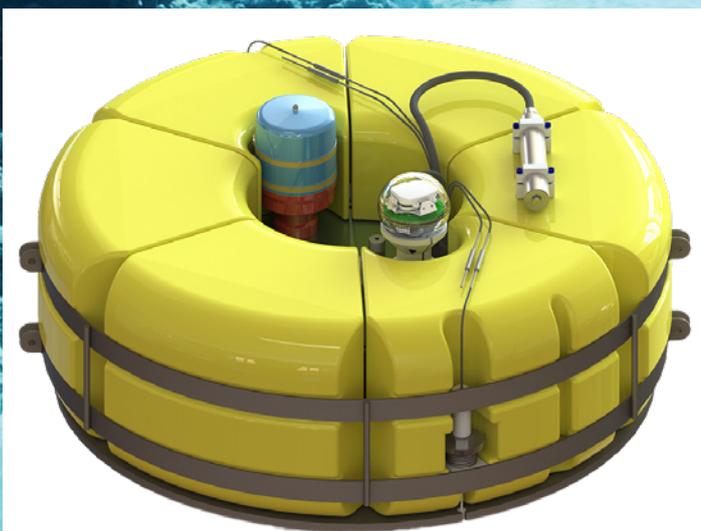


AQUARIUS

OCEAN BOTTOM SEISMOMETER WITH ACOUSTIC TELEMETRY



Compact Ocean Bottom Seismometer with multi-disciplinary research capabilities and optional features for earthquake or tsunami early warning

KEY FEATURES

- > Digital feedback triaxial broadband seismometer, operational at $\pm 90^\circ$, with a flat response between 120s and 100Hz
- > Aquarius - Research option: receive State of Health parameters and noise performance data direct from the seabed at deployment for confident seismic recording projects lasting up to 18 months
- > Aquarius+ - Research and alert option: receive triggered (STA/LTA) event notifications to the surface in near real time with options to receive more detailed data, selected by time-frame or by event, for further analysis
- > Bi-directional communication and controls between the underwater system and the surface unit

Güralp Aquarius OBS

This revolutionary ocean bottom seismometer (OBS) uses acoustic telemetry capability to deliver near real-time seismic data from the ocean floor to the surface without cables.

The Aquarius is a freefall OBS equipped with acoustic data telemetry and a digital feedback tri-axial broadband seismometer, operational at $\pm 90^\circ$, with a flat response between 120s and 100Hz. The long period frequency corner of this design is user-selectable from 120 sec to 1 sec allowing the sensor response to be tailored to the environment. On the Aquarius+ the long period frequency corner can also be configured post deployment via acoustic telemetry.

For alert operations (see Aquarius+ below), a surface station located on a buoy or rig is required to house an acoustic transceiver below the water line. The transceiver needs to be located within a radius range that has no more than a 40° inclination from the OBS.

AQUARIUS OPTIONS

AQUARIUS

Seismic Research

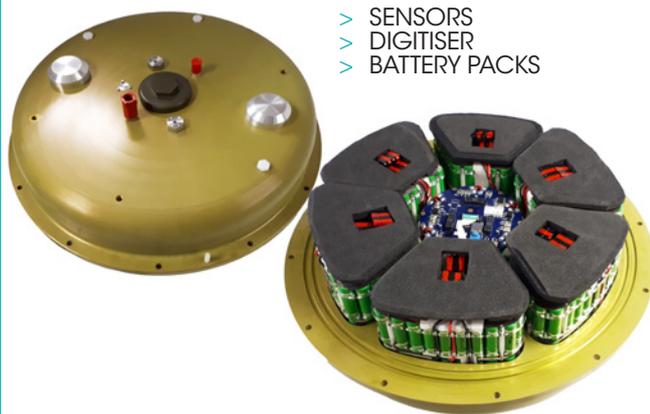
- > Suitable for deployment to depths of up to 6,000 m
- > When data transfer is needed only at the installation and at the recovery of the OBS
- > The OBS is equipped with an omnidirectional transducer
- > Battery is sized to record seismic data for 15 months
- > Transfer of State of Health parameters and noise performance plots from the seabed following installation ensures confident commencement of seismic recording
- > Measure the offset of the digitiser in the OBS using Güralp Discovery software from the surface
- > The acoustic link activates the burn-wire for release to the surface and an on-board satellite tracking system and LED strobe light guides recovery

AQUARIUS+

Seismic Research and Alert

- > Suitable for deployment to depths of up to 4,000 m
- > A near-real time seismic underwater observatory
- > Aquarius+ is equipped with a directional transducer
- > The battery is sized to transfer 10-15 MB of data per month for a deployment lasting ~ 12 months. With optional methods of data retrieval as follows:
 - > The data logger automatically detects seismic events using a STA/LTA trigger. An acoustic link with minimum power requirement sends the compressed list of triggered events rapidly to the surface where they can be viewed in Discovery's 'calendar view'. The operator can then select which detailed event data they wish to retrieve.
 - > Alternatively, the operator can stream portions of seismic data from a time window selected using the Güralp Discovery software available on the surface
- > Bi-directional communication with the underwater system allows interaction with the datalogger when the OBS is installed on the seabed, making it possible to change configuration settings to suit the environmental noise (long-period frequency corner and STA/LTA parameters) and to check fundamental settings during the experiment (i.e. State of Charge of the battery pack).
- > Measure the offset of the digitiser in the OBS using Discovery
- > The acoustic link activates the burn-wire (or a pre-programmed time-out can be set if preferred) to release the system to the surface. An on-board satellite tracking system and LED strobe light guides recovery

AQUARIUS PRESSURE VESSEL HOUSES:



A three-axis magnetometer and a MEMS accelerometer record the seismometer's 3D position on the seabed for data rotation during post-processing. The low profile and compact design is optimized to minimise the noise generated by the current flow.

The Aquarius is fitted with an absolute pressure gauge (APG) and a hydrophone. The APG has an accuracy of 0.25% of full scale, this is used to activate the recovery aids when the system is approaching the surface. The standard hydrophone has a frequency response of 2 Hz - 30 kHz, with the option to upgrade to an ultra low frequency version of 100 s to 8 kHz. There is also the option for an additional high performance APG, please see the specifications on the back page for more information.

Data transmission up to 9000 bps is possible between the surface and the Aquarius(+) on the seafloor using the direct acoustic communication.

Data are stored locally in a dual redundant 128 GB Micro-SD card and on recovery can be downloaded using a Gigabit Ethernet link available on one of the top lid connectors. A single cable connecting the OBS to the Güralp deck unit powers the system for data retrieval and system configuration. This allows for separate and concurrent charging of the batteries via a dedicated connector to an external charger, so that the system can be re-deployed as rapidly as possible.

Key features

Digital feedback tri-axial broadband seismometer with acoustic communication and operational at $\pm 90^\circ$, with a flat response between 120s and 100Hz

A three-axis magnetometer and a MEMS accelerometer record the seismometer's 3D position on the seabed

Transmission of State of Health parameters and noise performance plots from the seabed following installation

Up to 9000 bps transmission of data between seabed and surface

Aquarius+ automatically transmits compressed list of events detected using STA/LTA triggers, with option to request full data transmission for selected events

Dual redundant 128 GB Micro-SD card

Single cable connection to the Güralp deck unit for Gigabit Ethernet data download, system configuration and external power

Acoustic burn-wire release mechanism activated through acoustic command, pre-programmed time-out or optional critical level battery trigger

Satellite tracking system issues location alerts visible on Discovery and/or sent via email and SMS

Discovery acoustic localisation function and LED strobe light simplify navigating to the precise location of the surfaced OBS system



The system is equipped with rechargeable lithium-ion batteries for fast and easy re-deployments:
- One hour to re-charge per one month deployment

Applications

Aquarius

- > Local and regional seismic research
- > Energy exploration
- > Noise surveys
- > Aftershock monitoring

Aquarius+

- > Local and regional seismic research
- > Earthquake/Tsunami Early Warning
- > Temporary or permanent seismic monitoring via acoustic link connection with buoys or rigs

Easy and precise deployment

A key consideration in the design of the Aquarius OBS was to minimise transportation and installation costs. Aquarius is the most compact OBS, equipped with an acoustic modem, available in the market. It can be deployed from smaller vessels and once on the seabed, can be accurately located using a Sondardyne LMF USBL system installed on board the installation vessel.

The recovery system

The Aquarius recovery system is initialised either via the acoustic link, through a pre-programmed time-out, or with the optional critical level battery trigger.

Once activated a burn-wire system releases the ballast for recovery of the instrument. The syntactic foam around the aluminium pressure vessel provides the lifting force to bring the instrument back to the surface.

A satellite tracking system hosted in a pressure glass sphere tracks the instrument on the sea surface, following deliberate release but also in the unlikely event of accidental release.

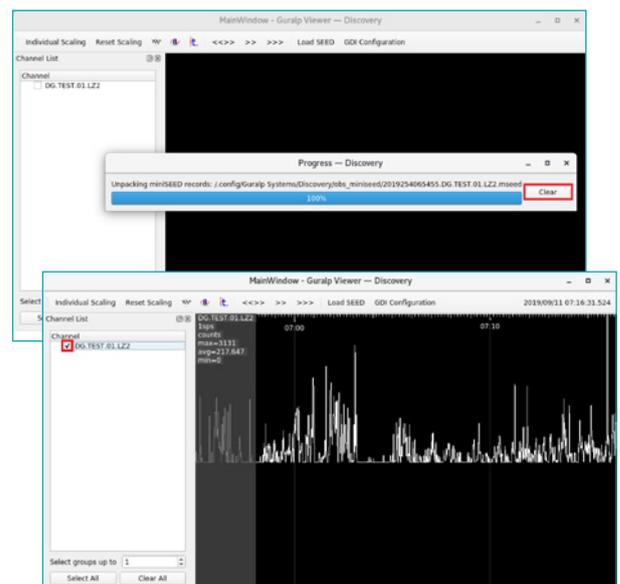
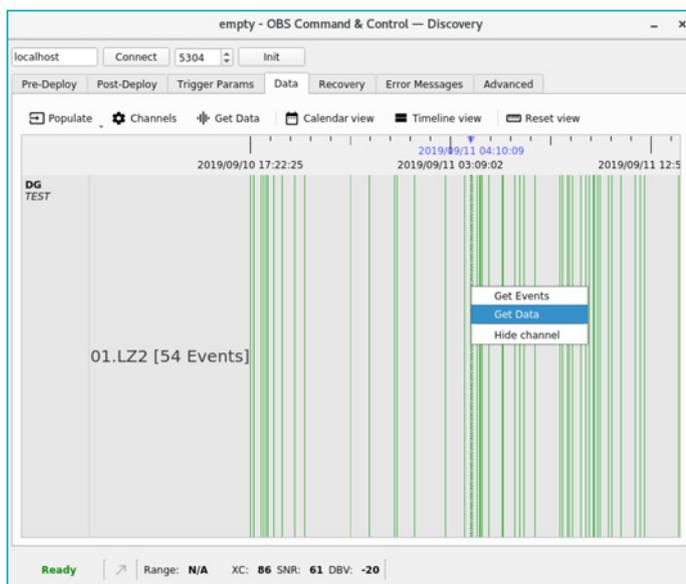
Messages from the tracking system can be viewed on Discovery and can be automatically sent by e-mail or text messages (to both satellite or standard mobile phones).

Once tracking information is received and the recovery boat is deployed, Discovery can provide a precise location using its acoustic ping localisation tool that calculates the slant range between the recovery boat and the OBS as the boat navigates the expected location of the OBS. To aid night recoveries, the OBS also has a strobe LED light.

Aquarius Discovery Toolkit

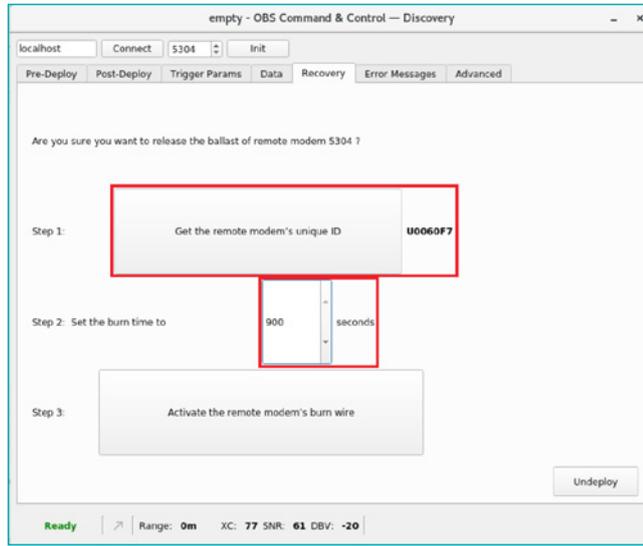
Use Discovery to request event data via acoustic telemetry.

Data is sent automatically to the data viewer

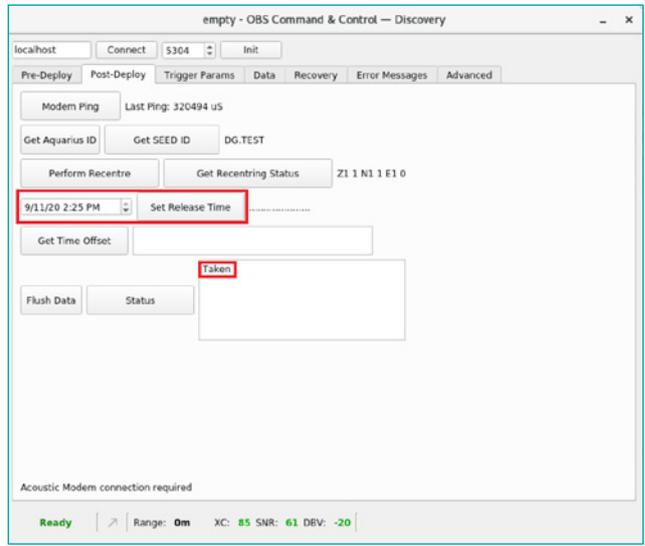


Aquarius recovery system

Use Discovery to request burn wire release using acoustic command...

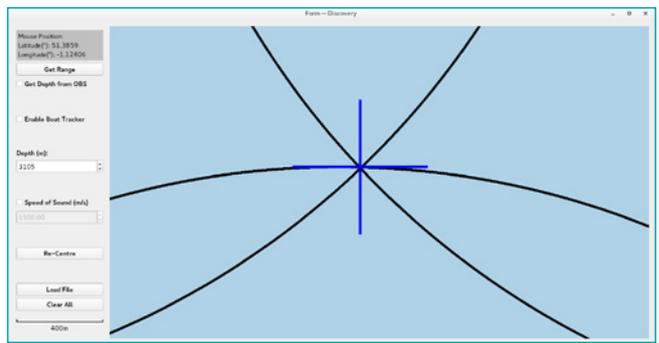
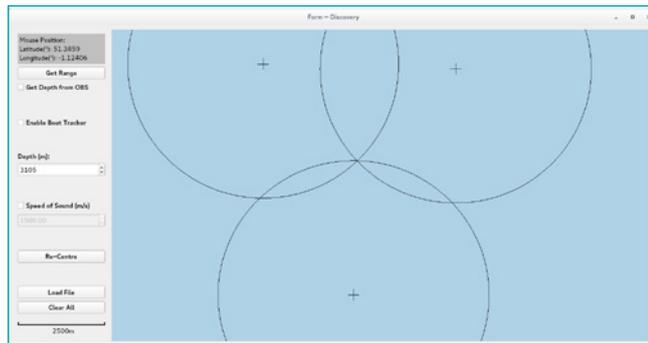


...or configure pre-set time-out



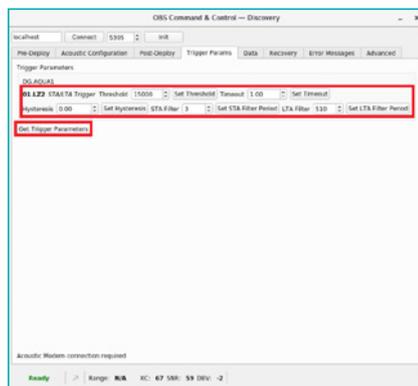
Aquarius recovery system

Discovery acoustic localisation tool triangulates the precise location of the OBS

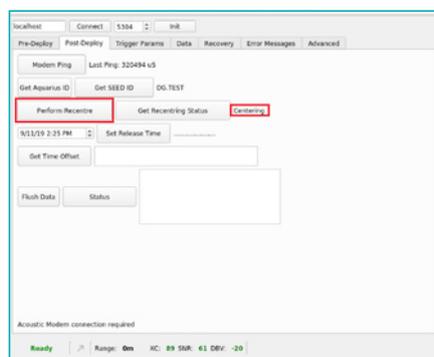


Configure instrument and digitiser settings after the OBS during deployment

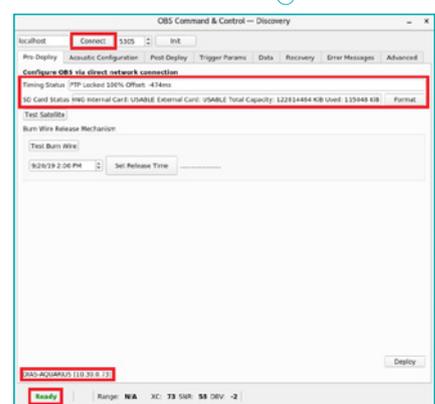
Set trigger parameters



Re-centre masses



Compare digitiser offset with PTP timing



SPECIFICATIONS

BROADBAND SEISMOMETER		DATA STORAGE	
Technology	Force-feedback (force-balance) sensor	Data recording formats	miniSEED (metadata stored in dataless SEED format)
Configuration / Topology	Triaxial orthogonal (XYZ with ZNE output)	Flash memory and storage	128 GB dual redundant Up to 2TB cards available upon request
Velocity output band (within -3 dB crossing points)	120 seconds to 100 Hz standard	Direct data download	Via Gigabit Ethernet connection
Output sensitivity	Nominal velocity response: 2000 V/ms ⁻¹	CLOCK AND CALIBRATION	
Self noise below NLNM (New Low Noise Model; Peterson, 1993, USGS)	-173dB re (m/s ²)/Hz @ 10s	Typical drift per day	VCXO clock: <1 ms (fully correctable during post-processing) Atomic clock option available.
Tilt tolerance	±90 °	Timing synchronisation sources	PTP on Ethernet link through Güralp surface deck unit
ABSOLUTE PRESSURE GAUGE		Calibration signal generator	1 Hz sinewave, step, triangle, broadband or white noise, all with adjustable amplitude
Resolution	1mm variation in 1000m of water	POWER	
Accuracy	0.25% of full-scale	Battery life:	Aquarius+ 12 months at 4,000 m Aquarius 15 months at 6,000 m
HYDROPHONE		Battery recharge time	1 hour per month deployment (approx.)
STANDARD VERSION		RECOVERY RELEASE	
Frequency response	2 Hz to 30 kHz	Release mechanism	Acoustically-operated burnwire release or timed release option
Sensitivity	Max -162 dB re: 1 V/μPa (562V/Bar); Min -240 dB re: 1V/μPa (0.1 V/Bar)	Recovery location tools	Satellite tracking system LED strobe light Discovery acoustic localisation tool
ULTRA-LOW FREQUENCY VERSION (OPTIONAL UPGRADE)		PHYSICAL / ENVIRONMENTAL	
Frequency response	100 s (0.01 Hz) to 8 kHz	Operating temperature range	-20 to +75° C
Sensitivity	-194 dB (1 V/μPa)	Pressure vessel casing material	Aluminium with corrosion-resistant treatment and anodic protection
HIGH PERFORMANCE ABSOLUTE PRESSURE GAUGE (OPTIONAL ADDITION)		Operational depth	Aquarius 6,000 m maximum Aquarius+ 4,000 m maximum
Repeatability	<0.01% of full-scale	Buoyancy	Syntactic foam buoyancy (glass micro-spheres) for extended life and durability
Calibrated temperature	-2 to +40° C	ACCESSORIES	
Hysteresis	≤± 0.01% Full Scale	Deck control unit	Acoustic command module and OBS communications unit for instrument control/ configuration and clock synchronisation
Resolution	4.5 parts per billion	Battery charger	Suitable for on-deck charging
ADDITIONAL CHANNELS & STATE-OF-HEALTH			
Environmental channels	Three component digital compass composed of a MEMS accelerometer and Magnetometer Temperature sensor Humidity sensor Supply voltage		
24-BIT DIGITISER			
Primary digitisation channels	Four at 24 bits		
ADC converter type	Delta-sigma		
Output format	32-bit		
Dynamic Range	>136.5 dB at 100 samples per second		
Output sample rates available	250 samples per second for seismic channels and 5 samples per second for environmental, auxiliary sensors and MEMS channels		
Decimation filters	±2, ±3, ±4, ±5 (Causal / Acausal)		
Trigger modes	STA/LTA		