WSIS FORUM 2022
Starting on 15 March
Final week 30 May - 3 June

New role of optical fibre network for global environment

Omar AIT SAB
Alcatel Submarine Network
NOKIA Corporation

Outline

- Ocean observation overview
- Ocean observation
  - Submarine Cables observatories
  - SMART
  - DAS, SOP
- ITU-T/SG15/Q8 activities and new study items
  - G.DSSSC
  - G.SMART

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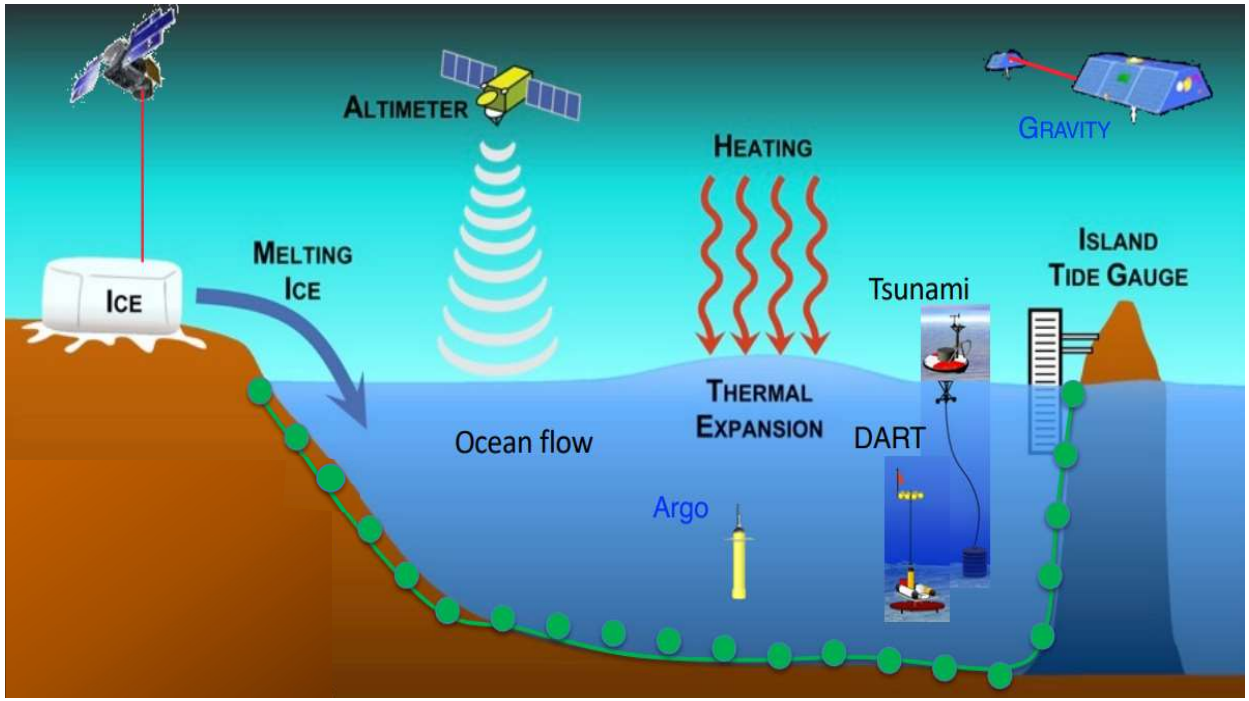
Ocean Observation: Overview

Objectives

- Seafloor seismic measurements and tsunami early warning
- Evaluation of the consequences of global warming on the behavior of the oceans - examples:
  - mean sea level rise (ice melting + thermal expansion)
  - ocean acidification (absorption of 30% of anthropogenic CO2)
  - disruption of thermohaline circulation (lower salinity due to melting ice)

Existing solution: Satellite and in-situ technologies

What role for submarine cables?



Adapted from B.Howe, JTF, 2021

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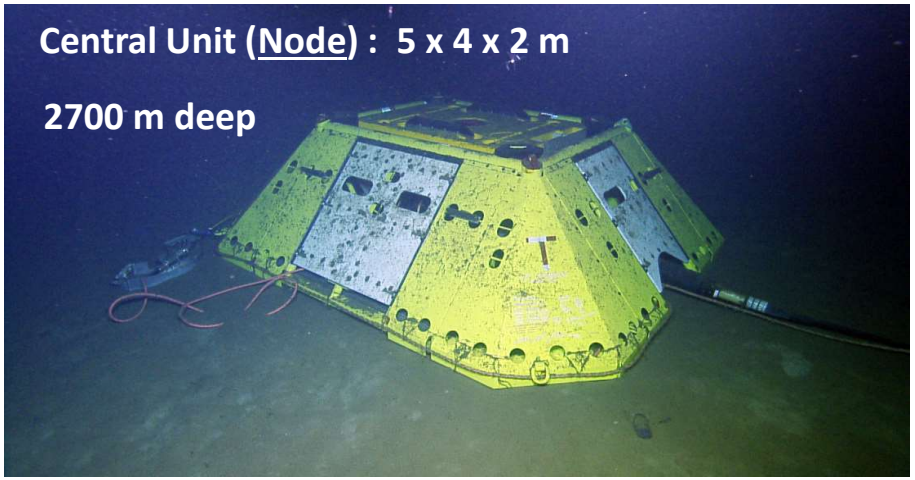
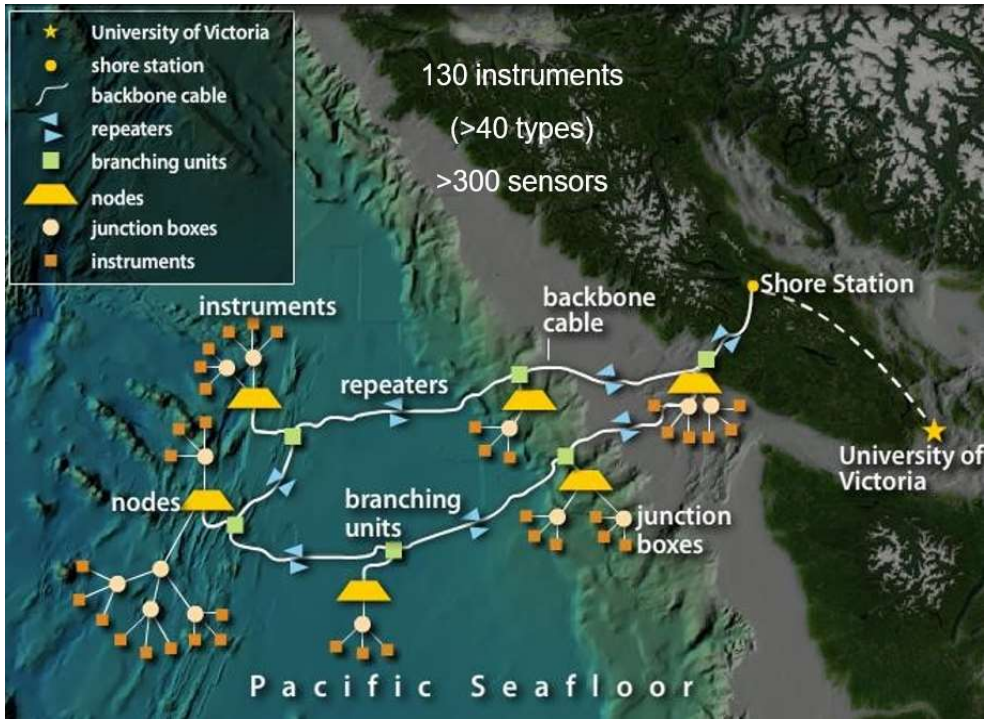
Ocean Observation: Submarine cables

First Ocean Bottom Observatory system connected with submarine cables: Neptune (2009)



Optical submarine cable main equipment:

- **PFE : 10 kV at 10 A**
- **EDFA based Repeaters with DWDM channels at 2.5 Gb/**
- **6 Nodes at 2700 m deep**



https://www.oceannetworks.ca/Observatories

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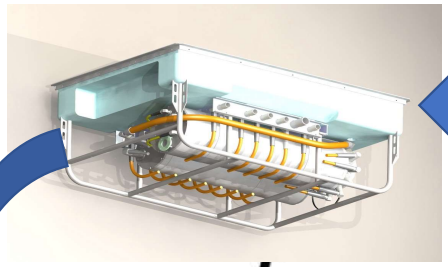
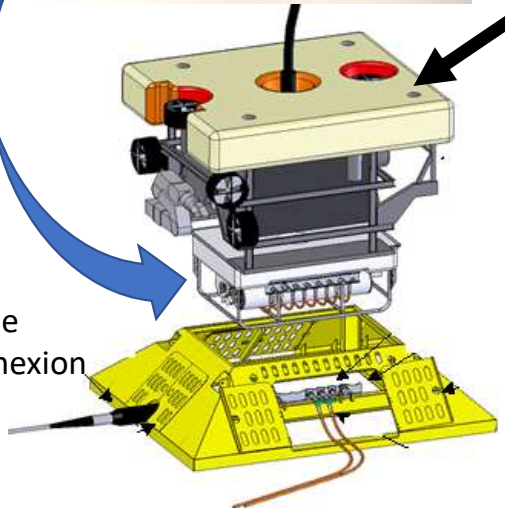
Ocean Observation: Submarine cables



Two modules in the Node:
1/ Tension Converter **10 kV => 50V**
2/ **2.5 Gb/s optical transceiver**

Robot handling the modules



Cable connexion

Sensors connections

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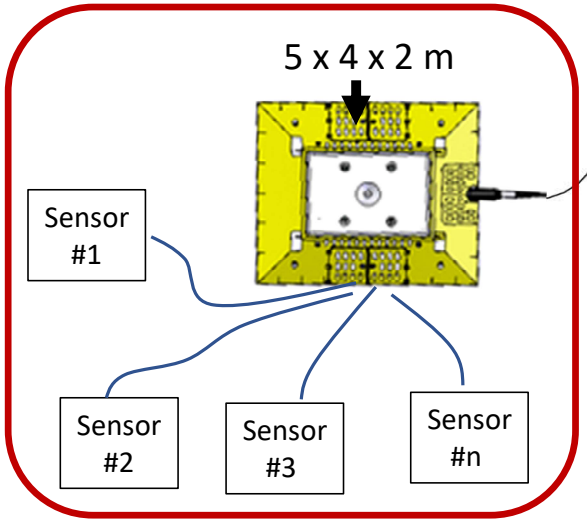
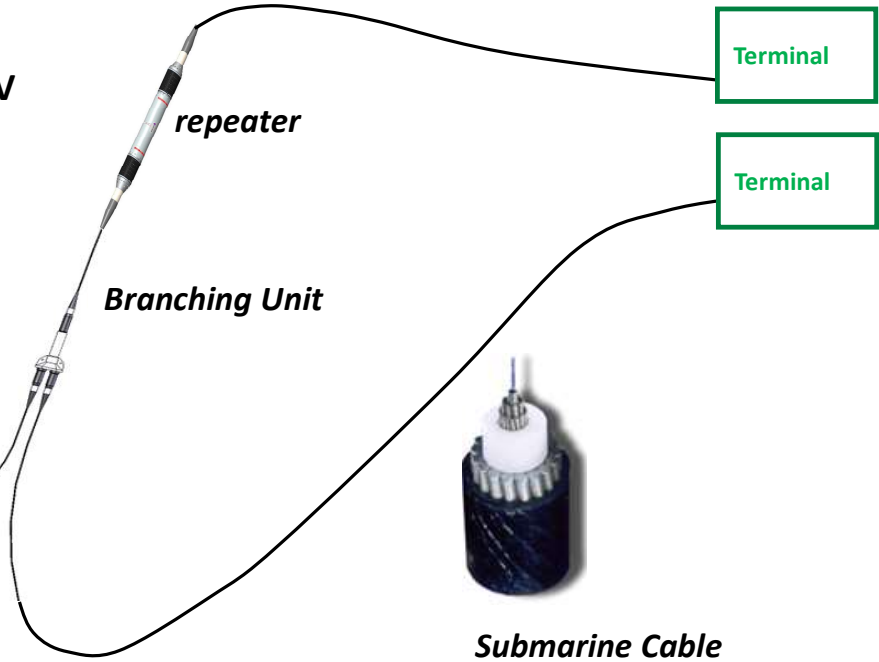


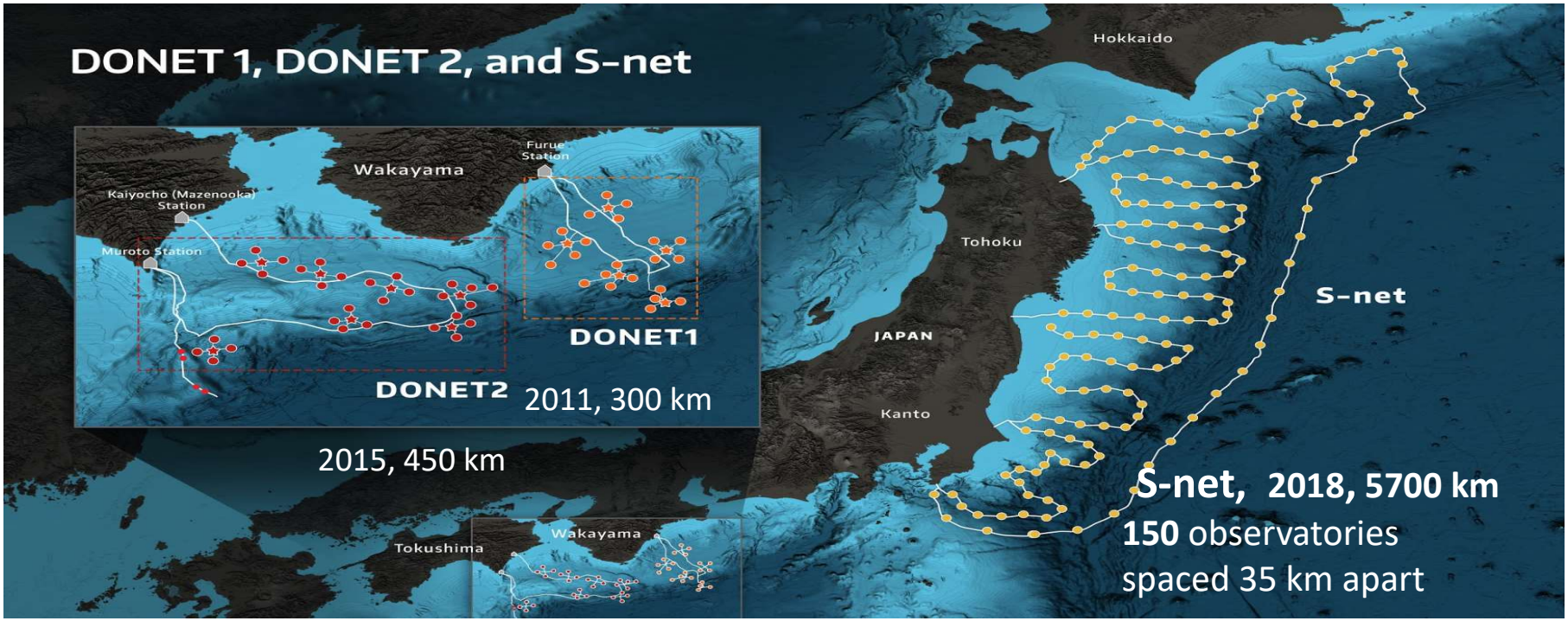
Observatory



Equipment and modules are extractible and replaceable using a remote-control robot

Ocean Observation: Submarine cables

Observatory system connected with submarine cables: DONUT and S-NET Japan



DONET = **D**ense **O**cean floor **N**etwork System for **E**arthquakes and **T**sunamis

Ocean Observation: Submarine cables

Observatory system connected with submarine cables: S-NET Japan

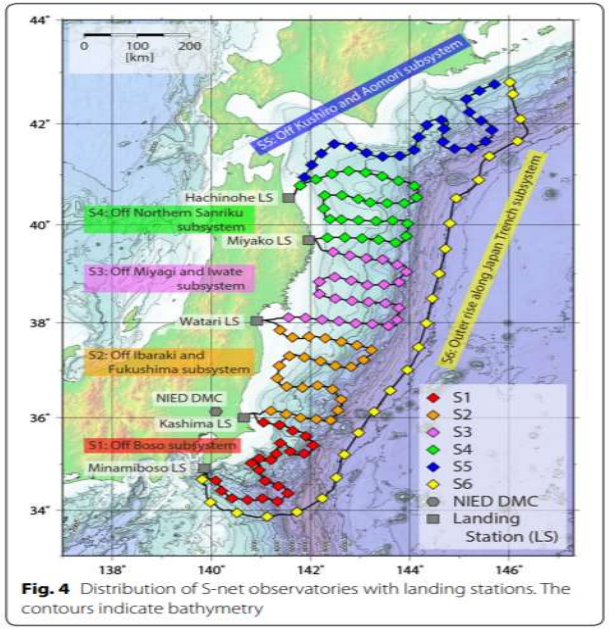


Fig. 4 Distribution of S-net observatories with landing stations. The contours indicate bathymetry

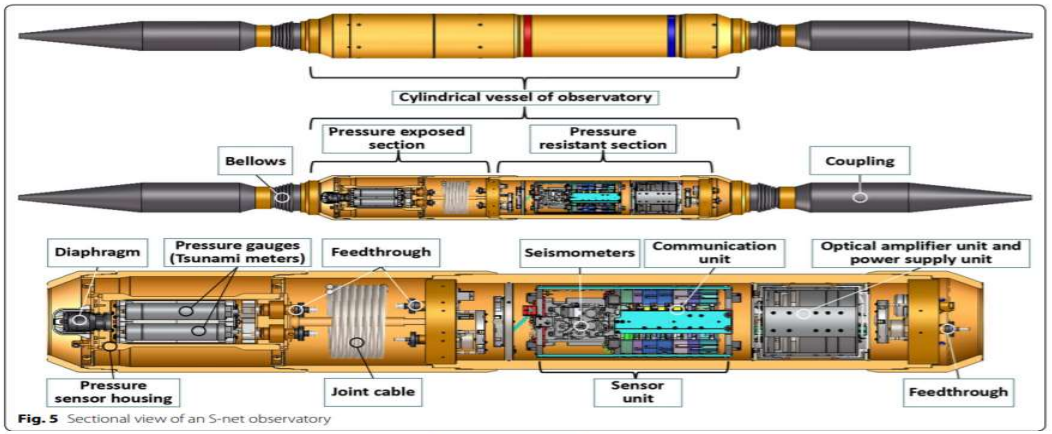
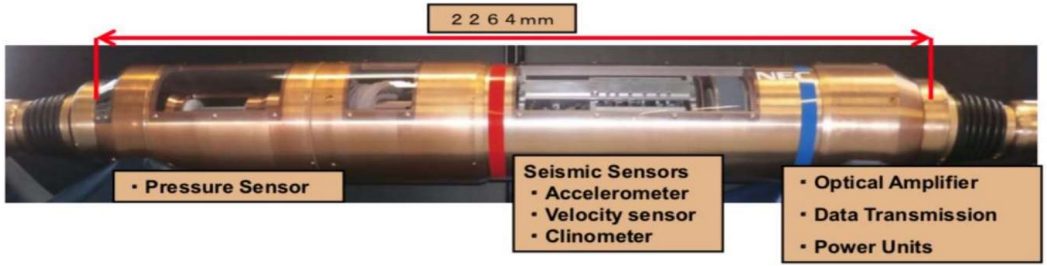


Fig. 5 Sectional view of an S-net observatory



Aoi et al. Earth, Planets and Space (2020)

MOWLAS: NIED observation network for earthquake, tsunami and volcano

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Ocean Observation: SMART

Concept

Equip a few telecommunication repeaters (10%) with scientific sensors

Objectif

Each year: 100.000 km of submarine cables are deployed which leads ~ 2000 repeaters

Assume 10% of SMART repeaters => **6000** sensors **installed in 10 years**

Advantages

- Coverage of all the seas of the globe
- Infrastructure and installation costs shared with the telecommunications network
- Equip only repeaters placed in useful observation areas
- Ocean Bottom Observation (8000m)
- Real-time measurement by high-speed optical fiber

UNESCO IOC | ITU International Telecommunication Union | WORLD METEOROLOGICAL ORGANIZATION Weather · Climate · Water

Intergovernmental Oceanographic Commission

UNESCO-IOC / ITU / WMO
Joint Task Force - 2012

Joint Task Force SMART SubSea Cable Systems

Chairman : B. Howe
University of Hawaii

SMART Cables for Observing the Global Ocean: Science and Implementation

B. Howe et al. , 2019

Frontiers in Marine Science

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Ocean Observation: SMART

JTF main Recommendations

- Accelerometers

Characteristics	Value
Configuration	3-Axis
Response	0.1 to 200Hz
Resonance frequency	>2,000Hz
Full scale range	+/-1.5g where g is 9.806 m/s2
Noise	≤ 2ng / √Hz
Sampling rate	200Hz
Sample resolution	24 bit

- Temperature Sensor:

Characteristics	Value
Range	-5.0 to +35°C
Initial Accuracy	0.001°C
Stability	0.002°C / year
Sampling Rate	0.1 Hz
Sample Resolution	24 bits

- Absolute pressure gauge:

Characteristics	Value
Range	0 to 73MPa (0 to 7,000m)
Overpressure tolerance	84MPa (8,000m)
Accuracy	+/-1mm relative to recent measurements
Sampling Rate	20 Hz
Sample Resolution	32 bits

JTF Engineering Team White Paper

General Requirements for Sensor Enabled and Reliable Telecommunications (SMART) Cable Systems

General requirements of a SMART Cable Issue

JTF Recommendations: Deploy 3 types of sensors

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Ocean Observation: SMART

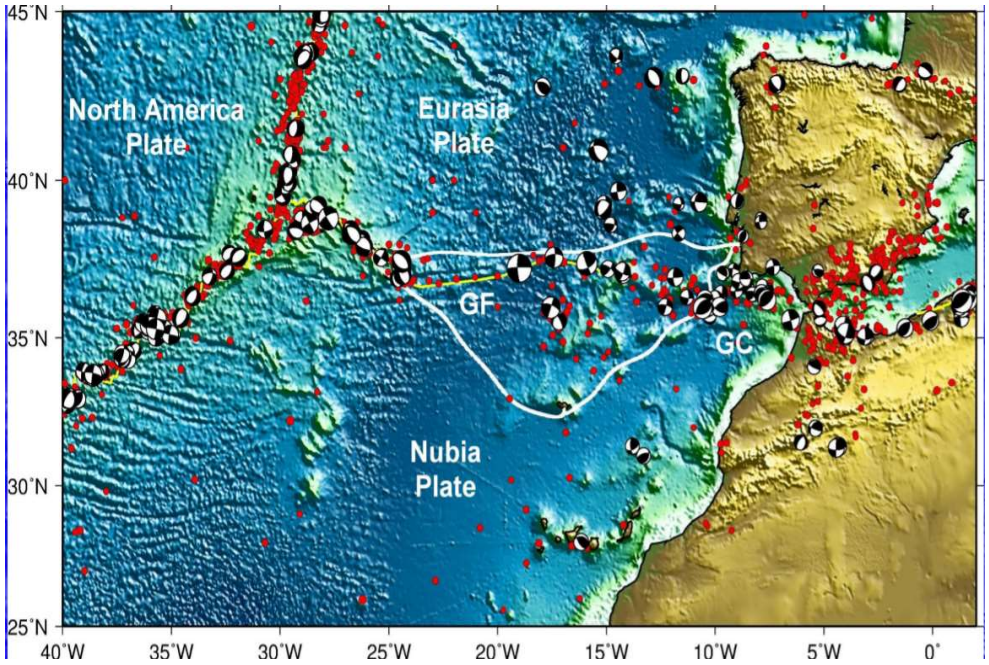
Expected first SMART Cables Project: CAM2 SMART Cables

Continent **Az**ores **M**adeira

- Domestic telecom system with international connection
- 3700 Km, €120M
- 50 SMART Repeaters
- Seismic, tsunami, ocean, environment
- RFP 2022
- RFS 2025

1755 Tsunami, 60.000 deaths in Lisbon
CAM2 will enhance with more than 10s the EEWS

- **Less loss of lives**



https://presentations.copernicus.org/EGU2020/EGU2020-13988_presentation.pdf

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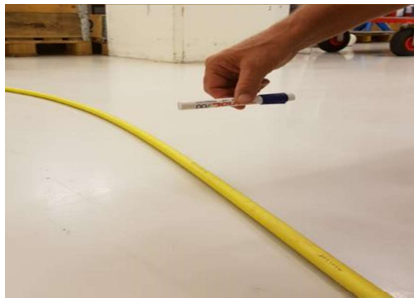
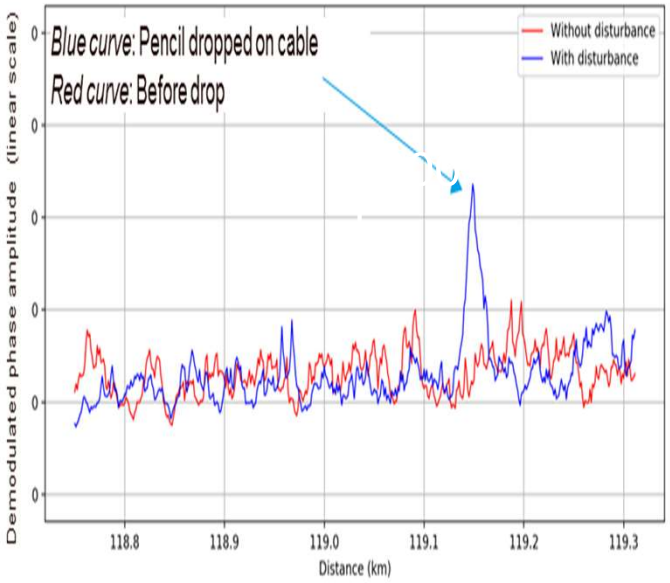
Ocean Observation: Reflectometry (DAS)

Observatory system using existing submarine cables: Distributed Acoustic Sensing

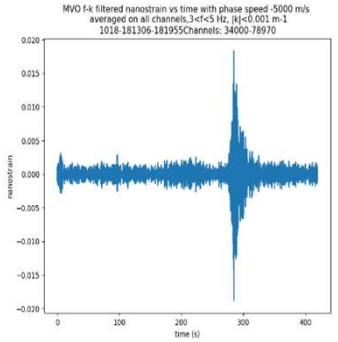
Distance range 150 km
Précision < 10 m



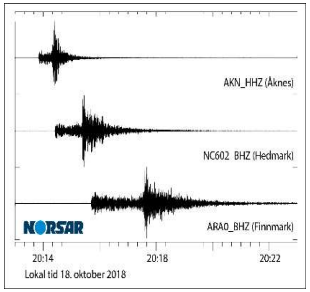
Pencil dropped from a height of 10 cm on an armored cable at 119 km from the optoDAS



Earthquake with magnitude of 4,5
18/10/2018



DAS measurements



3 Seismometers measurements

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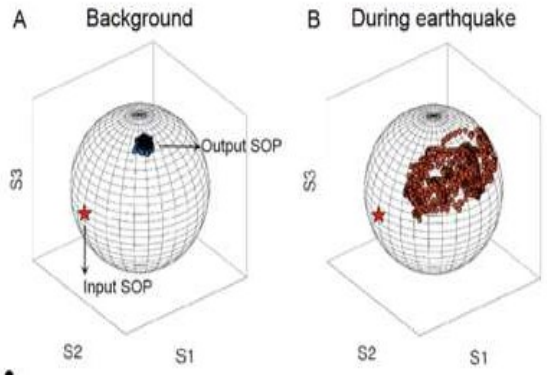
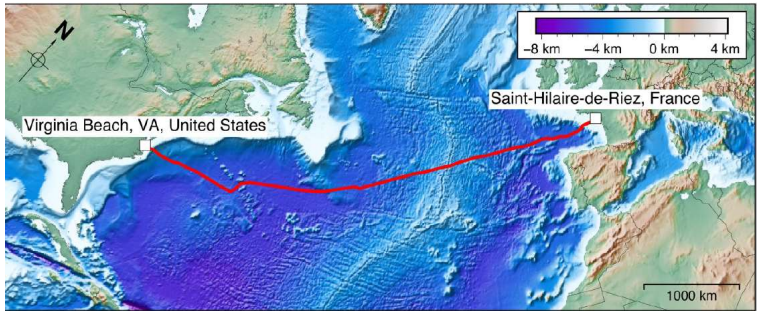
Ocean Observation: SOP Tracking

State Of Polarization (SOP) detection and analysis



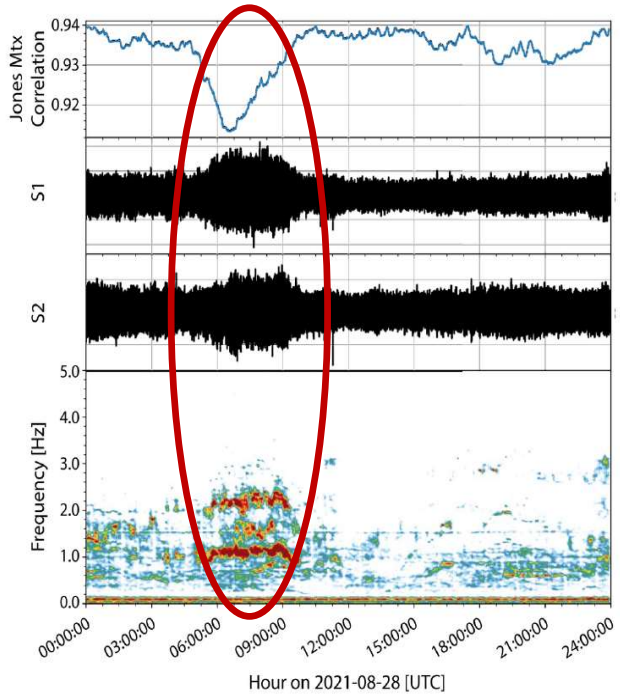
Zhan et al, « Optical polarization–based seismic and water wave sensing on transoceanic cables", 2021



Fiber Sensing using Coherent Transceivers

Mikael Mazur[1], Jorge C. Castellanos[2], Roland Ryf[1], Erik Borjeson[3], Tracy Chodkiewicz[4], Valey Kamalov[2], Shuang Yin[2], Nicolas K. Fontaine[1], Haoshuo Chen[1], Lauren Dallachiesa[1], Steve Corteselli[1], Philip Copping[4], Jurgen Gripp[4], Aurelien Mortelette[4], Benoit Kowalski[4], Rodney Dellinger[4] David T. Neilson[1] and Per Larsson-Edefors[3]

[1] Nokia Bell Labs, USA
[2] Google, USA
[3] Chalmers University of Technology, Sweden
[4] Nokia, USA



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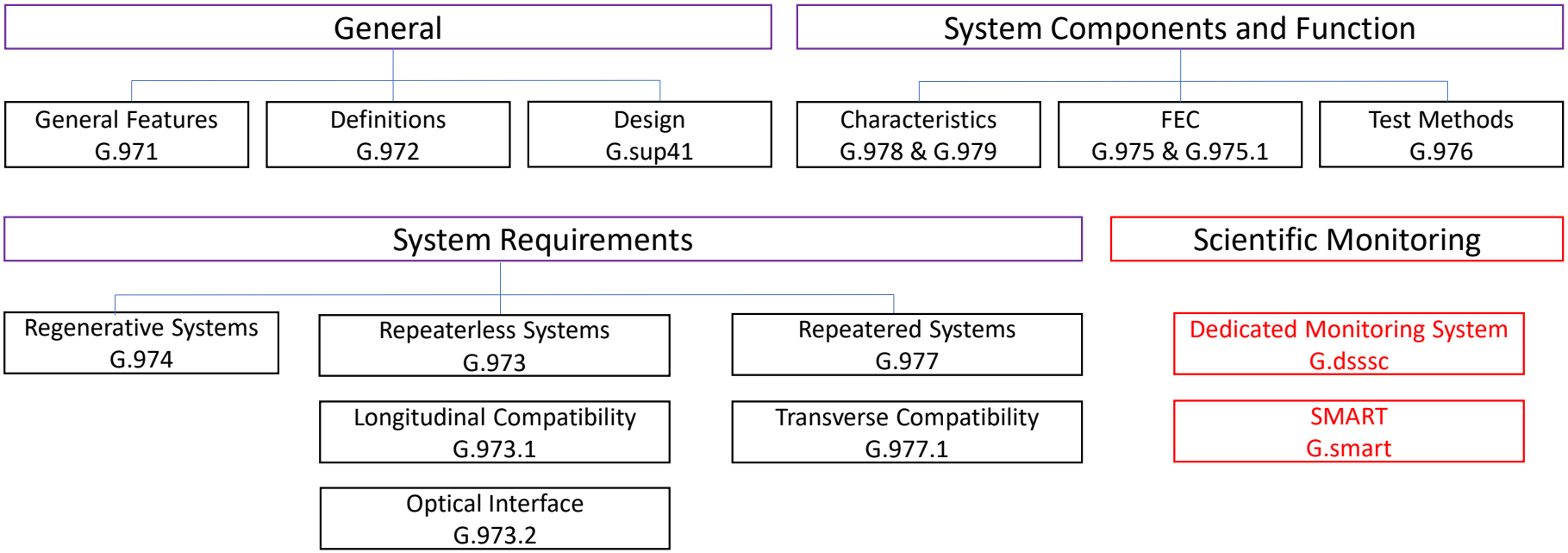
ITU-T SG15/WP2/Q8 presentation

Study all submarine transmission systems and related features within ITU-T



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Ocean Observation: ITU-T SG15/WP2/Q8

ITU-T SG15/WP2/Q8 New study items (April 2021):

G.dsssc : Dedicated scientific sensing submarine cable system

This Recommendation deals with the dedicated submarine cables system for scientific sensing. It covers the aspects related to submarine cable system architecture, functional blocks, interfaces between various sensor sets and submarine cables. This Recommendation covers qualitative high-level sensing characteristics and features as well as telecommunication interfaces in order to monitor the ocean and climate change as well as disaster warning.

G.smart : Scientific Monitoring and Reliable Telecommunication Submarine Systems

This Recommendation identifies the capabilities and features of fibre optical submarine telecommunication cable systems equipped with sensors at regular intervals along the entire length of the cables (i.e., SMART cables). It describes at a high-level characteristics and requirements of a SMART cable system (e.g., no interference between telecommunications and sensing functions, reliability of each function, operations and maintenance, general attributes of a power and communication interface).

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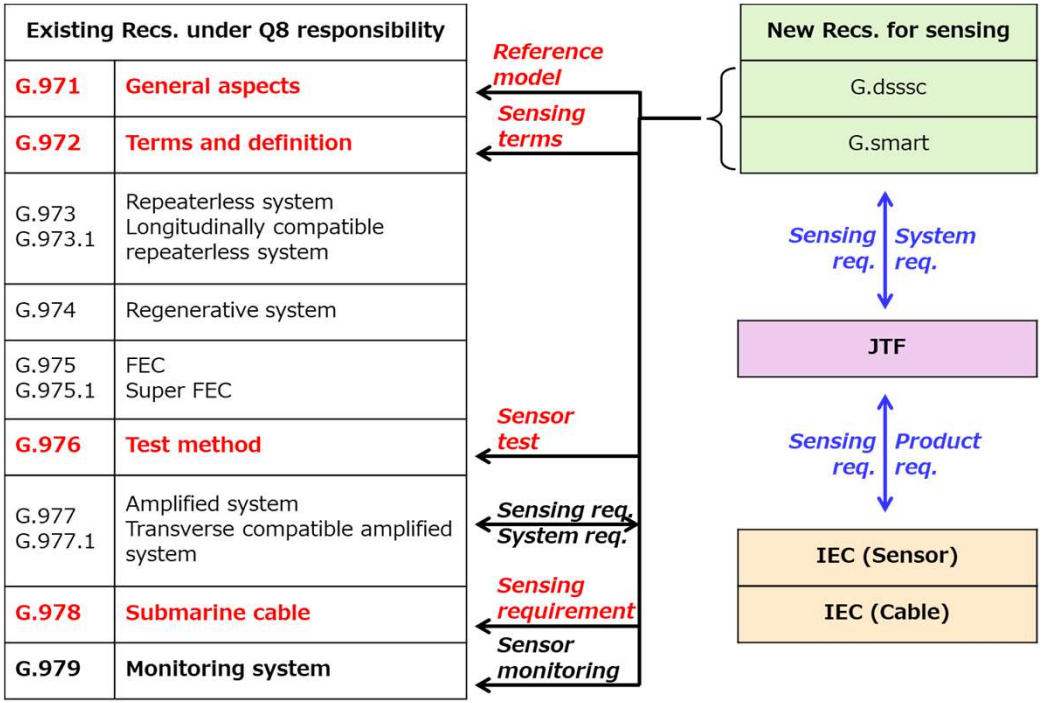
Ocean Observation: ITU-T SG15/WP2/Q8

G.smart & G.dsssc impact on Q8 Recommendations



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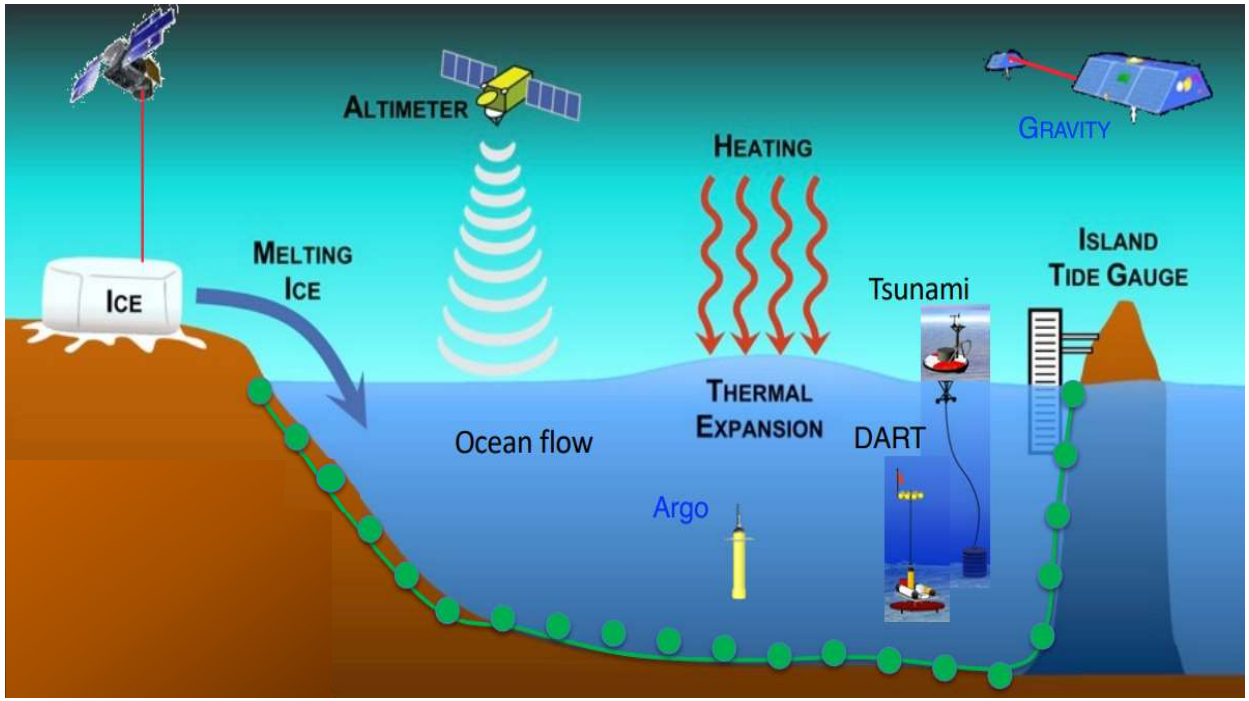
Ocean Observation: Summary

- Very few bottom observation with satellites and in-situ solutions
- High cost of dedicated submarine ocean observation system
- Dual use of submarine cable (SMART): enhance and complement existing solutions
- SMART cables would address the short- and long-term ocean observation needs
- Extensive research area on the use of existing submarine cables for ocean monitoring



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