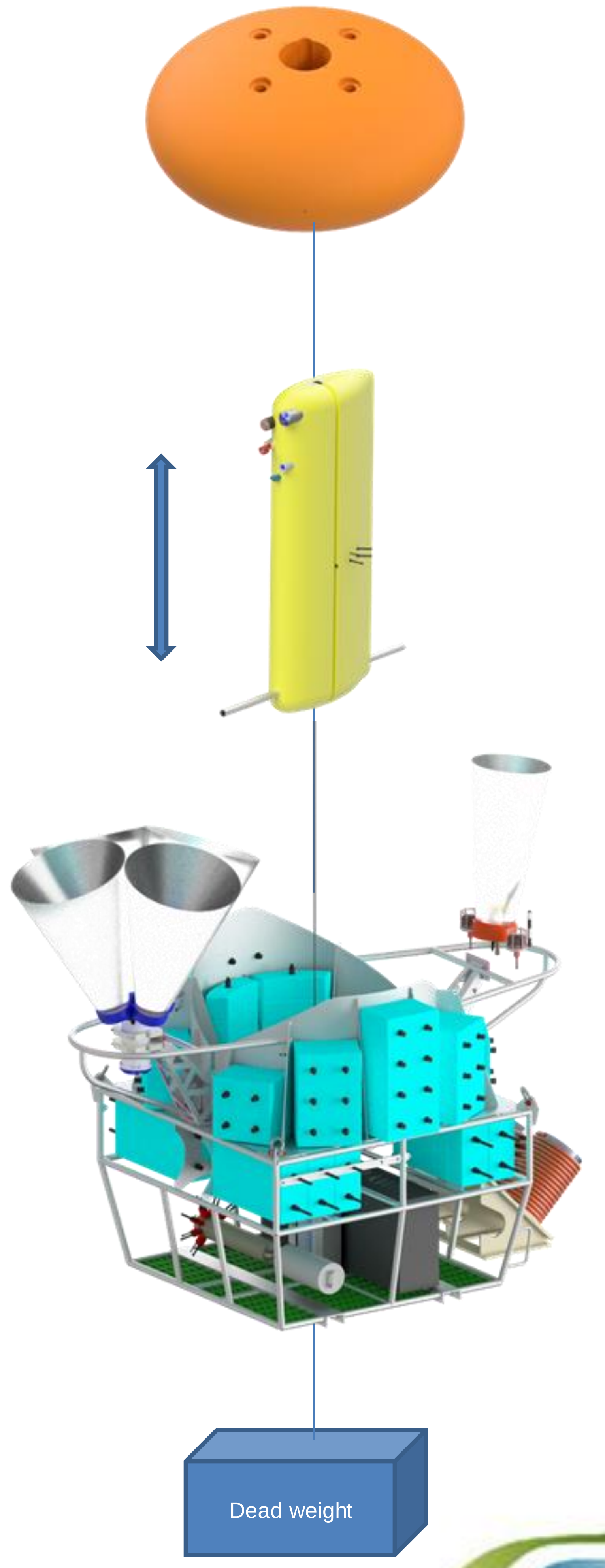
Sensors configuration

- Standard embedded sensors: CTD, optode, turbidimeter, current meter
- Biology configuration sensors: UVP camera, eDNA sampler
- Geochemistry configuration sensors: CH4 sensor, pCO2 sensor, pH and redox sensor

Sea-bottom long-range sensors: ADCP, echo-sounder, camera

MAIN FEATURES

- 6000 m maximal operating depth
- Capacity of being deployed by small vessels
- Compatible with both shallow and deep water deployments
- High speed profiling (0,6 m/s linear max)
- Sensors configuration versatility (biology, geochemistry, currentology)
- One year minimal operating duration
- In-situ decision making capacity for real-time adaptation of sampling strategy
- Energy and data transfer between the profiler and a docking station
- Power and control autonomy for a standalone deployment (batteries in the docking station)
- Possible connection to a cabled node for near real-time data transfer and power supply
- Future possible access to the surface with a winched pop-up buoy for data transmission



FULL-SCALE MODELS OF SUB-ASSEMBLIES

Profiler/ cable interface

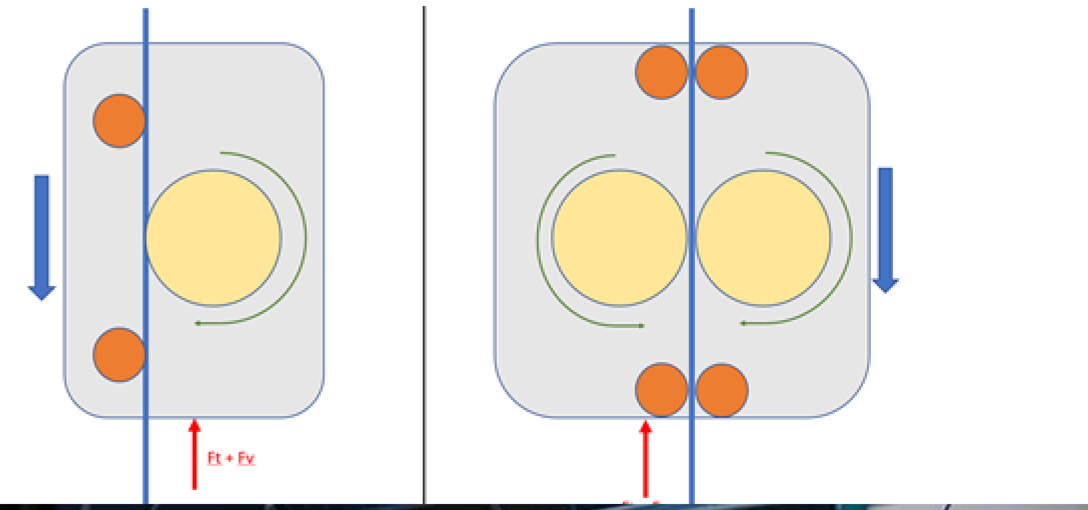
To allow the profiler to move along the cable without sliding

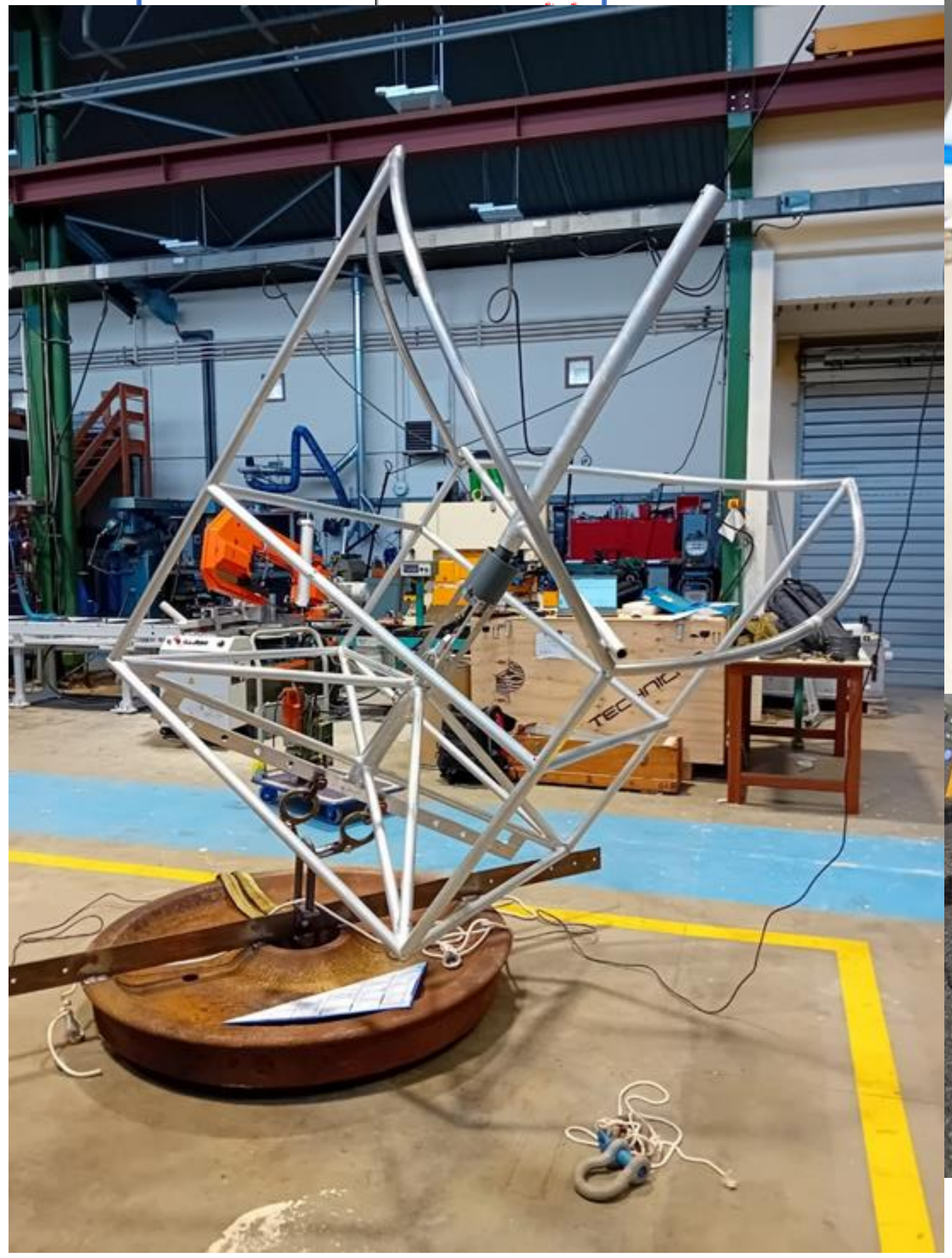
- Wheel combination (1,2 or 3)
- Wheel's groove shape
- Cable type (sheathed steel, sheathed aramid)

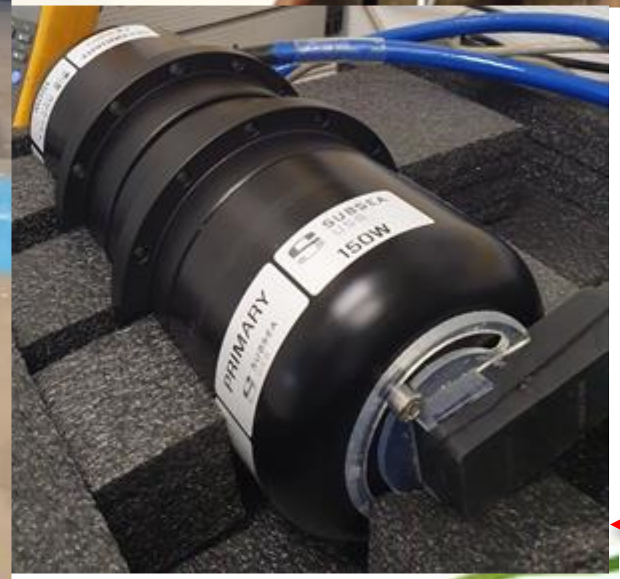
Profiler / docking station and docking station / dead-weight interfaces in cabled mode

To allow inductive connectors of both profiler and station to align:

- Degrees of freedom of the station lower interface to align with the cable
- Profiler able to rotate around the cable for connectors alignment







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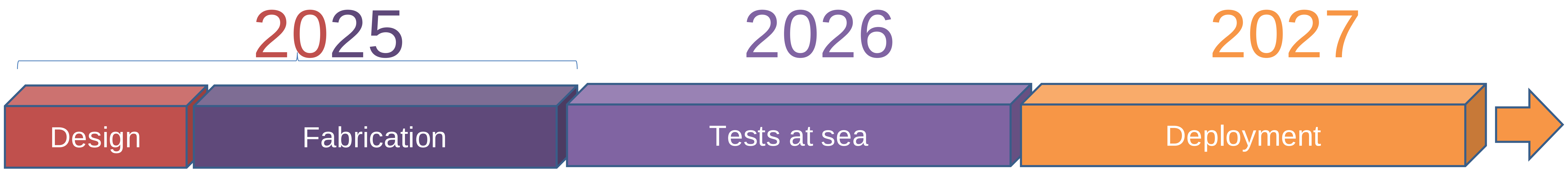
NEXT STEPS



2025

- Electronics and software design
- Drive wheel package design
- Profiler structural layout
- Fabrication, assembly and first tests in basin

2026

- 1 month test on standalone, shallow water, Brest Bay
- 3 month test on a cabled test base, deep water
- 14 month deployment, New Caledonia, 1200 m

2027

- Mechanical and electronics optimization
- Integration of embedded low-power AI

Alfredo Martins INESC TEC

EMSO Strategic Workshop
Rome, 12° March 2025

MOBILE AUTONOMOUS SYTEMS
Into the future of deep sea observation

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TURTLE Robotic deep sea landers

Hybrid lander / AUV

- **Long-term permanence on the bottom**
- **Autonomous locomotion for positioning/repositioning (AUV)**

Variable buoyancy system

Acoustic communication

Autonomous navigation (INS, DVL, USBL/LBL, multibeam sonar)

2016	2017	2018	2019	2020	2021	2022	2023	2024

TURTLE I – First dual use EDA project

TURTLE II – Tech transfer and commercial upscaling

TURTLE III – Commercial solution

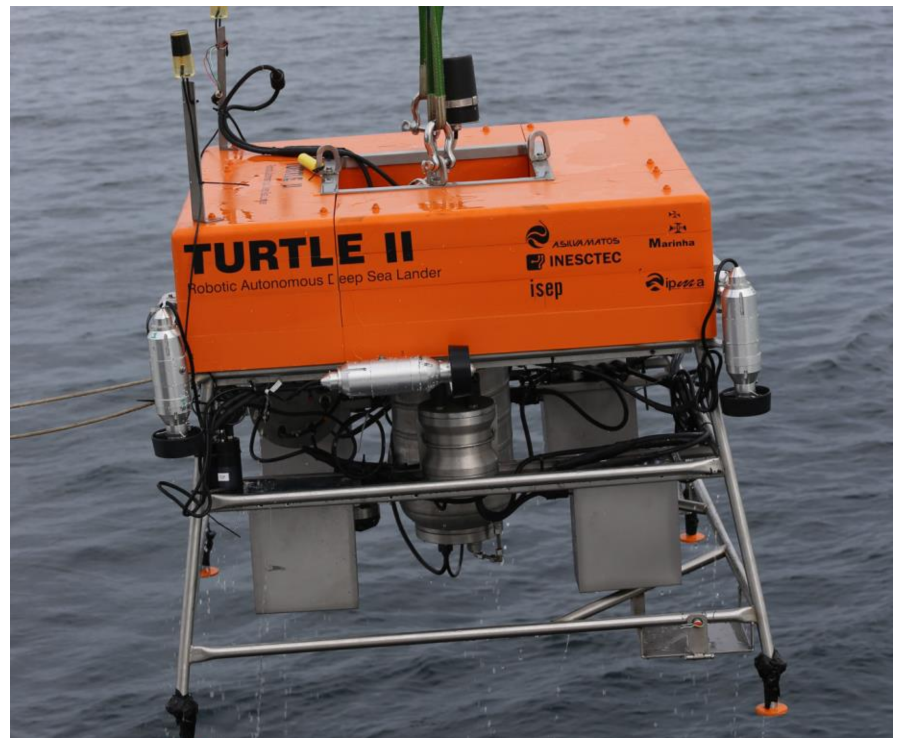
TURTLE IV – Higher depth

TURTLE I

1100 kg
1000 m

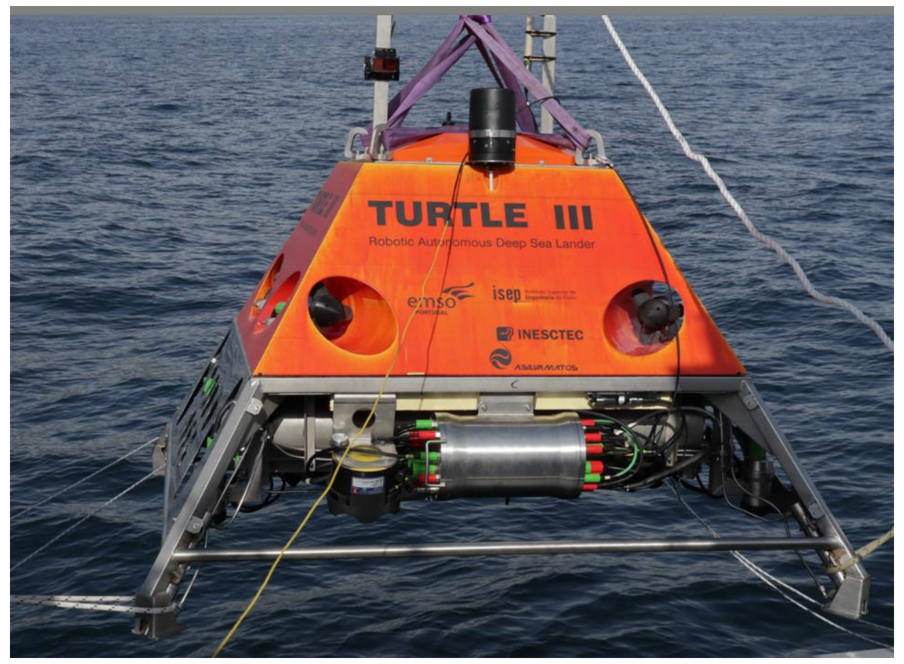
TURTLE II

600 kg
500 m



TURTLE III

700 kg
1000 m



TURTLE IV

900 kg
4000m

TURTLE III

- **700 Kg weight,** 100 Kg default payload configuration
- 1000m depth rated
- VBS for 4000m
- 8 Custom developed thrusters (15 to 25Kgf)

autonomous motion control

- 30 KWh NMC (lithium Nickel Manganese Cobalt oxide) pressure-tolerant batteries

energy management

- Two antenna RTK/GNSS receiver
- FOG INS
- RDI Tasman DVL

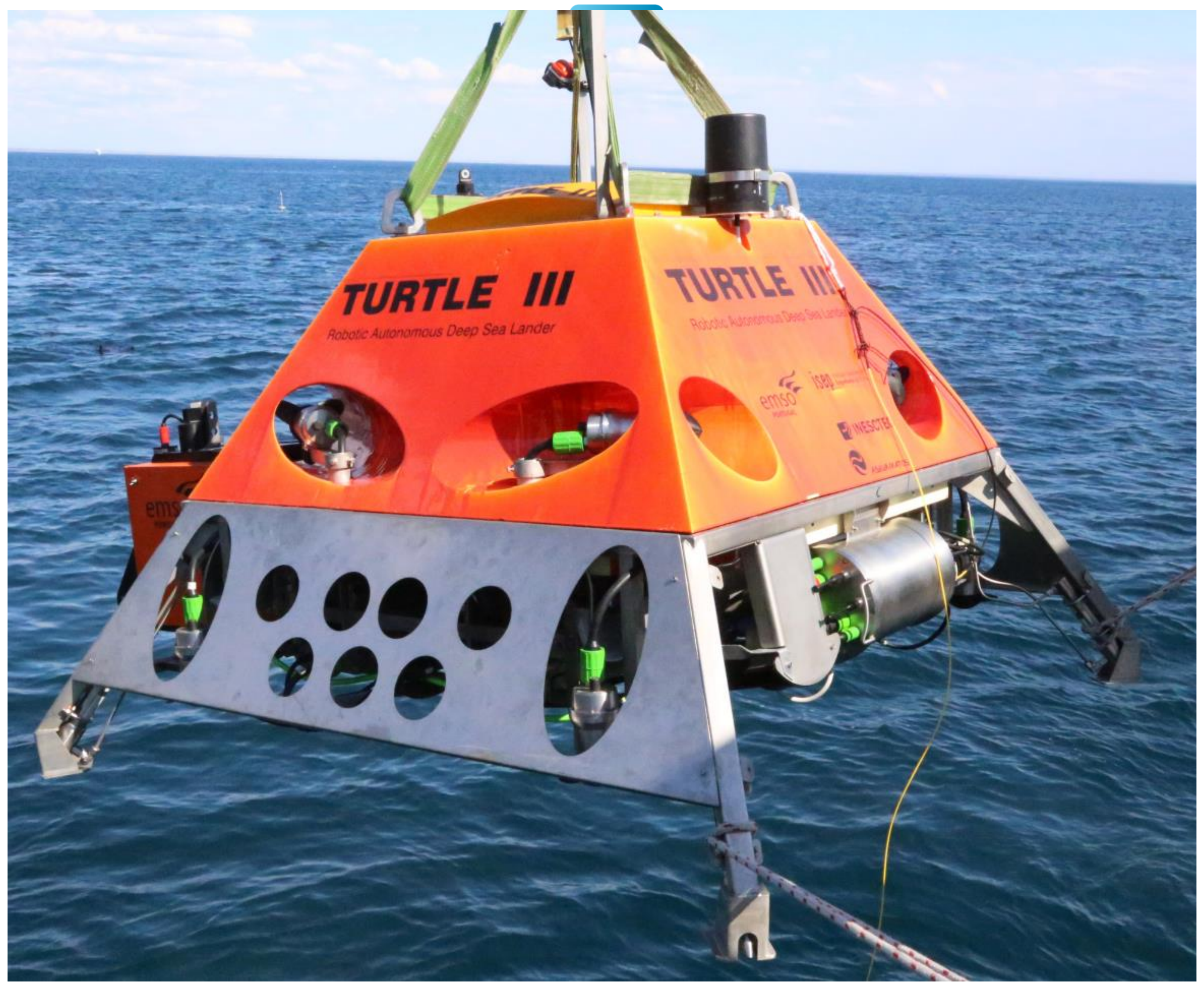
positioning and navigation

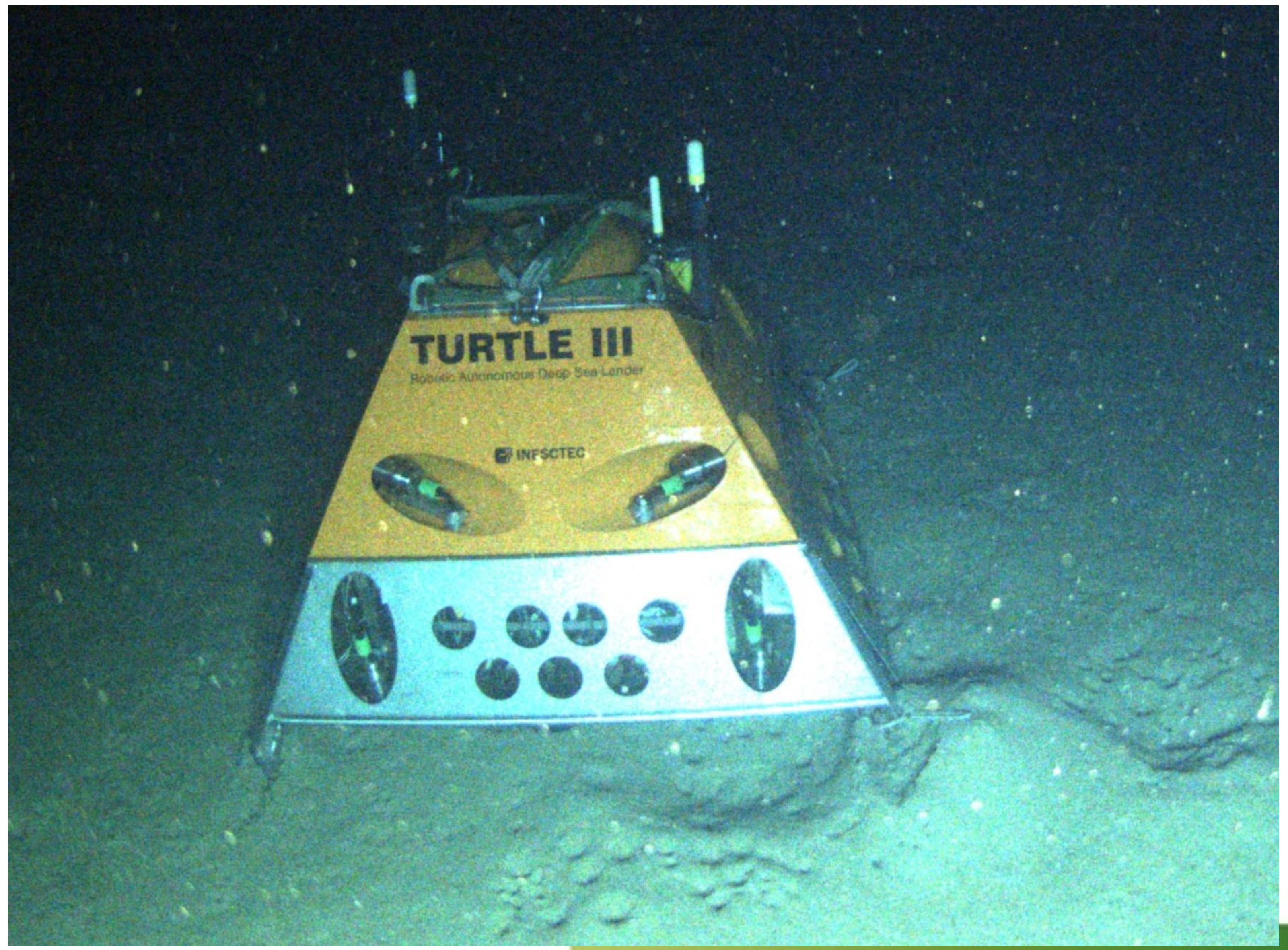
- Evologics USBL/modem (S2C R 18/34)
- Iridium communications
- Emergency acoustic release

communications and safety

- Kongsberg M3 multibeam sonar
- Custom cameras and SLS

perception and mapping





TURLE III at 830 m
in Setubal canyon

Mobile EGIM deployment

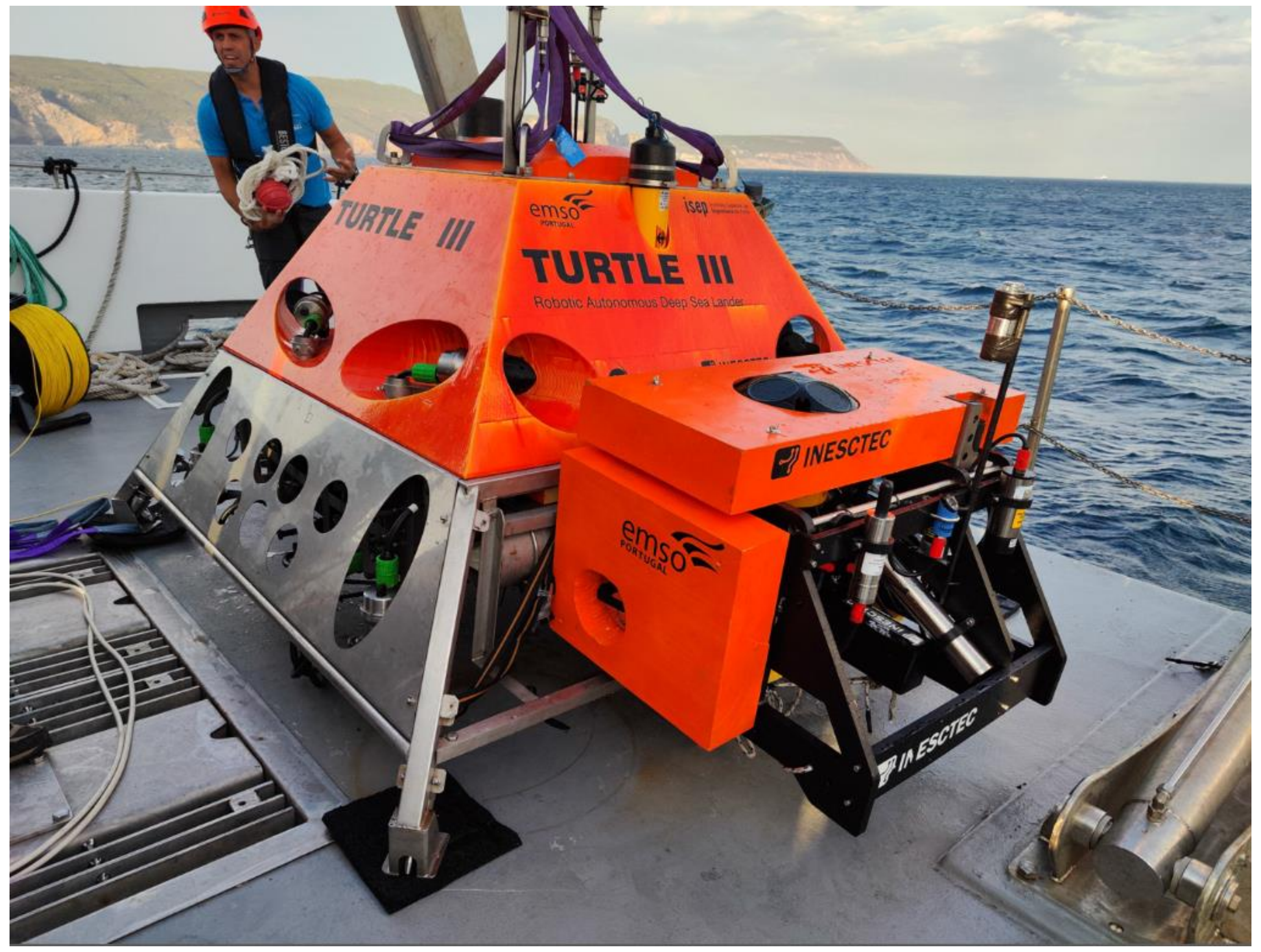
EGIM custom mechanical structure

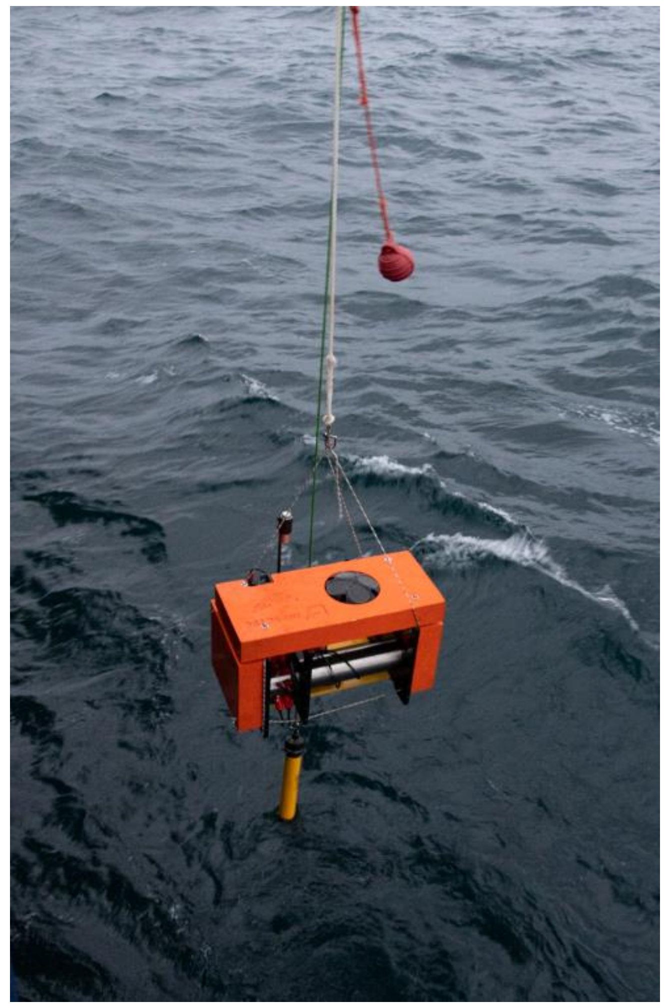
Turtle robot or standalone deployment

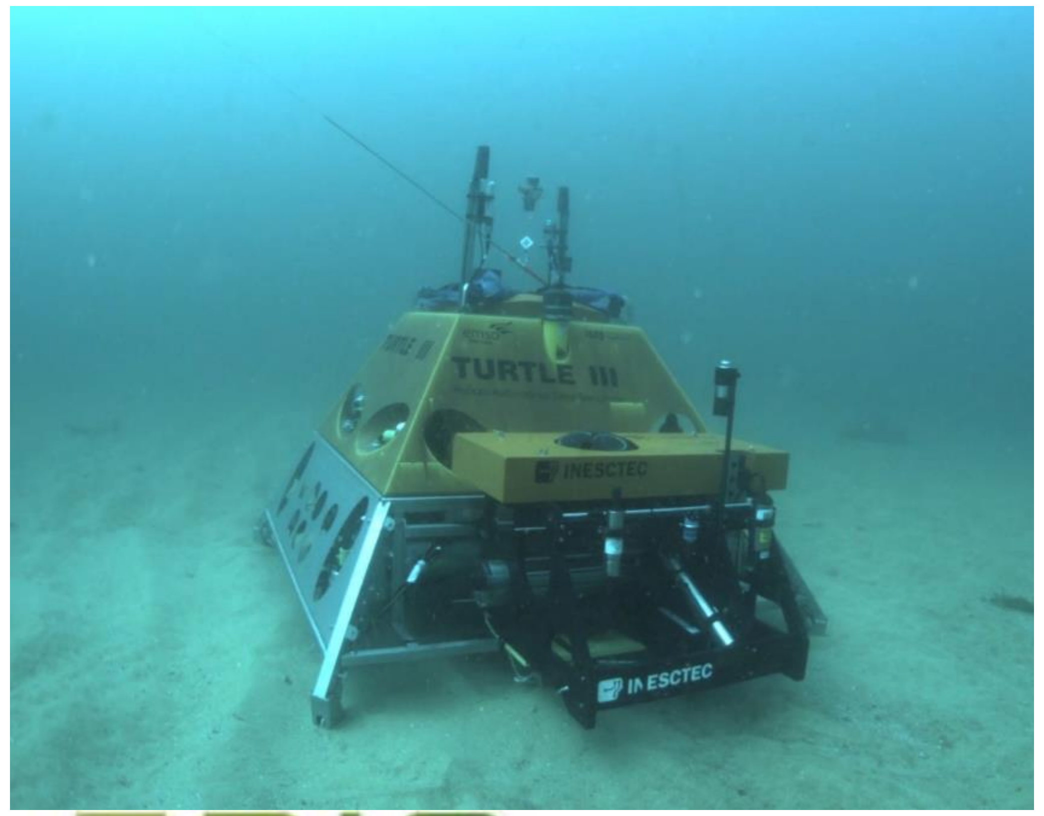
Relocation capabilities (with TURTLE robotic lander)

Standalone deployments in Madeira Tore (800m) and Tropic Seamount in the Atlantic (1100m)

TURTLE-EGIM deployments at shallow depths (50, 100m) in Portuguese coastal area (Aguçadoura, Sesimbra)







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AUV docking station

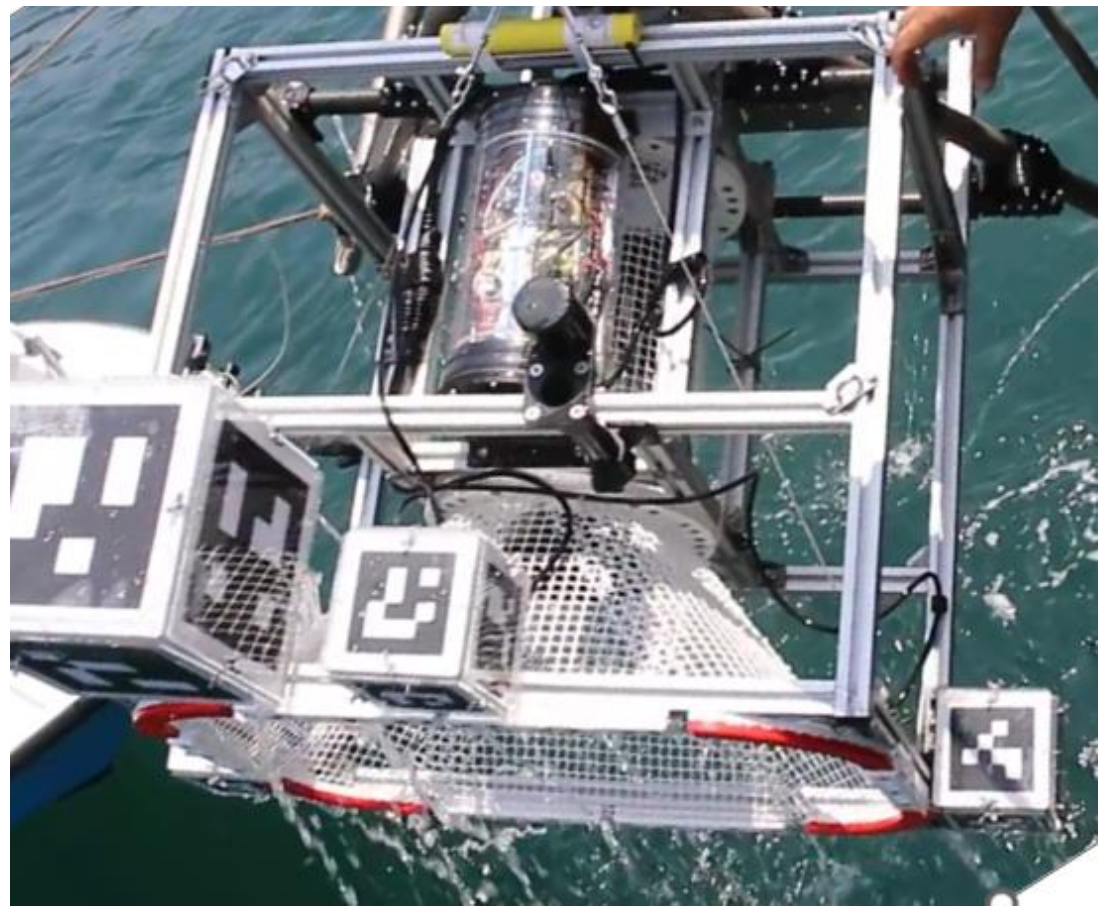
“Top docking” for EVA AUV in TURTLE

Docking station for MARES AUV

Acoustic and visual docking maneuver

Contactless power/data transmission (BlueLogic inductive system)

Shallow water field trials



Resident robotics

From offshore renewables to sea observation

TURTLE acting as docking station base

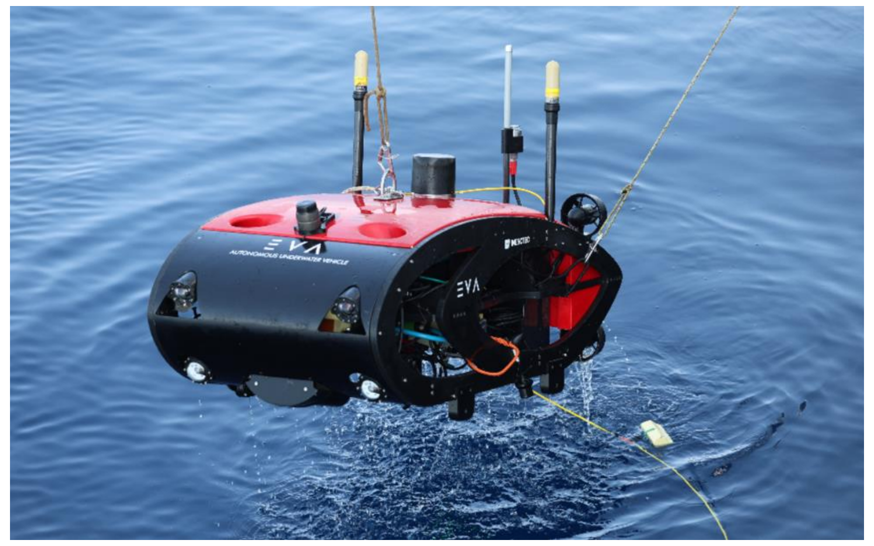
Custom station for EVA AUV

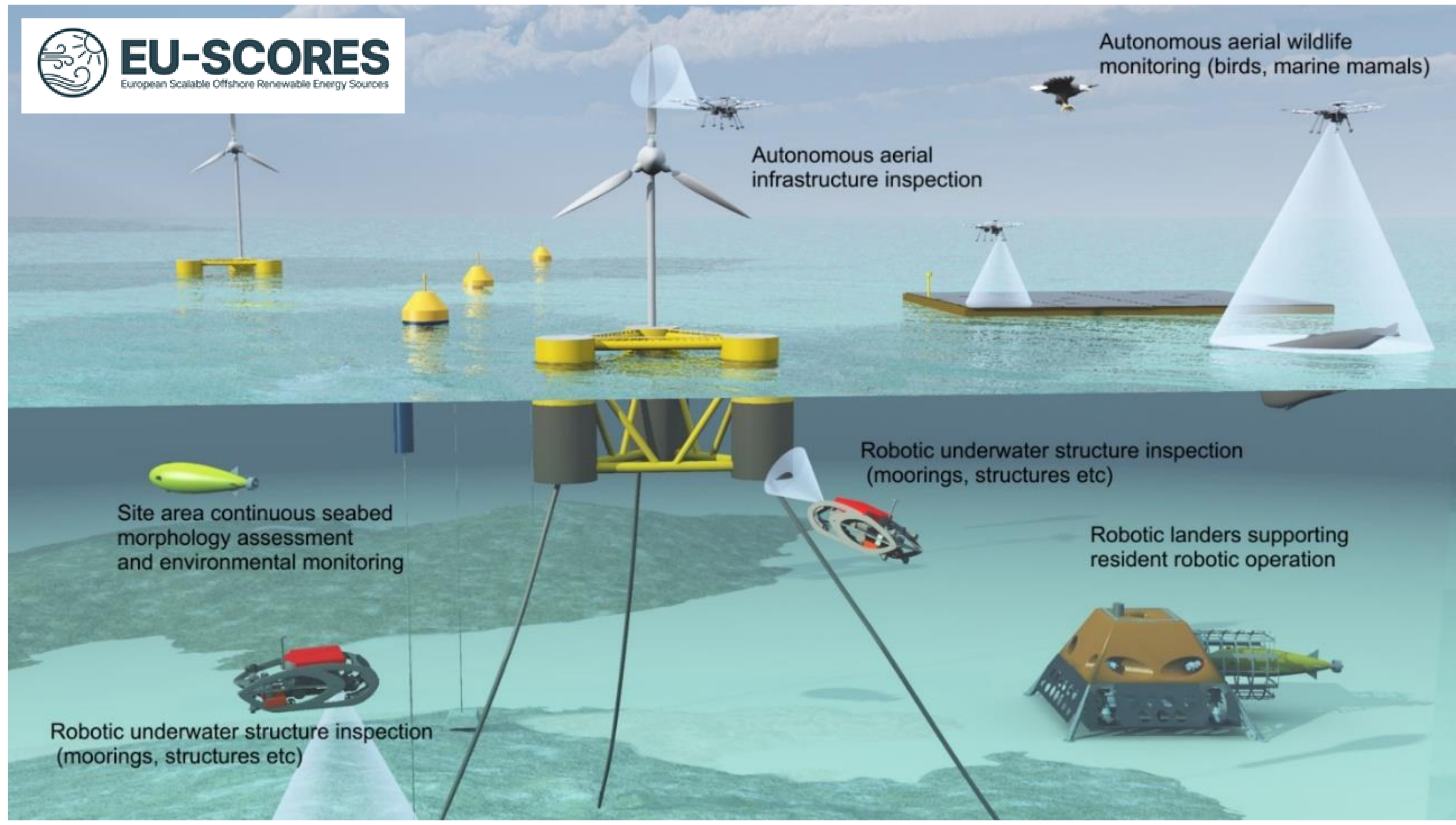
Inductive and contact charging

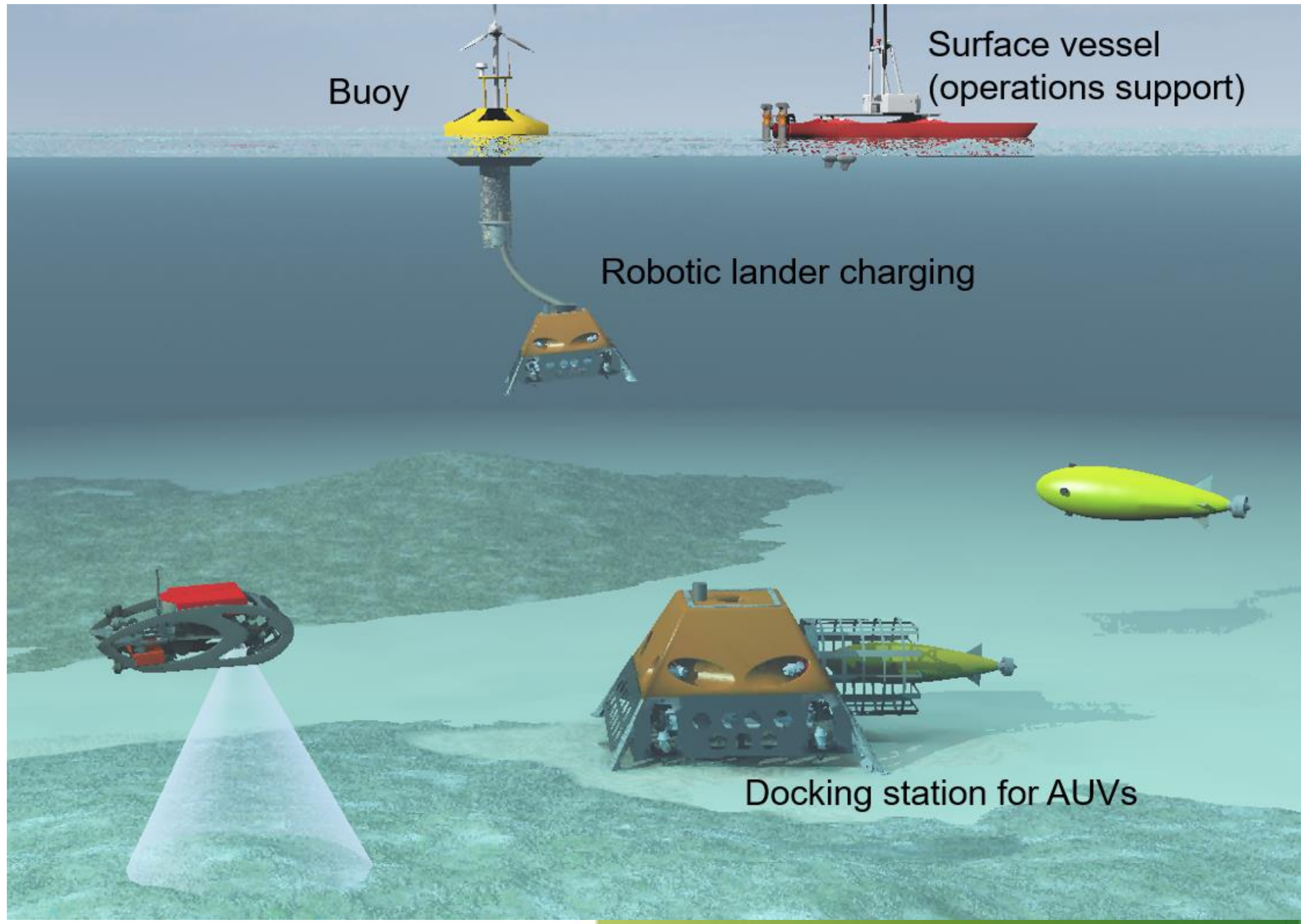
Optical and inductive communications

O&M and env. mon. tasks in offshore renewables

(EU- Scores project)







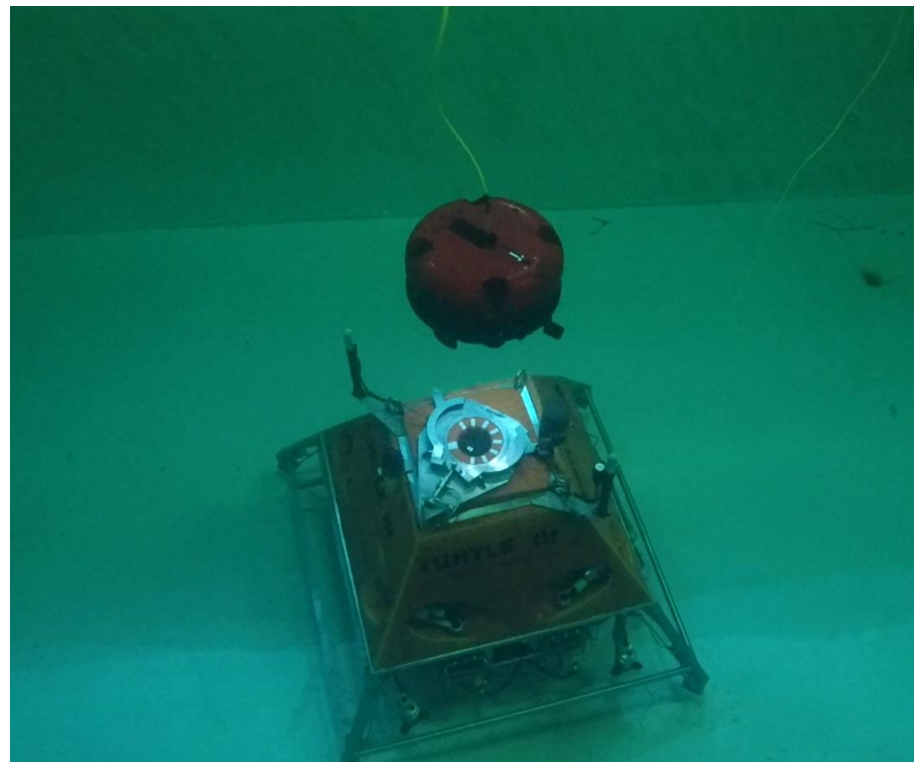
Resident robotics

Acoustic/ visual docking maneouvre

Tests in lab tank, harbour and shallow depth

EVA AUV and TURTLE

RITA AUV and TURTLE

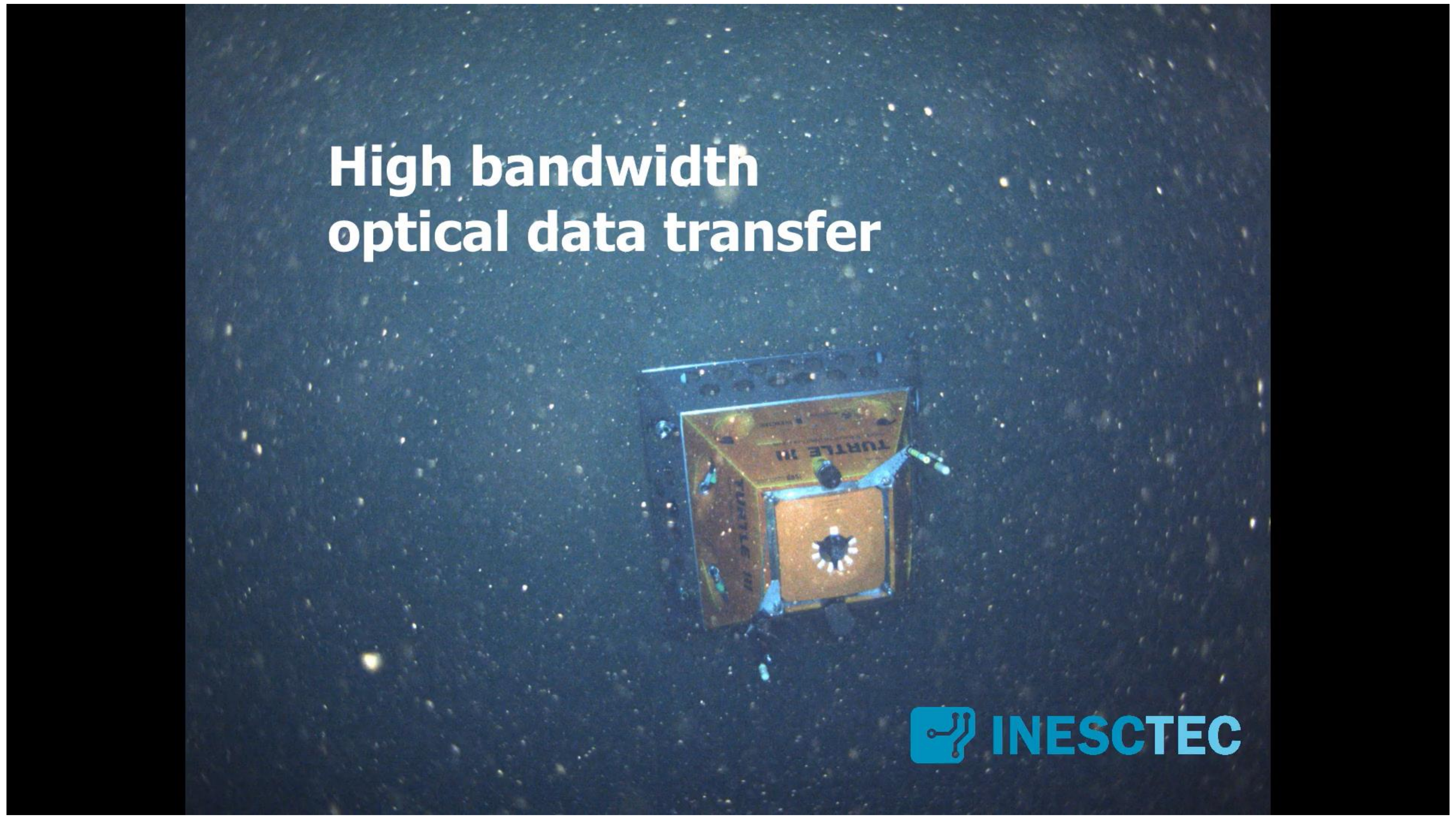


High bandwidth optical data transmission

Realtime video transmission at open sea (350m depth, up to 30m distance)

TTURTLE and EVA

Field trials at REPMUS 2034 / 2024

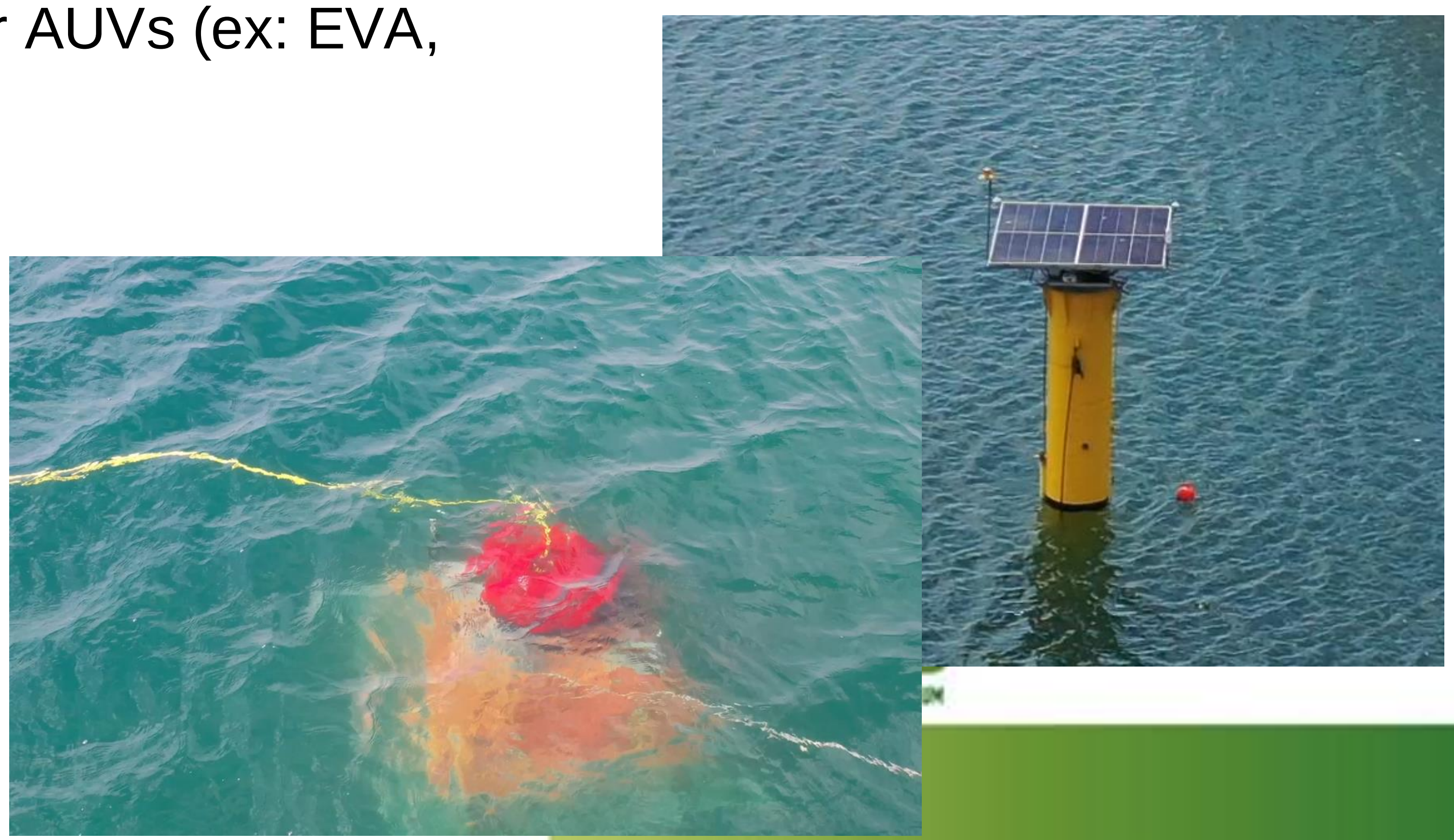


Energy charging

Surface buoy for TURTLE charging

TURTLE provides power to other AUVs (ex: EVA, MARES, etc)

Tests in lab tank and harbour



Smart cables + AUV interface

K2D Project (Fct MIT Portugal funding)

AUV navigating in water column using cable nodes as data gateways

Active nodes with sensors and interface with fiber optic repeaters

Field experiments at shallow depth in Sesimbra (20m – 85m)

N^{2}ODEs – Network Nodes for Ocean Data Exchange

- Interface with fiber optic repeaters
- Provide standardized PoE ports

MARES AUV docking

- Distributed acoustic receivers to get range and bearing to an acoustic source
- Forward looking camera for visual servoing

Robotic technology for deep sea env. monitoring – TRIDENT project

EU funded TRIDENT project

Development of robotic technology for seabed monitoring (6000m)

Multiple types of underwater mobile robots (gliders, AUVs, robotic landers)

Automated deployed sea-bottom sensors and relocatable seabed observing

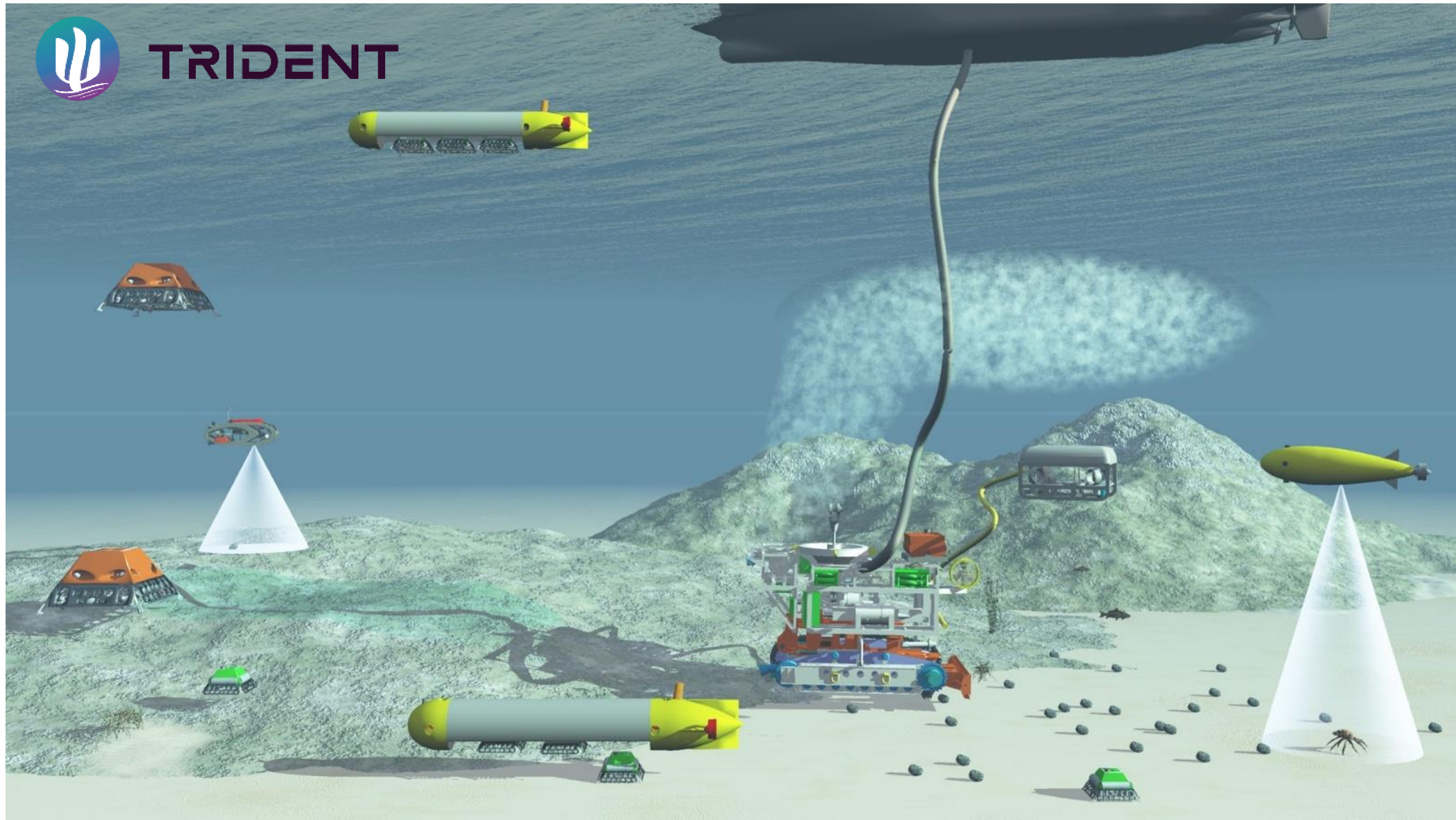
Small size datalogger

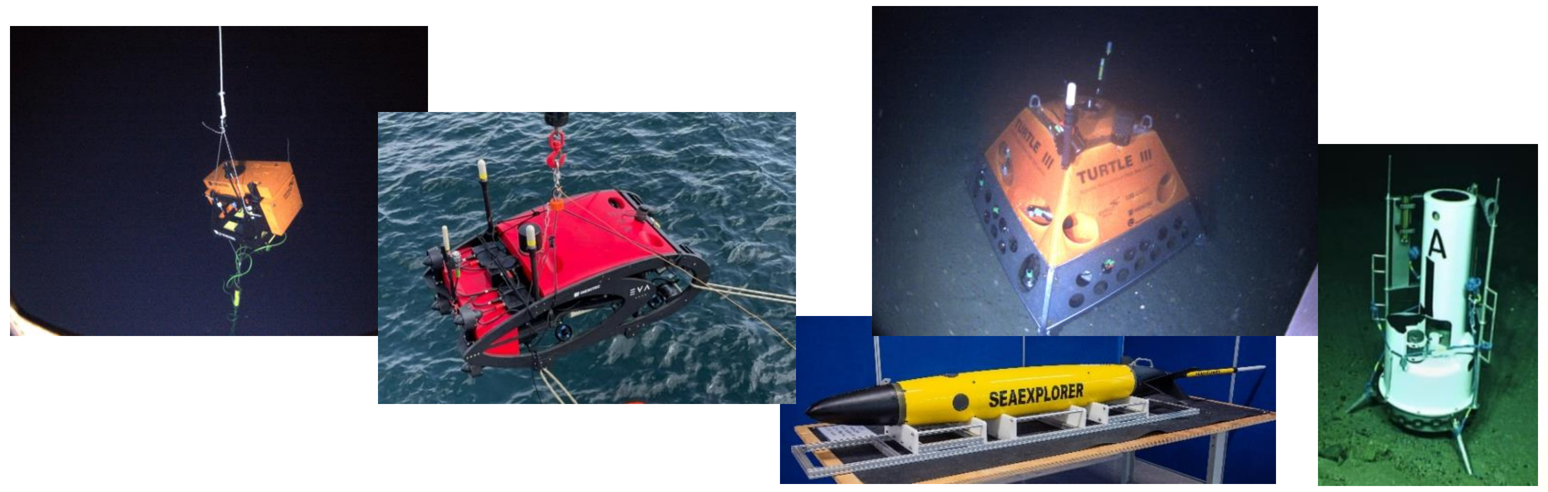
New sensors development (optical dust, EH)

Integrated (quasi) realtime environmental impact assessment

Long-range large AUV under development by INESC TEC

Final demonstration in 2027 on Tropic Seamount (Atlantic)





Next steps

Extend TURTLE deployment times from weeks to months in field validation (Aguçadoura, up to 100m depth)

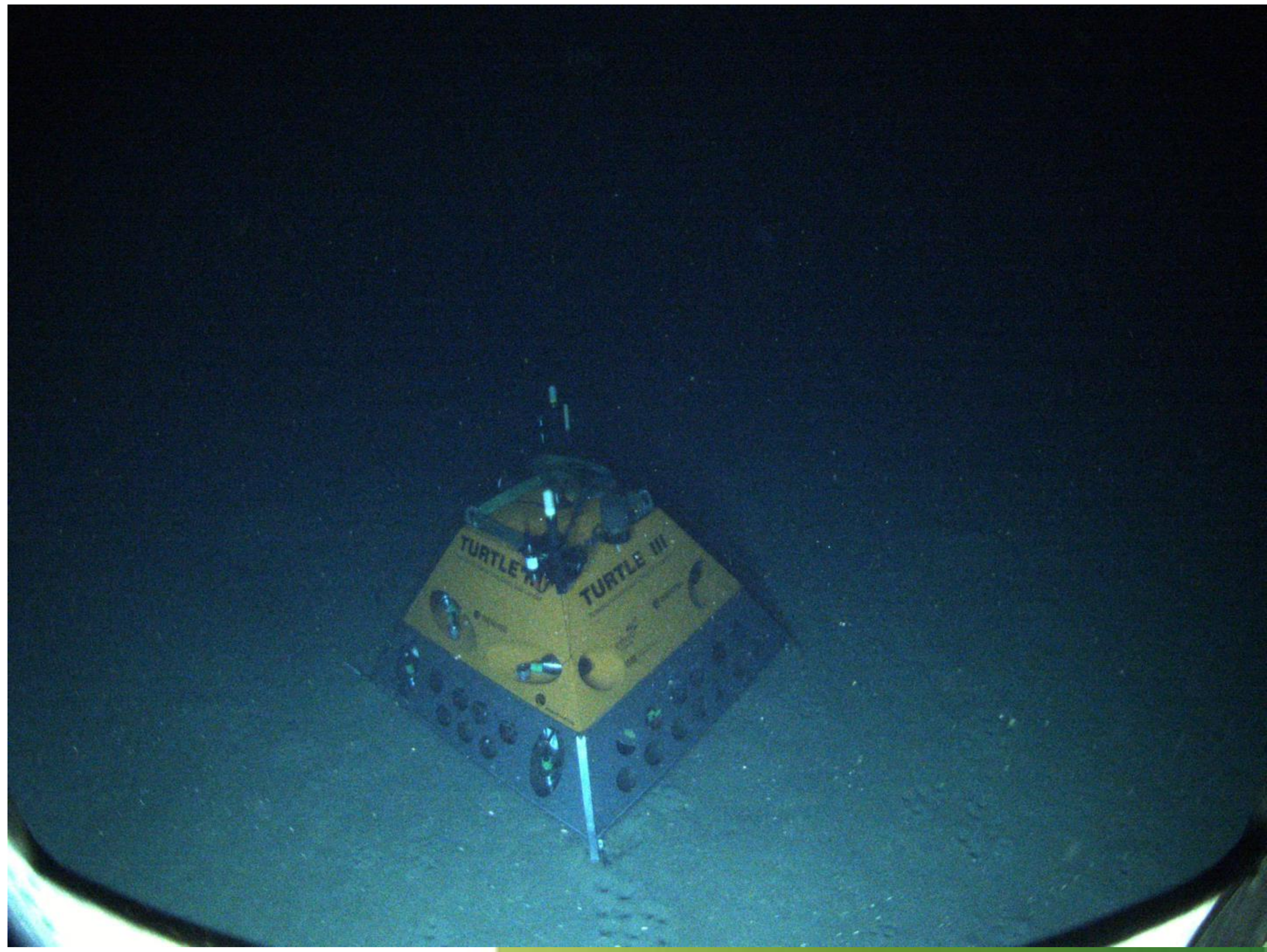
AUV docking tests at sea at higher depths (800-1000 m)

Integration of eDNA sampler for higher depths

Resident robotic longer deployment trials at Aguçadoura/ Troia

First trials long range AUV for 2026

Multi-system deployment and test at Trident final demo in 2027



Extending EMSO observation capabilities with mobile systems

Resident AUVs can provide a spatial extension of fixed nodes with reduced maintenance

Mobile seabed nodes (ex robotic landers or resident crawlers) allow for added flexibility (spatial and event-based) in open sea observation

Moored profilers add cost-effective water column observation in fixed point observation points

A combination of AUVs/Gliders with smart cables can add water column data to seabed cable measurements

Novel long-range AUVs add new open-sea observation capabilities and higher control

Autonomous mobile and resident systems will be key in the future of open sea observation and will play a relevant role in EMSO's future

Thank you for your attention.

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Observing the ocean to save the earth