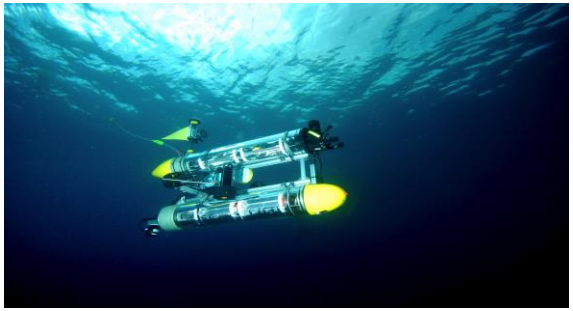
TÉCNICO LISBOA

MARINE & MARITIME INTELLIGENT ROBOTICS

ERASMUS Mundus MSc
FR, NO, PT. SP

Cooperative Robotics for Scientific and Commercial Applications

António Pascoal



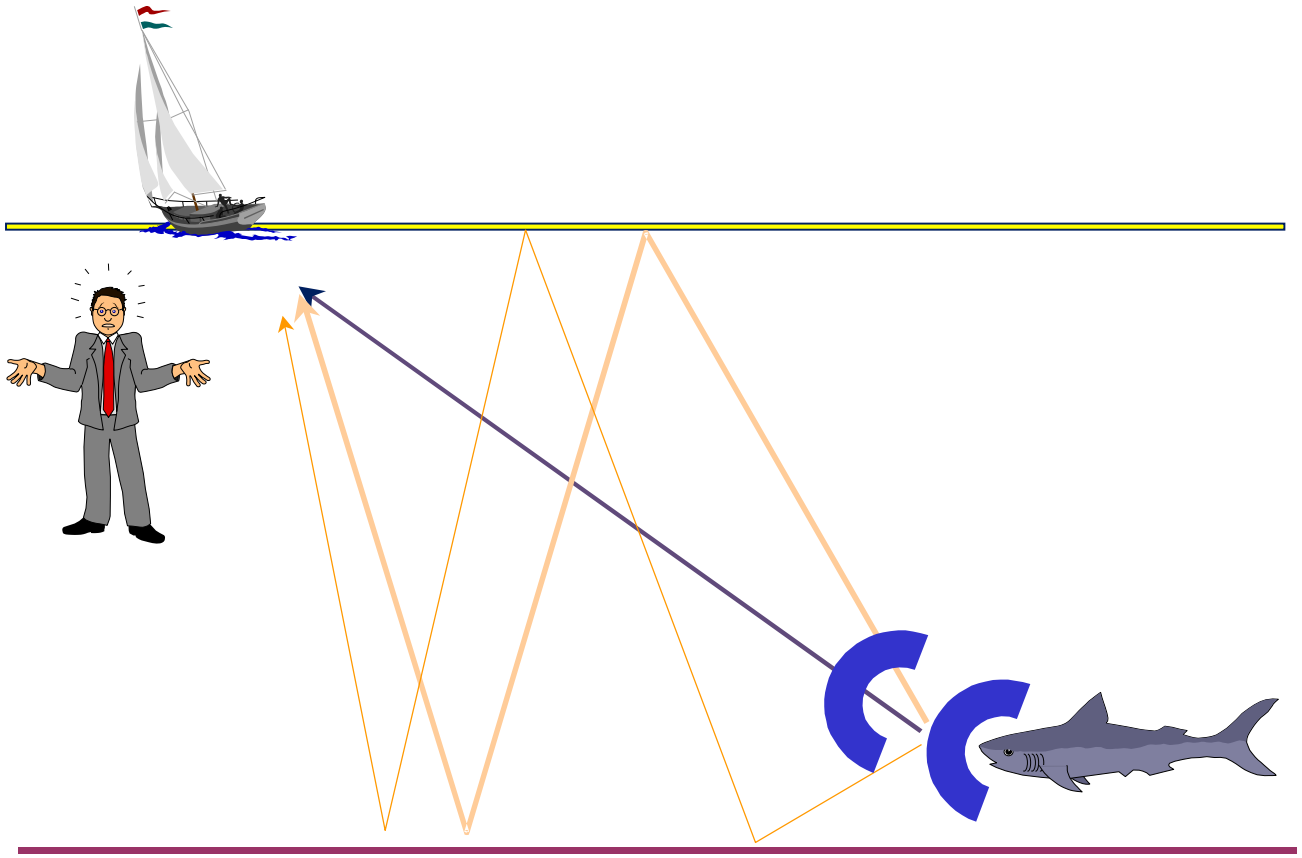
MARINETECH – IH Cascais, Dec. 5 2019

The work of many

Cooperative projects with Colombia, India, Korea, Mexico, Peru, USA, and EU members

Opening the multiple vehicle frontier

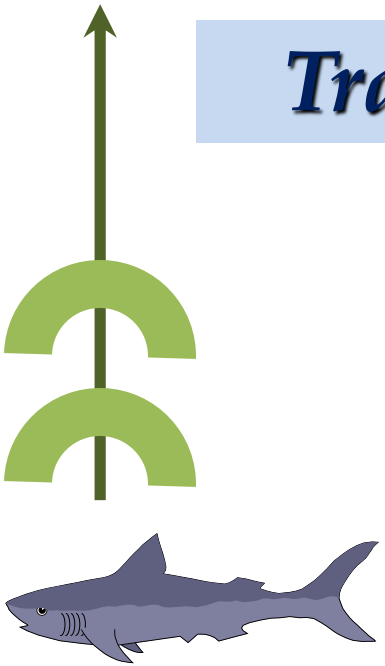
Underwater Communications – *very hard!*



Opening the multiple vehicle frontier

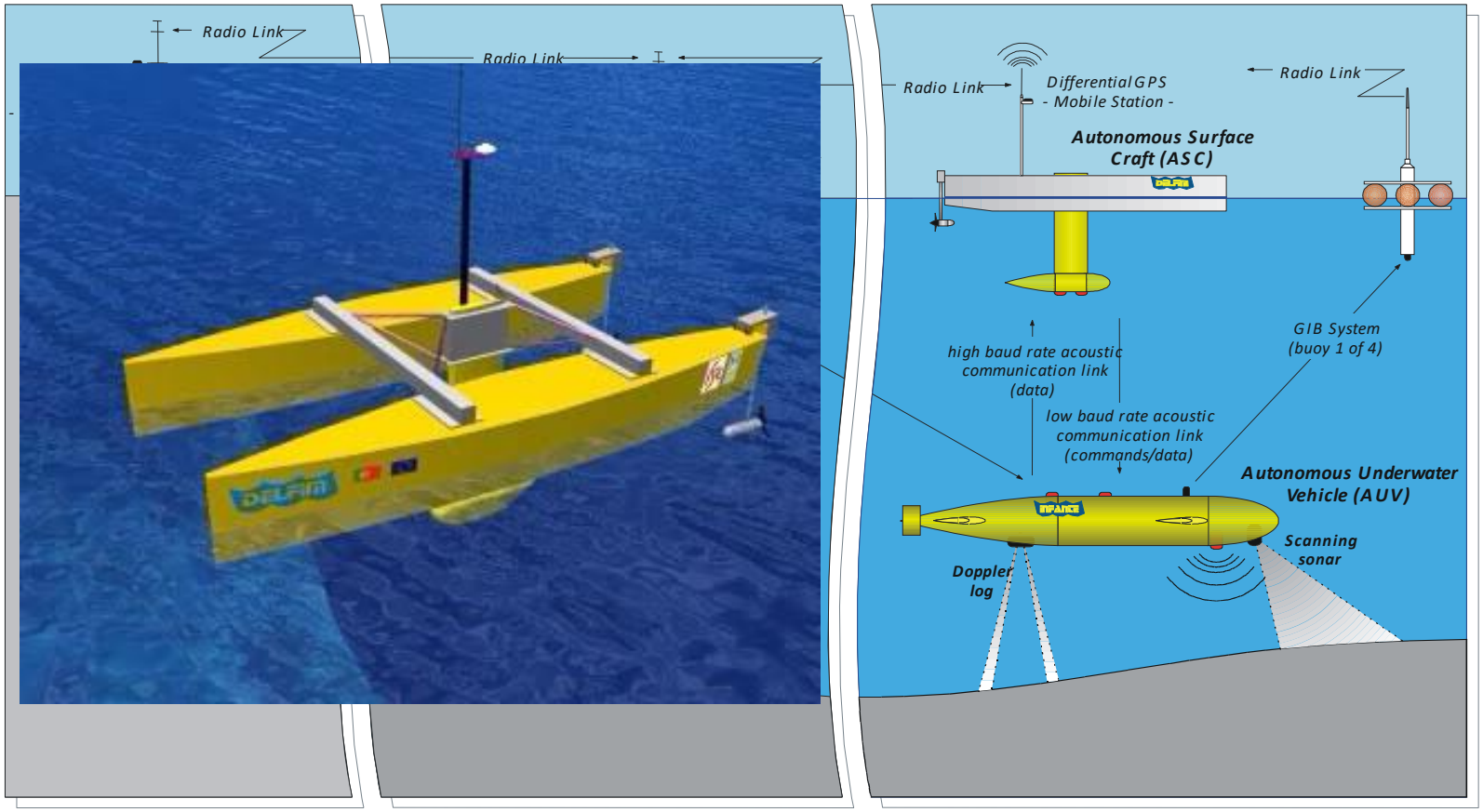
Underwater Communications

Transmit in the vertical !



Multi-vehicle operations

*The **ASIMOV** concept (ASIMOV project, EC – **2000**) – PT, FR, UK*



*Difficulties: **no** reliable comms, miniaturized acoustic positioning systems, and tools for seamless implementation of Motion and Mission Control systems (ROS was not born yet!)*

Neworked Systems : a New Era (2009 -)

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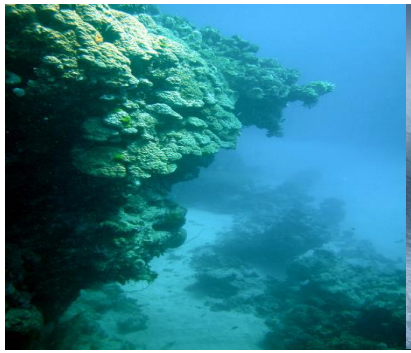
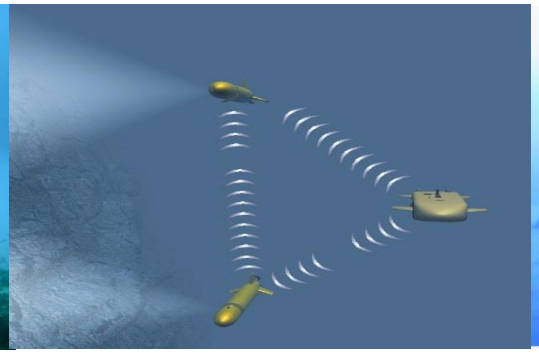
S

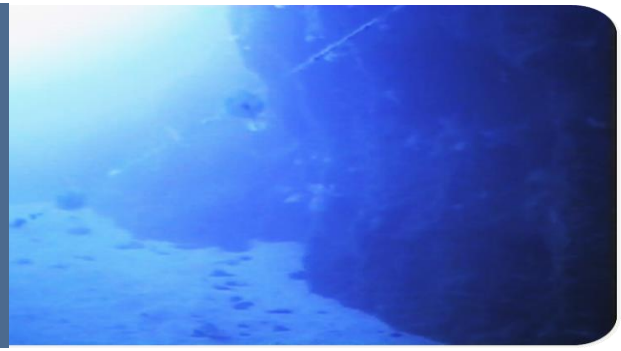
and Control

MORPH / EC (2012-2016)

Cooperative Marine Robots for Marine Habitat Mapping in Complex Underwater Environments: A New Paradigm







ATLAS ELEKTRONIK
A joint company of ThyssenKrupp and EADS

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Consiglio Nazionale delle Ricerche

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S&T organization CMRE

Universitat de Girona

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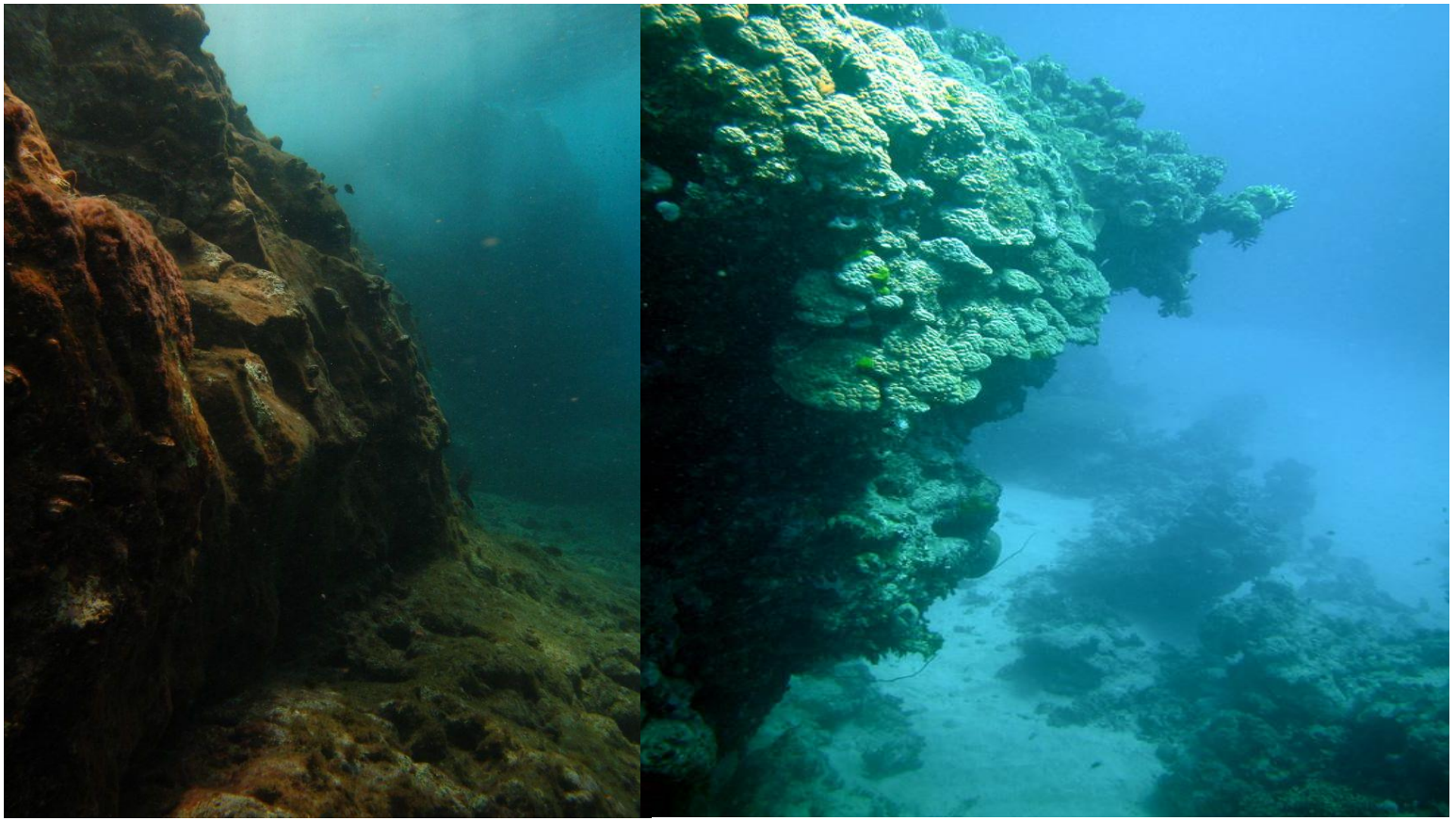
JACOBS UNIVERSITY

TECHNISCHE UNIVERSITÄT ILMENAU

DOP

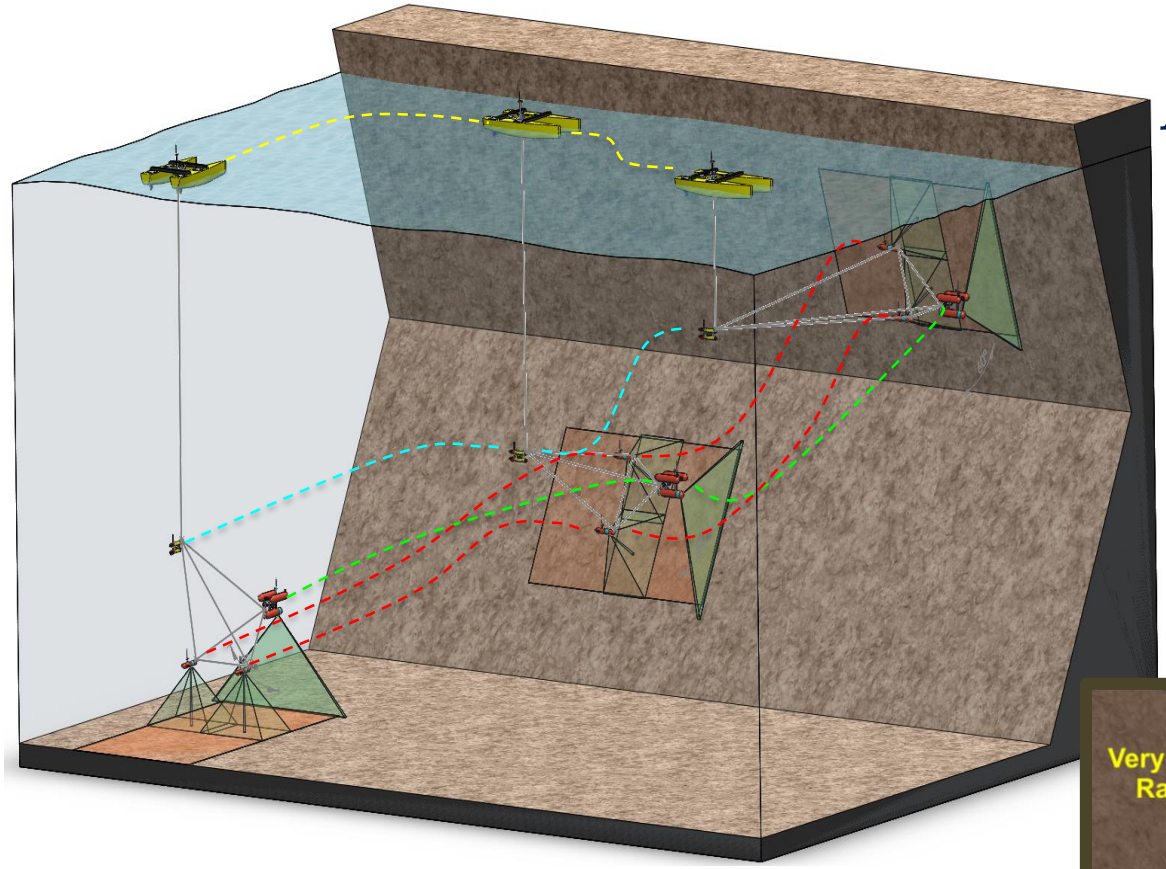
MORPH / EC (2012-2016)

Habitat Mapping in complex 3D environments

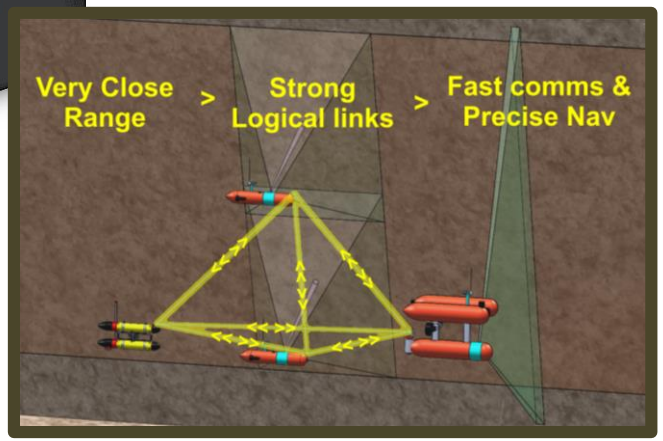


Underwater cliffs, canyon walls, fracture zones, seamount flanks, hydrothermal chimneys

MORPH / EC (2012-2016)



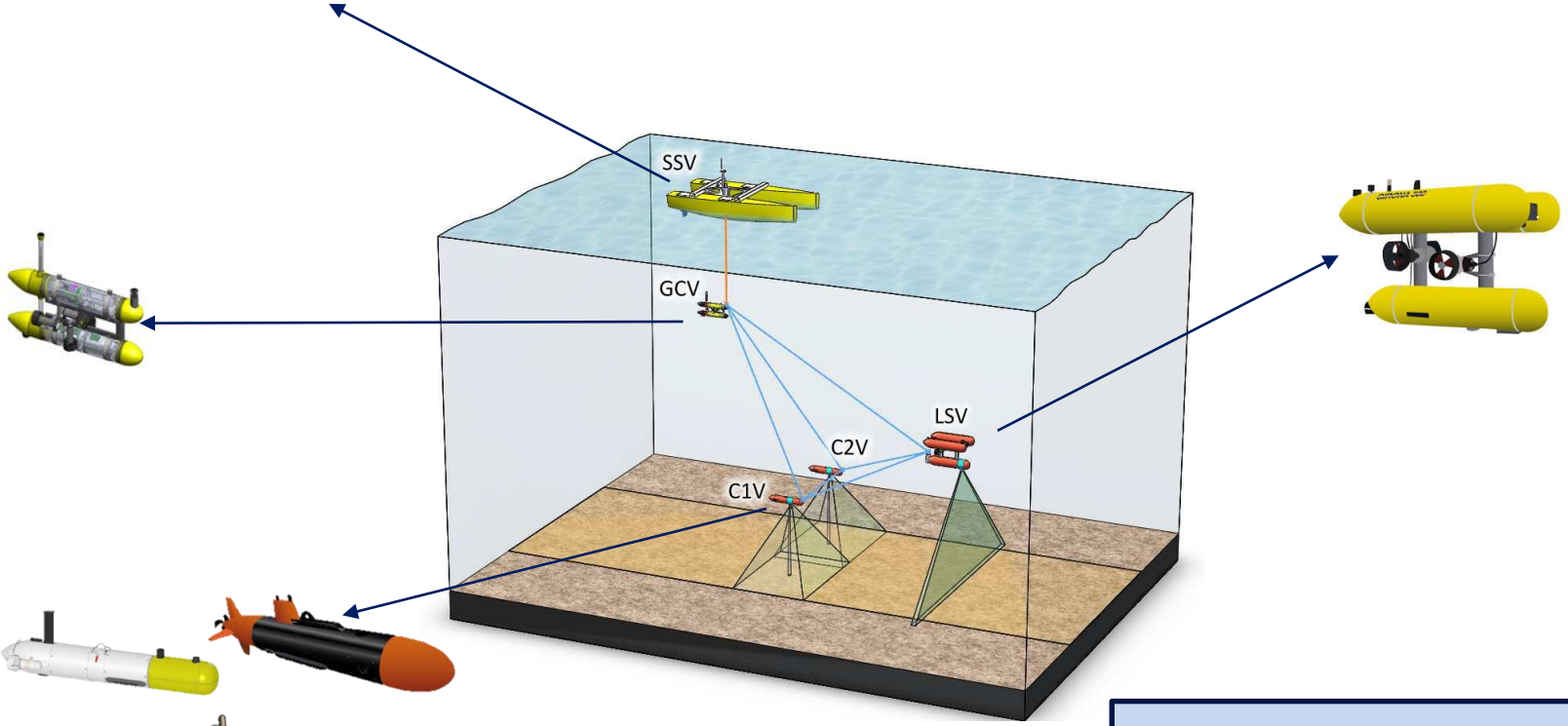
A team of agents operating as a virtual super marine vehicle



Key MORPH concept:
a self-reconfiguring robot for operations in complex 3D marine environments

MORPH

MORPH Vehicles



9 partners
5 vehicle providers

Universitat de Girona · ISR Pólo do I.S.T. · IST Técnico Lisboa · Jacobs University · ILMENAU University of Technology · imar · S&T organization · CMRE · ATLAS ELEKTRONIK A joint company of ThyssenKrupp and EADS · Ifremer · Consiglio Nazionale delle Ricerche · DOP

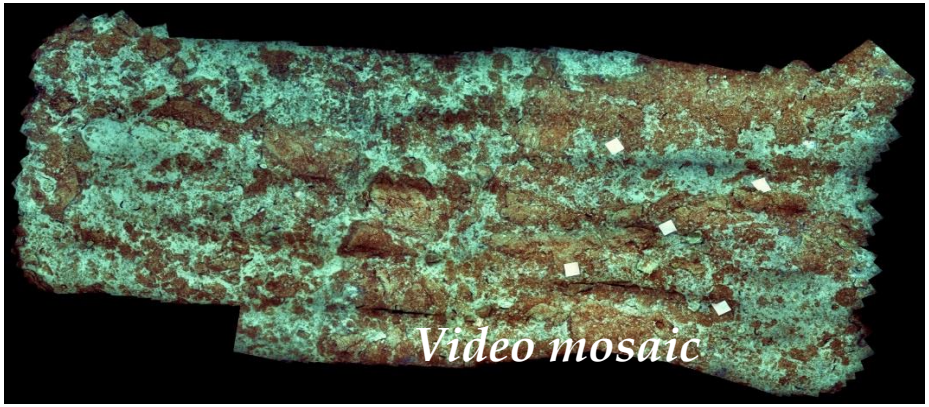
The EC MORPH project

MORPH / EC (2012-2016)

Cooperative Marine Robots for Marine Habitat Mapping in Complex Underwater Environments: A New Paradigm

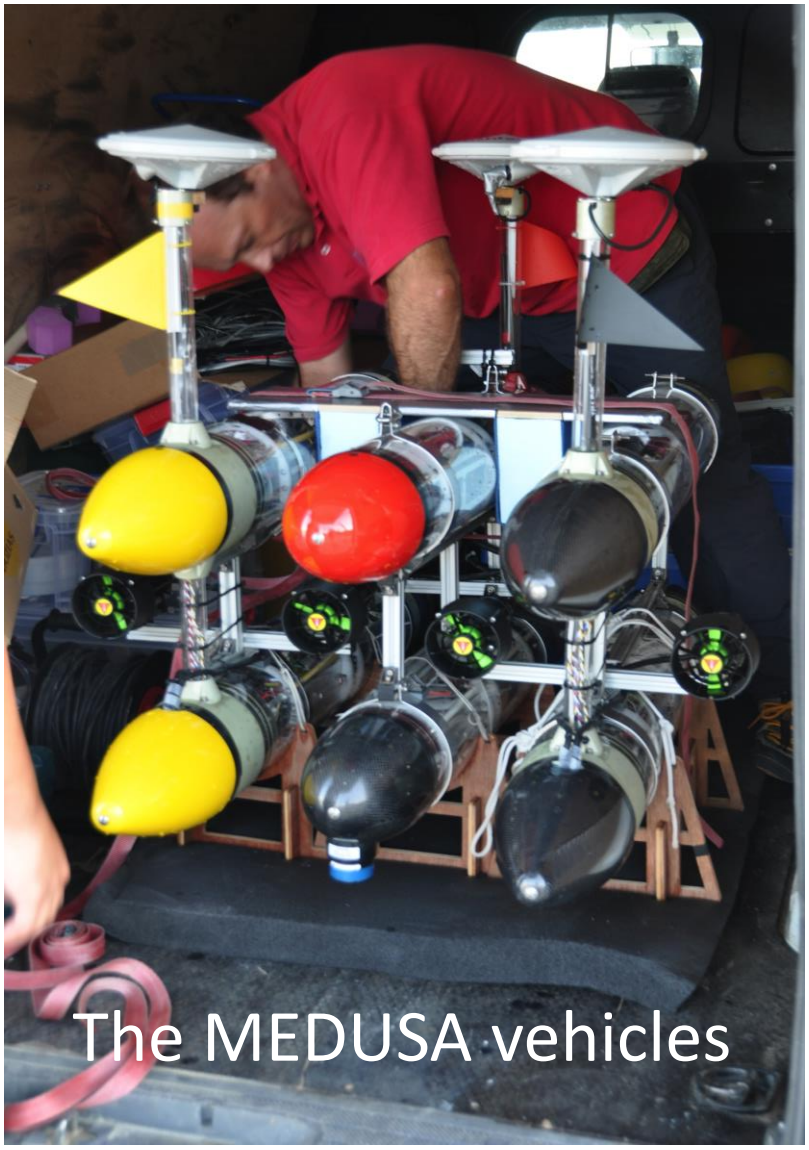
9 European partners

Mapping of vertical walls



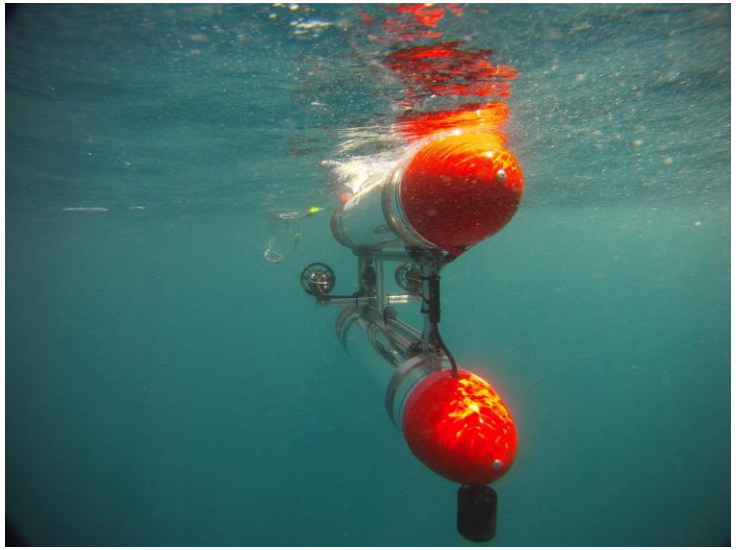
Video mosaic

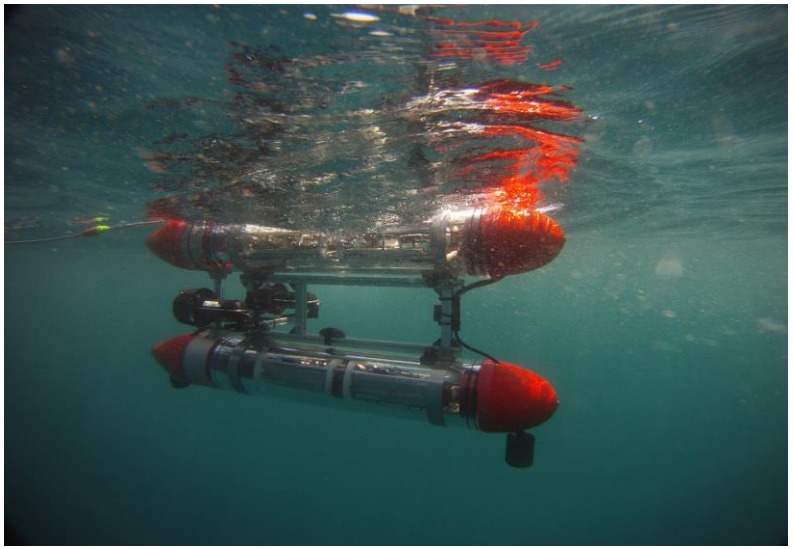
The sea-going machines

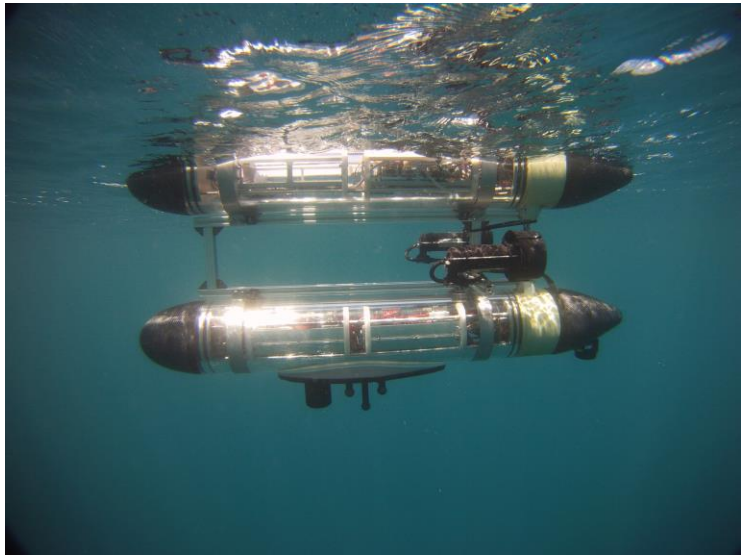


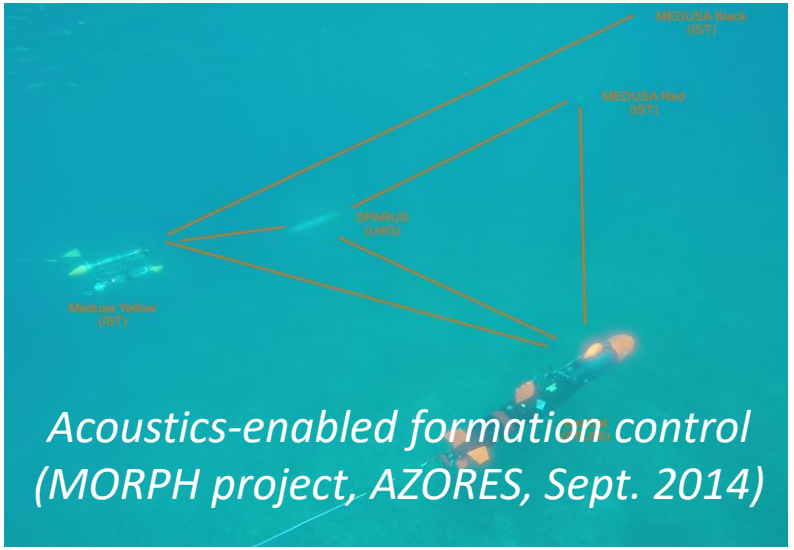
The MEDUSA vehicles

Labs and equipment





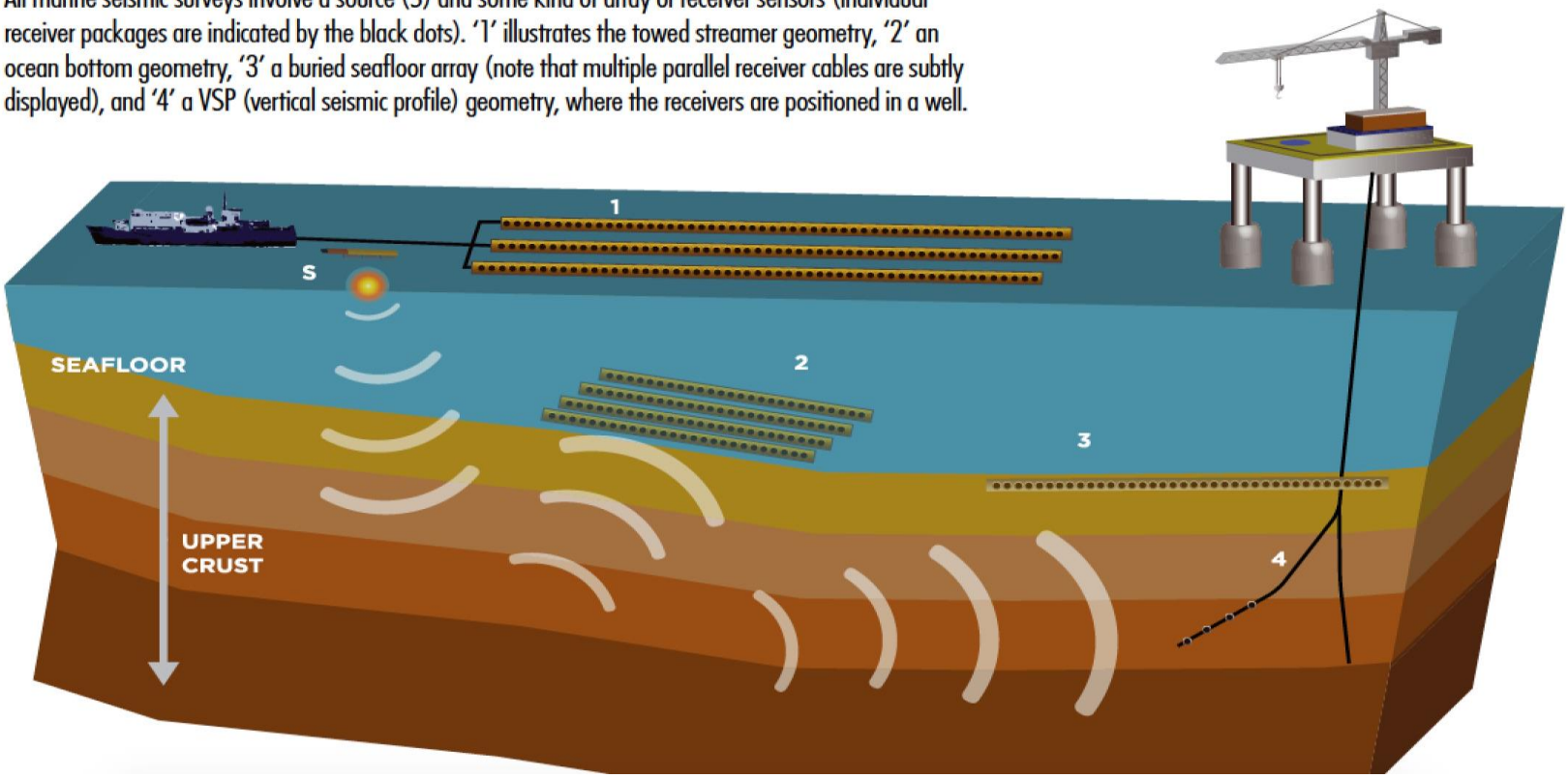




Acoustics-enabled formation control (MORPH project, AZORES, Sept. 2014)

Probing under the seabed : the EC WiMUST project

All marine seismic surveys involve a source (S) and some kind of array or receiver sensors (individual receiver packages are indicated by the black dots). '1' illustrates the towed streamer geometry, '2' an ocean bottom geometry, '3' a buried seafloor array (note that multiple parallel receiver cables are subtly displayed), and '4' a VSP (vertical seismic profile) geometry, where the receivers are positioned in a well.

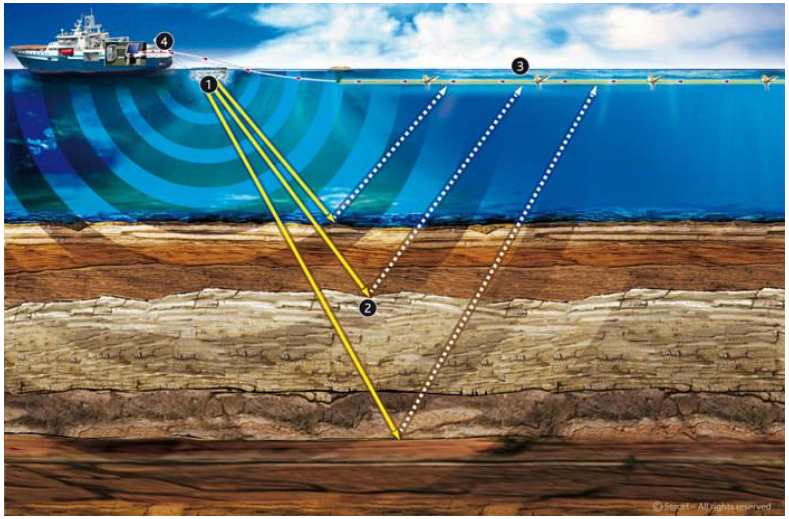


S-acoustic source
1-Towed receiver geometry (hydrophones)
2- Ocean bottom geometry
3- Buried seafloor array
4- Vertical seismic profiler

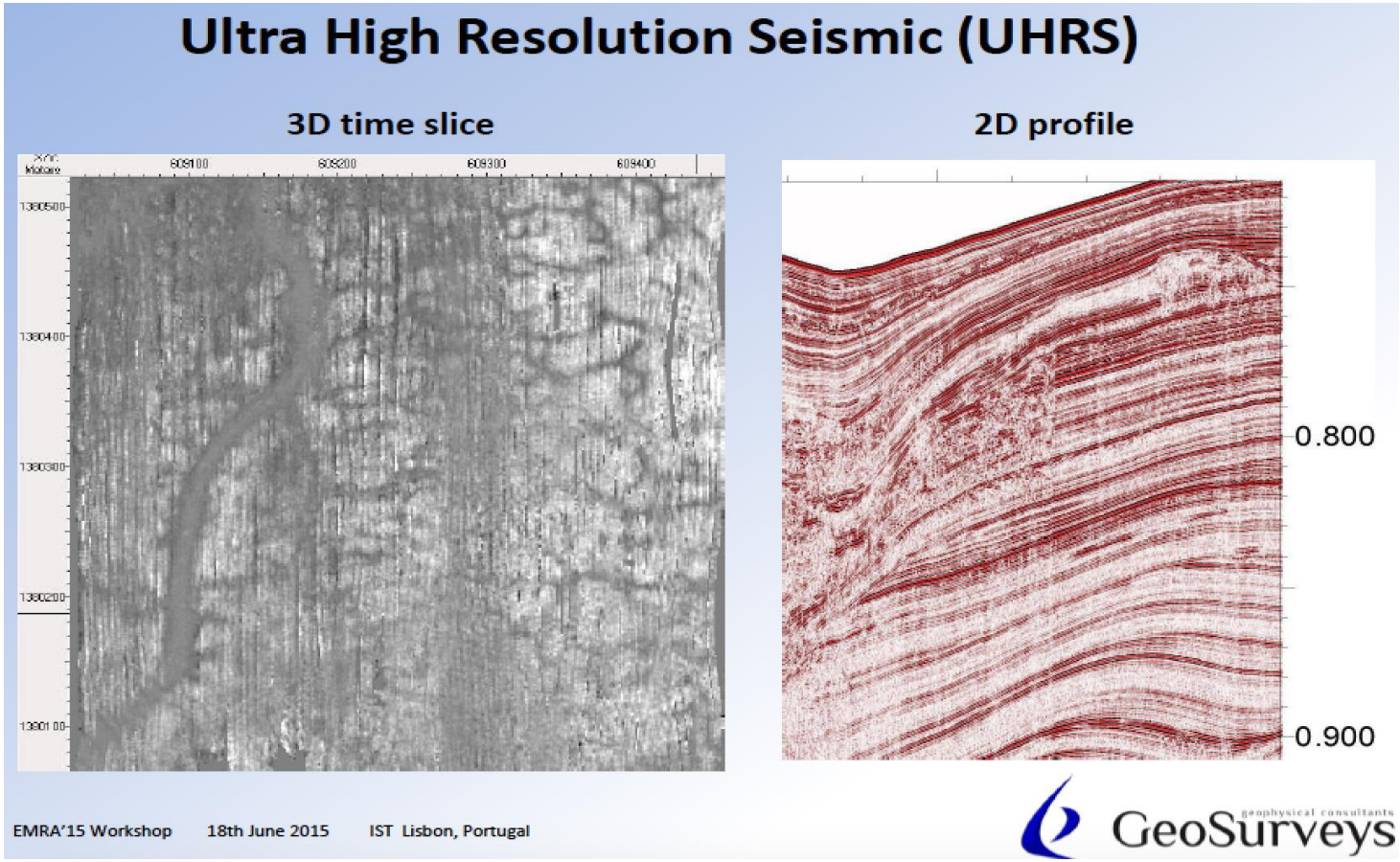
WiMUST
Widely scalable Mobile
Underwater Sonar Technology

Marine seismic surveys

- Vessel tows **acoustic sources** and long cables (**streamers**) up to 10km long, equipped with **hydrophones**, very close to the surface
- Acoustic sources shoot, waves reflect/refract off geological features on and beneath the seabed, hydrophones pick up these reflections
- Processing allows for inference of geophysical features

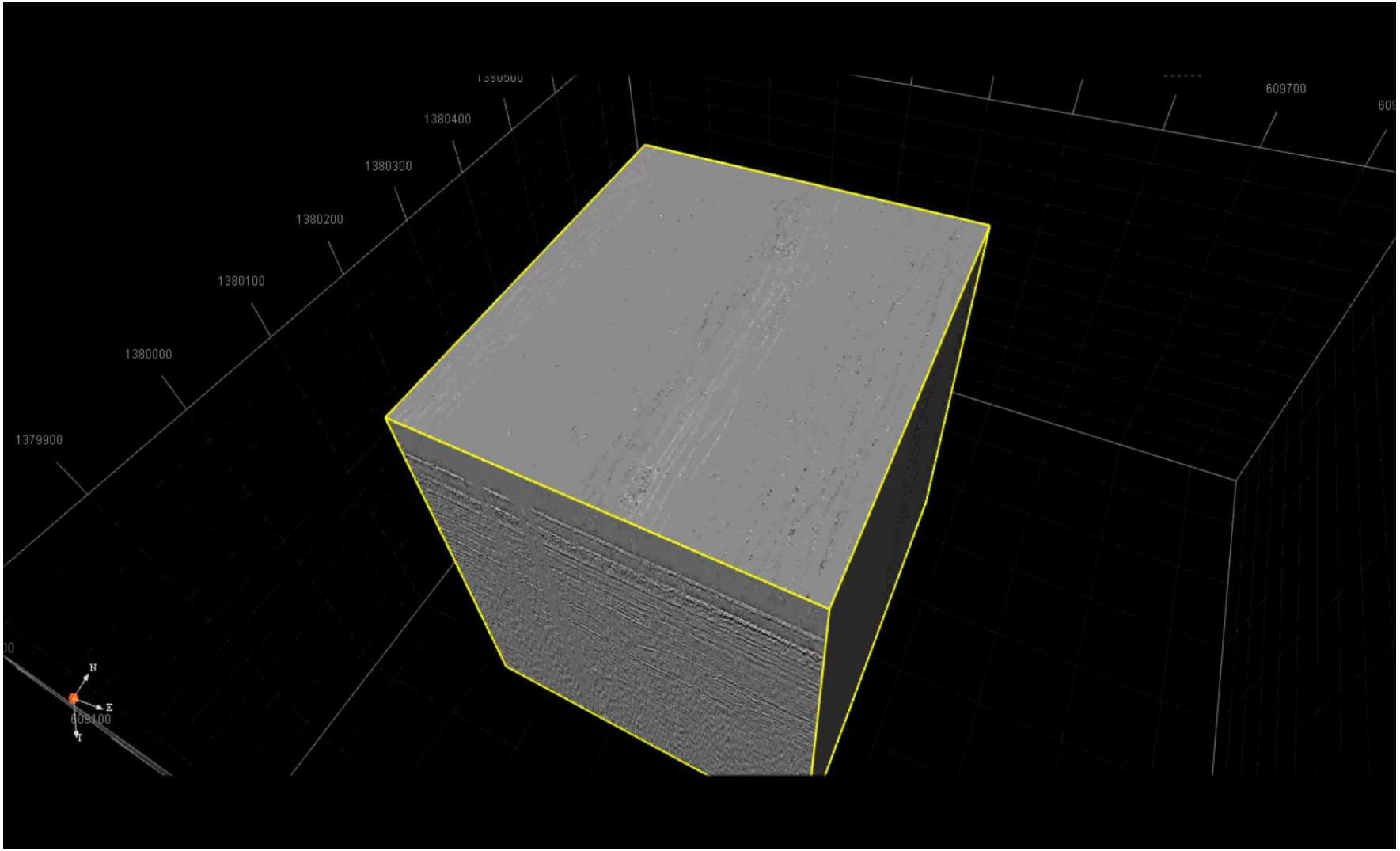


Ultra high resolution Seismic Surveys in 2D and 3D



Key applications: design of foundations for overwater and subsea structures and anchors; assessment of burial performance for pipelines and cables – marine windfarms

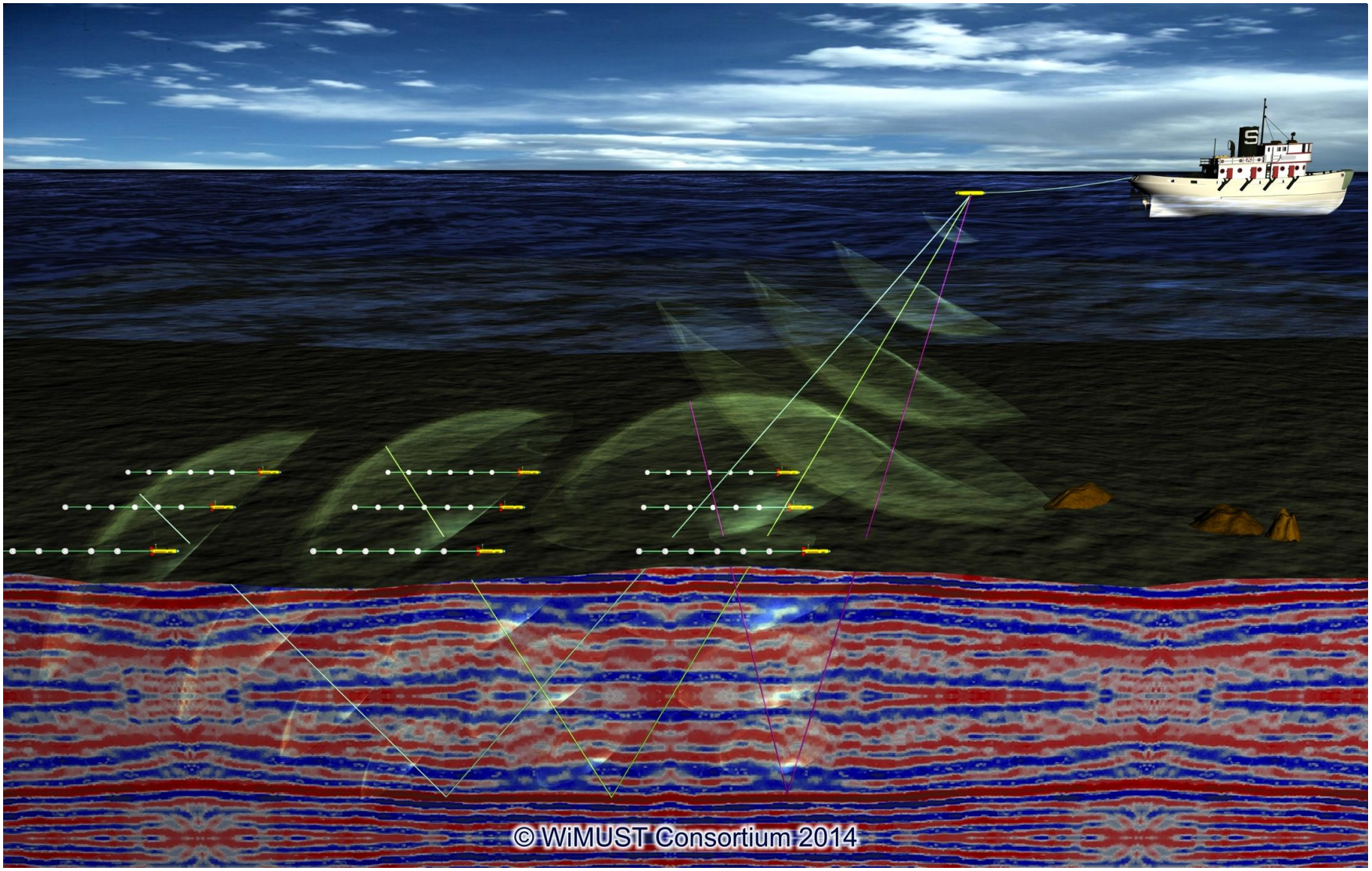
Ultra High Resolution Seismic (UHRS) surveys



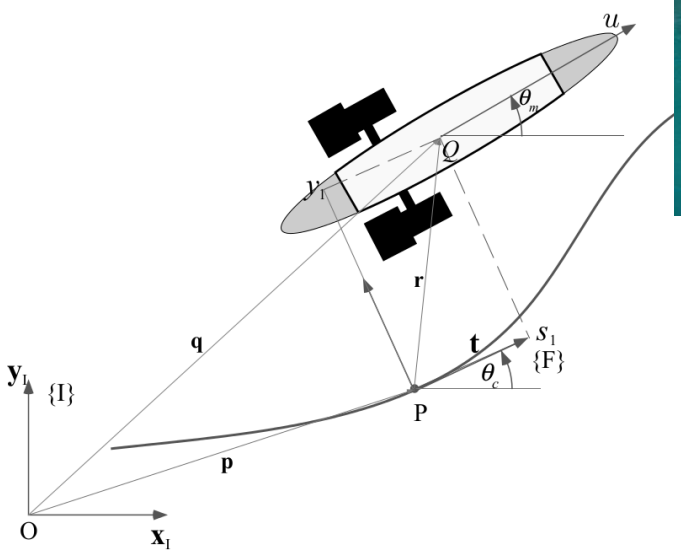
Courtesy of Henrique Duarte, GeoSurveys, Aveiro, PT

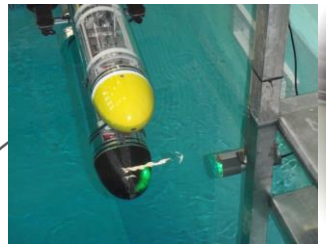
The WiMUST concept

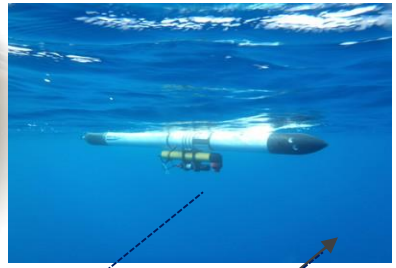
WiMUST
Widely scalable Mobile
Underwater Sonar Technology

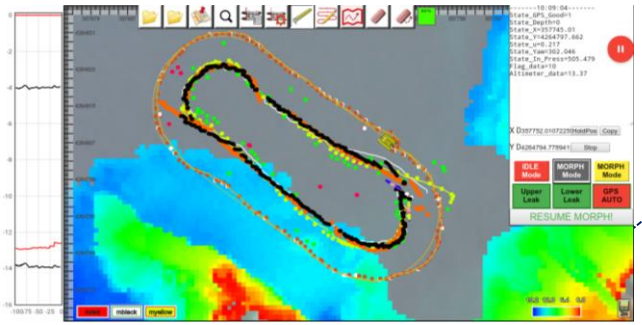


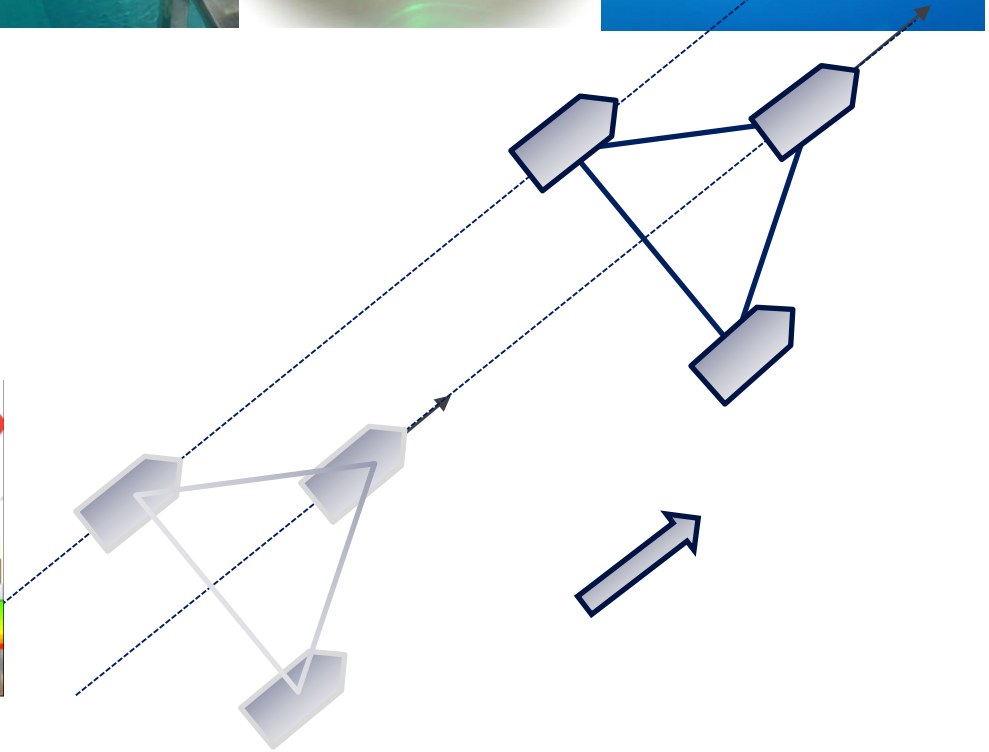
The theory behind: a glimpse





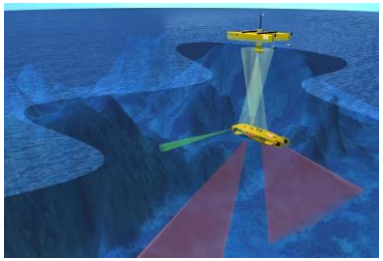


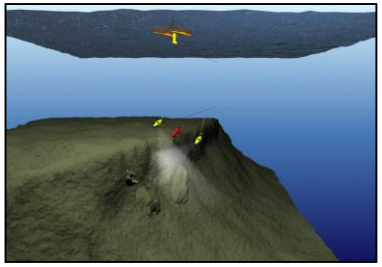




Cooperative, Networked Motion Planning, Navigation, and Control

Nonlinear Control and Estimation, Range-based Localization, Optimization, Event-Driven Systems, Optical and Acoustic Communications






Mission specification

Cooperative motion planning

Nominal trajectories & desired vehicle formation

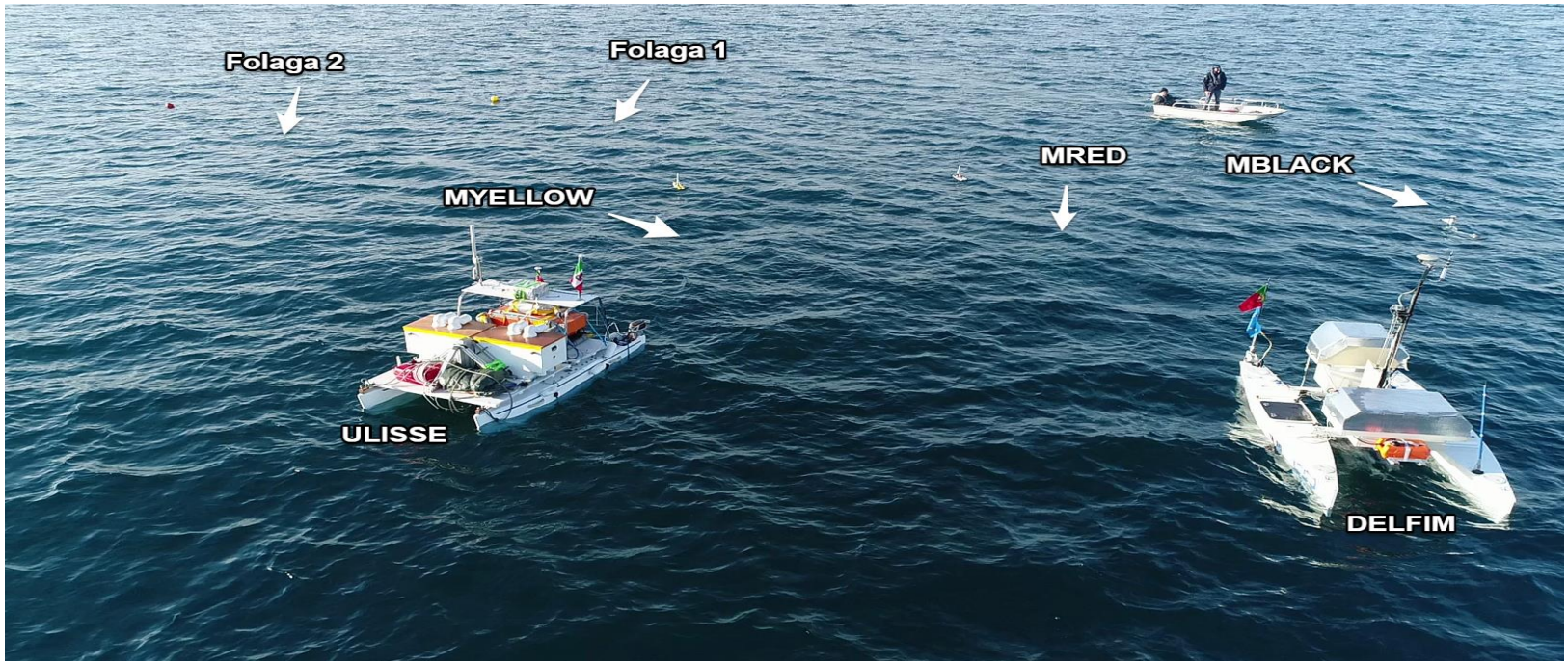
Cooperative motion control

Global and local, relative vehicle positions

Cooperative navigation

Cooperative systems: key blocks required

Basic Building Blocks



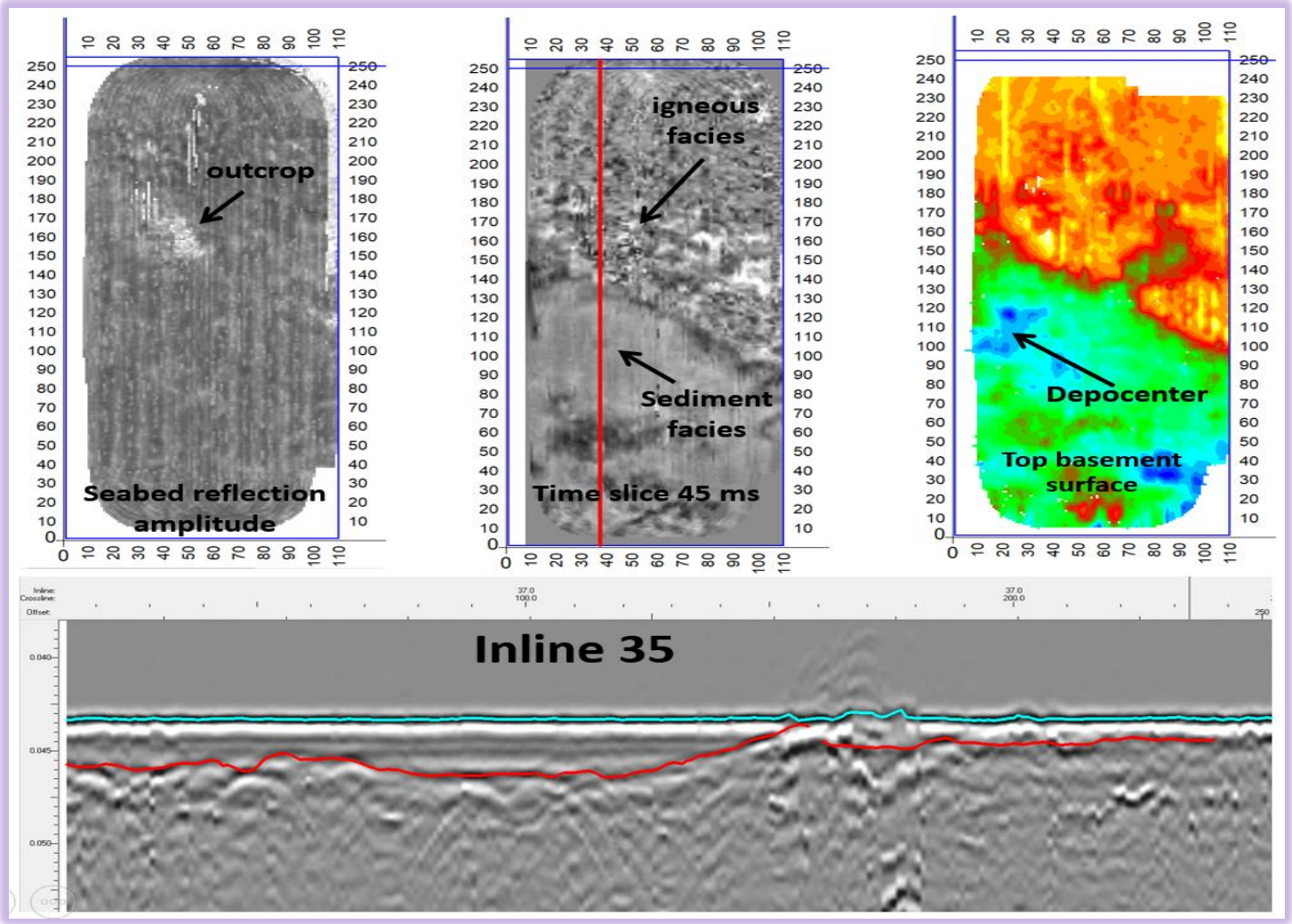
Basic building blocks

- 2 **Acoustic sources**: **Delfim and Ulisse ASVs**
- 2 **Anchors** and **Distributed acoustic receiver array**: Delfim and Medusa Black ASVs, **Folaga 1** and **Folaga 2 + Medusa Red** and **Medusa Yellow AUVs**

Full system implementation and final mission at sea

1:33

Full system implementation and final mission at sea



Technical Highlights & Seismic Data Acquired

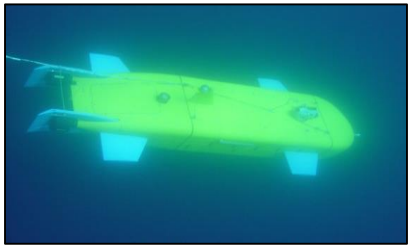
The big push forward

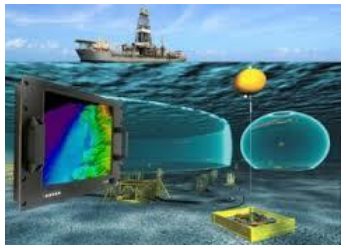
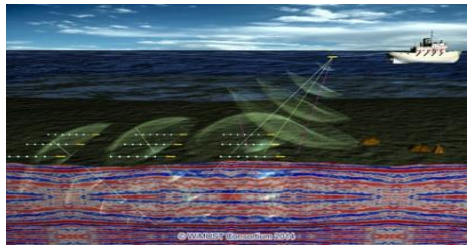
Bring about a true revolution in the marine technology area by:

- Focusing on challenging **flagship initiatives** driven by end-users (including aquaculture, renewable energies, fisheries, ocean modeling, resources assessment and exploitation, etc)

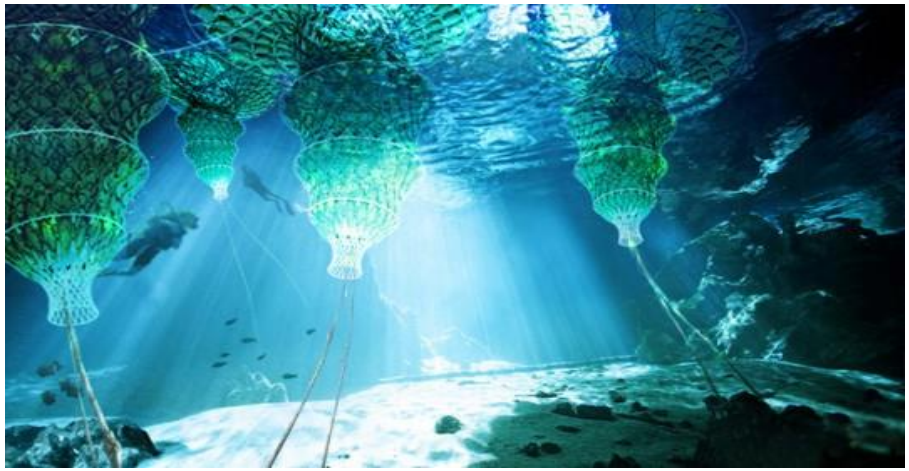
- Merging innovation with core technologies for seamless access to the water column, critical infrastructures, and the **deep sea**.

Cooperative multiple assets; sustained presence at sea; energy harvesting

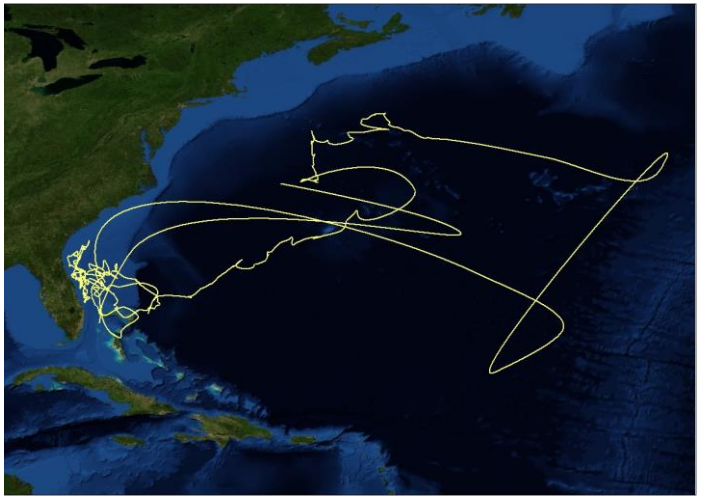


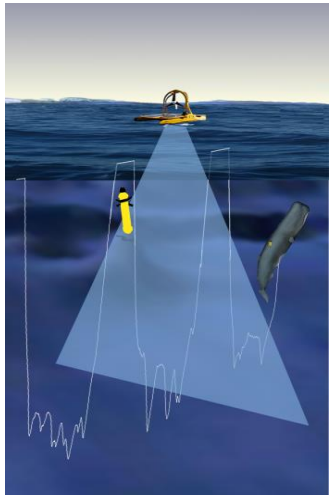



The future: Cooperative Robots and Humans in the Loop



Automated Offshore Aquaculture





Tracking of Marine Mammals

SOS4ATLANTIC: A NEW MIT-PT INIATIVE

A Multi-Domain Atlantic Ocean-Space Observation System: Science, Technology, and Society

tekever SPACE

deimos ENGENHARIA

TÉCNICO LISBOA

TEKEVER

hidrográfico marinha·portugal

Massachusetts Institute of Technology

efacec Empowering the future

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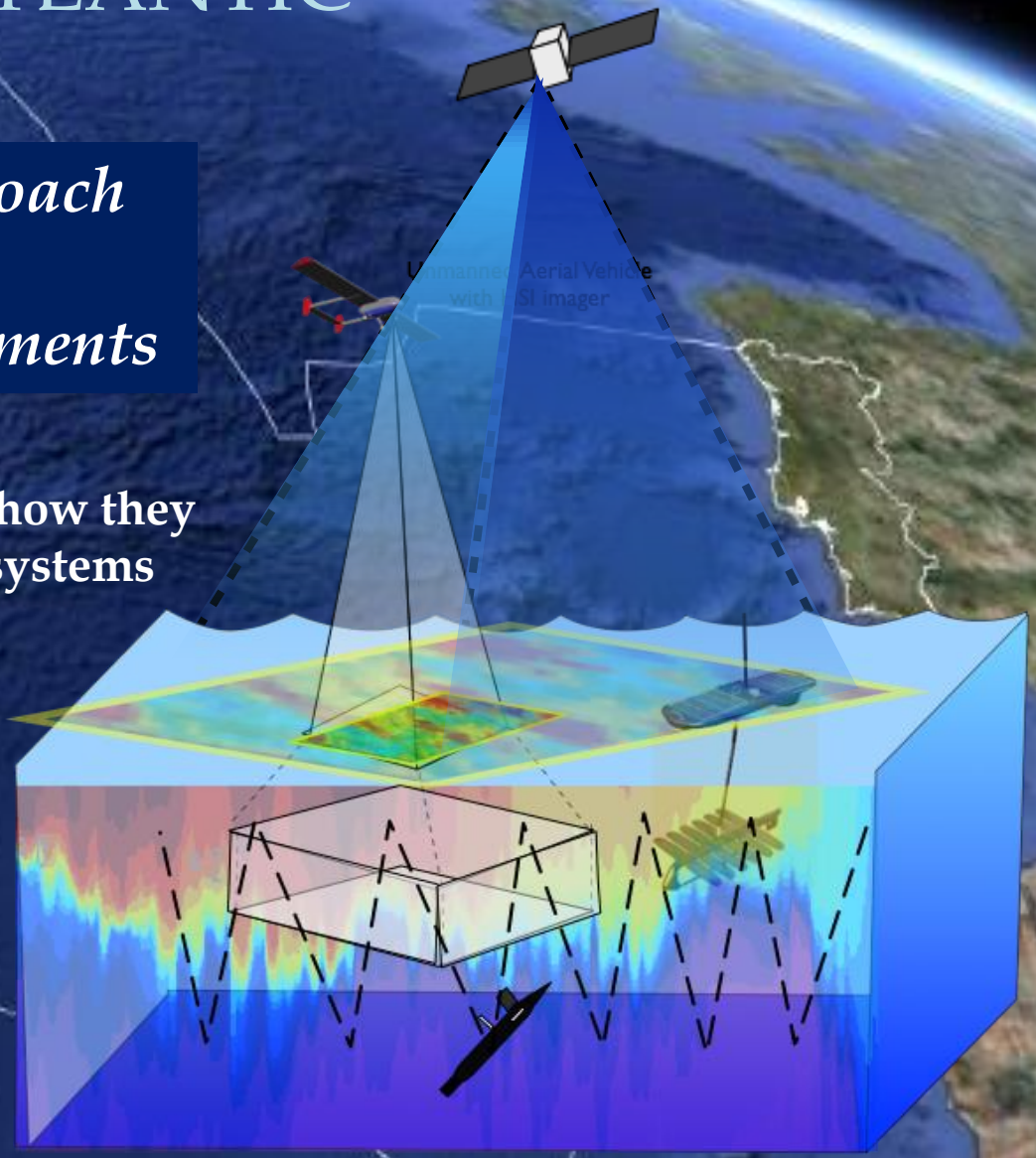
CoLab ATLANTIC

SOS4ATLANTIC

A System of Systems approach integrating
Space, Air, and Marine segments

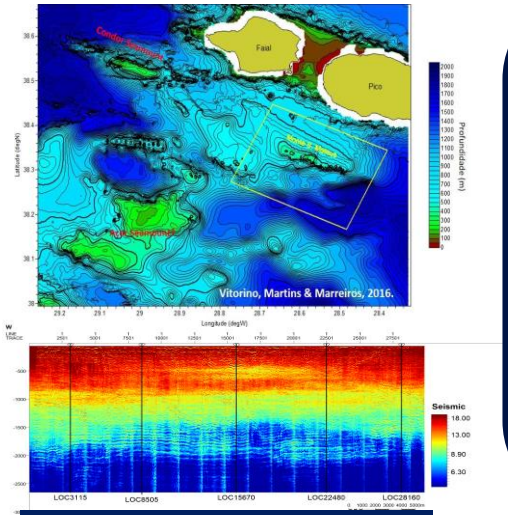
Target use-case:
Study of ocean front dynamics and how they impact on pelagic and deep sea ecosystems



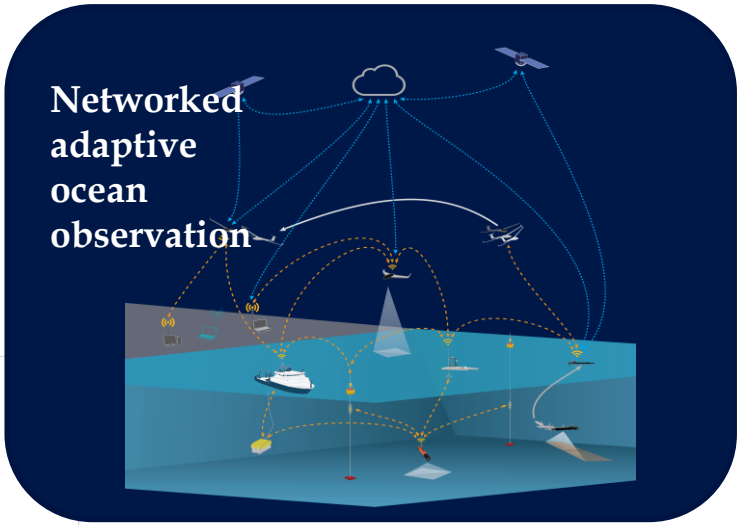
Vision:
lay the foundations for an **Atlantic Ocean Observation Platform** with far reaching scientific, commercial, and societal impact.

SOS4ATLANTIC

A System of Systems approach integrating Space, Air, and Marine segments for Ocean Science



Modeling and Forecasting



Multi-vehicle SOSystems

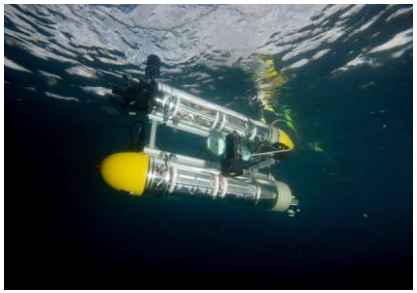
Ocean front and ecosystem studies

SOS4ATLANTIC

A showcase of technological assets for science and the industry

NRP D. Carlos class Oceanographic Vessel

RV Águas Vivas



Fleet of 20 surface and underwater autonomous marine robots – FEUP, IST, MIT

10 unmanned air vehicles – FEUP & TEKEVER

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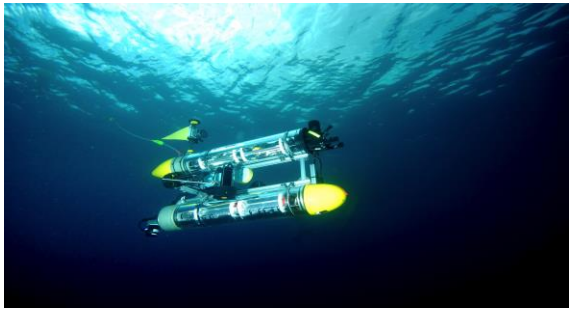

MARINETECH – IH Cascais, Dec. 5 2019