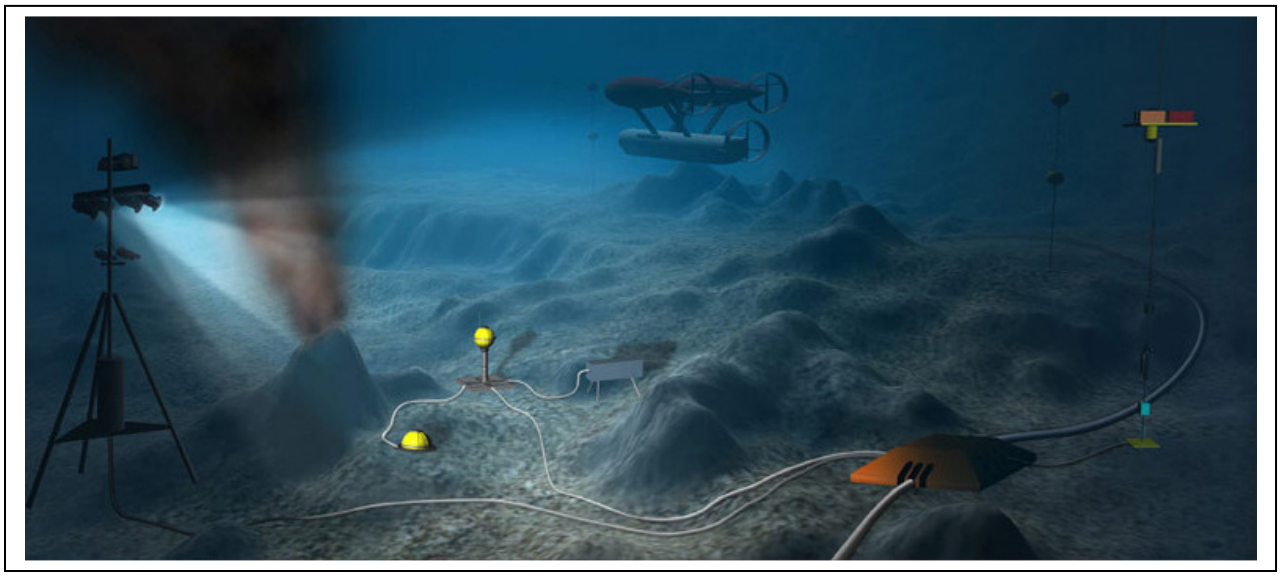
Ocean Observatories Initiative
Regional Scale Nodes

UNIVERSITY OF WASHINGTON

Short Period Seismometer Technical Specification

Version 1-04



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Version	Release Date	Description	By
1-00	2010-11-24	Initial release based on 1336-00000 Version 1-02	S. Denny
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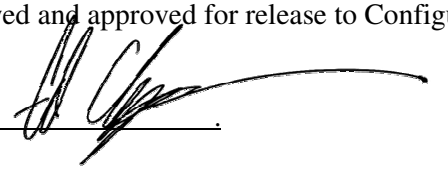
Signature Page

This document has been reviewed and approved for release to Configuration Management.

OOI Senior Systems Engineer:  .

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1. General

1.1. Ocean Observatories Initiative (OOI) Overview

Although the ocean is central to the habitability of our planet, it is largely unexplored. Biological, chemical, physical, and geological processes interact in complex ways in the ocean, at the seafloor, and at the air-sea interface. Our ability to learn more about these processes is severely limited by technical infrastructure, and developing a more fundamental scientific understanding of these relationships requires new and transformational approaches to ocean observation and experimentation.

The Ocean Observatories Initiative (OOI) will lay the foundation for future ocean science observations. OOI will enable powerful new scientific approaches by transforming the community's focus from expedition-based data gathering to persistent, controllable observations from a suite of interconnected sensors. The OOI's networked sensor grid will collect ocean and seafloor data at high sampling rates over years to decades. Researchers will make simultaneous, interdisciplinary measurements to investigate a spectrum of phenomena including episodic, short-lived events (tectonic, volcanic, oceanographic, biological, and meteorological), and more subtle, longer-term changes and emergent phenomena in ocean systems (circulation patterns, climate change, ocean acidity, and ecosystem trends).

The OOI will enable multiple scales of marine observations that are integrated into one observing system via common design elements and an overarching, interactive cyberinfrastructure. Coastal-scale assets of the OOI will expand existing observations off both U.S. coasts, creating focused, configurable observing regions. Regional cabled observing platforms will 'wire' a single region in the Northeast Pacific Ocean with a high speed optical and high power grid. Global components address planetary-scale changes via moored open-ocean buoys linked to shore via satellite. Through a unifying cyberinfrastructure, researchers will control sampling strategies of experiments deployed on one part of the system in response to remote detection of events by other parts of the system.

A more detailed discussion of the Oceans Observatories Initiative can be found in the OOI Final Network Design.

1.2. Document Scope and Purpose

This document contains specifications for the ***Short Period Seismometer Instrument*** to be used on the Regional Scaled Nodes (RSN) of the OOI. The instrument is comprised of a ***Short Period Seismometer*** and a ***Digitizer*** that is expected to be necessary to convert the analog signal and to interface with the RSN system. A ***Housing*** will be required to permit use on the seafloor. The Short Period Seismometer will measure 3-dimensional waves in the seafloor as specified by the requirements in the following sections.

Contractual terms and other non-technical information are not part of this document.

1.3. Documents

1.3.1. Informational

The documents listed in this section are for informational purposes only and may not have been referenced in

this specification.

- Consortium for Ocean Leadership, Inc. 2010, "Final Network Design", Washington, DC. [Online] Available: http://www.oceanleadership.org/programs-and-partnerships/ocean-observing/ooi/network-design/

1.3.2. Applicable

These documents contain additional requirements and specifications applicable to the instrument being specified for procurement.

None

1.4. Definitions

1.4.1. Glossary and Acronyms

- **Accuracy** – Closeness of the agreement between the result of a measurement and the value of the measurand (or true value of the measurement). (Taylor and Kuyatt, 1994).
- **Digitizer –** in this context, a device that converts analog signals to digital and provides an interface between the measurement sensors and the external system.
- **EIA** – Electronics Industries Association
- **Instrument** – A device that contains one or more sensors and a method for converting the information from the sensor into a transmittable and storable form.
- **Jitter –** the time, phase or amplitude variation in a digital signal, usually specified statistically as a 1σ deviation from an ideal signal.
- **Objective Value** – The desired value of a technical parameter. This value, if provided, may be more challenging to achieve than the Threshold value. It is a goal, not a requirement, for the instrument.
- **OOI** – Ocean Observatories Initiative
- **Operate** – Correctly performing designed functionality.
- **NLNM** – new low noise model
- **Precision** – The closeness of agreement between independent measurements obtained under stipulated conditions of repeatability, generally expressed as a standard deviation (or standard uncertainty) of measurement results. Used as a measure of stability of an instrument/sensor and its capability of producing the same measurement over and over again for the same input signal (Taylor and Kuyatt, 1994).
- **Resolution** – The least count (lc) voltage or velocity corresponding to an individual sample.

- **RSN –** Regional Scale Nodes
- **PSS** – Practical Salinity Scale, the UNESCO Practical Salinity Scale of 1978 (PSS78). PSS defines salinity as a dimensionless conductivity ratio.
- **Seismonument** - A concrete block of typically trapezoidal cross section with a hole bored in the long axis to accept short period seismometers.
- **Sensor** – A device that will convert a physical phenomenon into an electrical signal that can in turn be digitized through the use of an analog to digital converter. A sensor is normally housed in an instrument. Data coming from sensors is normally raw and needs to be calibrated.
- **Survive** – Experience an event without major loss of hardware. System might experience loss of functionality requiring repair to return to normal mode functionality. An example of this is knockdown of a global mooring or loss of some part of the mooring resulting in the instrument descending to the bottom. Any internal memory in the instrument would remain accessible, but the sensors might need to be replaced to return to normal functionality.
- **Sustain** – Experience an event (environmental extreme or condition) without permanent loss of normal mode functionality. System may experience reduction of functionality during event.
- **Threshold Value** – The limiting acceptable value of a technical parameter. If this item does not meet the performance as specified by the threshold value, it may not be sufficient for inclusion in the OOI system.
- **Short Period Seismometer –** a sensor that measures 3-axis, relatively high frequency motion of the earth.
- **USGS –** United States Geological Survey
- **NLNM –** New Low Noise Model, from USGS reflecting a noise floor standard for geophysical measurements.
- **UTC –** Coordinated Universal Time

1.4.2. Conventions

All values contained in this document are Threshold Values unless specifically stated otherwise.

The bidder shall ignore the references in angle brackets < > at the end of each specification. They are for internal OOI use only.

2. Specifications

2.1. Measurement

Values provided are threshold unless otherwise stated.

2.1.1. Seismic Response

a) Measurement with unit(s)

MEAS-001 The Short Period Seismometer shall measure ground motion velocity in 3 orthogonal directions in units of m/s. The calibration shall be performed by correlation to the output signal which is in units of V-s/m. <L4-RSN-IP-RQ-145>

b) Range

N/A

c) Accuracy

N/A

d) Precision

NA

e) Resolution

N/A

f) Drift

N/A

g) Response Times

N/A

h) Sampling Frequency

N/A

i) Dependencies

N/A

j) Self-Noise

MEAS-002 The Short Period Seismometer shall make measurements of ground velocity at instrumental noise levels that are no more than the USGS NLNM within a frequency band extending from ≤1 Hz (1 s) to ≥100 Hz (0.01 s). < L4-RSN-IP-RQ-146>

k) Response

MEAS-003 The Short Period Seismometer shall have a response of no less than 1200 V-s/m. < L4-RSN-IP-RQ-604>

MEAS-004 The Short Period Seismometer shall have a response of no more than 1500 V-s/m. < L4-RSN-IP-RQ-604>

l) Calibration

MEAS-005 The Short Period Seismometer shall be capable of calibration via remotely injected signals.

m) Frequency Range

MEAS-006 The Short Period Seismometer shall have a frequency pass band with a flat velocity response extending from ≤1 Hz (1 s) to ≥100 Hz (0.01 s). < L4-RSN-IP-RQ-423>

2.1.2. Digitizer Response

DIGI-001 The Digitizer shall convert analog signals from short period seismometer to digital representations of Voltage (calibrated to V-s/m).

a) Resolution

DIGI-002 The Digitizer shall collect short period seismic measurements with 16-bit resolution. < L4-RSN-IP-RQ-149>

DIGI-003 The Digitizer should collect short period seismic measurements with 24-bit resolution. This is an objective.

b) Sampling Frequency

DIGI-004 The Short Period Seismometer shall be capable of acquiring short-period measurements of ground velocity with a sample rate of 250 Hz.

c) Dependencies

DIGI-005 The Digitizer shall be capable of acquiring 3-axis analog short period measurements.

d) Self-Noise

DIGI-006 The Digitizer shall enable short period measurements of ground velocity at instrumental noise levels that are no more than the USGS NLNM within a frequency band extending from ≤1 Hz (1 s) to ≥100 Hz (0.01 s). <L4-RSN-IP-RQ-146>

a. Calibration Signals

DIGI-008 The Digitizer shall be capable of sending calibration signals (e.g. white noise, step gains) to the Short Period Seismometer on command.

2.2. Operational

2.2.1. Operational Depth Range

OPER-001 The Short Period Seismometer shall operate with full functionality to a water depth of 2000 meter. <L4-RSN-IP-RQ-156>

2.2.2. Environmental

a) Salinity

OPER-002 The Instruments shall be capable of operating in water salinities from 0 to 40 on the PSS. <L4-RSN-IP-RQ-583>

b) Temperature

OPER-003 The Instruments shall be capable of operating in water temperatures from -2 to 35 ℃. <L4-RSN-IP-RQ-530>

c) Biofouling

N/A

d) Corrosion

N/A

e) Maximum Wave Height

N/A

f) Maximum Wind Speed

N/A

2.2.3. Service Requirements

N/A

2.2.4. Calibration Requirements

OPER-004 The Short Period Seismometer shall be capable of remote- or self-calibration while deployed. <L4-RSN-IP-RQ-129>

OPER-005 The Short Period Seismometer velocity measurements shall be calibrated to a root mean squared residual of ≤0.05% at a signal level of one-third of the operating bandwidth. <L4-RSN-IP-RQ-129>

2.2.5. Maintenance

OPER-006 Instruments shall meet all performance requirements for a deployment of 60 months without the need for physical maintenance.

2.2.6. Deployment

OPER-007 Instruments shall be capable of being deployed, recovered, and redeployed without impairment of the performance of any of their components. <L4-RSN-IP-RQ-78>

2.2.7. Reliability

OPER-008 Instruments shall recover from sudden loss of power in a known state and with full functionality.

2.2.8. Availability

OPER-009 The Short Period Seismometer shall collect short-period measurements of ground velocity for 25 years, 95% of the time. <L4-RSN-IP-RQ-148>

2.3. Mechanical/Physical

This section of the document provides specifications for the mechanical properties of instruments.

2.3.1. Materials

MECH-001 The instrument housing shall be constructed using titanium alloy or non-metallic materials.

MECH-002 The instrument exterior connector shall be constructed using a titanium alloy or non-metallic materials.

MECH-003 Instruments shall have electronics housings capable of sustaining immersion in seawater to 2000 m. <L4-RSN-IP-RQ-156>

2.3.2. Size

MECH-004 Instrument housings shall be cylindrical with the major axis horizontal for deployment. Instruments will be mounted in a horizontally-drilled hole in rock or in a seismonument.

2.3.3. Weight

N/A

2.3.4. External Marking

MECH-005 Instruments shall have external markings or indicators that identify the internal alignment of measurement axes to ≤3°. <L4-RSN-IP-RQ-152>

2.4. Electrical

This section of the document provides specifications for the internal electrical properties of instruments.

2.4.1. Interference Requirements

ELEC-001 The Instrument electronics should be capable of operating in the presence of a +/- 50 VDC potential between the power conductors and the pressure case.

2.4.2. Voltage

ELEC-002 The interface between the short period seismometer and the digitizer shall be differential.

2.4.3. Current

N/A

2.4.4. Power

N/A

2.4.5. Grounding

ELEC-003 Instruments should ground all circuitry internally with no connection to the seawater. This is an objective.

2.4.6. Battery Life

N/A

2.4.7. Modes/State of Operation

N/A

2.4.8. Isolation

ELEC-004 All instrument electronics and electrical connections shall be isolated from seawater by greater than 10 MΩ.

ELEC-005 All instrument electronics and electrical connections should be isolated from seawater by greater than 100 MΩ. This is an objective.

2.5. Data Storage and Processing

N/A

2.6. Software/Firmware

N/A

2.7. Platform Interfaces

2.7.1. Mechanical

N/A

2.7.2. Electrical

a) Voltage

INTF-001 Instruments shall be powered by two-wire (+VDC, -VDC) voltages floating free of the housing. <L4-RSN-IP-RQ-85>

INTF-002 Instruments shall operate from a supply voltage of 5 VDC +/- 5%, 12 VDC +/- 5%, 24 VDC +/- 5%, or 48 VDC +/- 5%.

b) Current

N/A

c) Power

N/A

d) Connector

INTF-003 The short period seismometer shall be provided with a connector, to be specified, in order to interface with the RSN system.

2.7.3. Data and Communication

a) Timing

INTF-004 The instrument shall time-stamp data with accuracy of ≤1µs with respect to its internal clock. <L4-RSN-IP-RQ-150>

INTF-005 The instrument shall time-stamp data with jitter of ≤ 1 µs. <L4-RSN-IP-RQ-425>

b) Clock Synchronization

INTF-006 Instruments shall have an internal clock.

INTF-007 Instruments shall have the ability to time synchronize the clock and/or set the clock over the interface.

INTF-008 The instrument's internal clock shall be capable of being synchronized to a timing accuracy of ≤1 µs with respect to 1PPS. <L4-RSN-IP-RQ-150>

c) Data Rate

INTF-009 Instruments communicating via serial interfaces shall communicate at a minimum data rate of 9600 bits/s.

INTF-010 Instruments should have a user-settable data rate, up to 115,200 bits/s for serial interfaces. This is an objective.

d) Data Format

N/A

e) Protocols

INTF-011 Instruments with an Ethernet interface should provide an auto-discovery mechanism (e.g., PUCK, Universal Plug'n'Play', ZeroConf/Bonjour, etc.). This is an objective.

INTF-012 Instruments shall acknowledge command execution, including an indication as to whether a command has succeeded or failed. <L4-RSN-IP-RQ-92>

f) Physical Interface

N/A

g) Electrical Interface

INTF-013 Instruments shall communicate (Data and Commands) via EIA-485 or EIA-422. <L4-RSN-IP-RQ-88>

h) Remote Access

INTF-014 Instruments shall be capable of being remotely accessed and controlled via the communication interface. <L4-RSN-IP-RQ-91>

INTF-015 Instruments should support remote firmware installation. This is an objective.

INTF-016 All data stored on the instrument shall be accessible remotely over the communication interface.

i) Modes

N/A

j) Modem

N/A

2.8. Compliance

COMP-001 To the greatest extent practical, instruments should be compatible with applicable national and international standards, including those of the IEEE, ANSI, and IEC.

2.8.1. Environmental

N/A

2.8.2. FCC

N/A

2.8.3. OSHA

N/A

2.9. Safety

N/A

2.10. Shipping and Storage

2.10.1. Shipping

SHIP-001 Instruments in their shipping containers shall be capable of transport without damage or degradation during shipping conditions defined by ASTM D4169 truck assurance level 1.

2.10.2. Storage

SHIP-002 Instruments shall be capable of being stored without damage or degradation between -20 and 50°C for periods of up to twelve (12) months.

2.10.3. Safe Handling

SHIP-003 Instrument transportation cases shall have external labels specifying safe handling precautions.

2.11. Identification

2.11.1. Physical Markings

IDEN-001 Instruments shall be marked indelibly on an exterior surface. Marking shall include manufacturer's part number, unit serial number, and OOI provided identification numbers.

IDEN-002 Instruments shall be capable of being marked indelibly by OOI without damage to the instrument or housing.

2.12. Quality

2.12.1. Product Quality

QUAL-001 The materials used in construction of the instrument body, sensors, and sensor mounts shall be chosen and treated in such a way as to reduce the levels of wear, corrosion and deterioration to allow multiple deployments of each unit.

3. Documentation and Support

See the RFP for documentation that the vendor is required to supply.

4. Appendices

None