OSEAN
UNDERWATER TECHNOLOGY

HALIOS : VERSATILE OCEAN BOTTOM SEISMOMETER

Long Term Deployment

DETAILED FEATURES

APPLICATIONS

- Oceanographic Research
- Broadband Seismology
- Environmental Monitoring

FEATURES

- Up to 20 months Autonomy
- Up to 6000m depth
- Optimal seismometer coupling
- 120s Seismometer
- ULF Hydrophone
- Absolute pressure Sensor
- Recovery Station with acoustic mechanical release
- Station localization by GPS location transmission via proprietary VHF link and Strobe light
- Non corrosive material housing
- Anti-trolled Chassis frame

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HALIOS: VERSATILE OBS

DETAILED FEATURES

MECHANICAL:

•System Structure

The system structure is based on a well that ensures the protection of the main sensor. The frame, made of a PE shell filled with syntactic foam, protects the entire station from shocks both on the surface and underwater.

•Materials

The materials used (HDPE, titanium, glass, etc.) provide the system with unprecedented longevity.

•Reliability of Release System

OSEAN places crucial importance on the reliability of the release system for the OBS to surface. Therefore, a mechanical finger release was chosen instead of a burn wire release. This release mechanism, coupled with Dyneema slings, releases two weights that are easily sourced worldwide, even in the most remote locations. This ensures that the client can redeploy the OBS without unnecessary transportation for dead weights. To ensure the system does not get stuck on the seabed, carbon fiber blades are used to exert additional force when releasing the weights.

•Deployment/Recovery:

A titanium handle on the top of the station allows for free-fall deployment, winch deployment, and handling by ROV. In free fall, valves on the top of the station allow water to circulate, ensuring a stable descent at 0.6 m/s. During ascent, the volume and shape of the buoyancy ensure an ascent rate of 1 m/s. On the surface, the system is easily locatable both day and night thanks to a flashing light.

•Packaging and Transport

The OBS HALIOS units are delivered in wooden crates measuring 1240x1240x1050 mm, allowing for the transport of four units in a 20-foot container while leaving space for accessories and surface equipment.

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SPACIAL ARRANGEMENT:

As introduced earlier, the station is built around a 400x700mm well that houses the sensor securely.

The HDPE structure is assembled using mortise and tenon joints and handles all mechanical stresses.

The titanium containers (for data acquisition and batteries) are positioned on either side of the structure.

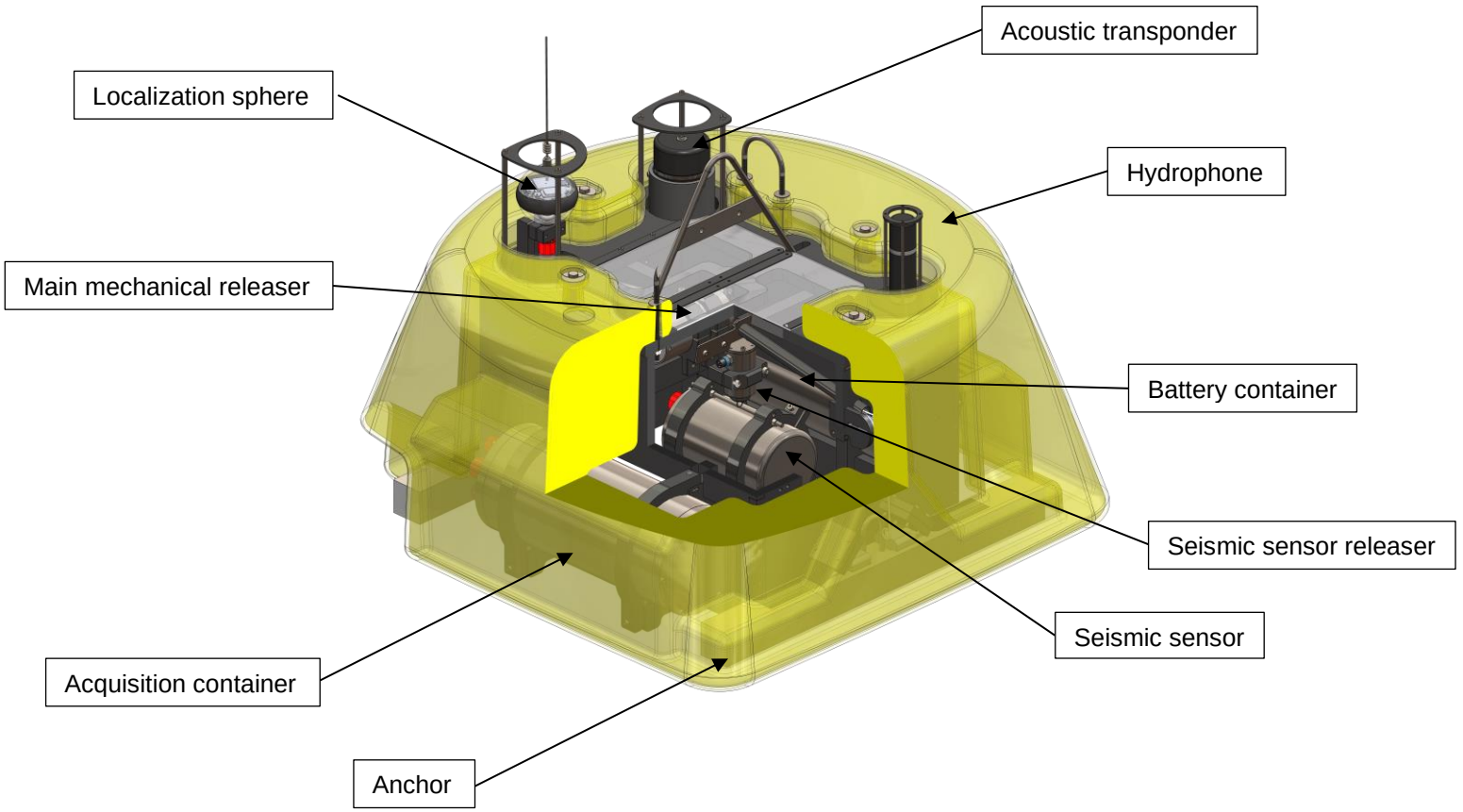
Other equipment is attached to the four corners of the structure.

To access the containers and ballast weights, the frame must be removed.

The ballast weights are placed symmetrically on the adjacent sides of the containers.

The main release mechanism is located in the center of the structure.

Similarly, the burn wire release mechanism, which ensures the sensor's release, is also centrally located.



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SENSORS:

•Seismometer/Accelerometer:

The chosen seismometer is the Nanometrics Trillium compact 120s. This 360° sensor is renowned for its exceptional performance and reliability. Its integration into the OSEAN container, along with coupling with the seabed, was conducted in collaboration with Nanometrics' technical teams.

This integration included adding a 3-axis MEMS accelerometer integrated with the sensor. This combination significantly extends the measurement bandwidth. The accelerometer takes over in case of a strong signal that could saturate the Trillium, eliminating the need to compromise on measurements. The container is released using a burn wire at the beginning of the mission. It then descends to the seabed, disconnecting from the structure. This structure protects the sensor from ocean currents. This unique configuration in OSEAN OBS ensures unparalleled measurement quality.

•Hydrophone:

In addition to the seismic sensor, an HTI04-ULF hydrophone from HIGHT TECH INC is integrated. A neoprene interface allows the hydrophone to be decoupled from the structure.

•Absolute pressure sensor:

Optionnally, an absolute pressure sensor can be integrated. The deep-sea bottom pressure sensor is a quartz transducer from Paroscientific. Specifically, it's a Digiquartz 46K pressure sensor capable of measuring from 0 to 10 000 psia, filled with oil. This sensor also includes a temperature sensor to compensate for thermal drift in the pressure measurements. Frequency measurements of both the pressure and temperature channels are then processed using an equation determined during the sensor calibration by the manufacturer.

The Digiquartz sensor provides two analog signals, with periods proportional to the pressure and temperature measurements. This technological choice ensures very low power consumption, which is crucial for use in deep-sea bottom stations. Simultaneous integration over periods of 1s, 10s, and 100s allows for resolutions of 50mm, 5mm, and 0.5mm respectively at 6000m. Sensors with a smaller full scale can be integrated, which will improve the measurement accuracy.

•Temperature sensor:

Optionally, a P2T module from the American company SEASCAN, Inc. can be integrated. The electronic module is housed inside the acquisition container and will digitally transmit its measurements to the acquisition unit.

A temperature probe is inserted into a TA6V "finger" positioned outside the acquisition container's tape to accurately measure the surrounding seawater temperature. Thermal coupling between the probe and the titanium tube is achieved using thermal grease.

Furthermore, the titanium finger is protected by a plastic cage that screws onto it.

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ACQUISITION:

The HALIOS acquisition unit is built on technologies integrated across the company's systems, ensuring robustness. With low noise and very low power

consumption, the acquisition system operates through a chain of pre-amplification followed by a SIGMA/DELTA type ADC (Analog-to-Digital Converter). It's a 32-bit digitizer with a dynamic range > 130 dB at 125 Sps for the full bandwidth 10mHz – 50Hz and a dynamic range >144 dB at 1 Hz.

Data acquisition is performed on 8 channels: 3 channels for the Trillium sensor, 3 channels for the MEMS accelerometer, one channel for the hydrophone, and one last channel reserved for the temperature and pressure sensor.

The WAV format files are recorded on two SD cards for redundancy purposes. Data can be downloaded via Ethernet or USB. It is possible to convert the data to MiniSEED format using provided OSEAN software.

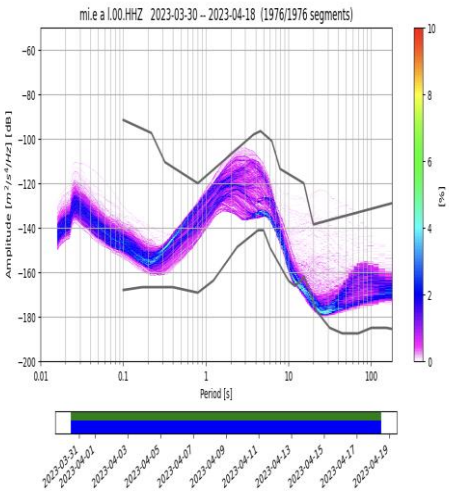
•Seismometer:

PPSD : Probabilistic Power Spectral Densities.

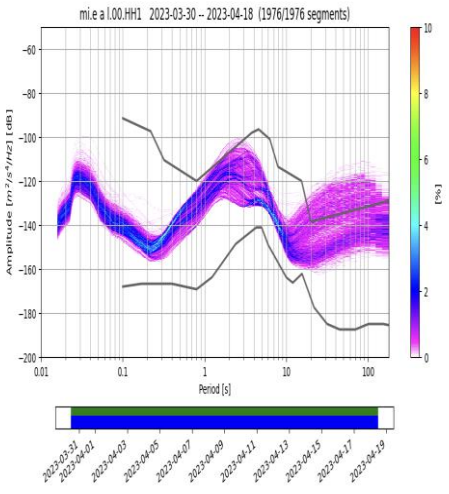
Ts = Ss / PE * ADC_res = 754.3 / 4. * 2**32 = 8.099e11 counts/(m/s)

Where:
Ss : 754.3 V.s/m -> seismometer sensitivity
PE : 4 V -> full-scale analog-to-digital converter
ADC_res : 2^32 counts -> converter resolution (full scale)

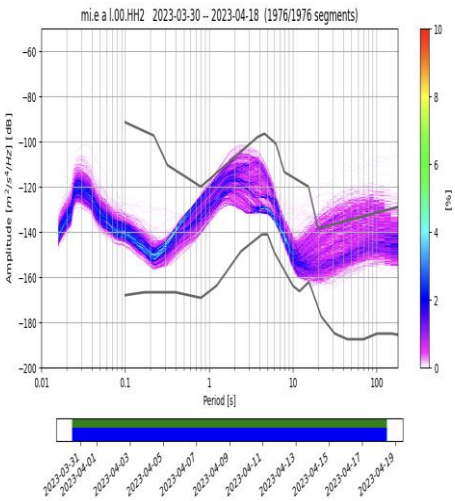
Below: Frequency representation within the IDC Seismic, Hydroacoustic and Infrasound Global Low and High Noise Models:



Vertical HHZ



Horizontal 1 HH1



Horizontal 2 HH2

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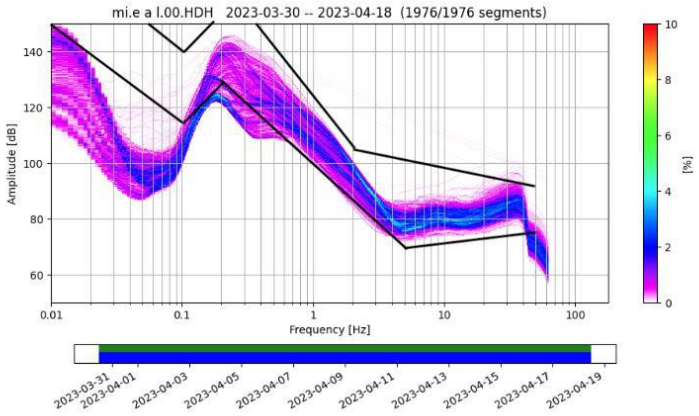
ACQUISITION:



•Hydrophone:

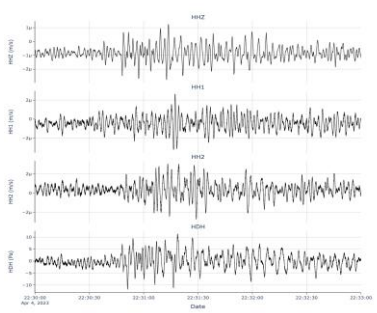
Conversion factor T from counts (numerical value) to Pascal is:

Th = 10**((Sh + Gain)/20) * RMSxVP / PE * ADC_res
= 10**((-193.6 + 25)/20) * 2**0.5 / 4 * 2**32
= 11.28 counts / uPa

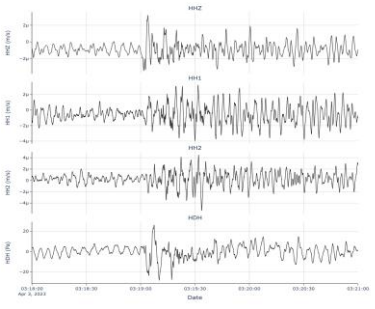
Sh : -193.6 dB ref 1V/µPa -> hydrophone sensitivity
Gain : 25 dB -> amplification gain before conversion
RMSxVP : √2 -> conversion from RMS volts to peak volts
PE : 4 V -> full-scale analog-to-digital converter
ADC_res : 2^32 counts -> converter resolution (full scale)

•Time management:
We know that the dating of data is essential in the field of geophysics. That's why the data is dated using a SEASCAN precision clock. As an option, if required, an ultra-stable CSAC atomic clock can be integrated. Before deployment, the station is automatically synchronised via GPS in the location sphere. On recovery, the GPS time is automatically retrieved from the surface and the clock drift measured and stored.

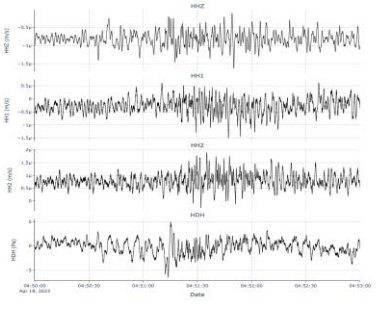
Recorded seismogram during April 2023. UP to DW : HHZ, HH1, HH2, HDH.



03/04/2023 at 5:07 am
(UTC+2)
Siberia
magnitude 6.5



05/04/2023 at 00:18
(UTC+2)
Boca Chica (Panama)
magnitude 6.3



18/04/2023 at 06h31
(UTC+2)
Pacific Ocean
magnitude 6.7

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BATTERY / AUTONOMY:

OSEAN has chosen to use primary lithium battery packs configured in 4S5P (with 4S3P and 4S2P assembled in the same pack). We rely on the expertise of an American manufacturer for the production of these packs. They are certified for air and sea transport according to the latest standards in effect.

The available energy is divided into three units. The majority of the energy is dedicated to sensors and data acquisition. The second part is allocated to the clock. Finally, the last part is assigned to the vital systems of the station, such as the acoustic transponder and the release/relocation system.

This technical choice ensures an autonomy of 20 months with a standard clock in acquisition mode. In the event that the OBS is not recovered within 20 months or in case of a malfunction, the energy allocated to the clock continues to keep it running for several months. This maintains the dating of the recorded data. The energy allocated to the vital systems allows for the recovery of the OBS well after the clock and acquisition have stopped (Prior to recovery up to 36 months after deployement).

It is also possible to replace the lithium packs with alkaline batteries, but the autonomy will be significantly reduced.

LOCALISATION SPHERE:

The localization sphere developed by OSEAN is a compact and reliable localization system. The electronics are housed within a 4.5-inch sphere rated for depths of up to 6000 meters. This complex system includes a GPS, which allows for the synchronization of the station's clock before deployment and the measurement of drift at the surface.

Additionally, the GPS enables communication via VHF to transmit the station's surface position to aid in recovery.

Integrated LEDs make it possible to locate the station during nighttime recoveries.

These same flashes inform the user about the station's operational mode: depending on the flash frequency, they can determine if the station is started, waiting for synchronization, synchronized, or in degraded mode for energy saving.

Finally, the sphere includes a WIFI module allowing for wireless configuration of the station.

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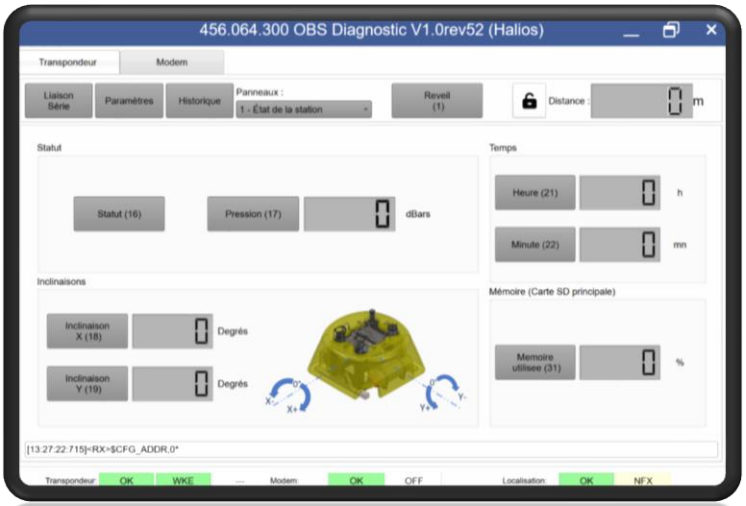
ACOUSTIC COMUNICATION:

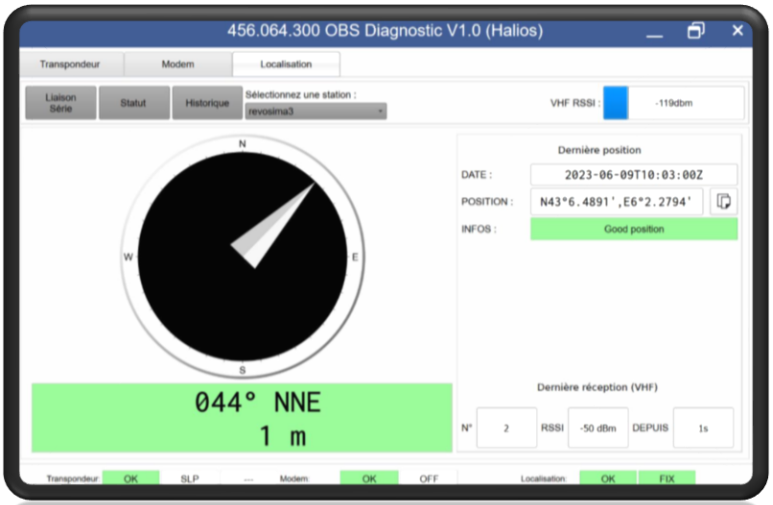
A surface acoustic remote control is used to communicate with the station. Through a user interface installed on a tablet or computer, the user can query the station to check its status (e.g., tilt, immersion pressure, available memory, battery voltages, etc.). They can also choose to level or calibrate the seismometer. Commands for releasing the station and the sensor are also available on this interface.

During each acoustic communication, the position of the surface case is associated with the slant distance measured to the station. By querying the station from different points and knowing its immersion depth, it is therefore possible to locate it using software.

The user interface is also used for system recovery. After issuing a release command, acoustic communications remain available, allowing the station's ascent to be tracked in real-time. Upon reaching the surface, the station's position is transmitted to the surface case. The user interface then provides the operator with the distance to the station and the heading to follow to reach the location.



Station status window



Localization window

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MODEM COMUNICATION:

OSEAN developed an LTA/STA algorithm for HALIOS to detect specific events. The detection parameters are chosen during the station's configuration before deployment. With the optional Sercel modem, it is possible to retrieve the list of events detected by the station, download acquisition data from the downloaded list, and obtain a general state of health (SOH) of the station. It is possible to specify the type of event (seismic and/or acoustic), a search period, a minimum and maximum SNR, as well as a minimum and maximum event duration.

WIRED CONFIGURATION:

The HALIOS OBS can be integrated into a wired infrastructure. The acquisition container has a base for connecting it to a junction box. Additionally, an opening on the float allows the passage of a cable.

In wired mode, the presence of voltage on the external power connector automatically switches the station's power source. The batteries are no longer used. In case of physical cable disconnection from the wired infrastructure causing a short circuit with seawater, the power module is protected. The batteries take over without interrupting the station's operation. The wired configuration keeps the Ethernet connection of the system active, through which all raw acquisition data is broadcasted in real time. Data is transmitted using the Ethernet UDP multicast protocol. Temperature and pressure sensor data are also transmitted using the same protocol. Remote monitoring and retrieval of older data are possible on demand, following a similar principle as with the acoustic modem but at much higher data rates. The system is continuously connected to the surface, enabling synchronization with a PTP time server. This allows the station's clock module to continuously measure its local drift and enables the surface system to correct temporal drifts in received files.