



Generating knowledge 2
Example of sensors and
installation requirements:
cabled seafloor platform

Davide Embriaco

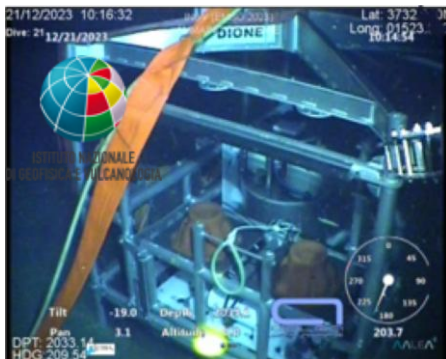
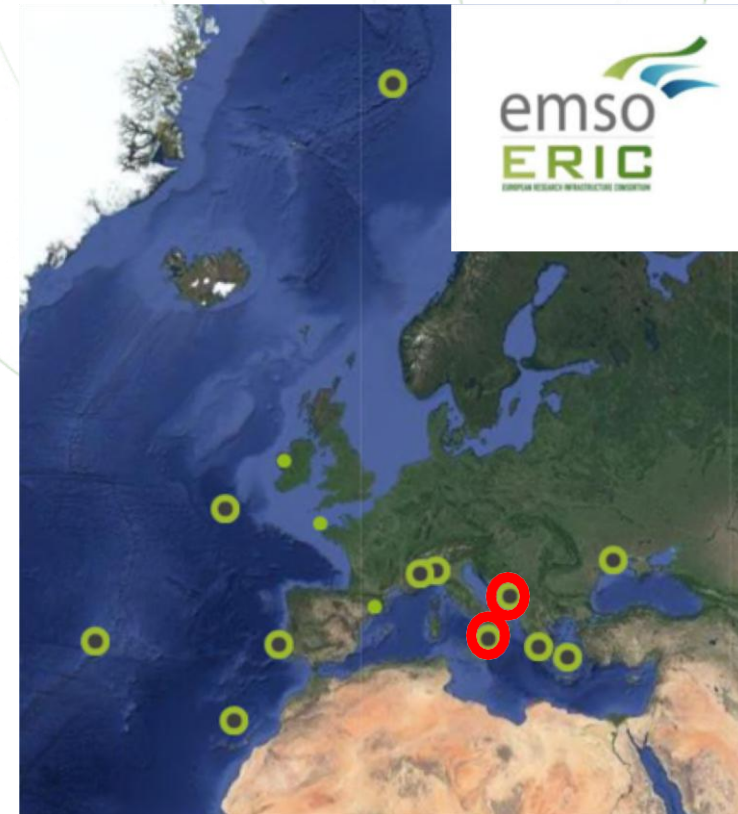
IR0000032 – ITINERIS, Italian Integrated Environmental Research Infrastructures System
(D.D. n. 130/2022 - CUP B53C22002150006) Funded by EU - Next Generation EU PNRR-
Mission 4 "Education and Research" - Component 2: "From research to business" - Investment
3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures"



Example of installation in Marine Infrastructures

EMSO ERIC

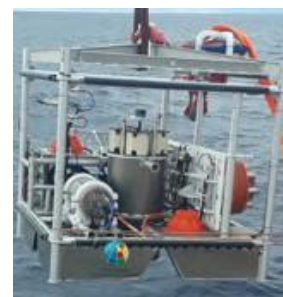
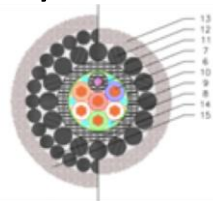
- Seafloor installation (Western Ionian Sea Facility, WIS)
 - Cabled
 - Monitor Seafloor in a area off shore Catania
- Mooring installation (South Adriatic Sea Facility)
 - Stand alone
 - Measures along the water column



Seafloor fixed cabled platform:

Main Components of a cables Subsea Research Infrastructure:

- Power and data transfer system at land station
- Electro-optical cable
- Seafloor terminations, junction boxes to provide power and data transfer capability to host measuring platforms
- Platform: Observatories and sensors



Seafloor fixed cabled platform: WIS

🌐 Electro-Optical Cable

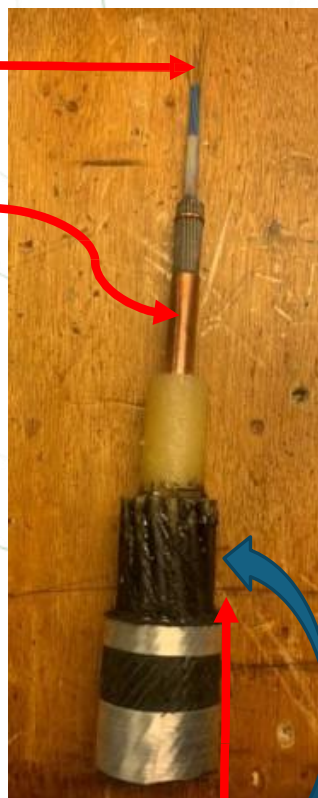
- Provides both electrical power and optical data transmission capabilities.

🌐 Characteristics:

- **Power Delivery:** Transmits high-voltage power to subsea equipment (up to 1000 V, can be VDC or VAC).
- **Data Transfer:** Uses optical fibers to send data at high speeds with minimal loss
- **Durability:** Designed to withstand harsh ocean conditions, including pressure, corrosion, and marine life interactions.
- **Length and Connectivity:** Can span large distances, connecting shore-based stations to deep-sea observatories (up to 100 km, longer distance with repeaters)

Internal core with FO

conductor



Protective armour

Power, Data Transfer System and junction boxes



Power System:

- **High Voltage:** Delivers consistent and reliable power to subsea instruments.
- **Distribution Units:** Distributes power to various observatories and sensors along the cable.
- **Backup Systems:** Ensures continuous operation during maintenance or failure of primary power sources.



Data Transfer:

- **Optical Fiber:** Provides high-bandwidth communication for real-time data transmission.
- **Data Nodes:** Collect and relay data from sensors to shore-based facilities.
- **Redundancy:** Multiple pathways for data to ensure reliability and prevent data loss.



Seafloor Observatories and Sensors

Observatories:

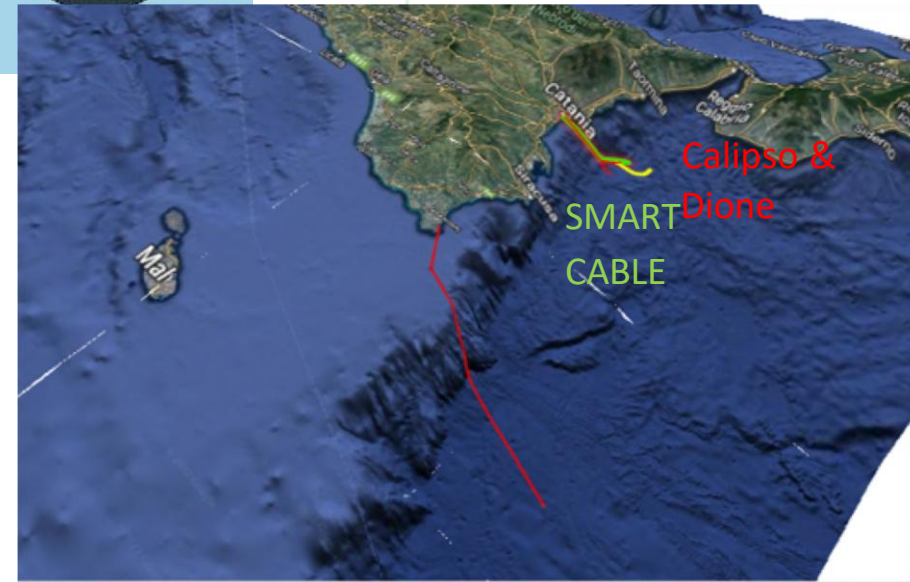
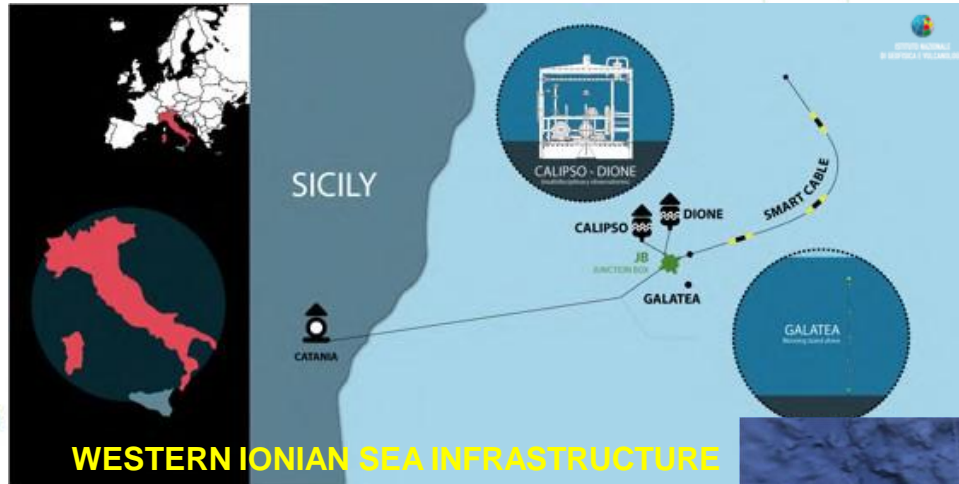
- **Deployment:** Installed at strategic locations on the seafloor to monitor various marine processes.
- **Equipment:** Equipped with instruments for long-term environmental monitoring.

Sensors:

- **Types of Sensors:**
 - **CTD (Conductivity, Temperature, Depth):** Measures water column parameters.
 - **Hydrophones:** Detect and record underwater sounds.
 - **Seismometers:** Monitor seismic activity.
 - **Magnetometers:** Measure magnetic field variations.
- **Data Collection:** Continuous real-time data collection for monitoring and research.
- **Applications:** Used in studying oceanography, marine biology, geology, and environmental science.



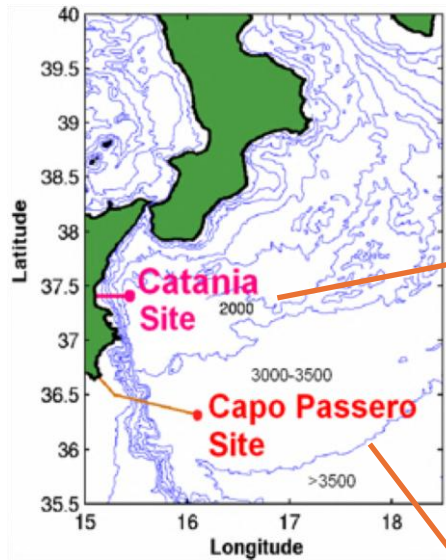
EMSO Western Ionian Sea



● Key facilities

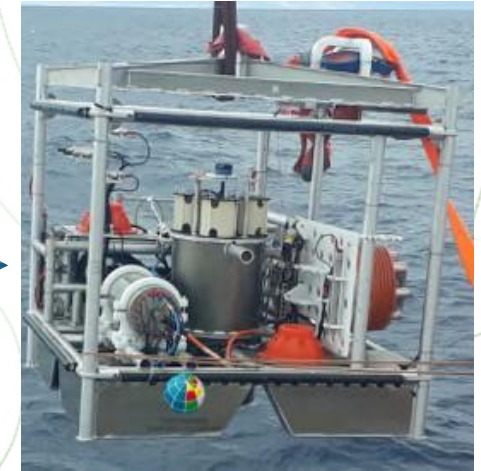
- Submarine 28 km long Electro Optical cable which enables Real Time (RT) data transfer from deep marine site (-2100m) to shore station
- Power System at land station (@ INFN) providing up to 750 W at sea
- New CTF with 2 ROV operable submarine connectors
- New JB with 4 available submarine ports to provide power/connection
- 2 seafloor new class observatories (Calipso, Dione)
- 21 km SMART cable with 3 repeaters every 6 km equipped each with seismometer, accelerometer, temperature and pressure sensors
- Mooring line (Galatea) stand alone (collaboration with CNR-ISMAR)

EMSO Western Ionian Sea infrastructure

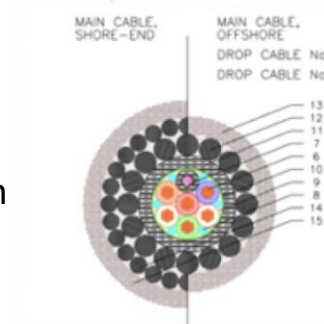


Land station at INFN-LNS
Laboratorio Porto (Catania)
Cable termination

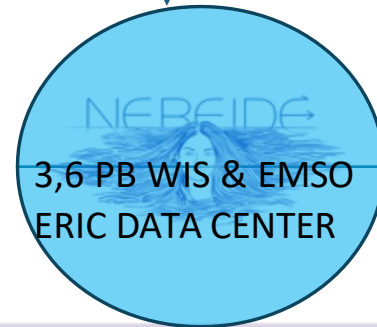
28 km
Submarine
EO cable



Deep sea installations



GARR
connection



Data &
services
available to
users

Pressure test chamber



**Porto
Palo
Shore Lab**

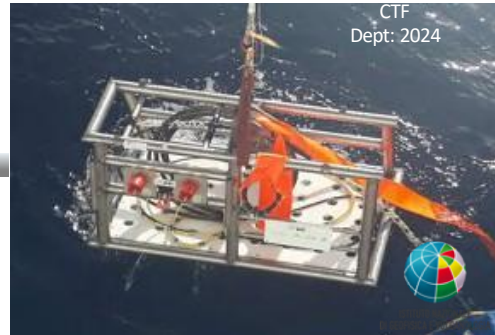
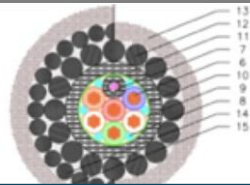


WIS Marine infrastructure



28 Km E-O Cable
(4x OF, 2x conductors)

On-Shore Lab



100 m E-O Jumper
(2x OF, 2x conductors)



- Cable head voltage (AC balanced): 1000 Vrms
- CTF output voltage range: 500-1000 Vrms
- Max Output power: 700 W @500 Vrms
- No short circuit protection
- Direct optical connection (30 Km) with 2 OF. On-shore GPS Master Clock: Provides hardware and ethernet synchronization protocols as PTP, NTP, PPS, IRIG, ecc.
- Connector: Teledyne Nautilus Rolling Seal Hybrid (2 Optical Fibers, 2 Conductors)

- Output voltage: 375 Vdc with 2 conductors
- Output power: 500 W
- Short circuit protection and inrush current limiter.
- Gigabit Ethernet communication with up to 2 OF
- Onshore<->Offshore optical connection through ethernet switch
- JB SFP Laser: Omnitron 7216-1 (20 Km)
- User SFP Laser: Omnitron 7217-1 (20 Km)
- Provided synchronization protocols: PTP and NTP. Off-shore devices can be synchronized with on-shore GPS Master Clock.
- Connector: Teledyne Nautilus Rolling Seal Hybrid (2 Optical Fibers, 2 Conductors)



ISTITUTO NAZIONALE
DI GEOFISICA E VULCANOLOGIA

WIS Land station



Land station at INFN-LNS
Laboratorio Porto (Catania)
Cable termination



Local control room



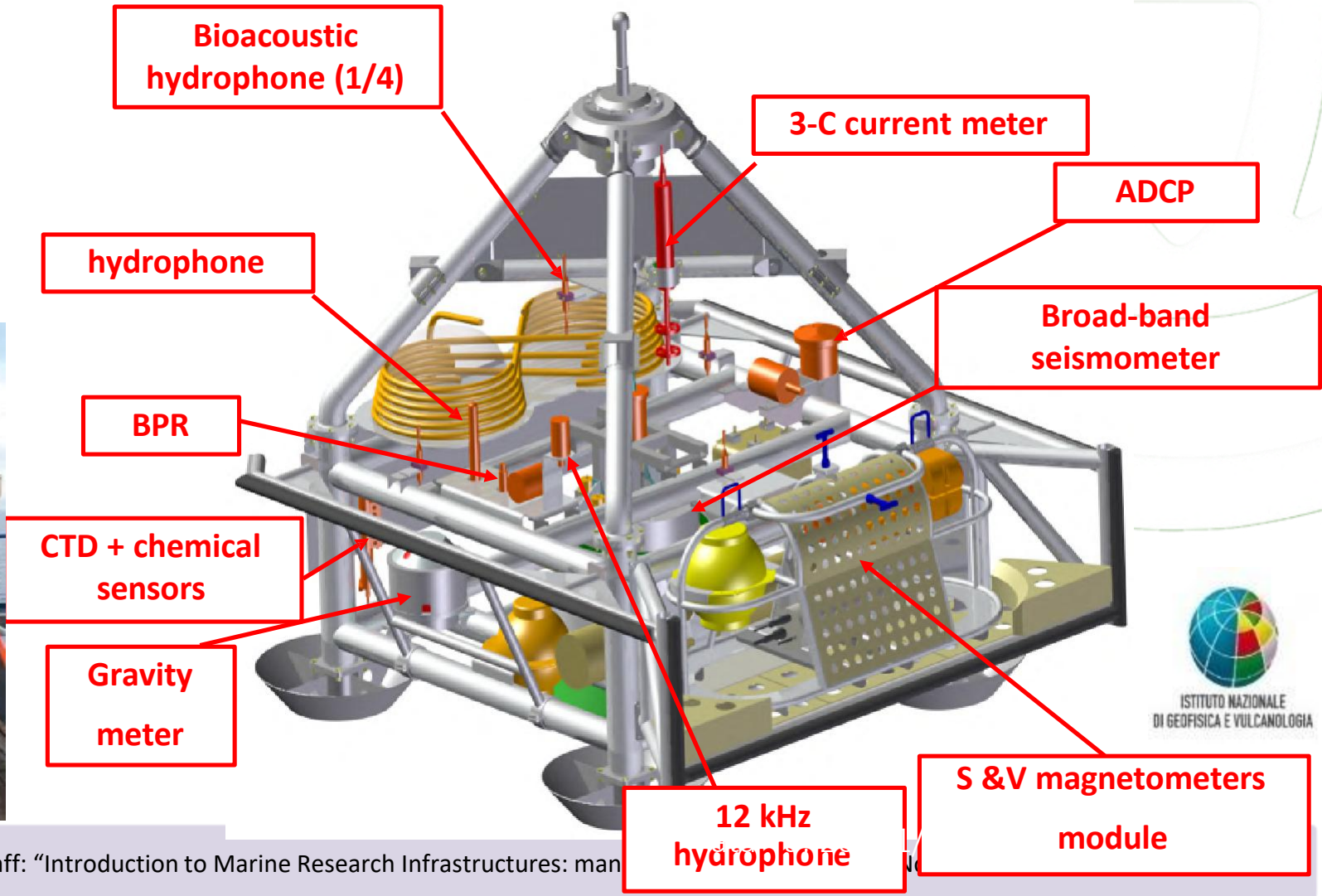
High voltage Power supply



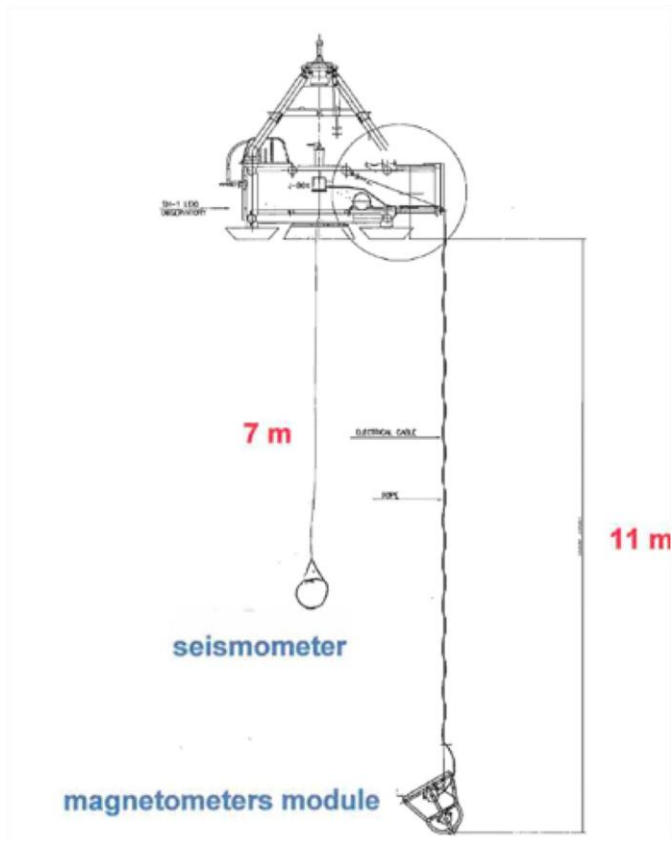
- Infrastructure control & management
- local acquisition and temporary storage system,
- time synchronization reference, fiber optic terminations
- data transfer to main data center
- Infrastructure management remotely operated

Deep sea observatory (SN1 operative 2005-2013)

Junction Boxes

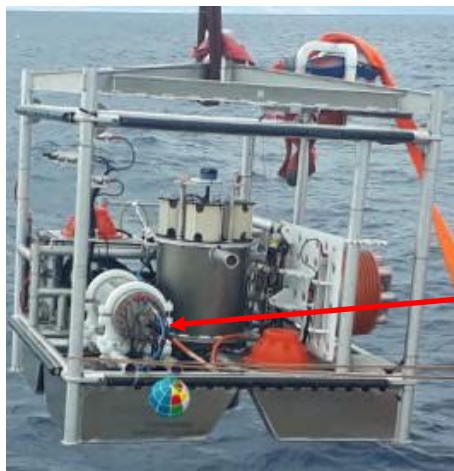


Seismometers: mechanical constrains

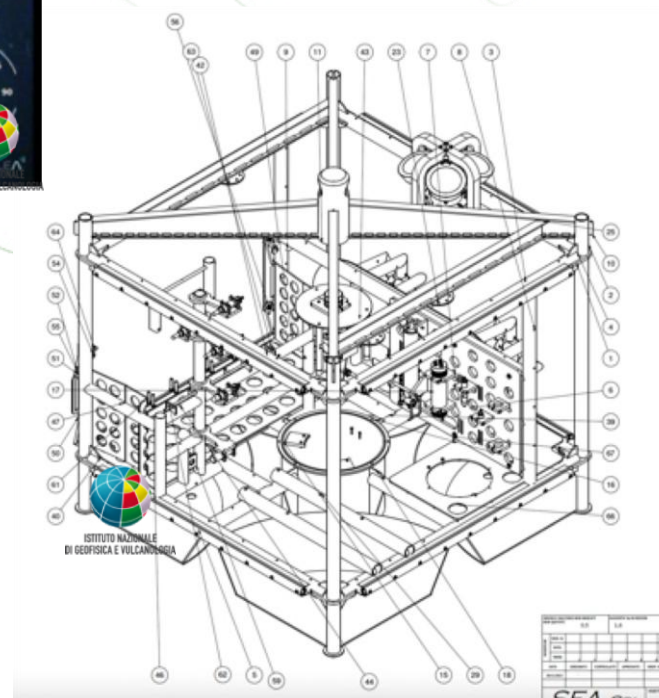


- Seismometer is fixed to the platform during deployment , after touch down it should be released in order to strongly couple with soil.
- A metallic bell protect the seismometer against sea current which cause noise on data
- During recovery particular care should be taken to recover the seismometer vessel attached to the platform by a rope and the magnetic module

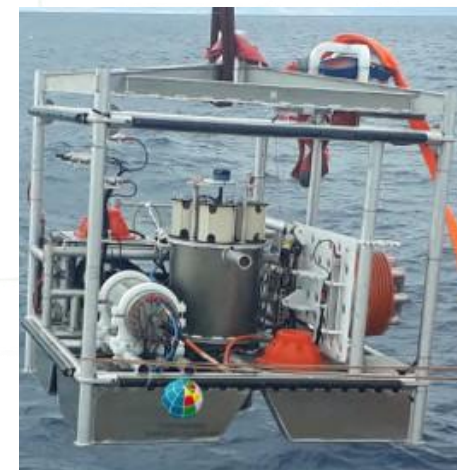
Western Ionian Sea (upgrade in 2023)



Power management
& control
Data transfer to/from
land

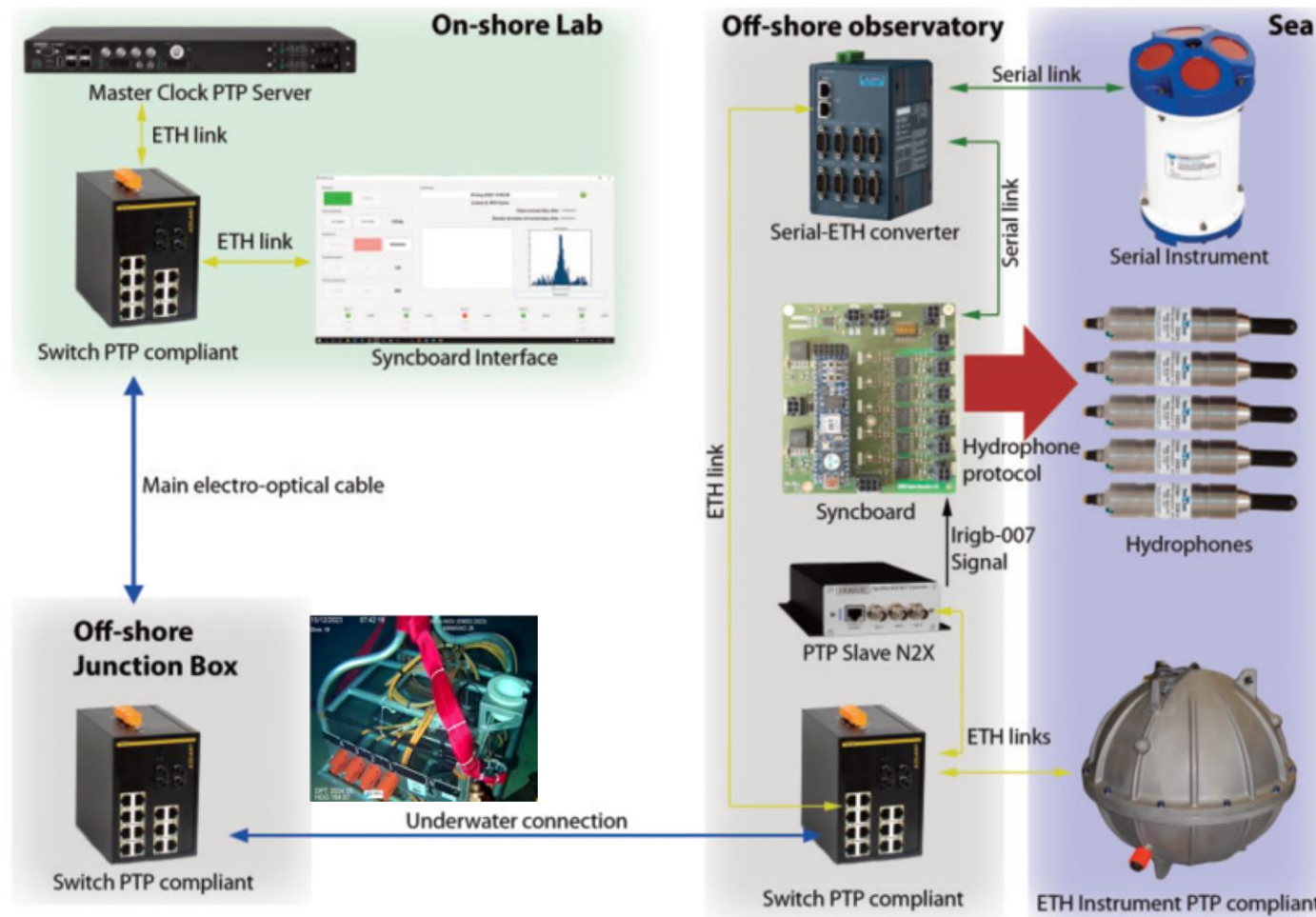


Calipso seafloor observatory @ WIS (2023)



Sensor	MODEL	Sampling rate
Seismometer	GURALP ORCUS	100Hz/200Hz
Low frequency hydrophone	idrofono HTP HTI-04-PCA7ULF	100/200Hz
gravimeter	Gravimetro AGI	1 Hz
Scala magnetometer	Magnetometro scalare Sentinel Marine Magnetics	1Hz
Vectorial magnetometer	Magnetometro vettoriale LEMI-039D	1Hz
CTD + Oxy + Turb	SBE CTD 16plus V2 with oxygen SBE63, turbidimeter WetLabs	1 sample every 10 minutes
Oxy	AANDERAA Optode 4831F	1Hz
ADCP	ADCP 75kHz	1 sample / 20 minutes
Current meter	AANDERAA Zpulse DCS 4930	1 sample / 20 minutes
4 hydrophones HF	OCEAN SONICS icListen SC35-ETH HF	10Hz-200kHz
Pressure sensor	RBR	

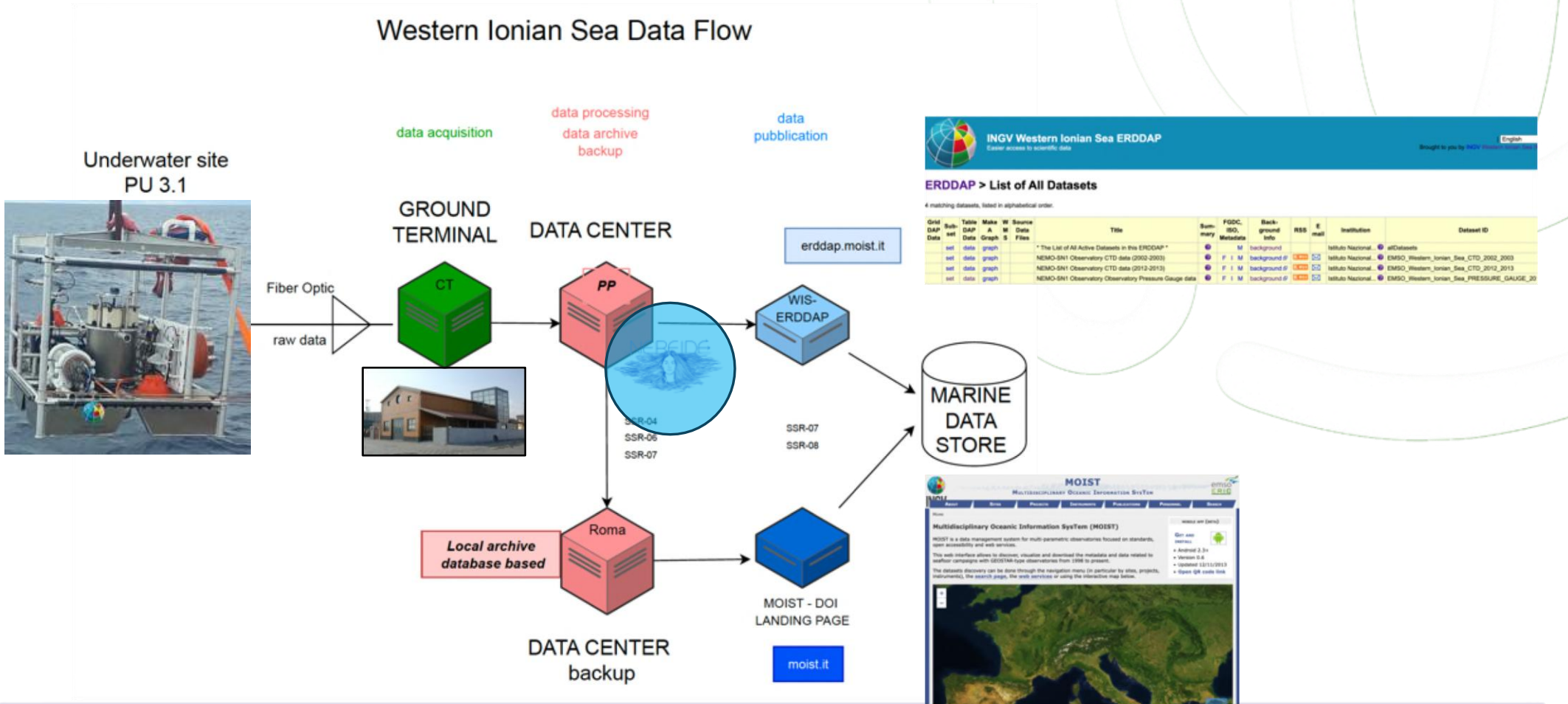
Time synchronization at Western Ionian Sea Facility



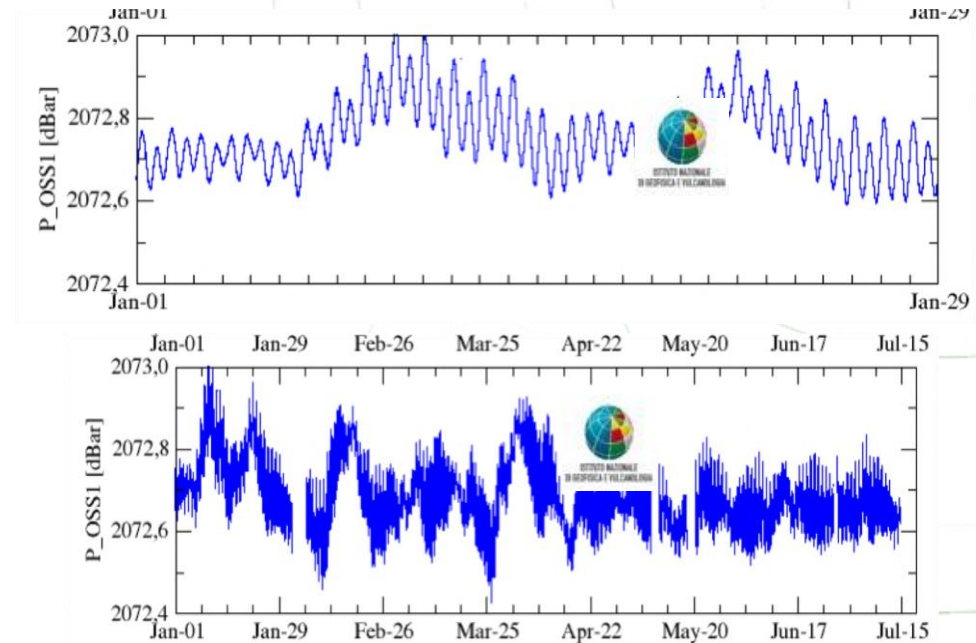
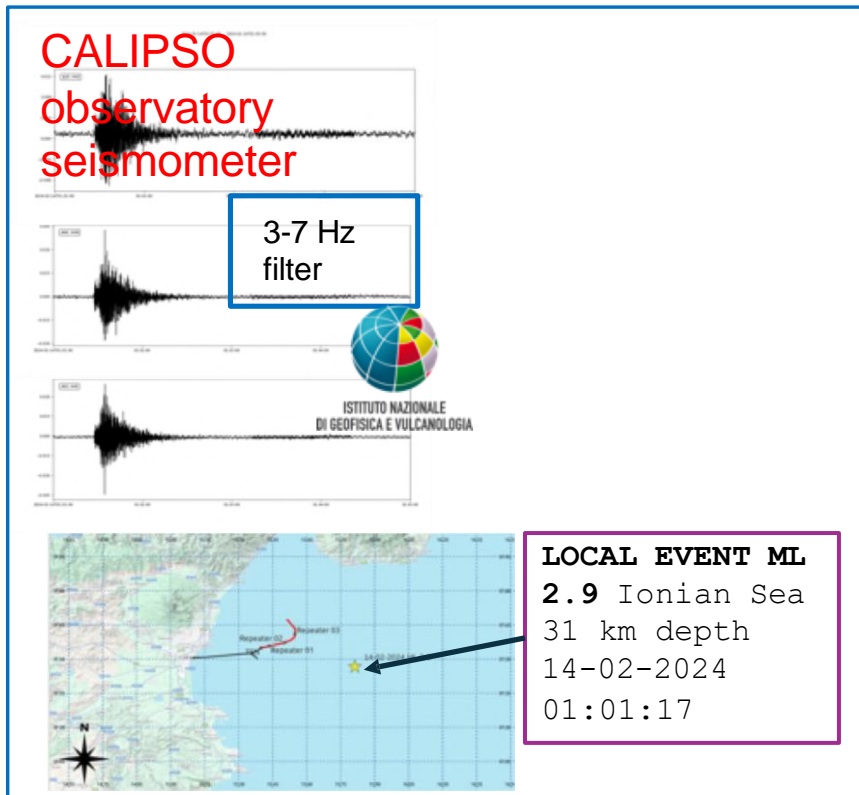
Giacomozzi E., Simeone F., Marinaro G., (2023). Sistema di sincronizzazione dei dati multiparametrici acquisiti dagli osservatori sottomarini cablati nella facility di EMSO Western Ionian Sea. Rapp. Tec. INGV, 471: 1-20, <https://doi.org/10.13127/rpt/471>

Western Ionian Sea data flow

Western Ionian Sea Data Flow

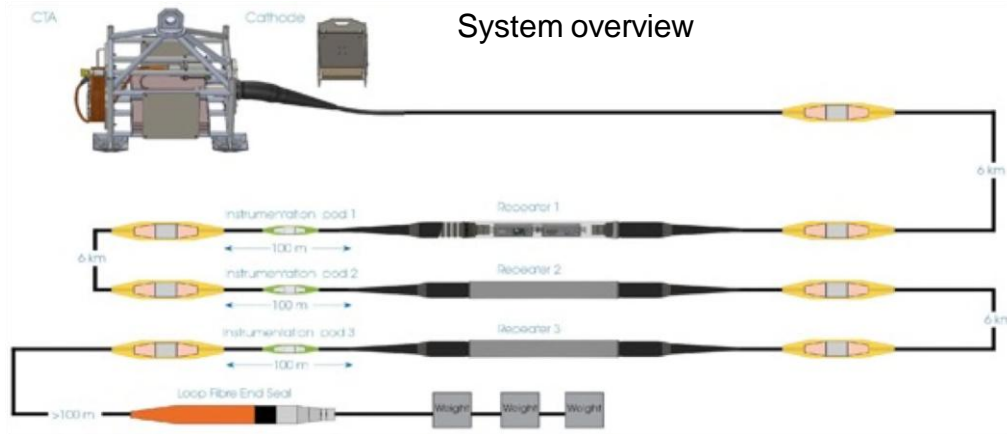


Western Ionian Sea : seismometer & pressure data



Western Ionian Sea: SMART CABLE

InSEA wet demo SMART cable



Power:

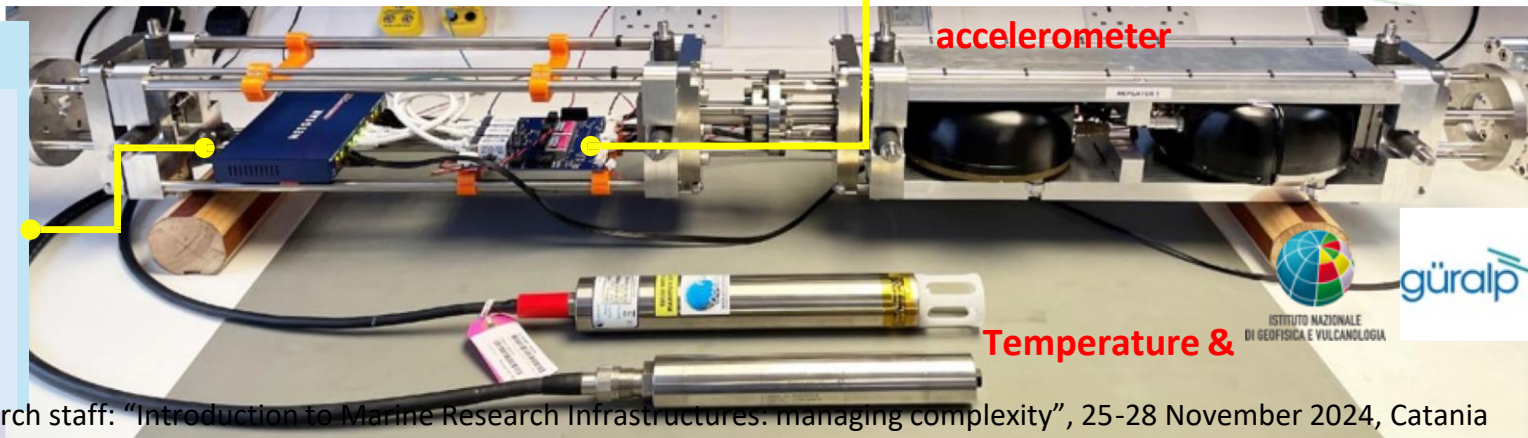
Power and control board

The SMART cable is a single conductor sea return cable. The power is provided to the repeaters by means of constant current power supply. Each instruments, both internal and external, could be individually power on/off.

Communication and timing:

Switch implementing hardware PTP

The communication is handled by a switch hosting the lasers and implementing the Precision Timing Protocol. The PTP provide the timing signal to the instruments with a precision $<1\mu s$. The SMART cable use two fiber in a ring topology to provide redundant communication in case of



Seismometer & accelerometer

Temperature & accelerometer

Western Ionian Sea: SMART CABLE

Instrument Pod

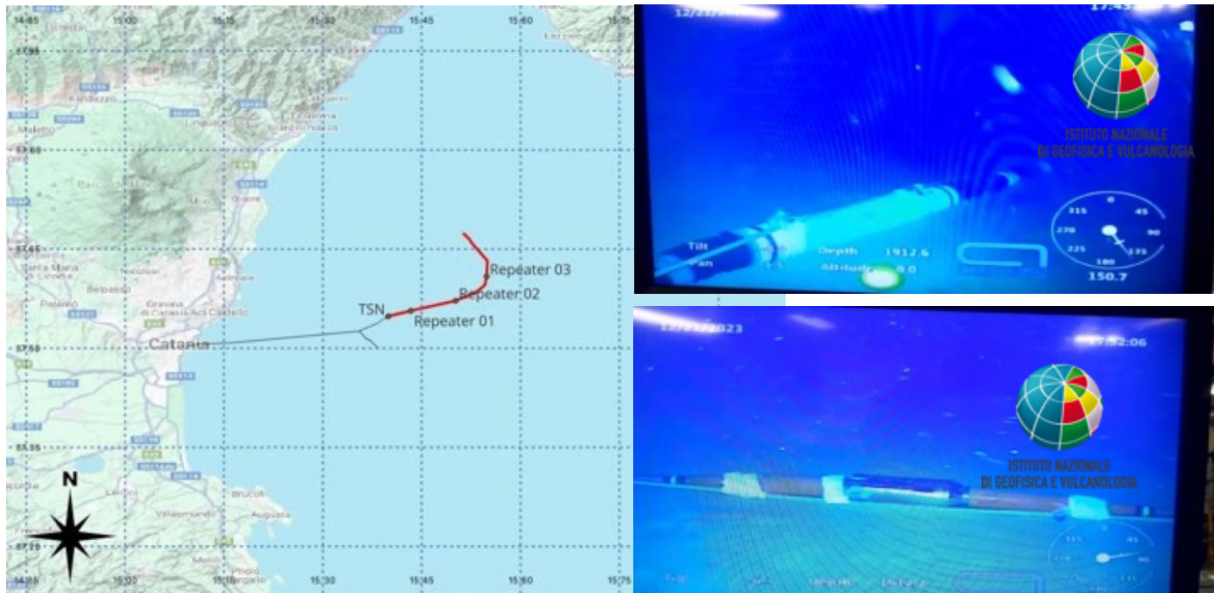


The **Seabird SBE 39Plus** and the **Paroscientific 8000 Series** are housed inside a titanium container called Instrument pod. Each instrument is isolated from pod by means of spacers. **Windows** put the instruments in contact with the external environment. The instrument pod can be deployed using **standard cable laying procedures**. The distance from the repeater is 30m.



Smart cable WIS

🌐 21 km long with 3 repeater, each one hosts: seismometer, accelerometer, pressure and temperature sensors



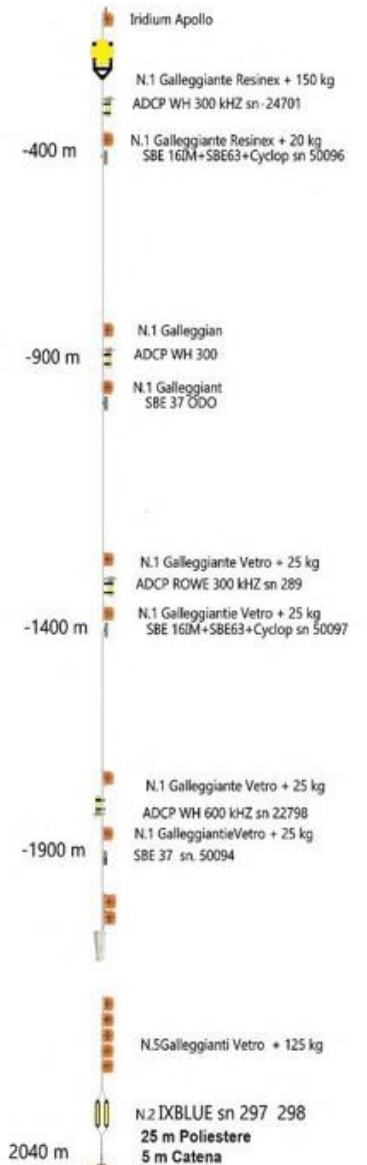
Repeater after the deploy

GALATEA MOORING A JOINT INGV – ISMAR SYSTEM



Since July 2021 Galatea has been monitoring water column dynamics of the Western Ionian Sea area

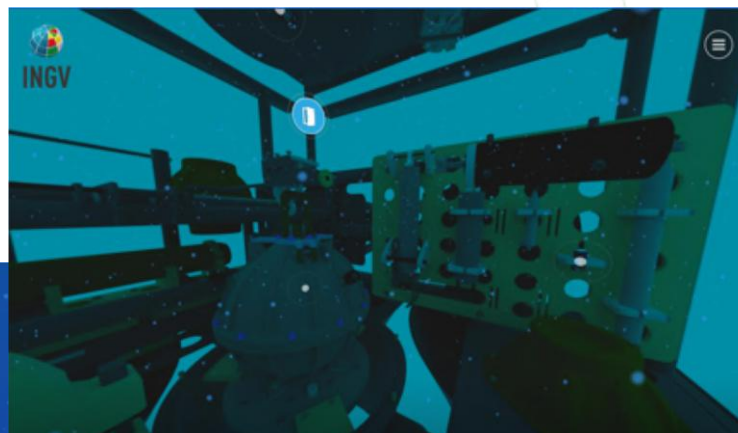
- Stand alone: no external power, no RT communications (yet)
- maintenance cruises every 6 month



Western Ionian Sea facility Virtual tour

<https://westernioniansea.ingv.it/virtualtour/oculus/index.htm>

ITINERIS





THANKS!

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