SSA 2023

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Novel Longer-Term Ocean Bottom Station Concepts Enabled by Advancements in Low Power Equipment

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Abstract

With over 70% of the earth's surface covered in ocean, the ability of land-based stations and networks to understand our planet is limited. To increase our global coverage, there is a continued need for higher quality and longer term seismic stations to augment existing networks. Meeting this need has traditionally been limited by the costs and complexities of the stations themselves and the significant operational costs of deploying and recovering systems.

Recent advances in high-performance, low Size Weight and Power (SWaP) instrumentation allows an examination of new approaches to increase the performance, density and duration of ocean bottom seismometer systems. The combination of higher value and lower footprint stations allows for new and previously infeasible approaches to be within reach.

Existing and emerging technologies in instrumentation, power generation, periodic telemetry and station design are examined to develop opportunities for advancement of worldwide coverage of seismic data.

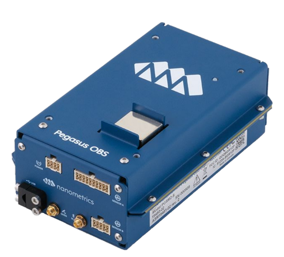
Size, Weight, Power, and Performance

As an instrumentation supplier, it is our mission to work to provide purpose built instrumentation and solutions that address these barriers and to push the boundaries of scalability and performance.

Ultimately, size weight and power all drive cost - and costs limit what is possible. Whether it is additional battery packs, more frequent deployments and recoveries, or additional deck space, advancements that impact Size, Weight and Power are what drive changes in the art of the possible.

Designed specifically for ocean bottom experiments, Pegasus OBS optimizes onshore and shipboard processes for simplicity and ease-of-use

- Mobile user interface manages system without opening pressure vessels
- Extremely low power
- Complete datasets - raw and time-corrected miniSEED and automatically generated
- StationXML metadata
- Smart sensor auto configuration

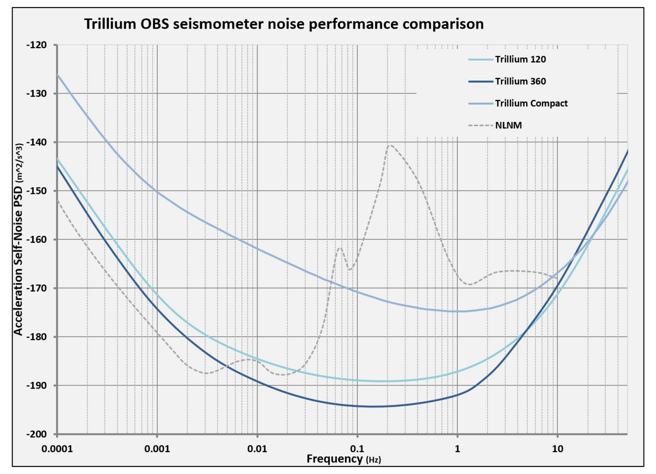


PegasusOBS

A full range of ultra-low power full-performance broadband seismometers for ocean bottom deployments of up to 6,000m depth

- Precise, kinematic gimbal auto-levels from any orientation
- Titanium pressure vessel and glass epoxy connectors ensure resistance to corrosion
- Shock protection with no mass or gimbal lock ensures reliable trouble free operation

TrilliumOBS



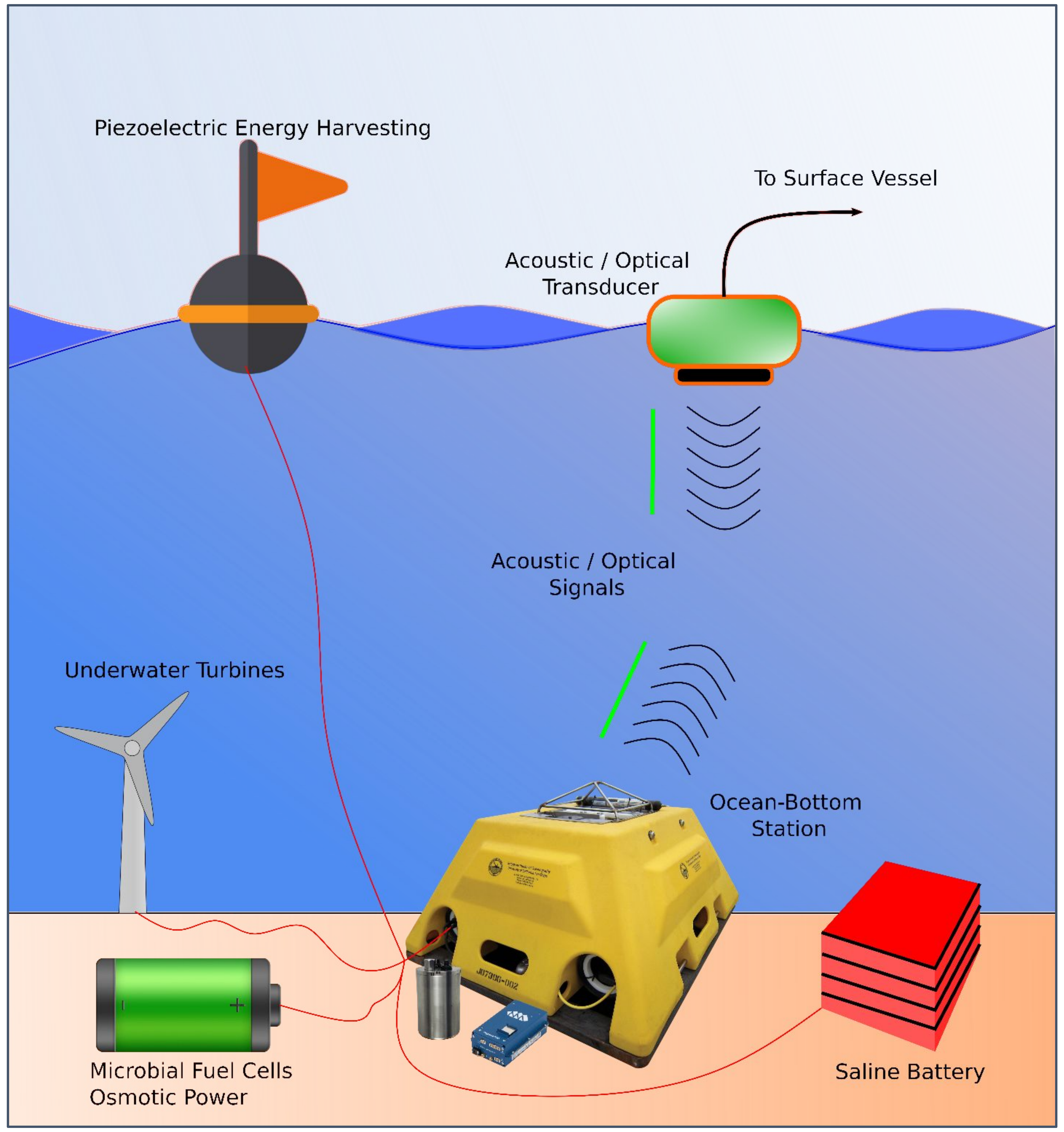
Instrument	Power Consumption
Pegasus OBS	200mW (3Ch), 240mW (4Ch)
Trillium Compact OBS	195mW (typical)
Trillium 120 OBS	250mW (typical)
Trillium 360 OBS	250mW(typical)

Opportunities for New Approaches

The end goal of any experiment is the recovered data and the findings based on the analysis. Approaches to collecting ocean bottom seismometer data have been optimizations based on the available technologies of the time. Improvements in many aspects have extended the quality and duration of the collected data, but emerging technologies can offer step changes in capability and full cost of data.

Nanometrics OBS instrument are available as complete systems, but are also available highly integratable instruments suitable as building blocks of new station designs.

- robust, reliable and high performance
- simplified workflows suitable for automation
- flexible internal connection schemes and interfaces
- modular components for incorporation into alternate pressure vessel designs



A View to the Future

At Nanometrics, we continue working with our partners to develop leading solutions to this challenging environment. Better mapping our current and future offerings to the tangible needs and requirements of our customers is our primary focus.

Within the domain of Ocean Bottom Stations, there exist multiple paths of capability generation. Here we share our vision of future developments of our OBS solutions.

- Simplified power solutions
- Improved integration ability with customer equipment and N-station subsurface networks.
- Questioning the constraint of system recovery. Data collection is the top priority of any experiment.
- Expanding the autonomous functionality of an OBS through Deployment, Servicing, Harvesting, & Recovery
- Streamline station footprint for rapid deployment, reduction of customer logistics burden.
- Enhance system reliability, availability, maintainability. As customer fleet size increases, so must our design for supportability.

Communications Options

Acoustic and optical underwater communications are two common methods used for transmitting data wirelessly in ocean bottom seismic systems. Here, we will contrast the two methods in terms of bandwidth, range, and power, with a focus on their use in ocean bottom seismic systems.

- Bandwidth: Acoustic communication systems typically have lower bandwidth compared to optical communication systems. Acoustic communication bandwidth ranges from a few hundred to a few thousand hertz, while optical communication systems can have a bandwidth in the range of several hundred megahertz to several gigahertz. This difference in bandwidth translates into differences in the amount of data that can be transmitted over a given time period.
- Range: The range of acoustic communication systems is typically greater than that of optical communication systems. Acoustic waves can travel through water for long distances, while optical waves are quickly absorbed by water. Acoustic communication systems can achieve ranges of several kilometers, while optical communication systems are generally limited to ranges of a few hundred meters.
- Power: Optical communication systems utilize less power due to the inherent efficiency of laser diodes and light-emitting diodes. Acoustic transducers require greater power due to the piezoelectric mechanism of transduction.

In the context of ocean bottom seismic systems, the choice between acoustic and optical communication systems is a multivariate one, highly dependent upon the use-case parameters. Acoustic communication systems are well-suited for long-term, long-range deployments, with moderate data requirements. Optical communication systems, on the other hand, are better suited for shorter-term deployments and for closer-range applications that require high bandwidth and fast data transmission. Future undersea communication systems may rely on hybrid designs of both methods.

Long Term and Indefinite Power Options

As the world continues to explore renewable energy sources, there is growing interest in harnessing the power of the ocean to generate electricity, even for low power applications. Here are three ocean bottom power generation technologies that show promise for low power applications:

- Piezoelectric Energy Harvesting: This technology uses the mechanical stress caused by ocean waves or currents to generate electricity. Piezoelectric materials convert this mechanical stress into electrical energy. Piezoelectric energy harvesting devices can be installed on the ocean floor and generate electricity for low power applications, such as underwater sensors or communication devices.
- Underwater Turbines: Similar to tidal energy turbines, underwater turbines can generate electricity from the flow of water in ocean currents, but they are smaller and designed for lower power applications. They can be installed on the ocean floor and used to power low power devices, such as underwater sensors or monitoring equipment.
- Microbial Fuel Cells: These fuel cells use bacteria to generate electricity. The bacteria consume organic matter, such as sediment, and produce electrons as a byproduct. These electrons can be captured and used to generate electricity. Microbial fuel cells can be installed on the ocean floor and used to power low power devices, such as underwater sensors or communication devices.
- Saline Battery: Saltwater batteries utilize surrounding sea water as an electrolyte solution for the required electrochemical reaction. While less energy dense than the Li-ion counterparts, saltwater batteries provide reduced cost and environmental impact.

These ocean bottom power generation technologies show promise for low power applications. As research and development continues, they may become increasingly important for powering a range of underwater applications.

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