JTF SMART Cables Meeting
Science Monitoring And Reliable Telecommunications

SMART Cables Website

GUEST WIFI:

Network: UHSMART
Password:
JTFSmart24

Join the JTF!

GORDON AND BETTY MOORE FOUNDATION

ITU WMO unesco Intergovernmental Oceanographic Commission

SCHMIDT MARINE TECHNOLOGY PARTNERS

JTF SMART Cables Meeting
Science Monitoring And Reliable Telecommunications

Bruce Howe
Chair, JTF SMART Cables

Mike Constable
Vice-Chair, JTF SMART Cables

JTF SMART Cables Meeting
Prince Hotel
20 January 2024
Honolulu, Hawaii

ITU WMO unesco Intergovernmental Oceanographic Commission

Opening Remarks

- Welcome!
- Joint Task Force (JTF) now 13 years old – still maturing!
- Mission – facilitate environmental sensing for climate and disaster risk reduction using commercial telecom
  - Suppliers ✓
  - Customers and users ✓
  - Funding sources ✓
  - Systems in pipeline, with more solid prospects following ✓
  - Still challenges
- Goal here: inform, obtain input, entrain new people including gov't and RENs

ITU WMO unesco Intergovernmental Oceanographic Commission

Agenda

Opening remarks - Howe (5 min)

Overview – Constable (10 min)

Brief on SMART technology (72 min, 12 min ea)

- Wet Demo for SMART Cables – INGV and Guralp
- TamTam Cable System - Jerome Aucan, Pacific Community
- SMART Atlantic CAM System – Fernando Carrilho, IPMA, Portugal
- Brief updates, other systems: Far North Fiber, PolarConnect, Antarctica
- Climate Change Solution – Emmanuel Danjou, Alcatel Submarine Networks
- Prototype of SMART technology – Steve Lentz, Subsea Data Systems

- Discussion (33 min)

Cocktails and dinner 6:30-10pm

Zoom information

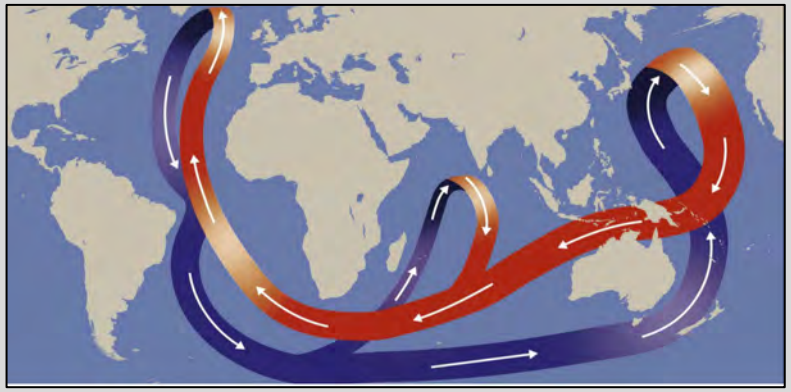
Session being recorded

SMART Cables: Status and a look into the future

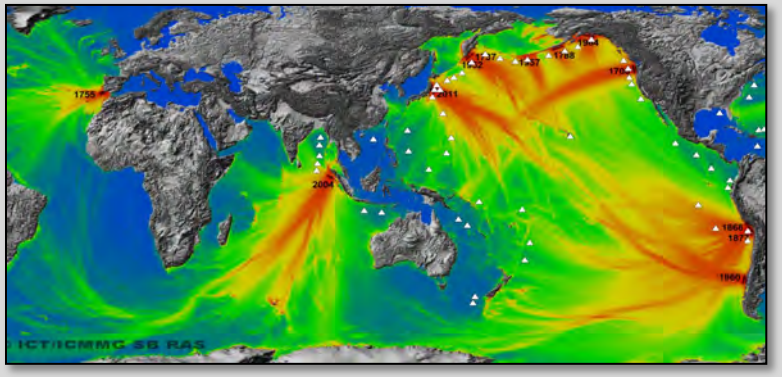
ITU
WMO
unesco
Intergovernmental
Oceanographic
Commission

What We Do: Climate and DRR

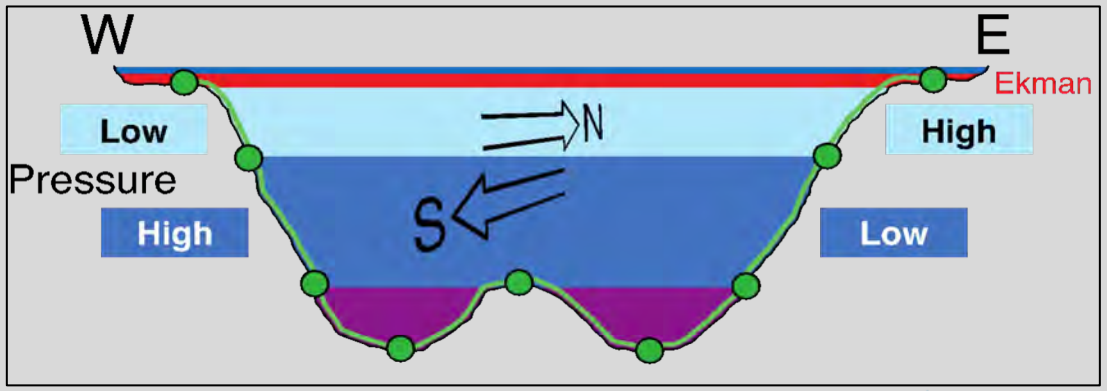
Ocean general circulation – all scales



Earthquakes & Tsunamis



Climate change



Sea Level Rise

Ocean heat and circulation

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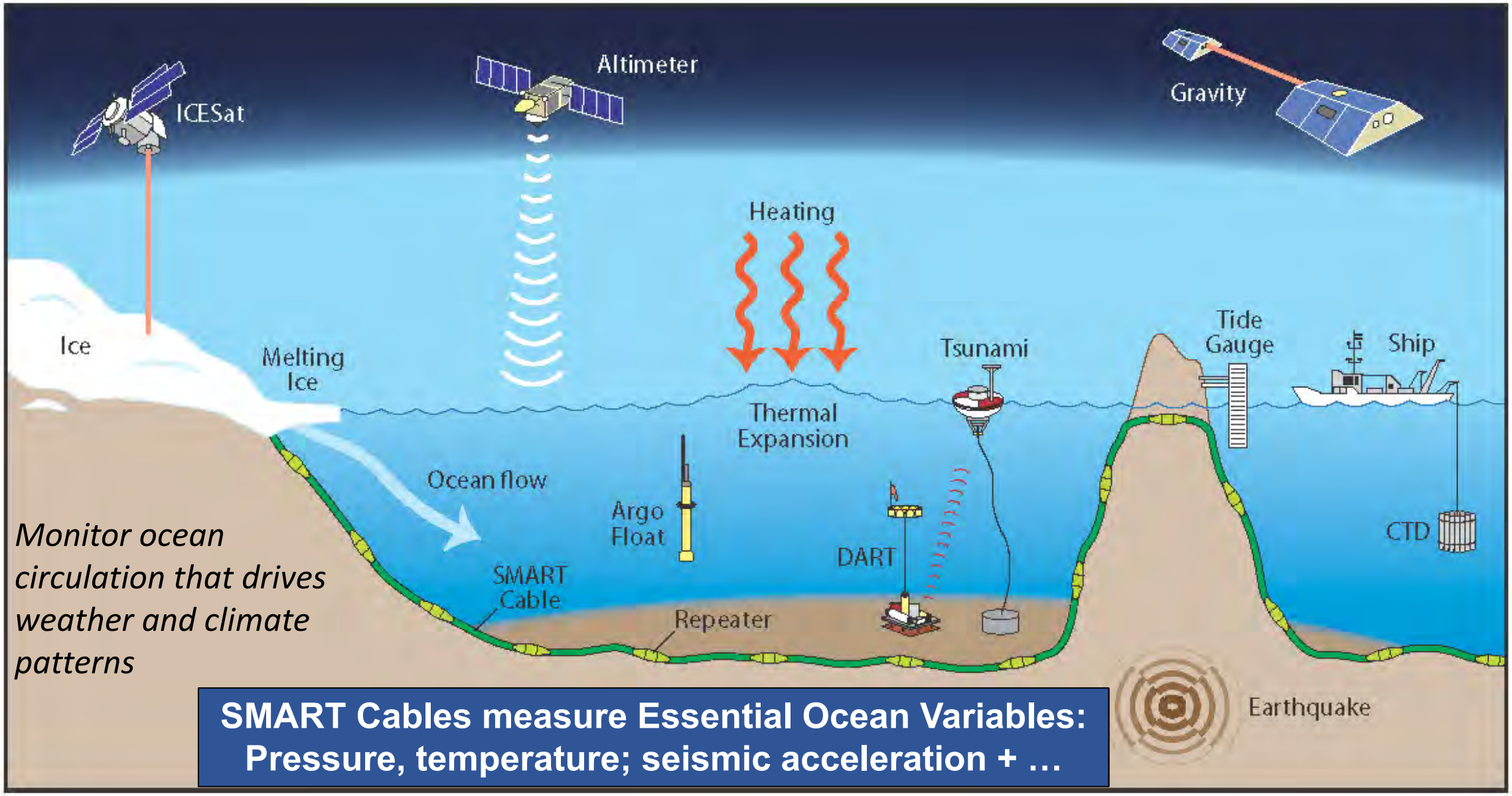
Ocean Sampling



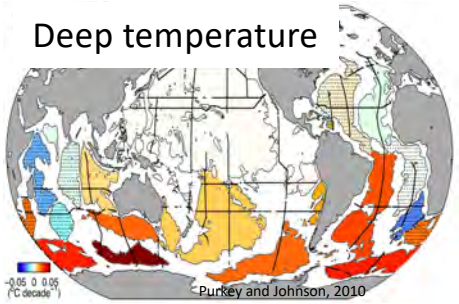
Monitor ocean circulation that drives weather and climate patterns

SMART Cables measure Essential Ocean Variables: Pressure, temperature; seismic acceleration + …

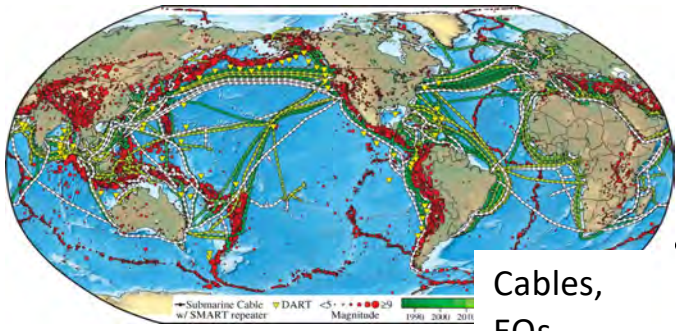
Science and Early Warning - Observables

Climate and Oceans

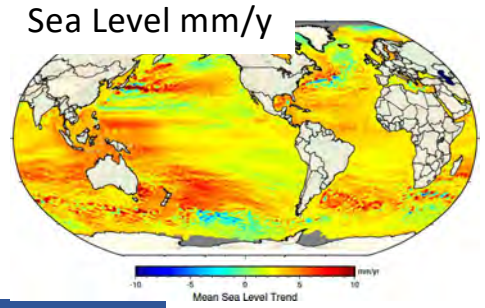
Temperature



- SMART ➜ **Subsurface temperature, EOV**
- Deep ocean warming ➜ sea level rise.
- Δ **deep ocean temperature** ➜ Δ circulation, Δ climate.

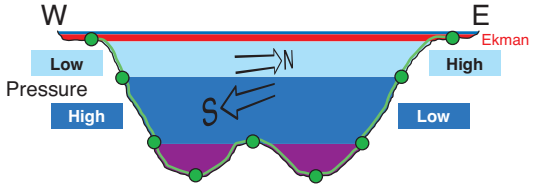


Cables, EQs, DARTs



Circulation, Sea Level Rise, Mass Distribution

- **SMART Ocean bottom pressure (OBP, eEOV)** ➜ melting ice ➜ sea level change (x,t).
- Δ_x between OBP ➜ depth-averaged currents and ocean circulation.



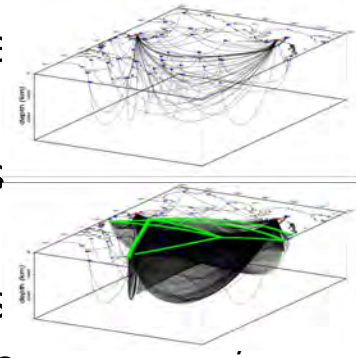
Hazards

Tsunami, Earthquake Warning

- SMART cables - vastly increase existing ocean **pressure/seismic sensors**
- Improve tsunami warning precision, Reduce unnecessary warnings/evacuations.

Seismology

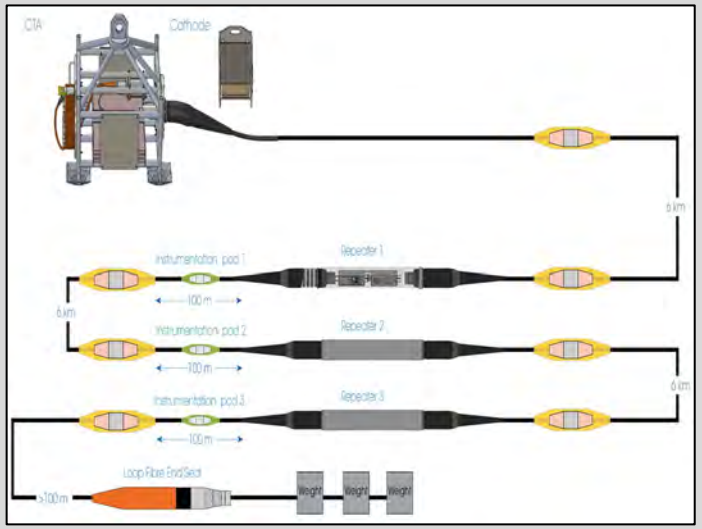
- SMART **Seismic accelerometers** ➜ advance seismology:
- Detect, locate small quakes below ocean floor
- Rupture type and dynamics larger offshore earthquakes
- Image Earth's interior



sampling w/o, w SMART

SMART Cables: Status

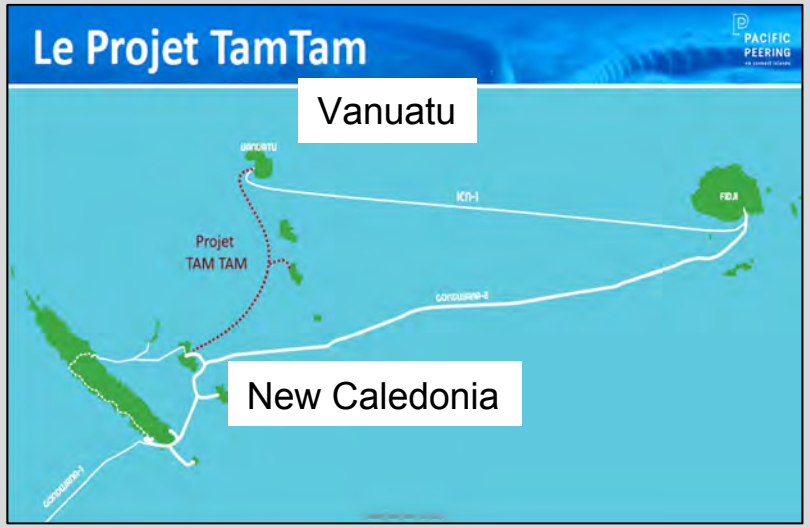
WET DEMO



Dec 2023 installed in Ionian Sea

Delivering real-time data

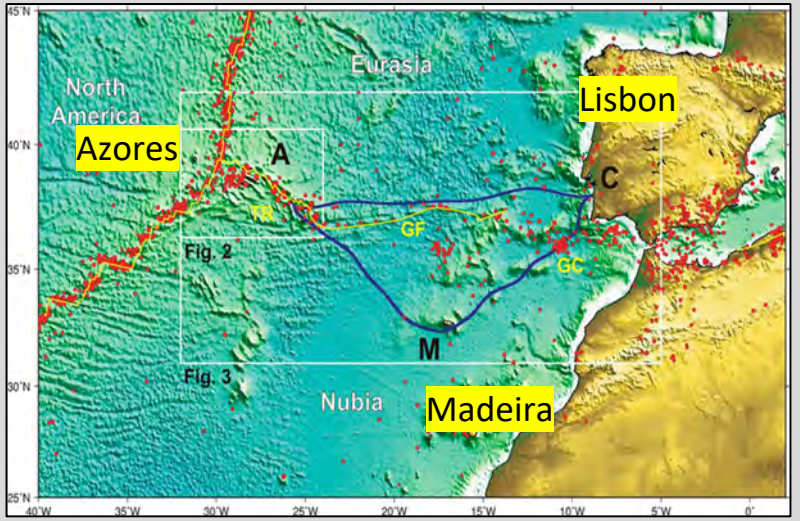
TamTam SMART Cable



450 km , 4-6 SMART Repeaters

Almost CIF, RFS 2026

Portugal SMART Atlantic CAM

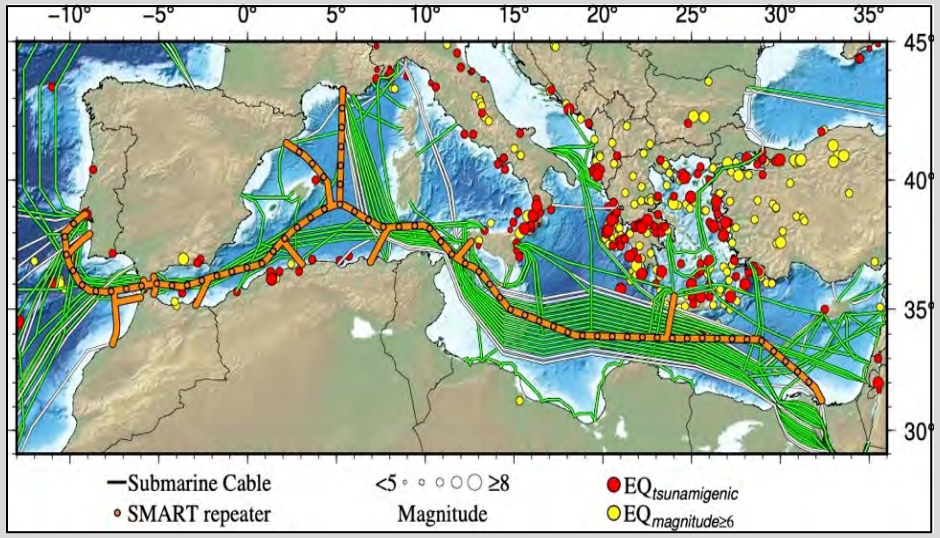


3,700 km 50 SMART Repeaters

Almost CIF, RFS 2026

detailed talks follow

SMART Cables: Planning (1)



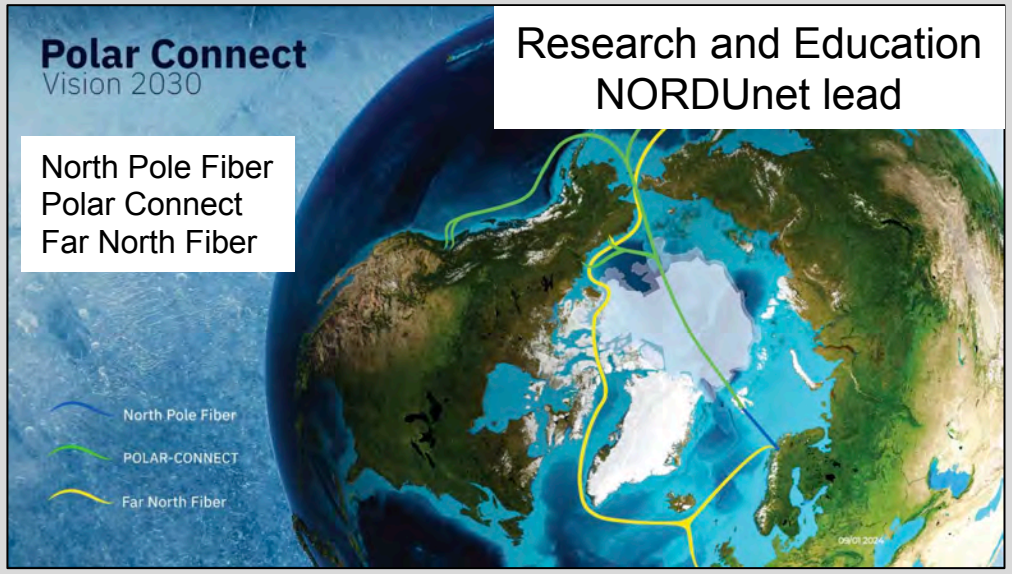
MEDUSA

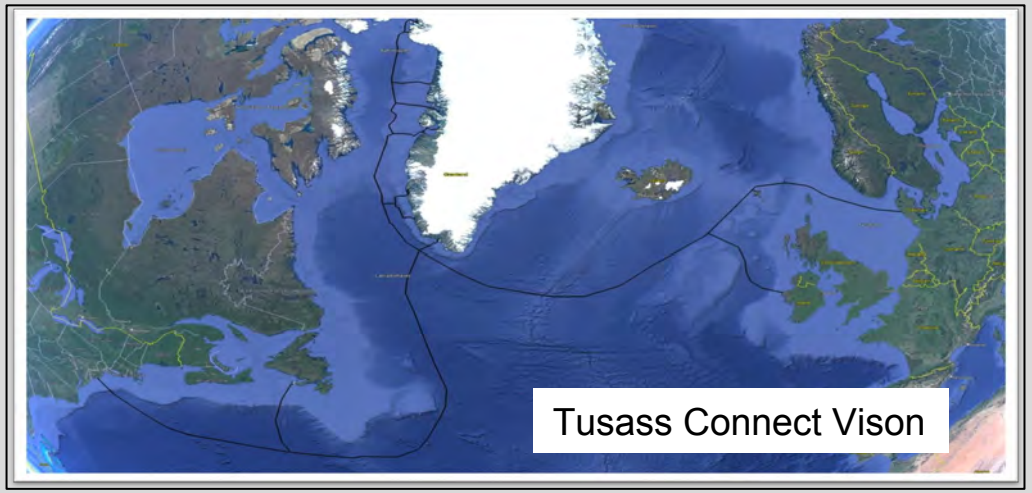
Install 2024/25

Improve coverage for large regional area

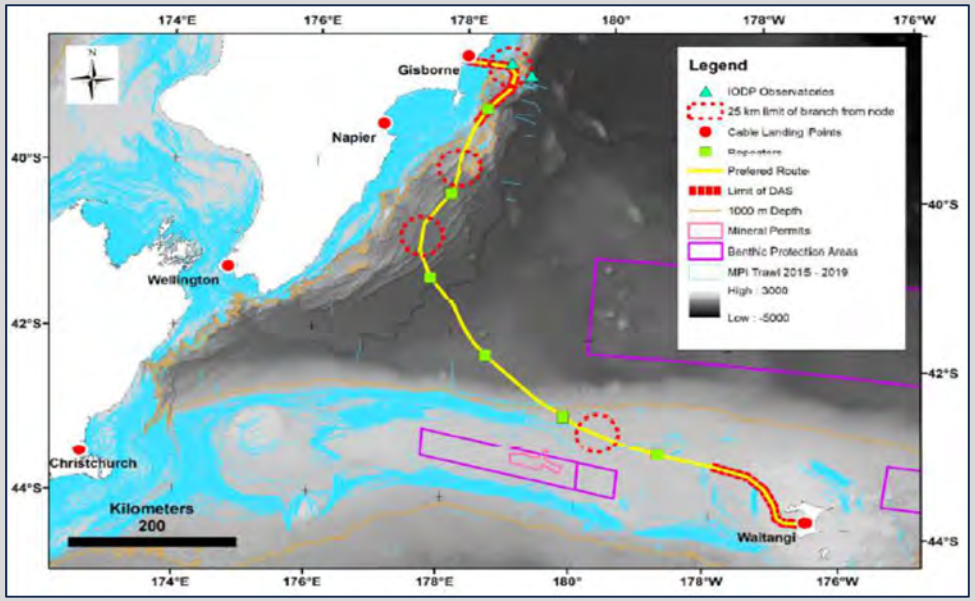
NEAMTWS

Raising funds for SMART capability now



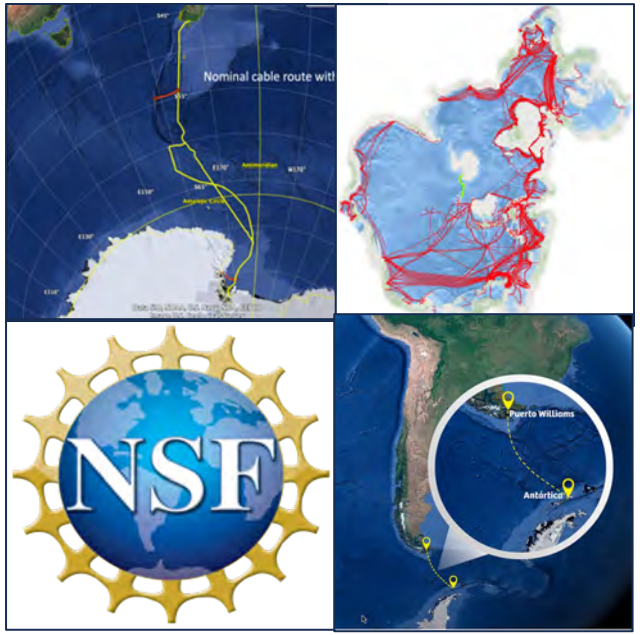


SMART Cables: Planning (2)



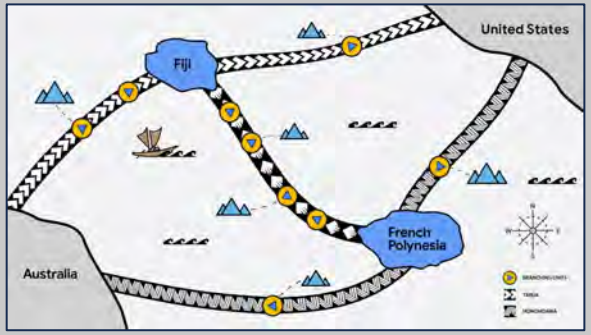
NZ - Chatham Islands

SMART + DAS + BUs/nodes
Under Gov't review (MBIE)



NZ - Antarctica

Improve connectivity
SMART Cable
Workshops, NSF, NAS, Chile



Indonesia

50 km, 2 module test system
installed off Labuan Bajo

Google Pacific ?

ITU-WMO-UNESCO IOC Joint Task Force (JTF)

Restructured 2023

Executive Council	
JTF Chair	Bruce Howe
JTF Vice Chair	Mike Constable
Advisor Telecom Regulatory	José Barros
Advisor Organization	Gayathri Unnikrishnan
Director International Program Office	Ceci Rodriguez Cruz

JTF Secretariat	
International Telecommunication Union	Hiroshi Ota

Steering Committee	
JTF Chair	Bruce Howe
JTF Vice-Chair	Mike Constable
Science and Society	Jérôme Aucan, Laura Kong
Engineering	Steve Lentz
Business Development	Josh Richards
Legal & Regulatory	Tara Davenport
Marketing & Publicity	Joanna El Khoury, Kate Panayotou
Data Management	Benoît Pirenne
Sensor Review WG	Laura Wallace, William Wilcock

ITU-WMO-UNESCO IOC JTF Staff	
International Telecommunication Union (ITU)	Bilel Jamoussi
World Meteorological Organization (WMO)	Enrico Fucile
World Meteorological Organization (WMO)	Champika Gallage
Intergovernmental Oceanographic Commission of UNESCO	Bernardo Aliaga
Intergovernmental Oceanographic Commission of UNESCO	Emma Heslop

SMART Subsea Cables: Future

Plan with our UN sponsors to brief countries across diverse regions on the opportunity to address climate change and disaster risk reduction via subsea telecommunication cables.

Collaboratively develop (where possible) Govt regulatory frameworks and financial incentives for cable investors to integrate SMART technology into industry networks

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Establish a platform where SMART stakeholders can share, interact and find opportunities to collaborate, exchange information to enhance, educate and accelerate the transition of subsea telecom cables to SMART cables

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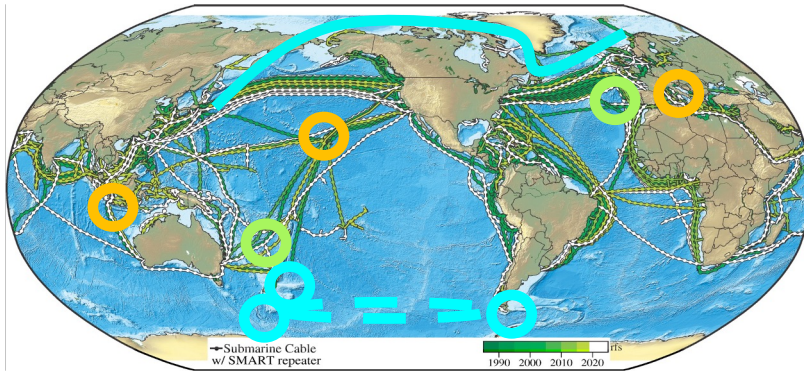
Conduct a workshop to develop white papers in relation to the goals of the JTF committees and working groups in 2025.

Major events JTF will attend: UN Ocean Decade (10 April, Barcelona); ICPC (30 April, Singapore); SN EMEA (29 May, London); SNW (25 September, Singapore)

Next plenary's: 6 May at 2100 UTC, 5 November at 0900 UTC

Summary

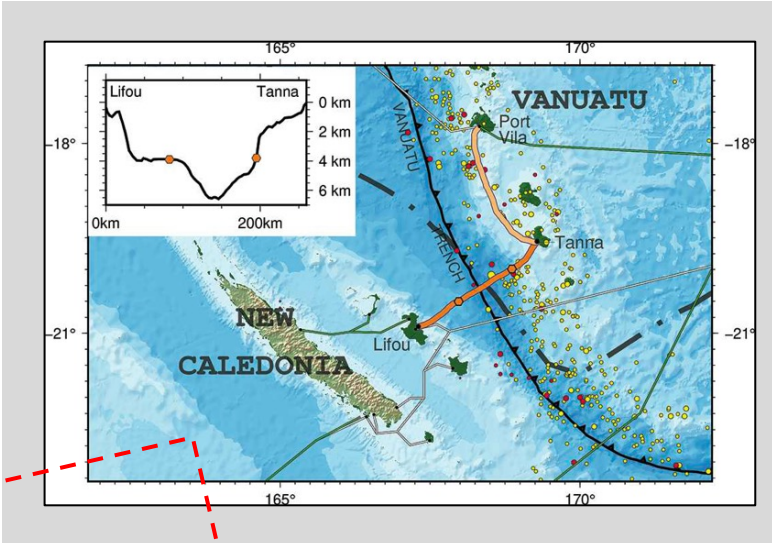
CLIMATE, OCEAN, SEA LEVEL, EARTHQUAKE, VOLCANO, TSUNAMI



SMART – working towards global scale & coverage

- a marriage with subsea telecoms industry

- Anticipated additional 1.3m km of cable in water by 2037
- Leverage annual investment ~ $ 3+ Billion
- 25+ year life, highly reliable, low lifetime cost
- Accomplishments – will set precedents for future systems
- EU Funding CEF-2: Cables, w/ SMART, outlying territories
- SMART – a fruitful marriage with telecom – connectivity, climate, DRR – three for the price of one – saves on all fronts
- Working with DOOS, GOOS, Tsunami, Ocean Decade



Still much to achieve

JTF SMART Cables Meeting
Science Monitoring And Reliable Telecommunication Cables

Thank you!
Cocktails and Dinner follow

SMARTCables.org

ITU JTF Smart Cables web

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Honolulu, Hawaii

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SCHMIDT MARINE TECHNOLOGY PARTNERS

güralp

UNDERSTAND OPTIMISE PROTECT

INGV

InSEA Wet Demonstrator Project

WILL REIS – GURALP

GIUDITTA MARINARO and WIS team– INGV

IN NUMBERS

1985
ESTABLISHED

30,000+
INSTRUMENTS SUPPLIED WORLDWIDE

90
DEDICATED STAFF

50
MILES FROM LONDON

ISO9001
APPROVED

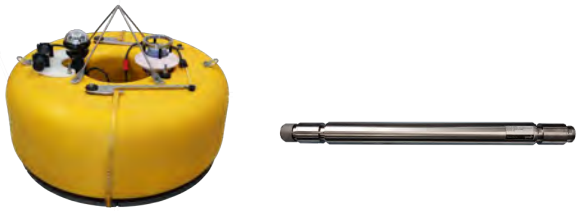
30
REGIONAL DISTRIBUTORS

3
ROBOT FED, 5-AXIS HURCO MILLING MACHINES

SUPPLYING OCEAN BOTTOM SEISMOMETERS SINCE
1989

OUR PRODUCT RANGE

BROADBAND SEISMOMETERS

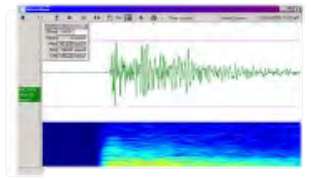


OCEAN-BOTTOM SEISMOMETERS

BOREHOLE SENSORS

STRONG MOTION ACCELEROMETERS

INSTRUMENT AND NETWORK MANAGEMENT SOFTWARE



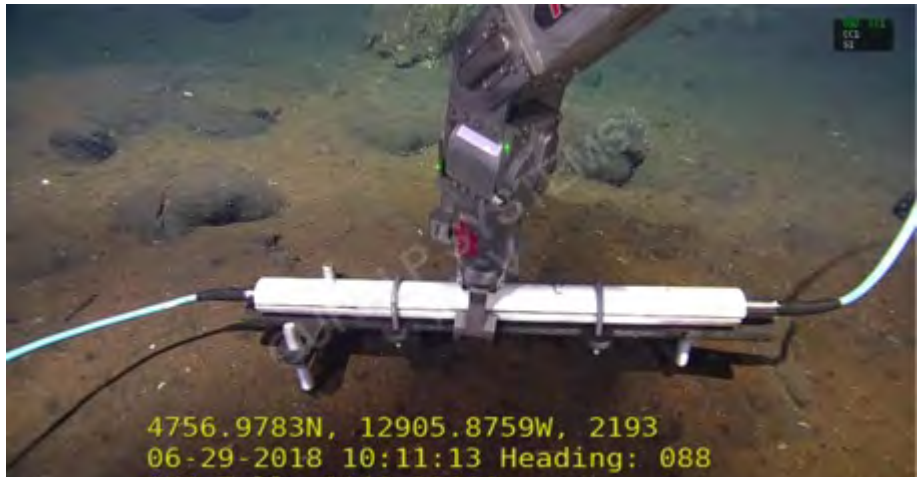
INTEGRATED DIGITAL SENSORS

DIGITIZERS

ACCESSORIES

WORLD-LEADING OBS EXPERTISE – FORCE-FEEDBACK SEISMIC MONITORING

- 35 YEARS OF OBS EXPERIENCE
- DEPLOYMENTS IN EVERY OCEAN BASIN
- AUTONOMOUS & CABLED
- FORCE-FEEDBACK SESIMIC SYSTEMS
- ANY-ANGLE OPERATION



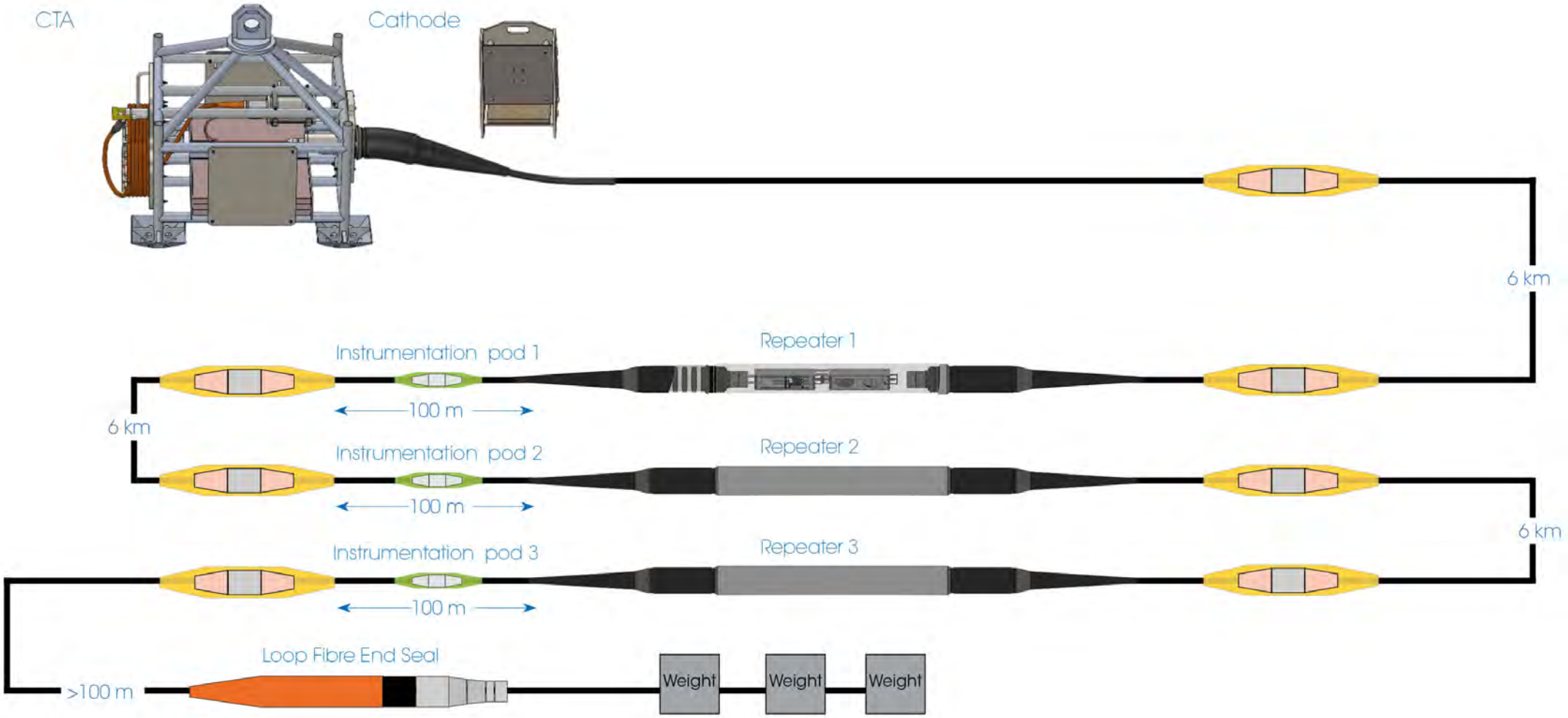
OCEAN-BOTTOM SEISMOMETERS

INGV WET DEMONSTRATOR PROJECT

- EXISTING EMSO WESTERN IONIAN SEA FACILITY
- 25KM EAST OF CATANIA, SICILY AT 2,100M DEPTH
- OBSERVATION AREA PRONE TO EARTHQUAKES AND TSUNAMIS
- INSEA PROJECT FUNDED IN 2019 BY THE ITALIAN MINISTRY OF RESEARCH
- AIMS TO ESTABLISH THE EFFECTIVENESS OF SEISMOMETERS AND ENVIRONMENTAL SENSORS DEPLOYED INSIDE COMMERCIALLY STANDARD REPEATER HOUSINGS

ISTITUTO NAZIONALE
DI GEOFISICA E VULCANOLOGIA

GURALP SYSTEM OVERVIEW

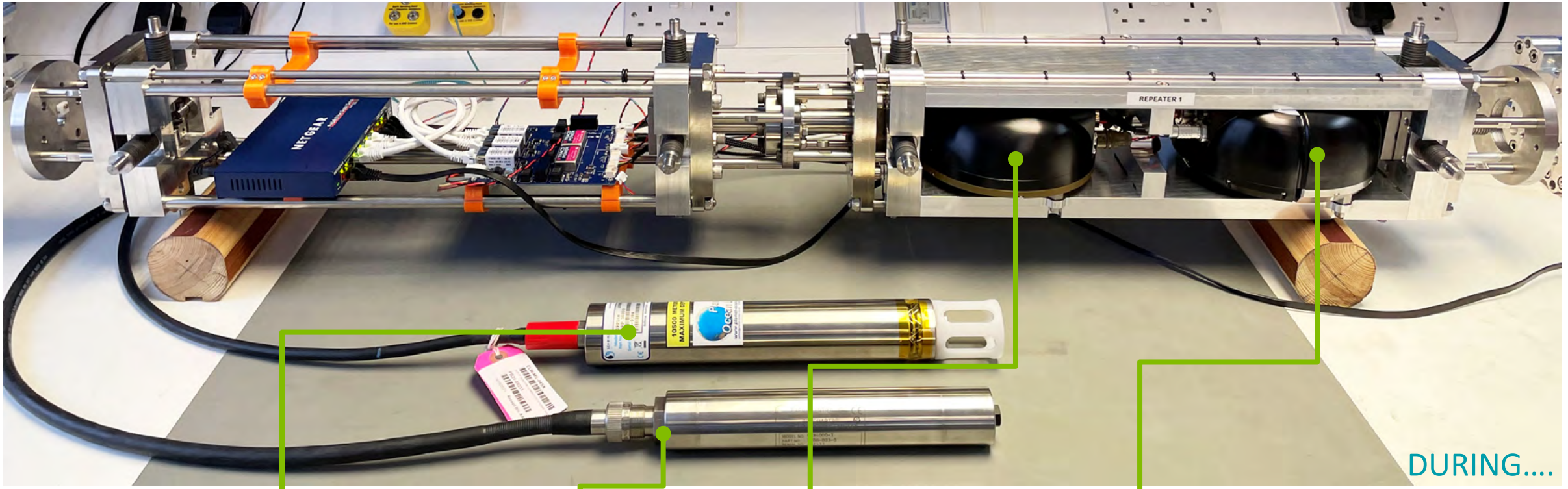


SYSTEM INTEGRATION

- PRE-USED COMMERCIAL REPEATER HOUSINGS
- POWER CIRCUITS AND OPTICAL AMPLIFIERS REMOVED AND REPLACED WITH POWER SUPPLY, MEDIA CONVERTERS AND SEISMIC SENSORS
- REPEATER SEALED BY TWO BULKHEADS
- BEND LIMITER ALLOWS FOR SYSTEM TO BE SAFELY DEPLOYED

BEFORE....

INSTRUMENT SELECTION AND PERFORMANCE



Instrument pod:

Seabird SBE 39Plus
The temperature sensor selected has an operating range between -5°C and 45°C with an accuracy of ±0.002°C. The sensor will help to facilitate the monitoring of sea floor oceanographic conditions and will feedback into existing oceanographic models.

Paroscientific 8000 Series
This APG has a depth rating of 3,000m and a precision of <0.01% full scale range. Selected for proven performance and robustness, the Paroscientific 8000 has been successfully used in other Güralp ocean bottom sensing systems. It has also proven crucial for tsunami warning systems globally.

Repeater:

Fortimus
A modern force balance accelerometer with integrated digitiser. It has a flat acceleration response between DC-315 Hz. The instruments' low self-noise, makes the data useful or local and regional seismic monitoring.

Certimus
A triaxial broadband seismometer with a flat frequency response between 120 s and 100 Hz. The Certimus has true broadband performance with a low instrument self-noise that makes it well suited for regional seismic monitoring. The Certimus is used globally for applications ranging from volcano monitoring to regional and national networks.

Combining Fortimus and Certimus provides an ultra-wide dynamic range

DECEMBER 2023 – INSTALLATION

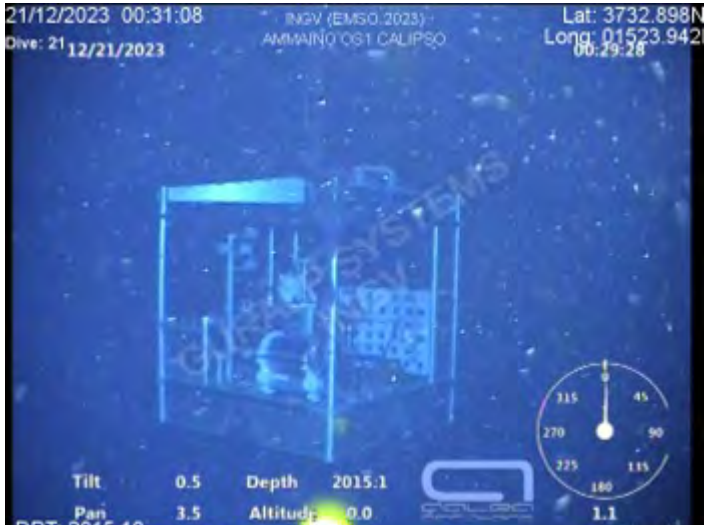
- ANTONIO MEUCCI CABLE LAYING VESSEL
  - ELLETRA TLC
- DEPLOYED USING STANDARD CABLE-LAYING METHODS
- MORE EFFICIENT METHODS AVAILABLE WITH SMALLER REPEATERS
- GSL, INGV & ELLETRA ENGINEERS

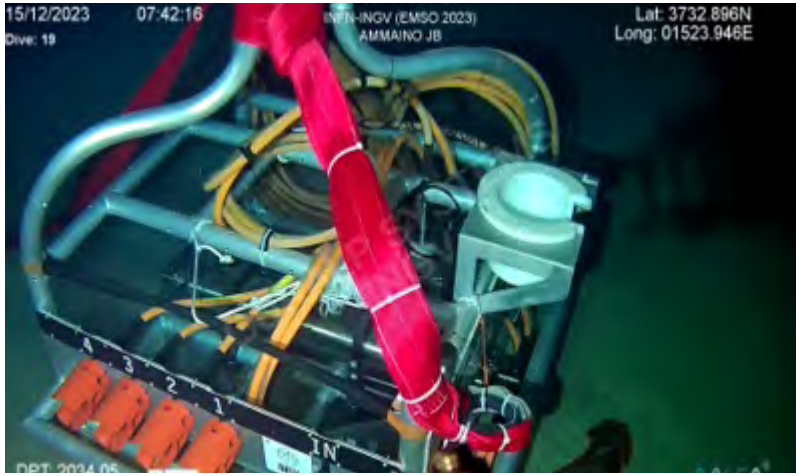
AFTER....

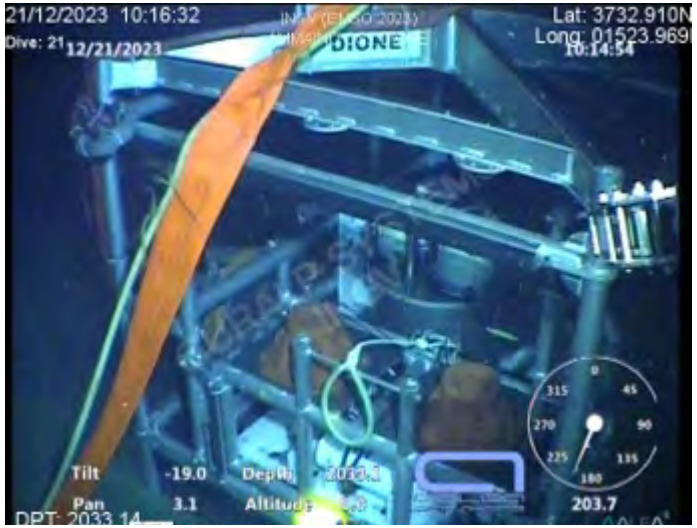
DECEMBER 2023 – INSTALLATION

- ONBOARD
- CABLE DRUM
- CRANE FOR REPEATER HOUSINGS
- CATHODE

WESTERN IONIAN SEA INFRASTRUCTURE





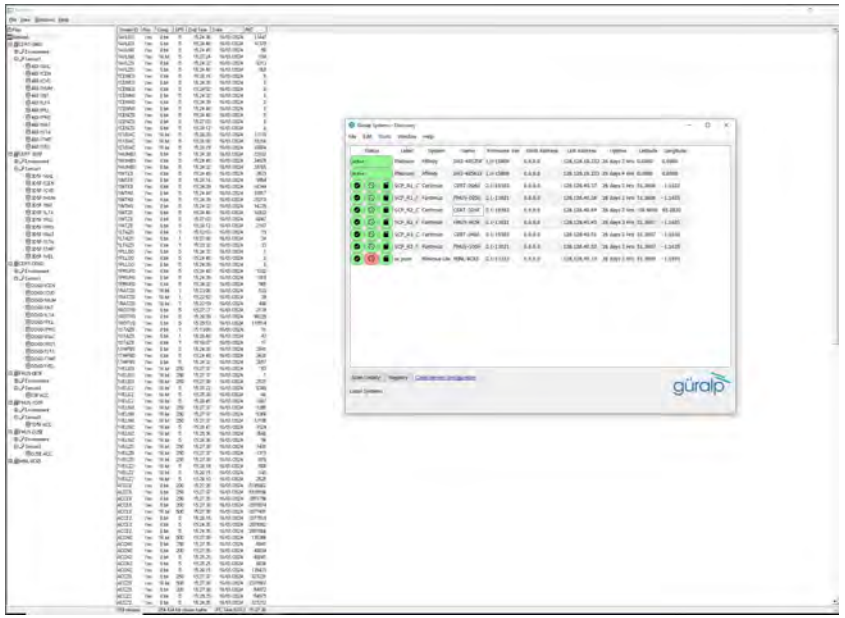


- CTF 1000V AC
- JB 4 output 375V DC
- 2 MULTIPARAMETER OBSERVATORIES
  - OBS
  - PRESSURE
  - HYDROPHONE
  - OTHER OCEANOGRAPHIC SENSORS

WESTERN IONIAN SEA INFRASTRUCTURE

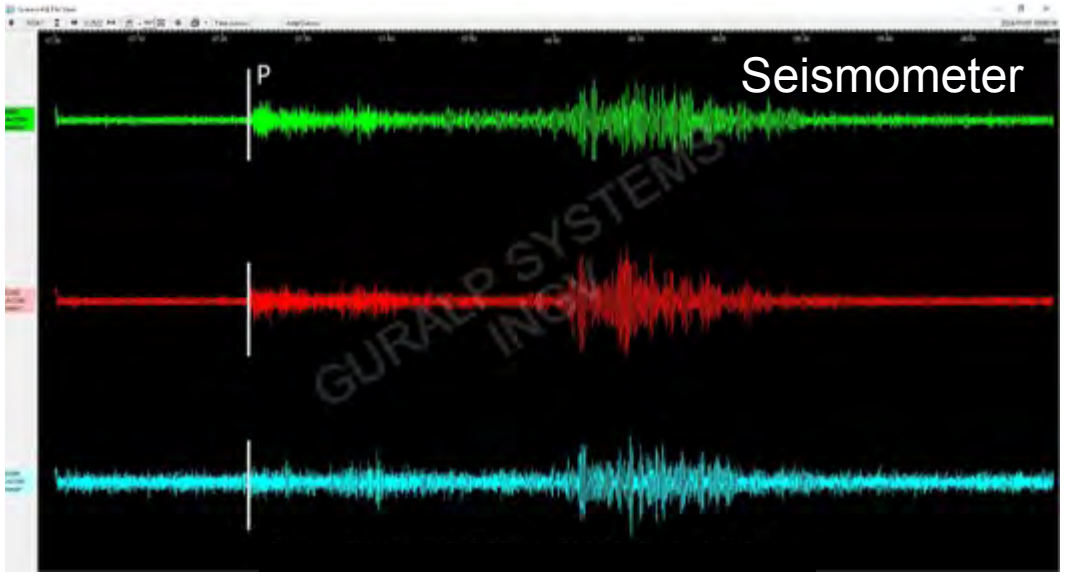
	Latitude	Longitude	Depth (m)
CTAi frame	37° 32. 896 N	015° 23.962 E	2.034
Rep 1	37° 33. 395 N	015° 26.017 E	1.928
Rep 2	37° 34. 309 N	015° 30.095 E	1.929
Rep 3	37° 36. 512 N	015° 32.899 E	1.899
SJ Looped	37° 39.409 N	015° 31.662 E	1.979
dead weight 1	37° 39. 962 N	015° 31.273 E	1.050
dead weight 2	37° 40. 353 N	015° 30.846 E	1.950

DATA ACQUISITION



- POWER & DATA ACQUISITION
  - INFN SHORE STATION, CATANIA HARBOUR
  - PTP SYNCHRONISATION VIA GPS
- SOFTWARE
  - GURALP DISCOVERY & SCREAM! ACQUISITION SOFTWARE
    - SEISMIC & TEMPERATURE
    - SOH & DATA RECORDING
  - CUSTOM ACQUISITION SOFTWARE
    - PRESSURE

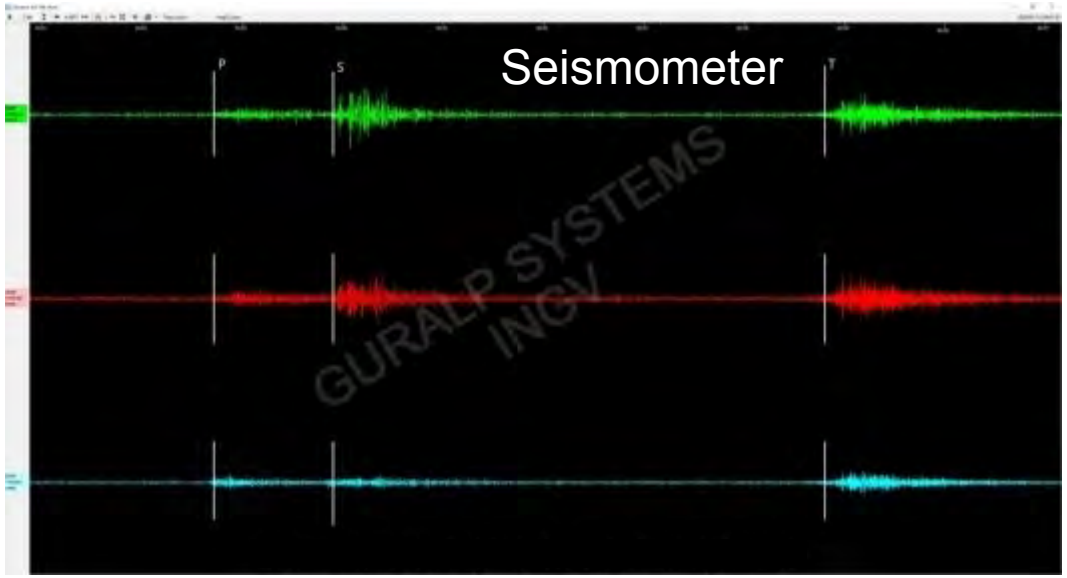
DATA EXAMPLES



REPEATER 1

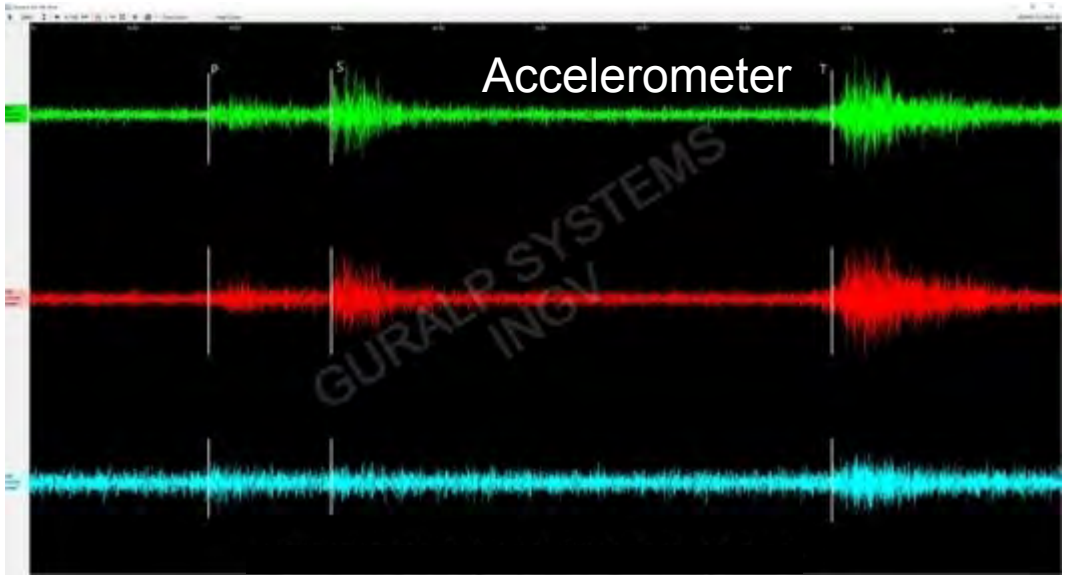
- TELESEISMIC EVENT
- WEST COAST, EASTERN HONSHU, JAPAN
- 01/01/2024 07:10:13 M_{wpd} 7.4

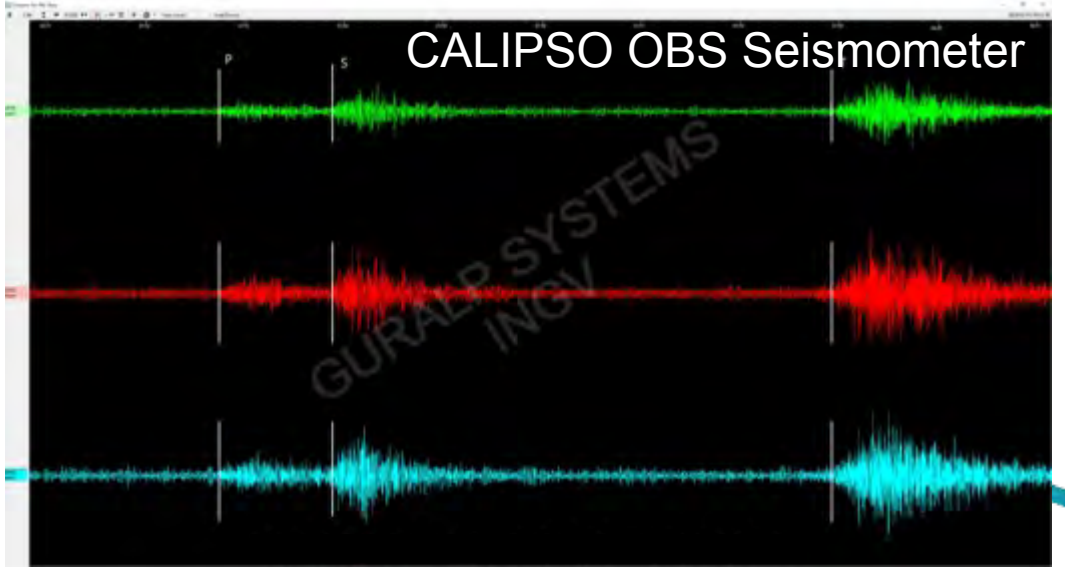
DATA EXAMPLES



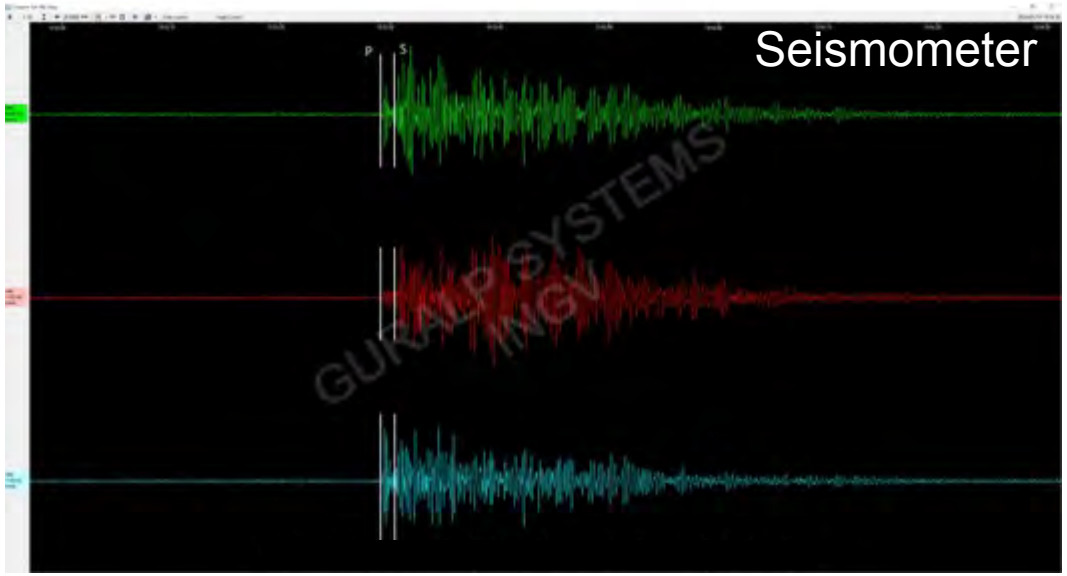
REPEATER 2

- REGIONAL EVENT
- WEST COAST CRETE, GREECE
- 12/01/2024 03:51:07 M_b 4.7



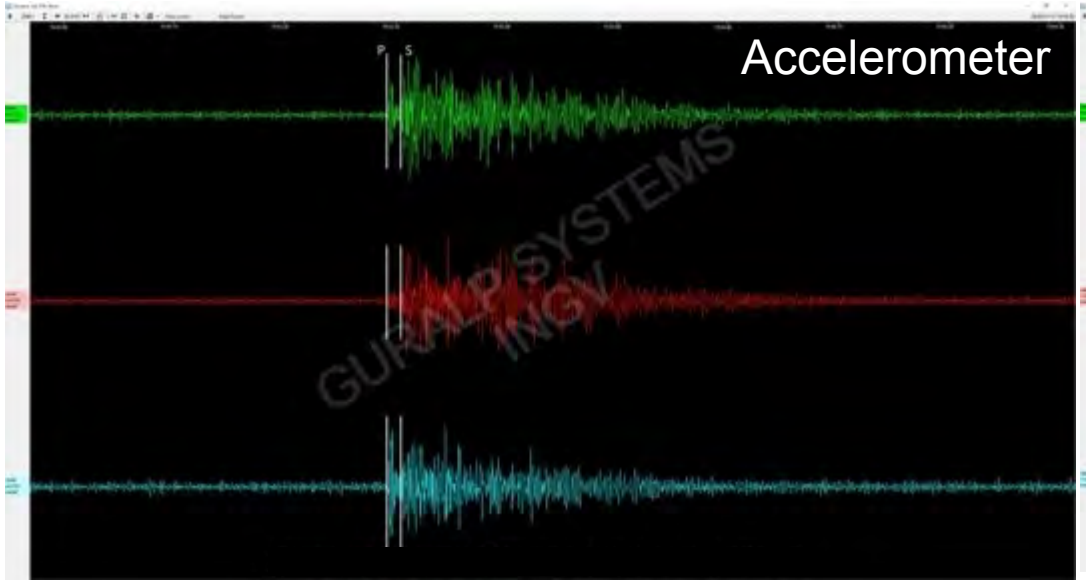


DATA EXAMPLES



REPEATER 3

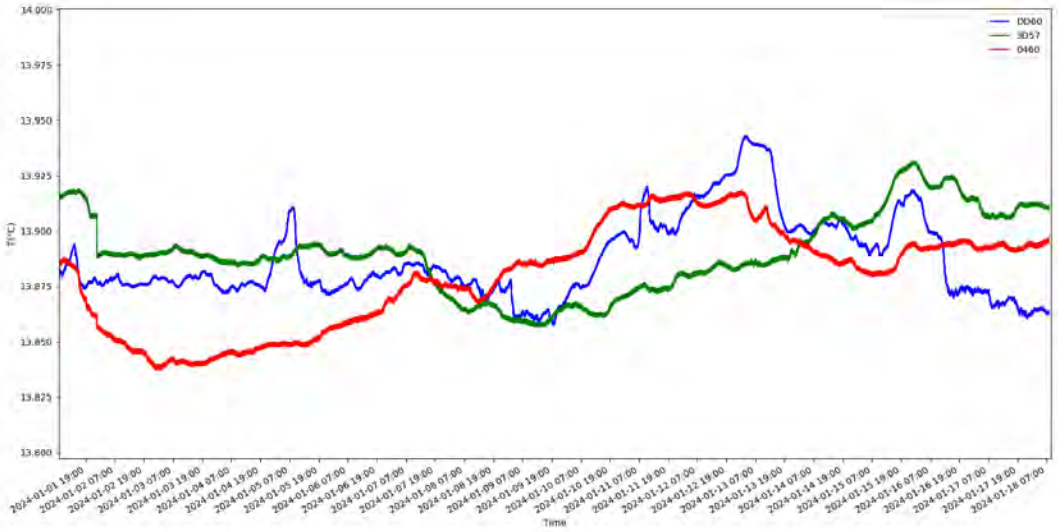
- LOCAL EVENT
- CATANIA COAST, ITALY
- 14/01/2024 19:53:23 M_L 2.0
- 24 KM DEPTH – VERY CLOSE TO SMART CABLE

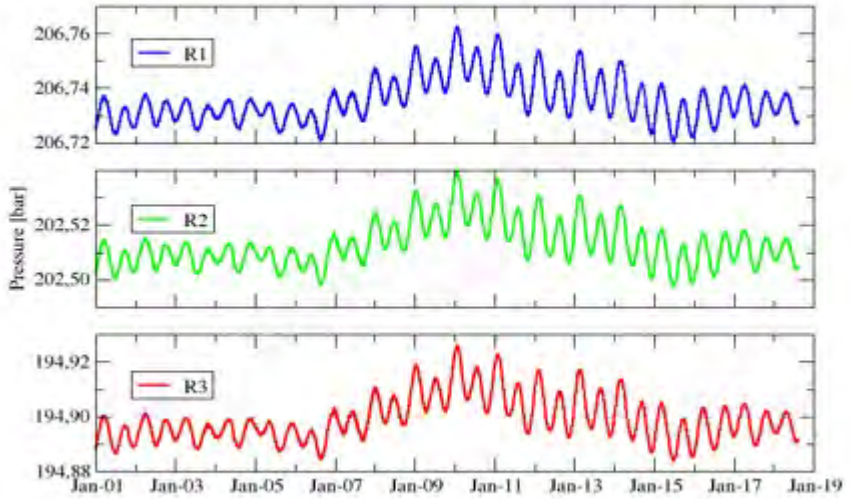


DATA EXAMPLES

ENVIRONMENTAL SENSORS - RAW DATA

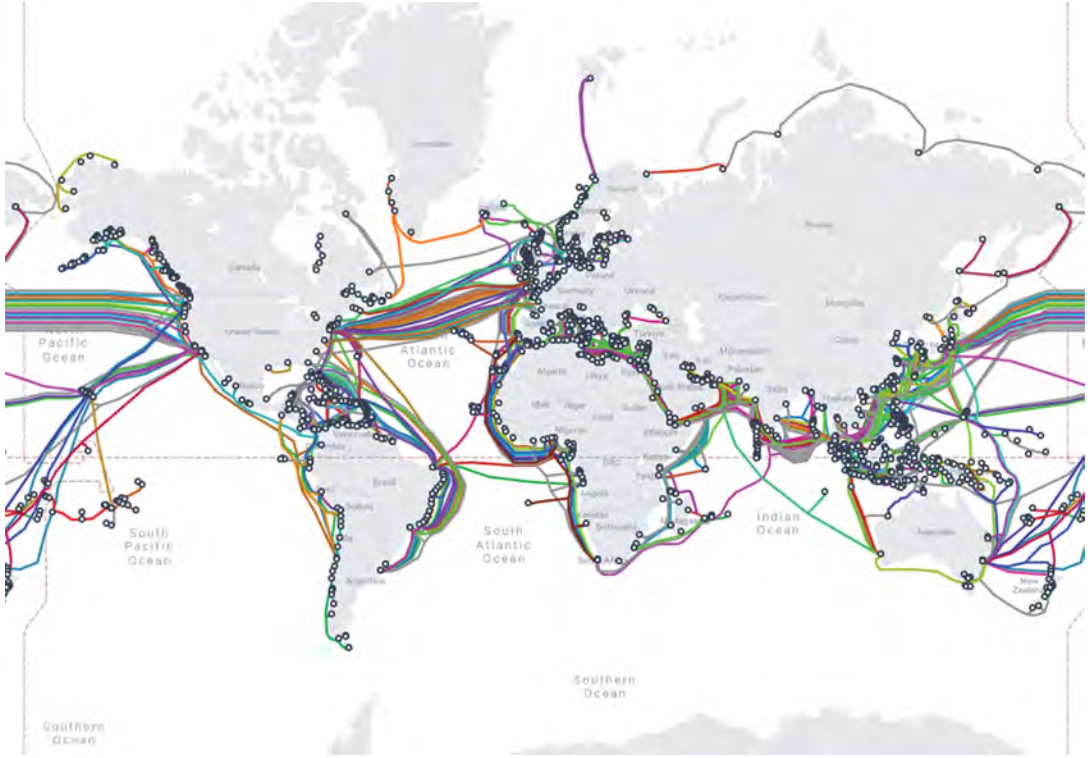
- TEMPERATURE (1Hz)
- PRESSURE (1 sample/15 s)





FUTURE WORK

- HUGE GLOBAL POTENTIAL FOR SMART CABLE OBSERVATORIES
- DATA COMPARISON WITH LAND/OBS STATIONS
- VALUABLE INTEGRATION EXPERIENCE LEARNED FROM THIS PROJECT
- CONFIDENT WITH GSL & THIRD-PARTY INSTRUMENT INTEGRATION
- MULTIPLE NEW ENQUIRIES FOR TSUNAMI AND EARTHQUAKE-EARLY-WARNING SYSTEMS



Submarine map credit: TeleGeography

güralp

WILL REIS – GSL

EMAIL: SALES@GURALP.COM
WEB: WWW.GURALP.COM

INGV

GIUDITTA MARINARO – INGV

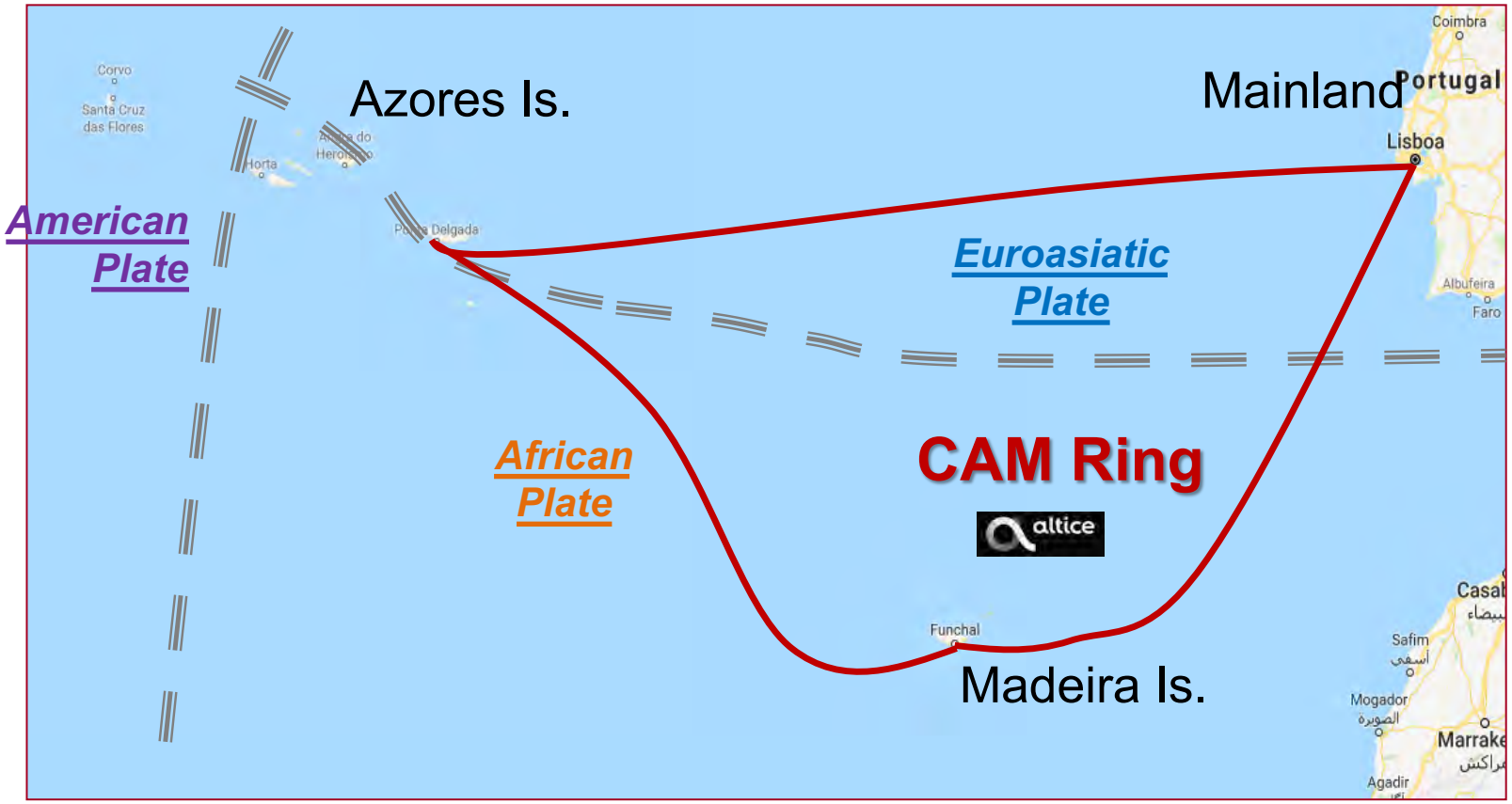
giuditta.marinaro@ingv.it

SMART Atlantic CAM System

Fernando Carrilho

JTF SMART CABLE Meeting
Honolulu, EUA, 20 Jan 2024

CAM Ring - Present situation
Operational until end of 2025

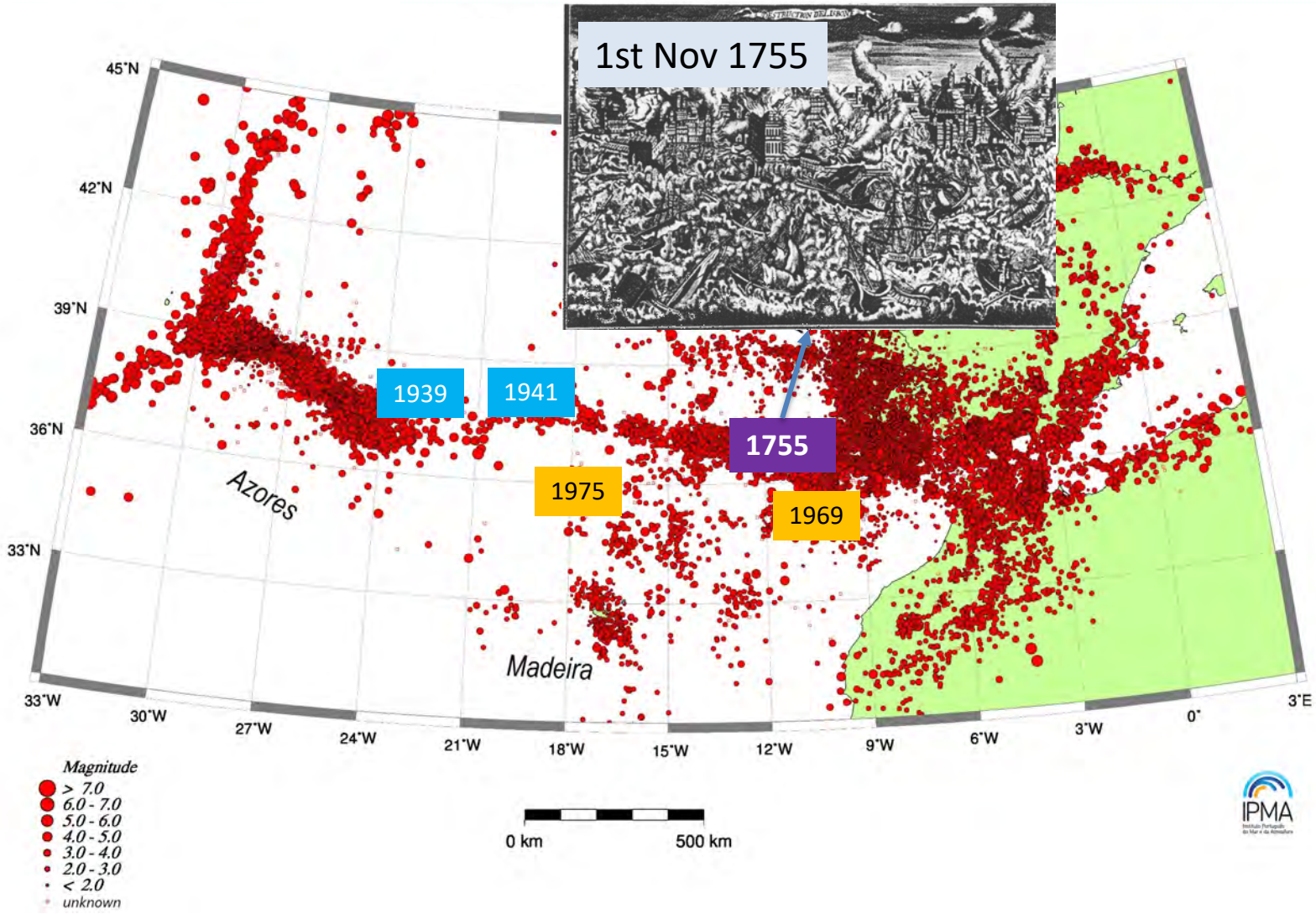


Opportunity – Raising awareness of the need to replace the CAM ring

New PT Mainland-Azores-Madeira Ring of submarine cables (CAM)

Ring configuration with ~4000km

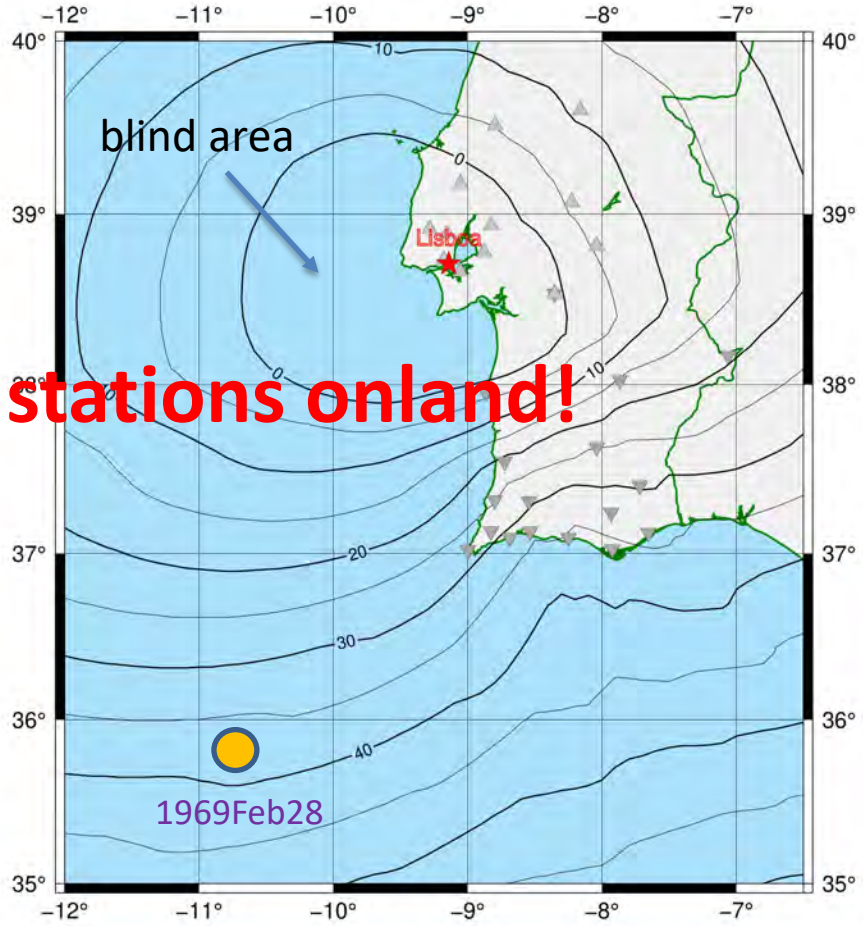
On portuguese EEZs and continental shelf


1st Nov 1755
1939
1941
1755
1975
1969
Azores
Madeira
45°N
42°N
39°N
36°N
33°N
33°W
30°W
27°W
24°W
21°W
18°W
15°W
12°W
9°W
6°W
3°W
0°
3°E
Magnitude
> 7.0
6.0 - 7.0
5.0 - 6.0
4.0 - 5.0
3.0 - 4.0
2.0 - 3.0
< 2.0
unknown
0 km
500 km
IPMA

Seismic Early Warning
Theoretical **Lead time**

SINES

LISBON



Problem: Only stations onland!

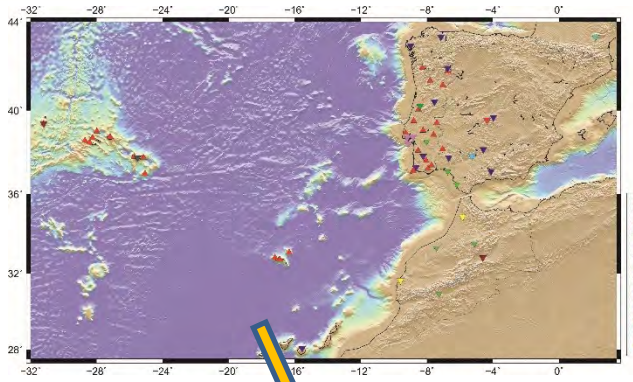
Lower Tagus Valley Accelerometric Network

South Mainland Accelerometric Network

10 stations

Tsunami Service

Seismic network



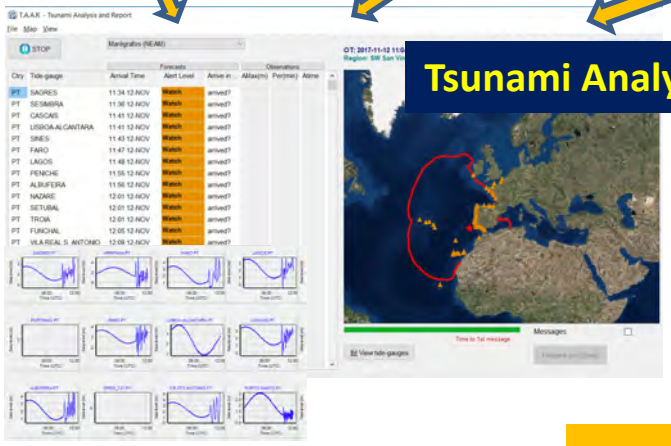
Tide-gauge network

Decision Matrix

Decision Matrix for the NE Atlantic

Depth (km)	Epicentre Location	Earthquake Magnitude (Mw)	Tsunami Potential	Type of tsunami message		
				Local	Regional	Ocean-wide
<100Km	Offshore or close to the coast (<=40Km inland)	≥5.5 and <6.5	Weak potential for a destructive local Tsunami	Advisory	Information	Information
		≥6.5 and <7.0	Potential for a destructive local Tsunami	Advisory	Information	Information
	Offshore or close to the coast (<=100km inland)	≥7.0 and <7.5	Potential for a destructive local Tsunami	Watch	Advisory	Information
		≥7.5 and <7.9	Potential for a destructive regional tsunami	Watch	Watch	Advisory
		≥7.9	Potential for a destructive ocean-wide tsunami	Watch	Watch	Watch
>100Km	Offshore or inland (<=100Km inland)	≥5.5	No tsunami potential	Information	Information	Information

Tsunami Analysis and Report



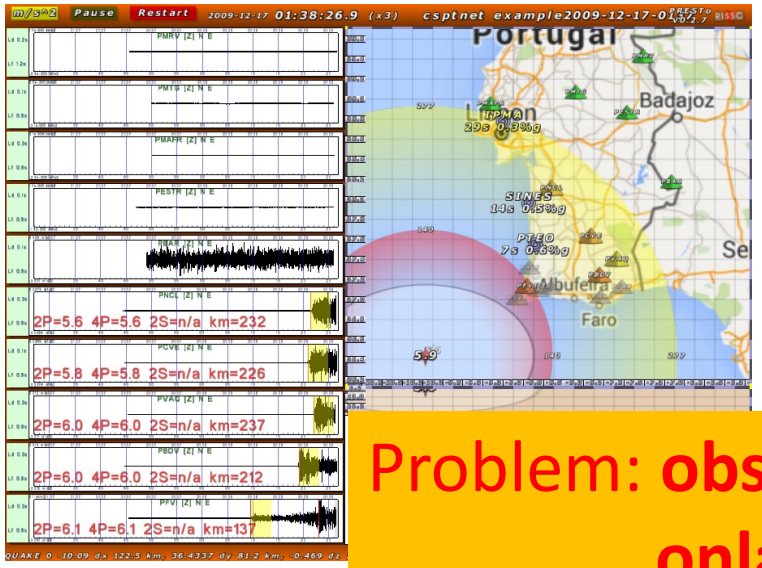
Tsunami Warning Focal Points / Civil Protection System

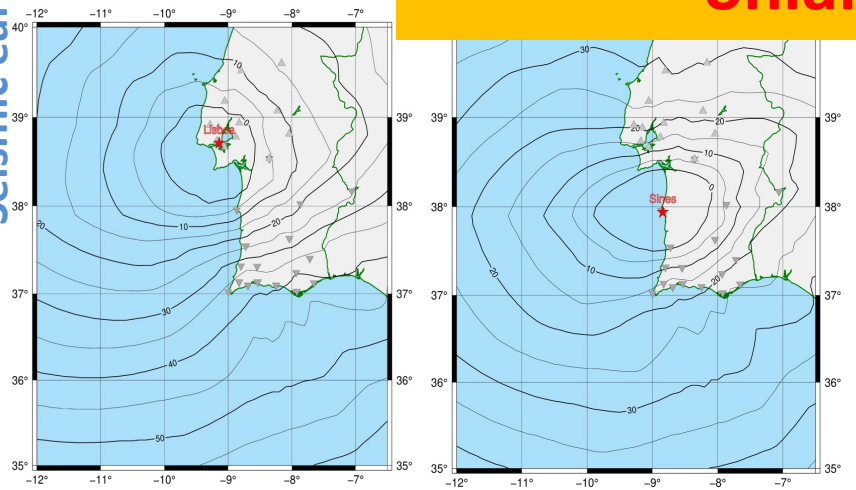
ALERT!

Seismic and Tsunami Early Warning

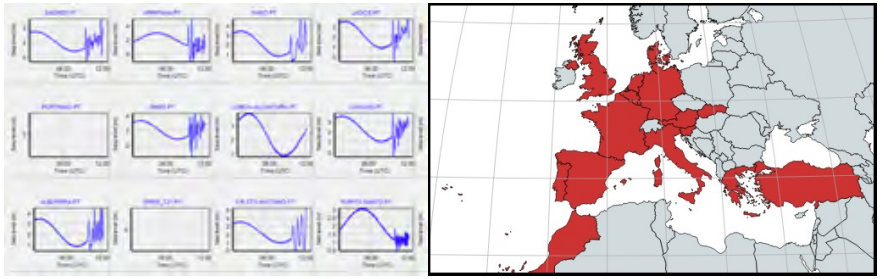
Seismic early warning

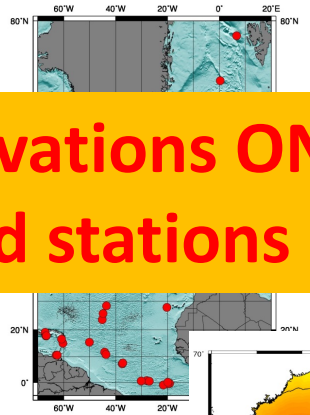
Tsunmai early warning

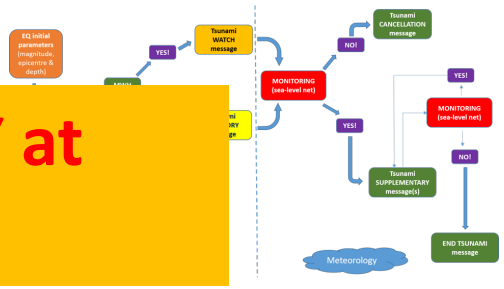


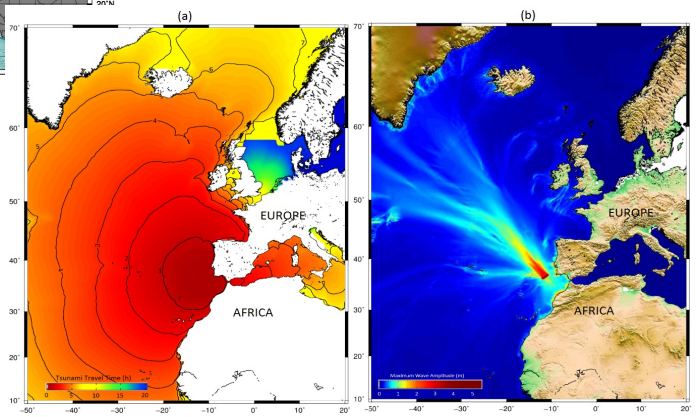


Problem: **observations ONLY at onland stations**

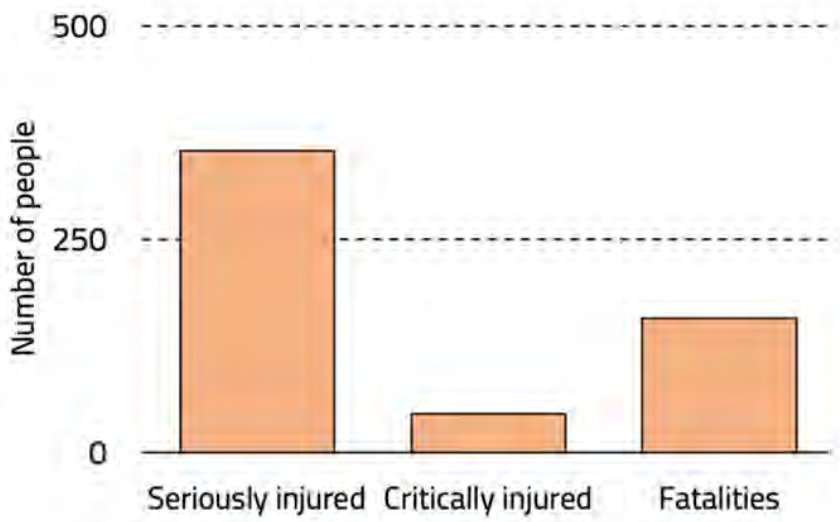


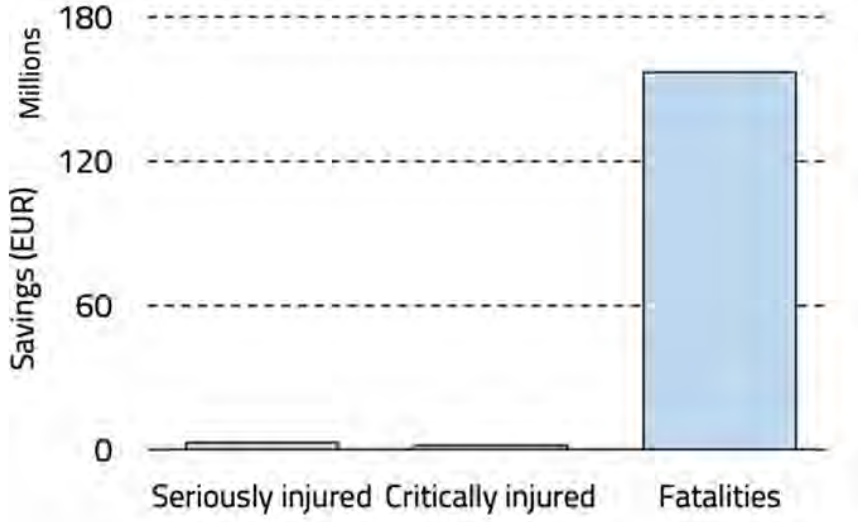






Seismic Early Warning
Benefits





Vitor Silva et. al, 2023

Potential reduction in the average annual number of injured and fatalities due to the EEWS during a **lifetime of 25 years** (left), and associated **economic savings** for the same time period (right)

LEA – Listening to the Earth Under the Atlantic

An initiative of IT, IPMA, and IDL, inspired by the vision of ANACOM on SMART cables and the CAM ring.

IT: Instituto de Telecomunicações
IPMA: Instituto Português do Mar e da Atmosfera
IDL: Instituto Dom Luiz [at the University of Lisbon]

Working together on seismological sensing with submarine cables since July 2018.

L · E · A

instituto de telecomunicações

IPMA

INSTITUTO DOM LUIZ

Opportunity

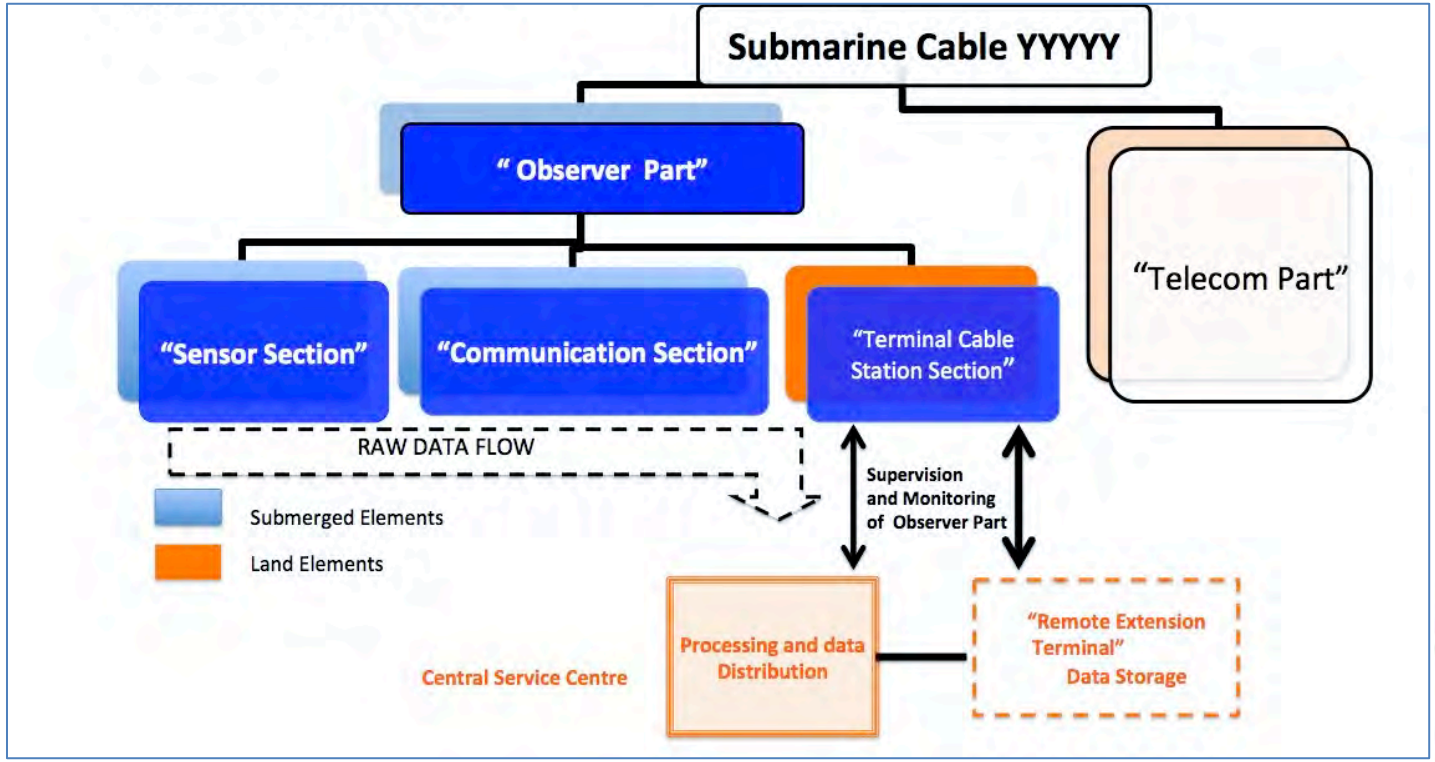
- Deployment of the new CAM ring by 2025/2026, in the PT EEZ.
- Portuguese state and ANACOM request additional services on the new infrastructure, namely public services for civil protection and scientific research.
- Opportunity to attach geophysical sensors and other environmental sensors to the submarine telecommunication repeaters/cables

Advantages

- Real-Time data allowing early warning for earthquakes and tsunamis
- Power supply: permanent
- Cost marginal, between 5% to 10% of the infrastructure
- Coverage: wide coverage of relevant area of Atlantic (repeaters every 70/80/90km)

Two main components of the SMART cable:

- **Telecom Submarine Cable System Part**
- **Observer Part**



L·E·A Listening to the Earth under the Atlantic

Instrumentation

- **Mandatory Sensors (JTF)**
  - **Accelerometer**
  - **Absolute pressure gauge**
  - **Temperature sensor**

- **Extra (not mandatory), to be defined, examples:**
  - **Broadband seismometer**
  - **Hydrophone**

Parameter	Mandatory	Minimum	Reference
Configuration	3-Axis		
Frequency bandwidth (±3 dB)		0.1 to 100 Hz	DC to 200 Hz
Resonance frequency			> 2,000Hz
Full scale range	±2g		

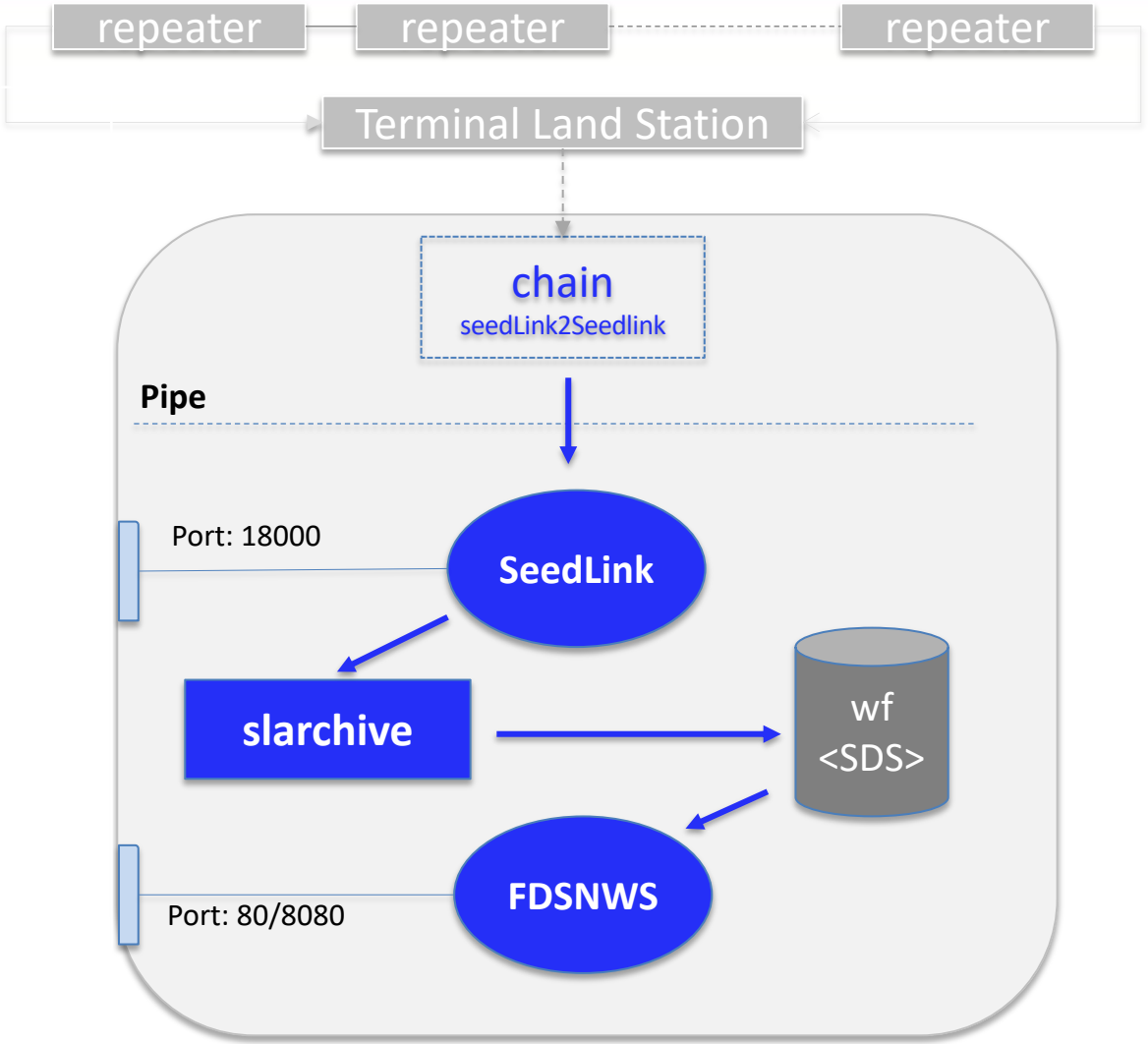
Parameter			Reference
Range			0 to 73MPa
Overpressure tolerance			84MPa (8,000m)
Accuracy			±1mm relative to recent measurements; 0.01% of full range absolute
Maximum allowable drift after a settling-in period			<10^{-4} / year
Hysteresis			≤ ±0.005% of full scale
Repeatability			≤ ±0.005% of full scale
Sampling rate			20 Hz
Sample resolution			32 bits
Noise Floor			0.14 Pa2/Hz

Parameter			Reference
Initial accuracy			± 0.001°C
Stability			0.002°C / year
Sampling rate			1 Hz
Sample resolution[2]			24 bits
Operating depth			To be defined
Lifetime Design Specification			25 years

Data aquisition / transmission:

- **Resolution: 24bits**
- **Format: miniseed**
- **Protocol: seedlink**

Standard protocols in Seismology!

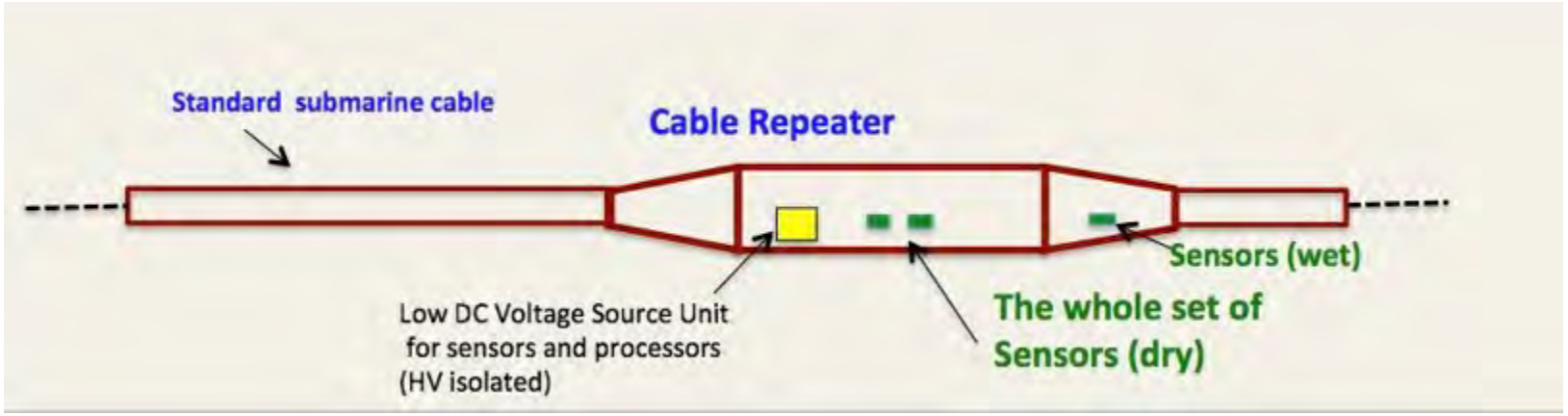


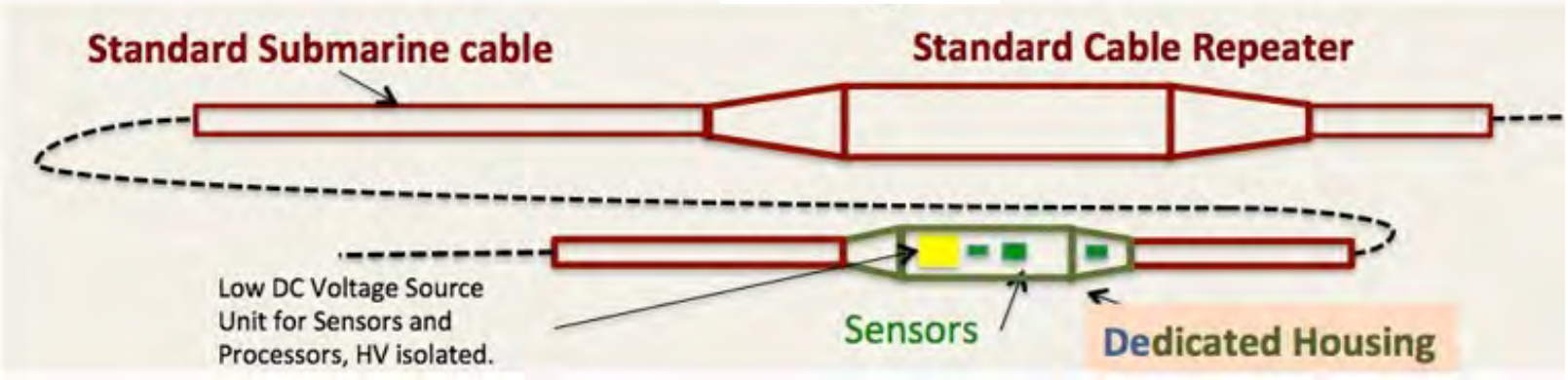
Acquisition (SC model)

Reliability objectives:

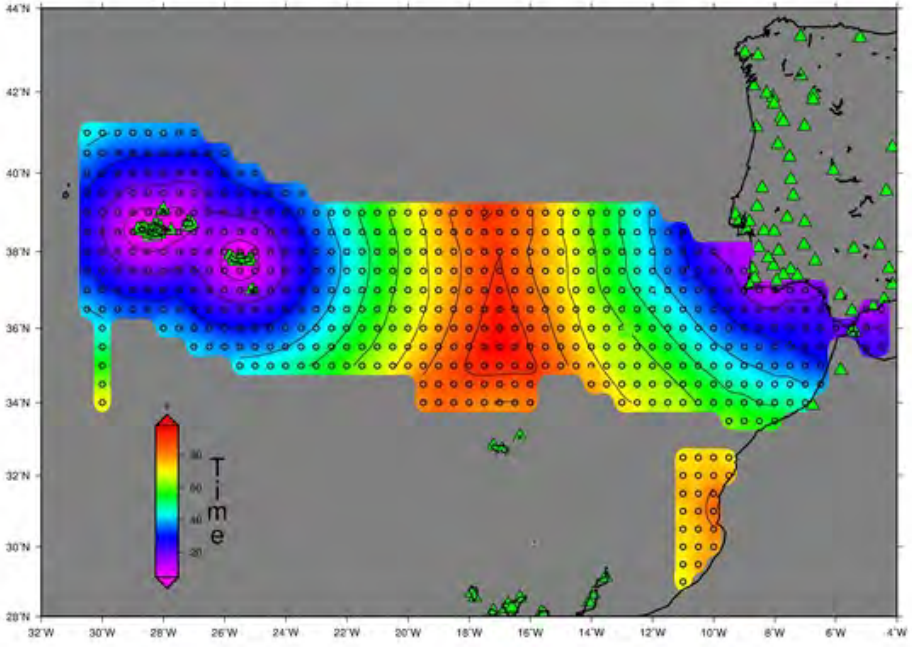
- **Design Lifetime (25 years [as for Telecom part])**
- **Maximum number of unavailable Sensors at the end of the Lifetime (<10% of faults)**
- **Reliability independency between "Observer Part" and "Telecom Part"**
- **Reliability Information required for the "Communication Section",** to be provided with 95% of confidence level

Possible configurations ....

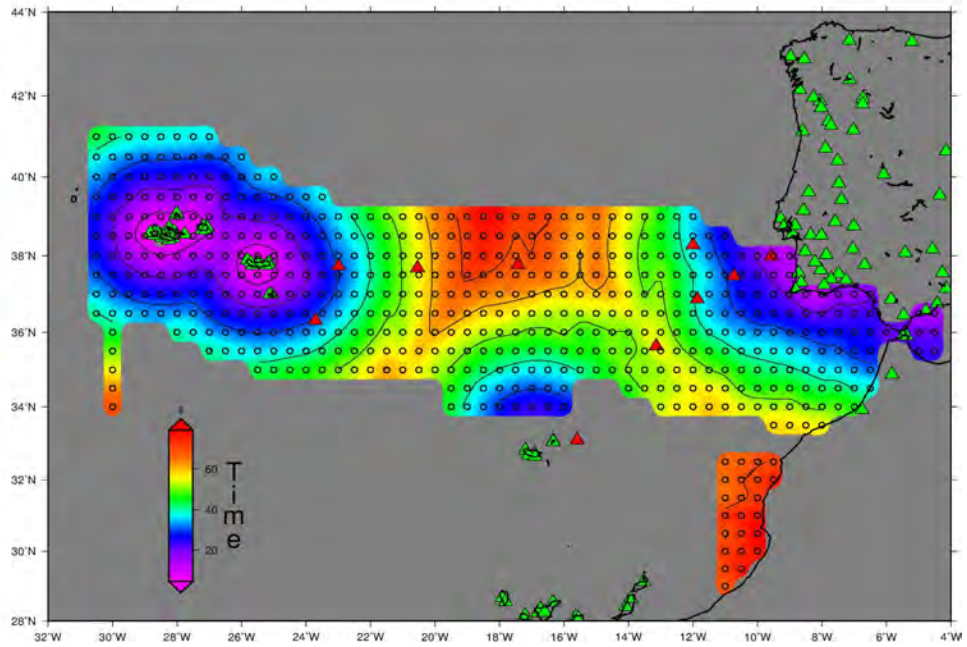




Seismic Detection Time



Existing IPMA stations (inland)

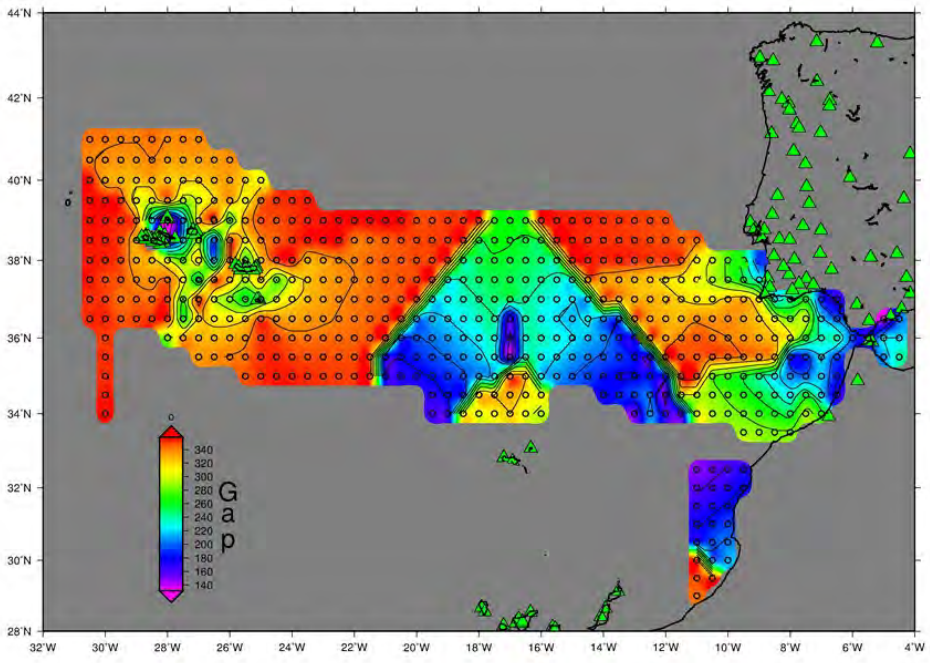


Existing IPMA stations (inland) + 10 stations within CAM

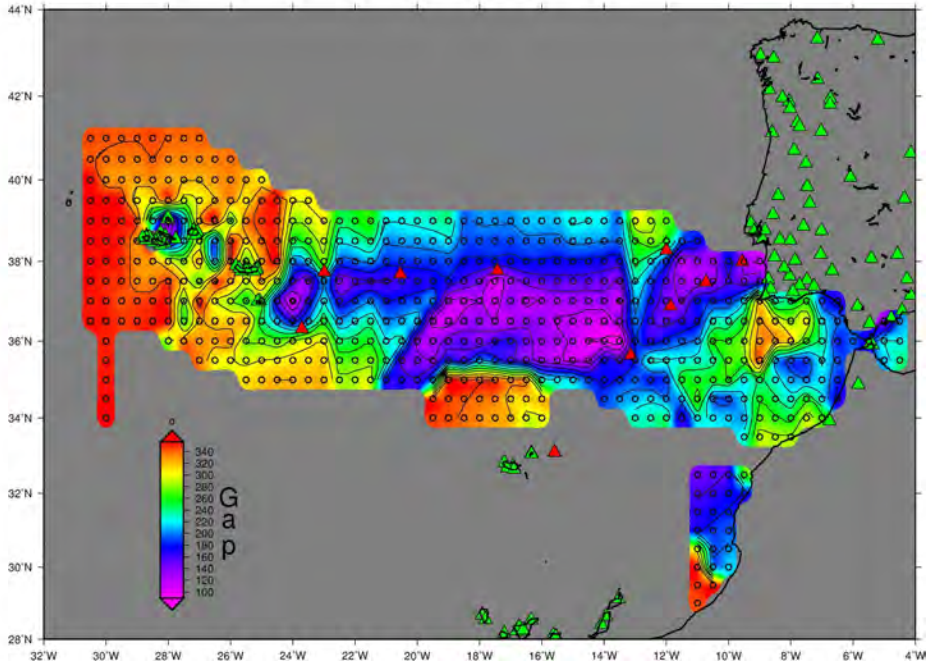
- Epicenters from IPMA tsunami scenario DB
- Existing stations (at IPMA)

- **Relevant improvement in the SW San Vincent Cape área (>5 sec)**
- **Very significant improvement at North Madeira (earthquake of 1975, Mag8.1)**

Quality (azimuth gap)



Existing IPMA stations (inland)

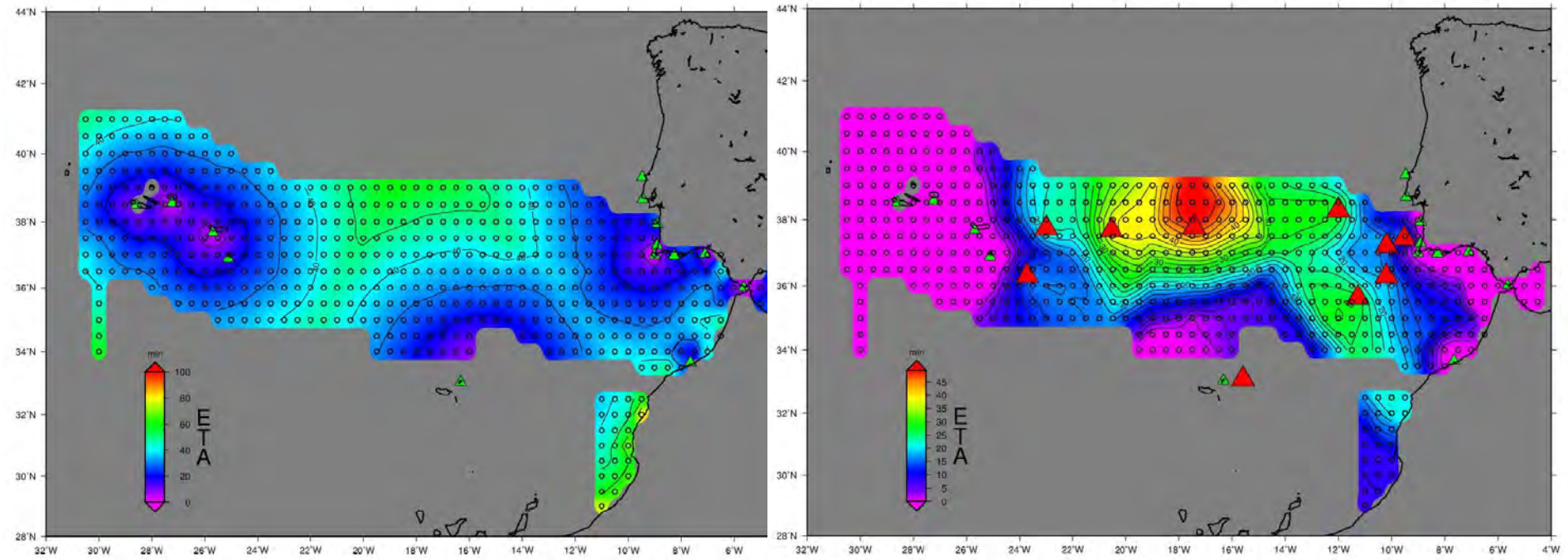


Existing IPMA stations (inland) + 10 stations within CAM ▲

- Epicenters from IPMA tsunami scenario DB
- ▲ Existing stations (at IPMA)
- ▲ Proposed new stations (CAM)

- **Significant improvement in the SW San Vincent Cape área**
- **Major improvement along the Gloria fault region (earthquakes of 1939, 1941, 1975 ...)**

Gain in Early Warning Time for Tsunamis



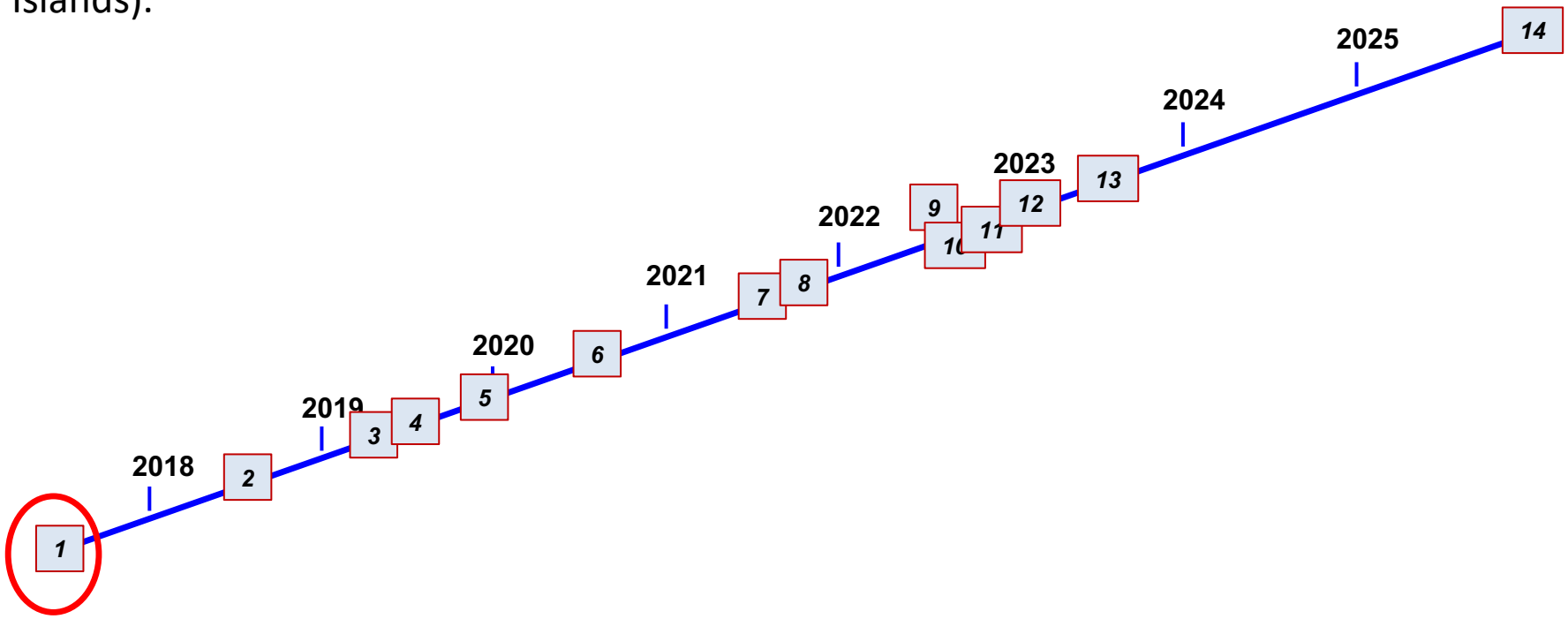
Minimum TTT from each of the database locations to 14 tide-gauges

- Significant improvement (>10min) in a wide area between 23ºW and Portugal and Morocco coasts

- For a large area of the Gloria fault and SW of Cadiz Gulf the gains are larger than 30 min

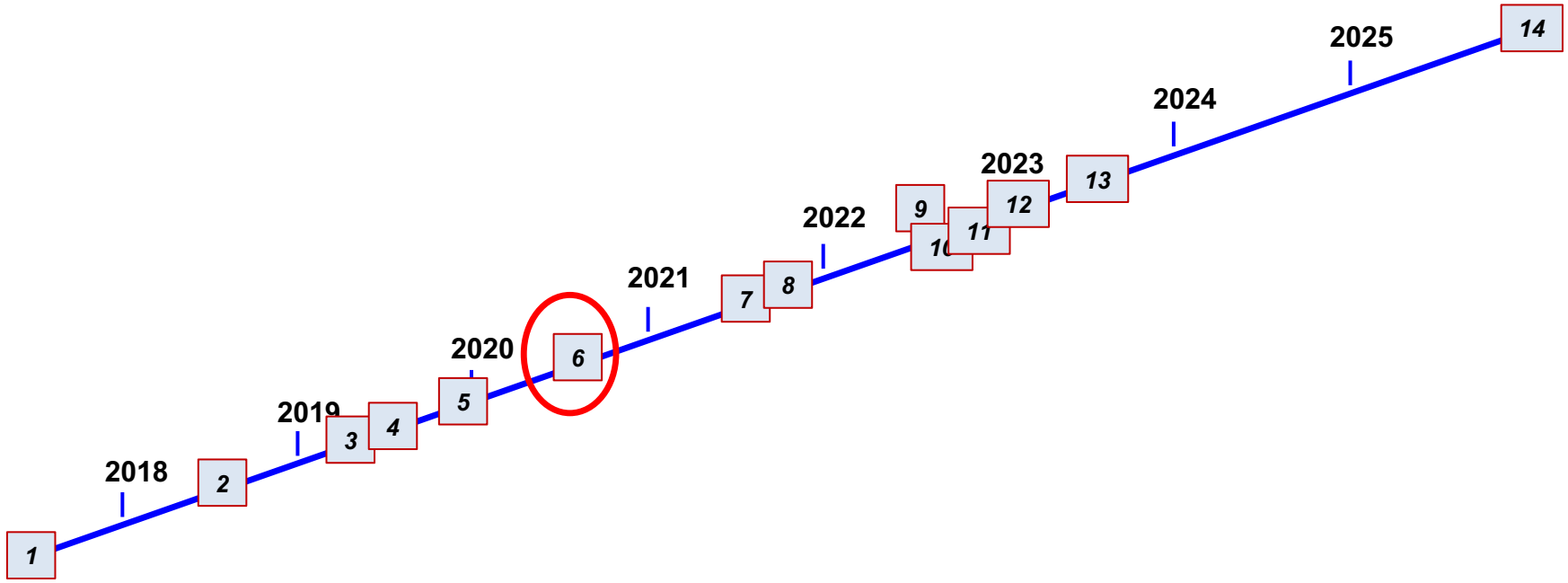
SMART CAM timeline

1. **July 2017.** Due to the expected end of life for 2024 (with a Ring configuration) of the actual CAM Ring, **ANACOM called attention** to the sector that **timely** preparations would need to be made **for the replacement of the current CAM Ring** (critical infrastructure that assures domestic traffic between Portugal mainland and Azores and Madeira Islands).



SMART CAM timeline

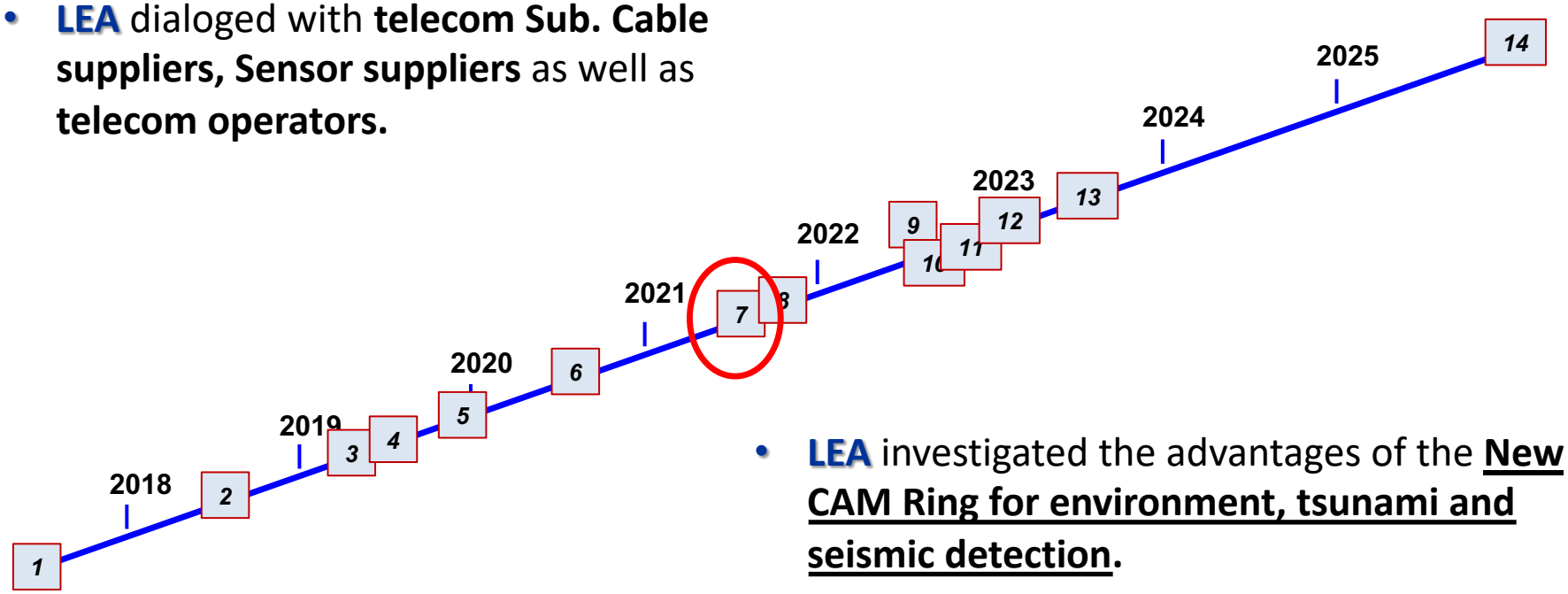
6. **September 2020,** The Government appoints **IP Telecom (100% State owned)** to deliver a business case and a list of specifications for the new CAM Ring **with seismic and environmental detection capabilities**.



SMART CAM timeline

7. **July 2021.** IPTelecom delivered to the Government a proposal of business case and a **list of specifications of the new CAM Ring as a SMART Cable** ("SMART CAM" to facilitate).

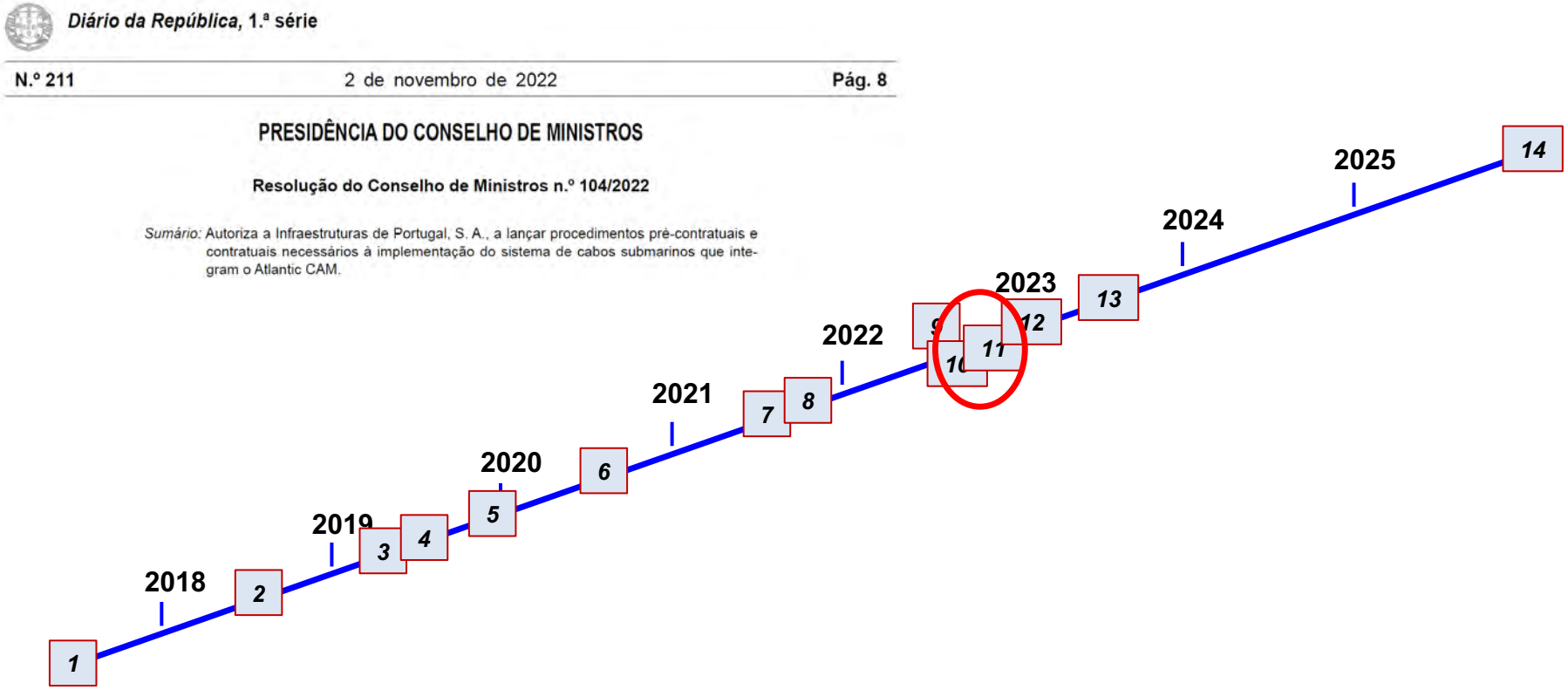
- **LEA** dialoged with **telecom Sub. Cable suppliers, Sensor suppliers** as well as **telecom operators.**



- **LEA** investigated the advantages of the **New CAM Ring for environment, tsunami and seismic detection.**
- **LEA delivered to IP Telecom a full packet of SMART specs. for the New CAM Ring.**

SMART CAM timeline

11. **November 2022**. By a Governmental Resolution, IP is attributed the competences for the full implementation of the Atlantic CAM.



Diário da República, 1.ª série

N.º 211 — 2 de novembro de 2022 — Pág. 8

PRESIDÊNCIA DO CONSELHO DE MINISTROS

Resolução do Conselho de Ministros n.º 104/2022

Sumário: Autoriza a Infraestruturas de Portugal, S. A., a lançar procedimentos pré-contratuais e contratuais necessários à implementação do sistema de cabos submarinos que integram o Atlantic CAM.

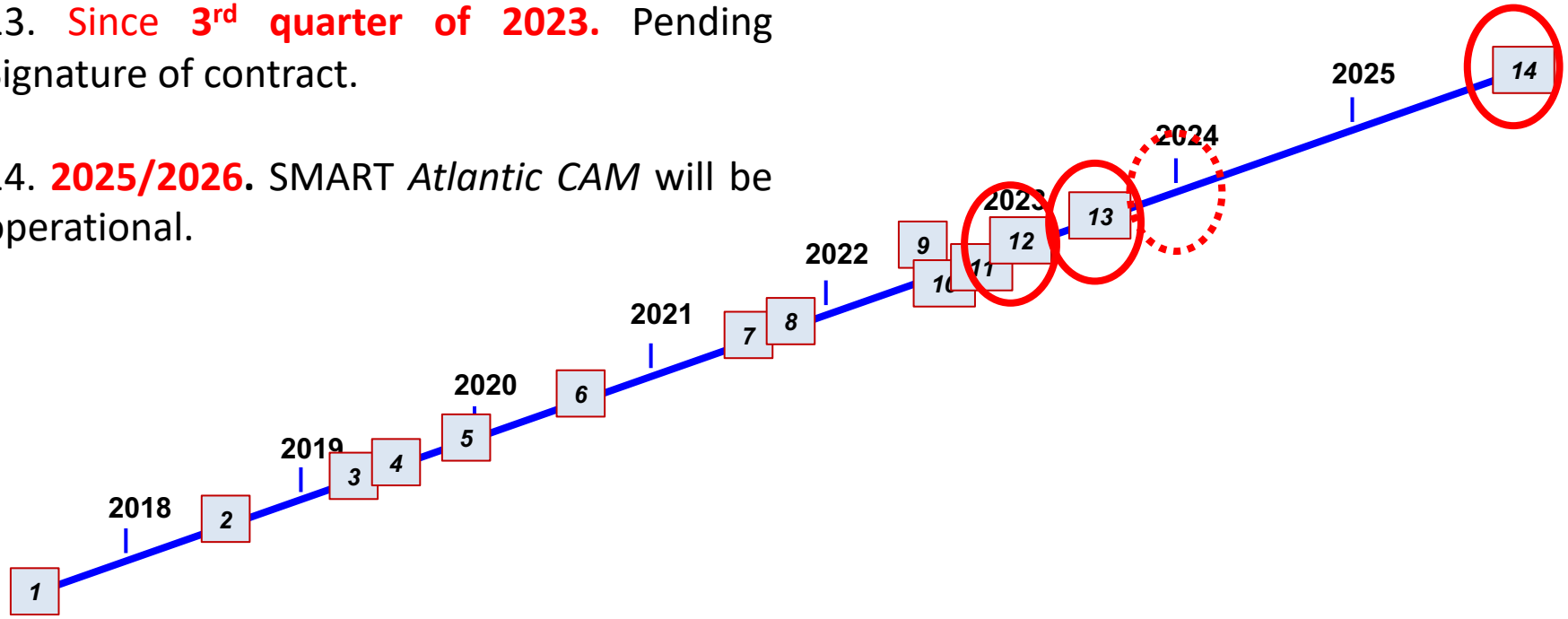
SMART CAM timeline

12. **December 2022**. IP launches the SMART *Atlantic CAM* RfT.

Next steps:

13. Since **3rd quarter of 2023.** Pending Signature of contract.

14. **2025/2026.** SMART *Atlantic CAM* will be operational.



Thank you!

NORDUnet
Nordic Gateway for Research & Education

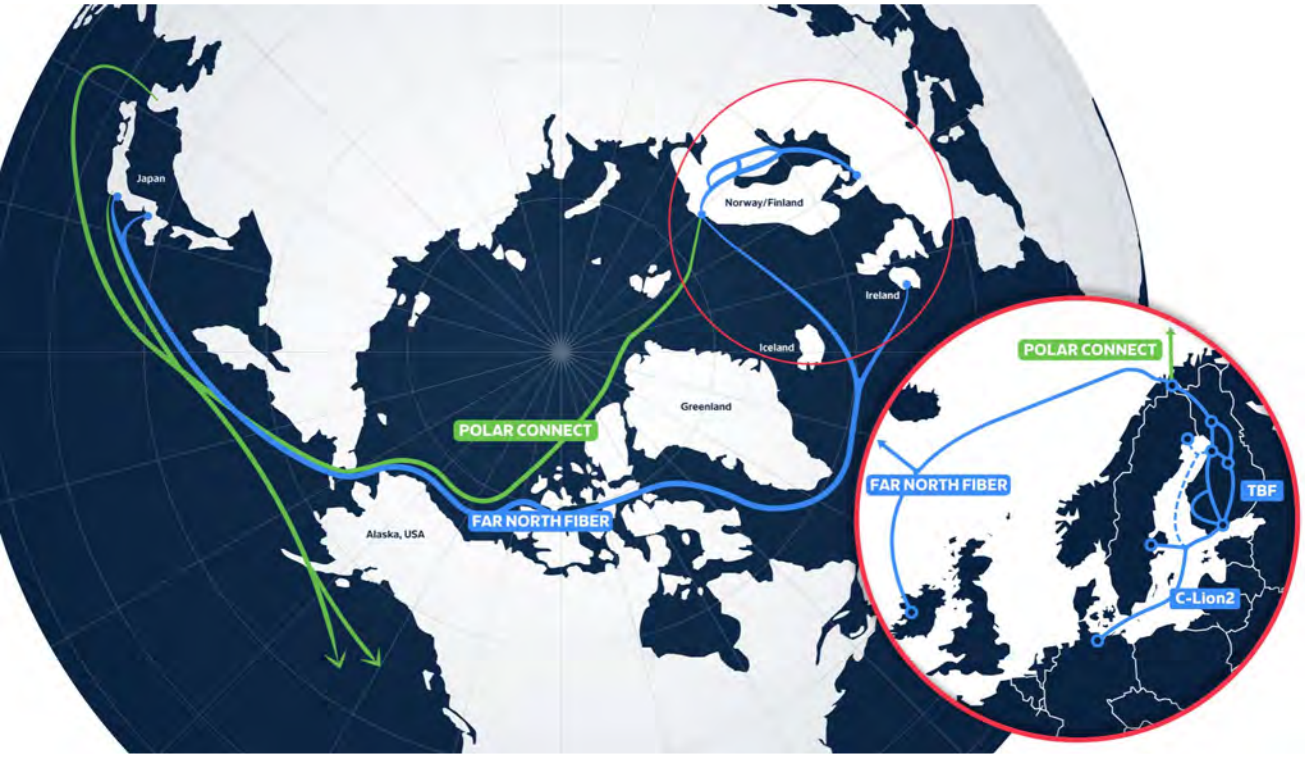
POLAR CONNECT

Ieva Muraškienė

JTF SMART Cables meeting

20 January 2024

Northern EU Gateways project



Cinia

NORDUnet
Nordic Gateway for Research & Education

Co-funded by
the European Union

Task 5.3 Sensing cable technologies

- Feasibility study to identify and evaluate the Arctic opportunities and obstacles in the field of sensing cable technology.
- Impact of using sensing cable technologies on science especially in the fields of climate change, marine biology, oceanography, and seismology.

Co-funded by the European Union

61

Workshop
Science opportunities on Polar Connect

- 3-4 October 2023 in Oslo, Norway
- Technology experts meet Arctic researchers
- Thinking without the limitations of current technology
- Workshop report with insights from technology and science synergy

Co-funded by the European Union

NEW POLAR RESEARCH VESSEL

Sweden to acquire and operate a modern climate-neutral polar research vessel

Concept illustration of the new polar research vessel. Illustration by Peter Mild.

THANK YOU FOR YOUR ATTENTION!

For more information:

ieva@nordu.net

NORDUnet
Nordic Gateway for Research & Education

Update: NSF Antarctic Subsea Cable

National Science Foundation
Office of Polar Programs

- **22 September 2023: Program Management Contract award to Global Broadband Solutions, LLC (GBS)**
  - Two-year Period of Performance. Scope:
    - Establish Project Management Office support to NSF OPP
    - Alignment of Concept Formulation with the NSF Research Infrastructure Office guidance for Major Facilities program development
    - Facilitate input from research community on science requirements for cable route and sensors (e.g., SMART, Distributed Fiber, Branching Units) to inform cable route/cable engineering
    - Develop requirements for a future detailed Marine Route Survey
- **22 December 2023: GBS Delivery of Supplemental Feasibility Study (augment to Comprehensive Desktop Study - DTS)**
  - Scope to assess issues flagged by DTS such as: ice scour risk, cable landing risk at McMurdo, sea ice cover risk to cable ships, cable industry interest, qualified cable ships for ice operations
  - Report asserts “no show-stoppers”
  - Report under review by NSF
- **27 December 2023: GBS Public Release Edition of Comprehensive DTS Posted**
  - https://www.nsf.gov/news/news_summ.jsp?cntn_id=308774&org=OPP

Patrick Smith, NSF/GEO Office of Polar Programs, Antarctic Infrastructure & Logistics Section; pdsmith@nsf.gov

JTF – Climate Change Solution Honolulu

Emmanuel DANJOU

20th January 2024

ASN sustainable commitment

Alain Biston | President of ASN

ASN's CEO words on sustainibility

"Today, at ASN, **our vision** is for all projects, to make our customers and partners constantly **trust ASN's ability to think ahead**, develop and implement subsea optical fiber networks throughout the world in **a responsible and sustainable way**. We want to actively contribute to a **greener future** for the benefit of the next generations and the planet while achieving our mission: **connecting the world in a responsible and sustainable way**."

ASN's values

Sustainability is no longer a nice to have but a must have for sustainable business and is part of ASN Values.

"Strive to protect our employees, suppliers, partners & customers health and safety at work. Respect human rights & make sure they are a priority for each employee and business partner. Care about our environment while achieving sustainable growth."

Agenda

1. ASN leadership and commitment on environmental subjects.
2. Monitoring the Climate Change with which solutions?
3. Summary

ASN leadership and commitment on environmental subjects

Climate Change and Sustainability are essential for our future

In 2021, **Green Charter developed** in order to demonstrate its leadership & commitment on environmental matters

ISO 14001 certification
develop a robust **environmental management system on all our sites**

Science-based target 1.5
aim to reach **zero net CO_2 emission** by 2050 *(as a Nokia subsidiary)*

ASN Part of the **Sustainable Subsea Network**

Waste management improvement
aim to reach the target of **100% of waste recycled**
& reduce the quantity of waste

Paper saving: - 19,5% the consumption (= 12 Paris NY by flight)

Reduce CO_2 emission
by offering new possibilities like the Factory Acceptance and Customer's audit *(FAT audit)* in **remote mode**
And by developing a **mobility plan** for employees commuting

Business travel: - 230 tons of CO2 in 2021 vs 2020

Climate ambassadors
20 ASN employees participating in environmental project

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

New products to reduce our environmental impact & support scientific

- CC-Nodes: **high accuracy sensors integrated in subsea cables to monitor climate change & ocean hazards**
- OptoDAS: subsea environment and CO_2 storage monitoring, earthquake detection and ocean fauna protection
- SDM: optimized design with the thinnest 24 FP cable on the market
- SLTE: latest DSP silicon integrated circuits enables greener and more sustainable networks with better power efficiency
- Smart Glasses: interactive and efficient remote support and training…

Energy Saving

- Heat recovery = to heat up 30% of the administrative offices.
- Solar Panels: in cable factory, HQ and in our CLS
- Water reduction for cable testing
- "3R" principles: Reduce/ Reuse and Recycle
- Life Cycle Assessment: ASN produced the LCA of a subsea cable…

Marine fleet

- Biofuel: **Available for our vessels to get Clean Cable Operations CCOp**
- New vessels which are more efficient and consume less fuel
- Shore power installations to reduce the environmental impact in port
- Optimization of the transit routes using the most recent technical solutions run by Artificial Intelligence *(AI)*
- Mobilization of regionally based chartered vessels to reduce transits…

2. Monitoring the Climate Change with which solutions?

ASN technologies toolbox – 3 complementary technologies

SOP

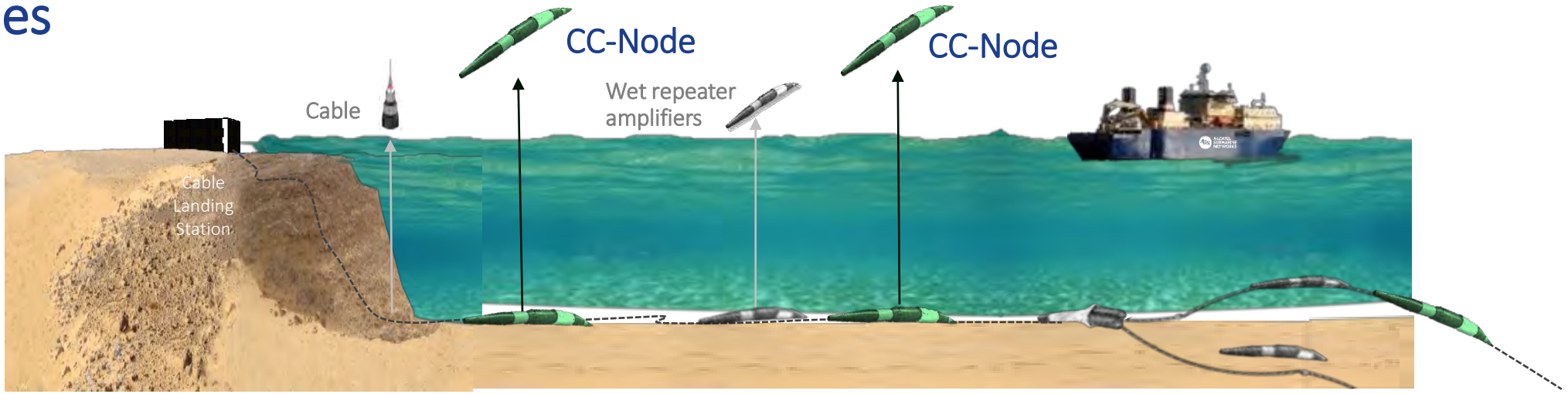
Polarisation/Phase: listen to the fiber along the full cable length

DAS

Acoustic sensing up to the first repeater or on new system up to 150km

SMART/ CC-Nodes

CC nodes can be put at any location - Monitor the events in real time 24/7



OptoDAS applications of monitoring

Surveillance

- Surface vessels
- Scientific measurements
- Marine life
- Explosion

Cable condition

- Abrasion
- Cable movement
- Burial depth
- Thermal changes
- Discharges

Cable threat

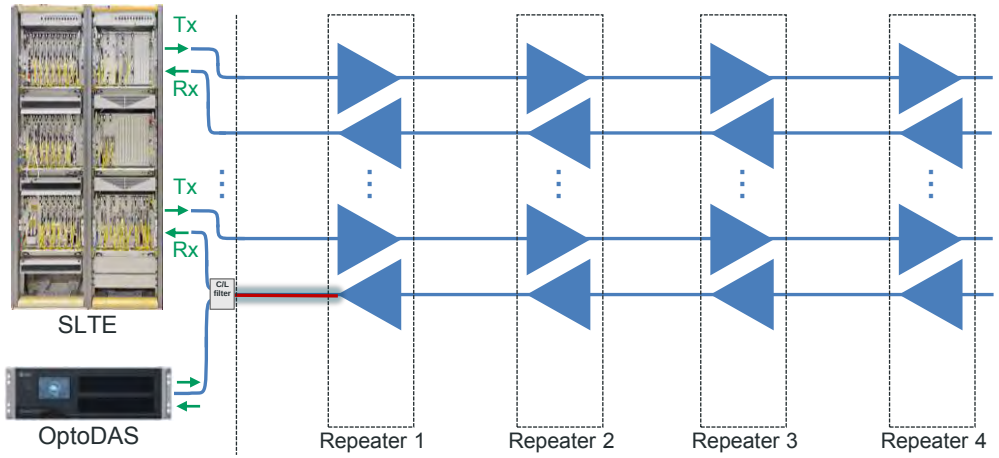
- Seabed fishing
- Anchoring
- Marine operations (cable lay, trenching, boulder relocation, dredging, …)
- Sabotage, physical contact

DAS sensing on submarine telecom networks

⌘ **On existing networks** – coexisting with traffic

- No interference between OptoDAS and live traffic
- Range: Down to 1st repeater (70 - 120 km)

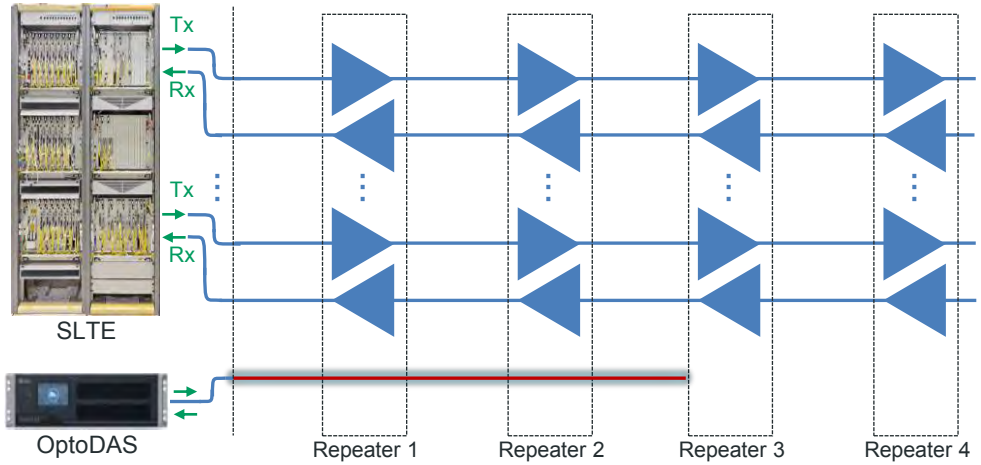
L-band DAS



⌘ **On new networks** – bypassing repeaters

- Enables full exploitation of measurement range achieved with OptoDAS
- Range: 150 km (potentially 200 km in future)

Repeater bypass



SMART cable – JTF initiative and concept

The Science Monitoring And Reliable Telecommunications (SMART) initiative is a Joint Task Force led by ITU, WMO, and UNESCO-IOC.

The SMART cable challenge is to get Dual use: bridging Telecom & Science

Focus on key areas => Climate Change

- Monitoring better earthquakes and tsunamis
  - 72% of tsunamis are caused by seafloor displacement from large submarine earthquakes
  - Until recently, the Pacific Tsunami Warning Center (PTWC) based warnings solely on earthquake location and magnitude

  => Improved data and modeling are needed to accurately assess impact of tsunamis - **Tsunamis Warning**
- Observing global warming and sea level rise
  - Current global warming trends are irreversible, with a projected increase of 1.5°C this century; this could reach 5°C without a reduction in CO_2 emissions
  - Sea level projections estimate a rise of around 65cm by 2100

  => More reliable data is necessary for accurate sea level projections

Key features of SMART cables:

- Sensors to measure temperature, pressure, and seismic acceleration
- Enhance the Global Seismic Network (GSN) with accelerometers along cable routes
- Provide sustained and recurrent climate-quality data from under-sampled ocean areas

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

ASN Climate Change solution on SMART technology

ASN takes benefit of widely deployed and well established wet plant product line platforms to customize them to accommodate dry and wet sensors in our Climate Change Node (CC-node).

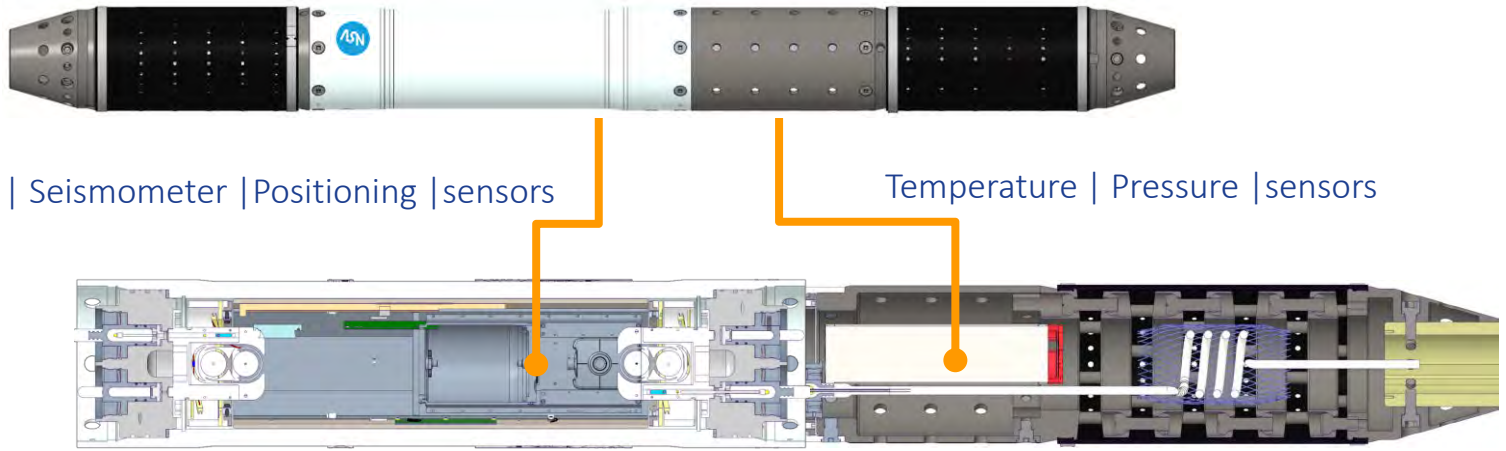
Main highlights :

Key Sensor suppliers are selected

- Customization of respective product on-going to match CC-Node requirements for Wet and Dry sensors

Main Achievements

- Adaptation of ASN platform to properly host them progressing on schedule
- Proprietary communication protocol to gather accurate data pack on shore
- Partnership established with external test facilities to support specific needs



ASN CC-Node

CC-Node: Compliance and Innovations in Specifications

- **Alignment with JTF Standards:** we largely aligns with the Joint Task Force's (JTF) specifications, showcasing its adherence to scientific expectations.
  - **Seismometer Integration:** Exceeding JTF's requirements, the inclusion of a seismometer in the standard configuration enhances the cable's capabilities for earthquake and tsunami detection.
  - **Temperature Specification Exception:** Despite non-compliance with JTF's temperature specifications, this deviation seems not to be an issue for the community.
- **Flexible CC-Node placement :** The introduction of dedicated nodes for sensors allows greater flexibility in positioning the CC-Nodes, independent of the repeaters' bodies.
- **Challenges in transmission data & Power**: The transmission of sensor data to shore and the power consumption of sensors require further optimization.
- Integrate CC-Nodes on new systems from other suppliers for repeated and unrepeated system.

CC-Node: Enhanced Telecom-Sensor Separation

- **Distinct channels for Telecom and Sensors:** The design distinctly separates telecommunications repeaters from sensor nodes (CC-node), ensuring minimal interference.
- **Dedicated Fiber Pair for sensor data:** A dedicated fiber pair for sensor data transmission ensures the integrity and prompt delivery of crucial information, critical for early warning systems and other applications.
- **Specialized Monitoring & Management Systems:** The project includes dedicated systems for the monitoring, analysis, and management of both telecom and sensor data.

3. Summary

CC-node & DAS technology : complementary measurements

+

- **Introduction of DAS Technology**: Integrating Distributed Acoustic Sensing (DAS) technology complements the standard sensors, providing additional seismic data and measurement redundancy.
- **Broader Applications**: Beyond seismic monitoring, DAS is valuable for acoustic applications like vessel monitoring, cable integrity and surveillance, and wildlife monitoring, including tracking whale movements.
- **Current Capabilities and Expansion**: Our DAS system is not only installable on a fiber pair in traffic up to the first repeater but is also currently extendable beyond the first repeater on a dedicated fiber pair. Future ambitions include further expansion of this capability on several spans from the shore.

Applications and positioning of the ASN technologies

Technology	Parameters	Spatial resolution	Maximum range	Sensitivity	Key applications / remarks
SOP (straight)	Polarisation	None - integrated signal	1000's of km	Low sensitivity to environmental events	• Very low cost – generic trans. eqpt • Seismic data collection • Deep sea data collection
Polarisation or Phase loopback	Phase delay	= span between repeaters	1000's of km	Low sensitivity to environmental events	• Cable monitoring • Seismic data collection • Deep sea data collection
DAS	Dynamic fibre strain	2-40m	150km	High	• Subsea asset protection • Geophysics • Mammals monitoring
SMART cable	Temperature Acceleration Pressure Sismometer	Sensor accuracy highest resolution	unlimited	Very high	• Tsunami warning • Seismic • Geophysics • Global warming

Possibility to combine the technologies in the same system.

Integrate solution(s) on new systems included other suppliers for repeated and unrepeated system.

Think ahead, trust ASN

SMART Cables:

Current Developments and Future Directions

SUBSEA DATA SYSTEMS

Steve Lentz, CTO

January 2024

SUBSEA DATA SYSTEMS: TEAM

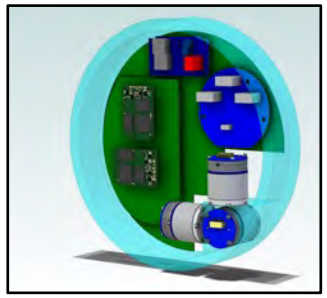
Matt Fouch, President and Co-Founder

- Also Chief Scientist, Samara/Data
- Former Professor of Geophysics, Arizona State University
- Former Staff Scientist, Carnegie Institution of Washington
- Member, JTF SMART Cables

Steve Lentz, CTO and Co-Founder

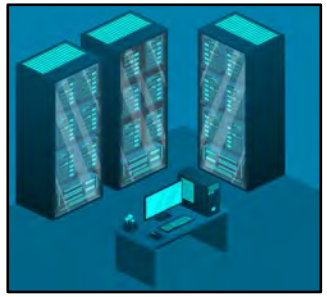
- Also Director of Network Development, Ocean Specialists Inc.
- Former Chief Architect, NEPTUNE Canada
- Chair, Engineering Subcommittee, JTF SMART Cables

SUBSEA DATA SYSTEMS: SERVICES



SMART Cable Sensor Systems

- Integrated sensor solutions for submarine fiber cable suppliers
- Consulting services for SMART cables and built-for-purpose cabled systems



SMART Cable Data Management

- Calibration / validation (Cal/Val) of SMART sensor systems
- Trusted partner in SMART data Quality Assurance / Quality Control (QA/QC)

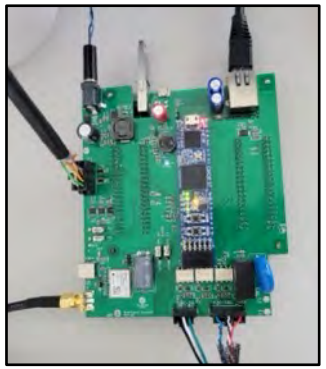
SMART Cable Data Products

- Bespoke SMART data products for cable operators and government agencies
- System monitoring and event alerts for enhanced cable security and integrity

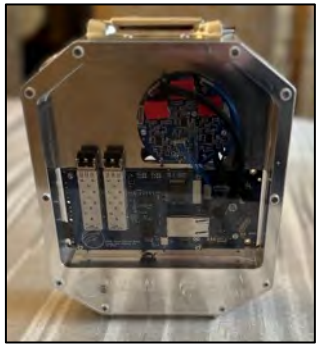
SUBSEA DATA SYSTEMS

SDS Hardware Development Plan

- **Phase 1: Proof of Concept**
  - Develop initial data collection, storage, and transmission protocols
  - Evaluate sensor integration complexity and develop detailed specifications for next phase
  - **Milestone**: Benchtop test of sensor data delivery to SAGE Data Repository



- **Phase 2: Integration with Repeaters**
  - Develop functional blocks following best practices
  - Develop circuit board design and embedded systems
  - **Milestones**: Fully functional firmware/software; wet test in off-the-shelf housing (shallow water)



- **Phase 3: Commercial Development**
  - Complete integration into repeater
  - **Milestone:** Wet test via sea trial

SDS SMART Repeater Sensor System

3-Axis Omni-Tilt Seismic Sensor

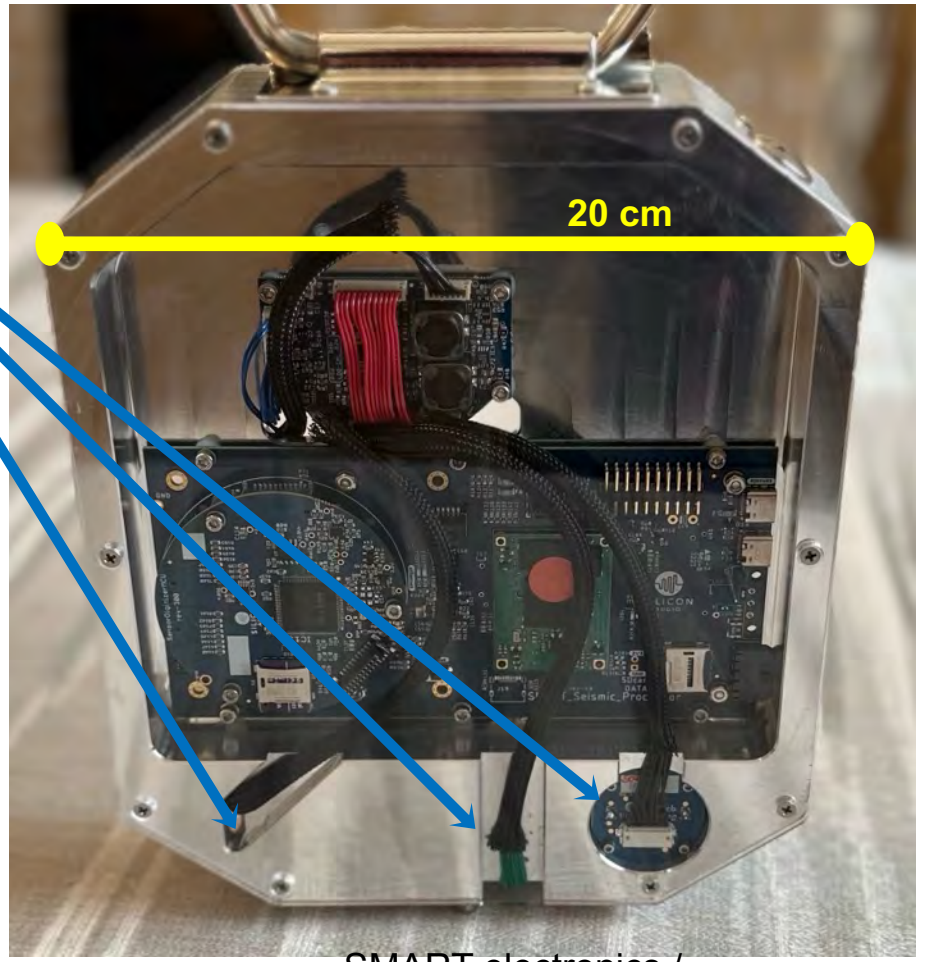
- Low-noise intermediate band switchable seismometer
- **Silicon Audio 205 (acceleration); 215 (velocity)**
- 0.01 to 500 Hz bandwidth
- Best in class noise performance
- 183 dB dynamic range (high+low gain digitization)
- 30 mm diameter x 35 mm length (each sensing element)

Temperature Sensor (external)

- Glass Coated Thermistor (GCT)
- **Sea-Bird SBE 03S**
- ±0.002ºC accuracy
- Maintains calibration over time
- 49 mm diameter x 256 mm length

Pressure Sensor (external)

- Absolute Pressure Gauge (APG)
- **Paroscientific 4*K-101-0**
- 1 part in 10^7 resolution
- Few parts in 10^6 accuracy; mainly limited by drift
- Signals of interest between 0.001 and 1 Hz
- 35 mm diameter x 108 mm length



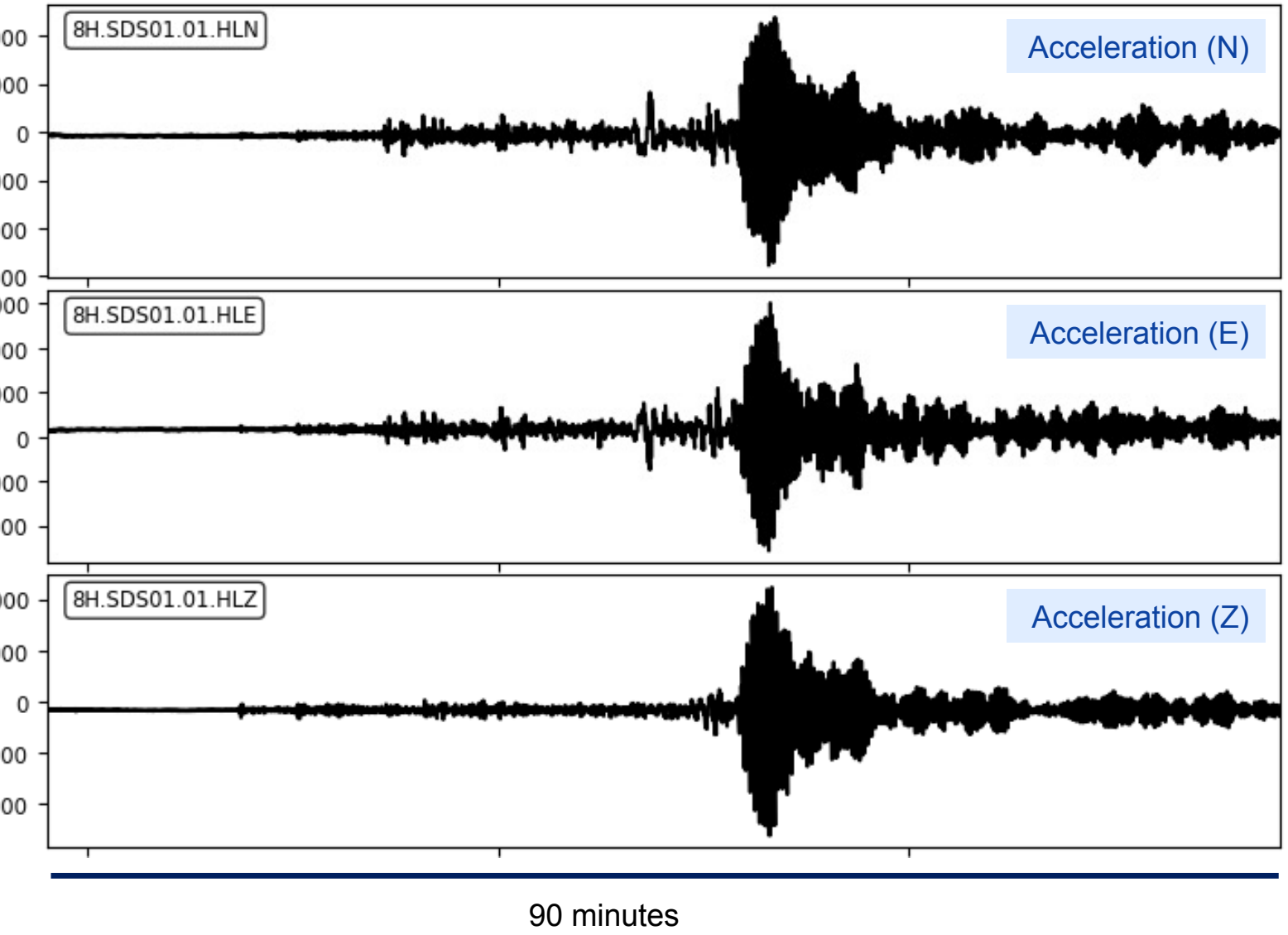
SMART electronics /

seismic sensor in ~20cm / 8in radius cylinder

SUBSEA DATA SYSTEMS

SMART SENSOR SYSTEM DATA

SDS SMART SEED Data
Retrieved from SAGE Data Repo via ObsPy
Raw data
Amplitudes autoscaled for each trace



Loyalty Islands M 7.7 mainshock
2023-05-19 02:57:03 (UTC)
18.0 depth
~11,400 km source – receiver distance

TSUNAMI OBSERVATIONS

* THE FOLLOWING ARE TSUNAMI WAVE OBSERVATIONS FROM COASTAL AND/OR DEEP-OCEAN SEA LEVEL GAUGES AT THE INDICATED LOCATIONS. THE MAXIMUM TSUNAMI HEIGHT IS MEASURED WITH RESPECT TO THE NORMAL TIDE LEVEL.

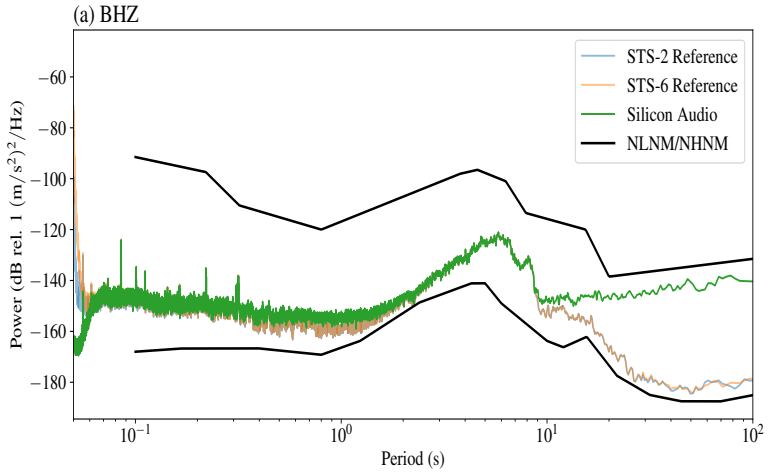
GAUGE LOCATION	GAUGE COORDINATES LAT	LON	TIME OF MEASURE (UTC)	MAXIMUM TSUNAMI HEIGHT	WAVE PERIOD (MIN)
LENAKEL VU	19.5S	169.3E	0511	0.61M/ 2.0FT	04
EAST CAPE NZ	37.6S	178.2E	0544	0.11M/ 0.4FT	08
FISHING ROCK RAOUL	29.3S	177.9W	0535	0.15M/ 0.5FT	04
RAOUL IS BOAT COVE	29.3S	177.9W	0523	0.07M/ 0.2FT	06
NORTH CAPE NZ	34.4S	173.0E	0532	0.21M/ 0.7FT	06
HIENGHENE NEW CALED	20.7S	164.9E	0454	0.03M/ 0.1FT	20
THIO NEW CALEDONIA	21.6S	166.2E	0409	0.07M/ 0.2FT	20
MARE NEW CALEDONIA	21.5S	167.9E	0413	0.19M/ 0.6FT	06
OUINNE NEW CALEDONI	22.0S	166.7E	0406	0.20M/ 0.7FT	08
LIFOU NEW CALEDONIA	20.9S	167.3E	0400	0.12M/ 0.4FT	06

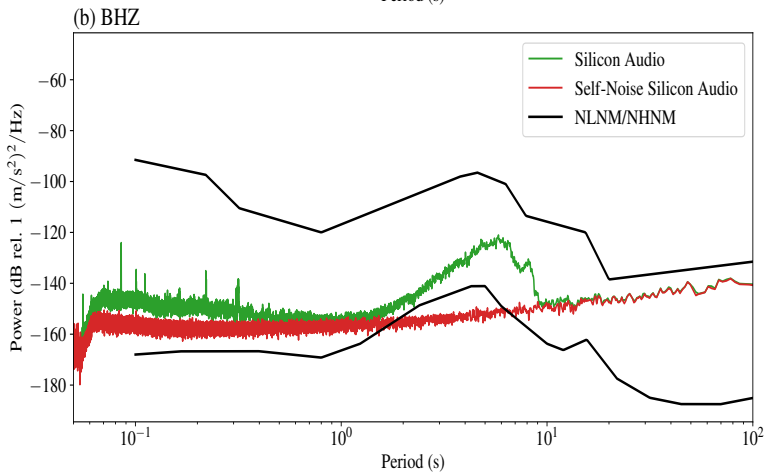
Minimal tsunami observed in
Vanuatu, New Caledonia, and New Zealand

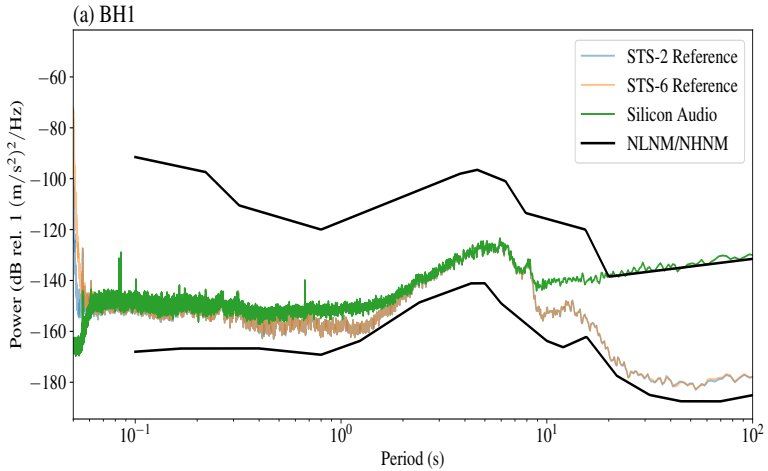
SUBSEA DATA SYSTEMS

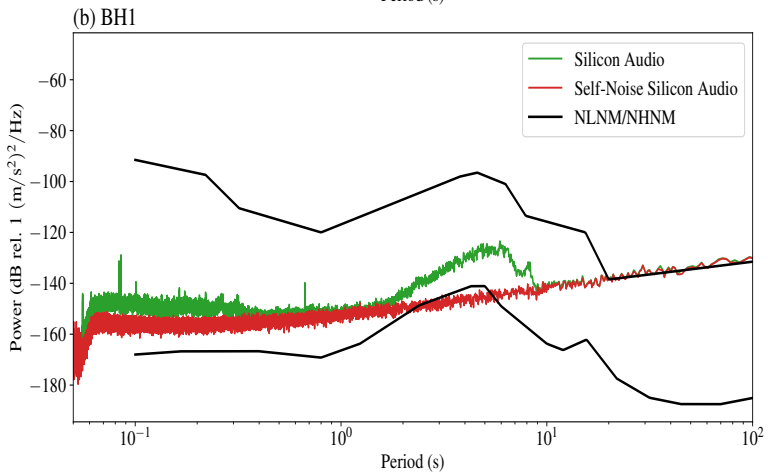
Continuous operation since August 2022

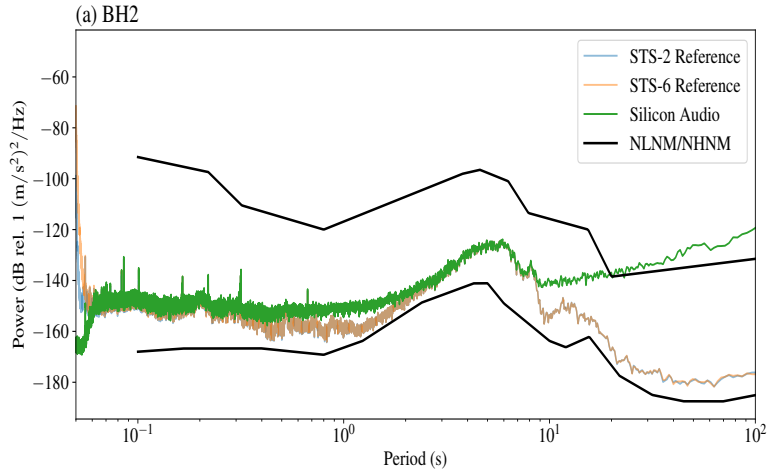
Seismic Noise Plots: Silicon Audio Low-Noise Omni-Tilt

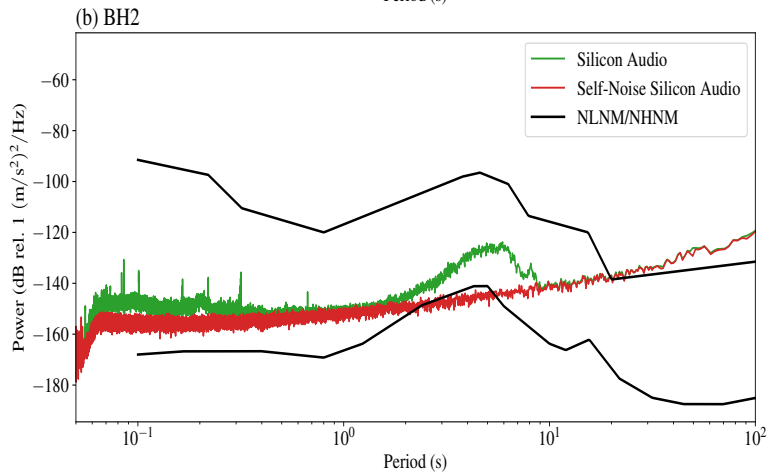








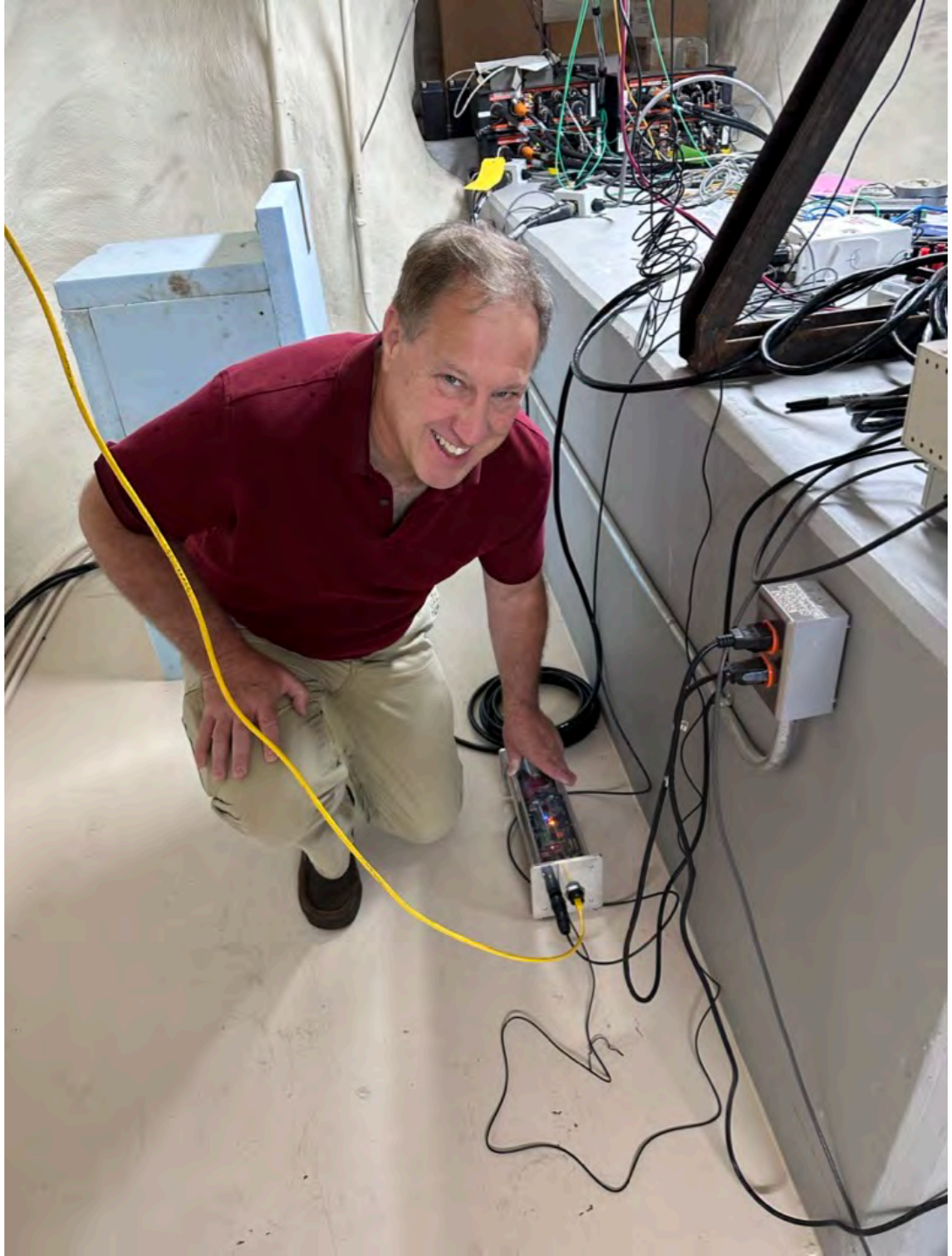


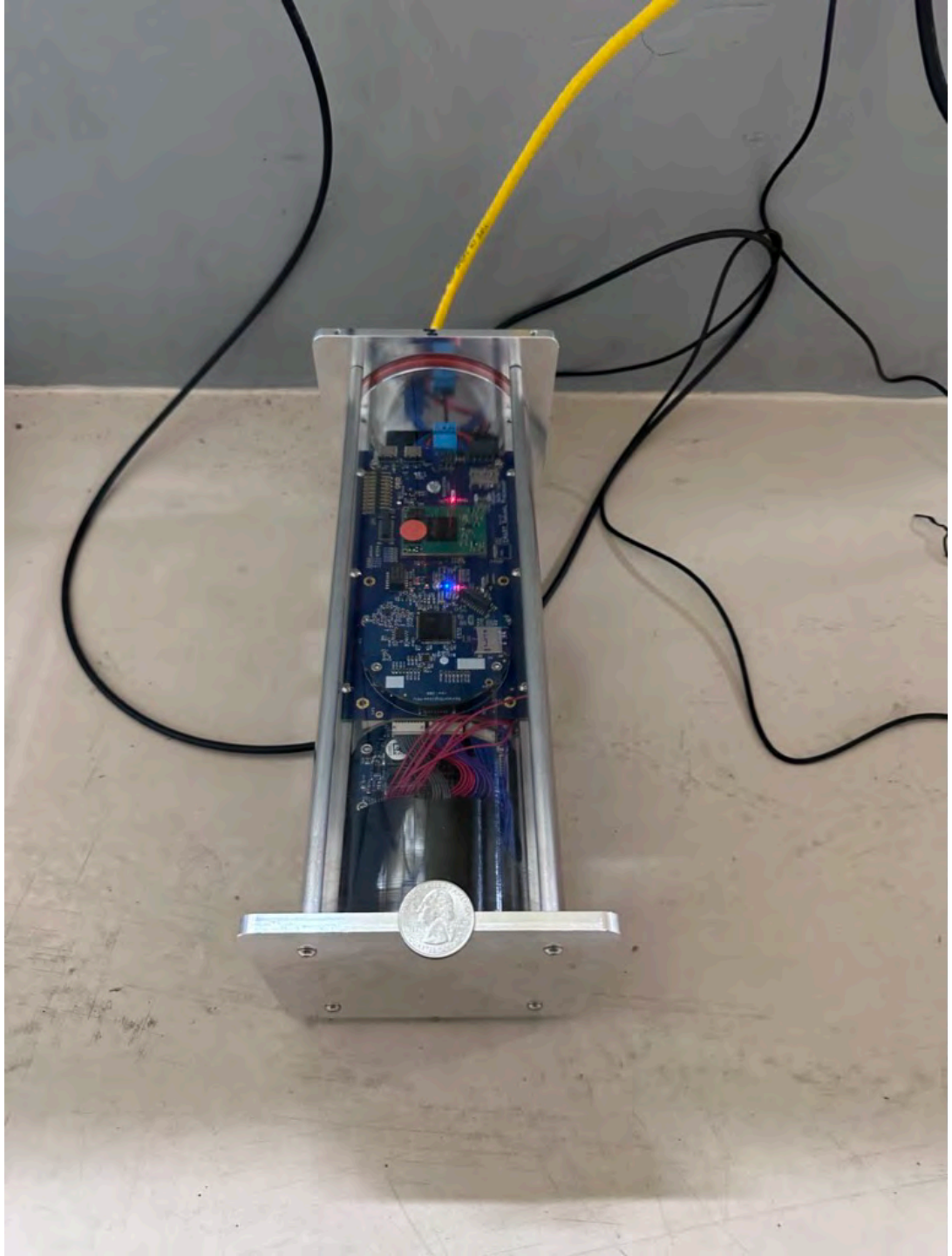


- Tested at U.S. Geological Survey's Albuquerque Seismological Lab (USGS ASL) in Fall 2023
- Nearly identical response to STS-2 (surface) and STS-6 (borehole) reference sensors to 10s on all components
- Response remains below/near high noise model at longer periods
- Self-noise remains near/below low noise model out to 10s

Data analysis courtesy of Dr. Adam Ringler, USGS ASL


Styrofo
Square Edge





SDS SMART SENSOR DEVELOPMENT

Our Solution

- SDS is finalizing a complete solution for SMART sensor systems including Seismic, Pressure, Temperature, Data Acquisition, Embedded Processor, Communications, Power and Isolation
- Sensors are tightly integrated to data acquisition and communications
- Our solution provides added value by serving miniSEED data directly from the repeater
- Each repeater is a data server; however, we recommend a ring buffer at the shore station for security

Timeline

- We expect to have the seismic sensor and processor ready by end of 2023 (completed)
- We expect to have a complete sensor solution ready in mid-2024 (ready for freshwater testing)
- Available to discuss solutions with all cable suppliers
- Current timeline is constrained by funding and people resources

BACKUP SLIDES

SDS SMART HARDWARE

Data Processing Unit

- Subsea Data Systems SMART system

Temperature Sensor

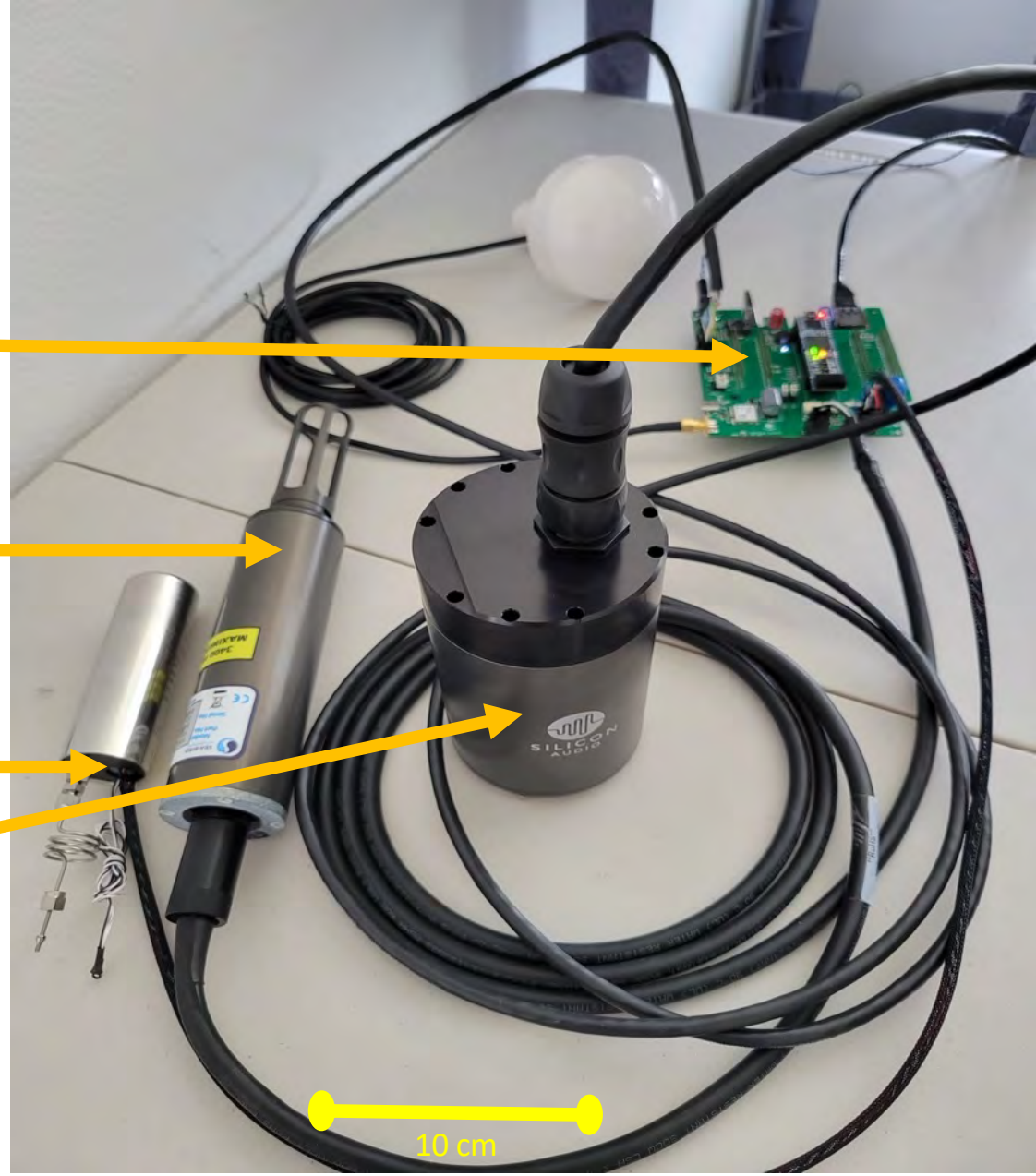
- Seabird Glass Coated Thermistor (GCT)

Pressure Sensor

- Paroscientific Absolute Pressure Gauge (APG)

3-Axis Seismic Sensor

- Silicon Audio high performance switchable accelerometer / seismometer



2.7 Watts total power consumption

SDS SMART
DATA PROCESSING UNIT

Ethernet Interface

FPGA

- COTS Daughter board
- Pressure and Temperature sensor frequency counts

Seismic Sensor Input

- Digitizers are in sensor housing

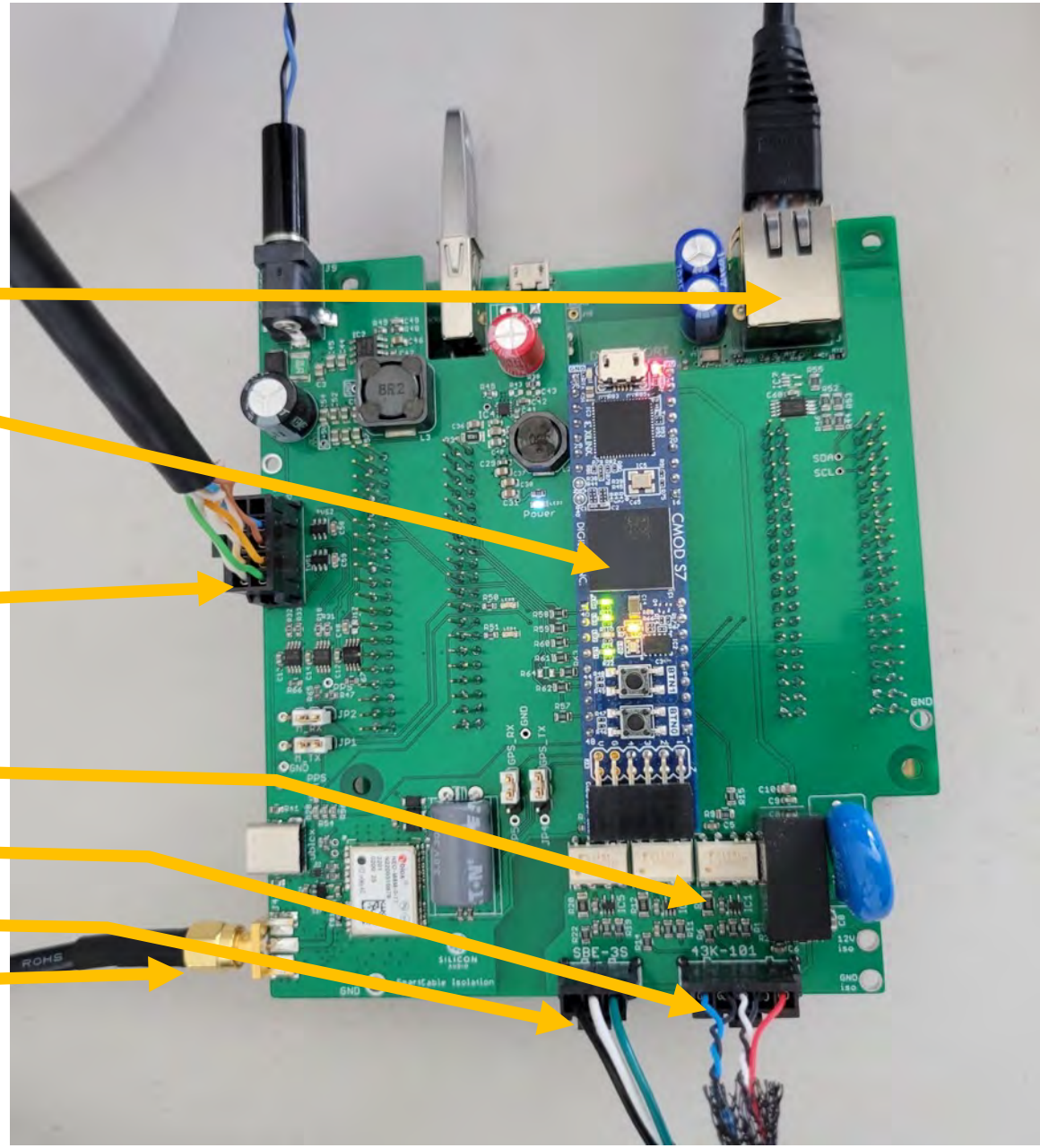
External Sensor Electrical Isolation

Pressure Sensor Input

Temperature Sensor Input

Timing (PPS) Input

- Using GPS for now;
  will migrate to PTP in Phase II



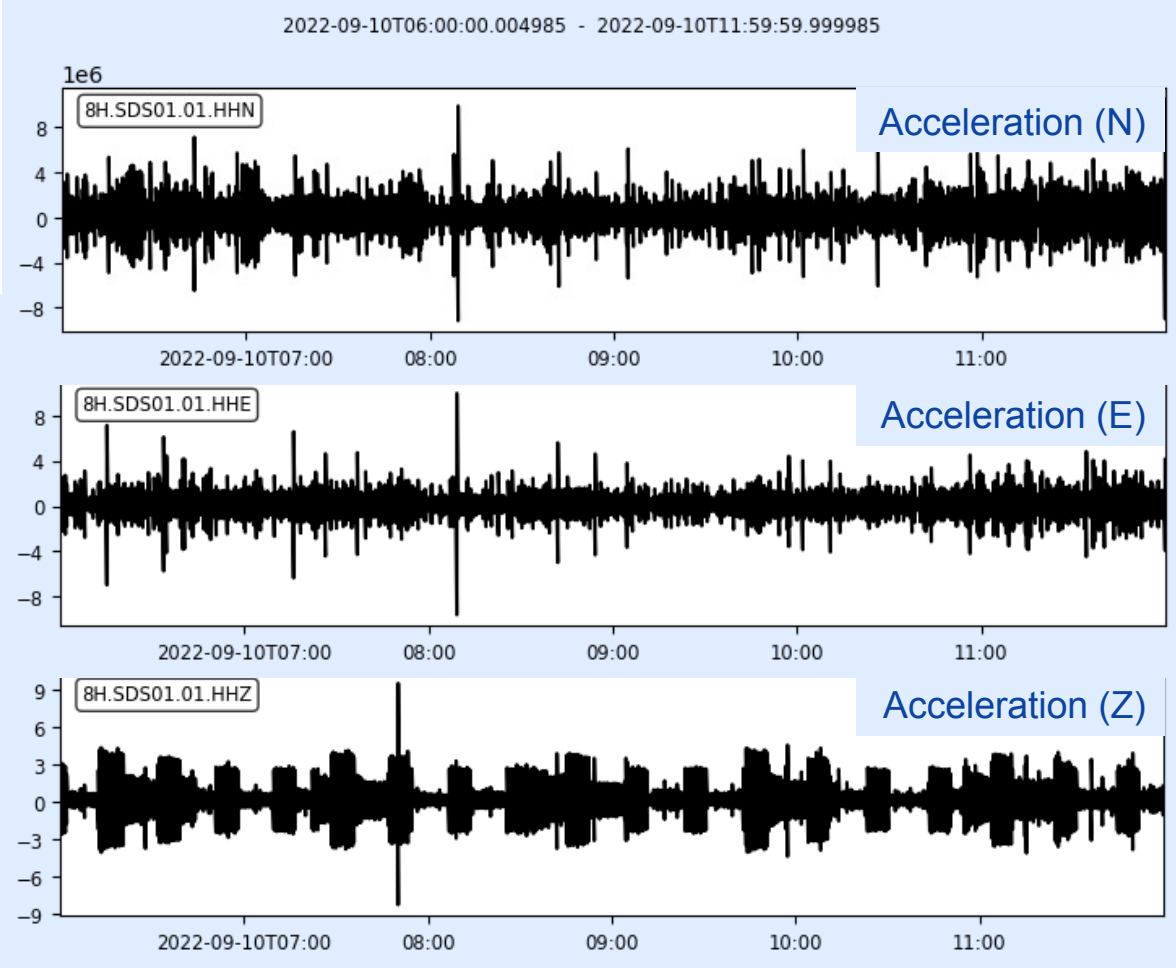
SMART Technology Readiness Levels

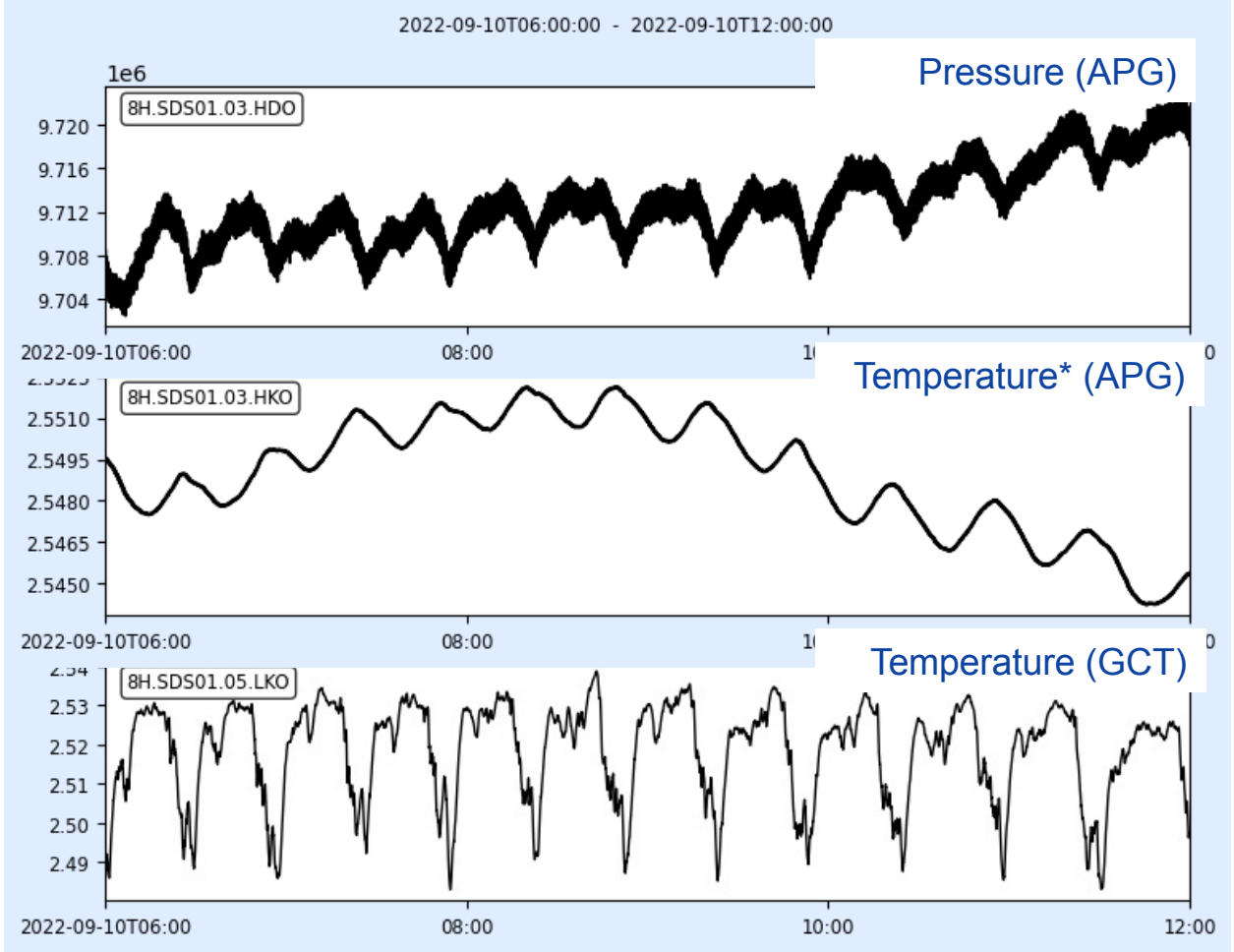
Level	Definition	SMART Repeater Requirements	SDS Status
TRL1	Basic principles observed and reported	Objective of seabed sensors in submarine cables stated; Existing sensor types identified; Telecom cables identified as key enabler.	**Completed**
TRL2	Technology concept and/or application formulated	Technical challenges and potential solutions identified.	**Completed**
TRL3	Analytical and experimental critical function and/or characteristic proof-of-concept	Electrical and mechanical design concepts developed and assessed.	**Completed**
TRL4	Component and/or breadboard validation in laboratory environment	Benchtop demonstration including streaming to data repository.	**Completed**
TRL5	Component and/or breadboard validation in relevant environment	Prototype testing in shallow water.	**2024 Q2 target (planning stages)**
TRL6	System/subsystem model or prototype demonstration in a relevant environment	Sea trial of SMART sensor system mounted in repeater housing.	**2024 target (planning stages)**
TRL7	System prototype demonstration in a space (subsea) environment	12-18 month trial of system with multiple SMART repeaters.	**2025 target**
TRL8	Actual system completed and "flight qualified" through test and demonstration	Prototype system delivered and commissioned.	**2025 target**
TRL9	Actual system "flight proven" through successful mission operations	First "generally available" product delivered and commissioned.	**2026 target**

Fouch and Lentz, 2022

SMART Sensor System Data

SDS SMART SEED Data
Retrieved from SAGE Data Repo via ObsPy
Raw data
Amplitudes autoscaled for each trace





6 hours

APG = Absolute Pressure Gauge (Paros Scientific)
GCT = Glass Coated Thermistor (Sea-Bird)
* APG temperature used to correct raw APG pressure signal

SUBSEA DATA SYSTEMS

Continuous operation since August 2022

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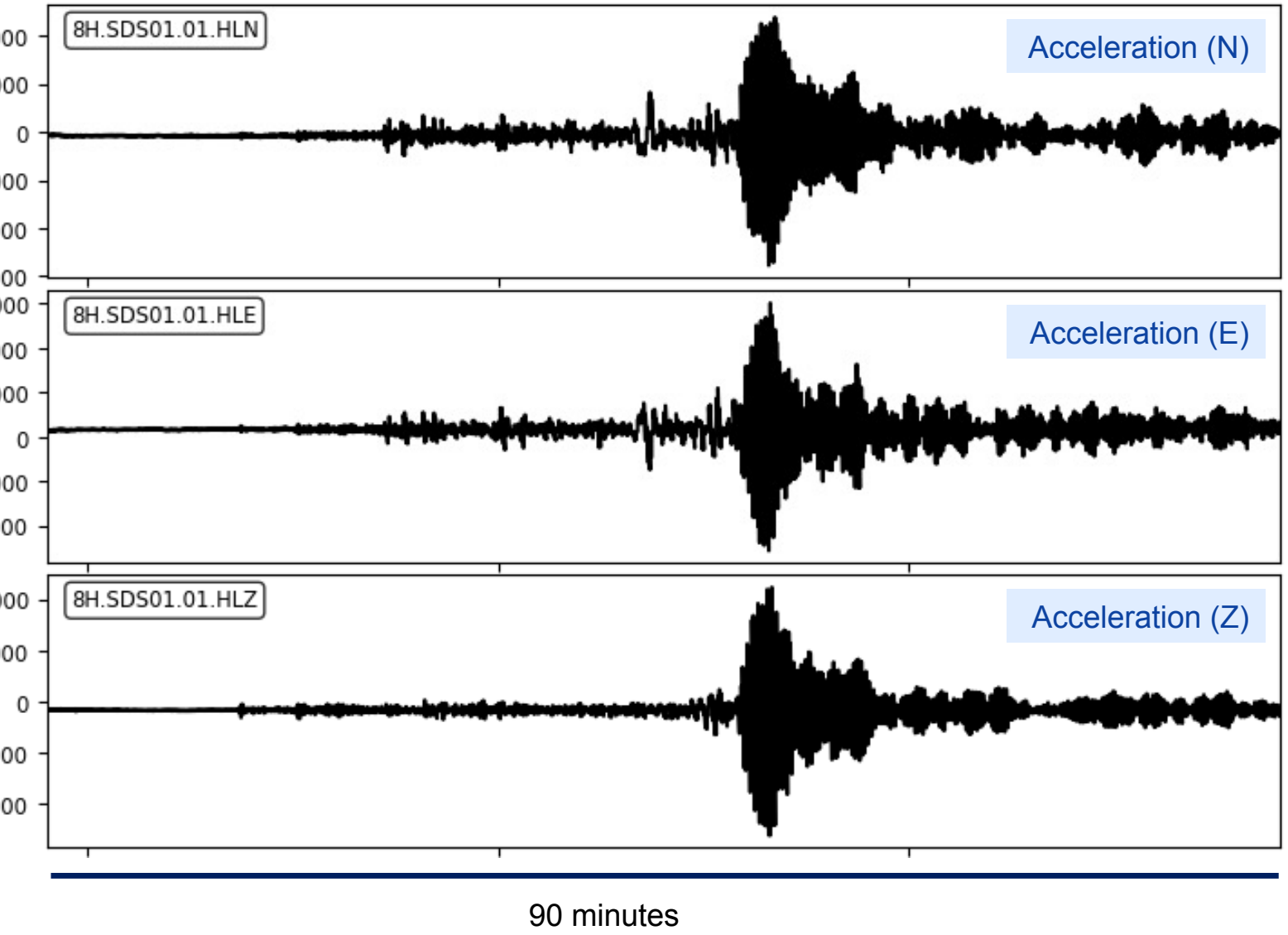

Loyalty Islands M 7.7 mainshock
2023-05-19 02:57:03 (UTC)
18.0 depth
~11,400 km source – receiver distance

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THIO NEW CALEDONIA	21.6S	166.2E	0409	0.07M/ 0.2FT	20
MARE NEW CALEDONIA	21.5S	167.9E	0413	0.19M/ 0.6FT	06
OUINNE NEW CALEDONI	22.0S	166.7E	0406	0.20M/ 0.7FT	08
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Minimal tsunami observed in
Vanuatu, New Caledonia, and New Zealand

SUBSEA DATA SYSTEMS

Continuous operation since August 2022

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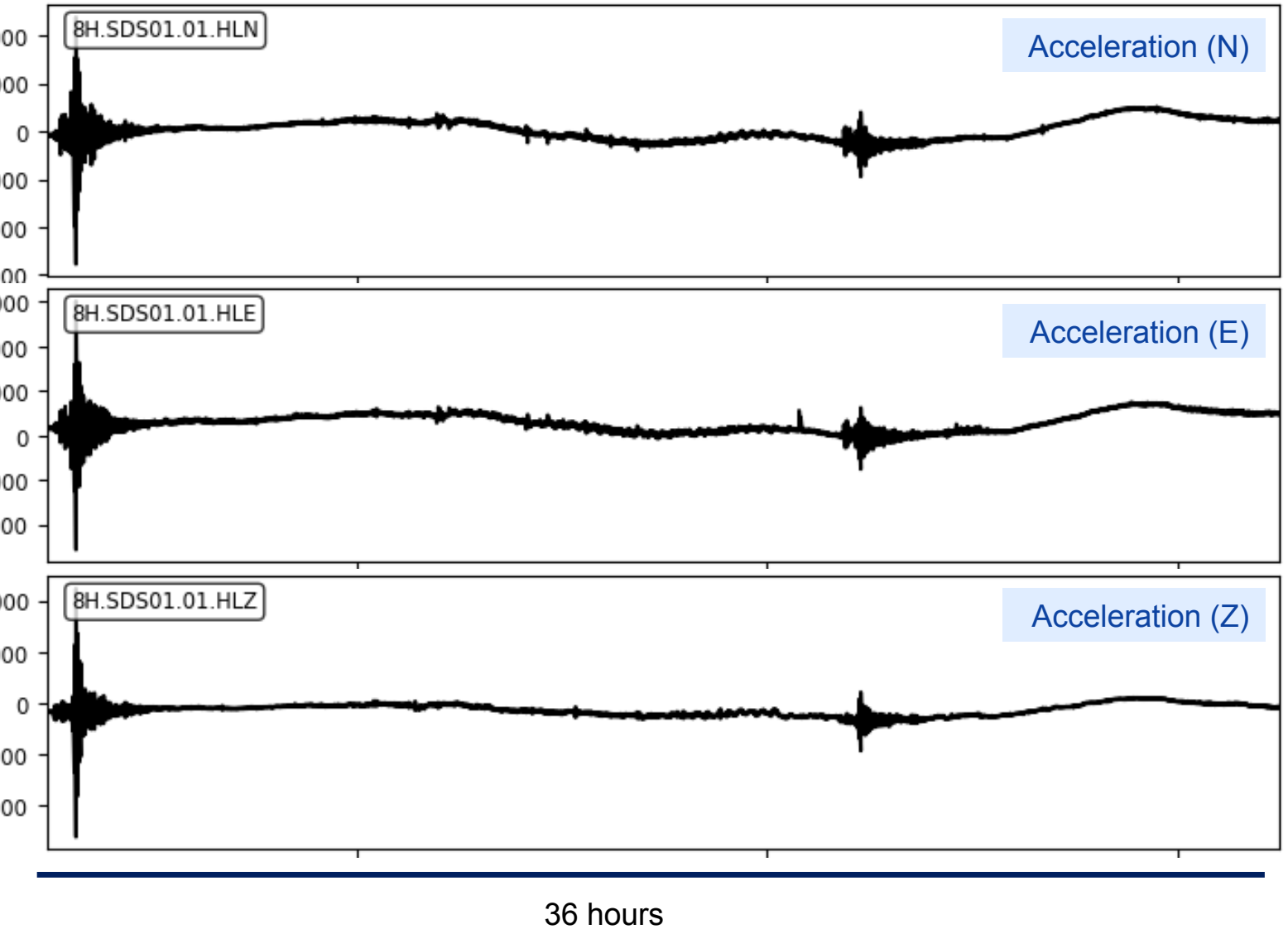
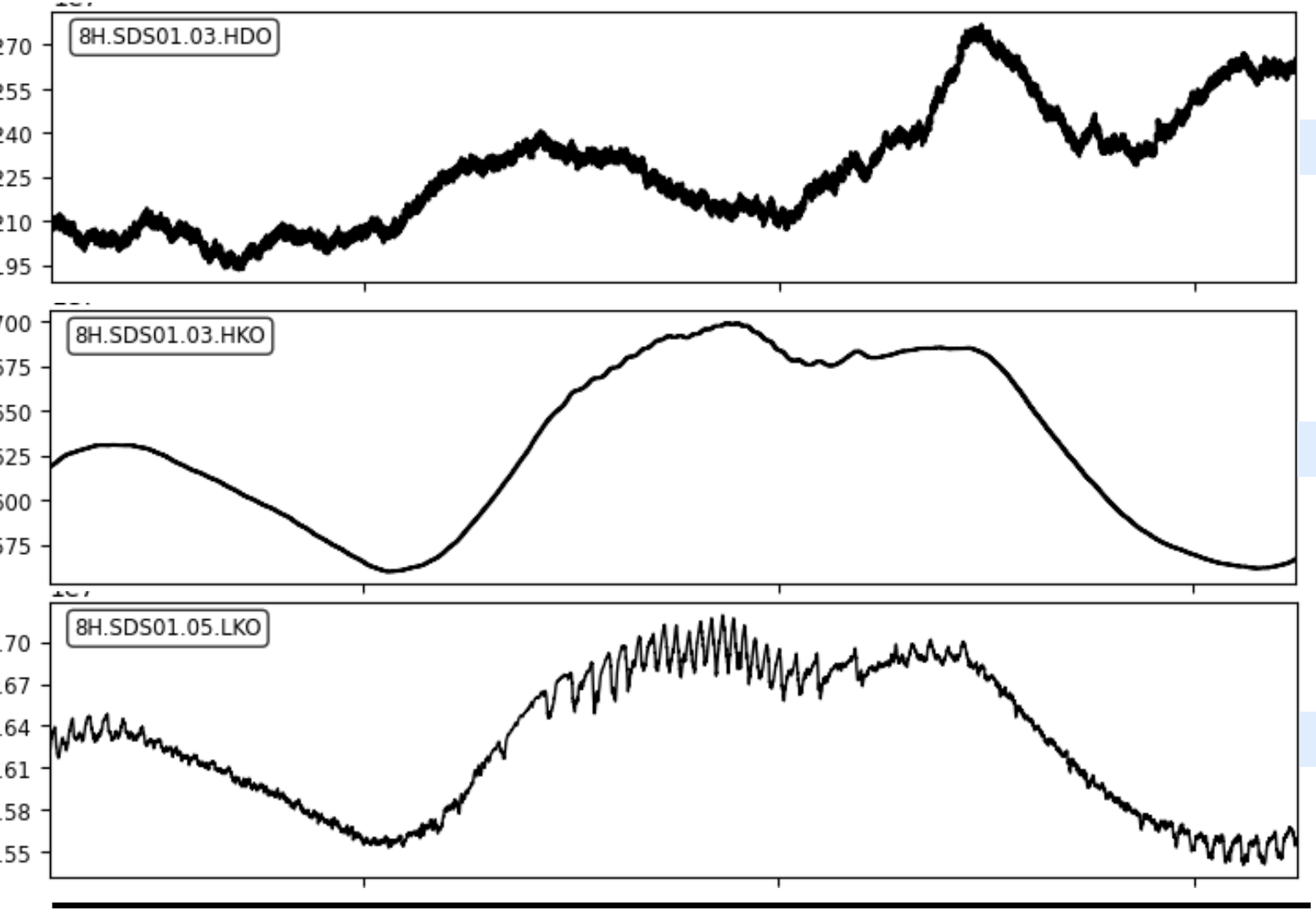


Loyalty Islands M 7.7 mainshock
+ M 7.1 aftershock
18.0 / 36.0 km depth
~11,400 km source-receiver distance

SMART SENSOR SYSTEM DATA

SDS SMART SEED Data
Retrieved from SAGE Data Repo via ObsPy
Raw data
Amplitudes autoscaled for each trace



Pressure (APG)

Temperature* (APG)

Temperature (GCT)

APG = Absolute Pressure Gauge (Paros Scientific)
GCT = Glass Coated Thermistor (Sea-Bird)
* APG temperature used to correct raw APG pressure signal

SUBSEA DATA SYSTEMS

Continuous operation since August 2022

SMART SENSOR SYSTEM DATA

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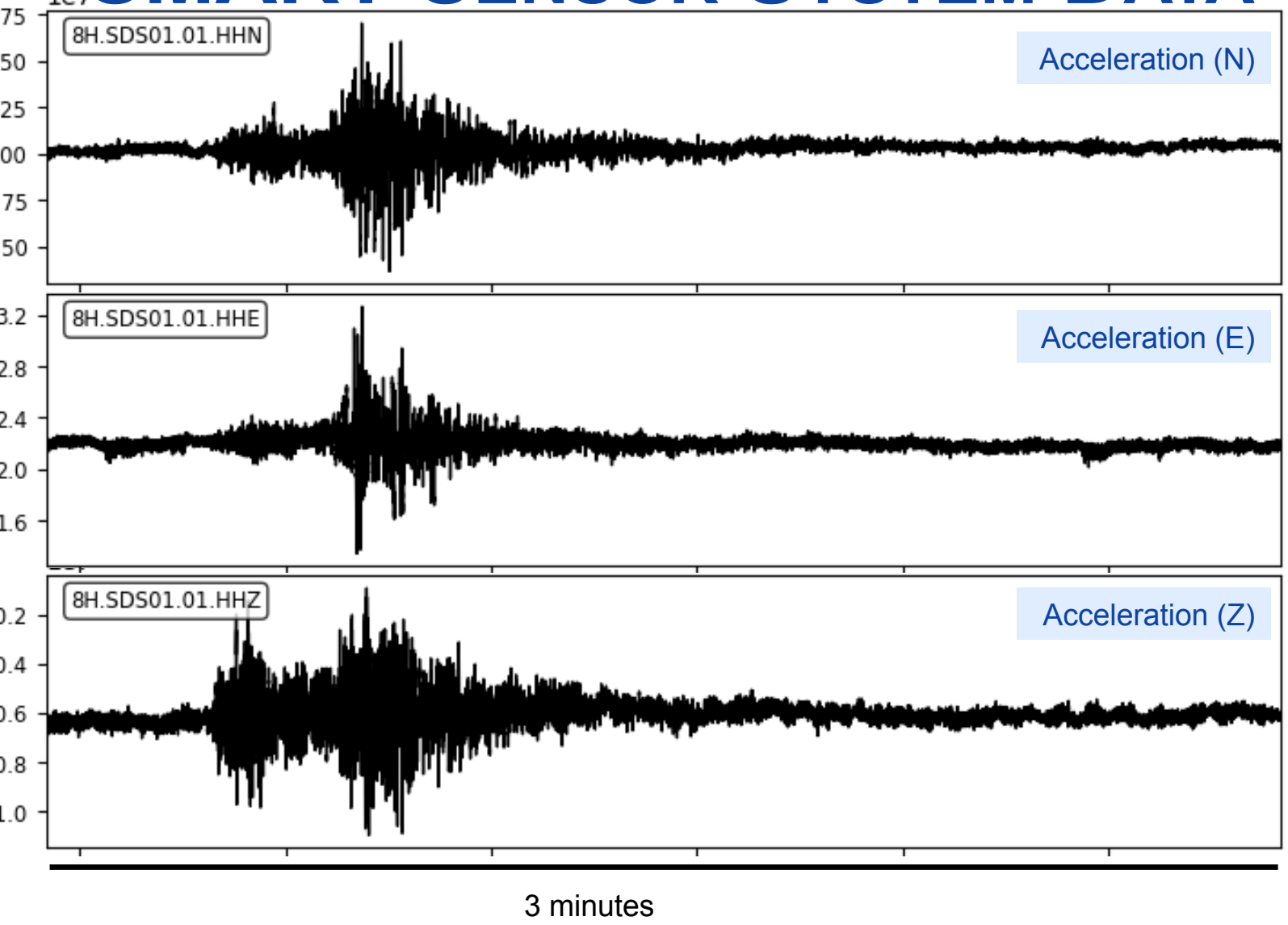


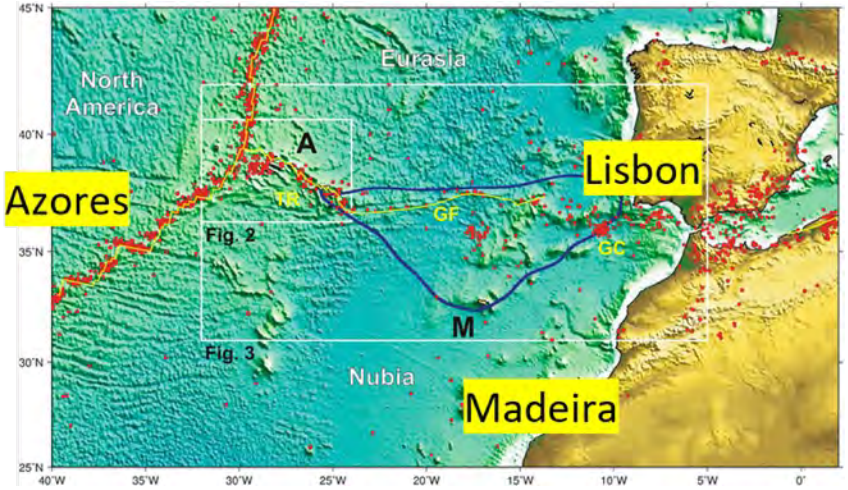
M 3.1 - 16 km S of Smiley, Texas
2023-05-22 08:36:25 (UTC)
5.1 km depth
146.0 km source-receiver distance

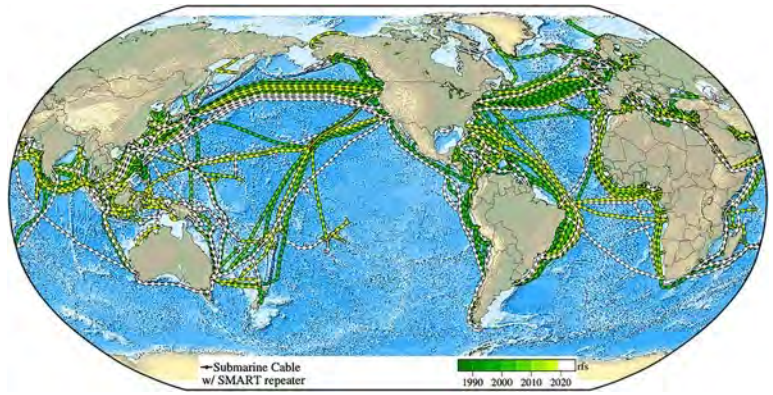
SUBSEA DATA SYSTEMS

Continuous operation since August 2022

SUMMARY AND A PATH TO ATLANTIC CAM

- Our solution provides a path to **achieving the original SMART Cable vision** of sensors in every repeater without the cost of additional subsea housings.
- Our seismic sensors have **true omni-tilt capability**, are **switchable between velocity and acceleration**, and have **excellent performance** from 0.01 to 500 Hz.
- Our solution is **modular** and can be **adapted to other repeater designs** or purpose-built systems.
- We can manufacture our systems in **quantities sufficient for the Atlantic CAM** SMART Cable system.
- We can **license our design** for manufacture by other companies.
- Our **comprehensive solution** delivers data in a format suitable for both **tsunami/earthquake early warning** and scientific research and can be **immediately ingested** by **Portugal's IPMA system**.






CAUTION
WATCH FOR
RATTLESNAKES