Bio-acoustic Sonar Instrument Package Specification

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Coastal and Global Scale Nodes
Ocean Observatories Initiative
Woods Hole Oceanographic Institution
Oregon State University
Scripps Institution of Oceanography

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Revision History

Version	Description	Originator	ECR No.	Release Date
1-00	Initial Release	S. White	1303-00084	26 January 2011
1-01	Updated definitions and INTF-001; added SOFT-001, INTF-018, QUAL-004, Appendices 4.1 and 4.2; Series A, B, C indicated.	S. White	1303-00229	9 March 2011
1-02	Changed OPER-005, OPER-009, and OPER-010 to objectives, per requirements changes (ECR 1303-00350), updated Threshold Value definition.	S. White	1303-00355	15 June 2011
1-03	Replace ASTM D4169 with ASTM-D3951.	S. White	1303-00413	06 Sept 2011

Signature Page

This document has been reviewed and approved for release.

OOI Senior Systems Engineer: _____

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1.0 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

The purpose of this specification is to provide the requirements for a bio-acoustic sonar instrument package to be purchased for use on the Coastal and Global Scale Nodes (CGSN) of the Ocean Observatories Initiative. Bio-acoustic sonars will be deployed at depths of ~520 m or less on moorings, and seafloor packages to detect zooplankton and fish. Deployment locations will include both Global sites where the sonar will be mounted on a mid-water platform at ~200 m; and Coastal sites where the sonar will be mounted on seafloor packages at depths from 25 m to 520 m.

This document describes the physical, functional and electrical characteristics of bio-acoustic sonar instrument packages required by CGSN.

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

- Ross, D., Ship Sources of Ambient Noise, IEEE JOE, Vol. 30, No. 2, 257-261, 2005.

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)
- **Burst Sampling** – Intermittent rapid sampling at or near the maximum sampling rate for short intervals between longer quiescent periods.
- **CGSN** – Coastal and Global Scale Nodes
- **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.
- **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.
- **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 (Taylor and Kuyatt, 1994). 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.
- **Resolution** – The smallest amount of input signal change that the instrument/sensor can detect reliably.
- **Response Time** – The time required for an output to reach a specified fraction of its final value as a result of a step change in input.
- **PSS** – Practical Salinity Scale, the UNESCO Practical Salinity Scale of 1978 (PSS78) defines salinity as a dimensionless conductivity ratio.
- **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 may 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 shall remain accessible, but the sensors may 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.

1.4.2 Conventions

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

Specification items are assigned unique identification numbers specific to this document. Items tied directly to requirements maintained in the OOI requirements database are followed by the requirement number in brackets (e.g., [L4-CG-IP-RQ-XXX]). The requirement number is intended for internal OOI use only.

2.0 Specifications

2.1 Measurement

Values provided are threshold unless otherwise stated.

2.1.1 Acoustic backscatter

a) Measurement with unit(s)

Acoustic volume backscattering strength, S_v (decibel, dB re 1 m^{-1})

b) Minimum Value

ACOU-001 Acoustic backscatter instruments shall have a measurement range with a minimum value of -100 dB re 1 m^{-1}. [L4-CG-IP-RQ-533]

c) Maximum Value

ACOU-002 Acoustic backscatter instruments shall have a measurement range with a maximum value of -20 dB re 1 m^{-1}. [L4-CG-IP-RQ-533]

d) Accuracy

ACOU-003 Acoustic backscatter strength shall be measured to an accuracy of ± 0.5 dB re 1 m^{-1}. [L4-CG-IP-RQ-429]

e) Precision

ACOU-004 Acoustic backscatter strength shall be measured to a precision of ± 0.1 dB re 1 m^{-1}. [L4-CG-IP-RQ-430]

f) Resolution

ACOU-005 Acoustic backscatter instruments shall have a resolution of less than or equal to 0.1 dB re 1 m-1. [L4-CG-IP-532]

g) Drift

N/A

h) Response Times

N/A

i) Sampling Frequency

ACOU-006 Acoustic backscatter instruments shall be capable of making measurements at intervals of 1 second. [L4-CG-IP-RQ-426]

j) Dependencies

N/A

k) Acoustic Characteristics

ACOU-007 Acoustic backscatter instruments shall have a total system noise floor that does not exceed the Sea State 0 ambient noise curve from Ross, 2005. [L4-CG-IP-RQ-534]

ACOU-008 Acoustic backscatter instruments shall have an instantaneous dynamic range of no less than 120 dB. True instantaneous dynamic range is defined as ten times the base-ten-logarithm of the maximum received power output by the analog-to-digital converter (ADC) divided by the minimum received power output by the ADC (minimum signal or system noise level, whichever is greater). [L4-CG-IP-RQ-431]

ACOU-009 Acoustic backscatter instruments shall be capable of a vertical resolution of 0.25 m. [L4-CG-IP-RQ-427]

ACOU-010 Acoustic backscatter instruments shall be capable of pulse durations of 1.024 msec or less for all frequencies. [LR-CG-IP-RQ-535]

ACOU-011 Acoustic backscatter instruments should be capable of pulse durations of 0.512 msec or less for all frequencies. This is an objective. [LR-CG-IP-RQ-536]

ACOU-012 Acoustic backscatter instruments shall have a beam width of no greater than 35 degrees. [L4-CG-IP-RQ-537]

ACOU-013 Acoustic backscatter instruments shall have sidelobes of no greater than -15 dB. [L4-CG-IP-RQ-538]

ACOU-014 Acoustic backscatter instruments shall have a frequency band at 38 kHz ± 15%. [L4-CG-IP-RQ-428]

ACOU-015 Global acoustic backscatter instruments should have a frequency band at 70 kHz ±10%. This is an objective. [L4-CG-IP-RQ-539]

ACOU-016 Acoustic backscatter instruments shall have a frequency band at 120 kHz ±10%. [L4-CG-IP-RQ-540]

ACOU-017 The 120 kHz frequency band of acoustic backscatter instruments shall have a split beam. [L4-CG-IP-RQ-541]

ACOU-018 Acoustic backscatter instruments shall have a frequency band at 200 kHz ±10%. [L4-CG-IP-RQ-542]

ACOU-019 Coastal acoustic backscatter instruments should have a frequency band in the 350-460 kHz range This is an objective. [L4-CG-IP-RQ-543]

ACOU-020 Acoustic backscatter instruments shall have a range of at least 200 m for all frequencies less than or equal to 220 kHz. [L4-CG-IP-RQ-544]

ACOU-021 Global acoustic backscatter instruments should be capable of making upward- and downward-looking measurements with a single instrument. [L4-CG-IP-RQ-550]

2.2 Operational

2.2.1 Operational Depth Range

OPER-001 The operational depth rating of the instrument shall be consistent with the depth rating of the platform on which it is mounted (See Appendix 4.1). [L4-CG-IP-292]

2.2.2 Environmental

a) Salinity

OPER-002 Instruments shall be capable of operating in water salinities from 0 to 40 PSU. [L4-CG-IP-RQ-443]

b) Temperature

OPER-003 Instruments shall be capable of operating in water temperatures from -2° to +35° C. [L4-CG-IP-RQ-442]

c) Biofouling

OPER-004 Sensors shall utilize biofouling mitigation to enable nominal operations over the defined deployment interval. [L4-CG-IP-RQ-446; L3-CG-RQ-867]

d) Icing

N/A

2.2.3 Service Requirements

N/A

2.2.4 Calibration Requirements

OPER-005 Sensors should maintain their calibration over the required deployment intervals. This is an objective. [L4-CG-IP-286]

2.2.5 Deployment Interval

OPER-006 The designed deployment interval for instrument packages on moored assets at Global sites shall be 13 months. [L3-CG-RQ-168]

OPER-007 The designed deployment interval for instrument packages on moored assets at Coastal sites shall be 13 months. (In some cases the actual deployment interval may be 7 months; see Appendix 4.1.) [L3-CG-RQ-496; L3-CG-RQ-497]

2.3 Mechanical/Physical

2.3.1 Materials

OPER-008 Instrument electronics housings shall be designed to be corrosion resistant. [L4-CG-IP-288]

OPER-009 Instruments fixed on Coastal moorings should have electronics housings capable of sustaining immersion in seawater to 600 m. This is an objective. [L4-CG-IP-435]

OPER-010 Instruments fixed on Global moorings should have electronics housings capable of sustaining immersion in seawater to 6000 m. This is an objective. [L4-CG-IP-448]

2.3.2 Size

N/A

2.3.3 Weight

N/A

2.4 Electrical

2.4.1 Interference Requirements

ELEC-001 Instruments shall be capable of controlled transmission cycles to avoid interference with other active elements (e.g., ADCPs).

2.4.2 Voltage

N/A

2.4.3 Current

N/A

2.4.4 Power

N/A

2.4.5 Grounding

ELEC-002 Instruments should ground all circuitry internally with no connection to the seawater. This requirement means that there should be no low resistance connection between either side of the power supply, or any communications line, and the ground (or seawater) at or within the instrument. This is an objective.

2.4.6 Battery Life

ELEC-003 Battery powered instruments shall have battery capacity to operate at the typical sampling rate for the defined deployment interval (see Appendix 4.1). [L4-CG-IP-298]

2.4.7 Modes/State of Operation

ELEC-004 Instruments shall return to a defined operational state upon being depowered and repowered. [L4-CG-IP-447]

2.4.8 Isolation

ELEC-005 All instrument electronics and electrical connections shall be isolated from seawater by greater than 10 megaohms.

2.5 Data Storage and Processing

2.5.1 Storage Capacity

DATA-001 Instruments shall provide non-volatile internal data storage. The data storage size shall accommodate data taken at the typical rate over the duration of the deployment interval (see Appendix 4.1).

DATA-002 Instruments should internally store calibration and sensors serial numbers. This is an objective.

DATA-003 Acoustic backscatter instruments should store all raw data. This is an objective. [L4-CG-IP-RQ-545]

DATA-004 Acoustic backscatter instruments shall be capable of outputting acoustic volume backscattering strength data in bins. [L4-CG-IP-RQ-546]

2.6 Software/Firmware

SOFT-001 Serial instruments requiring a break signal should be capable of emulating the break by a software character sequence. This is an objective.

2.7 Platform Interfaces

2.7.1 Mechanical

N/A

2.7.2 Electrical

INTF-001 The instrument package shall connect to the platform controller for power and communications (the connector type iss on the CGSN platform controller housing are TBS and will be detailed in an interface control document).

INTF-018 The instrument should include a standard type of OOI bulkhead connector on the instrument housing (see Appendix 4.2). This is an objective.

INTF-002 The instrument package shall operate from a supply voltage of either 12 VDC +/- 5% or 24 VDC +/- 5%. [L4-CG-IP-RQ-287]

INTF-003 Instruments shall be powered by two-wire (+VDC, -VDC) voltages floating free of the housing. [L4-RSN-IP-RQ-85]

INTF-004 The instantaneous power draw of the instrument shall not exceed 50 W.

2.7.3 Data and Communication

a) Timing

INTF-005 Instruments shall provide time-stamping capabilities or latency characterization between data sampling and data output. [L4-CG-RQ-450]

Preferences for instrument time stamping capabilities are as follows (best first):

- Time stamp embedded in every data record to the design accuracy of the instrument's clock, using ISO 8601 compliant timestamp
- Time stamp embedded in every data record to the design accuracy of the instrument's clock, using another described, parseable timestamp format
- Time stamp every data sequence, with fixed time between every data record
- Fully characterize the latency between data sampling and appearance of the data at the output connector
- Time stamp embedded in every data record, with precision that is less than the accuracy of the instrument's clock, using ISO 8601 compliant timestamp
- Time stamp embedded in every data record, with precision that is less than the accuracy of the instrument's clock, using another described, parseable timestamp format.

b) Clock Synchronization

INTF-006 Instruments should have an internal clock. This is an objective.

INTF-007 Instruments with internal clocks shall be capable of time synchronization. [L4-CG-RQ-449]

c) Data Rate

INTF-008 Instruments should have a user-settable baud rate, up to 115,200 bits/sec for serial interfaces. This is an objective.

d) Data Format

N/A

e) Protocols

INTF-009 Instruments with an Ethernet interface should provide an auto-discovery mechanism, (e.g., PUCK, Universal Plug'n'Play', ZeorConf/Bonjour). This is an objective.

f) Physical Interface

N/A

g) Electrical Interface

INTF-010 Instruments shall communicate (Data and Commands) while deployed with the OOI infrastructure (e.g. CI device driver or platform interface) via at least one of the following interfaces: Ethernet (10/100 Mb), or serial EIA standards: RS-422, RS-485, or RS-232. [L4-CG-IP-RQ-297, L4-CG-IP-RQ-291]

h) Remote Access

INTF-011 Instruments shall be capable of being remotely accessed and controlled via the communication interface. [L4-CG-IP-RQ-294]

INTF-012 All data stored on the instrument shall be accessible remotely over the communication interface.

INTF-013 Instruments should support remote firmware installation. This is an objective.

INTF-014 Acoustic backscatter instruments shall be capable of remote re-boot, even if internally powered. [L4-CG-IP-RQ-548]

INTF-015 Acoustic backscatter instruments shall have configurable parameters. [L4-CG-IP-RQ-547]
Hardware configuration parameters include but are not limited to: sound speed, pulse length, absorption coefficient.
Data acquisition parameters include but are not limited to: pings to average, vertical bin size.

i) Modes

INTF-016 Instruments should allow polled and asynchronous mode operation. This is an objective.

j) Inductive Modems

INTF-017 Instruments on Global moorings shall be capable of communication via an inductive modem.

2.8 Compliance

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

2.8.1 Environmental

COMP-002 Acoustic backscatter instruments shall have a source level no greater than 213 dB (re 1µPa @ 1m). [L4-CG-IP-RQ-549]

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 shall be provided with reusable transportation cases. [L4-CG-IP-RQ-660]

SHIP-002 Instrument Transportation Cases shall fit within an ISO shipping container. [L3-CG-RQ-494]

SHIP-003 Transportation cases shall meet or exceed ASTM-D3951 "Standard Practice for Commercial Packaging." [L4-CG-IP-RQ-660]

2.10.2 Storage

SHIP-004 Instruments shall be capable of being stored with out damage or degradation between -20° and 50° C for periods of up to 12 months.

2.10.3 Safe Handling

SHIP-005 Instrument transportation cases shall have external labels specifying safe handling precautions.

2.11 Identification

2.11.1 Physical Markings

IDNT-001 All components of the Bio-acoustic Sonar instrument package shall be marked indelibly on an exterior surface. Marking shall include:

- Manufacturer's part number
- Unit serial number
- CGSN part number as defined below:
  - P/N 3305-00008-00001 Series A Bio-acoustic Sonar
  - P/N 3305-00008-00002 Series B Bio-acoustic Sonar
  - P/N 3305-00008-00003 Series C Bio-acoustic Sonar

2.12 Quality

2.12.1 Product Quality

QUAL-001 Instrument packages shall be manufactured in accordance with the manufacturer's best practices. Records of quality assurance tests and inspections shall be available for review by the purchaser.

QUAL-004 A First Article Testing report shall be provided with each first article unit delivered.

QUAL-002 A certificate of compliance shall be provided with each delivered unit. The certificate of compliance shall be supported with copies of the Factory Acceptance Test report and calibration records for each sensor following integration into the unit.

QUAL-003 The materials used in construction of the instrument packages 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.

3.0 Documentation and Support

N/A

4.0 Appendices

4.1 Table of Bio-acoutics Sonar Types

Table 1. Variations of bio-acoustic sonars required for OOI

	Series A	**Series B**	**Series C**
	Global	**Coastal Cabled**	**Coastal Uncabled**
Deployment Interval	13 months	13 months	7 months
Typical Sampling Rate	3 pings/30 min	3 pings/30 min	3 pings/30 min
Battery Power Required	Yes	No	Possibly
Inductive Modem Communications	Yes	No	No
Operational Depth	~600 m	~600 m	~600 m
Survivability Depth	6000 m	600 m	600 m
Frequency Bands	38 kHz ±15% 70 kHz[a] ±10% 120 kHz[b] ±10% 200 kHz ±10%	38 kHz ±15% 120 kHz[b] ±10% 200 kHz ±10% 350-460 kHz[a]	38 kHz ±15% 120 kHz[b] ±10% 2005 kHz ±10% 350-460 kHz[a]

[a] It is an objective to include this frequency band.
[b] The 120 kHz frequency band shall be split beam

4.2 Preferred OOI Standard Connector types.

Instruments should use an MCBH connector installed on the housing. The number of pins, and pinout assignments, should be appropriate to the communication protocol of the instrument, and as shown in the table below. This is an objective.

If the instrument is deployed below the surface, the underwater connector should be water blocked so that there is a back-up o-ring seal in the event that the elastomeric sealing surface delaminates from the metal shell. This is an objective.
(An example of a 6 pin water blocked connector is the MCBH(WB)-6-FS-Ti, manufactured by Teledyne Impulse.)

Protocol	**RS-232**	**RS-232**	**RS-485 (half duplex)**	**RS-485 (full duplex)**
Pin #	**4 Pin**	**6 Pin**	**6 Pin**	**8 Pin**
1	Gnd	Pwr Gnd	Pwr Gnd	Data Gnd
2	RXD	RXD	Data B+	RD B+
3	TXD	TXD	Data A-	RD A-
4	12Vdc	12Vdc*	12Vdc*	Reserved
5		24Vdc*	24Vdc*	TD A-
6		Data Gnd	Data Gnd	TD B+
7				Pwr Gnd
8				+Vdc
9				
10				

* Only one voltage will be populated, depending on instrument input power needs.

Preferred vendors include:

Teledyne Impulse
9855 Carroll Canyon Road
San Diego, CA 92131
impulse@teledyne.com

SubConn, Inc.
www.subconn.com

mac-us@macartney.com