From Knowledge Generation To Science-based Innovation

INESCTEC
TECHNOLOGY & SCIENCE
ASSOCIATE LABORATORY
PORTUGAL

# INESC TEC – Underwater Mining

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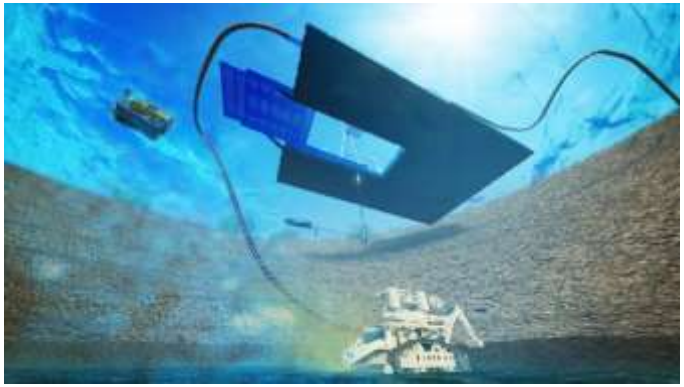
INESC TEC
Portugal

*This presentation looks at the current state of underwater inland and near-shore mining at INESC TEC and has much relevance in the future of deep-sea mineral exploitation*

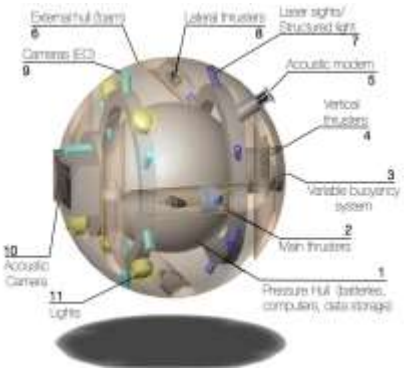
# Underwater mining

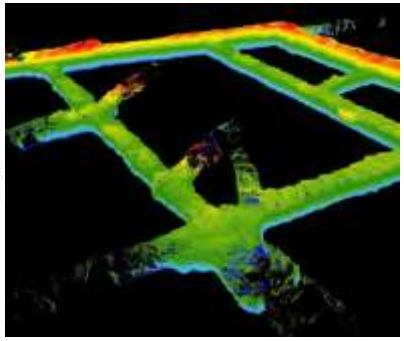
¡vamos!



•**Efficient underwater mining technology**
•H2020 Societal Changes 5 (Raw Materials) RIA
•2015- 2018
•17 partners, 9 countries
•12,4 M€
•INESC TEC Role: Positioning, navigation and awareness system, support AUV, LIBS sensor

UNEXMIN



•**Robotic Exploration of flooded mines**
•H2020 Societal Changes 5 (Raw Materials) RIA
•2015- 2018
•13 partners, 7 countries
•4.8 M€
•INESC TEC Role: Robot development, navigation, mapping

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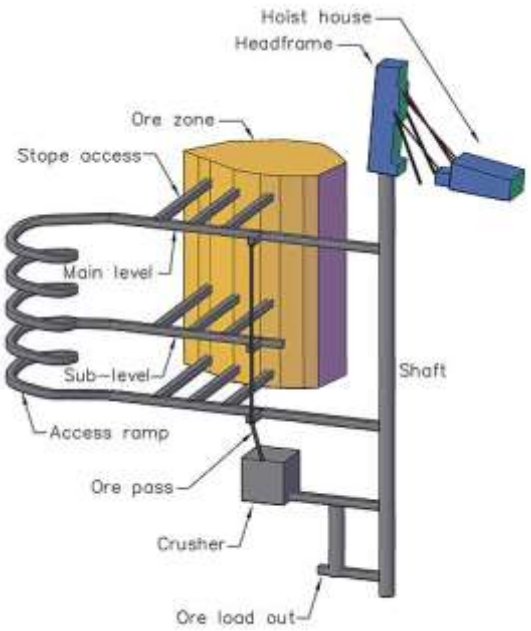
# Coral

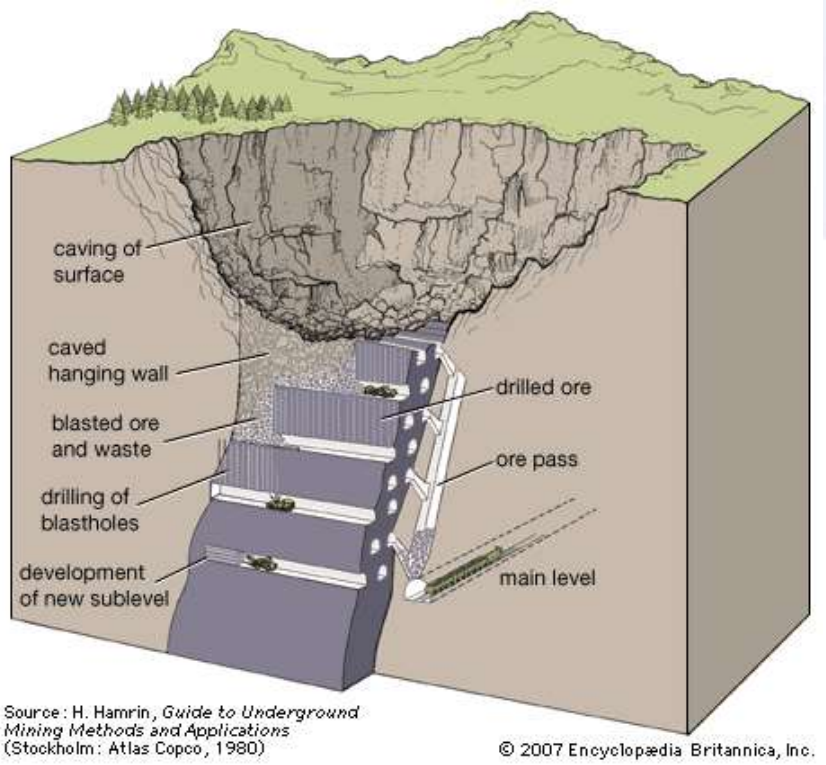
## Sustainable Ocean Exploitation: Tools and Sensors

*Apoio NORTE2020 através do Fundo Europeu Desenvolvimento Regional e do Fundo Social Europeu*

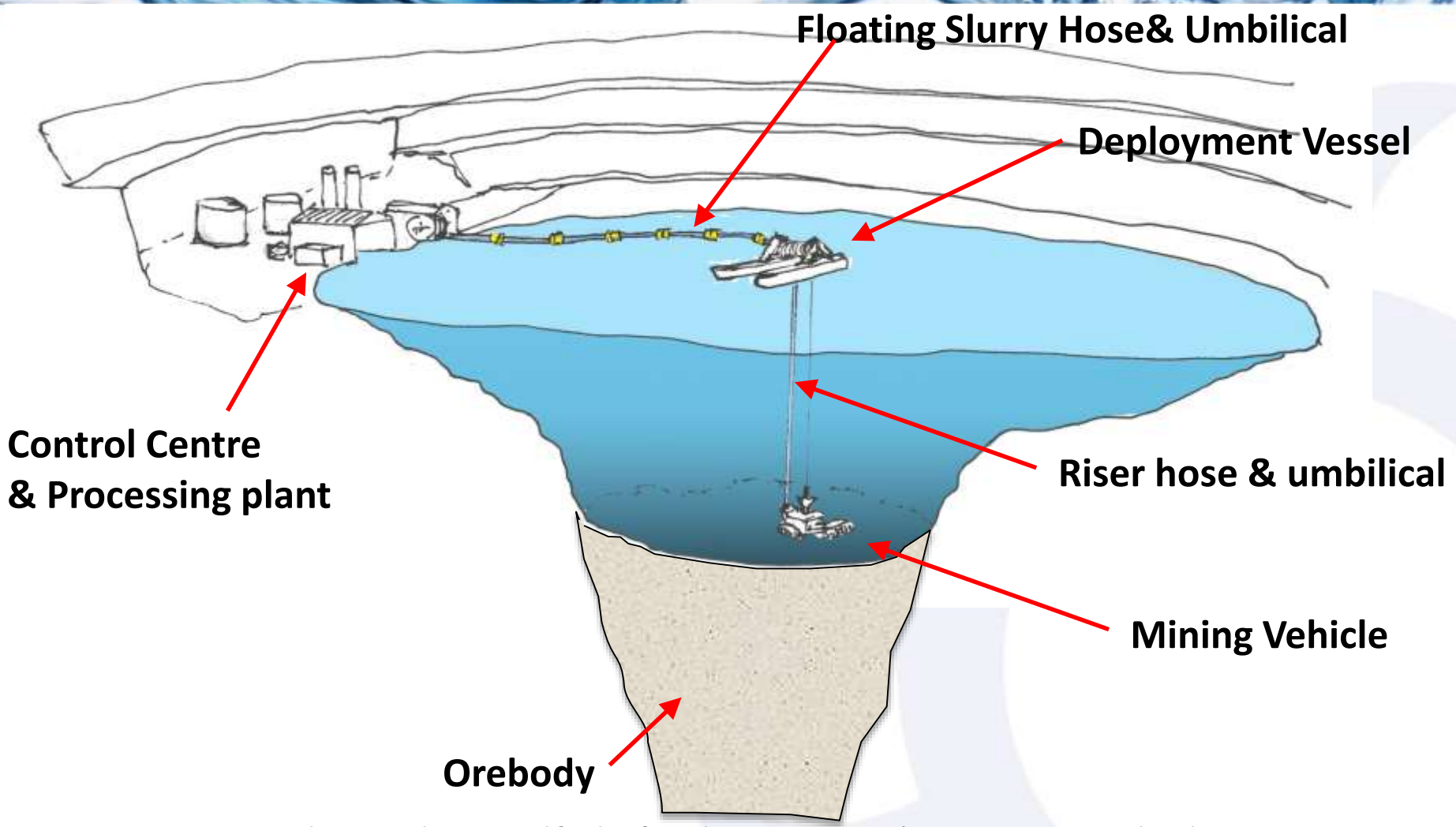
# Mining History

- Need to know some details of the underground mining as well as the open cut mining
- In particular whether block or sub-level caving has been used



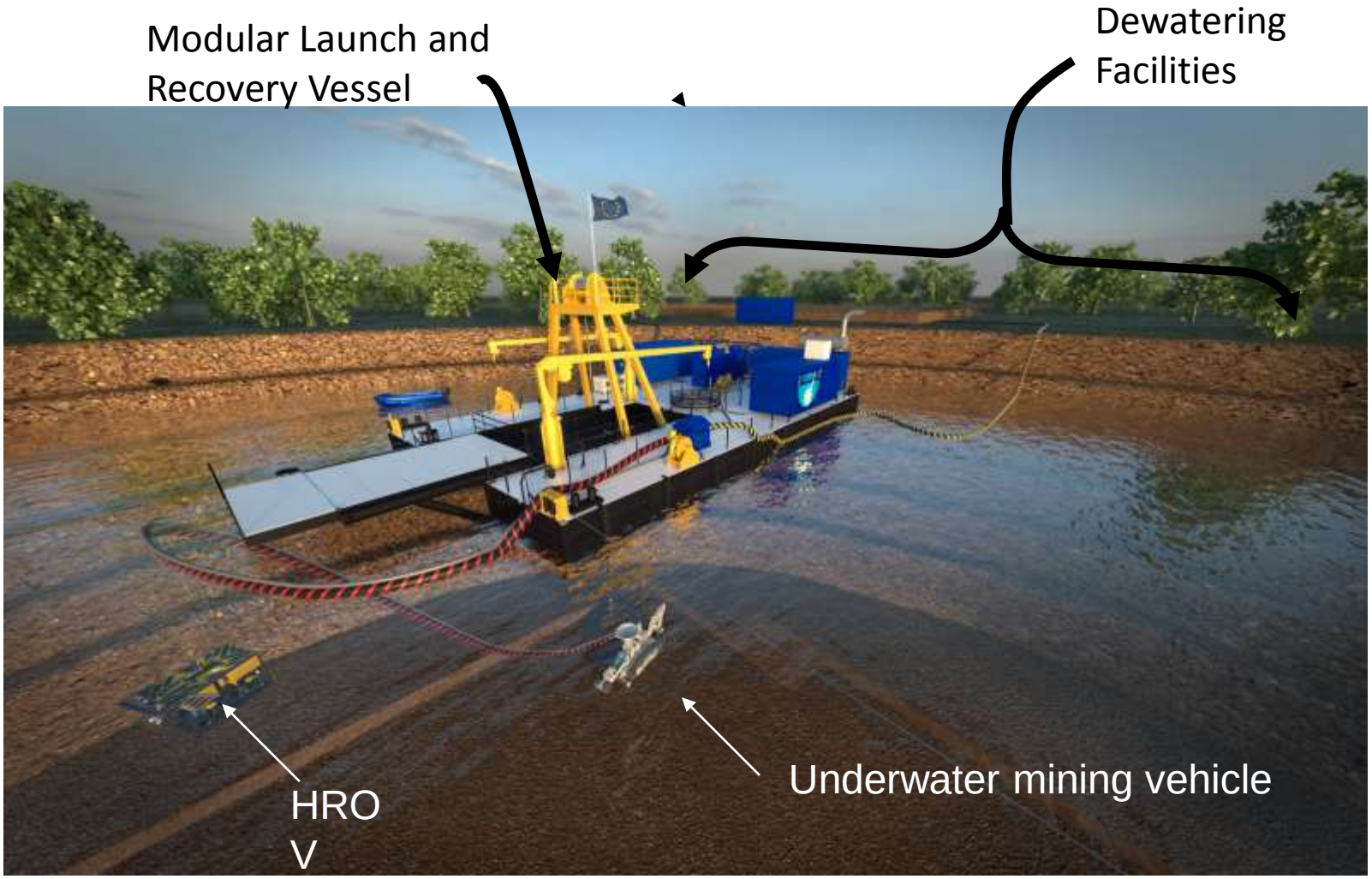



# Inland Submerged Mining (Concept Prototype)




This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 642477

# ¡VAMOS! overview…

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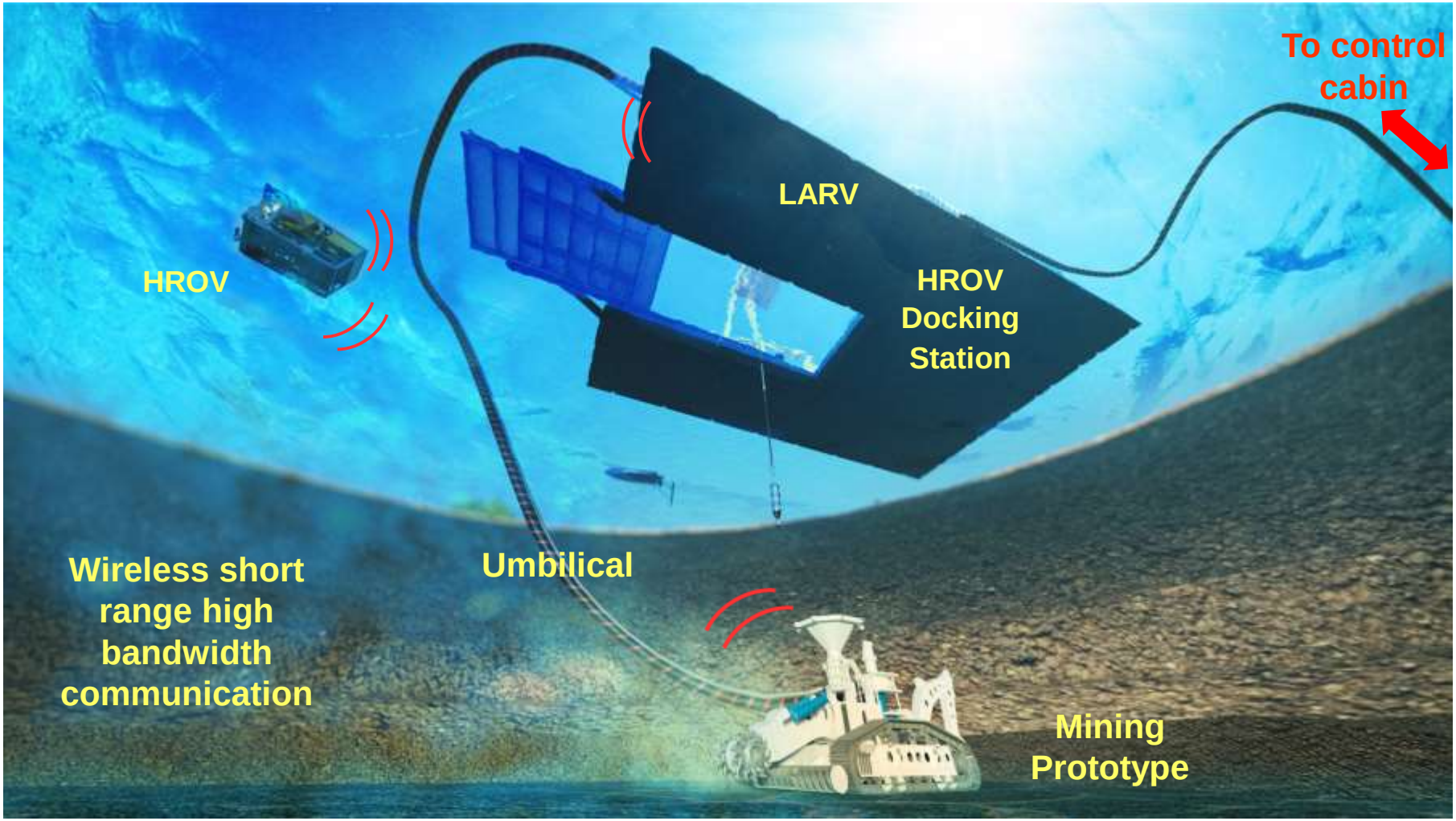
# iVAMOS! Underview…

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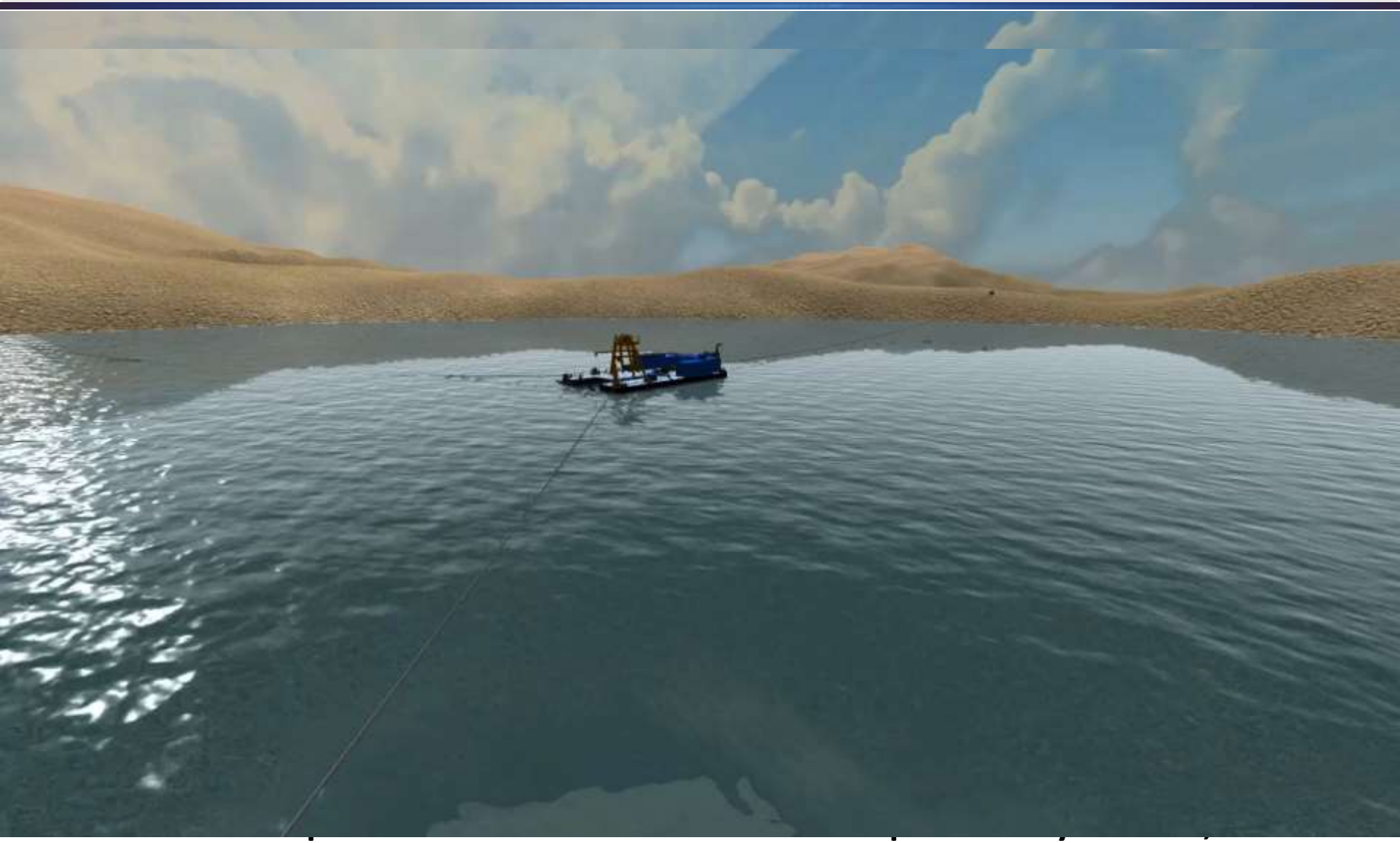
# VAMOS! virtual view…



allowing remote operation at night and in turbid water.

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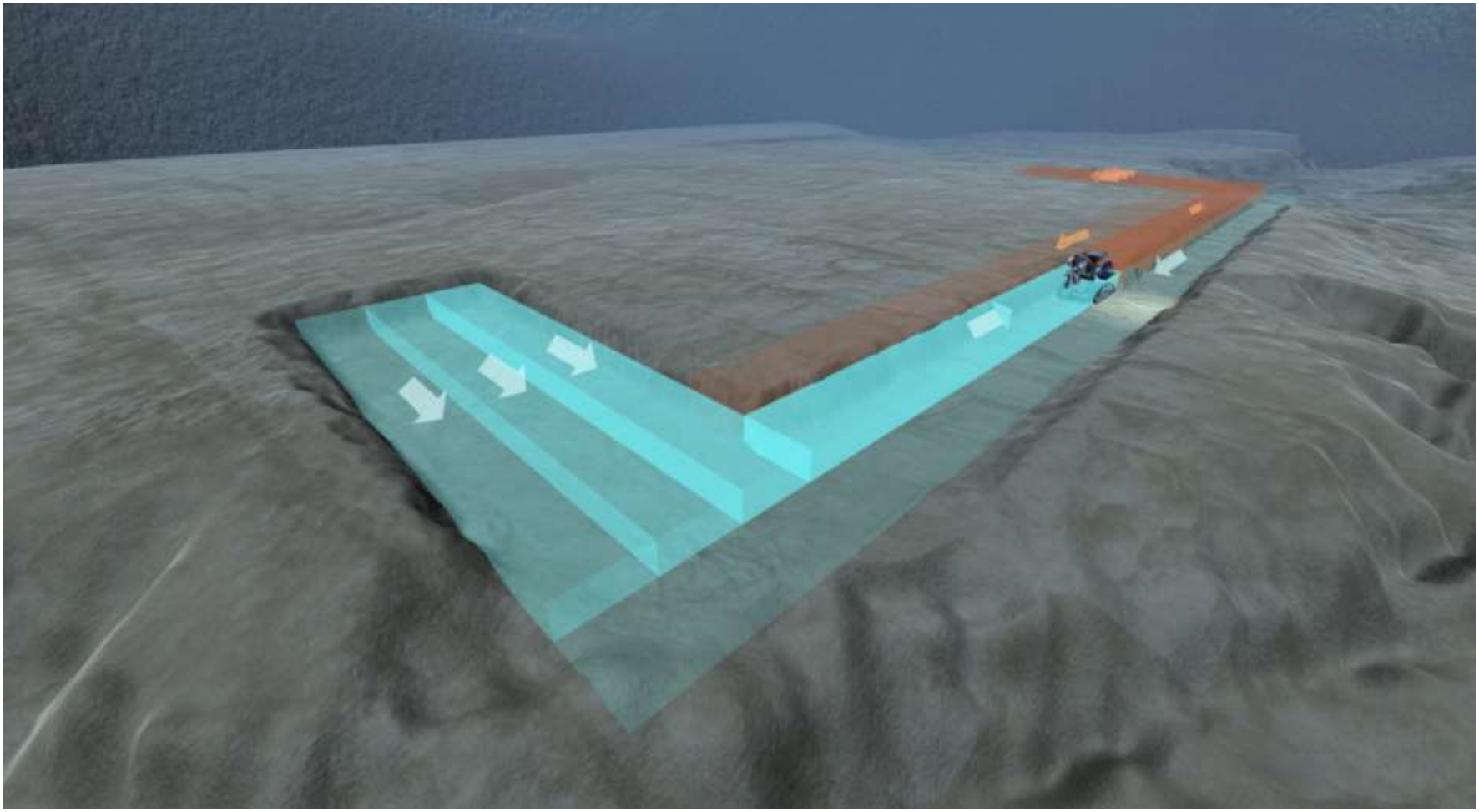
# Mine planning views…



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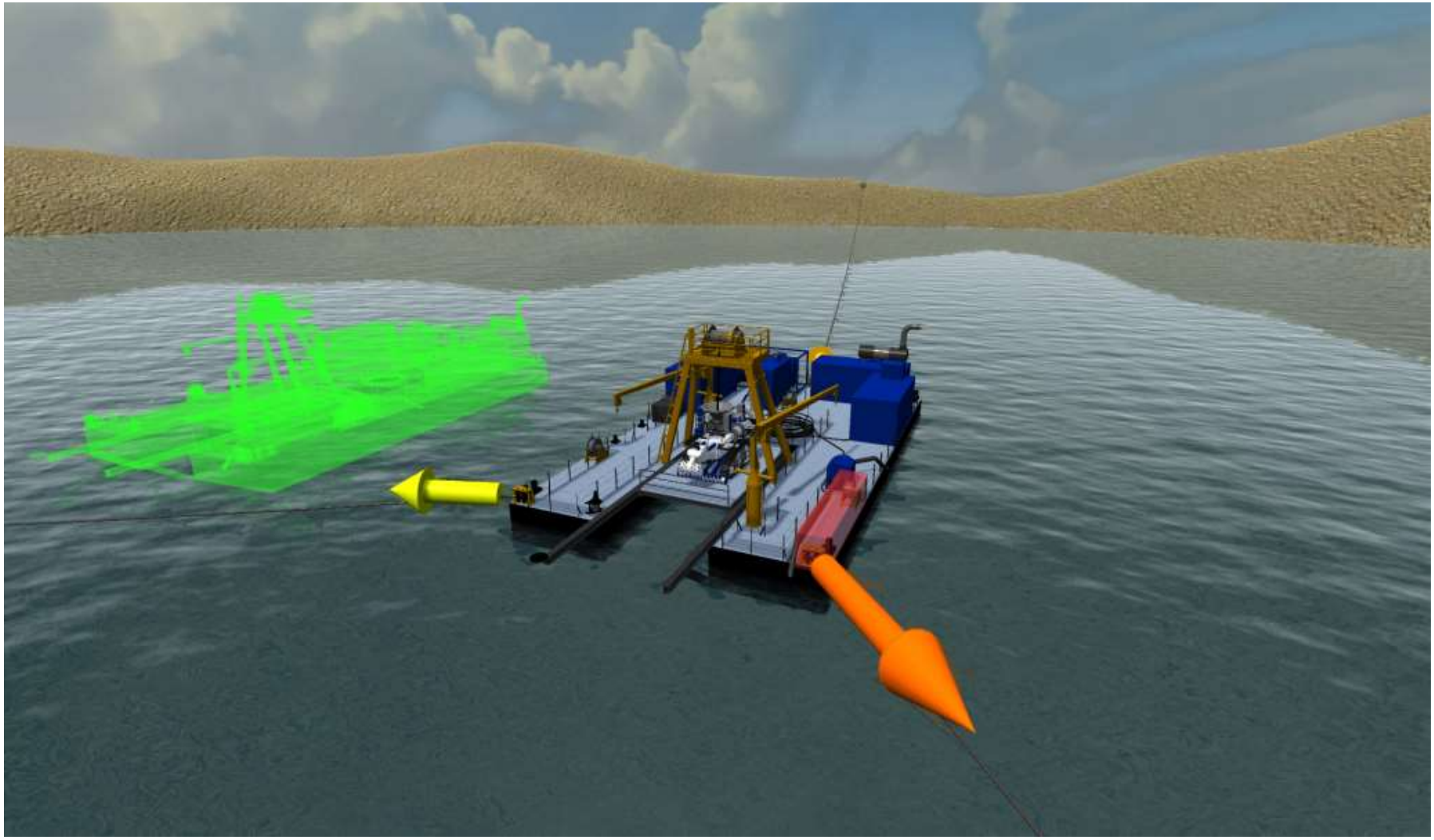
# Positioning of launch and recovery vessel…



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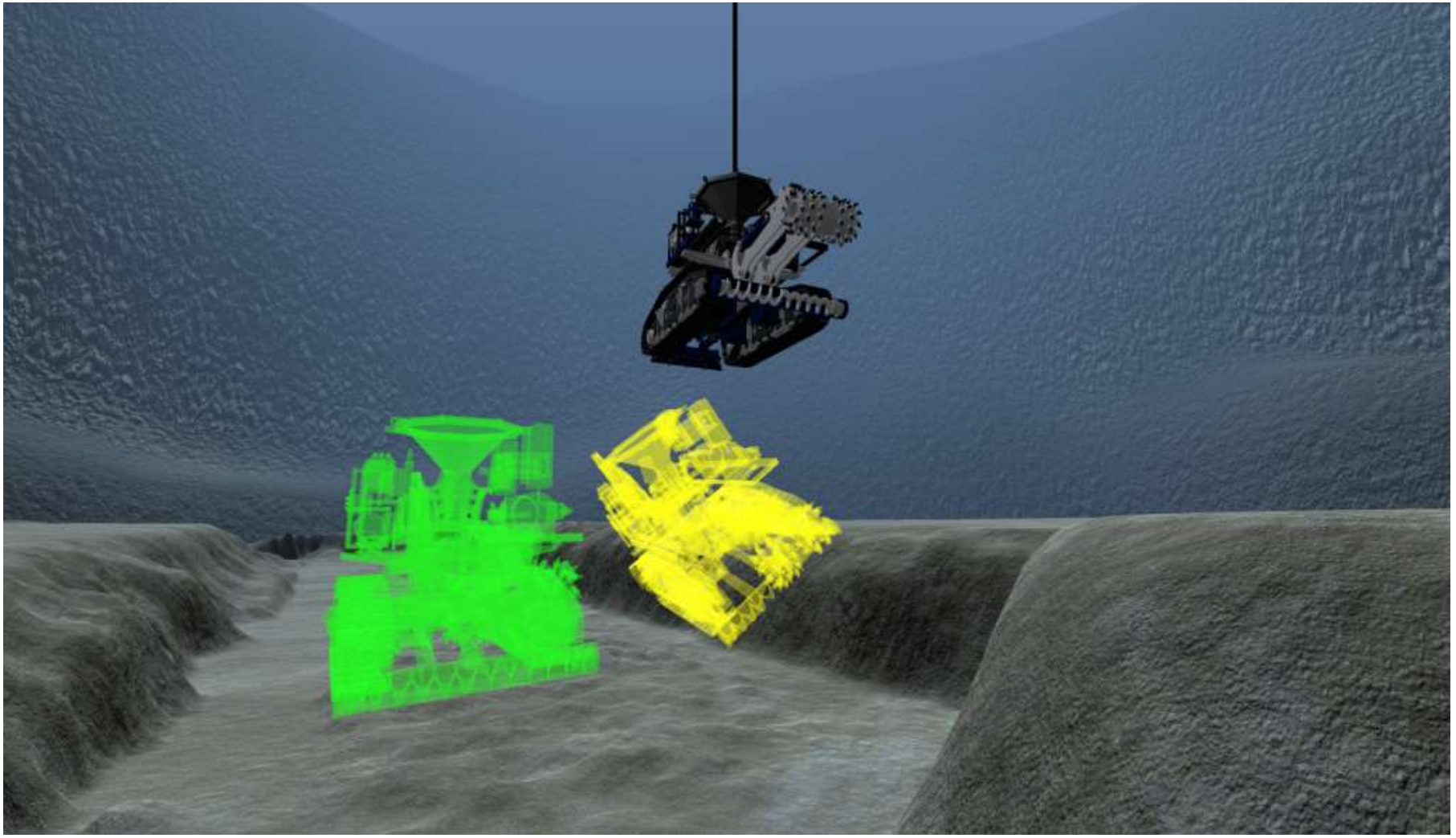
# Landing the mining vehicle…



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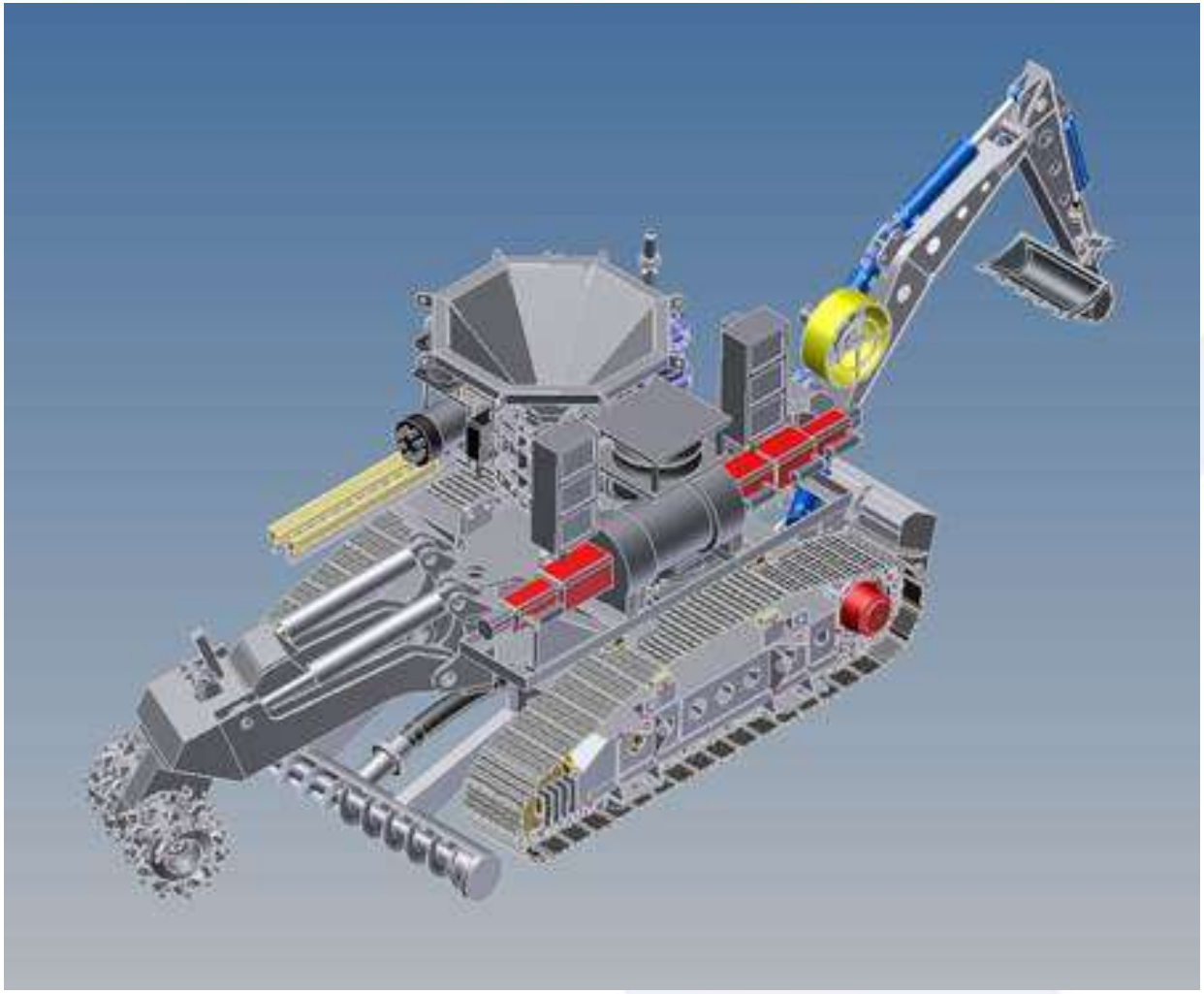
# Concept design MV (after WP2)



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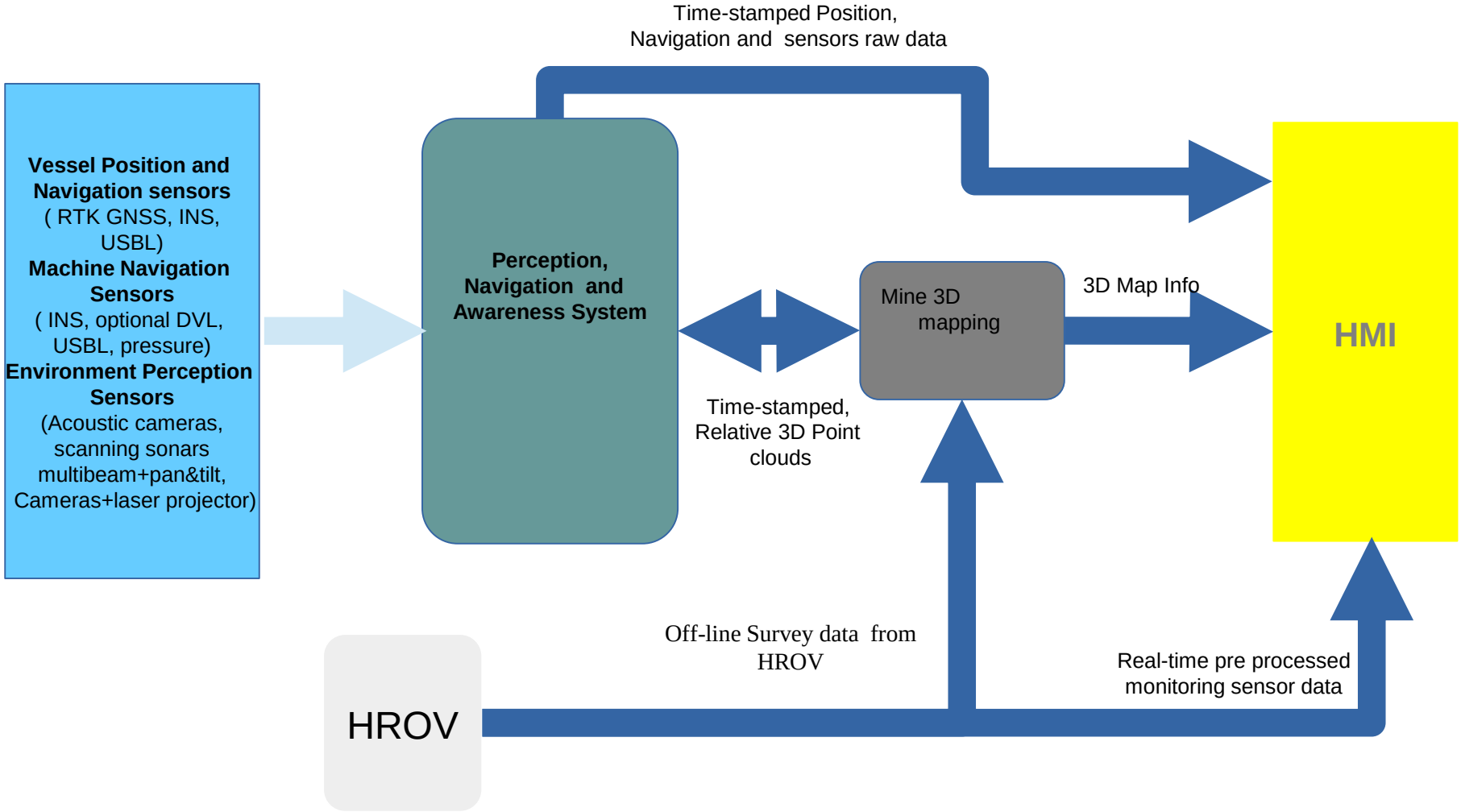
# ¡vamos! Hybrid Satellite AUV/ROV

- Preliminary mine survey
- Detailed localized mapping
- Operations support
  - "Other view" assistance
  - Realtime mapping

- Multiple laser structured light systems/cameras
- 3D Multibeam sonar
- Redundant full 6DOF control
- Custom inverted USBL/ SBL positioning
- High precision INS system
- DVL sonar
- Pressure tolerant batteries
- Docking station

# Global PNA Data Flow…

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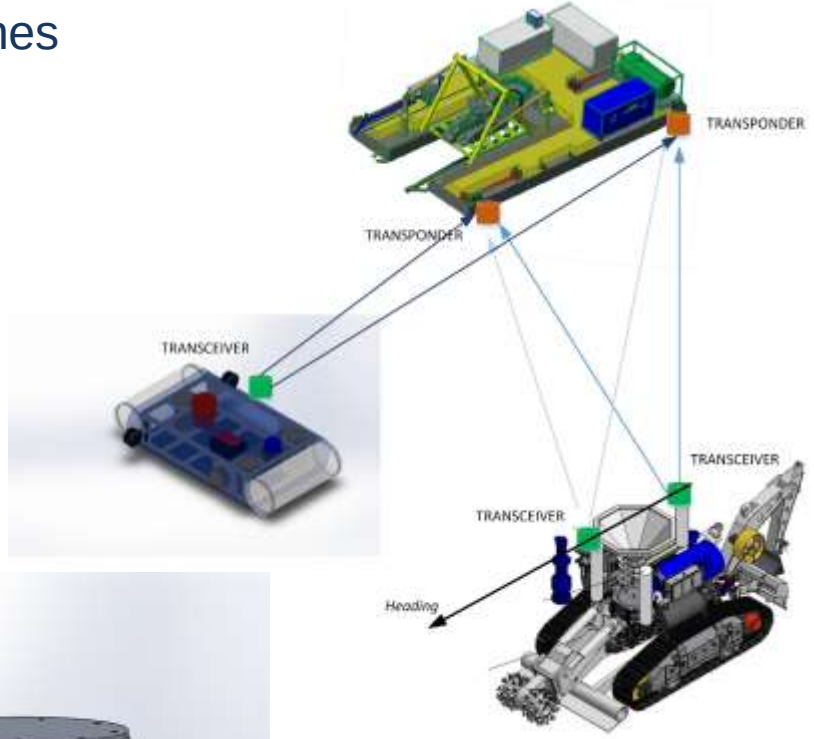
# Multi-sensor navigation system

- Hybrid SBL and iUSBL system for enclosed mines




- Development of a
- Laser based structured light system scanner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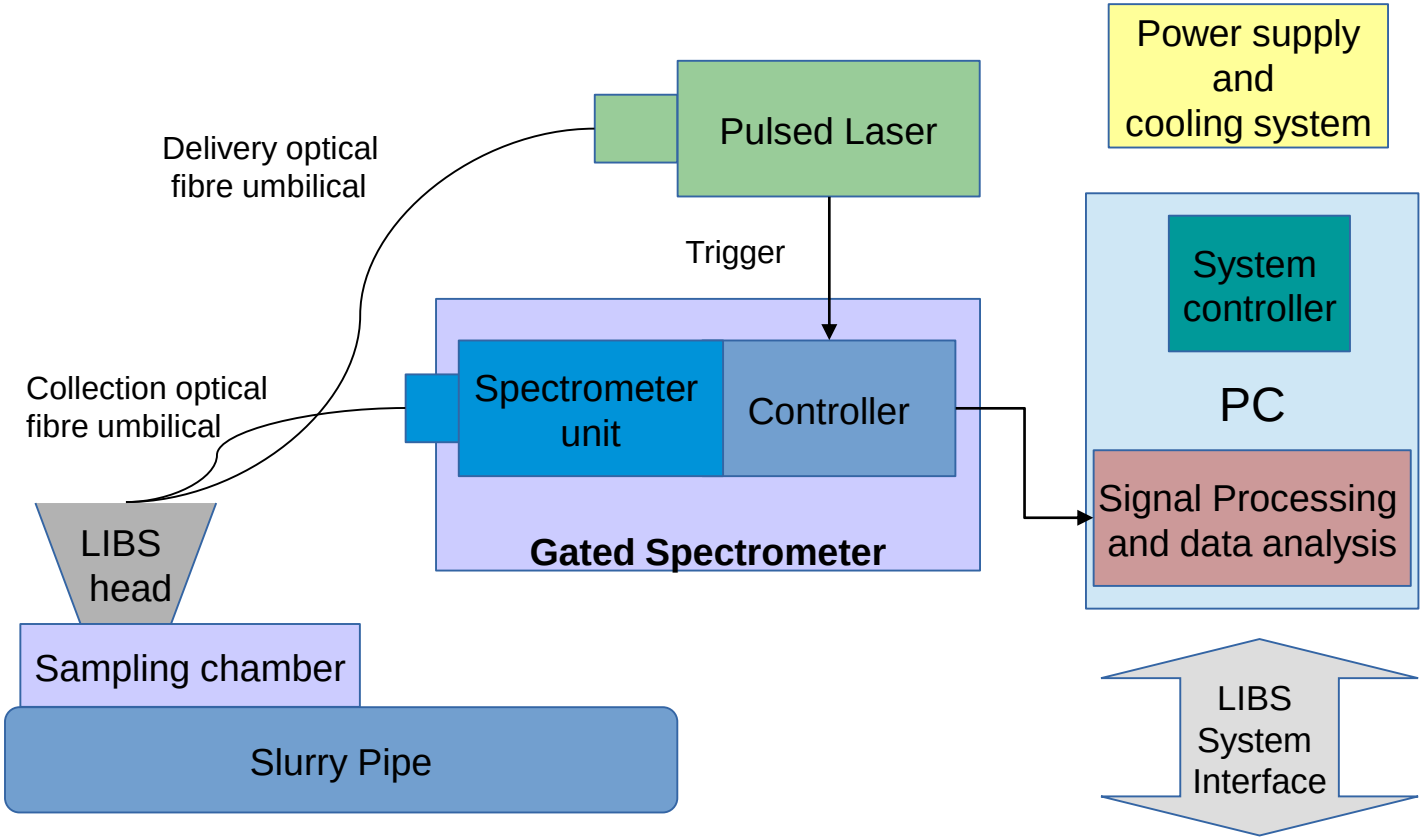
# Real Time Grade Control…

**Key chalenge**

Enable real-time monitoring **boosting sensitivity** and establishing robust calibration protocols. *(double pulse configurations and gas assisted sampling)*

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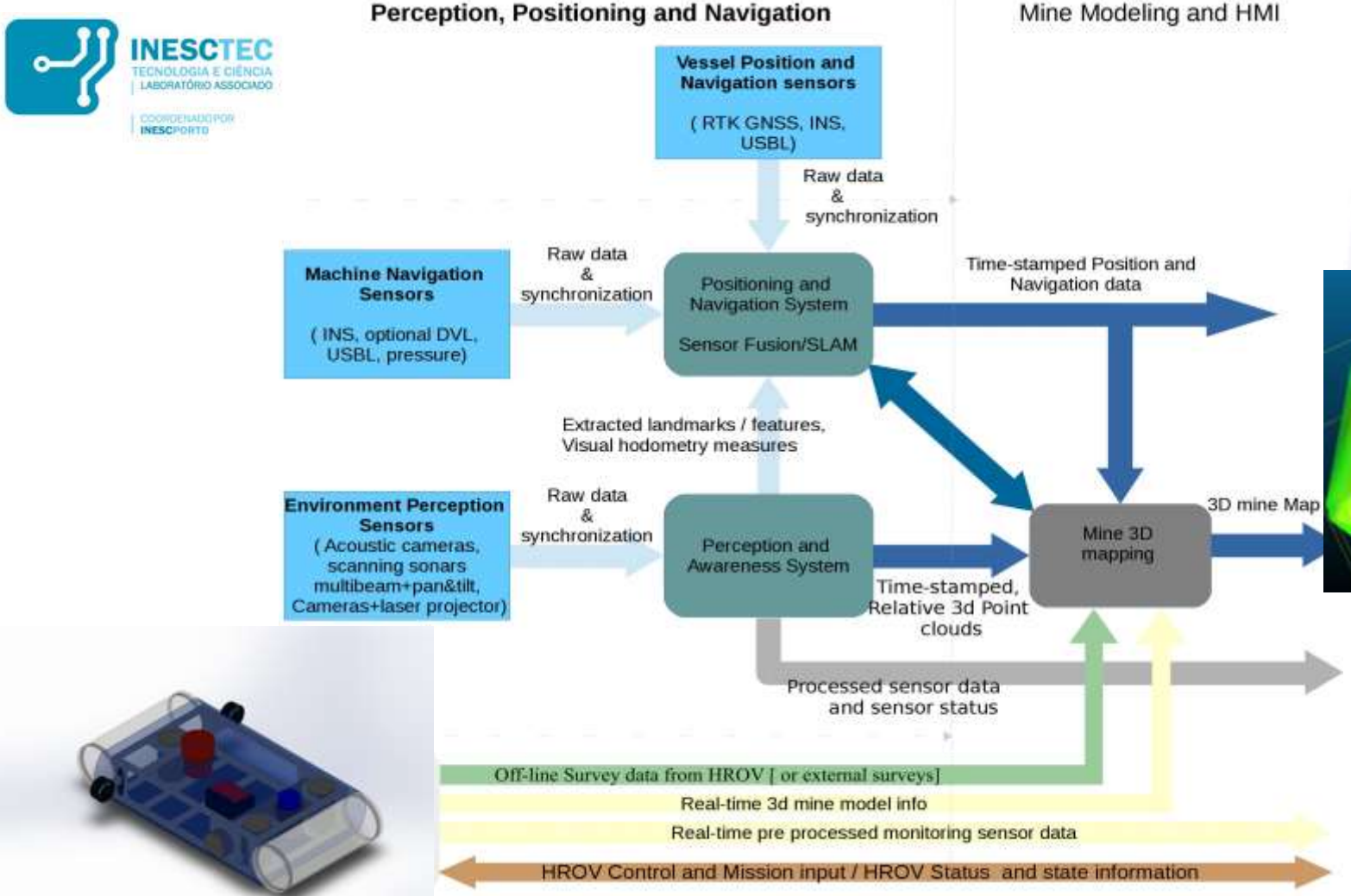
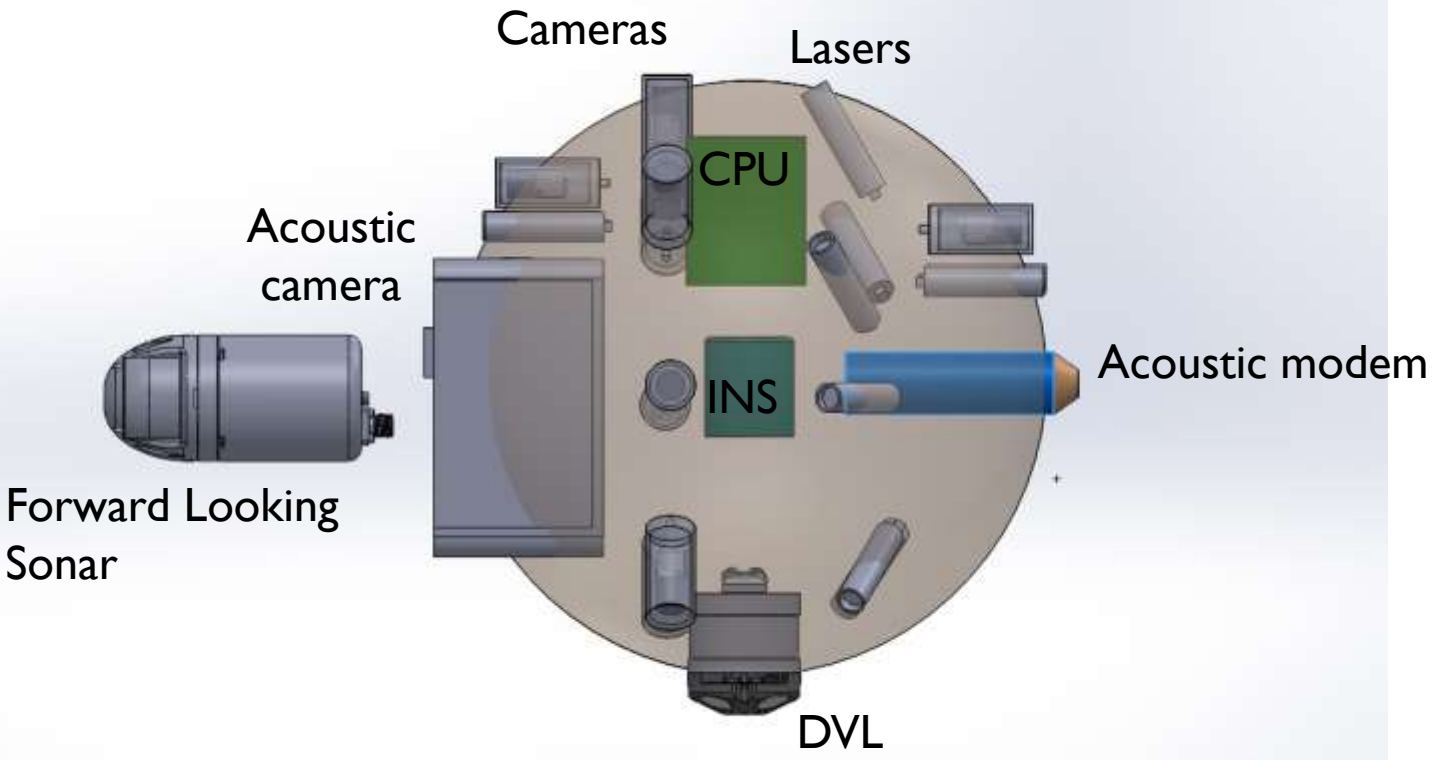
# PNAS system diagram incl HROV



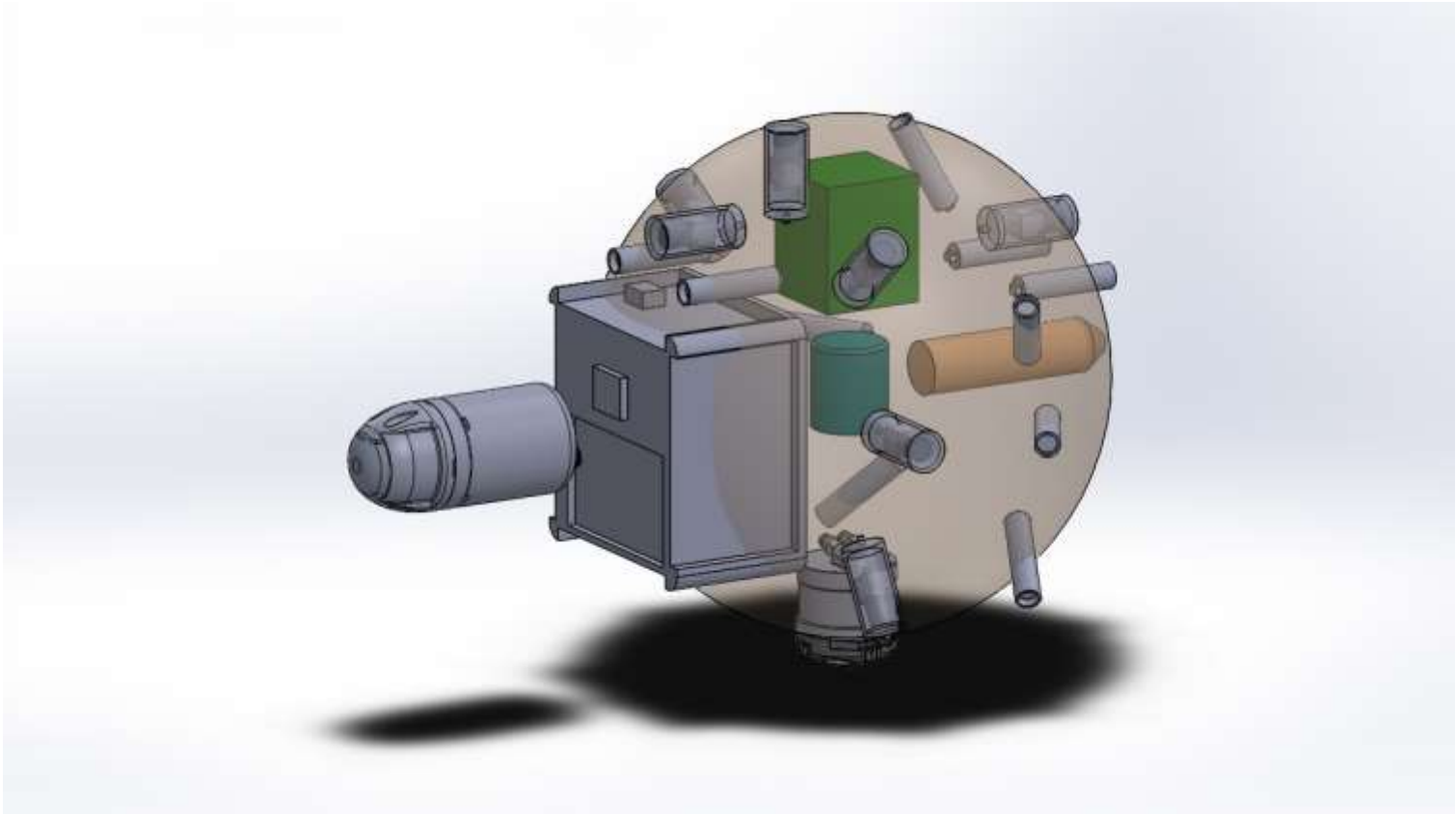
# EXAMPLES OF SIZES /VOLUMES NAVIGATION SENSORS

| | weight (g) | volume (L) | | Power (W) |
|---|---|---|---|---|
| Multibeam (5kg) / Acoustic camera ( 17kg) | 17000 | 15.75 | | 50 |
| INS | 700 | 0.46 | | 10 |
| DVL | 1000 | 1.16 | | 3 |
| Pressure sensor | 400 | 0.10 | | |
| Acoustic modem | 1000 | 0.30 | | 30 |
| Cameras + Lens 8 | 4000 | | | 40 |
| Laser (8 a 12) ref 10 | 3000 | | | |
| Lights 8 | 1600 | | | |
| CPU, SSD, interfaces | 1500 | | | 60 |
| Electronics (BMS, Energy management and distribution, synchronization, trigger) | 500 | | | |
| | 30700 | 17.77 | | 193 |

# EX. 60CM DIAM / NAVIGATION SENSORS



# EX 60 CM DIAM. NAVIGATION SENSORS



# Coral Research Questions

•Explore the effectiveness of robotic technologies and solutions to achieve lower cost and more efficient, exploration and environmental impact monitoring;

•Provide advanced understanding of biogeochemical processes in deep sea ecosystems;

•Develop innovative technologies and methodologies to assess the resilience and biodiversity of deep sea ecosystems under mining extraction;

• Identify potentialities on new biotechnological applications of deep sea organisms;

•Develop a framework and guides for risk and impact assessment for sea floor exploitation;

•Develop modelling tools in support of risk assessment scenarios;

•Develop  legal instruments framed in EU regulation to foster an effective management of sea floor resources.

# From the surface to the deep

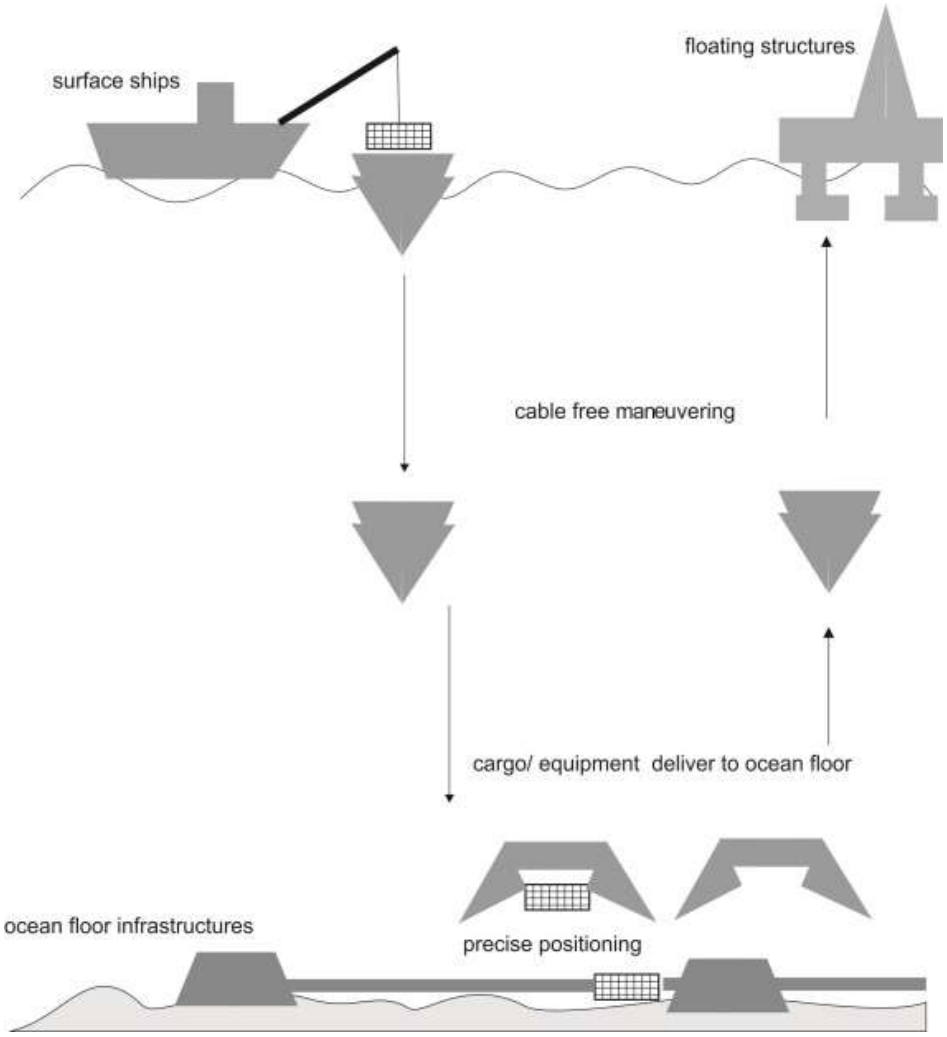
## TURTLE – Hybrid robotic landers


- **Robotic Autonomous Deep sea lander**
- QREN, National funds
- 1 M€
- 1400Kg, 1000m prototype
- Efficient ascend/descent
- Long term presence at sea bed

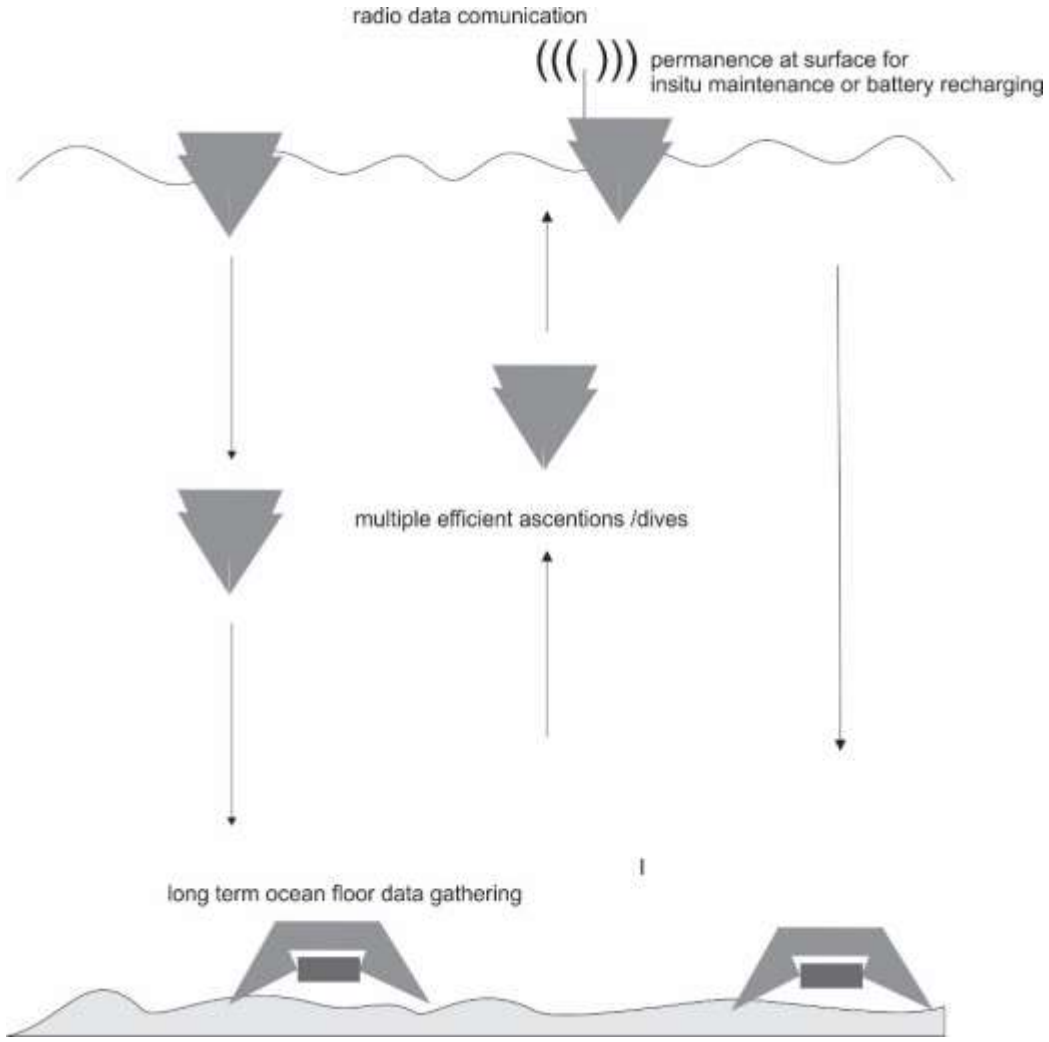
## Mission planning (EDA)

- **AUV mission planning for mine countermeasures**
- EDA – European Defence Agency
- 5 Partners, 5 Countries
- 1 M€

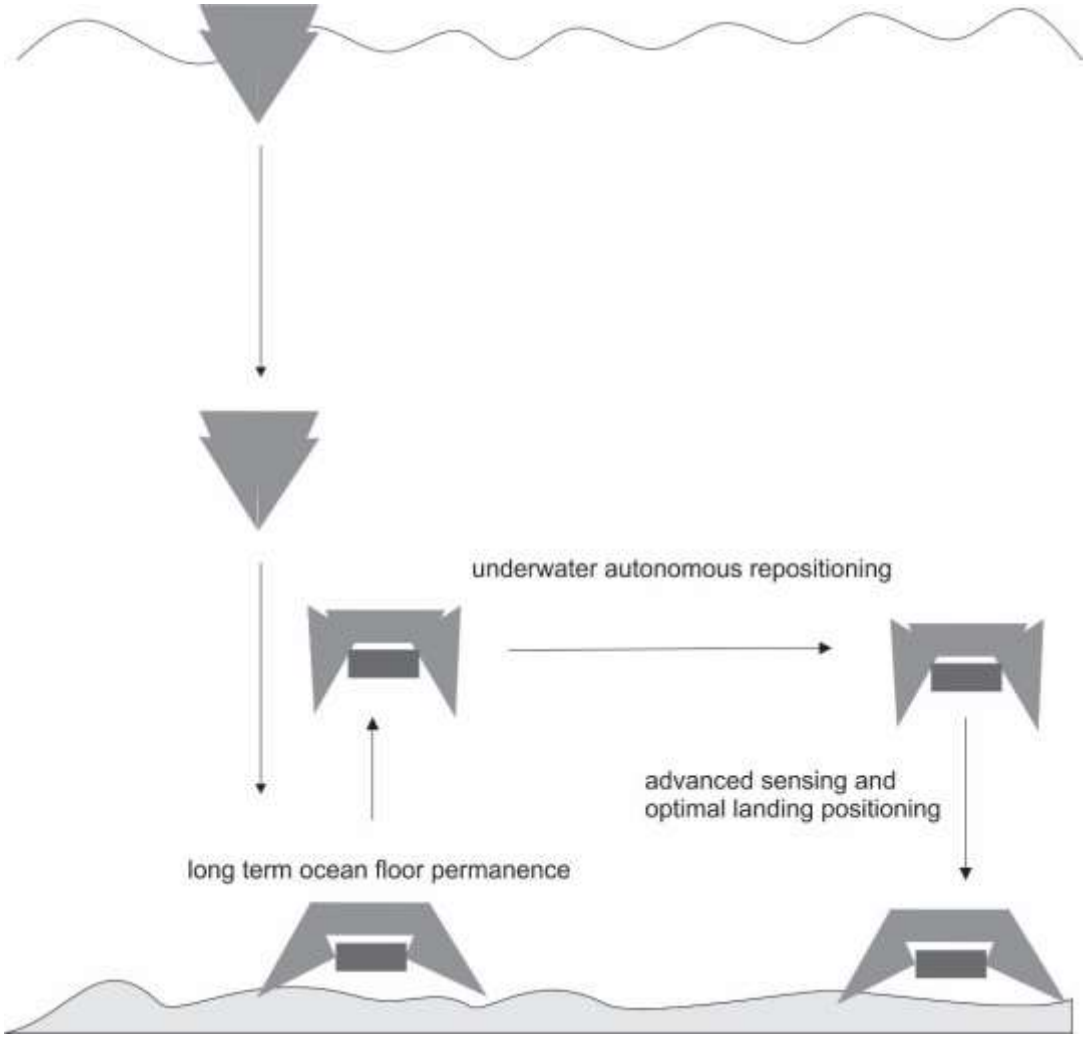
# Transport


surface ships
floating structures
cable free maneuvering
cargo/ equipment deliver to ocean floor
ocean floor infrastructures
precise positioning

# Long-term presence

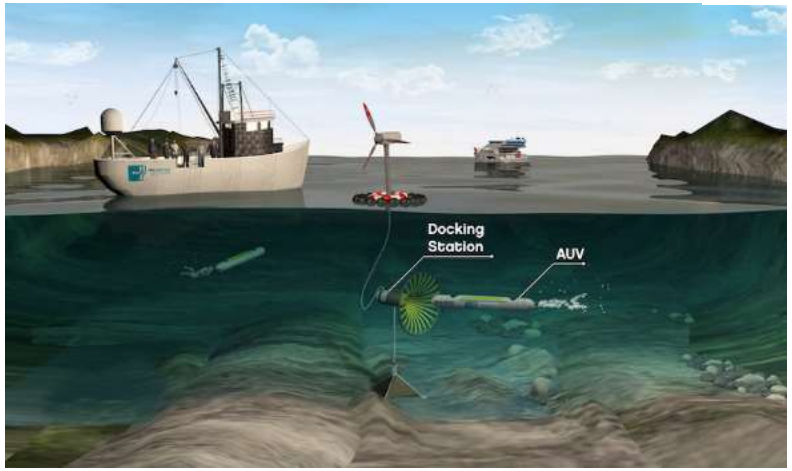


# Repositioning



# Sea tests

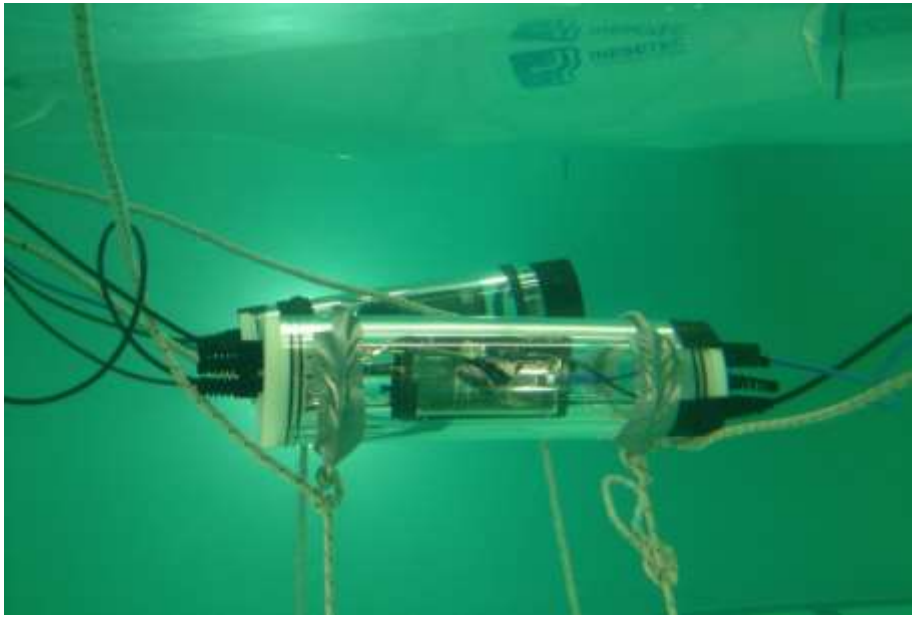
# Other projects (complementary technology)




- EEA Grants
- 2015-2016
- 0.3 M€
- Underwater energy transmission
- Underwater RF communications

- EEA Grants
- 2015-2016
- 0.3 M€
- Long range maritime communications
- Broadband communications in marine environment
- Surface and underwater internet access

# Short range communications



- **Propagation of RF waves in seawater is well suited for short-range broadband communications**
  - *A 100 MHz carrier suffers a 30 dB attenuation for each 10 cm of propagation*
- **Based on Wi-Fi radios using sub-GHz frequencies**

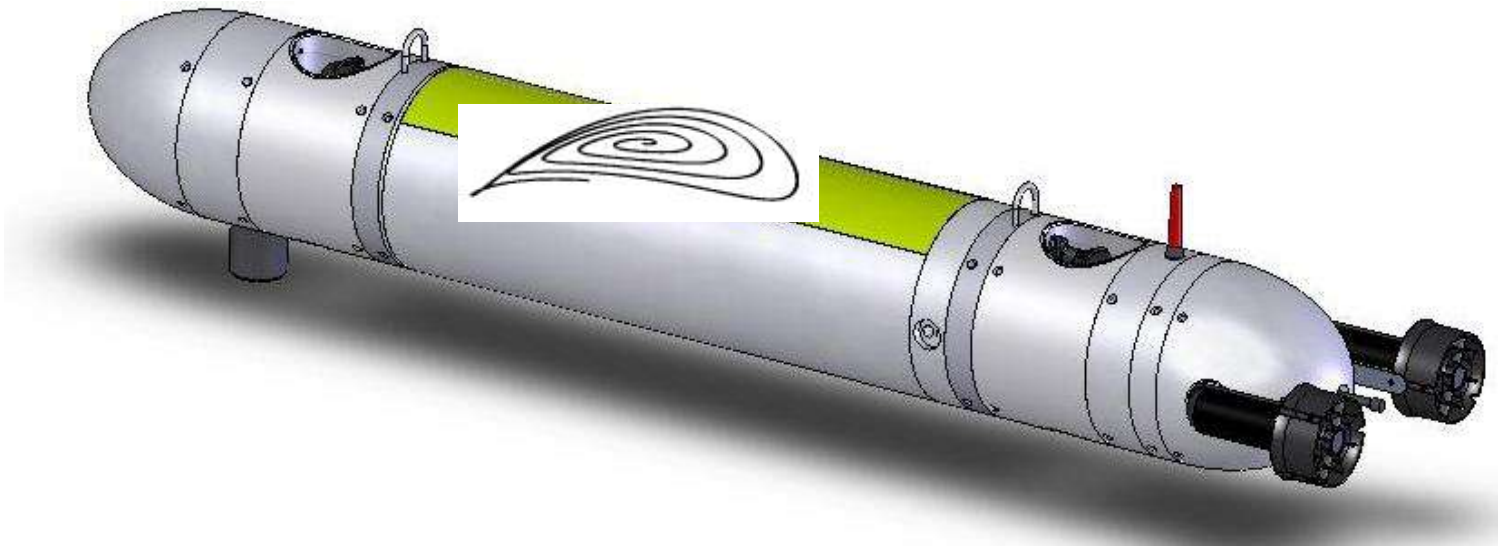
# Wireless power transfer (WPT) in the underwater environment

**Wet mateable connectors are problematic:**

- *Needs to be plugged-in*
- *Pins are exposed to seawater,*
- *Suffers from fouling and corrosion*

**A wireless connector has been proven to be a better choice.**

- Limits the size of inductors to approx. 16 cm of diameter
- AUV can dock in near contact (< 5 cm distance)



Thanks