Report of Transnational Access Projects

Project ID: *101058518*

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Project title: *Deep Learning Early Warning Platform for Subsea Cable-Seabed Interaction Sensing and Monitoring*

Project acronym: *DEEP-SENSE*

Hosting installation: *GFZ Helmholtz Centre for Geosciences (GFZ), Germany, Regional Agency for the Development of Research, Technology and Innovation (ARDITI), Oceanic Observatory of Madeira*

Hosting team: *Dr. Afonso Loureiro, Universidade de Lisboa,*

Period of access: *19-22.04.2026*

Report of activities:

This project exploits the GeoLab research infrastructure (a 56 km optical-fibre cable installed along the southern coast of Madeira Island, Portugal) to develop and validate a physics-informed deep-learning (PIDL) framework for seabed–cable interaction monitoring. The primary dataset consists of Distributed Acoustic Sensing (DAS) recordings collected between 26 October and 3 November 2023, totalling approximately 7 TB of raw strain measurements. The cable forms the shore-end segment of the EllaLink telecommunications system and is archived under FDSN network code 3X (2023) through GEOFON / GFZ Data Services.

The central research goal during the current phase has been to characterise the ambient seabed environment around the cable corridor in sufficient detail to attribute observed strain anomalies to specific physical mechanisms. This characterisation covers seabed geology, geomorphology, sediment dynamics, oceanographic forcing, and seismic-fault context, collectively providing the physical basis required to train and validate the PIDL model.

Environmental and Geomorphological Characterization

The primary activities during the reporting period centered on assembling a multi-source environmental dataset to underpin the PIDL framework. The following domains were investigated:

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- *Seabed geology and sediment type: Bathymetric and sub-bottom profiling data were compiled to map the sediment cover along the cable route (see fig. 1), distinguishing volcanic bedrock outcrops from unconsolidated pelagic and hemipelagic sediment drapes.*
- *Seismic fault condition: Available earthquake catalogues and published fault-trace maps (e.g., Hensen et al. 2019) for the Madeira–Tore Rise region were reviewed to identify active tectonic structures that could influence cable dynamics through ground shaking or fault creep.*
- *Wave climate and direction: Climate data and CMEMS (www.data.marine.copernicus.eu) reanalysis products were used to extract significant wave height, peak period, and mean wave direction for the Madeira sector, enabling assessment of wave-induced near-bed current velocities over the inner shelf.*
- *Sediment transport processes and rates: A dual sediment-transport regime was identified. In shallower depths (< ~500 m), wave- and current-driven processes dominate near-bed sediment mobility. In the deep-water section (> ~1,500 m), episodic turbidity currents are the principal transport agent, consistent with the canyon system morphology south of Madeira (Roque et al., 2022, 2023).*
- *Abyssal hill morphology and erosion potential: The presence of abyssal hill structures in the deep section of the cable corridor was assessed to evaluate their role in focusing bottom-current acceleration, which could promote sediment erosion and scour around the cable.*
- *Correlation with measured strain: The compiled environmental dataset was cross-referenced with along-cable strain statistics derived from the DAS records to establish which geomorphological conditions correspond to elevated cable loading.*

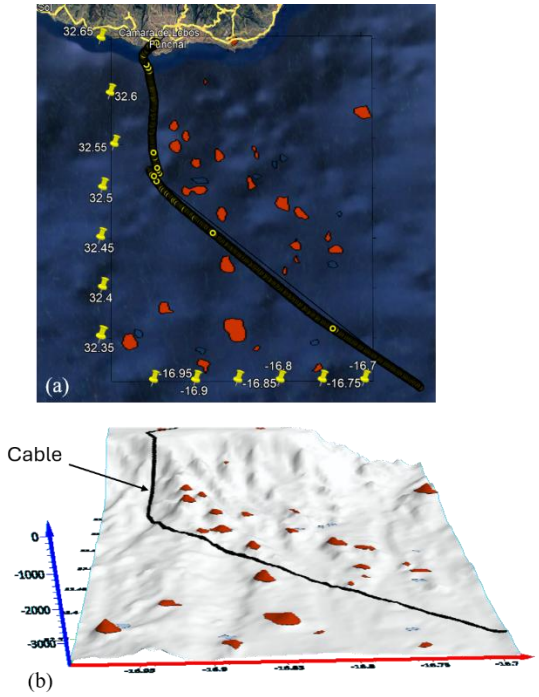

Fig. 1. Geometry of the seabed along the cable route

Key Results: Strain Anomaly Locations

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Analysis of the 7 TB DAS dataset, based on Loureiro et al. (2025), identified four sections of the cable exhibiting statistically elevated root-mean-square (RMS) strain, each correlating with a distinct geomorphological feature. Pronounced strain anomalies were observed at approximately 9.5, 13.5, 26, and 53 km along the cable. The 9.5 km and 13.5 km segments are interpreted as potential free-hanging sections, whereas the remaining anomalies are more consistent with seabed sediment–cable interaction processes.

Project outcomes:

Data Archive and Access

The GeoLab DAS dataset is archived and publicly accessible through the GEOFON / GFZ Data Services infrastructure under FDSN network code 3X, year 2023. Access is available via standard FDSN web services and S3-compatible object storage (Loureiro et al., 2025). The data analysis to detect strains is ongoing.

FDSN Network Record: https://fdsn.org/networks/detail/3X_2023/

GEOFON / GFZ Archive (DOI): https://geofon.gfz.de/doi/network/3X/2023

VA Installation / Network ID: FDSN Network 3X, 2023 — GeoLab (ARDITI, Portugal)

Data access method: FDSN web services (fdsnws-station, fdsnws-dataselect) and S3 object storage

Software and Digital Products

The primary software tool used for raw data ingestion is simpleDAS, an open-source Python library developed by ASN Norway for reading and processing ASN OptoDAS files. The library is publicly available and was integral to converting proprietary DAS recordings into analysis-ready NumPy arrays.

SimpleDAS GitHub repository: https://github.com/ASN-Norway/simpleDAS

Publications

No publications have been submitted or accepted at this stage.

References

Hensen, C., Duarte, J. C., Vannucchi, P., Mazzini, A., Lever, M. A., Terrinha, P., ... & Nuzzo, M. (2019). Marine transform faults and fracture zones: a joint perspective integrating seismicity, fluid flow and life. Frontiers in Earth Science, 7, 438241.

Loureiro, A., Schlaphorst, D., Matias, L., Pereira, A., Corela, C., Gonçalves, S., & Caldeira, R. (2025). First DAS observations from the GeoLab fibre in Madeira, Portugal. Seismica, 4(2).

Roque, C., Hernández-Molina, F. J., Madureira, P., Quartau, R., Magalhães, V., Brito, P., ... & Somoza, L. (2022). Interplay of deep-marine sedimentary processes with seafloor morphology offshore Madeira Island (Central NE-Atlantic). Marine Geology, 443, 106675.

Roque, C., Hernández-Molina, J., Brito, P., Madureira, P., Quartau, R., Magalhães, V., & Carrara, G. (2023). Contourite depositional systems offshore Madeira Island: Decoding the deepwater circulation since the Late Cretaceous to the Quaternary in the NE-Central Atlantic. Global and Planetary Change, 225, 104118.