Global Hybrid Profiler Mooring Integration and Verification Plan

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Revision History

Version	Description	Originator	ECR No.	Release Date
0-00	Initial draft	C. Begler	N/A	
0-01	General update of entire	C. Begler		
0-02	Update of Draft, Format	P. Chua		
0-03	Update of Draft, Format	P. Chua		
0-04	Update of Draft, TC006, TC007	M. Moldovan		
0-05	Update of Draft, CDR comments	C. Begler		
0-06	Format	T. Mangano		
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Scope

1.1. Identification

This Integration and Verification Plan applies to the **Global Hybrid Profiler Mooring (HYPM)** to be produced for the Coastal and Global Scale Nodes (CGSN) implementing organization (IO) of the Ocean Observatories Initiative (OOI). This plan describes the integration and verification activities (Product Verification Test - PVT) to demonstrate compliance to the requirements specified for the mooring and its sub-systems.

1.2. System Overview

The Global Hybrid Profiler Mooring configuration will include a global surface-piercing profiler (GSPP) and one or two wire-following profiler (WFP) in the mid water column. The four global HYPM variant design overview drawing numbers are shown below:

- 3601-40002

  GS02HYPM Southern Ocean Hybrid Profiler Mooring Deck Drawing

- 3602-40002

  GI02HYPM Irminger Sea Hybrid Profiler Mooring Deck Drawing

- 3603-40002

  GP02HYPM Station PAPA Hybrid Profiler Mooring Deck Drawing

- 3606-40002

  GA02HYPM Argentine Basin Hybrid Profiler Mooring Deck Drawing

The GSPP has a mechanism float in a nominal depth of about 165m which wind an instrument float with a communications float above up to the surface. While the instrument float profiles up the mechanism float winds down with a ratio 1:5 to balance the energy. About 400m profiling cable can be paid out. At the surface the communications float can establish a 2-way communication to shore using an Iridium satellite link or to a nearby vessel via FreeWave.

An acoustic release is installed at the lower wire termination of the mechanism float cable to allow a separate recovery of the GSPP. A 64" syntactic sphere located underneath the acoustic release maintains vertical tension on the mooring. The center hole of the sphere provides space for the installation of additional instruments and controller, like a Zooplankton sonar (ZPLSG). A GPS beacon, radio beacon and flasher are installed on the sphere for emergency location and as recovery aids. A universal-joint and EM-chain are installed below the sphere as bend relief during deployment and recovery. A wire following profiler (WFP) profiles underneath the sphere through the mid water column along a 2000m section wire. On sites with water depth greater than 3000m a second WFP profiles the deep water column. A 51" syntactic sphere with about 350kg buoyancy will be installed between these profiling wires. Below the profiling

wire is the HYPM controller installed in a load cage. The HYPM controller is developed and built at SIO and is also called SIO controller.

A closed inductive loop is maintained from the GSPP mechanism float to the load cage. Bypass cables are installed between each termination of the mooring wire sections. The HYPM controller interfaces via inductive communication to the WFP and GSPP. The HYPM controller transfers the profile data from the WFP to the GSPP for transmission to shore. An acoustic modem located in the load cage provides a capability to perform acoustic data transmission with other platforms that have an acoustic modem

The lower part of the mooring consists of several sections of mooring wire and glass floatation spheres whose quantities are adjusted based on the water depth at the specific sites. Up to (40) 17” glass flotation spheres are installed at the lower end of the recoverable part of the mooring as backup buoyancy, followed by a dual acoustic release. Nystron rope (20m) below the dual acoustic release reduces shock tension during the launch of the anchor. For the actual values refer to released top level assembly drawings.

The platform system include the onshore server that receives the data from the GSPP and passes it on to the OMC Data Server.

1.3. Document Overview

Sections 1-3 provide general information relevant to this plan. Section 4 describes the integration and test environments for the **Global Hybrid Profiler Mooring**. Section 5 contains the integration plan. Section 6 outlines the Verification Plan and lists the test cases to be conducted after the integration. Section 7 outlines requirements traceability. The integration flow charts and checklists are provided in Appendix A.

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

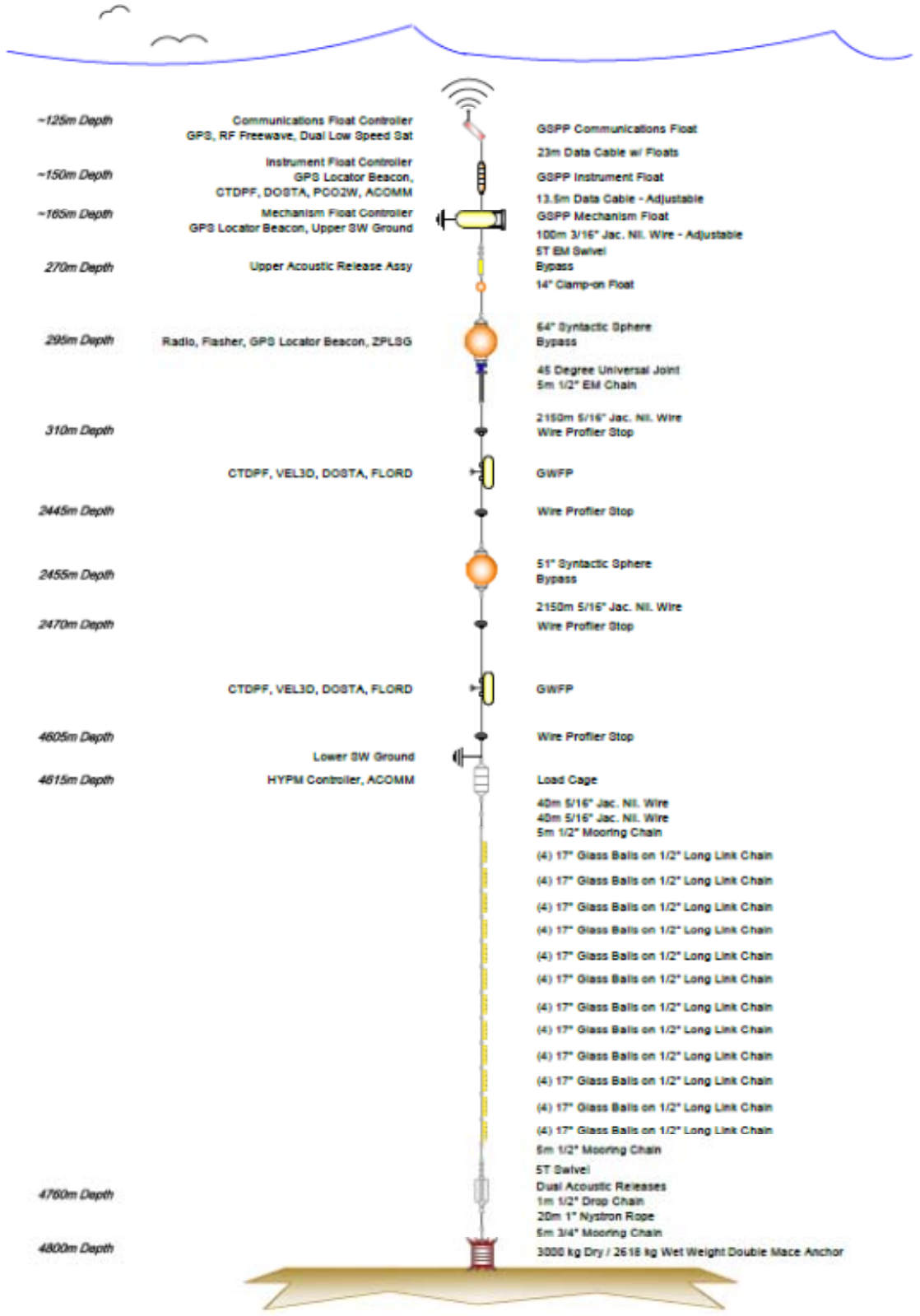


Figure 1 Southern Ocean Hybrid Profiler Mooring Deck Drawing (3601-40002)

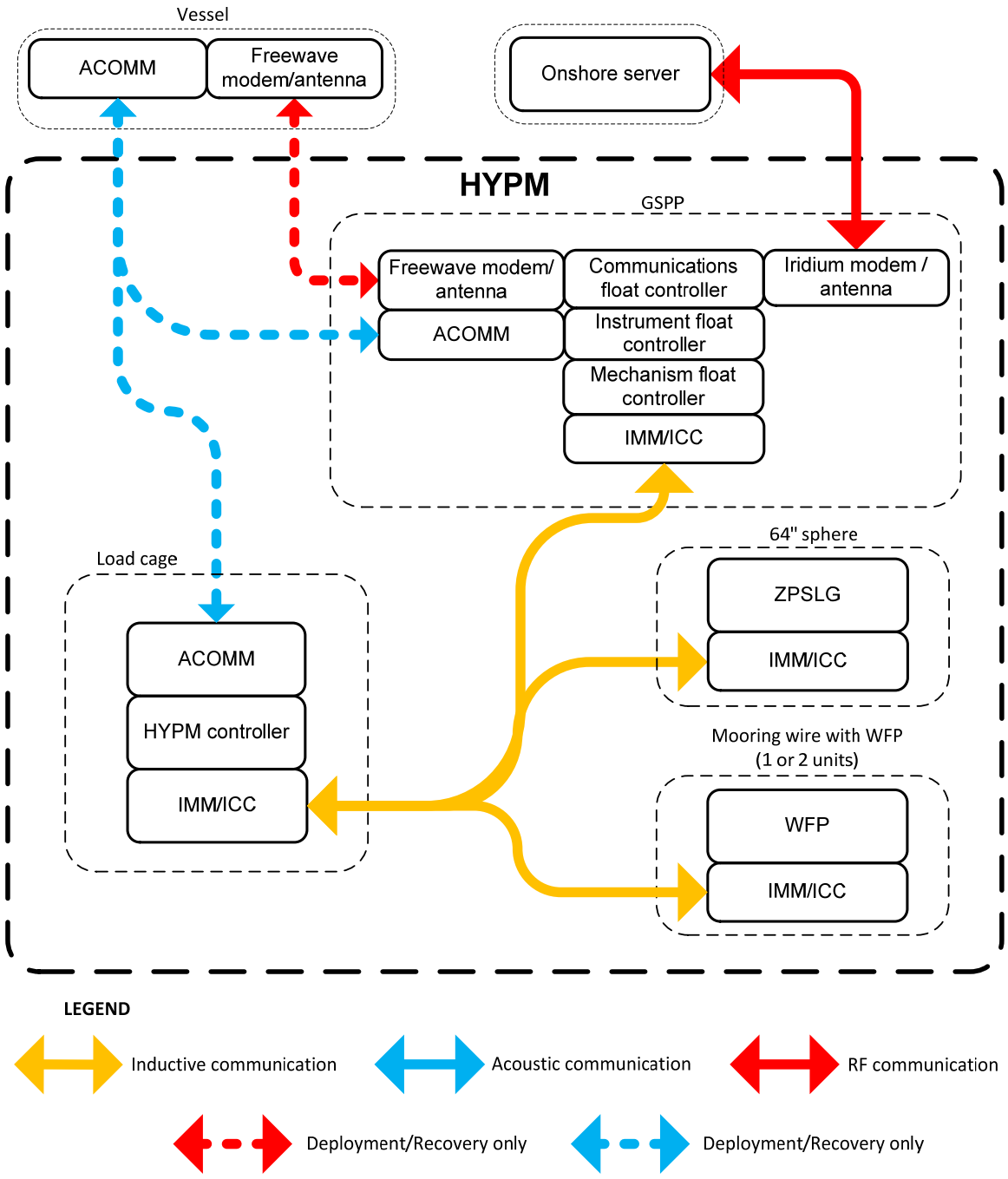


Figure 2 Global HYPM Block Diagram

2. Referenced Documents

The following documents are referenced in this integration plan. The latest revision of each applies unless noted in the text.

Table 1: Referenced Documents

Document Identifier	Document Title
3101-00033	CGSN_Integration_and_Verification_Plan_(IVP)
1010-00000	Operations_and_Maintenance_Plan
3102-00011	CGSN_Mooring_Platforms
3166-50000	Coastal_Profiler_Mooring_Integration_and_Verification_Plan
3307-00003	CGSN_Standard_Engineering_Details
3601-40002	GS02HYPM_Southern_Ocean_Hybrid_Profiler_Mooring_Deck_Drawing
3602-40002	GI02HYPM_Irminger_Sea_Hybrid_Profiler_Mooring_Deck_Drawing
3603-40002	GP02HYPM_Station_PAPA_Hybrid_Profiler_Mooring_Deck_Drawing
3606-40002	GA02HYPM_Argentine_Basin_Hybrid_Profiler_Mooring_Deck_Drawing
3601-00008	HYPM_Southern_Ocean_Top_Assembly
3602-00006	HYPM_Irminger_Sea_Top_Assembly
3603-00006	HYPM_Station_PAPA_Top_Assembly
3606-00006	HYPM_Argentine_Basin_Top_Assembly
3703-00220	SIO_Controller_Assembly
3703-00221	Controller_Battery_Assembly
3703-00222	Controller_Board_Top_Assembly
3703-20225	Controller_Board_Assembly_Schematic
3703-20229	Power_Board_Assembly_Schematic
3707-00804	Load_Cage_Top_Assembly
3707-00809	Global_Hybrid_Profiler_64_Sphere_Assembly

3. Definitions & Acronyms

Table 2: Definitions & Acronyms

Acronym	Definition
ACOMM	Acoustic Communication Modem
ADCPS	Acoustic Doppler Current Profiler instrument
CF2	Micro Controller from Persistor Instruments Inc.
CGSN	Coastal and Global Scale Nodes
CTDPF	Conductivity Temperature Depth Profiling instrument
DC	Direct Current
DOORS	Dynamic Object Oriented Requirements
DOSTA	Dissolved Oxygen instrument
FLORD	Fluorometer Two Wavelength instrument
EM	Electro Mechanical
GPS	Global Positioning System
HYPM	Hybrid Profiler Mooring
I&T	Integration and Test
ICC	Inductive Cable Coupler
IM	Inductive Modem
IMM	Inductive Modem Module
IMS	Integrated Master Schedule
IVP	Integration and Verification Plan
MFM	Mesoscale Flanking Mooring
OL	Ocean Leadership
OOI	Ocean Observatories Initiative
PC	Personal Computer
PCO2W	Partial carbon dioxide concentration in water instrument
PHSEN	pH Instrument
PVT	Product Verification Test
RF	Radio Frequency
RUDICS	Iridium Router-Based Unrestricted Digital Internetworking Connectivity Solution
RVCM	Requirements Verification Matrix
SIO	Scripps Institution of Oceanography

SPP	Surface Piercing Profiler
STS	Shipboard Technical Support
VEL3D	3D turbulent point Velocity meter
WFP	Wire Following Profiler
WHOI	Woods Hole Oceanographic Institution
WLL	Work Load Limit
ZPLSG	Zooplankton Sonar

4. Integration and Verification Environment

The HYPM assembly and test will be conducted in the SIO Seaweed Canyon facility, which is designed for the handling of large and heavy-duty equipment such as mooring buoys, wire and anchors. Some of facility specifications include:

- Building Square footage: 8,500
- Shelving and storage capacity:
  - Storage capacity: 150 wire baskets (48”x40”x40”))
  - Each shelf capacity: 2,500 lbs
- 110V outlets, 1 ceiling drops
- Roll-up door with a height clearance of 10’-6”, 25' width
- Loading platform
- Exterior concrete staging area
- Eye wash and waste disposal stations

SIO Tank/Pressure Test/Calibration Facilities

Ocean Atmosphere Research Pool located at the Keck Center is used for pool testing.

- Oval shape, interior dimensions are 5.5 m width x 12.5 m length.
- Shallow depth is 4 m with a deep section at 9.1 m. Fresh or salt water is available.

Pressure Test Chambers

Pressure test chambers are available with either ambient or chilled working fluids (fresh or salt water). Pressure measurement is accurate to (<+/- 0.1%) full scale. Electrical feed-throughs are available.

- 10,000 psi (689 bar), interior dimensions: 0.23 m diameter and 0.63 m length plus 0.40 m conical bottom
- 10,000 psi (689 bar),interior dimensions: 0.35 m diameter and 1.8 m length
- 2000 psi (138 bar), interior dimensions: 0.48 m diameter and 0.89 m length plus hemispherical heads

Temperature/Pressure Calibration Facility

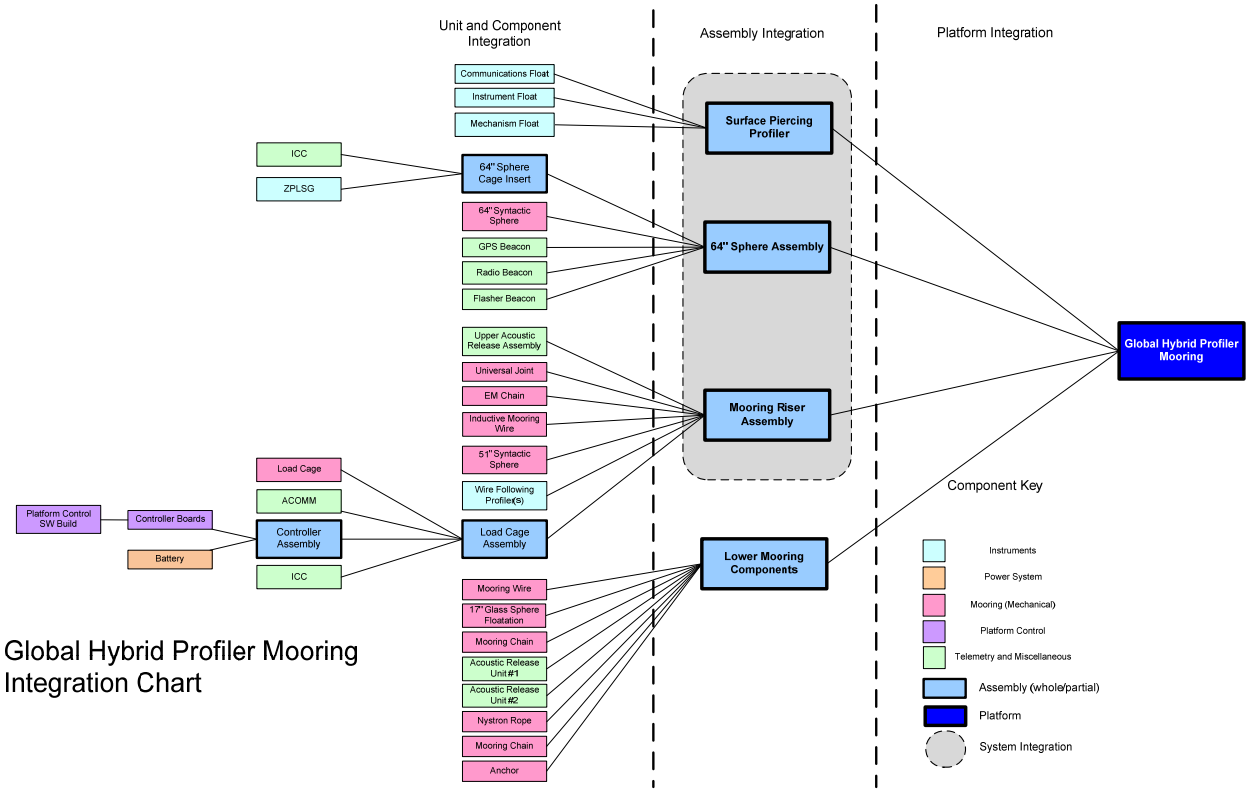
SIO’s Shipboard Technical Support (STS) group operates a high-precision temperature calibration facility, which focuses on the calibration of electronic instrumentation using very high precision automatic temperature bridges with an accuracy of 0.1 mK. The STS calibration lab has two Ruska Model 2400 piston gages for the generation of known pressures with an accuracy of 0.01% of the reading. The facilities offer calibrations of pressure for both oceanic and atmospheric instrumentation. The goal of the STS Calibration facility is to provide full instrument calibration and an understanding of instrument performance: a goal that differs significantly from, but is just as necessary as the goals of a commercial calibration lab.

- Calibration tank
- 0.51 deep by .51 m wide by 1.83 m long (.48 cubic meters)
- Temperature control of several millidegrees and temperature measurement = +/- one millidegree.
- There are two separate pneumatic pressure standard measurement and control systems ranging from atmospheric to either 100 or 300 PSIG with < +/-.01 % full scale accuracy.

5. Integration Plan

All of the individual components complete an acceptance process prior to integration to the platform or assembly level. The unit/component, assembly and platform integration flow is depicted in Figure 3 below. The assembly integration flow charts are in Appendix A. Self-powered instruments, modems, beacons and acoustic releases will have batteries installed following the manufacturer's procedures.

Lower mooring components are integrated during platform integration which takes place during deployment.



Global Hybrid Profiler Mooring Integration Chart

Figure 3 Global Hybrid Profiler Mooring Integration Chart

5.1. HYPM ControllerIntegration

5.1.1. Controller Housing Pressure Test Assembly

Flow chart A.1

Assembly Drawing 3703-00220

Checklist C.1

The controller housing will be pressure tested prior further integration.

The bulkhead connectors and o-rings are installed on the endcap. The endcap will be installed on the housing and the housing evacuated to -15 inHg. In a pressure chamber the housing will be pressurized to 10,000 PSI for one hour.

Entrance Criteria

- Controller housing is available and inspected
- Controller endcap with installed bulkhead connectors and o rings are available and inspected
- Vacuum pump and pressure gage are available
- Pressure chamber is available

Exit criteria

- The assembled controller housing passed the pressure test without leak

Labor:

L1.1 - Install endcap with bulkheads connected to housing, cover all connectors with dummy plugs
L1.2 - Evacuate housing to -15in Hg trough pressure port with vacuum pump, install vacuum port plug
L1.3 - Install housing in pressure chamber
L1.4 - Pressurize to 10,000 PSI for 1 hour

Checks:

C1.1 - Check housing to ensure there was no implosion
C1.2 - Check internal vacuum to verify there were no leaks

- Use a pressure gage with Valve to vacuum port on endcap, should read -15 inHg

C1.3 - Check housing interior to verify there were no leaks

- Open the housing and inspect the interior for water intrusion

5.1.2. Controller Datalogger Board Assembly

Flow chart A.2

Assembly Drawing 3703-00222, 3703-20225,

Check list C.2

The controller Datalogger board will be assembled with IMM and Persistor CF2 controller.

Prior installation of the IMM and CF2 the output voltage of the 5V DC-DC and 3V DC-DC Converter have to be tested after 15VDC is applied to the Datalogger board from an external power supply

After that test passed the IMM and CF2 can be mounted on the Datalogger PCB

Entrance Criteria
- Datalogger PCB available and inspected
- IMM and Persistor CF2 available and inspected
- 15VDC power supply and voltmeter available

Exit criteria
- IMM and CF2 are assembled on the Datalogger controller board after voltage was check passed

Labor:
L2.1 - Install IMM on Datalogger board
L2.2 - Install Persistor CF2 on the Datalogger board after voltage check passed

Checks:
C2.1 - Check voltage of 5V DC-DC converter (w/15VDC applied from power supply)
- Apply 15VDC to J1 (3703-20225, page 2)
- Should measure 5V DC between J11.6 and J11.8 (3703-20225, page 4)

C2.2 - Check voltage of 3.3V DC-DC converter (w/15VDC applied from power supply)
- Apply 15VDC to J1 (3703-20225, page 2)
- Should measure 3.3V DC between J11.7 and J11.8 (3703-20225, page 4)

5.1.3. Controller End Cap / Chassis Assembly

Flow Chart A.3

Assembly Drawings 3703-00220, 3703-20225, 3703-20229

Check List C.3

The controller components (Datalogger board, Power board, Atomic clock board) will be assembled on the chassis which is mounted to the endcap. All wiring between the boards and to the bulkheads will be installed.

After the assembly, the controller will be powered with a 15VDC lab power supply and the latest firmware gets installed.

Entrance criteria
- Datalogger board, Power board and Atomic clock board are assembled
- Controller housing endcap with installed bulkheads available, Chassis parts are available
- 15VDC power supply, Voltmeter are available
- Latest CF2 and Watchdog Firmware are available
- PC with 1 serial ports and with Motocross and Watchdog software installed is available
- Serial cables for CF2, Watchdog and auxiliary ports dummy plugs (shorting Rx and Tx together) are available

Exit criteria
- The controller is installed in the chassis mounted to the end cap

Labor:
L3.1 - Mount Power board on Datalogger board, install wiring
L3.2 - Mount Atomic clock board on Datalogger board, install wiring
L3.3 - Install controller board assembly on chassis
L3.4 - Install chassis on end cap
L3.5 - Install wiring from controller board assembly to bulkhead connectors
L3.6 - Apply 15VDC power from power supply to Power boardvia connector J1 (3703-20229, page 2)
L3.7 - Upload latest firmware to CF2 and watchdog

Checks:
C3.1 - Check 5V DC-DC converter using a Voltmeter
- Should measure 5V DC between J11.6 and J11.8 (3703-20225, page 4)

C3.2 - Check 3.3V DC-DC converter using a Voltmeter
- Should measure 3.3V DC between J11.7 and J11.8 (3703-20225, page 4)

C3.3 - Check 12V power switches on power board using a Voltmeter and CF2 software
- Should measure 12V DC between pin 1 and pin2 of J3, J4, J5 and J6 (3703-20229, page 2)

C3.4 - Check functionality of all auxiliary serial ports using CF2 software and auxiliary ports dummy plug
- Plug dummy plug into auxiliary port bulkheads
- Verify communication to serial port with CF2 software, with local echo deactivated from both terminal and CF2 software. Then, all characters typed should be echoed back to the terminal

C3.5 - Check Watchdog functionality by leaving CF2 software in Menu mode for 2 hours
- Connect PC to controller communication port, monitor output
- Monitor serial output, controller should reset after 1 hour w/o user input in menu mode

C3.6 - Check 5V power switches on controller board using a Voltmeter and CF2 software
- Should measure 5V DC between pin 1 and pin2 of J13 and J14 (3703-20225, page 4) after activation trough CF2 software

5.1.4. Battery Chassis Assembly

Flow Chart A.4

Assembly Drawing 3707-00221

Check List C.4

Entry criteria:
- Controller batteries are available

- Battery chassis parts are available
- Wiring harnesses are available
- Voltmeter is available

Exit criteria
- The battery chassis is assembled

Labor
L4.1 - Install batteries
L4.2 - Install and connect wiring harness

Checks
C4.1 - Test open circuit battery voltage
- Should measure 15V $\pm$ 0.5V

5.1.5 Controller Assembly,

Flow chart A.5

Assembly drawing 3707-00220

Check List C.5

The battery chassis will be installed to the controller end cap / chassis. The full assembled end cap / chassis will be installed in the housing, the housing evacuated to -15 inHg.

Entrance criteria:
- Controller End cap/ chassis assembly is available
- Battery chassis assembly is available
- Controller housing is available
- Vacuum pump and pressure gage are available
- PC with 1 serial port and with Motocross is available
- Serial cable for CF2 is available

Exit criteria.
- The controller is fully assembled in its sealed housing

Labor:
L5.1 - Mount battery chassis assembly on end cap assembly
L5.2 - Connect battery wiring to controller board
L5.3 - Install controller housing onto controller end cap assembly
L5.4 - Evacuate housing to -15 inHg and backfill with nitrogen or argon 6 times.
- Conclude on vacuum to -15 inHg

Checks:
C5.1 - Check vacuum after 1 day to verify no leaks
- Use pressure gage on vacuum port

C5.2 - Check controller communication
- Connect PC serial port to communication bulkhead
- Start Terminal Software
- Verify communication to controller

C5.3 - Check Controller Voltage under load
- Connect PC serial port to communication bulkhead
- Start Terminal Software
- After 1 day, check Battery voltage using CF2 software

5.2. 64" Sphere Integration

Flow chart A.6

Assembly Drawings: 3707-00809

Check List C.6

The ZPLSG will be installed into the 64" sphere cage. The cage will be installed into the sphere, the emergency beacons installed to the sphere.

Entrance criteria
- 64" sphere with attached weldments available
- 64" sphere cage insert with instrument clamps and bypass cables are available
- ZPLSG and cables are available
- GPS Beacon, Radio Beacon, Flasher Beacon are available and inspected
- A PC with serial connection to communication cable to controller is available
- An Ohm meter is available

Exit criteria
- The 64" sphere is fully assembled, the inductive bypass cable is installed in the 64" sphere

Labor:
L6.1 - Install instruments in sphere cage insert
L6.2 - Connect cables from ICC to instrument
L6.3 - Install inductive bypass cable through inductive cable coupler
L6.4 - Install populated sphere cage insert into 64" sphere
- Make sure that the end of the controller communication cable is accessible at the lower weldment of the sphere

L6.5 - Install beacons at top of 64" sphere

Checks:
C6.1 - Verify communication integrity of the ZPLSG instrument through serial communication with instrument
C6.2 - Verify inductive bypass cable continuity

- Measure the resistance between both ends of inductive bypass cable. Should measure less than 1 Ohm between pins 5, 6, 7, & 8; should measure infinite at pins 1, 2, 3, & 4.
- Measure resistance between pins and metal structure of cage insert and metal structure of sphere weldments. Should measure infinite

5.3 Load Cage Integration

Flow chart A.7

Assembly Drawing 3707-00804

Check list C.7

Entrance criteria

- Load cage with instrument clamps is available
- HYPM Controller with proper firmware available
- Acoustic Modem (ACOMM), ICC and cables are available and inspected
- A local acoustic modem is available
- A PC with serial connection to local acoustic modem is available

Exit criteria

- The load cage with main Controller and acoustic modem is assembled., the lower part of the inductive loop is installed

Labor:
L7.1 - Install controller, ACOMM and ICC in load cage
L7.2 - Connect cables from controller to ACOMM and ICC
L7.3 - Install inductive loop cable through inductive cable coupler

Checks
C7.1 - Verify communication integrity through ACOMM

- Connect PC to local acoustic modem
- Interrogate the ACOMM in the load cage with local Acoustic modem
- Switch ACOMM to pass-through mode to controller, verify communication to controller

C7.2 - Verify inductive loop cable connectivity

- Measure at open end of inductive loop cable the resistance between pins 1,2,3,4 and 5,6,7,8. Should measure less than 1 Ohm
- Measure resistance between pins and metal structure of cage. Should measure infinite

5.4 System Integration

Flow chart A.8

Assembly Drawings: 3601-00008, 3602-00006, 3603-00006, 3606-00006

Check List C.8

Entrance criteria

- SPP is available
- 64" sphere assembled with cage insert, controller, instrument, ICC
- Load cage assembled with controller, ACOMM, ICC
- Inductive bypass installed in 64" sphere assembly and load cage
- U-joint and EM chain with lower adapter to mooring wire are available
- 51" sphere and bypass cables available
- Mooring wire with inductive terminations available
- Upper acoustic release assembly with bypass cable is available
- WFP instruments are available
- An Ohm-meter is available

Exit criteria

- The SPP, 64" sphere with secondary controller and ZPLSG, WFP(s) and main controller are connected through the inductive loop
- The HYPM controller and instruments are ready for the PVT

Labor:
L8.1 - Install U-joint and EM-chain with adapter to 64" sphere assembly
L8.2 -Close inductive loop

- Connect SPP winch wire to upper acoustic release assembly
- Install bypass along upper acoustic release assembly
- Install mooring wire between upper acoustic release assembly and 64" sphere
- Install mooring wire between EM chain adapter and 51" sphere
- Install bypass 51" sphere
- Install mooring wire between 51" sphere and load cage

Checks:
C8.1 - Verify inductive loop continuity

- Measure resistance of inductive loop between seawater grounds
- Check for shortcuts to exposed metal on inductive terminations and assemblies

6. Verification Plan

6.1. HYPM Platform Verification Test (PVT)

At the Platform level, it is expected that the majority of the requirements will be verified by inspection and analysis of lower level tests. Any remaining unverified requirements will be verified at the Platform level. The platform testing follows integration and the PVT event conduct is witnessed by the appropriate stakeholders (CGSN, OL if desired).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 simulated and examined at the external interfaces and proper operation exhibited infers that the internal interfaces were operating correctly. The platform testing will take place in dry and if applicable wet conditions as required. The requirement verification strategy is through testing where applicable and analysis for higher level requirements.

6.2. Objectives

The objectives for the HYPM platform test are:

1. Demonstrate transition to an operational state
2. Demonstrate connectivity to engineering and scientific sensors and instruments
3. Demonstrate inductive connectivity and functionality
4. Demonstrate SPP control functions
5. Demonstrate error handling/recovery capabilities

6.3. HYPM Test Case Descriptions

6.3.1. TC-001 HYPM Controller Functionality

This test consists of performing a series of command and controls operations to verify proper behavior and functionality for

- the controller in the SPP Communications Float,
- the controller in the SPP Instrument Float,
- the controller in the SPP Mechanism Float,
- the WFP and
- the HYPM controller

prior to integration and deployment of the HYPM. Emphasis will be placed on communications paths to all mooring nodes to ensure that all paths can be established. Each of the controllers will be checked individually. Inductive modem communications will not be exercised as part of this test.

Test Procedure Document No.: 3167-00101

Table 3: TC-001 Addressed Requirements

ID	Verification Method-CM	Verification Level	Description
L4-CG-PC-RQ-81	Demonstration	Component	Platform Controllers shall have a low power or quiescent state to conserve power.
L4-CG-PC-RQ-82	Demonstration	Component	Platform Controllers shall be capable of awakening from the low power/quiescent state by an interrupt from any serial port.
L4-CG-PC-RQ-814	Analysis Demonstration	Component	Platform Controllers shall implement power conservation features to maximize endurance and scientific measurement potentials.
L4-CG-PC-RQ-219	Analysis Demonstration	Component	Platform Controllers shall provide the data storage capacity to accommodate the engineering and science data to be recorded over the deployment interval for the platform in which it is located.
L4-CG-PC-RQ-255	Demonstration	Component	Platform Controllers shall provide an operator interface for purposes of performing diagnostics, operational verification, testing and troubleshooting.
L4-CG-PC-RQ-844	Analysis Demonstration	Component	Platform Controllers shall support an acoustic bi-directional communications capability.

TC-001 Objectives Addressed

- Verify the SPP,WFP and HYPM controllers are properly functioning.

TC-001 Test Environment

- Dry, at the assembly site

TC-001 Pre-Conditions

- SPP assembled: Mechanism Float, Instrument Float, Communications Float
- 64" sphere assembled with cage insert, instrumentation.
- WFP assembled

- Lower load cage assembled: HYPM controller, acoustic modem

TC-001 Hardware Preparations
- Test PC with RS232 serial port
- FreeWave modem with antenna, interface to test PC
- Local acoustic modem with transducer, RS-232-interface to test-PC
- Comm-Cables for SPP, WFP, HYPM controller

TC-001 Software Preparation
- SPP serial port configuration: 19200,8N1,no handshaking
- SPP FreeWave configuration: 19200,8N1,no handshaking
- WFP serial port configuration: 9600,8N1,no handshaking
- WFP terminal software: CrossCut
- HYPM controller serial port configuration: 9600,8N1,no handshaking
- HYPM controller terminal software: HyperTerm, RealTerm, TerraTerm
- Local acoustic modem serial port configuration: 9600,8N1,no handshaking

TC-001 Test Inputs
- Wakeup SPP, system check
- Wakeup WFP, system check, bench test
- Wakeup HYPM controller, system check, bench test
- Wakeup local acoustic modem, system check
- Switch local acoustic modem into pass-through mode with modem in load cage

TC-001 Expected Results
- Communication to SPP can be established
  - Via serial port
  - Via FreeWave Modem
- Communication to WFP can be established
- Communication to HYPM Controller can be established
  - Via serial port
  - Via acoustic modem pass-through mode

TC-001 Criteria for Evaluating Results
- Communication can be established consistently and maintained uninterrupted during the test.

6.3.2. TC-002 HYPM Instrument Data Acquisition and Telemetry

This test will be performed to obtain a first full data transfer from all available instruments and sensors connected to the various controllers on the mooring prior to deployment. Water pumps will be turned off for the test, the SPP winch motor control will be disabled.

Test Procedure Document No.: 3167-00102

Table 4: TC-002 Addressed Requirements

ID	Verification Method-CM	Verification Level	Description
L3-CG-RQ-163	Demonstration	Platform	CGSN platforms shall transmit data to shore
L3-CG-RQ-164	Demonstration	Platform	CGSN platforms with telemetry links shall receive commands and status from CGSN shore-based assets.
L3-CG-RQ-527	Demonstration	Platform	Global Surface-Piercing Profilers shall include a telemetry link to the Deep Profiler and other instruments on the mooring.
L3-CG-RQ-761	Demonstration	Platform	CGSN platforms shall be capable of having their sampling or operational protocols changed remotely via CGSN assets.
L3-CG-RQ-890	Demonstration	Platform	CGSN platforms without a CI presence and without sufficient bandwidth for real-time transfer of raw data, shall compress or decimate data.
L4-CG-PC-RQ-76	Demonstration	Component	Platform Controllers shall be capable of autonomous operation based on one or more predefined missions.
L4-CG-PC-RQ-75	Demonstration	Component	Platform Controllers shall be capable of initiating communications based on a predefined schedule.
L4-CG-PC-RQ-77	Demonstration	Component	Platform Controllers shall be capable of responding to an external request to enable communications via an available telemetry device for that purpose.
L4-CG-PC-RQ-269	Demonstration	Component	Platform Controllers shall time stamp engineering and science instrument data with a precision of 1 ms.
L4-CG-PC-RQ-625	Analysis Demonstration	Component	Platform Controllers shall be capable of establishing communications with instruments on a mooring to obtain measurement data.
L4-CG-PC-RQ-626	Analysis Demonstration	Component	Platform Controllers shall provide the capability to configure instrument sampling strategies, power duty cycles and operational durations.
L4-CG-PC-RQ-628	Analysis Demonstration	Component	Platform Controllers shall log data from scientific instruments on the mooring.
L4-CG-PC-RQ-635	Analysis Demonstration	Component	Platform Controllers shall provide the capability to compress or decimate recorded data.
L4-CG-PC-RQ-639	Demonstration	Component	In the absence of GPS-based time string information, Platform Controllers shall maintain a time drift of no more than 0.16 seconds per day.
L4-CG-PC-RQ-643	Analysis Demonstration	Component	Platform Controllers shall monitor and record data storage capacities.
L4-CG-PC-RQ-651	Analysis Demonstration	Component	Platform Controllers shall provide access control capability for local recorded data, configuration files, and hardware settings.
L4-CG-PC-RQ-727	Analysis	Component	Platform Controllers shall provide the capability to accept mission

	Demonstration		control from the OMC.
L4-CG-PC-RQ-732	Analysis Demonstration	Component	Platform Controllers shall have the capability to send platform status and data to the OMC over a telemetry link.
L4-CG-PC-RQ-738	Analysis Demonstration	Component	Platform Controllers shall provide data logging capabilities for engineering sensors.
L4-CG-PC-RQ-742	Analysis Demonstration	Component	Platform Controllers shall log scientific instrument data in native instrument format.
L4-CG-PC-RQ-775	Analysis Demonstration	Component	Platform Controllers shall support remote operation, configuration, status reporting and scientific data retrieval when communicating via an available telemetry device for that purpose.
L4-CG-PC-RQ-840	Analysis Demonstration	Component	Platform Controllers shall support an inductive bi-directional communications capability interface to communicate with assets on the mooring not electrically connected to the controller.
L4-CG-PC-RQ-878	Demonstration	none	Platform Controllers shall be capable of receiving operational and diagnostic commands from ship/shore via any available telemetry channel.
L4-CG-PC-RQ-879	Demonstration	none	Platform Controllers shall be capable of transmitting operational and diagnostic responses and data to ship/shore.
L4-CG-MO-RQ-223	Demonstration	Assembly	Inductive Mooring risers shall enable communications from surface or sub-surface platform controllers to sub-surface instruments mounted on the mooring riser.
L4-CG-TS-RQ-195	Demonstration	Platform	Inductive Telemetry components shall interface with Platform Controllers per ICD 3102-10008.
L4-CG-TS-RQ-197	Analysis Demonstration	Platform	Acoustic Telemetry components shall interface with Platform Controllers per ICD 3102-10009.
L4-CG-TS-RQ-198	Analysis Demonstration	Platform	Inductive telemetry systems shall interface to mooring riser components.

TC-002 Objectives Addressed

- Test of instrument data acquisition on SPP, WFP and HYPM Controller
- Test of data and command transfer between the units via inductive link
- Test of data and command transmission via FreeWave-link and satellite connection
- Test of data and command transmission via acoustic link.

TC-002 Test Environment

- Dry, at the assembly site
- Communications float of SPP needs to be able to establish a satellite connection, i.e. outside positioning with clear view to the sky as needed

TC-002 Pre-conditions

- Pre-Conditions as in TC-001
- TC-001 has been completed and passed
- Instruments and controllers are ready to be setup for test deployment mode
- All inductive bypass cables at the HYPM are connected
- SPP, WFP, HYPM Controller are connected through inductive loop

TC-002 Hardware Preparation

- Same as in TC-001
- Internet connection to server

TC-002 Software Preparation

- As in TC-001
- Shore side setup:
  - RUDICS connection to server
  - SPP communication software will be running on server

TC-002 Test Inputs

- Set all instruments and controllers into deployment mode
- Telemetry data retrieval from SPP through freewave link
- Telemetry command transfer to SPP through freewave link
- Telemetry data retrieval from SPP through satellite link
- Telemetry command transfer to SPP through freewave link
- Telemetry command transfer to SPP through acoustic link
- Telemetry data retrieval from HYPM controller through acoustic link
- Telemetry command transfer to HYPM through acoustic link
- Stop deployment mode
- Download data from individual instruments and controllers
- Store Data on Profiler Server

TC-002 Expected Results

- HYPM Controller
  - Logs data from WFP
  - Logs status data
  - Forwards data (decimated as required) to SPP upon request
  - Forwards all data (decimated as required) to acoustic modem in load cage
  - Accepts and interprets correctly commands through acoustic link
  - Forwards commands received through acoustic link to WFP and SPP
- Acoustic modem in load cage transmits stored data to local acoustic modem
- SPP
  - Logs instrument data
  - Logs engineering and status data
  - Polls HYPM Controller
  - Transmits data viaFreeWave link and satellite link
  - Accepts and interprets correctly commands through freewave link and satellite link
  - Forwards commands received freewave and satellite link to HYPM controller
  - Accepts and interprets correctly commands through acoustic link
- Profiler Server

- Platform data is stored on the Profiler Server and available for retrieval by the Data Server

TC-002 Criteria for Evaluating Results

- No signs of defects in data records or any indications of corrupted records are found in data downloaded directly from instruments and controllers.
- Data stored in controller align to the data internally stored in instruments .
- Inductive Communication path works without interruption
- Freewave, satellite and acoustic data transfer works without unexpected interruption
- No signs of defects of controller based on engineering/status data reported
- Data retrieved through telemetry aligns with data internally stored in instruments and controller.
- Transmitted commands were successfully forwarded and executed.
- Data stored on the Profiler Server is available in the required format for retrieval by the Data Server.

6.3.3. TC-003 HYPM Error Handling and Recovery Test

This test will be performed to check the mooring controller's capability for error handling and recovery. This test will be performed by periodically disconnecting the controllers from the inductive loop prior to and during ongoing communication sessions.

Test Procedure Document No.: 3167-00103

Table 5: TC-003 Addressed Requirements

ID	Verification Method-CM	Verification Level	ID
L4-CG-PC-RQ-624	Analysis Demonstration	Component	Platform Controllers shall be fault tolerant to communication failures of instruments.

TC-003 Objectives Addressed

- Test of error handling and recovery while periodically disconnecting the HYPM Controller from the inductive loop prior to and during ongoing communication sessions.
- Test of error handling and recovery while periodically disconnecting the SPP from the inductive loop prior to and during ongoing communication sessions.
- Test of error handling and recovery set SPP inductive communication schedule to perform during ongoing communication session from WFP to HYPM controller.
- Test of error handling and recovery set WFP inductive communication schedule to perform during ongoing communication session from SPP to HYPM controller.
- Test of error handling and recovery when the acoustic communication interrupted.

TC-003 Test Environment

- Dry, at the assembly site

TC-003 Pre-conditions

- Same Pre-Conditions as in TC-002
- TC-002 has been completed and passed

TC-003 Hardware Preparation

- Same as in TC-002

TC-003 Software Preparation

- Same as in TC-002

TC-003 Test Inputs

- Communication path will be interrupted periodically.
  - HYPM controller to inductive loop prior and during communication to SPP and WFP.
  - FreeWave connection to SPP during communication.

- Treatment of controllers with defective external communication cables as applicable.
- Acoustic communication will be interrupted during ongoing communication of acoustic modem with local modem during data telemetry and command telemetry/pass-through mode.

TC-003 Expected Results

- The impacted controller resumes its programmed schedule after an acceptable timeframe.
- Data will be present during the next scheduled connection if communications are successfully reestablished.

TC-003 Criteria for Evaluating Results

- All missed data gets transmitted on the following communication sessions.

6.3.4. TC-004 Instrument and Sensor Data Quality Test

This test will be performed to ensure the sensor elements are functional. The test will also ensure that the sensors report reasonable measurements based on the environmental test conditions.

Test Procedure Document No.: 3167-00104

Table 6: TC-004 Addressed Requirements

ID	Verification Method-CM	Verification Level
L3-CG-RQ-163	Demonstration	Platform
L3-CG-RQ-890	Demonstration	Platform

TC-004 Objectives Addressed

- Verification of test mission progress: telemetry data retrieval through freewave or satellite link.
- Verification during test mission: Acoustic data telemetry from acoustic modem with local acoustic modem.
- Verification during test mission: Acoustic pass-through communication to HYPM controller with local acoustic modem.
- Stop test mission, data download, processing, display and verification.

TC-004 Test Environment

- Dry, at the assembly site
- Saltwater tank SPP instrument float and WFP if available

TC-004 Pre-conditions

- TC-002 has been completed and passed.

TC-004 Hardware Preparation

- Computer, printer, screen.

TC-004 Software Preparation

- Appropriate data processing and visualization software.

TC-004 Test Inputs

- Data downloaded from instruments and controller.

TC-004 Expected Results

- Sensors report reasonable measurements based on the environmental test conditions.

TC-004 Criteria for Evaluating Results

- No signs of defect sensors based on evaluation of instrument data.

- No signs of defects of controller based on engineering/status data reported.

6.3.5. TC-005 Straight Line Proof Load of Load Cage & Spheres

This test will be performed to ensure the load cage, spheres, dualing bracket for the release and universal joint meet the requirements for straight line proof load.

Test Procedure Document No.: 3167-00105

Table 7: TC-005 Addressed Requirements

ID	Verification Method-CM	Verification Level	Description
L4-CG-MO-RQ-288	Analysis Demonstration	Component	Instrument Frames on Global subsurface moorings shall be designed to sustain a straight line proof load of 6,000 lbs.
L4-CG-MO-RQ-289	Analysis Demonstration	Component	Sub-surface spheres shall be designed to sustain a straight line proof load of 10,000 lbs.
L4-CG-MO-RQ-290	Analysis Demonstration	Unit	Mooring Riser weldments shall be designed to sustain a straight line proof load of 10,000 lbs.
L4-CG-MO-RQ-280	Analysis Demonstration	Unit	Dualing brackets shall be designed to sustain a straight line proof load of 10,000 lbs.
L4-CG-MO-RQ-267	Analysis Demonstration	Unit	Universal joints shall be designed to sustain a straight line proof load of 10,000 lbs.

TC-005 ObjectivesAddressed

- Verify the load cage frame can sustain a straight line proof load of 6,000 lbs
- Verify the spheres can sustain a straight line proof load of 6,000 lbs
- Verify the dualing bracket can sustain a straight line proof load of 10,000lbs
- Verify the universal joint can sustain a straight line proof load of 10,000lbs

TC-005 Test Environment

- Dry, at the assembly site
- - Test conduct will be in accordance with Scripps EH&S policies located at: http://blink.ucsd.edu/Blink/External/Topics/1,1105,7,00.html

TC-005 Pre conditions

- 64" sphere, 51" sphere are assembled with weldments but w/o instruments
- Load cage w/o controller, ICC and ACOMM
- Dualing bracket on site
- Universal joint on site

TC-005 Hardware preparations

- Lifting device with appropriate WLL
- 5ton dynamometer with logging functionality
- 6,000lbs weight for spheres and load cage
- 10,000lbs weight for dualing bracket and universal joint
- Lifting slings and hardware with appropriate WLL
- 64” sphere
- 51” sphere

- Load Cage
- Dualing Bracket
- Universal Joint

TC-005 Software preparations
- NA

TC-005 Test inputs
- Attach load cage to lifting device
- Attach load cage to 6,000lbs weight with opposite end
- Lift load cage and weight assembly off ground for 1 minute

- Attach 64” sphere to lifting device
- Attach 64” sphere to 6,000lbs weight with opposite end
- Lift 64” sphere and weight assembly off ground for 1 minute

- Attach 51” sphere to lifting device
- Attach 51” sphere to 6,000lbs weight with opposite end
- Lift 51” sphere and weight assembly off ground for 1 minute

- Attach dualing bracket to lifting device
- Attach dualing bracket to 10,000lbs weight with opposite end
- Lift dualing bracket and weight assembly off ground for 1 minute

- Attach universal joint to lifting device
- Attach universal joint to 10,000lbs weight with opposite end
- Lift universal joint and weight assembly off ground for 1 minute

TC-005 Expected Results
- The load cage frame can sustain the weight for the test duration.
- The spheres can sustain the weight for the test duration.
- The dualing bracket can sustain the weight for the test duration.
- The universal joint can sustain the weight for the test duration.

TC-005 Criteria for Evaluating Results
- No signs of defect or fatigue based on inspection of the load cage frame.
- No signs of defect or fatigue based on inspection of the spheres.
- No signs of defect or fatigue based on inspection of the dualing bracket.
- No signs of defect or fatigue based on inspection of the universal joint.

6.3.6. TC-006 Requirements Analysis and Inspection

This test procedure will have a list of requirements that have been verified by analysis. The analysis will be included in the test procedure and/or Technical Data Package.

Test Procedure Document No.: 3167-70106
Table 8: TC-006 Addressed Requirements

ID	Verification Method-CM	Verification Level
L4-CG-MO-RQ-74	Analysis Inspection	Unit
L4-CG-MO-RQ-76	Analysis	Assembly
L4-CG-MO-RQ-79	Analysis	Assembly
L4-CG-MO-RQ-207	Analysis Inspection	Component
L4-CG-MO-RQ-210	Analysis	Component
L4-CG-MO-RQ-213	Analysis	Component
L4-CG-MO-RQ-221	Analysis	Unit
L4-CG-MO-RQ-228	Analysis Inspection	Unit
L4-CG-MO-RQ-229	Analysis	Assembly
L4-CG-MO-RQ-230	Analysis	Assembly
L4-CG-MO-RQ-231	Inspection	Assembly
L4-CG-MO-RQ-233	Analysis	Assembly
L4-CG-MO-RQ-238	Analysis Inspection	Component
L4-CG-MO-RQ-241	Inspection	Component
L4-CG-MO-RQ-249	Analysis	Assembly
L4-CG-MO-RQ-264	Analysis	Component
L4-CG-MO-RQ-268	Inspection	Unit
L4-CG-MO-RQ-269	Analysis	Component
L4-CG-MO-RQ-272	Analysis	Unit
L4-CG-MO-RQ-273	Analysis	Platform
L4-CG-MO-RQ-279	Analysis	Component
L4-CG-MO-RQ-283	Analysis	Unit
L4-CG-PC-RQ-260	Analysis	Component
L4-CG-PS-RQ-103	Analysis	Unit
L4-CG-PS-RQ-284	Analysis	Component
L4-CG-TS-RQ-86	Analysis Demonstration	Unit
L4-CG-TS-RQ-98	Analysis	Unit
L4-CG-TS-RQ-119	Analysis	Unit
L4-CG-TS-RQ-120	Analysis	Unit
L4-CG-TS-RQ-127	Analysis	Unit
L4-CG-TS-RQ-130	Analysis	Unit
L4-CG-TS-RQ-151	Demonstration	Unit
L4-CG-TS-RQ-152	Demonstration	Unit
L4-CG-TS-RQ-153	Demonstration	Unit
L4-CG-TS-RQ-156	Analysis	Unit
L4-CG-TS-RQ-164	Analysis	Unit
L4-CG-TS-RQ-165	Demonstration	Unit
L4-CG-TS-RQ-166	Demonstration	Unit
L4-CG-TS-RQ-167	Demonstration	Unit
L4-CG-TS-RQ-168	Demonstration	Unit
L4-CG-TS-RQ-169	Analysis	Unit
L4-CG-TS-RQ-181	Analysis	Unit
L4-CG-TS-RQ-182	Analysis	Unit
L4-CG-TS-RQ-206	Analysis	none
L4-CG-TS-RQ-207	Analysis	none
L4-CG-TS-RQ-208	Analysis	none
L4-CG-TS-RQ-209	Analysis	none
L4-CG-TS-RQ-210	Analysis	none

L4-CG-PC-RQ-283	Analysis	Component	L4-CG-TS-RQ-211	Analysis	none
L4-CG-PC-RQ-744	Analysis	Unit	L4-CG-TS-RQ-212	Analysis	none
L4-CG-PC-RQ-745	Analysis	Platform	L4-CG-TS-RQ-213	N/A	none
L4-CG-PC-RQ-835	Inspection		L4-CG-TS-RQ-214	N/A	none
L4-CG-PC-RQ-845	Analysis	Component	L4-CG-TS-RQ-216	Analysis	none
L4-CG-PC-RQ-856	Analysis	Assembly	L4-CG-TS-RQ-217	Analysis	none
L4-CG-PC-RQ-857	Analysis	Assembly	L4-CG-TS-RQ-218	Analysis	none
L4-CG-PC-RQ-858	Analysis	Unit	L4-CG-TS-RQ-220	Analysis	none
L4-CG-PC-RQ-863	Inspection	none			
L4-CG-PC-RQ-874	Analysis	none			
L4-CG-PC-RQ-875	Analysis	none			

6.3.7. TC-007 L3 Requirements Analysis

This test will be an analysis of the L3 requirements.

Test Procedure Document No.: 3167-70107

Table 9: TC-007 Addressed Requirements

ID	Verification Method-CM	Verification Level	ID	Verification Method-CM	Verification Level
L3-CG-RQ-160	Analysis	Platform	L3-CG-RQ-485	Analysis	Platform
L3-CG-RQ-166	Analysis	Platform	L3-CG-RQ-489	Inspection	Platform
L3-CG-RQ-168	Analysis	Platform	L3-CG-RQ-490	Inspection	Platform
L3-CG-RQ-191	Inspection	Platform	L3-CG-RQ-494	Analysis	Platform
L3-CG-RQ-193	Analysis	Platform	L3-CG-RQ-495	Analysis	Platform
L3-CG-RQ-195	Analysis	Platform	L3-CG-RQ-499	Analysis	Platform
L3-CG-RQ-199	Analysis	Platform	L3-CG-RQ-524	Analysis	Platform
L3-CG-RQ-200	Analysis	Platform	L3-CG-RQ-526	Analysis	Platform
L3-CG-RQ-201	Analysis	Platform	L3-CG-RQ-528	Analysis	Platform
L3-CG-RQ-202	Analysis	Platform	L3-CG-RQ-530	Analysis	Platform
L3-CG-RQ-204	Analysis	Platform	L3-CG-RQ-533	Analysis	Platform
L3-CG-RQ-205	Analysis	Platform	L3-CG-RQ-855	Analysis	Platform
L3-CG-RQ-206	Analysis	Platform	L3-CG-RQ-856	Analysis	Platform
L3-CG-RQ-208	Analysis	Platform	L3-CG-RQ-867	Analysis	Platform
L3-CG-RQ-210	Analysis	Platform	L3-CG-RQ-885	Analysis	Platform
L3-CG-RQ-211	Analysis	Platform	L3-CG-RQ-894	Analysis	Platform
L3-CG-RQ-212	Analysis	Platform	L3-CG-RQ-923	Analysis	Platform
L3-CG-RQ-213	Analysis	Platform	L3-CG-RQ-947	Analysis	Platform
L3-CG-RQ-432	Analysis	Platform	L3-CG-RQ-948	Analysis	Platform
L3-CG-RQ-433	Analysis	Platform	L3-CG-RQ-987	Analysis	Platform
L3-CG-RQ-438	Analysis	Platform	L3-CG-RQ-993	Analysis	Platform
L3-CG-RQ-439	Analysis	Platform	L3-CG-RQ-1006	Analysis	Platform
L3-CG-RQ-444	Analysis	Platform	L3-CG-RQ-1030	Analysis	none
L3-CG-RQ-445	Inspection	Platform	L3-CG-RQ-1035	Analysis	none

6.3.8. TC-008 Platform Controller Pressure Test

This test procedure will verify that the SIO platform controller housings are able to survive pressure equivalent to 6000m water depth by testing them in a high-pressure tank.

Test Procedure Document No.: 3166-70108

Table 10: TC-008 Addressed Requirements

ID	Verification Method-CM	Verification Level
L4-CG-PC-RQ-275	Test	Unit

TC-008 Objectives Addressed

- Platform Controller pressure housings on Global Moorings shall survive pressures equivalent to 6000 m water depth.

TC-008 Test Environment

- Pressure housings will be located at a pressure testing facility.
- At SIO, the Keck pressure testing facility will be used.

TC-008 Pre conditions

- Pressure testing facility capable of at least 9,000psi available.

TC-008 Hardware preparations

- SIO Platform Controller Pressure housings are assembled.

TC-008 Software preparations

- NA

TC-008 Test inputs

Pressure test platform controller pressure housings for 1hr at 9,000psi

TC-008 Expected Results

- Pressure housing does not leak.

TC-008 Criteria for Evaluating Results

- No signs of leakage based on inspection of the pressure housings.

7. Requirements Traceability

HYPM requirements traceability is captured in the DOORS database in the following module:

- L3 - CG System
- L4 - CG Instrument Package
- L4 - Mooring Riser
- L4 - Platform Control
- L4 - Power System
- L4 – Profiler
- L4 - Telemetry Systems

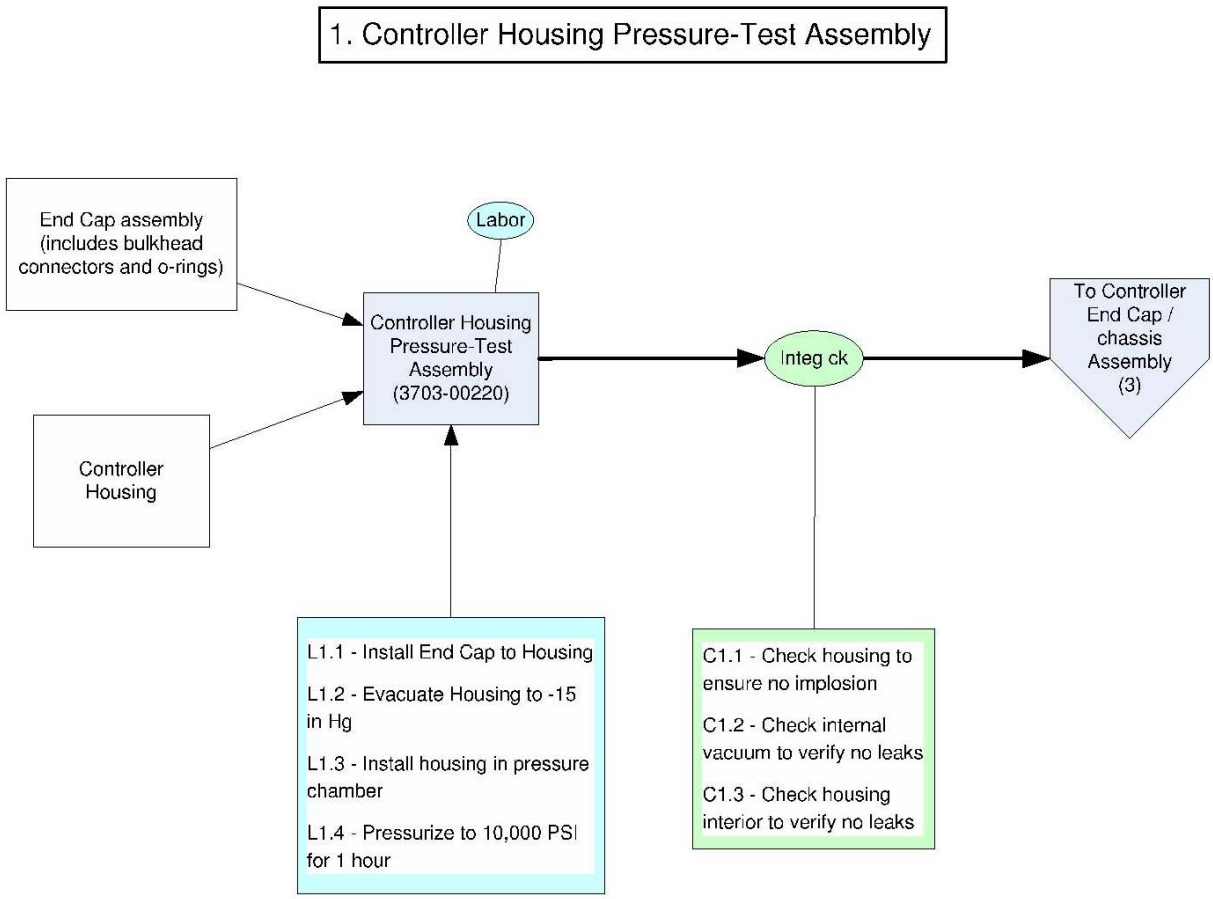
The RVCM view in DOORS for this mooring is RVCM_HYPM.

8. Integration and Verification (I&V) Schedule

- See the CGSN IMS for latest schedule information.

APPENDIX A Integration Flow Charts

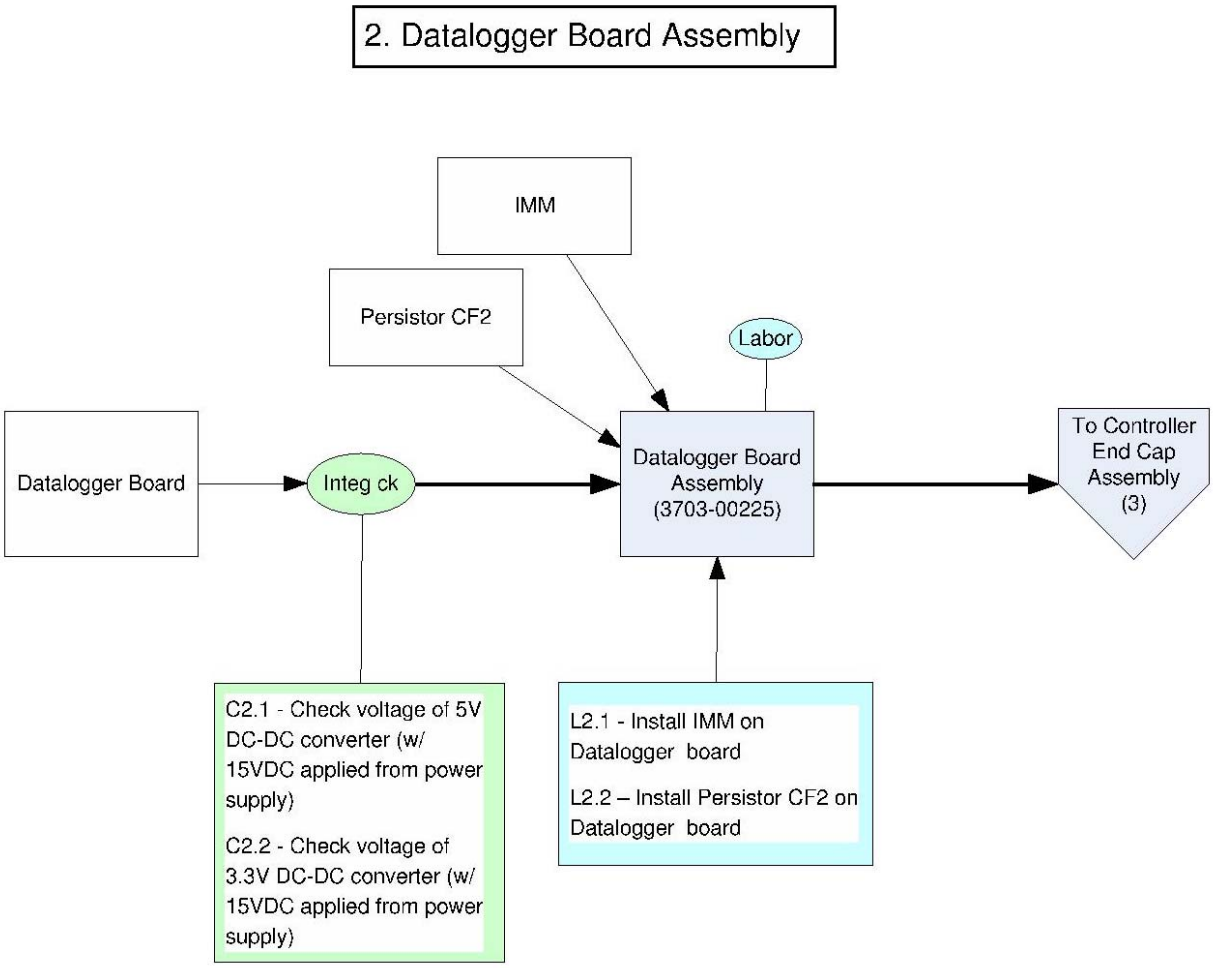
A.1 Controller Housing Pressure-Test Assembly



Checklist 1: Controller Housing Pressure Test Assembly

No.	Integration Check/Action	Pass	Fail	Notes
C1.1	Check housing to ensure no implosion			
C1.2	Check internal vacuum to verify no leaks			
C1.3	Check housing interior to verify no leaks			

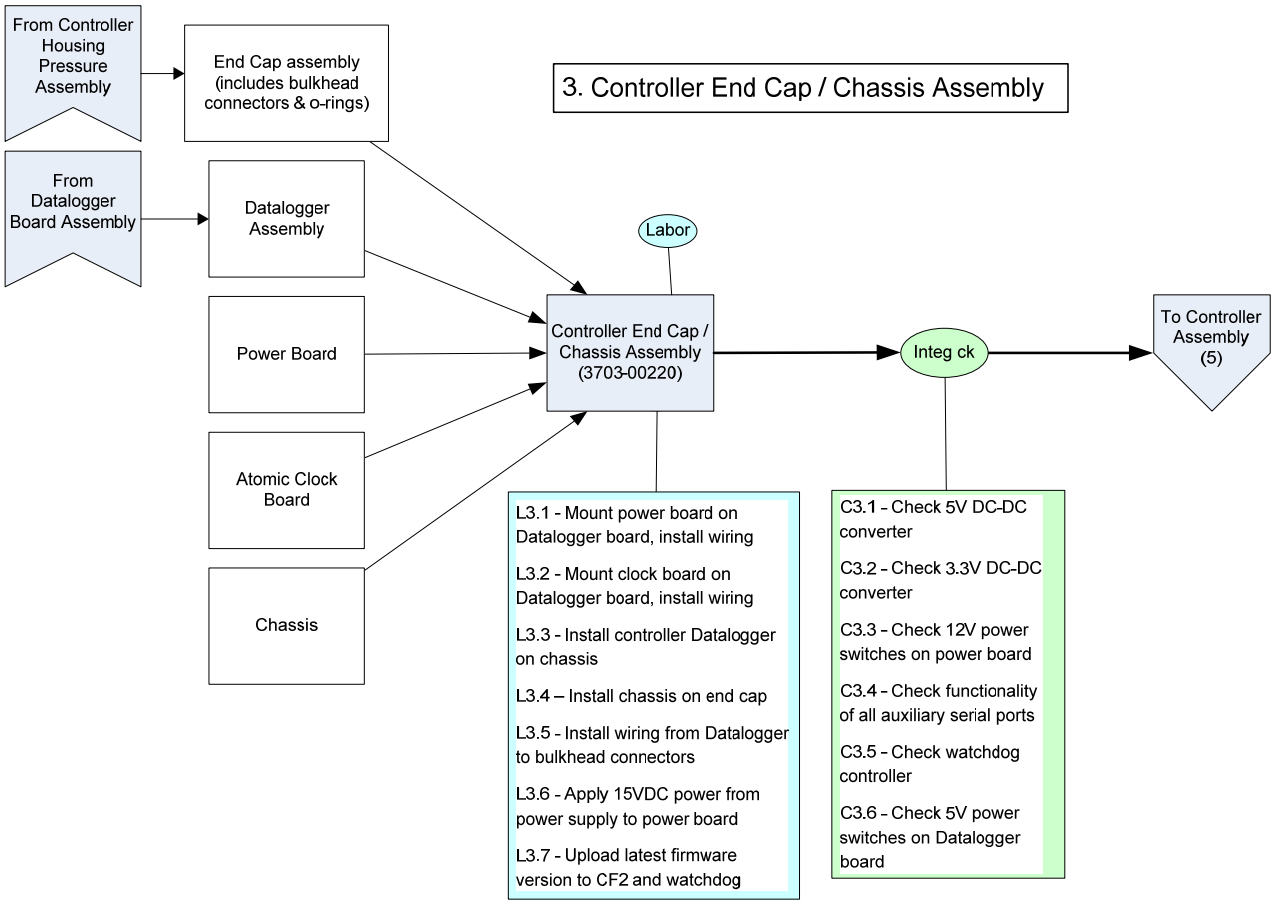
A.2 Datalogger Board Assembly



Checklist 2: Controller Datalogger Board Assembly

No.	Integration Check/Action	Pass	Fail	Notes
C2.1	Check voltage of 5V DC-DC converter			
C2.2	Check voltage of 3.3V DC-DC converter			

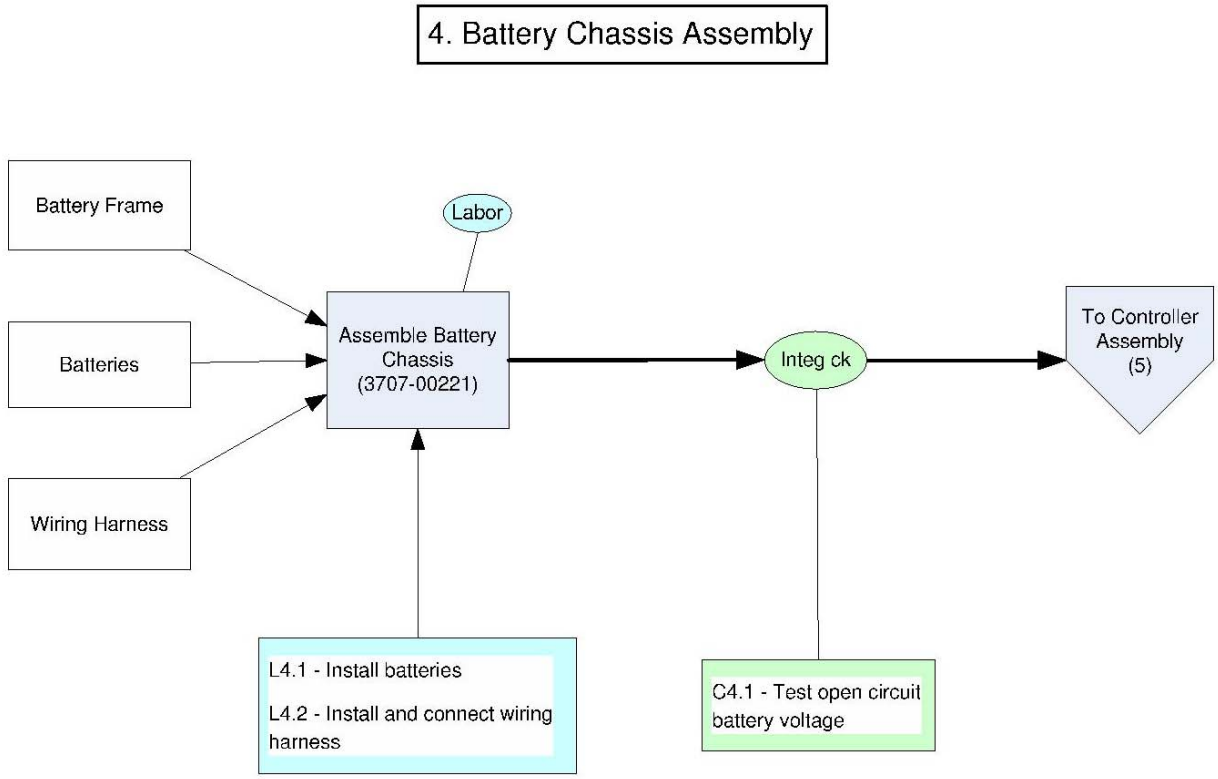
A.3 Controller End Cap/Chassis Assembly



Checklist 3: Controller End Cap / Chassis Assembly

No.	Integration Check/Action	Pass	Fail	Notes
C3.1 C3.2	Check 5V DC-DC converter Check 3.3V DC-DC converter			
C3.3	Check 12V power switches on power board			
C3.4 C3.5 C3.6	Check functionality of all auxiliary serial ports Check watchdog controller Check 5V power switches on controller board			

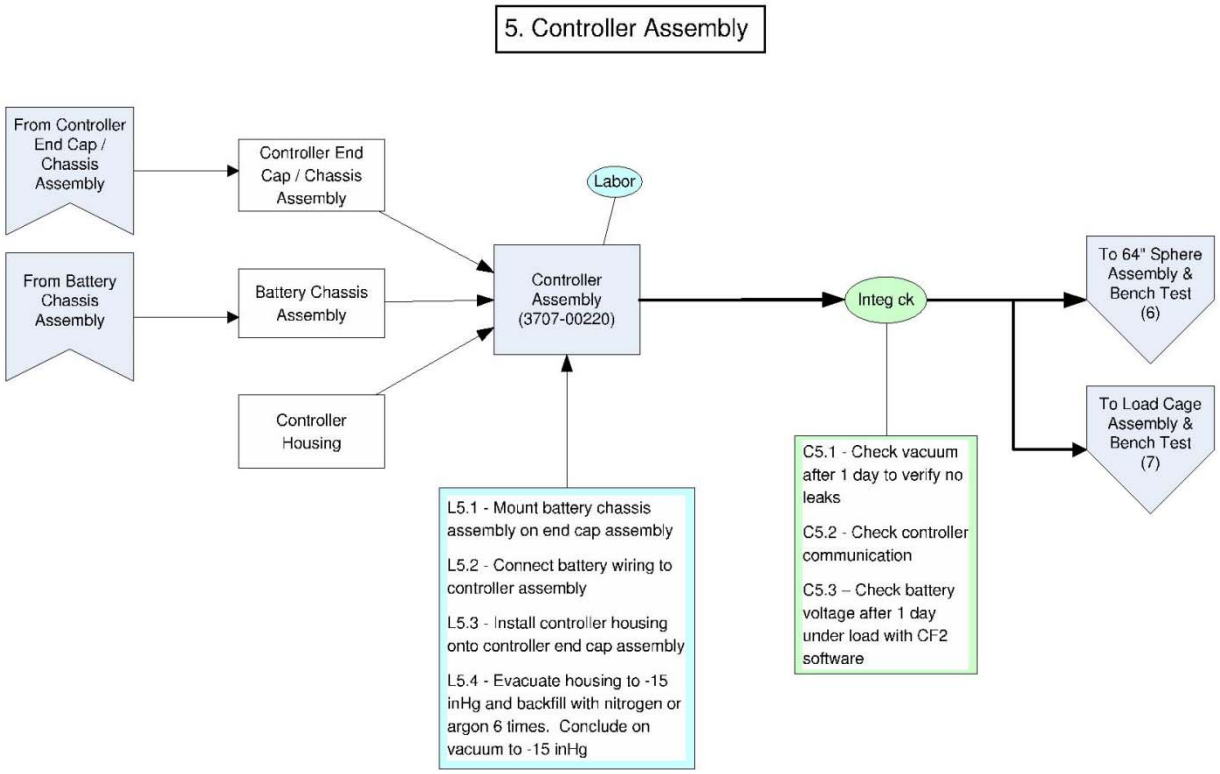
A.4 Battery Chassis Assembly



Checklist 4: Battery Chassis Assembly

No.	Integration Check/Action	Pass	Fail	Notes
C4.1	Test open circuit battery voltage			
C4.2	Test battery voltage under load			

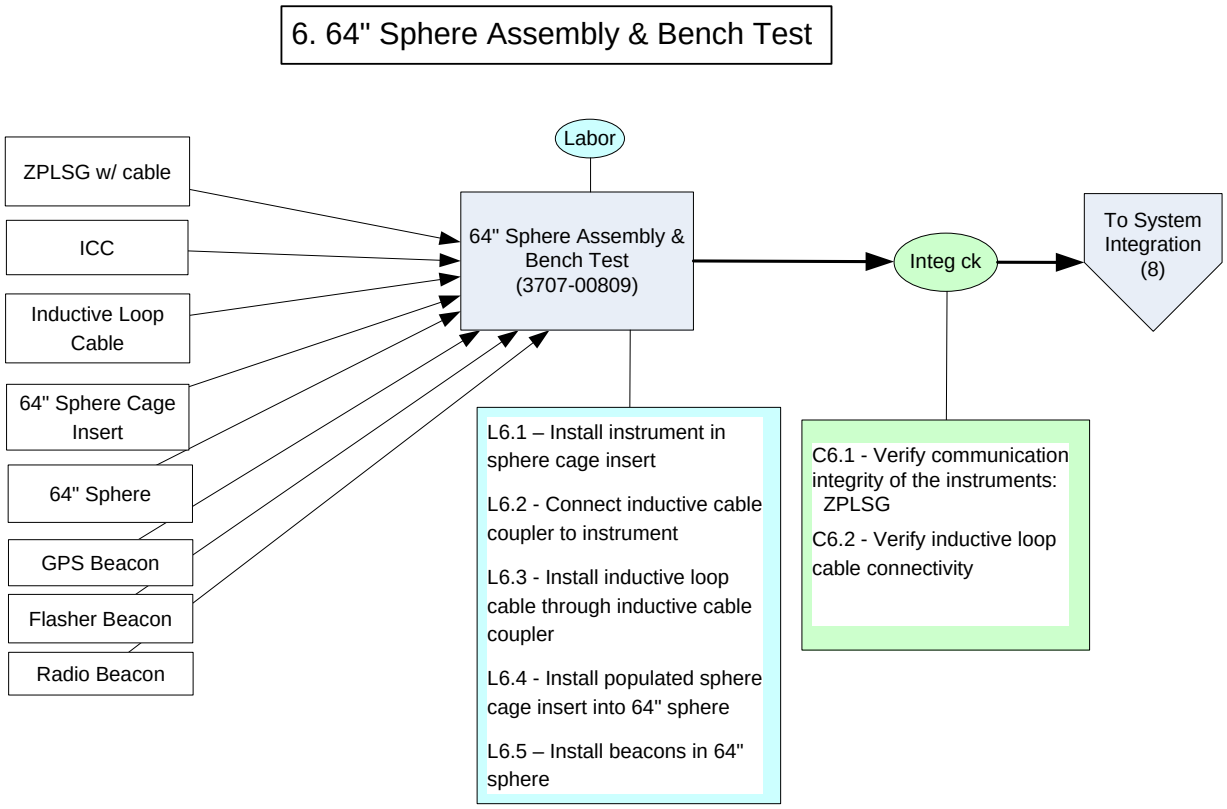
A.5 Controller Assembly



Checklist 5: Controller Board Assembly

No.	Integration Check/Action	Pass	Fail	Notes
C5.1	Check vacuum after 1 day to verify no leaks			
C5.2	Check controller communication			

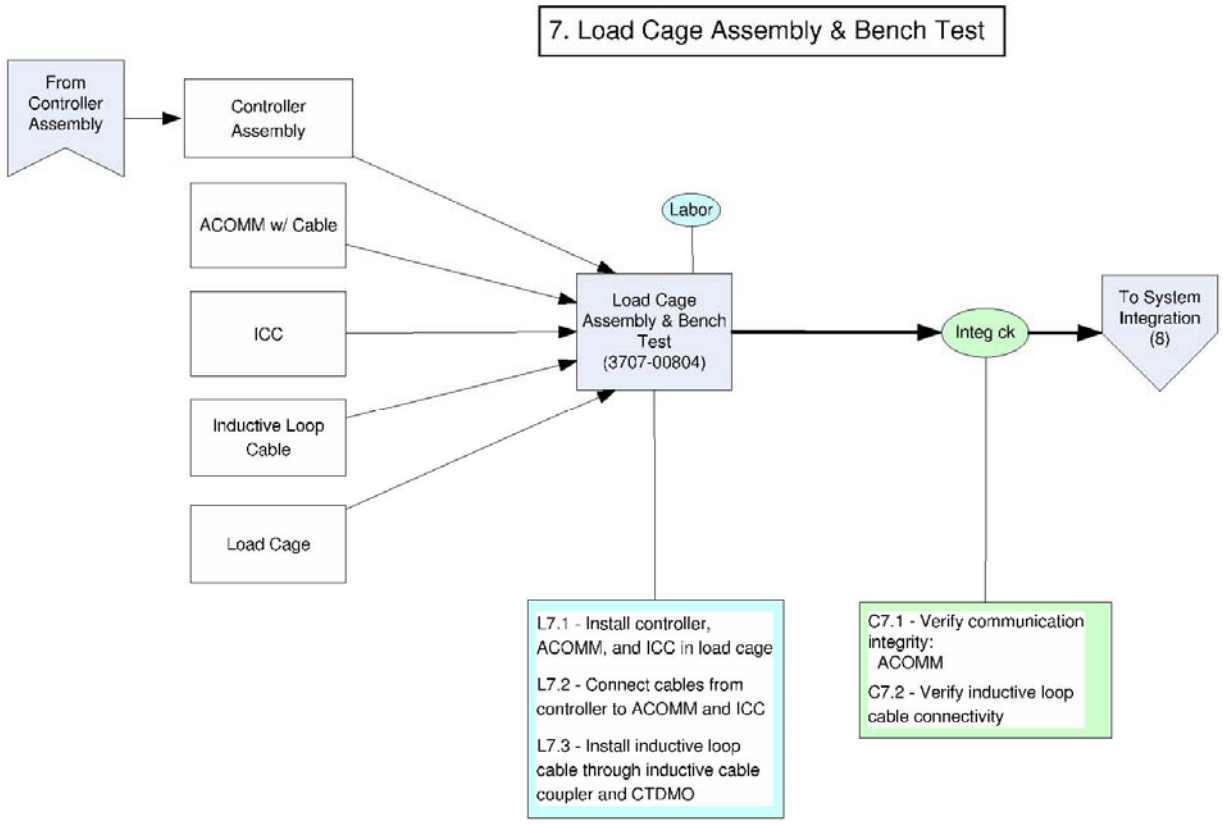
A.6 64” Sphere Assembly & Bench Test



Checklist 6: 64" Sphere Assembly Assembly and Bench Test

No.	Integration Check/Action	Pass	Fail	Notes
C6.1	Verify communication integrity of the instruments through serial communication with controller: ZPLSG			
C6.2	Verify inductive loop cable connectivity			

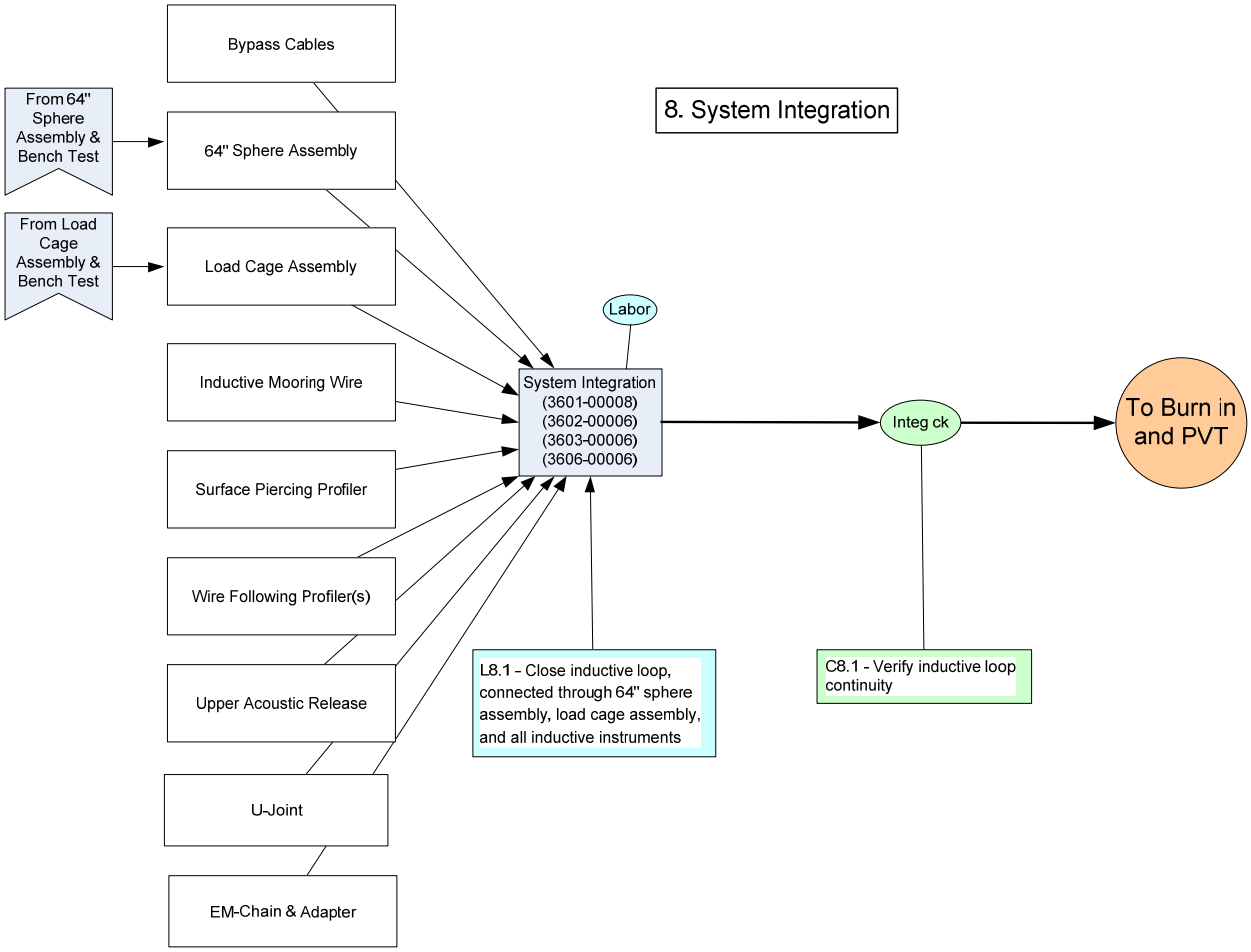
A.7 Load Cage Assembly & Bench Test



Checklist 7: Load Cage Assembly

No.	Integration Check/Action	Pass	Fail	Notes
C7.1	Verify communication integrity through ACOMM			
C7.2	Verify inductive loop cable connectivity			

A.8 System Integration



Checklist 8: System Integration

No.	Integration Check/Action	Pass	Fail	Notes
C8.1	Verify inductive loop continuity			