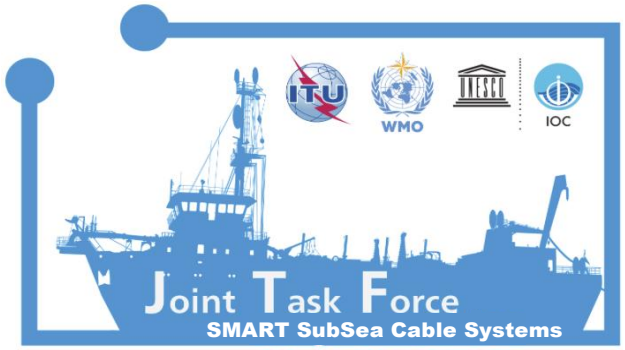
SMART Subsea Cables for Observing the Ocean and Earth:

Workshop

Science Monitoring And Reliable Telecommunications



2021 2030 United Nations Decade of Ocean Science for Sustainable Development

DEEP OCEAN OBSERVING STRATEGY

pogo Partnership for Observation of the Global Ocean

GORDON AND BETTY MOORE FOUNDATION

JTF SMART Subsea Cables Workshop
University of Hawai'i at Mānoa
20 January 2022

NASA

Welcoming Remarks – Chaesub Lee, ITU

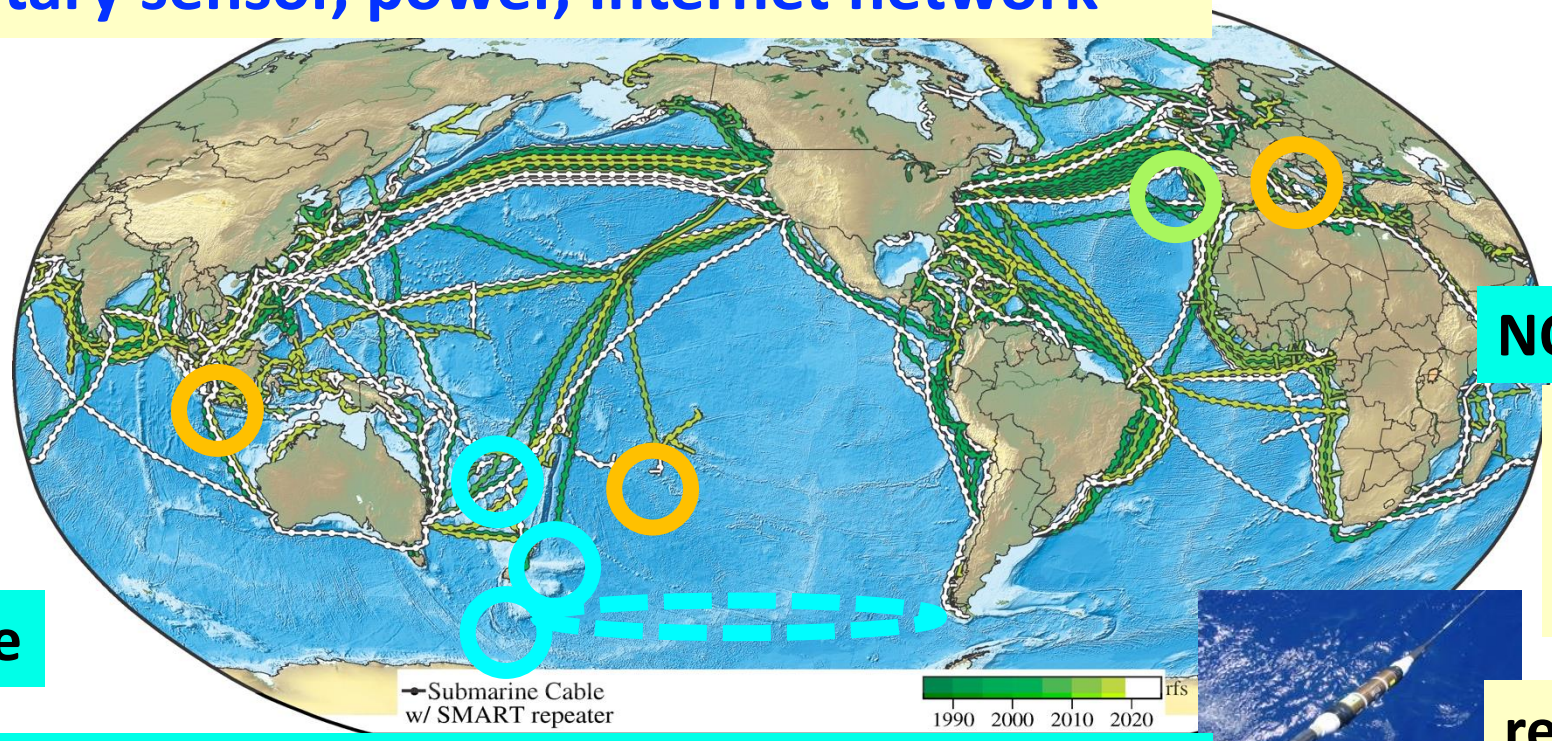
- Director, Telecommunication Standardization Bureau, International Telecommunication Union
- ICT standardization - integrated services digital networks (ISDN), global information infrastructure (GII), Internet protocol, next-generation networks (NGN)
- Prior: Korea Telecom, Electronics and Telecommunications Research Institute (ETRI), Korea Advanced Institute of Science and Technology (KAIST), senior advisor to Korea's Ministry of Science, ICT and Future Planning (MSIP).
- Within ITU, Chairman of the ITU Focus Group on Next-Generation Networks (NGN)
- SMART Cable advocate for many years !!!

SMART Subsea Cables

Global Array: Climate, Oceans, Sea Level, Earthquakes, Tsunamis

Create a Planetary sensor, power, Internet network

1st order addition to Ocean-Earth observing system



Share submarine cable infrastructure
Telecom + science
↓€$

NO Interference

1.2+ Gm
~20,000 repeaters
20 year refresh

repeaters ~70 km

UN Decade

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Know the environment – protect the network

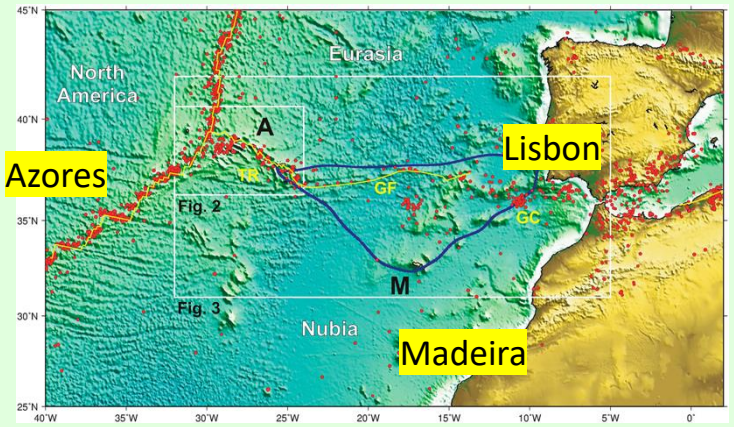
CAM: 3700 km, Gov't, install 2025 ➜ SMART Continent/Lisbon-Azores-Madeira ring

Bottom temperature, pressure, seismic acceleration

WMO

ITU

SMART Cables - Europe



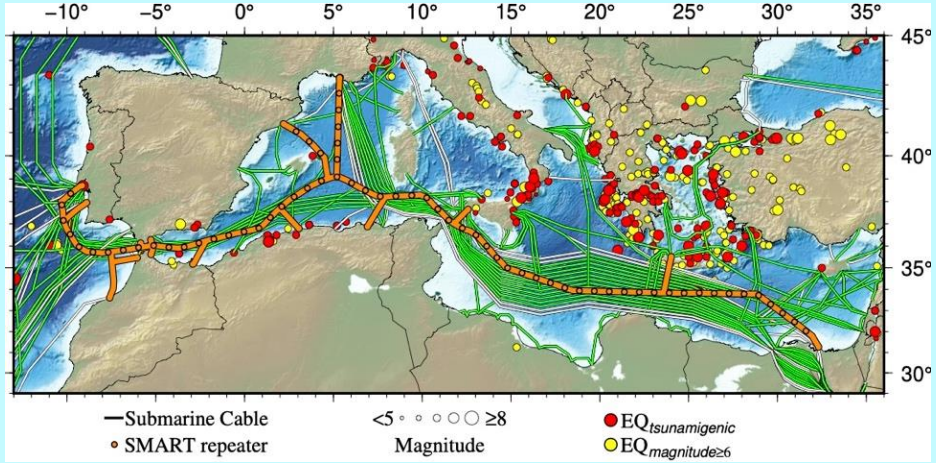
- **Wet Demo**, Install 2022
- Three test SMART repeaters (sans telecom)

- **CAM2**
- Domestic, international connections, Digital hub
- 1755 earthquake tsunami
- Seismic, tsunami, ocean, environment
- 3700 km, 50 SMART repeaters, €120M
- RFP 2022, Ready For Service 2025
- ANACOM connection to telecom

Risk analysis ((V. Silva, pers. comm.)

- Improved EEW (10 s) with less loss of life will more than pay for the system
- Next: include infrastructure and tsunami inundation

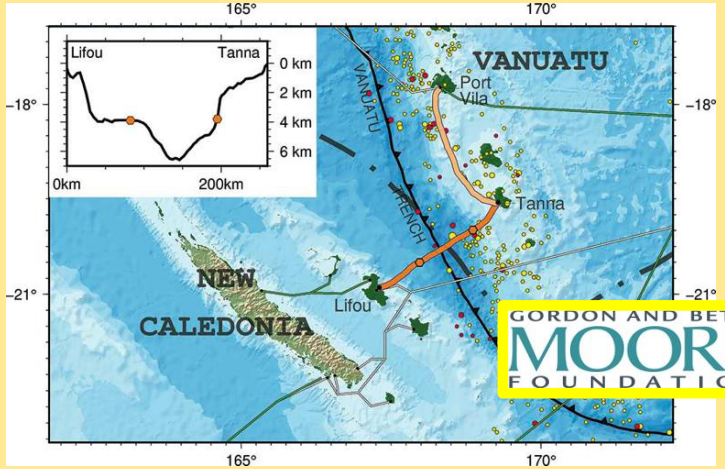
NEAMTWS



- **MEDUSA**
- Install 2024/25
- Possibly up to ~60 SMART repeaters on main cables

- Improve coverage for large regional area
- Raising funds for SMART capability now

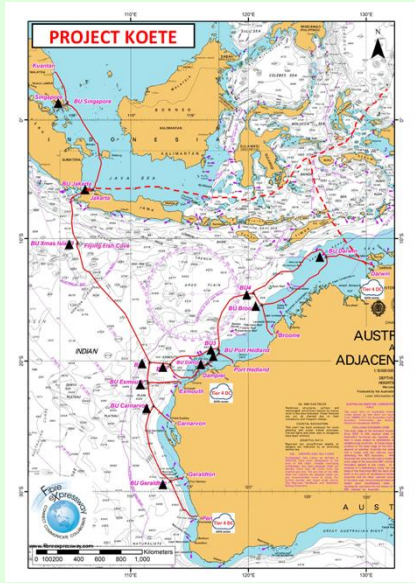
SMART Cables - Pacific



Vanuatu – New Caledonia

SMART, DAS

Partial funding; under gov't review



Project Koete

Perth-Darwin-Malaysia

Communities

SMART integral

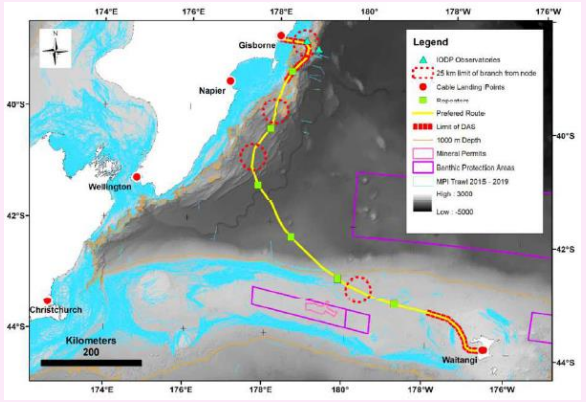
Raising funds

Indonesia

In country development Ina-CBT

Single ended test systems underway

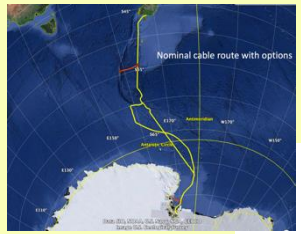
Follow with Makassar Strait, **with telecom**

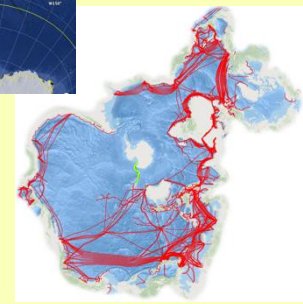


NZ–Chatham Islands

SMART + DAS + BUs/nodes

Under gov't review (MBIE)





NSF

Antarctica – NZ

Improve connectivity

SMART Cable

Workshops, NSF, NAS, Chile

Arctic Express

14,000 km

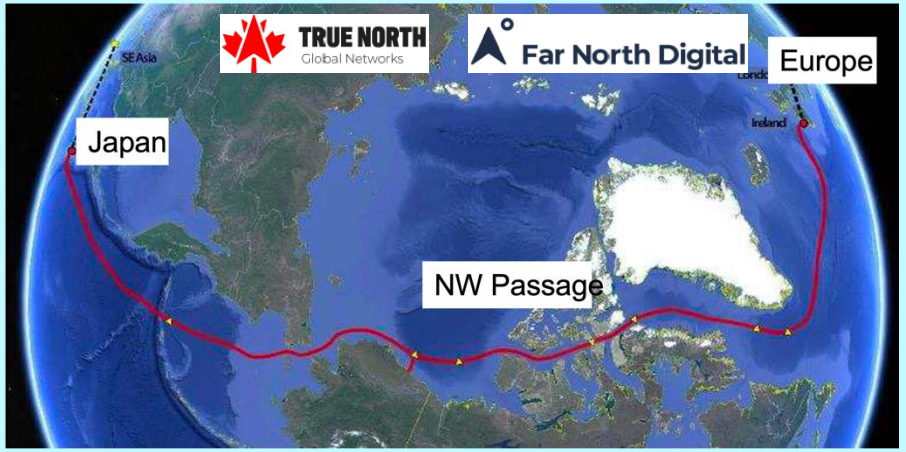
Low latency

Communities

Contract Q1 2022

RFS Q4 2025

SMART integral



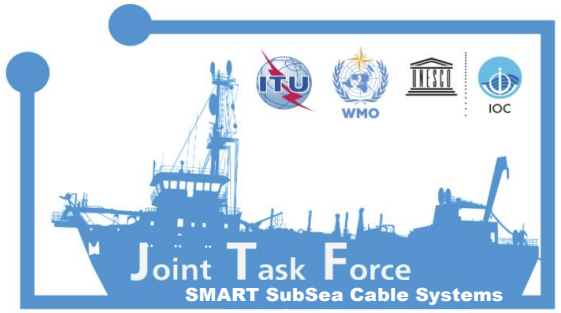
Concluding Remarks

- **SMART available commercially (ASN and Subsea Data Systems)**
  - first install in 2025 timeframe
- **SMART systems: CAM2, MEDUSA, V-NC, Antarctica, Arctic, … will**
  - Set valuable precedents (science/tech, funding, permitting / legal / security, …)
  - Catalyze other related activity (rising tide raises all ships)
  - Lay the foundation for more complex systems in the future
- **SMART and the UN Decade**
  - Perfect example of Blue Economy – leverage $5B/y industry, ”new” funding?
  - Address SDGs

International Tsunami Information Center
UNESCO / IOC – NOAA Partnership

Joint Task Force SMART Subsea Cables Workshop
20 January 2022, Honolulu, Hawaii (hybrid)

SMART Cables for Tsunami Warning



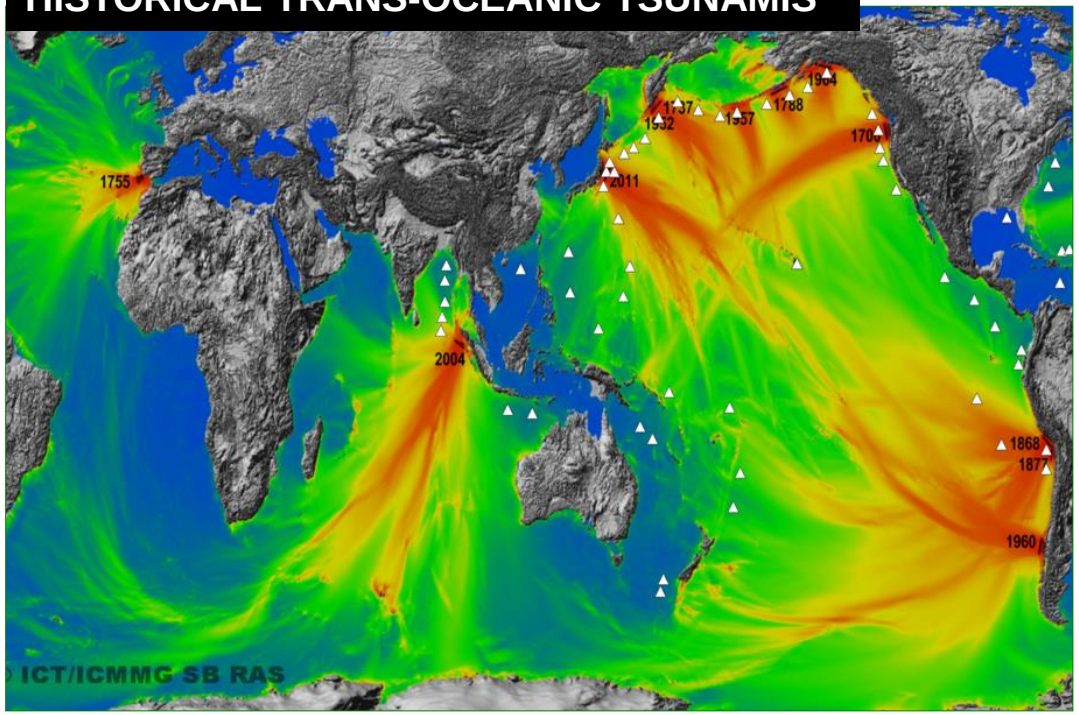
Dr. Laura Kong
Director, ITIC, USA NOAA

Cdr. Carlos Zuniga
Associate Director, ITIC, Chile SHOA

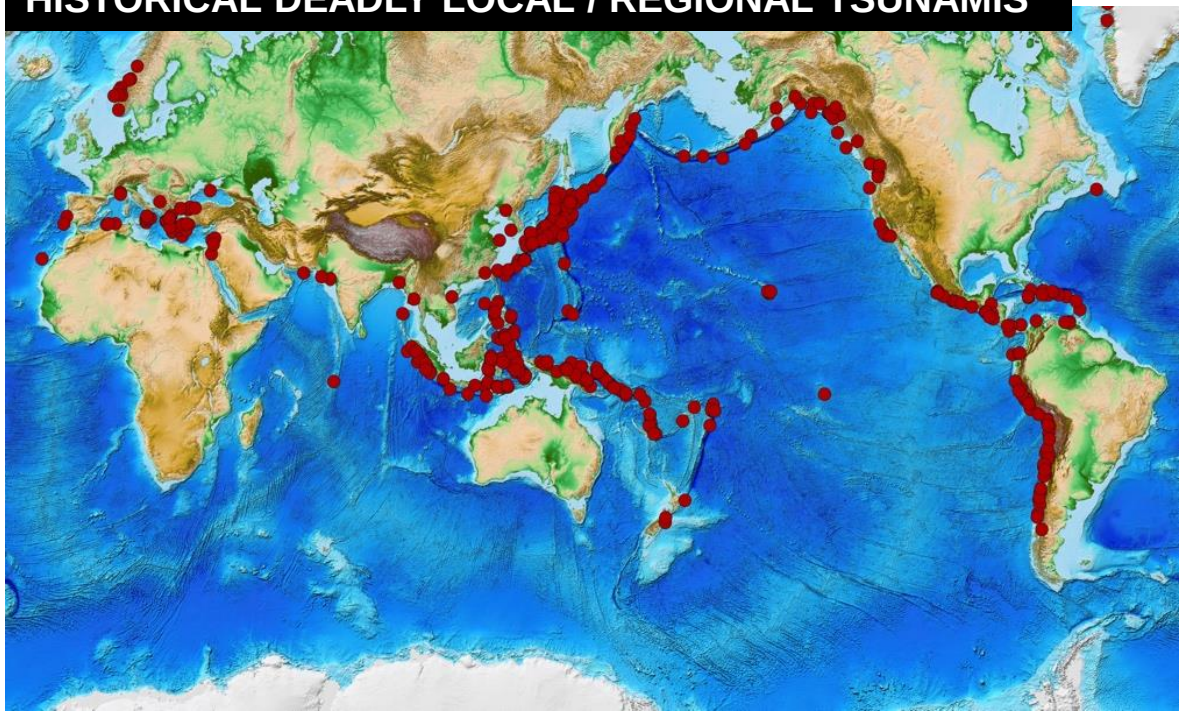
Christa von Hillebrandt
Deputy Director, ITIC Caribbean Office, USA NOAA

HISTORICAL TSUNAMIS

HISTORICAL TRANS-OCEANIC TSUNAMIS

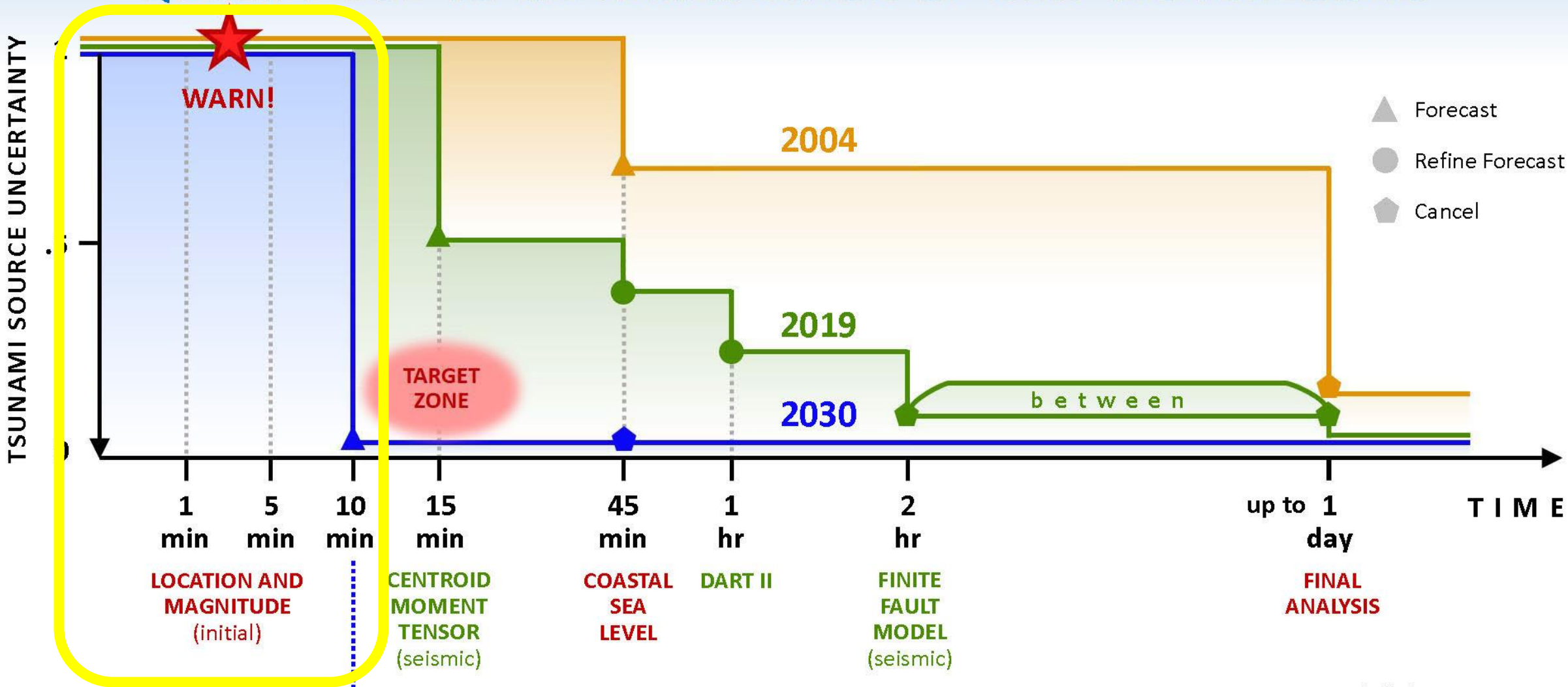


HISTORICAL DEADLY LOCAL / REGIONAL TSUNAMIS



- 70% of world's tsunamis in Pacific and marginal seas
- 99% of deaths in Pacific from Local or Regional Tsunamis

EXPECTED IMPROVEMENT IN TSUNAMI FORECAST TIME AND ITS QUALITY DUE TO IMPLEMENTATION OF NEW TECHNOLOGIES



▲ Centroid Moment Tensor (GNSS)/Finite Fault Model (GNSS)

▲ Full Bottom Pressure (eg. Tsunameters, Cables, dedicated observatories)

▲ In-situ Accelerometers

Data Availability 2004—2030

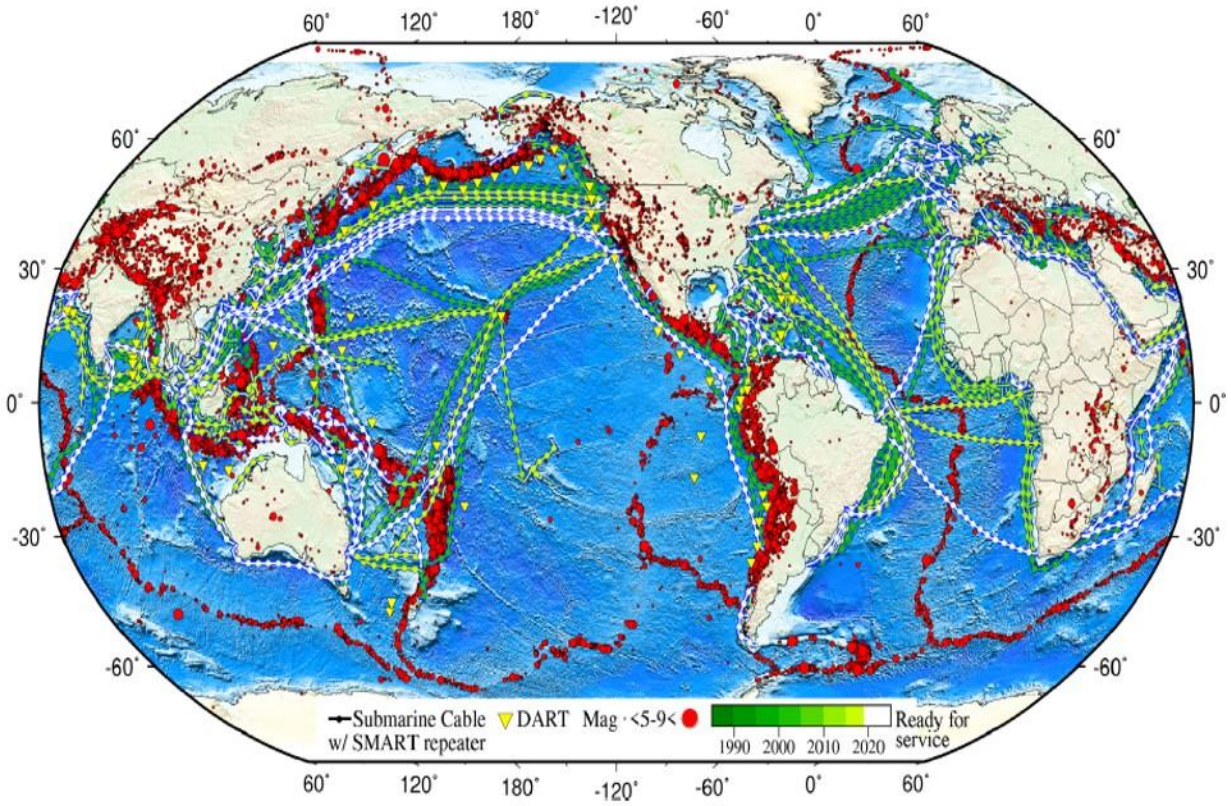
Angove et. all, 2019

FASTER, BETTER EARTHQUAKE SOURCE CHARACTERIZATION
FASTER TSUNAMI DETECTION / REAL-TIME MONITORING:
UNDERSEA SMART CABLES, GNSS NETWORK

Historical seismicity (red), DART tsunami buoys (yellow triangles)

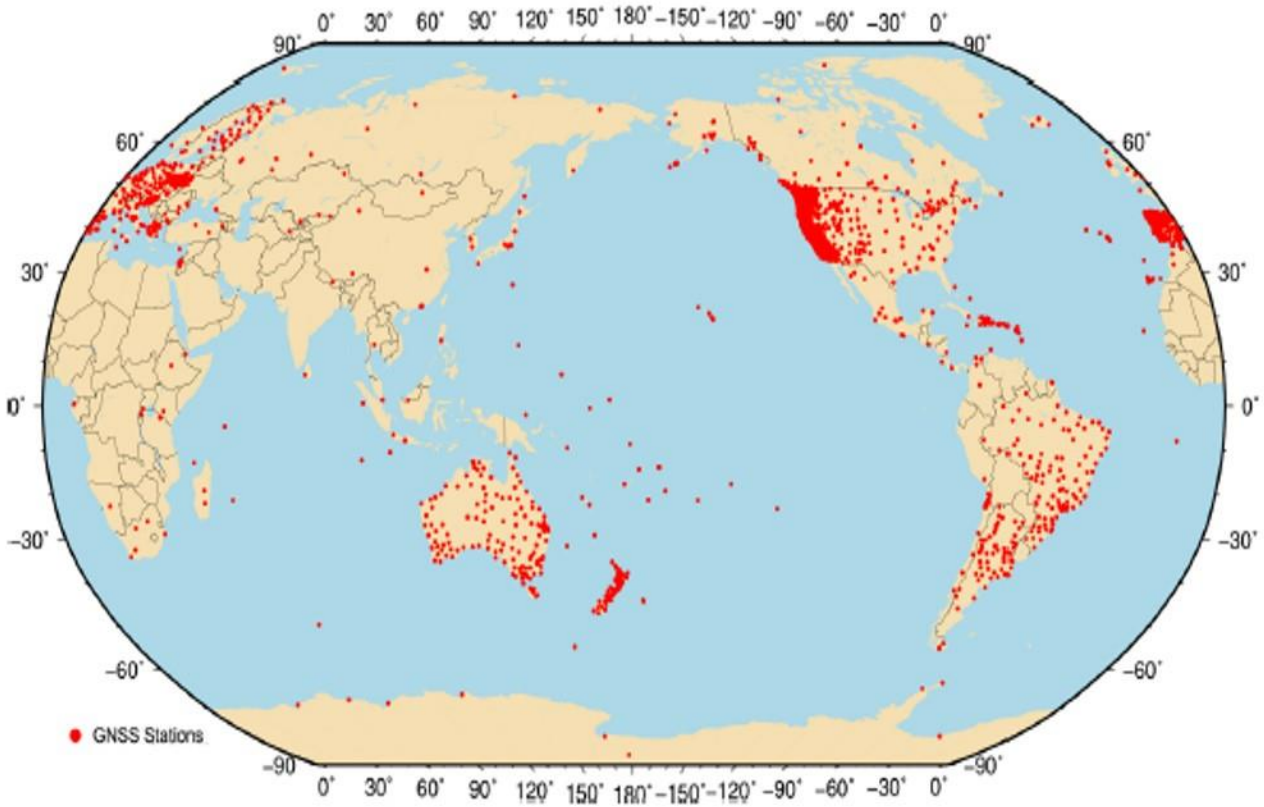
Current / planned (green/white) submarine cables

SMART repeaters shown every 300 km



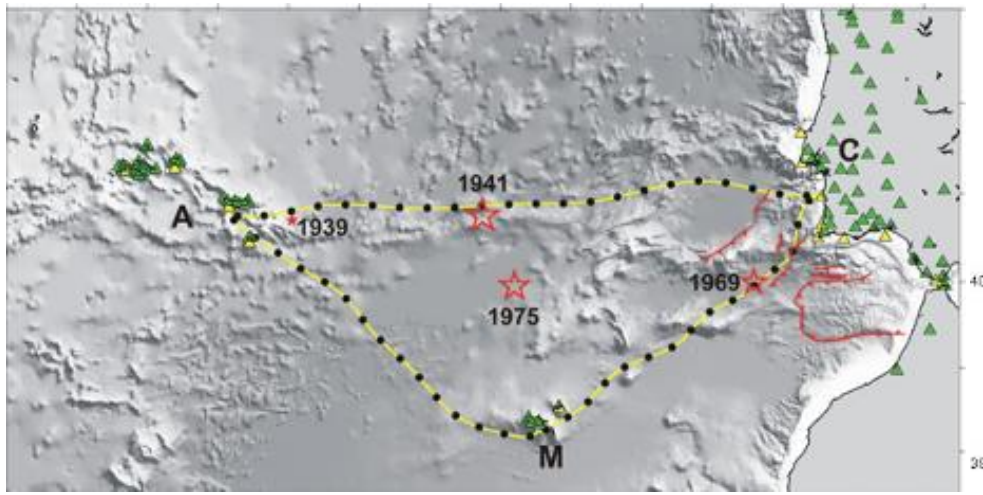
Angove, M . et. al, 2019

Real-time GNSS stations (public networks, n=2,260)



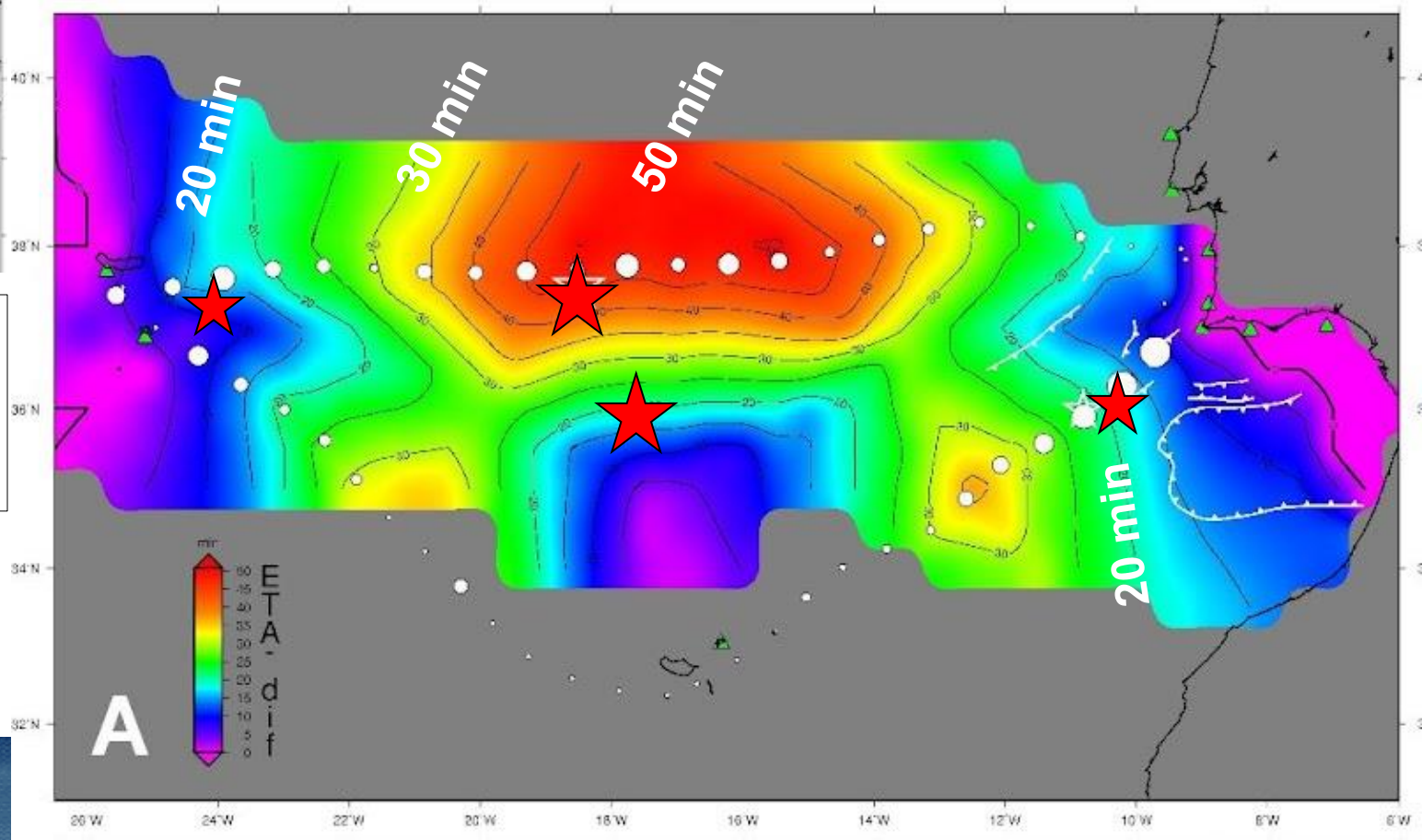
Pacific Northwest Geodetic Array/Central Washington University

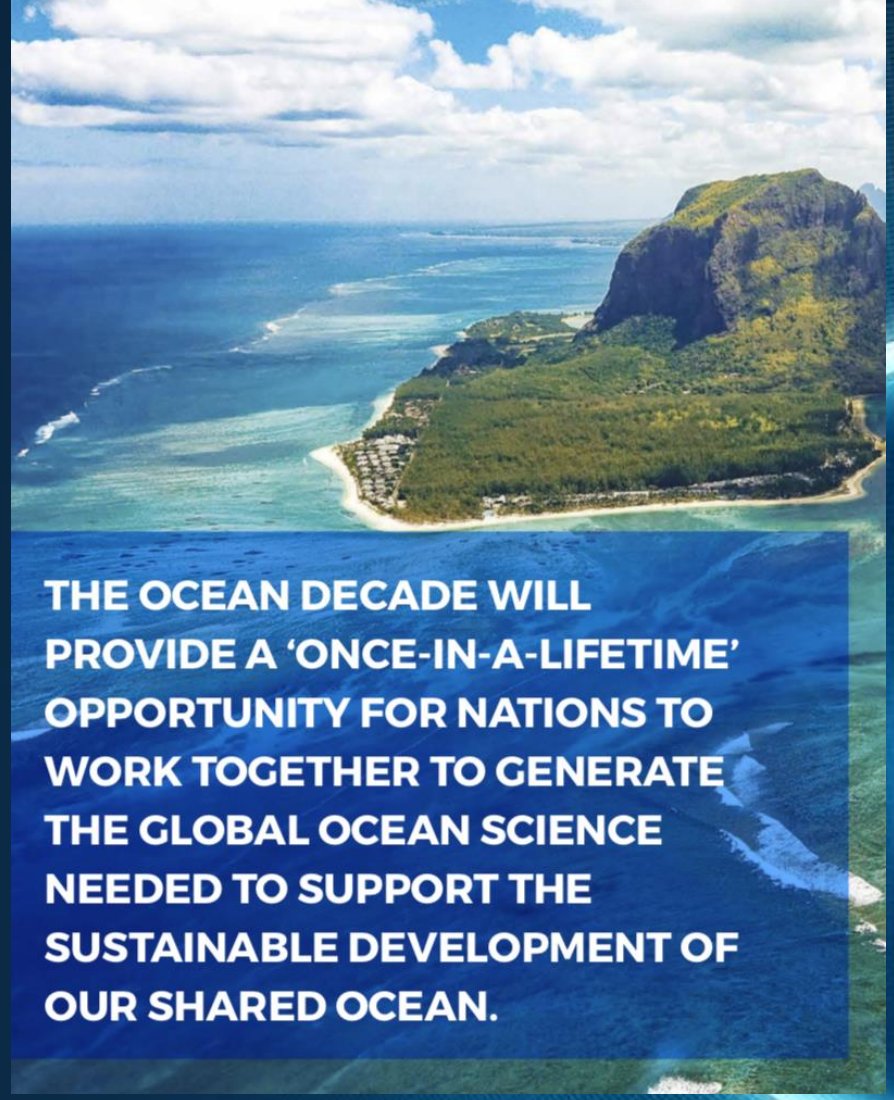
PORTUGAL: Continent/Azores/Madeira (CAM)



CAM submarine cable (SMART repeaters every ~70 km)
Green triangles - seismic stations (Instituto Português do Mar e da Atmosfera (IPMA).
Yellow triangles - coastal tide-gauges monitored (IPMA).
Red stars - M > 7.7 large tsunamigenic earthquakes

Reduction in tsunami arrival time (min)
obtained by CAM-2 sensors (white circles) compared to coastal tide gauge network (**green** triangles).





2021 2030 United Nations Decade of Ocean Science for Sustainable Development

Joint Task Force
SMART SubSea Cable Systems

Decade Challenge 6:
Increase community resilience to ocean hazards (e.g., early warning)

Decade Challenge 7:
Expand the global ocean observing system

Societal Outcome 5:
Safe Ocean

Actions – Projects:
SMART will strengthen Tsunami Early Warning System

⇒ Faster Detection
⇒ Better Forecasts
⇒ Faster warning save lives

© Maxiewyou / Getty Images

Geophysical (Seismic / Tsunami) Sensing and Applications with SMART Cables

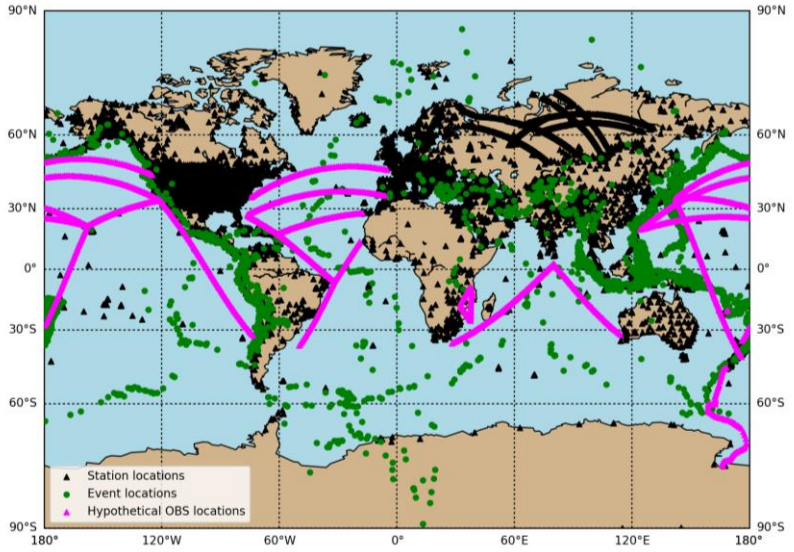
Charlotte Rowe
Los Alamos National Laboratory

Frederik Tilmann
GFZ Potsdam

William Wilcock
University of Washington

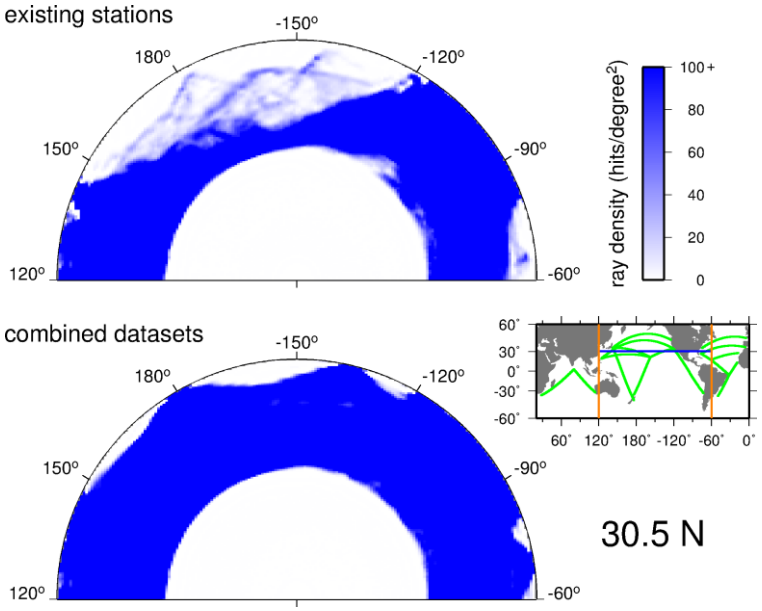
JTF SMART Cables Workshop
Honolulu, HI
20 January, 2022

SMART Cable Benefits to Global Seismology

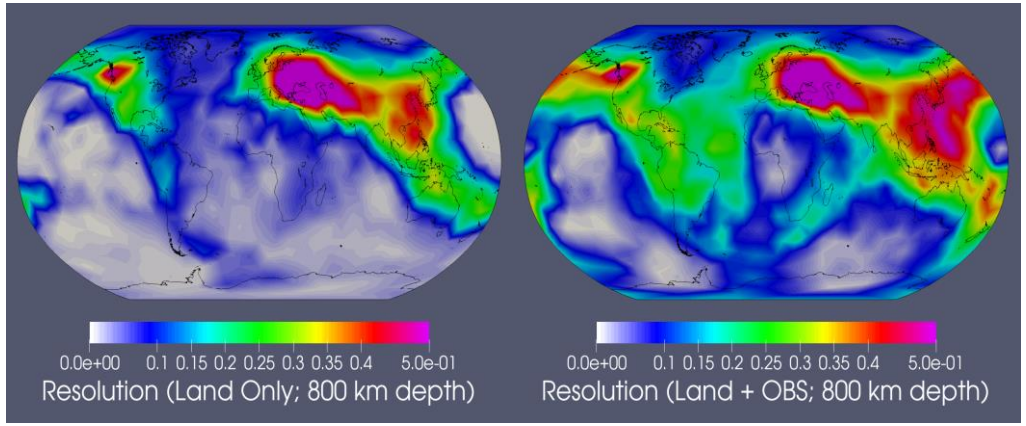


LEFT: Global Earthquakes >M6 (green), seismic stations (black) and notional SMART Cable paths (pink). Heterogeneity in current coverage leads to heterogeneity in global model robustness.

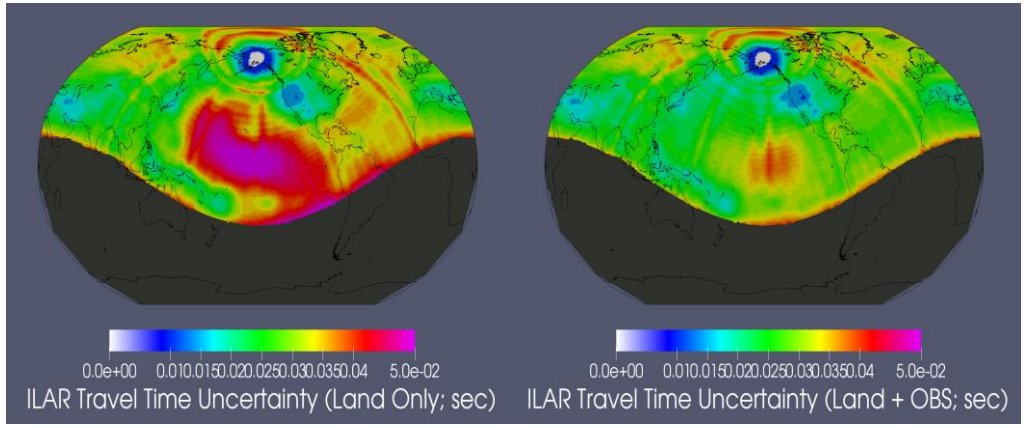
RIGHT: Cross section of global seismic ray coverage improvement with addition of SMART Cables. Better seismic sampling leads to higher quality earthquake location and characterization globally, as well as insights into geodynamic features.



Improvement in global tomographic model resolution when hypothetical SMART sensors are included in the inversion. Left: existing sensors; Right: with notional SMART cables.



BELOW: Addition of the transoceanic cable sensors shows significant improvement in anticipated travel-time uncertainty for an example station in Alaska, as shown by TT uncertainty surfaces without (Left) and with (Right) SMART Cables.



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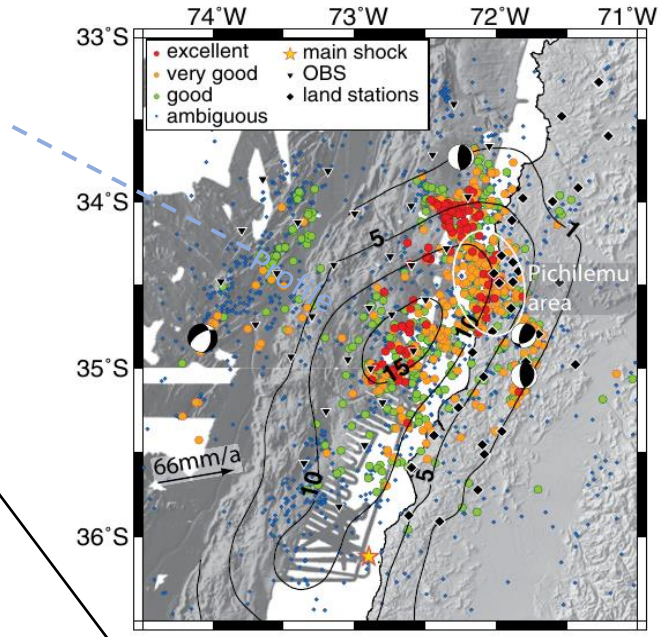
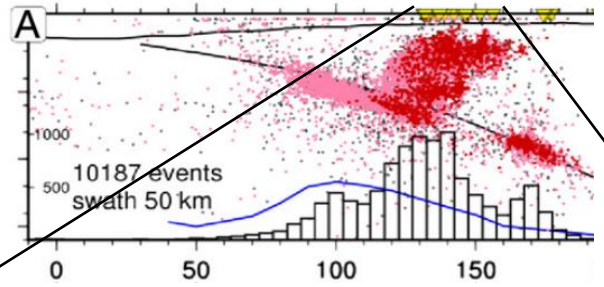
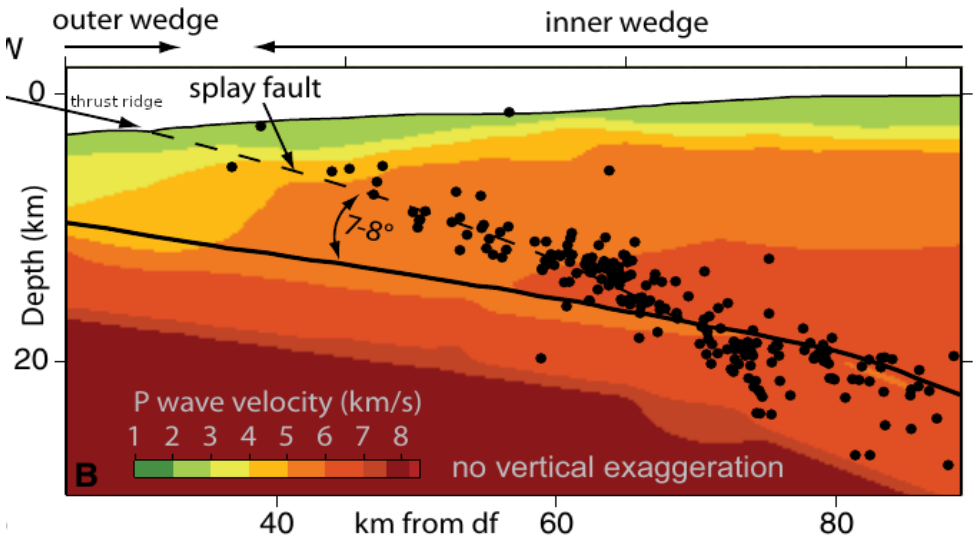
Seafloor Sensors Benefit Seismotectonic Studies

The 2010 Maule M 8.8 Chilean earthquake's aftershocks can define the rupture area, improving source understanding. Addition of offshore sensors has improved offshore earthquake locations, showing migration of rupture to a splay fault.



Lange et al. (EPSL 2012)

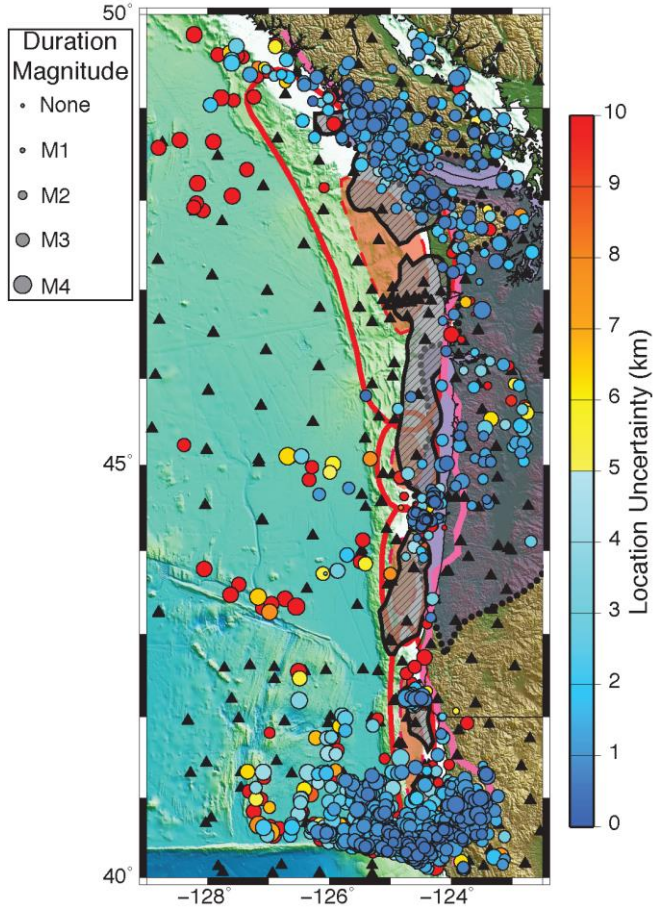




Lieser et al. (Geology 2014)

Two examples shown here highlight the critical importance of seafloor sensors in the detection and characterization of offshore seismicity; resulting tectonic interpretations can better illuminate seismic and tsunami risk.

The Cascadia Subduction Zone has been the subject of intense study. Deployment of the Cascadia Amphibious network has increased offshore earthquake detection by a factor of 4, and has allowed for far greater earthquake location confidence, outlining important tectonic features..



Bilek, Morton and Rowe, Geology 2020

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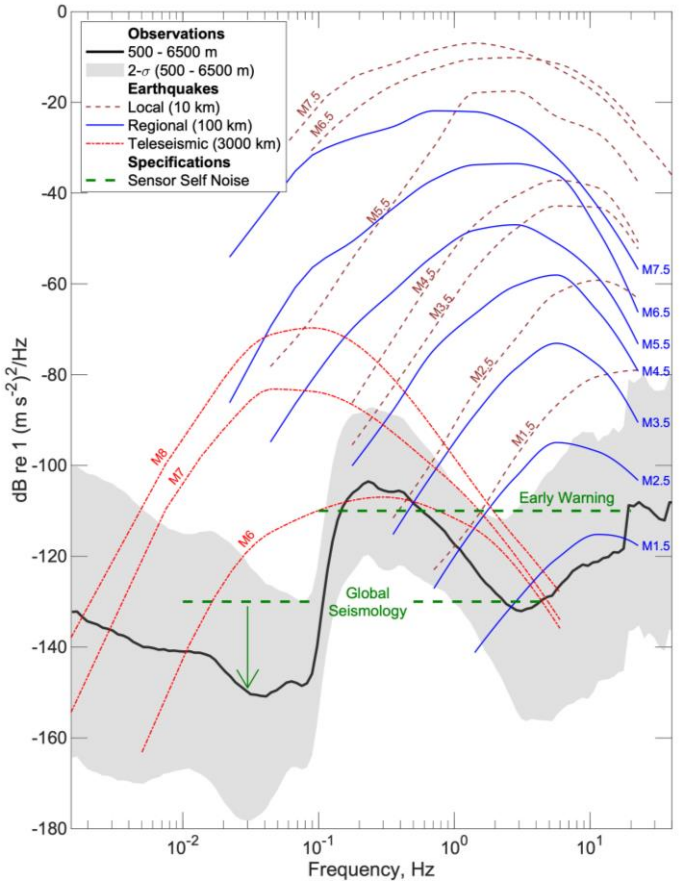
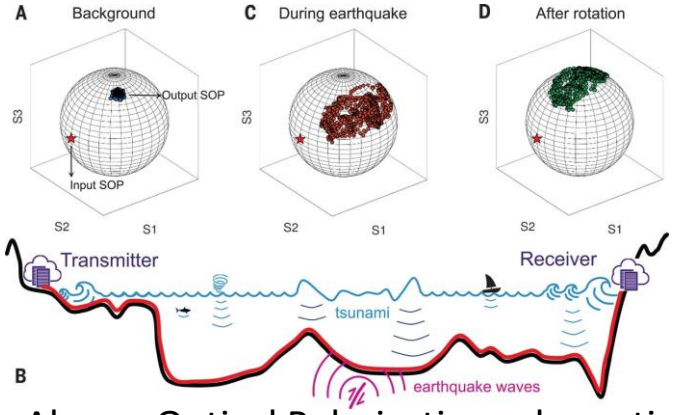
Practical Capability and Other Sensing Methods for Seismic and Tsunami detection



Seafloor seismic sensing capability: Typical amplitude ranges for local, regional and teleseismic sources as a function of frequency, compared to seafloor seismic noise average PSD and two sigma range. This does not address sensor coupling.

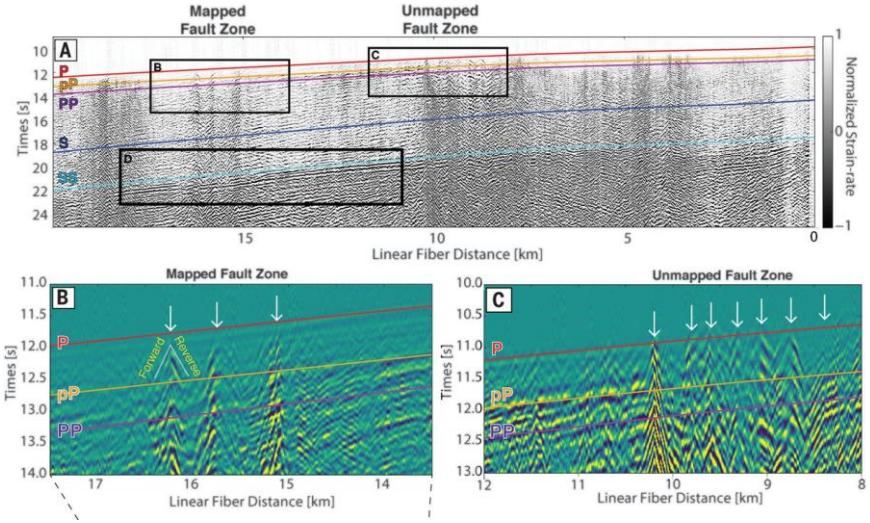
Other sensing beyond SMART sensors: The cables themselves can serve as sensors using such methods as Distributed Acoustic Sensing, Optical Polarization and Ultrastable Laser Interferometry.

Zhan et al. (*Science*, 2021)

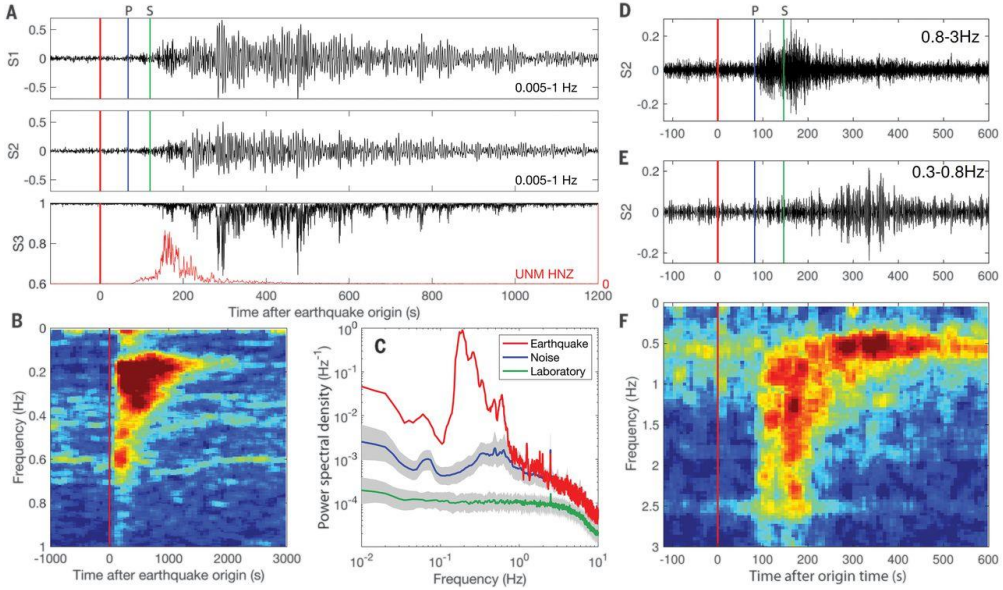


Above: Optical Polarization schematic

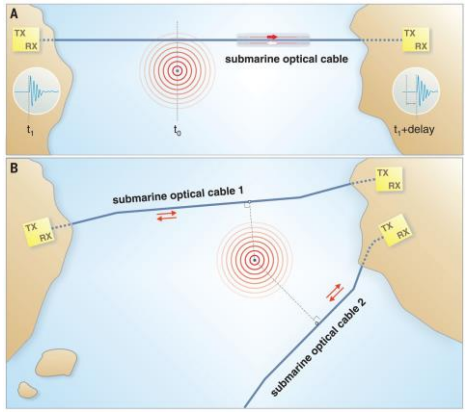
Below: Example seafloor DAS



Lindsey et al. (*Science*, 2019)



Below: Ultrastable Laser Interferometry can identify closest cable segment to source, can estimate source location with multiple cables.



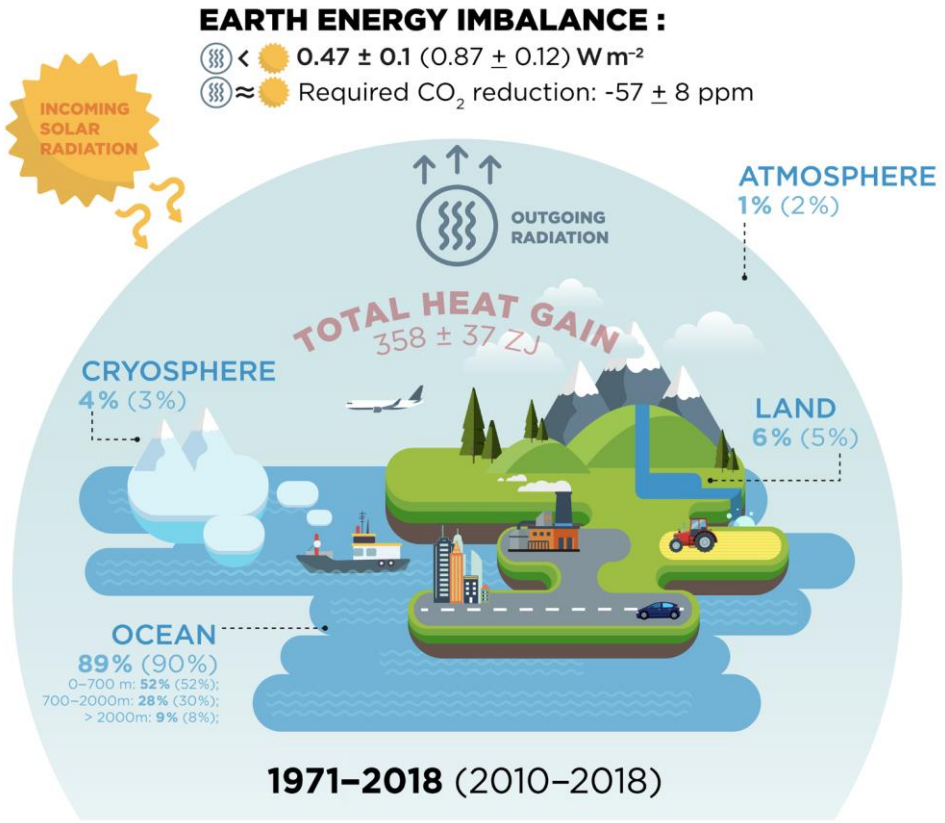
Marra et al. (*Science*, 2019)

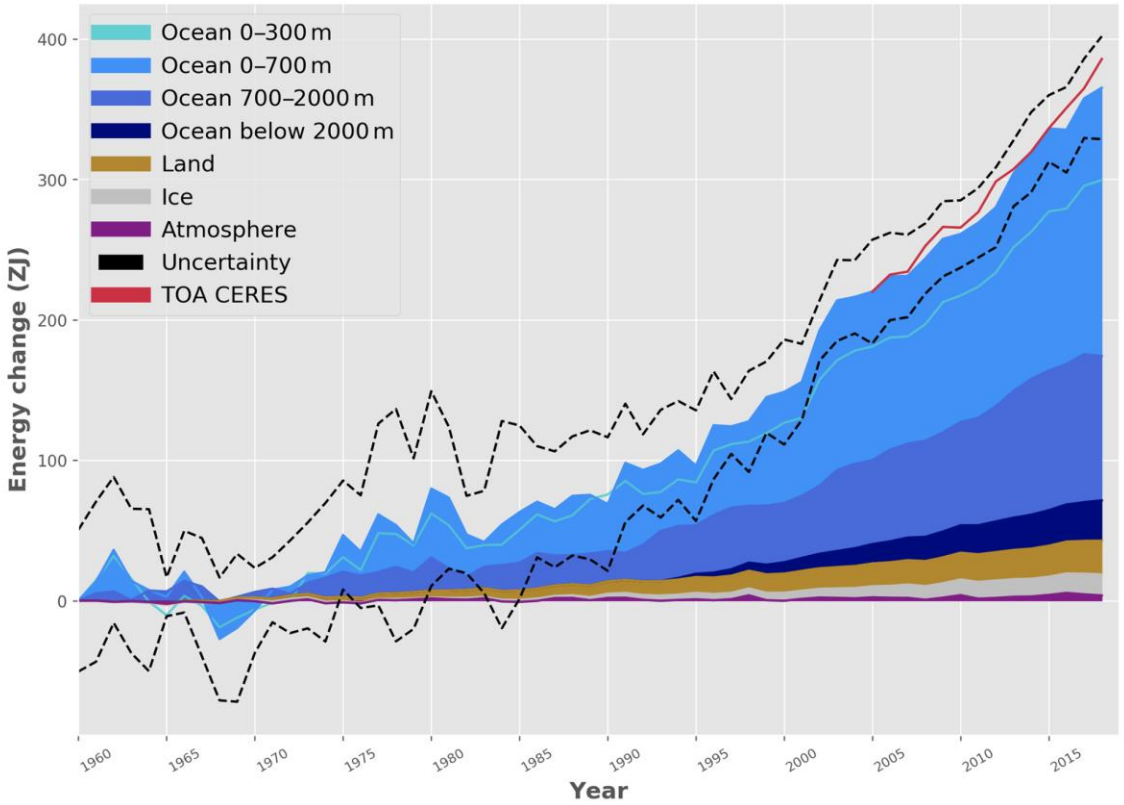
Quantitative Observing System Design in support of SMART Subsea Cables deployment: Vanuatu-New Caledonia to Global

Patrick Heimbach, *University of Texas at Austin*

David Trossman, *Louisiana State University*

Climate change is fundamentally ocean change





von Schuckmann et al., ESSD (2020)

Quantitative Observing System Design in support of SMART Subsea Cables deployment – Vanuatu-New Caledonia to Global

- **Objective:** Quantify impact of SMART Subsea Cable sensor deployment on improved estimation of physical Essential Ocean Variables (EOVs)
- **Approach:** Use advanced 4D-Variational (adjoint) data assimilation (DA) framework developed within NASA's ECCO Consortium (https://ecco-group.org; *Wunsch & Heimbach 2007, 2013*)
  1. *Observing System Simulation Experiments (OSSEs)* will be performed, in which the impact of assimilating synthetic / hypothetical observations will be quantified
  2. We will explore a recently developed *adjoint-based optimal design method* (a dual version of the representer method) for assessing observation complementarity vs. redundancy (*Loose et al. JGR 2020; Loose and Heimbach JAMES 2021*).

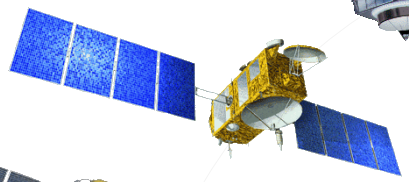
Estimating the Circulation and Climate of the Ocean (ECCO)

Wunsch & Heimbach, Physica D (2007)

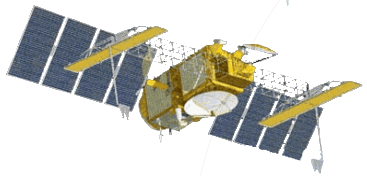
Heimbach et al., Front. Mar. Sci. (2019)

TOPEX-POSEIDON

GRACE, GRACE-FO



JASON I



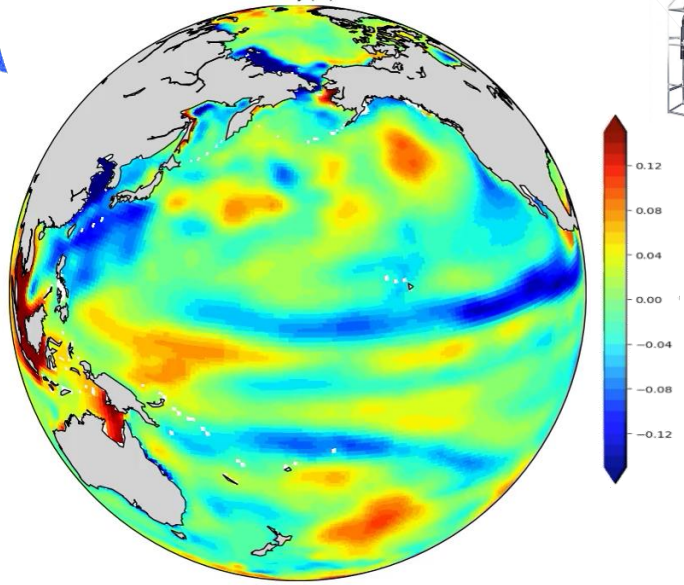
JASON 2

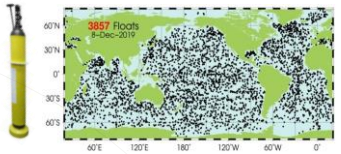
JASON 3

SARAL/AltiKa

Aquarius/SAC-D

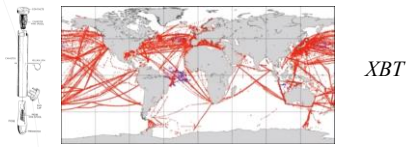
AVHRR



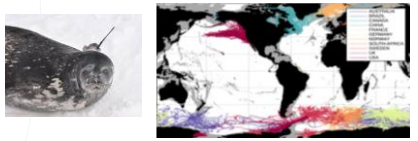


Argo Profiling Floats

CTD
- *GO-SHIP*
- *WOCE*
- *NODC*
- *ACES*

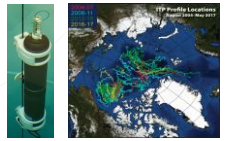


XBT



Marine mammals

Instrumented moorings



Ice-tethered profilers

$$\frac{\partial \boldsymbol{v}}{\partial t} + (f+\zeta)\hat{\boldsymbol{k}} \times \boldsymbol{v} + \nabla_z * \mathrm{KE} + w\frac{\partial \boldsymbol{v}}{\partial z} + g\nabla_z * \eta + \nabla_h \Phi' = \boldsymbol{D}_{z^*,\boldsymbol{v}} + \boldsymbol{D}_{\perp,\boldsymbol{v}} + \mathcal{F}_{\boldsymbol{v}},$$

$$\frac{\partial \Phi'}{\partial z} = g\frac{\rho'}{\rho_c},$$

$$\frac{1}{H}\frac{\partial \eta}{\partial t} + \nabla_z * (s^* \boldsymbol{v}) + \frac{\partial w}{\partial z^*} = s^* \mathcal{F},$$

$$\frac{\partial (s^* \theta)}{\partial t} + \nabla_z * (s^* \theta \boldsymbol{v}_{\mathrm{res}}) + \frac{\partial (\theta w_{\mathrm{res}})}{\partial z^*} = s^* (\mathcal{F}_\theta + D_{\sigma,\theta} + D_{\perp,\theta}),$$

$$\frac{\partial (s^* S)}{\partial t} + \nabla_z * (s^* S \boldsymbol{v}_{\mathrm{res}}) + \frac{\partial (S w_{\mathrm{res}})}{\partial z^*} = s^* (\mathcal{F}_S + D_{\sigma,S} + D_{\perp,S}),$$

MIT general circulation model

Courtesy: I Fenty (JPL/Caltech)

https://ecco-group.org

Business – Industry Update

- **Industry Overall**
  - **Living up to constant 30-35% CAGR Growth**
  - **Builds driven by more than just the OTTs**
- **Technology**
  - **Ever onward – 24 fiber pair in Atlantic to be done by NEC**
  - **Transmission advances – with high fiber count, ½ petabit cables by 2025**
- **Supplier Situation**
  - **Extremely busy – wet resources becoming a problem**
  - **Delivery timelines are longer than desired**
  - **Chip shortages beginning to impact card delivery**
- **Investment**
  - **High interests by may types of invests –OTTS, Governments, Private and now – Infrastructure Funds**
  - **Data Centers beginning to become full players – Data centers plus cable**

JTF – For Discussion: Funding Approaches

- **Targeted Strategy for Donor Funding (grants)**
- **Development Bank Support (blended finance)**
- **Integrated Smart Cable Finance (project finance based on longterm data contracts)**
- **“Lighthouse projects” under the Decade for Ocean Science, the EU Mission Ocean and other initiatives**

Sensor Monitoring And Reliable Telecommunications

SMART Cable Development

SUBSEA DATA SYSTEMS

Steve Lentz, CTO

SMART Cables Workshop

January 20, 2022

Technology Readiness Levels

Level	Definition	SMART Repeater Requirements	Status	Additional R&D Funding ROM
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**	$0
TRL2	Technology concept and/or application formulated	Technical challenges and potential solutions identified.	**Completed**	$0
TRL3	Analytical and experimental critical function and/or characteristic proof-of-concept	Electrical and mechanical design concepts developed and assessed.	In progress System supplier involvement (TBD) **2022 completion (anticipated)**	$750K - $2M
TRL4	Component and/or breadboard validation in laboratory environment	Benchtop demonstration including streaming to data repository.	In progress **2022 completion (anticipated)**	$0
TRL5	Component and/or breadboard validation in relevant environment	Prototype testing in shallow water.	Requires SBIR Phase II funding **2023 objective**	$500K – $1.5M
TRL6	System/subsystem model or prototype demonstration in a relevant environment	Sea trial of SMART sensor system mounted in repeater housing.	**2024 target**	$3M - $5M
TRL7	System prototype demonstration in a space (subsea) environment	12-18 month trial of system with multiple SMART repeaters.	**2025 target**	$3M-$10M
TRL8	Actual system completed and "flight qualified" through test and demonstration	Prototype system delivered and commissioned.	**2025 target**	$3M-$10M
TRL9	Actual system "flight proven" through successful mission operations	First "generally available" product delivered and commissioned.	**2026 target**	$7.5M-$15M

SUMMARY

- R&D Investment is needed at every stage in the value chain
- Ongoing, operational funding is needed to justify R&D investment
- Trials and demonstrations are essential to manage risks
- Social responsibility is taken seriously within the submarine cable industry, but companies cannot be forced to take part
- Set achievable goals and do not be afraid to fail
- Initial funding will start a virtuous cycle

GeoLab

Submarine cable for scientific research

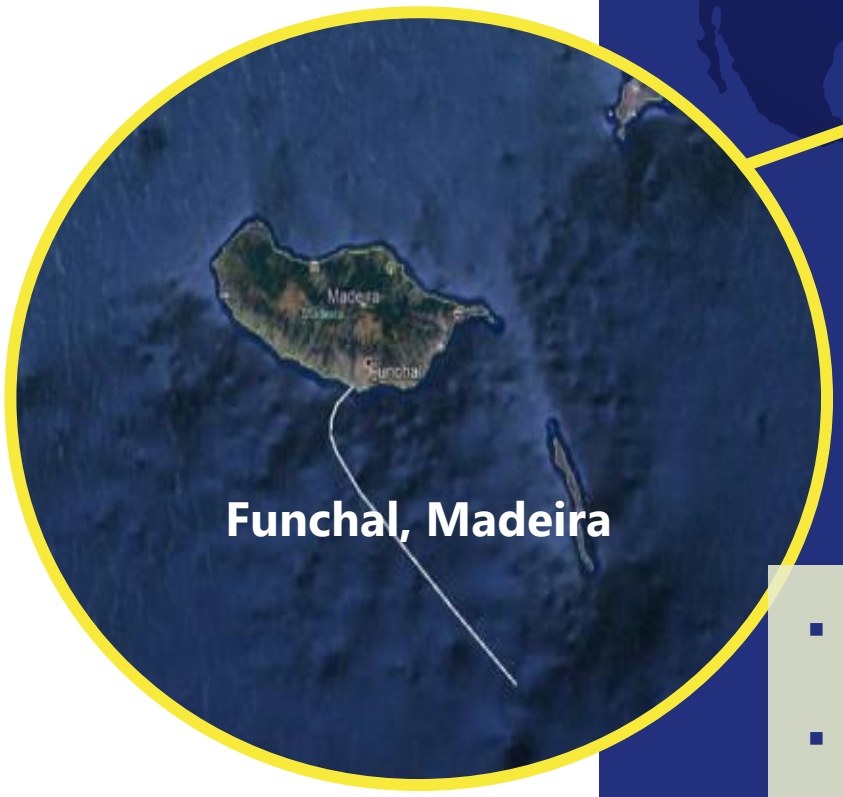
Chris Atherton
Senior Research Engagement Officer

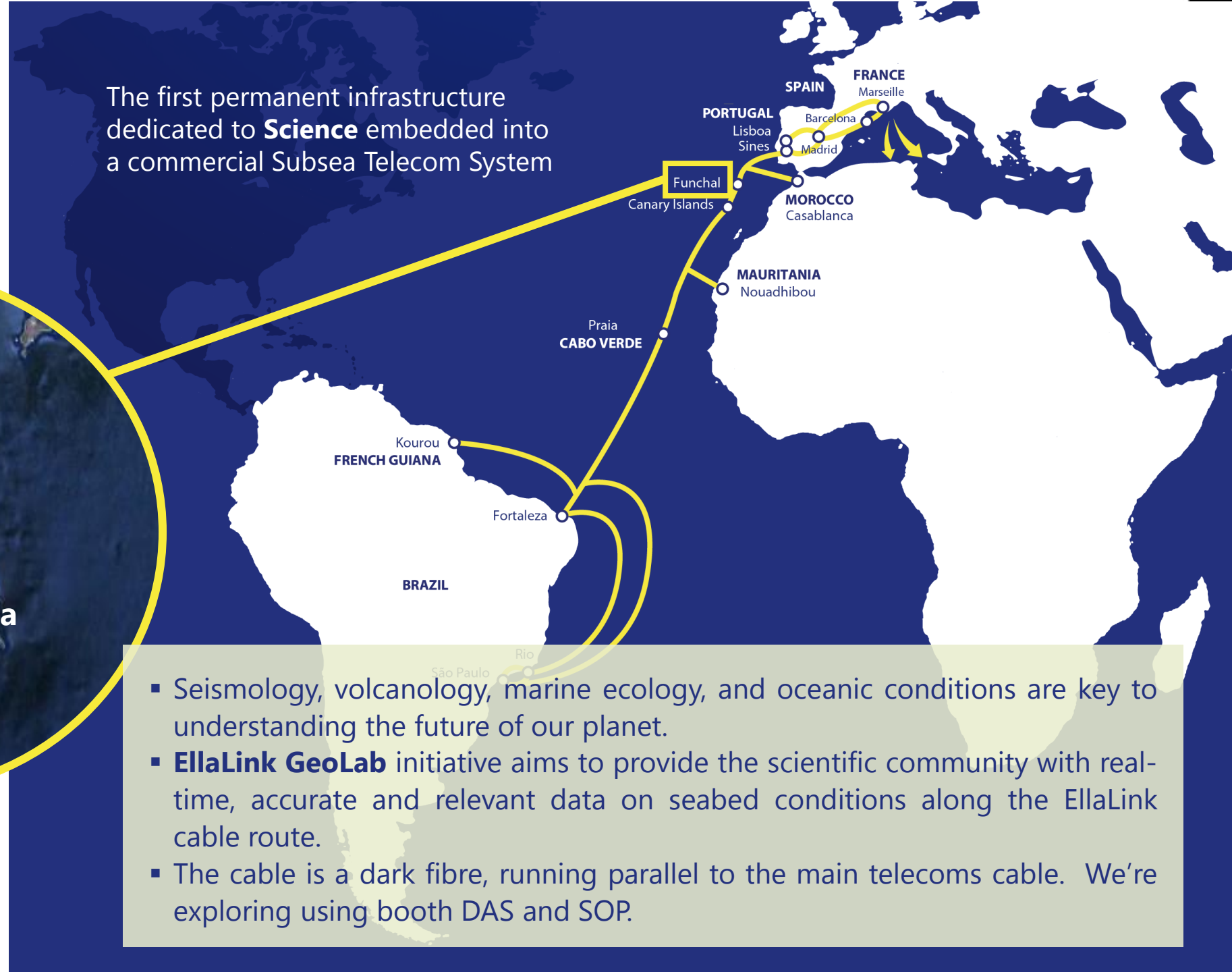
Public

www.geant.org

GEOLAB

The first permanent infrastructure dedicated to **Science** embedded into a commercial Subsea Telecom System





- Seismology, volcanology, marine ecology, and oceanic conditions are key to understanding the future of our planet.
- **EllaLink GeoLab** initiative aims to provide the scientific community with real-time, accurate and relevant data on seabed conditions along the EllaLink cable route.
- The cable is a dark fibre, running parallel to the main telecoms cable. We're exploring using booth DAS and SOP.

United Nations Educational, Scientific and Cultural Organization

Organisation des Nations Unies pour l'éducation la science et la culture

Organización de las Naciones Unidas para la Educación la Ciencia y la Cultura

Организация Объединенных Наций по вопросам образования науки и культуры

Intergovernmental Oceanographic Commission

Commission océanographique intergouvernementale

Comisión Oceanográfica Intergubernamental

Межправительственная океанографическая комиссия

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

UN Decade of Ocean Science for Sustainable Development: 2021-2030:

Safe Oceans Outcome

Rick Bailey

Head of Secretariat for the UNESCO-IOC Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWMS)

UN Decade of Ocean Science for Sustainable Development: 2021 - 2030

The United Nations
Decade of Ocean Science
for Sustainable Development
(2021-2030)

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

"The United Nations Decade of Ocean Science for Sustainable Development is a unique opportunity to engage the ocean science community in achieving the Sustainable Development Goals - globally, regionally and locally."

Vladimir Ryabinin
Executive Secretary of the Intergovernmental Oceanographic Commission of UNESCO

UN Decade of Ocean Science for Sustainable Development: 2021 - 2030

VISION:

The Decade will harness, **stimulate and coordinate interdisciplinary research efforts** at all levels, in order to support **delivery of the information, action and solutions** needed to achieve the UN's 2030 Agenda for Sustainable Development.

Goal:

Goal 1:

To generate **the scientific knowledge and underpinning infrastructure and partnerships** needed for sustainable development of the ocean.

Goal 2:

To provide **ocean science, data and information to inform policies for a well-functioning ocean** in support of all SDG-2030 Agenda.

SOCIETAL OUTCOMES:

1. **A Clean Ocean;**
2. **A Healthy and Resilient Ocean;**
3. **A Predicted Ocean;**
4. **A Safe Ocean;**
5. **A Sustainable harvested and productive ocean;**
6. **A "Transparent and Accessible" Ocean;**

2021 2030 United Nations Decade of Ocean Science for Sustainable Development

The Vision of A Safe Ocean

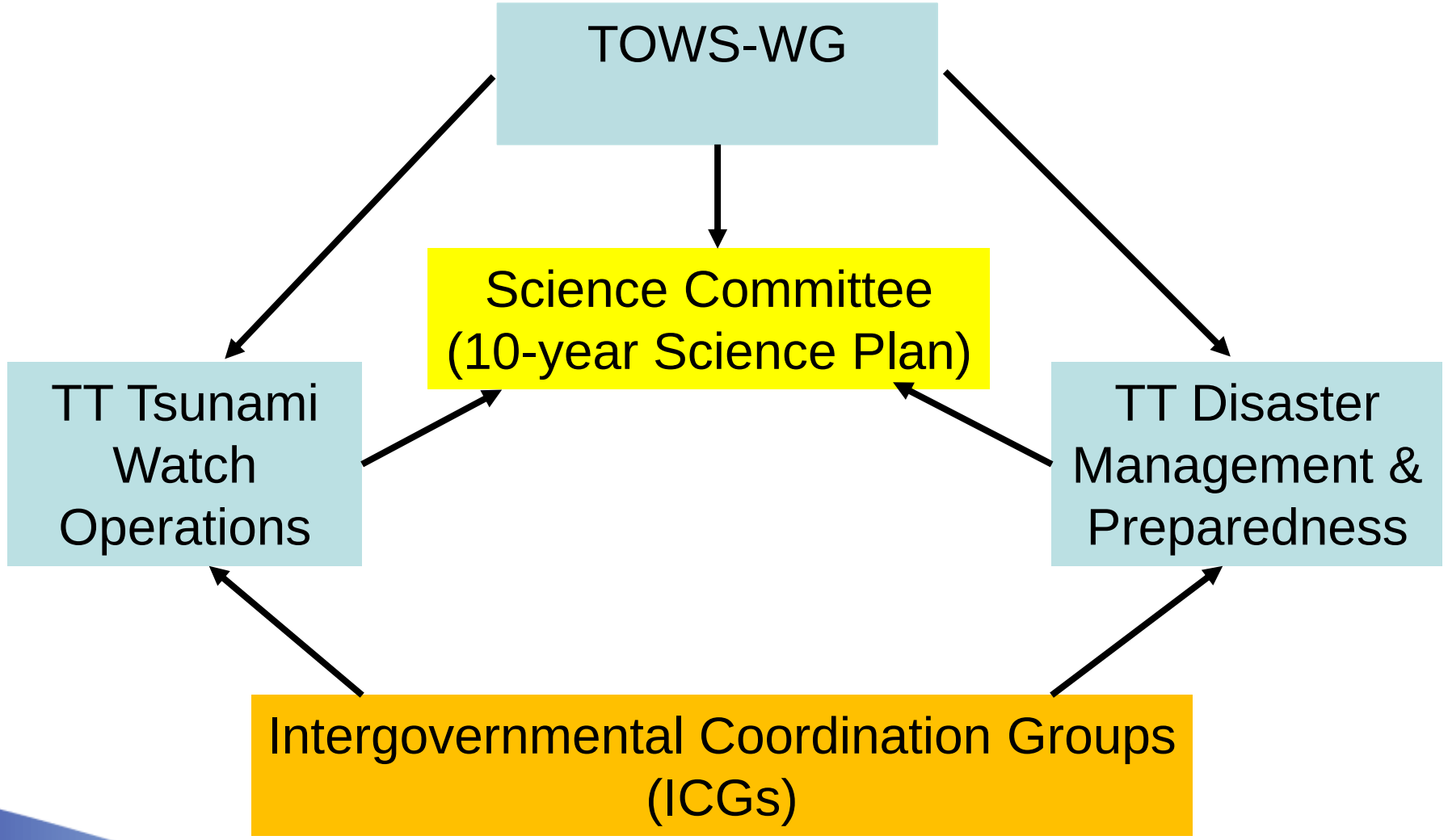
A Safe Ocean is:

- ***not*** an ocean in which tsunamis do not occur;
- ***is*** an ocean in which tsunamis are understood, observed, and their impact is ***accurately predicted before*** they reach the coast;
- ***is*** an ocean in which those that live, work, and recreate along it are ***armed with knowledge and prepared*** to act before a tsunami strikes.

Tsunami Dedicated Programme within UNDOS

1. **Expansion of existing observational systems** including seismometers, coastal tide gauges, and deep ocean tsunameters (DARTs) to fill identified gaps;
2. **Deployment of new technologies to address observational gaps that cannot be covered by existing networks**. For example, this would include the widespread implementation of scientific instrumentation on deep-ocean telecommunications cables as developed by the ITU/WMO/ UNESCO-IOC Joint Task Force (JTF) SMART Subsea Cables effort; and submission of a Programme to the UN Decade of Ocean Science for Sustainable Development;

UNDOS Tsunami Programme Governance



ITU-T SG15, WTSA-20

- ITU-T SG15 Q8/15 created work items related to SMART cables and started discussion towards standards:
  - G.smart: SMART cables
  - G.dsssc: Dedicated scientific sensing submarine cable system
  - Related Recommendations (standards) on submarine cables will also be updated to accommodate these functions
- CEPT proposed to create a new Resolution on SMART cables
  - to be discussed at WTSA-20 (Geneva, 1-9 March 2022)

ASN business development

SMART and Climate Change
ASN update

January 2022

ASN is committed to climate action → S.M.A.R.T !

SMART repeaters, currently under development, will add, on top of the core telecom amplification, a range of environmental measurement capabilities (ocean temperature, sea bottom pressure, undersea currents, undersea seismic activity, etc.)

Data collected by SMART repeaters will be carried back to shore through the telecom cable, for further processing, allowing a variety of analyses needed to better understand climate change and its effect on the oceans ecosystem.

Applications will range from tsunami / earthquake early warning to collecting data on global warming and sea level rise.

ALCATEL SUBMARINE NETWORKS

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ASN and the JTF Framework

JTF Framework is the right approach to obtain a cost effective and global deployment of a wide array of sensors under the oceans:

- Systems designed for a primary telecom use
- Wide deployment thanks to the continuous demand for new systems and alternative routes
- Taking full benefit of the cable infrastructure and installation services
- SMART Sensors integration need to minimize impact on telecom and O&M services

Submarine cable design has been characterised by its strict design rules to ensure a high level of service and maximum reliability:

- SMART Solution components will be fully integrated in ASN submerged plant portfolio
- All new components to undergo a strict qualification programme
- Same reliability constraints should apply where possible, realistic objectives to be refined,

ASN Climate Change Team:

- Emmanuel DANJOU, Antoine QUEVAL: Business Development
- Jean-Francois BAGET: Product Management

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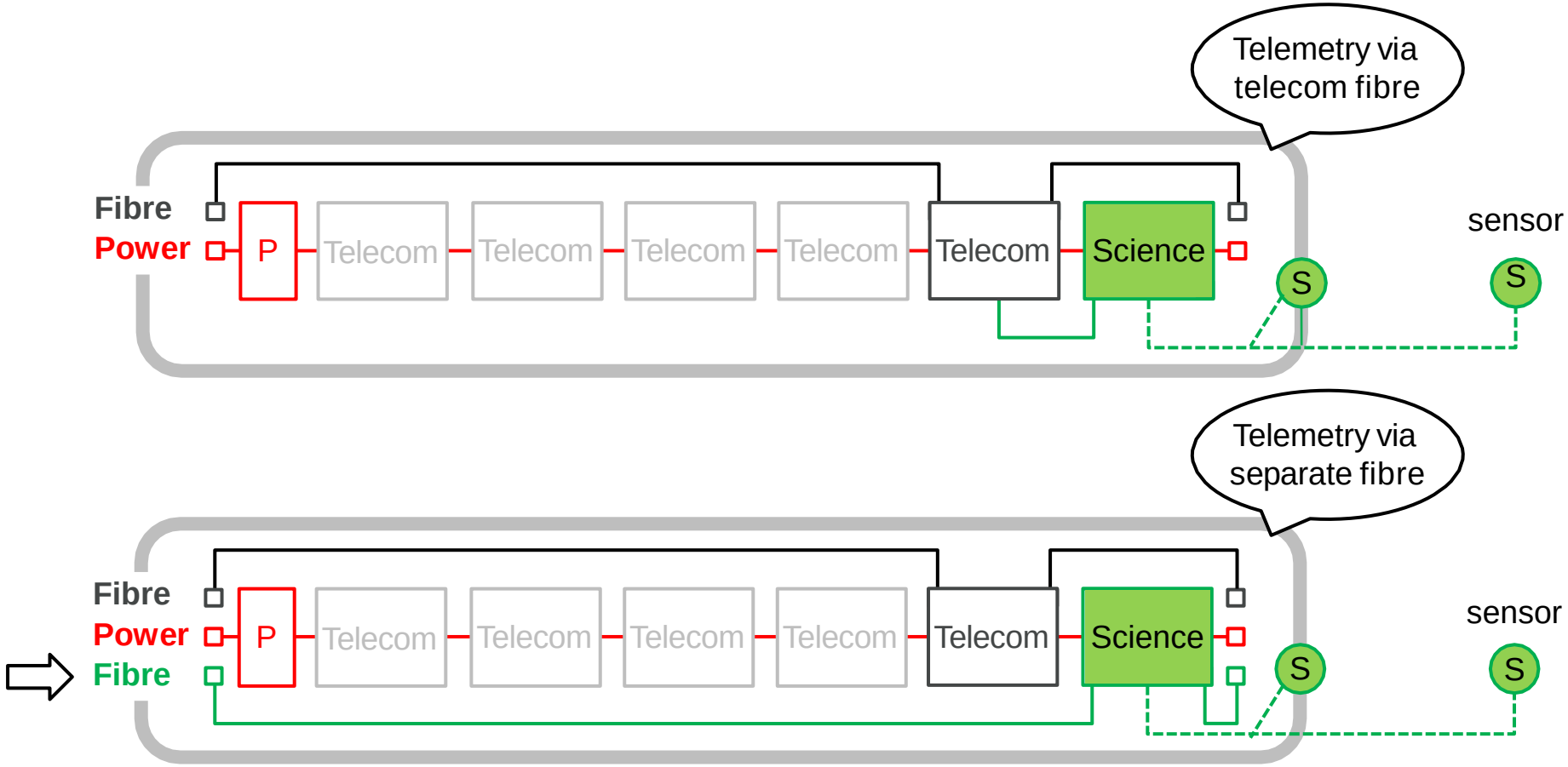
Suppliers

- Subcom Ron Rapp, Dmitriy Kovsh
- NEC Motoyoshi Tokioka

SMART repeater models



- Reliability is very important
- Science powering needs to fail in a safe way

- Xtera could provide Hi-REL power module
  - Variable voltage
  - DC-DC converter

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Sensor Monitoring And Reliable Telecommunications (SMART)

Repeater Development and Data Management

SUBSEA DATA SYSTEMS

Matt Fouch, President and Steve Lentz, CTO

Joint Task Force

SMART Subsea Cables Workshop

January 20, 2022

SUBSEA DATA SYSTEMS (SDS)

- Startup company formed to drive SMART repeater/cable development
  - Partnership between Samara/Data and Ocean Specialists, Inc.
  - SDS staff are on loan part time from parent companies (based on current funding scenario)
  - Dr. Matt Fouch, President; Mr. Steve Lentz, CTO

- **Primary mission**: Develop and facilitate data gathering and data management from SMART Cable systems

- Prerequisites to accomplish our mission:
  - Catalyze SMART cable development
  - Bridge the gap between the scientific community and submarine cable system manufacturing industry at the working level

Product and Services Offerings (Long Range Plan)

- **SMART Repeater (in progress)**
  - Licensable circuit board design, firmware, and software for data acquisition OR
  - Complete bespoke sensor package for provider's repeater design

- **SMART Cable Data Management (in progress)**
  - Shore side solution for data storage, processing, and forwarding from SMART Cables

- **SMART Cable Data Products (future development)**
  - Bespoke preprocessed data products for commercial and government customers

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SUMMARY

- **Subsea Data Systems is developing a benchtop SMART prototype system**
  - Initial prototype complete by end of 2022
  - Current funding from U.S. National Science Foundation
- SDS will develop fully functional firmware/software
- Direct collaboration with providers will be necessary to fully integrate sensor system into a repeater
- Current SMART repeater sensor system development timeline is 36 months

- **Subsea Data Systems is developing the infrastructure for SMART Cable data flow and delivery**
  - Funding from Gordon and Betty Moore Foundation (New Caledonia – Vanuatu use case)

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Wet demo SMART cable @ Western Ionian Sea

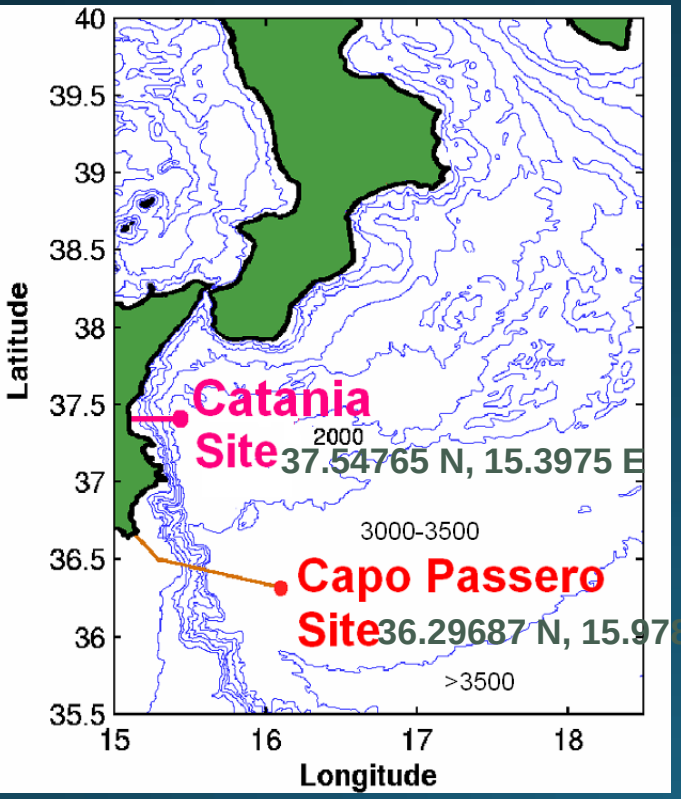
Giuditta Marinaro – INGV

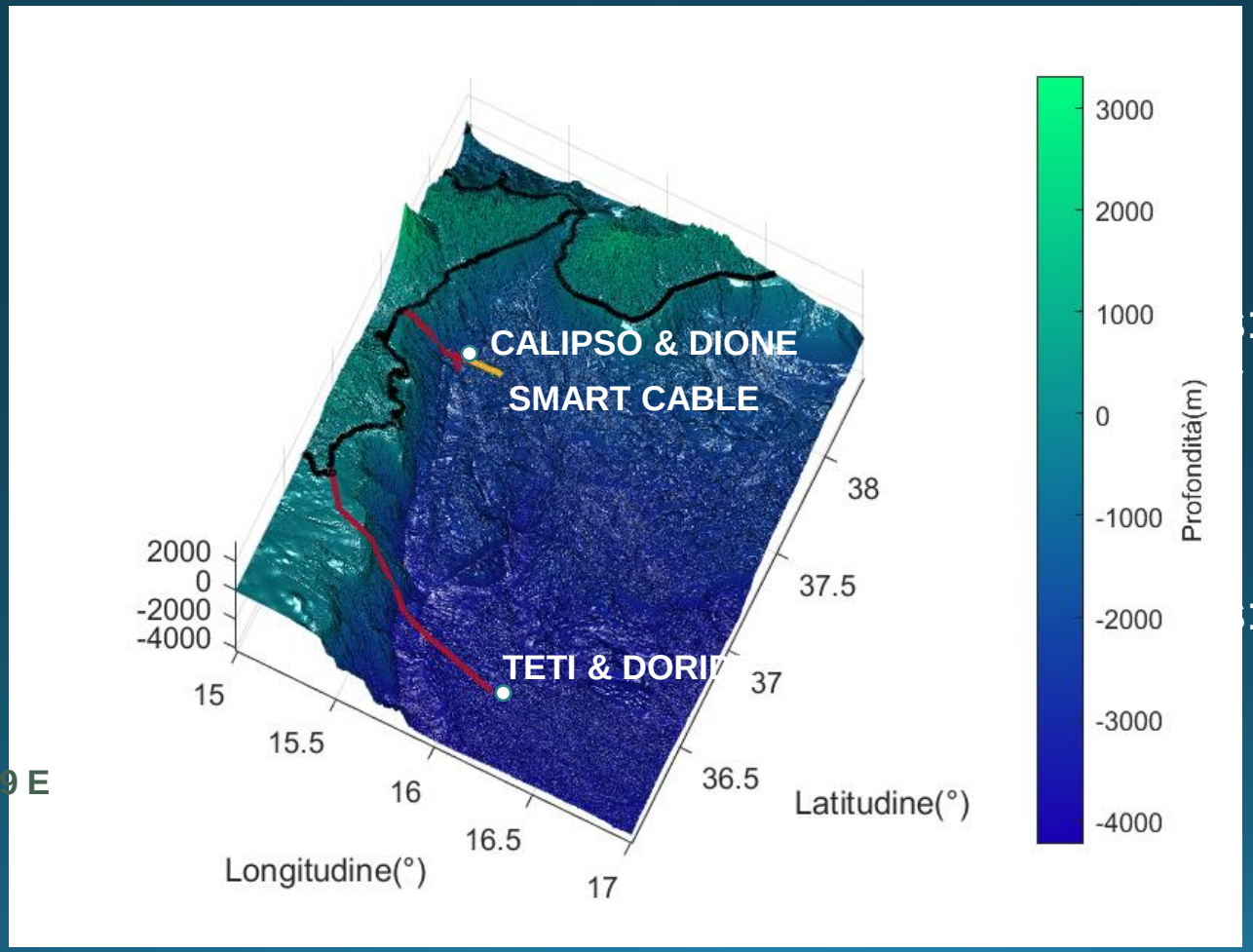
Will Reis – Güralp Systems Ltd

InSEA project: enhancement of Western Ionian Sea

National Operative Programme – Research and Innovation 2014-2020

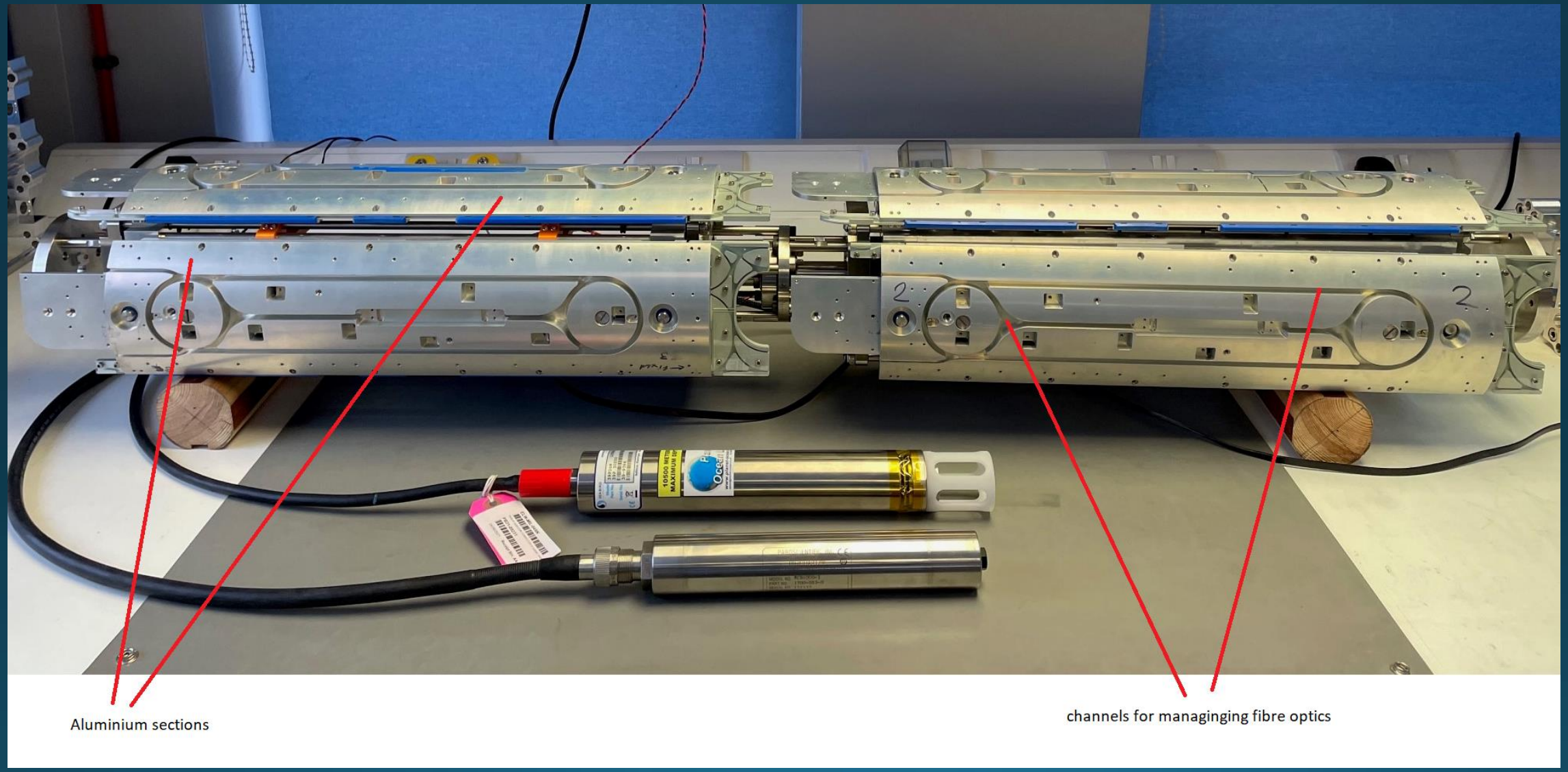
InSEA: Initiatives in Supporting the consolidation and enhancement of EMSO infrastructure and related Activities

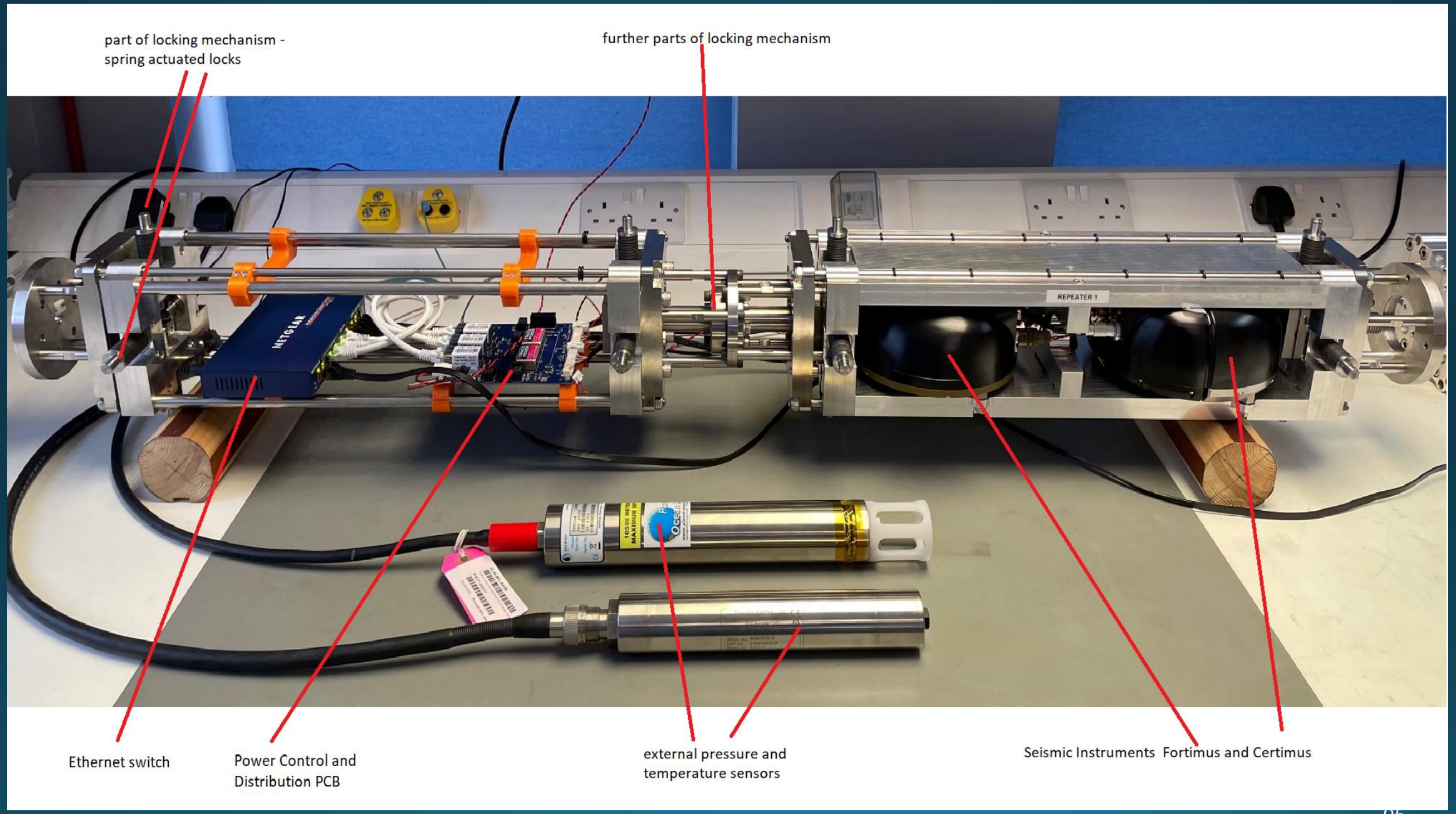




: CALIPSO and DIONE
2kVA)

: TETI and DORIDE


Aluminium sections
channels for managinging fibre optics


part of locking mechanism - spring actuated locks
further parts of locking mechanism
REPEATER 1
Ethernet switch
Power Control and Distribution PCB
external pressure and temperature sensors
Seismic Instruments Fortimus and Certimus

Results

Catania Site (2100 m bsl, 30km E/O cable):

- 2 seafloor platforms with seismo and BPR
- Ionian SMART cable wet demo – 3 seismo and 3 BPR

Capo Passero Site (3500 m bsl, 100km E/O cable):

- 2 seafloor platforms with seismo and BPR

What we expect:

- Development of methods for tsunami detection using distributed submarine measurement points that will be integrated with the data recorded by the INGV earthquake monitoring network

- Having data from different BPRs available in several observation points and acquired synchronously allows the simultaneous analysis of the data acquired in several points.

- By integrating several closely spaced measurement points into a single detection system, it will help to increase measurement sensitivity without increasing the probability of false detection.

SMART CAM-2

Joint Task Force SMART Subsea Cables Workshop

University of Hawaii

20 January 2022

Presented by

ANACOM
AUTORIDADE NACIONAL DE COMUNICAÇÕES

L·E·A
LISTENING TO THE EARTH UNDER THE ATLANTIC

SMART CAM-2

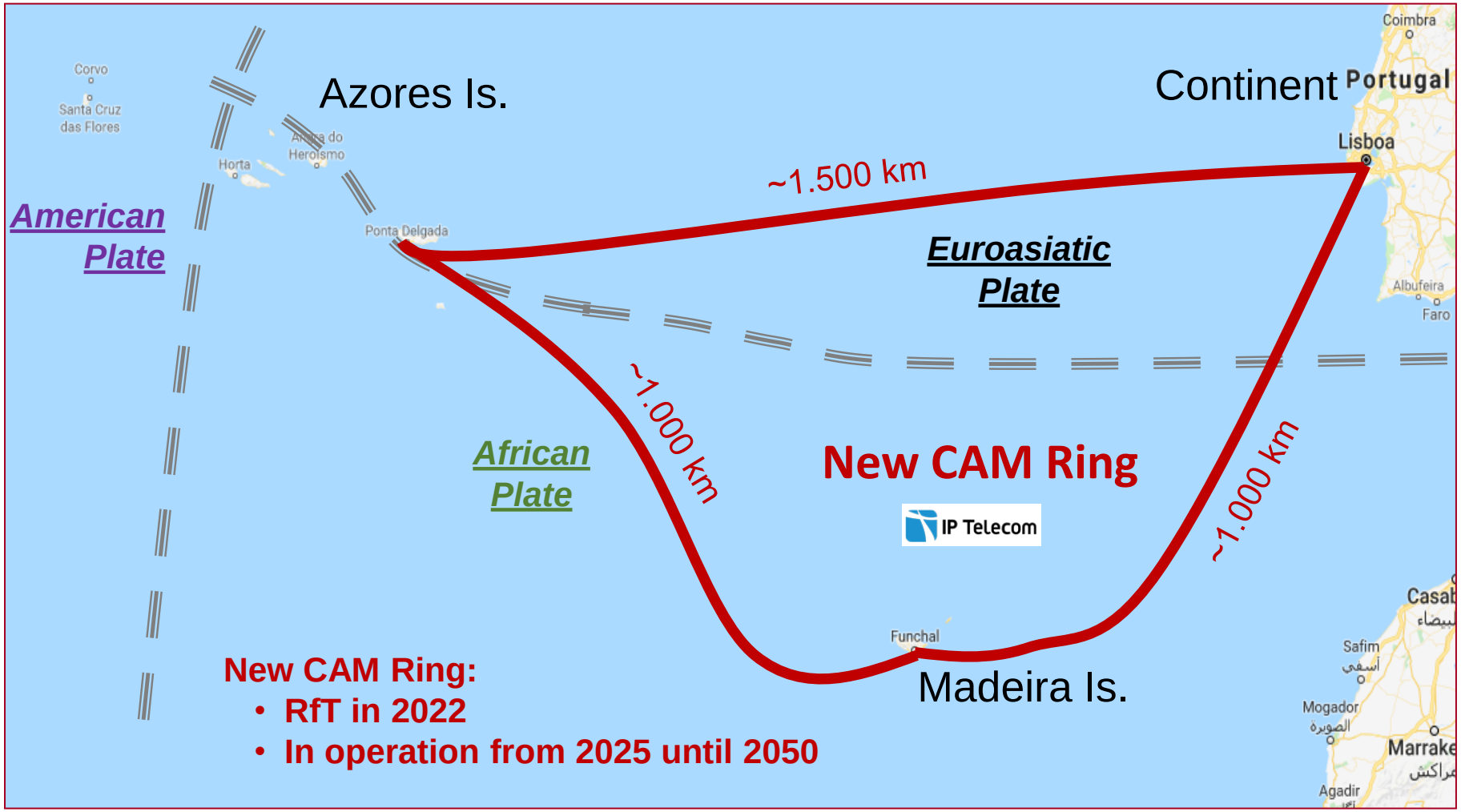
Portugal has a need of having a new telecom submarine cable to interconnect the mainland, Azores Is. and Madeira Is. (2024/25)

+

Portuguese Continental Shelf is a meeting area of three tectonic plates with considerable seismic activity

===>

It is a lifetime opportunity and we have the expectation that the <u>new CAM Ring</u> (telecom submarine cable) <u>will be a SMART Cable</u>, obtaining real time data for oceanography, environmental (climate change) and geophysics studies, as well as for seismic detection, being possible to have early warnings of earthquakes and tsunamis, serving Portugal and beyond (Spain, Morocco, France, …).



SMART CAM-2

The path to an RfT for a geophysicist

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

SMART CAM-2 specificities

→ Top-down organization

→ No problems with sovereignty

→ SMART RfT required by governmental decision

→ SMART CAM-2 to be implemented by a state owned entity (IP Telecom)

→ LEA (Listening to the Earth under the Atlantic)

→ LEA as advisory council to IP Telecom on the RfT definition

→ Governmental funding. Business plan?

frontiers in Earth Science

ORIGINAL RESEARCH
published: 20 July 2021
doi: 10.3389/feart.2021.686296

The Contribution of Submarine Optical Fiber Telecom Cables to the Monitoring of Earthquakes and Tsunamis in the NE Atlantic

Luis Matias[1], Fernando Carrilho[2], Vasco Sá[3], Rachid Omira[1], Manfred Niehus[3,4], Carlos Corela[1], José Barros[5] and Yasser Omar[6]*

frontiers

In press

SMART Subsea Cables for Observing the Earth and Ocean, Mitigating Environmental Hazards, and Supporting the Blue Economy

Bruce M. Howe[1*], Michael Angove[2], Jerome Aucan[3], Christopher R. Barnes[4], Jose Barros[5], Nigel Bayliff[6], Nathan C. Becker[7], Fernando Carrilho[8], Matthew Fouch[9], Bill Fry[10], Anthony Jamelot[11], Laura S. Kong[12], Stephen Lentz[13], Douglas S. Luther[1], Giuditta Marinaro[14], Luis M. Matias[15], Charlotte A. Rowe[16], Amir Salaree[17], Andi E. Sakya[18], Torsten Thiele[19], Frederik J. Tilmann[20], Christa von Hillebrandt-Andrade[21], Laura Wallace[22, 10], Stuart A. Weinstein[23], William Wilcock[24]

LEA Activities

The RfT

→ Cable Observer Part separated from Telecom RfT in a dedicated Annex (see document at JTF website)

→ Definition of a methodology to evaluate the Tenders for the Observer Part

Western Mediterranean Subsea Infrastructure Operator

Neutral & Independent

Medusa
Submarine Cable System

Presentation
January 20th 2022


Marseille
France
Italy
Barcelona
Portugal
Spain
Lisbon
Alacant
Mazara del Vallo
Greece
Turkey
Zahara
Torreguadiaro
Sines
Heracklion
Tetuán
Nador
Algiers
Collo
Bizerte
Timpaky
Yeroskipou
Algeria
Tunisia
Morocco
Libya
Egypt
Port Said

Medusa as Smart Cable

RFQ – Process

a) RFQ launched early 2021 – One Response “Smart JTF compliance”, some including DAS, some with other options.

b) BAFO launched August 2021 – One Response “Smart JTF compliance”, some including DAS, some with other options.

c) Final negotiation:

- MEDUSA :
- -RFS West MED (2024)
- -RFS East Med (early 2025)

No commercial product available for MEDUSA for manufacturing 2023-2024 and deployment 2024-2025.

What do we doand nextsteps?

- DAS will be in MEDUSA – (we will have an additional fiber for DAS and DAS implemented in the European Union Cable Landing Stations).
- DAS: Project already launched in January 2022 to process in real time DAS information jointly with research centers. (Financed by EU Horizons 2020).
- We do not expect Smart Cable products qualified for systems in 2023/2024
- Smart cables can be added in some extension on MEDUSA (optional branches, but not main lay in 2023/2024). Maybe in extensions RFS end 2025 or 2026
- Our technical team would prefer not to have smart inside the repeater and consume one FP.
- The scientific community needs to be coordinated for smart cables. Difficult to identify stakeholders.
- There is availability of funds – technology availability is now the issue.

FAR NORTH FIBRE ROUTE

Far North Fibre will be the first submarine fibre system through the Northwest Passage connecting Asia to North America, Europe, and Scandinavia. SMART cable technologies offer remarkable new tools to study the most rapidly changing ocean on earth, climate change mechanisms and seafloor seismicity.

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Introduction to Ocean Networks System Projects

Connecting Continents


United States
Virginia Beach
Atlántico
Florida
Gulf of California
Gulf of Mexico
Mexico
Bahamas
Cuba
Cayman
Jamaica
Dominican Republic
Puerto Rico
Guatemala
Honduras
Nicaragua
Costa Rica
Panama
Caribbean Express
Oahu, Hawaii
SAPL Segment 3
Venezuela
Guyana
French Guiana
Suriname
Colombia
Ecuador
Brazil
Peru
Bolivia
Paraguay
Chile
SAPL Segment 2
South Pacific Ocean
South Atlantic Ocean
North Atlantic Ocean
Portugal
Spain
Morocco
Algeria
Western Sahara
Mauritania
Mali
Senegal
The Gambia
Guinea-Bissau
Guinea
Sierra Leone
Liberia
Côte d'Ivoire
Ghana
Togo
Benin
Burkina Faso
Gulf of Guinea
OCEAN Networks

PROGRESS REPORT ON INDONESIA CBT

Compiled by

Andi Eka Sakya

National Research and Innovation Agency (BRIN)

Geostech Build, 3rd Fl., Kaw. PUSPIPTEK, Serpong, Tangerang Selatan 15314, Indonesia

Presented at Joint Task Force SMART Subsea Cables Workshop, University of Hawaii, Zoom, 20 January 2022

Distribution of BPPT's InaCBT 2020 – 2024

The installation plan up until 2024: (1) 13 Buoys, (2) 7 CBTs, and (3) 3 Tomography

SUMMARY

- InaTEWS which was built after tsunami Aceh (2004), has been well operated since its official inauguration in 2008 until now;
- The tsunamis events in Palu and Sunda Strait accelerated the endeavor to strengthening of the existing InatEWS which was formerly built on tectonic-tsunami based to include the atypical ones;
- Development guidance is reinforced by Presidential Decree No. 93/2019 considering structural and cultural elements which is carried out by institutions that have the relevant mandate;
- InaCBT technology have been developed by BPPT (BRIN)
- Seven InaCBTs will be deployed in Indonesian waters till 2024.

Potential for instrumented submarine cables off New Zealand's East Coast

Laura Wallace[1,2], Charles Jarvie[3], John Townend[4], Craig Stevens[5,6], Richard Kellett[1]

[1]GNS Science, New Zealand
[2]University of Texas Institute for Geophysics, Austin, Texas
[3]Ministry for Business, Innovation, and Employment
[4]Victoria University of Wellington, New Zealand
[5]National Institute for Water and Atmospheric Research (NIWA), New Zealand
[6]University of Auckland, New Zealand

The New Zealand Ministry for Business, Innovation and Employment (MBIE) is investigating the feasibility of a fiber-optic cable from New Zealand's East Coast to the Chatham Islands to improve connectivity for the Chatham Islands

New 4G based network in the Chathams commissioned in December 2021 along with 250Mbps satellite backhaul link to NZ mainland

A fiber-optic cable from mainland NZ to Chathams may be better long-term solution (in terms of cost and technical performance): Business case is in preparation for the Minister for Digital Economy and Communications

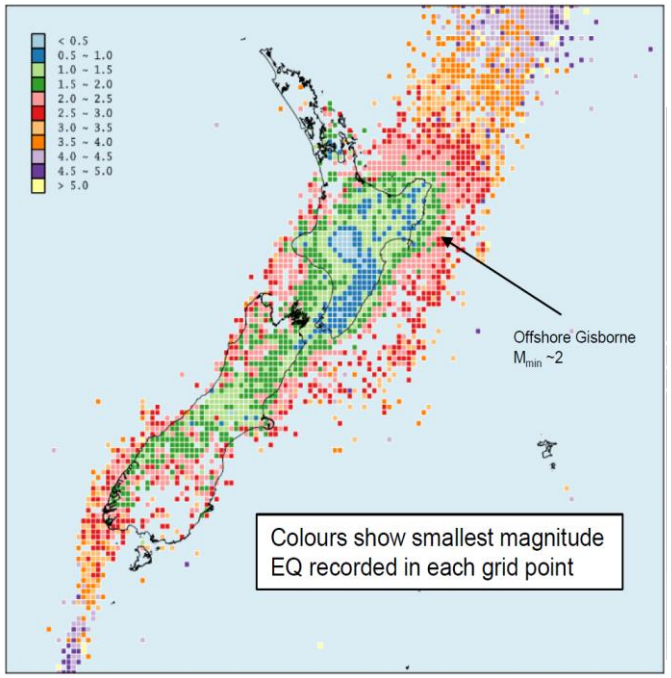
Potential opportunities to integrate seabed sensing into submarine cable for geoscience and oceanographic research and geohazards monitoring

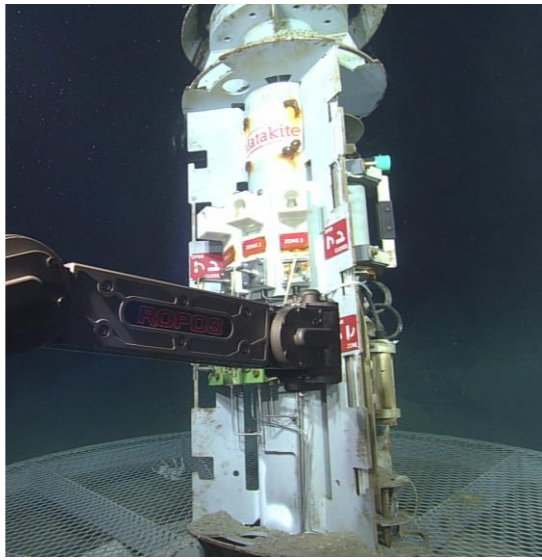
Single territorial jurisdiction simplifies consent process, and initial and ongoing governance

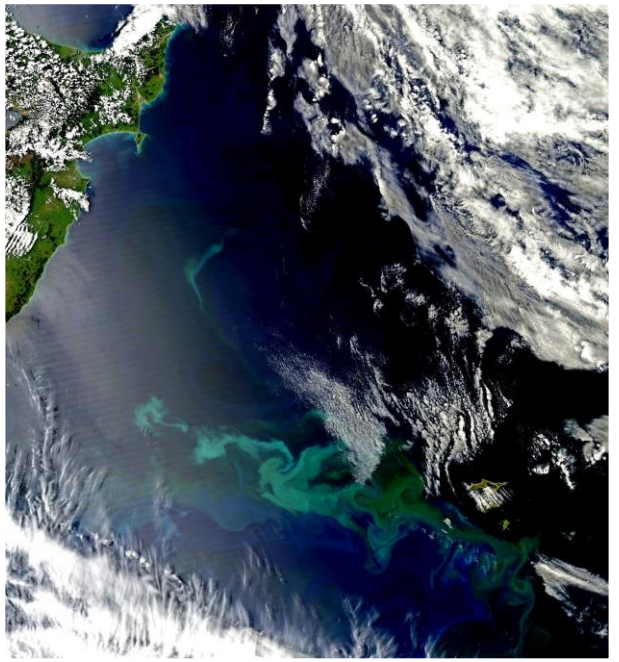
Government funding would simplify procurement process and act as an anchor/catalyst for supplementary funding of the potential science sensors

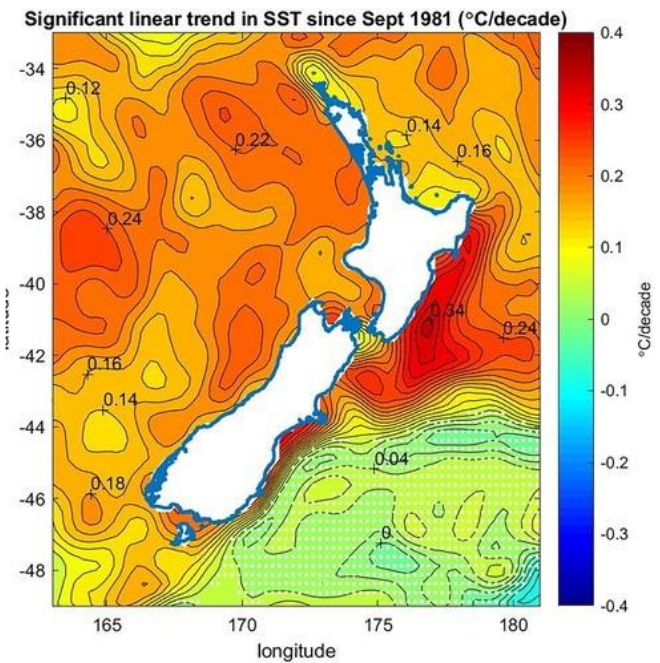
Principal science and hazard monitoring goals that would benefit from addition of sensing capability to the cable

- Biophysical oceanography in a changing climate (including impact on commercial fisheries)
- Ocean forecasting and coastal processes
- Ocean heat content
- Ocean productivity
- Biodiversity and marine biology (including cetaceans)
- Subduction zone earthquake and slow slip event processes (including connection to existing IODP subseafloor observatories)
- Tsunami science and tsunami early warning
- Offshore earthquake detection and characterization, with earthquake early warning applications
- Submarine landslide and sediment transport studies
- Gas hydrate processes and seep environments









SMART Cables – Moore Foundation Project

LEAD

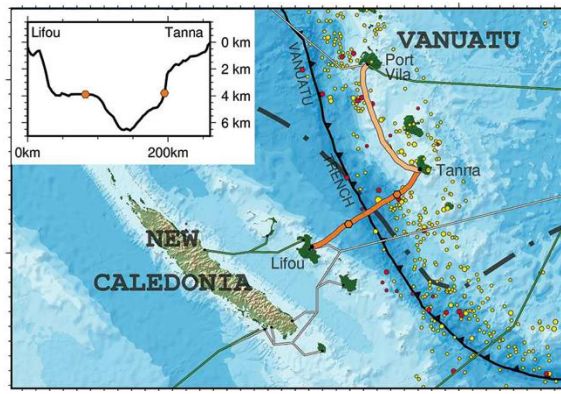
PI Bruce Howe
University of Hawai'i at Mānoa

FUNDING: 2022 – 2026, $7M

GORDON AND BETTY MOORE FOUNDATION

COLLABORATORS

University of Hawai'i at Mānoa
Univ Texas-Austin
Louisiana State University (LSU)
University of Otago, NZ
National University of Vanuatu (NUV)
Pacific Community (SPC)
California Institute of Technology
Subsea Data Systems
Los Alamos National Laboratory (LANL)
French Institute for Research and Sustainable Development (IRD)
Vanuatu Meteorology and Geohazards Department (VMGD)
GNS New Zealand
International Tsunami information Center (ITIC)



GOAL:

SMART cables become the world standard, leading to a global network for sustained ocean observation, geophysical study of earthquakes, and earthquake and tsunami warning in a world with rising sea levels.

Objectives:

- Lay groundwork for science and early warning use by simulations of the observing system before deployment, data analysis after deployment, and sustained scientific operation.
- Apply results to the modest-scale 300 km Vanuatu-New Caledonia system and extract scientific results from this active tectonic subduction zone and dynamic ocean region. Demonstrate SMART earthquake and tsunami early warning.
- Establish the international project office for Joint Task Force Scientific Monitoring And Reliable Telecommunications cables to facilitate adoption of scientific sensors in all new telecommunications cables to reach a global scale.

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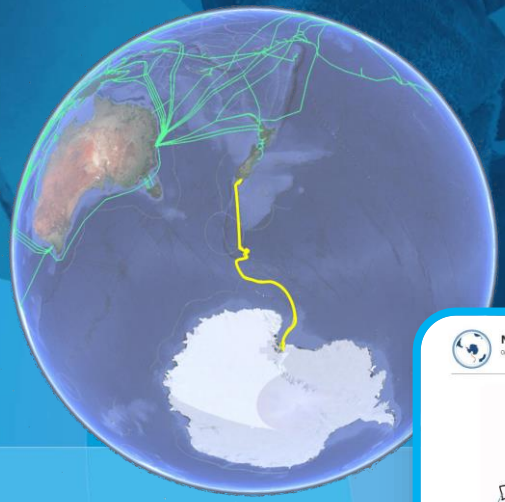

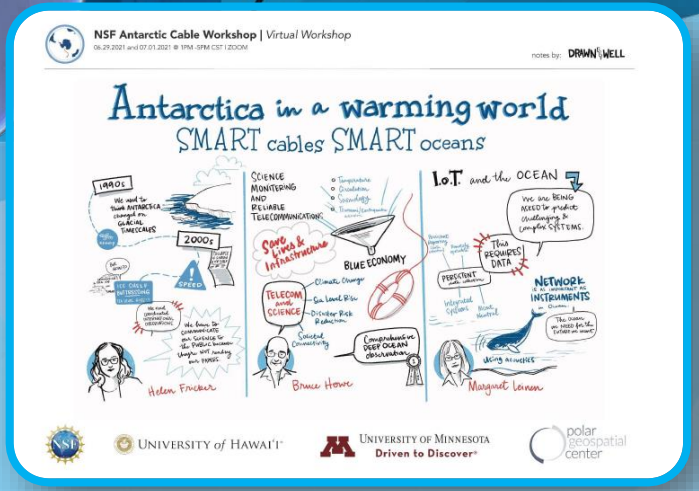

Comprehensive Desktop Study (DTS) Antarctica SMART Submarine Fiber Optic Cable System

Achieving SMART Connectivity to Antarctic Research Facilities

Patrick D. Smith, Manager, Technology Development, Polar Research Support, National Science Foundation
Geosciences Directorate, Office of Polar Programs pdsmith@nsf.gov

National Science Foundation
WHERE DISCOVERIES BEGIN

Nicholas Koopalethes, C.E.O., Global Broadband Solutions
A Certified USG HUBZone Company nkoopalethes@gbs1.com

GBS® Global Broadband Solutions, LLC

2021 Antarctic Subsea Cable Workshop: High-Speed Connectivity Needs to Advance US Antarctic Science

A GEO/OPP and CISE/OAC sponsored workshop

June 29 - July 1, 2021

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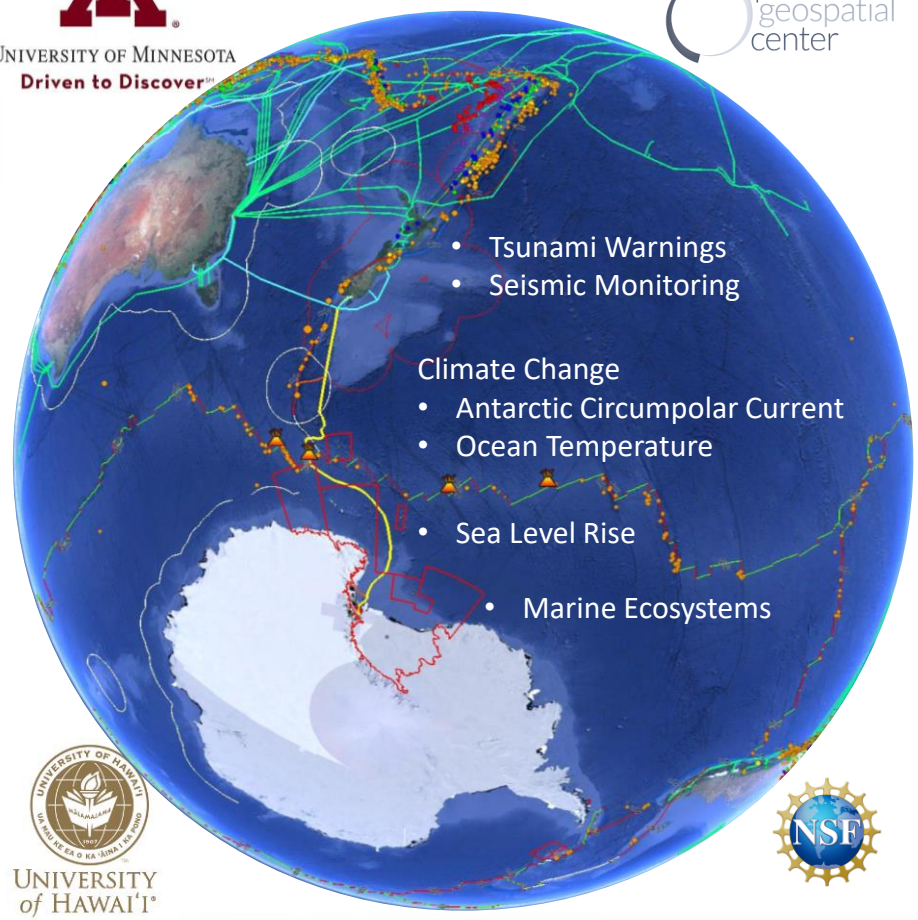


NSF sponsored a workshop to assess the value of a submarine fiber optic telecommunications cable from New Zealand to McMurdo Station.

Goals

- Explore the transformative impacts of full digital connectivity to/from McMurdo Station, Antarctica
- Outline the utility of a New Zealand - McMurdo Station submarine cable as an instrument for scientific research

Workshop Home Page:

https://www.pgc.umn.edu/workshops/antarctic-cable/

- Recorded Workshop Sessions:
  - Day 1 https://youtu.be/vPFwooW1kEk
  - Day 3 https://youtu.be/G3bb8QXpg0o
- Final Report:
  https://z.umn.edu/AntarcticCableFinalReport

The Southern Ocean remains the least observed ocean on the planet due to its remoteness, harsh weather and sea conditions

NSF Follow-on to the Workshop

OFFICE OF POLAR PROGRAMS

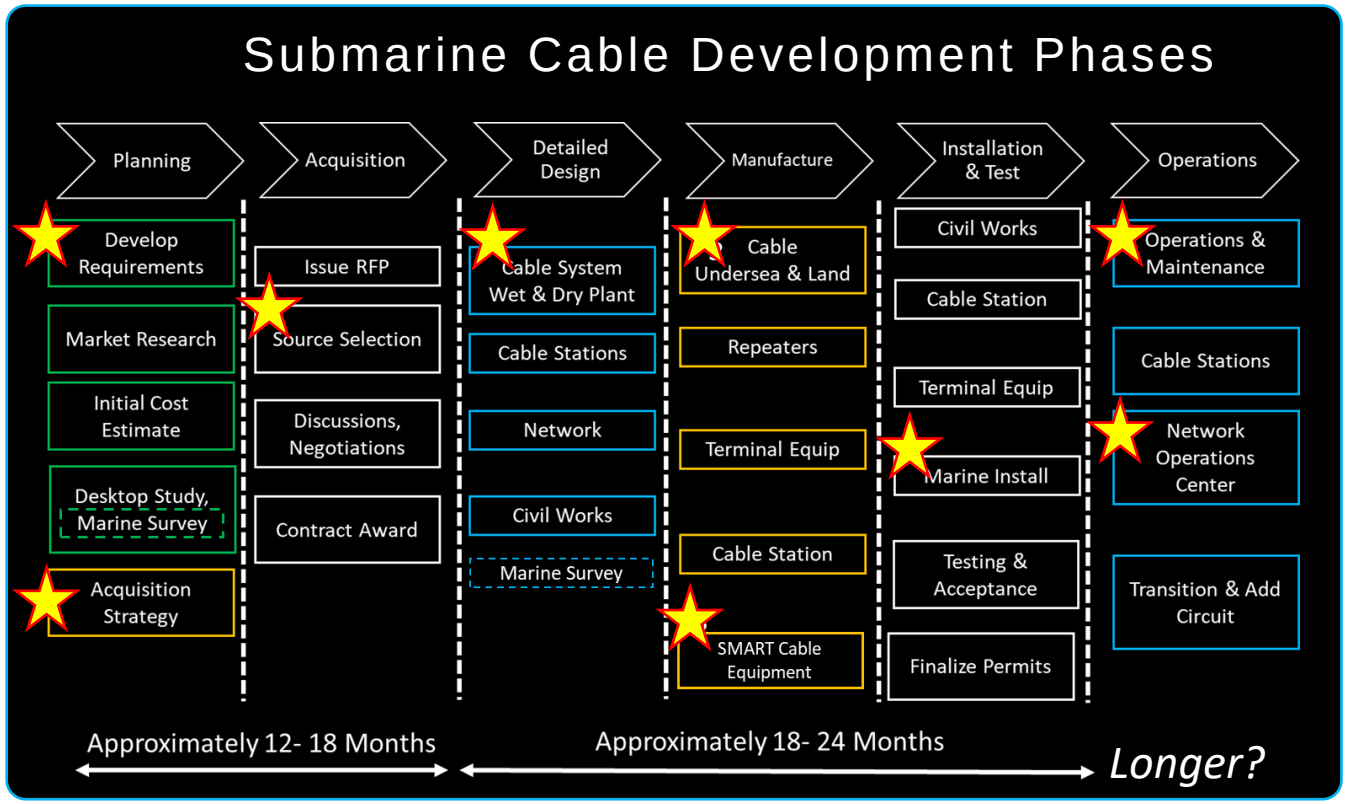
I. Initiate Desktop Study (DTS)

- **DRAFT report: mid-May 2022**
- **FINAL Report: mid-August 2022**

ICPC Recommendations and other detailed information relating to proposed wet and dry plant, ROM costs for all phases of SFOC development, deployment and sustainment challenges, schedule, system performance and backup

II. Government Evaluation of DTS Results
- Technical feasibility & risk
- Cost magnitude
- NSF Leadership vetting
- NSF federal budget cycle implications
- Science sensor technology maturity
- Time/effort/budget for next development phase

III. Course of Action Decision Gate
- COA #1 – Continue
- COA #2 – Pause



Possible COA#1 Follow-On Activities

- Continued SMART sensor development:
  - NSF Small Business Innovation Research
  - Explore Federal Interagency Collaboration
  - Consider Public Private Partnerships
- Additional Work:
  - Science Workshop(s) on sensors, routes, science & data management plan; Pacific R&E networking partnerships
  - Evaluate linkage to Ocean Decade US Ocean-Shot
  - Targeted Issues Desktop Studies
  - Marine Route Survey
- Explore SFOC Program Development Formulation
  - NSF Large Facilities
  - Public Private Partnerships (PPP)
  - Governmental Collaborations (National, International)

Award Abstract # 2104205
SBIR Phase I: SMART Repeaters: Sensor-Enabled Submarine Fiber Optic Repeaters for Multi-Scale and Multi-Use Monitoring and Observing
https://www.nsf.gov/awardsearch/showAward?AWD_ID=2104205&HistoricalAwards=false

NSF Org:	IIP Div Of Industrial Innovation & Partnership
Awardee:	SUBSEA DATA SYSTEMS, INC.
Initial Amendment Date:	November 30, 2021
Latest Amendment Date:	November 30, 2021
Award Number:	2104205
Award Instrument:	Standard Grant
Program Manager:	Benaiah Schrag bschrag@nsf.gov (703)292-8323 IIP Div Of Industrial Innovation & Partnership ENG Directorate For Engineering
Start Date:	December 1, 2021
End Date:	November 30, 2022 (Estimated)
Total Intended Award Amount:	$254,816.00
Total Awarded Amount to Date:	$254,816.00
Funds Obligated to Date:	FY 2022 = $254,816.00
History of Investigator:	•Matthew Fouch (Principal Investigator) matt.fouch@subseadatasystems.com
Awardee Sponsored Research Office:	SUBSEA DATA SYSTEMS, INC. 8502 SW Kansas Avenue Stuart, FL US 34997-7120

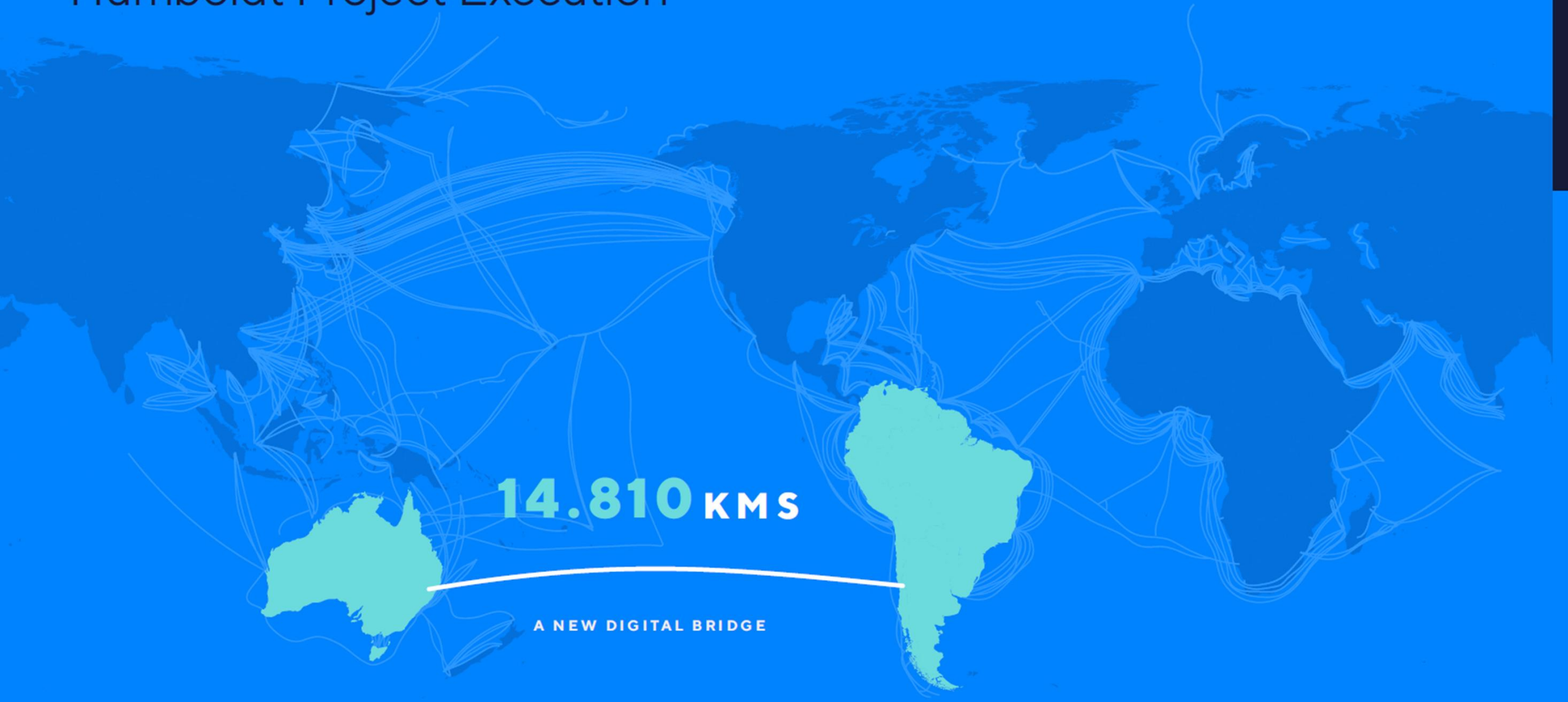
DESARROLLO PAÍS
INFRAESTRUCTURA PARA CHILE

Humboldt Cable System

JANUARY 2022

WHAT IS HUMBOLDT PROJECT ABOUT?

Humboldt Project Execution



ABOUT US

Desarrollo País' digital projects

CONNECTION ANTARCTICA

Desarrollo País promotes the first submarine cable to Antarctica from Chile.

It will support scientific studies at Antarctica such as climate change, evolutionary and ecological processes, astronomy and cosmology, pollution, fishing activity, limited by current connectivity conditions.

Desarrollo País' digital projects

CONNECTION ANTARCTICA

During 2022 a RFI and a RFP will be launched for developing a feasibility study.

CIL
CENTRE FOR INTERNATIONAL LAW
National University of Singapore

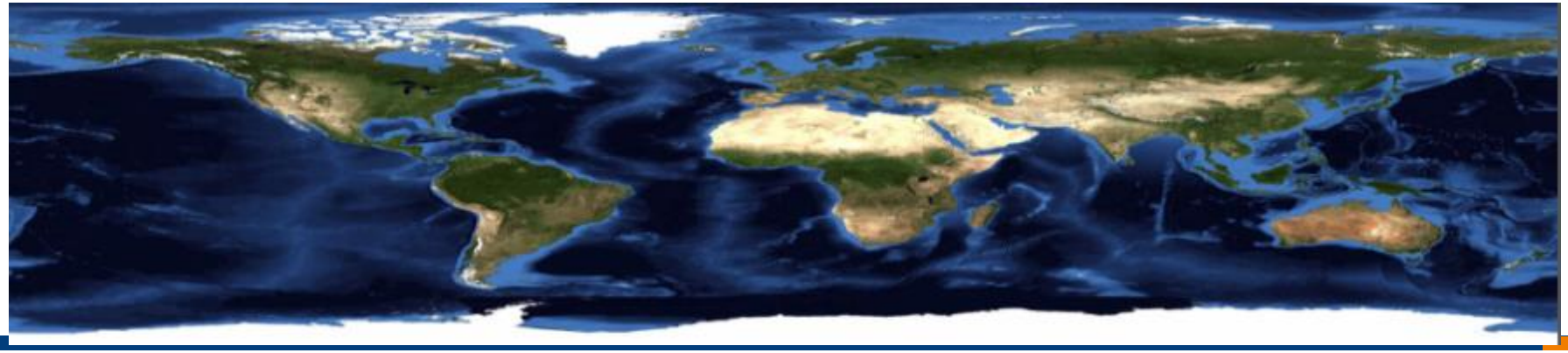
NUS
National University of Singapore

SMART CABLES: LEGAL ISSUES

Dr. Tara Davenport,
National University of Singapore

Link to Zoom recording

https://nus-sg.zoom.us/rec/share/_xIIV5tmCySjHS5r-CE6gWoG12kZLTnxH0N9QWlkvprui5pChSsw3WF7ZHpuVi3Q.6hVE34y8-RRHJt6D



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CONCLUDING REMARKS

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NUS National University of Singapore

- SMART Cables are a prime example of scientific and technological developments not foreseen by drafters of UNCLOS
- Approach has been to focus on the easy cases and deploy such green cables in maritime zones where the submarine cable regime and MSR regime do not conflict or in jurisdictions which do not heavily regulate marine data collection
- UNCLOS is a “living” instrument and should be interpreted in a way that it should be able to address issues not foreseen during the negotiations and in a way that benefits the international community

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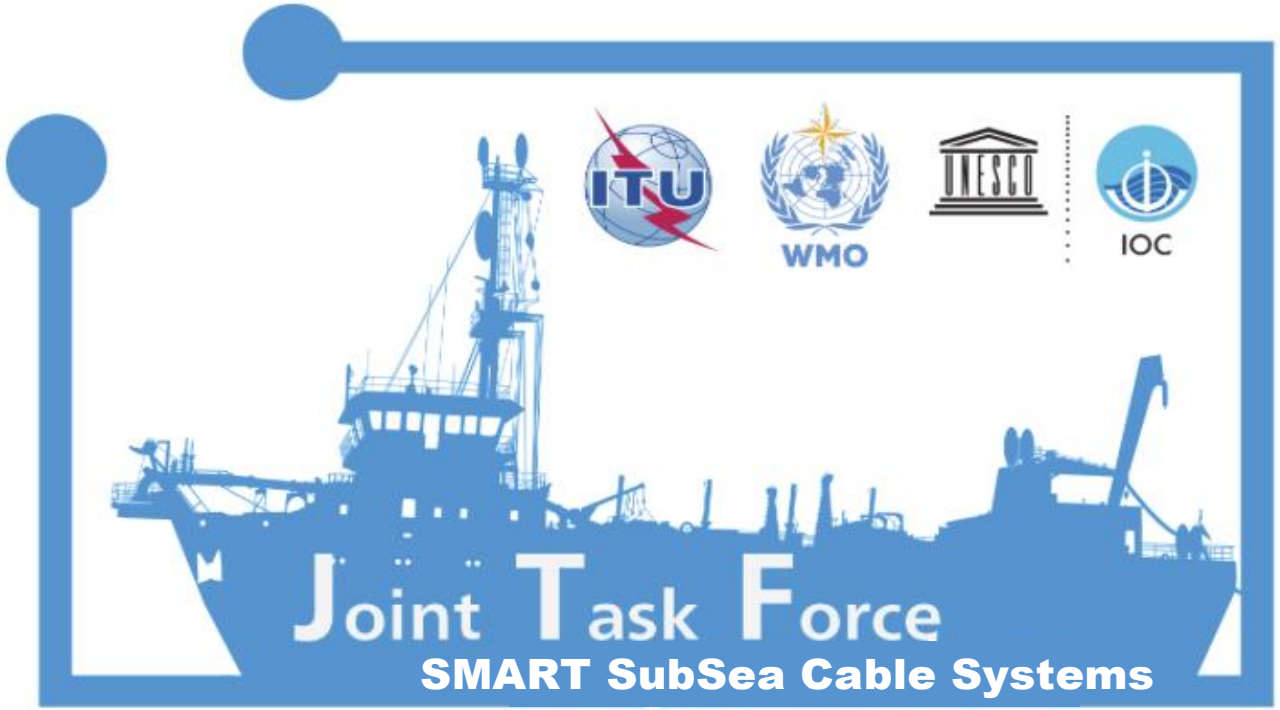
Public and Ocean Industry Outreach

Paul Holthus, Founding President and CEO,
World Ocean Council

Kate Panayotou, Technical Director, GHD



Next steps - Securing support for society from our leadership

- Facilitate – further partnerships / nexus between commercial, scientific, investment and government communities
- Bring – next generation of engineers, scientists and technologists along the journey
- Our response to climate and DRM needs - data from these sensors would align with CC understanding, SDG, DRM to assess physical risk to society. Allow clearer understanding of change over time, more effective short term and long term planning and co-ordination, ability to mitigate and adapt to these future changes.
- Focus now is on societal risk and response - direct impact of climate change and disaster events on communities, infrastructure, livelihoods – feeding into measuring vulnerability and implementing better resiliency and disaster risk management responses.

World Ocean Council (WOC)

WORLD OCEAN COUNCIL
The International Business Alliance for Corporate Ocean Responsibility

International, Cross-Sectoral Business Leadership Alliance

- **Bringing together the global ocean private sector**, e.g. shipping, tourism, fisheries, aquaculture, offshore energy, ports, legal, insurance, investment, etc.
- **Catalyzing leadership, collaboration and action for "Corporate Ocean Responsibility"**
  Formal recognition by UN and business entities, e.g. UNESCO IOC, WMO, IHO, ISA, ICC
- **35,000+ in global network, 75+ members globally; 100's of actively engaged companies**
- **Sustainable Ocean Summit (SOS)** - Only annual global, multi-industry gathering developed by and for the business community, focused on sustainable development
- **Ocean Investment Platform -** Bringing industry, investors and innovators together

Goal: Healthy, productive global ocean and its sustainable use and stewardship by responsible ocean business community

Creating business value for responsible companies

- Access and social license for responsible ocean use
- Synergies and economies of scale in addressing issues
- Stability and predictability in ocean operations

WOC – the Global "Blue Economy" Business and Investment Organization

Create Multi-Industry Interest in Smart Cables

WORLD OCEAN COUNCIL
The International Business Alliance for Corporate Ocean Responsibility

- Link to business priorities and economic value, e.g.
  - Extreme weather events in coastal areas
  - Tsunamis
- Link to international ocean management needs, e.g.
  - Ocean acidification
  - CO2 sequestration
- Link to international issues, e.g.
  - Climate change adaptation
  - Deep seabed ecosystem assessment and monitoring

WOC Ocean Investment Platform

WORLD OCEAN COUNCIL
The International Business Alliance for Corporate Ocean Responsibility

Connecting investors to:

- **The global ocean investment community**, via the *WOC Ocean Investor Roundtable*
- **The Ocean ESG Framework**, via the *WOC Ocean ESG Task Force* which is working to create the categories, criteria, metrics, indicators, impact measures, etc. for investing in the Blue Economy
- **The ocean challenges/issues** of sustainable development
- **The market**, i.e. ocean industry corporations
- **The drivers** for change, e.g. regulation, policy, public pressure, social license, etc.
- **The innovation community**, e.g. via the *WOC Global Blue Innovation Initiatives Network*

Funding Models for SMART Cables

Paul Seaden, World Bank

- **Governments will likely be the main driver of potential funding for SMART cable systems as they look to improve on disaster early warning response, scientific research of the seabed and climate change research**
- **In the Pacific region, continued development of smaller inter-island systems will continue as countries look to build redundancy to existing cables. However, many of these systems continue to have low commercial feasibility due to the small size of the market- necessitating public investment from Governments and International Development Organisations**
- **This presents an opportunity for Governments to incorporate SMART technology into smaller systems with a lower commercial feasibility as a way to improve the benefits case for the investment and meet their broader policy goals**
- **International Development Organisations, as providers of finance to developing countries, may work with Governments to provide development finance to such systems**

Discussion

- Funding
  - Develop a pitch to a targeted group - MLDB, Insurance, Big Tech, infrastructure investment, tax laws, legislative branches – hearings, …
  - Government – subscription way (pay over time) - Make smart part of cable, tax deductible?
  - Learn what insurance wants
  - Need to set up implementation organization(s)
- Regulators, Security
  - Priority, red carpet, reduce fees, taxes, (return to country)
  - Security – helps cable protection, wmo discussion – sensitivities, shore side data processing to “clean” data; get IOC and WMO with UN, to address “legal” issues (MSR)
- JTF Organization WOC has MOUs with WMO IOC etc.
- Incentivize funds for better smart technology – continuous development cycle, improve sensors, incorporation, get disparate agencies to work together (best if smaller topics – develop below) NOAA, NASA, NSF collab program, get language in RFPs – Craig McLean NOAA etc, get to highest level of NOAA. ONR
- NEED stakeholder entities (governments, funders) in place to coordinate and quickly take advantage of candidate cable systems – have generic funding lined up to apply to specific systems
- Re-start discussion with OTTs