UNDERSTAND
OPTIMISE
PROTECT

SMART CABLE

SYSTEMS

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DEPLOYMENT DECK OF THE ANTONIO MEUCCI CABLE-LAYING SHIP, DURING DEPLOYMENT OF THE INSEA SMART CABLE OFF-COAST CATANIA, ITALY

What is a SMART cable?

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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.

The expectation is that if the scientific community can realise the potential for utilising existing industry cable laying 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.

ITU-UNESCO/IOC-WMO Joint Task Force

The advocacy for the SMART cable concept is currently led by the ITU-UNESCO/IOC-WMO Joint Task Force ("JTF"), established in 2012 by the United Nations to investigate the potential of using submarine telecommunications cables for ocean and climate monitoring and disaster warning. This project is hosted by the Ocean Decade programme, Ocean Observing Co-Design: Evolving ocean observing for a sustainable future.

The JTF, of which Güralp is an active member, collaborates with a number of public and private organisations to assess and develop technologies that have the potential to make SMART cables feasible (Howe et al., 2022).

About us

Established in 1985, Güralp Systems Ltd. is a leading global provider of seismic instrumentation and seismic monitoring systems.

We manufacture a wide range of broadband seismic instrumentation for research, civil and industrial applications.

We also have extensive experience in developing ocean bottom systems to house our seismic instrumentation, with projects dating back as far as 1989. We have created ocean floor systems for virtually every type of deployment scenario you can think of and are familiar with accommodating additional multidisciplinary sensors to maximise the system value.

Based in the UK, we have supplied in excess of 50,000 seismic instruments over our nearly forty year history. Our technology is deployed across all continents and in all major ocean basins.

A full service offering

In addition to the instrumentation that we manufacture we also offer the following:

> Bespoke engineering and system design
> Design and supply of turnkey seismic monitoring systems
> Field services, including integration testing and commissioning
> Data archiving and network state of health solutions
> Project management
> Maintenance and after-sales support
> Summary data analysis
> Quality Control
> Compliance monitoring solutions

Designed and built in the UK

All of our instruments and systems are manufactured by our dedicated team at our specialist facilities based fifty miles from London in the United Kingdom.

Our business is certified to ISO9001:2015 recognising our quality management system covering the design and manufacture of low noise broadband seismometers, accelerometers, digitisers and networking equipment for science and engineering. Software design and development.

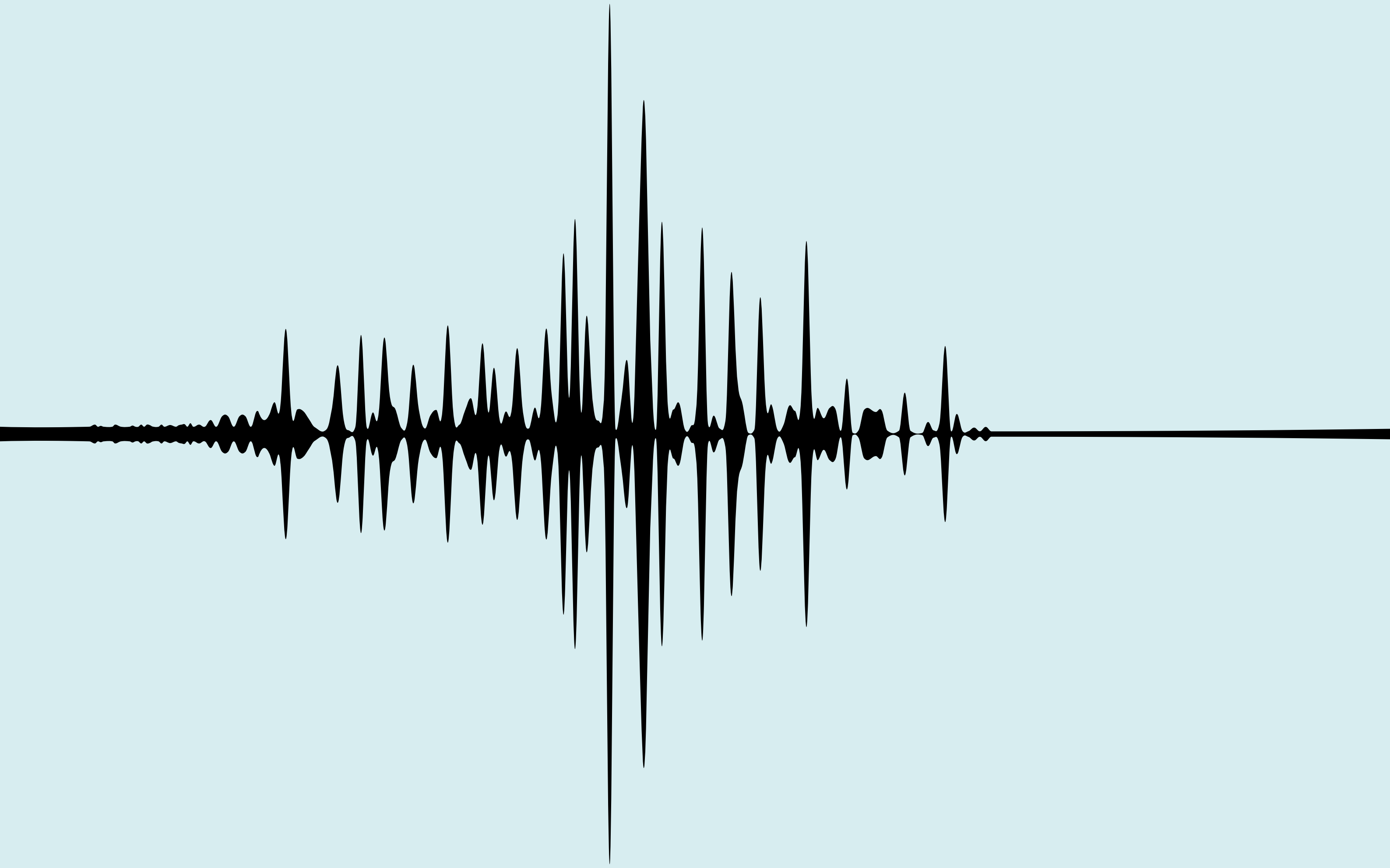
British Assessment Bureau
UKAS MANAGEMENT SYSTEMS 8289
ISO 9001
QUALITY MANAGEMENT

Trusted around the world

We are proud to list governments, leading academic and research institutions and commercial ventures from across the globe as our customers.

We have an impressive history of working collaboratively with leading research scientists to deliver innovative solutions for challenging projects.

As well as suppying our instrumentation to numerous arrays that form part of the CTBT International Monitoring System (IMS) we have also been operating the UK seismic array that contributes to the IMS for more than twenty years.



The importance of broadband

Broadband data is critical for accurate magnitude estimation and event location.

True broadband capability is vital to the effective implementation of a seismic monitoring system where earthquake magnitudes must be accurately quantified.

Earthquake magnitudes are measured from displacement spectra. Only broadband instruments are capable of capturing the full range of displacement spectra, producing a robust estimate of earthquake magnitude. Geophones are limited to measuring higher frequencies, resulting in systematic underestimation of magnitudes.

Viegas et al. (2012)* show that using data from geophones rather than broadband sensors can lead to measurement errors of as much as 0.6 magnitude units, crucial when monitoring seismicity and effectively understanding the source mechanisms.

The Full Energy Spectrum

The moment magnitude of an earthquake is calculated from ground displacement. The larger the magnitude, the greater the amount of low frequency ground motion that cannot be accurately recorded by traditional high-frequency geophones.

Broadband seismometers can record low frequencies, providing accurate magnitude estimates. This is the reason that the world's leading seismic monitoring networks utilise broadband sensor technology to provide accurate earthquake information and alerts.

*Viegas G., Baig A., Coulter W., and Urbancic T., 2012: Effective monitoring of reservoir-induced seismicity utilizing integrated surface and downhole seismic networks: First Break 30, 77-81

Force-Feedback instrumentation provide lower self-noise performance, allowing for the full energy spectrum of natural and induced seismic events to be monitored, even at global distances and with small magnitudes.

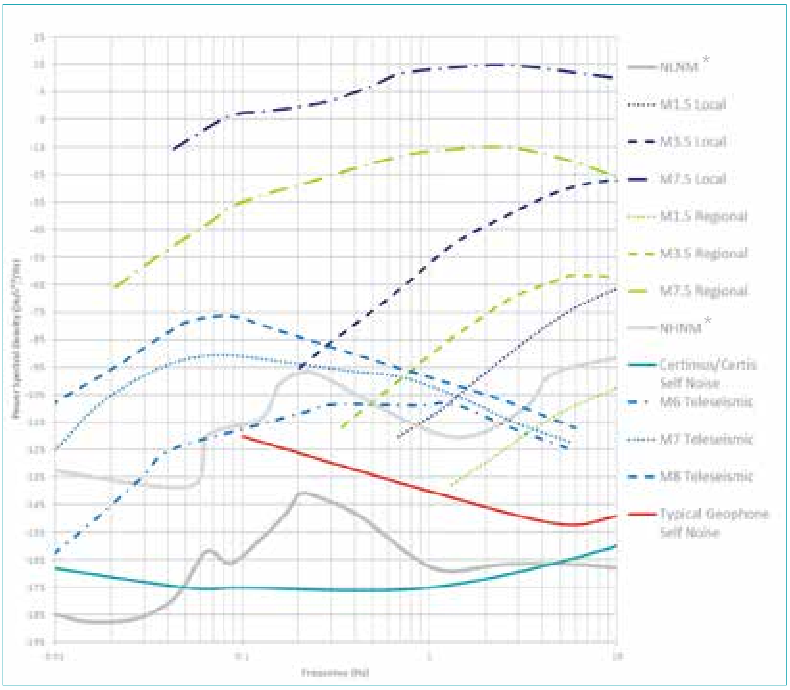


DIAGRAM 1 COMPARISON OF SELF-NOISE OF TYPICAL GEOPHONE VS GÜRALP CERTIS/CERTIMUS BROADBAND SENSOR

* New Low Noise Model/New High Noise Model; Peterson,1993, USGS

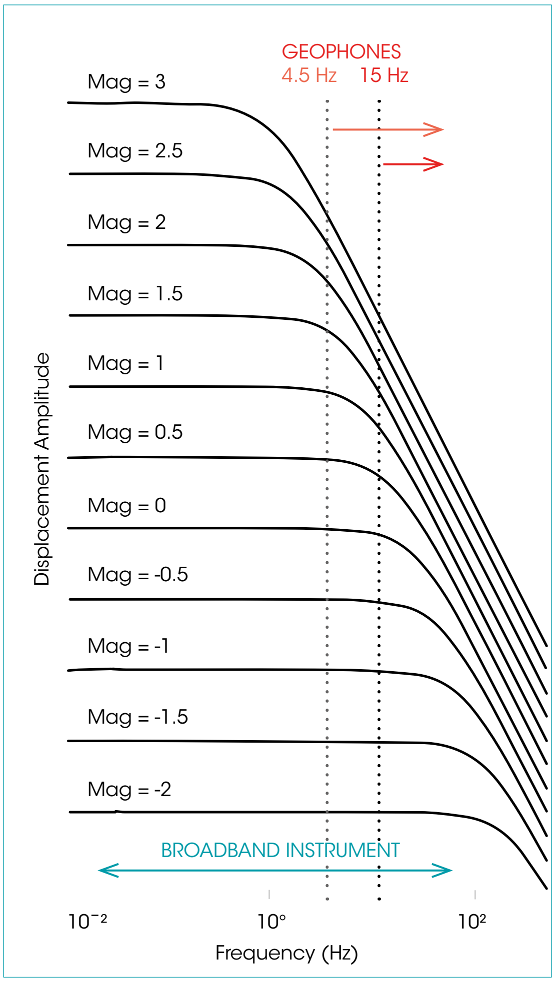


DIAGRAM 2 INSTRUMENT RESPONSE COMPARISON FOR GÜRALP BROADBAND INSTRUMENT AND GEOPHONE

Detect and Locate

Locating the earthquake's hypocenter can determine whether an earthquake is natural or related to human activities (e.g. explosions, fluid injection, etc).

Identifying and accurately recording the earthquake's S-waves provides a much more accurate hypocentre location. S-waves appear clearer on broadband data, making it easier to distinguish near-local events from regional events, reducing the risk of data interpretation errors. S-waves are especially vital for microseismic monitoring because the S-wave of a typical fracture event has 5–15 times more energy than its P-wave.

Broadband instruments are the key to recording the full spectrum of seismic events in an area (shallow vs. deep; small vs. large), allowing for the most complete catalogue of events.

Broadband instruments are ideal for baseline monitoring, crucial for constraining the design and event detection capability of a larger seismic network across a wider area.

Determine Complex Faulting Behaviour

Earthquakes have complicated rupture mechanics. For example, induced events may have highly non-double couple mechanisms, which can be identified using Moment Tensor inversion. The Moment Tensor must be calculated at the lowest frequencies of the seismic source, in which most energy is released. Broadband seismometers offer the optimum solution for accurate determination of source mechanisms across a wide range of natural and induced events.

Lower frequency data from broadband sensors also facilitate large scale tomography studies, helping researchers characterise the properties of the Earth's interior. This is crucial for understanding deep Earth structure and also improves our wider event monitoring capabilities for earthquake and explosion detection.

SMART Cables

ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

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.

A year on, it is still the only SMART cable system, in the water, streaming good quality seismic data.

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.

SMART CABLE REPEATER BEING DEPLOYED

SMART CABLE INSTRUMENT POD BEING DEPLOYED

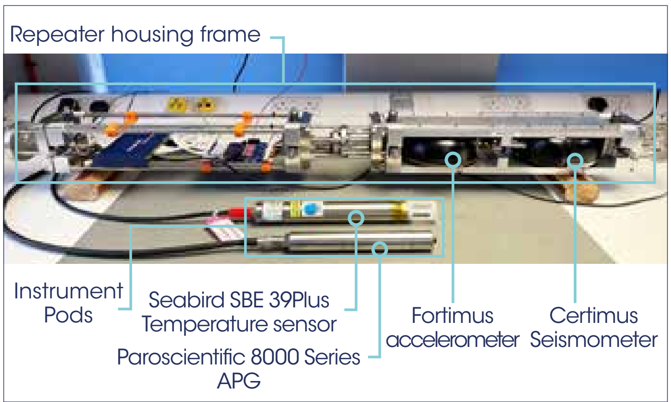
ILLUSTRATION OF THE CABLED REPEATER AND INLINE INSTRUMENT POD ON THE SEAFLOOR

System Design

The InSEA system designed by Güralp incorporates three instrumented repeater housings and three inline instrumentation pods. The repeater housings used for the project were reclaimed from a decommissioned system and modified internally by Güralp to incorporate the necessary instrumentation. This enabled the system to be tested using industry standard cable-laying techniques.

The instrumentation consists of a Güralp Fortimus accelerometer and a Güralp Certimus seismometer mounted within the repeater frame. These instruments are high performance sensors, utilised for local and teleseismic monitoring.

The instrumentation pods, which are external from the repeater and set some distance away, house an Absolute Pressure Gauge ("APG") and a premium temperature sensor favoured by the global ocean science community.



SMART CABLE INSTRUMENT POD BEING DEPLOYED

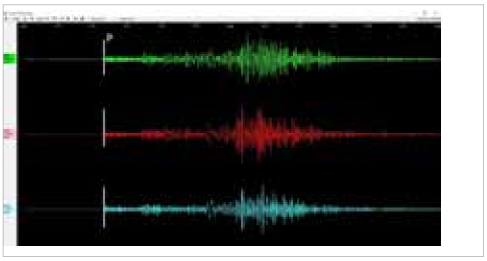
Deployment method

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

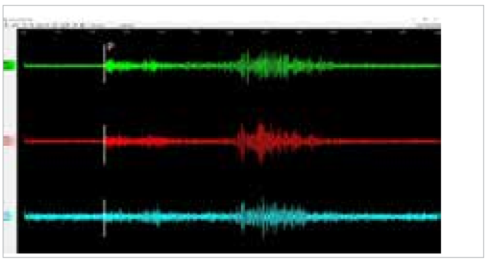
The SMART cable was installed approximately 30 km off the coast of Catania with full deployment taking 36 hours. The data below, produced from one of the instrumented repeaters is from a teleseismic event that occurred just a couple of weeks following deployment.

TELESEISMIC EVENT

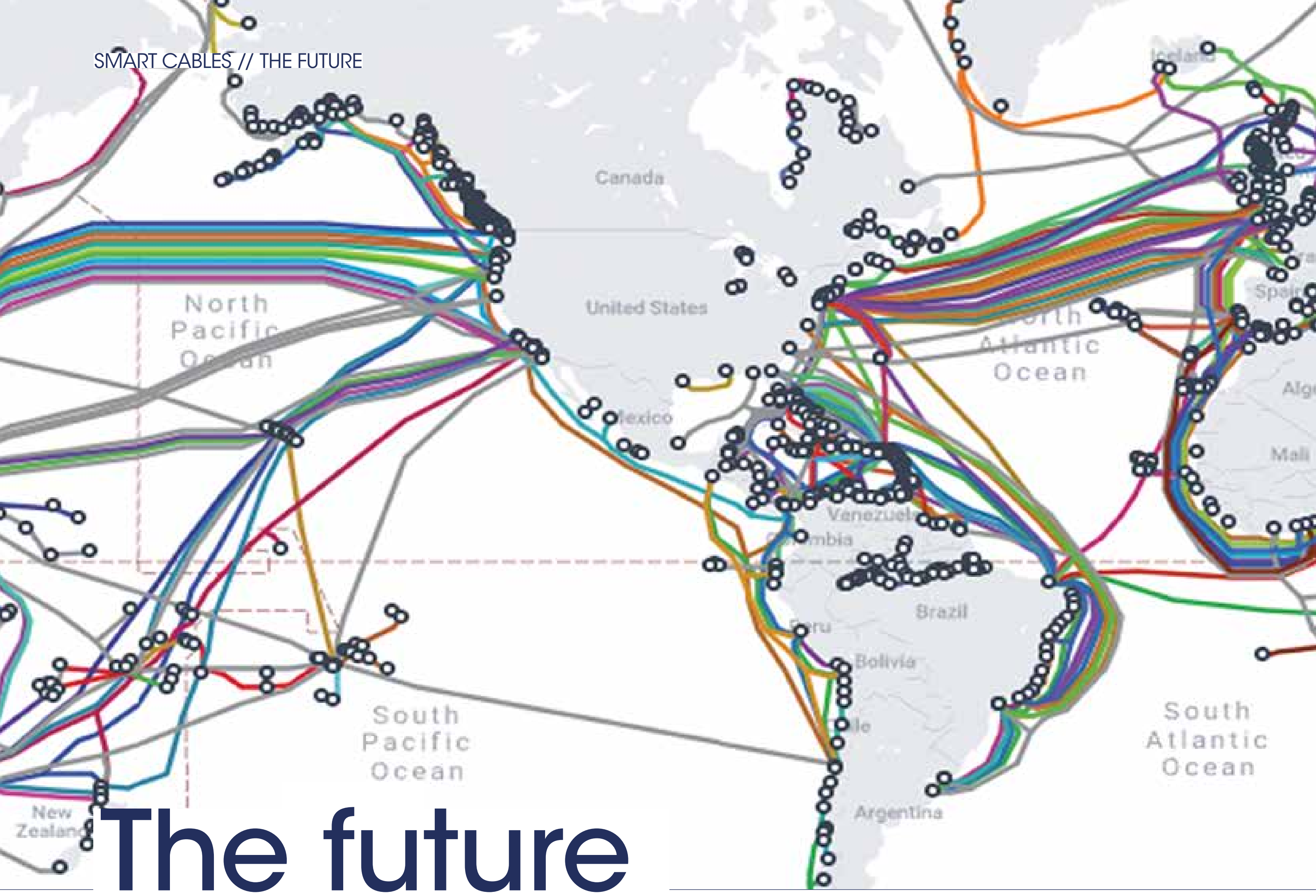
WEST COAST, EASTERN HONSHU, JAPAN
01/01/2024 07:10:13 M_{wpd} 7.4



WAVEFORM DATA: REPEATER 1, CERTIMUS SEISMOMETER



WAVEFORM DATA: REPEATER 1, FORTIMUS ACCELEROMETER



The future

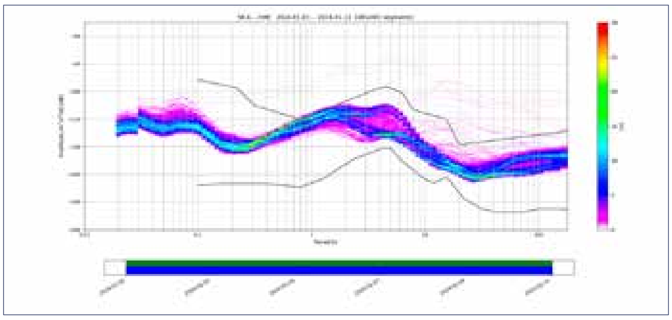
Ease of integration and reliable results

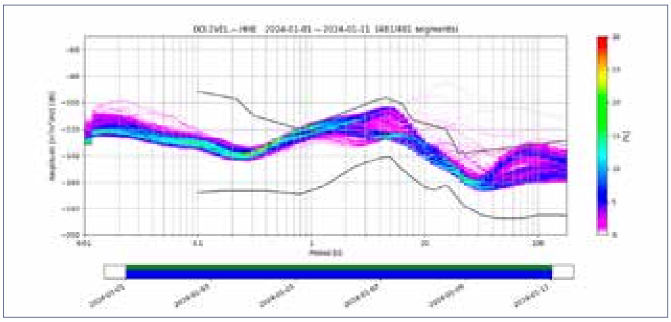
Our ‘next generation’ seismic instruments offer user-friendly features and advanced data communication capabilities that make them ideally suited to integration with SMART cable systems.

The advanced sensor technology utilised in the medium motion Certis and Certimus sensors allow them to operate at any angle. This unique feature removes uncertainty for uncontrolled deployment at depth and eliminates the requirement for gimbal mechanisms to orientate the sensors once on the seabed.

Data quality from our instrumentation is significantly higher than that available from geophones. On the right you can compare the quality of an observatory grade Calipso ocean bottom seismometer with the instrumented InSEA SMART cable repeater.

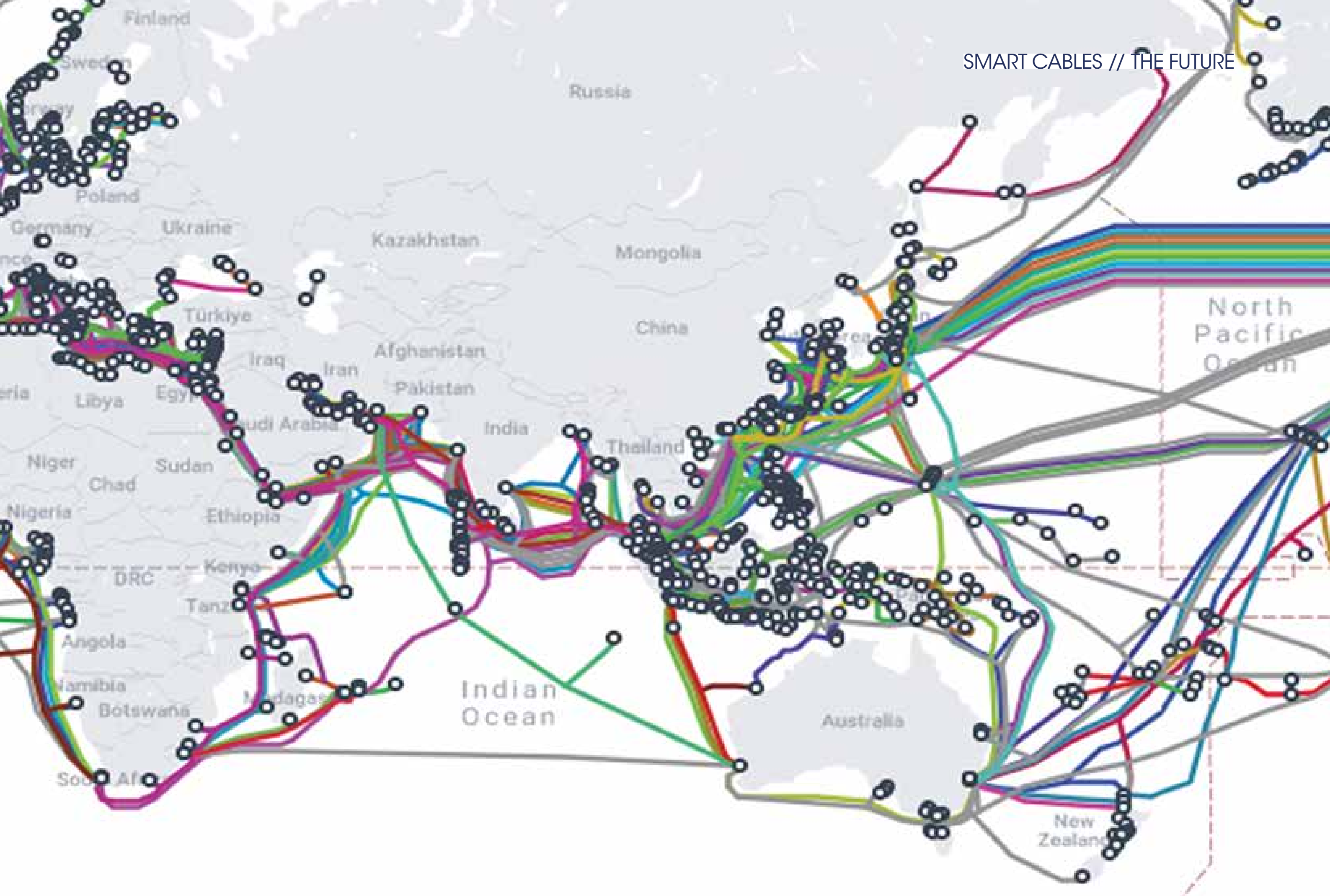
Data comparisons between the SMART cable seismometer and the Calipso station show very close agreement down to periods of ~30 seconds. Even at longer periods, the SMART cable data shows low noise behaviour, remaining below the Peterson high noise model across the bandwidth, confirming the sensor’s suitability for local, regional and global seismic monitoring applications.





TOP: POWER SPECTRAL DENSITY GRAPH FOR OBSERVATORY GRADE ORCUS OCEAN BOTTOM SEISMOMETER*
BOTTOM: POWER SPECTRAL DENSITY GRAPH FOR THE INSTRUMENTED SMART CABLE REPEATER*

**The Orcus OBS and the instrumented SMART cable repeater are located in very close proximity to each other on the seabed.*



Submarine cable map courtesy of TeleGeography

Future Work

Since the InSEA project successfully demonstrated that high performance seismic and ocean observing sensors can be deployed using standard commercial telecommunication cable-laying procedures, international interest in the SMART cable concept is increasing. The ocean is naturally an under-sampled environment due to the inherent capital requirements for instrumentation and deployment, so the possibility of reducing these costs is extremely beneficial for the scientific community.

Building on the concepts successfully tested during the InSEA project, Güralp is now pioneering the development of our mission proven sensor technologies into sensing modules specifically designed to enable the SMART concept to thrive.

Our modular approach to designing SMART instrumentation and the data acquisition system will make SMART sensing capabilities accessible to a wider audience.

The next generation of Güralp SMART instrumentation will be versatile enough to be integrated into a range of cabled inline sensing modules, ranging from dedicated scientific use cases to combined sensing and amplifying repeaters fit for commercial telecom use. The inline methodology will allow a range of stakeholders to leverage more cost-effective deployment strategies.

LEFT TO RIGHT: GURALP'S CERTIMUS DIGITAL SEISMOMETER, CERTIS SEISMOMETER AND MINIMUS DIGITISER

Our proven and high quality seismic sensors are already designed for operation at any angle, and will be further refined for use in smaller volumetric space and with variable power inputs. Güralp's data acquisition system, the Minimus, is already deployed in 1000's of multi-disciplinary seismic stations globally so is a ready-made platform for ingesting data from different categories of sensor, a key feature of future SMART systems.

Güralp is proud to position itself as a leading instrumentation provider that is open to working with industry and academia alike to facilitate the progress of SMART cables globally.

You can stay up-to-date by visiting our SMART cable web-page here: www.guralp.com/smart-cables

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