CASE STUDY – SEISMOLOGY

SMART Cables

InSea SMART Cable: wet demonstrator project

Image 1. Satellite image of Sicily, Italy

Background

Historically, the deployment of oceanographic sensors with real-time communications has proven to be demanding in terms of budget, deployment and support requirements.

A global SMART Cable initiative is exploring a number of ways in which these sensors could be integrated into commercially standard telecommunication cables to create SMART cable systems.With planned large-scale carbon storage projects due to commence in the region of the Horda platform, offshore Norway in 2024, NORSAR in partnership with Equinor, undertook the Horda Network project to assess the potential for seismic hazard in the area.

The expectation is that if the scientific community can realise the potential for utilising existing industry and deployment methods to deploy ocean bottom sensors, there is potential to deliver real savings. This would pave the way for increasing ocean bottom sensor density, accelerating research and monitoring strategies for climate change and Earthquake/Tsunami warning.

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World's first SMART cable

In December 2023, Güralp, working with Istituto Nazionale di Geofisica e Vulcanologia (INGV), successfully deployed the Worlds first 'SMART Cable' to monitor seismic activity on the floor of the Ionian Sea.

The 21 km SMART (Science Monitoring and Reliable Telecommunications) cable, is an innovative system developed by Güralp in partnership with INGV for the Italian InSEA SMART Cable Wet Demonstrator project.

The SMART cable project is funded by the Italian Ministry of Research and aims to investigate the effectiveness of seismometers and environmental monitoring sensors deployed in and around the repeater housings of a traditional telecommunications cable. (Howe et al., 2022).

In particular, the project is investigating if the system can be deployed in a commercially standard manner without compromising the scientific or operational value of the data being transmitted by the sensors.

The Observation Area

The selected observation area for the SMART cable is prone to numerous natural hazards including seismicity caused by the nearby Mount Etna. Past events include a major earthquake and tsunami in 1693 that caused ~60,000 casualties in Catania (Tonini et al., 2011).

The in-situ measurements from the deployed seismic and pressure sensors will be crucial for generating reliable tsunami height forecasts for the region and will also aid with improving tsunami warning times.

Figure 1. Map showing the location of the deployed SMART cable

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Güralp Design

The cable system

At one end of the cable there is a Cable Termination Assembly (CTA). The CTA connects to an existing underwater junction box via a wet-mateable connector and jumper cable. It was deployed and connected using an ROV.

The CTA houses the constant current power supply, fibre optic systems and facilitates connection to the sea cathode. The power system uses a single conductor in the telecoms cable and utilises a sea-return via the sea anode.

The repeaters housing the seismic sensors are connected by standard telecoms cable. The final part of the power system is the sea anode which is housed on the final length of cable in the Loop Fibre End Seal.

The repeaters

The InSEA system totals 21km in length and incorporates three instrumented repeater housings and three inline instrumentation pods. The repeater housings are reclaimed from a decommissioned system that has been modified internally by Güralp to incorporate the necessary instrumentation. This allows the system to be tested using industry standard cable-laying techniques.

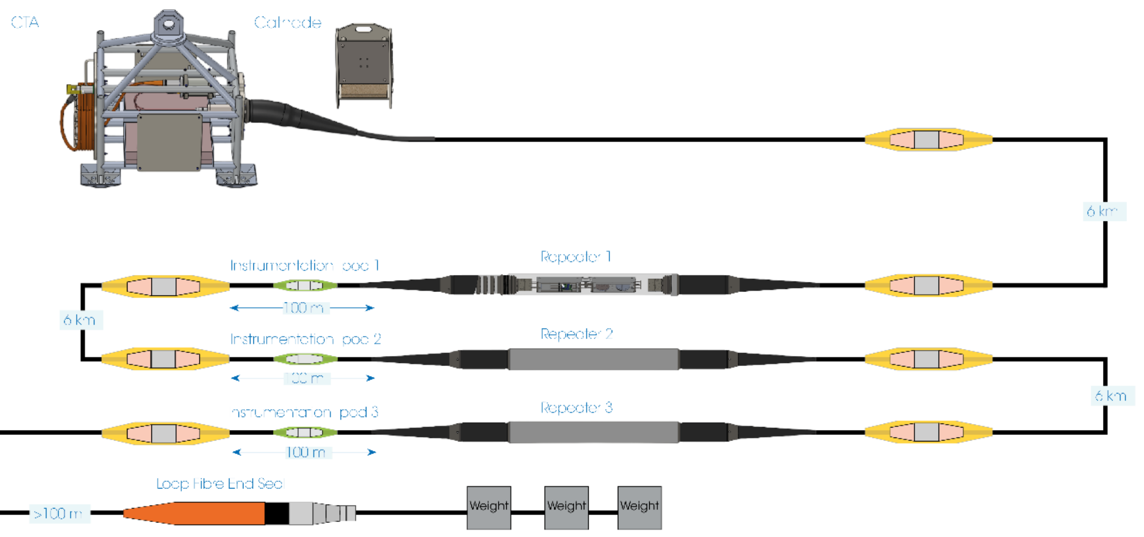

Figure 2. InSEA SMART cable system design

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The instrumentation

The instrumentation in the repeater housings consists of a Fortimus Force Balance Accelerometer ("FBA") and a Certimus Broadband Seismometer ("BBS") mounted within the frame. These instruments are high performance sensors with integral digitisers, utilised for local and teleseismic monitoring. The instrumentation pods house an Absolute Pressure Gauge ("APG") and a premium temperature sensor favoured by the global ocean science community.

Image 2. Fortimus

The pod is external from the main repeater and set some distance away to provide the sensors with exposure to the seafloor environment without the risk of heat transfer from the instrumentation in the repeater.

Image 3. Certimus

Additional Ocean Bottom Seismometers

Güralp also supplied three cabled Orcus ocean bottoms seismometers (OBS). The Orcus is an observatory grade station that delivers exceptionally high quality data for research applications. Each Orcus incorporates a 3T broadband seismometer, a 5T broadband accelerometer, a hydrophone and a high resolution Affinity digitiser.

The Orcus were deployed in the same area and at the same time as the SMART cable as part of a related scheme within the InSEA project. They provide a high-quality reference for evaluating the effectivenesss of the sensors located inside the repeater housings.

Image 4. Orcus

Deployment method

The system was installed adhering to a standard method for telecommunication cable deployment using a commercial cable-laying vessel, the Elettra Tlc ship 'Antonio Meucci'. The ship has a full suite of fibre optic termination equipment and utilises dynamic positioning to ensure accurate placement of the subsea cable.

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A dockside test was undertaken before the system components were loaded onto the vessel to ensure all instrumentation and hardware was working as expected.

Once onboard the repeaters and instrument pods were spliced into the main cable, and the loop fibre end seal fitted.

The cable connections required seven universal joints to be made in the 21 km cable, which was contracted by Güralp to specialist contractors, Global Marine.

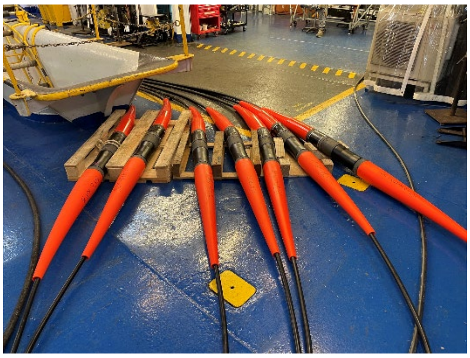

Image 5. The seven universal joints required to splice the repeaters into the cable

Deploying the system

The CTA was deployed via winch and connected to an existing junction box on the seafloor using a remotely operated vehicle (ROV). With the CTA in place, the 21 km cable system could be installed following the predefined route.

The SMART cable was installed approximately 30 km off the coast of Catania with full deployment taking 36 hours.

A bathymetry map was utilised to ensure the planned cable path achieved an installation depth in the region of 2,000 m and avoided sharp deformation areas or assets already located on the seabed.

Image 6. CTA being deployed

Image 7. Repeater being deployed

Power and data acquisition

Data is streamed via cable to a shore station in Catania Harbour run by the National Institute for Nuclear Physics (INFN) which also supplies power to the system. Timing is provided using GNSS with Precision Time Protocol (PTP) synchronisation.

Güralp Discovery software provides an instant view of seismic and temperature data alongside instrument state-of-health data and control over data recording on the instruments.

Image 8: INFN Shore station in Catania Harbour

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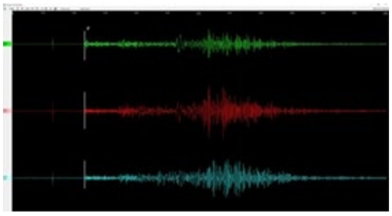
Outcome

The InSEA Wet Demonstrator SMART cable instruments have provided high quality seismic data for teleseismic, regional and local events.

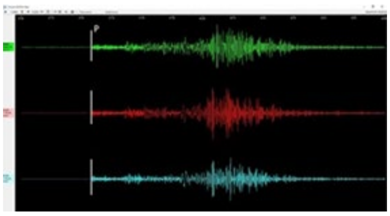
A Güralp Orcus OBS was deployed at the same time as the SMART cable, as part of a broader InSEA project, in close proximity to the three repeaters. Data from the Orcus OBS (CALIPSO station) is given as reference for each event. It is not a direct comparison as the Orcus is an observatory grade instrument, however it does provide a comparison for the SMART cable data. The SMART cable waveform data is very closely correlated to CALIPSO waveform data demonstrating successful operation of the instruments housed in the three repeaters

TELESEISMIC EVENT

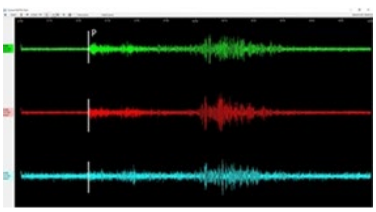
WEST COAST, EASTERN HONSHU, JAPAN
01/01/2024 07:10:13 M_{wpd} 7.4



Waveform data: CALIPSO Station



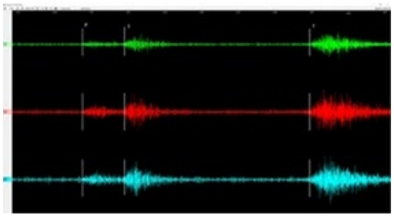
Waveform data: Repeater 1, (Certimus seismometer)



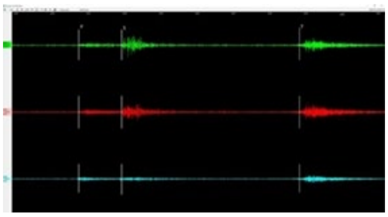
Waveform data: Repeater 1, (Fortimus accelerometer)

REGIONAL EVENT

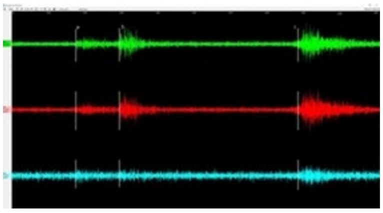
WEST COAST CRETE, GREECE
12/01/2024 03:51:07 M_b 4.7



Waveform data: CALIPSO Station



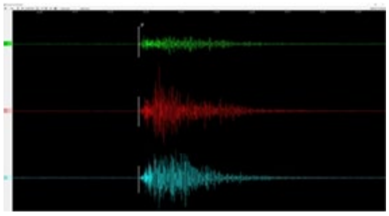
Waveform data: Repeater 2, (Certimus seismometer)



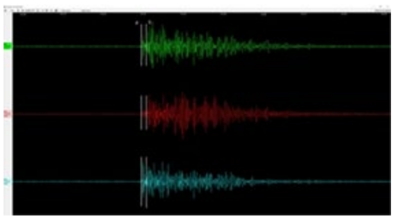
Waveform data: Repeater 2, (Fortimus accelerometer)

LOCAL EVENT

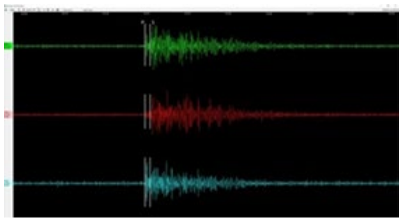
CATANIA COAST, ITALY
14/01/2024 19:53:23 M_L 2.0



Waveform data: CALIPSO Station



Waveform data: Repeater 3, (Certimus seismometer)



Waveform data: Repeater 2, (Fortimus accelerometer)

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The Future

The InSEA wet demonstrator project is a critical step towards wider acceptance and implementation of SMART cable systems globally. The project has demonstrated that high performance seismic and ocean observing sensors can be deployed using standard commercial telecommunication cable-laying procedures.

The broadband sensor's ability to work at any angle combined with the engineering effort to ensure that the instruments were coupled effectively with the repeater housing has resulted in good coupling with the seismic sensor. Initial data would appear to be of a high quality and although not directly comparative to observatory grade OBS data such as provided by the Orcus, we can see with the reference data that it is certainly to be of significant scientific value.

There has already been an increasing level of interest in projects seeking to utilise the SMART cable concept so we are developing our relationships with industry specialists further to ensure that we can respond effectively to any opportunities that arise.
We are committed to further developing this technology and have already identified strategies to explore further improvements to our design.

Vital to our success has been our collaboration with other key parties involved on the project.

"The use of innovative underwater telecommunications cables, i.e. equipped with geophysical and environmental instrumentation, represents a solution to extend observations to marine areas never reached, to have real-time access to observations and to support studies on the climate, oceans, on the structure of the Earth and on natural disasters.

INGV has been very satisfied with the level of project management, engineering support and collaboration that Güralp have demonstrated on this project. I wouldn't hesitate to recommend Guralp as a supplier for future SMART cable projects globally."

Giudditta Marinaro
Head of Multidisciplinary Research on Geosphere-Ocean-Atmosphere Interactions of the Rome 2 Section of INGV

More details and initial data from the project can be found in the InSEA project booklet also available on our website.