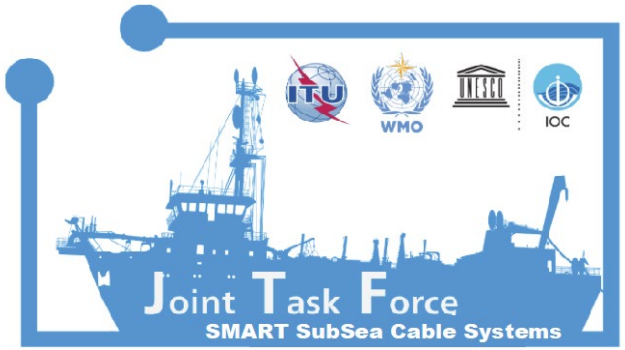
Observing the Ocean and Earth with SMART Subsea Cables: Tsunami Challenges

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

DEEP OCEAN OBSERVING STRATEGY

pogo Partnership for Observation of the Global Ocean

United Nations Ocean Decade 2021-30
Safe Ocean Laboratory Satellite Activity
“Further Challenges for Warnings of Tsunamis”
6 – 7 April 2022

GORDON AND BETTY MOORE FOUNDATION

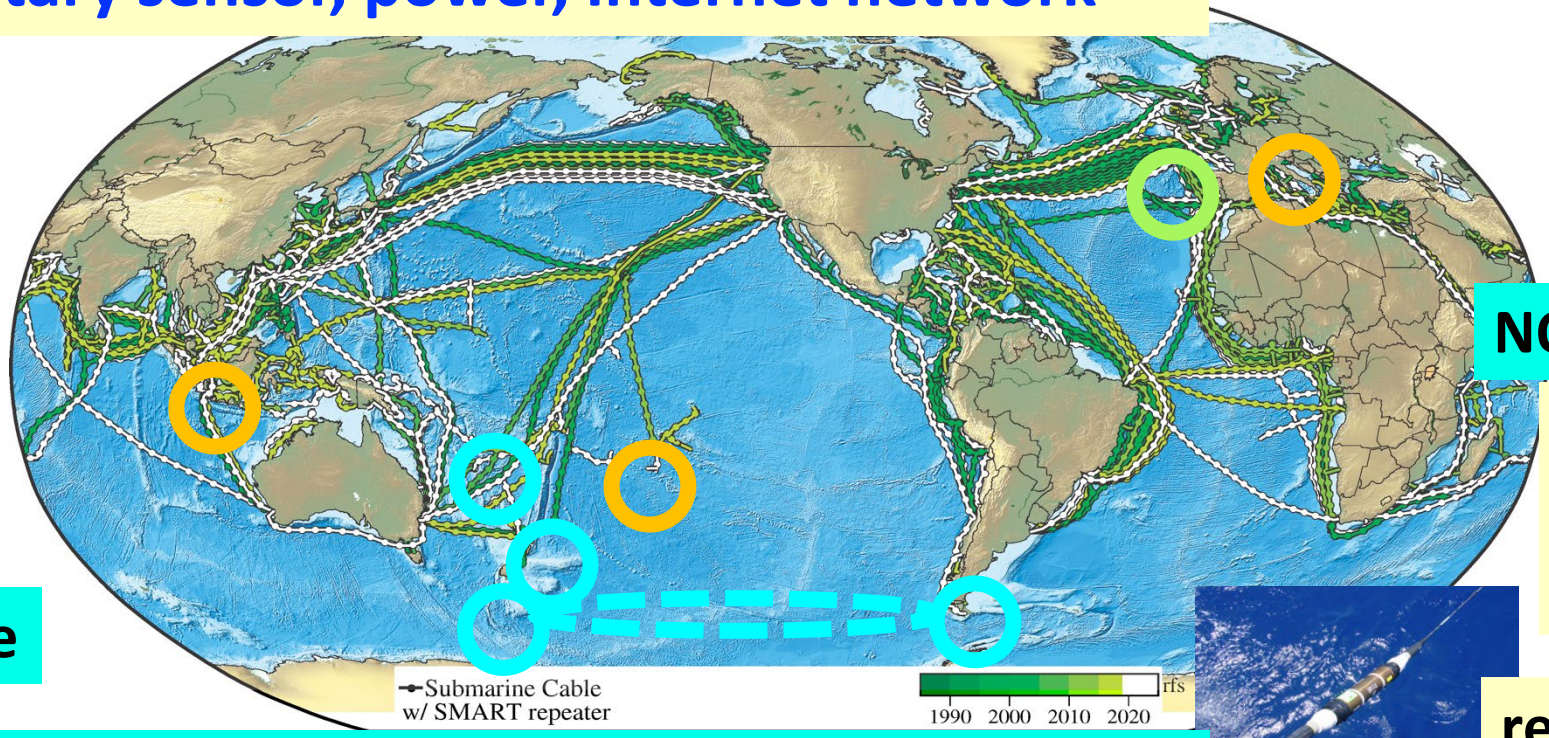
NASA

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

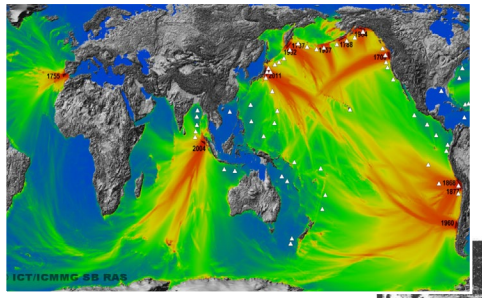
Know the environment – protect the network

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

Bottom temperature, pressure, seismic acceleration

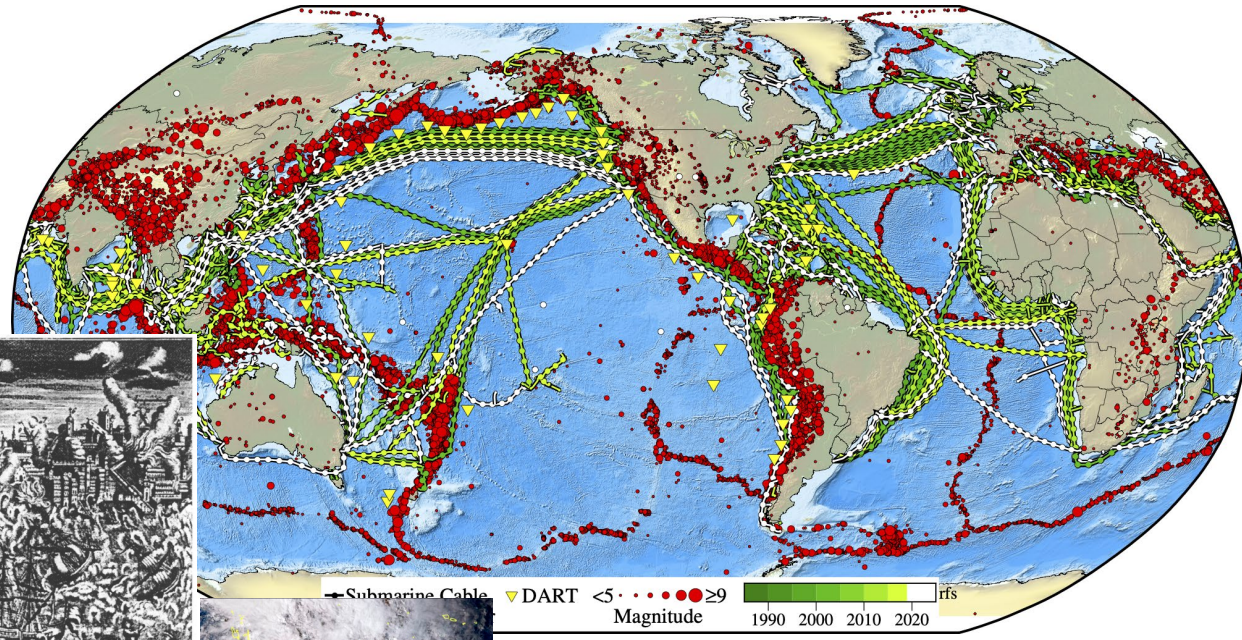
Earthquakes and Tsunamis

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

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

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

UN Decade of Ocean Science for Sustainable Development 2021 - 2030

Challenge 5: Ocean-Climate nexus

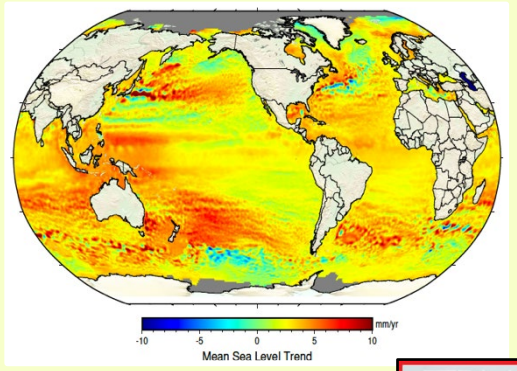
CLIMATE EMERGENCY

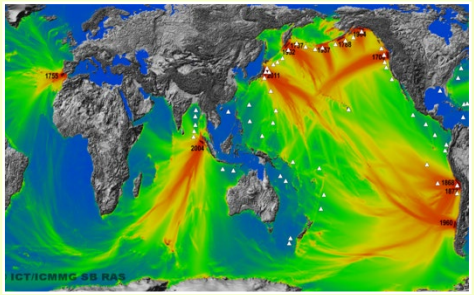
- Contribute to monitoring the atmosphere-ocean-climate-Earth system
- Ocean heat, circulation, time/space variability
- Secular changes of tidal coefficients

Lives and Infrastructure

Outcome 4: Predicted Ocean

Challenge 6: Early warning services





Tonga

- Early warning earthquakes and tsunamis
- Mitigate coastal flooding, exacerbated by sea level rise.

Outcome 5: Safe Ocean

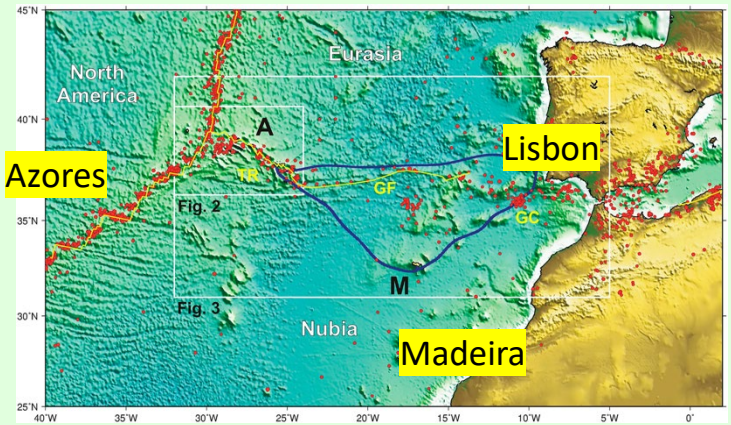
Challenge 7: Sustainable ocean observing system

- Absolutely!
- Potentially 1000s SMART repeaters
- Global, real time, long life, reliable, sustained, maintained, expandable

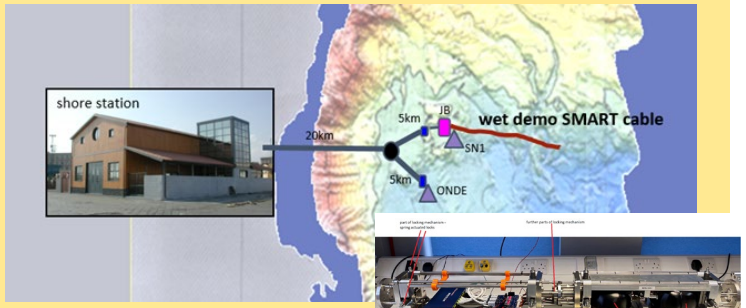
- QC'ed data to users
- Capacity building
- Programme office - all stakeholders

Outcome 6: Accessible Ocean

SMART Cables - Europe



- **Wet Demo**, Install 2023
- Three test SMART repeaters (sans telecom)



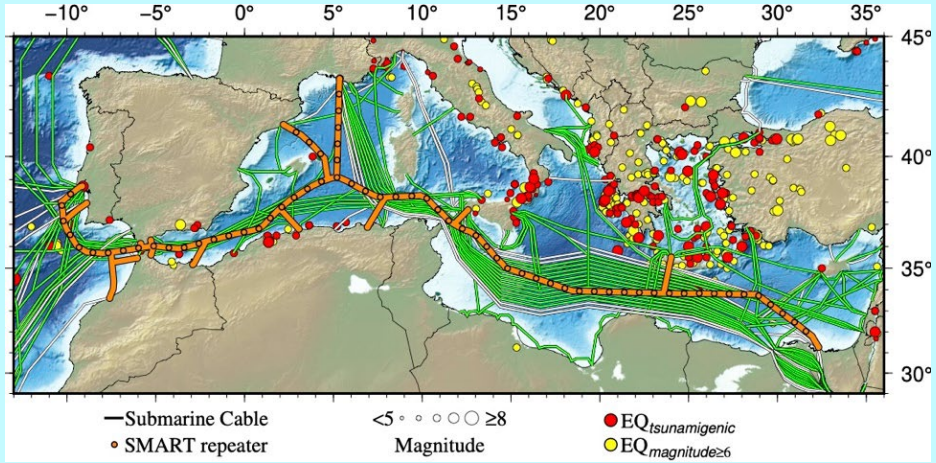
- **CAM2**
- Domestic, international connections, Digital hub
- 1755 earthquake tsunami
- Seismic, tsunami, ocean, environment
- 3700 km, 50 SMART repeaters, €120M
- RFP 2022, Ready For Service 2025
- ANACOM connection to telecom

LEA – Listening to the Earth under the Atlantic

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

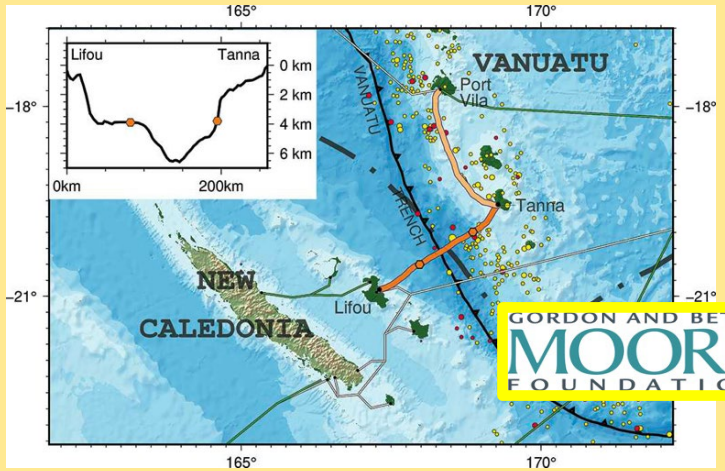
NEAMTWS



- **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

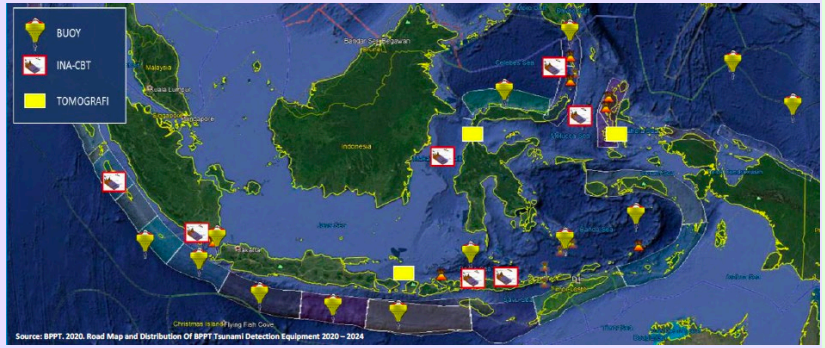
SMART Cables - Pacific



Vanuatu – New Caledonia

SMART, DAS

Partial funding; under gov't review

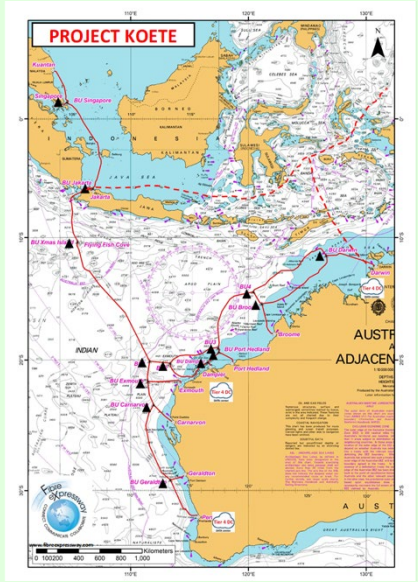


Indonesia

In country development Ina-CBT

Single ended test systems underway

Follow with Makassar Strait, **with telecom**



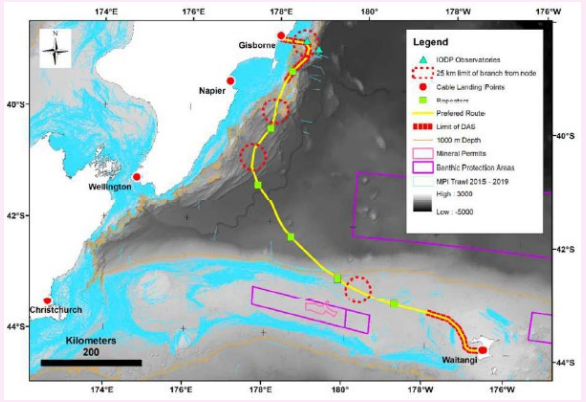
Project Koete

Perth-Darwin-Malaysia

Communities

SMART integral

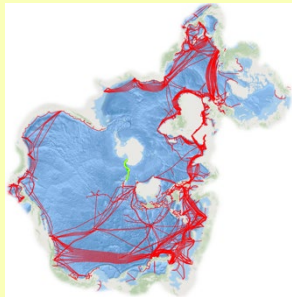
Raising funds



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

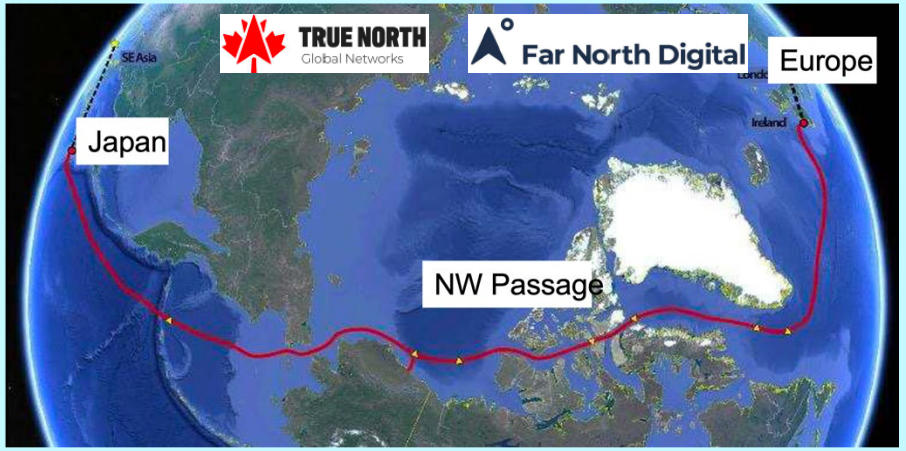
Low latency

Communities

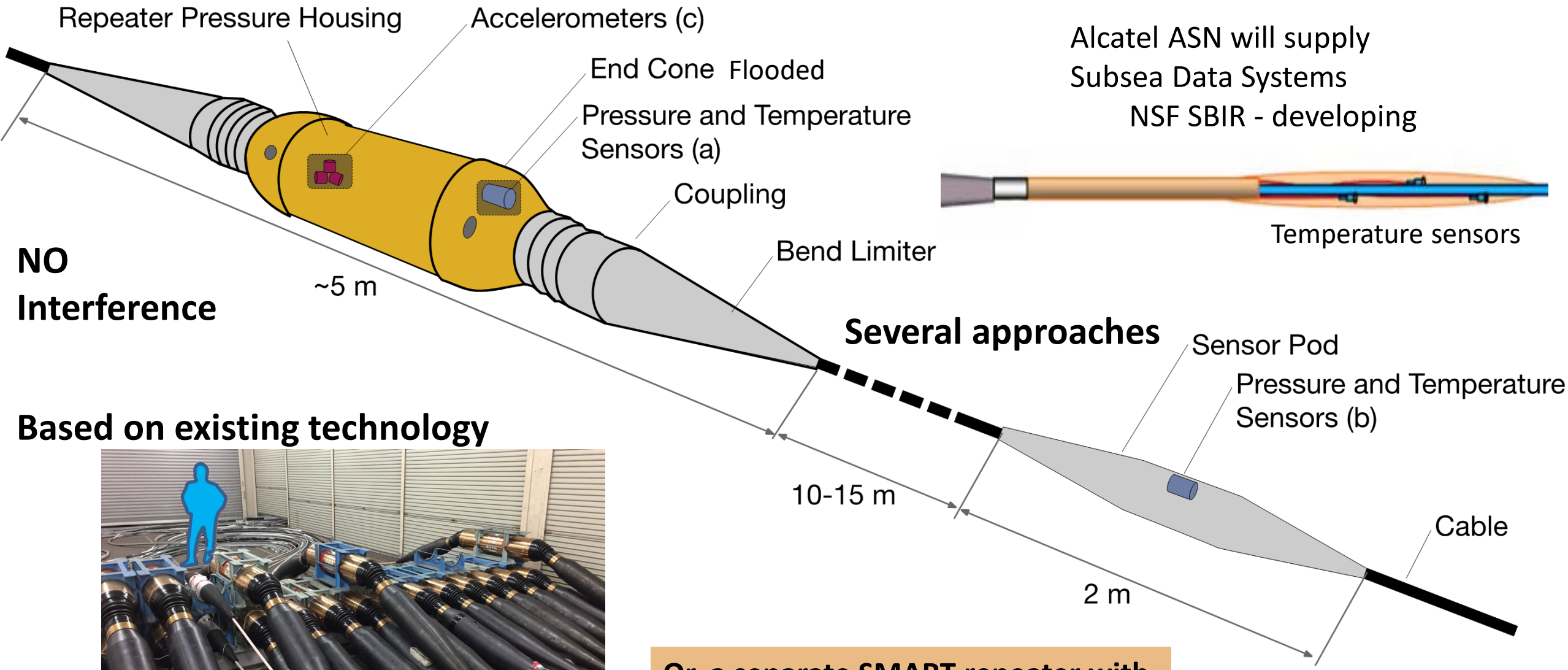
Contract Q1 2022

RFS Q4 2025

SMART integral



SMART Repeaters



Alcatel ASN will supply Subsea Data Systems

NSF SBIR - developing

Temperature sensors

NO Interference

Several approaches

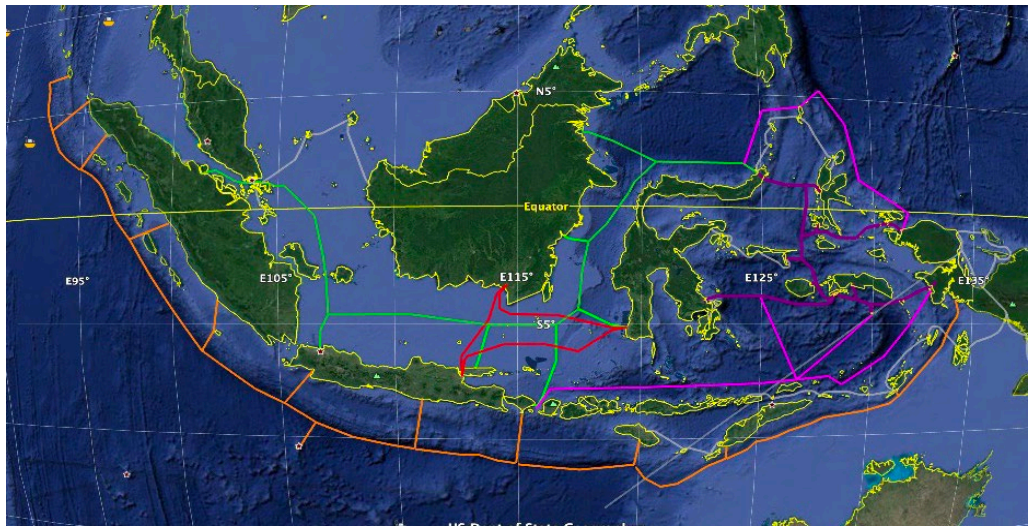
Based on existing technology

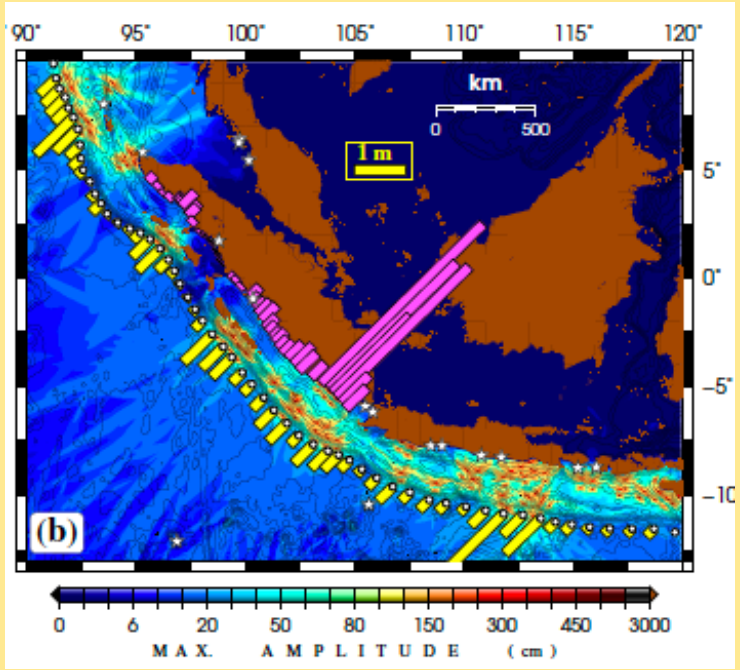
Or, a separate SMART repeater with Telecom fiber pass-through

Different tsunami types – and solutions

- SMART Cables can help with some cases with larger areas/distances, or going by a known hazard (e.g., Tonga, Krakatoa)
- Indonesia good example
- Seismic tsunamis – generated by faults (typical)
  - Megathrust – “simple” - SMART offshore of fault
  - NE – “randomly” faults, build up sampling from multiple smart or hybrid cables
- Landslides – seismic induced (figure, Palu)
- Volcano – Anak Krakatoa, Tonga

- Other solutions for smaller areas with hazards
- Between close islands (< 300 km) with telecom
- Known local hazards – volcanos, Anak Krakatoa – dedicated





Landslides

- SMART cable (yellow dots),
- 52 landslide scenarios
- Bottom slope
- Acceleration
- Tsunami height at cable
- Tsunami height near shore
- A. Salaree, et al.

Shinohara et al. 2021

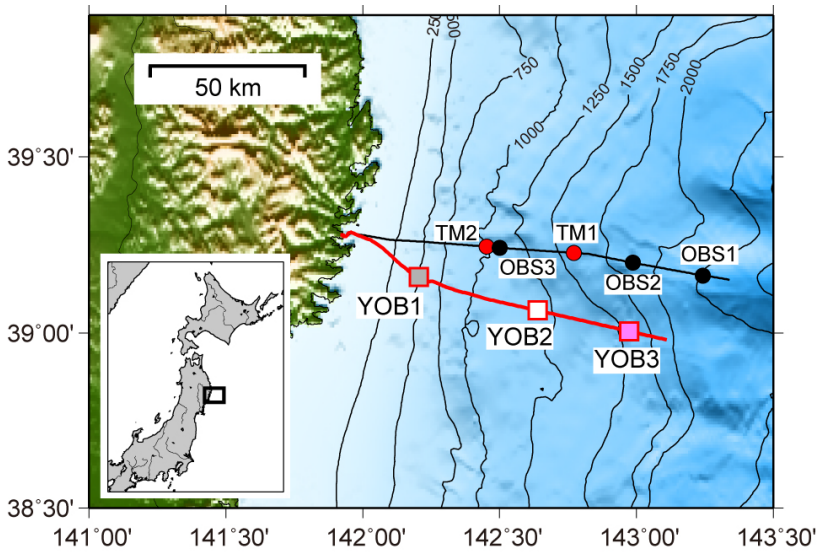
An in-between hybrid alternative: Sanriku system

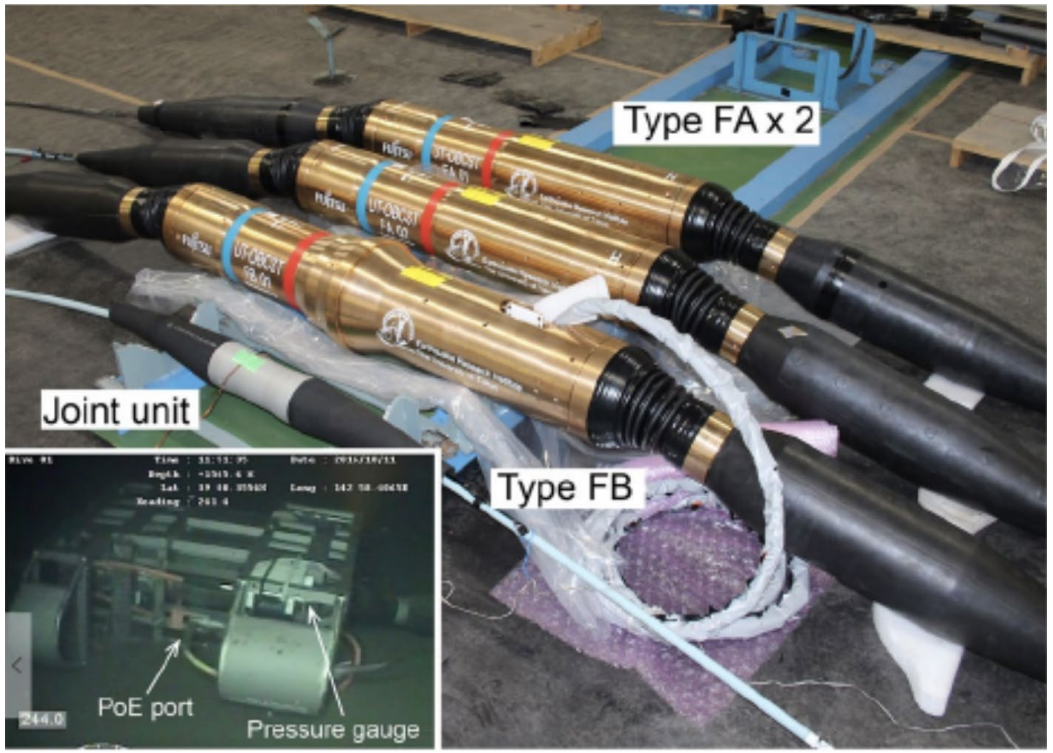
Early SMART prototype (sans telecom), standard repeater housings and terminations

Could pass telecom through unit

Also demonstrates single port plug-and-play interface, standard ROV UW-mateable connector, PoE

In between a SMART repeater and a full “Powered Branch Node”



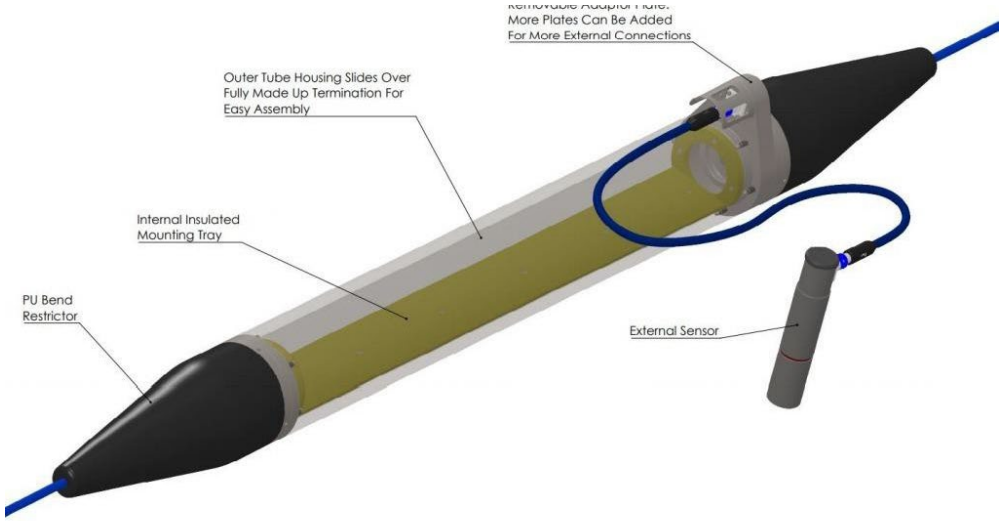


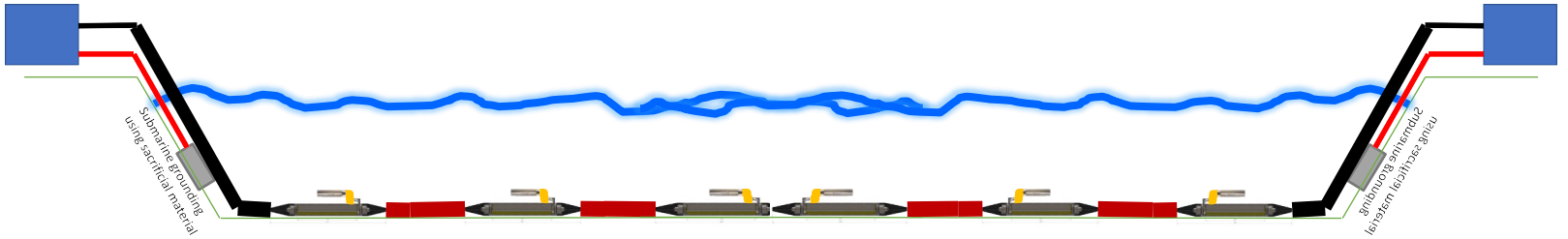
Indonesia InaCBT “OBU” solutions – ocean bottom units

Short distance (< 300 km) – no optical amplifiers required for telecom

“simple” ethernet based system for OBUs

Single (dedicated) or double ended (can have telecom)





Makassar Strait

2021 INA-CBT Labuan Bajo & Rokatenda

Start simple
Dedicated local system

Concluding Remarks

- SMART – essential ocean variables and disaster risk reduction
- Global scale, realtime, sustained, 25+ year life, highly reliable, power+internet on seafloor, low lifetime cost, leverage $5B/y industry, 170 y experience,
- SMART available (ASN, Subsea Data Systems), 2025+
- SMART systems: CAM2, MEDUSA, V-NC, Antarctica, Arctic, … will set valuable precedents
- Local hazards may require special treatment – a challenge, solutions tailored to specific situation