HDAS

High-Fidelity Distributed Acoustic Sensor

Javier Vidal
Product Manager

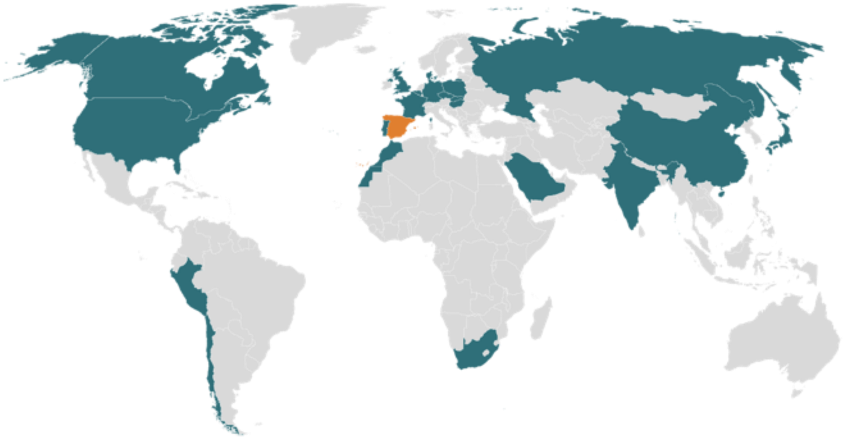
ARAGÓN PHOTONICS

CONTENTS

Aragon Photonics

Who are we?

Manufacturer of photonic test, measurement & sensing equipment started in Zaragoza (Spain) in 2004.



Innovative: exploiting 11 patents, highly technical staff (4 PhD, 9 MSc), strong R&D collaboration with Universities in Spain.

International: Sales in >20 countries, strong network of distributors & partners, exhibiting in major industry trade shows.

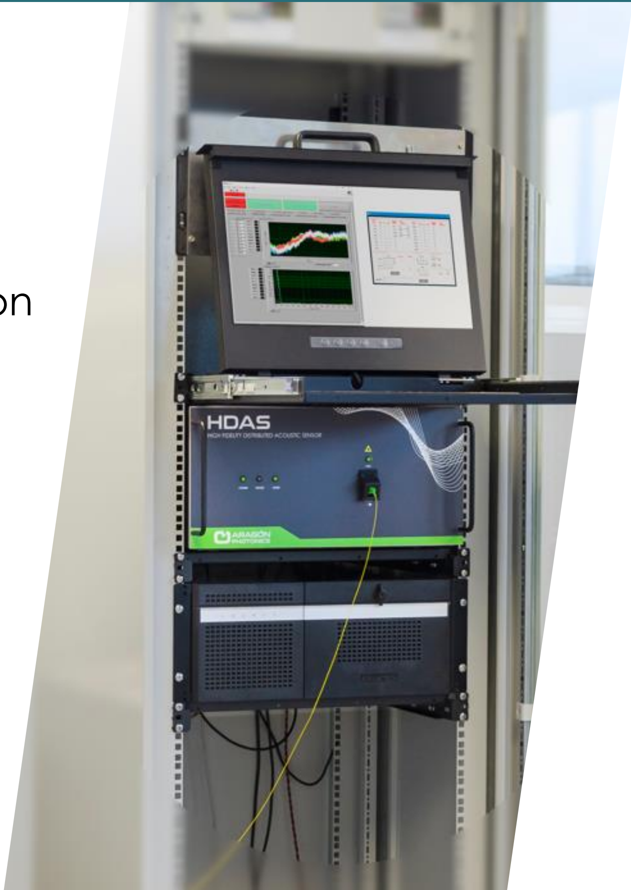
Solid & growing: 1.5 M€ 2019 turnover (2.2 M€ 2020 forecast). Current staff: 20(+5 2020). 28% CAGR.

What do we have to offer?

HDAS

High-fidelity Distributed Acoustic Sensor

- **High performance:** 70 km, 1 nstrain sensitivity, 10m resolution
- **High fidelity:** no distortion, no fading, homogeneous SNR
- **Open:** Access to Raw Data & instrument response
- **Cost-effective**
- **Proven for seismic monitoring**



How did we get here?

CSIC
Consejo Superior de Investigaciones Científicas
Pedro Corredera

Universidad de Alcalá
Miguel González

focus
Fiber optics consulting, services and technologies

HDAS protoype

2 patents
- CP-ΦTDR
- Reach ext.

Research contract signed

2004 | 2011 | 2017 | 2018 | 2019

ARAGÓN PHOTONICS

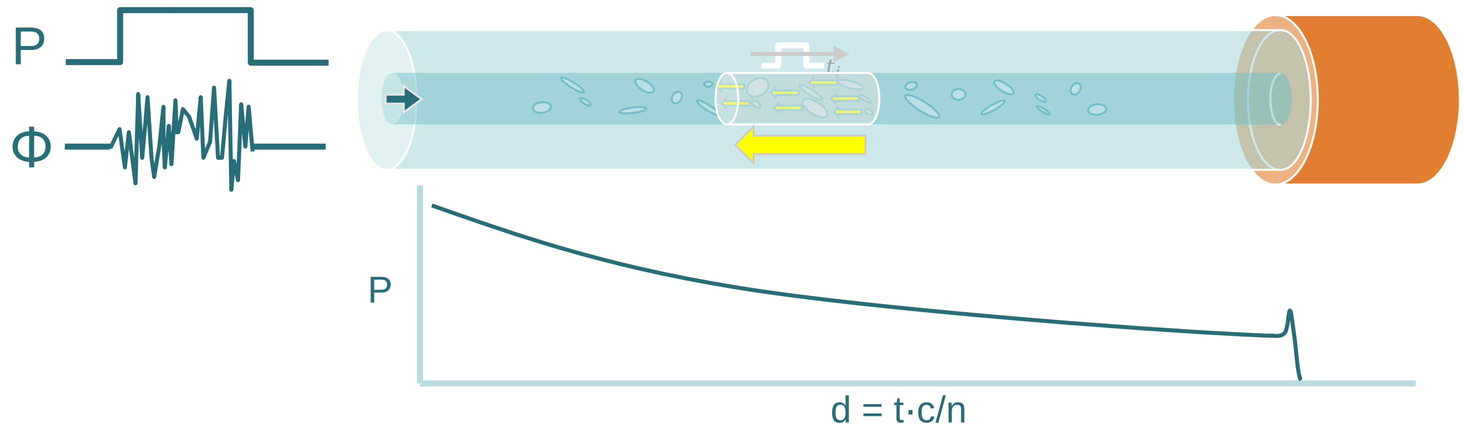
BOSA

Chirped Pulse ΦOTDR

HDAS TECHNOLOGY

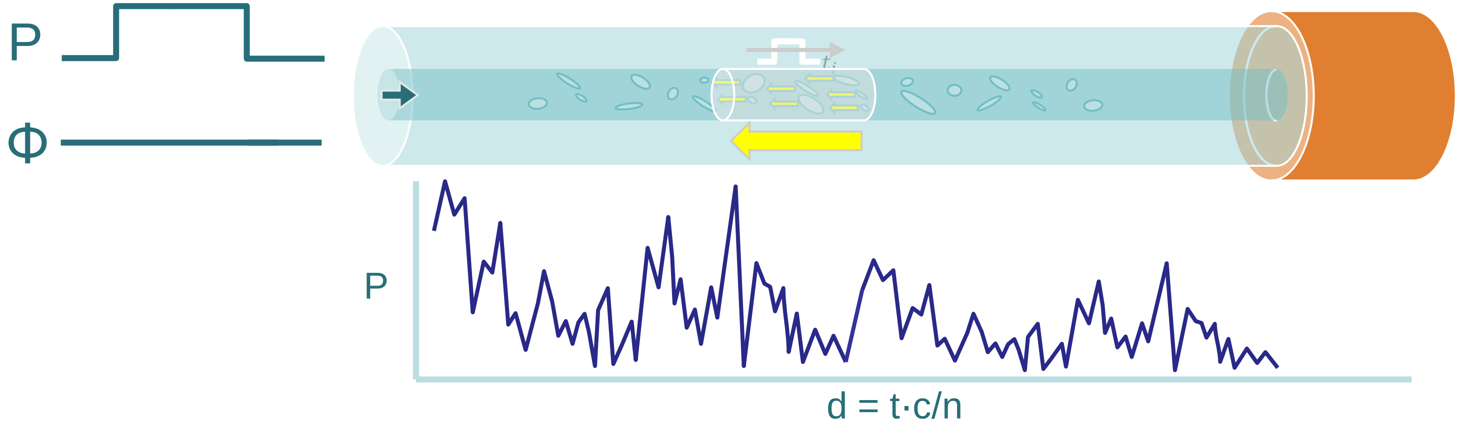
ARAGÓN PHOTONICS

How does DAS work?



- Optical fiber reflects a small portion of the injected light as photons “rebound” on the fiber imperfection. This effect is known as Rayleigh Backscattering.
- By using a pulsed light source, only a section of the fiber is lightened at a time, providing a distributed measurement of the scattering on the fiber.
- If injected light is incoherent, the backscattered light decays with fiber losses. This is the base of the OTDR, a common tool to check fiber optic cables.

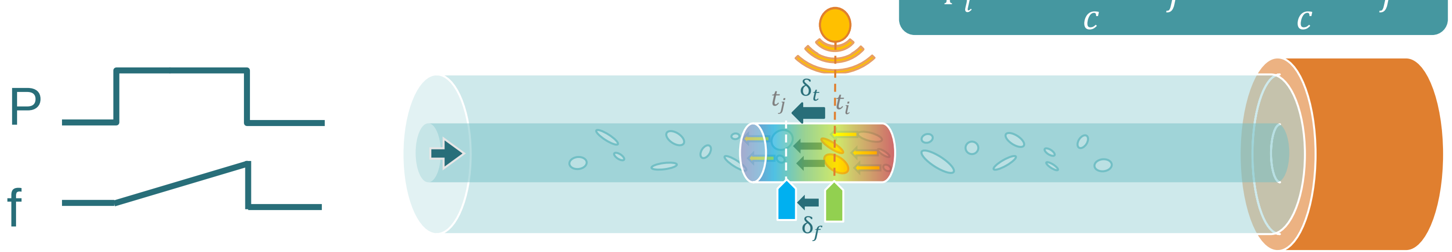
How does DAS work?



- Optical fiber reflects a small portion of the injected light as photons "rebound" on the fiber imperfection. This effect is known as Rayleigh Backscattering.
- By using a pulsed light source, only a section of the fiber is lightened at a time, providing a distributed measurement of the scattering on the fiber.
- If injected light is coherent, the backcattered light shows an interference pattern

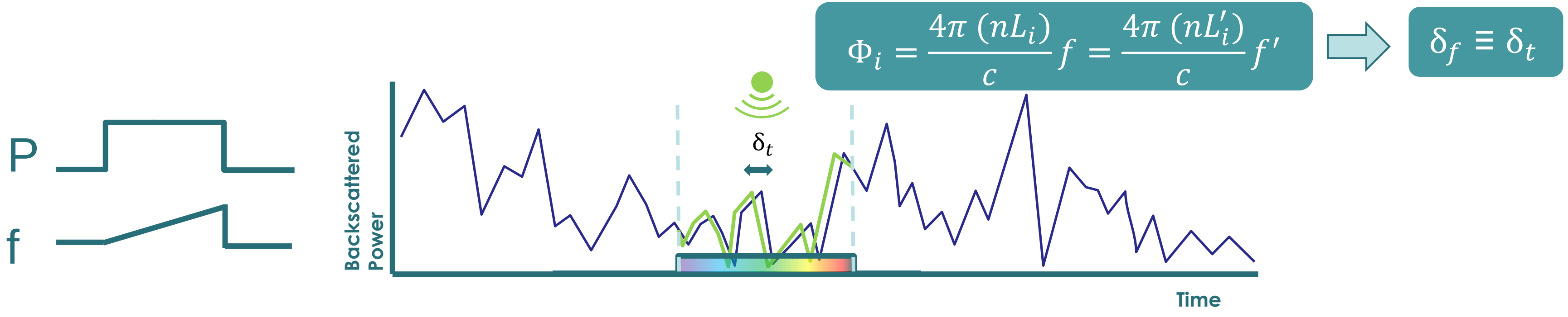
CP-ΦOTDR Technology

$$\Phi_i = \frac{4\pi\,(nL_i)}{c} f = \frac{4\pi\,(nL'_i)}{c} f' \Rightarrow \delta_f \equiv \delta_t$$



- A frequency swept is done inside the pulse → Chirped pulse
- For a given small change in refractive index Δn, the phase will be kept if f is changed the same relative amount.
- Strain changes over the fibre are transformed to time delays over the portion of the trace illuminated by the pulse

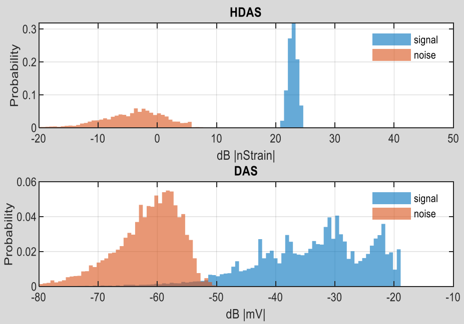
CP-ΦOTDR Technology



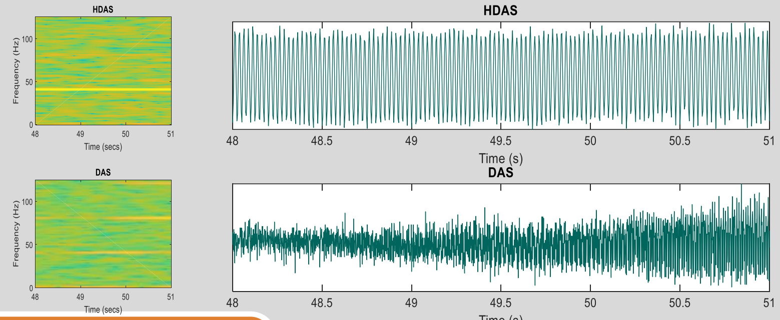
- A frequency swept is done inside the pulse → Chirped pulse
- For a given small change in refractive index Δn, the phase will be kept if f is changed the same relative amount.
- Strain changes over the fibre are transformed to time delays over the portion of the trace illuminated by the pulse
- Information is extracted using correlation → achieves low sensitivity to low power sections (no fading)

Patented

Key Features



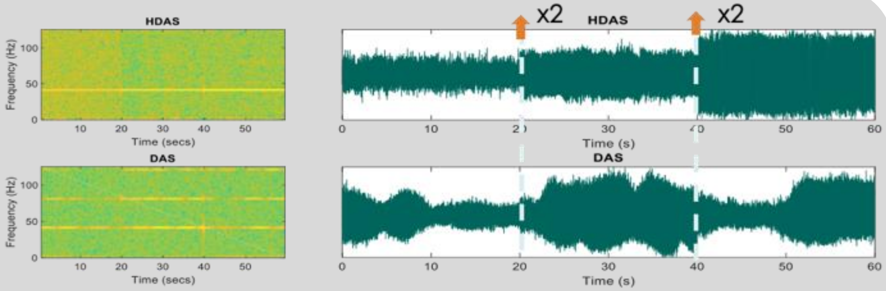
Homogeneous & stable SNR



Key Features

Linear measurement

Quantitative measurement



This performance is given by the technology itself, before any post processing

HDAS for

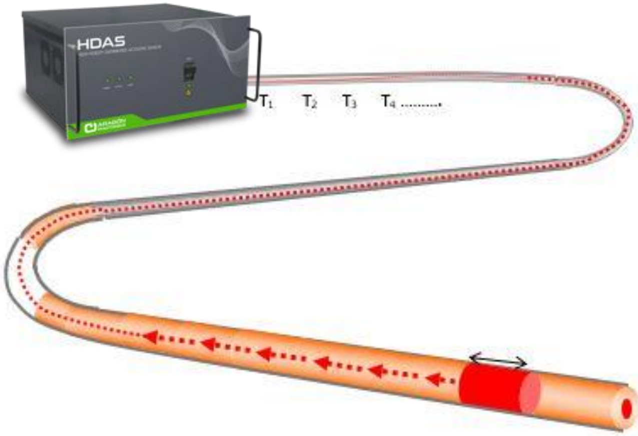
SEISMOLOGY APPLICATIONS

ARAGÓN PHOTONICS

HDAS vs conventional seismometers

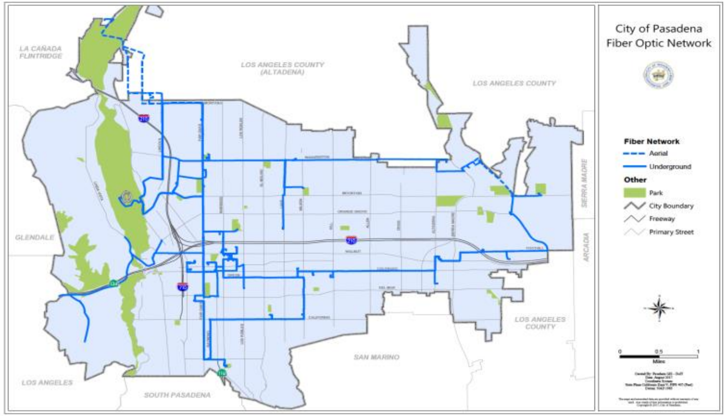
- Point Seismometer
  - Single channel, GPS sync available on the earth Surface
  - No spatial information
  - Higher Sensitivity

- HDAS
  - Thousands of synchronized channels
  - Spatial & directional information
  - Lower sensitivity

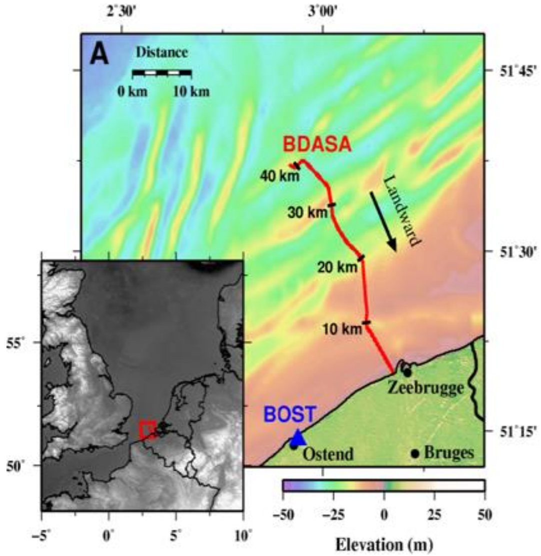


Land and sea optical fibers

- Underground buried fibre



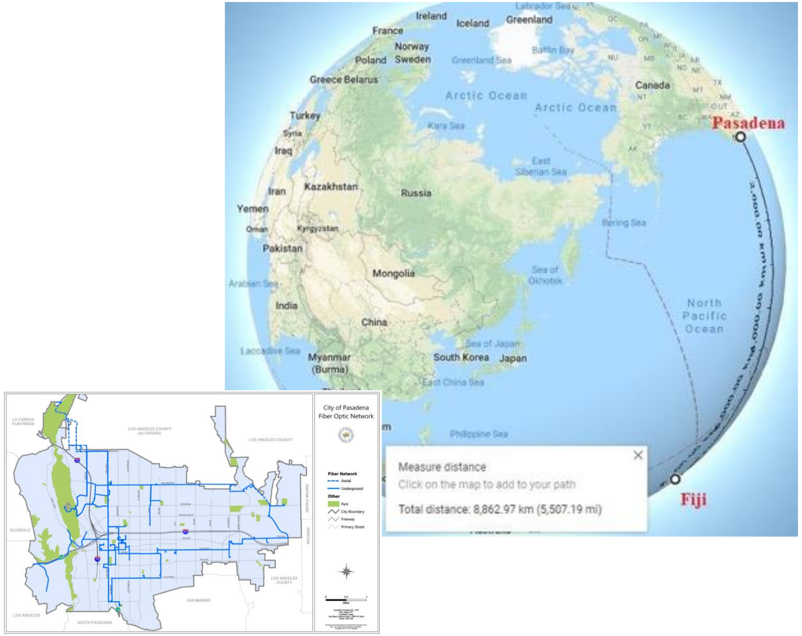
- Submarine fibre



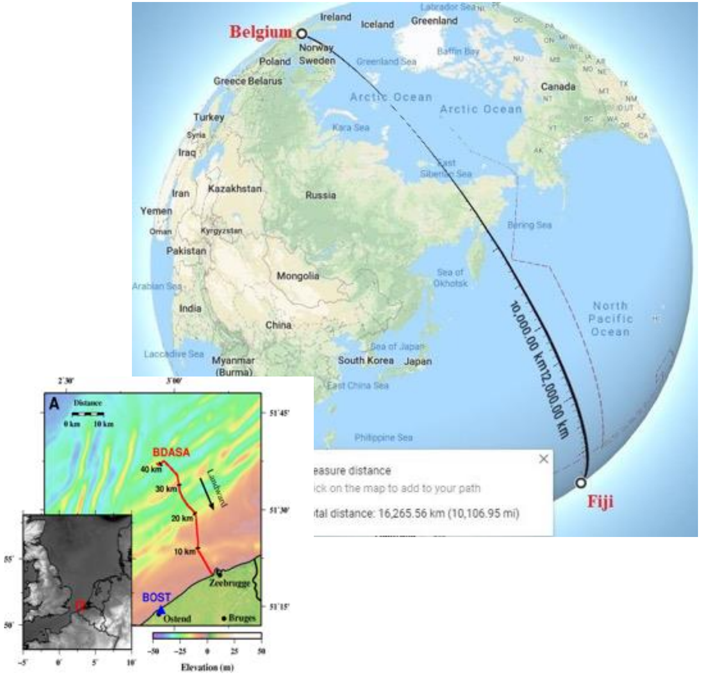
Caltech · Universidad de Alcalá · MARLINKS

Detecting teleseisms

- >9000km distance from the epicenter to Pasadena, California



- >16300 km distance from the epicenter to Zeebrugge, Belgium



Submarine fibre

nature COMMUNICATIONS

ARTICLE

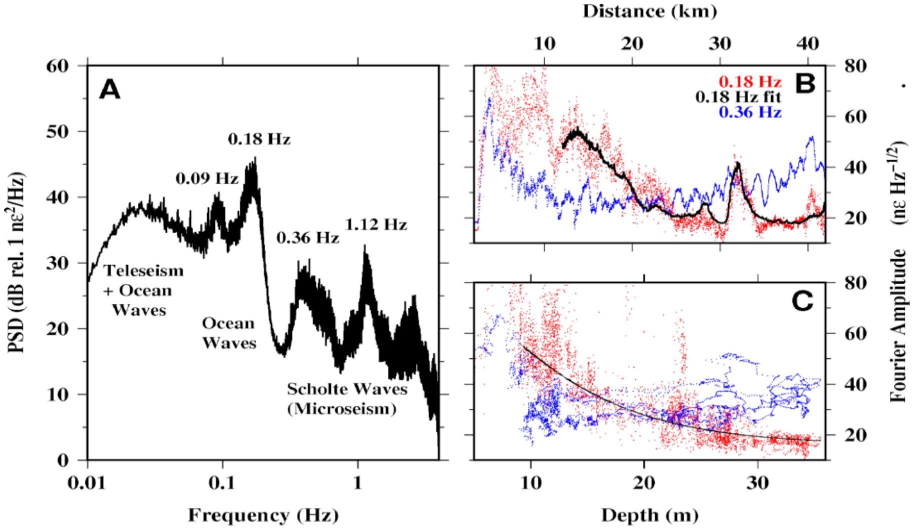
https://doi.org/10.1038/s41467-019-13262-7 OPEN

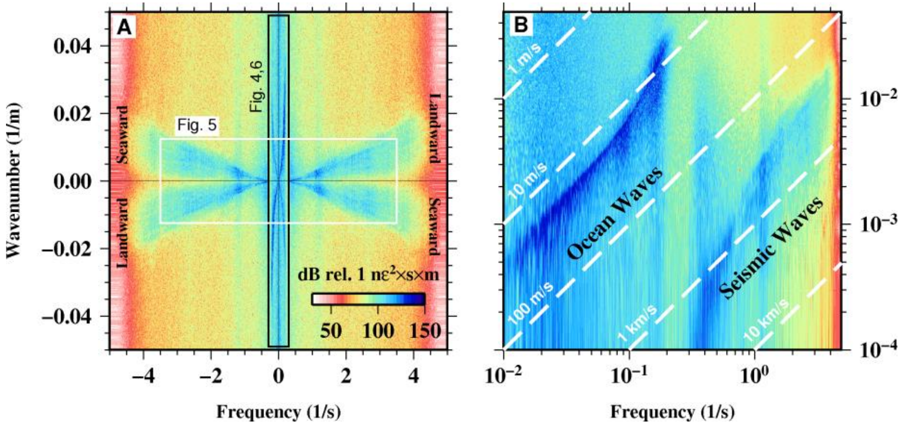
Distributed sensing of microseisms and teleseisms with submarine dark fibers

Ethan F. Williams[1*], María R. Fernández-Ruiz[2], Regina Magalhaes[2], Roel Vanthillo[3], Zhongwen Zhan[1], Miguel González-Herráez[2] & Hugo F. Martins[4]

Submarine fibre

- Significant coherent noise from surface waves and in-situ micro-seismic noise.
- Surface waves have a completely different dispersion relation.

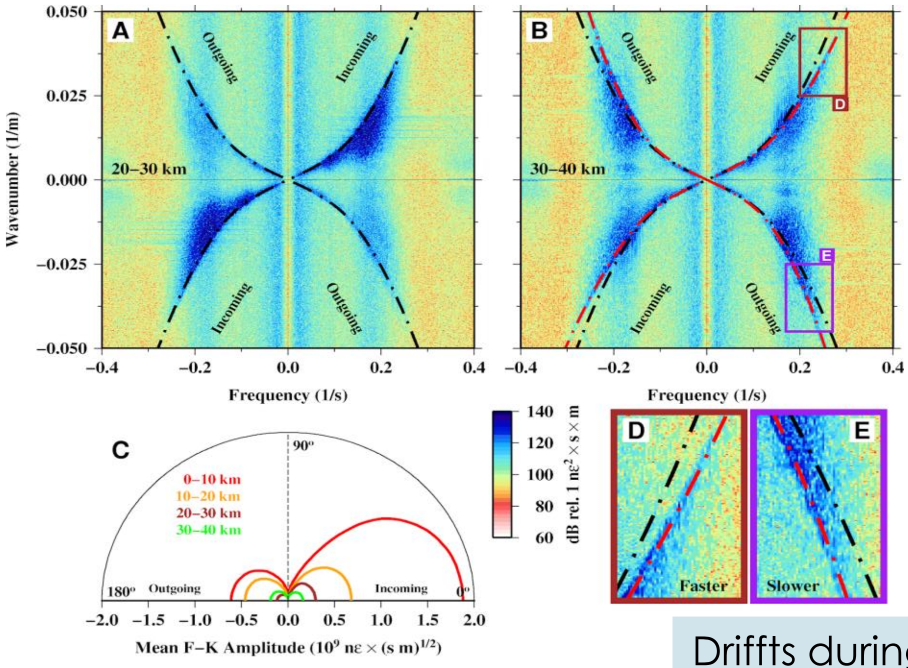




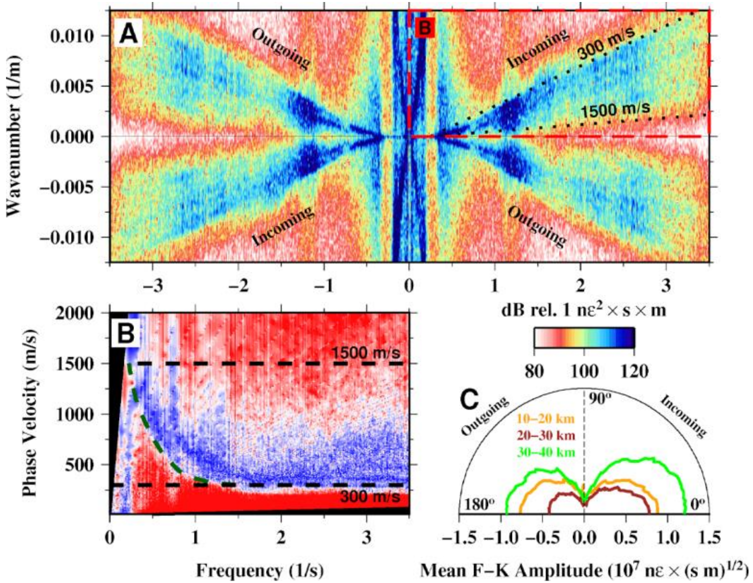
HDAS for seismology

Separation of coherent signals

- Surface waves



- Micro-seismic waves



Driffts during the day

Underground buried fibre

Rose Parade Seismology: Signatures of Floats and Bands on Optical Fiber

Xin Wang[1], Ethan F. Williams[1], Martin Karrenbach[2], Miguel González Herráez[3], Hugo Fidalgo Martins[4], and Zhongwen Zhan[*1]

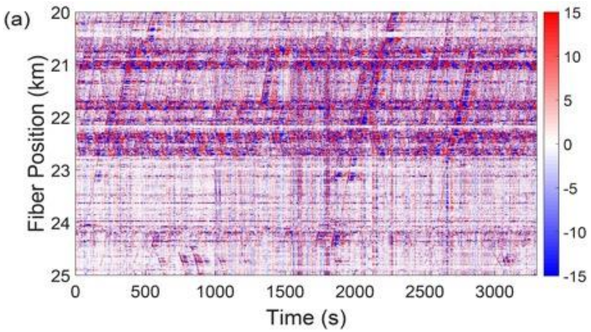
Abstract

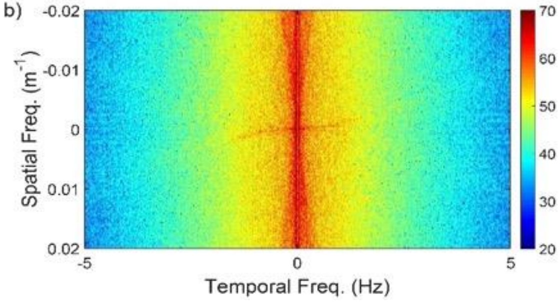
The 2020 Rose Parade in Pasadena, California, was recorded by the Pasadena distributed acoustic sensing array, which utilizes the underground telecom fiber optic cables as sensors. The floats and bands generate remarkable broadband seismic signatures that can be captured at meters' resolution.

Cite this article as Wang, X., E. F. Williams, M. Karrenbach, M. G. Herráez, H. F. Martins, and Z. Zhan (2020). Rose Parade Seismology: Signatures of Floats and Bands on Optical Fiber, *Seismol. Res. Lett.* **XX**, 1–4, doi: 10.1785/0220200091.

Supplemental Material

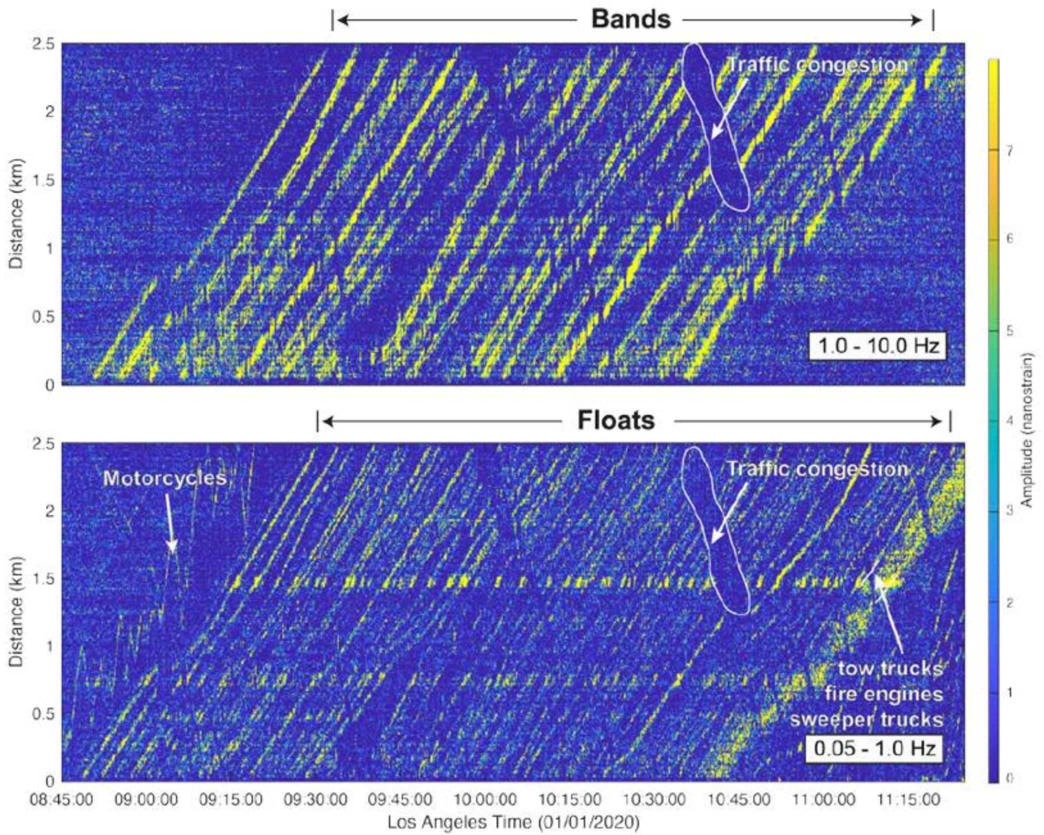
Significant coherent noise from vehicles and urban activity





Background noise has wavelengths <100 meters

Underground buried fibre



- Caltech used HDAS and Optasense

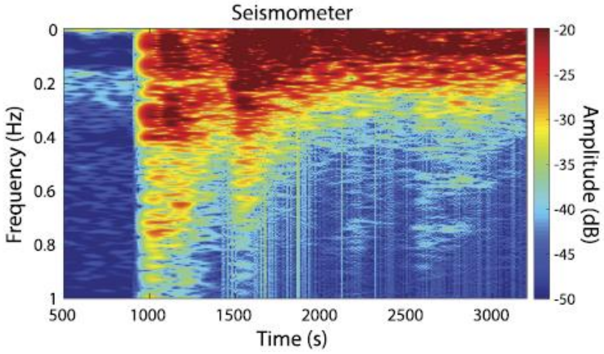
Review paper

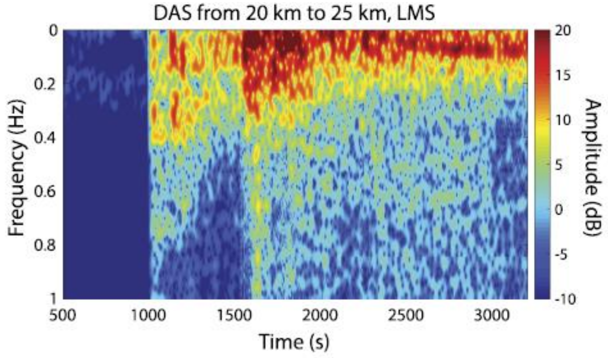
Distributed acoustic sensing for seismic activity monitoring

Cite as: APL Photon. 5, 030901 (2020); doi: 10.1063/1.5139602
Submitted: 22 November 2019 • Accepted: 27 February 2020 •
Published Online: 24 March 2020

View Online Export Citation CrossMark

María R. Fernández-Ruiz,[1,a)] Marcelo A. Soto,[2] Ethan F. Williams,[3] Sonia Martin-Lopez,[1] Zhongwen Zhan,[3] Miguel Gonzalez-Herraez,[1] and Hugo F. Martins[4]





HDAS for seismology
Customer References

SEISMIC ACTIVITY MONITORING

GFZ Helmholtz-Zentrum Potsdam

CNRS Géoazur

Universidad de Granada

MARLINKS

Universidad de Alcalá

Seismological Laboratory, California Institute of Technology

Caltech

ARAGÓN PHOTONICS

For more information

j.vidal@aragonphotonics.com
www.aragonphotonics.com