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 ±90 °, 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 ±90°, 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:
- SENSORS
- DIGITISER
- BATTERY PACKS
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 Hz 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 ±90 °, 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

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

The system is equipped with rechargeable lithium-ion batteries for fast and easy re-deployments:

- One hour to re-charge per one month deployment
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 Sondaryne 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 SEISMMETER

<table>
<thead>
<tr>
<th>Technology</th>
<th>Force-feedback (force-balance) sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Configuration / Topology</td>
<td>Triaxial orthogonal (XYZ with ZNE output)</td>
</tr>
<tr>
<td>Velocity output band</td>
<td>120 seconds to 100 Hz standard</td>
</tr>
<tr>
<td>Output sensitivity</td>
<td>Nominal velocity response: 2000 V/ms²</td>
</tr>
</tbody>
</table>

Self noise below NLNM (New Low Noise Model; Peterson, 1993, USGS): -173 dB re (m/s²)²/Hz @ 10s

Tilt tolerance: ±90 °

#### ABSOLUTE PRESSURE GAUGE

<table>
<thead>
<tr>
<th>Resolution</th>
<th>1 mm variation in 1000 m of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>0.25% of full-scale</td>
</tr>
</tbody>
</table>

#### HYDROPHONE

**STANDARD VERSION**

<table>
<thead>
<tr>
<th>Frequency response</th>
<th>2 Hz to 30 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>Max: -62 dB re: 1 V/µPa (622 W/Bar); Min: -240 dB re: 1 V/µPa (0.1 V/Bar)</td>
</tr>
</tbody>
</table>

**ULTRA-LOW FREQUENCY VERSION (OPTIONAL UPGRADE)**

<table>
<thead>
<tr>
<th>Frequency response</th>
<th>100 s ± 0.01 Hz to 8 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>-194 dB (1 V/µPa)</td>
</tr>
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</table>

**HIGH PERFORMANCE ABSOLUTE PRESSURE GAUGE (OPTIONAL ADDITION)**

<table>
<thead>
<tr>
<th>Repeatability</th>
<th>&lt;0.01% of full-scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibrated temperature</td>
<td>-2 to +40 °C</td>
</tr>
<tr>
<td>Hysteresis</td>
<td>≤± 0.01% Full Scale</td>
</tr>
<tr>
<td>Resolution</td>
<td>4.5 parts per billion</td>
</tr>
</tbody>
</table>

#### ADDITIONAL CHANNELS & STATE-OF-HEALTH


#### 24-BIT DIGITISER

<table>
<thead>
<tr>
<th>Primary digitisation channels</th>
<th>Four at 24 bits</th>
</tr>
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<tbody>
<tr>
<td>ADC converter type</td>
<td>Delta-sigma</td>
</tr>
<tr>
<td>Output format</td>
<td>32-bit</td>
</tr>
<tr>
<td>Dynamic Range</td>
<td>&gt;136.5 dB at 100 samples per second</td>
</tr>
<tr>
<td>Output sample rates available</td>
<td>250 samples per second for seismic channels, and 5 samples per second for environmental, auxiliary sensors and MEMS channels</td>
</tr>
<tr>
<td>Decimation filters</td>
<td>÷2, ÷3, ÷4, ÷5 (Causal / Acausal)</td>
</tr>
<tr>
<td>Trigger modes</td>
<td>STA/LTA</td>
</tr>
</tbody>
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#### DATA STORAGE

| Data recording formats       | miniSEED (metadata stored in dataless SEED format) |
| Flash memory and storage    | 128 GB dual redundant |
| Direct data download        | Via Gigabit Ethernet connection          |

#### CLOCK AND CALIBRATION

Typical drift per day: VCXO clock: <1 ms (fully correctable during post-processing)

Timing synchronisation sources: PTP on Ethernet link through Güralp surface deck unit.

Calibration signal generator: 1 Hz sinewave, step, triangle, broadband or white noise, all with adjustable amplitude.

#### POWER

- **Battery life:**
  - Aquarius+ 12 months at 4,000 m
  - Aquarius 15 months at 6,000 m

- **Battery recharge time:** 1 hour per month deployment (approx.)

#### RECOVERY RELEASE

- **Release mechanism:** Acoustically-operated burnwire release or timed release option

- **Recovery location tools:** Satellite tracking system. LED strobe light. Discovery acoustic localisation tool.

#### PHYSICAL / ENVIRONMENTAL

| Operating temperature range | -20 to +70 °C |
| Pressure vessel casing material | Aluminium with corrosion-resistant treatment and anodic protection |

<table>
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<tr>
<th>Operational depth</th>
<th>Aquarius+ 6,000 m maximum</th>
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<tbody>
<tr>
<td></td>
<td>Aquarius 4,000 m maximum</td>
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</tbody>
</table>

| Buoyancy | Syntactic foam buoyancy (glass micro-spheres) for extended life and durability |

#### ACCESSORIES

<table>
<thead>
<tr>
<th>Deck control unit</th>
<th>Acoustic command module and OBS communications unit for instrument control/configuration and clock synchronisation</th>
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<tbody>
<tr>
<td>Battery charger</td>
<td>Suitable for on-deck charging</td>
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In the interests of continual improvement with respect to design, reliability, function or otherwise, all product specifications and data are subject to change without prior notice.