



# Introduction & Use Cases of Fibre Sensing

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Fibre Sensing Incubator lead

GÉANT Infoshare: NREN Fibre Infrastructure for Sensing

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Public (PU)

**Welcome!**

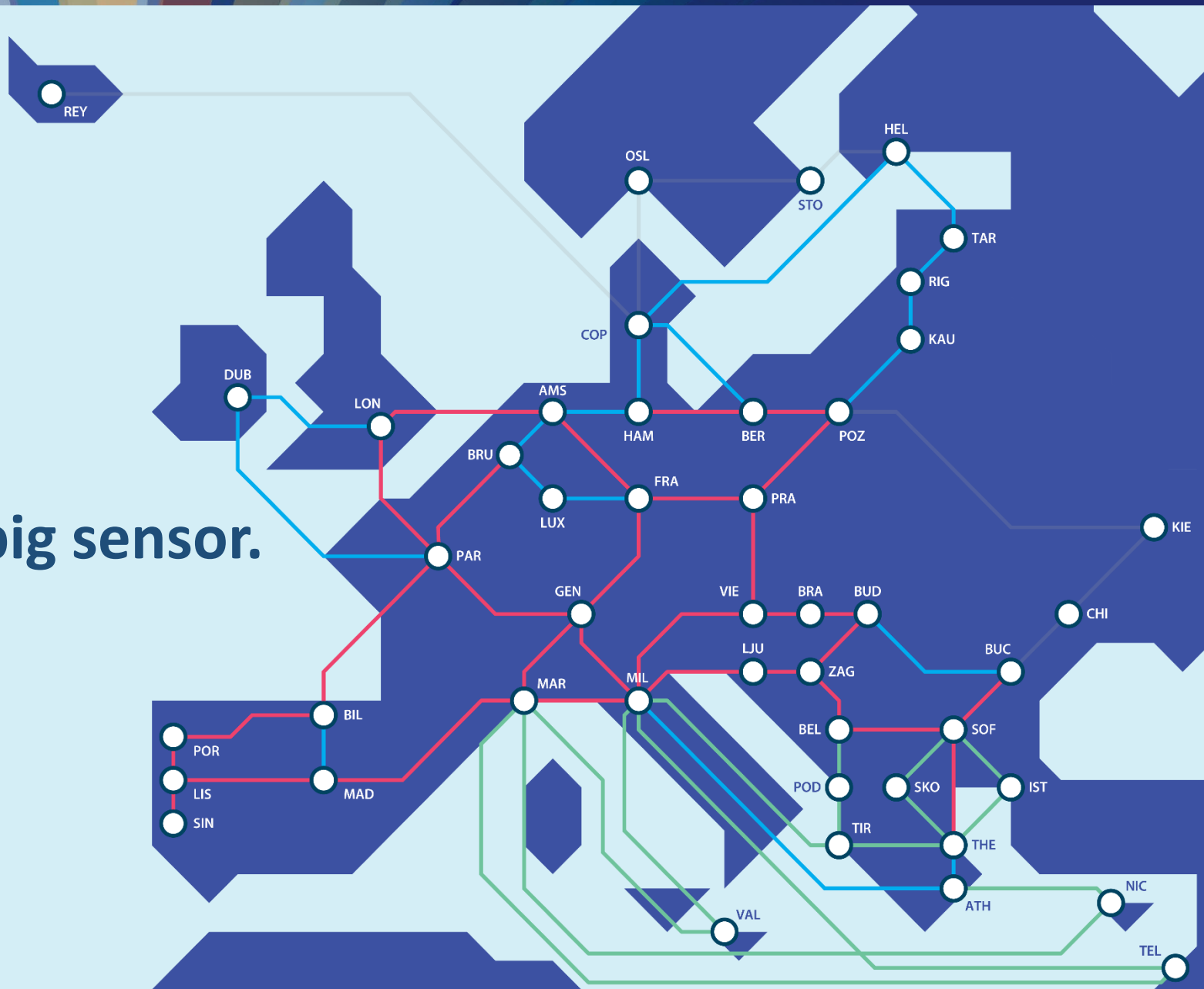
## Info share Agenda

- Use Cases of fibre sensing – Chris Atherton (GÉANT)
- Fibre Sensing technologies – Jan Radil (CESNET)
- Data Acquisition – Hannah Mihai (DeiC)
- Q&A

# Use cases of fibre Sensing

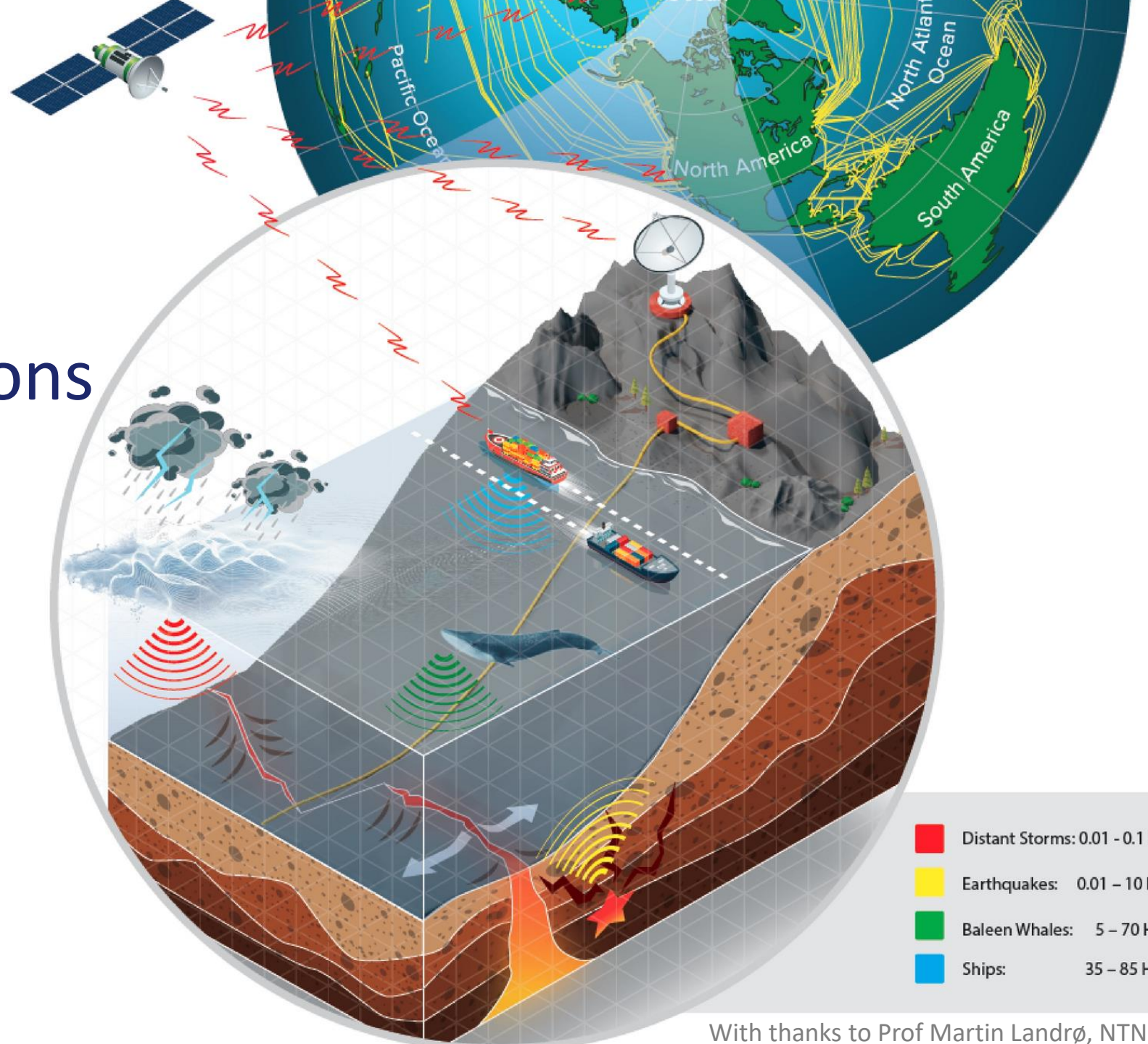
- The vision
- The three user areas
- Some examples

**Our Vision:**  
**Our networks as one big sensor.**



# 3 types of users

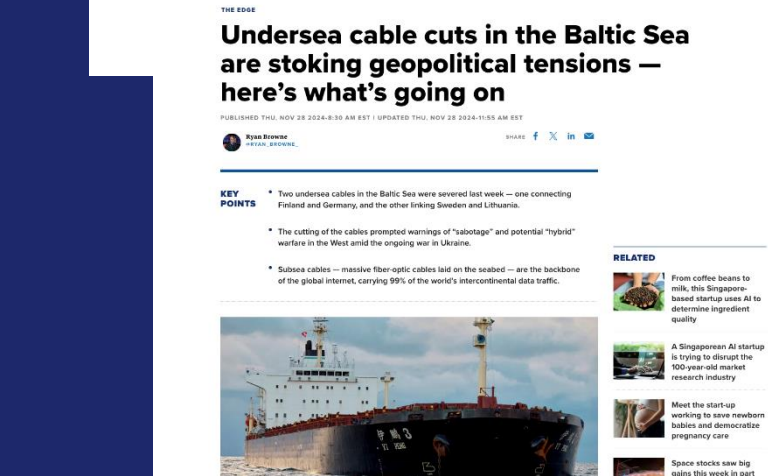
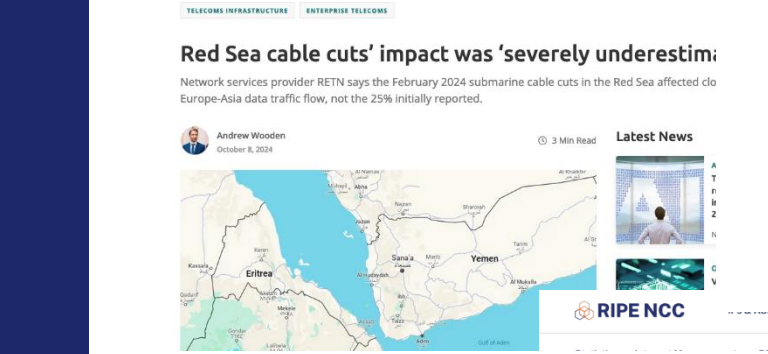
- Security & operations
- Civil protection
- Scientific Research



With thanks to Prof Martin Landrø, NTNU

# Security & Operations – Cable cuts

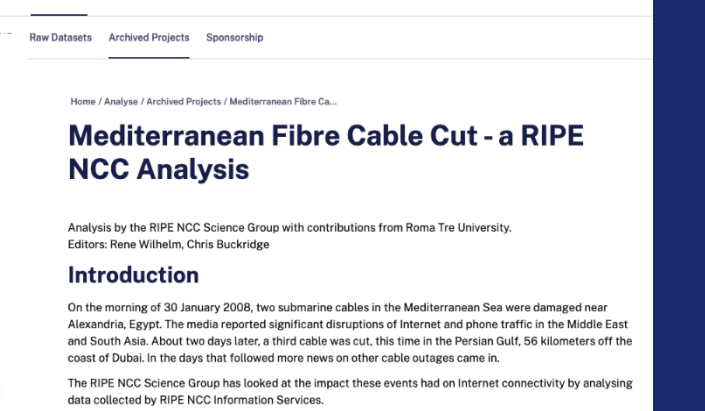
- On average 150-200 submarine cable cuts per year. Terrestrially it's assumed more, but there's no real public data source for this.
- Most caused by human interaction (fishing is main issue in submarine cables), 10% by natural forces, abrasion is also a cause in small number of cases.
- Key issues:
  - Disruption
  - Traffic impacts on network from rerouting
  - Delays to other planned work to respond to emergencies
- Protecting the key infrastructure of submarine or terrestrial fibres is in our collective interest.
- Knowing what caused an issue and where can help with decreasing the time to repair.
- Identifying risks and notifying cable operators can prevent cable cuts.
- Trespass - Fibre sensing can be used to detect trespass or animal movements on or near a fibre.
- Digging – noise or vibrations caused by digging (either humans or machines) can be detected allowing for monitoring and alerting of potential theft or interference.



British and French Submarine Communication Cables Cut

Since the explosion of the Nord Stream gas pipeline in September, Europe has witnessed the breaking of submarine communication cables in Norway and the deliberate cutting of railway cables in Germany. The 20 October, the UK submarine fiber optic cable linking the Shetland Islands to Scotland was damaged. At the same time, submarine cables in the south of France also failed, affecting three important lines of communication.

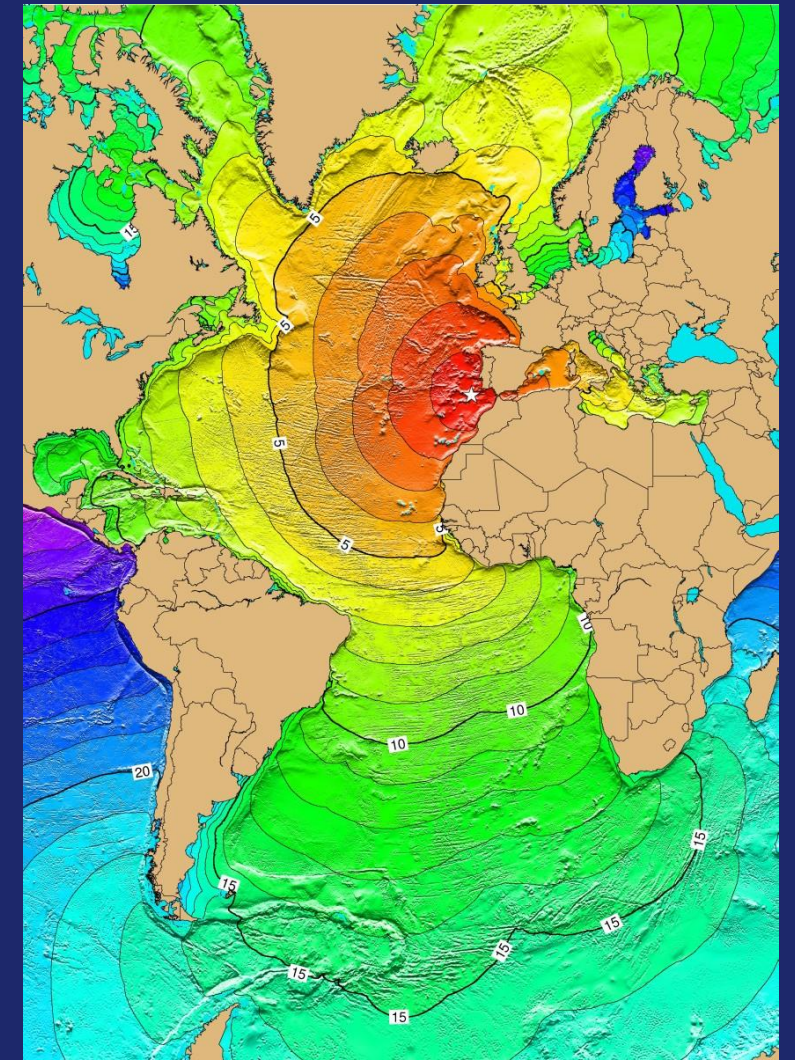
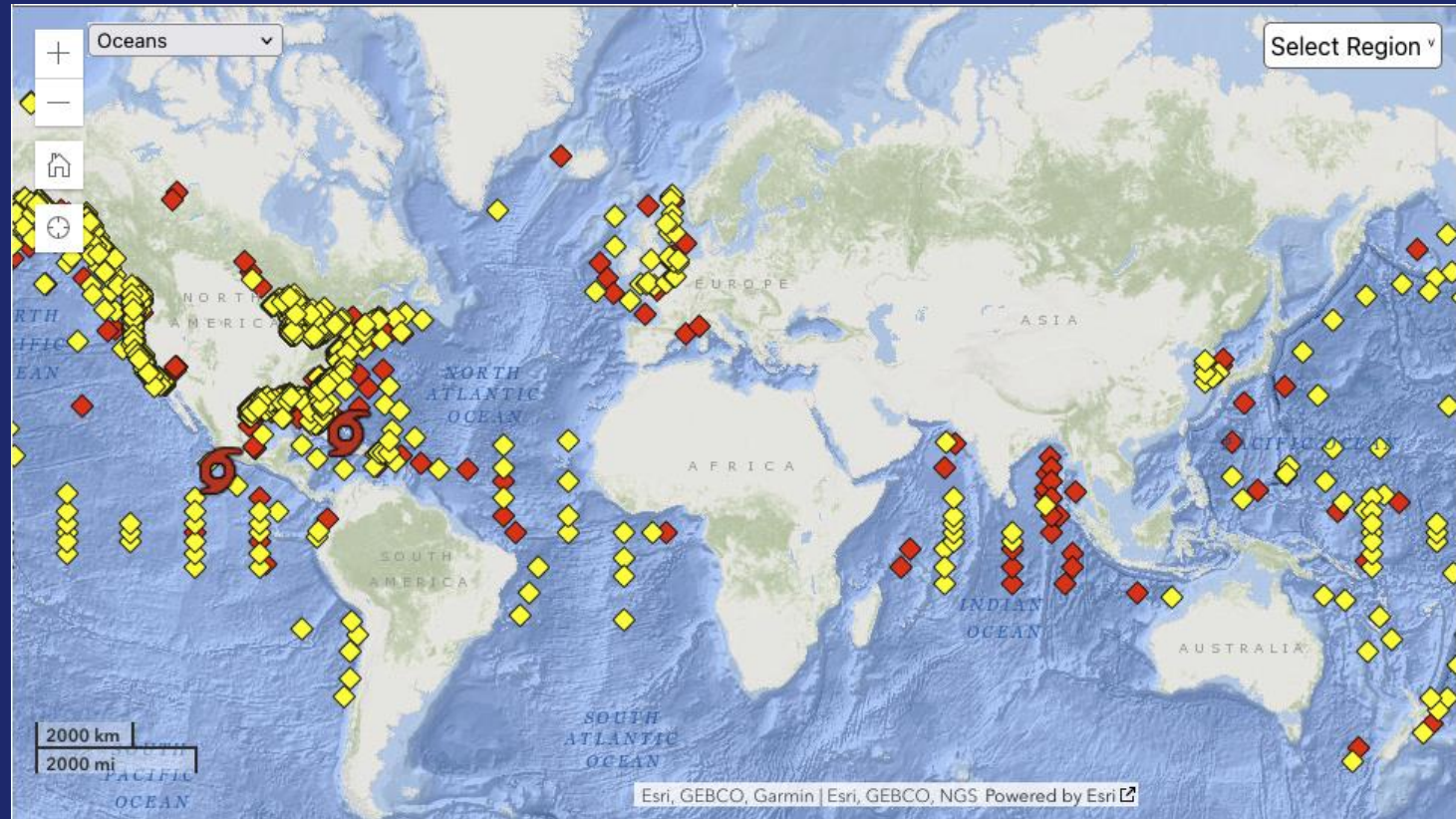
The successive interruptions of infrastructures have raised concerns about the security of communications. The vulnerability of critical energy and communications infrastructure is of great concern.





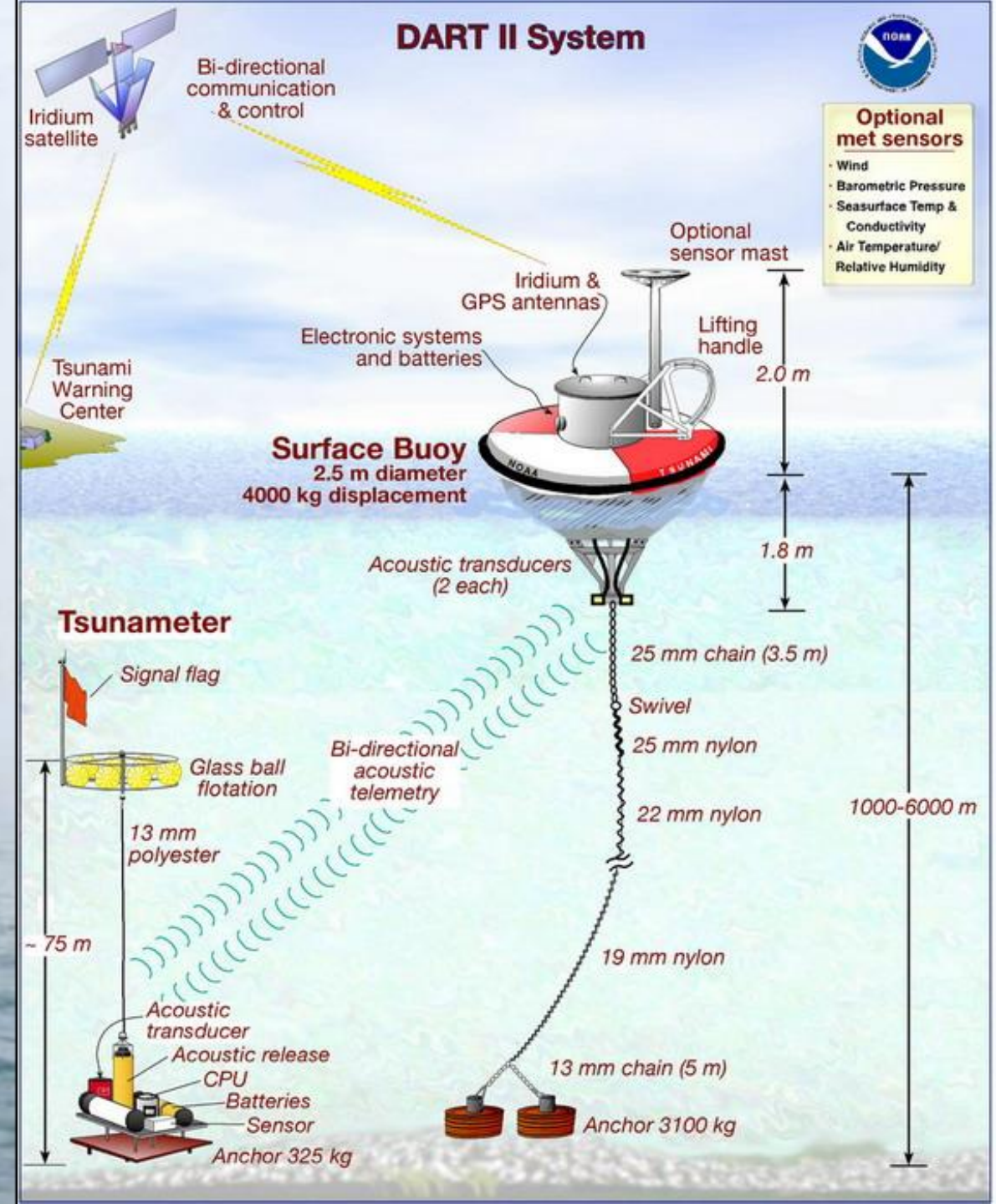


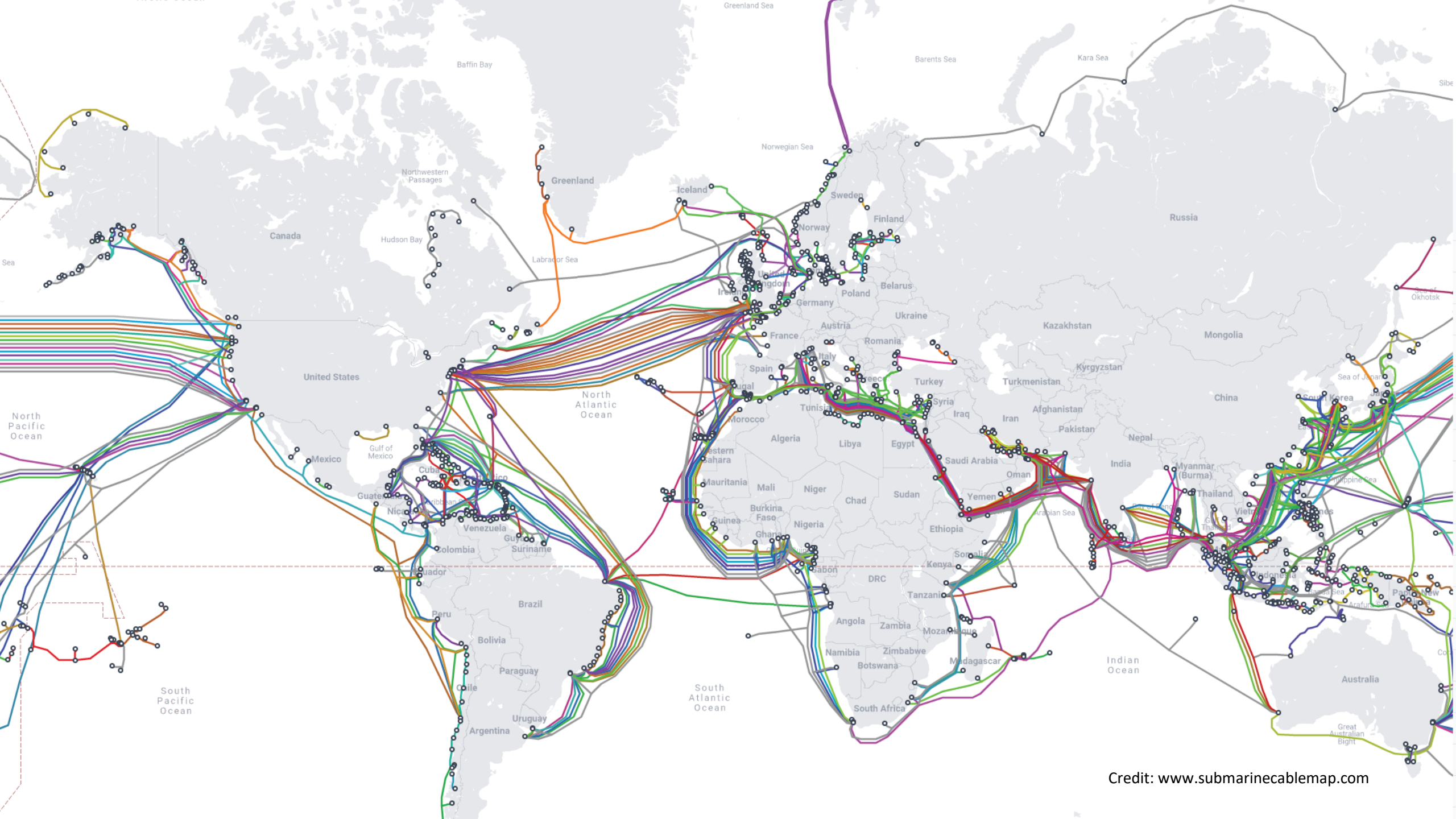
# Civil protection – Tsunami Warning



[https://www.ngdc.noaa.gov/hazard/tsu\\_travel\\_time\\_events.shtml](https://www.ngdc.noaa.gov/hazard/tsu_travel_time_events.shtml)

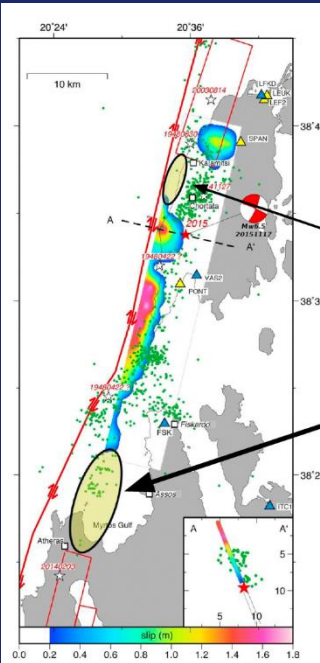
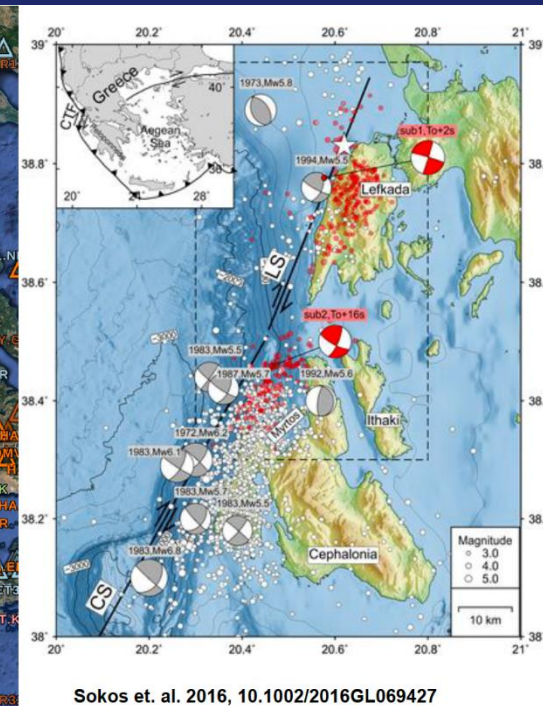
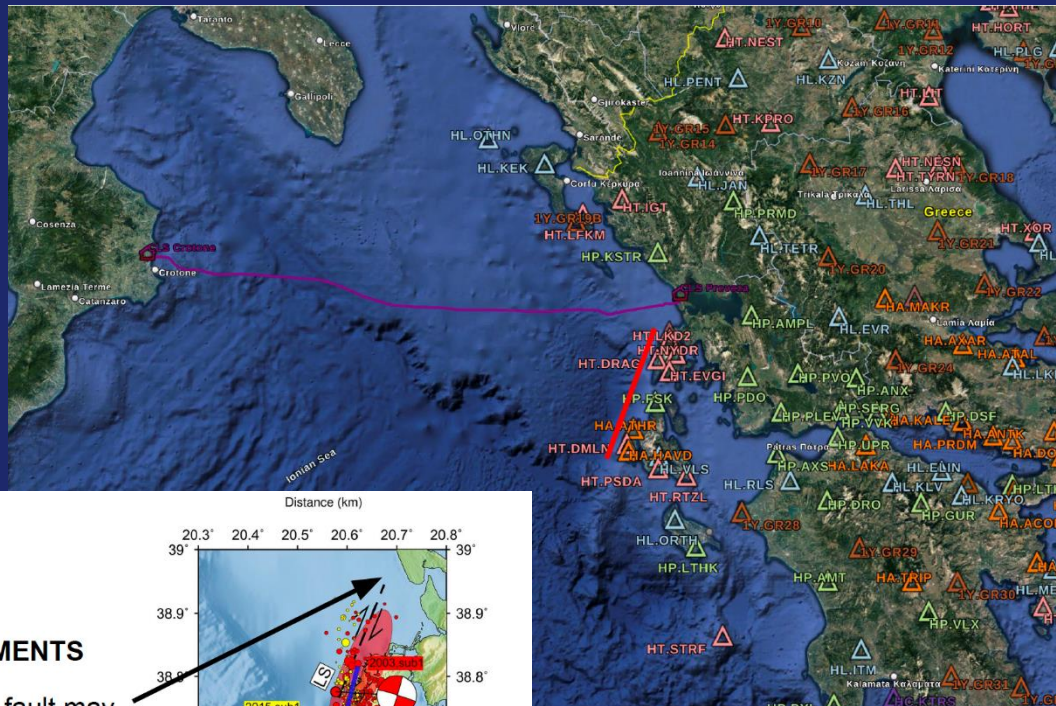
# Civil protection – Tsunami Warning





# Civil protection - Earthquake monitoring

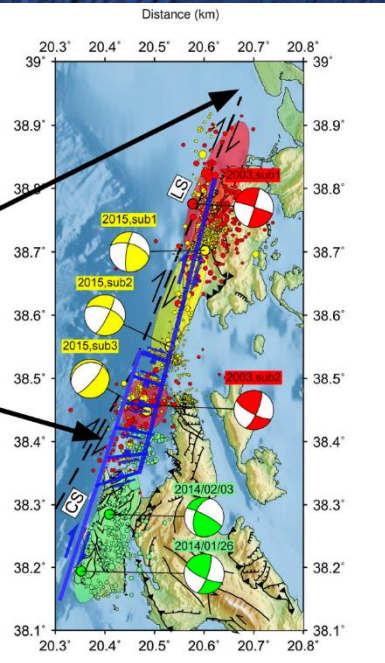
## Ionian Sea



### THREE POSSIBLE UNBROKEN SEGMENTS

- North of Lefkada towards Amvrakikos (the fault may not exist there)
- Central Lefkada
- North Cephalonia (Assos segment)

Avallone et. al, 2017 *Sci Rep* g/10.1038/s41598-017-10431-w



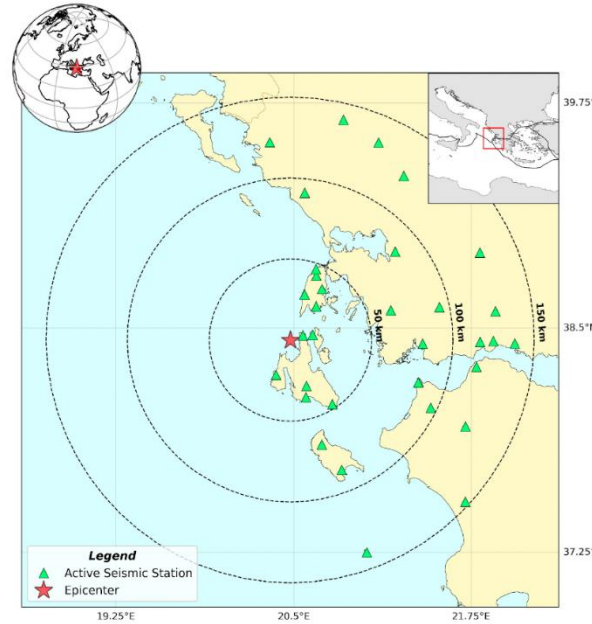
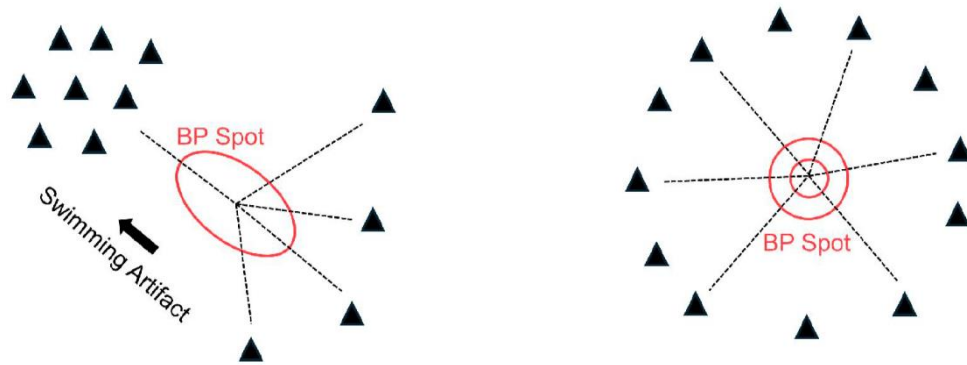
Sokos et. al. 2016, *GRL*, 10.1002/2016GL069427

*Fountoulakis and Evangelidis, 2024. Back-projection with DAS Data: Utilizing Open Data and Synthetic Testing for Future Deployments. SUBMERSE Project*

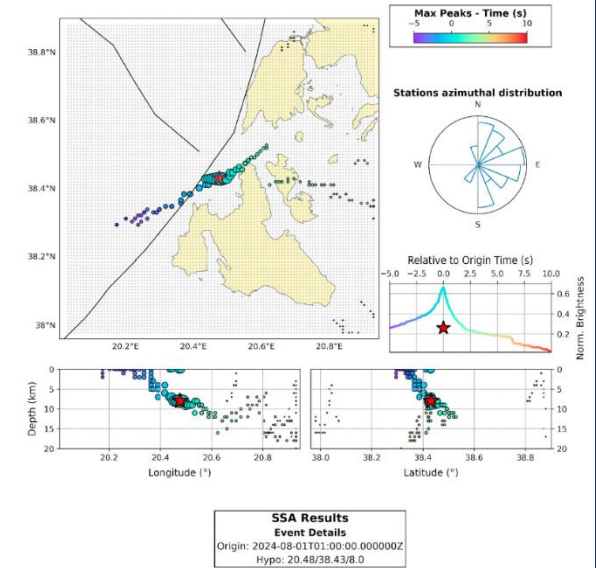
# Civil protection - Earthquake monitoring

“When BP executions have missing or insufficient data for some azimuths around the source, the resulting images typically feature poorly defined sources and significant uncertainty”

~swimming artifact~



Maximum Brightness Per Time Step



## Civil protection – Building regulations

Building codes are sets of regulations governing the design, construction, alteration and maintenance of structures. They specify the minimum requirements to adequately safeguard the health, safety and welfare of building occupants.

Some provisions within the International building code standards (from International Code Council (ICC)) are intended to ensure that structures can adequately resist seismic forces during earthquakes. These seismic provisions represent the best available guidance on how structures should be designed and constructed to limit seismic risk.

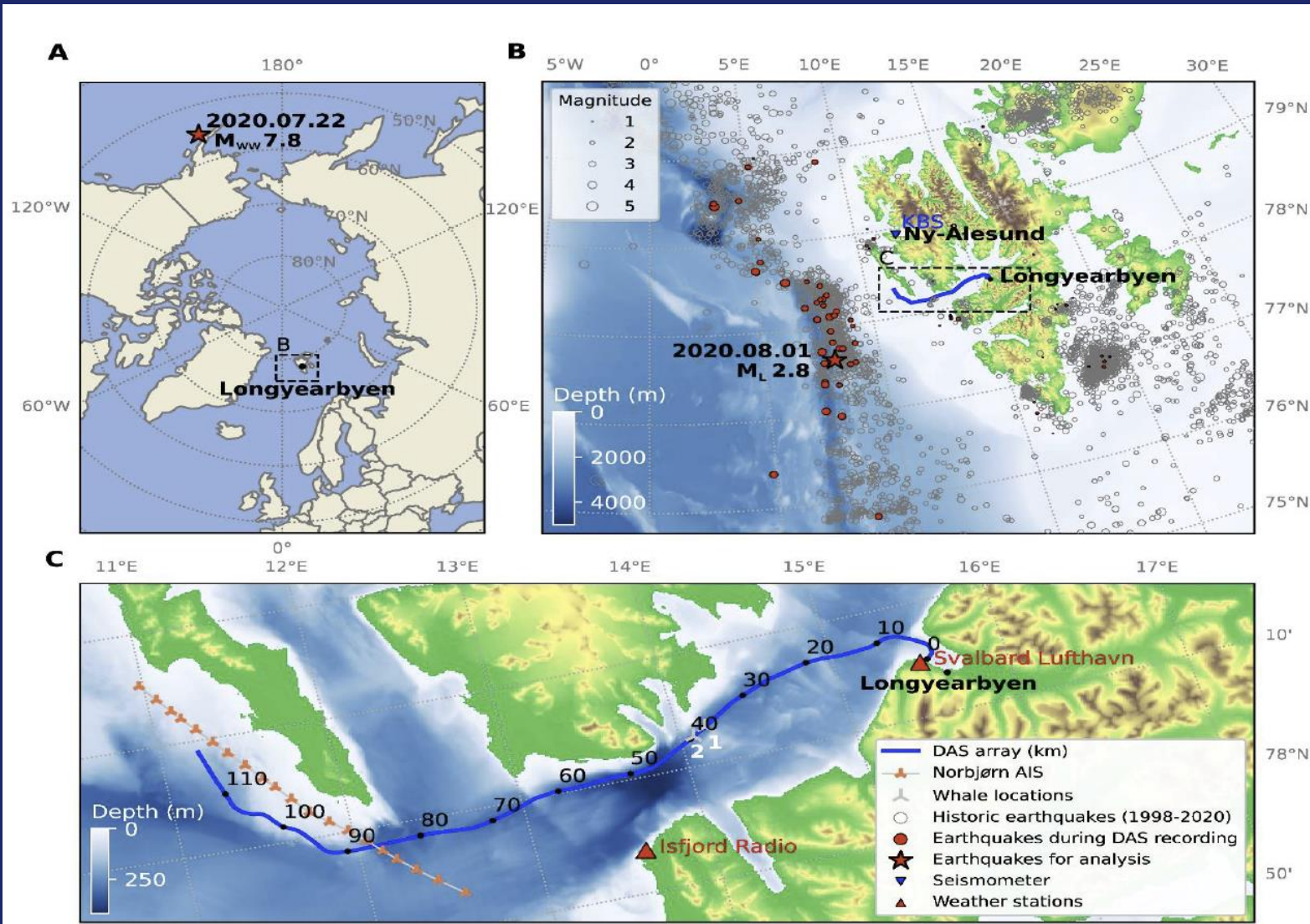
Changes or additions to the seismic provisions come from many different sources, including new research results and documentation of performance in past earthquakes.

Several seismic institutes, whom NRENs already serve with connectivity and services, define the seismic provisions in the building regulations in their respective country.



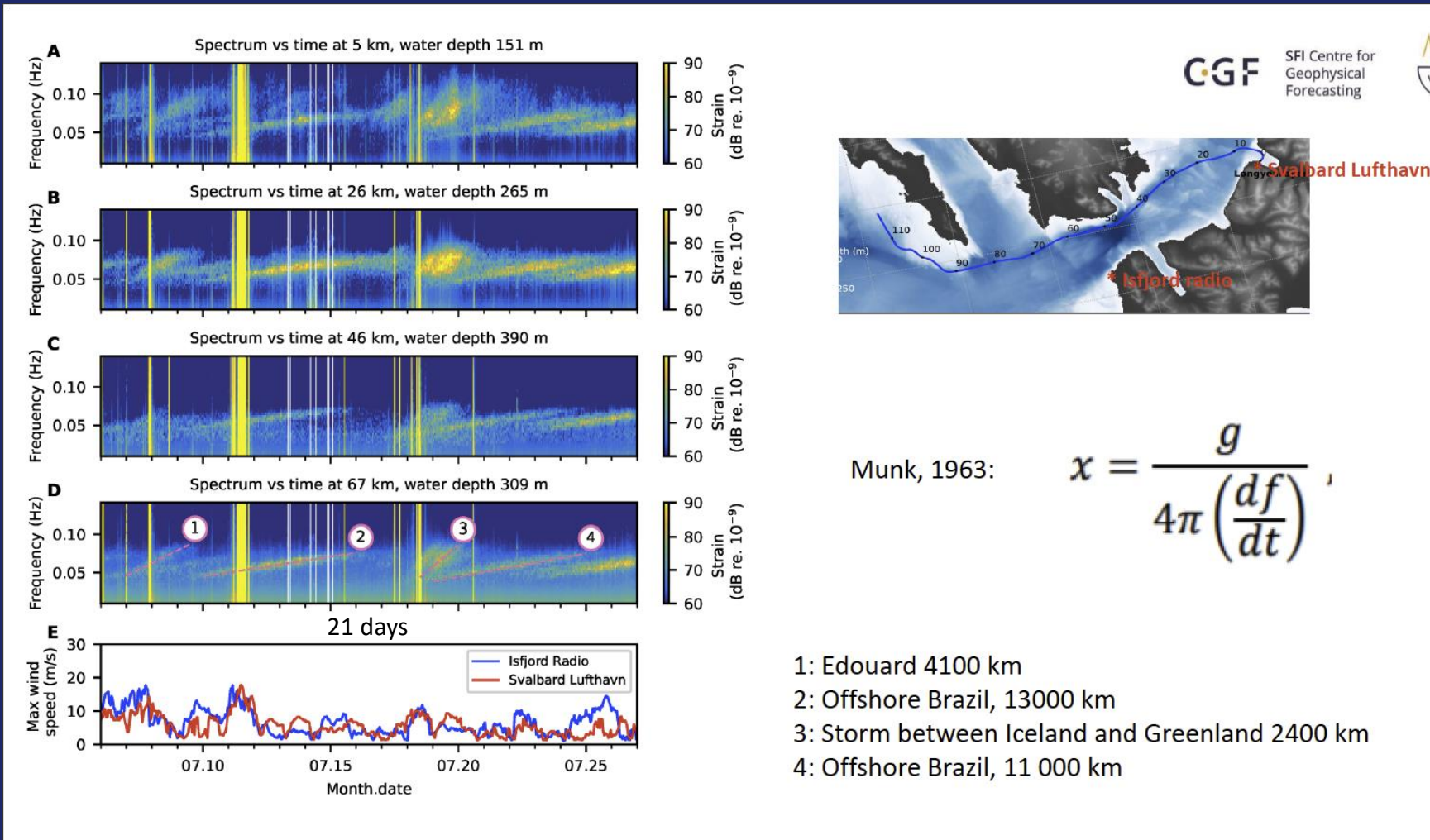
<https://www.fema.gov/emergency-managers/risk-management/earthquake/seismic-building-codes>

# Scientific Research - Seismology



Audio of an earthquake recorded from a submarine fibre using DAS

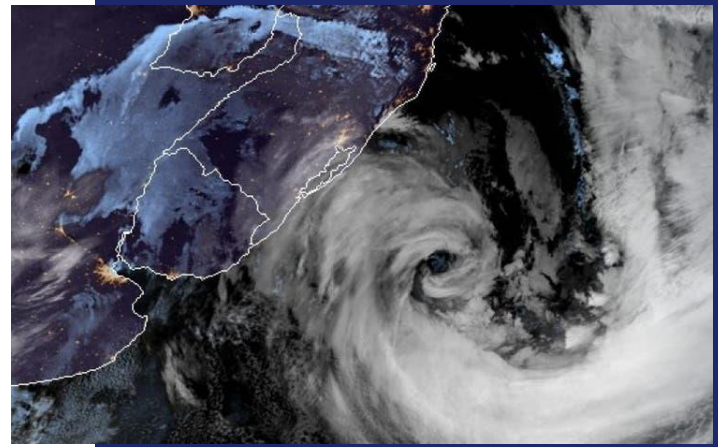
# Scientific Research - Oceanography



Munk, 1963:

$$x = \frac{g}{4\pi \left(\frac{df}{dt}\right)}$$

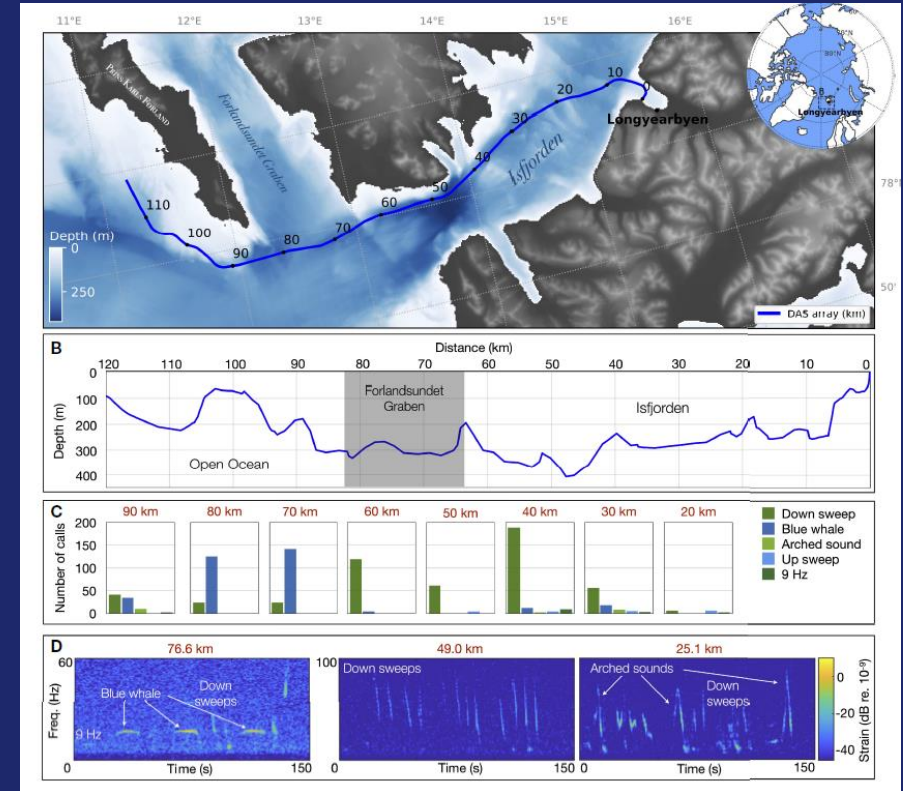
- 1: Edouard 4100 km
- 2: Offshore Brazil, 13000 km
- 3: Storm between Iceland and Greenland 2400 km
- 4: Offshore Brazil, 11 000 km



L. Farias. Extratropical cyclone will hit the west and south of Santa Catarina this Tuesday. NOTISUL, 2020



# Scientific Research – Marine biology



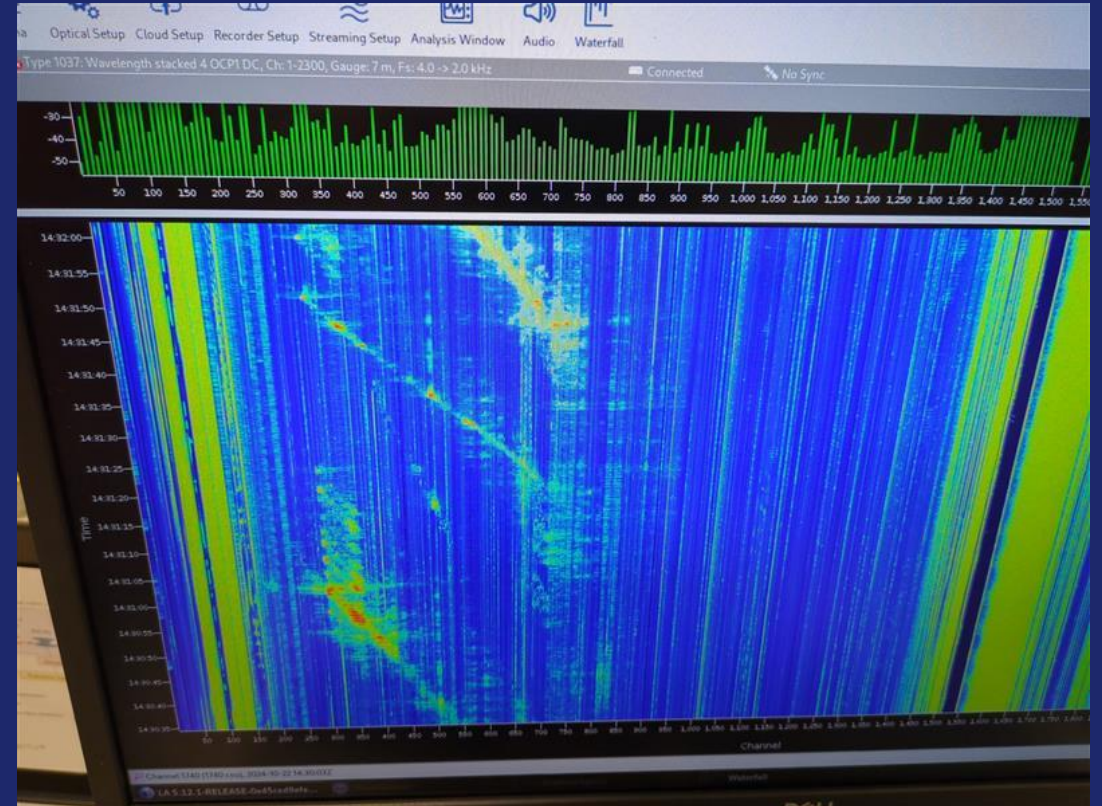
Baleen whale vocalizations detected over the 120 km of the Svalbard underwater distributed acoustic sensing (DAS) array

## Scientific Research – Sociology / Urban planning

### Traffic monitoring is possible with fibre sensing

M. van den Ende, A. Ferrari, A. Sladen and C. Richard, "Next-Generation Traffic Monitoring with Distributed Acoustic Sensing Arrays and Optimum Array Processing," 2021 55th Asilomar Conference on Signals, Systems, and Computers, Pacific Grove, CA, USA, 2021, pp. 1104-1108, doi: 10.1109/IEEECONF53345.2021.9723373.

Fontana, Marco and García-Fernández, Ángel F. and Maskell, Simon, Notch Periodogram for Multiple Vehicle Trajectory Estimation with Distributed Acoustic Sensing. Available at SSRN: <https://ssrn.com/abstract=4845199> or <http://dx.doi.org/10.2139/ssrn.4845199>



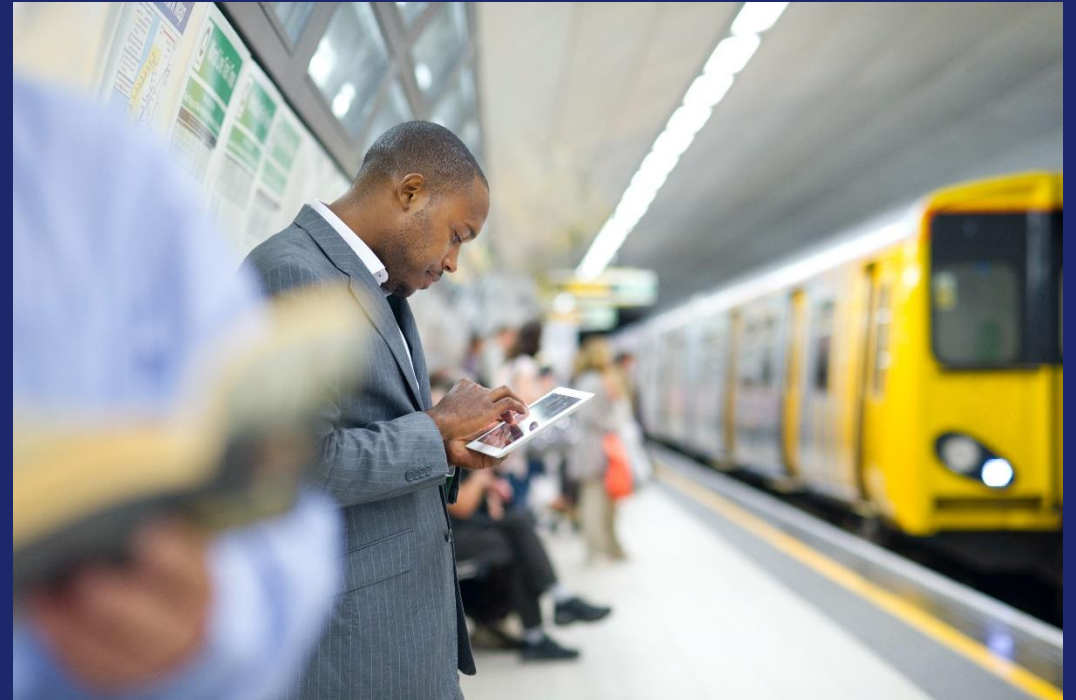
Car travelling along road outside University College Cork.

With thanks to Dónal Cunningham (HEANet) and Dr. Abhinav Gautam of the Tyndall Institute, University College Cork

## Scientific Research – Applied sciences

Fibre sensing can also be used for monitoring train or tram health

- Rockfalls –Vibrations from falling rocks on or near a fibre can detected.
- Landslides – Movement of large volumes of soil, rock, earth generate vibrations which can also be detected on or near a fibre.
- Catenary flashovers: When electrification faults cause a flashover (for example from tree branches too close to overhead power lines), it makes a brief but distinctive noise. Fibre sensing can geolocate the fault saving inspection and repair team's significant time.
- Track condition monitoring: Because fibre sensing can be used to monitor changes over time it can be used to detect performance changes in the rail infrastructure (track condition) or the trains themselves as they pass by or along the fibre.



The background is a dark blue to black gradient with a faint grid. It features numerous vertical lines of varying colors (cyan, magenta, orange) and sizes. Scattered throughout are small circles in red, white, and blue, some connected to lines. The overall effect is a sense of digital data and connectivity.

**Now over to the technologies**



# Thank You

[www.geant.org](http://www.geant.org)



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