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Intergovernmental Oceanographic Commission

Task Team NEW EMERGING TECHNOLOGIES (NET) for Observation and Forecasting

Wahyu W. Pandoe

Chair of TT New / Emerging Technologies

National Research and Innovation Agency (BRIN)

wahyu.widodo.pandoe@brin.go.id

19th Meeting of ICG/IOTWMS Steering Group, Jakarta, 17-19 June 2025

Term of Reference

1. Developing a methodology for gap and sensitivity analysis that combines multiple sensing technologies for tsunami detection and characterisation.
2. Designing optimal notional seismic and sea level networks to enhance the timelines of Tsunami Early Warning by TSPs and NTWCs.
3. Integrating emerging techniques and sensor technologies (e.g. better use of tide gauges; GNSS technology and processing; sensors on SMART Cables) with the existing sensing network to meet tsunami warning service requirements in support of UN ODTP goals.
4. Undertake to establish direct collaboration between ICG/IOTWMS Member States, with other ICGs, and expert groups (such as International Association of Geodesy (IAG), International GNSS Service (IGS) for the purpose of collaborating on data sharing and research efforts that are adaptable to the tsunami warning systems and operations.
5. Assess the utility and limitations of emergent technologies and techniques, e. g. GNSS and SMART Cable, that have potential to deliver ocean height in real-time.
6. Investigate emerging methods including PTF, AI/ML, real-time data assimilation and modelling etc for suitability to be adopted for operational tsunami warning.
7. Share information and procedures on deployments of new technologies to monitor sea level variations used for tsunami warning purposes, including undersea cable installations being deployed by Indonesia and India.

Members and Experts:

Established in the ICG/IOTWS XIV Meeting in Jakarta, Nov 2024
The Task Team open to TSPs,

Members nominated by Member States,

- Chair: Dr Wahyu Widodo Pandoe (Indonesia), wpandoe@gmail.com
- Vice Chair: --tbd--
- Mr Adam Gimes (Australia), adam.gimes@bom.gov.au
- Mr Iyan Turyana (Indonesia), iyan001@brin.go.id
- Mr Afiq Zhofri Abdul Razak (Malaysia), afiq@met.gov.my
- TSP Australia Representative
- TSP Indonesia Representative
- TSP India Representative

Poposed invited experts.

1. Dr. MA Purwoadi (BMKG)
2. Dr. Widjo Kongko (BRIN)
3. Dr. Wiwit Suryanto (Geophysics, UGM)
4. proposed experts from TSP Countries

Content:

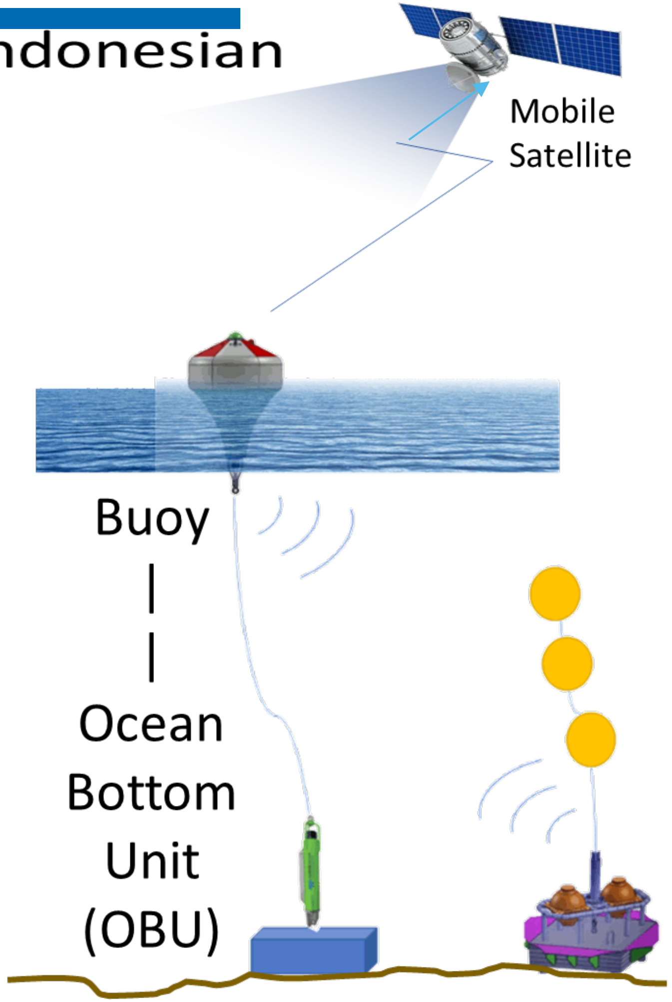
Recent (new) Emerging Technologies:

	Research Fields	pertners
1	Ina-CBT (Indonesian Cable-Based Tsunameter)	Indonesian developed sytem
2	SMART Cable	U. Hawaii / Joint Task Force (JTF) IOC, WMO and ITU
3	Distributed Acoustic Sensing (DAS)	Institute Physique du Globe de Paris (IPGP)
4	Research on Acoustic Sensing -- "Listening Tsunami and or Disaster"	
5	Numerical Model & Forecasting	n/a

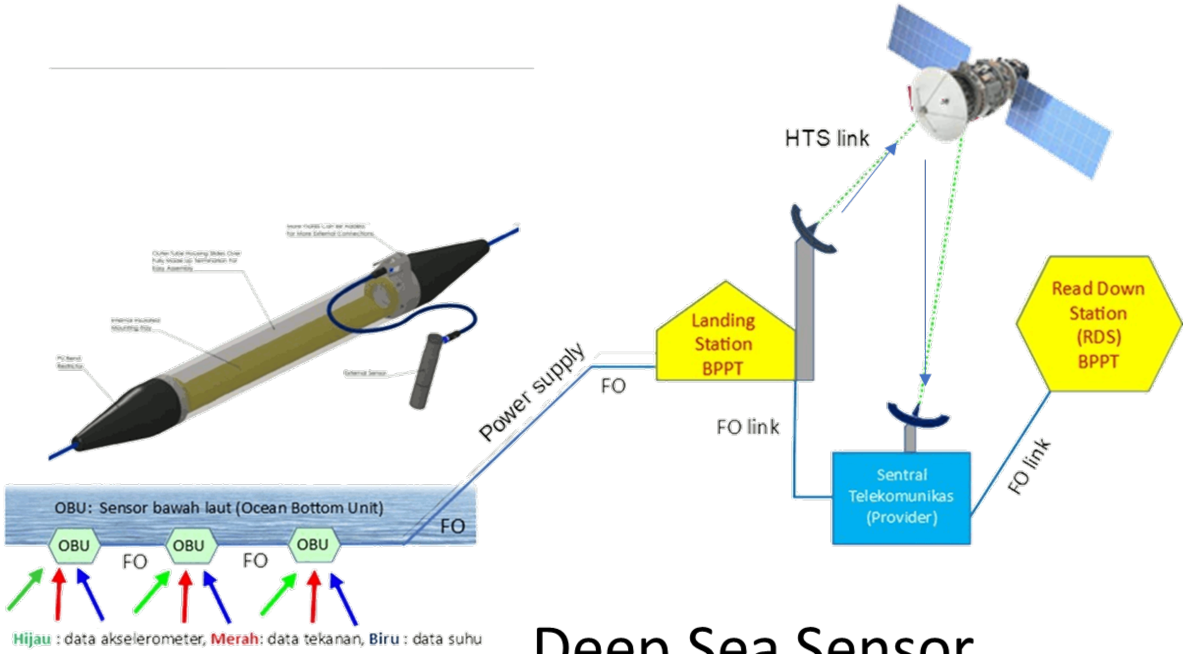
Introduction to InaCBT

TEWS Indonesian Buoy

DART (Deep-ocean Assessment and Reporting of Tsunamis)



Indonesian Cable-Based Tsunameter

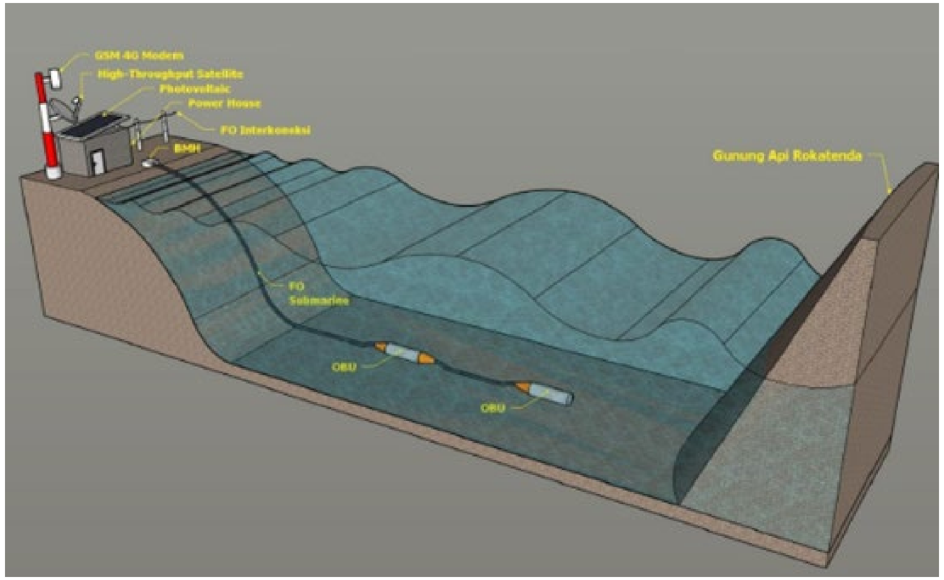


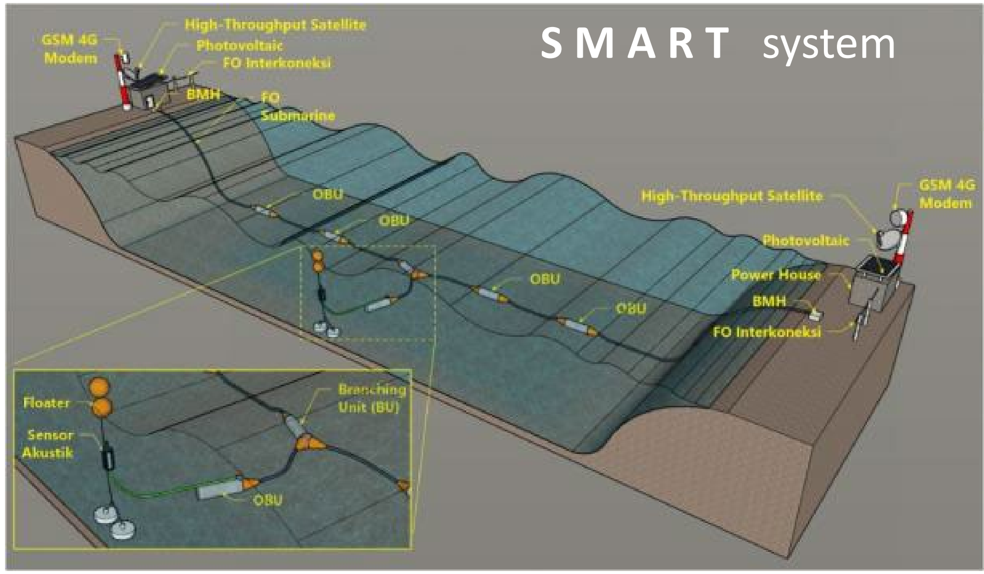
Deep Sea Sensor

Hydrostatic pressure + 3D Accelerometer + Temp sensor

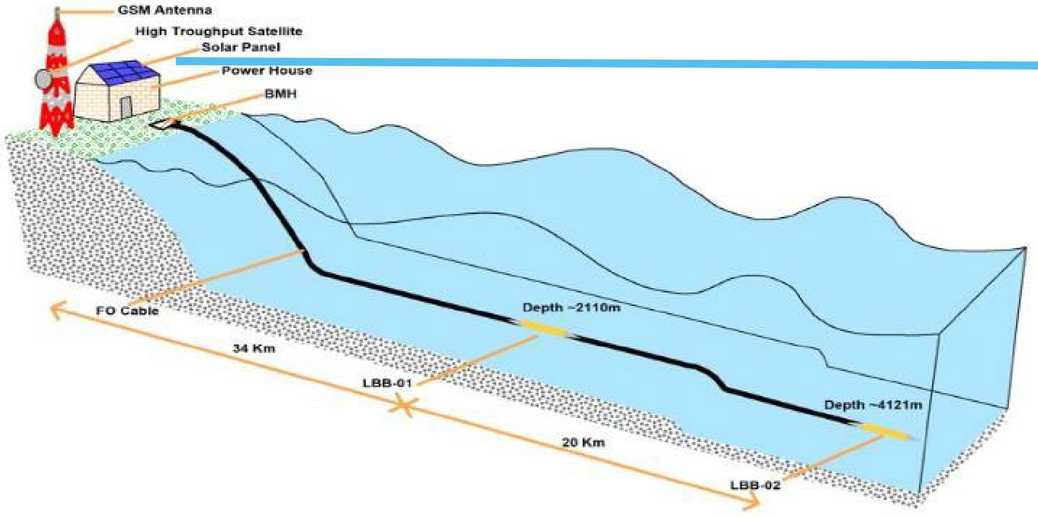
Introduction: Cable-Based Tsunami sensors (CBT)

- Effective for Near Field and Atypical Tsunami
- Can be integrated with ocean bottom seismic sensors (OBS)
- High data sampling rate
- Fast data transmission
- Life time expectation > 20yrs,
- no need yearly regular maintenance except the Landing Station
- NO vandalisms
- International efforts:
  - SMART Cable System (JTF WMO-IOC-ITU)
  - Japan: S-NET, DONET
  - USA: MARS Landing System
  - Indonesia: InaCBT
  - India: ....





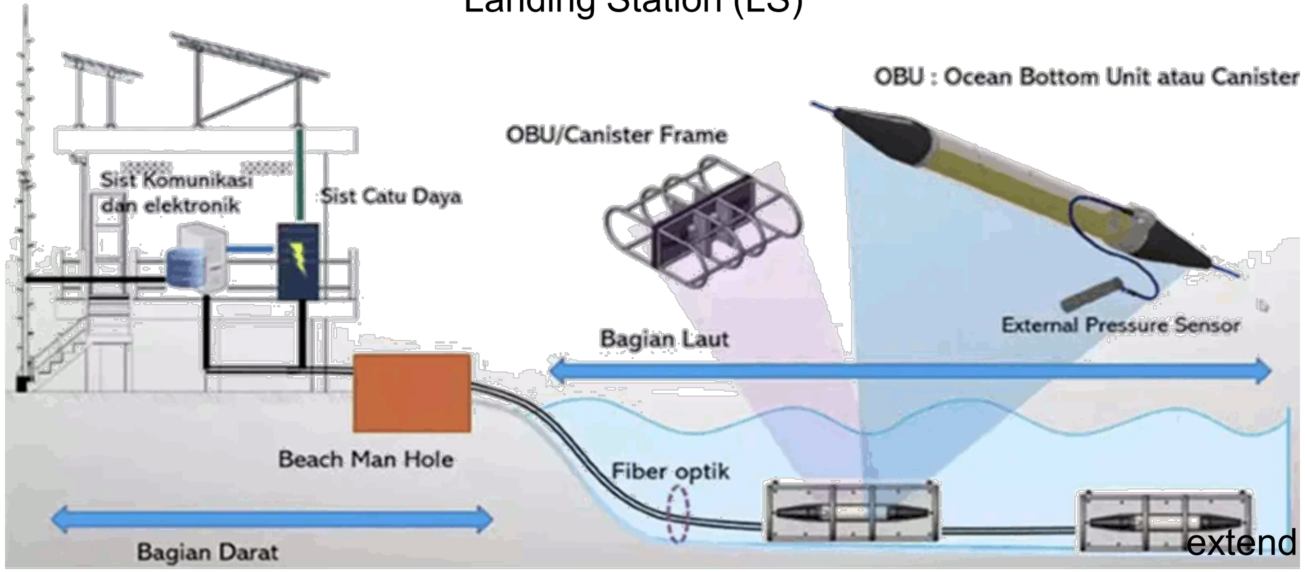
Configuration InaCBT



Landing Station (LS)

Location: Labuan Bajo – FLores Sea.

- Deployment: February 2022
- Operating since: February 2022
- Sensors (now):
  - ❑ Hydrostatic Precise Pressure Gauge (1Hz)
  - ❑ 3D Accelerometer (125Hz)
  - ❑ Temperature



extend to 2nd LS (optional)

Cable-based Tsunami & EQ Detection:

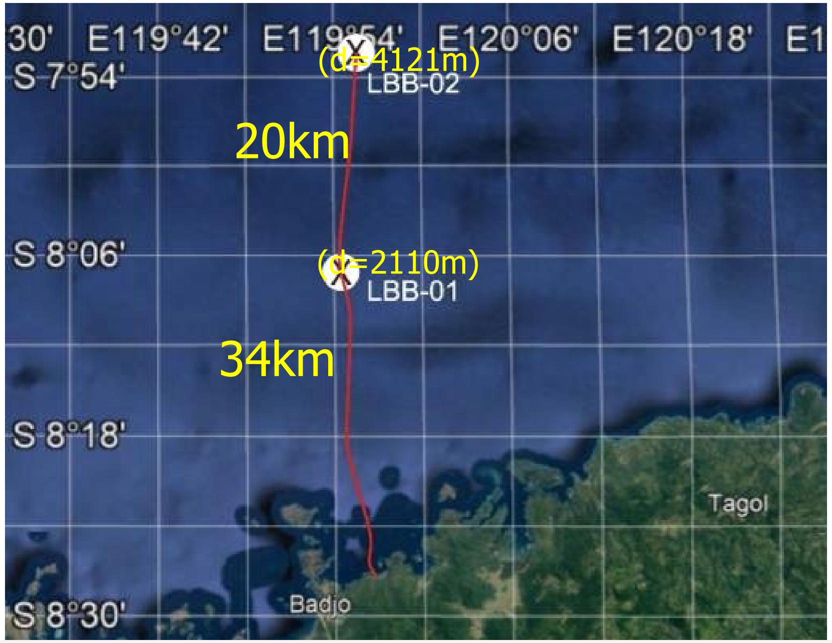
Location: Labuan Bajo – L. FLores.

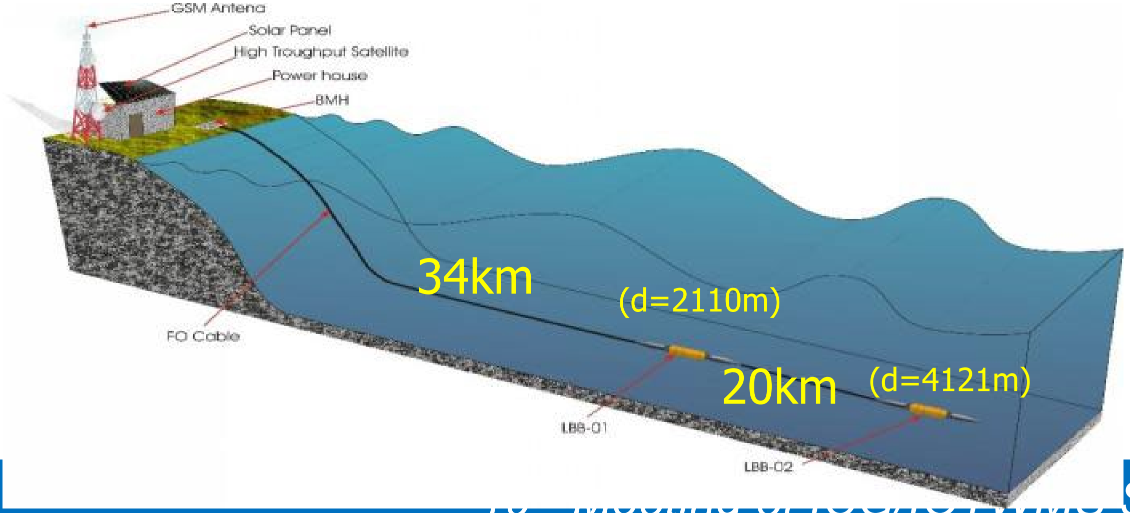
Length: 54 km (LBB-01 34km + LBB-02 20km)
- Operating since: February 2022
- Sensors (InaCBT):
  - ❑ Precise Pressure Gauge (1Hz)
  - ❑ 3D Accelerometer (125Hz)
  - ❑ Temperature

- Add 'optional' Sensors (MHEWS):
  - ❑ Ocean Bottom Seismometer (OBS)
  - ❑ Hydrophone
  - ❑ others

InaCBT

MHEWS





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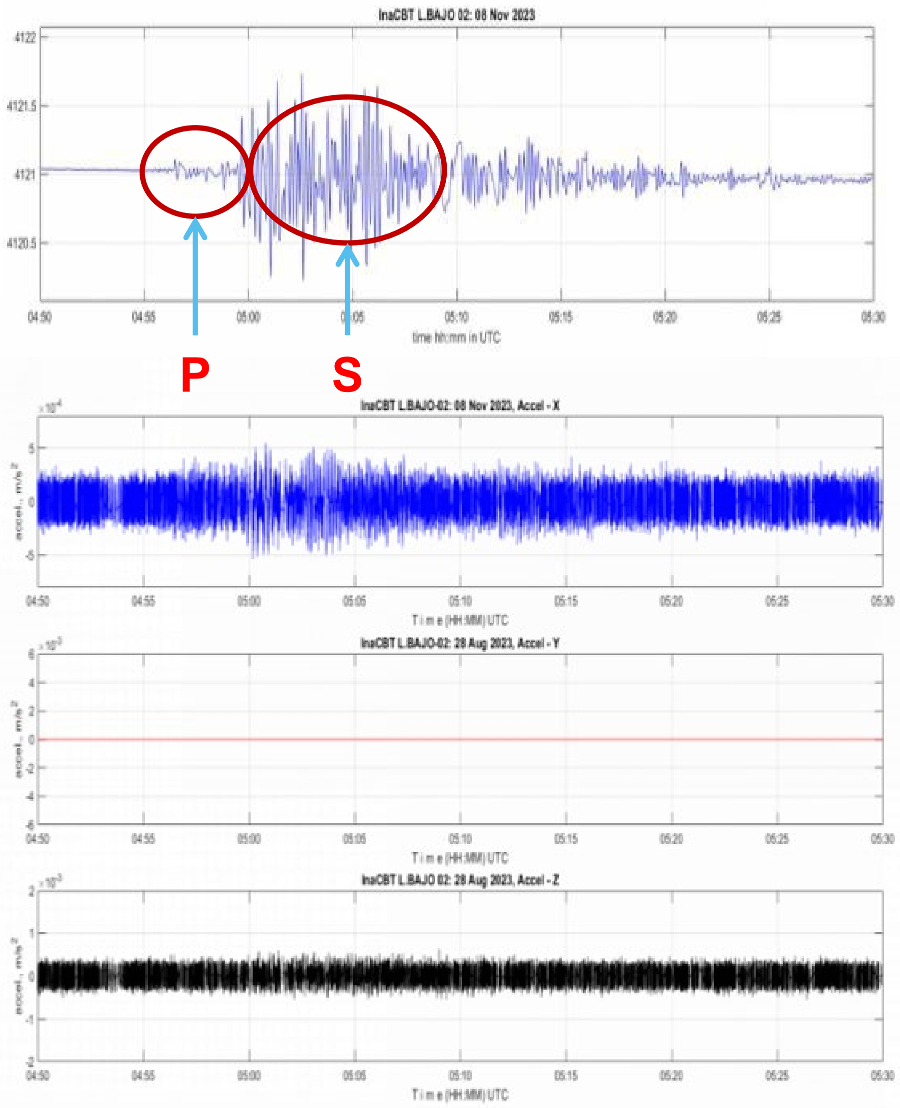
EQ Aru 08 Nov 2023 Vs EQ Banda 9 Jan 2023

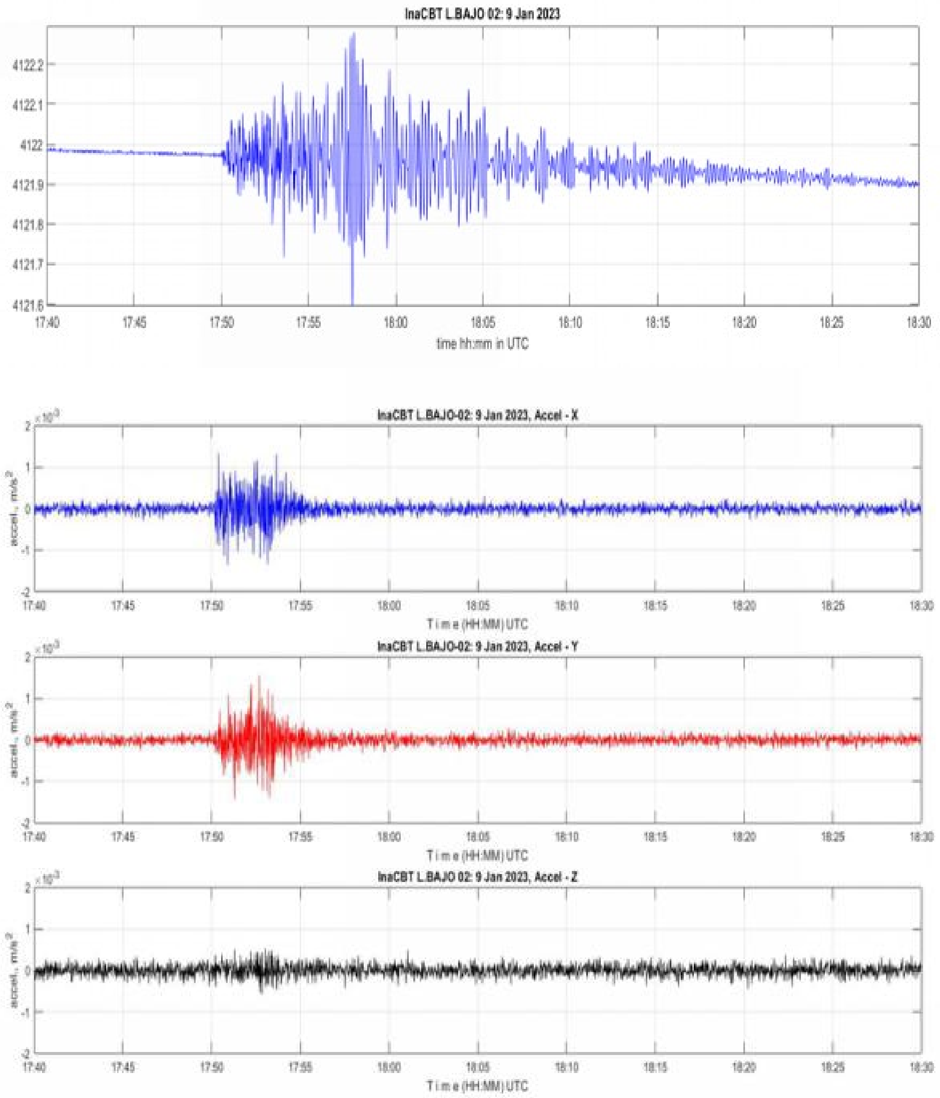


Pressure

Accel-x

Accel-y

Accel-z

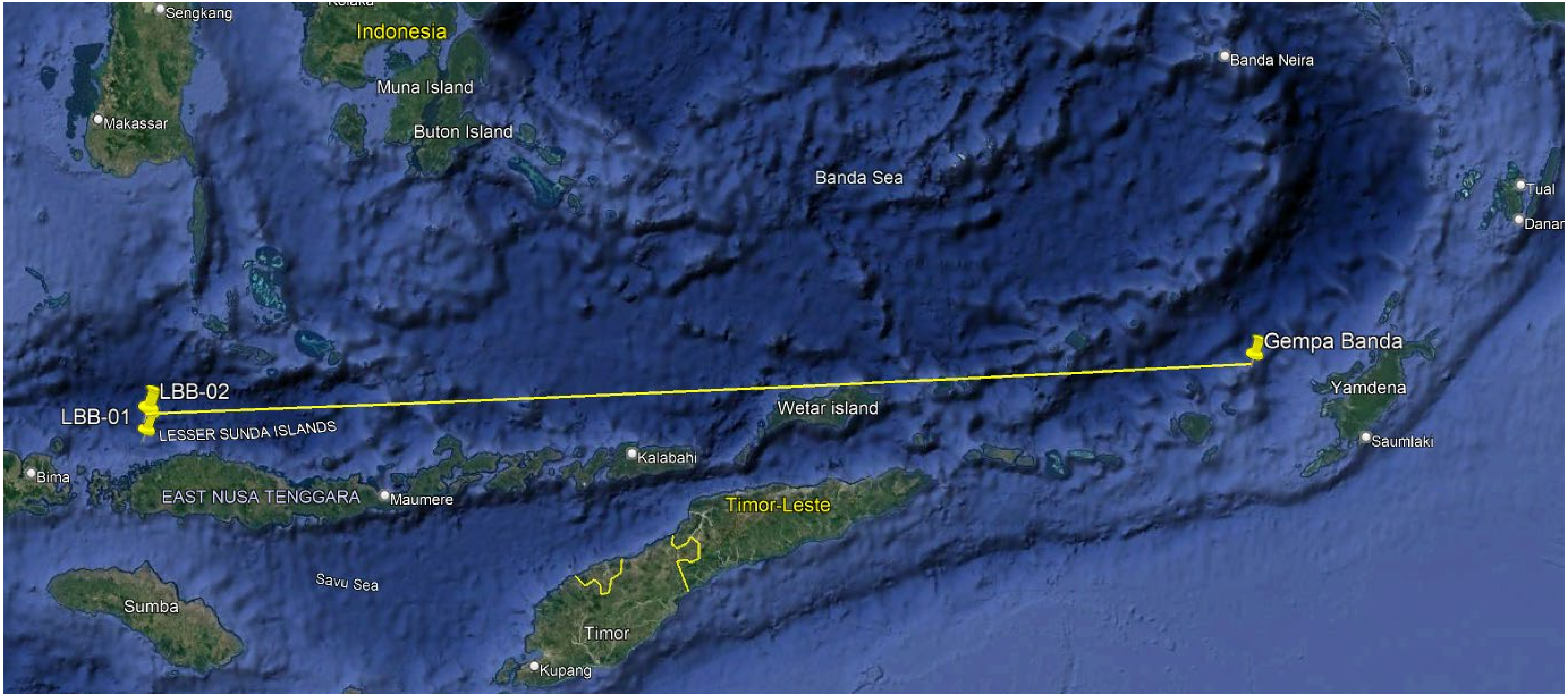


Q: How to identify P, S, Surface and other Waves ?

Ina CBT: M7.9 Banda EQ

Jan 09 2023 17:47:34 UTC

Distance Epicenter – Sensor : 1130 km



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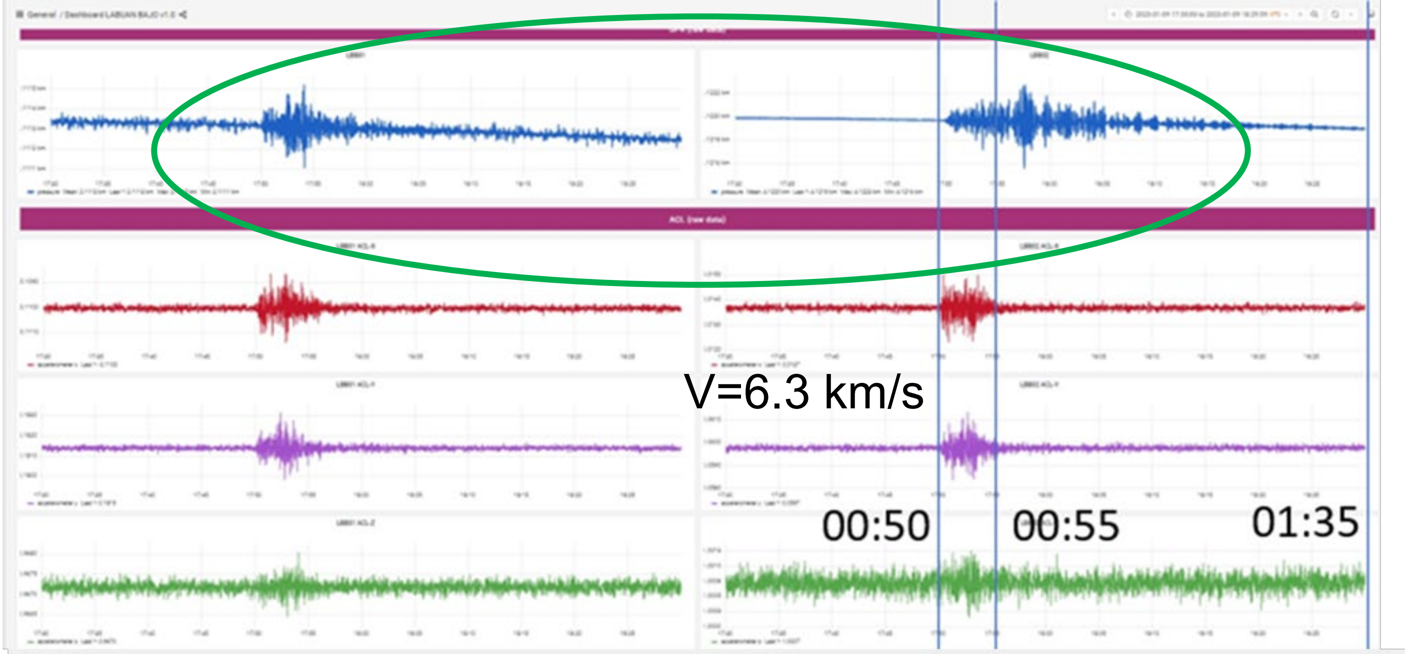

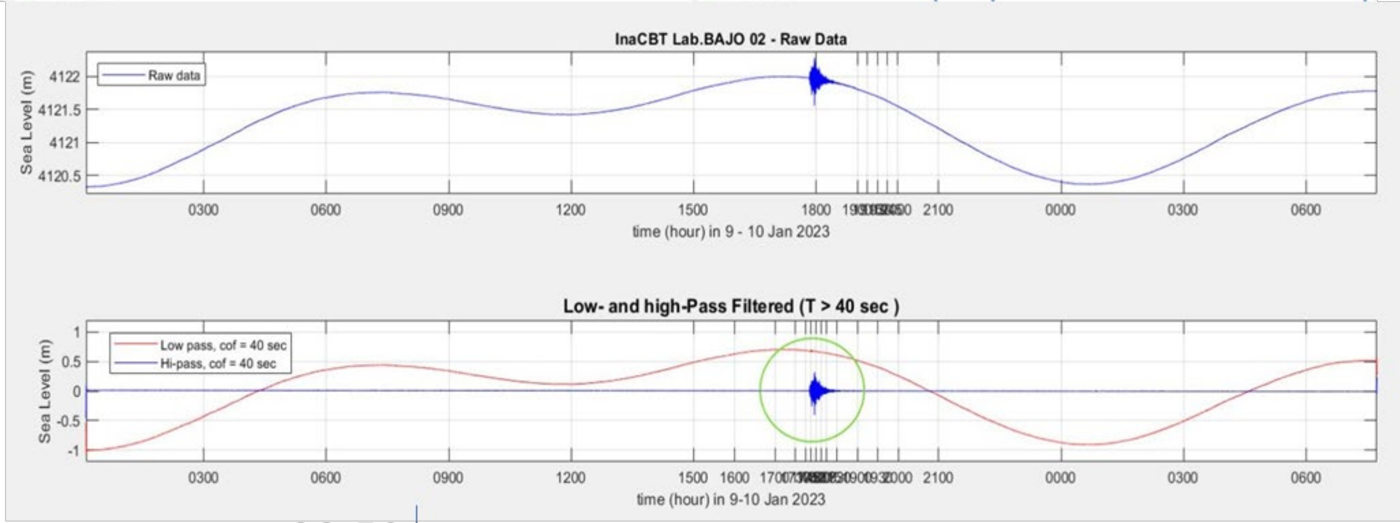

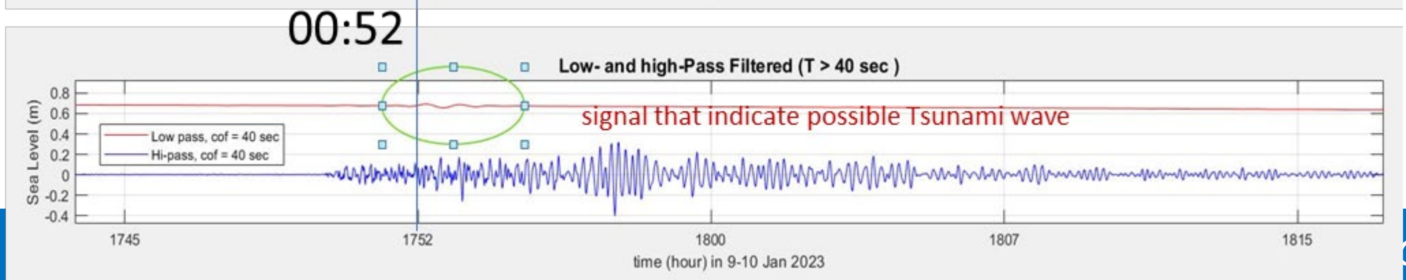

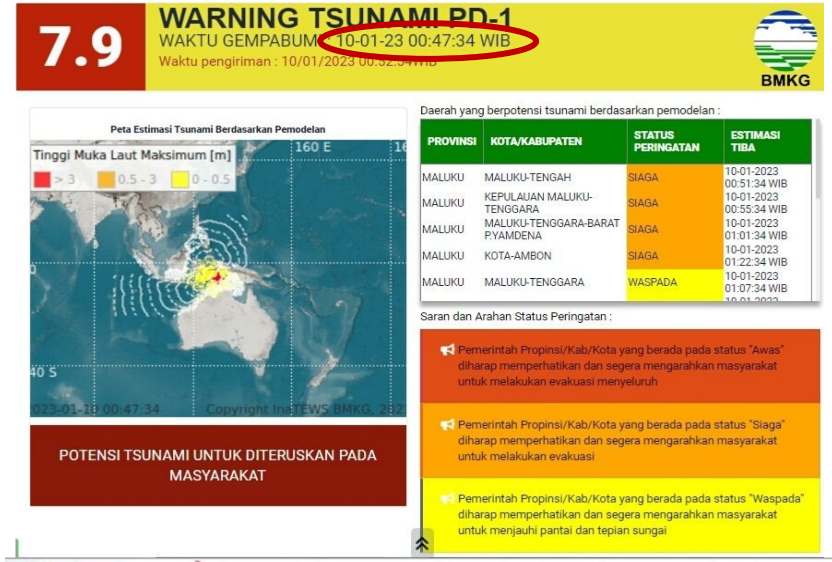

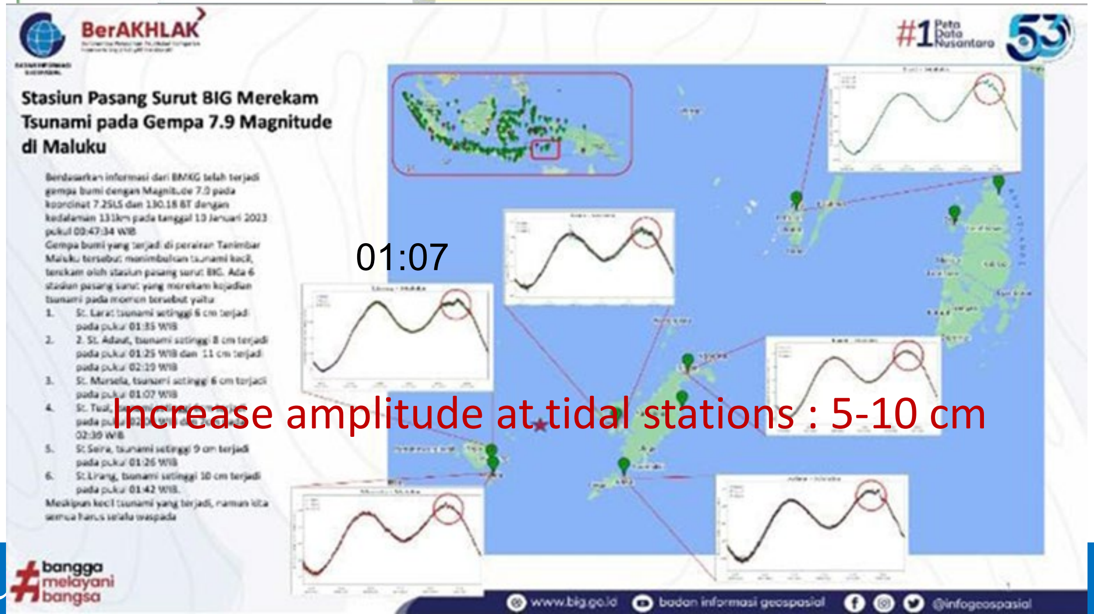

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SMART System: the JTF **ITU, WMO** & UNESCO-IOC

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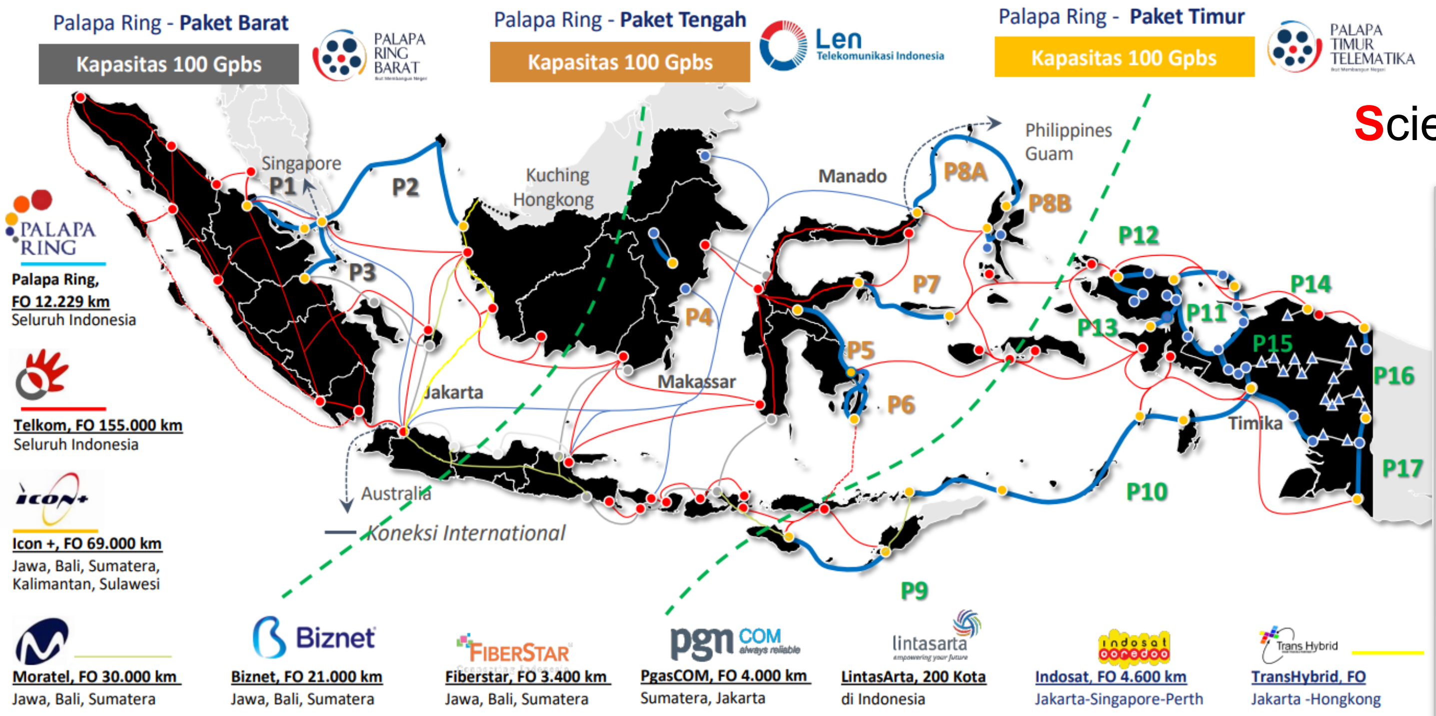
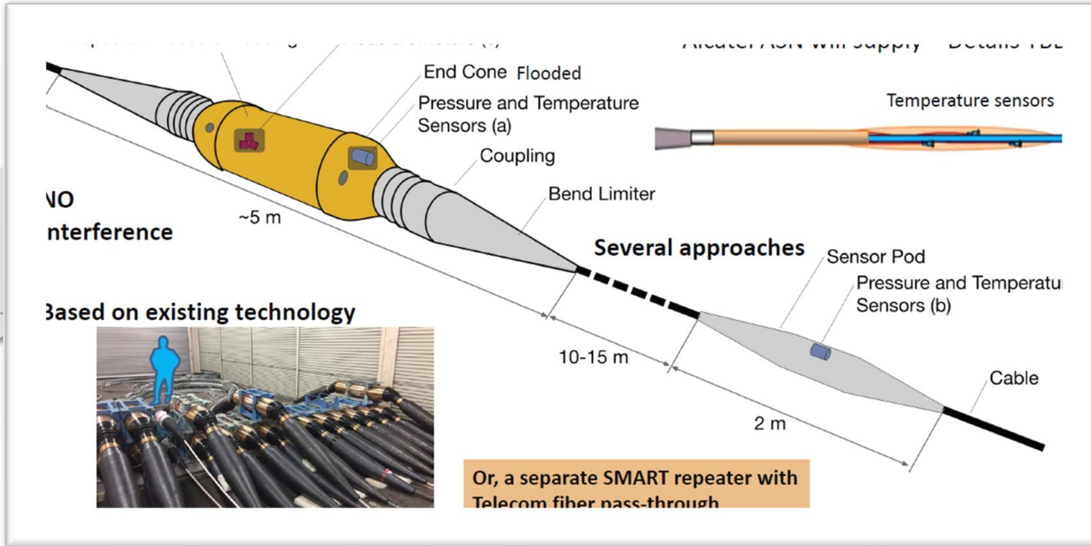
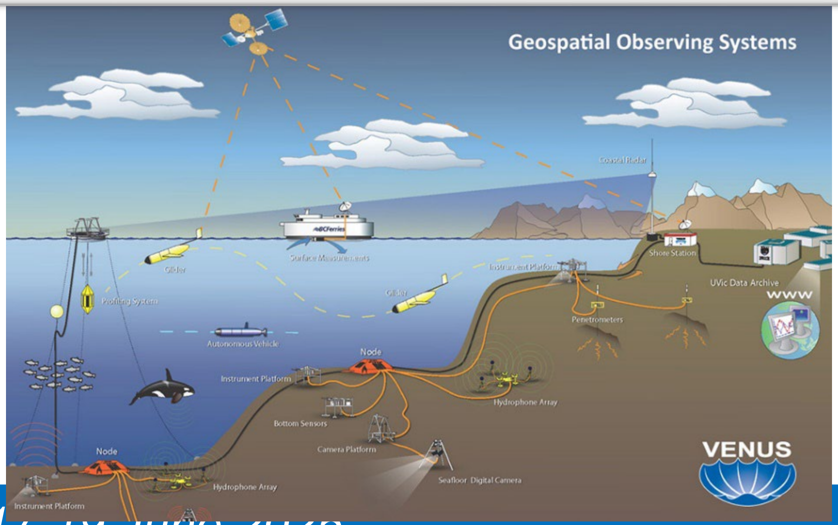


Scientific Monitoring and Reliable Telecommunication



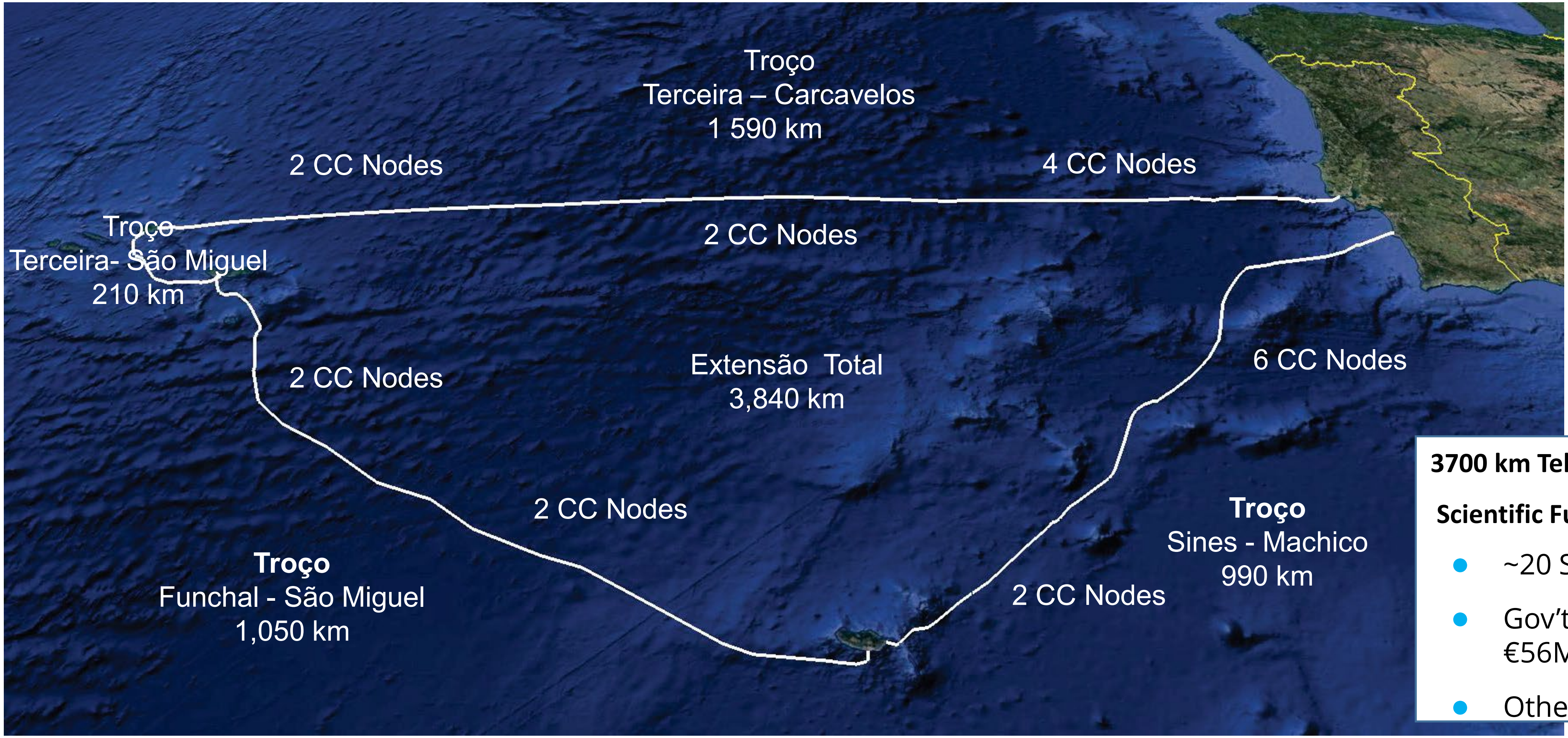
- To use the underwater (UW) telecommunication cables crossing the oceans and waters to become the network of real-time data for disaster mitigation and environment monitoring system.
- Three United Nations agencies: ITU, WMO, and IOC-UNESCO have arranged a Joint Task Force (JTF) established in 2012, aims towards incorporating environmental monitoring and tsunami sensors into trans-oceanic submarine cable systems → SMART cable system.
- No underwater telecommunications monitoring system is in place today.



Atlantic CAM

Physical Layout

Infraestruturas de Portugal



3700 km Telecom Cable

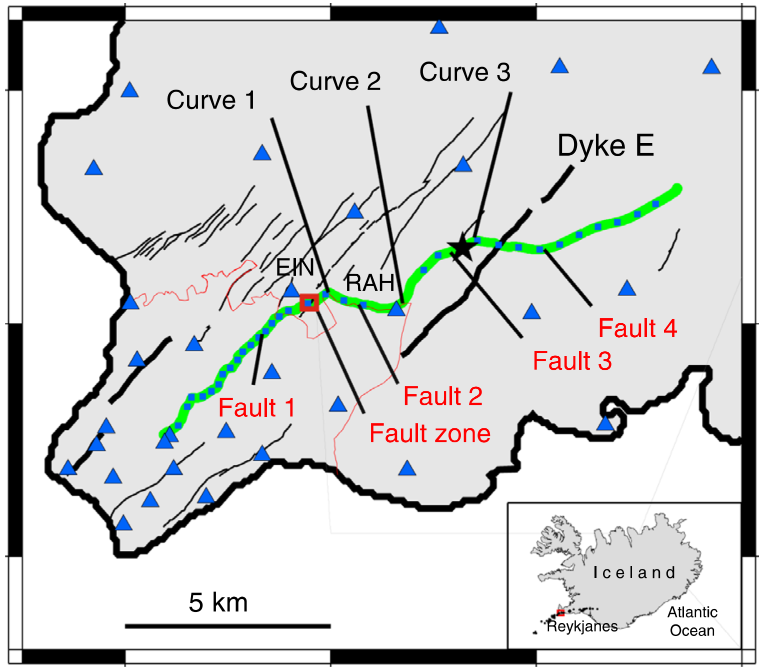
Scientific Funding :

- ~20 SMART modules
- Gov't €154M. EU support €56M
- Other sensing techniques

Distributed Acoustic Sensing (DAS):

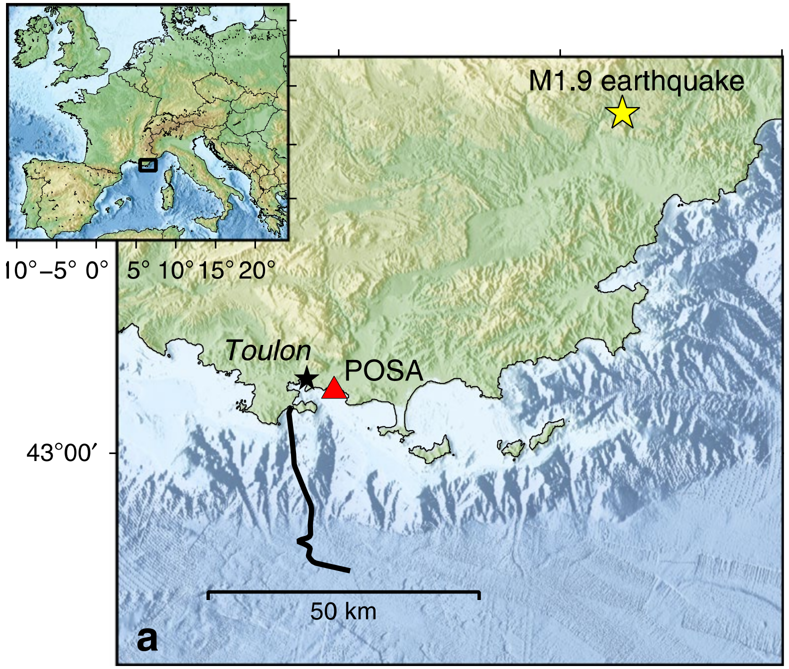
Distributed fiber optic sensing main capacities

1) Increase seismic network density (high spatial resolution)
2) Observation in remote areas and hostile environment (sea bottom, volcanoes)



Jousset et al., 2018

15 km fibre ~ 1000 equivalent sensors
(1 channel every 15m)



Sladen et al., 2019

40 km fibre ~ 6500 acoustic sensors

Source: Wiwit Suryanto Geophysics Laboratory Faculty of Mathematics and Natural Sciences UGM

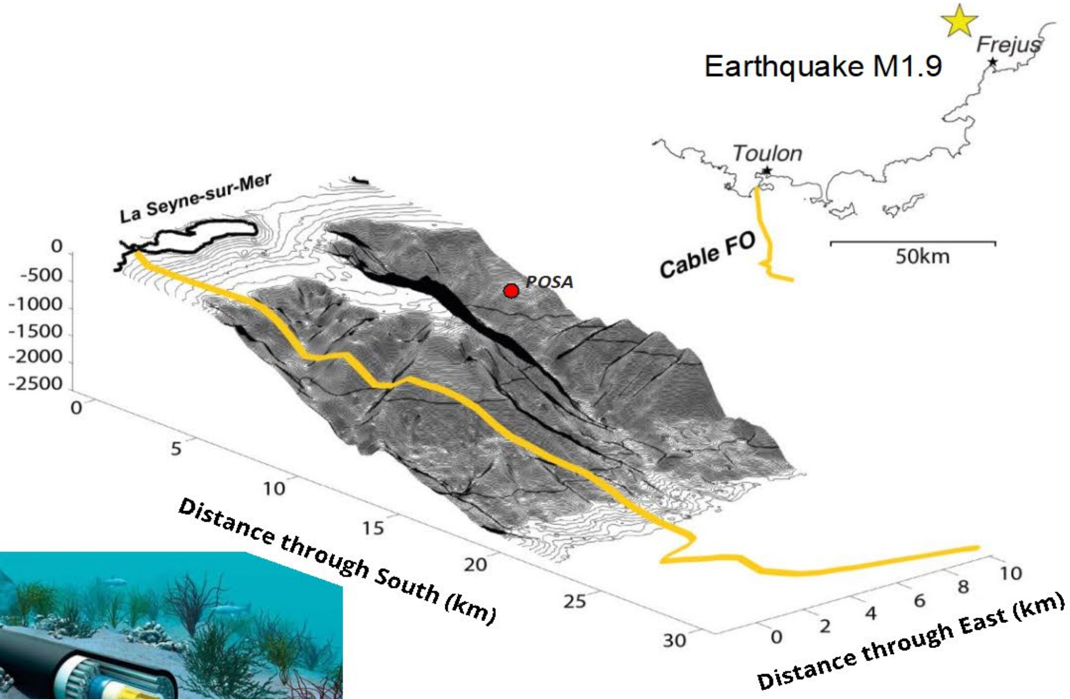
Seismic monitoring in Mediterranean sea (Toulon)

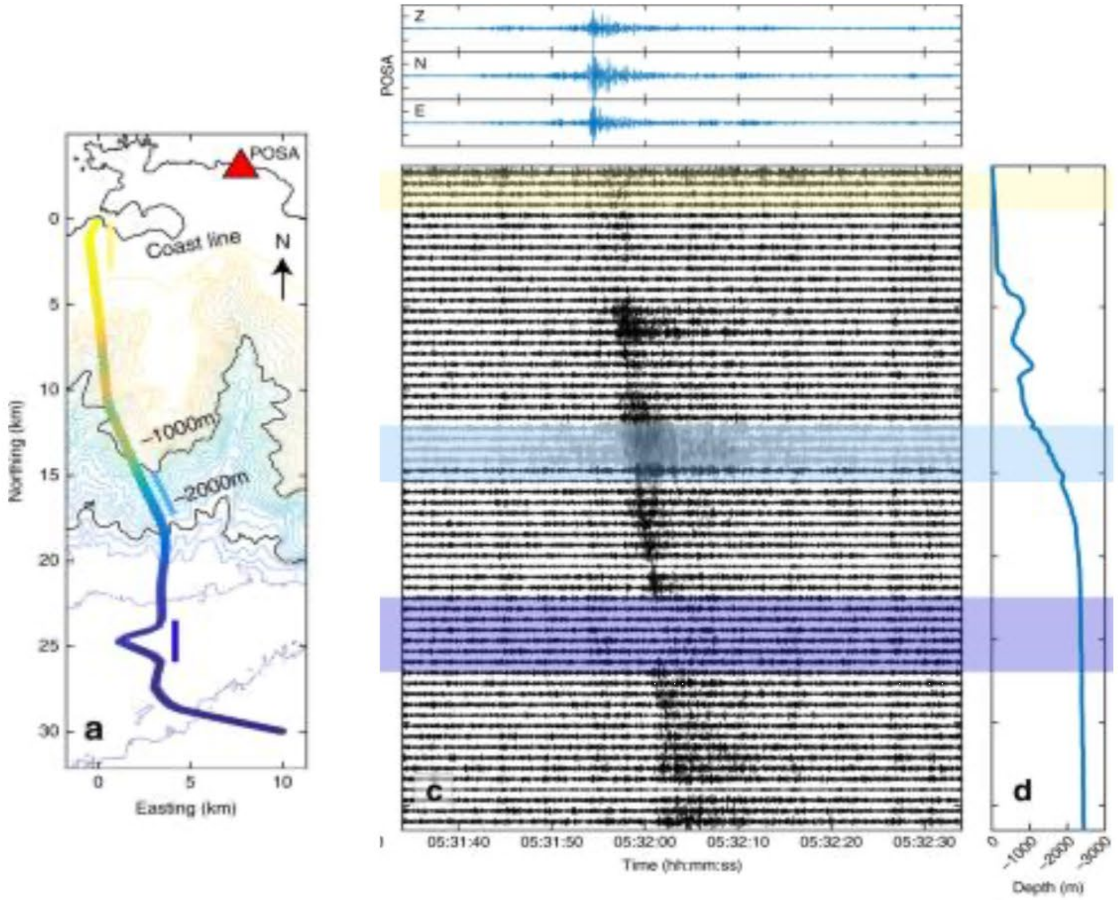
https://doi.org/10.1038/s41467-019-13793-z

OPEN

Distributed sensing of earthquakes and ocean-solid Earth interactions on seafloor telecom cables

A. Sladen[1*], D. Rivet[1], J. P Ampuero[1], L. De Barros[1], Y. Hello[1], G. Calbris[2] & P. Lamare[3]

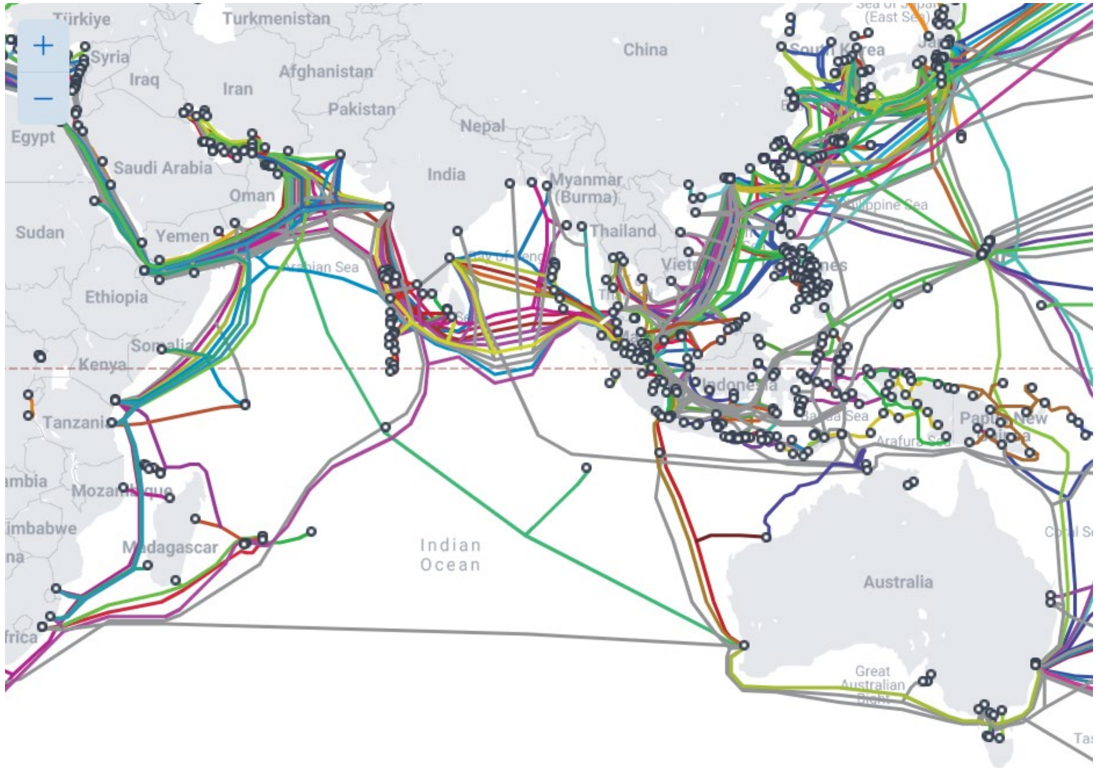


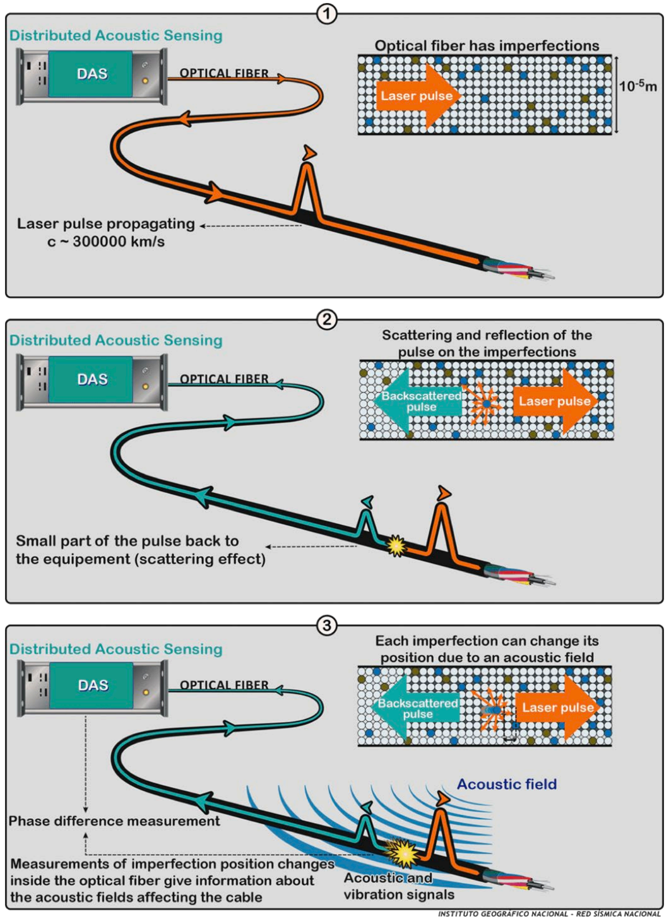


Source: *Wiwit Suryanto Geophysics Laboratory Faculty of Mathematics and Natural Sciences UGM*

Distributed Acoustic Sensing (DAS): How does it works

Existing cables over the Indian Ocean





Action Plan: Wet test DAS in Rokatenda-Flores site, in July/Aug 2025

Distributed Acoustic Sensing (DAS)

UNESCO Intergovernmental Oceanographic Commission

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News › Research and Innovation › Technological Innovation

UGM and Telkom Develop Earthquake Detection System Using Distributed Acoustic Sensing

Technological Innovation | 23 May 2025, 08.24 | By : Salma

Universitas Gadjah Mada (UGM), in collaboration with PT Telkom Indonesia Persero Tbk, is developing an early warning system for earthquakes based on Distributed Acoustic Sensing (DAS) technology.

This innovative disaster management system utilizes Telkom's undersea optical cable infrastructure as a key component to detect seismic activity in real time.

The innovation is considered a strategic breakthrough in geological disaster mitigation, particularly in addressing the threat of potential megathrust earthquakes.

"This technology offers a fast and precise solution capable of reaching high-risk areas that have long lacked adequate monitoring," said Professor Kuwat Triyana, a member of the research team, on Wednesday, May 21, 2025, during a meeting with the President Director of PT Telkom Indonesia and the board of directors at Telkom Hub, Jakarta.

Professor Triyana explained that the DAS-based earthquake detector works by sensing primary waves (P-waves), which appear earlier than the more destructive secondary waves (S-waves).

This capability allows the system to issue warnings seconds to minutes before the main shock occurs, providing crucial time for early evacuation.

https://ugm.ac.id/en/news/ugm-and-telkom-develop-earthquake-detection-system-using-distributed-acoustic-sensing/

Listening an Earthquake

Occur in Tropical Sea Water

Reseach collaboration BRIN-Indonesia with UPHF France 2025 – 2029

A Tertiary wave (or T-wave) is the acoustic signal from these earthquakes. A T-wave typically has frequencies ranging from 4 to 50Hz. T-waves propagate efficiently in the ocean compared to seismic waves through the earth and can be detected at great distances.

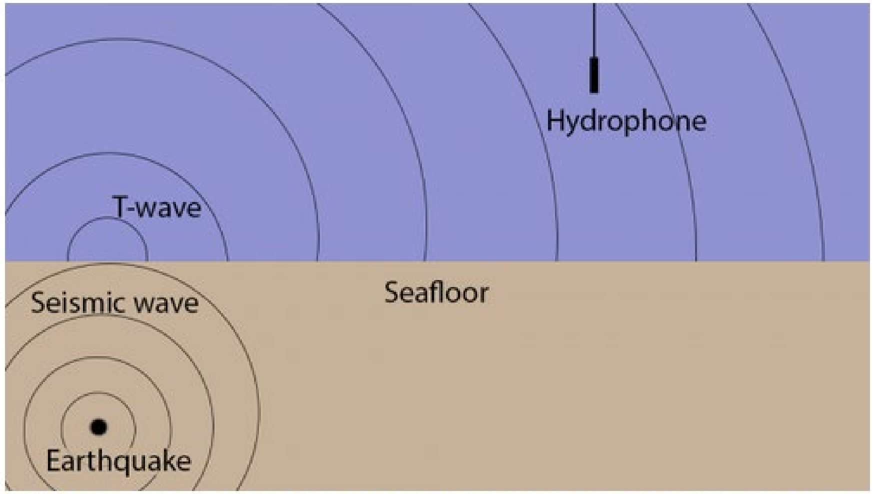
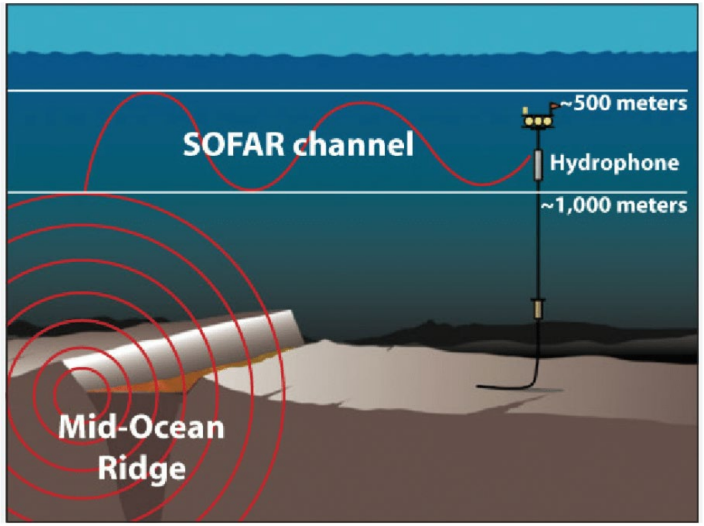


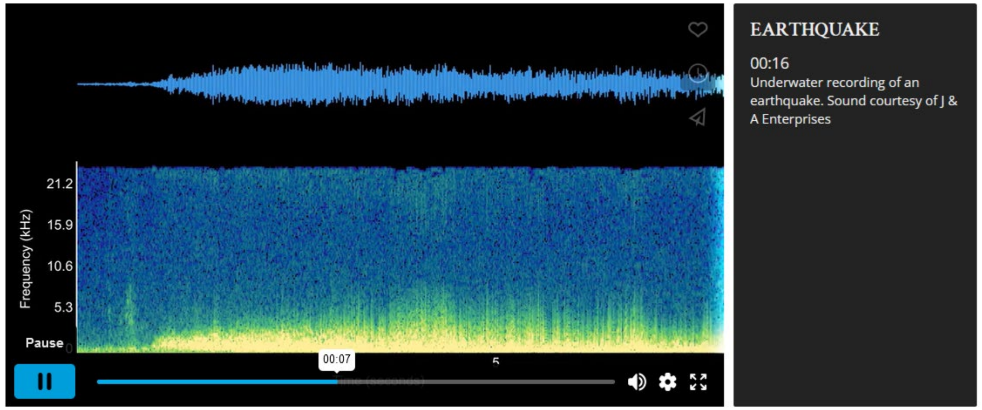
Diagram showing the creation of T-waves from seismic waves and detection by a hydrophone. Image credit URI

https://dosits.org/people-and-sound/examine-the-earth/earthquakes/

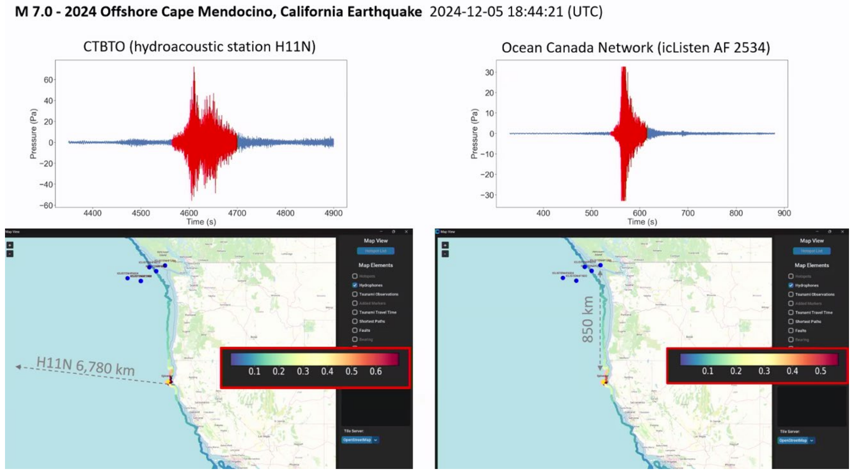


Example of how a hydrophone deployed in the ocean sound channel

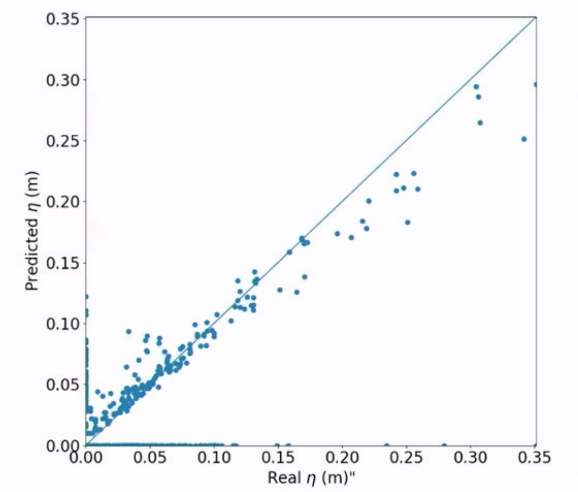
Listening an Earthquake

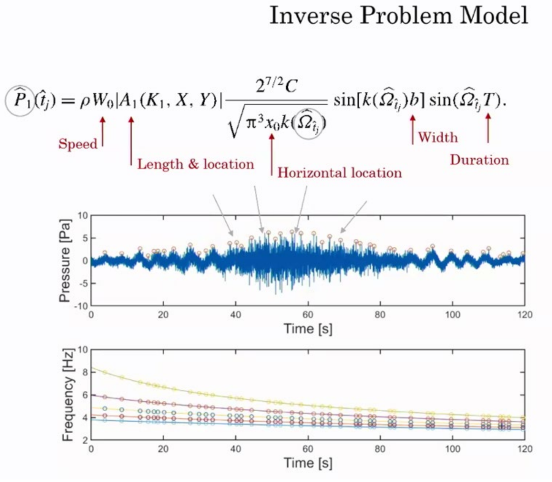


In the Pacific Ocean, sounds from a volcanic eruption have been heard thousands of miles away. Hydrophones located around the Pacific Ocean monitor the ocean for sounds of seismic events. Earthquakes produce acoustic signals known as T-waves



Reseach at Cardiff University Tsunami Center UK :





Machine Learning Model Predict Surface Elevation of Tsunami from Earthquake Acoustic signal

Inverse Problem Model

Numerical Models

Negara / Institusi	Model Numerik	Keterangan Utama
Global (NOAA, UNESCO)	COMCOT, MOST, Tsunami-HySEA	Model propagasi dan genangan berbasis NSWE.
AS (NOAA)	MOST, SIFT	Forecast real-time dan asimilasi buoy.
Jepang (JMA, NIED)	JAGURS, TUNAMI-N2	Model resolusi tinggi untuk prediksi lokal.
Indonesia (BMKG, BRIN)	COMCOT, TUNAMI-N2, HySEA	Simulasi propagasi dan genangan dengan validasi buoy.
Australia (Geoscience)	ANUGA	Open-source, 2D finite-volume.
India (INCOIS)	TUNAMI-N2	Custom model berbasis TUNAMI.
Eropa (JRC, INGV)	Tsunami-HySEA, SELFE, TeLEMAC	GPU-based, semi-implicit models.
Peru (IGP)	COMCOT, NAMI-DANCE	Prediksi tsunami Pasifik Selatan.
Thailand	COMCOT, MIKE21, TUNAMI-N2	Pasca tsunami 2004.
Karibia (CTIC)	Tsunami-HySEA	Simulasi pelatihan dan skenario.

Closing (& Questions)

- ❑ InaCBT is still in the research / experimental stage
- ❑ How to distinguish EQ source: seismic vs non seismic Tsunami ?
- ❑ How to distinguish Primary, Secondary, Surface and other waves ?
- ❑ Any other emerging/new technologies to be considered ?
- ❑ Consider:
  - ➢ Each type of wave can be classified by range of frequency, period and duration of the wave generation
  - ➢ Input/feeding for the numerical model
  - ➢ Requires high sampling rates sea level monitoring

THANK YOU

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Related Publications

Privadi, A., Damara, D. R., Widati, P. L. & Triputra, F. R. 2021. Indonesia's Cable Based Tsunameter (CBT) System as an Earthquake Disaster Mitigation System in East Nusa Tenggara. Proceeding - 2021 IEEE Ocean Engineering Technology and Innovation Conference: Ocean Observation, Technology and Innovation in Support of Ocean Decade of Science, OETIC 2021 (pp. 63-67), Jakarta. DOI: https://doi.org/10.1109/OETIC53770.2021.9733734

Purwoadi, M. A., Anantasena, Y., Pandoe, W. W., Widodo, J. & Sakya, A. E. 2023. Introduction to Indonesian Cable-based Subsea Tsunameter. 2023 IEEE International Symposium on Underwater Technology, UT 2023, March (pp. 1-6), Tokyo. DOI: https://doi.org/10.1109/UT49729.2023.10103368

Shinohara, M., Yamada, T., Sakai, S., Shiobara, H. & Kanazawa, T. 2015. New ocean bottom cabled seismic and tsunami observation system enhanced by ICT. 2014 Oceans - St. John's, OCEANS 2014, St. John's. DOI: https://doi.org/10.1109/OCEANS.2014.7003045

Wahyu W. Pandoe, Michael A. Purwoadi, Zulfa Qonita, Alfi Rusdiansyah, Aris Suwarjono. 2024. Indonesia Cable-Based Tsunameter (InaCBT): Tsunami Detection and Identification on Other Seismic Wave Signals. Ocean and Coastal Research, *accepted*.