



Awareness at sea: From the surface to the deep ocean

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Who we are: INESC TEC

- **R&D non-profit research center and technology interface institution**
- Joins researchers from several schools
 - Porto University
 - Porto Polytechnic Institute
 - Minho University
 - UTAD
- 700 researchers, 350 PhDs
- **Research areas**
 - Communications and multimedia
 - Power systems
 - Manufacturing
 - Information and computer graphics
 - Optoelectronics
 - Robotics
 - Technology transfer
 - Artificial Intelligence
 - Industrial management
 - Embedded systems



isep Instituto Superior de Engenharia do Porto
Porto Polytechnic Institute Engineering School

COORDINATED BY
INESC PORTO
PORTUGAL

INESCTEC
TECHNOLOGY & SCIENCE
ASSOCIATE LABORATORY

ROBOTICS group

Expertise areas

- Platform development
 - **Aerial, land and water robotics**
 - **Industrial and services robotics**
- Operations with autonomous robots
- Smart sensors and systems

Research lines

- Reconfigurable systems
- Distributed perception
- Cooperative robotics
- Long term autonomy
- Rapid teaching

Application areas

- Surveillance, security and defence
- Environmental monitoring and mapping
- Risk analysis
- Search and rescue
- Process automation

Close collaboration with other INESC
TEC R&D units



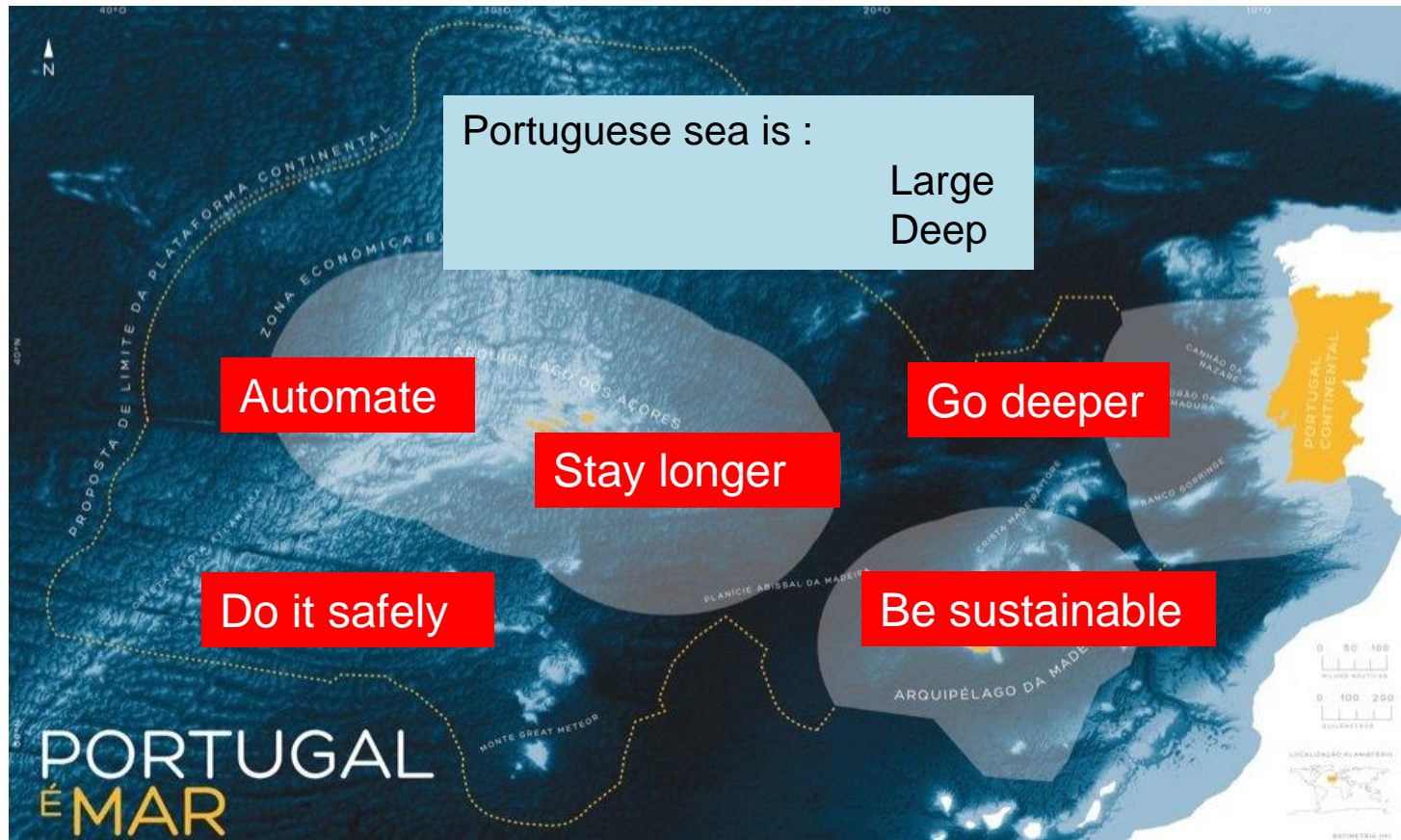
ROBOTICS group

- More than 1000m² of lab space
- Two test tanks
 - 10 x 6x 5 m
 - Underwater vision based ground-truth system
- 70 researchers
- 15 PhD students
- Current marine related projects
 - 5 European (FP7, H2020, ESA, EDA)
 - 2 national
 - 2 other international contracts



Motivation

- Increase of economical and scientific interest in the sea
- Research in marine robotic systems
- Portugal interest on the sea economy and exploration of its natural resources



Motivation

- **Awareness at sea** plays a relevant part
 - Situational awareness for safety, security or rescue
 - Environmental monitoring for risk assessment and safety awareness
 - Environment knowledge for resource exploration and management
 - Perception for decision autonomy and long term presence
 - Regulations and awareness
 - Local precision perception and awareness for intervention
- From the air, the surface or underwater

Robotic systems provide a efficient tool for increased awareness at sea

Robotic perception in this context also a key issue:

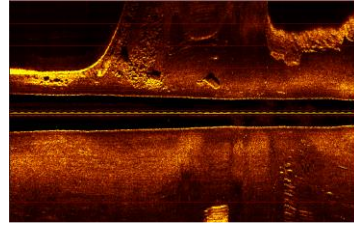
- Localization
- Obstacle avoidance
- Target detection, tracking and classification
- Environment modeling

Coastal monitoring and surveillance

Autonomous bathymetry

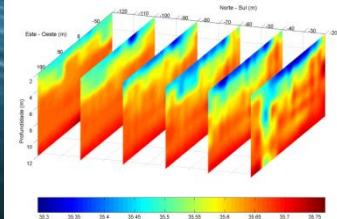
Automate

- ROAZ ASV
- Bathymetry in the near shore zone
- Risk Assessment
- Precise navigation
- Underwater seabed characterization



Environmental monitoring

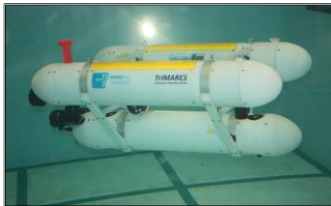
- MARES AUV
- Hovering capabilities
- Sewage outfall
- Water quality monitoring
- Plume tracking



Infrastructure inspection

Stay longer

- TriMARES hybrid ROV/AUV
- Visual inspection
- Sonar profiling
- Brazil contracts (Lageado)

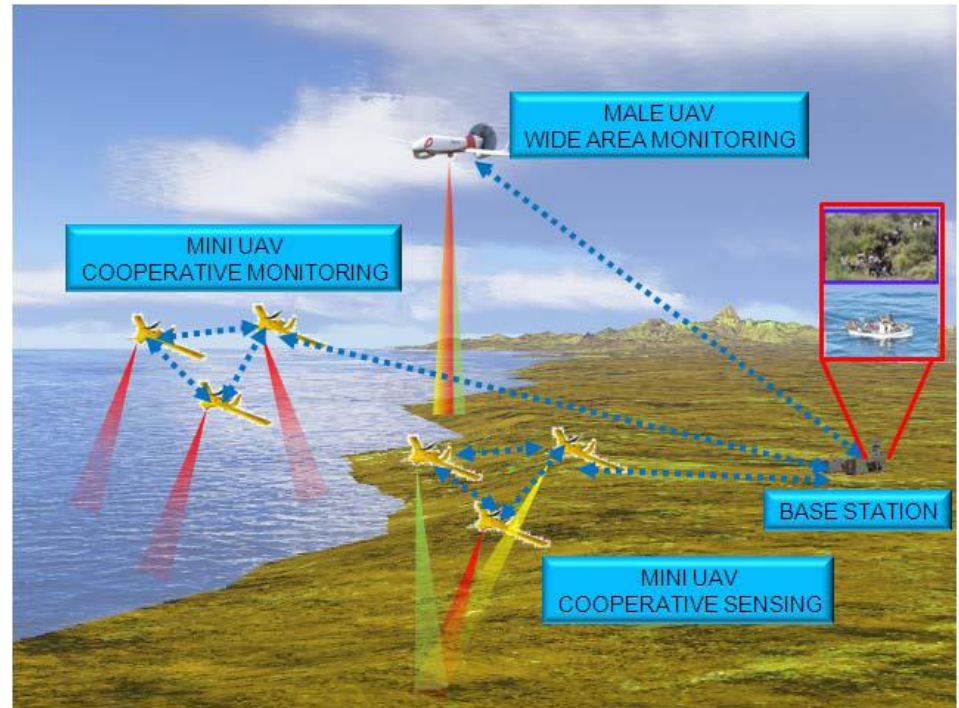


Acoustic monitoring

- FAST Autonomous Sailboat
- SLOCUM Glider
- Acoustic recording and processing
- Long term



- Maritime border surveillance
- 18 partners, 10 countries, 13M€, FP7 EU project
- 2014-2017
- 2 tier UAV sensor network (large field + focused surveillance)
- Novel sensors and on-board processing
- INESC TEC role : on-board processing and preliminary detection



Awareness issues

- Surface (remote)
- Large areas
- High detailed discrimination
- Integration with human controlled infrastructures
- Irregular entries in European maritime space

- Integrated Robotic Tools for Search and Rescue
 - Robots, Sensors, Communications, Command & Control, Training
- 24 partners, 10 countries, 2 end users, 17.5M€, FP7 EU project
- 2012-2016
- **Large Scale Disasters**
 - USAR Scenario
 - **Maritime Scenario**
- Royal Military Academy, Belgium (leader)
- INESC TEC leading maritime scenario
 - INESC TEC, CINAV/Portuguese Navy, Portugal
 - Calzoni, NATO CMRE, Italy
 - ASCAMM, Spain
 - ETH, Switzerland
- Fixed wing UAVs
- Multirotor UAVs
- Transport USVs
- Unmanned rescue robotic capsules



Integrated Components for Assisted Rescue and Unmanned Search operations

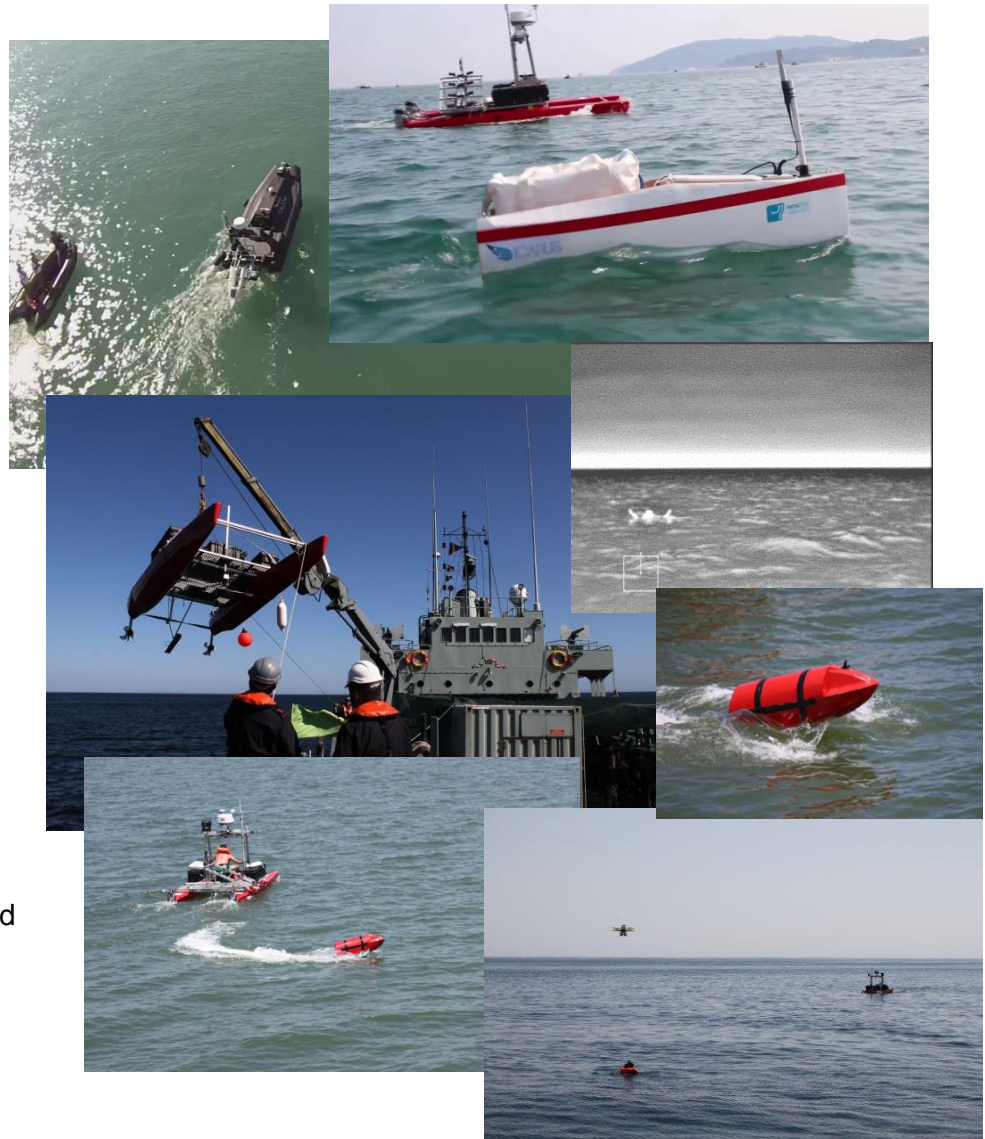


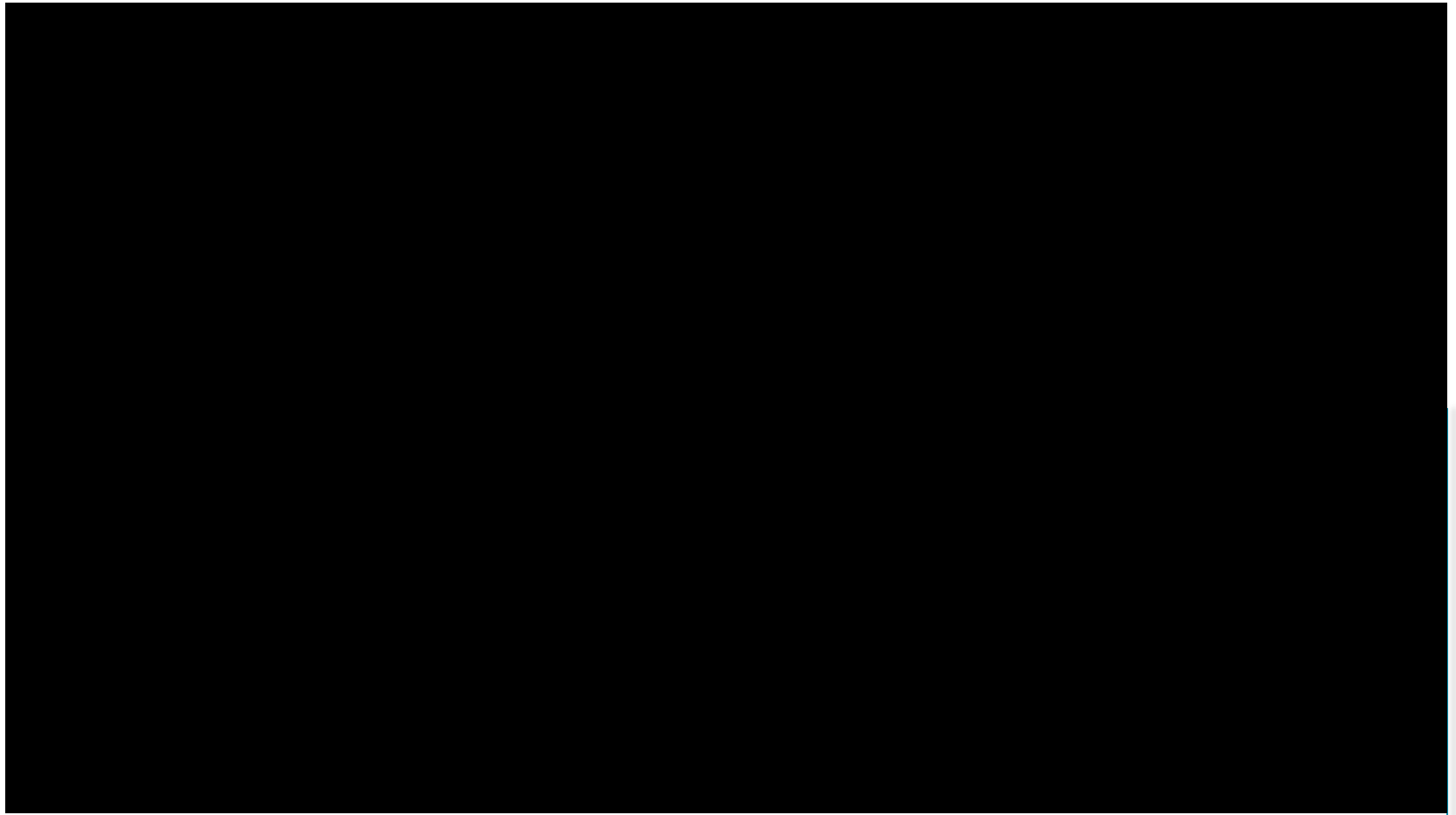
Field missions

- REP 2012
 - Data collection
- REX 2013, 2014
 - UCAP validation, deployment system
 - Victim detection
- Field tests at CMRE – La Spezia
 - U-Ranger sensor suite integration
- UAV integration tests (CMRE, La Spezia)
- Final demonstration Jul /2015 Alfeite, Portugal

Awareness issues

- Robots in non segregated space (dynamic obstacles, victims...)
- Tight integration with human controlled assets and rescue infrastructure
- System interoperability plays a relevant role
- Time critical in rescue scenarios
- Victim detection and tracking in possible very harsh conditions

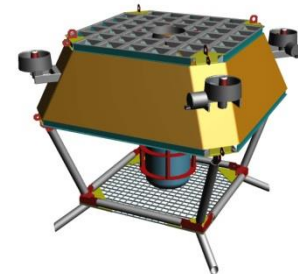
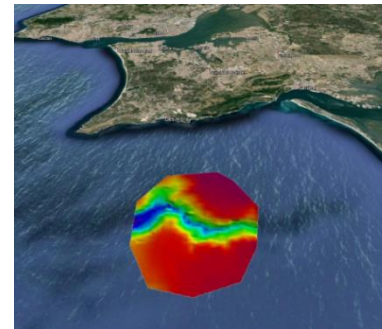
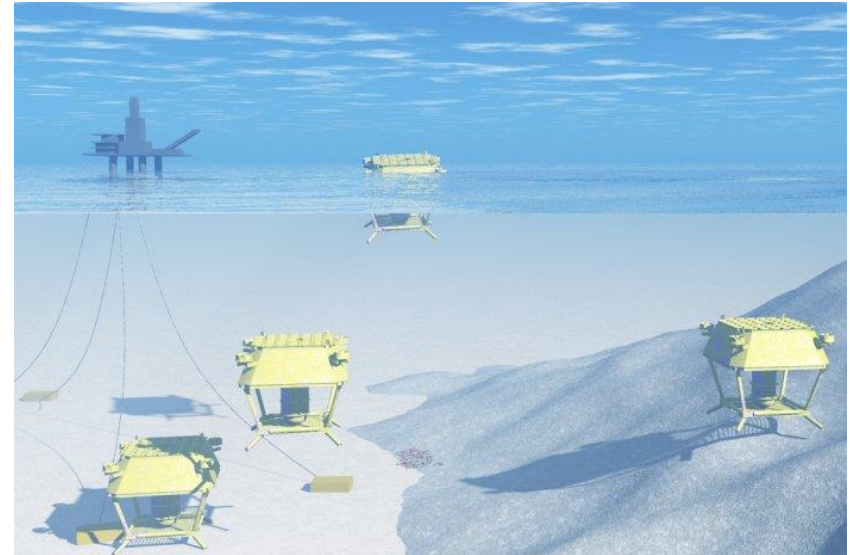




TURTLE

Go deeper

- Developing technologies for sustainable and long term presence in the **deep ocean**
- High performance structures for the deep sea with lower manufacturing cost
- Energy efficient technologies of descent and ascent operations
- Demonstrator to validate the robotic transport solution (fixed/mobile system) for deep sea monitoring (1000 m)
- One of the 6 (out of 70) EDA approved dual-use projects
- QREN (national) funds
- 2014-2015
- Budget 1.3M €
- Partners: **A. Silva Matos Metalomecânica**, Ply Engineering, INESC TEC, ISEP, Portuguese Navy



A. SILVA MATOS
METALOMECHANICA

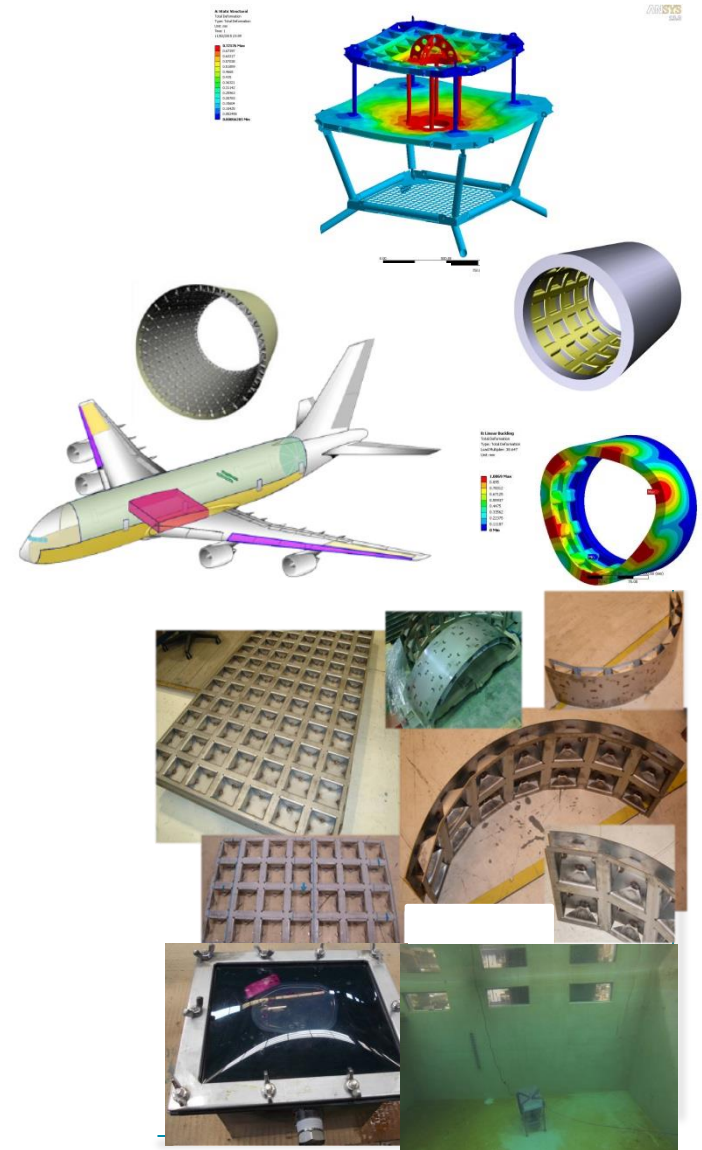


TURTLE autonomous lander

- New structural elements based on Innovative Open Sandwich Panel Structures – PLY OpenCell TM
 - Lightweight high pressure resistant composite
 - Knowledge gained from aeronautic and space applications
- Variable buoyancy system
- Pressure tolerant LiFePo4 batteries (10KWh)
- Dual use monitoring
 - Acoustic monitoring
 - Seabed seismometer

Awareness issues

- Localization
- Long term system survivability (marine growth, energy)
- On board processing /energy
- Event detection

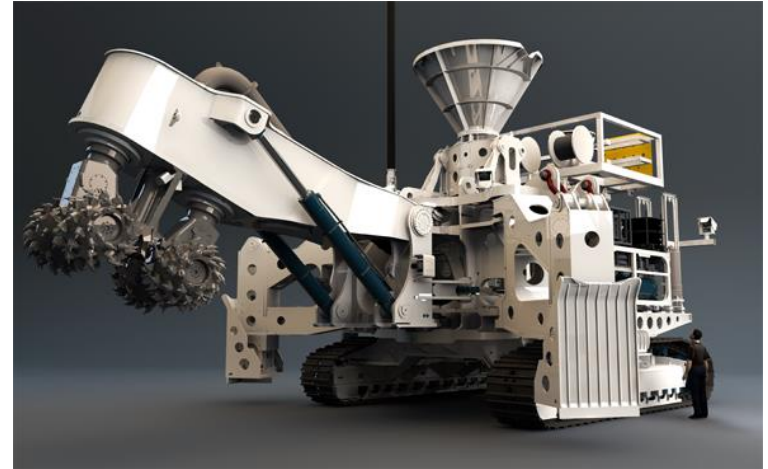


VAMOS – Viable and Alternative Mine Operating System

Go deeper

Be sustainable

- Underwater mining technology
- Awareness for precision mining, environment modeling in difficult conditions
- H2020 Societal Changes 5 (Raw Materials) RIA
- 2015- 2018
- 17 partners, 9 countries
- 9,2 M€
- Partners: BMT, SMD (UK), INESC TEC, Damen Dredging (NED), Trelleborg (NED), Sandvik (AU)...
- INESC TEC Role: Positioning, navigation and awareness system



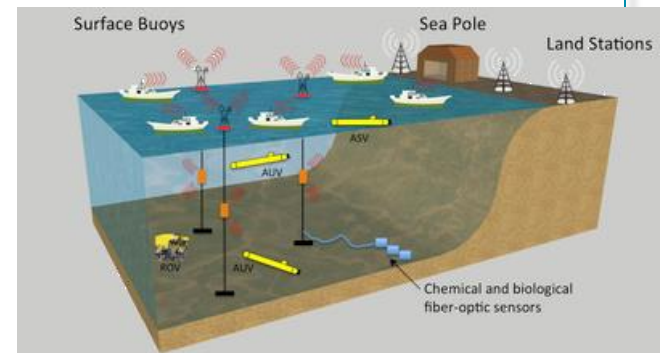
Awareness issues

- Harsh environment (noise, turbidity, light)
- In situ soil chemical composition analysis
- Local bellow sea-bottom fine grained perception
- Autonomy issues
- Deep sea

TEC4SEA: collaborative and integrated approach

Distributed research infrastructure to support research, development, and test of marine **robotics**, **telecommunications**, and **sensing** technologies

- Common use research infrastructure
 - Laboratories (robotics, test tanks, communications, microfabrication, support facilities at Leixões harbour)
 - Technology assessment, experimentation and validation testbeds
 - Instrumented marine areas
 - Access to relevant assets
- Approved in the National Roadmap for Research Infrastructures
- To promote technology development with impact in the economy
- In the national and regional strategy (smart specialization)
- National funding, structural funds, H2020, services



Algarve University Technology
Research Center

Concluding remarks

- INESC TEC has a commitment to create and promote technological knowledge based value for the sea economy
- Awareness at, and of, the sea, is a common issue in the ocean exploration and economic exploitation
- In the sea we want to
 - Stay longer
 - Do more
 - Go deeper
 - Do it safely
 - Do it sustainably
- With the increased interest in the sea, marine robotics plays a relevant part for improved awareness.
- INESC TEC has been developing a strategy for robotic technology development leading to the exploration of the sea:
 - Design, implementation and operation of marine robots (aerial, surface and underwater)
 - Develop and promote science, knowledge and technologies for the deep sea
 - Promoting common research infrastructures (TEC4SEA)
 - Establishing international partnerships for a sustainable, long term, economical technological presence at the sea

thanks for your attention

