Technological challenges for a significant improvement in coverage and resolution in Global Ocean Observing Systems

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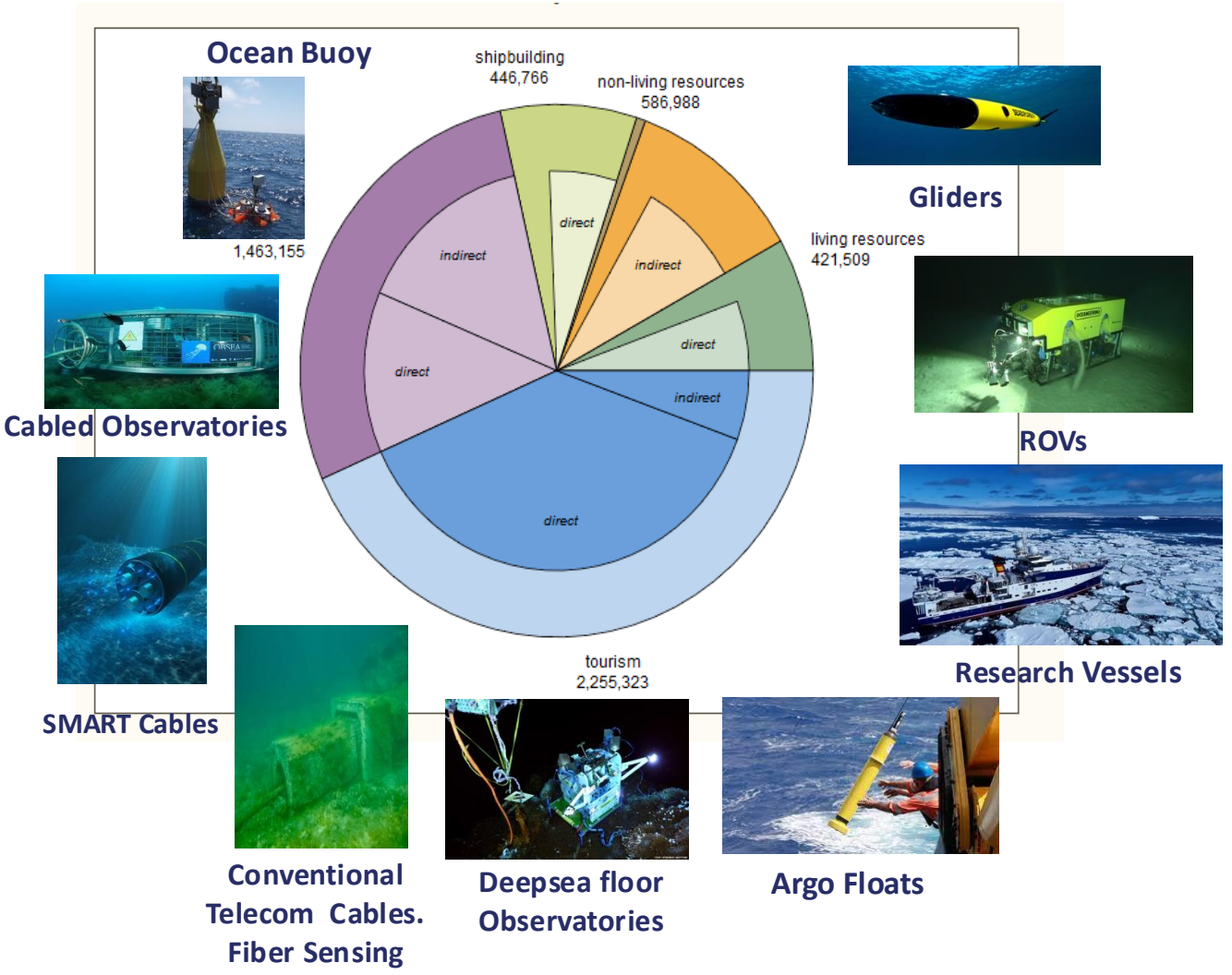
EMSO workshop
11th-13th March 2025
Roma, Italia

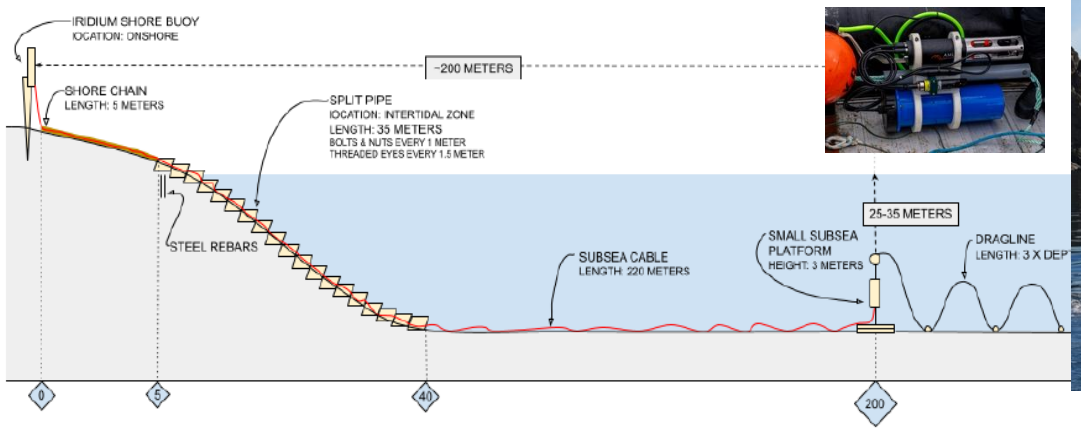
Key structures in Ocean Observation Systems. Benefits and opportunities for the Blue Economy

Science-based governance of oceans benefits blue economy

- employs **3.6 million people** (+17% compared to 2020)
- has a turnover of nearly **€624 billion** (+ 21% compared to 2020)
- accounts for **€171 billion** in Gross Value Added (+35% compared to 2020)
- New jobs **increasing cross-border cooperation between EU countries** to develop
- renewable energy, allocate shipping lanes, lay pipelines and submarine cables etc,
- The ocean is the new Blue economic frontier reducing conflicts and
- creating synergies between different activities
- **Grand challenges**
- Climate change
- Biodiversity & Ecosystems (**Anthropogenic action- loss of diversity, limited resources)**
- Pollution **(toxic algal, pesticides, plastic)**
- Geohazards **(Earthquakes, Tsunamis, Submarine slides)**
- **We need knowledge, information and effective Management**



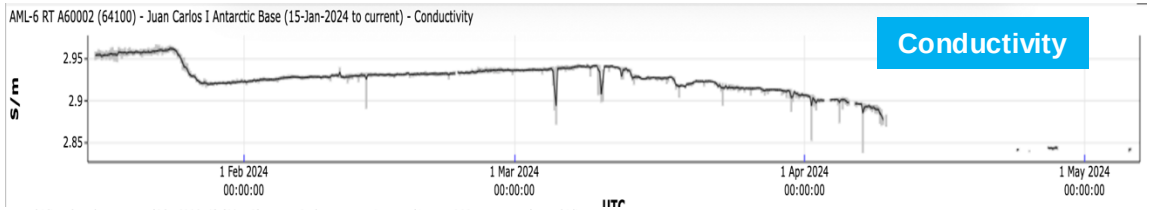
ONC-CSIC Seafloor Observatory at Antarctic Spanish Station JCI

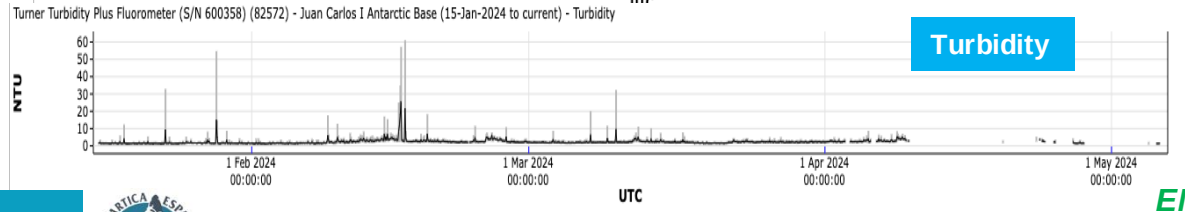


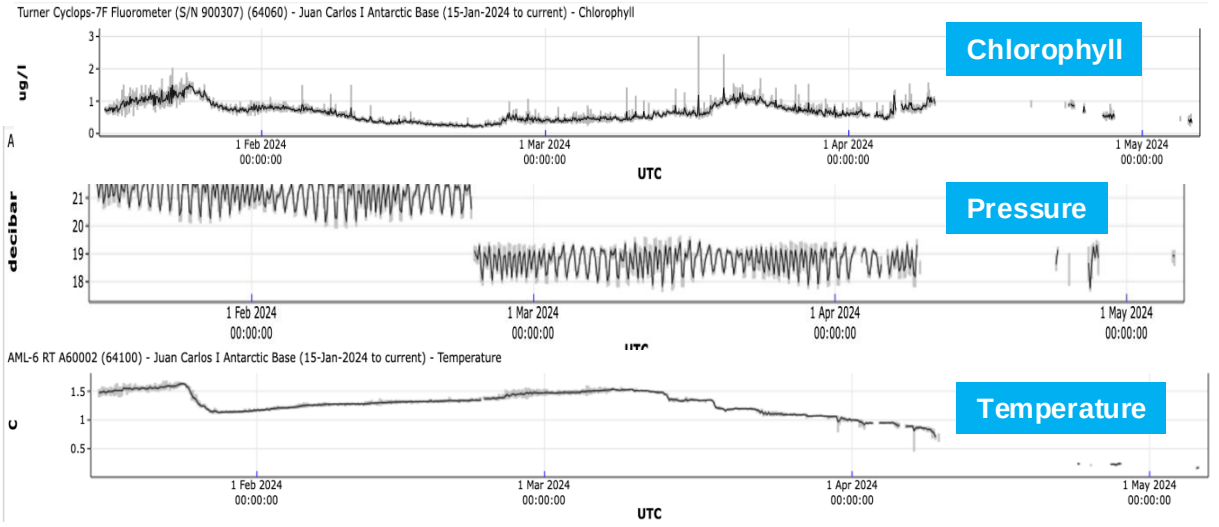
The continuation of the CSIC's partnership with Ocean Networks Canada with the installation of a new observatory, that improves the reliability of the one installed in the previous campaign, will further boost the scientific interest and capacity of the research community that carries out its studies in the area of the BAE Juan Carlos I,

Real Time DATA from Antarctic Station JCI

Antarctic Observatory at Spanish Station JCI : Starts March 4th 2025, at 21:01 h UTC time providing EOVs







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Funded by the European Union

SMART Cables in WMO and IOC: GOOS

GOOS *in situ* networks [1]	Implementation	Data & metadata			Best practices [6]	GOOS delivery areas [7]		
	Status [2]	Real time [3]	Archived high quality [4]	Metadata [5]		Operational services	Climate	Ocean Health
Ship based meteorological - SOT	★★☆	★★☆	★★☆	★★½	★★☆	✓	✓	
Ship based oceanographic – SOT	★★½	★★½	★★★	★★☆	★★★	✓	✓	
Repeated transects - GO-SHIP	★★★	Not applicable	★★★	★½☆	★★★		✓	✓
Sea level gauges - GLOSS	★★½	★★☆	★★★	½☆☆	★★☆	✓	✓	
Time series sites - OceanSITES	★★☆	Not applicable	★★½	★☆☆	★★☆		✓	✓
Coastal Moored buoys – DBCP	★★★	★★★	★★★	★☆☆	★★½	✓	✓	✓
Tsunami buoys - DBCP	★★½	★★★	★★★	★★☆	★★★	✓		
Tropical moored buoys - DBCP	★★½	★★★	★★★	★★★	★★☆	✓	✓	✓
HF radars	★½☆	★½☆	½☆☆	½☆☆	★★★	✓	✓	
Drifting buoys - DBCP	★★★	★★½	★★½	★★½	★★★	✓	✓	
Profiling floats - Argo	★★★	★★★	★★★	★★★	★★½	✓	✓	
Deep & biogeochemistry floats - Argo	★½☆	★★½	★★½	★★★	★★☆	✓	✓	✓
OceanGliders	★½☆	★★☆	★☆☆	★★☆	★★☆	✓	✓	✓
Animal borne sensors - AniBOS	½☆☆	★☆☆	★★☆	½☆☆	★★☆	✓	✓	✓

GOOS Report Card 2023

Existing GOOS Networks

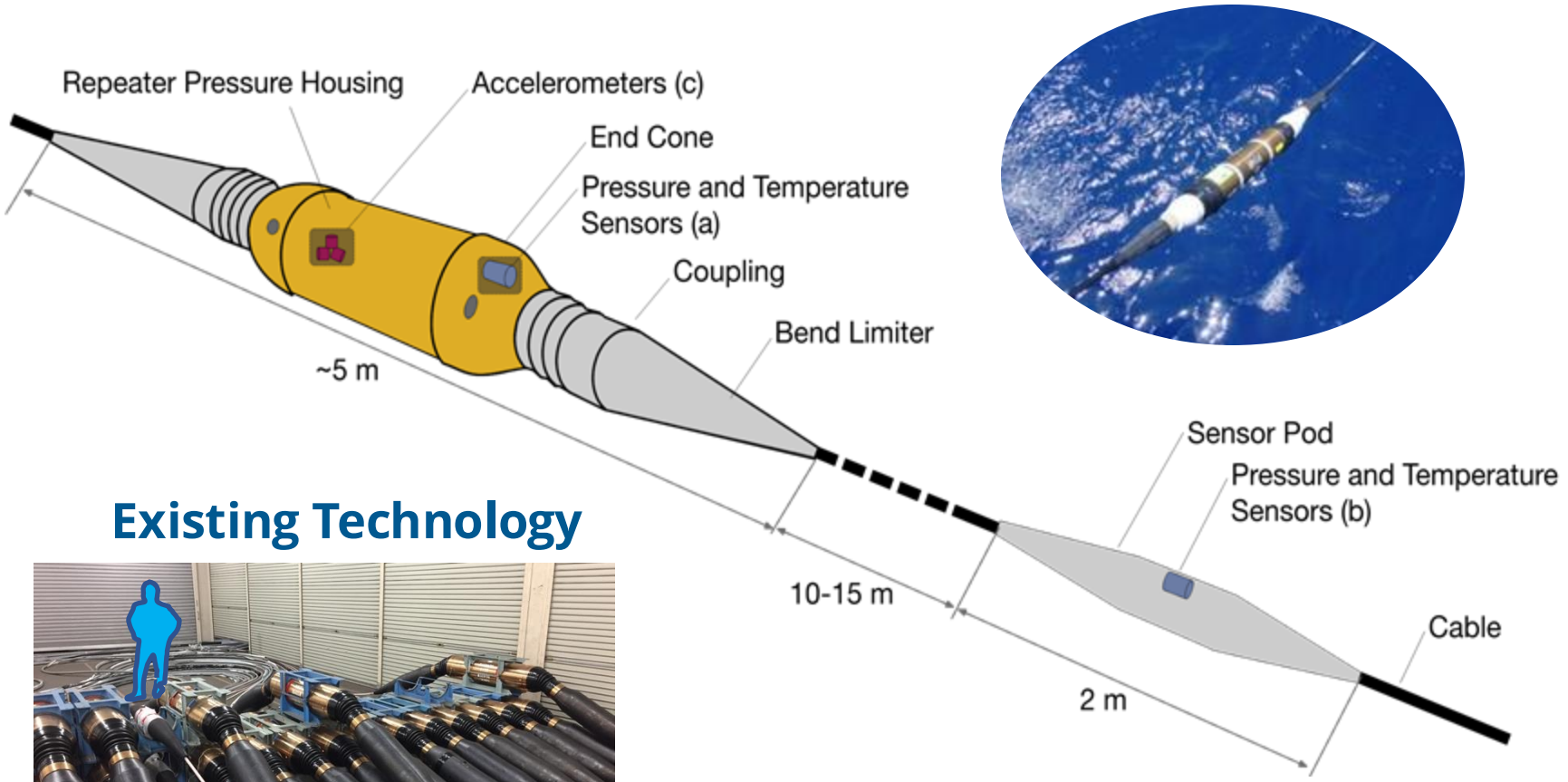
SMART Cables

SMART Cables is a GOOS Emerging Network

SMART Cables

Shared Cable Infrastructure: Telecom + Science

Climate change, ocean, DRR (Earthquakes + Tsunamis)



Existing Technology

No Interference

Sensors:

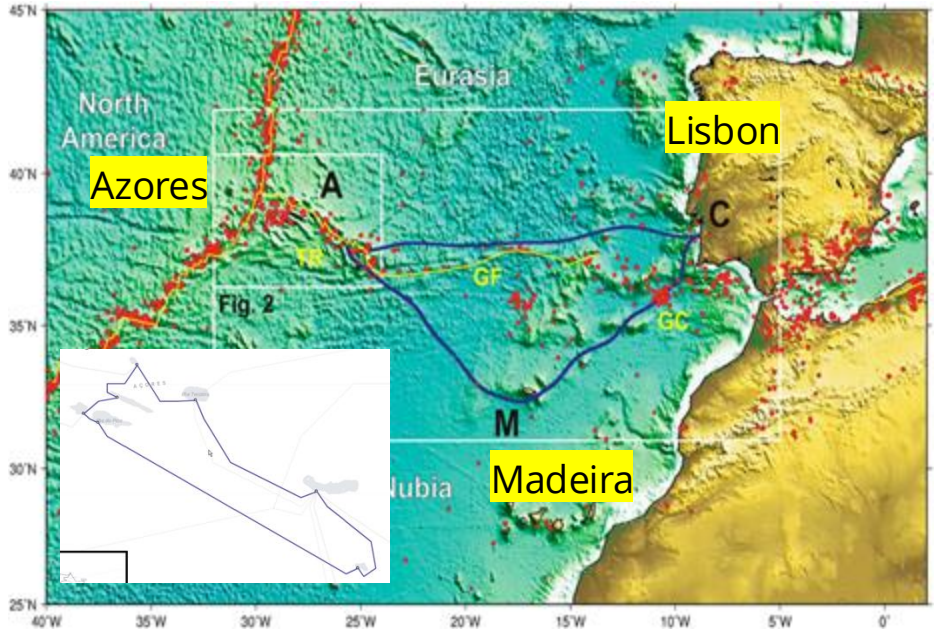
- Temperature
- Pressure
- Seismic

Key points:

- Spacing ~100 km
- Essential Ocean Variables, Global Ocean Observing System

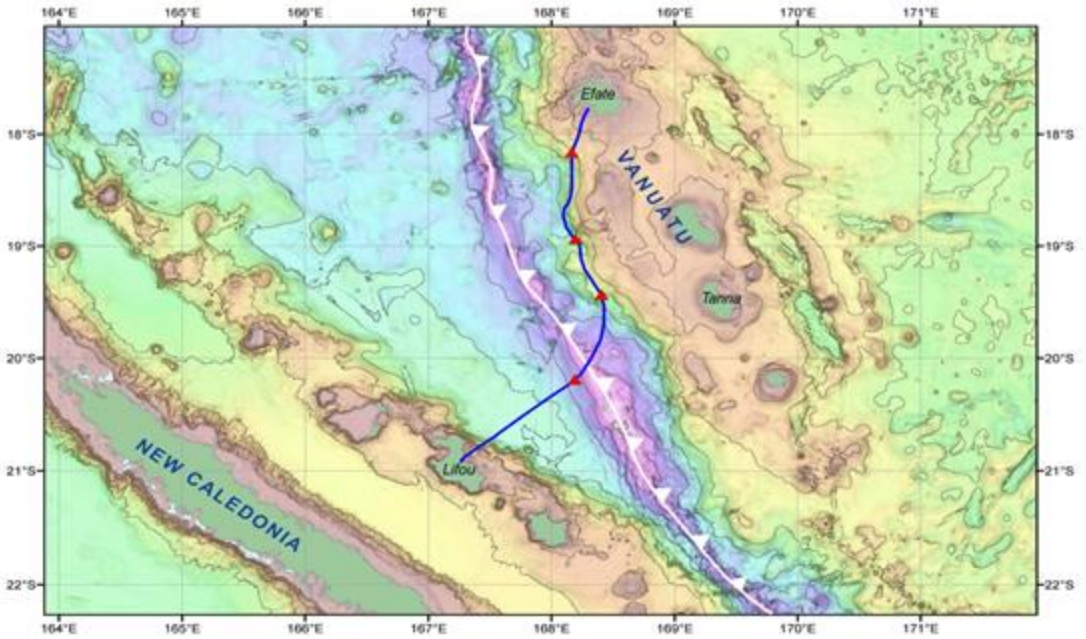
Funded SMART Cable Systems

Portugal SMART Atlantic CAM



- 3700 km, ~20 SMART modules
- Gov't €154M. EU support €56M
- SMART 15% ➔ €22M ~ €2/citizen/25 y

TAMTAM SMART Cable System



- 450 km long, 4 SMART CC nodes, 2 DAS
- Data Center, Scientific Research
- France funding SMART (telecom: AFD, ADB)

- 25+ year life, reliable, low lifetime cost
- Leverage $5B/y industry, 170 y

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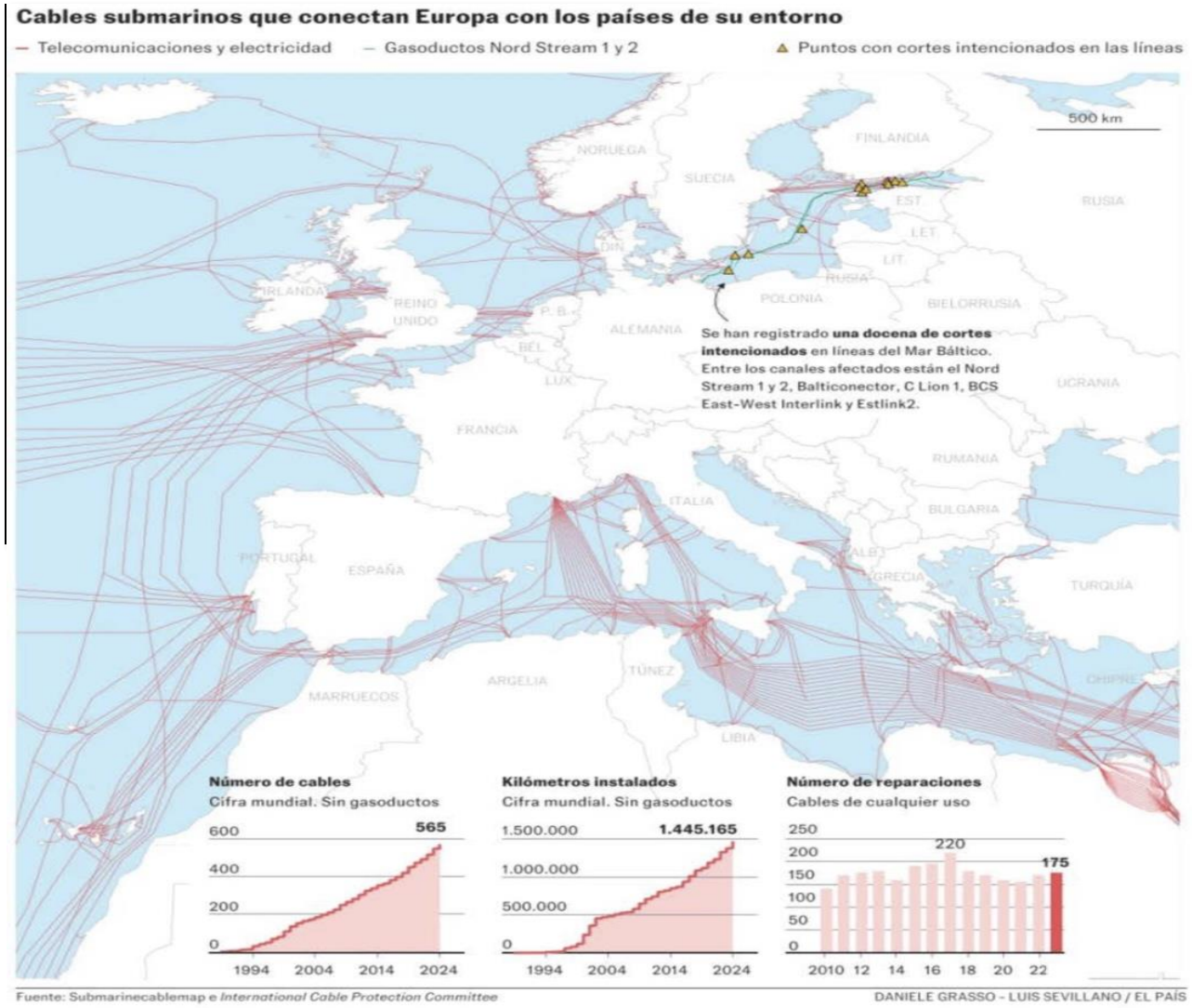
Future Systems

Polar Connect Far North Fiber and neighboring Atlantic Projects (Tussas, PISCES, IRIS, IOMEA, etc.



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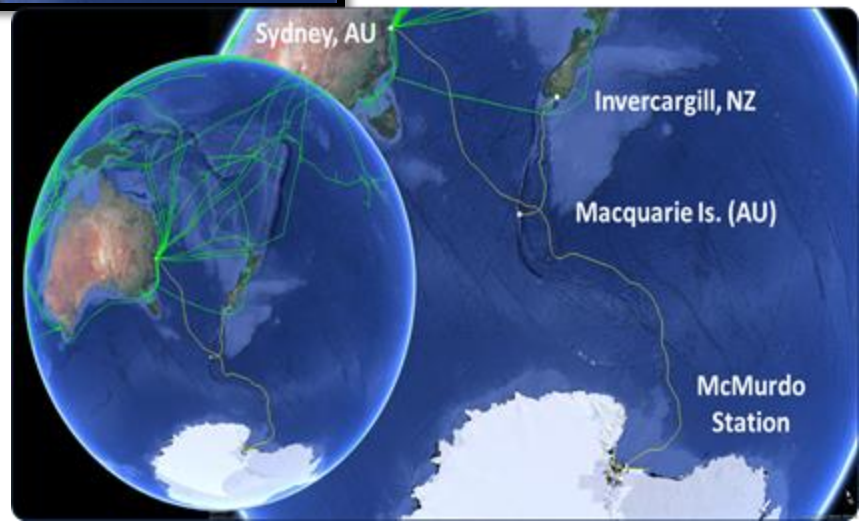
Antarctica Chile



AUS/NZ Antarctica (NSF MacMurdo)

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Complementary Sensing – SMART + DAS

Application	Measurement	SMART Sensors	Fiber Sensing
Oceanography / Climate Change	Temperature, heat content	Thermistor – one part of density, point, well characterized	DTS, Short Range; many telecom cables buried near shore
	Pressure, sea level, circulation/currents	Pressure gauge / A-0-A pressure gauge (low drift)	DAS, Higher Frequency, unknown if useful for low frequency ocean, presently coastal
	Salinity	TBD (Oceanographic standard – BUT drifts – future, perhaps occasional cal with ship/AUV, with temp, get density – dynamically important)	Not yet
	Ocean current	TBD (future ADCP acoustic doppler current profiler – complements pressure)	DAS, Using dispersion of surface gravity waves, shallow water only (near coast)
Tsunamis	Pressure	Pressure Gauge – well characterized	DAS (coastal), SOP (integrated between repeaters)
Earthquake early warning	Ground motion	Accelerometer, 3-axis, well characterized	DAS (can saturate), SOP and USLI (integrated between repeaters)
Seismology	Ground vibrations Pressure waves	Accelerometer, 3-axis – all well characterized Seismometer, 3-axis Pressure gauge	DAS, SOP and USLI/phase (integrated between repeaters)
Geodesy and slope stability	Seafloor elevation	A-0-A pressure gauge (low drift)	-
	Tilt	Accelerometer w/ DC response	-
	Strain	-	DSS (short range)
Marine mammals	Sound waves	Seismometer (Hydrophone)	DAS (lower sensitivity – low range)
Ships	Sound waves	Seismometer (Hydrophone)	DAS (lower sensitivity – low range)

Operational

Research

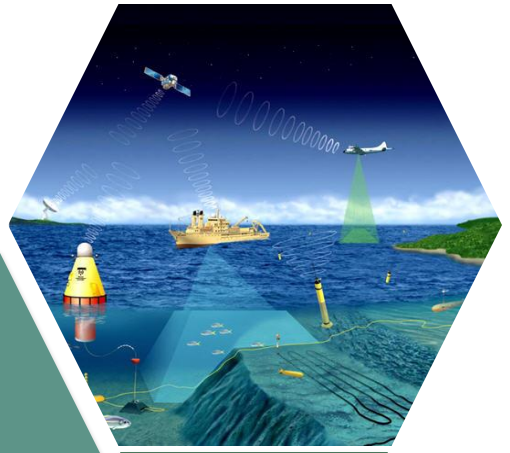
Complementary Sensing – SMART + OFS

Optical Fiber Sensing

- Measurements characteristics can differ in complementary ways
  - Measure different variables.
  - Spatial and temporal resolution, precision, self-noise.
- SMART sensors can calibrate fiber sensing observations
  - Conversion of DAS fiber strain rate measured to ground strain rate is dependent on the coupling, unique to each installation.
  - Interpretation of SOP in terms on quantitates of interest (ground deformation, pressure).
- Validating unexpected observations
  - A simple way to discriminate between an observational discovery and a measurement error is to measure the same phenomenon with a different technique.
- Research sensors can take 10 years to become operational

A way to go forward ?

Enhancing EU synergies and interoperability to improve real-time monitoring of Global Observations



Marine best practices and assessment of shared HQ data management

Strengthen collaboration with scientists, telecom companies, sensor providers and stakeholders with environmental monitoring capacity

Increase cooperation with Industry for multipurpose Observation infrastructures & cable protection issues

Develop new sensors designs (salinity, hydrophones, potential fields, biological?)

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Thank you

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