

Detecting physical impacts and movements of optical fibre cables

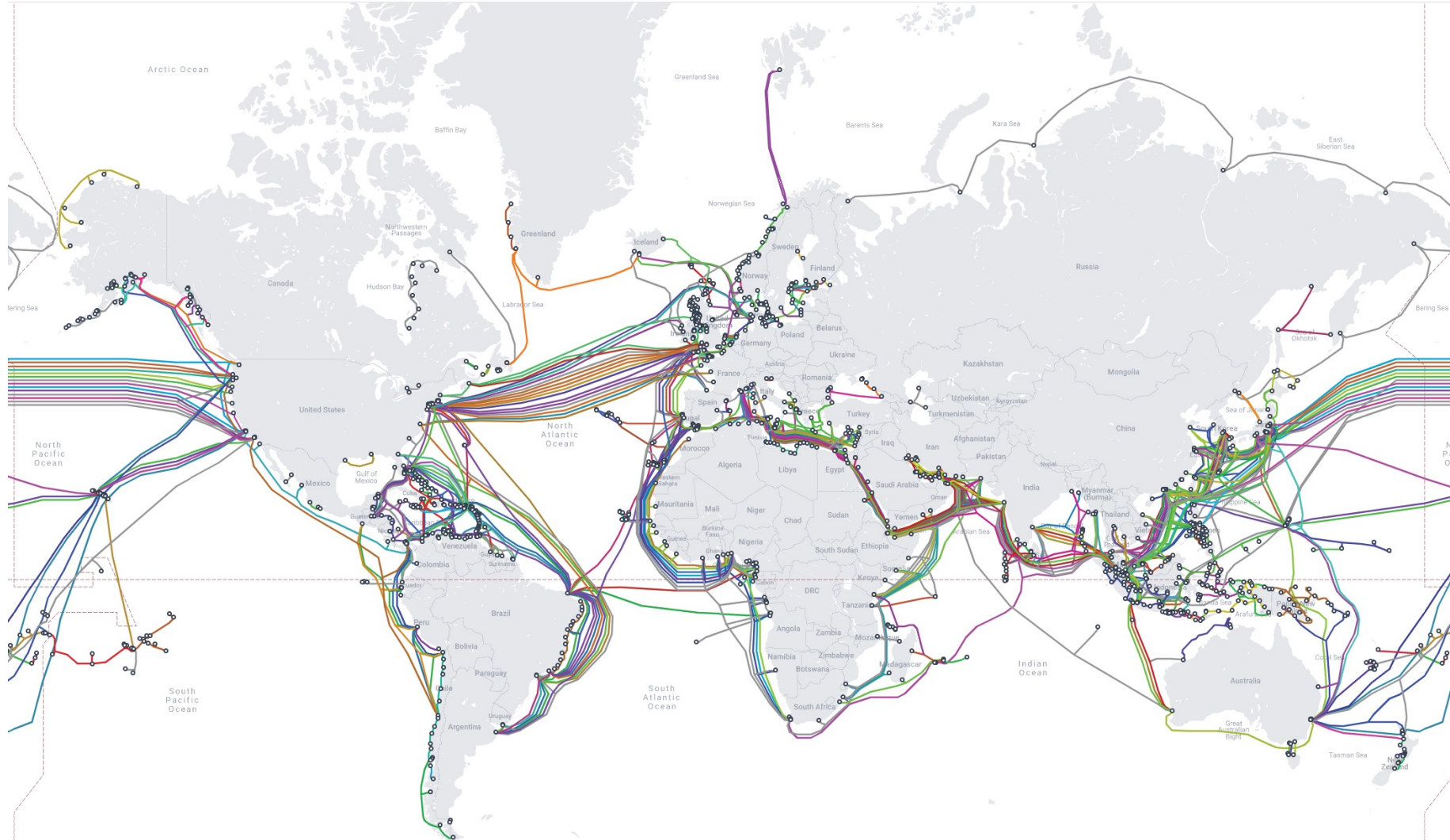
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Introduction

Sub-Sea Optical Cable Main Routes



Fibre optic Internet cables are vulnerable

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Attacks show fiber optic Internet cables vulnerable

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Tapping the world's fiber optic cables

Huge masses of data flash around the world along thousands of miles of fiber optic cables. They are regularly tapped - sometimes legally, mostly secretly. While this technology is simple, filtering is a huge challenge.

Date 30.06.2013

Author Fabian Schmidt / bk

Related Subjects National Security Agency (NSA)

Keywords fiber optic cable, spying, tempora, prism, hack, NSA, intelligence agencies

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Detection of vulnerabilities around optical fibres

- A low cost, simplified State of Polarisation (SOP) based proactive fibre monitoring system to,
 - Detect vibrations around optical fibre
 - Classify events around the optical fibre
- SOP based system can integrate with standard optical communication systems.
- Dedicated fibre is not required for sensing.

Physical Layer Vulnerabilities

1. Fibre cuts or unauthorised access

- Damage due to digging, access in node rooms

2. Eavesdropping/ Signal Splitting

- Fibre Taps (Bending)

3. Attacks to the Physical Infrastructure

- Disaster like attacks (Digging, fish trawler)
- Component level attack
- Critical location attacks (Node rooms, data centre)

Scope of the project

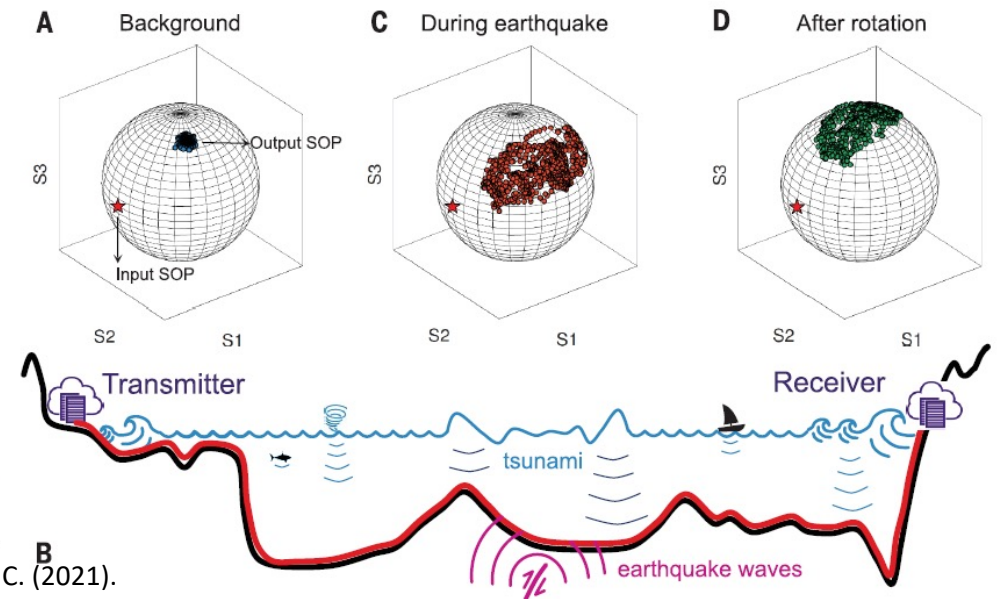
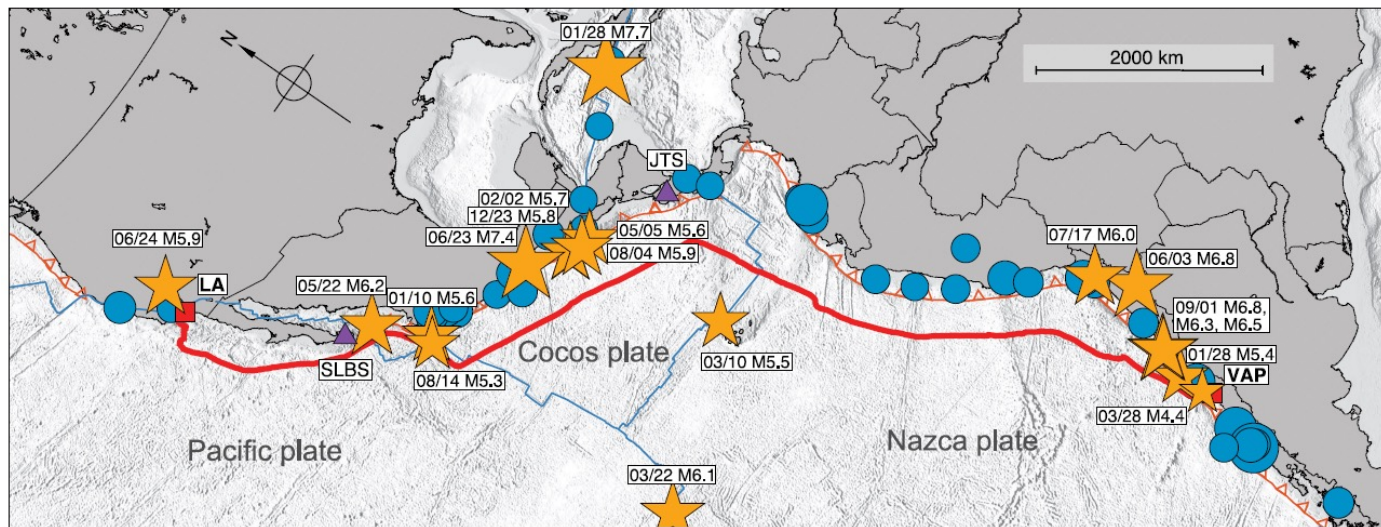
- Identifying vulnerabilities in optical networks through fiber movement detection
 - Potential fiber breaks
 - Potential eaves dropping attacks

Limitation of the current technology

- Distributed acoustic sensing (DAS) systems can detect mechanical movements of fiber cables caused by e.g. trawler boats and digging activity
 - Dedicated fiber
 - Range limitation ($\approx 200\text{km}$)

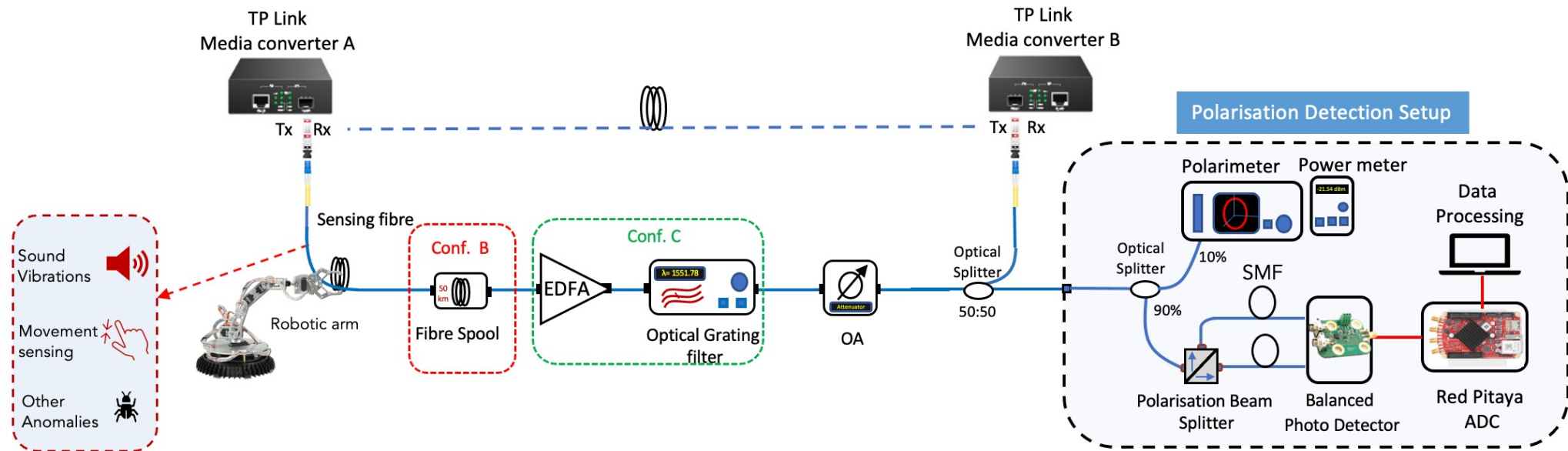
Why State of Polarisation based sensing?

- State of Polarization (SoP) monitoring can be added to commercial transmission systems that can enable mechanical movement detection.
- Low cost and simplified detection.
- Already proven for geophysical events (earthquake etc.) detection.

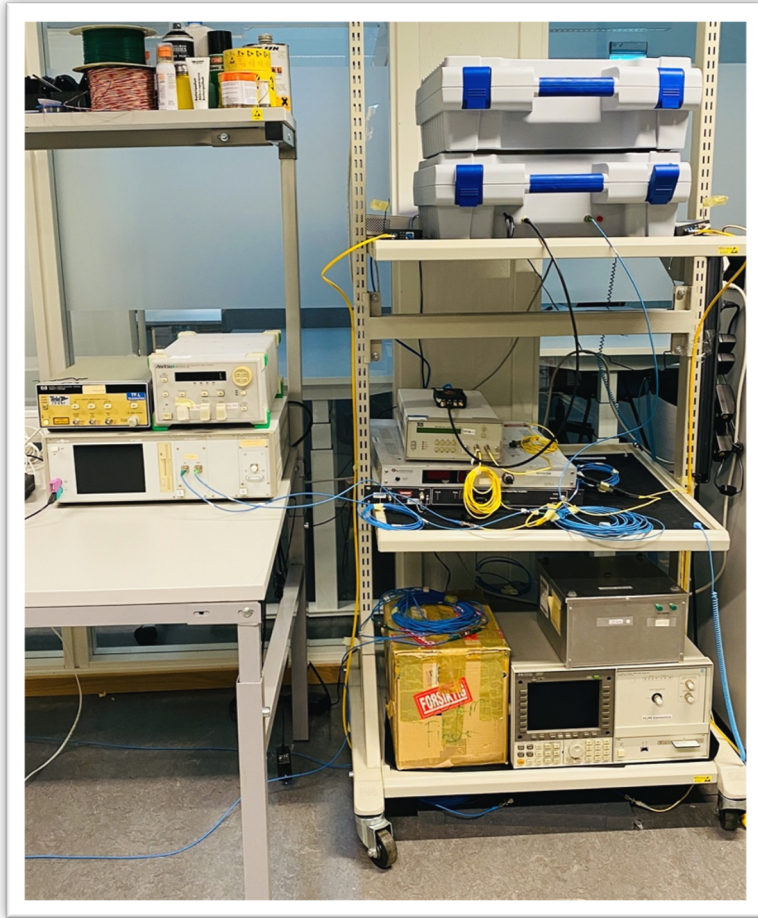


State of Polarisation: Ongoing work at Simula

- Test setup measuring SOP variations in GBE system



SoP based Anomaly detection: Complete setup

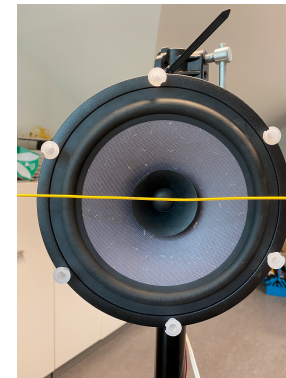
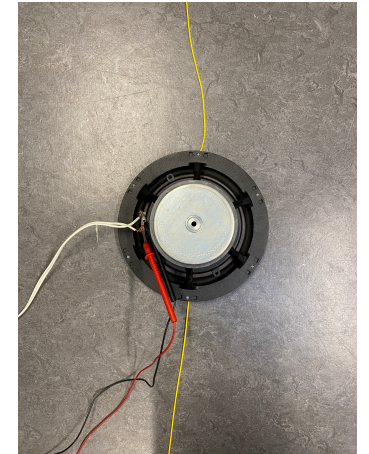


Setup with all devices



Setup with aerial fibre configuration

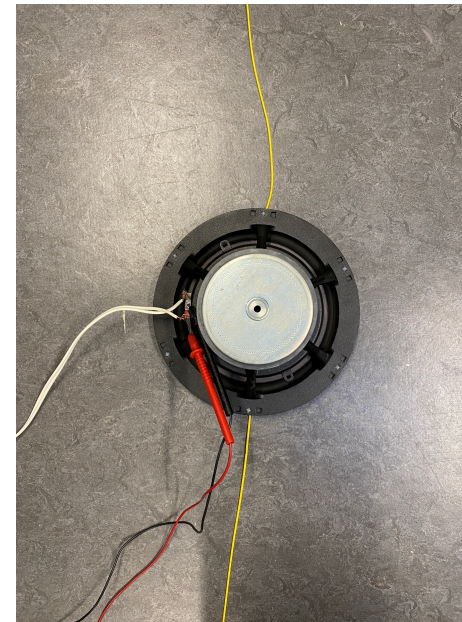
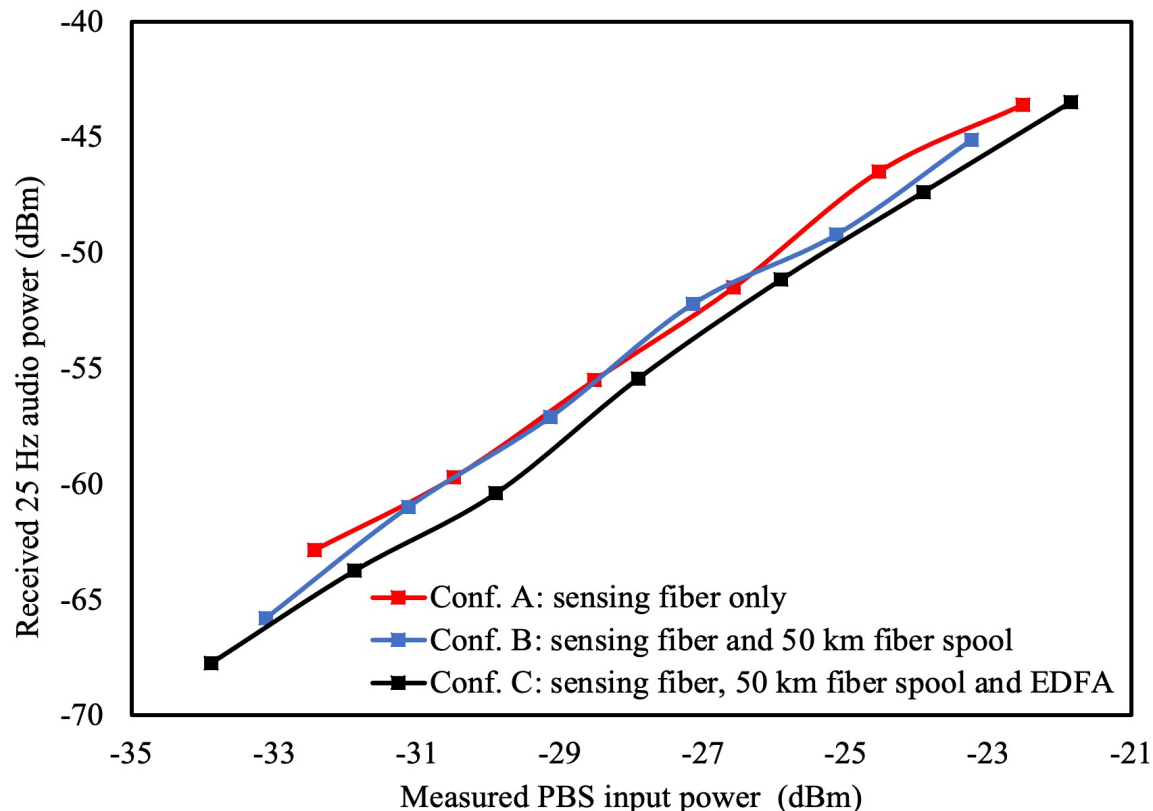
Vibrations through surface



Vibrations through air (side)

SOP sensing sensitivity analysis on firm surface

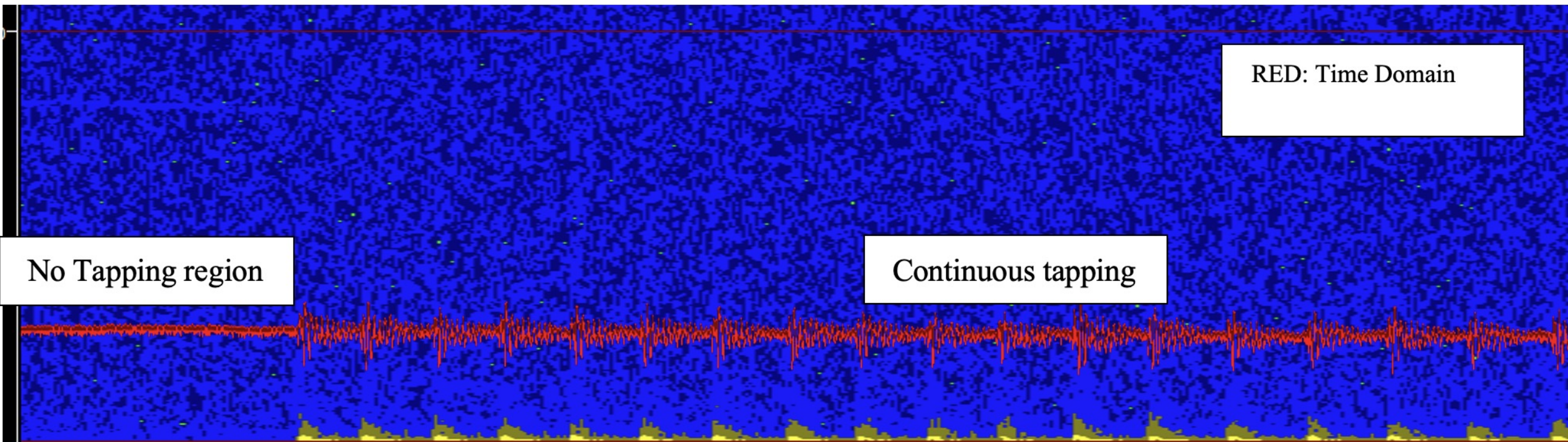
- Fibre on the floor shows highest sensitivity at 25 Hz.
- Very high sensitivity: 2 Microwatts on speaker!
- Insignificant impact from 50 km fibre and optical amplifier



Vibrations through a firm surface

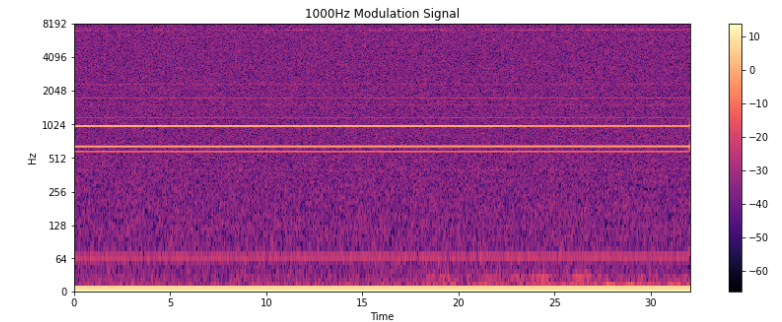
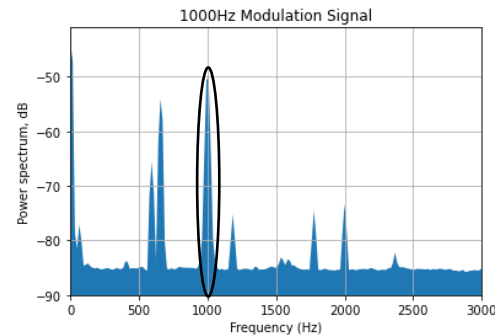
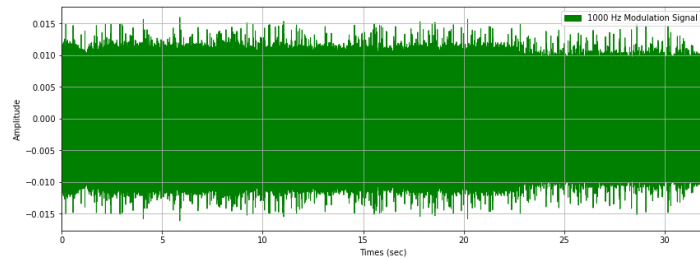
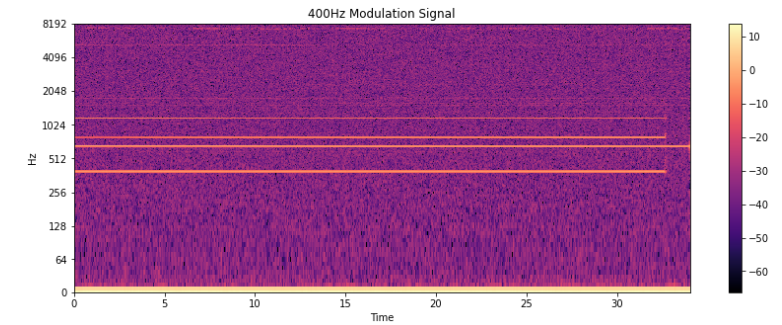
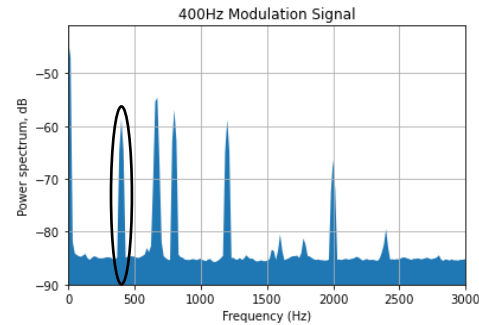
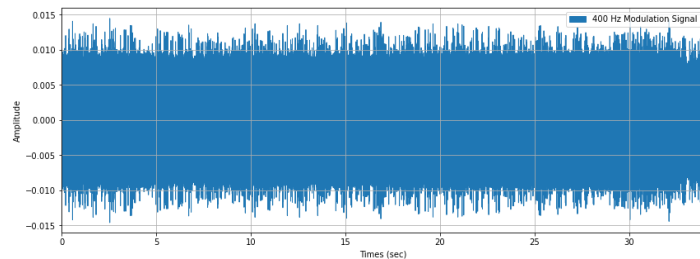
Identification of signatures examples

- Tapping: Example shown below



Data processing and signature detection

400Hz and 1 kHz Frequency Vibrations



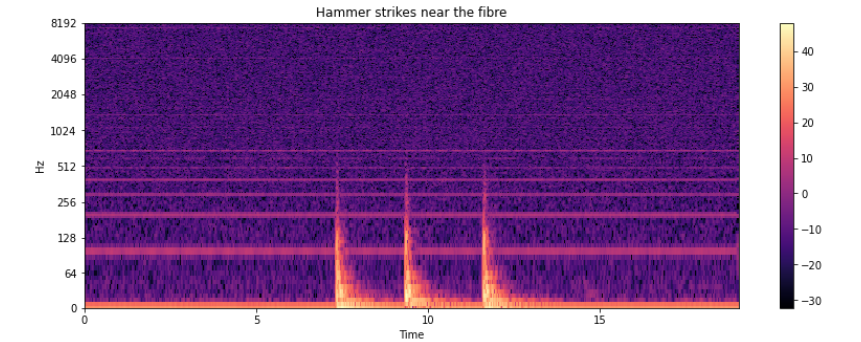
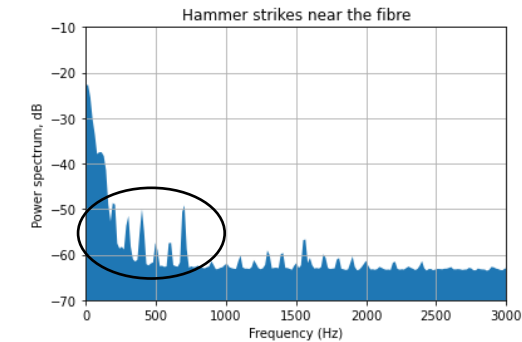
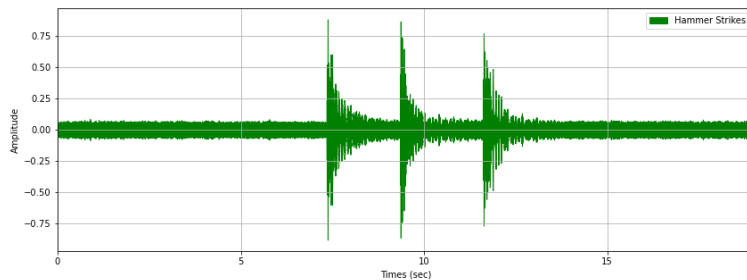
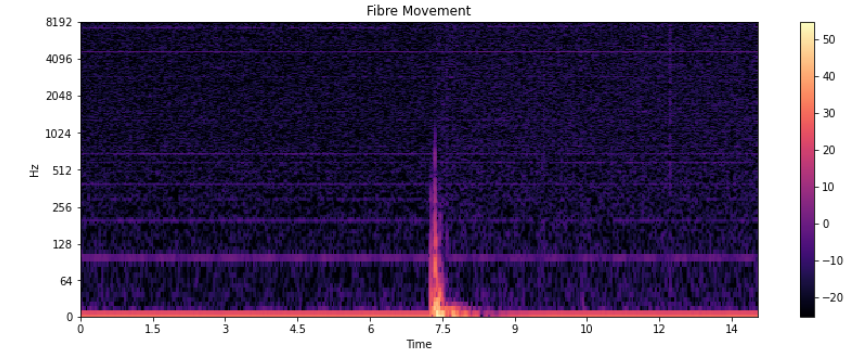
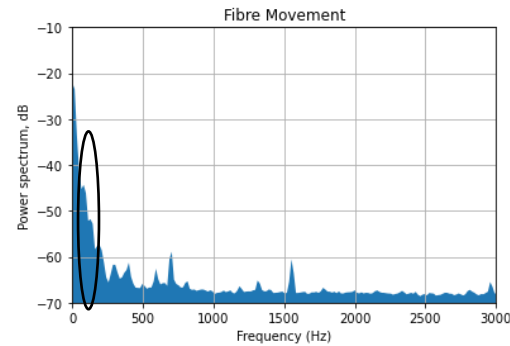
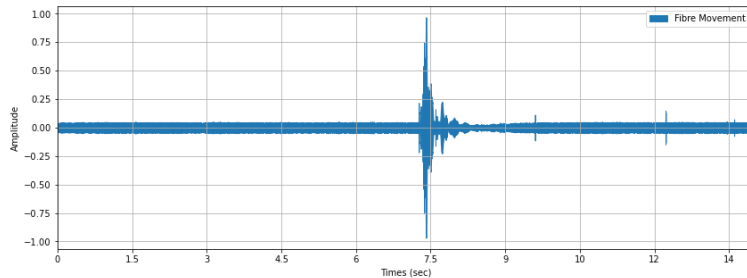
Time domain

Frequency domain

Spectrogram

Data processing and signature detection

Moving a fibre and Hammer strikes near optical fibre



Time domain

Frequency domain

Spectrogram

Summary

- Monitoring of SoP variations can be performed in currently deployed optical communication systems
 - No separate fibre needed
 - Adding a simplified polarization analyser or,
 - Collecting existing SOP data from coherent receivers (long distance systems)
- Experiments at Simula shows
 - Fibre on a firm surface: Detecting low frequency sounds likely to occur from e.g. digging activity, hammering, drilling and earthquakes.
 - Anomalies can be categorised by analysing time and frequency domain data.
 - Position sensing in SOP based sensing is a challenge.