Benthic Experiment Package Integration and Verification Plan

Verification Event CG-VE-3102

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

Revision History

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1-00	Initial draft presented at BEP CDR as 3167-40000	D. Neiman	N/A	5/8/2012
1-01	Initial 1163-40000 document	D. Neiman	N/A	6/19/2012
1-02	Revisions after discussions with RSN	D. Neiman	N/A	7/18/2012
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2-00	Revised for new instrument placement, schedule	D. Neiman	1300-00324	

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1 Scope

1.1 Identification

This Integration and Verification Plan applies to the Benthic Experiment Package (BEP) to be produced for the Endurance Array (EA) of the Coastal and Global Scale Nodes (CGSN) implementing organization (IO) of the Ocean Observatories Initiative (OOI). This plan describes the integration and verification activities leading up to the Product Verification Test (PVT) to demonstrate compliance to the requirements specified for the BEP and its constituting sub-systems. Full integration and requirements verification are considered part of OOI Verification Event CG-VE-3102.

1.2 System Overview

BEP subsystems comprise the hazard-resistant frame and sheathing structure of the BEP, electrical and physical interfaces of the Regional Scale Nodes (RSN) incoming cable to the RSN Low Power Junction Box (LPJBox), physical interfaces of the LPJBox to the BEP structure, electrical and physical interfaces of the LPJBox to the BEP science sensors, and physical interfaces of the BEP science sensors to the BEP structure to be deployed at the Endurance Oregon 80m (shelf) and 600m (offshore) locations. The instrument suite requirements are defined in L4-CG Instrument Package Requirements current 2.23 (CG-CCB-2012-1-11) in the OOI Dynamic Object-Oriented Requirement System (DOORS) database. Electrical and mechanical interfaces between the RSN cable, LPJBox, and science sensor suite are detailed in Document Control Number (DCN) 1133-00001 (Off-shore) and DCN 1133-00002 (Shelf). The BEP physical layout is depicted in Figure 1 and has been captured in DCN 3715-10000. The BEP is designed at the CGSN/EA facility at Oregon State University (OSU) and constructed at the OSU Ocean Observing Center (OOC). The BEP is designed to be deployed *via* an OOI Service-class Remotely Operated Vehicle (ROV) controlled from a global-class ship. Two BEP variants will be deployed, one at the Endurance Oregon 80m site (CE02SHBP) and the other at the Endurance Oregon 600m site (CE04OSBP). The two variants are described in the following table:

Comment [DN1]: External sensors?

Comment [DN2]: update

Table 1-1: Main BEP components and sensors

Item	Endurance Oregon 80m site (CE02SHBP)	Endurance Oregon 600m site (CE04OSBP)
BEP assembly (includes main frame, cover, instrument attachment frames, LPJBox mounting, ROPOS interface)	See DCN 3715-10000	See DCN 3715-10000
Platform controller and power/communication interface to cabled infrastructure	RSN Low Power Jbox CE02SHBP-LJ01D Port assignments per ICD 3715-90001	RSN Low Power JBox CE04OSBP-LJ01C Port assignments per ICD 3715-90002
Conductivity-Temperature-Depth (CTD) instrument	Sea-Bird Electronics 16plus V2 Seacat (CTDBP-N) with Digiquartz® pressure sensor and SBE19 profiling firmware	Sea-Bird Electronics 16plus V2 Seacat (CTDBP-O) with Digiquartz® pressure sensor and SBE19 profiling firmware
Dissolved Oxygen instrument	Aanderaa Optode 4831 (DOSTA-D), connects to LPJBox through CTD	Aanderaa Optode 4831 (DOSTA-D) , connects to LPJBox through CTD
Acoustic Doppler Current Profiler (ADCP) instrument	Teledyne RDI 300kHz Monitor (ADCPT-B)	Teledyne RDI 75kHz Long Ranger (ADCPS-I)
3-D Single Point Current Velocity Meter	Nortek AS Vector (VEL3D-C)	Nortek AS Vector (VEL3D-C)
Spectrally Resolved *In-situ* Optical Absorption and Beam Attenuation instrument	WET Labs, Inc. AC-S (OPTAA-C)	WET Labs, Inc. AC-S (OPTAA-C)

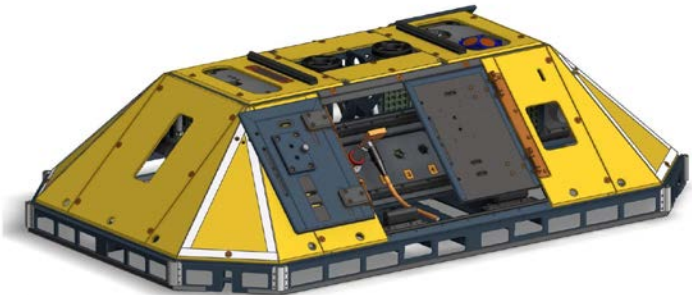
Item	Endurance Oregon 80m site (CE02SHBP)	Endurance Oregon 600m site (CE04OSBP)
Partial Pressure of CO_2 in Water instrument	Sunburst Sensors, LLC SAMI^2-CO_2 (PCO2W-B)	Sunburst Sensors, LLC SAMI^2-CO_2 (PCO2W-B)
Total hydrogen ion scale in seawater instrument	Sunburst Sensors, LLC SAMI^2-pH (PHSEN-D)	Sunburst Sensors, LLC SAMI^2-pH (PHSEN-D)
Passive Hydrophone(*)	Instrument Concepts IC Listen HF (HYDBB-A)	Instrument Concepts IC Listen HF (HYDBB-A)
Still camera (**)	Kongsberg oe14-408 with flashgun (CAMDS-B) (custom)	Kongsberg oe14-408 with flashgun (CAMDS-B) (custom)
Zooplankton sonar (ZPLSC)***	Kongsberg/Simrad EK60	NA

(*) To be installed in a separate frame away from the BEP but connected to the LPJBOX

(**) Considered part of the BEP, but on a separate frame and connected to the node upstream of the BEP. For the CE04OS site, the upstream node is LJ01C. For the CE02SH site, the upstream node is MPJBox MPJ01C.

*** Considered part of the BEP, but on a separate frame and connected to MPJBox MPJ01C.

The hazard-resistant lander of the BEP is constructed of a mild steel framework with ½" high density polyethylene (HDPE) sheathing. Exterior dimensions are nominally 139" x 89" x 37" high, which allow the structure to fit inside a standard ISO container. Internal instrument mounts are designed so that the lower frame can be populated with instruments, cabling, and the LPJBox before the cover is fastened in place. Doors on the long sides allow access to the interior for setup and maintenance. The doors also allow access to the Wet Mate bulkhead plug used by the deployment ROV to connect the BEP to the RSN cabled infrastructure during installation on site. After installation and attachment of the RSN cable, the doors will be closed during the deployment interval to provide protection for the BEP internal components from damage. Details of the hazards which the BEP is designed to withstand are detailed in DCN 3315-00001.



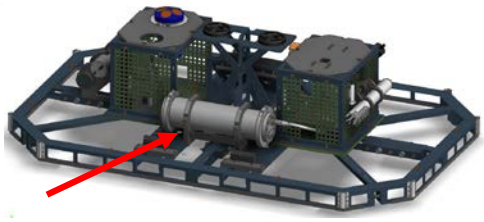


Figure 1 BEP Diagram, showing the assembled lander and populated lower frame, per 3315-00001. Note that internal cabling is not shown. The cylinder noted by the red arrow is the LPJBox. Hydrophone. camera, and bioacoustics sonar are not shown.

The BEP platforms are part of the EA cabled asset set. A block diagram of the relationship of the BEPs to the cabled infrastructure is shown in Figure 2 (from the CG-RSN shelf and offshore ICDs).

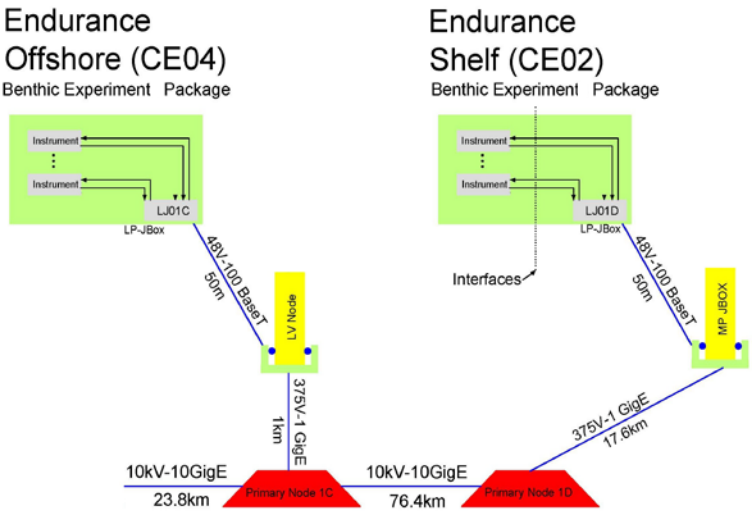


Figure 2: Cabled Block Diagram this figure is updated from Figure 4-1 in document number 1133-00000 Interface Agreement CG-RSN. Note: profiler moorings are not indicated.

LV Node denotes a low-voltage RSN node, MP JBOX is an RSN Medium Power Junction Box

Developmental tests of a preliminary BEP frame and cover were performed in August-September 2011 as part of BEP Development Test 1 (BEPT1). The Test Plan for BEPT1 is DCN 3315-00003, and other documents generated from this test are listed in Table 2-1. Results from this development testing were used to inform design changes to the doors, fasteners, ADCP mount, and other aspects, and demonstrated that the BEP could be recovered and deployed safely.

1.3 Document Overview

Sections 1-3 provide general information relevant to this plan. Section 4 describes the integration and test environments for the BEP. Section 5 contains the integration plan. Section 6 outlines the Verification Plan and lists the test cases to be conducted. Section 7 outlines requirements traceability. Section 8 presents a rough schedule. The integration checklists are provided in Appendix A. Appendices B, C, and D detail requirements verified in the three detailed test cases.

Refer to the CGSN Integration and Verification Plan (IVP) for general process description and definition of terms utilized within this document, including identification of the test events and activities described herein.

2 Referenced Documents

The following documents are referenced in this integration plan. The latest revision of each applies unless noted in the text. Requirements Verification Compliance Matrices (RVCMs) are referenced to the views in DOORS

Table 2-1 Referenced Documents

Document Identifier	Document Title
1010-00000	Operations and Maintenance Plan
1133-00001	INTERFACE CONTROL DOCUMENT CG-RSN OFFSHORE
1133-00001	INTERFACE CONTROL DOCUMENT CG-RSN SHELF
3101-00033	CGSN Integration and Verification Plan (IVP)
3102-00008	Reference Designator Spreadsheet for CGSN
3161-10000	Instrument Qualification Test Plan
3315-00001	Benthic Experiment Package Trade Study
3315-00003	BEP Developmental Test 1 Plan
3315-00005	Benthic Experiment Package Test 1 (BEPT1) Dockside Deployment Simulation Procedure
3315-00006	BEPT1 Popup Buoy CO Procedure
3315-00007	BEP Predeployment Quick Look report
3315-00009	BEPT1 recovery cruise plan
3315-00010	BEPT1 deployment and recovery quick look report
3315-00012	BEPT1 Mechanical Assembly and Sea Deployment Quick Look report
3315-00013	Benthic Experiments Package Test 1: BEPT1 Engineering Data Report
3315-00014	Benthic Experiment Package TDP Analysis
3315-00015	ADCP Teledyne RD Instruments Workhorse Monitor LP-JBox Integration Procedure
3315-00017	VEL3D Nortek Vector LP-JBox Integration Procedure
3315-00016	OPTAA WET Labs AC-S LP-JBox Integration Procedure
3315-00018	PCO2W Sunburst Sensors SAMI2-CO2 LP-JBox Integration Procedure
3315-00019	PHSEN Sunburst Sensors SAMI2-pH LP-JBox Integration Procedure
3315-00020	CTDBP SBE16plus V2 With DOSTA Aanderaa Optode 4831 LP-JBox Integration Procedure
3315-00021	Hydrophone Frame to Benthic Experiment Package Proof-Weight Test
3315-00022	HYDBB Ocean Sonics icListen HF LP-JBox Integration Procedure
4160-66182-000	Regional Scale Nodes Instrument Test Plan

Verification of the BEP design requirements will draw upon Benthic Experiment Package TDP Analysis, which presented a summary of how the design of the BEP is able to satisfy requirements for ROV compatibility and deployment endurance. That document summarizes incorporated suggestions from the BEP CDR. It also summarizes discussions with operators of the ROVs ROPOS and JASON/MEDEA about the ability of their

ROVs to deploy and service the BEP. Post-CDR modifications to the BEP have been also documented and the new configurations reviewed by ROPOS.

The electrical integration procedures were performed with a prototype LP-JBox obtained from RSN. Each instrument will have its own set of CGSN Instrument Verification and Quality Conformance procedures per 3161-10000, as well as verification that the instruments meet the RSN general requirements for instruments operated on the cabled infrastructure.

The following documents are to be generated in support of this document:

Document Identifier	Document Title
1163-40101	Procedure, BEP mechanical verification, TC-001 (Ver-CG-186)
1163-40102	Procedure, BEP interface verification, TC-002 (Ver-CG-187)
1163-40103	Procedure, BEP operation, TC-003 (Ver-CG-188)
1163-40101-00001	Results, BEP mechanical verification, TC-001 (Ver-CG-186)
1163-40102-00001	Results, BEP interface verification, TC-002 (Ver-CG-187)
1163-40103-00001	Results, BEP operation, TC-003 (Ver-CG-188)
1163-47000	Quick look report, BEP mechanical integration
1163-47001	Quick look report, BEP electrical integration
1163-47002	Quick look report, BEP operation
1163-47010	BEP Verification Report

7 Definitions & Acronyms

Table 3-1: Definitions and Acronyms

Acronym	Definition
ADCPS	Acoustic Doppler Current Profiler, 75kHz
ADCPT	Acoustic Doppler Current Profiler, 300kHz
APL	Applied Physics Laboratory
BEP	Benthic Experiment Package
CAMDS	CAMera, Digital, Still
CGSN	Coastal and Global Scale Nodes (shortened to CG for requirements modules)
CI	Cyberinfrastructure
CTDBP	Conductivity Temperature Depth instrument
DCN	Document Control Number
DOORS	Dynamic Object-Oriented Requirement System
DOSTA	Dissolved Oxygen, STAble instrument
EA	Endurance Array
ECR	Engineering Change Request
HYDBB	HYDrophone, BroadBand instrument
IO	Implementing Organization
I&T	Integration and Test
ICD	Interface Control Document
IVP	Integration and Verification Plan

Acronym	Definition
LPJBox	Low Power Junction Box
LV Node	RSN Low-voltage node
MP JBOX	RSN Medium Power Junction Box
OMS	Observatory Management System
OOC	Ocean Observing Center (at Oregon State University)
OOI	Ocean Observatories Initiative
OPTAA	OPTical Attenuation and Absorption sensor
ORB	Object Ring Buffer **
OSU	Oregon State University
PC	Personal Computer
PCO2W	Pressure of CO_2 in Water sensor
PHSEN	PH SENsor
PIP	Portable Instrument Port
PRESF	PRESsure, SeaFloor sensor(*)
PVT	Product Verification Test
ROPOS	Remotely Operated Platform for Ocean Science
ROV	Remotely Operated Vehicle
RSN	Regional Scale Nodes
RVCM	Requirements Verification Compliance Matrix
SPP	Surface Piercing Profiler
UW	University of Washington
VEL3D	VELocity of water, 3 Dimensional instrument
WHOI	Woods Hole Oceanographic Institution
ZPLSC	Zooplankton Sonar, Coastal instrument

Notes:

(*) The PRESF was originally defined as a separate instrument. The high available power and bandwidth of the cabled system allowed OOI to combine the PRESF functionality with the pressure sensing function of the CTDBP.

(**) The ORB is used by the US Navy to filter hydrophone information before distribution to CI. This is per requirement L3-RSN-RQ-670

3 Integration and Verification Environment

Initial integration and test of the LPJBox and BEP instrumentation will take place at the OSU OOC facility. The BEP structural assembly will be conducted in the OSU OOC facility, which is designed for the handling of large and heavy-duty equipment such as buoys, landers, and anchors. Some of the OSU OOC facility specifications include:

- Building area; 1,200 square foot (high bay)
- Overhead gantry crane, 5 ton capacity, maximum lift 16 feet
- 110V outlets
- Roll-up door with a clear height of 18’ high x 16' wide
- ~40,000 square foot exterior paved staging area

- Eye wash and waste disposal stations

OSU Test Facilities

The OSU OOC maintains facilities for electrical test and fault-tracing. The BEP lander itself does not have any pressure-vessel volumes, and thus does not require pressure testing. The LPJBox will be pressure tested at RSN prior to delivery to OSU, and all sensors will be installed in their vendor-supplied pressure cases.

RSN/UW Test Facilities

RSN maintains facilities for simulation of the cabled infrastructure. UW has a large seawater immersion tank with access for the cable simulator for operational testing of the fully-integrated BEP, cameras, and bio-acoustic sonar.

4 Integration Plan

Integration describes all activities from receipt of article through to its readiness for deployment. For instruments, the following flowchart will be used to consider them ready for use (adapted from 4160-66182-000 and the CGSN Instrument Test Plan DCN 3161-10000)

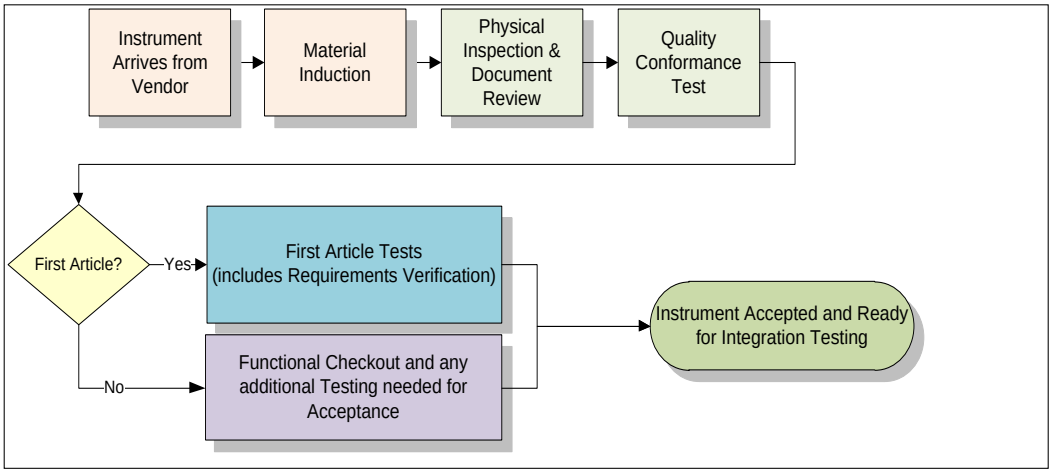


Figure 3: Instrument acceptance flow chart

Integration will be divided into two categories: electrical/communications integration of instruments with the RSN-supplied LPJBox and mechanical integration of the electrical components with the BEP structure. RSN has an emulator for the LPJBox to simulate the communications from the BEP sensors to the controller and

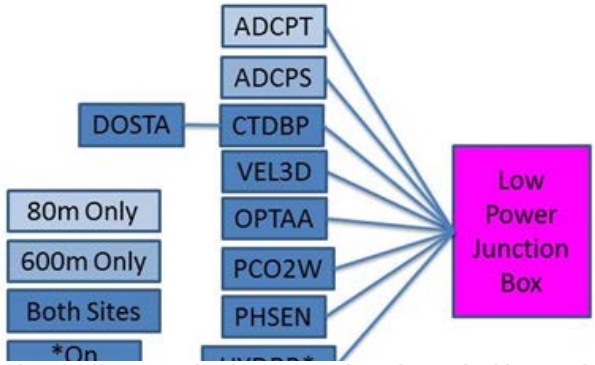


Figure 4: BEP Electrical/Communication Integration Chart. Final integration and conformance testing of these components will probably be performed at the RSN test facility, although integration tests of individual instruments with single port emulators will be done elsewhere prior to full instrument suite/JBox integration.

thence to the RSN cable and OOI Cyberinfrastructure (CI). Figure 4 shows the electrical/data integration of BEP instruments and to the RSN-supplied LPJBox.

For initial integration testing, the instruments will be interfaced to either a test stand fixture or (if available) a production LPJBox. These tests will verify the instruments operate according to OOI requirements from sensor to CI.

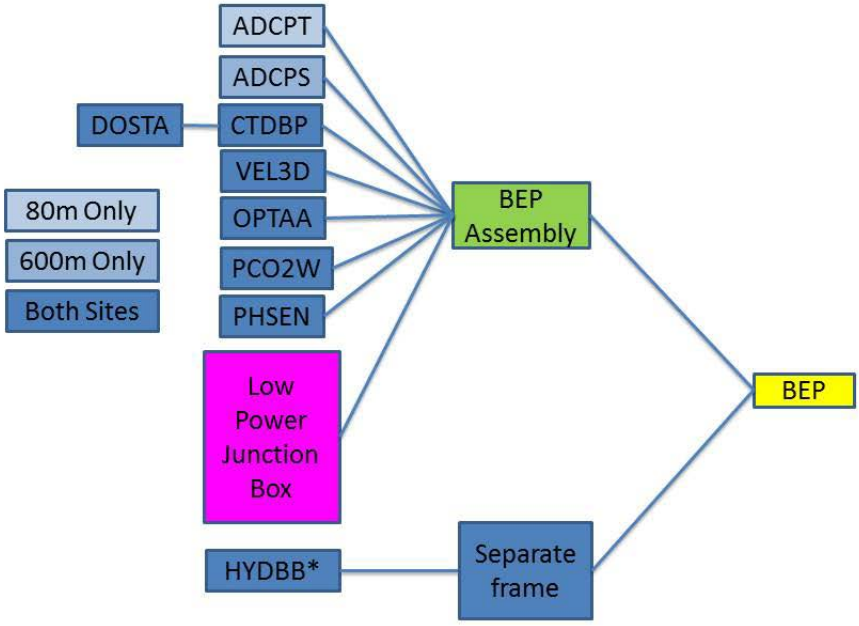


Figure 5: Mechanical integration of BEP components.

Mechanical integration of the LPJBox and instruments will be designed and executed in such a way that all environmental needs of the components (such as ability to bleed excess heat) are met and the instruments are mounted in ways that do not impede their ability to make meaningful scientific measurements. A pin diagram of mechanical integration is presented below:

After full mechanical integration of the electrical components into the BEP structure, the assembled platform will be tested in a saltwater environment local to RSN before initial deployment at the Endurance sites. The integration procedures for each of these checkpoints are listed in Appendix A. Note that instrument/LPJBox/CI integrations can take place independently of platform construction, and *vice versa*.

4.1 Electrical and Communications Integration

4.1.1 Equipment required

- Ambient-pressure immersion basin
- Test cabling
- Oscilloscope (Tektronix TD2024C)
- Precision resistor (mounted in 'current measurement' test box)
- Portable Instrument Port (PIP) (RSN-built emulator for a single LPJBox instrument port)
- 6½ digit precision multimeter (Agilent 34410A)
- Zinc Reference Anode
- DC Power supply, 60 Volt 1.5 Amp (BK Precision 1623A)
- Insulation Resistance Tester, 0.01 MW to 10 GW at 50 V (Fluke 1507)

- Computer
  - Hardware
    - Computer capable of running instrument-specific software
  - Software
    - Terminal emulator (LabView)
    - Instrument-specific software from the instrument vendor
    - LPJBox control emulator
- 200W/48VDC power supply and wet-mate breakout cable (for testing LPJBox and fully integrated instrument package)

4.1.2 Functional Checkout

All instruments will undergo the Instrument Receiving Procedure (3305-00100) and appropriate QCT Procedure (3305-001XX). Instruments on the BEP will additionally be subject to electrical testing per 4160 -66182-000 section 4.

For each instrument, ground isolation will be measured in water to a zinc reference node. Instruments may be powered and controlled by lab power supplies and local Personal Computers (PCs) or through the PIP.

4.1.3 CI integration with individual instruments

Prior to integration, instruments require connection to CI for driver development. CI instrument drivers may be developed as part of other RSN or CGSN platform integration, or as part of the BEP integration. Where CI driver development as part of the BEP integration is identified (see Table 6-2), these instruments will be registered with the CI instrument pipeline immediately after instrument receipt and functional checkout. All instruments will be individually checked for CI connectivity as part of functional testing. CI connectivity requires either a PIP or a combination of power supply and serial/Ethernet converter. At this point, inrush, operating, quiescent, and transmit power can also be characterized.

4.1.4 LPJBox integration

The LPJBox-Observatory Management System (OMS) interface will be exercised. Port control via the OMS will be demonstrated. After functional checkout and confirmation of OMS connectivity, all instruments will be then integrated to the LPJBox for full-package integration. This step will allow development of power-cycle and fault-isolation procedures through OMS.

Comment [DN3]: add to acronym list

4.2 Assembly and Platform Construction

CAUTION

The BEP frame, assembled cover, LPJBox, and instrument frames are all very heavy (>>100lbs.). Use care with all moving operations and use supports when working under the BEP.

CAUTION

Voltage and current sources potentially dangerous to personnel and equipment will be present during testing. Ensure power is disconnected before plugging/unplugging electronics.

- BEP Upper and Lower Frames and Sheathing
  - Visual inspection
  - Fit of frames and sheathing
  - Door operation
  - Accessibility of instrument mounting points
  - Verification of ROPOS attachment geometry
  - Verification of exterior dimension requirements
  - Verification of dry weight

- Verification of weight balance
- Derive specifications for cable lengths

4.3 Integration Testing

- Verification that instruments as configured match RSN instrument specifications for power and communication
- Verification of isolation of instrument grounds to pressure cases
- Test of instruments based on factory acceptance prior to BEP assembly
- Verification of configuration of LPJBox ports
- Verification of interconnect wiring
- Verification of instrument-specification inrush currents
  - Determine need for phased sensor activation
- Verify that all systems return to a known state after reset
- Determine power use under stable sampling conditions
- Determine quiescent current (if applicable)
- Calibration of Instruments
  - Compass calibration of VEL3D current meter
  - Calibration of compass on ADCP
  - Verification of operation of attitude sensors in LPJBox
- BEP Assembly End-to-end Test
  - Operation in controlled saltwater environment
    - Absence of ground loops in submerged package
    - Test mission setup and start
  - Error handling and recovery test
    - Simulate error conditions both from the instruments and from the cable
  - Verify test mission progress
    - Sensor command, control, and data retrieval through the RSN cable
  - End test mission, verification

5 Verification Plan

5.1 BEP Platform Verification Test (PVT)

A majority of the requirements for the BEP will be verified by inspection and analysis of lower level tests. These verifications include the RSN LPJBox, the BEP instrument package, and the interfacing of the LPJBox to the instruments. Requirements requiring full assembly of the BEP (*e.g.* assembled weight) will be verified at the Platform level. The platform testing follows integration and the PVT event conduct may be witnessed by the Program Management Office (Ocean Leadership). The PVT primarily consists of reviewing evidence of verification at the lower levels and a comprehensive demonstration of the integrated platform. The demonstration would be 'end-to-end' in that the platform would be stimulated and responses to the stimuli examined at the external interfaces. Proper operation demonstrates that the internal interfaces are operating correctly. The platform verification testing will take place in dry conditions.

5.1.1 Objectives

The objectives for the BEP platform test are:

1. Demonstrate connectivity to engineering and scientific sensors and instruments
2. Demonstrate internal (LPJBox to instrument) cable connectivity and functionality
3. Demonstrate communication of instrumentation through the LPJBox to the RSN cable
4. Demonstrate error handling/recovery capabilities
5. Demonstrate readiness for transition to an operational state

5.1.2 Roles & Responsibilities

A table of personnel, roles and responsibilities for this procedure is given below:

Table 6-1: Personnel, roles and responsibilities

Name	OOI title	Roles and responsibilities
Ed Dever	Endurance Systems Engineer	oversight of all plans and procedures
Walt Waldorf	Senior Field Engineer	Safety
David Neiman	I&V/Test Engineer	Test planning, assist deployment/recovery
Kent Fletcher	Mechanical engineer	BEP design, mechanical integration, oversight of mechanical systems, assist operations
Michael Vardaro	Project Scientist	Oversight of instrument integration with CI
Linda Fayler	Electrical Engineer	Electrical design, Power/data budgeting, electrical/communication interface documentation, test execution
Chris Wingard	Senior Instrument Technician	Instrument interfacing
Dana Manalang	RSN I&V/Systems Engineer	RSN Integration liaison
Bill French	Programmer analyst	CI integration liaison
Tim McPhail	CI Chief Systems Engineer	responsibility for interface requirement verification from the CI side

6.1.3 BEP Test Case Descriptions

Instrument verification

The BEP instrument suite is listed in the table below. Instruments used in the BEP are subject to verification testing independently of this PVT, and BEP instruments must have verification reports on file prior to the BEP PVT.

Table 6-2: Instruments on the BEP

Item	Site	Verifying IO L4-RSN-IP	Verifying IO L4-CG-IP	Need for first time CI driver development
Platform controller and power/communication interface to cabled infrastructure	RSN Low Power Jbox CE02SHBP-LJ01D RSN Low Power JBox CE04OSBP-LJ01C	RSN	NA	No

Item	Site	Verifying IO L4-RSN-IP	Verifying IO L4-CG-IP	Need for first time CI driver development
Dissolved Oxygen instrument Aanderaa (DOSTA-D)	both	RSN	CGSN	Yes (connected 12/20/2012 through CTDBP-O)
Teledyne RDI 300kHz Monitor (ADCPT-B)	Endurance Oregon 80m site (CE02SHBP)	EA	CGSN	No
Teledyne RDI 75kHz Long Ranger (ADCPS-I)	Endurance Oregon 600m site (CE04OSBP)	RSN	CGSN	No
CTD instrument Sea-Bird Electronics 16plus Seacat (CTDBP) with PRESF digiquartz sensor and SBE19V2 profiling software	Series N Oregon 80m site (CE02SHBP) Series O Oregon 600m site (CE04OSBP)	EA	EA	Yes
3-D Single Point Current Velocity Meter Nortek AS Vector (VEL3D-C)	both	EA	CGSN	Yes
Spectrally Resolved *In-situ* Optical Absorption and Beam Attenuation instrument WET Labs, Inc. AC-S (OPTAA-C,D)	Series D Oregon 80m site (CE02SHBP) Series C Oregon 600m site (CE04OSBP)	RSN	CGSN	Yes (completed)
Partial Pressure of CO_2 in Water instrument Sunburst Sensors, LLC SAMI^2-CO_2 (PCO2W-B)	both	RSN	CGSN	Yes
Sunburst Sensors, LLC SAMI^2-pH (PHSEN-D)	Both	RSN	CGSN	Yes
Passive Hydrophone Instrument Concepts IC Listen HF (HYDBB-A)	both	RSN	EA (may use RSN verification)	No (connects through Antelope/ORB)

Item	Site	Verifying IO L4-RSN-IP	Verifying IO L4-CG-IP	Need for first time CI driver development
Still camera Kongsberg oe14-408 with flashgun (CAMDS-B)	both	RSN	EA (may use RSN verification)	No

Requirements Addressed

This case does not directly relate to BEP requirements but instead shows the instruments in the BEP package meet OOI requirements and are ready for operation through CI.

6.1.4 Mechanical Integration and verification of BEP structure (TC-001)- Ver-CG-186

The BEP is a custom-designed instrumented station for housing oceanographic instruments and interfacing them to a power and communications cabled infrastructure. It houses the LPJBox that supplies the power/communications infrastructure between the instruments and the cable, and provides a hazard-resistant mounting platform for the instruments. This test case is intended to verify that the BEP design is mechanically suited to these tasks and provides the environmental access required by the instruments and LPJBox to operate in scientifically-valid ways.

This step and TC-002 Ver-CG-187 can be run in any order (e.g. electrical integration of the LPJBox and instrument is not required to perform instrument and LPJBox mechanical integration to the BEP structure, and *vice-versa*).

Requirements Addressed

L4-CG-BP-1863,L4-CG-BP-1866,L4-CG-BP-1879,L4-CG-BP-1861,L4-CG-BP-1862,L4-CG-BP-1864,L4-CG-BP-1857,L4-CG-BP-1915,L4-CG-BP-1858, L4-CG-BP-1876,L4-CG-BP-1867,L4-CG-BP-1868, L4-CG-BP-1869,L4-CG-BP-1870,L4-CG-BP-1871,L4-CG-BP-1873,L4-CG-BP-1872,L4-CG-BP-1874,L4-CG-BP-1875,L4-CG-BP-1877,L4-CG-BP-1859,L4-CG-BP-1889, L4-RSN-JB-292,L4-CG-BP-1890,L4-CG-BP-1886, L4-CG-BP-1878,L4-CG-BP-1860, L3-CG-RQ-920,L3-CG-RQ-855,L3-CG-RQ-494,L3-CG-RQ-438,L3-CG-RQ-439,L3-CG-RQ-885,L3-CG-RQ-1006,L3-CG-RQ-987,L3-CG-RQ-445,L3-CG-RQ-867, L3-CG-RQ-555,L3-CG-RQ-922,L3-CG-RQ-433,L3-CG-RQ-923,L3-CG-RQ-497,L3-CG-RQ-408,L3-RSN-CG-RQ-126

Pre-conditions

All BEP frame, cover, and door structures have been fabricated. Instrument cages have been fabricated. Bracketing and hardware are available. All required fasteners are available. All sensors have been selected and examples are available. An LPJBox is available. All cables and connectors from bulkhead to LPJBox and LPJBox to instruments are available.

Hardware Preparation

The basic frame should be placed in a location which allows test completion without moving the assembly. This should lessen the risk of mechanical damage

Software Preparation

None

Test Inputs

None

Expected Results

All structural components will fit together. Operating parts will function as desired (doors will open and close, etc.). All instruments fit in their assigned places and will have environmental access required for proper function. The LPJBox will fit in its assigned bracketing. Cables will route appropriately.

Criteria for Evaluating Results

All components will show satisfactory fit and function. Sensor functionality will not show risks due to design or fabrication issues (*e.g.* have necessary access to water). Cables do not chafe or exceed maximum bend curvature, and have sufficient access for assembly and disassembly as needed for operation and refurbishment.

6.1.5 BEP interface verification (TC-002)- Ver-CG-187

The BEP integrates the RSN-designed LPJBox that supplies the power/communications infrastructure and the CGSN-supplied instruments package. A wet mate bulkhead connector on the BEP allows an ROV to attach the BEP to the RSN cable. This test case is intended to verify that the BEP instrument package interfaces successfully to the LPJBox for power and communications.

This step and TC-001 Ver-CG-186 can be run in any order (e.g. electrical integration of the LPJBox and instrument is not required to perform instrument and LPJBox mechanical integration to the BEP structure, and *vice-versa*).

Requirements Addressed

L4-RSN-JB-RQ-80,L4-RSN-JB-RQ-81,L4-RSN-JB-RQ-81,L4-RSN-JB-RQ-82,L4-RSN-JB-RQ-113,L4-RSN-JB-RQ-236,L4-RSN-JB-RQ-124,L4-RSN-JB-RQ-144,L4-RSN-JB-RQ-147,L4-CG-IP-RQ-669, L3-RSN-CG-IA-103,L4-RSN-JB-RQ-291, L3-RSN-CG-IA-124,L4-RSN-JB-RQ-290, L3-RSN-CG-IA-85, L4-RSN-IP-RQ-78,L4-RSN-IP-RQ-79,L4-RSN-IP-RQ-80,L4-RSN-IP-RQ-623,L4-RSN-IP-RQ-85,L4-RSN-IP-RQ-88,L4-RSN-IP-RQ-91,L4-RSN-IP-RQ-92,L4-RSN-IP-RQ-399,L4-RSN-IP-RQ-530,L4-RSN-IP-RQ-583, L4-RSN-IP-RQ-402,L3-RSN-CG-IA-461

Pre-conditions

All sensors have been selected and examples are available. An LPJBox is available for each BEP. All cables and connectors to the LPJBox and LPJBox to instruments are available. A communications path to CI is available to simulate sensor-to-CI communications. If available, a water vessel in which the instruments can be submerged can provide a check for ground loops.

Hardware Preparation

Before full integration of the instruments to the LPJBox, the instruments will be individually tested to determine inrush current. If possible, the instruments will be connected through the PIP to CI for communication validation prior to full LPJBox integration.

Software Preparation

None

Test Inputs

None

Expected Results

The LPJBox will be able to provide sufficient power to initialize and operate the instrument suite. Communications from CI to the instruments will be demonstrated, and instruments will be able to receive commands and send data as needed. Any information required to determine power-up sequences will be acquired. Fault recovery will be demonstrated.

Criteria for Evaluating Results

Startup, stable operation, and shutdown of the instrument suite in response to RSN cable conditions will be demonstrated. Response to anticipated fault conditions will be satisfactory.

6.1.6 BEP operational verification (TC-003)- Ver-CG-188

At this point in testing, the BEP structure and the ability of the BEP to carry the LPJBox and BEP instrument package have been verified. The test case demonstrates the full capability of the BEP to receive power and commands from the RSN cabled infrastructure, route the power and commands appropriately through the LPJBox to the instruments, and return scientifically-valid data to the cabled infrastructure.

Requirements Addressed

L3-CG-RQ-412,L3-CG-RQ-739,L3-CG-RQ-739,L3-CG-RQ-741,L3-CG-RQ-742,L3-CG-RQ-743,L3-CG-RQ-744,L3-CG-RQ-747,L3-CG-RQ-748,L3-CG-RQ-740,L3-CG-RQ-746,L3-CG-RQ-745,L3-CG-RQ-932

Pre-conditions

The BEP structure, instruments, and LPJBox have been successfully integrated. No identified issues pertaining to structure, mechanical operability, or ROV deploy/connect/disconnect/recover capability remain unresolved.

Hardware Preparation

The fully-integrated BEP is delivered to an appropriate test facility (RSN test tank). All required handling equipment is available. Appropriate cabled infrastructure and the means to connect the BEP to it during the test deployment are available.

Software Preparation

The operating sequence for the BEP, from cable connection to full operation to shut down and disconnection, has been identified. Required software to vary sampling protocols is ready.

Test Inputs

Power-up, sustained operation, and power-down sequences.

Expected Results

Deployment and hookup will not present serious difficulty. Instruments will behave in a controlled fashion. The LPJBox will be able to provide sufficient power to initialize and operate the instrument suite. Communications from OMS to the instruments will be demonstrated, and instruments will be able to receive commands and send data as needed. Any information required to determine power-up sequences will be acquired. Fault recovery will be demonstrated.

Criteria for Evaluating Results

Startup, stable operation, and shutdown of the instrument suite in response to RSN cable conditions will be demonstrated. Response to anticipated fault conditions will be satisfactory.

6.1.7

8 Requirements Traceability

BEP requirements traceability is captured in the DOORS database in the following modules:

L3 CG System Requirements module (/L3 System/CG System/L3 CG System Requirements). Use the 'View' pull-down to select the "RCVM_BEP" view. This view will show the CGSN L3 requirements linked to Verification Event and Verification Procedure(s).

L4 CG Benthic Experiment Package Requirements module (/L4 Subsystem/ L4-CG Benthic Experiment Package). Use the 'View' pull-down to select the "RCVM" view. This view will show the CGSN L4 BEP requirements linked to Verification Event and Verification Procedure(s).

Instrument Package requirements traceability is captured in the DOORS database in the following module

L4 CG Instrument Package Requirements module (/L4 Subsystem/ L4-CG Instrument Package Requirements)

Use the 'View' pull-down to select the "RCVM_BEP" view. This view will show the CGSN L4 BEP Instrument Package requirements linked to Verification Event and Verification Procedure(s).

Common requirements for power and communications for BEP instruments defer to RSN general requirements stated in the following module

L4 RSN Instrument Package Requirements (/L4 Subsystem/ L4-RSN Instrument Package Requirements)

Use the 'View' pull-down to select the "RCVM_BEP" view. This view will show the relevant RSN L4 BEP Instrument Package requirements.

Requirements for the BEP are listed in the following module

L4-CG BEP Requirements (/L4 Subsystem/ L4-CG-BEP Requirements)

Use the 'View' pull-down to select the "RCVM_BEP" view. This view will show the relevant CG L4 BEP requirements.

Requirements for the LPJBox are listed in the following module

L4-RSN JBox Requirements (/L4 Subsystem/ L4-RSN JBox Requirements)

Use the 'View' pull-down to select the "RCVM_BEP" view. This view will show the relevant RSN L4 LPJBox requirements.

RSN-CG Interface requirements are listed in

L3-RSN-CG-IA module (/L3 System/CG System/L3 CG System Requirements)

Use the 'View' pull-down to select the "RCVM_BEP" view. This view will show the relevant L3 CG-RSN IA requirements.

L3 RSN System

The only relevant requirement in this module is L3-RSN-RQ-648.

9 Integration and Verification (I&V) Schedule.

Event	Location	Primary responsibility	Date
CDR	OSU	OSU	9 May 2012
Bid out frame/cover components	OSU	OSU	September 2012
Vendor manufacture of frame/cover components	Oregon	Vendor w/ OSU oversight	September 2012-February 2013
Determine instrument/CI integration needs	OSU	OSU	June- December 2012
Acquire PIP	OSU and UW	OSU and UW	September 2012
Acquire BEP-specific instruments	OSU	OSU	August 2012-March 2013
Instrument functional testing and connection to CI.	OSU	OSU	August 2012- March 2013
Complete delivery of BEP mechanical components	Oregon	vendor	March 2013
Prototype LPJBox delivery to OSU	OSU	RSN	March 2013
BEP Mechanical assembly	OSU	OSU	November 2012-May 2013
Instrument package mechanical integration to BEP.	OSU	OSU	March-May 2013
BEP delivered to RSN.	OSU	OSU	June 2013
Pre-Installation Integration and Test Offshore Benthic Package (CE04OS) Endurance Array	UW	UW	June 2013
Integration and Verification complete for CE04OS first build	UW	OSU/ UW	June 2013

APPENDIX A: Integration Checklist(s)

Except where noted, these checklists do not need to be followed in order either by step or by list.

A.1.1 BEP Frame and Cover Mechanical Integration Checklist

This checklist covers the BEP structure. Pass/fail criteria are based on visual inspection of fit and function except for measurement of footprint.

No.	Integration Step/Action	Pass	Fail	Notes
1	Frame welds are satisfactory. No distortions of frame components that could compromise functionality are observed.			
2	No obvious faults in galvanizing that would compromise corrosion protection are observed.			
3	Cover framing and base framing fit together satisfactorily			
4	Plastic cover panel welds are satisfactory			
5	Plastic panels fit in assigned places satisfactorily			
6	Instrument cages fit in assigned locations			
7	BEP footprint does not exceed dimensions allowed by requirements			

A.1.2 Instrument Functional Checklist

This checklist documents that instruments are checked for functionality prior to integration. Functional checkout is part of Quality Conformance Testing (QCT), and includes confirmation that the electrical power does not ground to the instrument case.

No.	Instrument	Pass	Fail	Date	Notes and QCT report number
1	CTD				**3305-00102-00003 (N)** **3305-00102-00007 (O)**
2	DOSTA				**3305-00115-00009**
3	ADCPS-I ADCPT-B				**3305-00107-00004** **3305-00107-0000?**
4	VEL3D				**3305-00106-00001** **3305-00106-00002**
5	OPTAA				**3305-00113-00003**
6	PCO2W				**3305-00110-00008**
7	PHSEN				**3305-00109-00013**
8	CAMDS				
9	HYDBB				**3305-00117-00002**

A.1.3 Instrument/LPJBox Integration Checklist

In this checklist, instrument integration to OMS is verified. The instruments will be first individually powered from bench supplies with interface to OMS through a direct connection. Direct connection may be facilitated by an RSN-designed Portable Instrument Port (PIP). Instrument testing will consist of powering the individual instrument (in water if the instrument is pumped) and connecting it to OMS. Passage criteria are demonstration of instrument function including sensor operation, sampling control, and ability to return data to OMS. Following individual instrument-to-OMS interfacing, the instruments will be function-tested through the LPJBox. Steps 1-18 run prior to full-up instrument integration and testing of the BEP instrument suite, step 19 is the full integration of the instrument suite to the LPJBox. The integration environment for this checklist will be RSN.

No.	Instrument	Integration Step/Action	Pass	Fail	Date	Notes
1	CTD	Bench test, Individual instrument to OMS				
2	CTD	Bench test, Individual instrument through LPJBox to OMS				
3	DOSTA	Bench test, Individual instrument through CTD to OMS				
4	DOSTA	Bench test, Individual instrument through CTD to LPJBox to OMS				
5	ADCP	Bench test, Individual instrument to OMS				
6	ADCP	Bench test, Individual instrument through LPJBox to OMS				
7	VEL3D	Bench test, Individual instrument to OMS				
8	VEL3D	Bench test, Individual instrument through LPJBox to OMS				
9	OPTAA	Bench test, Individual instrument to OMS				
10	OPTAA	Bench test, Individual instrument through LPJBox to OMS				
11	PCO2W	Bench test, Individual instrument to OMS				
12	PCO2W	Bench test, Individual instrument through LPJBox to OMS				
13	PHSEN	Bench test, Individual instrument to OMS				
14	PHSEN	Bench test, Individual instrument through LPJBox to OMS				
15	CAMDS	Bench test, Individual instrument to OMS				
16	CAMDS	Bench test, Individual instrument through LPJBox to OMS				
17	HYDBB	Bench test, Individual instrument to OMS				

No.	Instrument	Integration Step/Action	Pass	Fail	Date	Notes
18	HYDBB	Bench test, Individual instrument through LPJBox to OMS				
19	all	Bench test full instrument suite to OMS through LPJBox with RSN cable simulator				

A.1.4 Mechanical/Electrical Integration Checklist

In this checklist, the instruments and LPJBox are installed and cabled in the BEP. Integration location is not critical. This step will verify that the BEP can house the requisite instruments and LPJBox, and that the controller and instruments can be connected together. Passage criteria are that the instrument fit in its assigned bracketing, cabling routes from instrument to LPJBox are available, and that the full assembly does not compromise functionality of ROV interfacing or instrumentation.

No.	Integration Step/Action	Pass	Fail	Notes
1	Install instrument and JBox bracketing			
2	Install main-cable bulkhead			
3	Install JBox, cable to bulkhead			
4	Install CTD in bracket, route cable to JBox			
5	Install DOSTA in bracket, route cable to CTD			
6	Install ADCP in bracket, route cable to JBox			
7	Install VEL3D in bracket, route cable to JBox			
8	Install OPTAA in bracket, route cable to JBox			
9	Install PCO2W in bracket, route cable to JBox			
10	Install PHSEN in bracket, route cable to JBox			
11	Install CAMDS on tripod, verify connection to LV Node or MPJBox			
12	Install ZPLSC on frame, verify connection to MPJBox			
13	Install HYDBB in separate frame, route cable to JBox			
14	Visual examination: verify that instrument and JBox installations do not conflict with BEP mechanical operation or ROV accessibility.			
14	Visual examination: physical layout of instruments and JBox do not interfere with scientific validity of sensor operation or create enhanced biofouling opportunities.			

A.1.5 BEP Assembly/RSN Cable Integration Checklist (Full Integration Checklist)

This checklist covers activities related to full testing of the BEP. The fully-integrated BEP will be exercised in air with power and communications provided by the equivalent of the deployment-environment cabled infrastructure. Successful passage of this step will clear the BEP for shipment to RSN for completion of in-water testing in the UW test facility.

No.	Integration Step/Action	Pass	Fail	Notes
1	Dry end-to-end test from instruments through LPJBox to RSN cable: cable connects through bulkhead connector to LPJBox, no faults detected			
2	Wet end-to-end test from instruments through LPJBox to RSN cable: cable connects through bulkhead connector to LPJBox, no faults detected			