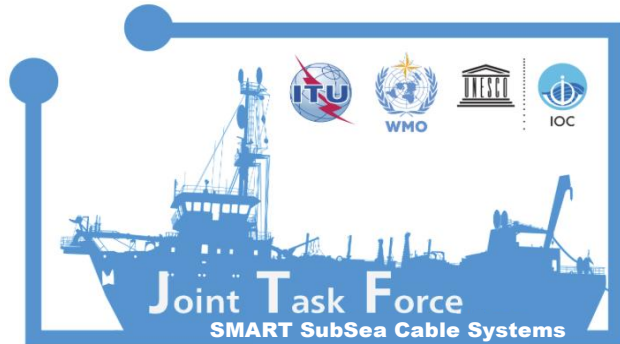


Observing the Ocean and Earth with SMART Subsea Cables

Science Monitoring And Reliable Telecommunications



Bruce M. Howe
Chair, JTF SMART Cables
University of Hawai'i at Mānoa
And many others!



**2021
2030** United Nations Decade
of Ocean Science
for Sustainable Development



GORDON AND BETTY
MOORE
FOUNDATION

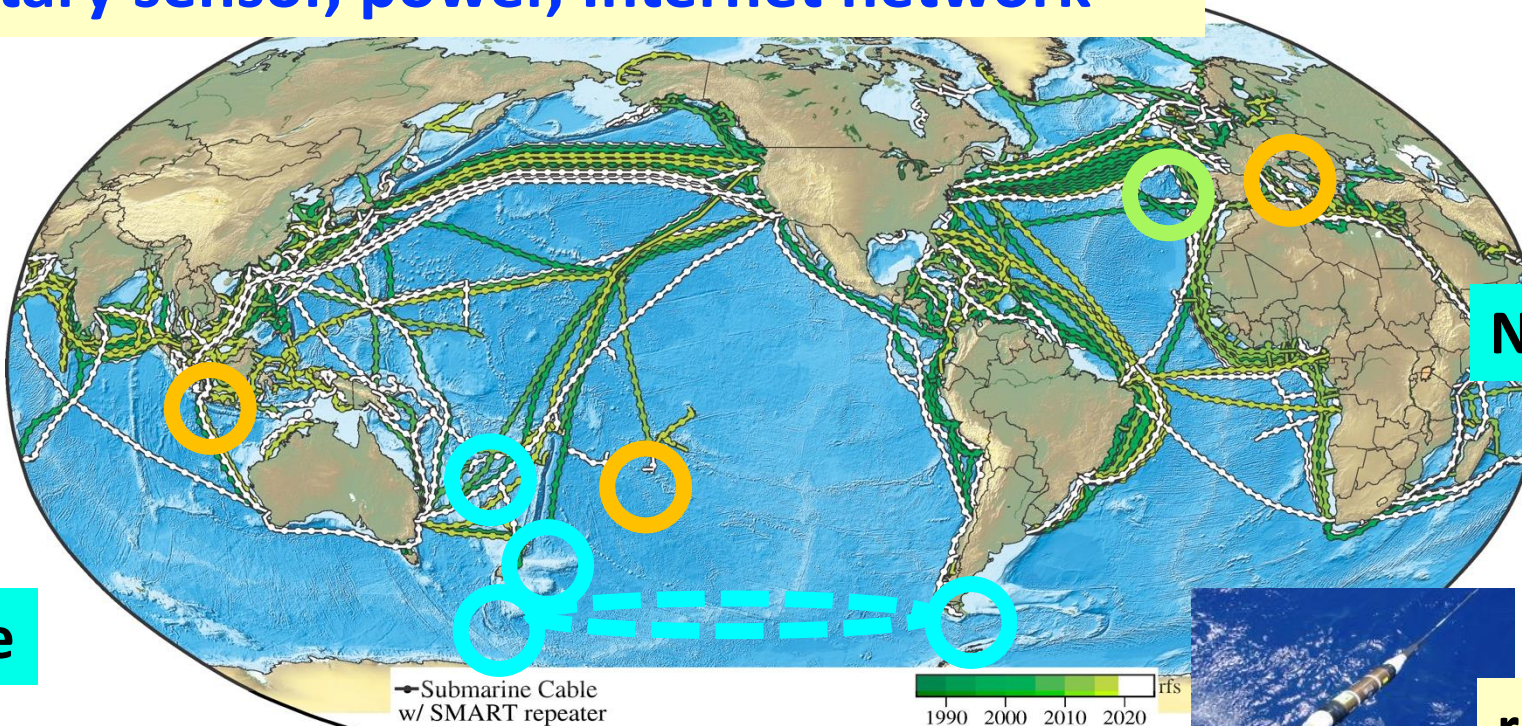
Portugal
March 2022



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

Create a Planetary sensor, power, Internet network

*1st order
addition to
Ocean-Earth
observing
system*



2021
2030
United Nations Decade
of Ocean Science
for Sustainable Development

UN Decade

Know the environment – protect the network

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

**Bottom temperature, pressure,
seismic acceleration**

*Share
submarine cable
infrastructure
Telecom + science*

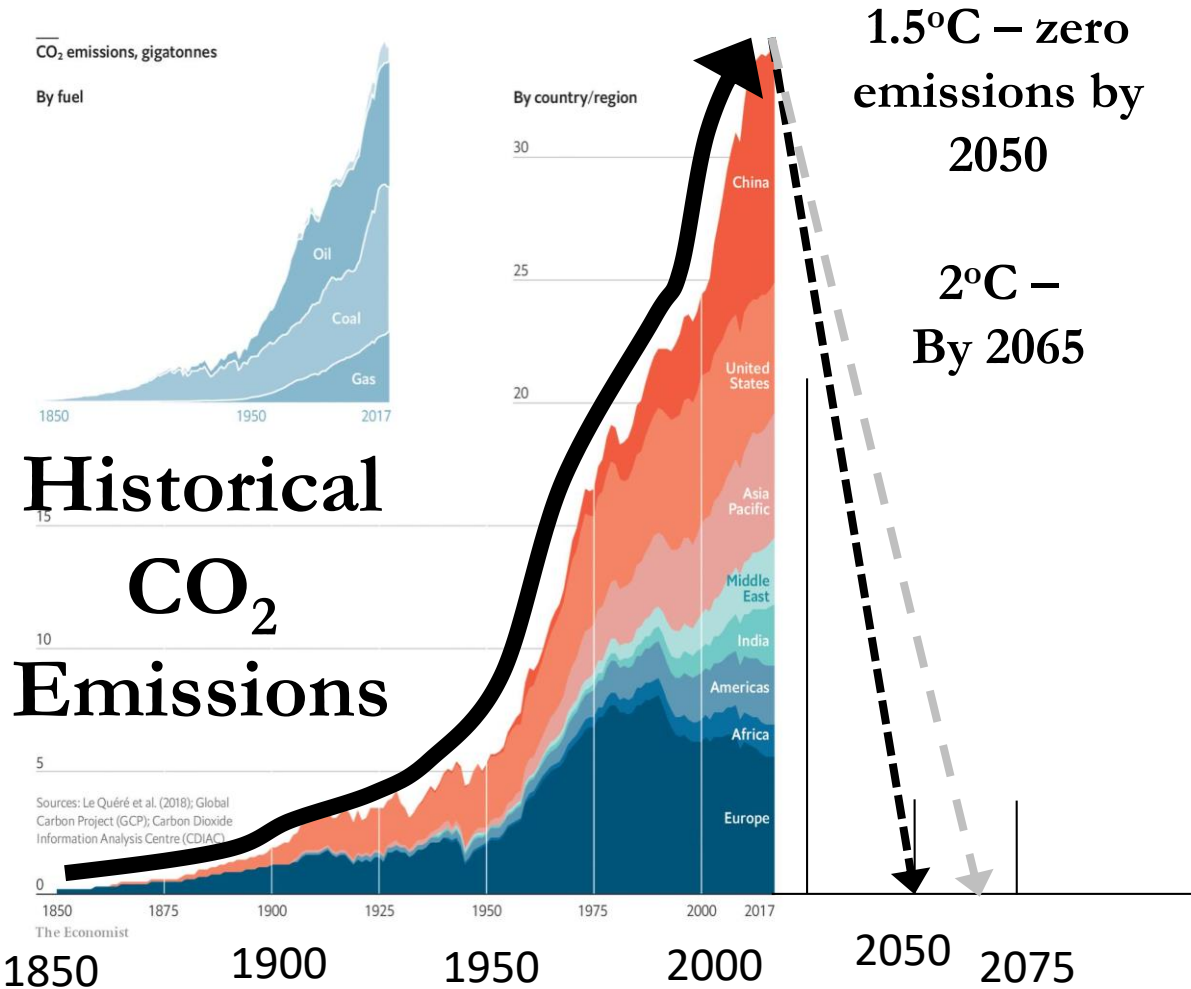
NO Interference ↓ €\$

**1.2+ Gm
~20,000 repeaters
20 year refresh**

repeaters ~70 km



Global Warming

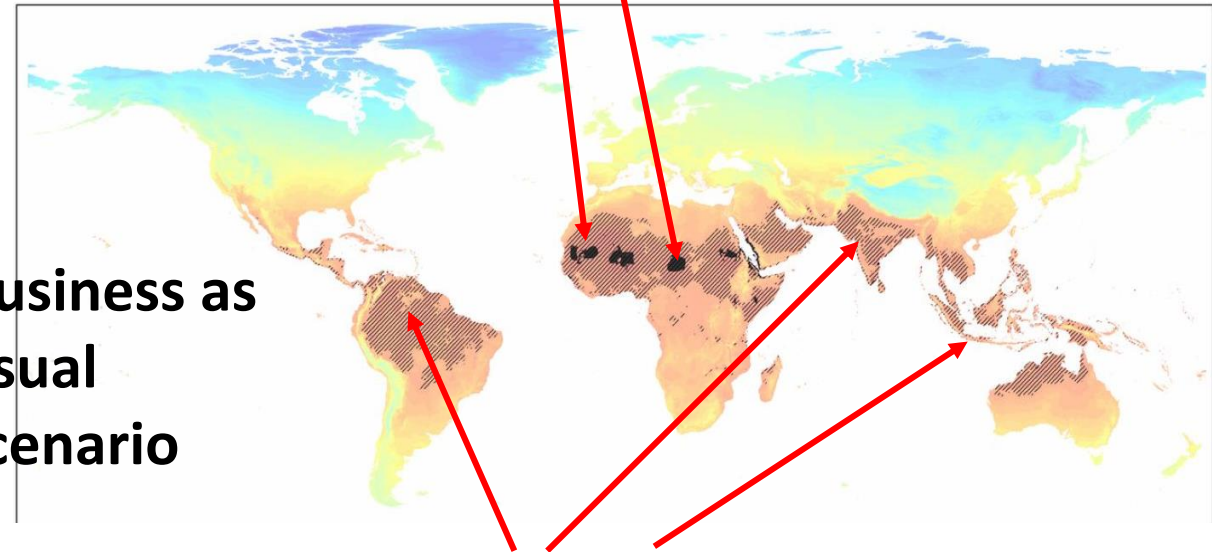


We must remove CO₂ from the air for the rest of the century.

Why SMART? Ocean = Flywheel of Climate : Stores 90% Heat, CO₂, Determines future Temperature

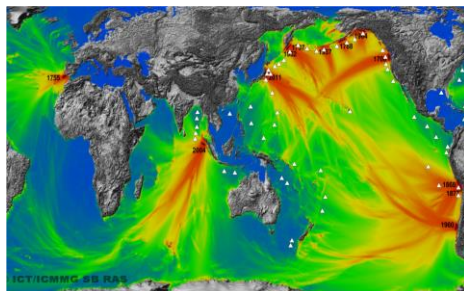
TODAY – 0.8% of land surface, too hot for human existence

Business as usual scenario

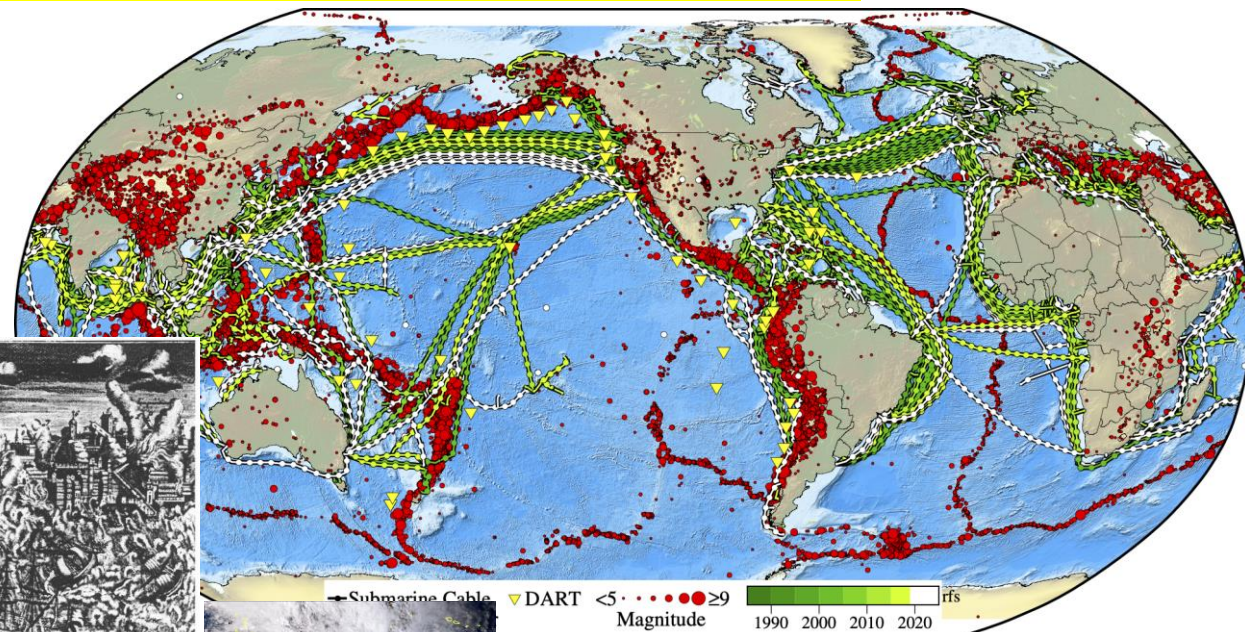


Earthquakes and Tsunamis

Earthquake warning: time to “Drop, Cover, and Hold On!”
Survive to escape Tsunami



1755



Tonga

DART tsunami warning buoys
Mar 2022, 38/64 working

Place	Year	Mag	H (m)	Deaths
Chile	1960	9.5	25	6000
Alaska	1964	9.2	30	132
Mindinao	1976	7.9	9	7,800
Papua N. Guinea	1998	7.1	15	2200
Sumatra	2004	9.2	33	230,000
Samoa	2009	8.1	14	189
Maule, Chile	2010	8.8	3	525
Tohoku	2011	9.0	10	19,000
Palu	2018	7.5	7	2000

Taiwan

Climate change increasing typhon number and intensity (e.g., Morakot 2009)
+ earthquakes trigger submarine turbidity currents - Cut 42 cables 2006-2013

Place	Year	Mag	H (m)	Deaths	Cables cut
Algiers	2003	6.8	3	2,244	All Europe-Mid-East
Tohoku	2011	9.0	10	19,000	~10

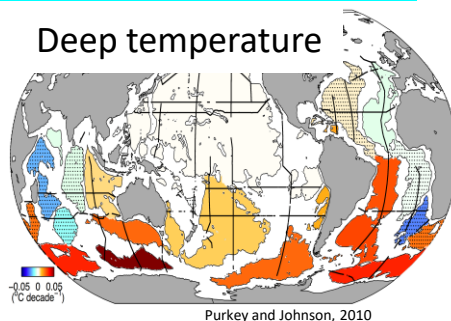
Science and Early Warning - Observables

Climate and Oceans

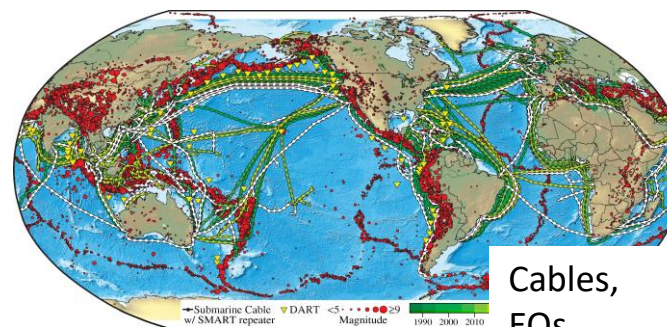
Hazards

Tsunami, Earthquake Warning

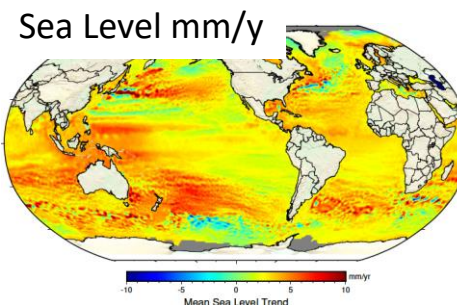
Temperature



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



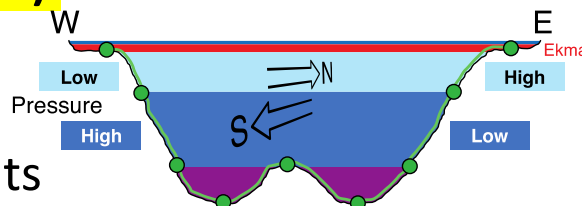
- SMART cables - vastly increase existing ocean **pressure/seismic sensors**
- Improve tsunami warning precision, Reduce unnecessary warnings/evacuations.



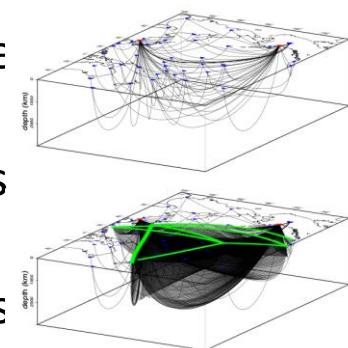
Circulation, sea level rise, mass distribution

Seismology

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



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



sampling with and without SMART

Climate change – humanity's greatest existential threat

Societal and environmental issues

SMART: UN Decade of Ocean Science Project

Climate
SDG 13



– **Climate change** – ocean temperature, circulation
direct impact on societies, short and long term

Ocean
SDG 14



– **Sea level rise** – hazard for coasts, islands, cities

UN
DRR

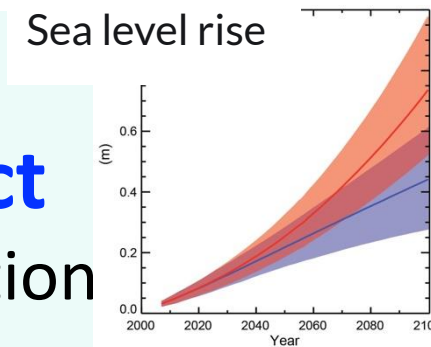


– **Disaster Risk Reduction** – tsunami
and earthquake monitoring
throughout ocean basins and coastal margins

Infrastructure
SDG 9, 11



– **Societal Connectivity** – Enable progress with
resilient and sustainable telecom infrastructure

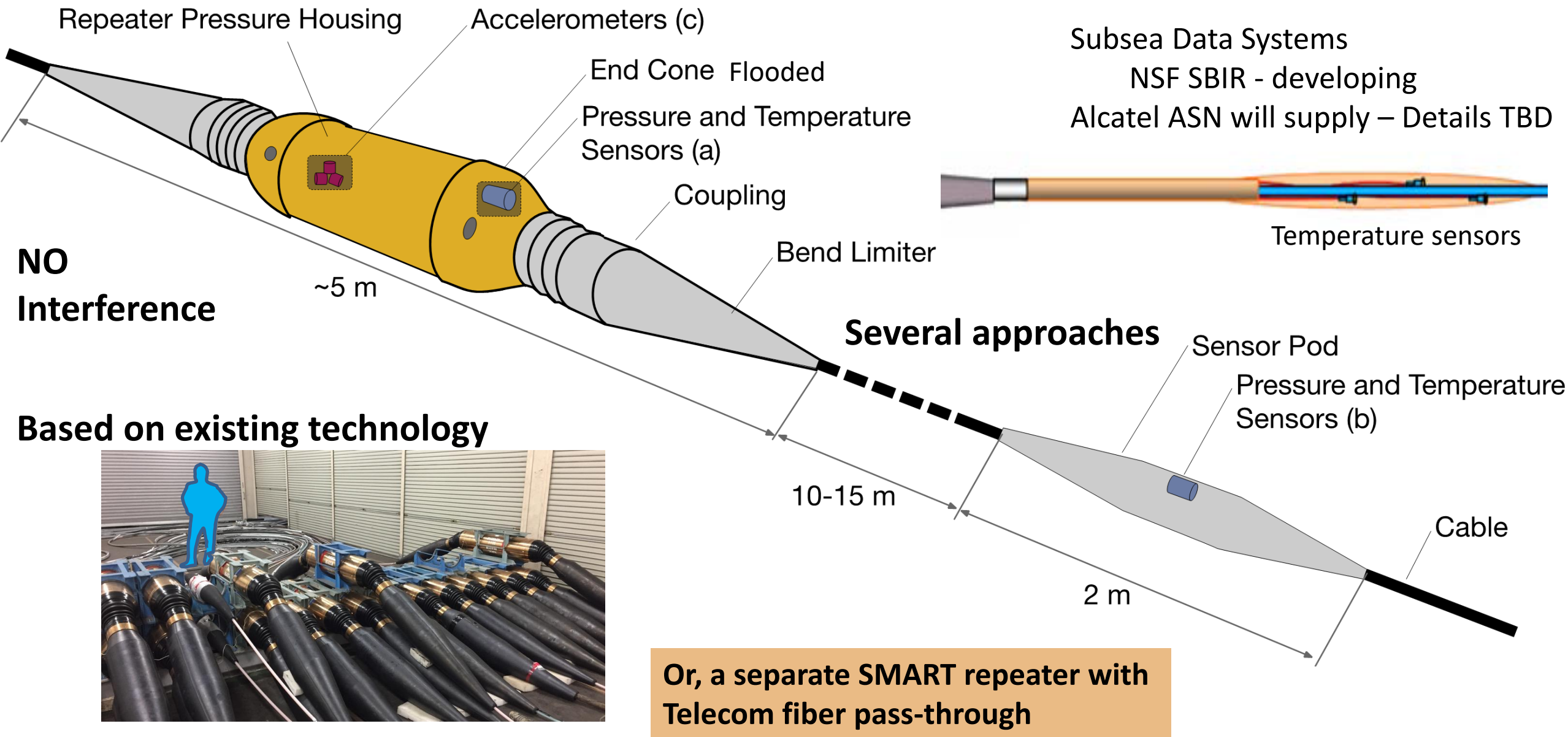


Tsunami

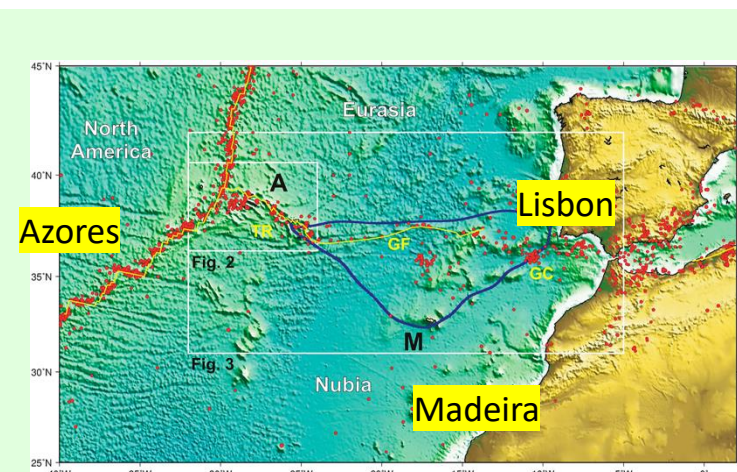




SMART Repeaters



SMART Cables - Europe

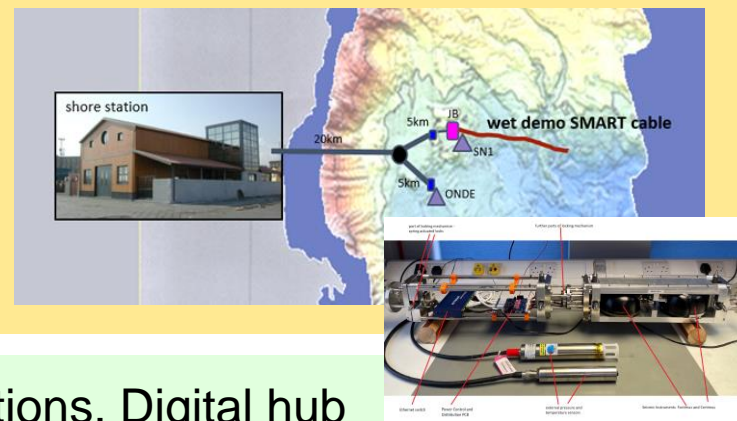


- **CAM2**
- Domestic, international connections, Digital hub
- 1755 earthquake tsunami
- Seismic, tsunami, ocean, environment
- 3700 km, 50 SMART repeaters, €120M
- RFP 2022, **Ready For Service 2025**
- ANACOM connection to telecom

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

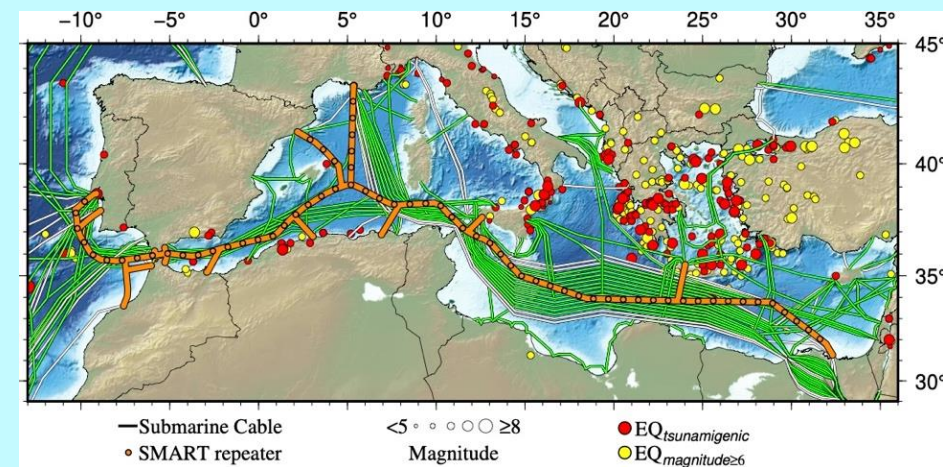
- Improved EEW (10 s) with less loss of life will more than pay for the system
- Next: include infrastructure and tsunami inundation

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



LEA – Listening to the Earth under the Atlantic

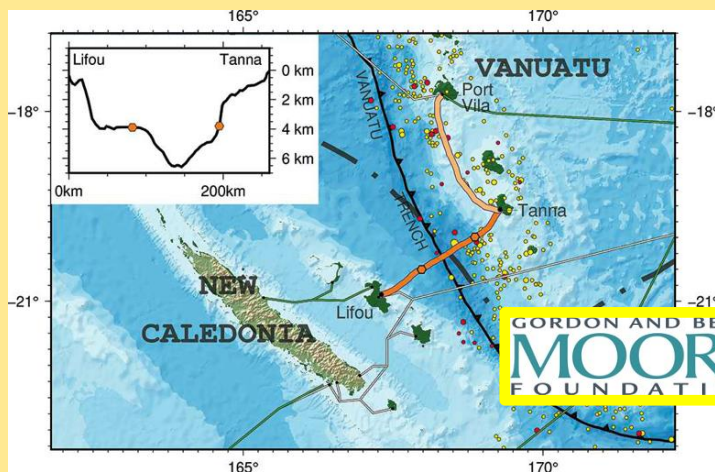
NEAMTWS



- **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**



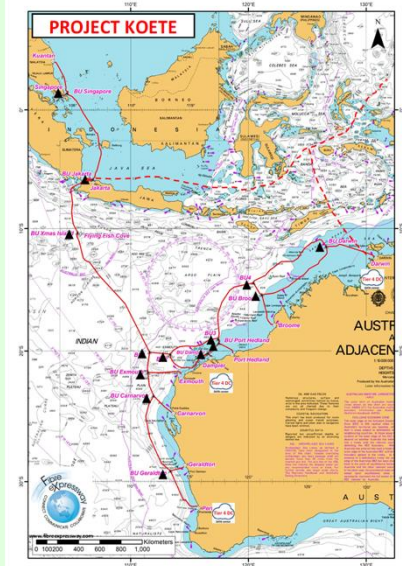
SMART Cables - Pacific



Vanuatu – New Caledonia

SMART, DAS

Partial funding; under gov't review



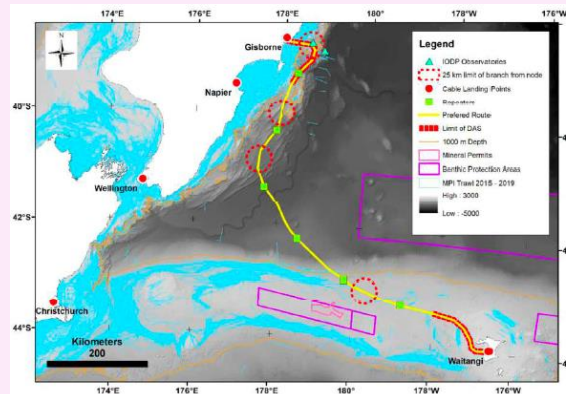
Project Koete

Perth-Darwin-Malaysia

Communities

SMART integral

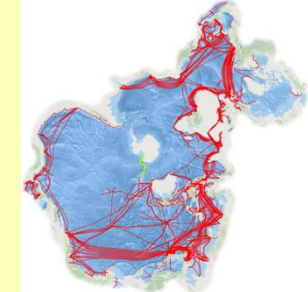
Raising funds



NZ–Chatham Islands

SMART + DAS + BUs/nodes

Under gov't review (MBIE)



Antarctica – NZ

Improve connectivity

SMART Cable

Workshops, NSF, NAS, Chile



Indonesia

In country development Ina-CBT

Single ended test systems underway

Follow with Makassar Strait, with telecom

Arctic Express

14,000 km

Low latency

Communities

Contract Q1 2022

RFS Q4 2025

SMART integral





Concluding Remarks

- SMART – essential ocean variables and disaster risk reduction
- Global scale, power+internet on seafloor, sustained, realtime, 25-year life, highly reliable, leverage \$5B/y industry, 170 y experience, low lifetime cost
- SMART available (ASN, Subsea Data Systems), 2025+
- SMART systems: CAM2, MEDUSA, V-NC, Antarctica, Arctic, ... will set valuable precedents
- SMART well integrated in the UN
 - Our sponsors – ITU, WMO, IOC
 - Ocean Decade - perfect example of Blue Science and Blue Economy – “new” funding
 - Address SDGs
- SMART CAM will catalyze many subsequent actions
- Portugal leading this global endeavor by example



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Science Monitoring And Reliable Telecommunications



**Obrigado
Thank you**



**2021
2030** United Nations Decade
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GORDON AND BETTY
MOORE
FOUNDATION

**Portugal
March 2022**

