SPECIFICATIONS FOR CONDUCTIVITY TEMPERATURE DEPTH (CTD) INSTRUMENTS ON MOBILE ASSETS AND PROFILERS

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Document Control Sheet

Version	Date	Description	Originator
0-01	5/18/2010	Derived Profiler specs from general CTD spec.	Rob DelCoco
0-02	5/19/2010	Changed title to include all mobile assets and profilers	Rob DelCoco
0-03	5/19/2010	Added SALT -002 and COND-001 to account for wire following profilers on CG that descend to 120 meters or less	Lorraine Brasseur
1-00	5/21/2010	Corrections from SE (typos only)	Lorraine Brasseur
1-01	6/1/2010	Added pres-002 and adjusted pres-001 to correct for depth range on profilers as opposed to mobile assets – discussed with SE; removed draft watermark, formatting for OOI compatibility	Lorraine Brasseur
1-02	10/15/2010	Modified SALT and COND to be consistent with the CTD spec for fixed platforms as directed by 10/15 CCB.	Rob DelCoco
1-03	1/24/2010	Updated the mobile CTD Spec to be consistent with the new spec template	Jennifer Dorton
1-04	2/2/2011	Minor corrections	Jennifer Dorton
1-05	2/15/2011	Made corrections to Section 1.2 and updated the requirements based on info provided by Art.	Jennifer Dorton
1-06	2/16/2011	Updated spec based on corrections/explanations from Al Plueddemann	Jennifer Dorton
1-07	2/18/2011	Updated spec based on discussions with Lorraine & Ed.	Jennifer Dorton
1-08	2/22/2011	Updated traceability to new requirements.	Ed Chapman
1-09	2/25/2011	Update based on CCB	Lorraine Brasseur
1-10	3/02/2011	Refined pump and accuracy specs.	Lorraine Brasseur Al Plueddemann
1-11	3/10/2011	Liens from ECR #1300-00130	Ed Chapman
2-00	3/10/2011	Release version. ECR#1300-00130	Ed Chapman
2-01	10/03/2011	Administrative Changes and removal/addition of some traceable CG requirements	Ed Chapman

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 the specifications for conductivity, temperature, depth (CTD) instruments for use on mobile platforms assets and profilers for the OOI. These assets include buoyancy-driven gliders, propeller-driven Autonomous Underwater Vehicles (AUVs), wire-following profilers, and moored shallow/surface piercing profilers.

Gliders are buoyancy-driven, battery powered underwater vehicles that achieve propulsion by changing their volume by pumping to or from an oil-filled bladder. When they dive or rise, the glider's wings achieve lift allowing the glider to fly forward through the water. They can achieve speeds of about one tenth of those of the AUVs or ~25 to 35 cm s^{-1}. At the surface, gliders acquire position information using GPS and transmit data and receive commands via satellite.

AUVs are somewhat like instrumented torpedoes, though optimized for longer life at slower speeds while carrying a sensor payload. Optimum speeds for AUVs used in oceanographic applications are near 1.7 m s^{-1}, while maximum speeds of about 2.5 m s^{-1} may be reached. AUVs have a high payload capacity relative to gliders, and will carry a broad suite of sensors for interdisciplinary observations. They surface to obtain position fixes using GPS and while at the surface they also enter the OOI communications network using satellite telemetry.

Moored wire-following profilers contain a suite of sensors that are raised and lowered through the water column on a regular basis. These are generally used for deep measurements and profiles

that can extent to more than 1000 meters in depth. It is expected that these profilers will move vertically at speeds up to about 0.25 m/s.

Moored shallow/surface piercing profilers are expected to be deployed in the shallowest 200 meters of the water column on OOI arrays. These profilers will carry a somewhat larger payload than wire-following profilers and can move vertically at speeds up to 0.5 m/s

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, D.C. [Online] Available: http://www.oceanleadership.org/programs-and-partnerships/ocean-observing/ooi/network-design/

1.3.2 Applicable

These documents contain requirements and specifications applicable to the instrument specified. The referenced section, requirement, or specification shall be met by the instrument specified herein.

- N/A

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 measure and (or true value of the measurement). (Taylor and Kuyatt, 1994).
- **AUV** – Autonomous Underwater Vehicle
- **Cabled** – Any OOI platform that is connected to a communications/power cable connected to shore. The platforms on the backbone cable in the Northeast Pacific are examples.
- **Coastal** – For OOI, a coastal or coastal ocean site is located on the continental shelf or upper slope at a depth of 1000 m or less.
- **CTD** – Conductivity, Depth and Temperature
- **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
- **Open Ocean** – Open ocean site is any site located at an ocean depth greater than 1000 meters or more than 500 km from shore.
- **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. 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 smallest amount of input signal change that the instrument/sensor can detect reliably.
- **PSS** – Practical Salinity Scale, the UNESCO Practical Salinity Scale of 1978 (PSS78). PSS 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 might experience loss of functionality requiring repair to return to normal mode functionality. An example of this is a glider loss resulting in the glider and its on-board instrument suite 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.

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.

The numbering of the specification statements (Such as “COND-005” appearing before COND-001) is for compatibility with a legacy specification and is not meant to imply any sort of priority.

2 Specifications

2.1 Measurement

Values provided are threshold unless otherwise stated.

2.1.1 Salinity Calculation Accuracy

SALT-001 For all CTD instruments, conductivity, temperature, and pressure measurements shall be collected such that salinity calculated using UNESCO Seawater Equations of State (Fofonoff and Millard, 1983) has an accuracy in the laboratory of ±0.005 on the Practical Salinity Scale (PSS). <L2-SR-RQ-3143, L2-SR-RQ-3468, L2-SR-RQ-3684, L2-SR-RQ-3486>

SALT-002 For CTD instruments on profilers that do not ascend to shallower than 200 m, conductivity, temperature, and pressure measurements shall be collected such that salinity calculated using UNESCO Seawater Equations of State (Fofonoff and Millard, 1983) has an accuracy of ±0.005 on the PSS for a full

deployment interval. < L2-SR-RQ-3143, L2-SR-RQ-3468, L2-SR-RQ-3486>

SALT-003 For CTD instruments on profilers that ascend to shallower than 200 m, conductivity, temperature, and pressure measurements shall be collected such that salinity calculated using UNESCO Seawater Equations of State (Fofonoff and Millard, 1983) has an accuracy of ±0.01 on the PSS for a full deployment interval. < L2-SR-RQ-3143, L2-SR-RQ-3468, L2-SR-RQ-3486>

SALT-004 For CTD instruments on gliders and AUVs, conductivity, temperature, and pressure measurements shall be collected such that salinity calculated using UNESCO Seawater Equations of State (Fofonoff and Millard, 1983) has an accuracy of ±0.005 on the PSS for a full deployment interval. < L2-SR-RQ-3143, L2-SR-RQ-3468, L2-SR-RQ-3486>

2.1.2 Conductivity Measurements

a) Measurement with unit(s)

Conductivity ($S \cdot m^{-1}$)

b) Minimum Value

COND-005a CTD instruments on mobile assets and profilers shall measure conductivity over a range with a minimum value of 0 $S \cdot m^{-1}$. <L2-SR-RQ-3474, L4-CG-IP-RQ-171, L4-RSN-IP-RQ-288>

c) Maximum Value

COND-005b CTD instruments on mobile assets and profilers shall measure conductivity over a range with a maximum value of 7 $S \cdot m^{-1}$. <L2-SR-RQ-3474, L4-CG-IP-RQ-171, L4-RSN-IP-RQ-288>

d) Accuracy

COND-001 For CTD instruments on mobile assets and profilers, conductivity measurements shall have an accuracy in the laboratory of ±0.0003 $S \cdot m^{-1}$ for all instruments. <L2-SR-RQ-3471, L4-CG-IP-RQ-166, L4-RSN-IP-RQ-287>

COND-002 Conductivity measurements shall have an accuracy, for the full deployment interval, of ±0.0003 $S \cdot m^{-1}$ for CTD instruments on profilers that do not ascend to shallower than 200 m.

COND-003 Conductivity measurements shall have an accuracy, for the full deployment interval, of ±0.001 $S \cdot m^{-1}$ on CTD instruments on profilers that ascend to shallower than 200 m.

COND-007 Conductivity measurements shall have an accuracy, for the full deployment interval, of ±0.0003 $S \cdot m^{-1}$ for CTD instruments on gliders and AUVs.

e) Precision

Not specified

f) Resolution

COND-006 Conductivity measurements shall have a resolution ±0.00001 $S \cdot m^{-1}$ for CTD instruments on mobile assets and profilers. <L2-SR-RQ-3472, L4-CG-IP-RQ-167, L4-RSN-IP-RQ-286>

g) Drift

COND-004 For CTD instruments on mobile assets and profilers, conductivity measurements shall have an annual drift of no more than 0.004 $S \cdot m^{-1}$. <L2-SR-RQ-3473, L4-CG-IP-RQ-344, L4-RSN-IP-RQ-477>

h) Response Times

Not specified

i) Sampling Frequency

COND-008 For CTD instruments on mobile assets and profilers, conductivity shall be sampled at a frequency of 1 Hz. < L4-CG-IP-RQ-440, >

j) Dependencies

2.1.3 Temperature Measurements

a) Measurement with unit(s)

Temperature (°C)

b) Minimum Value

TEMP-003a CTD instruments on mobile assets and profilers shall measure temperature over a range with a minimum value -2°C. <L2-SR-RQ-3463, L4-CG-IP-RQ-163, L4-RSN-IP-RQ-289>

c) Maximum Value

TEMP-003b CTD instruments on mobile assets and profilers shall measure temperature over a range with a maximum value of 35°C. <L2-SR-RQ-3463, L4-CG-IP-RQ-163, L4-RSN-IP-RQ-289>

d) Accuracy

TEMP-001 For CTD instruments on mobile assets and profilers, temperature measurements shall have an accuracy, for the full deployment interval, of ± 0.002º C. <L2-SR-RQ-3465, L4-CG-IP-RQ-342, L4-RSN-IP-RQ-291>

e) Precision

Not specified

f) Resolution

TEMP-004 For CTD instruments on mobile assets and profilers, temperature measurements shall have a resolution of 0.0001º C. <L2-SR-RQ-3461, L4-CG-IP-RQ-159 >

g) Drift

TEMP-002 For CTD instruments on mobile assets and profilers, temperature measurements shall have an annual drift of no more than 0.01º C per year. <L2-SR-RQ-3462, L4-CG-IP-RQ-343, L4-RSN-IP-RQ-478>

h) Response Times

i) Sampling Frequency

TEMP-005 For CTD instruments on mobile assets and profilers, temperature measurements shall be sampled at a frequency of 1 Hz. <L2-SR-RQ-3460, L4-CG-IP-RQ-162>

j) Dependencies

2.1.4 Pressure (Depth) Measurements

a) Measurement with unit(s)

Pressure (dbar)

b) Minimum Value

PRES-001a CTD instruments on mobile assets and profilers shall measure pressure over a range with a minimum value of 0 dbar. <L2-SR-RQ-3478, L2-SR-RQ-3479, L4-CG-IP-RQ-180, L4-RSN-IP-RQ-292>

c) Maximum Value

PRES-001b CTD instruments on mobile assets and profilers shall measure pressure over a range with a maximum value that meets the full operational depth range of the host platform. <L2-SR-RQ-3478, L2-SR-RQ-3479, L4-CG-IP-RQ-180, L4-RSN-IP-RQ-292>

d) Accuracy

PRES-003 CTD instruments on mobile assets and profilers shall measure pressure with an accuracy of ±0.1% of the maximum operational depth range. <L2-SR-RQ-3481, L2-SR-RQ-3480, L4-CG-IP-RQ-174, L4-CG-IP-RQ-176, L4-RSN-IP-RQ-294>

e) Precision

While precision is important to this measurement, a threshold value for precision is not provided in this document.

f) Resolution

PRES-005 For CTD instruments on mobile assets and profilers, pressure sensors shall have a resolution of 0.002% of the maximum value of its operational depth <L2-SR-RQ-3482, L2-SR-RQ-3483, L4-CG-IP-RQ-175, L4-CG-IP-RQ-177, L4-RSN-IP-RQ-293>

g) Drift

PRES-004 For CTD instruments on mobile assets and profilers, pressure sensors shall have an annual drift of no more than 0.05% of the maximum value of the operational depth range. < L2-SR-RQ-

3485, L2-SR-RQ-3484, L4-CG-IP-RQ-345, L4-CG-IP-RQ-346, L4-RSN-IP-RQ-479>

h) Sampling Frequency

PRES-006 For CTD instruments on mobile assets and profilers, pressure measurements shall be sampled at a frequency of 1 Hz. <L4-CG-IP-RQ-594>

i) Dependencies

(Note: There is no PRES-002 statement.)

2.2 Operational

2.2.1 Operational Depth Range

See platform specifications

2.2.2 Environmental

See platform specifications

2.2.3 Service Requirements

See platform specifications

2.2.4 Calibration Requirement

MECH-001 CTD instruments on open ocean profilers should operate for at least 13 months without recalibration. This is an objective. < L4-CG-IP-RQ-286, LR-RSN-IP-RQ-295>

MECH-005 CTD instruments on coastal profilers should operate for at least 7 months without recalibration. This is an objective.< L4-CG-IP-RQ-286>

MECH-006 CTD instruments on gliders and AUVs should operate for at least 3 months without recalibration. This is an objective.< L4-CG-IP-RQ-286>

2.2.5 Maintenance Interval

See platform specifications

2.3 Mechanical/Physical

2.3.1 Materials

See platform specifications

2.3.2 Size

See platform specifications

2.3.3 Weight

See platform specifications

2.3.4 Pump

MECH-002 The CTD instrument shall include a pump or equivalent design solution that fulfills the same purposes. The purposes of a pump are 1) controlled flow, especially in regions of reduced or obstructed flow 2) reduced biofouling,

2.3.5 Additional Instruments

MECH-003 The CTD instrument's pump should be capable of supporting additional instruments. This is an objective.

MECH-004 CTD instruments should be capable of supporting additional instruments. Support shall consist of power, command and control, and data recording. This is an objective.

2.4 Electrical

See platform specifications

2.5 Data Storage and Processing

See platform specifications

2.6 Software/Firmware

See platform specifications

2.7 Platform Interfaces

See platform specifications

2.8 Compliance

See platform specifications

2.9 Safety

See platform specifications

2.10 Shipping and Storage

See platform specifications

2.11 Identification

See platform specifications

2.12 Quality

See platform specifications

3 Documentation

3.1 Documentation

See the RFP for documentation that the vendor shall be required to supply.