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Using the fibre cables as sensors, detecting security threats and earthquakes

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Raising the Standard

A vibration and sensor network:

Can this be realized using fibre optical communication networks?

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Tampnet Business Areas

We deliver unparalleled connectivity for your business critical operations.

Oil & Gas

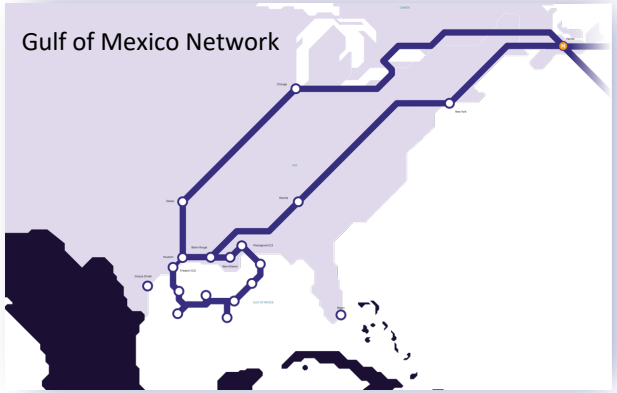
Offshore Wind

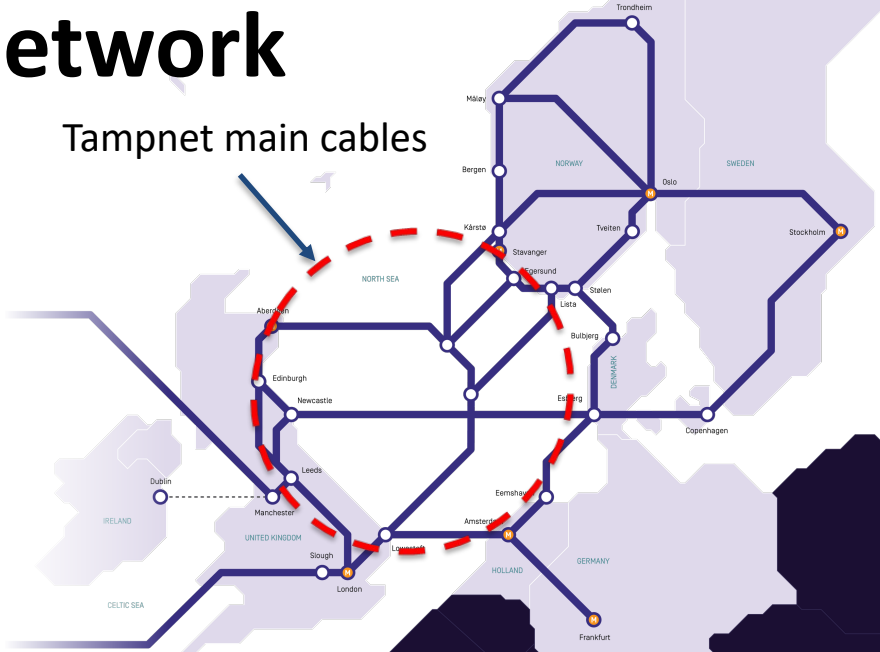
Maritime

Carrier

The North Sea Network

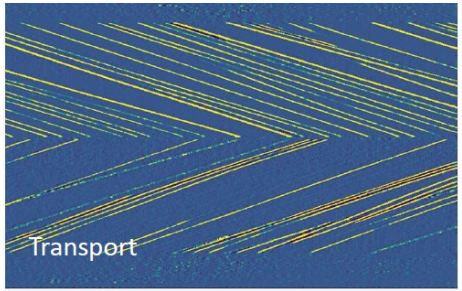
Tampnet main cables



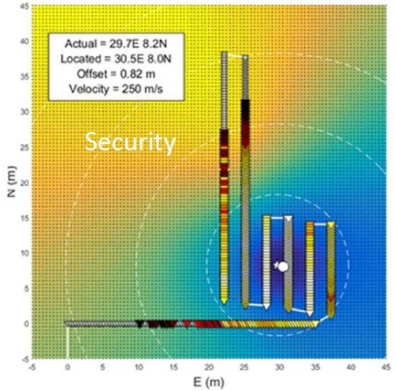


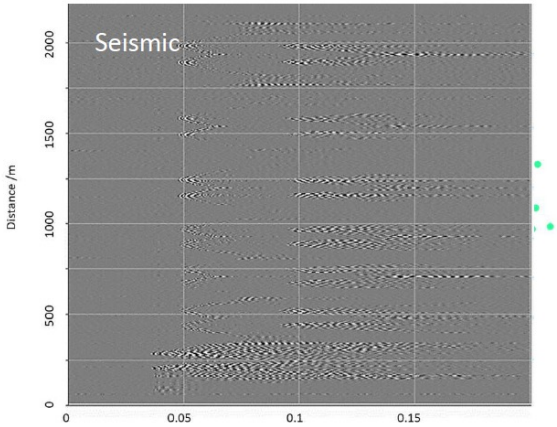
Fibre as a sensor: Application areas

Applications



NORCE





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Telecom operator fibre-cable monitoring motivation

- Protection of infrastructure
  - Detection of vulnerabilities (trawlers, potential eaves-dropping) and geophysical activity
- Enabling new business on existing fiber infrastructure
  - Monitoring geophysical activity: Earthquakes, tsunamis, Co2 storage….
  - Railway, roads.

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Two main techniques for monitoring

- Distributed Acoustic Sensing (DAS)
  - Based on detecting backscattered light (advanced OTDR)
  - Position, time and magnitude of fibrestrain
- State of Polarisation (SoP) sensing
  - Detecting changes in the lights state of polarization at receiver end
  - Time and magnitude of e.g. twisting or pressure on fiber.
    - Position localization challenging.

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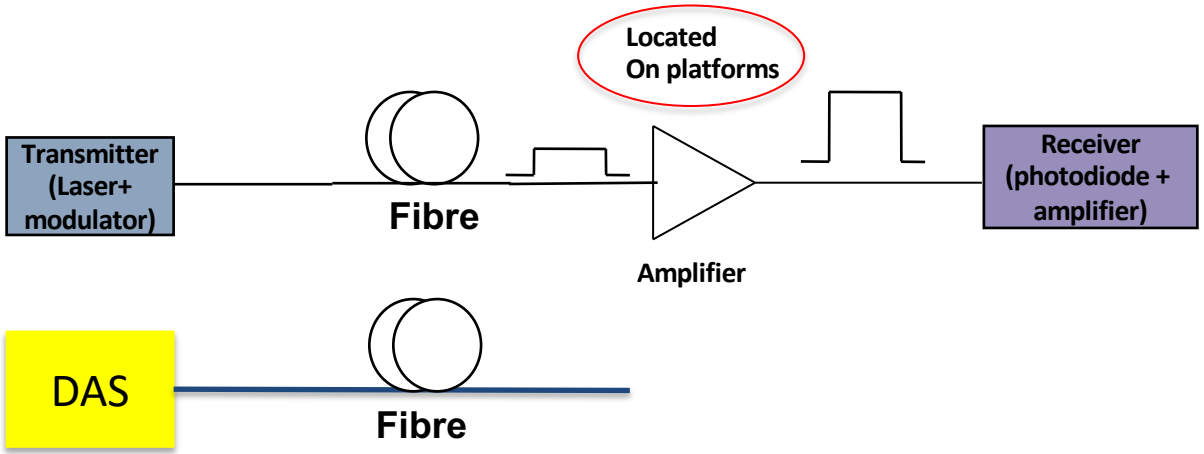
Distributed Acoustic Sensing (DAS) currently typically use a separate fibre in the cable



Up to approx. 200 km

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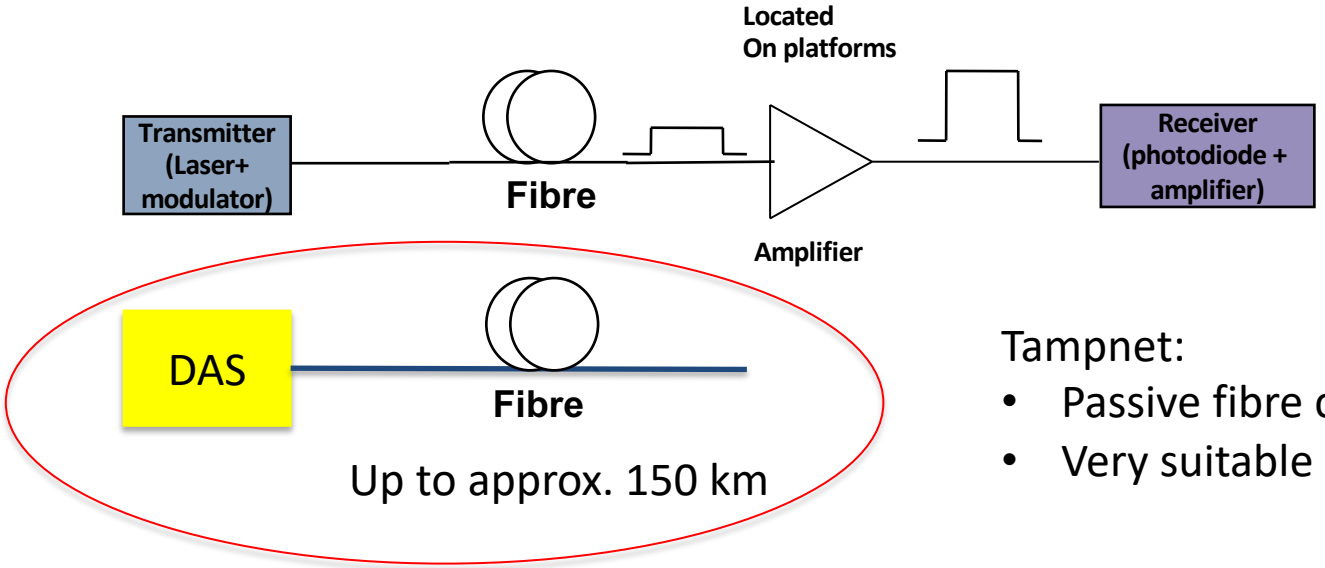
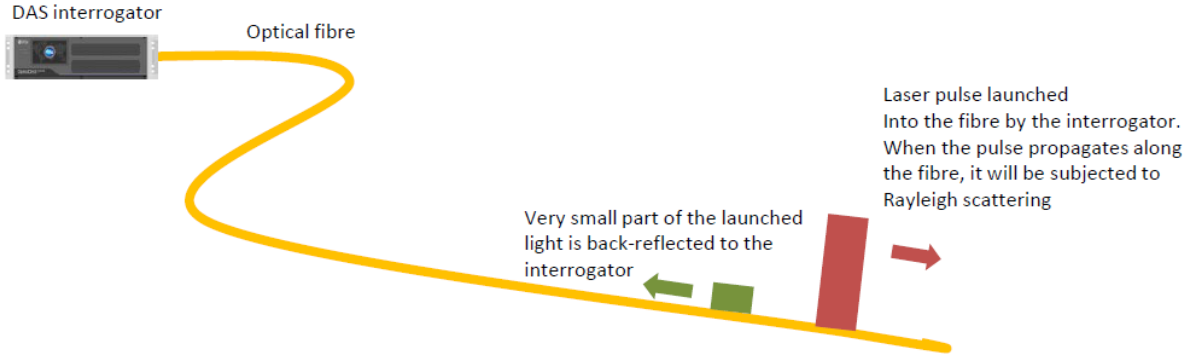
Distributed Acoustic Sensing (DAS) currently typically use a separate fibre in the cable



Tampnet:

- Passive fibre cable infrastructure
- Very suitable for DAS

DAS Technology - Dynamic Monitoring of Strain Distribution along an Optica Fibre



- If a section of the optical fibre is subjected to strain, the propagating light will experience an optical phase delay.
- By analyzing the back-reflected signal one can extract the optical phase modulations induced along the optical fibre. This is done with a coherent OTDR technique where the phase between two adjacent scattering regions is taken to be proportional to strain. The distance between the centers of the two scattering regions is known as the gauge length.
- Any measurand impacting the cable strain condition can, in principle, be recorded.

ASN Targeted DAS Applications

DAS has many application areas (terrestrial and subsea).

ASN is targeting applications within the offshore oil and gas industry and the subsea telecom and power cable industry.

Any optical cable on the seabed can be used as a distributed sensor.

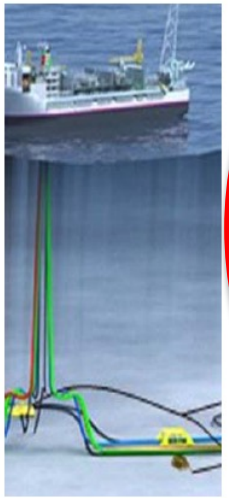
Offshore Oil and Gas Applications

In-well monitoring

- ❑ ***Monitor platform and subsea wells***
  - VSP, flow, sand, valves, integrity, micro-seismic

Seabed monitoring

- ❑ ***Pipeline leak detection***
  - Flexible pipes used in subsea fields
- ❑ ***Overburden monitoring***
  - low-frequency seabed surface waves (Scholte)
- ❑ ***Reservoir monitoring***
  - PP imaging for 4D seismic
- ❑ ***Subsea infrastructure monitoring***
  - Health monitoring
  - Electrical fault monitoring (HV power cables)



Subsea Cable Applications

- ❑ ***Monitor integrity threats to subsea cables and associated infrastructure***
  - Trawl activities
  - Anchor drops
  - Dredging activities
  - Vortex induced vibration
- ❑ ***Detect earthquakes***
- ❑ ***Measure oceanographic conditions***
  - Ocean currents
  - Seabed rock-slides etc
- ❑ ***Monitor mammal activities***
- ❑ ***Localize electrical failures (HVDC cables)***

DAS system installed for trial on Tampnet cable from Lowestoft: Detecting trawlers and ships

Measuring along approx. 100 km of the cable

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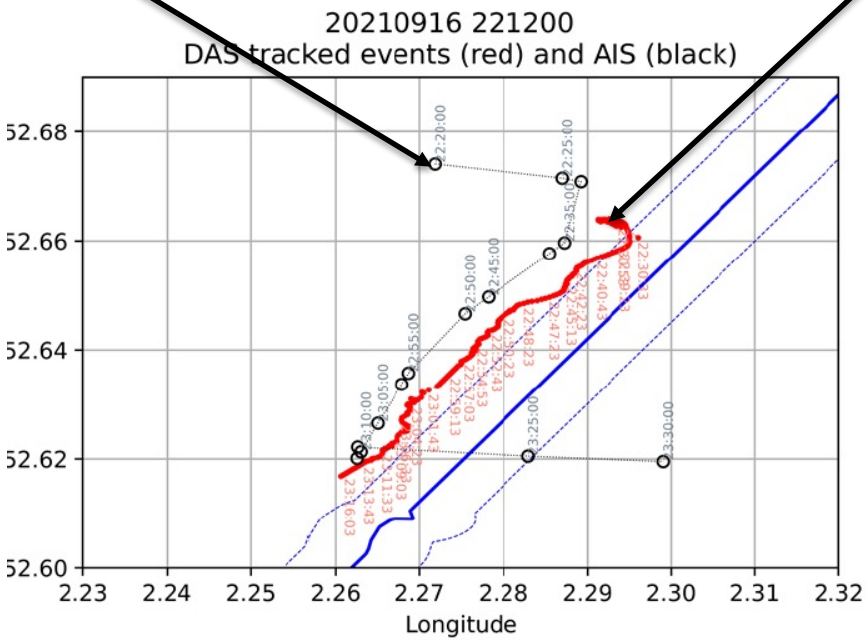
DAS trawler tracking

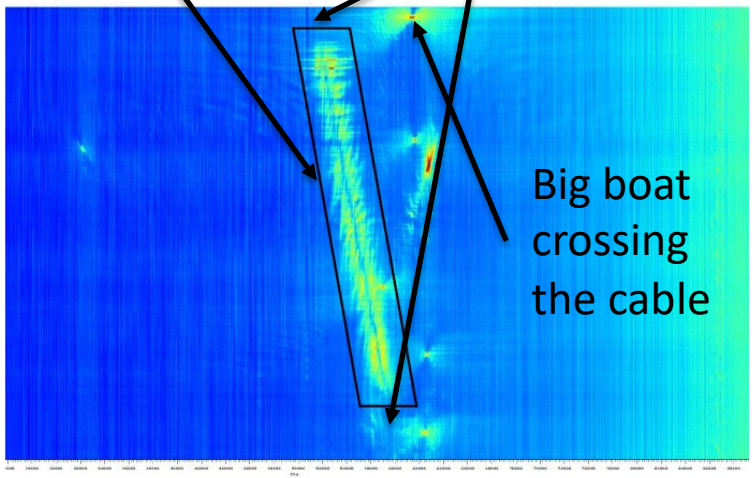
AIS shows vessel in motion
(Also after trawl lifted)

Trawl on seafloor



Time

Trawl lifted, no signal

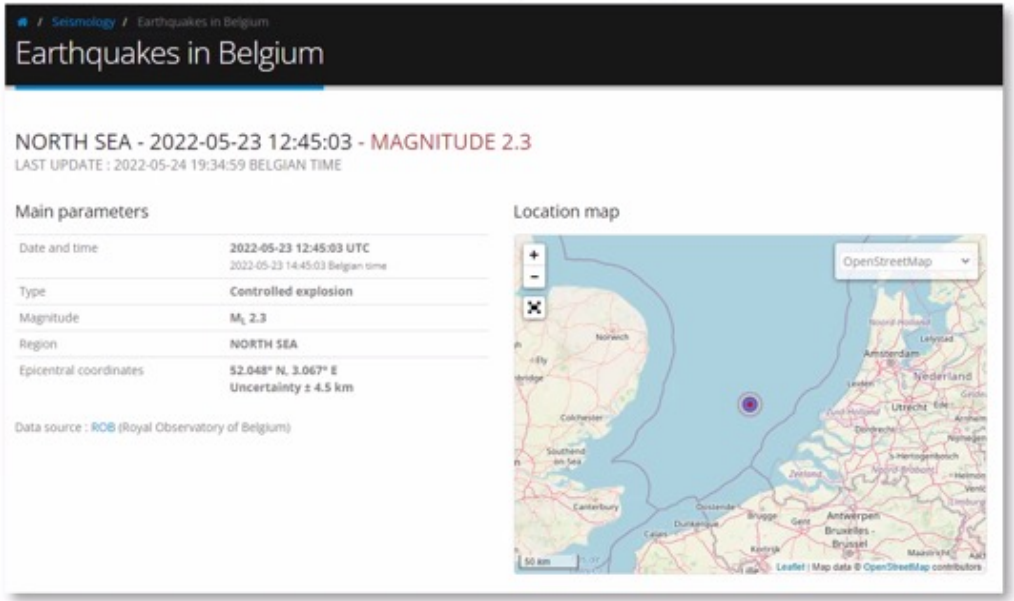


Big boat crossing the cable

Position along cable

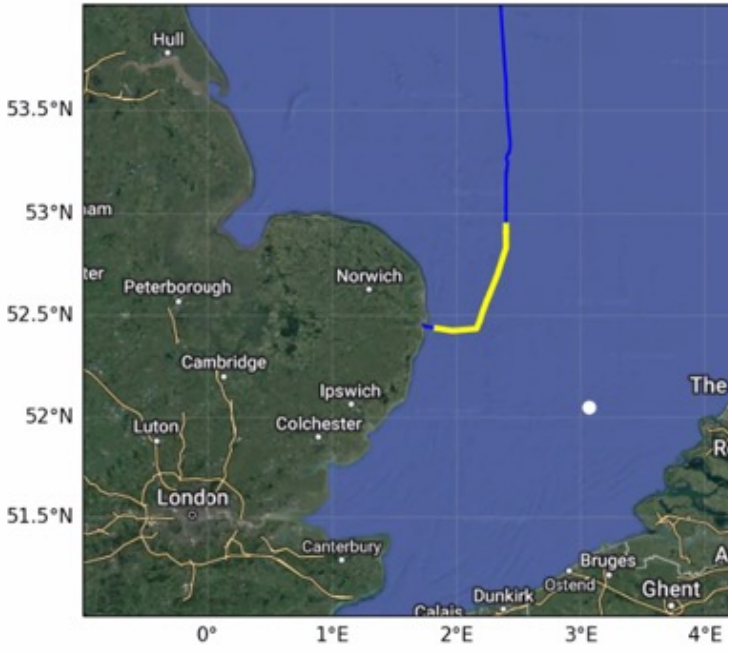
Underwater explosion located

Event location and magnitude estimates from The Royal Observatory of Belgium



https://seismologie.be/en/seismology/earthquakes-in-belgium/k1xxj0l16

Location relative to TAMPNET cable



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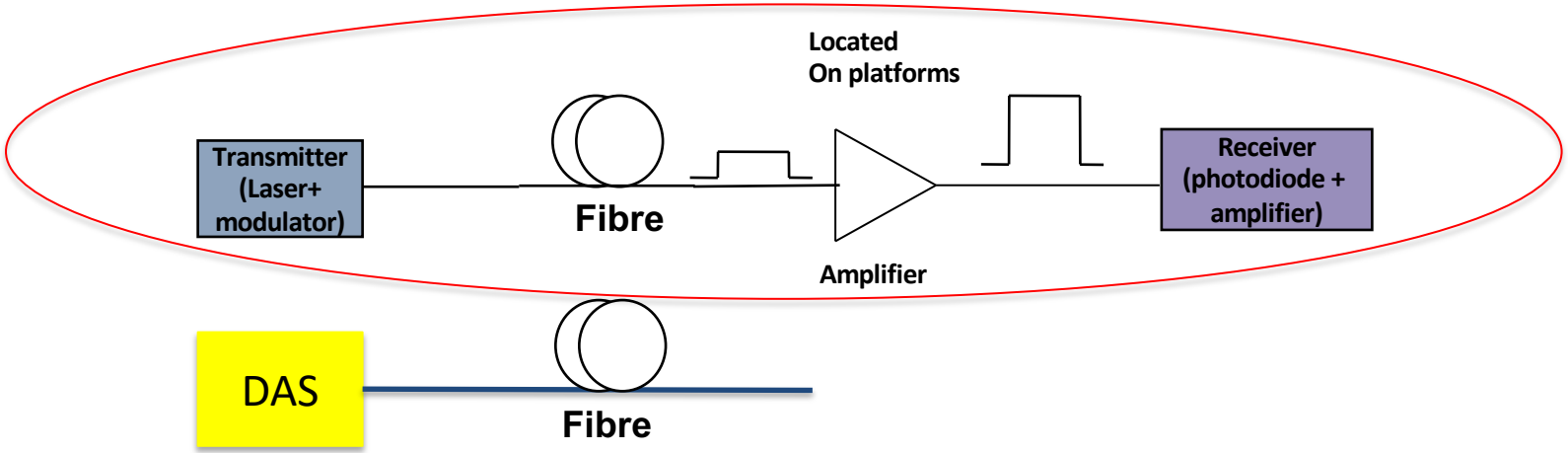
State of Polarisation sensing can be integrated with the telecom transmission system



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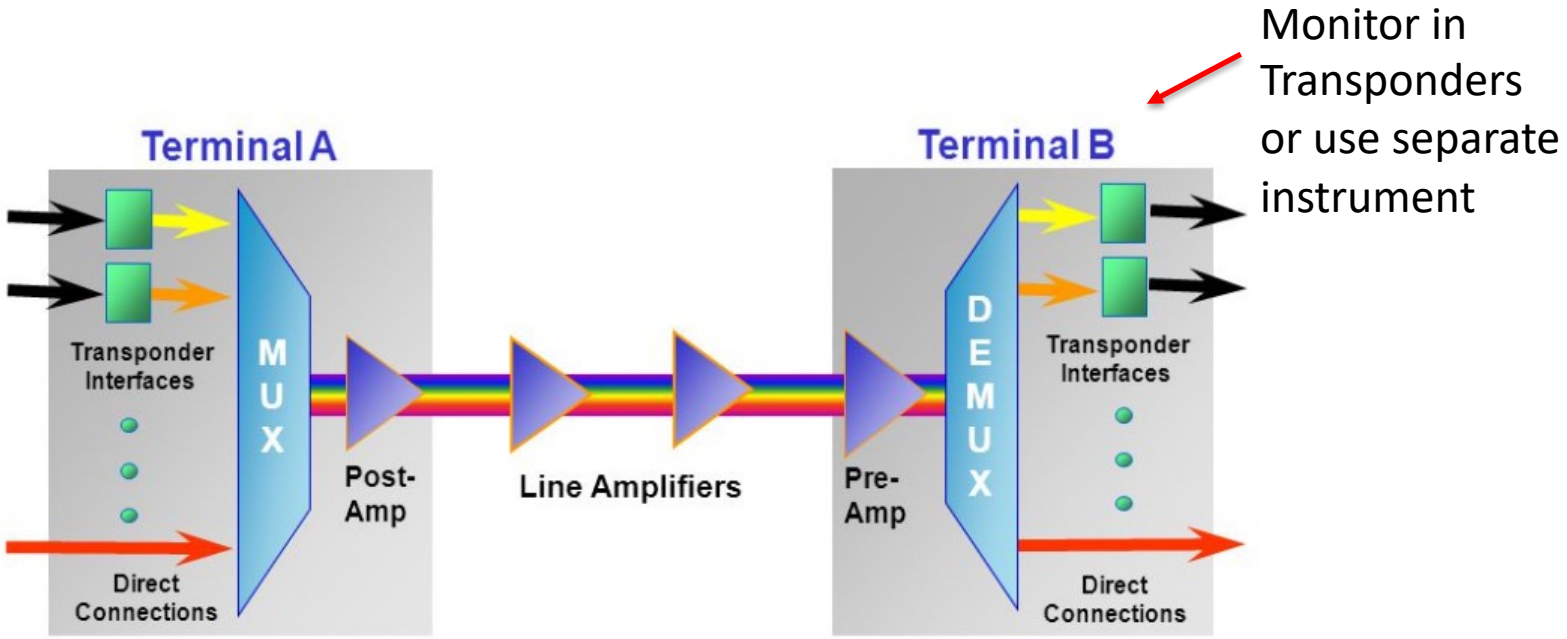
Monitoring polarisation in WDM system



Monitor in Transponders or use separate instrument

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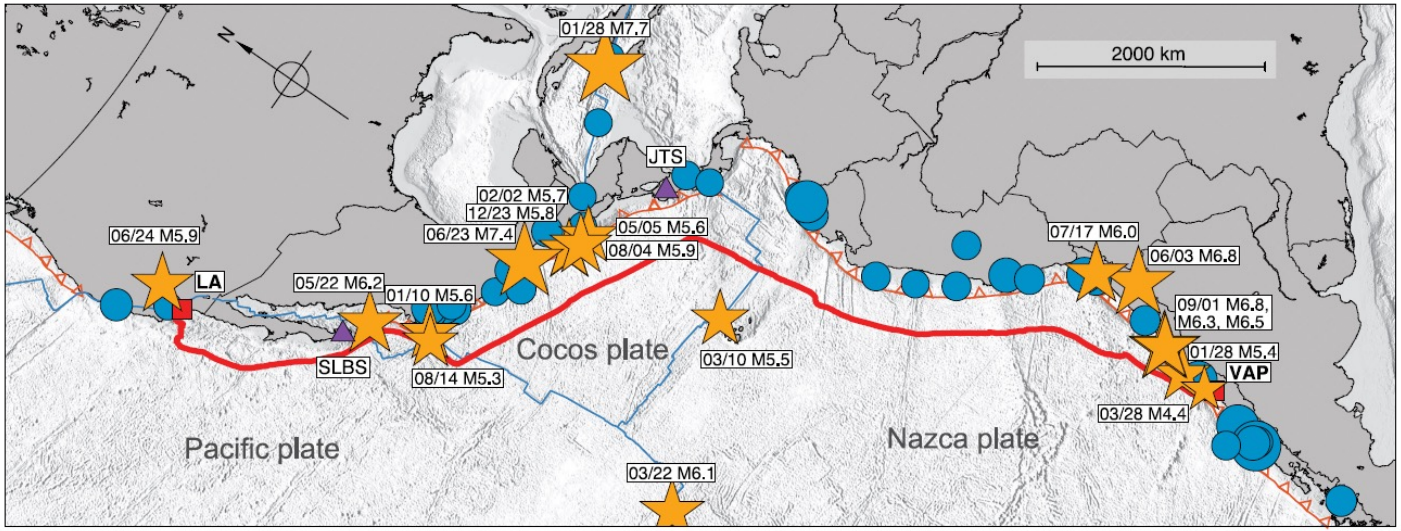
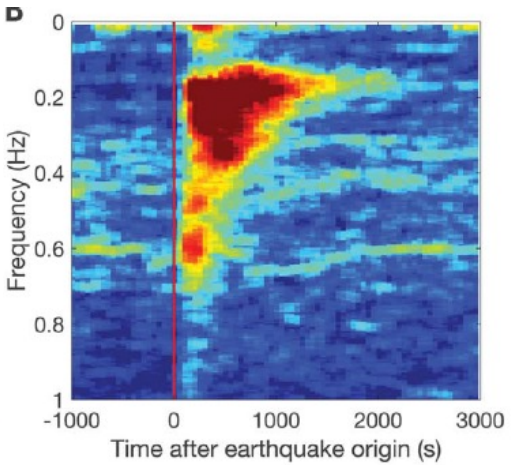
Google: Sensing earthquakes using polarisation sensing on Curie sub-sea cable (thousands of km)





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Polarisation sensing: Developed instrument for cloud storage

- Polarisation data from transponders not easily available and may be difficult because of security concerns.
- 1 U rack-mount dedicated instrument
- Easy install, low-cost components < 15 KNOK
- Local storage, compression + collecting data to central cloud server

Detect: Trawlers, work in node rooms, earthquakes

No accurate position information

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SoP recorder instrument

HDMI

Ethernet
Keyboard/mouse

Fiber input

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Lab-experiments examples

- Local perturbation caused by cat touching the fibre
  - Cat strikes the fibre on the largest pulse
- Demonstrates ability to detect small local movements of the fibre

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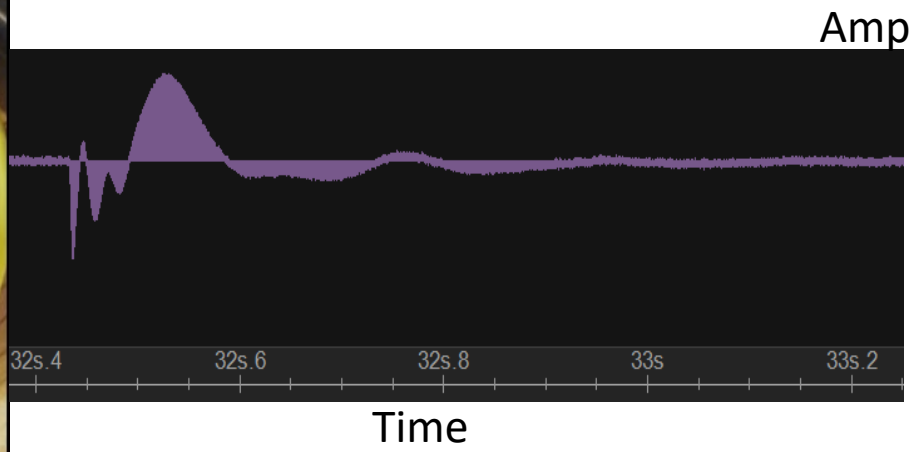
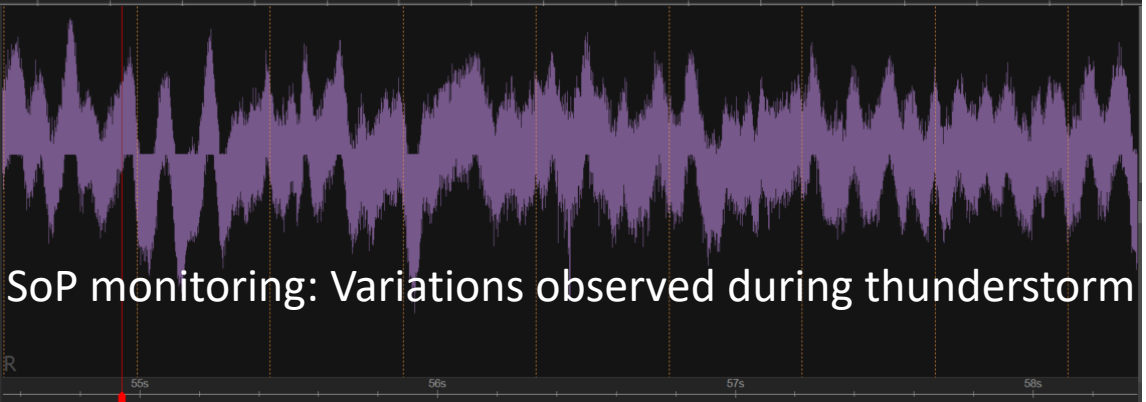
Lab-experiments examples

- Airgun shot triggering fast polarization variations



Field-experiment Fiber to the home

- Split incoming optical signal: 50% to network communication, 50 % to polarization recorder instrument
- Thunderstorms creates windy and rainy weather conditions
- Variations with approx. 100 ms period.



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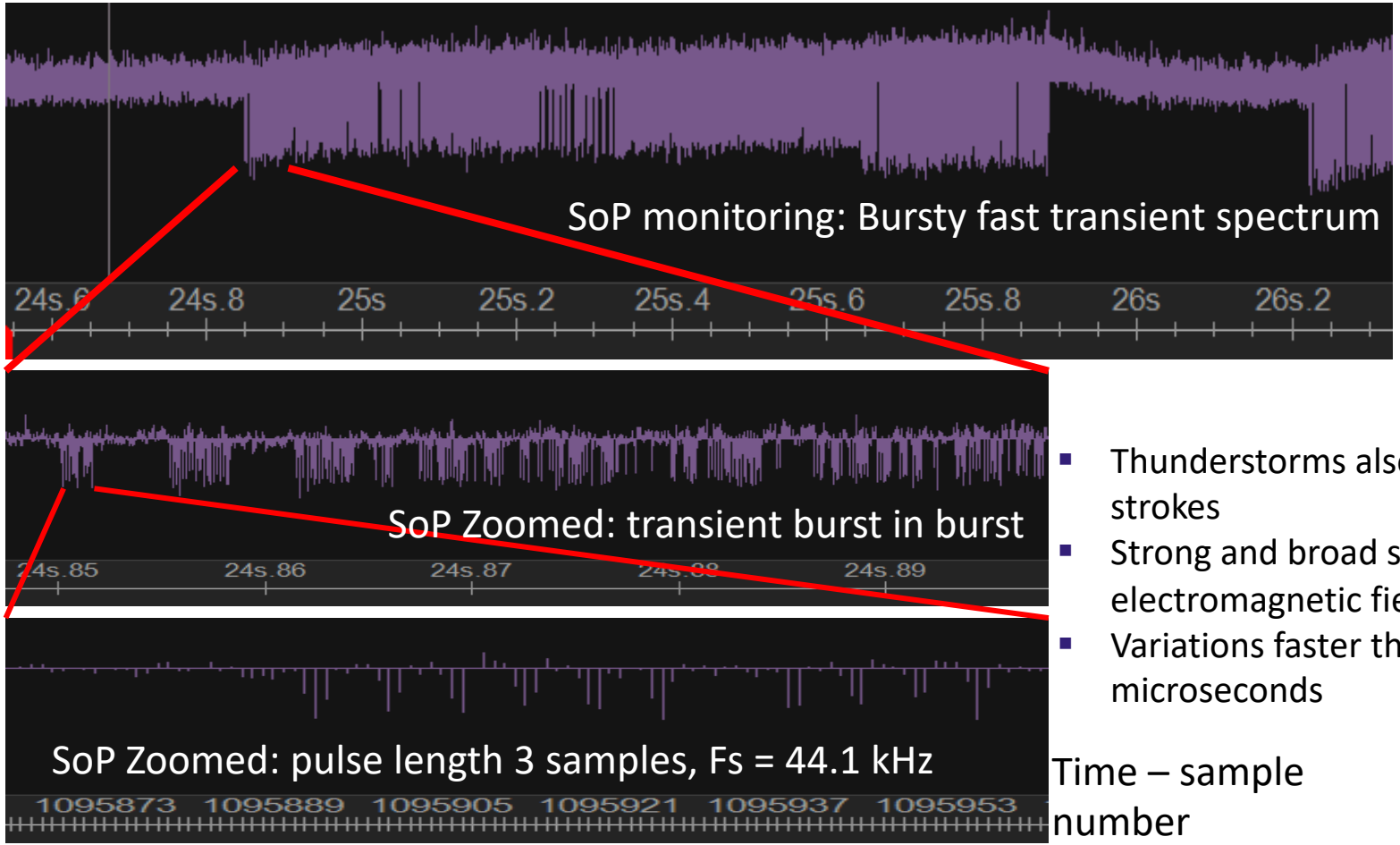
Field-experiment Fiber to the home



- Thunderstorms also creates lightning strokes
- Strong and broad spectrum electromagnetic fields
- Variations faster than 100 microseconds

Time – sample number

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Summary fibrecables for monitoring

- Reveal vulnerability incidents on Tampnet infrastructure that may cause dropouts
  - Trawler activity potentially cutting subsea cables
  - Detecting node room activity and/or temporarily installed cables
- Potential new business
  - Co2 storage – Earthquakes etc. and instabilities that may cause leakages
  - Seismic sensing
  - Earthquake detection
  - Noise detection, e.g. from windfarms, explosions…..
  - Whale sound detection
  - Temperature detection
  - ……