# **Next-Generation Broadband Seafloor Instruments to Support New Discovery**

## Abstract

The densification of offshore observatories is the next important challenge for scientists as described in "A Vision for NSF Earth Sciences 2020-2030: Earth in Time" (National Academies of Sciences, Engineering and Medicine, 2020).

Nanometrics is combining our latest land based technology with our proven OBS technologies to enable the next steps in offshore observation. Specifically, we are building both 360 second and 120 second corner observatory class seismometers with the same performance specifications as land based instruments, but in a form factor allowing deployments to 6000m. These seismometers come in a form factor unique to the OBS community allowing exceptional advances in SWaP (size, weight, and power), critical to reducing the expensive logistics of OBS work, and are suitable for autonomous and cabled stations. Power usage and volume are reduced 60-70% versus previous generation options.

These new instruments expand our range of products enabling new ocean bottom science, reducing integration risk and time to deploy, while improving outcome certainty

## Seismometers

#### Bringing seismometer selection to the seafloor

The Trillium 120 OBS and Trillium 360 OBS seismometers bring performance previously only available on land to the seafloor. Combining the reliability, performance and ease of use of the Trillium Compact OBS, with the latest low-power and low-noise performance advances of the Trillium line of seismometers. The titanium ellipsoidal pressure vessel capable of deployments to 6000m depth. The space efficient design allows a direct upgrade path for solutions based on the Trillium Compact OBS.

The Trillium OBS 120 provides a 60-70% reduction of SWaP at the same low-noise performance as Trillium 240. The Trillium 360 OBS provides an even lower noise floor in the same form factor.

- Power consumption: typical (leveled, quiescent)
  - Trillium Horizon OBS 120: 230 mW
  - Trillium Horizon OBS 360: 290 mW
- Dual degree-of-freedom motorized gimbals allow ±50° tilt range • Jam-free mechanism, no mass lock/unlock

• Kinematic design preserves full seismometer performance • Levelling Features

- Levels to within ±0.5° of true vertical
- Time-based and automatic initiation
- Fully configurable three stage levelling check schedule



## **Expanding the art of the possible**

### The performance to support your science ...

On land, there are a wide range of instruments available to measure ground motion specifically because the best results are achieved by using the right tool for the job. Traditionally, science at the sea floor has been limited to lower performance instruments or customized approaches that limited performance and the number of instruments. To address these limitations, Nanometrics has developed purpose-built instrumentation to bring the recent advancements and performance of land based instrumentation to the sea floor. Workflow efficiencies and rich supporting tools allow reduced preparation time, increased scale, reduced costs and provide outcome certainty.

#### ... at the lowest available power

Significant improvements in Size, Weight and Power (SWaP) are particularly valuable in the challenging sub-sea environment, opening up new possibilities to integrations and science. These advancements bring efficiency in volume and costs of batteries, allowing new approaches, without having to trade it off against performance.

# TrilliumOBS

## **Digital Recorders**

## A purpose-built full capability datalogger for the seafloor

Pegasus OBS has been specifically designed for the ocean bottom environment, incorporating the technology platform developed for the Pegasus Portable data acquisition system. The Pegasus OBS includes four high performance digitizer channels, typically used with a triaxial seismic sensor and single channel pressure sensor or hydrophone. Comprehensive state of health (SOH), simplified GPS timing synchronization shipboard pre- and post-deployment, intuitive easy-to-use workflows, and rapid data retrieval of time-corrected ready-to-analyze miniSeed data and StationXML metadata help ensure both high outcome certainty and deployment efficiency. The Pegasus OBS also supports telemetry function to enable low-power transmission from the seafloor of system status, low-bandwidth data and segments of any recorded historical data.

- Extremely low SWaP (200mW for 3 channels, 240mW for 4 channels – including timing system)
- Low drift Seascan Time Base Module with reserve power input
- Streamlined workflow without the need to open pressure vessels
- Mobile app dashboard provides confidence in correct configuration
- Support for wide range of sensors and the capability to achieve the highest performance
- One-tap timing synchronization pre- and post-deployment
- Rapid data retrieval (1 year of 4-channel 100sps data in <2 min)
- Complete datasets including full metadata (with timing sync records and serial numbers)
- SOH and remote data access to enable advanced capabilities Plug and Play detection of Nanometrics instruments allows complete automated station xml creation on site, including the sensor response

### An OBS workflow to support managing at science at scale

Months out	Weeks out	Days out	Deployment	Recovery	Analysis
<ul> <li>Establish equipment</li> <li>Define/Choose Configuration(s)</li> <li>Create and iterate Campaign</li> <li>Plan Station Locations/ Names</li> </ul>	<ul> <li>Build up OBS Units</li> <li>Establish detailed equipment plan</li> <li>Arrange equipment for transfer to ship</li> </ul>	<ul> <li>Deploy Station Configuration</li> <li>Confirm deployment in planning tool</li> <li>Confirm equipment function</li> <li>Power in standby</li> <li>Put systems on ship</li> </ul>	<ul> <li>Apply power to device</li> <li>Verify power &amp; sensor status</li> <li>Perform time synchronization</li> <li>Ready to deploy</li> </ul>	<ul> <li>Bring to ship deck</li> <li>Perform post- deployment time synchronization</li> <li>Retrieve Data</li> <li>Disconnect devices and power down</li> <li>Complete dataset of deployment is available</li> </ul>	<ul> <li>Datasets are in a format ready to be analyzed</li> <li>Available complete station records with metadata including timing synchronizations</li> <li>Audit trail for all stations</li> </ul>
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## The impact of lowering power

Pegasus OBS Datalogger

Case Study 2: A reduction of 100mW in instrumentation consumption (300mW to 200mW

300 mW Data I 200 mW Data I

Results: 23% greater duration, 80% of the volume of batteries required. *Note: Pegasus OBS is* 200mW for 3 Channels at full performance



## Solutions

### Versatile complete systems

The versatile and proven Abalones OBS platform, licensed from the Scripps Institution of Oceanography, has been enhanced with the low-power and high performance Pegasus OBS data logger and support for the family of Trillium OBS seismometers.

- Proven platform
- Trawl resistant design
- Current shielding design with deployed seismometer decoupled from frame
- Streamlined workflows
- Predictable manufacturing, supply and support
- Increased instrumentation options including Trillium 120/360 OBS
- Versatile battery provisioning with built in timingbackup (2-20months)
- Flexible configurations for primary and secondary sensors
- Wide recovery beacon support

Customer units are already shipping, a proven flexible system with the next generation of performance available now.

## A solid foundation for new ideas

Pegasus OBS and Trillium OBS instruments are integrated in multiple operational systems from research institutions and commercial partners to date. The latest options enable streamlined workflows at the lowest power, while expanding the range of available performance.

These next generation instrument are built with six guiding design principles:







Minimize Size, Weight No compromise in & Power (SWaP) instrument performance efficient workflow

These instruments are also forming the core seismic function of upcoming system designs both planned and in active development. The Pegasus OBS and the range of Trillium OBS Seismometers are available now on standard lead times to support designs enabling the future of ocean bottom science.

Case Study 1: Moving from a Trillium 240 OBS (700mW) to a Trillium 120 OBS (230mW),

	Duration (months)	Duratio	on w DPG
Trillium 240		8.7	8.2
Trillium 120 C	BS	18.8	16.5
Posults: Double the dur	ution Half the volume of ha	18.8	for the sam

or roomwinnistramentation consumption (Soomwit							
	Duration (months)	Duration w DPG					
ogger	16.5	14.6					
ogger	20.4	17.6					



## Abalones







Complete, Ready to use Datasets