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**A collaborative innovation that
uses telecom subsea infrastruc-
tures to help scientists in their
understanding of our planet.**

White Paper



Subsea telecoms cables: A driver for scientific research

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Introduction

« Two thirds of the surface of our planet are covered by water and are still poorly instrumented, which has prevented the earth science community from addressing numerous key scientific questions. The potential to leverage the existing fiber optic seafloor telecom cables that criss-cross the oceans, by using them as dense arrays of seismo-acoustic sensors, remains to be evaluated. Here, we report Distributed Acoustic Sensing measurements on a 41.5 km-long telecom cable that is deployed offshore Toulon, France. Our observations demonstrate the capability to monitor with unprecedented details the ocean-solid earth interactions from the coast to the abyssal plain, in addition to regional seismicity (e.g., a magnitude 1.9 micro-earthquake located 100km away) with signal characteristics comparable to those of a coastal seismic station.”

Distributed sensing of earthquakes and ocean-solid Earth interactions on seafloor telecom cables, article published in Nature on 18th Dec. 2019.

2021 offers an opportunity for the global scientific community with the establishment of a new cable system by EllaLink. This white paper describes possibilities about what could be done once a number of outstanding points are resolved. GÉANT issues this paper to stimulate debate and discussion on what could be achieved in the field of Science Monitoring and Reliable Telecommunications (SMART) submarine cable systems.

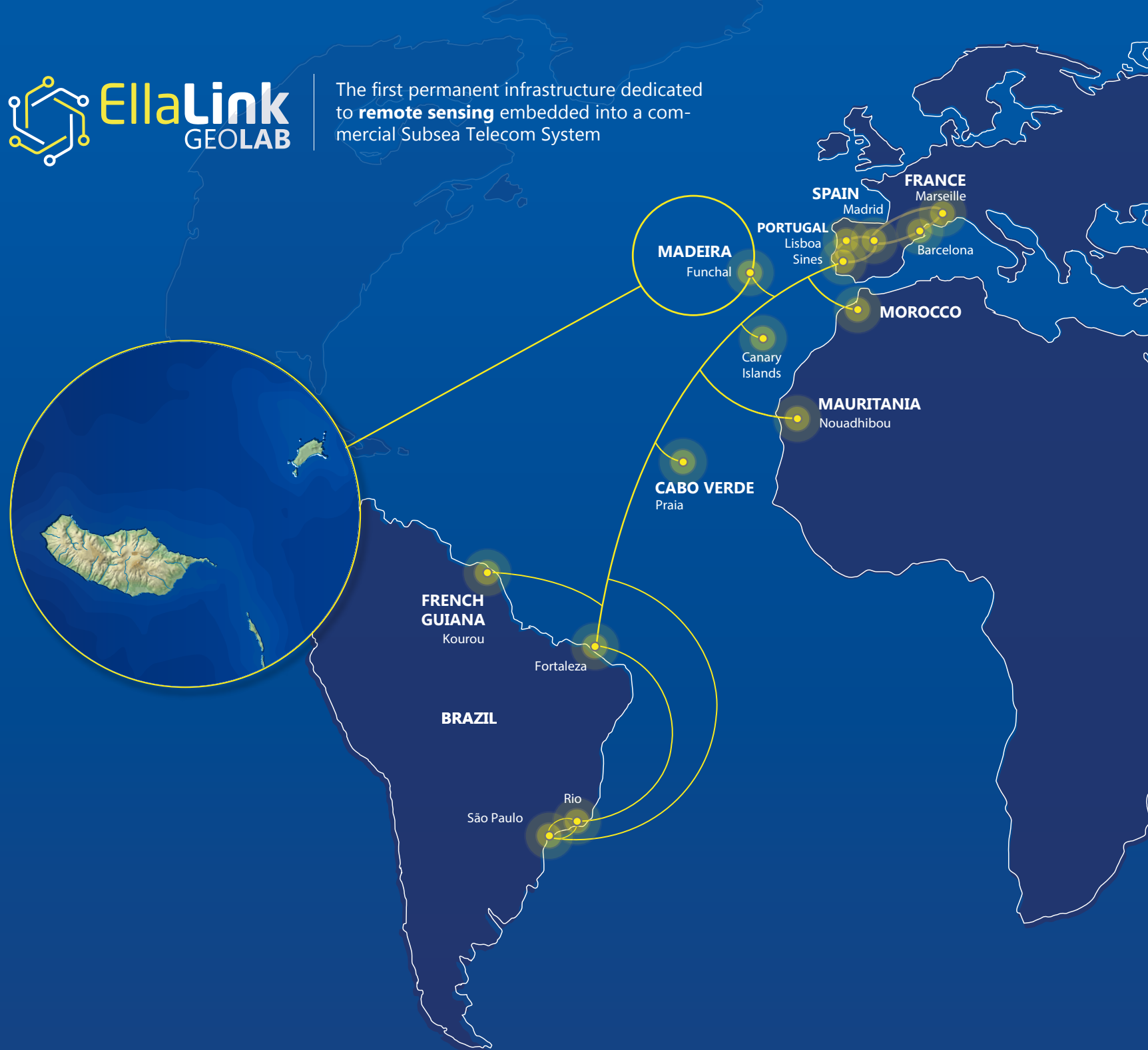
Submarine telecommunication cables lie in one of the least explored areas of our planet. The seabed is often seen as a place that is not subject to change. However, it is subject to constant transformation caused by a variety of factors. Some changes are caused by interactions between the ocean and the seabed, while longer-term changes occur far below the surface, in the crust of our planet.

Because more than 70% of the earth's surface is covered by water, research is very difficult to perform. Traditionally, research in sub-sea regions has only been possible using large research vessels or sensors tethered by very expensive dedicated cable systems usually limited to near-coastal installations. This limits the ability of the scientific community to investigate what is happening in our Oceans on a broad scale.

The EllaLink cable that is being deployed across the Atlantic, between Portugal and Brazil, has opened up an opportunity to integrate a scientific component into a commercial submarine cable system. The GeoLab concept was created as a partnership between EllaLink, EMACOM, FCT, and GÉANT to provide an infrastructure for the benefit of the global scientific community.

This infrastructure consists of a spare fibre pair built into the Funchal branch of the EllaLink cable, which stretches out for 75km, southeast from the coast of Madeira, into the Atlantic Ocean. Along with the fibre, space, power, air-conditioning, storage, and internet connectivity will be made available to researchers at shore based facilities. Collectively, this testbed service is called GeoLab.





- Seismology, volcanology, marine ecology and oceanic conditions are key to understanding the future of our planet.
- **EllaLink Geolab** initiative aims to provide the scientific community with real-time, accurate and relevant data on seabed conditions along the EllaLink Cable route.
- EllaLink is **the first telecoms submarine cable to integrate SMART cable concept**.

Overview

As GeoLab is the first of its kind in the world, it is unclear exactly which types of research will ultimately be conducted using GeoLab. However, both abiotic and biotic research areas could be investigated:

1. Seismology

Seismology is a scientific discipline that deals with the analysis, description, and measurement of natural and artificial seismic waves. Studying these waves allows seismologists to image the interior structure of the Earth, inferring composition, temperature and the distribution of fluids. Analysis of the seismic waves excited by earthquakes are used to infer its hypocentre (the latitude, longitude and depth where the earthquake rupture begins), the orientation of the causative fault, the detailed distribution of the rupture. Done rapidly, this information can be used for tsunami early warning or to get a quick understanding of affected areas, or even for detection of offshore earthquakes up to a few tens of seconds warning before strong shaking begins.

2. Continental plate movement

Plate tectonics describes a geological phenomenon in which parts of the Earth's crust shift relative to each other. At one time, all the continents were united in one large supercontinent, Pangea. This shifting does not happen overnight; plate sliding occurs at a rate of several centimetres per year. The shifting causes changes and stresses in the earth's crust that could trigger an earthquake. While these earthquakes are usually small and not noticeable, it is not uncommon for an earthquake of enormous magnitude to occur.

Tectonic plates consist of continental crust, oceanic crust, or a combination of both. If undersea plates slide away from each other, a new oceanic crust is formed. If plates slide against each other, mountains can form. Also, an oceanic plate can dip under another plate. This phenomenon is called subduction, and generally gives rise to both volcanoes and giant earthquakes, which can trigger hugely destructive tsunamis (e.g. 2011 Japan, and 2004 Sumatra, where the tsunamis caused fatalities as far away as India and even East Africa).

3. Ocean Seabed interaction

The range of interactions with the seabed is diverse, with vertical and horizontal interactions with the seabed occurring. For example, a vertical motion of the seafloor as caused by an earthquake. Such an interaction can be very easy to observe with the right equipment given the associated impact on the surrounding areas. Horizontal ocean-seabed interactions, however, are very difficult to observe without extensive local research at the relevant seabed location.

Changes in the seabed can be due to a variety of causes, namely sea currents, sea creatures, and marine traffic. Some changes in the seabed are too small to be observed with other research methods. Technologies which utilise in-line strain-sensing, such as Distributed Acoustic Sensing (DAS), offer the opportunity to observe even the smallest changes in the seabed.

Figure 1. Map of the EllaLink cable pointing out the location of GeoLab.

Thus, it is possible to record the vibrations excited by the interaction of ocean currents and the seabed. By extracting the amplitude and frequency, it might be possible to understand the erosion of the seabed induced as a function of prevailing currents.

The seabed changes partly due to ocean currents, which also change the relief of the seabed and the vegetation present on the seabed. The relief created by the ocean currents can have different influences on the seabed or the vegetation in the oceans. As the effects of this have only been studied to a limited extent, GeoLab can contribute to the science of the underwater world and other effects of sea currents.

Importantly, by continuously recording the ambient noise excited by these processes we could be able to map minute changes (sub percent) in the elastic properties of the seabed, a technique that is well established on land. On land, the susceptibility to velocity changes appears to be a good indicator for soil stability and is strongly correlated with the occurrence of landslides. It seems reasonable that this observation carries over into the marine realm, and that submarine slopes at high risk of failure could be identified in this way.

It is very important that detailed research into ocean-ground interactions is carried out to gain further knowledge of the interactions between the seabed and the ocean, partly because these interact on the relief that is created, sea currents (tides), waves, and vegetation. These effects on the maritime climate require further research that will become possible through the use of equipment connected to the GeoLab is absorbed by DAS. By extracting the amplitude and frequency, it is possible to deduce what kind of change is occurring in the seabed. DAS also determines the exact location of the source of the sound. This is done by recording the time it takes for the light-beam to reach the observation station. Using the speed and time the light-beam takes as factors, the exact location of the observation can be determined.

• **Benthic flows**

The Benthic zone is a region in oceans and sea. This ecological region is located at the ocean-surface, between the oceans water and the earth crust. This zone exists in all waters across the world. The organisms living within this zone have a close relationship with the substrate as most of them are permanently located at the seafloor or within the seafloor sediment. This zone varies from a few centimetres in depth to hundreds of meters. In deeper areas, this zone is strongly associated with low sunlight and low temperatures. In these areas, little biodiversity is present.

• **Anthropogenic movements**

In addition to being active on land, human activity can also have an influence on the oceans. Examples of movements caused by humans include marine traffic, offshore (oil and gas or windmills), and fishing.

• **Abiotic and biotic marine interactions**

Humans have various effects on the marine ecosystem and, thereby, marine mammals. These effects can be structural or incidental. Incidental disturbances can arise from research, offshore industrial activities, and boat traffic. Structural influences include global overfishing of marine mammals. Marine mammals are known to adapt their behaviour and reproductive strategy to human activity on the oceans. Studying these abiotic and biotic marine interactions can be very valuable to research on marine mammal evolution.

• **Cetology**

Cetology is part of oceanic mammal science which examines the behaviour of species in the category of Cetacea. Research of animals in this category is conducted by cetologists. The purpose of this research is to get a better understanding of the behaviour, community dynamics, and evolution of these animals, for example dolphins, orcas, and porpoises. These animals spent just 10% of their time above the ocean’s surface which makes it extremely difficult and time-consuming to track them and conduct research.

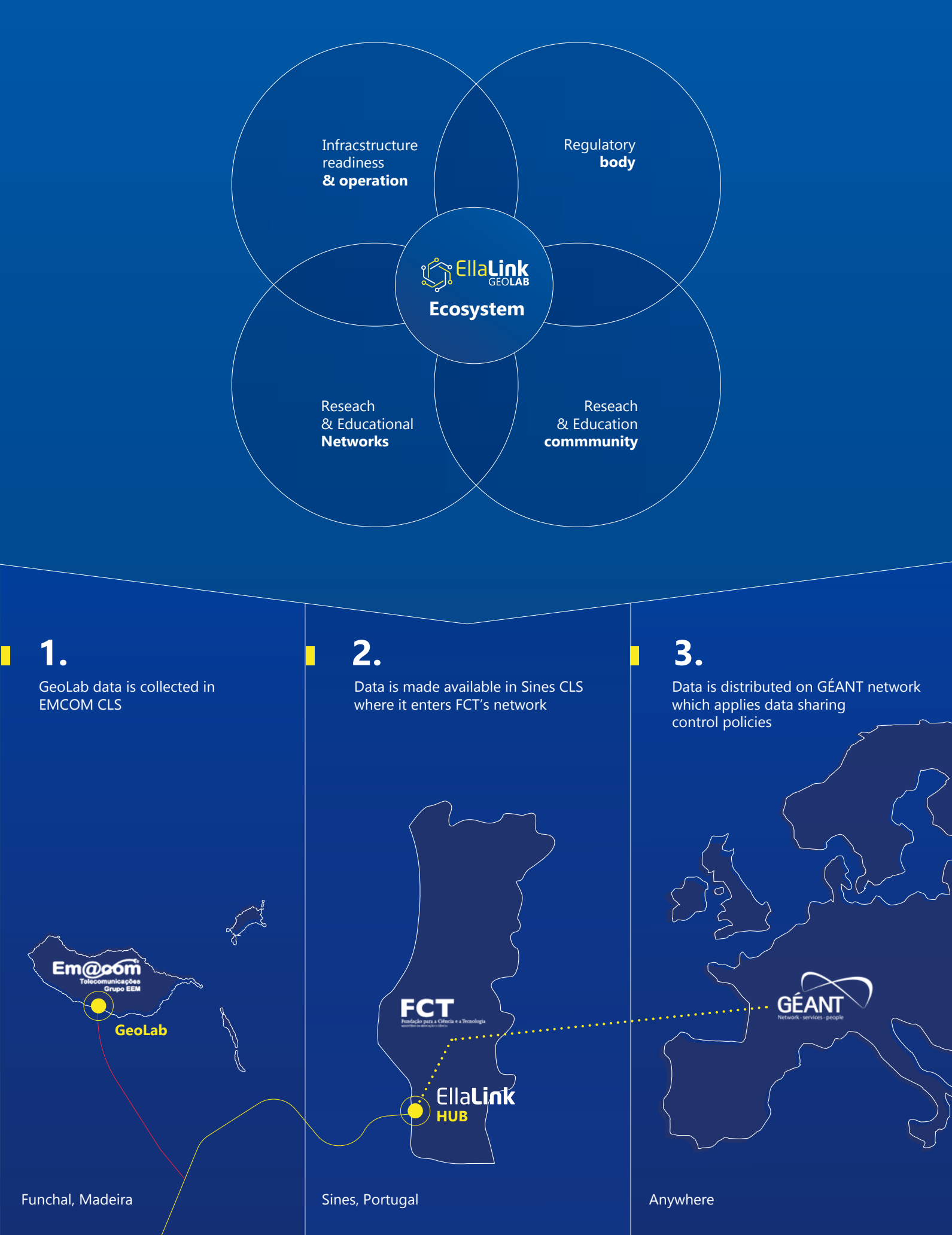


Figure 2. Overview of the GeoLab architecture



Different scientific and technical uses

The cable itself is limited to a 75km stretch between Funchal, Madeira, and the junction box on the main EllaLink cable. The cable contains the GeoLab fibre pair and the primary EllaLink telecoms fibre pair. The sensing range for any equipment installed on the GeoLab fibre is limited to the area directly surrounding the cable span from Madeira out to the junction box of the main EllaLink cable in the Atlantic.

GeoLab could not only advance science but also provide economic benefits to society at large through:

- **Tsunami warning**

GeoLab could be used to test associated technologies and processes for tsunami warnings in the Atlantic. Madeira has historically suffered from cliff instability and coastal destabilisation, which in 1930 resulted in an 8m high landslide-induced tsunami, which killed 20 people along Madeira's southern coast. A facility such as GeoLab could provide the technology demonstration to include submarine cables as sensor to support tsunami warning activities of the Portuguese Institute for Sea and Atmosphere (IPMA), which is responsible for monitoring and alerting Portuguese authorities to such threats.

- **Earthquake detection**

The Madeira archipelago lies in a seismically active region close to the Azores-Gibraltar fault between the Eurasian and African continental plates. The last major earthquake occurred in 2020 with a magnitude of 5.3 on the Richter scale. Although the offshore earthquakes of this size generally cause no damage, the famous Lisbon earthquake of 1755, which is thought to have had a magnitude of at least 8 and caused a devastating tsunami has occurred in the same wider plate boundary zone. By using GeoLab, public authorities would be able to utilise the data from the equipment to monitor and detect when earthquakes occur and understand the tectonics of the area. This will inform civil protection authorities of the seismic hazard to plan for, and allows implementation of early warning system in case of a comparable event in the future.

- **Testing and calibration**

Currently, any equipment or sensor which uses submarine cables can only be tested in an onshore laboratory, unless access to a sub-sea cable system can be gained temporarily. As GeoLab will be available all year round, it can give academics and commercial organisations the opportunity to perform research, testing, and calibration of equipment using an actual sub-marine environment. The facility could provide an opportunity to perform in-depth research on the calibration of cables, potentially leading to discoveries which could reduce costs for cable operators, and installers. The data from the cable could also be used for the calibration and validation of spacecraft-derived data, such as the satellites which are part of the Copernicus project.

- **Long-term environmental impact research (such as climate change research)**

It may be possible to utilise the cable to develop distributed temperature sensing, which would allow long-term monitoring of sub-sea temperature in the region. However, it should be noted that the long-term stability of such a system in the seafloor environment still has to be assessed. Data from Distributed Temperature Sensing interrogators attached to GeoLab, would be beneficial for models and long-term research into climate change. By having a long-term view of the seismic activity in the area, data produced from GeoLab could also contribute to longer-term Earth system research.

A new technical and collaborative solution: GeoLab

GeoLab presents the prospects of accessing a seafloor cable infrastructure, which could easily support existing technologies or ideas from fibre optics sensing, e.g., distributed acoustic/temperature/strain sensing, integrated laser interferometry, polarisation tracking etc. However, It would not have sensors built into the cable or cable repeater system itself.

Supported Technologies

- **Distributed Acoustic/temperature/strain sensing**

Launched laser light undergoes elastic (known as Rayleigh) and inelastic (known as Brillouin and Raman) scattering in the optical fibre. The former enables dynamic but relative measurements (e.g., strain) to be made. This is done by tracking the differential changes in the phase of the backscattered Rayleigh scattering, which is influenced by acoustic (pressure) and shear waves and hence the term DAS (distributed acoustic sensor) used for such systems. Using the intensity of Rayleigh scattering one can also detect losses and imperfections from the fibre itself. This feature is also available in DAS systems. In the case of latter (inelastic scattering), depending upon which scattering regime is exploited, i.e., Brillouin (sensitive to temperature and strain) or Raman (sensitive to temperature only), distributed absolute measurements of strain and temperature can be made. Commercially used DSS (distributed strain sensor) and DTS (distributed temperature sensor) systems which use Brillouin and Raman scattering, enable absolute strain and temperature measurements of the cable, respectively. Such measurements over long-term help visualise the cable movements more reliably and can be used for the long-term environmental impact studies, described earlier. These distributed fibre optic sensing technologies allow a submarine cable to be utilised as a giant underwater sensor, up to the first junction box/amplifier.

- **Laser interferometry**

Laser interferometry measures integrated strain across the whole cable. This type of technique would require both ends of a cable to be instrumented. Earthquake signals have been recorded with this technique, but the localisation of the signal along the cable has only been demonstrated in a laboratory so far. This method works across cables with filters and repeaters. For example, an experiment could be set up between GeoLab in Madeira and the cable landing station at Sines, Portugal, to create a trans-Atlantic seismic sensor.

- **Polarisation of communication channel lasers (SOP)**

State of polarisation (SOP) is a relatively new technique introduced in a blog post in 2020 by Google and a recent publication. It uses active optical fibre cables, used for telecommunications and measures, at the receiving end, the light pulses of the laser which are corrected for distortions experienced during the traversal along the cable. These distortions are corrected by digital signal processing. One of the properties of the laser light, that is tracked as part of the optical transmission, is the state of polarisation (SOP). The SOP changes in response to disturbances along the cable, and tracking these disturbances. enables the detection of seismic activity. Such a technique could in theory be used to turn a standard telecommunications cable into a trans-Atlantic seismic sensor.

⁽¹⁾<https://science.sciencemag.org/content/361/6401/486>

⁽²⁾<https://cloud.google.com/blog/products/infrastructure/using-subsea-cables-to-detect-earthquakes>

⁽³⁾<http://dx.doi.org/10.1126/science.abe6648>

Proof of Concept Campaign with FEBUS OPTICS



Figure 3: FEBUS A1-R DAS system

FEBUS OPTICS is an innovative company based in Pau (France), that brings a new generation of optical fibre-based sensor system to the market, for the maintenance and monitoring of infrastructures. Its patented technology uses state-of-the-art optical physics to measure temperature, strain and vibrations of a structure or soil over tens of kilometres. FEBUS manufactures DAS, DSS, and DTS equipment, and provides high performance equipment, solutions, and its expertise to a wide variety of markets.

The FEBUS A1-R, a Distributed Acoustic Sensing (DAS) system developed by FEBUS OPTICS, is an interrogator that can turn a fibre-optic cable into thousands of acoustic sensors. It is a single-end device which analyses the backscattered light generated by the interaction between the intrinsic presence of asperities along the fibre and a closely monitored pulse of light sent by the interrogator. This backscattered light is submitted by the stretches along the cable, and contains the information on the strain generated by acoustic waves at its neighbourhood. This strain is expressed in nm/m. More commonly, DAS releases data expressed in strain rate, expressed in nm/m/s, corresponding to the temporal derivative of the strain. The FEBUS A1-R has been developed with the aim of reaching both short and long (around 50km) distances, with the possibility of variations of the spatial and temporal resolutions. It is a broadband device able to reach frequencies from the order of 1mHz to 100kHz.

The FEBUS A1-R was installed in Funchal, Madeira, from the 4th to the 9th of February 2021. It acquired data along the 56.5km-cable installed in the seabed. Figure 4 shows an example of data acquired during this acquisition campaign. For this survey, the spatial resolution is fixed to 20m with a sampling of 10m and a cut-off frequency set to 250Hz.

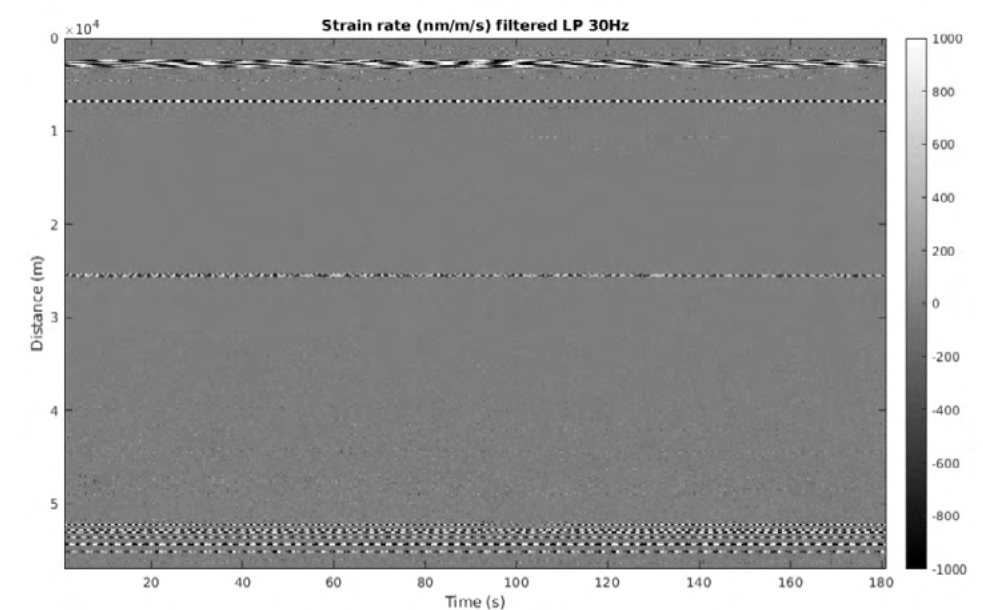


Figure 4: Results of 3 minutes DAS acquisition along the 56.5km-fibre deployed offshore Funchal, Madeira. DAS data are expressed in nm/m/s and are here filtered with a low-pass filter at 30Hz

Different parts of the signal with higher strain values can clearly be observed. From 2,250 to 4,500m, the area corresponds to the entrance of the fibre-optic cable in the water (Figure 5). The generated signal is associated with the very low frequency interactions between waves and shallow seabed. Two major orientations of the signal can be observed, corresponding to the back and forth movement of the waves through the littoral zone. After this area, the cable might be plunging into higher depths leading to the disappearance of these interaction phenomena.

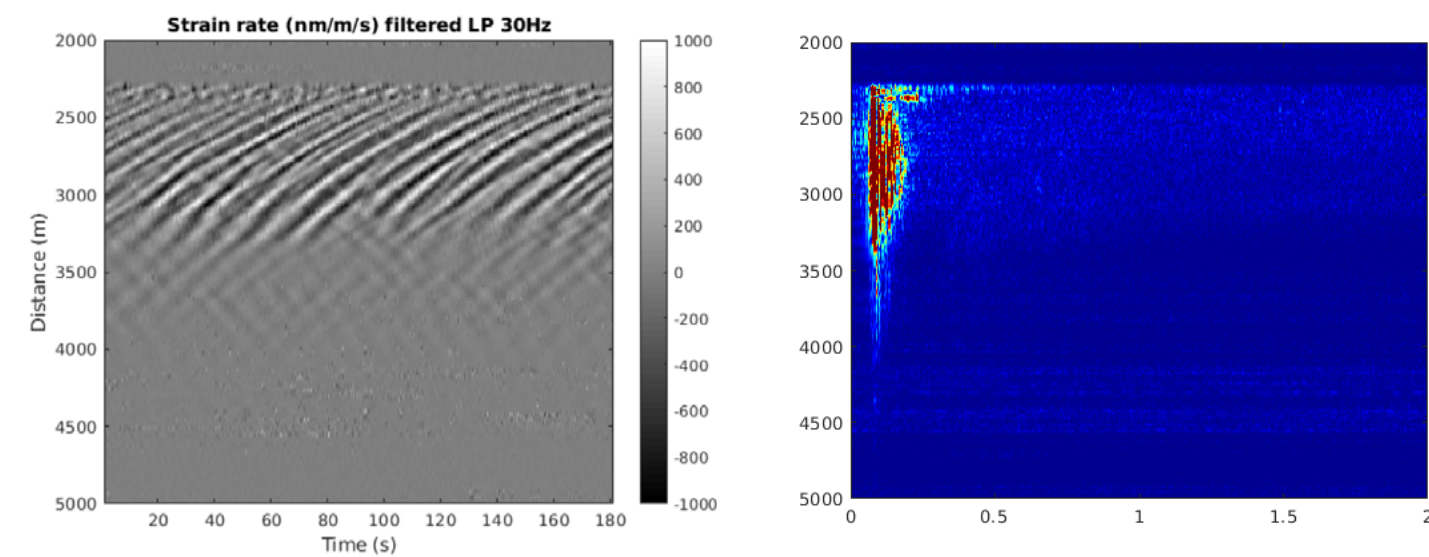


Figure 5: Strain rate recorded at the entrance of the fibre in the water (2.25km) filtered with a low-pass filter at 30Hz. The shallow water ends after around 4.5km of cable. Right: Frequency content of strain rate signal along the fibre

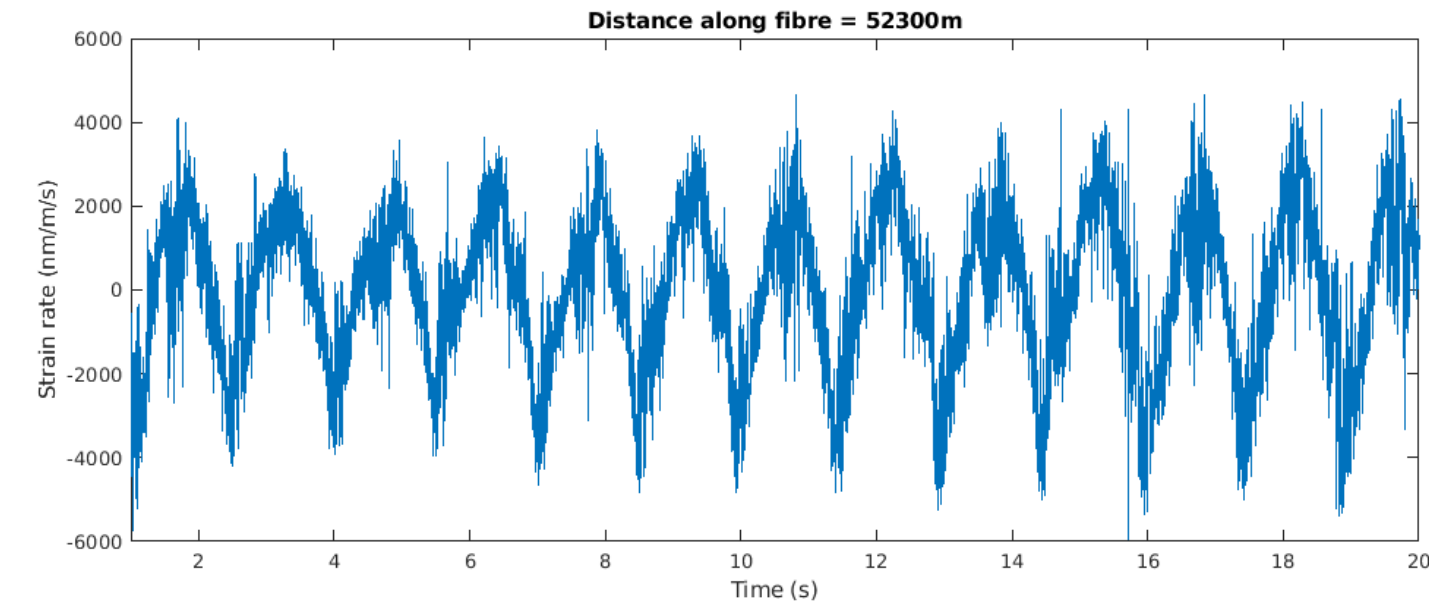
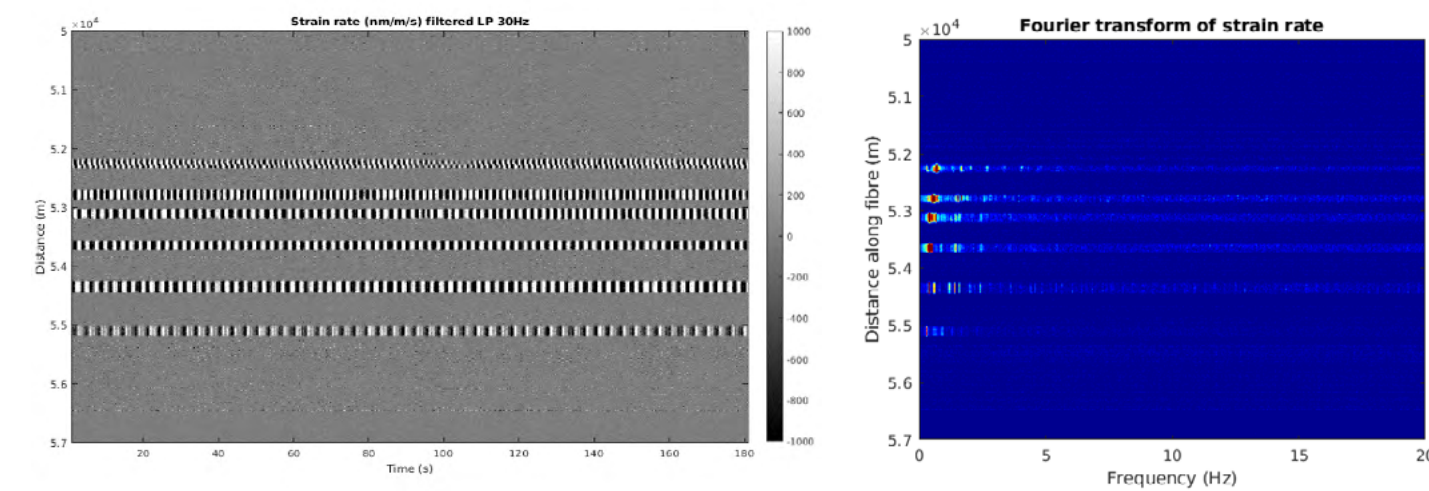


Figure 6: Top left: Strain rate along the end of the fibre (from 50km to 56.5km) filtered with a low-pass filter at 30Hz. Top right: Frequency content of strain rate signal at the same distance. Bottom: Strain rate signal at 52,300m in nm/m/s

The presence of high oscillations can be seen at various positions along the cable. An example of these oscillations is given in Figure 6. The frequency content of these signals is very low, under 5Hz. These oscillations are associated with the parts of the fibre-optic cable that are not coupled with the seafloor and are vibrating at defined frequencies like a guitar string. Because they represent zones of high risks of a potential break, these spotted areas must be closely monitored.



GeoLab Requirements

- Physical access to the cable
- Access to the data generated on the cable
- Governance for GeoLab

PHYSICAL ACCESS

During the operation of GeoLab, the intention is to provide opportunities for researchers to apply for access to GeoLab infrastructure in order to run experiments. When no external experiments are scheduled, DAS (or other equipment) would be installed (subject to financing) to ensure continuous monitoring of the environment around the fibre, and for the benefit of the local area and long-term research.

It is envisioned that GeoLab itself will be technology-agnostic for equipment installed on the fibre cable. Instead, it will allow different technologies and equipment to be installed on the land-based end of the fibre.

For those performing experiments at GeoLab, detailed information about the specification of the fibre will be provided, such as:

- Fibre path
- Fibre depth profile
- Fibre standard specification (i.e. ITU-T, IEC, BS-EN)
- Fibre specification categorisation/type
- Fibre minimum and maximum mode field diameter (MFD)
- Fibre mode field diameter tolerance
- Fibre attenuation
- Micro bending loss
- Polarisation-mode dispersion (PMD)

This information will be released once the required paperwork has been signed off (see the Governance section).

The laboratory will be located within the Madeira cable landing station of the EllaLink cable system. This is a secure site, and subject to access control for authorised personnel only.

Access to the laboratory will be by way of an agreement between the researcher/research group/research project and the GeoLab governance board, for a period of time agreed between the parties, on a case-by-case basis. Access will allow a research group to bring hardware that can fit within a standard 42U comms rack. The rack will have a dual 32A redundant power supply, with an internet connection via the FCT/FCCN Portuguese research and education network at a speed of up to 100Gbps.

The connection to the GeoLab fibre-pair will be presented with an angled physical contact (APC) connector, to minimise backscatter.

Secure | Fast | Diverse | Open





DATA STORAGE

While the final data storage architecture still needs to be fully designed, it is envisioned that it will comprise a POSIX-compliant distributed file system, for example, Ceph, that is encrypted with an SSL or X.509 certificate. Access to the file store will be restricted through access control and a VPN, so that only the equipment in Madeira, and those systems within the VPN can access the file store. This could be achieved using the eduTEAMS AAI platform.

This data store would be supported with an FTP server, used to distribute the files from the file store to researchers, or whoever wishes to access the data, globally. In the interim, it is suggested to set up an FTP server with 900 TB of space, to which researchers can upload their data directly from GeoLab using software such as GridFTP from the GeoLab site. The FTP repository will be hosted by FCCN/FCT on mainland Portugal.

The raw data from experiments run by visiting researchers will initially be accessible to the researcher/s working on the experiment, civil protection, and government authorities. The data will remain under an embargo for 2 years, after which the raw data will be made available to the wider scientific community. Alternatively, whenever a GeoLab-managed piece of equipment is used and not associated to an independent research project or group, the data will immediately be made available to civil protection and government authorities. After 2 weeks, the raw data will be released to the public via the same FTP repository.

The envisaged way of disseminating the data is to notify the projects and infrastructures within the ENVRI-FAIR cluster project about the data's availability for processing. The raw data will be available to download for 2 years before it is deleted. It is hoped that an arrangement can be made with one of the cluster infrastructures for long-term archiving of the data. Long term archival is essential as natural phenomena often do not repeat, and some of the science targets imply repeat measurements to capture long term trends.

GOVERNANCE

A partnership agreement between the organisations providing GeoLab infrastructure is suggested. The partnership agreement would set out what each member was providing, for example:

- Storage
- Physical space and access at the cable landing station
- Access to a fibre pair for the purposes of scientific research and civil protection
- Data transmission back to mainland Portugal and the global academic R&E network

The partnership agreement would also set out the high-level responsibilities of the organisations involved, and who would cover the costs for GeoLab, or who would be the entity financially responsible for this laboratory. It is suggested that a Portuguese national body or not-for-profit entity fulfil this role, as this laboratory concept will be located in Portuguese territory.

It is suggested that this body apply for European Regional Development and / or European Social funding to support the operation of the infrastructure, and also to fund capital expenditure for DAS, which could then be used whenever no experiment is present.

Research groups or projects who use the laboratory would be asked to contribute towards the running costs of the laboratory for the time they use the site. Further financial support for the running costs of the site could come from civil protection or regional government, as the data produced would be utilised in earthquake-, volcano-, and tsunami-monitoring for the local region.

It is proposed that the partnership constitute a board of 5 people from the following backgrounds: 2 infrastructure providers (such as the cable owner and FCN/FCCT), 3 scientists (Seismology, Oceanography, Cetology).

Some examples of the responsibilities of the GeoLab committee are:

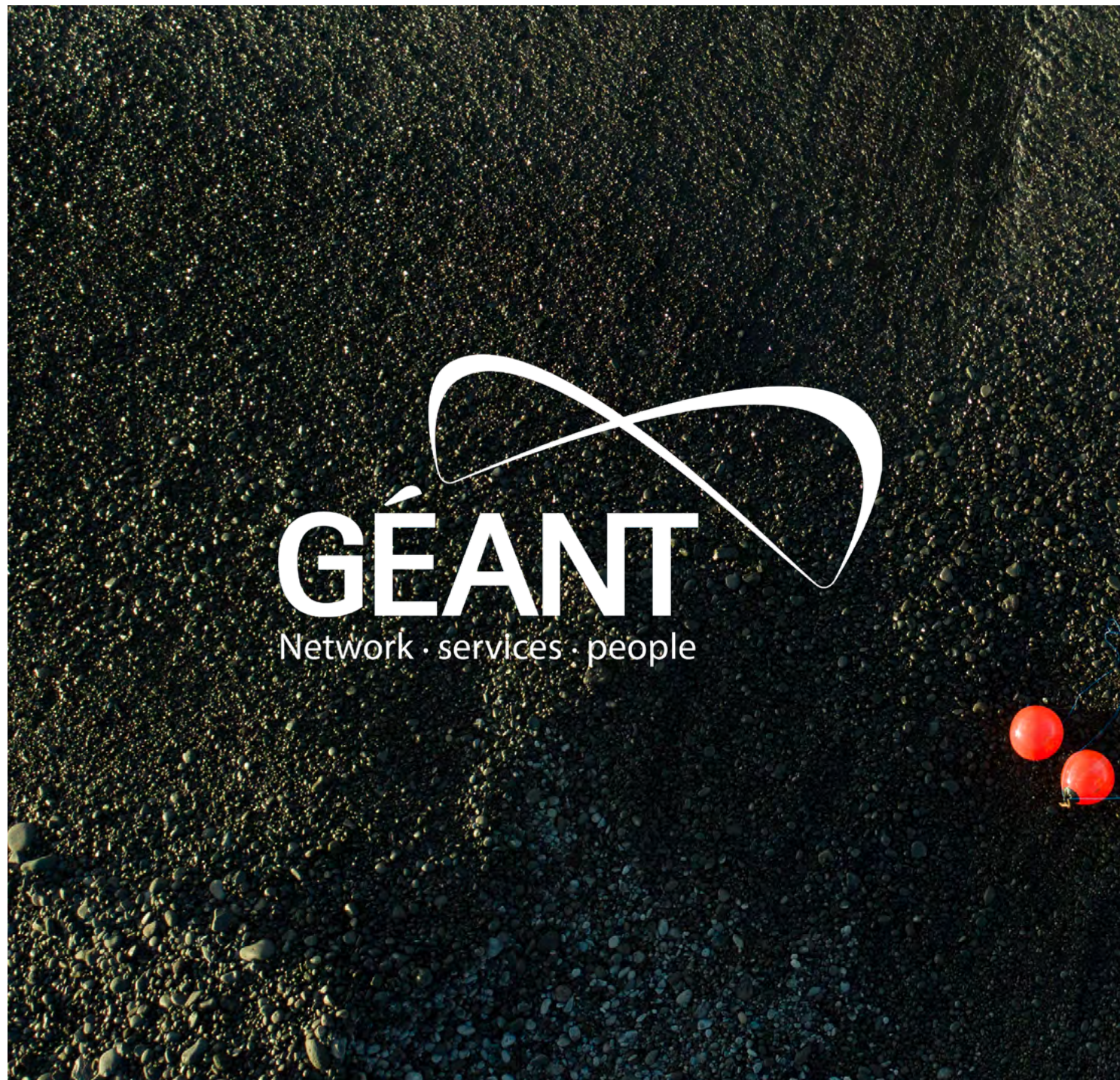
- Setting the rules for accessing GeoLab.
- Selecting the projects to use GeoLab.
- Managing the diary for when projects can use GeoLab infrastructure.
- Setting and updating the data access rules such as embargo periods etc.
- Approving and updating the access agreements.
- Approving disclosure of detailed fibre specifications for research groups accessing public information.
- Acting as the reference point for national government and civil protection, with regards to GeoLab.

A collaborative initiative

A number of partners have come together to create GeoLab:

- GÉANT have been involved in developing governance model for access to the infrastructure in a consultancy-coordination role.
- Hosting of data, network connectivity and data interface will be provided by FCCN.
- The fibre pair infrastructure and on-site hosting in Madeira will be provided by EMACOM and EllaLink.

GeoLab would not be possible without the involvement of our project partners.



1. GÉANT

GÉANT is the leading collaboration on network and related infrastructure and services for the benefit of research and education, contributing to Europe's economic growth and competitiveness.

- **Support**
We provide practical support for members, educators, researchers and other partners to collaborate, innovate, share knowledge and agree on policies and strategies.
- **Network operations**
We plan, procure, build and operate large-scale, advanced international high-speed networks, including the 500Gbps pan-European GÉANT network.
- **Events**
We organise events such as workshops, meetings, training and conferences, including TNC Europe's largest networking conference for research and education.
- **Services**
We develop, operate and support services relating to such areas as trust and identity, security and certification, mobility and access, and media and real-time communications.
- **Expertise**
We gather community expertise, and provide staff expertise in procurement, project management, community engagement, network operations, and outreach including dissemination and training.
- **Collaboration**
We liaise with other e-infrastructure organisations, user communities, industry and with the European Union.

Many of our task forces, special interest groups, workshops, conferences, and other activities are open to anyone with appropriate expertise, manpower, equipment, or services. Other activities are carried out by staff or partners in the context of a specific project or as part of the core business of GÉANT.

2. EMACOM

EMACOM is a Portuguese telecommunications operator wholly owned by the Empresa de Eletricidade da Madeira and have its activity based at Madeira and Porto Santo islands. Since its inception, the main goal of the company is to provide telecommunications services as a neutral wholesale supplier in Madeira, operating in the market for terrestrial and submarine connectivity, promoting telecommunications services, technological development and new business opportunities in the region.

It's with great satisfaction that EMACOM in partnership with ELLALINK deploys the first telecommunications submarine cable with SMART capabilities, positioning Madeira as a platform for collection and storage of scientific information, allowing real-time access to the data on the GEANT network. This is an important milestone for this autonomous region that will allow in the future the development of new scientific infrastructures, capabilities and competences.



Em@com
Telecomunicações
Grupo EMM



FCT

Fundação para a Ciência e a Tecnologia

MINISTÉRIO DA EDUCAÇÃO E CIÊNCIA

3. FCT

Fundação para a Ciência e a Tecnologia is the Portuguese public agency that supports science, technology and innovation in all scientific domains under the responsibility of the Ministry for Science, Technology and Higher Education. FCT was founded in 1997, succeeding the Junta Nacional de Investigação Científica e Tecnológica (JNICT). Since March 2012, FCT has coordinated public policies for the Information and Knowledge Society in Portugal, after the integration of the Knowledge Society Agency-UMIC.

FCT's mission is to continuously promote the advancement of knowledge in science and technology in Portugal, attain the highest international standards in quality and competitiveness, in all scientific and technological domains, and encourage its dissemination and contribution to society and to economic growth.

FCT pursues its mission through the attribution, in competitive calls with peer review, of fellowships, studentships and research contracts for scientists, research projects, competitive research centres and state-of-the-art infrastructures. FCT ensures Portugal's participation in international scientific organisations, fosters the participation of the scientific community in international projects and promotes knowledge transfer between R&D centres and industry. Working closely with international organisations, FCT coordinates public policy for the Information and Knowledge Society in Portugal and ensures the development of national scientific computing resources.

The results of FCT accomplishments are, in essence, the outcome of the work carried out by individual scientists, research groups and institutions that are funded by FCT.

In 2013, FCCN became a Unit of FCT, whose mission is to plan and manage the RCTS – the Science, Technology and Society Network, which is a digital research infrastructure covering the whole Portuguese territory, that transcends all areas of knowledge.



4. EllaLink

EllaLink will provide telecoms connectivity between Europe and Latin America connecting key financial centres, major data centres and the key populations areas.

EllaLink will be ready for service in 2021, providing the first-ever direct fibres between the two continents with point of presence in Sines, Madrid, Lisbon, Marseille, Barcelona, Fortaleza, São Paulo and Rio and onward connectivity to the USA, Europe, Asia and Africa and the Middle East.

EllaLink

Secure | Fast | Diverse | Open

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Chris is a Senior Research Engagement Officer at GÉANT, an e-infrastructure organisation providing cutting-edge pan-European networking, and trust and identity services exclusively for the research and education community. His role focuses on supporting international user communities and organisations, as well as identifying new technical and political solutions to specific research requirements and challenges. Chris has over 15 years' experience working in the IT and Space industry prior to joining GÉANT and holds a BSc (Hons) in Computer Networks and Security.



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Auke is a Project Manager and Consultant at GÉANT, an e-infrastructure organisation providing cutting-edge pan-European networking, and trust and identity services exclusively for the research and education community. In this role he is responsible for the delivery of externally funded projects and providing technology consultancy with the focus on cloud and disruptive technologies. Auke has over 10 years' experience working in the IT, management consultancy and Internet governance industry prior to joining GÉANT and holds a BSc in Information Science and an MSc in Information Studies (Major: Information Systems).



Camille
Jestin



After obtaining her Master's degree in geophysics at the EOST Engineering school of Strasbourg, in 2014, Camille Jestin joined the Norwegian company Petroleum GeoServices as quality control engineer onboard seismic vessels. She then started a PhD in geophysics, focussed on seismology, at the Institut de Physique du Globe in Strasbourg and defended in November 2018. Since December 2018, she works within FEBUS OPTICS as geophysicist, for the applications of Distributed Fibre Optic solutions to geophysical purposes.

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